

Multi-scale water resources planning in England

Ali Leonard

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School of Engineering, Newcastle University

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Abstract

Water resources planning in England is undergoing a significant transformation to address growing challenges posed by climate change, population growth, and environmental pressures. Historically fragmented and company-specific, the planning framework has evolved towards a more multi-scale governance approach with the addition of national, and regional planning tiers. Operating within strict economic and legal constraints, though not legislated for itself, the introduction of England's National Framework for Water Resources in 2020 marked a major step toward overcoming company-boundary limitations by fostering regional and national coordination. This study highlights both the successes of the emerging multi-scale governance model, alongside difficulties linked to misalignments and gaps in the framework.

By analysing England's 2020-2024 water resource planning cycle through qualitative analysis, including semi-structured interviews with industry practitioners, document reviews, and embedded research in planning groups, this research critically examines how historical pathway dependencies have characterised the development of the new arrangements, the embryonic role of strategic coordination, and the balance between granularity and trust in water modelling.

A key tension in water planning lies in the complexity of modelling approaches used to justify investment decisions. The proliferation of models, ranging from climate and hydrological simulations to econometric forecasting, creates challenges in transparency and decision-making, leading to doubt in the robustness of planning outcomes. Adaptive governance, and greater interdisciplinary collaboration can improve trust and clarity in decision outputs.

Enhancing coordination and adaptive governance will be crucial for ensuring long-term water resilience. Key recommendations include the establishment of a national coordination office, improved regulatory alignment, and a commitment to open and iterative learning. Ultimately, bridging science, governance, and resilience can create a more robust and transparent future for water resource management in England.

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Table of Contents

Contents

1. Chapter 1. Introduction	13
1.1 From scarcity to security: setting the stage for water resources management	13
1.2 Water resources planning in England	18
1.3 Research project and case study aims	22
Key research aim.....	24
1.4 Key research objectives	24
1.5 Structure of the thesis	24
2. Chapter 2. Methods	27
2.1 Philosophical perspective	27
2.2 Theoretical foundations of the methodology.....	28
2.3 Choice of methods	31
2.3.1 Data collection methods.....	32
2.3.2 Data analysis	39
2.4 Positionality	41
2.5 Validity	43
2.6 Summary	45
2.7 Signpost to the next chapter	46
3. Chapter 3. The Changing Landscape of Water Resources Planning in England.....	47
3.1 Abstract.....	47
3.2 Introduction	47
3.3 Method statement	49
3.4 Evolution of the scale of planning	50
3.4.1 Piecemeal.....	51
3.4.2 Early consolidation	51

3.4.3	National strategy	52
3.4.4	Integrated regions.....	53
3.4.5	Privatised and regulated.....	54
3.4.6	Transition to multi-scale planning	56
3.5	Features of planning	58
3.5.1	Biophysical/material conditions: fragmented boundaries	58
3.5.2	Political-economic context	61
3.5.3	Planning discourses.....	62
3.5.4	Rules	68
3.5.5	Communities of actors	70
3.6	Conclusion	74
3.7	Signpost to the next chapter	76
4.	Chapter 4. Collaborative Multi-scale Water Resources Planning in England.....	77
4.1	Abstract.....	77
4.2	Introduction	77
4.2.1	Collaborative, coordinative, and cooperative multi-scale planning.....	80
4.2.2	Water resources practice in England	85
4.3	Materials and methods	89
4.4	Results	92
4.4.1	Successes and limitations of the 2020 2024 planning round	92
4.5	Discussion.....	102
4.5.1	Why a multi-scale framework is needed	104
4.5.2	Principles of subsidiarity, adaptive planning, and transparency.....	105
4.5.3	A stepped approach in the transition to integrated planning.....	106
4.6	Conclusion	107
4.7	Signpost to the next chapter	109

5.	Chapter 5. The Complexity of Clarity: Balancing Granularity and Trust in Modelling for Water Resources Planning in England	110
5.1	Abstract	110
5.2	Introduction	110
5.2.1	Trust	111
5.2.2	Complexity.....	112
5.2.3	Granularity	113
5.2.4	Transparency	113
5.2.5	Case study: water resources planning in England.....	115
5.3	Methods	118
5.3.1	WRMP, business plan, and price review analysis	118
5.3.2	Semi-structured interviews with water industry practitioners.....	119
5.4	Results: landscape of water resources modelling in England	119
5.4.1	Modelling underpinnings of investment.....	119
5.4.2	Model abundance.....	120
5.4.3	Heavy documentation.....	121
5.4.4	Binary, quantitative outputs.....	123
5.4.5	Concrete decisions amid uncertainty.....	126
5.4.6	Investment modelling: picking solutions	135
5.5	Discussion.....	149
5.5.1	Inherent planning tensions	149
5.6	Discussion and recommendations	152
5.6.1	Embed adaptive planning.....	153
5.6.2	Simplify	155
5.6.3	Build adaptive governance	156
5.7	Conclusion	157
5.8	Signpost to the next chapter	159

6.	Chapter 6. Integrated Discussion	160
6.1	Cross cutting themes.....	160
6.1.1	Scale: transition towards strategic, multi-scale planning	160
6.1.2	Institutional context: privatised and regulated	172
6.1.3	What we value: eliciting objectives.....	179
6.1.4	Uncertainty and complexity: adaptability in a dynamic environment	187
7.	Chapter 7. Conclusion	191
7.1	Findings of each chapter	191
7.1.1	Chapter 3: The Changing Landscape of Water Resources Planning in England	191
7.1.2	Chapter 4: Collaborative, Multi-scale Water Resources Planning in England	193
7.1.3	Chapter 5: The Complexity of Clarity: Balancing Granularity and Trust in Modelling for Water Resources Planning in England	195
7.2	Disciplinary implications	199
7.2.1	Future risks and challenges	199
7.2.2	Insights from research	201
7.2.3	Targeted recommendations.....	202
7.2.4	Recent developments in policy.....	204
7.3	Strengths, limitations, and suggestions for future research.....	209
7.3.1	Strengths of the thesis	210
7.3.2	Limitations of the study.....	210
7.3.3	Areas for future research.....	212
7.3.4	Overall summary	214
8.	Chapter 8. References.....	216
9.	Appendices	242
9.1	Documents reviewed for the document analysis.....	242
9.1.1	Policy and industry chapters	242

9.1.2	Legislation	254
9.2	Semi-structured interviews	257
9.3	Lessons learned reports.....	260
9.4	Research timeline	276
9.5	Thematic analysis.....	277
9.6	Additional information to support Chapter 5.....	298

List of figures

Figure 1. Images of significant historical water resources infrastructure from around the world.....	13
Figure 2. Timeline from Affinity Water’s revised draft WRMP	19
Figure 3. Timetable envisaged for regional planning.....	21
Figure 4. Representation of Ostrom's IAD Framework	29
Figure 5. Simple graphic illustrating the iterative nature of qualitative data analysis. ...	41
Figure 6. Contextual factors influencing a research design.....	43
Figure 7. The changing scale of water resources governance in England.....	50
Figure 8. Graphic to illustrate the distinctions between coordination, collaboration and cooperation	83
Figure 9. Map of water resources planning boundaries in England	88
Figure 10. Proposal for an evolution of the planning framework	97
Figure 11. Proposal for the components of national programme management	97
Figure 12. Map of UK water companies and water resource zone (WRZ) boundaries and regional planning groups.....	117
Figure 13. Table of the number of documents published for final WRMPs	122
Figure 14. Summary of final outputs across WRMPs, business plans, and final determinations, and customer bills.	124
Figure 15. Difference in Deployable Output (DO) impact between 2 models.....	129
Figure 16. Main Licence Change Scenarios	134
Figure 17. Example of a comparison across best value (Plan B) and least cost (Plan C) plans	141
Figure 18. Performance of WRSE’s best value, least cost, and other plans	143
Figure 19. Performance of WRSE schemes	144
Figure 20. Representation of key stages of modelling for water resources planning investment	148
Figure 21. Inherent planning tensions.....	152
Figure 22. Categorising uncertainty	154

List of tables

Table 1. The nature of economic goods.....	16
Table 2. Defining terms: consumptive and non-consumptive water use	18
Table 3. National bodies overseeing national and regional planning.....	20
Table 4. Defining philosophical terms.	27
Table 5. Breakdown of interviews.	33
Table 6. Details of three placements during the PhD.	38
Table 7. Lessons for implementing good governance from previous studies.	82
Table 8. Framework for delivering water resources outcomes.....	86
Table 9. Success and limitations of the 2020-2024 water resources planning round....	94
Table 10. Best value metrics published by regional groups grouped into 12 categories.	139
Table 11. Price Review Water Supply enhancement expenditure model – unit cost model	146
Table 12. Change in return rate between draft and final determinations.	147
Table 13. Stages of planning.	176

Chapter 1. Introduction

1.1 From scarcity to security: setting the stage for water resources management

Adequate water provision for uses including drinking, cooking, cleaning, irrigation, and industry is essential for a functioning society. The task of ensuring sufficient water, for both ancient civilisations and modern societies alike, has demanded great effort and attention (Gleick, 2000), and advanced our understanding of hydrology, climate, and engineering. It has led to spectacular infrastructure feats such as Roman aqueducts, Stepwells in Rajasthan, and colossal dam projects such as the Aswan Dam, the Hoover Dam, and the Three Gorges Dam (**Figure 1**). In some cases, water has formed an enduring basis for how society can be organised with some water governance arrangements lasting centuries, such as the Tribunal de las Aguas de Valencia (or the Valencia Water Court) - considered to be one of the oldest sustaining democratic institutions in the world (Green, 2008).



Gwyther-Jones, 2008, Pont du Gard.
<https://www.flickr.com/photos/12587661@N06/2853533206/>, accessed 25/02/2025.



Aqua Mechanical, 2016, Chand Baori, One Of The Deepest Stepwells In India,
<https://www.flickr.com/photos/aquamech-utah/24445288653>, accessed 25/02/2025.



McBey, 2019, The Hoover Dam.
<https://www.flickr.com/photos/158652122@N02/32627448447>, accessed 25/02/2025.



Barrison, 2011, Three Gorges Dam.
<https://www.flickr.com/photos/hbarrison/5892180766>, accessed 25/02/2025.

Figure 1. Images of significant historical water resources infrastructure from around the world. Photos from flickr.com under the creative commons licence.

Planning begins with assessing available water resources, including surface and groundwater, over a defined period (for example 25 years), alongside current and projected demands across sectors such as public water supply for domestic use, agriculture, and industry. If the balance of available water (i.e. supply) is less than the projected demand, a deficit is indicated, and action is required to avoid water shortages (Loucks and Van Beek, 2017).

Traditionally, planning and management have involved capital-intensive engineering solutions to avoid water shortages. These efforts focus on the expansion and integration of water resource networks to augment supplies, involving both increasing water storage and availability, such as with reservoirs and boreholes, and increasing connectivity across water zones, such as with canals and pipelines. A common strategy may involve enhancing the supplies of areas with plentiful water, for example by reservoir development, and transporting surplus to less well-endowed areas, particularly those at risk of shortage and drought or where shortfalls in demand may constrain productivity and growth. Technological advances have expanded water supply options such as the development of desalination and water reuse treatment works. Alongside supply solutions, demand management and leakage reduction strategies have become increasingly prominent in recent decades alongside the rise of sustainability and efficiency narratives which promote less wasteful water usage (Gleick, 2000; Taylor *et al.*, 2009).

Water resources planning immediately concerns providing for our water needs, however, other objectives quickly become integral. Observing the photos above, we might consider how these schemes relate to dimensions of economic and political power, spiritual, amenity, and social spaces, and environmental impacts. Water resources planning involves technical engineering assessments of water needs; however, it is also supported by a legal and policy framework that defines rights, responsibilities, and institutional roles. The combination of the essential yet multi-disciplinary nature of water resources management, involving both 'hard' and 'soft' sciences, makes it a fascinating area of research that cuts across engineering, environmental and social sciences (Hall and Borgomeo, 2013; Krueger *et al.*, 2016; Mollinga, 2020; Whaley, 2022; Harou, 2023; ter Horst *et al.*, 2024).

Whilst interesting, this inherent complexity has led some to label water resources management as a ‘Wicked Problem’ (Grafton, 2017). Wicked problems are characterised by subjectivity and uncertainty, necessitating trade-offs between contested values (sometimes amid conflict), and the exploration and navigation of multiple future pathways with profound uncertainty, especially regarding long-term outcomes. The framing of a ‘problem’, deserving a ‘solution’, requiring a process of deliberation and decision-making alludes to the centrality of decision-making, planning, management, and governance as part of efforts to promote water resources resilience. It is useful to define these related but distinct concepts: governance, planning, decision-making and management.

Governance: Broad in scope, governance concerns the institutions, actors, rules, policies, and processes which establish the overarching framework in which planning, decision-making, and management occur (Newson, 2009; Watson, Deeming and Treffny, 2009; Brisbois and de Loë, 2016a).

Planning: Strategic and forward looking, planning involves long-term goal setting and considers possible management strategies and solutions to problems or anticipated risks (including possible governance reforms) (Friend and Hickling, 1997; Marshall, 2012).

Decision-making: Decision-making refers to the process of selecting between options, marking the point at which deliberation between trade-offs is made concrete (Loucks and Van Beek, 2017).

Management: Practical and operational, management concerns the implementation of strategies, resource allocation, and conflict resolution on a daily basis. (Loucks and Van Beek, 2017).

None are static; all the above concepts tend to be iterative, adaptive, and involve both formal-structural and informal-social dimensions, and power relations, across multiple, vertically and horizontally, integrated networks of actors (Healey, 1997; Newson, 2009).

Imbued within the practice of water governance, planning, decision-making and management is the question: what is fair or just entitlement to water, for individuals, for communities, for society, for the environment and ecology, for industry? Some advocate

for enshrining water as human right (Gleick, 1998, 2000). Yet, the framing of entitlement creates a difficulty; unlike land, water is a transient and elusive resource. It may as easily evaporate as soon as it is captured, and flows through us, the landscape, and the atmosphere quickly, slowly, invisibly, destructively, and cyclically (Kinnersley, 1988; Hanemann, 2005).

The dynamic and essential qualities of water have led scholars to consider how different management strategies might align to the economic nature of water as a good or service. This can be classified according to:

- (1) how easy it is to control access (excludability), and
- (2) whether one person’s use subtracts from another (subtractability) (Polski and Ostrom, 2017).

This creates four categories, defined in **Table 1**.

Table 1. The nature of economic goods, adapted from (Polski and Ostrom, 2017). E = excludability. S = subtractability. H = High. L = Low.

E	S	Good	Description	Example
H	H	Private	Pay barrier, once consumed, another cannot	Bottled sparkling water
H	L	Toll	Pay/infrastructure barrier, once connected one person’s use does not prevent another (<i>depending on resource and infrastructure</i>)	<i>Abundant</i> metered water
L	H	Common pool	Difficult to limit access, <i>excessive</i> use depletes the resource for others; “easily destroyed, often to everyone’s disadvantage” i.e. tragedy of the commons (Hardin, 1968)	Irrigation systems, groundwater from a <i>limited</i> shared aquifer
L	L	Public	Difficult to limit access, one person’s use does not prevent another (<i>within limits</i>)	Navigation, amenity

As suggested by the caveats indicated in *italics* in Table 1, there is a degree of fluidness to subtractability. For example, goods or services might move between private and toll, or common pool and public, depending on the scarcity of the resource (the balance

between supply and demand). Scarcity depends on physical abundance and variability, built infrastructure, as well as management strategies such as allocation, regulation, licencing, property rights, payment for services, use of markets, and coordination.

A preference for one strategy over another starts to introduce the debate around public, versus private, versus community management, which has been a long running contentious topic since the establishment of water supply services, particularly since industrialisation (Hassan, 1985). One view supporting commercialisation considers water a private good similarly to other essential economic goods, that can efficiently be run by companies for profit, accountable to their customers and shareholders, using pricing to incentivise water saving behaviour in scarcity. This position was affirmed by the ‘Dublin Principles’:

“The 1992 International Conference on Water and the Environment set out what became known as the “Dublin Principles”: including the principle that “water has an economic value in all its competing uses and should be recognized as an economic good”. The Dublin Principles have been adopted by numerous international, multilateral and bilateral agencies.” (Bakker, 2007, p. 449)

However, this view is contested. Others consider water a non-substitutable, non-excludable resource that the state has a duty to provide for all and should be protected against privatisation in light of multiple market failures. Looking for more nuance within the ongoing debate between public and private provision, Bakker (2007) emphasises the requirement for some form of collective management and oversight given water’s critical health, economic, and environmental functions, highlighting that:

“a high degree of state involvement... is usually found even in countries that have experimented heavily with neoliberal forms to water management” (p442).

How such collective management is structured is subject to a great deal of inquiry and theoretical analysis within governance and policy design, such as exploring the role of (1) spatial scale, (2) scope and remit, (3) participation, roles, and power, including the balance between the state, market, and community, (4) value, (5) incentives, (6) information, knowledge, science and methods, (7) the decision-making process, (8) temporal scale, (9) accountability, checks and balances, sanctions, and enforcement, as well as other dimensions (Ostrom, 2005).

Case and place specific contextual factors will dictate the character and bounds of many of these dimensions, generating almost infinite possible water governance and management arrangements that may be evaluated as more or less successful. Exploring some of these concepts applied to the specific case study of England forms the foundations of this research project, with the underlying question: how to establish effective water resources management.

1.2 Water resources planning in England

Like anywhere, water resources planning in England has developed in unique ways. Agriculture dominates water resources in many countries around the world, on average accounting for 70% of abstractions, and as much as 95%, in some countries (FAO, 2017). However, this is not the case in England where it represents only ~2.5% of daily average consumptive, licenced abstraction, at a national level (EA, 2020b, p. 51). Although the picture varies locally, with some regions having proportionally higher agricultural demand, public water supply (PWS) dominates water abstraction in England. Water companies put 14,000 million litres into supply every day, accounting for ~93% of consumptive abstraction (p.21) (see **Table 2** for a definition of consumptive abstraction).

Table 2. Defining terms: consumptive and non-consumptive water use. Source: (EA, 2020b, p. 50).

Water use	Definition
Consumptive	<p><i>“Removes some or all of the water they take from the system and therefore affect[s] water availability” (p.50)</i></p> <p>Example: water used for fruit growing</p>
Non-consumptive	<p>Water is <i>“put back into the system close to where it is taken” (p.50)</i></p> <p>Example: water used for cooling purposes in a power station</p>

Due to the privatised, monopoly nature of the sector, a strong regulatory framework was established and has matured over repeated planning cycles. Water companies produce a water resources management plan (WRMP) every five years. The process involves numerous stages of guidance setting, supply and demand balance modelling, environmental assessments, options scoping, customer and stakeholder engagement, decision-making, consultation and scrutiny, and ultimately the publication of final plans

(see **Figure 2** for an example planning cycle). Plans are then funded through a price review process by the economic regulator, Ofwat (Ofwat, 2024).

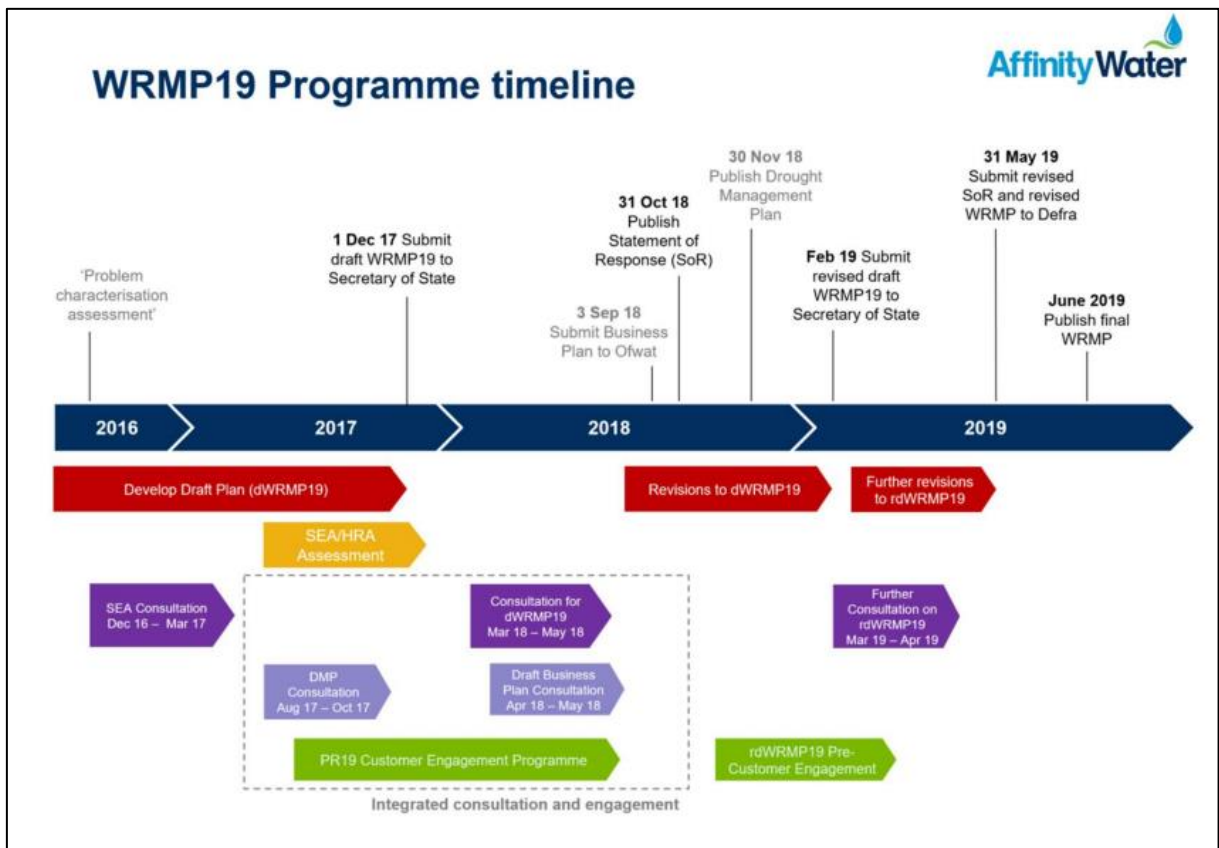


Figure 2. Timeline from Affinity Water’s revised draft WRMP illustrating key stages in plan development including problem characterisation, customer engagement, SEA/HRA (environmental) assessments, consultation, publication. (Affinity Water, 2019, p. 14).

At each new round of planning there is a chance to update the process, and as has often been the case, additional guidance is prescribed. Examples include additional requirements for environmental assessments such as the introduction of biodiversity net gain (Environment Act 2021), new technical methods (UKWIR, 2016), and recently an expectation on companies to coordinate as regional groups (EA, 2020a).

The adoption of a regional planning tier for the 2020-2024 stemmed from concerns that the company-based WRMP process was unable to consider more strategic options that might provide greater resilience at a national level such as cross-company and inter-regional transfers (Khadem, Dawson and Walsh, 2021).

As such, a parallel planning process of regional planning was instituted along the statutory WRMP process. The regional groups were:

1. Water Resources South East (WRSE, established in 1997)

2. Water Resources East (WRE, established in 2014)
3. Water Resources West (WRW, established just prior to 2020)
4. Water Resources North (WReN, established just prior to 2020)
5. West Country Water Resources (WCWR, established just prior to 2020)

Several national planning groups were established to oversee regional planning and the National Framework:

Table 3. National bodies overseeing national and regional planning; source (EA, 2020b, p. 20).

National group	Frequency of meeting	Participants	Role
The Senior Steering Group (SSG)	Quarterly	<i>“40 representatives from government, regulators, water companies, bodies that represent water using sectors such as the NFU and Energy UK, academics and environmental non-governmental organisations”</i>	<i>“provides a strategic steer to the project and has shaped this work [the National Framework]”</i>
The Regional Coordination Group (RCG)	Monthly	<i>“includes each regional planning group, government and regulators”</i>	<i>“The group is about making sure that the regional plans are coordinated and that they are ambitious enough to meet national needs”</i>
The Modelling Advisory Group (MAG)	Ad-hoc, roughly every 2-3 months (personal communication, 2025)	<i>“includes technical representatives from the regional groups”</i>	<i>“sub group of the RCG... about making sure that technical methodologies are in alignment so that cross regional options can be explored”</i>

A timetable was set (**Figure 3**) which outlined expectations for regional plans to be published alongside final WRMPs in September 2023 (EA, 2020a).

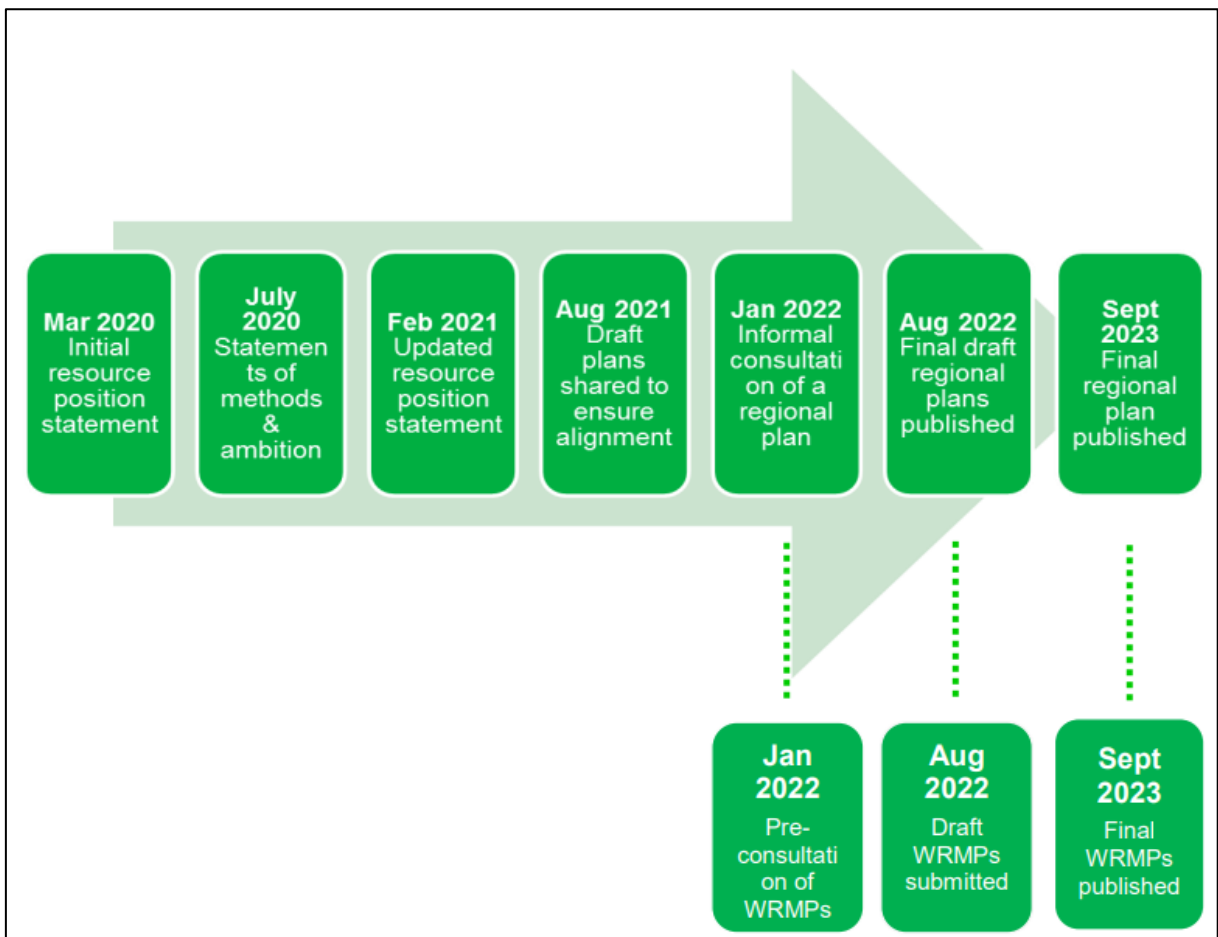


Figure 3. Timetable envisaged for regional planning by the Environment Agency in 2020 (EA, 2020a, p. 16).

The integration of well-established company planning, operating within their own borders, according to their own culture, and using models and tools developed in-house, with a new expectation for collaborative working was a significant change and instigated new requirements for cross-company consistency and coordination across objectives, tools and information (including modelling), and timetabling.

Water resources management literature identifies a gap between theory and practice, calling for case studies that provide greater empirical evidence of how multi-scale planning operates in practice (Raadgever, Mostert and van de Giesen, 2012; Brisbois and de Loë, 2016b; Conrad, 2018; Özerol *et al.*, 2018). Research on planning in England has tended to focus on public versus private provision, and the introduction of the Water Framework Directive (Bakker, 2005; Watson, 2014; Lobina, 2019). With this recent introduction of regional and national planning, England provides a good case study of multi-scale governance. Literature had not captured these recent shifts in the scale of governance, or the developments in evidenced-based decision-making and use of modelling, and how the two interact.

1.3 Research project and case study aims

This 4-year PhD project, titled *Multi-Scale Water Resources Planning in England*, explores the evolving landscape of water resources planning within the context of England's 5-yearly planning cycle from 2019 to 2024. Initiated in October 2020 through the Water Infrastructure and Resilience (WIRe) Centre for Doctoral Training (CDT), the research is a collaboration between academia and industry, aiming to address real-world challenges in water resilience.

The Water Infrastructure and Resilience Centre for Doctoral Training (WIRe CDT; <https://cdtwire.com/>) supports applied research by linking industry-proposed problems with academic expertise, including opportunities for placements within industry and the civil service, ensuring practical impact and skill development, and helping bridge gaps between research and practice. United Utilities Water, the water company serving northwest England, sponsored this research as part of its contribution to the regional planning group Water Resources West, of which it is a member. The study addresses a real-world challenge faced by both the company and the regional group: navigating evolving governance structures.

The project evaluates the shift towards multi-scale planning, driven by the establishment of new national and regional governance structures alongside traditional company-level planning. These frameworks aim to enhance collaboration among regulators, water companies, public and non-public water supply abstractors, and stakeholders to deliver efficient, robust water supply infrastructure and demand management initiatives.

The focus, however, is primarily pointed at water companies providing the public water supply rather than non-public supply abstractors. As discussed, this reflects the fact that in England the public water supply accounts for more than 90% of the country's consumptive demand. Furthermore, the new framework and regulatory support for regional and national planning were directed at public water supply abstractors, with the aim of encouraging water companies to work together to consider inter-company and inter-regional long-distance transfers. While the consideration of other sectors has grown in prominence over time, it was not the primary concern at the start of the planning round.

Practically, the project itself arose from a partnership between academia, a water company, and a regional group director, who, in response to the regulatory promotion of regional and national planning for public water supply, recognised an opportunity to evaluate the ongoing changes in governance structures.

Supervised by an industry leader with an extensive network across national, regional, and company levels, it was possible to closely observe and follow the framework as it played out in real-time, including through engaging with practitioners in 'Lessons Learned' exercises.

This study provides the first in-depth analysis and actionable recommendations for future planning phases in England, addressing gaps and fostering a collaborative, multi-scale approach to water resource management.

Key research aim

To investigate how effective water resources management can be achieved through improved planning processes, collaboration, and technical evidence, with a focus on current practices in England.

1.4 Key research objectives

1. To critically examine the structure, processes, and challenges of water resources planning in England, identifying key opportunities and risks.
2. To participate in and observe the ongoing 2020 - 2024 water planning cycle in real-time, capturing insights through active engagement with stakeholders.
3. To evaluate the implementation of the National Framework for Water Resources and associated regional plans, providing evidence-based recommendations for future improvements.
4. To explore the interplay between governance structures (including collaboration among stakeholders) and the technical foundations of planning (such as modelling and evidence), assessing how these dimensions influence overall effectiveness.

1.5 Structure of the thesis

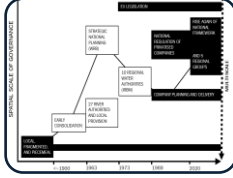
This thesis is organised into eight chapters (including this introduction), structured around three papers, two of which are published, with the third under review, as follows:

1. Leonard, A., Amezaga, J., Blackwell, R., Lewis, E. and Kilsby, C., 2025. The Changing Landscape of Water Resources Planning in England. *Water Resources Management*, pp.1-18.
2. Leonard, A., Amezaga, J., Blackwell, R., Lewis, E., Kilsby, C. and Murgatroyd, A., 2025. Collaborative multiscale water resources planning in England. *International Journal of Water Resources Development*, 41(3), pp.580-605.
3. Leonard, A., Amezaga, J., Blackwell, R., Lewis, E. and Murgatroyd, A., under review. The Complexity of Clarity: Balancing Granularity and Trust in Modelling for Water Resources Planning in England. *Water Alternatives*.



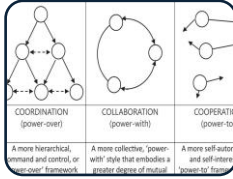
Chapter 2: Methods

- This chapter includes a discussion of the philosophical stance, theoretical foundations, data collection techniques, research method, positionality and validity.



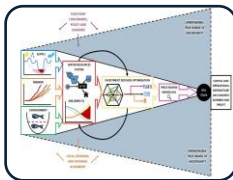
Chapter 3:

- This chapter presents a paper titled: The Changing Landscape of Water Resources Planning in England.
- This paper was published in Water Resources Management (Q1) in January 2025.



Chapter 4:

- This chapter presents a paper titled: Collaborative multi-scale water resources planning in England.
- This paper was published in the International Journal of Water Resources Development (Q1) in December 2024.



Chapter 5:

- This chapter presents a paper titled: The Complexity of Clarity: Balancing Granularity and Trust in Modelling for Water Resources Planning in England.
- This paper is under review for publication in a special issue of Water Alternatives (Q1) titled: Modelling Water Worlds.



Chapter 6: Integrated discussion

- This chapter identifies four key themes, linking them to the theoretical framework and existing literature.



Chapter 7: Conclusion

- This chapter summarises the key findings of the research.
- It discusses the implications of the findings and their relevance to the research problem.
- It also outlines the limitations of the research and suggests directions for future studies.



Chapter 8: References

- This chapter includes the complete list of references cited in the thesis.

Chapter 2. Methods

2.1 Philosophical perspective

Table 4. Defining philosophical terms.

Epistemology (the theory of knowledge – ‘how we know what is’)	Ontology (the nature of reality – ‘what is’)	
	There is an objective reality	There is no one objective reality, rather multiple subjective realities
We can understand the nature of reality, such as through empirical study	Positivist (truth is observed)	Pragmatist (“truth” is what works, emphasis on utility, purpose, and problem solving)
Our understanding of reality is subjective and positional	Critical realist (truth is about describing real mechanisms, even if imperfectly)	Relativist (truth is constructed)

The aim of this research is to inform the development of water resources planning. This implies a search for an objective reality independent of those immediately involved in the research (relating to ontology – see **Table 4**). Yet, while stating this as the aim, epistemologically, the research is necessarily conducted through human perception and experience. The extent to which the outcomes of the search arrive at truth is difficult to evaluate, given any evaluative criteria themselves are fallible constructions conditional on particular vantagepoints. This philosophical stance aligns with the critical (Bhaskar, 2013) or subtle (Hammersley, 2018) realist stance that holds an ontological realism (an objective reality exists) alongside epistemological relativism (our understanding of reality is partial and influenced by our perspectives) (Maxwell, 2012). This perspective sits between positivism (objective discovery of reality), and constructivism or relativism (there is no objective reality, only subjective interpretations of diverse socially constructed perspectives).

The advantage of the critical realist stance is that it allows for an earnest exploration for solutions that ‘work’ (aligning also with a “pragmatist” stance (Maxwell, 2012; Kaushik and Walsh, 2019) - see **Table 4**), while inviting critical reflection and emphasising a need for humility in the face of inherently incomplete and positional understanding. This

reflection is important for quantitative studies, for example being dependent on imperfect instrumentation and being conducted under certain contextual constraints such as geography, institutional setting, funding, expertise etc. It is also crucial for qualitative studies which involve the interpretation and parsing of multiple perspectives, by a researcher or team of researchers with their own perspectives. Ultimately, research aims to build a picture or model of reality, recognising that the model will never be a one-to-one replica (Maxwell, 2012; Hole, 2023). While the model will be imperfect, the process and outputs can be judged as either more or less successful depending on (1) whether the study was carried out with skill, reliability and validity, and (2) the values of those judging. The stance therefore is also somewhat pragmatic in that the validity is assessed through social constructions of those involved in the study, the academic and wider literature in which the study is situated, and the peer review process (Maxwell, 2012; Kaushik and Walsh, 2019).

2.2 Theoretical foundations of the methodology

This study is grounded in a range of theoretical frameworks, each contributing distinct insights into the governance of complex socio-ecological systems, infrastructure risk, and public policy. At the core is Elinor Ostrom's Institutional Analysis and Development (IAD) framework (Ostrom, 1990, 2005), a foundational approach for understanding collective decision-making and resource governance by examining interactions among actors, rules, and biophysical conditions within an action arena (see **Figure 4** below).

Ostrom's work centres institutions as core to the analysis of water management, identifying eight core principles (Ross and Martinez-Santos, 2010):

- (1) Clearly defined boundaries (of the resource system and its users),
- (2) Proportional equivalence between benefits and costs (allocation matching local conditions),
- (3) Collective-choice arrangements (users participate in rulemaking),
- (4) Effective monitoring,
- (5) Graduated sanctions for rule violators,
- (6) Conflict-resolution mechanisms,
- (7) Minimal recognition of rights to organise, and
- (8) Nested enterprises (multiple scales).

Further studies which applied the IAD framework to real case studies helped guide the approach taken in this thesis. For example, Blomquist, Schlager and Heikkila's (2010) book 'Common Waters: Diverging Streams' demonstrated how different institutional arrangements in Arizona, California, and Colorado impacted water management strategies and outcomes. Related research which guided this work was Feiock's (2013) extension of IAD into the Institutional Collective Action Framework (ICA). Feiock outlined how networks of actors can work together without a central authority with the use of joint powers agreements, regional councils, and collaborative policymaking arenas that overcome coordination barriers (such as coordination costs, transaction costs, commitment and enforcement challenges, and free riding).

A clear evolution can be traced from the early applications of Ostrom's IAD framework toward more critical, power-aware, and historically situated approaches. This developed through applications of the IAD framework in research carried out at Newcastle University's Centre for Water. Floriane Clement's "politicised IAD" represents a key turning point in this trajectory. Her adaptation incorporates analysis of the broader politico-economic context and the role of dominant discourses, highlighting how these shape institutional dynamics and policy effectiveness (Clement and Amezaga, 2009; Clement, 2010). Drawing on empirical work in Vietnam, she reveals the lack of synergy between national afforestation policies and local collective management, underscoring how centralised narratives often obscure local realities and generate unintended outcomes.

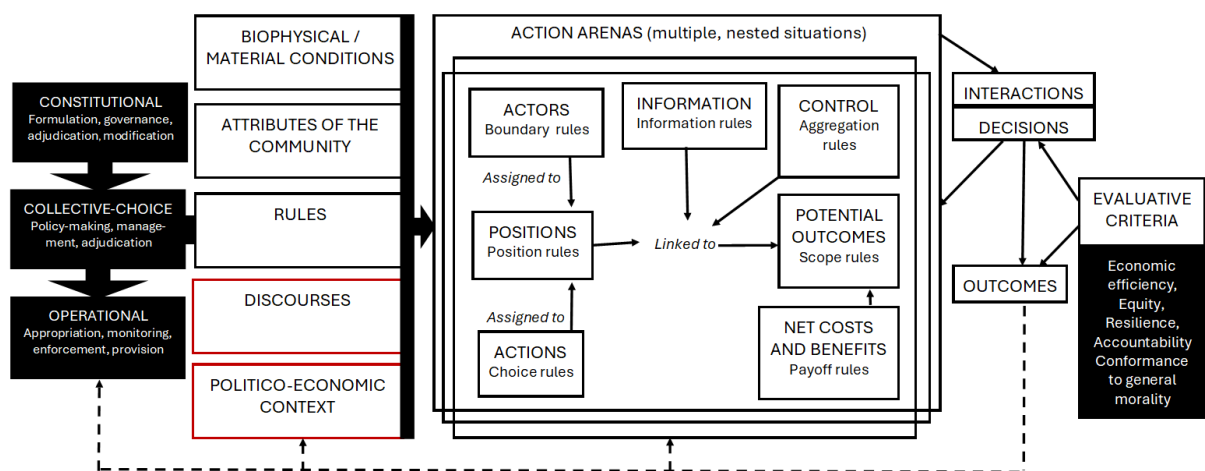


Figure 4. Representation of Ostrom's IAD Framework, with Clements's adapted 'politicised' version included in red (discourses and politico-economic context) adapted from (Ostrom, 2005; Clement, 2010; Polski and Ostrom, 2017).

This critical turn is further developed in the work of Pablo Méndez, whose studies in the Doñana region of southern Spain expose the persistent influence of historical path dependencies, and entrenched discursive and political power, in water governance. Méndez illustrates how rigid, command-and-control regimes have become locked into unsustainable infrastructural trajectories, resisting reform despite ecological and institutional degradation (Méndez *et al.*, 2012; Méndez, Amezaga and Santamaría, 2019; Méndez, 2021; Méndez, Fajardo-Ortiz and Holzer, 2022). His work advocates for adaptive governance rooted in systemic, multi-level analysis and an openness to pluralism, both institutional and discursive, as essential to navigating complexity and enabling sustainability transitions.

Finding dissatisfaction with static or decontextualised models of policy and governance, these authors show that transitions to sustainability require not just institutional change but a deep reckoning with the discourses, power relations, and histories that shape action. This research by Clement, Méndez and others was carried in collaboration with Jaime Amezaga, one of the supervisors of this research project, who guided the approach taken (Ambituuni, Amezaga and Emeseh, 2014; Kennedy-Walker, Amezaga and Paterson, 2015; Ambituuni, Azizsafaei and Keegan, 2021).

These institutional approaches are closely linked with traditions in systems thinking. Originating in the philosophical work of Churchman (1968) and Vickers (1965), and developed methodologically by Ackoff (1979, 1981) and Checkland (1981), systems thinking offers a counterpoint to reductionist science. These authors emphasise taking more qualitative, iterative, participatory and human-centred approaches that wrestle with, rather than ignore, the complexities of politics, morality, religion, and aesthetics (Churchman, 1979). This emphasis on the integration of diverse knowledge systems is particularly important in the context of environmental governance, including water management (Polaine, Dawson, *et al.*, 2022).

A systems based approach underlies Loucks and Van Beek (2017) foundational text 'Water Resources Systems Planning and Management' which applies an integrated, systems-based thinking to planning incorporating the use of decision-support systems, such as modelling and optimisation tools, for evidence based planning. Similarly, Thissen and Walker and their colleagues (Thissen and Walker, 2013; Thissen *et al.*, 2017; Thiel, Blomquist and Garrick, 2019) advance frameworks that blend policy analysis with

systems engineering, advocating adaptive, multi-scale planning that is transparent, participatory, and responsive to uncertainty.

Collectively, these theoretical foundations call for a shift away from technocratic, linear models of policymaking. Instead, they promote politicised, participatory, and adaptive governance approaches that reflect the complexities and contestations inherent in the real-world. This orientation underpins the methodology adopted in the present study.

2.3 Choice of methods

The methodological approach to data collection and analysis adopted for this research was pragmatic, reflexive, flexible, and interactive. This reflects the context of the research embedded within a planning process unfolding in real-time which allowed for expanded data collection strategies as opportunities arose. For example, taking up invitations to present at and observe regional and national planning meetings, or the unexpected publication of policy guidance and planning reports that could be incorporated into the analysis. This approach ties into the critical realist philosophical perspective, emphasising the iterative and non-linear nature of knowledge building, involving ongoing feedback and interaction with practitioners, published reports, theory, and wider experience (Maxwell, 2013).

The research is primarily shaped by qualitative research methods: (1) document analysis, (2) semi-structured interviews, (3) workshops, (4) observations, and (5) placements, which are detailed below. The final chapter also involved analysis and summarising of quantitative planning outputs.

The same qualitative methods are used throughout the three chapters presented in Chapters 3 to 5, but to different degrees.

- Chapter 3 ‘The changing landscape of water resources planning in England’ has a strong basis in historical texts and policy documents.
- Chapter 4 ‘Collaborative multi-scale water resources planning in England’ is strongly grounded in observations, interviews, workshops.
- Chapter 5 ‘The complexity of clarity: balancing granularity and trust in modelling for water resources planning in England’ uses planning outputs and interviews.

2.3.1 Data collection methods

2.3.1.1 Document analysis

Document analysis was particularly relevant for Chapter 3 which used historical policy documents (listed in **Appendix A**) and pieces of legislation (listed in **Appendix B**).

Academic literature helped support the discovery and analysis of documents (Harwood, 1895; Hassan, 1985; Kinnersley, 1988; Archer and Marriot, 1993; Roberts, 2000; Parker, 2004; Evans and Howsam, 2005; McCulloch, 2006, 2009; Spar and Bebenek, 2009; Taylor *et al.*, 2009; Kendon, Marsh and Parry, 2013; Lambert, 2015; Penning-Rowsell and Johnson, 2015; Turner and Jeffrey, 2015; Atkins, 2018; Turner *et al.*, 2021; Bromwich, Crilly and Banerjee, 2022). The documents were additionally gathered through online searches. The documents were parsed to find pertinent information, which was ordered chronologically to construct a picture of how the scale of planning developed over time, and ultimately to outline the key characteristics of planning in England to provide the foundation and context for further analysis (Méndez, Amezaga and Santamaría, 2019).

Recent policy documents and legislation were critical for Chapters 4 and 5 for understanding the contemporary context and how it evolved in real-time. For Chapter 4, material from the document analysis was incorporated into the thematic analysis (discussed in more detail below). Chapter 5 depended on the publication of final water resources management plans (WRMPs) and business plans at the end of the 2024 planning round, as well as Ofwat's final determinations. Both quantitative and qualitative analysis was carried out using the information in the published reports and data tables. The outputs of the analysis included:

- (1) summary tables and figures presenting planning outcomes across the sector,
- (2) a review of the number of pages and reports to indicate how much documentation was involved in the planning round, and
- (3) an analysis of modelling methods used to demonstrate how they relate to the wider picture of how uncertainty propagates through the planning process.

Benefits of document analysis lay in the ability to follow the trajectory of planning over time, providing a rich source for understanding the formal rules and how they evolved. This is essential for understanding historic periods for which interviews are no longer possible, but also for more recent periods whereby documents can help corroborate

data gathered from other methods such as interviews, as well as help to generate research questions (Bowen, 2009). Furthermore, there is a practical aspect; many documents are freely and easily available online which provides a useful and accessible starting point. Additionally, Bowen (2009) identifies a major benefit of documents as their lack of ‘reactivity’, referring to the potentially distorting impact that a researcher’s presence can have in interviews and observation.

It is also important to note several limitations of document analyses. Although legislation and many reports are made available, these reflect only a small sample of the vast amounts of documentation and interactions that are involved in planning. More informal aspects of the planning process (such as internal correspondence through emails, draft reports, meeting minutes, and conversations) cannot be deciphered from final published reports. It is also possible that relevant documents may be excluded or redacted for political, commercial or other reasons, creating gaps that may limit the depth of work. This issue is also true for the documents that are made available, whereby the choice of what is made public should be considered in the analysis and how it might relate to the interests of those publishing the material. Therefore, a critical eye is required to build a picture through multiple sources considering potential biases and gaps (Bowen, 2009).

2.3.1.2 Semi-structured interviews

The use of interviews is common in qualitative data. For this research project, 28 participants were interviewed over the course of 33 interviews (see **Table 5**).

Table 5. Breakdown of interviews.

Time period	Regional planning leads	Water company technical planners	Consultants (on behalf of regions)	Regulators and civil servants	Example questions
Jun-Aug 2021	4	4	0	4	Appendix D
Nov 2022-Jan 2023	5	3	1	2	Appendix E
Apr 2023-Nov 2024	0	3	2	5	Appendix F

All interviews were one to one, except two interviews which both involved two participants in the same meeting. The meetings were arranged by email through the industrial supervisor's network with the exception of four interviews which happened through the snowball effect of participants recommending colleagues (Patton, 2002; Braun and Clarke, 2013). Interviews were carried out online using either Zoom or Microsoft Teams and were organised to run for 30 minutes or one hour, with several continuing for longer.

An introductory speech was given outlining the research project and ensuring the participant(s) consented to being recorded (see **Appendix C**). This is in line with ethical guidelines regarding consent, attribution, and confidentiality (Braun and Clarke, 2013). Questions were tailored to the individual participant(s) allowing time and space to explore beyond the initial prompts into new areas. This reflects the nature of semi-structured interviews being flexible and interactive (Oppenheim, 1992; Braun and Clarke, 2013). However, broadly similar questions were covered (outlined in **Appendix D, Appendix E & Appendix F**).

The interviews were recorded; both Zoom and Teams automatically generate a transcription. However, the quality of the transcription was poor and required editing (though notably the quality improved over time with technological advancements and the final interviews towards the end of 2024 required less editing). Transcribing was initially carried out by the researcher, and subsequently by a transcription service. The recordings and transcriptions meant that notetaking was not required, although some key points were noted down when considered useful.

For the final four interviews towards the end of 2024, the Artificial Intelligence (AI) tool Chat GPT was used to help with transcribing and analysing the interviews, which participants commented provided accurate summaries. Editing and quality checking were necessary, and it was most effective to use AI tools immediately after the interviews while the discussion was still fresh in mind. This ensured a more accurate assessment of the AI-generated outputs. Additionally, the transcript was used to verify the validity of AI generated statements.

ChatGPT also helped to analyse and critique the interview technique and style of the researcher, offering helpful praise and areas to improve (see **Box 1**). This tool was only available for the last few interviews. If available from the beginning it would have been a

helpful way to track improvements and highlight skills to improve over the course of the interviews.

Box 1. Example of ChatGPT response when prompted to evaluate interview technique.

When prompted with “Could you comment on the interviewer style, and suggest any possible areas for improvement (considering best practice)?”, Chat GPT replied:

Deeper Probing for Examples and Evidence:

- While the interviewer effectively engages with broad concepts (e.g., complexity, regulation, and governance), there are moments where more detailed follow-up could elicit richer insights. For example, when the interviewee discusses "arbitrary cost adjustments" or "local environmental objections," the interviewer could ask for additional concrete examples to strengthen the points.
Suggestion: Use prompts like, "Can you provide another example of how this plays out in practice?" or "How do you think this issue could be resolved in future cycles?"

Use Paraphrasing to Validate Understanding:

- After the interviewee answers, paraphrase their key points to ensure understanding and create a clear summary for later reference.
- Example: "So, if I understand correctly, you're saying that the five-year cycle is critical for course corrections in a changing context. Is that right?"

An interesting aspect of interviews is the balance between asking probing questions and maintaining rapport. A risk exists that the interviewer will avoid potentially critical or sensitive questions at the expense of valuable insights to avoid discomfort and straining relationships. Similarly, if a participant becomes defensive, the interview may be derailed, limiting the depth of responses. Skilled interviewers are able to tread this line by framing questions constructively, demonstrating empathy and fostering open dialogue using active listening, adaptive questioning, and reflexivity to elicit candid responses (Silverman and Marvasti, 2008; Prior, 2018). For a novice researcher, mastering these skills takes time. Fortunately, while critical discussions were sometimes necessary, participants generally understood structural challenges and engaged candidly. The high level of respect within the industry and a shared understanding of the problem helped mitigate risks of discomfort, defensiveness, or conflict, common in industry-specific research where stakeholders often face similar challenges (Patton, 2002). Additionally, the interviewer was familiar with industry language and acronyms and had a good awareness of the planning context, allowing for an unconstrained conversation and deeper engagement.

Interview summaries were sent back to participants to review, correct any misinterpretations or have a chance to retract. Most participants replied with either no

or minor changes. Some participants did not respond in which case the summary was assumed to be acceptable.

The benefits of semi-structured interviews are an in-depth exploration of participants experiences (Braun and Clarke, 2013). The questions provide some structure and allow comparison between interviews, yet the flexibility allows for a deeper probing into sometimes unanticipated areas. Many participants were able to ‘put different hats on’ and distinguish between different perspectives, either from their own personal standpoint, that of the organisation they were part of, or other organisations, as well as more broadly.

2.3.1.3 Observations

Between 2021 and 2024, the weekly decision-making meetings of the regional planning group Water Resources West (WRW) were observed. The meetings took place online via Microsoft Teams and usually lasted one hour. Participants included the Director of WRW (also the industrial supervisor of the research project) and representatives from the four constituent water companies, United Utilities, Severn Trent, South Staffs, and Welsh Water. Several meetings also included others such as consultants and regulators. Notes were taken which helped to inform the thematic analysis (discussed in more detail below).

One of the main benefits of observations is the exposition of the more informal and practical aspects of planning that as mentioned above are not clear from reports, as well as interviews (Baker, 2006).

A limitation of observational data collection is the impact of the presence of the observer (Baker, 2006); however, this was mitigated to some degree by the ability through Teams to turn the camera and microphone off to minimise the observer’s presence. Like all qualitative data there is potential bias from the interpretation of the data, which again can be minimised through an iterative and broad approach that does not rely on a single method or event but is built on and tested over time (described in more detail below).

2.3.1.4 Workshops

Building on the interviews, a series of Lessons Learned Workshops were conducted.

- (1) The first Lessons Learned Workshop was conducted online in December 2021 following the first round of interviews, and the first national reconciliation process (Sep-Dec 2021). Participants included seven regional group planning leads and an academic supervisor.
- (2) A second Lessons Learned Workshop was held in January 2023 in London between 10am and 4pm. Participants included seven representatives across the five regional planning groups, with an academic supervisor also joining through a remote link. The representatives were not the same as in the first workshop; though two participated in both.
- (3) A third Lessons Learned Workshop was held in November 2023 following a Regional Coordination Group meeting with five regional planning leads, one national planning lead, and an academic supervisor. Again, the representatives were not the same, though three had participated in either the first or second workshops.

The workshops involved a presentation providing feedback from interviews and observations of the planning process. This was followed by discussion around navigating progressing planning in the short term and longer term. Workshops finished with summing up key lessons and actions going forward. A short report was produced following each workshop and presented at a national planning meeting.

The workshops led to reports that were presented at several national planning meetings.

1. Regional Coordination Group – January 2022 (report included in **Appendix G**)
2. Regional Coordination Group – February 2023 (report included in **Appendix H**)
3. Regional Coordination Group – February 2024 (report included in **Appendix I**)
4. National Framework Leadership Board meeting – October 2024

Recommendations from workshops and reports became part of the process itself, for example contributing to the direction of how future national reconciliations should be organised.

There were several benefits from engaging in the process in a more active way through these workshops. Firstly, they allowed for knowledge sharing and collective learning, both between the participants themselves as well as the researchers. They allowed an independent platform for continuous discussion and development of the national coordination and further development of team cohesion and collaboration.

Similarly with other methods, limitations of holding workshops include dependency on the skill of the facilitation, rapport between participants, potential bias of the observations, and constraints of time to cover all topics (Baker, 2006). These were mitigated to some extent by the familiarity of the participants with each other, having been in similar planning meetings, and the willing and collegiate culture that already existed.

2.3.1.5 Placements

The final method of qualitative analysis was through placements in several planning environments, outlined in **Table 6**.

Table 6. Details of three placements during the PhD.

Dates	Organisation	Location	Duties and outputs
Feb-May 2022	Hydro-logic consultancy	Remote working	Helping with the preparation and management of the Second National Reconciliation
May-Jun 2022	United Utilities	Warrington	Working in the Water Resources Management Plan (WRMP) team (data analysis and writing tasks for the draft plan)
May-Aug 2024	Defra	London	Working in the Water Resources Team producing a report on viewpoints across industry on possible future directions

Like observations, the benefits of placements provide firsthand experience working in different industry and public service environments, stepping away from research responsibilities and being immersed in the ‘field’. This provides the chance for a deeper understanding of social and professional contexts, behaviours, and interactions that are not possible through other methods. Again, limitations include subjectivity of the interpreter and dependency on the quality of the placement and interaction (Baker, 2006).

Overall, the methods (see **Appendix J** for a timeline) involved an iterative process of engaging with texts and people through multiple methods in a variety of settings that allowed for a deeper understanding of the planning period, compared to a more distant approach (Srivastava and Hopwood, 2009; Kapiszewski, MacLean and Read, 2022). Much of this engagement benefitted from the strong links of the industrial supervisor and the collegiate working culture of the regional and national planning groups.

2.3.2 Data analysis

Qualitative data was gathered across multiple methods: documents, interviews, observations, workshops, and placements, producing data in different forms. Textual data was derived directly from documents and interview transcripts, while observational methods required researcher descriptions, such as notes and minutes from meetings, workshops and placements. The integration of data from multiple sources, known as triangulation (Maxwell, 2013), enhances the validity of qualitative research by cross-referencing findings from different perspectives and reducing reliance on a single data source.

2.3.2.1 Interpretation and thematic analysis

Once collected, the qualitative data underwent a selection and interpretation process, which involved discarding irrelevant material and summarising key findings to focus on pertinent information. This stage is inherently vulnerable to researcher biases, including confirmation bias, where data is interpreted in ways that reinforce pre-existing assumptions (Maxwell, 2013, p. 20). To mitigate these risks, 'member checking' was implemented: summaries of interviews and workshop reports were sent back to participants for review and feedback. This process ensured that the interpretations accurately reflected participants' perspectives and minimised potential misrepresentations. The selected, refined data was then analysed through a process of conceptualisation and theory building.

There are several techniques for how to conduct this stage. An approach modelled on thematic analysis (Braun and Clarke, 2013; Hole, 2023) was used in this study. Thematic analysis involves categorising and coding data, identifying patterns, and developing tentative hypotheses. These hypotheses are continually tested and refined as additional data is incorporated. The validity of emerging themes was assessed through an iterative process, in which new data was compared against existing categories. If discrepancies arose, hypotheses were revised to ensure alignment with the full dataset.

Categories, 'codes,' and later 'themes' can be identified deductively (using existing theory), inductively (emerging from the data), or through a combination of both (Braun and Clarke, 2013). This study adopted a mixed approach. Initially, the data was reviewed inductively, drawing from the data itself rather than pre-defined theory or categories. As

the process went on, data came in from new sources, in line with the iterative and pragmatic approach to data collection. This ensured that findings remained dynamic and adaptable rather than being rigidly predefined.

The analysis was supported by qualitative data management software tools such as NVIVO, Excel, and other database tools, which were used at different stages of this study to facilitate efficient coding, retrieval, and comparison of data (Wong, 2008).

2.3.2.2 Role of theory: a pragmatic approach

In qualitative research, there are multiple ways to integrate theory. While some qualitative research studies rely on grounded theory, which prioritises data as the primary source of theory and focuses on "*the discovery of theory from data*" (Glaser and Strauss, 1967, p. 1), this approach was not used. Grounded theory, though valuable, presents methodological challenges due to potential fallibilities in data collection and testing, including bias, incompleteness, unrepresentativeness of participant responses, and researcher interpretation (Prince, 2020).

Instead, this study was guided by the theoretical and analytical frameworks (discussed above) where useful, adopting a pragmatic approach that avoided imposing a pre-existing model onto the data but rather used theory selectively to provide useful structure, while ensuring that interpretations remained grounded in the case study's real world policy context.

This approach comes with risks, such as the potential for confirmation bias and a lack of systematic comparison with other studies. However, given the applied nature of the research, it was more appropriate to centre the empirical evidence rather than adhere rigidly to one theoretical framework.

2.3.2.3 Iterative refinement of theoretical insights

Over time, thematic categories and theoretical interpretations were refined not only by new data but also broader academic engagement across a range of academic fields, including wider reading, conferences, presentations, supervisions, interactions with peers, and completion of two Master's modules. This iterative refinement ensured that theoretical developments were not static but evolved alongside the empirical data, reinforcing the validity and depth of the study's conclusions.

The main results chapters (3, 4 and 5) were particularly influenced, respectively, by (1) the Institutional Development Framework (Ostrom, 2011) and its politicised version (Clement, 2010; Clement and Amezaga, 2013), (2) theories of collaboration (Ostrom, 2005; Polski and Ostrom, 2017; Stout and Keast, 2021), and (3) considerations of the interplay between governance and modelling (Funtowicz and Ravetz, 1993; Molle, Lankford and Lave, 2024). This literature is developed in more depth in each chapter.

Insights were also shaped by the nature of the project following a planning process in real time, and developed through the Lessons Learned Workshops and reports, into successes and limitations, and recommendations. Further checking occurred along the process through engagement with practitioners. This iterative process, reflecting back through ongoing interaction, refining theories based on empirical evidence and observations gives greater validity to the results (**Figure 5**) (Srivastava and Hopwood, 2009; Kapiszewski, MacLean and Read, 2022).

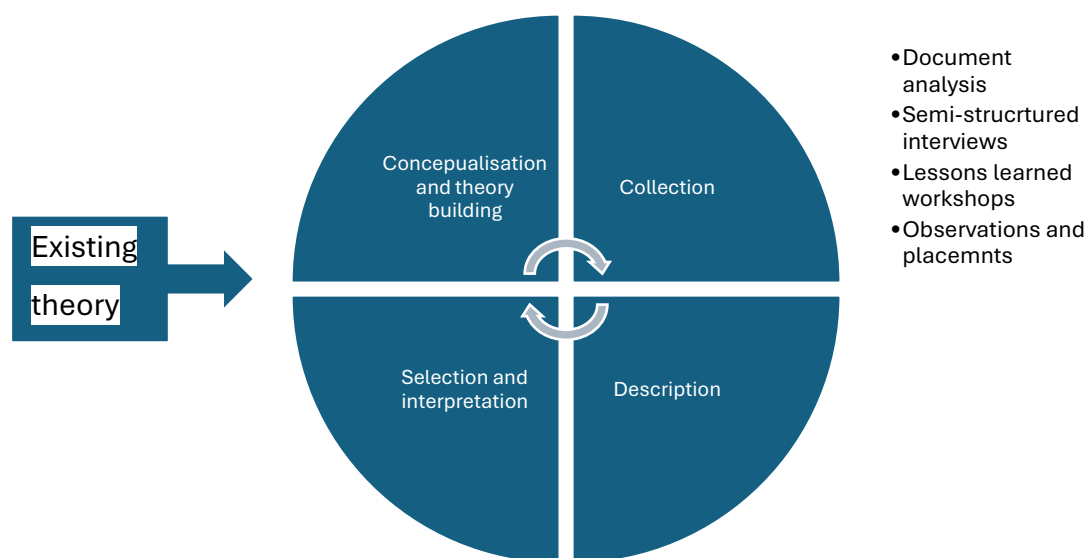


Figure 5. Simple graphic illustrating the iterative nature of qualitative data analysis.

2.4 Positionality

The critical realist stance emphasises the importance of epistemological fallibility which brings in positionality. Positionality refers to the awareness of the researcher as to how their work may be shaped and influenced by their own social and cultural background, experiences, biases and framings, considering aspects related to gender, age, class, and

education among many others (Holmes, 2020). Critically reflecting on positionality explicitly and transparently helps:

- (1) frame the context of the research,
- (2) identify potential limitations and blind spots,
- (3) enable readers to evaluate the findings, and
- (4) promote trust (Soedirgo and Glas, 2020).

For this project, three aspects of positionality are considered. The first relates to the demographic characteristics of the researcher being a thirty-year-old woman, without previous experience in the field of water resources planning, conducting interviews and workshops with predominantly older, more experienced male practitioners. Although this likely had an impact on the conduct of some interviews due to dominant societal norms and power relations linked to age, gender, and hierarchy (Secules *et al.*, 2021), overall, the practitioners involved demonstrated a culture that emphasised professionalism and equality. In this environment, the researcher's demographic and identity characteristics did not prove notably disadvantageous, for example, compared to other qualitative social science research where greater consideration of the dynamic between the researcher and participants is required.

The second aspect is the position as a PhD student within industry. This enabled privileged access through the industrial supervisor's network, whilst maintaining the ability to remain independent and removed from the process itself, guided by academic supervisors with experience in the research area and methodological approach. One of the stated benefits of the project was the ability to present views from practitioners from a neutral position. This positioning bridging academic and industrial worlds was further supported by relatively strong existing networks between universities, industry, and policy, as it is not uncommon for industry and policy experts in water resources planning to have PhDs. There was clearly an existing and developing social capital among those involved in the strategic planning of water resources planning. This familiarity with one another and links with academia eased the process of interaction between the researcher and participants (Perkmann and Walsh, 2007).

Thirdly, an aspect was the researcher's inexperience with qualitative methods and interviews, coming from a more quantitative background in physical geography and hydrology. The dynamic between the researcher and different participants ranged

between interviews, relating to tone and rapport, which partly reflects this inexperience. As mentioned previously, the use of AI tools in the final interviews was useful to assess and evaluate the researcher’s skill, and perhaps would also have been helpful at an earlier stage. One aspect of interviewing technique, which became more pronounced through the second round of interviews as the researcher’s understanding grew, was the balance between demonstrating understanding to avoid being retold similar information, without dominating the conversation. This requires skill, such as using clear and pertinent questions, that was honed better in some other interviews compared to others. Nonetheless, the interviews were all informative and there were no notable incidents of serious misunderstanding, conflict, or lack of rapport.

2.5 Validity

There are many contextual factors that shape a qualitative research project and the validity of the outcomes. Maxwell (2013, p. 6) outlines the following, highlighting interactions and crossovers between the categories:

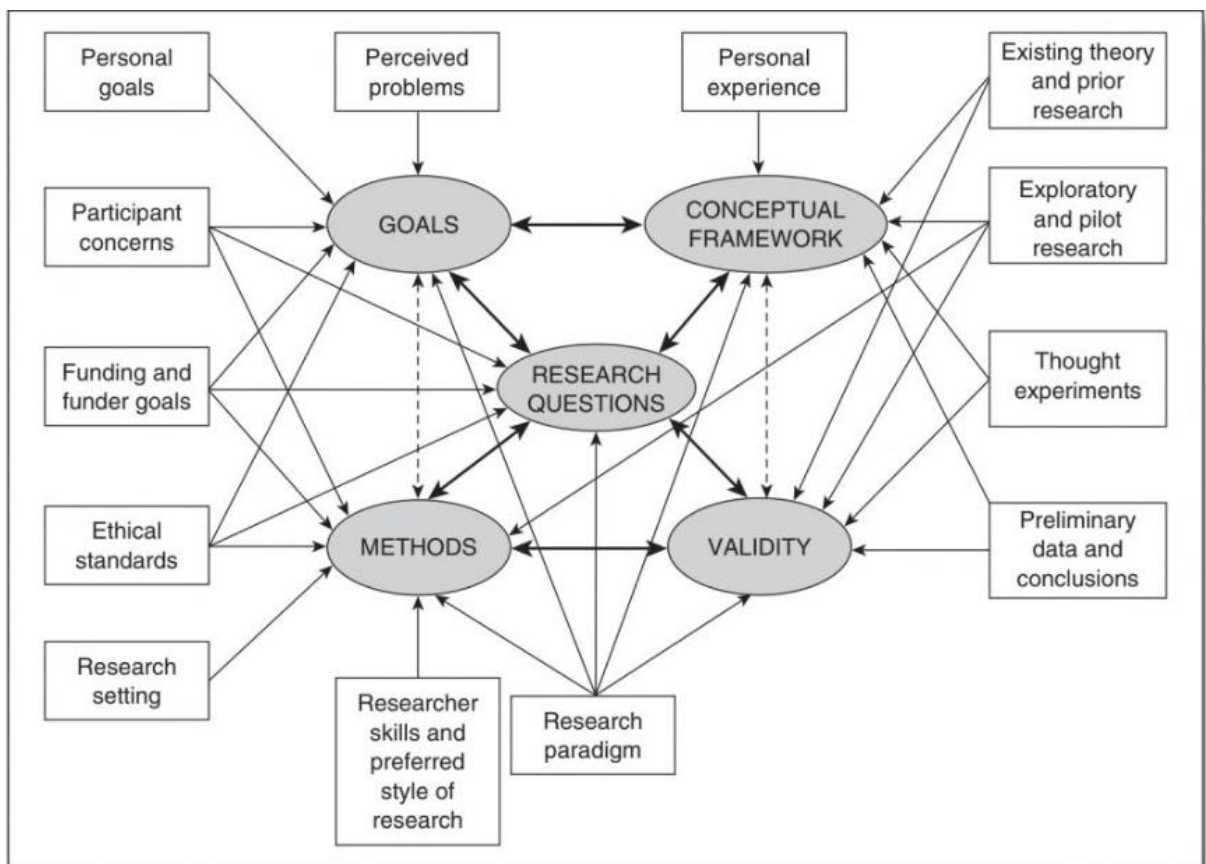


Figure 6. Contextual factors influencing a research design, taken from (Maxwell, 2013, p. 6).

This project is framed through working with industry in a real-world applied setting with the aim of understanding how planning works, how it developed, and possibilities for how it might improve and evolve. The work is situated within the existing bounds of the planning and legal framework and socio-political environment. This involves accepting certain assumptions and constraints, sitting within the contemporary ‘Overton Window’, describing the range of policies deemed to be within the window of political possibility at the current time (Johnson *et al.*, 2023). Setting the bounds of the research in this way is a useful step for transitioning either towards incremental or radical and transformative visions. Both approaches require an understanding of pathway dependencies, narrative framings, and coalition building, rather than designing alternative systems unshackled from the current context (Méndez *et al.*, 2012). The approach emphasises the importance of context and alludes to the difficulty of making generalisations for wider applications. Yet, it is possible to compare with other studies to elicit recurring elements of what works and what doesn’t work in particular contexts, which may provide useful lessons for similar scenarios (Blomquist, Schlager and Heikkila, 2010).

The approach is also situated within the confines of what was included in the data collection stages, including:

- (1) which documents were analysed,
- (2) who was interviewed and included in workshops, and
- (3) what was the extent of the exposure to the field of water resources planning through placements.

The breadth and depth of research will necessarily be limited by the time, resources, and capacity constraints of the researchers involved, and their access (Maxwell, 2013). Interviewing and engaging with a wider and more diverse pool helps broaden the scope. However, the project aim was focused on water resources planning in the English public water sector and as mentioned, the researcher was able to engage actively with this group through the partnership with an industry supervisor.

Consistency and reliability are less relevant for qualitative research compared to quantitative research, which emphasises the repeatability of studies and often relies on large representative sample sizes for statistical significance. Nonetheless, it is important to conduct qualitative research in a way that is appropriate, careful, honest, and accurate, whilst noting the inevitable constraints laid out by the critical realist

stance. This was carried out by implementing peer debriefing, prolonged engagement and persistent observation, audit trails and member checks (Morse *et al.*, 2002).

The validity of the research, referring to its accuracy and meaningfulness, as discussed is caveated by bounds of critical realism that emphasises that research will be relative to the participants involved, the researcher, and the literature. However, aspects of the design of the research (some of which have already been mentioned) attempted to mitigate some of the potential biases and misrepresentations (Morse *et al.*, 2002):

- using participant reviewing and cross-checking,
- interviewing and engaging with a variety of water industry practitioners across companies, regional groups, consultants, regulators and the civil service,
- repeating interviews, workshops, and observations over 4 years in different action situations and at different scales,
- reviewing insights from empirical data against wider literature, considering alternative interpretations, and
- critically reflecting throughout the process.

2.6 Summary

The research process followed an iterative model, where data collection, analysis, and theory-building informed each other continuously. This reflexive engagement ensured that findings remained empirically sound and theoretically robust. By integrating multiple data sources (triangulation), checking findings through participant engagement (member checking), and refining interpretations through academic discourse and practitioner feedback, this study enhances the soundness of its conclusions. Rather than adopting a rigid theoretical model, the pragmatic approach allowed for theory evolution, ensuring that the research remained contextually relevant and adaptable to real-world policy challenges.

2.7 Signpost to the next chapter

The first results chapter that follows this section was shaped predominantly by a document analysis. This chapter provides a historical context to the evolution of water resources planning in England and outlines six characteristics of planning. The chapter provides foundational context for the following two chapters on current governance arrangements and the use of modelling in planning.

Chapter 3. The Changing Landscape of Water Resources Planning in England

3.1 Abstract

Water resources planning in England has undergone a significant transformation from a fragmented, piecemeal approach to a more strategic, multi-scale framework. This shift is a response to the pressing need for increased resilience in the face of climate change, population growth, and environmental pressures. Recognising the limitations of existing planning frameworks established during privatisation, new national, regional, company, and sub-regional frameworks have emerged to address gaps and enhance strategic planning efforts. Understanding the critical pathway dependencies, opportunities, and constraints allows reforms to be designed and implemented with a better chance of success. Several key features characterise water resources planning in England. Firstly, the systems are inherently complex and fragmented, requiring tailored approaches rather than one-size-fits-all solutions. Secondly, planning operates within a neoliberal framework emphasising economic efficiency. Thirdly, subjective concepts like risk, uncertainty, and value are managed through technical quantitative methods which can pose challenges for transparency. Fourthly, while legislation often operates in silos, there is a growing demand for more integrated planning approaches. Funding and regulatory powers play crucial roles in water resources planning. Access to capital is influenced by the institutional environment and broader economic and political factors, with government and regulators ultimately holding power over the framework. Companies, driven by the profit motive, are responsible for detailed planning and delivery, regulated by standards and reputational incentives. Public participation is framed as consumer engagement. Aligning incentives for public good with financial rewards and ensuring effective regulation are vital for the framework's success.

3.2 Introduction

In this chapter, our purpose is to outline key features of water resources planning in England, bringing in Wales where relevant. The objective is to consider these features in the context of how they evolved, identifying existing pathway dependencies. This approach positions us more effectively to assess the prospective opportunities and constraints associated with proposals aimed at enhancing planning in the future.

It is possible to distinguish five approaches to water resources management:

- (1) allocation of water between competing uses,
- (2) increase supply,
- (3) water transfers from areas of surplus to areas of deficit,
- (4) reduce demand and leakage, and
- (5) plan use according to supply.

In tandem with ensuring sufficient water supply, a range of intrinsically interconnected objectives emerge. Salient issues include risks around drought and water shortage, resilience of supply networks, health and sanitation, environmental protection, economic cost and efficiency, carbon mitigation, issues of equity spanning both time and space, preservation of landscape and heritage, and providing amenity value. How trade-offs between competing objectives are balanced depends on the values and motivations of the decision makers and those they represent. The values and motivations of those in decision making positions have changed dramatically over time as society has evolved and developed new norms, as it faced arising challenges and responded to social, political, economic, and environmental drivers (Hassan, 1985; Roberts, 2000; Spar and Bebenek, 2009; Taylor *et al.*, 2009).

The task of long-term planning for resilience against risks of water scarcity is confounded by inherent subjectivity and uncertainty, often characterised as a "wicked" or "messy" problem (Grafton, 2017). The uncertain nature of decision-making becomes evident in long-term planning efforts that involve future projections, notably predicting substantial deficits. The complexity arises from the intersection of various objectives, governance structures, and information dynamics. Numerous actors with responsibility over water resources planning operate within a maze of rules at different administrative levels. Additionally, the coexistence of multiple plans in parallel, coupled with perceived inadequacies in planning frameworks contributes to the challenge of effective coordination. Pathway dependencies, recognised as legacy factors influencing the pace and structure of change, emerge as a pivotal aspect. Rooted in historical influences, these dependencies often entrench the status quo serving to embed the existing institutions and power structures (Sehring, 2009). Understanding their temporal influence and longevity is useful to consider how proposals for change may be

constrained by or fit within the existing features of governance and decision making. These pathway dependencies may exist physically, such as through “lock in” to built infrastructure, as well socially, such as through cultural memory, traditions, and practices, and reservations to change. In this way, although wider principles and broader generalisations can offer understanding and provide guidance, any study of water resources governance will depend intrinsically on the specific time and context of each case.

We focus on public water supply in England, examining the evolution, history, and path dependency of water resources planning in this region. This case study is salient as water regulators have called on water companies to meet higher standards of supply resilience in response to growing pressures from climate change, environmental needs and growth whilst still maintaining affordability (EA, 2020b). New national and regional governance structures have been established with the aim of enabling better collaboration across water companies and other water abstractors to find and deliver the most efficient and robust water supply infrastructure schemes. We want to understand how and why a more strategic direction and multi-scale structure has been introduced to open discussions around evaluating its likely success.

This report begins with a brief method statement, followed by an overview of the evolution of governance categorised into six periods. Following that, features of water resources planning in England are discussed. Finally, the chapter concludes with possible future directions, advocating using the analysis as a starting point for further evaluation and recommendations.

3.3 Method statement

This study takes a qualitative approach reviewing sources from published planning and policy documents and the available literature and using insights from observations of the planning process from interviews, workshops, and through being embedded in the planning process between 2020 and 2024 at national, regional, and company levels. Twenty-seven semi-structured interviews investigating the recent changes to water resources governance structures with a particular focus on the introduction of regional planning have been conducted with twenty-one participants from across the water industry. Participants included regional planning leads (9), regulators (5), a government official (1), and water resources planners from water companies (3) and consultancies

(3). Three workshops were carried out with regional planning leads exploring issues arising from the interviews and lessons learned going forward. Primary and secondary material has been analysed and categorised to provide an overview through time (section 3) and to identify key features (section 4) of water resources planning in England using Clement’s “Politicised” variation of Ostrom’s “Institutional Analysis Development” framework to structure the analysis (Clement, 2010; Clement and Amezaga, 2013; Polski and Ostrom, 2017).

3.4 Evolution of the scale of planning

We find that water resources planning in England has undergone several historic shifts in scale that have occurred in a non-linear fashion, responding to a complex landscape of physical and institutional pathway dependencies, drivers, and constraints. We have demarcated six periods of water resources planning; (1) piecemeal, (2) early consolidation, (3) national strategy, (4) integrated regions, (5) privatised and regulated, (6) transition to multi-scale. This evolution is illustrated in **Figure 7**.

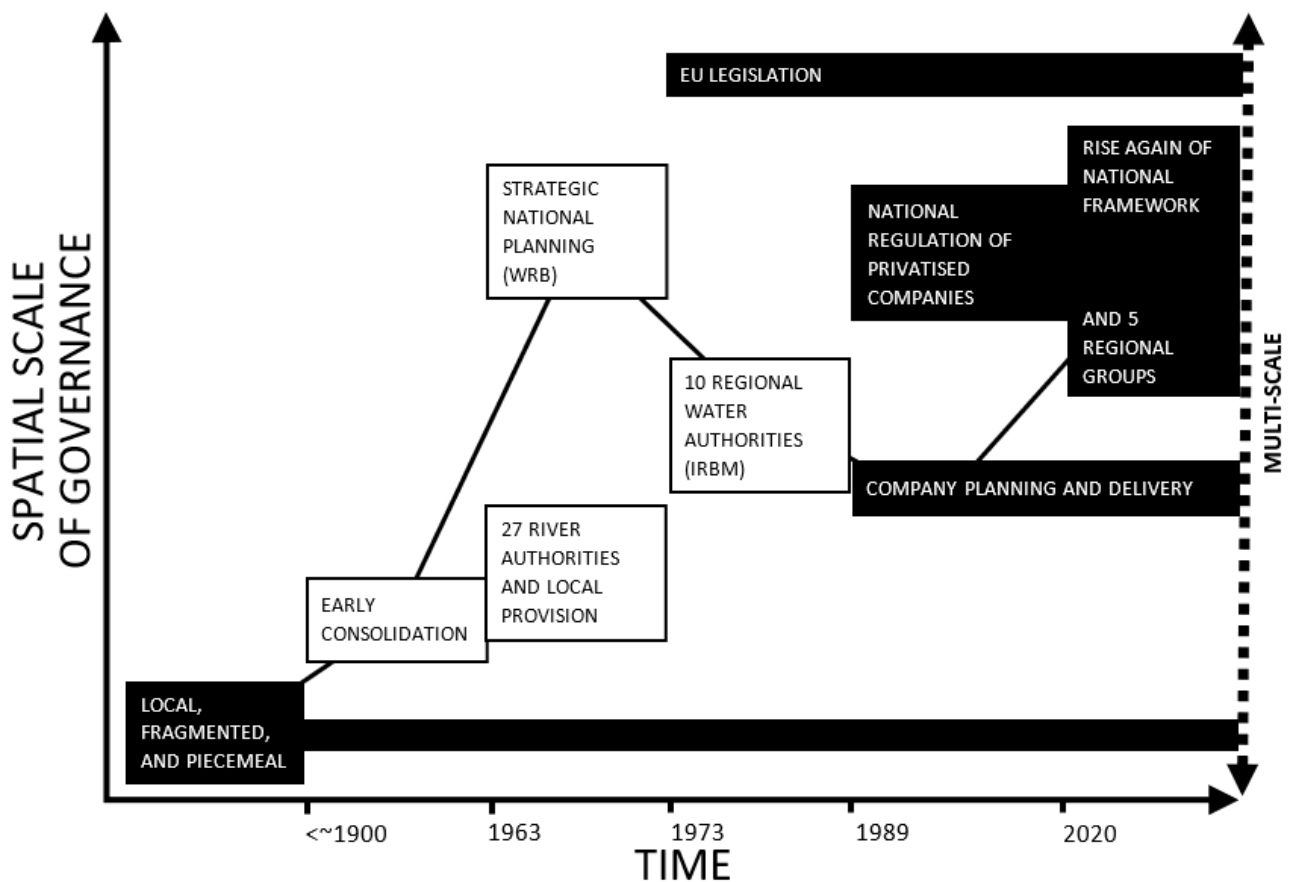


Figure 7. The changing scale of water resources governance in England (black filled boxes represent continuing governance structures, white filled boxes represent defunct governance structures). Acronyms: Water Resources Board (WRB), Integrated River Basin Management (IRBM) (timeline is not to scale).

3.4.1 Piecemeal

Early stages of water resources planning in England were local and fragmented. For a long time, England and Wales had a relatively small population. People collected rainwater or abstracted water from rivers, springs, and hand-dug wells for drinking, cooking, washing, and farming. Demand and competition between users were generally low and supplies were often managed collectively. As cities and industries grew, both private enterprises and public municipalities started to develop a burgeoning water storage and supply infrastructure in a piecemeal manner to feed the rapid increase in demand for navigation, industry, workers health, and firefighting. For each new reservoir, canal, or aqueduct, companies or municipalities had to seek approval from Parliament through individual Acts (Kinnersley, 1988). Efforts to increase supplies were spurred further by the degradation and pollution of traditional water sources (Hassan, 1985). Planning was locally driven with no overarching strategic thinking. By the turn of the 20th century, water management was fragmented. Hundreds of local councils and private statutory companies resourced and supplied their localities. Other users, including power plants, navigation authorities, and irrigators, supplied their needs. Overall coordination was limited (Ofwat, 2006).

3.4.2 Early consolidation

The second phase of water resources planning is marked by a shift in scale with greater integration and coordination to meet growing demand and tackle disparity across the rural-urban divide, for example the introduction of legislation incentivising joint working and transfers between authorities (Ofwat, 2006). The Metropolis Water Act (1902) brought London's eight water companies under one public supplier. The Supply of Water in Bulk, 1934 encouraged transfers between supply authorities, followed by the Water Act, 1945 which encouraged local authorities to form joint boards further improving connectivity (Ofwat, 2006). As water storage and transport infrastructure developed, so too did disparities in provision with rural areas falling behind in the proportion of people receiving piped supply. The disparity across the rural-urban divide led to the Rural Water Supplies and Sewerage Act, 1944, through which grants were made available for extending supply into rural areas (Ofwat, 2006). Alongside the advance towards universal supply and meeting growing demand from industrial users, a series of

droughts occurred in the forties and fifties (Taylor *et al.*, 2009). Reservoir development expanded exponentially to catch up with the supply and demand pressures. However, approval for new reservoir schemes faced growing opposition and placed an increasing burden on Parliament's time. Faced with complex and contentious proposals for new infrastructure, Members of Parliament sought a new system of advice and decision making with discussions in particular continuing over the question of whether national planning should be established (McCulloch, 2009; Atkins, 2018).

3.4.3 National strategy

Local water supply providers continued consolidating. Between 1956 and 1970, the make-up of statutory water undertakers changed from;

- 883 to 64 local authorities,
- 42 to 101 joint boards, and
- 90 to 33 statutory companies (Ofwat, 2006).

Despite arguments to maintain local autonomy, a more centralised approach to planning became national policy with the introduction of the Water Resources Act, 1963. This Act, for the first-time, established organisations with specific responsibility for water resources management, conservation, and augmentation: twenty-seven newly created River Authorities, and the Water Resources Board (WRB). The WRB was set up to advise government on the long-term strategic view of water resources planning and:

“benefitted from a sympathetic political environment, favourable financial arrangements and technical innovations” (McCulloch, 2009, p. 467).

The WRB, dominated by engineers, proposed a national water grid with new reservoirs and long-distance transfers. The top-down schemes were to be funded by central bodies and aimed to control and maximise the use of water as a resource (Smith, 1997; McCulloch, 2009).

Unfortunately, several problems beset the Water Resource Board's approach. Firstly, it had no jurisdiction over water quality. Against a background of worsening river pollution, there would be little point in transferring water unfit to abstract (McCulloch, 2009). Secondly, large infrastructure projects, and reservoir schemes in particular, were receiving increasing criticism. Third, the board's extensive schemes were premised on

inaccurate projections of continued growth in demand, justified by appeals to keep developing supply to protect domestic industry in the face of global competition (Archer and Marriot, 1993; McCulloch, 2009). The boards' engineer-led, single focus on national water resources planning received growing criticism and a weakening mandate. Although some new infrastructure was built, such as Kielder Water Reservoir in Northumberland, several of the Water Resources Board's proposed schemes were eventually abandoned.

3.4.4 Integrated regions

The fourth phase of water resources planning sees the fall of national planning and introduction of regional planning. In 1973, a new Water Act abolished the WRB. Another centralised body, the Central Water Policy Planning Unit was established, with an advisory role over water resources planning and pollution control, but it had limited influence (Ofwat, 2006). The Act also abolished the twenty-seven River Authorities in favour of ten Regional Water Authorities (RWAs), also known as water boards. The RWAs borders were defined by the ten largest river basins and the remit was expanded in pursuit of a more integrated approach. Integrated river basin management (IRBM), which was being promoted at the European level, was central to the new institutions. As well as governing water resources, assets and responsibilities for supply and sewerage responsibilities were transferred from local authorities and joint boards to the new Regional Water Authorities (Ofwat, 2006). The reforms represented a significant shift from local provision to regional management and the complete restructure of public institutions was a substantial upheaval.

“Ten Water Authorities were created with much broader terms of reference including water supply, sewerage, sewage disposal, pollution prevention, land drainage, flood prevention and fisheries. Local authorities lost all of their functions in relation to water supply, the 29 River Authorities disappeared. Porter (1978) writes “It is difficult to exaggerate the magnitude of the change” (McCulloch, 2009, p. 472)

Although the 1973 reforms are often considered a form of nationalisation, it is important to note the reforms did not extend to private statutory companies which represented about twenty per cent of supply (Page and Bakker, 2005).

Several interrelated problems hampered the RWAs from the outset. Their integrated nature produced an inherent tension and lack of effective scrutiny and accountability. Furthermore, the institutions were hampered by a lack of finance exacerbated by a period of high inflation and instability in the wider economy, and a political shift towards more fiscally conservative approaches (Ofwat, 2006; Tribe, 2009). Both these factors hindered progress towards meeting environmental targets set by the European Economic Community (EEC), which the UK had joined in 1973. The targets demanded substantial investments in water treatment infrastructure. Additionally, wider events added further pressure to the RWAs including a severe drought in 1976, and the growing likelihood of privatisation after the election of the Conservative party in 1979, amid the growing influence of neoliberal ideas that favoured market solutions over state planning.

3.4.5 Privatised and regulated

In 1989 parts of the ten RWAs became water and sewerage limited companies (Ofwat, 2006). The twenty-nine existing private water-only companies continued as before. This arrangement remains largely the same today discounting some boundary changes as companies consolidated, undergoing mergers and acquisitions. Alongside the water companies, privatisation also established the other crucial actors: the regulators. Notwithstanding some restructuring, the primary water resources regulators for water resources planning have remained relatively constant: Ofwat, in charge of economic regulation, and the Environment Agency (EA) in charge of environmental regulation, who work alongside the Department for Environment, Farming, and Rural Affairs (Defra). Since privatisation, water resources planning has been strongly steered by government and regulators through legislation, policy, guidance, and ongoing coordination (Watson, Deeming and Treffny, 2009). Meanwhile, the institutional arrangements put the technical planning, delivery, and operation in the hands of private companies clearly incentivised and legally mandated to prioritise the needs of their own customers. Consequently, the scale of planning and accountability has aligned primarily to these company boundaries.

Alongside privatisation, European legislation, notably the Water Framework Directive (WFD) 2000, has been influential in defining new scales and forms of governance. The legislation has not yet been rescinded in England despite the UK's departure from the EU in 2016. The WFD was significant in instigating river basin as well as catchment-based

planning (Watson, 2014). The regional river basin approach is mandated for all EU member states and River Basin Management Plans (RBMPs) have been produced every six years since 2009. The river basin approach aimed to establish a more integrated and holistic approach to water management to meet “good status” targets by 2015, or as a backstop by 2027. The Catchment Based Approach, or CaBA, was established in 2011 by Defra (Defra, 2013) as a voluntary initiative. One hundred catchments were defined with the objective to develop local partnerships, supported by EA catchment coordinators, to support meeting the “good status” objectives in tandem with RBMPs. However, aligning with the interests of the lead authorities assigned to the task, the translation of WFD into RBMP and CaBA planning prioritised water quality and habitats over water resources management and other considerations (Watson, 2014).

Calls for institutional restructuring stemmed from concerns over resilience to drought and water scarcity, propelled by the 2010-2012 drought. A new duty, ‘the resilience objective’, was codified in the Water Act 2014: “to secure the long-term resilience of water undertakers’ supply systems” (Section 22, 2DA(a)). Later reports projected large future deficits and called for investment in water resources infrastructure to avoid high emergency costs in the future (Water UK, 2016; National Infrastructure Commission, 2018). Furthermore, despite growing acceptance of the need to invest in drought resilience, particularly in the southeast of England, several barriers were understood to block planning efforts. Firstly, the limitations of company based zonal planning, which, as described above, incentivised companies to provide for their own customers, rather than work collaboratively with other companies and third parties to identify more efficient solutions on a regional or national basis. Secondly, there was also a growing acknowledgement that the decision-making frameworks used by companies to assess and possibly demonstrate the need for large infrastructure schemes were inadequate. No new reservoirs had been constructed since privatisation, and planning efforts had failed to gain consent for the proposed Abingdon Reservoir in Oxfordshire in 2010, which also saw further proposed delays to the scheme in water resource management plans in 2019. The combination of these factors (need to increase resilience, projected deficits, lack of collaboration across companies and regulators to identify the most efficient solutions, and inability of decision-making frameworks to implement schemes) drove new policy, legislative, and institutional changes targeted at improving national resilience to drought and water scarcity.

3.4.6 Transition to multi-scale planning

The sixth and current phase of planning marks a transition to multi-scale planning including the return of more strategic, national planning. This is evidenced by:

- (1) regulatory support and funding for strategic supply options,
- (2) nationally focused policy and legislation establishing new ambitious targets and
- (3) accompanying institutional changes with the establishment of regional planning to help deliver the objectives.

Firstly, to facilitate the development of strategic water supply options, Ofwat organised a new regulatory alliance in 2019 and made £469 million available in funding for water companies to progress schemes.

“For the final determinations we allocate up to £469 million for companies to investigate and develop integrated strategic regional water resource solutions during 2020-25. This will enable companies to develop solutions on behalf of customers that are ‘construction ready’ for the 2025-2030 period... The Regulatory Alliance for Progressing Infrastructure Development (RAPID) will support and oversee this process.” (Ofwat, 2019, p. 3).

The Regulators’ Alliance for Progressing Infrastructure Development (RAPID) represents a partnership between Ofwat, the EA, and the Drinking Water Inspectorate (DWI) with the aim to facilitate construction of Strategic Resource Options (SROs). The initial list of options included a variety of cross-boundary water transfers, reservoirs, and reuse schemes to be assessed through a new formal gated process, alongside water company and regional planning (University of Oxford *et al.*, 2021). The process has evolved since 2019 to accommodate scheme development beyond 2025-2030.

Secondly, complementing the progression of nationally significant water supply infrastructure schemes, another more encompassing piece of national policy was published in 2020. The National Framework (EA, 2020b) set out ambitious targets to “meet national needs” through improving drought resilience and reducing pressures on the environment in recognition of climate change and growth forecasts. Targets for water companies include the introduction of a new resilience standard such that companies should plan based on 0.2% annual probability of emergency drought restrictions, such as rota cuts and standpipes, improving the previous 0.5% standard. Targets were also

introduced to reduce demand per capita from an average of 150 litres per day to 110 litres a day and reduce leakage by 50% from 2017 levels by 2050. Furthermore, ambitions were set to reduce abstraction rates from surface and groundwater stores in line with new “environmental destination” targets.

Thirdly, the National Framework introduces new regional institutional arrangements to deliver the national objectives through encouraging collaboration across water companies and other stakeholders. The regional groups have been tasked to identify nationally efficient solutions to the resilience challenge. This may include cross-border solutions, such as water transfers and multi-stakeholder schemes, if they can be demonstrated as having greater benefits than options identified under traditional company planning. This regional tier extended existing regional governance (Water Resources South East (WRSE) since 1997 and Water Resources East (WRE) since 2014) across the rest of England with the creation of three new regions: Water Resources West (WRW) (which includes parts of Wales), Water Resources North (WReN), and West Country Water Resources (WCWR). Regional planning is now operating on a voluntary basis with final plans to be published in 2024 alongside company Water Resource Management Plans (WRMPs). Although regional planning is currently voluntary, the Environment Act 2021 tentatively gave new powers to the Secretary of State to direct *“two or more water undertakers to prepare and publish a joint proposal”* (Section 78).

This transitional period marks an interesting turn to multi-scale planning with directives coming from the government and the regulators around meeting national needs to be carried out through the workings of five new regional groups, currently operating on a voluntary basis. These strategic approaches are working alongside continuing legally mandated and highly regulated water company planning, which has developed and matured over the last three decades. How this transition unfolds depends on whether the design and implementation of the new multi-scale planning structures and agendas are suitable. Evaluating the suitability of proposed reforms depends on a deep understanding of the context they are applied to.

Thus, the following section sets out core features of water resources planning in England, considering how they have come to be and why they are important for meeting stated objectives around improving the level of resilience against water scarcity,

improving the condition of the environment, ensuring plentiful water for economic and societal needs, and providing this service within the constraints of affordable budgets.

3.5 Features of planning

This section details key features of water resources planning in the English and Welsh context using the politicised IAD framework to help guide the contextual analysis according to five categories (1) biophysical/material conditions, (2) political-economic context, (3) planning discourses, (4) rules, and (5) communities of actors (Clement, 2010; Clement & Amezaga, 2013). The boundaries between categories and features are somewhat blurred, as in many attempts at categorisations, but hopefully the analysis still provides useful context as to the evolution and operation of water resources planning in England.

3.5.1 Biophysical/material conditions: fragmented boundaries

This section discusses the fragmented boundaries of water resources planning in England. There are several aspects to this heterogeneity and fragmentation: (1) spatial patterns of supply demand and existing built infrastructure, and geographies of (2) political and (3) institutional fragmentation. The complex and interconnected social, physical, and technical systems of storage, abstraction, treatment, and management may have local constraints heretical to “one-size-fits-all” assumptions that are often useful for consistency when planning but sometime encounter difficulties when put into practice.

3.5.1.1 Spatial patterns of supply, demand, and built infrastructure

The climate in England is wetter in the west, and drier in the east reflecting climate and topography (Browning, Pardoe and Hill, 1975). Combined with the expected north-south gradient in temperature and evaporation, this creates a wetter northwest and drier southeast (Simpson *et al.*, 2016). Such a pattern is mirrored in the use of surface or groundwater, with greater reliance on surface water stores in the north and west and greater reliance on groundwater stores in the south and east, partly reflecting the varied hydro-geology of the UK (Abesser and Lewis, 2015).

The pattern of water demand is also geographically fragmented and continuously evolving according to socio-economic trends, such as industrialisation and its decline, agricultural needs, population growth, and changing water use practices (Butler and

Memon, 2006). Per capita consumption is expected to decline with measures such as the roll out of smart metering, water efficient devices and public water saving campaigns, however, behaviour regarding water consumption is difficult to predict and there remains significant uncertainty over the pace, scale, and even direction of change (Roberts, 2000; Butler and Memon, 2006). Pockets of high demand are expectedly concentrated according to cities, particularly in the southeast and around London. Irrigation demand is concentrated in the East Anglian region. Industrial demand, once concentrated in the north and Wales, has declined with the decline of industries like coal and steel (Hassan, 1985). Overall, there remains an enduring pattern of higher water demand in the south and east.

Thirdly, existing built infrastructure reflects historical investments such as into reservoirs and aqueducts. Noteworthy long distance transfers include connections from the Lake District to Manchester (Harwood, 1895; Taylor *et al.*, 2009), from Wales to Liverpool and Birmingham (Roberts, 2000), and from rural Northumberland to industrial centres along the Rivers Tyne and Tees (Soulsby, Gibbons and Robins, 1999). The rapid expansion of infrastructure initially with industrialisation and later with the WRB's vision for a national grid has slowed down in fact to a halt, with the last reservoir constructed in 1991. In the southeast, despite debates going back to the sixties, proposals for wider connectivity, such as between the River Severn and the River Thames, were never realised. Additionally, it is important to recognise geographical fragmentation between water resources infrastructure and water quality infrastructure, as limited water treatment capacity poses a difficulty for the expansion of water resources infrastructure. Overall, there has been more network integration in the north and west relative to the south (Simpson *et al.*, 2016).

These physical characteristics are fundamental to the pattern of water supply in England setting constraints and underlying the direction of travel of proposals for transfers from the north and west towards the south and east.

3.5.1.2 Geographies of political fragmentation

Political fragmentation also plays a part, particularly between England and Wales. For example, a controversial case was a reservoir built in Wales to supply Liverpool, which drowned Tryweryn Valley, considered a bastion of Welsh culture and language (Atkins, 2018). Liverpool City Council gained approval through Westminster avoiding a public

inquiry and the need to gain consent from Welsh authorities despite almost unanimous opposition (Liverpool Corporation Act, 1957). This top-down approach exposed the Welsh MPs lack of political power in determining the future of Welsh resources and added impetus to Welsh devolution. The Tryweryn case is still remembered today more than sixty years later. This was evidenced in the House of Lords in 2019 when Lord Wigley described Tryweryn as an experience that “*colours all our considerations in Wales of issues relating to the supply of water to English conurbations*” (House of Lords, 2019) potentially indicating signs of a more tentative approach from Wales towards water sharing with England in light of the shared history.

3.5.1.3 Geographies of institutional fragmentation

Finally, water resources planning is fragmented by the institutional and governance arrangements of suppliers. As previously mentioned, the current governance structures for public water supply are heavily influenced by boundaries defined in 1973 which established the ten RWAs, which later became the ten privatised major water and sewage undertakers, alongside the twenty-nine smaller private companies. The twenty-nine smaller private companies were mostly based in the southeast and have since reduced in number having undergone consolidation through mergers and acquisitions (Ofwat, 2006). The legacy of the small, private water-only companies has resulted in provision in the southeast remaining more fragmented compared to the rest of the country. This fragmentation acts as barrier to improving drought resilience by hindering network integration. The lack of regional connectivity in the southeast drove the establishment of the regional coordination body, WRSE, in 1997 to encourage inter-company collaboration. In contrast, the north integrated before privatisation. The three large water companies in the north, Northumbrian Water, Yorkshire Water and United Utilities inherited already connected and integrated infrastructure which, with some additional investment, enabled them to create single grids that now supply between 98 and 99% of their customers. However, the integrity of these grids has been tested in practice; for example, during the drought in 2022 Yorkshire Water took emergency actions to maintain supply in the northwest of their “strategic grid” including using helicopters to lay a temporary pipeline between reservoirs (Adie, 2023). Such events such as this call into the question the claim that all customers within these large water resource zones or “strategic grids” in practice face the same level of supply risk. Since privatisation, cross-company network integration has been limited, as legal

requirements mandate companies to prioritise their own customers' needs without obligations to collaborate with others beyond their own boundaries. This issue has prompted recent efforts to encourage greater cooperation between companies. It led to the introduction of national and regional planning to encourage more collaboration and network integration, as well as greater consideration of non-public water supply abstractors and other sectors (EA, 2020b). As discussed earlier, this included the establishment of regional groups (WRSE, WRE, WRW WReN, and WCWR). These new regional structures are redefining the boundaries of water resources planning providing platforms for greater collaboration between water companies as well as other abstractors and wider stakeholders.

With greater emphasis on regional, as well as national and catchment planning, these recent developments mark a critical shift towards multi-scale planning for which an important objective is overcoming and capitalising on the geographical fragmentation in all its forms.

3.5.2 Political-economic context

We find ourselves within a period shaped by privatisation and regulation since the uptake of neoliberalism (Page and Bakker, 2005). The decision-making space is relatively constrained within legally defined boundaries and fiduciary responsibilities. Delivery of water for all existing or future demands is mandated to be provided by private companies, motivated by profit, within a regulatory system that emphasises economic efficiency (McCulloch, 2009).

The UK is relatively rare in having a privatised water supply. At privatisation, the new regulatory framework set minimum legal service standards and enabled the water companies to pay for operational (maintenance) and capital (new assets) expenditure, by raising investment through debt and equity. Investments are paid back over time through customer bills which also cover returns on investments (profit) (Bakker, 2003). Investment has delivered improvements in service levels across a range of areas, including reductions in leakage, as well as improved drinking water quality, and wastewater treatment. Yet the new system has also been challenged as concerns have arisen around whether legal standards are appropriate, are being sufficiently enforced, and are being delivered in a way that is economically and politically acceptable to the public (Hall and Bayliss, 2017; Lobina, 2019; Helm, 2020).

The combination of greater focus on economic efficiency combined with the ascension of the sustainability rhetoric aligned with a greater focus on demand management and leakage reduction (POST, 1995) seen as less wasteful and environmentally damaging than continually expanding supply. However, recently this has changed. Investment into water resources including new supply infrastructure is back on the agenda due to recognition of climate change, resilience and the need to meet environmental protection standards (EA, 2020b). Pursuing both demand and supply strategies has been termed the “twin-track” approach.

3.5.3 Planning discourses

Planning is in a period where methods and frameworks, often technical and quantitative, are evolving to try and accommodate complex, contested and related concepts of risk, uncertainty, and value. The developments are happening quickly and simultaneously with limited coordination causing misalignments and inconsistencies, and sometimes the wrong or inappropriate tool being applied. Different actors tend to prefer different approaches, either more technical, more participatory, more legal, or simpler. Ideally frameworks allow for innovation but also ensure suitable and clear assumptions to avoid plans becoming overly complicated, error-prone, opaque, inconsistent, or misunderstood.

3.5.3.1 Risk

A key boundary condition of water resources planning relates to establishing the risk appetite to act in light of water scarcity (Hall et al., 2012). However, risk is an elusive concept steeped in inherent subjectivity and uncertainty. What is considered an acceptable level of risk may be influenced by events such as droughts and funding barriers shaped by wider political and economic conditions. Clear planning assumptions allow for the development of plans on a consistent basis that can be held accountable. Recently multiple approaches to risk have developed and are in concurrent use, including the 0.02% resilience standard, headroom, and emergency storage. However, variation in approaches introduces incompatibilities and confusion, particularly when guidance is undefined.

3.5.3.2 Uncertainty

Grappling with the challenge of uncertainty, particularly in the long term, planners are developing new, increasingly sophisticated methodologies to try and encompass a more robust attitude to risk with methods spanning use of stochastic forecasts, adaptive planning, scenario scanning and robust optimisation, and storyline approaches (Fowler and Kilsby, 2007; Hall *et al.*, 2012; Glenis *et al.*, 2015; Chan *et al.*, 2022; Dawkins *et al.*, 2022).

3.5.3.3 Multiple values (trade-offs)

Investment decisions have long used cost-benefit analyses. Recently, regulatory guidance has introduced concepts such as “best value” planning, encouraging the use of multi-criteria decision-making methods that use a broader range of metrics beyond monetary cost, such as environmental and carbon metrics. The evolving approaches have potential to better capture risk and value. The technical knowledge required for the complex planning primarily resides within water companies and consultancies which tend to favour quantitative methods. However, having a wide variety of modelling approaches may not fit within the constraints of collaborative planning frameworks. Furthermore, the increased sophistication and complexity of developing approaches make them vulnerable to accusations of being “black box” and difficulties understanding and communicating their outputs can hinder transparency and accountability. Moving towards more transparent and adaptive approaches to align with the needs of inherently uncertain and subjective “wicked problems” requires a shift in regulatory and company perspectives, likely causing disruption and requiring training. Furthermore, there are growing expectations for more participation and engagement with stakeholders and the public to better elicit their preferences in decision-making (Page and Bakker, 2005; Metcalfe and Sen, 2022). Successfully navigating this intricate landscape requires effective elicitation and facilitation techniques to integrate competing priorities. It is interesting to note how priorities have evolved dramatically over time (see Box 2), which requires decision-making frameworks that evolve alongside societal developments and changing values.

Box 2: Mapping changing objectives and values over time

The first regulating reservoirs were motivated by demands for improvements to the canal network as navigation was affected by seasonally varying flow which impacted the transport

of goods that were helping fuel industrialisation (Harvey-Fishenden & Macdonald, 2021). Decisions were balanced against costs and risks including land costs, construction costs, and safety concerns particularly risks of dam failure due to heavy rainfall which had precedent, and which could have legal ramifications (Hassan, 1985). The motivation to expand water resources for navigation purposes was eventually made redundant due to the expansion of rail and road networks.

Later came growth in water resources infrastructure for potable water needs, particularly for those at risk of shortage and drought or where shortfalls in demand may constrain productivity and growth or pose threats to health and sanitation. Water systems to supply cities were sited increasingly further afield in search of purer and softer water benefitting domestic use as well as industries such as the textiles industries. These grander projects may in part relate to eagerness to apply the technological innovations in hydraulic engineering, and boost civic pride for the visionary schemes. This in turn generated competition between cities further motivating municipalities to seek improved supplies (Hassan, 1985).

This supply driven approach was motivated by strivings for economic growth providing for industry and business needs. In fact, water played a key role powering the industrial age, in part being an essential ingredient for the steam engines. Water was also increasingly valued for public goods including for firefighting, and for improving public health and sanitation during a time when science was haphazardly developing a growing understanding of the links between water and the spread of disease (Roberts, 2000). In fact, motivations for economic and public goods are interlinked as the benefits of the expansion of municipal supply in manufacturing towns aligned with the interests of the propertied and commercial classes due to enhanced property values, lowered industrial costs, and healthier workforces (Hassan, 1985).

Although private enterprises driven by the profit motive at times led the drive for expanding water infrastructure, the effort was eventually outpaced by municipal provision as municipal authorities responded to market failures seen to hinder growth as they pushed up costs; for example, businesses had to deal with increasing pollution, increasing hardness of water, and undersupply since companies preferred demand to slightly outpace supply, rather than the municipal preference for supply to outpace demand (Hassan, 1985).

A clean and constant supply of water came to be considered vital for the development of society to improve public health and reduce poverty (Spar & Bebenek, 2009; Taylor et al., 2009). Supply infrastructure continued to expand at pace into the twentieth century to meet societies' demand for universal provision of piped, treated water to supply growing domestic needs, tied to health, prosperity and partly inspired by links between high water use and

notions of a civilised society. Taylor et al. (2009, p.586) quotes the Conservative MP Thomas Levy saying, in 1932:

“in the greatest civilised country in the world, in this twentieth century, all members of the community should have a sufficient supply of pure, clean, cold water”

which was pursued in line with liberal democracies emphasis on freedom of consumption and reflective of an enduring cultural normalisation of supply expansion. Improving living standards with an increasing number of water hungry appliances continued to push demand.

As reservoir growth continued, debates in Parliament over consent for new schemes became increasingly complex and technical crossing concerns about industrial competitiveness, the character of the countryside and loss of farmland, flooding rural communities, the viability of price controls and metering, and technical alternatives such as desalination (McCulloch, 2009). When the WRB was introduced in 1963, it was hoped that technical experts would be able to help guide a more “objective” way through the sea of competing motivations. However, McCulloch (2009) defines this period as the “*reign of the engineers*”; the planners in power were seemingly motivated by large scale, techno-rational, engineered schemes to solve the challenges, and the prioritisation of supply resilience over other issues, including the economic costs and concerns over ecology (McCulloch, 2009). Although it is important to recognise that throughout the development of water supply infrastructure, debates did arise around wasteful water use, particularly becoming more contentious in drought periods (Taylor et al., 2009), the supply-driven logic based on centralised, technocratic solutions remained the dominant mode into the sixties with ongoing reservoir construction and network integration (Newson, 2009). However, although at the beginning of the WRB’s tenure, it had strong backing and significant influence, by the end it faced a changing economic, social and political landscape which made it increasingly difficult to enact its vision (McCulloch, 2009).

The seemingly perpetual growth in supply eventually declined due to wider society trends, notably increased water efficiency, the decline in demand with the collapse of industry, increasing environmental awareness and the rise of the anti-reservoir movement, and the increasing complexity of the planning and consultation process (Ofwat, 2006).

Furthermore, critically there was a growing focus on financial efficiency and public debt reduction. Although the River Water Authority’s stated mandate was to invest in infrastructure considering water alongside other agendas in a more integrated and holistic manner, in reality they were limited by constraints, under pressure to reduce pollution and be fiscally stringent.

Additionally, the restructuring of the previously fragmented local providers of water supply and sewage services into the ten amalgamated integrated RWAs and introduction of tight budget controls made them more amenable to privatisation (Page & Bakker, 2005). Ultimately:

“the new business culture, leaner organisational structure, and negative public opinion of the RWAs meant that the water industry was ready for privatisation” (Lobina, 2019, p. 159).

The change in focus towards economic efficiency and the greater use of market instruments and incentives was cemented in 1989 by privatisation under Thatcher's government, motivated by neoliberal arguments. Such arguments arose throughout the 20th century, reacting against perceived state and economic repression, and advocated for market forces to drive economic prosperity and curtail state infringement on people's freedoms. Ideas alone are rarely sufficient to bring about change, however, the stagflation crisis in the seventies, attributed by some to a failing Keynesian planned economy, provided an opportunity for neoliberal ideas to gain traction. The ideas had been “peddled relentlessly through free market think tank, through the financial community and business organisations, and through the elite and mainstream media” (Peck, 2010a, p. 5) and interfaced with conservative politicians in the UK. The ideas were then developed in ways that were rhetorically helpful for the conservative party to resolve tensions between moral conservatism and liberal economics amidst inherent contradictions between ensuring freedom (economically) and order (socially and politically) (Freeman, 2021). Thatcher's vision of privatisation was clearly influenced by these ideas (Peck, 2010b). The problem of how to improve water infrastructure became a question of how to improve water infrastructure in ways that would not expand the state and would keep investment off government books, that would enable market forces and competition to promote efficiency, and that would shift water users from passive citizens to active shareholders and customers. This neoliberal framing was enabled by institutional restructuring of water services, the spread of these specific ideas by individuals and networks, broader societal shifts, and moments of crises.

“The 1980s were marked by a dramatic shift away from state and towards private management of utilities. This shift was in part engineered by a political and economic elite that believed that the state had failed to meet the needs of a growing economy and that the market was a more efficient arena for containing competing interest groups. Under this new dispensation, citizens were reconstructed as customers of utilities and the government was reconstructed as a (temporary) regulator, whose role would wither away as the market matured – a scenario that proved unworkable in the case of the water sector.” (Page & Bakker, 2005, p. 43)

Privatisation further shifted focus away from increasing supply in pursuit of economic efficiency and in opposition to centralised planning efforts.

“[The perceived] legacy of over-provision may have contributed to the drastic change to full privatisation of the Water Authorities in 1989 under the neo-liberal Thatcher government, which believed not only Hayek’s commentary on the dangers of special interest groups but also his solution of reliance on market forces to deliver a better outcome” (McCulloch, 2009, p. 472).

Overall, there has been no investment in national-scale water resources infrastructure since privatisation. In 2006 a report by the Environment Agency called “Do we need large-scale water transfers for south east England?” concluded:

“the cost and environmental impact mean that large scale transfers of water from the north of England or Wales to the south east are unnecessary and inappropriate... some local or regional resource development will be necessary but that there must be further progress on leakage control and demand management” (EA, 2006, p. 20).

This message was repeated in 2008 with the publication of the Government’s water strategy for England; “we do not support the development of a national water grid” (Defra, 2008, p. 37). Although there was recognition of the benefits of improving local connectivity to move water from areas of surplus to those in deficit, and governments statements on the necessity for “speeding the process of reservoir development” (Defra, 2008, p. 9), overall there was a view that that large scale transfers were not necessary and that the emphasis of planning should be focused on demand management and leakage reduction

The change in focus to demand management represents the beginnings of change in the previously voluntarist approach to demand management, which aligned with liberal intuitions to minimise interfering in people’s lives. The anti-interventionist stance always faced challenge during times of drought since times of greater scarcity raised questions over consumption and waste, and considerations of restrictions. This raises a pertinent question over which conditions should delineate between ordinary times and states of emergency (Taylor et al., 2009). In general, these concerns are assuaged once drought recedes, arbitrated by the media (Dayrell et al., 2022). However, with the growing concern for climate change, growing need to meet environmental requirements, and calls to increase resilience, there has been growing acceptance of demand management approaches, particularly after drought in 1995 and 2006 (POST, 1995). Currently, the more stringent measures, such as compulsory introduction of metering, are limited to areas classified by the EA as “water scarce”.

Recent developments have put greater emphasis on pursuing demand management and supply-side measures together, known as the “twin-track” approach (Every & Foley, 2006).

Supply expansion is back on the agenda due to recognition of climate change and the need to meet environmental protection standards. As previously discussed, regulators have started to develop new funding and collaboration opportunities at regional and national levels to develop strategic infrastructure, alongside setting ambitious targets to reduce leakage and water consumption.

In summary, the framing of water resources management has shifted from allocation-based, to supply-driven, to demand-driven, to a twin-track approach. Policy makers must juggle a myriad of public values. Today discussions span considerations of affordability, environmental consciousness, climate change mitigation and adaptation, considerations for tourism and leisure, energy generation through hydropower, flood prevention, and emerging trends such as hydrogen power, new developments, and the expansion of spray irrigation in response to drier summers. There are growing expectations for more participation and engagement with stakeholders and the public to better elicit their preferences in decision-making. Successfully navigating this intricate landscape requires effective elicitation and facilitation techniques to integrate competing priorities.

3.5.4 Rules

3.5.4.1 Siloed legal frameworks

Planning is characterised by its siloed nature in terms of legislation and policy guidance. Despite the interconnected nature of many policy areas such as water quality, the wider environment, spatial planning, agriculture, and energy, planning frameworks tend to be separate and constrained by legislation (Kidd and Shaw, 2007). This can be beneficial for setting minimum requirements and maintaining accountability within the responsible authorities.

In 1879, a more holistic, integrated approach was proposed by geologist F. Toplis in an essay submitted to the Royal Society of Arts which defined twelve authoritative regions according to their natural watersheds that would exercise power over water supply, sewerage, and drainage (Kinnersley, 1988). Little attention was paid to the proposal at the time. However, as discussed earlier, this thinking did arise a century later in 1973 with the establishment of the Regional Water Authorities. The RWAs defined the ten largest river basins in pursuit of a more integrated approach with the institutions responsible for water resources, sewage, and supply, but were hampered by a lack of scrutiny and problems of finance. The experimentation with integrated water planning

ended with privatisation which re-entrenched a more siloed approach. Legislation clearly defined water companies responsible for delivering and ensuring sufficient water to the public, overseen and scrutinised by the established regulators who have tended to operate in a technocratic style within their own defined remits (Fritsch, 2017; Ofwat, 2006).

Notable legislation has ensured the delivery of substantial investment to meet critical objectives, including (1) EU WFD stipulations for environmental protection and (2) the Water Industry Act 1991 which includes clauses ensuring protection of supply to customers. On the other hand, siloed legislation can also create barriers to a more comprehensive evaluation of trade-offs across intrinsically related agendas.

More integrated planning is advocated as a solution to short-term and narrow decision making, however, the approach hasn't been widely adopted in practice (Biswas, 2008; Fritsch, 2017). The National River Authority, which later became the Environment Agency, was instrumental in instigating more holistic and participatory river basin and catchment planning at the EU level, although the approach largely became focused on habitats, ecology, and water quality, rather than a broader scope that included water resources planning (Fritsch and Benson, 2013). Alongside these early attempts by governments at initiating integrated approaches through river basin and catchment planning, there have been localised, non-governmental efforts at more integrated planning. In 2014, Water Resources East was established with a stated aim for the “region to be seen as an international exemplar for collaborative integrated water resource management (IWRM)” (WRE, 2023). The regional group was established with a broad membership, including industry, environmental groups, internal drainage boards, and water companies. This inclusive approach may offer opportunities to discover innovative solutions and increase participation and engagement. It also introduces complexity and requires effective facilitation and resourcing to guide discussions among diverse members with potentially competing interests over contentious issues.

Given the increasing uncertainty and potential for conflict, a more holistic approach to planning across water resources, as well as wider sectors could be beneficial as it could reflect the interconnected nature of issues such as climate change, growth, and the need for greater resilience. Building on the first experiments with integrated planning in England and Wales, such as with the RWAs, RBMPs, CaBAs, and WRE's IWRM, as well

as experiences in other countries, lessons can be learnt as to how best to represent integrated planning in frameworks, legislation, and governance arrangements.

3.5.4.2 Cost of capital

A critical part of water resources planning relates to the importance of finance and access to capital to pay for investment into sometimes large and costly infrastructure projects, shaped by legislative and institutional arrangements. This is true today as well as historically, for example Hassan (1985, p.534) notes that in the 1800s:

“another consideration in a period of rapidly growing water demand was [local authorities’] ability to raise capital for expanding works under the terms of their enabling legislation. By contrast “the facilities for long term borrowing . . . were entirely lacking to the local authorities” in the early nineteenth century.” (Hassan, 1985, p. 534).

Under privatisation, water companies use shareholder equity and borrow on capital markets based on their credit ratings to fund proposals for investments. All capital raised for investment plus interest, dividend payouts, and fees is ultimately paid for by customers’ bills over time (Hall, 2021). The framework has allowed companies flexibility in financial management with some companies choosing higher levels of gearing/debt than others. Greater debt can create financial pressures during times of economic instability and fluctuating interest rates. The additional costs of servicing debt placed on customers carries risks, particularly if seen to constrain proposals for investment. Ofwat must balance the risks around politically acceptable levels of debt, equity, and profit making against its duty under the Water Industry Act 1991 to make the sector attractive to capital investment and ensure the companies survive financially (notably also serving to ensure privatisations success and safeguard its own role). These financial arrangements are relevant to water resources planning as investment may be constrained by the models of financing taken up by companies and regulated by Ofwat.

3.5.5 Communities of actors

3.5.5.1 The government (and executive)

Power ultimately rests with the government, including the prime minister, the cabinet, the treasury, the Secretary of State for Defra, Defra itself, and latterly the regulators. The government exercises power through approving final water resource management plans, through having the final decision in public inquiries, through producing policy and

legislation, and through issuing top-down steer. However, despite maintaining a strong, central control on ultimate decision-making and overseeing the planning process, the government is distanced from the technical operation and function of the systems, devolving accountability away from the centre and placing responsibility for delivery onto the regulators and water companies (Watson, Deeming and Treffny, 2009). It is noteworthy that ministers are influenced by wider events such as upcoming elections, media stories, recent droughts, competing priorities, and internal political questions. These exogenous factors can potentially constrain or create opportunities for long term planning of water particularly regarding politically acceptable levels of investment and affordability.

3.5.5.2 The regulators

Ofwat and the EA operate within their distinct remits as defined in legislation, setting guidance, incentives, pricing, and issuing fines. Despite initiatives encouraging collaboration, their structures promote a compartmentalised approach due to their distinct responsibilities. Over time, the reach of regulatory guidance has grown considerably whereby planning frameworks such as the water resources planning guideline are increasingly prescriptive (Watson, Deeming and Treffny, 2009). They work closely with the government and water companies, leveraging their technical teams' expertise on economic and environmental matters in the development and scrutiny stages of water company planning. They ultimately advise the government as to whether company plans should or should not be approved, based on their interpretation of policy and legislation, which contain a certain degree of flexibility. There is no specific regulator for the technical aspects of water resource planning, such as relating to defining methods for uncertainty and risk or approaches around demand management, leakage, and distribution networks. These responsibilities generally fall across regulators, but they rely heavily on the expertise of water companies and consultancies.

3.5.5.3 The water companies

Water companies are crucial actors within water resources planning as they are responsible for the technical planning, delivery and operation of their water networks. As natural monopolies, regulation is required to ensure companies meet their statutory obligations and policy guidance to deliver sufficient water to their customers. Companies are incentivised by both “carrot and stick” regulation approaches. Under the

price cap system, they are able to recoup profits gained from the difference between expected and actual cost of delivery, i.e., profit maximisation by cost minimisation. Companies are motivated primarily to deliver profit under their fiduciary duties to their shareholders, with the exception of Welsh Water which operates as a not-for-dividend company (Bakker, 2003; Owen, 2013). If companies fail to meet the legal and expected minimum requirements, they can be held accountable by the government and regulators, either by the rejection of their proposed plan, or by penalties, fines, and theoretically licence withdrawal, though this has not happened in practice and is unlikely as licences have a 25-year notice period. Water companies have also highlighted a recent move towards “purpose-driven capitalism” whereby organisations aim to embed long-term sustainability rather than short-term financial self-interest. The British Standards Institution (BSI) released a Publicly Available Specification (PAS 808:2022) which establishes guidance and good practice for companies to transition to become Purpose Driven Organisations (PDOs), in collaboration with a number of organisations including Anglian Water and HM Government (The British Standards Institution, 2022). The BSI state they hope the PAS will be developed into a more formal global corporate purpose standard through the International Organisation for Standardisation (ISO) process (The British Standards Institution, 2024). Empirical studies are still emerging over the effectiveness of companies adopting Environmental, Sustainability and Governance (ESG) driven goals through ISO standards. One study found evidence that the adoption of ISO 14001 which specifies requirements for environmental management systems led to improved performance across environmental and business indicators; however, the study also found evidence in some cases of negative or neutral impacts and cautions that positive results may be subject to bias such as through poor certification practice (de Vries, Bayramoglu and van der Wiele, 2012).

“We don’t actually know if strong ESG performance causes better returns, or if both are a function of good management” (Pucker, 2021).

Further research is likely needed to follow the implementation of such standards, evaluating their proposed benefits such as enhanced legitimacy, innovation, and improved long-term business and societal outcomes, while staying critical of “greenwashing”, inaccurate reporting (given a lack of auditing, specious targets, opaque

supply chains, lack of comparability, and complexity (Pucker, 2021)) and whether more a fundamental change to economic paradigm would be required to truly transition to more sustainable future accounting for the wider picture, rather than individual companies (Feola, 2020).

3.5.5.4 Public participation

Local public participation dropped in 1972 with the creation of RWAs and consequent severance between water planning and local authorities (Watson, Deeming and Treffny, 2009). Technocratic frameworks continued to develop establishing decision-making strongly dominated by the government and water authorities. With privatisation in 1989 the public were reframed as customers and as such have seen their representation grow through Ofwat's duties to protect their rights as consumers. Ofwat sets rules and incentives for water companies (Franceys, 2006), subject to influence from changing public expectations reported by the media, such as the increased attention on leakage following drought and hosepipe bans in 2020, seen as driving the introduction of higher leakage reduction targets. In this way the public may influence the direction of water resources planning. Ofwat has also encouraged the elicitation and representation of customer views by water companies through "willingness to pay surveys" and other developing methods to justify that investments in water resources infrastructure reflect public value (Metcalf and Sen, 2022). Additionally, the statutory consumer protection body the Consumer Council for Water (CCWater) aims to represent the collective voice of consumers in policy debates (Franceys, 2006), however, participation with CCWater may be considered secondary to consulting directly with Ofwat and water companies. Other forms of participation such as through lobbying by special interest groups continue as an important means of influence. For example, in 2010, the Group Against Reservoir Development (GARD) successfully campaigned against a new reservoir in Oxfordshire in the southeast of England during a public inquiry on the matter. More formal modes of consultation and public inquiry tend to reflect participation by already influential technical and strategic actors in water resources decision-making or "sanctioned" opposition groups, rather than necessarily the wider public (Page and Bakker, 2005; Kidd and Shaw, 2007). Finally, emerging forms of participation at regional, sub-regional, and catchment levels may become important as sites of engagement, particularly in places where local water allocation becomes more contested (Grecksch and Landström, 2021).

3.6 Conclusion

Water resources planning has changed from a piecemeal to a multi-scale approach. The recent transition sees new and evolving frameworks at national, regional, company, and sub-regional levels. These arose in response to growing recognition of the need to increase resilience in the face of climate change, growth, and environmental pressures, alongside recognition that the existing planning frameworks established at privatisation had gaps and limitations that would hinder efforts to plan more strategically and potentially gain consent for large new infrastructure assets, such as reservoirs. The shifting landscape illustrates the need for adaptive governance which allows frameworks that acknowledge the world as it is; uncertain and unstable, with inherent misalignments and fragmentation, and continually developing technical methods and innovations which have the potential to disrupt established systems. The shape of change will vary in each region at a particular time. It is therefore important to understand the specific local context and dynamics as they play out to be able to introduce reforms that are a good fit with a better likelihood of success.

We discuss key features of planning in the English context. Firstly, these are fragmented, complex systems which cannot be addressed via a one-size-fits-all approach. Secondly, planning operates under a neoliberal backdrop, established since the 1980s, which emphasises economic efficiency. Thirdly, while concepts of risk appetite, uncertainty and value are inherently subjective, they tend to be managed using technical quantitative approaches, which have advantages for representing complex systems but can introduce challenges for transparency. Fourth, legislation is often siloed, although there are increasing calls for more integrated planning. Funding is a critical aspect, with access to capital determined by the institutional environment and wider economic and political forces. Additionally, ultimate power lies with the government and latterly with regulators. Companies are accountable for detailed planning and delivery, motivated by profit, and regulated by standards and reputational incentives. Finally, public participation is framed by consumer engagement.

Overall, there are some inherent tensions in the system whereby the government and regulators setting the rules lack detailed understanding of the systems, resulting in sometimes contradictory, misguided guidance, and the companies controlling the systems, who may be better placed to make decisions over how to improve their

operation, are incentivised to meet statutory requirements to avoid penalties, maintain reputational standing and make efficiencies to generate profits, rather than directly deliver improvements for wider societal good. Key to the framework functioning is aligning incentives for the public good with financial rewards and ensuring regulators are able to hold the companies to account to meet societies' expectations as well as curb tendencies that do not align with the public good.

It is useful to outline the shifting landscape of water resources planning and highlight key features in light of the more strategic approach that has recently emerged. A new more collaborative model has been instigated with a multi-scale governance structure, including five new regional groups currently operating on a voluntary basis, instilling new requirements for alignment, cooperation, and resourcing. Further research could explore and evaluate the current arrangements and how they are evolving in order to recommend how reforms may best succeed, acknowledging existing constraints and opportunities such as those laid out in this chapter.

3.7 Signpost to the next chapter

Having established the historical development and institutional context of water resources planning in England, the next chapter builds on this foundation by examining the contemporary practice of collaborative, multi-scale planning. Chapter 4 explores how newly introduced regional and national planning structures have been implemented during the 2020–2024 cycle.

Chapter 4. Collaborative Multi-scale Water Resources Planning in England

4.1 Abstract

Practitioners in water resources planning in England are navigating new multi-scale planning structures. A National Framework introduced in 2020 embeds strategic cooperation across a privatised industry to meet higher resilience standards. This study presents a critical analysis of the National Framework to identify feasible solutions to navigate England's water crisis. Findings are based on engagement with practitioners identifying successes, challenges, and lessons learned throughout 2020-2024.

Recommendations include establishing a national coordination office as part of an explicit multi-scale framework. Over time, the framework can continue to be built upon for a more informed transition to adaptive, collaborative, integrated planning.

4.2 Introduction

The institutions of water resources management in England are in transition. Concerns have arisen over the resilience of planning water supply systems constrained by company boundaries, in light of climate change, growth, and statutory requirements to reduce abstraction in environmentally sensitive areas. In response, the government and regulators introduced a National Framework for water resources planning (EA, 2020b). The framework established higher standards for drought resilience, set new targets to reduce leakage rates and water demand, and instituted regional planning across the whole of England where previously it was only prevalent in the southeast and east. This study was motivated by the desire to observe and evaluate the live implementation of the National Framework in England to identify possible ways to improve planning in the future, making reference to theories of good governance.

The backbone of water resources infrastructure developed throughout the 19th and into the 20th century has withstood the demands placed on it well. There has been consensus in recent decades to concentrate investment in improving water quality rather than water resources (Ofwat, 2006). However, cracks have appeared in periods of drought such as 1976 and 1995, which also revealed less public tolerance for supply interruptions, particularly as the sector has increasingly shifted towards a customer orientated service (Taylor *et al.*, 2009). Furthermore, the accounting of population

growth and climate change in water resources planning, not initially deemed necessary at the time of privatisation, is now mandated in detail. Expectations and legal standards have also risen regarding environmental condition, particularly with the passing of the European Water Framework Directive in 2000. Against this wider context, a close shave in occurred 2012, the year of the Olympics, when planners feared London was close to introducing emergency measures after two dry winters (Chan *et al.*, 2022). Fears were relieved at the last moment with the onset of heavy rains that resulted in an unusual, brief pattern of simultaneous drought and floods. This event in particular led to recognition of the need for greater resilience to droughts with fears raised of the increased likelihood of a three-year drought considering climate change and the move towards non-stationarity (Slater *et al.*, 2021).

Discussions sparked the adoption of longer planning horizons to higher resilience standards. Projections revealed supply plummeting in a warming climate, alongside a continuing trend of increasing demand as populations grow, conjuring an evocative picture of the supply demand balance in deficit, described by James Bevan, the Head of the Environment Agency, as the “jaws of death” (Bevan, 2019). Furthermore, substantial abstraction reductions are likely needed in environmentally sensitive habitats, such as chalk streams, to accord with the European Union Water Framework Directive 2000, which still applies despite Brexit under ‘no deterioration’ obligations. The resulting picture is one of aging infrastructure networks that will come under increasing strain due to population, environmental, and climatic pressures.

A key premise of introducing planning at national and regional levels is that it will allow for the development of strategic schemes, to cope with the risks of climate change, environmental protections, and growth, namely long-distance transfers of water from the north and west of England and Wales towards the south and east, reflecting supply and demand gradients. Proposals for such large-scale infrastructure investments in the vein of a ‘national grid’ had been largely absent in policy discourse since a brief period of national planning in the sixties (McCulloch, 2009).

Somewhat complicating the move towards strategic schemes such as transfers is the unusual nature of privatised water provision in England and Wales. The specific nature of privatisation and how water resources planning has developed in England has several implications. In this case, it is not the question of ownership we are primarily concerned

with, but rather the question of scale and collaboration. Zonally defined water companies are legally obliged to ensure the needs of their own customers, potentially at odds with regional or national scale transfers. The new legal and regulatory frameworks are therefore attempting to incentivise greater cooperation across companies at regional and national levels to meet the strategic goals of improving national resilience. This change in approach represents a significant challenge and creates new requirements for alignment, cooperation, and resourcing.

Prompted by the new national framework, between 2020 and 2024, five regional groups covering England and part of Wales have coordinated within their own areas, as well as with each other, to give a national picture of the state of water resources now and in the future. Each region has its own unique context, and this is reflected in the diversity of regional governance arrangements. This pattern of heterogeneity, both physical, reflecting for example climate and geology, as well as social, reflecting the diverse histories of the companies in different regions, and developments in planning and regulation, creates both opportunities and challenges for strategic cooperation.

National strategic planning in England has not been institutionalised since the sixties with the brief reign of the Water Resources Board (McCulloch, 2009). The new regional and national tiers provide an interesting case to analyse an evolving multi-scale planning framework facing the ongoing challenge of fostering cooperation within a strongly regulated framework that has a focus on shaping the incentives and constraints of privatised companies driven by shareholder duties.



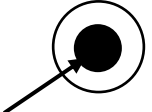
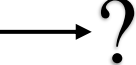
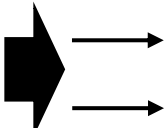
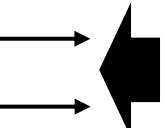


As such, this study seizes on the opportunity to analyse this case study in action following how the National Framework is being implemented in practice. It takes a qualitative approach based on interviews and workshops with practitioners within the water industry, and observations from being embedded in the planning process throughout the 2020-2024 planning round, crossing both company level, regional, and national planning negotiations. The report sets the fieldwork against lessons learned from academic theory and other cases studies which have highlighted benefits and risks involved with instigating developments towards collaborative, multi-scale water resources planning. This aim is to identify successes, constraints, and possible steps to improve planning in the future in England as well as consider more generalisable lessons.

The chapter is structured as follows; the next section introduces the concept of collaborative multi-scale planning with reference to relevant literature, followed by an introduction to the case study of water resources planning in England. The following section describes the methodological approach to evaluate the National Framework. Results are reported on the successes and limitations of the recent planning round in England and Wales, followed by five lessons learned and a proposed iteration of the governance structure. We then identify critical issues and principles in moving from current practice to the proposed structure. Finally, the report ends with seven recommendations as clear next steps in the transition to collaborative, integrated, multi-scale planning.

4.2.1 Collaborative, coordinative, and cooperative multi-scale planning

Structures of governance and institutions shape the nature of planning and operating in ways that can be conducive to productive discussions and positive outcomes or, alternatively, can hinder practitioners and become obstructive. Ideally, governance structures can be explicitly designed to enable participation, collective endeavour, and transparency, allow for alignment and coordination, and maintain accountability and other principles of good governance including efficiency, resilience, effectiveness, distributional equity and justice, legitimacy, and conformance to general morality (Ostrom, 2005; Lockwood *et al.*, 2010; Ahopelto *et al.*, 2024).

Literature indicates an emerging trend for institutional design to transition towards collaborative, polycentric, adaptive governance, where decision-making is dispersed horizontally and vertically rather than being centralised (Marshall and Smith, 2010). Proposed benefits include inclusion of local knowledge and trustworthy participants, better adapted rules, and lower enforcement costs (Ostrom, 2005). Studies have identified design principles and enabling conditions such as trust and transparency, as well as limiting factors and threats, such as a lacking leadership and limited funding (summarised graphically in Table 7). Crucially, there has been a growing emphasis on considering how the role of power explicitly shapes discourses and the political-economic context in ways that may provide or constrain possibilities for reforming institutions in a more collaborative direction (Clement and Amezaga, 2013).

Design principles and enabling factors		Limiting factors and threats		Examples from the literature for positive factors (+) and limiting factors (-)
Aligned interests and vision (same direction)		Incohesive direction and misaligned interests (different directions)		(+) shared perceptions (Lopez-Gunn, 2003), bipartisan support (Ibrahim, Bartsch and Sharifi, 2024), conflict-resolution mechanisms, clearly defined boundaries, rigorous institutional research, developing better curricula on local governance in schools (Ostrom, 2005) (-) absent strategic direction (Colloff and Pittock, 2019), strong and powerful opposing lobbies (Alexandra, 2019), misaligned incentives such as favouring local economic development over wider sustainability (Wang, van Rijswick and Dai, 2022), conflict (Ostrom, 2005)
Understanding, certainty (known direction)		Lack of understanding, uncertainty (unknown direction)		(+) clarity, expertise, applying a broad knowledge base (Ostrom, 2005) (-) lack of quality and quantity data (Colloff & Pittock, 2019), treatment of science and expertise in an adversarial manner and disputes over facts (Grafton <i>et al.</i> , 2020), limited access to scientific information (Ostrom, 2005)
Embrace change, power balance (pushforward)		Resistance to change, power imbalance and hegemony (pushback)		(+) trust, commitment to collaboration (Memon, Painter and Weber, 2010), recognition of rights to organise, and nestled enterprises (multi-scale governance), creating associations of community-governance entities (Ostrom, 2005), embedded principles of subsidiarity and polycentricity (Memon, Painter and Weber, 2010; Curtis <i>et al.</i> , 2014; Wang, van Rijswick and Dai, 2022; Ahopelto <i>et al.</i> , 2024; Ibrahim, Bartsch and Sharifi, 2024) (-) local tyrannies, inappropriate discrimination, corruption and rent-seeking, blueprint thinking via external funds (elite capture rather than context-centred solutions) (Ostrom, 2005), embedded hierarchy, capture by political manoeuvring, participation and consultation viewed as symbolic (Chowdhury and Behera, 2022), path dependency of the hegemonic and often siloed status quo that is a poor match for increasingly complex and ‘turbulent’ conditions of present day problems (Watson, Deeming and Treffny, 2009; Memon, Painter and Weber, 2010)
Sustaining and boosting momentum		Difficulties sustaining momentum (disruption and stagnation)		(+) capitalizing on windows of opportunity and events that generate momentum for change, particularly as planning often reacts to these catalysts rather than proactively anticipating them (Castán Broto <i>et al.</i> , 2014; Walsh <i>et al.</i> , 2015), adaptability (Alexandra, 2019), a flexible and adaptive management approach with strong collaboration between scientists, water supply agencies, and water users (Ross and

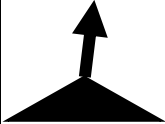

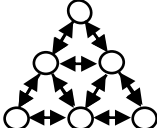
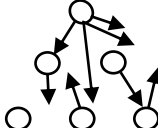



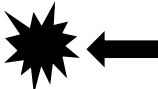
				Martinez-Santos, 2010) (-) stagnation, rapid exogenous changes, transmission failures (later generations not upholding the design of effectively governed institutions) (Ostrom, 2005), overreliance on leadership that becomes vulnerable to turnover (Margerum and Robinson, 2015)
Adequate resources (sufficient capacity)		Inadequate resources (lack of capacity)		(+) funding and resourcing linked to collaborative planning (Koontz and Newig, 2014) (-) lack of large-scale supportive institutions, inability to cope with larger-scale common-pool resources (Ostrom, 2005), limited staff and resources (Marshall and Smith, 2010), limited facilitation and leadership (Conrad, 2018), lack of funding (Koontz and Newig, 2014)
Organisation, rules (efficiency)		Poor organisation, lack of rules (inefficiency)		(+) appropriate scales of organising (Curtis <i>et al.</i> , 2014; Yakubov, 2022), binding rules with purpose (Cuadrado-Quesada and Schwartz, 2022), effective network management and lead agencies (Conrad, 2018), strong leadership, good facilitation, knowledge sharing, collective choice arrangements (rules) (Ostrom, 2005) (-) some self-organised efforts will fail (Ostrom, 2005), tendency towards excessive bureaucracy to ensure public funds are spent properly unintentionally hindering transparency and constraining the development of truly innovative partnerships and projects (Conrad, 2018; Watson <i>et al.</i> , 2009), lack of learning (Koontz and Newig, 2014), ambiguous definitions (Memon, Painter and Weber, 2010)
Positive motivation (incentives)		Lack of positive motivation (lacking incentives)		(+) reciprocity and trust (Ostrom, 2005) (-) some actors will not organise (Ostrom, 2005), participation viewed as symbolic (Chowdhury & Behera, 2022)
Effective deterrence/ sanctions (effective disincentives)		Lack of effective deterrence/ sanctions (lack of effective disincentives)		(+) effective monitoring, penalties and enforcement (Chowdhury & Behera, 2022), graduated sanctions (Ostrom, 2005) (-) poor assurance monitoring and compliance (Chowdhury & Behera, 2022)

Table 7. Lessons for implementing good governance from previous studies.

The term collaboration is used freely in academia, policy and industry, often interchangeably with coordination and cooperation. Yet, in recognition of material differences between these terms, definitions and distinctions have been proposed (see Figure 8).

Diagram	Term	Description	Pros	Cons
	COORDINATION (power-over)	A more hierarchical, command and control, or 'power-over' framework with greater homogeneity, aligns with traditional governance	Greater certainty, scrutiny and efficiencies linked to 'economies of scale'	May restrain innovation
	COLLABORATION (power-with)	A more collective, 'power-with' style that embodies a greater degree of mutual inter-personal trust, reciprocity, and self-organising	Potential for both efficiency and innovation	Is difficult to enact in practice due to strong dependency on high levels of trust, inclusivity, leadership, and distributed power structures, and vulnerability to change
	COOPERATION (power-to)	A more self-autonomous and self-interested, 'power-to' framework with greater fragmentation aligns with market-based thinking	Allows more dynamism and innovation	Can suffer from inefficiencies and difficulties for scrutiny

Figure 8. Graphic to illustrate the distinctions between coordination, collaboration and cooperation , adapted from (Stout and Keast, 2021).

Despite ongoing ambiguity, coordination generally aligns to a more hierarchical, command and control, or 'power-over' framework that can create efficiencies linked to 'economies of scale', but may restrain innovation. Cooperation aligns to a more self-autonomous and self-interested, 'power-to' framework that may incentivise innovation, but due to greater fragmentation, can suffer from inefficiencies and difficulties for scrutiny. Finally, collaboration may be characterised by a more collective, 'power-with' style that signifies a greater degree of mutual trust, reciprocity, and self-organising that theorists posit can overcome the lack of innovation and dynamism associated with

coordination, and the lack of collective effort and efficiency linked with cooperation (Stout & Keast, 2021). However, this vision of collaboration is difficult to enact in practice due to strong dependency on high levels of trust, inclusivity, leadership, and distributed power structures, and its vulnerability to change (Rouillard and Spray, 2017; Ulibarri *et al.*, 2020; Lukat *et al.*, 2023). It is useful to assess whether planning frameworks subscribe dominantly to one form over another, and the extent to which the established rules survive complex operational and inter-personal realities. Most likely, a mix of collaboration, cooperation and coordination interactions can be observed, both in the established rules and on the ground. Proposals for reform may benefit from diagnosing the mix of (or lack of) coordination, cooperation, and collaboration and the benefits and feasibility of shifting emphasis from one form to another.

Case studies suggest that institutional reform should take note of established principles and lessons from the past to avoid falling into the same pitfalls (Cuadrado-Quesada and Schwartz, 2022; Huang *et al.*, 2022; Wang, van Rijswick and Dai, 2022; Yakubov, 2022). They also highlight the importance of time and context (Pierson, 2004). Successful transitioning requires a deep understanding of the specific actors, their interactions, relationships, physical conditions, institutional setups, established rules, and pathway dependencies. Grounded in this knowledge, it may be possible to identify the unique barriers and steps that have a better chance of success within that context. A key factor includes capitalising on windows of opportunity and events that generate momentum for change, particularly as planning often reacts to these catalysts rather than proactively anticipating them (Alexandra, 2019). In an unpredictable landscape with many uncertainties and events appearing unexpectedly both endogenously and exogenously, success will vary and will face challenges to persist over generations (Ibrahim, Bartsch and Sharifi, 2024). Recognising the local specificity and dynamism means accepting that there is no one-size-fits-all approach that will work in all contexts.

This is why it is important to continually study how collaborative, multi-scale planning arrangements work in practice in different contexts to be able to firstly, suggest appropriate reforms in that specific area, and secondly, continue to test which lessons may be more broadly generalisable across institutions in different contexts. Good candidates include the principles of subsidiarity and polycentricity in recognition of the need for engagement, ownership, and effectiveness, and of adaptability in recognition of


the inherent messiness of an uncertain world with inherent subjectivity, complexity, change, and shifting power dynamics. This study will explore some of these questions in the context of water resources planning in England.

4.2.2 Water resources practice in England

4.2.2.1 Public Water Supply (PWS) abstractors (water companies)

The planning systems that were established at privatisation, and which have matured in the ensuing decades, can be considered relatively robust in ensuring a defined level of resilience to water security. They provide this through a strongly regulated and structured, technical process for the planning, scrutiny, and funding of investments needed to meet water supply needs. As mentioned earlier, England is unusual globally for having a privatised public water industry. **Table 8** represents the actors, guidance, and processes of planning that allow for decisions to be made on which Public Water Supply (PWS) schemes are required.

Table 8. Framework for delivering water resources outcomes, current remit covers investment into public water supply (PWS) schemes. Jagged shape represents the process between planning decisions and outcomes (beyond scope of this report).

Scale	Actors	Guidance	Process	Plans / decisions	Outcomes
National	Defra, Welsh Ministers Ofwat, EA, NRW, DWI, NE, RAPID, CCW NIC, WaterUK, UKWIR National stakeholders	<u>Legislation:</u> EU, Water Acts, etc. <u>Policy and guidance:</u> NF, WRPG, Welsh Guiding Principles, PR, WISER etc Reports e.g., by UKWIR, NIC, WaterUK etc.	National planning groups (SSG, RCG, TAG, ACWG, MAG, etc.) Gated Process WINEP process	Reconciliation reports Gated decision reports for national SROs	PWS interregional schemes, including SROs
Regional	5 Regional groups Regional stakeholders		Regional planning	Regional plans Gated decision reports for regional SROs	PWS cross company schemes, including SROs
WRZ/ company boundary	16 Water companies Consultants WRZ stakeholders		WRMP planning	WRMPs/ Business plans Final determinations Gated decision reports	PWS schemes, including SROs (supply, demand, WINEP)
Sub-regional and local	River Basin Partnerships Local authorities EA Area teams 100 CaBA groups Abstractor groups Local abstractors Local stakeholders			 <p>Planning consents, design, supply-chain, build</p>	

Acronyms: Environment Agency (EA), Natural Resources Wales (NRW), Drinking Water Inspectorate (DWI), Natural England (NE), Regulators Alliance for Progressing Infrastructure Development (RAPID), Consumer Council for Water (CCW), National Infrastructure Commission (NIC), UK Water Industry Research (UKWIR), European Union (EU), National Framework (NF), Water Resources Planning Guideline (WRPG), Price Review (PR), Water Industry Strategic Environmental Requirements (WISER), Senior Strategic Group (SSG), Regional Coordination Group (RCG), Technical Advisory Group (TAG), All Company Working Group (ACWG), Modelling Advisory Group (MAG), Water Industry National Environmental Programme (WINEP), Strategic Resource Option (SRO), Water Resources Zone (WRZ), Water Resources Management Plan (WRMP), Catchment Based Approach (CaBA).

Water Resources Management Plans (WRMPs) establish the water resources need over at least a 25-year horizon, based on supply and demand balance modelling that considers a range of factors, including climate change projections, environmental needs, and population growth forecasts. They are developed by water companies according to minimum requirements and standards set by aiming to ensure an agreed level of service to customers. The primary regulators are Ofwat, a non-ministerial government department responsible for economic regulation, and the Environment Agency (EA) who sit within the Department of Environment, Farming and Rural Affairs (Defra) who are responsible for environmental regulation. Companies also submit business plans setting out their expected expenditures to fulfil the investment needs established by their WRMPs. Ofwat then conducts the Price Review whereby they assess company business plans and set how much companies can charge customers with the aim of driving companies to be increasingly efficient. Both WRMPs and business plans are subject to ministerial sign-off by the Secretary of State for Defra. Produced every five years and reviewed annually, there is an inherent adaptive nature to the plans, and companies are under strong legal requirements and financial incentives to deliver the agreed-on programmes.

The process has benefitted from sustained technical expertise within the industry to conduct and develop plans based on detailed understanding of local water resource systems. This local understanding is crucial given the inherently heterogeneous conditions of climate, surface and ground-water availability, built infrastructure including treatment and distribution, and variable patterns of demand both spatially and temporally. The plans and models have been developed over decades to represent these complex systems and ensure sustained supply.

However, while it is beneficial for systems to be designed for their local contexts and complexities, aspects of the existing planning framework may be considered overly fragmented (Defra et al., 2018). The boundaries and resource constraints of the WRMP framework can create barriers for better consistency and connectivity potentially obstructing efforts to increase resilience more strategically (Figure 9).

Water resources planning boundaries 2024

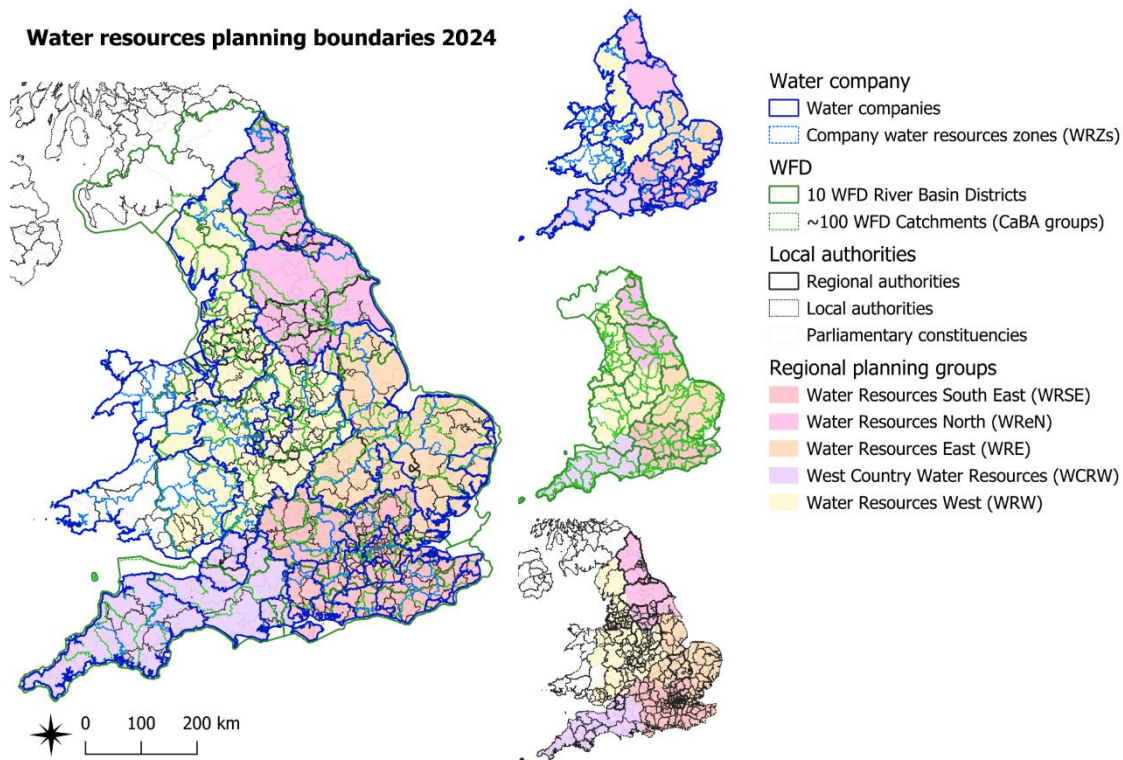


Figure 9. Map of water resources planning boundaries in England including relating to water company planning, river basin and catchment planning related to the Water Framework Directive (WFD), local authority planning, and regional water resources group planning. Water companies: © Ofwat copyright and/or database right 2024. WFD: © Environment Agency copyright and/or database right 2014. All rights reserved. Local authorities: contains OS data © Crown copyright and database right, Office for National Statistics licensed under the Open Government License v.3.0. Regional planning groups.

For example, the boundaries of the privatised water companies have evolved through institutional reorganisations and mergers or acquisitions and may obstruct hydrologically optimal ways to organise such as according to river basin or catchment, as well as at larger scales such as regionally or nationally. Defra and water regulators sent a joint letter to water companies in 2018 which stated:

"Water companies should take a genuinely regional approach to producing plans that transcend company boundaries and identify optimum solutions for the region as a whole" (Defra et al., 2018, p.2).

Fragmentation also poses a problem for regulators whereby guidance may not be applied perfectly consistently across local area zones, or nationally among regulators with different remits (Huang et al., 2022).

The introduction of regional planning and the National Framework reflects the recognition of the need to tackle fragmentation and enable collaboration, or at least better cooperation and coordination (Stout and Keast, 2021), across water companies

and regulators, moving from zonal to multi-scale planning, to improve connectivity and resilience (Water UK, 2016; National Infrastructure Commission, 2018; EA, 2020b). The new framework aims to deliver more efficient and robust water supply infrastructure schemes and demand initiatives across public water supply (PWS) and possibly expand its scope into other policy areas such as non-public water supply planning (non-PWS), emergency planning (droughts and floods), water quality, and spatial planning. At this early stage in the new framework's evolution there remains questions of how it should evolve and at what pace.

4.2.2.2 Non-Public Water Supply (Non-PWS) abstractors

There is no analogous process of long-term planning, investment, and accountability for non-PWS which leaves abstractors exposed to water scarcity, particularly in the face of license reductions to comply with environmental legislation and increased risk of drought as the climate warms.

4.2.2.3 Integrated River Basin Management and Catchment Planning

Aiming to embed a more integrated approach to water management, EU legislation mandated that member countries produce River Basin Management Plans (RBMPs) every six years since 2009 as laid out in the Water Framework Directive 2000. The Environment Agency (EA) is responsible for producing RBMPs for seven defined river basins in England. The UK government also introduced the Catchment Based Approach (CaBA) in 2011 which defined 100 catchments across England and Wales in pursuit of a more local approach (Defra, 2013). RBMPs and CaBA planning have been focused on water quality and habitats rather than water resources and the plans have not yet met their intended aims to restore ecosystems; only 16 per cent of water bodies met 'good status' requirements in 2019 (Defra, 2023b), decreasing from 43 percent in 2009 (Tsakiris, 2015) reflecting difficulties meeting all the necessary criteria and changing standards, particularly for good chemical status with the addition of new and updated priority substances such as through amendment 2013/39/EU (Backhaus, 2023).

4.3 Materials and methods

This project focused on engaging with water industry practitioners involved in water resources planning at multiple scales and aims to capture and reflect the expressed opinions and observed experiences of participants involved in the planning process. The

study takes a qualitative approach using data from interviews, workshops, observations, and analysis of published planning documents and the available literature.

Between 2020 and 2024, 26 semi-structured interviews were conducted with 19 participants from across the water industry. Participants included regional planning leads across the five regions (nine), regulators (five), a government official (one), and water resources planners from water companies (three) and consultancies (three).

Two lessons learned workshops were carried out with six and eight participants respectively with the outputs reported back to a national planning group as part of the ongoing planning round. A summary report was discussed in a third workshop with regional groups representatives and later presented at a national planning committee.

One of the authors, as part of their PhD research programme, took part in four placements which allowed for a rich insight into the planning process from different perspectives. One of the placements was based in a water company between May and July 2022 and involved working with the decision-making team on developing their Water Resources Management Plan. Between 2021 and 2024 the author observed one of the regional group's weekly decision-making meetings involving coordination across five companies. Between January and May 2022, the author supported a consultant with the management of the second national reconciliation, with duties including taking minutes at meetings and helping to schedule and coordinate meetings with five regional planning groups, regulators, and a government official. The author also spent three months with Defra in the Water Resources team between May 2024 and August 2024 consulting views and preparing a report on possible future reforms to water resources management.

The placements and workshops allowed for a close observation of the action arenas, while allowing the author to be able to step away and have time to analyse the multi-scale planning process and how the multiple arenas relate to one another and to the wider context. The research reflects one of the author's position as a PhD student embedded amongst professional experts aiming to capture their perspectives and the institutional framework they operate within, acknowledging that insights will be shaped through (1) the lens of the author whose experience developed over the course of the PhD training programme, (2) the author's industrial and academic supervisors, and (3) of the participants. Steps were taken to minimise misinterpretations and bias. Firstly,

following interviews, meetings, and lessons learned workshops, summary reports were sent back to participants, so they were able to review that the author had understood and fairly represented their views. Secondly, the analysis is situated against wider academic literature and case studies around water resources governance as referred to in the introduction and discussion (albeit itself shaped and constrained by the authors' literature review, time and capacities).

Policy and planning documents and academic literature were also reviewed and analysed.

The interview transcripts, meeting minutes and notes, and planning documents were collated and organised thematically to identify patterns across the data, and support the development of the results and conclusions (see **Appendix K**). This process of thematic analysis involved highlighting relevant excerpts from the source material and coding them into sub-themes using the qualitative research software NVIVO. At first the data was coded inductively with no predetermined sub-themes. As more data sources were incorporated, the sub-themes were refined, highlighting salient and reoccurring concepts.

While the data reduction inevitably results in some detail getting lost, the approach allowed for flexibility and researcher judgement in identifying the most relevant material (without adhering to emergent codes as strictly as grounded theory). Eventually, the sub-themes were synthesised into broader themes to more effectively and concisely communicate the conclusions.

This final stage of presenting the data clearly was guided by previous theory, namely Institutional Analysis Development (IAD) (Clement and Amezaga, 2013) and the Strategic Choice Approach (Friend and Hickling, 1997). These frameworks were used to group the themes into:

- successes and limitations (of the National Framework), and
- the categories: (1) objectives, (2) information, (3) governance, and (4) outcomes.

While recognising a degree of inevitable overlap between categories, they helped structure the outputs in a more coherent and accessible format.

The credibility of the data was reinforced through interacting with practitioners throughout to ensure the results fairly reflected their perspectives. Additionally, the results were presented at a conference and received positive feedback from a regulator who had not been interviewed but affirmed that the conclusions aligned with their own experience of the Framework's implementation.

4.4 Results

4.4.1 Successes and limitations of the 2020-2024 planning round

The planning round 2020-2024 saw the initiation of regional planning for the first time nationally alongside the raising of resilience standards, environmental ambitions, and demand and leakage targets. To meet the challenge, regulators issued new expectations for water companies and regional groups to work collaboratively. However, there was little guidance on how this collaboration should be managed with a lot of room given to companies and regions as to how they should establish themselves and their cross-party working arrangements.

The structure of regional planning closely resembled the WRMP process which was not unexpected given many of the same teams of people were involved. However, from the outset, the five regional groups were characteristically different and at different stages of development with one existing since 1997, one since 2014, and the other three established between 2017 and 2020. Each region individually published the approach it would follow. To co-ordinate across regions, a series of technical and strategic working groups were established, an initial planning timeframe was set, and discussions commenced over a national alignment of methods and assumptions. Crucially, the schedule included periods of national reconciliation whereby the regions and regulators would come together to ensure any transfers between regions would be consistent. The reconciliation approach emerged from a similar iterative approach that one of the regions, Water Resources South East (WRSE), had developed to agree transfers across its constituent companies for their WRMPs. The first national reconciliation was to run towards the end of 2021. It was expected that further reconciliations would be required as plans changed through their development and following consultation. Each reconciliation was organised in a relatively ad-hoc manner by the regional leads throughout the planning round and each varied in its level of cross-party organisation and management. For the second and third reconciliation external support from a

consultant was commissioned to help with programme management. The second involved the greatest level of engagement across all regions, and the third ran in a more bilateral manner between relevant parties in cross-regional schemes.

Practitioners acknowledged several important successes (see **Table 9**). Firstly, planners shared the view that it was important to increase the resilience of water supplies and that the step up in cooperation and coordination across water companies, regions, and regulators was necessary. The increase in collective effort opened up discussions and allowed for learning and sharing of best practice across companies and regions. This helps transition towards better consistency and alignment in approach, reducing some drivers of uncertainty. Planners also agreed that the new framework benefits from the expertise of water companies and regulators building on the existing framework of company focused water resources management planning that has matured over several decades and respects the need for locally tailored approaches. Outcomes included reconciliation across regions to agree a national picture of strategic schemes, including pathways to inter-regional, long-distance transfers, based on common assumptions.

Table 9. Success and limitations of the 2020-2024 water resources planning round in England. Acronyms: WRMP, Water Resources Management Plan; PWS, Public Water Supply (PWS); IRBM, Integrated River Basin Management.

	Successes	Limitations
Objectives	<ul style="list-style-type: none"> · Increasing ambition matches increasing needs 	<ul style="list-style-type: none"> · Uncertainty around objectives and trade-offs · Late / changing expectations
Information	<ul style="list-style-type: none"> · Improving consistency and alignment of methods · Recognition of the importance of maintaining locally tailored approaches · Benefits of national modelling work · Reducing uncertainties 	<ul style="list-style-type: none"> · Remaining inconsistency · Lack of data/knowledge/understanding/ inherent uncertainty · Limitations of national modelling work · Outputs mismatch the nature of uncertainty in the long term · Complexity and opaqueness of methods, alongside excessive reporting/duplication creating difficulties for effective scrutiny, hindering transparency, and lowering confidence and trust
Governance	<ul style="list-style-type: none"> · Building on existing mature WRMP framework · Improving collaboration opened up discussions and learning · Wider consultation and engagement 	<ul style="list-style-type: none"> · Uncertainty / difficulties around process and disruptions to the schedule · Limitations of funding and resourcing · Difficulties handling change / new information · No framework for other sectors · Difficulties matching scale between PWS and non-PWS · Lack of framework for catchment / nature-based / IRBM solutions · Difficulties of participation and engagement
Outcomes	<ul style="list-style-type: none"> · Agreed national set of transfers (core pathway and alternative pathways) · Improving consistency and alignment 	<ul style="list-style-type: none"> · No schemes funded for non-PWS · Limited options in some areas · Risk of plans not meeting affordability criteria at Price Review 2024 · Risks with planning and implementation

However, despite these efforts, the planning framework was compromised by several interrelated factors (see **Table 9**). Firstly, regulatory guidance, expectations and definitions changed throughout the process. Secondly, companies and regions missed planning deadlines (with reasons including difficulties meeting the changing regulatory expectations, drought management diverting limited resourcing, and prioritisation of

statutory planning requirements). Thirdly, the original planning timetable unravelled because of the missed deadlines and delays, and particularly as some companies were issued extensions creating syncing issues across companies with interdependencies, and as the WRMP schedule encroached and overlapped with the business planning timetable. Finally, the risk of challenge and rejection of plans increased as the lack of coordination meant arising concerns were not solved, ultimately undermining confidence in the assumptions and decision-making behind plans. The changing expectations and delays created additional work and problems of consistency, and generally increased uncertainty across companies and regulators as to whether the final plans will meet expectations.

Similar risks continue into the final stages of the planning round. Final determinations on plans are expected in 2024 but there continues to be uncertainty as to how trade-offs should be balanced between meeting resilience standards, meeting environmental ambitions, progressing strategic schemes, meeting demand targets amid significant uncertainty surrounding future changes in water-use behaviours and the introduction of government interventions, and crucially meeting the government and Ofwat's criteria for affordability. There may be a risk that late introduction of affordability constraints (recognising the increasing political attention on water quality and higher interest rates) will limit investment proposals for water resources and therefore void water resources investment planning work across companies and regional groups between 2020 and 2024.

The problems reflect issues of management and coordination, particularly relating to an unclear and unstable vision, and a misunderstanding of the constraints imposed by the statutory timeframe for planners within regional groups and companies. In light of the issues encountered so far during the 2020-2024 planning period, several key lessons learned were identified. Firstly, establishing a clear timetable and frontloading work helps mitigate uncertainty, fostering trust and confidence in the process. Secondly, change is inevitable, and the process should be adaptable through well-organised coordination that respects the constraints of stakeholders. Thirdly, avoiding duplication of (1) technical work, (2) reporting, and (3) consultation across WRMPs, regional plans, Strategic Resources Option (SRO) planning, and business plans reduces unnecessary workload and enhances effective scrutiny. Fourth, ensuring simplicity and clarity

through early engagement and agreement on common definitions, methods (including assumptions and modelling) and outputs that can be communicated with all stakeholders is vital for building trust and transparency. Finally, structures that enable ongoing collaboration are essential, as this process is key to achieving better action and implementation, underpinned by trust and transparency.

Consequently, this study proposes that the existing arrangements evolve into an explicit multi-scale framework that recognises the need for and facilitates discussions and decision-making at the appropriate scale (**Figure 10** and **Figure 11**).

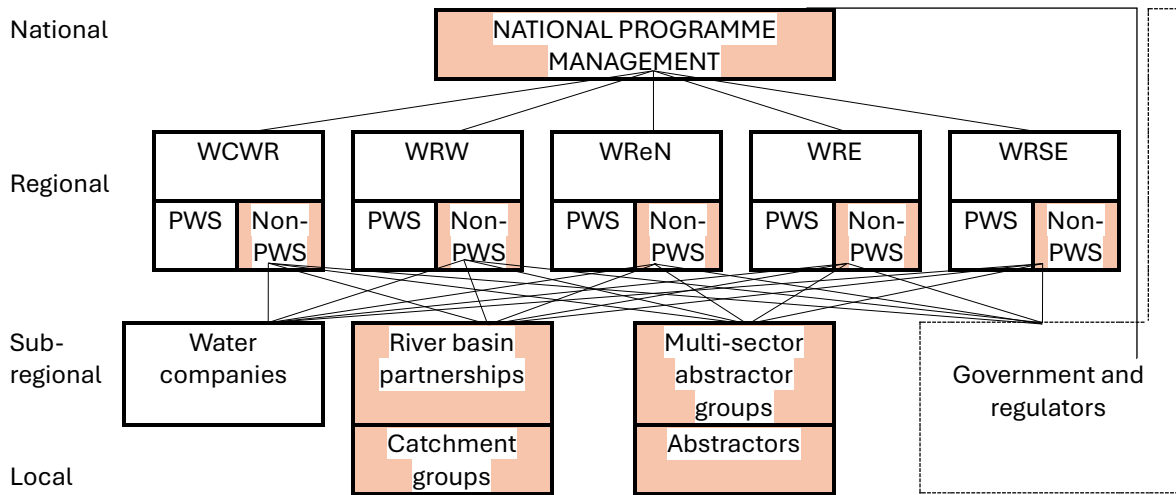


Figure 10. Proposal for an evolution of the planning framework to make explicit the multi-scale nature of decision-making bodies involved for public water supply (PWS) and non-public water supply (PWS). Orange boxes indicate where a formal investment process is lacking. The dashed border indicates that the government and regulators cross scales. Regional groups include West Country Water Resources Group (WCWR), Water Resources West (WRW), Water Resources North (WRn), Water Resources East (WRE), and Water Resources South East (WRSE).

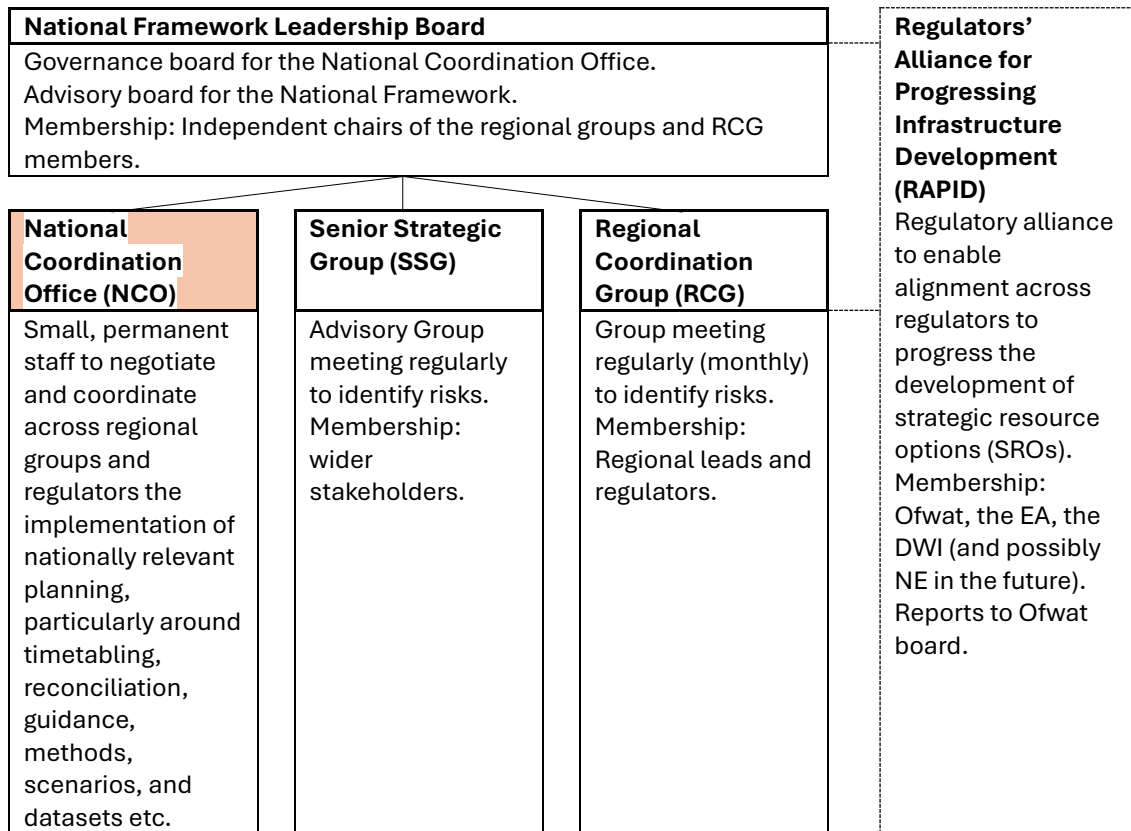


Figure 11. Proposal for the components of national programme management, with the addition of the National Coordination Office (NCO), highlighted in orange, alongside the existing National Framework Leadership Board, Senior Strategic Group (SSG), Regional Coordination Group (RCG), and Regulators' Alliance for Progressing Infrastructure Development (RAPID). The dashed border indicates that the government and regulators cross scales.

Clearly, the two schematics provide only a simple overview of a multi-scale water resources governance structure. If new forums are set up to improve water resources planning there are difficult choices at each level regarding form, function and funding

that require consideration of trade-offs, possible unintended consequences, and feasibility within the constraints of broader structures of decision-making and politics.

Components of this proposed framework exist (water company investment via WRMPs and regional plans) or are already developing (national collaboration via the Regional Coordination Group (RCG), Senior Strategic Group (SSG), and National Framework as illustrated in **Figure 11**). As discussed, these could be clarified and funded on a sustainable basis, alongside the formation of currently missing components (non-PWS investment and greater collaboration and investment at the river basin and catchment scale).

4.4.1.1 National-level coordination

A useful first step is to prioritise the establishment of a national coordination office that can facilitate agreement amongst regional groups (representing PWS, non-PWS, and wider stakeholders) and regulators on areas of national relevance on a long-term basis. Although the National Framework (2020) set expectations for improved collaboration at regional and national levels, there was little guidance as to how this would be achieved or managed in practice. The regional groups stepped into this space and established rules of engagement and organised three national reconciliations. However, as discussed, several challenges arose that would have benefitted from central coordination, such as clarifying definitions and expectations amid multiple interpretations, managing the impact of new policy expectations on the timetable, holding actors to account when the agreed upon rules are broken or deadlines missed, and ensuring continual channels of communication between actors to proactively solve problems rather than encounter delays late in the schedule.

This ties into the critical challenge of fostering collaboration while maintaining accountability and responsibility within a tightly regulated industry. One of the problems identified in the literature in theory and in case studies is the tendency towards excessive bureaucracy and strengthening of central control as hindering the transition towards more collaborative and adaptive models (Conrad, 2018). A key lesson learned was the benefits of good facilitation by “trusted intermediaries’ (Rouillard and Spray, 2017). Better facilitation by a national coordination office would help improve the functioning of the current framework by maintaining responsibilities and accountability

locally but improving interactions between actors through the ability to establish forums to solve arising problems in real time.

An office may help to fill a strategic void without compromising accountability. Not unexpectedly, staff within agencies focus on the problem from the perspective of their organisation using the tools at their disposal to design solutions. For example, a water company or regional planning group focuses on the customers and problems within their geographical boundaries, Ofwat takes an economic framing to solve issues such as considering incentives or penalties, the Environment Agency and Natural England work to solve environmental issues according to established law and policy, and Defra focus on legislative and regulative levers. However, although this picture accords with the stated remit and powers of each party, it does not allow for oversight of the whole picture. Each actor tries to solve problems according to their own framework with the tools within their scope, which may not be appropriate (Enserink *et al.*, 2022). Rather than assuming each institution is capable of considering all aspects of a problem, improved coordination and facilitation through an independent and neutral chair (Watson, 2004) can help enable a more holistic framing of problems and bring the right people with the right tools together to deliver better solutions, while maintaining accountability, scrutiny, specialisation, and subsidiarity.

Therefore, the role of the office would be to improve the existing framework and maintain bottom-up accountability, facilitating cooperation between companies, regional groups, and regulators while allowing them to fulfil their existing duties without compromising the separation needed for scrutiny or placing an excessive burden on resourcing.

Seeking agreement across parties following a bottom-up approach, the office could help clarify expectations, common definitions, and methods early on in the process. Areas potentially benefitting from national consistency: (1) establishing the acceptable risk envelope and approach to defining it; (2) spatially coherent stochastic hydrology; (3) climate data sets and scenarios; (4) definitions of best value metrics; (5) property and population forecasts; (6) costing methods for interregional schemes; (7) definitions, for example environmental destination (ED) and distribution input (DI); and (8) adaptive planning scenarios and interdependencies. Coordination should include regular workshops held early on and throughout the planning cycle to determine the changing

needs, the evolving state of knowledge, and appropriate methods to deliver objectives considering scale and the principle of subsidiarity.

A crucial function would be to facilitate agreement on and ensure sustained management of a coordinated timetable. The office could hold parties to account as an independent voice by making visible when expectations are not met, backed up by the authority of the chairs group. Additionally, a further role would be to improve national engagement through coordinated reporting and communication.

Having a small team of experienced water resources planners able to negotiate independently across regional groups and regulators to facilitate better cooperation amid the imperfect and changing landscape of planning would smooth the transition to the vision of multi-scale, resilient water resources planning as set out in the National Framework.

4.4.1.2 Regional coordination

The regional planning groups can play a key role in connecting local constraints and needs up to the national level and national strategies and priorities down to the local level where appropriate. Alongside enabling coordination vertically, regional groups are well positioned to connect actors across sectors and facilitate the exploration and development of new options across PWS and non-PWS, as well as help to identify critical catchments requiring immediate attention to prioritise for further study due to their importance for supply or particularly difficult trade-offs.

A risk of regional planning is the duplication of work. This was a problem encountered in the 2020-2024 planning round. Practitioners signalled the benefits of regional planning stemmed more from the process of planning and collaboration rather than necessarily in the production of the plans themselves which duplicated much of the information of WRMPs and the national reconciliation reporting and created additional burden on workloads for water companies, regional groups, regulators, and other stakeholders reviewing the burgeoning documentation. This raises the question of ensuring an appropriate level of reporting at each scale that does not compromise transparency and scrutiny.

4.4.1.3 Sub-regional and local Integrated River Basin and Catchment Planning

For integrated planning to work effectively, resourcing is needed at sub-regional and local levels to support stakeholders and abstractors as they develop catchment-based approaches (CaBA) to collaboration and long-term planning. The formation and strengthening of collectives such as river basin partnerships, catchment groups, and multi-abstractor groups may be useful vehicles for local voices to convene and where necessary feed up to higher levels. The emergence of stronger catchment action will help identify and resource those considered critical for regional water resources planning. Funding and staff will be needed to improve capacity and coordination and widen the group's representation and remit. The forums could become vehicles for the participation of those interested in other catchment needs, such as flooding, water quality, spatial planning, and amenity, and help in the development of more catchment and nature-based schemes.

4.4.1.4 Public Water Supply (PWS) and Non-Public Water Supply

As indicated in **Table 9**, the process for PWS is evolving with some successes as well as areas for improvement across objectives, information, and governance. Overall, there is a strong case to maintain what works with current practice, but also facilitate cooperation via regional groups and a national office, alongside better resourced local planning.

For non-PWS, it is critical that potential risks of future water scarcity and license reductions are well-communicated and understood. It is important to recognise the diversity of context and scale across non-PWS. Abstractors range across sectors with different cultures and attitudes to risk, from smallholdings planning seasonally, to industrial power stations with stringent requirements for water for cooling, to local business such as breweries or hotels managing their own private supplies. All these businesses may be vulnerable to license changes, or water shortages in unique ways.

For non-PWS, it is critical that potential risks of future water scarcity and license reductions are well-communicated and understood. It may be beneficial for abstractors to establish collective forums, such as multi-sector abstractor groups, to represent their needs and vulnerabilities at the relevant scale, whether at a local, catchment, river basin, regional or national level. A degree of freedom and ownership is required to encourage experimentation, learning, and capacity building to develop networks and

planning frameworks that fit their needs and capabilities. However, as the non-PWS framework evolves, it may benefit from being integrated with PWS at all scales to enable knowledge sharing and learning, reveal and take advantage of collective opportunities, build trust, and facilitate a more collaborative approach to the sharing of a common resource and conflict resolution.

Alongside designing a sustainable funding mechanism for non-PWS multi-sector planning, overcoming constraints to enable effective communication across and between scales will be critical to success, else each level or sector risks becoming a silo in itself. These links between scales are therefore crucial and likely work effectively with independent, trusted facilitators and when the same practitioners work across levels (Margerum and Robinson, 2015; Rouillard and Spray, 2017; Conrad, 2018).

4.5 Discussion

Models of collaborative, multi-scale, integrated planning following principles of subsidiarity, polycentricity, and adaptability and generating outcomes that are fair and robust are promoted in the wider literature on good governance and decision-making. However, as previously discussed, in practice it is difficult to transition to a system that encapsulates all these characteristics given tough barriers such as path dependencies, power structures, and the costs of trust and capacity building. This is drawn out through the example of water resources planning in England, mirroring some of the threats identified in other studies (summarised in **Table 7**).

Despite general agreement across water planners around the need for a collaborative and multi-scale approach to increase resilience, ensuring water for society and the environment, there has been less clarity around how to realise these aims, for example how to effectively reflect calls for ‘collaboration’ in governance structures with sufficient resourcing and buy-in.

Efficiencies initially expected from finding collaborative solutions accounted neither for the substantial step up in ambition around resilience and the environment, which created large deficits in many regions, nor for the level of additional work and regulatory input needed to develop a new planning approach across companies and other stakeholders at the local, regional, and national scale.

The collective action that arose over the course of the multiple rounds of reconciliation was ad-hoc and adapted to the changing circumstances, including a drought in 2022, evolving policy expectations, and an increasingly mis-aligned schedule as companies, regions, and regulators did not keep to the initial deadlines.

Yet, although unplanned, the flexible approach taken so far may turn out to be advantageous, as it has facilitated experimentation. Entrenching a framework from the outset likely would not have proved to be a good fit throughout the process, particularly considering the heterogeneous development of the regional groups.

All three modes, coordination, cooperation, and collaboration (depicted in Figure 8) were observed over the course of the planning round. Regulators tended to exemplify a top-down ‘coordinated’ approach through setting targets and directions, alongside the longest standing regional group, WRSE, which developed a top-down regional model to optimise decision-making for its constituent water companies. WRE also showed characteristics of top-down coordination by setting regional objectives and using regional modelling. However, it remains unclear whether this approach would have held if its constituent water companies had strongly opposed it.

Regional groups Water Resources West (WRW), Water Resources North (WReN), and West Country Water Resources Group (WCWR), tended to demonstrate a more bottom-up cooperative approach with constituent water companies working together to find mutual solutions, while also exhibiting a stronger sense of independence. This more cooperative regional approach arguably aligns better with the regulatory framework which holds that water company boards are accountable for their decision-making through WRMPs and business plans, rather than the non-statutory regional groups.

This study also finds evidence of the more elusive ‘collaboration’ that involves greater reciprocity, mutual understanding, and acting towards a larger collective goal, superseding the goals of individual participants. This vision of collaboration is less discernible in the explicit governance structures and rules but is observed through the interactions of participants. In many interviews and workshops, and throughout discussions over the course of the reconciliations, participants demonstrated a personal commitment to and recognition of the need for more integrated, catchment-based planning that included abstractors across different sectors, society, and the environment. Practitioners also understood that the constraints of legal and regulatory

frameworks inhibited a more integrated vision, while simultaneously recognising the safeguards provided by the existing frameworks and the possible risks and unintended consequences of introducing reforms.

The landscape continues to rapidly evolve with ongoing questions around appropriate abstraction reductions and multi-sector planning. A key lesson, therefore, is the need for ongoing flexibility, improving the links between actors through ongoing facilitation and coordination. This requires funding and management, which could be effectively supported by the proposed multi-scale structure.

4.5.1 Why a multi-scale framework is needed

As discussed, the introduction of more participatory and transparent governance involving more open data and the input of citizens, stakeholders, private interests, and the state at all levels can enable decision-making that is better informed by local contexts and interests (Perry and Easter, 2004; Curtis *et al.*, 2014). However, the introduction of such approaches alongside existing frameworks requires careful consideration. This is particularly true in the English case where there are marked divisions between public and private spheres operating according to prescriptive incentives and rules, raising questions of how collaboration can be fostered when planning is constrained by statutory duties. Furthermore, the evolving nature of more integrated decision-making risks becoming complicated and opaque, blurring the lines of accountability and authority (McCloskey, 1999; Ibrahim, Bartsch and Sharifi, 2024).

Building long term water resources planning frameworks for non-PWS raises many questions; how to fund and resource the planning, how to fund and resource investments, how to ensure fairness across a diverse range of abstractors operating across scales with different needs and abilities and capacities to engage, which aspects should be devolved to local groups (such as catchment groups or abstractor groups) and which aspects require greater consistency in approach (such as via national or regional planning)?

There is also the crucial question of whether to better integrate water resources management with related areas of planning (water quality, flooding, drought, land planning, energy, agriculture, ecosystems etc.) at the catchment scale, which may require substantial changes to existing siloed frameworks (Orr, Colvin and King, 2007). In

fact, there are many ongoing questions and challenges for water resources management, and it is likely that unanticipated complex issues will continue to arise.

Having a multi-scale framework as suggested in **Figure 10** allows for engagement and coordination to begin exploring solutions to these questions. One of the lessons through the recent planning round that concurs with findings in other studies is that a process that enables cooperation builds human and social capital and reveals inadequacies, with the aim of facilitating better outcomes (Memon, Painter and Weber, 2010). Although establishing an integrated multi-scale management structure involves increased transaction costs with additional administrative resources, including experienced staff on a long-term basis, the gains of collective endeavour in tackling these challenges are worth considering, and have proved to be beneficial in other regions (Conrad, 2018). The literature recognises that actors will act as ‘bricoleurs’ modifying and reshaping the formal frameworks in pursuit of their interests (Wang, van Rijswick and Dai, 2022). Good network managers can facilitate and support informal dynamics to help build trust while simultaneously ensuring rule compliance and continuing adherence to the strategic objectives (Koontz and Newig, 2014; Conrad, 2018). Therefore, an explicit multi-scale framework allows for participation and trust building while maintaining transparent accountability and rule abiding, institutionalising the benefits of both inclusive and effective planning.

4.5.2 Principles of subsidiarity, adaptive planning, and transparency

Decision-makers will always face gaps in understanding, new issues will continue to arise, and approaches and methods will continually evolve (Friend and Hickling, 1997). Therefore, it is important to build adaptive structures of collaboration and scrutiny that can accommodate the changing and imperfect landscape (Ahopelto *et al.*, 2024).

Keeping in mind the principle of subsidiarity, rather than impose a new top-down structure, a process of information gathering, engagement, and trust building is likely needed to bring on board relevant stakeholders (Marshall and Smith, 2010; Colloff and Pittock, 2019). This engagement would provide insight on how best to implement the proposed collaborative multi-scale architecture, and would help clarify (1) the vision; (2) the approach; (3) appropriate metrics, scenarios, and performance indicators; (4) a coordinated timetable; (5) the compliance model; and (6) reporting requirements.

Having effective intermediaries, able to facilitate ongoing cooperation and negotiation across and between scales, helps reveal misunderstandings, potential conflicts, and other issues that may arise. This itself builds adaptive capacity within the institutional framework through the creation and management of forums that can be used to tackle unexpected challenges.

Transparency is at the core of this challenge, enabling feedback loops to (1) improve collective understanding supported by evidence, and therefore (2) refine objectives, and (3) refine the rules and governance required to achieve them (Alexandra, 2019).

4.5.3 A stepped approach in the transition to integrated planning

There is wide agreement that to meet future challenges in a holistic and effective way, we will need a more integrated approach to planning that brings together overlapping policy problems including water resources, water quality, flooding, and drought planning (Grigg, 2008). However, this would involve transformational change requiring new legislative and policy frameworks, more resources and strong networks built on trust and confidence (requiring higher levels of human and social capital) (Watson and de Loë, 2021).

It may be more effective to first establish multi-scale governance arrangements with a clear remit for water resources planning. As more collaborative networks develop, and a greater understanding is developed of areas of priority and potential opportunities, the multi-scale framework could expand to encompass a broader range of objectives (Kidd and Shaw, 2007; Orr, Colvin and King, 2007).

The rigid regulatory structure may not allow for a fully reciprocal, self-sustaining collaborative framework, which may itself pose risks for safety, legitimacy, and accountability (McCloskey, 1999). However, while maintaining benefits of efficiency and accountability through structured coordination of the regulated policy and legal framework with accompanying funded duties and responsibilities (Rouillard & Spray, 2017), as well as innovative cooperation between water companies through regional groups and national reconciliations, the evolving nature may foster greater collaboration through ongoing, facilitated interaction towards collective aims. With additional funding and support, the innovative and collaborative opportunities may be maximised by

widening the pool of representation beyond water companies to include interested and affected stakeholders and sectors.

4.6 Conclusion

This study demonstrates the findings of research based on engagement with water practitioners in England as they respond to the introduction of multiscale working and collaboration. Findings demonstrate successes, limitations, and lessons learned from the implementation of the new framework. Based on practitioners' insights, this study outlines proposals to move towards more collaborative, adaptive, integrated, multi-scale planning.

Collaboration was envisioned and expected by the regulators at the onset of the planning round and received buy-in from regional groups. However, the fact that it was not explicitly designed for how it would work in practice, and was not allocated additional resourcing, or assigned central management, reflects the nature of the planning framework in England being obscure as to who is ultimately responsible. In reality, planning of public water supply is a joint venture between the companies, who operate and understand local system constraints and opportunities and are legally accountable to deliver, the regulators in charge of scrutinising plans, issuing guidance, and advising government, and the government, who may be held democratically accountable for the constitutional structures and strategic policy objectives. However, a void has emerged since the establishment of a multi-scale structure as to how this additional collaborative effort should be managed.

This study recognises the benefits of continuing to improve coordination and cooperation, and questions the feasibility of a truly collaborative approach given the existing regulated and privatised model. However, there are benefits of shifting as far as possible in a more collaborative direction. The study demonstrates improving interactions between actors, such as through the reconciliations organised by the regional groups, has potential to develop the kind of human and social capital required for fostering greater levels of collaboration.

To further foster this emerging collective effort, seven recommendations are proposed. First, to establish an independent national coordination office to structure the process around nationally relevant collaboration and decision-making, particularly for inter-

regional reconciliation, alignment, and consistency. This will help to fulfil the second recommendation to progressively align guidance, methods, scenarios, and datasets, creating a shared pool of knowledge that allows for diversity according to local conditions while maintaining consistency and transparency. Relatedly, the third recommendation is to develop a joint approach to active adaptive planning at all scales. Fourth, regional groups should be embedded as forums for collaboration over issues at the regional level and for feeding up to the national level. Regional groups can streamline existing reporting to reduce duplication with WRMP, SRO, and business planning. Fifth, a sustainable means of funding is required to incorporate non-PWS planning alongside PWS decision-making and investment frameworks at the regional and sub-regional or local levels, including greater support and resourcing for multi-sector abstractor groups to widen representation. Sixth, greater support and resourcing should be established for catchment level and river-basin level environmental investigations and decision-making that can feed up to higher levels where necessary, focusing on identified critical catchments. Finally, there needs to be sufficient resourcing and transparency for the Environment Agency, Natural Resources Wales, and Natural England across scales, particularly at the local level where there is a need for greater consistency in assessments and better visibility of decision making, alongside a need for setting up modern and transparent monitoring systems to permit effective oversight and evaluation.

The recommendations acknowledge the existing gaps and aim to strike a practical balance between encouraging collaboration within an existing highly regulated framework. More coordinated and cooperative multi-scale planning helps to start the process of building a better understanding of water requirements and strategies and managing issues as they arise. Yet, these steps recognise that time and resourcing is needed to start building the relationships and levels of trust and confidence required for the long-term goal of truly collaborative, integrated management.

The emerging planning frameworks are attempting to establish and integrate multiple scales for the first time since the sixties in England and Wales, and ultimately will be judged to have succeeded if there is confidence and trust that the process delivered aligned plans across scales that meet long term water supply needs. Success or failure, lessons learned from this transition to a multi-scale approach may provide wider insight

for decision makers involved in complex, long-term, multi-stakeholder decision making under uncertainty.

4.7 Signpost to the next chapter

Building on the examination of governance structures and collaborative processes in multi-scale planning, the following chapter turns attention to the technical dimension of water resources planning, specifically, the role of modelling. Chapter 5 investigates how modelling practices influence investment decisions, trust, and transparency within the planning process.

Chapter 5. The Complexity of Clarity: Balancing Granularity and Trust in Modelling for Water Resources Planning in England

5.1 Abstract

A core part of water resources planning in England involves the translation of policy and regulation into quantitatively framed modelling exercises, which demonstrate the planning assumptions and decision-basis for investments. However, in practice the transparency of decisions can be undermined by the number, diversity, and complexity of models (spanning climate, hydrology, water resources systems, cost-benefit, multi-criteria optimisation, customer preference, and econometric models) outputting a vast sea of documentation. Critically each model introduces uncertainty of different and unknown forms and magnitudes. A lack of understanding of the propagation of uncertainties across sub-disciplines makes it difficult to maintain a grasp of the bigger picture. In this study we consider whether the use of models in water resources planning in England was well balanced in the 2020-2024 planning round in meeting both the aims of appropriate granularity and technical sophistication alongside trust in decision-outputs. The study is informed by document analysis and semi-structured interviews with water industry practitioners. Recognising several inherent planning tensions, we recommend capitalising on promising signs of adaptive governance that embed open self-reflection and learning. Effective, interactive, interrogative coordination can help to continually (1) refine positive developments, namely adaptive planning, in the face of uncertainty, (2) review the appropriateness of the use of modelling, streamline complexity and enhance transparency through standardisation where appropriate, and (3) build adaptive governance structures that embody responsiveness, learning, and openness to challenge.

5.2 Introduction

Investing in water resources infrastructure is a core part of future societal and environmental resilience. In general, the costs of operating and maintaining public water supply systems, both operational and capital, are funded by public money, which may come from taxation or, in England's case, through charges levied on customers by privately owned water companies. Deciding on which water resources investments are

required to future-proof a water system is complex. The final bill, a statement of how much will be raised to provide an expected level of system resilience, is returned from a long modelling chain which embed decisions over what we consider relevant and valuable through explicit (though not always transparent) assumptions and compromises capturing uncertainty and subjectivity. However, the uncertain, non-quantitative, subjective, and elusive components do not easily translate into static figures (Molle, Lankford and Lave, 2024). These core features: (1) a static collection of payment for investment for a list of planned investments and proposed outcomes over a set timeframe and (2) a dynamic, uncertain, and subjective process to determine the problem and solution, are both fundamental to water resources planning, and yet, like any complex long-term planning, are difficult to reconcile.

Decisions are rarely taken in a context of perfect information. Rather, they are taken amid simplifications, with the best data available that can be processed and interpreted within the time and resources available. This indicates trade-offs (Harou, 2023) between accurate or sophisticated representations, and the introduction of uncertainty, time, and money. Critically, the trade-off between granular complexity and understanding the bigger picture, requires effective, strategic management of what is involved along the modelling chain. The decision-making process for water resources infrastructure involves both a highly complex technical landscape and a highly complex governance landscape, making it inherently difficult for any individual to grasp the entirety of the process. The complexity and granularity invite obscurity and doubt, and risk loss of confidence that the decision-making process is robust and produces trustworthy outcomes.

Whilst it is difficult to avoid complexity, tendencies towards lack of trust can be mitigated through good governance practices such as clarity, transparency, coordination, and scrutiny. These concepts of trust, complexity, granularity, and transparency underlie the work in the paper; thus, it is useful to define them and introduce how they relate to decision-making and one-another.

5.2.1 Trust

Trust is the mutual belief among participants that others are acting in good faith and that the process (including the objectives, methods, and outcomes) is legitimate and fair. Trust is central to effective decision-making. People need to believe that their

engagement is meaningful (reflecting rational choice and game theory) and that potential errors are the result of inherent difficulty rather than manipulation or incompetence. However, trust is also fragile, shaped by cultural, institutional, and contextual variables (Laurian, 2009). It is difficult to measure objectively and is vulnerable to external influences, such as political shifts or public controversies. When trust breaks down, the process itself can stall or collapse (Laurian, 2009). The implications of lost trust vary depending on who withdraws their confidence and at what stage this occurs, but the damage can be long-lasting and difficult to repair. Governance strategies must therefore include intentional efforts to nurture and protect trust across all levels of engagement.

“Trust emerges from complex and dynamic social and interpersonal processes and contributes to various positive and negative feedback loops... [yet] not only is it difficult to foster and maintain trust, but the roles of both trust and distrust in local governance, open communication and collaborative planning, are complex and fraught with paradoxes” (Laurian, 2009, p. 385).

Building and sustaining trust involves several factors, including transparency, reciprocity, consistent communication, and appreciation of differing perspectives. Face-to-face interactions often enhance trust by humanising the process. Collaborative, participatory approaches, that encourage sharing and social learning, and promote the co-production of decisions, can enhance legitimacy and buy-in, which help to build trust (Quimby and Beresford, 2023; Sowby *et al.*, 2025).

5.2.2 Complexity

Complexity refers to the cognitive and systemic challenges posed by the multifaceted nature of water infrastructure decision-making (Lund, 2021). These systems often involve feedback loops, multiple drivers, uncertainty, and non-linear interactions that can overwhelm human understanding. Although having an increasingly data rich world contributes to the evidence base for decision-making, it can also increase the complexity and specialism of planning, as well as the sheer volume of information to integrate.

In the absence of trust, complexity may be seen as a deliberate tool to obscure decision-making and consolidate power, fostering disengagement and scepticism. More

complex systems often require more trust among participants to substitute for certainty (Merton and Thakor, 2021). This is particularly the case when a problem is identified to pose a high risk, in need of mitigation, and that would benefit from a collaborative and participative process (Zhen, Barnett and Webber, 2020).

5.2.3 Granularity

Granularity refers to the level of detail at which decisions are made and analysed. It is closely related to both complexity and trust, particularly with regard to scale. For instance, operational decisions about a single reservoir require fine-grained understanding of local hydrology, environmental requirements, demand patterns, and flood control mechanisms. This level of detail enables stakeholders to trust that the infrastructure is being managed responsibly.

However, granularity can become a liability at larger scales, such as in national water resource planning. It is often impractical to collect detailed data across vast geographic areas, particularly when computational or methodological inconsistencies arise between regions (Mikkelsen, Sørdaahl and Solås, 2022). Yet overly coarse models may be perceived as lacking credibility, undermining trust in strategic decisions. Thus, finding the right balance of granularity is critical: too much may overwhelm, too little may discredit. In these ways granularity is deeply tied into scale; the interaction of multi-scale and polycentric governance structures must balance the transfer of information across scales at appropriate levels of granularity, complexity, and transparency (Basco-Carrera et al., 2017).

5.2.4 Transparency

Transparency is a key mechanism for maintaining and reinforcing (or in some cases substituting for) trust by making information, assumptions, and decision processes accessible and open to scrutiny (Merton and Thakor, 2021). When used effectively, transparency reassures stakeholders that decisions are evidence-based and accountable.

However, transparency must be thoughtfully managed. Simply making large volumes of technical data available does not necessarily build trust, particularly if the audience lacks the time, expertise, or context to interpret it. If not tailored to the audience, transparency can have the opposite effect, appearing to overwhelm rather than clarify

(Mooney et al., 2012; Mikkelsen, Sørdaahl and Solås, 2022). For example, overly technical documentation or opaque models may give the impression of complexity being used to mask power imbalances or errors. Therefore, effective transparency must be contextualised, considering the audience's needs and capacity, and communicated in ways that support understanding and engagement.

Decisions over where more or less transparency is followed are often politically mediated according to the wishes of those in power. A growing open data and open science movement has helped to enhance transparency. Yet, there is still a long way to go to create truly transparent access to relevant, and understandable information.

Table 10. Defining the roles of “trust”, “complexity”, “granularity”, and “transparency” in governance

Dimension	Role in Governance	Key considerations
Trust	Enables stakeholder buy-in and commitment	Cultural / contextual variation; trust formation pathways; participation key
Complexity	Reduces cognitive confidence; necessitates trust/ transparency	Need for simplification without obfuscation
Granularity / scale	Determines credibility; lacking or mismatched granularity can undermine legitimacy	Data comparability; institutional fit and appropriateness
Transparency	Builds accountability, enables scrutiny; overloading damages clarity (counterproductive)	Tailored disclosure; technical accessibility (data and algorithms); power balance

The interactions between the four dimensions (Table 10) are interesting to consider (see Table 11 and Table 12).

Table 11. Influence of scale and granularity on complexity.

	Small scale	Large scale
Low granularity	Less complex	More complex
High granularity	More complex	More complex (impractical)

Table 12. Influence of complexity and trust on the dynamics between transparency and trust.

	Less complex	More complex
Less trust	Solution is clear	Transparency substitutes trust
More trust	Solution is clear	Transparency useful to maintain and bolster trust

A lack of complexity suggests that the solution is clear (i.e. within human cognitive capacity), therefore trust and transparency become less critical. In complex situations the solution is not clear, requiring a strategic effort involving management and planning. Here, trust is useful to engage relevant stakeholders. However, transparency may substitute for trust or build a bridge to begin developing trust where it is lacking. At a local scale, it may be easier to build trust, with less need for transparency, compared to national scale planning where transparency is likely to be critical.

5.2.5 Case study: water resources planning in England

Why has the issue of trustworthy modelling become pertinent? In England, since privatisation in 1989, the landscape of modelling used for water resources has grown increasingly complex. Inadequacies of modelling have been on the peripheral radar of company and regulatory planning teams. However, resolving such issues were not prioritised given the perception that water resources were relatively secure. Furthermore, designing and implementing a more consistent and transparent modelling and planning framework takes considerable effort. Unsurprisingly, resources are not directed towards areas of policy that are considered to pose little anticipated risk, particularly within a political economy that prioritises efficiency, and more so in a country facing economic austerity since 2010. As such, there was a level of acceptance of imperfect but functional planning as in practice the system was seen to work and would be expensive to reform. However, there has been a gradual recognition that water resources in England may not be secure (Murgatroyd *et al.*, 2022). Concern cumulated in substantial reforms in 2020, including raised ambitions for resilience of water supplies to drought, and protection of water for the environment. Strategic infrastructure projects, such as large-scale water transfers and new reservoirs, are increasingly seen as essential to address regional and national deficits. Such schemes require planning across company boundaries (Hall *et al.*, 2019; Murgatroyd and Hall, 2020), and regional

water resource groups have begun to play a pivotal role in developing coordinated plans (**Figure 12**). Such changes have had implications for modelling, revealing that some of the previously accepted inconsistencies and misalignments need addressing through better coordination and governance (Leonard *et al.*, 2024).

Models representing physical and social components including the climate, hydrology, water demand, infrastructure networks, and value have proliferated within a fragmented landscape of company boundaries and regulation. However, the encapsulation of knowledge in models as they evolved (Abbott, 1993), along with the propagation of uncertainty across modelling chains, has made it difficult to understand the level of risk being faced, and whether the approach being taken is robust. It is not possible in the scope of this study to outline all the complexities of modelling in England's water sector, however, by presenting a selection of salient examples, we evidence how granular choices in modelling have had consequential impacts on investment decisions in the 2020-2024 planning round. The impact of these decisions can get lost amid the sheer quantity of modelling and planning involved, which hinders transparency (already constrained to an extent by the privatised nature of the industry in England where commercial sensitivities limit the sharing of data and models). In turn this limits the kind of scrutiny and challenge which should be encouraged. Interrogating the underlying assumptions related to risk and robustness helps to reveal vulnerabilities and inadequacies and improve problem characterisation and solutions (Krueger *et al.*, 2016).

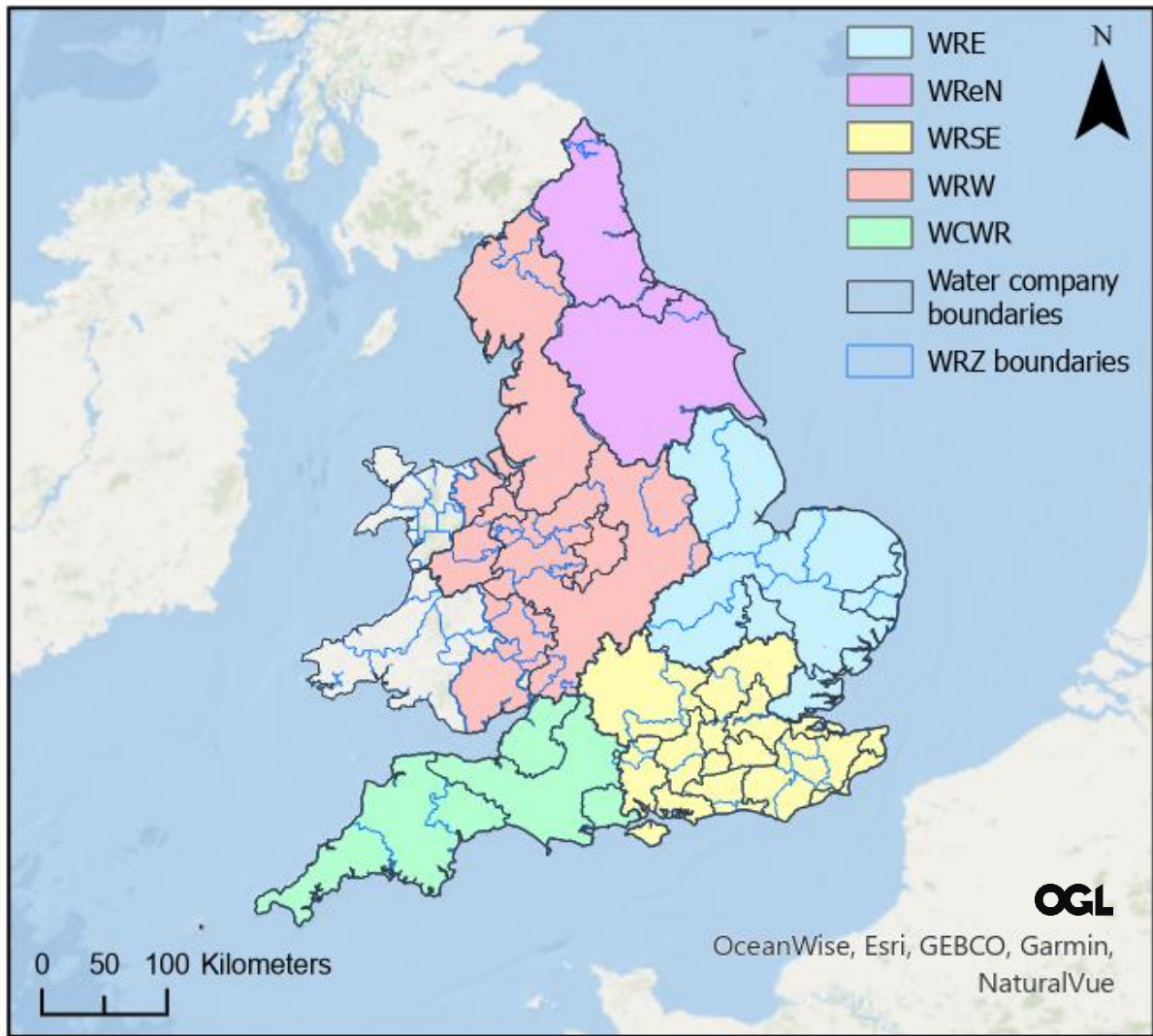


Figure 12. Map of UK water companies and water resource zone (WRZ) boundaries and regional planning groups. Map created using ArcGIS basemaps as indicated and OGL boundary layers.

We focus on the 2020-2024 planning round. This primarily involves 19 private water companies producing statutory Water Resources Management Plans (WRMPs). WRMPs optimise water resources investment according to Water Resource Zones (WRZs), defined as a region in which customers face the same risk of supply (**Figure 12**). Planning happens in coordination with five newly established regional groups, the regulators (primarily the environmental regulator the Environment Agency (EA) and the economic regulator Ofwat), the responsible governmental department (Defra), as well as other stakeholders and to some extent the public, framed as customers (Leonard *et al.*, 2025). We aim to highlight the potentially significant impact of granular modelling choices on the final level of investment proposed, water resources system resilience, and the communication of the planning outcomes.

In Section 5.3 we describe the methodology used to assess and evaluate the state of modelling in the heavily regulated context of private water companies planning water resources in England. Section 5.4 outlines the landscape of modelling developed in the 2020-2024 planning round. Here we compare the approaches taken by companies and regions to demonstrate how modelling choices, for example regarding granularity and specific assumptions, may have a significant impact on the overall problem definition, supply deficits projected, and subsequently the level of investment required to secure supplies into the future. In the following section (5.5) we discuss inherent planning tensions, and finally (in Section 5.6) we discuss and recommend pragmatic steps going forward that build on promising developments.

5.3 Methods

5.3.1 WRMP, business plan, and price review analysis

We illustrate the broader landscape of modelling as well as some of the more detailed specifics used in WR planning in England. Firstly, to demonstrate the quantity of modelling work that is involved in producing WRMPs, we counted the number of pages and appendices of final WRMPs (or drafts where final is not yet published), as well as regional plans and appendices. We also categorised the reoccurring sub-sections to present an overview of what is included in the plans and which sections involve modelling. Secondly, to understand the purpose and outcomes of the modelling, we analysed and summarised (1) the supply and demand balances as published by water companies in their WRMP data tables, (2) company proposed investments for WRMPs in company business plan data tables, (3) the allocated funding for water supply investments published by Ofwat in the Price Review Final Determination data tables, and (4) the average rise in customer bills reported by Ofwat. All information is publicly available online on water company and Ofwat's websites. Thirdly, we reviewed in more detail the modelling behind these figures to investigate and illustrate the level of uncertainty that underpins planning outcomes. We note that going through the process itself of finding and analysing the plans was illuminating regarding the transparency and clarity of decision-making.

5.3.2 Semi-structured interviews with water industry practitioners

To inform a more detailed understanding of how modelling is used we also conducted semi-structured interviews with 5 water company employees, 5 regional planning leads, 2 consultants, and 2 regulators. Questions centred on (1) the use of modelling, (2) examples of uncertainty, and (3) thoughts about balancing granularity with trust and standardisation, as well as (4) broader governance questions. The research reflects one of the author's role as a PhD student embedded among professionals, capturing their perspectives within their institutional context. To reduce bias and misinterpretation, firstly, participants reviewed summary reports of interviews to ensure the views were accurately represented, and secondly, findings were analysed in relation to broader academic literature (inevitably shaped by the authors' review scope, time, and resources).

5.4 Results: landscape of water resources modelling in England

5.4.1 Modelling underpinnings of investment

Water companies in England are subject to a statutory obligation under the Water Industry Act 1991 to ensure the provision of secure, reliable, and sustainable water supplies to their customers both now and in the future. The interpretation of how privatised water companies fulfil this requirement has been through its translation into a quantified modelling exercise. The exercise involves projecting the supply demand balance over a minimum 25-year planning horizon and, any time that deficits are projected (i.e. that demand outstrips supply), identify and invest in sufficiently sized schemes to close shortfalls and ensure the system remains in surplus. Thus, through this approach companies fulfil the statutory duty and are held accountable through the interrogation of modelling methods and outputs. This legal mandate is reinforced by regulatory frameworks that have developed and matured since privatisation, including the Water Resources Planning Guidelines (WRPG) (EA, 2023), the National Framework for Water Resources (EA, 2020b), and the Water Framework Directive (WFD) (EU, 2000). Alongside water supply resilience, these collectively aim to ensure that water resources are managed in a way that supports environmental sustainability and economic efficiency.

5.4.2 Model abundance

The planning process involves a long chain of models tackling a variety of complex problems often characterised by uncertainty and subjectivity and which can be difficult to isolate in scope from wider planning problems. We can categorise the process into several stages (which in theory should occur chronologically, though the 2020-2024 round saw some overlap between stages):

- (1) company WRMPs – assessing future supply needs, and selecting options,
- (2) company business plans – proposing investment for these options as well as across all areas of water company responsibility over five years, and
- (3) the Price Review – determinations by Ofwat over water company allowances for investment and financial returns.

Each stage concludes with the publication of reports, on water companies and Ofwat's websites, documenting the process and outcomes.

For WRMPs, although the format varies, plans cover several core components for which modelling will be a foundational part (as prescribed by the Water Resource Planning Guideline (WRPG) and other guidance). Assessing the content's pages and appendices from 2020-2024 WRMP planning round, a typical final plan's core components include:

1. Introduction and background (summary, regulatory framework, scope and problem characterisation, progress since the previous WRMP, a review of the 2022 drought)
- 2. Baseline assessments and future scenarios**
 - a. Demand modelling
 - b. Environmental modelling
 - c. Supply modelling
 - d. Managing uncertainty (headroom)
 - e. Supply demand balances for a range of scenarios
- 3. Customer and stakeholder engagement**
- 4. Options appraisal and sensitivity analysis**
- 5. Preferred plan: least cost versus best value, adaptive planning**
6. Consultation and statement of response
7. Assurance

8. Statutory environmental assessments

The stages highlighted in bold involve modelling spanning different fields and specialisms, from climate and hydrological modelling to customer preference elicitation modelling to robust optimisation and multi-criteria analysis. The process is assessed and shaped by regulators throughout. Draft plans go to public consultation (sometimes multiple rounds) and, ultimately, final plans are given permission to publish by Defra (or rather the Secretary of State signs that they will not prevent companies publishing plans - somewhat limiting government accountability). Once WRMPS are published, the need is established (i.e. the modelled future supply demand balance considered most likely) as well as the list of schemes chosen by companies that are considered the most efficient, and best value to meet the need.

Further modelling, and particularly financial and econometric modelling, is conducted by water companies and Ofwat for business plans and final determinations. For these stages, the scope is widened beyond water resources to encompass all the activities undertaken by water companies, including net zero ambitions, wastewater treatment, customer services, cyber security and so on. Once companies set out their business requirements, Ofwat assesses whether the proposed investments align with customer priorities, provide value for money, are financeable and meet legal requirements. Through the price review process, Ofwat determines the prices that companies may charge customers, incorporating allowances for capital expenditure, operational costs, and regulated returns, informed by (1) benchmarking across companies, (2) 'shallow and deep dives' into specific scheme costings, and (3) economic modelling of future risks. Unless challenged through the Competition and Markets Authority (CMA), these determinations form the basis for customer bills over the subsequent five-year regulatory period, as well as the capital and operational costs and profits for water companies.

5.4.3 Heavy documentation

This system of planning has matured over the course of multiple planning rounds since privatisation, with each company developing their own models and databases, and regulatory guidance has become more prescriptive. Overall, the landscape has become more complex. The current planning process involves hundreds of people over five years producing thousands of pages of documents. For the 2020-2024 planning round the 19

companies (some being joint companies), published final plans and linked appendices made up of ~500 documents encompassing ~50,000 pages (**Figure 13**).

Region	Company name	No. WRZs	Number of customers (million people)	DI (Ml/d)	Number of documents	Number of pages				
						Total	Main plan (incl. summaries, guides)	Environmental assessments	Consultation appendices	Additional appendices
WRSE	Thames	6	10	2,600	62	13,997	934	1,316	9,147	2,600
WRW	United Utilities	4	7	2,100	18	1,941	114	936	241	650
WRW	Severn Trent (draft)	15	9	2,000	19	1,340	110	726	55	449
WReN	Yorkshire	2	6	1,300	8	1,192	407	565	220	0
WRE	Anglian	27	5	1,200	23	2,012	164	861	0	987
WRSE/WRE	Affinity	8	4	950	35	3,715	324	972	707	1,712
WRW	Dŵr Cymru	23	3	850	6	338	181	157	0	0
WReN	Northumbrian*	2	3	710	24	884	243	475	165	1
WCWR	South West (draft)	5	2	600	29	3,250	207	2,316	294	433
WRSE	Southern (draft)	14	3	560	42	3,655	134	631	1,158	1,732
WRSE	South East	8	2	540	42	4,798	143	2,402	420	1,833
WRE	Essex and Suffolk*	4	2	460	25	1,815	387	1,172	255	1
WCWR	Wessex (draft)	1	1	340	17	1,505	104	607	215	579
WRW	South Staffs	1	2	310	42	2,249	163	456	157	1,473
WCWR	Bristol	1	1	280	10	778	251	491	0	36
WRSE	Portsmouth	1	1	180	42	2,411	291	441	626	1,053
WRSE	SES*	1	1	160	10	994	157	182	218	437
WRE	Cambridge (draft)	1	0	90	42	2,571	222	365	212	1,772
WRW	Hafren Dyfrdwy	4	0	60	14	386	128	31	0	227
	Total	128	61	15,290	510	49,831	4,664	15,102	14,090	15,975

Figure 13. Table of the number of documents published for final WRMPs (or draft where companies have not yet published final plans). The data is based on what has been made publicly available on company websites. *Northumbrian Water and Essex and Suffolk Water have not published additional appendices online, indicating that they are available by email. Population data is rounded to the nearest million. Distribution input (DI) is rounded to the nearest 10 million litres / megalitres per day (Ml/d).

The format, style, scope and the quantity of pages and appendices varies widely across companies. Some companies publish a main plan without or with very few appendices (presumably covering all required elements in this plan), whereas others publish a core plan with many additional appendices. Almost a fifth of all pages published come from Thames Water’s consultation, around 6,000 of which were responses to online submissions. Conversely, the Welsh companies did not publish consultation responses alongside WRMPs. Additional appendices (see **Appendix L**) varied across a range of themes, often similar to the core components listed above, with some companies publishing many more documents and pages in specific areas. For example, of the ~3,500 pages of additional appendices relating to customer and stakeholder engagement, ~3,000 (or ~85%) were published by three companies (Cambridge, South Staffs – part of the same company –, and Affinity).

The data in **Figure 13** includes only final plans which build on previous documentation, including draft plans, consultations, and in some cases revised drafts. Also not included in the count are excel spreadsheets (including data tables). Additionally, this data excludes regional plans (see **Appendix M**) for which an additional ~10,000 pages were

published online spanning initial statements, updated resource positions, emerging plans, draft plans, consultations and statement of responses, and revised drafts (only WRSE) and a final plan (only WRE when this report was written). Regional groups also linked to national reports on the regional reconciliation process (~150 pages total) with different groups sharing different documents. Companies also go through similar processes for Drought plans, Drainage Water Management Plans (DWMP), business plans, and assessments linked to the Gated Process for Strategic Resources Options (SROs). As mentioned above, there is further public documentation published by regulators including policy and guidance, consultation responses, and the final determinations.

This complexity, diversity, and abundance of documentation can be in conflict with efforts to enact clear and transparent decision-making that helps build trust and confidence in planning (Weber and Baisch, 2023). Such complexity and fragmentation can also conflict with the recent emphasis on national and regional planning, where there is a greater need for consistency and clarity to evaluate risks and options at higher levels based on aligned assumptions and methods (Leonard *et al.*, 2024).

5.4.4 Binary, quantitative outputs

The vast WRMP documentation provides the justification for the final outcomes of planning. The outcomes are presented in quantitative terms in the data tables that accompany the WRMPs, the business plans, and the final determinations. These data tables themselves can be difficult to parse with many tabs and linked formulas. **Figure 14** summarises these final outcomes across some of the key headline decisions namely:

- (1) supply demand balances,
- (2) business plan investment proposals,
- (3) final determinations, and
- (4) customer bills.

It is difficult to translate exactly how they relate to one another due to the complexity of timings, inconsistent categories, and reallocations. However, they do provide an overview (as reported in plans and data tables) for each of these modelled outcomes across each company, and the industry as a whole.

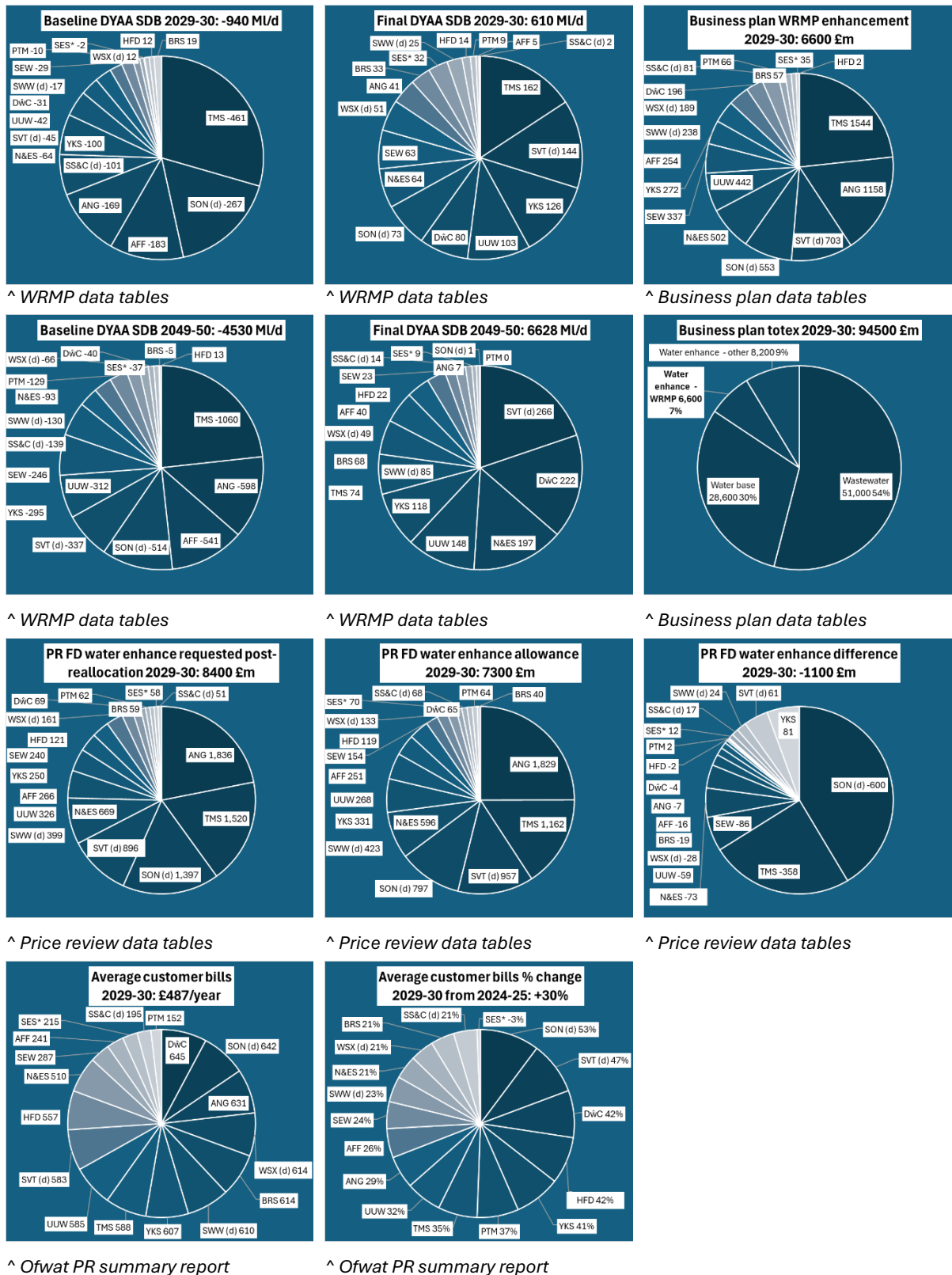


Figure 14. Summary of final outputs across WRMPs, business plans, and final determinations, and customer bills. Data was collected from online sources, indicated below each pie chart (Ofwat, 2024, p. 21). The data is presented as a table in **Appendix N**. Acronyms. DYAA: dry year annual average. SDB: supply demand balance.

The final outputs for supply demand balances at the national level indicate substantial deficits of almost a billion litres per day by 2030, and over 4.5 billion by 2050 following the baseline scenario. The final plan reverses the deficits creating a surplus of over half

a billion litres per day in 2030, and over 6.5 billion litres per day in 2050. The cost of these plans over the next five years as proposed in business plans is £6.5 billion which represents about 7% of the totex proposed by companies for water supply and wastewater base and enhancement spending. In the price review, water supply related enhancements (enhancement expenditure models for: (1) supply, (2) demand, (3) metering, (4) leakage, (5) SROs, and (6) supply interconnectors) were assessed to total £8.4 billion, and were allocated £7.3 billion, with a substantial proportion of the shortfall (£1.1 billion) falling on Southern Water supply schemes (£600 million). The average customer bill in 2030 is £487/year, increasing on average 30% from 2024. However, it is difficult to attribute how much of this rise equates specifically to water resources investment.

What these numbers demonstrate is the power of quantification stated in unambiguous terms in clearly setting out the problem, the solution, the costs, and the expectations on delivery. Framing a problem and solution in this way can be an expedient for change and clear decision-making. Stating clear planning assumptions is arguably an essential part of long-term planning, particularly involving large scale infrastructure decisions and investment. Ultimately schemes are either in or out of a plan, and someone pays the bill for the chosen schemes.

The power of numbers was also evident in the use of modelling and quantification by the National Infrastructure Commission (NIC). The NIC estimated the costs of emergency drought measures at £40 billion over 30 years, compared to £21 billion in costs if resilience standards were increased from 0.10% annual return period (or once every 100 years) of emergency restrictions to 0.05% (or once every 500 years), through investing in infrastructure, halving leakage, and reducing demand (National Infrastructure Commission, 2018). These persuasive figures from a respected organisation are often cited for the adoption of these policies in the National Framework 2020, which represented a significant step-up in ambition regarding the need to increase the resilience of water resources. This illustrates the supremacy of modelling and quantification to at the very least justify, and likely even drive, policy and investment choices, particularly if they align with the wider socio-political environment.

5.4.5 Concrete decisions amid uncertainty

What gets hidden behind these clear figures are the many modelling choices, complexities, subjectivities, and uncertainties that underlie them (Dobson, Wagener and Pianosi, 2019; Vesely *et al.*, 2019; Moges *et al.*, 2021; Lin and Yang, 2022; McInerney *et al.*, 2024; Panchanathan *et al.*, 2024), relating to (focusing on climatological and hydrological modelling):

1. our understanding of the world: physics, tipping points, extremes, random variability,
2. our understanding of what we value: problem framing, objectives, risk appetite,
3. our simplified representation of the world: choice of model, model structure, scope of model, parameters, interpolation method, equifinality (difficulty defining the ‘correct’ input given multiple that produce the same outcome), calibration, validation, bias correction,
 - a. the representation of human influences: dams, irrigation, abstraction, land use change,
4. data availability and quality: historical record, boundary and initial conditions,
5. computational capability: processing constraints, algorithm limitations, rounding errors,
6. temporal and spatial resolution, and
7. forecasting the future: unforeseeable drivers and trends.

The details of these choices and uncertainties will (at least in part) be reported in the documentation, though as described can be difficult to parse. However, even with the justifications laid out it is almost impossible to understand the full implications of these often-granular level complexities, how they propagate and interconnect, particularly given the nature of multiple modelling stages that cross quite separate fields. Given the specialised nature of models, yet broad scope of the planning problem, it is difficult to manage the process as a whole and easy to miss the big picture.

In the following sub-sections, we present examples of when granular choices along the chain of modelling have large implications for the final outputs.

5.4.5.1 Supply demand balance modelling to define the risk envelope

The foundation of the planning exercise begins with understanding the current and future performance of the water resources system, and under the current framework involves a wide variety of models. The principal aim of the exercise is to produce a central supply and demand balance over the planning horizon to identify potential deficits, which provides the basis for investments in schemes.

The 2020-2024 planning round has also seen the rise of adaptive planning, a crucial methodological development involving generating a range of alternative future scenarios alongside the core pathway. The use of adaptive planning helps:

- (1) plan for multiple futures including identifying ‘robust’, low regrets options that provide resilience across a broad range of futures, and
- (2) map out potential drivers of supply and demand that may diverge from central expectations, how these can be monitored, and identify trigger points that will flag divergences, and initiate pre-planned alternative investment pathways to better meet the needs of alternative futures.

Alternative pathways may include additional options if population growth exceeds projections, new environmental regulations (e.g., abstraction reductions) are introduced, or major infrastructure projects fall through.

5.4.5.1.1 Water resources systems models

The performance and design of water resources systems is assessed using water resources systems models. Models represent the core components for a given water resources zone (WRZ), including: reservoirs, boreholes, river abstractions, demand centres, pipes and connections, abstraction constraints, and treatment works. A key output is Deployable Output (DO), a measure of the available water supply during the reference drought. Like all models, water resources models are simplifications for which compromises must be struck. In an interview, one water practitioner reflected on difficulties defining the boundaries of WRZs:

“In practice, within WRZs, local areas may experience shortages, not because they run out of supply within the wider WRZ, but because of network or storage issues (for example a burst main in an area where there is limited treated water storage capacity and connection), especially as storage reservoirs can run down quickly. In the past the

company has tried to make the case for improved connectivity. However, the WRMP process is not designed to allow for distribution network upgrades within WRZs that are modelled to be in surplus. This means it can be harder to get investment for aspects relating to maintenance and connectivity (that may appear more gradually, for example due to long term growth) compared to brand new capital projects. This highlights the issue of defining WRZs, which may not operate in practice exactly in line with how they are defined by the long-term planning teams. One solution would be to make WRZs smaller which may reveal deficits and allow for investment through the WRMP process.

However, changing the boundaries of WRZs can create other problems such as problems for comparison with historical baselines, increasing granularity and detail that may not be an effective use of resources, increased reporting, and resistance to change both from within water companies and regulators. They are in the process of being reviewed but there is often no perfect answer; inherently there exists a certain degree of grey in a dynamic environment, and a need for pragmatism.” (paraphrased)

The practitioner also discussed how companies can struggle to balance theoretical best practices with operational realities, particularly during incidents that require deviating from planned approaches (e.g. reservoir rule curves) that are designed for ‘normal operating conditions.’ Water resources teams for long term planning (likely working at a disconnect from the operations teams, particularly in the larger water companies) work within specified remits that may not necessarily be responsive to unforeseen complex interactions, such as complicated local dynamics between water levels and water quality, outages, or budget cuts. These examples of the difficulties faced, balancing long-term planning with dynamic boundaries and operations, help to highlight the multi-faceted compromises (technical and management-related) required when using modelling to tackle planning problems.

As well as implications from the spatial and temporal simplifications of water resources models, there can also be material consequences from the choice of modelling software. Two common models used in England are Aquator and Pywr which both simulate water resources systems to output the balance of supply and demand. However, model differences mean they can give different results with the same input data and problem formulation. We can see this in an example from United Utilities’ WRMP, which demonstrates a difference of 50 ML/d (mega or million litres per day)

between the two models for the same climate scenario (RCM_15) (highlighted in yellow in **Figure 15**), representing 16% of their projected deficit of 312 MI/d by 2050 (**Figure 14**).

Rank	Scenario	Pywr 1 in 500 EDO DO impact (MI/d)	Hydro-Logic® Aquator 1 in 500 EDO DO impact (MI/d)
N/A	Baseline		
1	RCM_13	-592	
2	RCM_10	-391	
3	RCM_01	-390	-381
4	RCM_05	-299	
5	RCM_08	-297	
6	RCM_15	-276	-226
7	RCM_06	-257	-215
8	RCM_11	-245	
9	RCM_09	-241	
10	RCM_12	-224	-202
11	RCM_04	-90	-79
12	RCM_07	-88	

Figure 15. Difference in Deployable Output (DO) impact between 2 models (Pywr and Aquator) and across 12 Regional Climate Model (RCM) scenarios. Table 24 copied from United Utilities Supply Forecast Technical Report, “The median scenario from the scenario sampling and Aquator results is in bold” (United Utilities, 2024, p. 75).

This is one example of the material implications of granular level modelling choices, such as choice of model software, on the final outcomes. The table also demonstrates the wide variability across the 12 Regional Climate Model (RCMs) scenarios which will be discussed further below.

5.4.5.1.2 Supply modelling

A core input for water resources systems models are plausible supply inputs of flow and groundwater data. Inputs should represent the range of variability in water supply due to climatological and hydro(geo)logical factors that society is likely to face and is willing to pay to protect against. Understanding the range of variability, and particularly extremes (i.e. droughts) can be approached in several ways (Reyniers *et al.*, 2022). Previously, the most common method was to simply plan for the worst historical drought on record, on the basis that the system should be designed to cope with this drought, plus a degree of additional capacity (headroom). Over the last decade, methods have become more sophisticated to explore a wider range of uncertainty, particularly for surface water modelling, incorporating stochastic techniques and climate change modelling, as well

as updated hydrological modelling. The updated methods are still subject to the potential flaws and biases outlined at the beginning of section 3. There are many examples, throughout the WRMPs and regional plans, that demonstrate how supply modelling uncertainties stemming from granular level modelling choices can be significant. We will outline two examples.

Firstly, we highlight the wide uncertainty around projecting future climate change. Regional groups commissioned the consultancy Atkins to produce new climate datasets (of precipitation (PP) and potential evapotranspiration (PET)) for baseline and future scenarios (Atkins, 2020). These PP and PET datasets are key inputs for the next step in the chain; hydrological models (which produce the flow inputs required for water resource systems models). There are many questions related to the appropriateness of climatological and hydrological modelling. For example, are stochastic weather generators the best tool for generating the long slow dynamics of drought, especially when combined with conceptual hydrological models, “*since the effects of sustained dry conditions cannot accumulate within these models*” (Fowler *et al.*, 2020, p. 1). However, early-stage modelling assumptions around climate change create such a wide range of uncertainty, they potentially dwarf later uncertainties.

This is clear in **Figure 15** above which indicates that for the same emission pathway (RCP8.5), United Utilities faces a range, across UK Climate Projection 2018’s 12 Regional Climate Models (RCMs), between -88 ML/d to -592 ML/d. The difference of 504ML/d equates to 160% of their total projected deficit of 312ML/d by 2050, which, as other figures in their WRMP demonstrate, would increase further if other climate models such as global climate models (GCMs) and probabilistic models were included alongside RCMs. Thames Water demonstrate a similar challenge, highlighting that the range across models of the same scenario greatly outweighs the range across different scenarios:

“The uncertainty in DO impact of climate change associated with a single emissions scenario is significantly larger than the difference between the median impacts calculated from different emissions scenarios. The interquartile range for RCP8.5 probabilistic projections at 2070 is around 200 ML/d, whereas the difference between the median impact for the RCP2.6 and RCP8.5 scenarios is around 20 ML/d” (Thames Water, 2024, p. 47).

The implication is that material changes will result from modelling choices such as which climate model to use, which emissions pathway to use, whether to use the mean, median, or upper quartile, alongside many others. A key issue is simply that we do not know which model, or emissions pathway, or level of risk, will most accurately map future reality. Choosing models which appear now to be most accurate according to their skill at matching current conditions may not be appropriate given the non-stationarity of future climate change (Rust, 2021), particularly given risks around tipping points (Lenton *et al.*, 2008). This example demonstrates uncertainties related to both our lack of confidence in methodological method and model build, as well as the difficulties of making predictions about how the future will unfold according to different socio-political and environmental trajectories.

It is also useful to highlight the implications of modelling choices that may not be as well-known but can still have material impacts. One example of this came from Anglian Water's draft Supply Forecast report which explains how the choice between two methodological approaches for estimating the return period for particular drought events can produce very different results (Anglian Water, 2022). For example, extreme value analysis (EVA) estimated the worst plausible drought event to be much more severe compared to the inverse ranking method (~110MI/d difference in DO for their Ruthamford region, just under 20% of their total forecast deficit in 2050) (p. 15-16). The EVA method was selected based on it being a better match with the historical record (on account of the fact that the estimated 1 in 500-year drought did not occur in the historical record which is only 127 years). Although the method appears justifiably more appropriate compared to the inverse ranking approach, it is difficult to assess how robust the EVA method (or indeed any method) is given difficulties matching rare statistical events with only comparatively short historical records (Slater *et al.*, 2021). Again, this example demonstrates the complexity and uncertainties of modelling approaches, and material impact on outcomes.

These two examples of uncertainty assessment demonstrate outcomes with hundreds of megalitres of impact. It is almost impossible to grasp how all the different uncertainties might propagate in nonlinear ways down the chain of modelling and what that means for the final estimation of future supply.

5.4.5.1.3 Demand modelling

Like supply, time series of demand over the planning period are a critical input to water resources system models for producing supply demand balances (and calculating possible deficits). The distribution input (DI) is the volume of treated water put into the network from water treatment works. This can be broken down into different categorisations (such as domestic, non-domestic, leakage etc) and micro-components (such as shower, toilet, etc) to help understand and predict usage alongside possible future trends. Future trends include changes in population for example due to migration, housing development and occupancy, major policy decisions such as Brexit, HS2, and evolving decentralisation agendas such as the ‘Northern Powerhouse’, ‘Levelling up’ and ‘local government’, and behaviour changes for example due to the covid pandemic, climate change, and policy and regulatory drivers. Furthermore, it is necessary to understand the temporal dynamics and particularly peaks in demand during dry periods and how they might evolve. However, complications arise due to a lack of detailed measurements in the absence of (smart) metering, giving rise to the need for estimations and predictions. Furthermore, there are many uncertainties arising from modelling demand, related to the uncertain trajectory of the future, as well as methods, which vary across companies. This is illustrated by the wide range between lower and upper forecasts of future demand in WRMPs.

Targets for 2050 to reach 110 litres per capita consumption (PCC) and reduce leakage by 50% were introduced at the outset of planning in the National Framework in 2020. However, interim targets legally binding on the Secretary of State were brought in as part of the Sunak government’s Plan for Water to:

“reduce household water use to 122 litres per person per day, reduce leakage by 37%, and reduce non-household (for example, business) water use by 9% by 31 March 2038 [as] part of the trajectory to achieving 110 litres per person per day household water use, a 50% reduction in leakage and a 15% reduction in non-household water use by 2050”
(Defra, 2023a).

This change in policy, which the regulators translated into measures for water companies, impacted the supply and demand balances with the consequence that companies needed to remodel their systems, define updated deficits, and adjust scheme selections, including the removal or pushing back of supply schemes. Because

of the interconnected nature of national and regional planning, changes introduced late in the planning cycle such as this can result in substantial rework. This reveals a tension between the democratic political system that can be turbulent and disruptive in response to a variety of political, economic and social forces, and long-term infrastructure planning, more compatible with stability.

An interesting granular consideration is how companies quantify the impact of uncertain future changes in government policy aiming to encourage water efficiency. The key policy in this area is whether the government will introduce new legislation, such as the mandatory labelling of white goods and tighter building regulations. The general election and change of government in May 2024 likely disrupted the timetable for introducing these measures. However, because the industry expects the measures to be instated, companies factored in savings into their demand forecasts. Estimating the impact of the measures is difficult given the uncertain response of consumer behaviour. Approaches vary across companies, with many defining different low, medium and high impact scenarios. Like many of the examples presented, a more consistent approach may avoid distorting regional and national supply and demand balances based on misaligned assumptions.

5.4.5.1.4 Environmental modelling

Alongside supply and demand, the other critical input into water resource system models are the constraints on water available for use due to environmental considerations. The amount of water required to sustain habitats and ecosystems depends on which habitats are considered valuable, how that is translated into environmental law, and how that is translated into quantified flow limits. All abstractions (from reservoirs, rivers, and boreholes) that make up company supply are licenced and monitored by the Environment Agency through abstraction licences. Other constraints include Environmental Flow Indicator and Hands Off Flow limits.

Reduced abstraction for environmental protection is driving a large proportion of projected deficits in the future. However, there is high uncertainty around environmental needs. Several practitioners commented in interviews that modelling by the EA is not transparent, can be difficult to understand, and is often based on high-level averages rather than verified local assessments. Uncertainties are driving environmental investigations via the Water Industry National Environmental Programme (WINEP),

which underlie WRMP24 adaptive pathways. It is hoped that the outcomes of investigations will determine whether a more or less stretching pathway will be needed. **Figure 16** illustrates the challenge faced by Wessex Water. A substantial drop is indicated in 2035 “as a result of Sustainability Reductions which are largely related to the Water Industry National Environment Programme (WINEP) and the longer-term Environmental Destination Programme” (Wessex Water, 2023, p. 30). The difference between the lowest and highest scenario is ~80 ML/d by 2050, which compared to the overall central supply demand balance of -6 ML/d shows the sensitivity of final balances to these environmental assessments. High uncertainty around environmental destination is similar across other companies with sensitive habitats. For example, the difference for Severn Trent between the Ofwat Low and Enhanced scenarios is ~130 ML/d (or ~50% of its overall deficit predicted for 2050, ~260 ML/d).

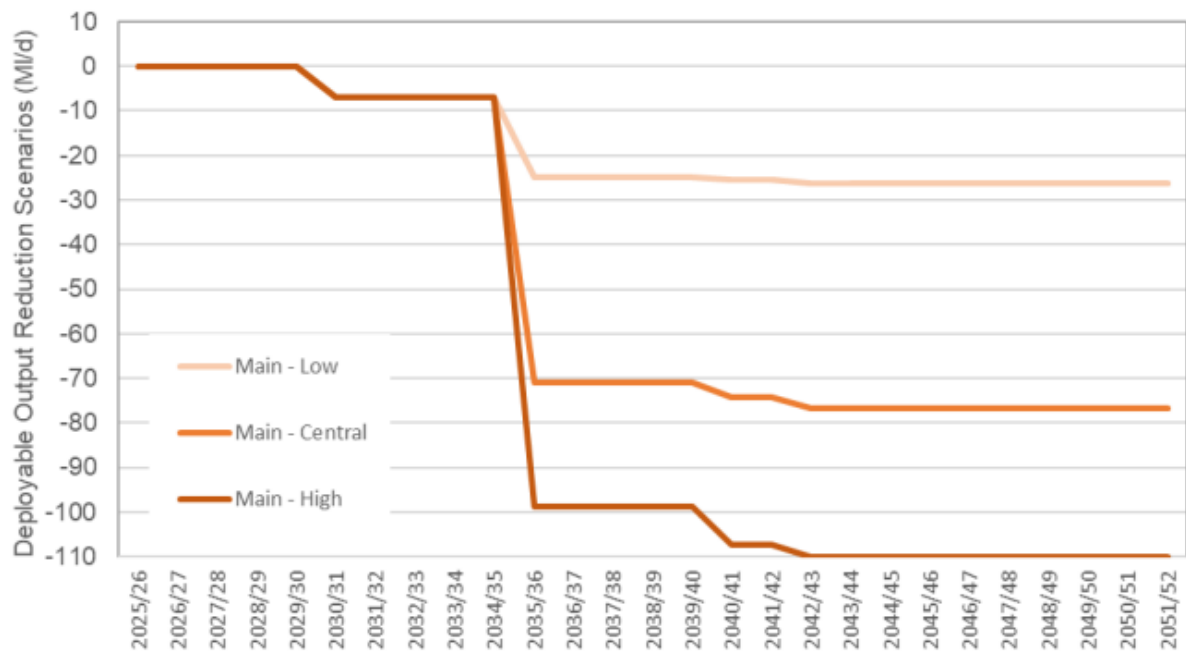


Figure 16. Main Licence Change Scenarios with alternative scenarios reflecting uncertainty in future licence changes under DYCP scenario. Note: Deployable Output loss shown. (Wessex Water, 2023, p. 33).

Interviewees noted difficulties establishing aligned and consistently applied definitions for environmental destination scenarios, particularly when there is heterogeneous local understanding, with some areas having greater understanding at a more granular level, compared to others who must rely on sparse datasets averaged across catchments. Additionally, some commented that differences in the culture and resourcing of local EA teams can have material impacts if teams across neighbouring catchments use

inconsistent approaches, creating artificial deficits across boundaries. This risk is heightened due to the qualitative and subjective nature of environmental assessments.

The precision and singular nature of these final numbers, which form part of the foundation for companies to justify investments, masks the wide propagation of uncertainties that was involved in their production. Many further uncertainties are involved in the investment modelling choices, discussed next.

5.4.6 Investment modelling: picking solutions

Considerable work, including detailed modelling and appraisal, is undertaken by companies to assess the costs and benefits of individual schemes and combinations of schemes. Companies evaluate a wide range of options, aiming to identify combinations that fill deficits and provide the best value across a range of metrics (including, and most notably, low cost).

Standard practice is to aggregate deficits (or surpluses) by water resource zone:

“This represents a significant abstraction from reality as, for example, the model does not concern itself with the details of how water will move within a WRZ” (Archibald, 2022, pp. 6–7).

The risk of this simplification is if the investment model selects schemes with poor operational fit within the water resources network. Good practice follows that companies rerun their water resources systems models with the additional schemes to understand the impacts of the new schemes on their networks at a more granular level (Harou, 2023). However, some practitioners noted that this iterative task requires time and good integration between modelling teams, possibly across different consultancies. This aspect is not a statutory requirement of the WRMP process, and it is hard to assess how rigorously companies carry out these assessments.

The process of decision-making involves multiple stages, many of which involve modelling of differing levels of technical sophistication, alongside expert judgements, and the incorporation of customer and stakeholder preferences (which itself involves modelling based on sampling). Most companies define their approach and results for the following stages in the options appraisal:

1. Option scoping (involving collaborating with others such as regional groups, other companies and third parties)
 - a. Unconstrained list
 - b. Screening
 - c. Constrained list
2. Option appraisal according to defined metrics (including cost, and supply benefit)
3. Customer and stakeholder preference elicitation (willingness to pay surveys)
4. Programme appraisal
 - a. Best value (versus least cost/EBSD),
 - b. Optimisation modelling
 - c. Adaptive planning

Despite efforts made to make decision-making as explicit as possible, the process is often more of an art than a science because of the need to balance the direct use of modelling outputs, against reasonably straying from the outputs based on (1) judgements and (2) the outputs of other models.

The diversity in appraisal approach across the 19 water companies and five regional groups is a challenge. Although there is guidance setting out expectations, with some aspects being more controlled than others, for example following the Green Book (HM Treasury, 2024) costing methodologies, there is still a wide variation across companies and regions. There are benefits to having greater variation through the tailoring of methods to local contexts and the potential development and innovation in methods. However, the lack of consistency can pose challenges for evaluating methods and outcomes, which is becoming an increasingly salient issue since the growing interdependence across companies through regional and national planning.

Focusing on the implications of balancing granularity and trust, we focus on the introduction of best value planning (BVP) to illustrate some of the difficulties of achieving clarity in practice in a complex and diverse environment.

5.4.6.1.1 Introduction of Best Value Planning

Before this round of planning, option selection was primarily based on cost, with the cheapest options picked using 'Economics of Balancing Supply and Demand' (EBSD)

models. EBSD models are designed to select options which fill the supply and demand deficits over the planning horizon, optimising the selection according to lowest cost. How options perform in other aspects, such as environmental impact, carbon impact, or customer preference is not explicitly modelled. Best value planning was introduced for the 2020-2024 planning round to enable more explicit consideration of wider impacts that are less easily monetised. Companies were expected to compare plans produced by the more traditional EBSD approach with plans produced by the new best value approach to illustrate additional benefits.

With regional planning taking a more dominant role alongside the introduction of best value plans, the regional groups shaped the approaches taken by their constituent companies. The variation in approach across regions was considerable (**Table 13**), reflecting the origins, history, and challenges faced. For example, WRSE, which has existed since 1996, had a regional team that favoured a more technical approach and developed a sophisticated robust-optimisation model, the outputs of which would feed directly into their six constituent water companies' WRMPs. WReN on the other hand is only made up of two companies, of which only one is facing future deficits. Subsequently the regional group, which formed just before 2020, did not develop a regional model but worked together towards:

“facilitating in particular the effective consideration of in-region and inter-regional transfer options” (WReN, 2022, p. 35).

WRE developed an approach, including two regional optimisation models, which were developed in collaboration with non-public water suppliers, reflecting the region's focus on integrated planning since its inception in 2014. Water Resources West commissioned a regional best value model to bring greater consistency across companies in their approach to decision-making. Yet, unlike WRSE, the region promotes a more bottom-up approach where the regional model was taken up alongside companies existing models. WRW's approach emphasises that statutory accountability for decision-making ultimately rests with companies rather than regions. The West Country initially outlined a simple, qualitative scoring approach to best value decision-making, however the group agreed a change in approach including developing regional models (WCWRG, 2023, p. 29) amid growing concerns around resilience after the 2022 drought,

strengthened environmental policies resulting in projections of greater deficits, changes in personnel, and regulatory expectations.

How metrics are assessed involves both quantitative and qualitative considerations with some metrics having more prescriptive guidance, such as cost. Other metrics which are more difficult to monetise are generally qualitatively scored, effectively giving them a relative quantified measure to assess alongside the monetised costs. Though the legitimacy of this is debated, as Funtowicz and Ravetz (1994) succinctly posit, what is 'the worth of a songbird', referring to the difficulties and subjectivities involved in measuring and quantifying something's value. Furthermore, the choice to weight metrics can materially impact outcomes. Only WRW decided to weight metrics based on elicitation workshops following. Other regional groups decided to average across metrics.

Table 13. Best value metrics published by regional groups grouped into 12 categories.

	BVP METRICS	WRen	WRW	WRE	WRSE	WCWR
	No. of metrics	12	13	8	17	16
	Weighting	Averaged	Elicited	Averaged	Averaged	Averaged
	Use of regional model	No regional model (deficits only projected in Yorkshire Grid)	Commissioned regional best value/ MCDM model allow companies to assess options consistently, regional model used alongside companies existing models	Multi-objective robust decision regional simulator to explore options and a regional EBSD model + sensitivity testing to apply best value	Regional optimisation model to select options across nine adaptive pathways	No regional model, metrics qualitatively scored (consultation responses stated a model was in development)
1	Cost	Financial cost (optimise)	Cost	Cost (optimising)	Programme cost (NPV £m) using social time preference rate (STPR)	Cost to customers and affordability
2	PWS supply / drought resilience	PWS drought resilience (achieve/ enhance)	PWS drought resilience	PWS TUBs and NEUBs (optimising)	PWS final SDB (constraint) Distribution input (DI) per property (optimised)	Increase resilience to extreme droughts (1 in 500) Reduce frequency of TUBs and NEUBs restrictions
3	Non-PWS supply / drought resilience Multi-abstractor	Multi-abstractor benefit (optimise)	Multi-abstractor benefits-positive, negative	Agricultural SDB (optimising) Energy SDB (optimising)	Non-PWS SDB (constraint)	Increase resilience of non-PWS
4	Carbon	Carbon (optimise)	Carbon cost		Cost of carbon offsetting (optimised)	Carbon emissions / energy use
5	Demand and leakage	PCC reduction (achieve/ enhance) Leakage reduction (achieve/ enhance)	PCC and leakage (constraint)		50% leakage (constraint) Leakage reduction above 50% (optimised)	Reduce leakage Reduce PCC Reduce non-household demand Reduce non-PWS demand
6	Customer preference	Customer preference option type (optimise)			Customer preference for option type (optimised)	
7	Environment	Biodiversity (optimise) Natural capital (optimise)	Ecosystem resilience-positive, negative	Agricultural catchment SDB Construction and operation impacts (SEA) Biodiversity Deviation from environmental flow requirements (tracked)	Programme benefit (SEA max), Programme disbenefit (SEA min), (optimised) Enhancement of natural capital value (optimised) Abstraction	Meeting statutory requirements on abstraction (BAU) Reduce abstraction from environ. sensitive sources Biodiversity net gain

					reduction (constraint) Biodiversity net gain score (optimised)	Enhancing natural capital
8	Human and social wellbeing	Human social well-being (optimise)	Human and social wellbeing-positive / negative			
9	Option deliverability	Option deliverability (optimise)				
10	System resilience / national resilience		PWS customer supply resilience		Resilience: Reliability Adaptability Evolvability	Increase sharing of water resources to improve national resilience (transfers)
11	Flood risk	Flood risk management (optimise)	Flood risk-positive, negative			Increase supply system resilience to other risks (e.g. flooding)
12	Inter-generational equity				Inter-generational equity using the long-term discount rate (LTDR)	Inter-generational equity and stakeholder priorities

The variability between regions, as well as between companies, illustrates the tension of scale as trade-offs arise between encouraging consistency to enable fair assessments of inter-regional and inter-company schemes, versus the need for tailoring the approach to the needs of the area. Tailoring may legitimately call for different approaches and allow for greater experimentation, and create possibilities for the development of more innovative approaches.

A critical aspect of introducing other objectives alongside cost, is that it is computationally difficult to optimise the selection of options against multiple objectives over a long planning horizon. This is because the decision space increases, becoming orders of magnitude larger than the feasible range that optimisation algorithms can explore (Harou, 2023). Consequently, a subset of metrics is used to optimise the selection, with the performance of other metrics tracked and evaluated outside of model optimisation. For example, when producing their emerging plan, WRE initially tried optimising against 11 search metrics, however the:

“number of search metrics had to be reduced to 7 for the WRE phase 1 search to converge” (WRE, 2020, p. 118).

WRSE’s model has a ‘BVP mode’ which optimises two objectives, usually cost with an additional metric. The performance scores of the other metrics are tracked rather than optimised and can be considered using judgement. It is hard to judge how sensitive the outcomes of planning are to these kinds of choices made around modelling methods without coordinated investigation and evaluation.

Detailed technical appendices of WRMPs explain how the preferred best value plan outperforms the least cost plan. For example, Anglian present the difference between their best value plan (Plan B) versus their least cost plan (Plan C) in terms of the trade-off between average abstraction reduction versus environmental metrics. The graphic shows the two plans performing similarly across metrics both scoring ‘203’ for positive impacts, with Plan B appearing to score slightly worse for negative impacts.

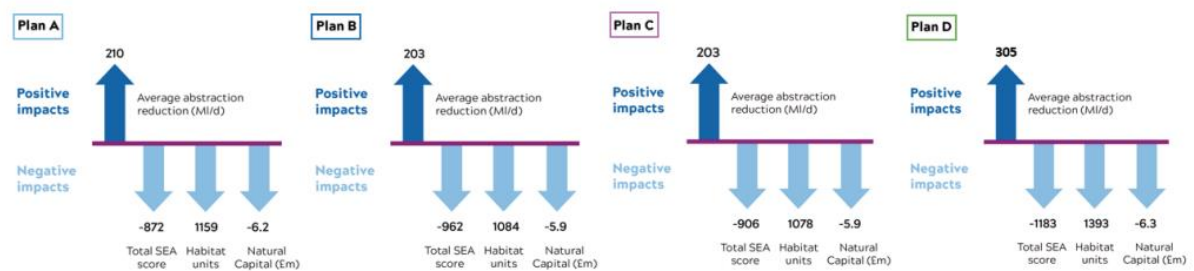


Figure 117 Trade-off of average annual abstraction against cost and carbon metrics

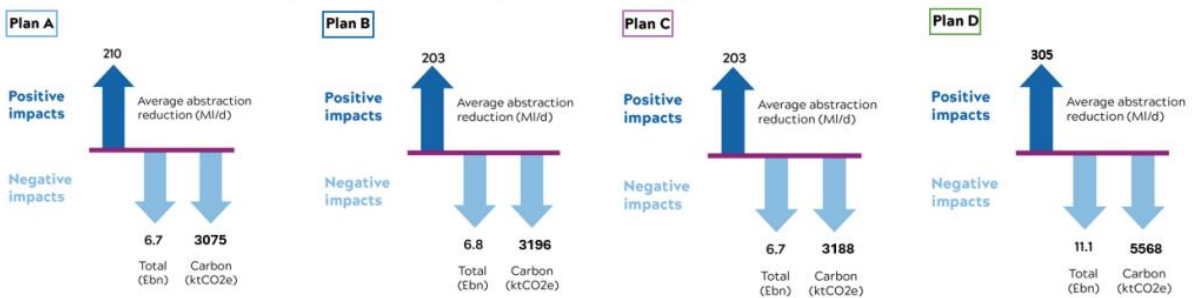


Figure 17. Example of a comparison across best value (Plan B) and least cost (Plan C) plans from Anglian Water’s decision making report, “trade-off of average annual abstraction against environmental metrics” (Anglian Water, 2024, p. 120).

However, the aggregated scores are difficult to interpret. As Molle et al., (2024) states:

“composite indicators must combine and weigh the sub-indicators arbitrarily. Once this is done, the information included in each of them ends up being lost and the final apex indicator becomes largely meaningless” (p334).

The description, which describes the differences between the two plans, clarifies more concretely why Plan B is preferred:

“The main difference between Plan B and C is the selection of Caister desalination in Plan C instead of Bacton desalination in Plan B. As described in Section 6.2.6 our assessment has shown that Bacton desalination is likely to be more favourable in terms of deliverability due to opportunities for shared assets with the energy sector and better water quality, meaning that overall Plan B has the lowest delivery risk.” (Anglian Water, 2024, p. 121)

“We have two desalination plant options on the Norfolk coast located at Caister and Bacton. Both options include a transfer to connect into the same location within our existing network, the main difference is that Bacton is further away and requires a longer pipeline. This is reflected in Bacton being slightly higher in cost. However, locating the desalination plant further north up the Norfolk coast to Bacton could provide opportunities to work with other industries, in particular the energy sector. This may provide benefits of shared assets such as intakes/outfalls which could reduce costs and provide efficiencies. This stretch of coastline also benefits from greater certainty that the shoreline will continue to be protected into the future, see WRMP24 Supply-side options development technical supporting document, Appendix 1 - Desalination. There are water quality benefits of locating the plant at Bacton compared to Caister as the seawater is less turbid meaning it is easier and cheaper to treat.” (Anglian Water, 2024, p. 83)

Based on the evidence of our best value planning assessment, and the advantages over Plan C as described above, Plan B offers best value for our customers and stakeholders whilst providing benefits to society and protection to the environment.” (Anglian Water, 2024, p. 122)

This detailed level of explanation was not consistent across companies of regions. For example, WRSE’s approach, which was frequently highlighted in interviews as being both advanced in terms of technical sophistication, as well as black box, also given its technical sophistication, justified option selection based on outputs of its investment model.

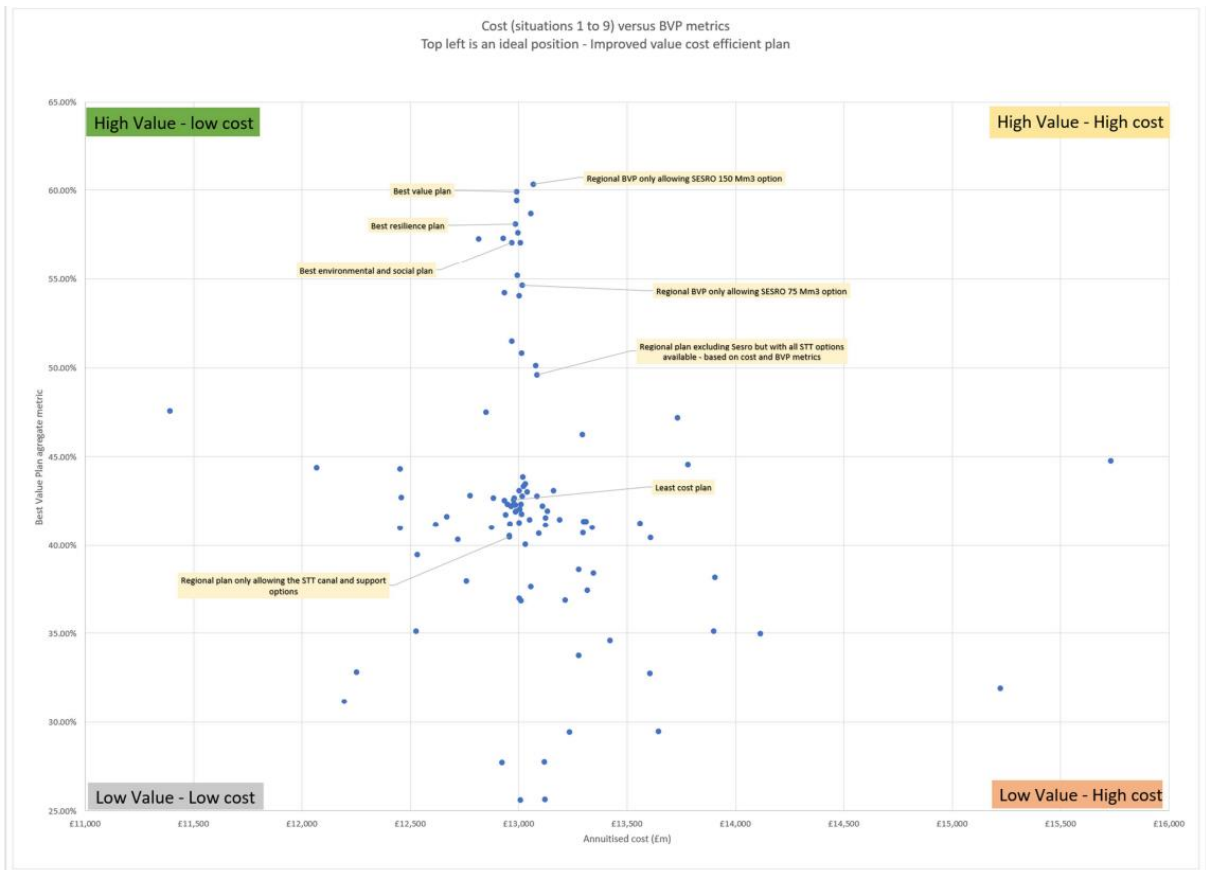


Figure 18. Performance of WRSE's best value, least cost, and other plans comparing the cost and summary BVP metric score (WRSE, 2022, p. 12).

run_id	Y	GUC	SESRO	Teddington DBA	Broad Oak Reservoir	Black stone reservoir	Beckton desalination	Peacehaven - Arlington	STT - pipe option	Beckton water recycling	Ovenhams water recycling	Peacehaven - River Ouse	STT - canal option	Havant/Thicket recycling scheme
st-hybrid2035-dy-w1-tree16.05-options-v37-gov-led-hybridb-drpo-v4-2075	9	9	9	9	7	6	0	0	2	0	2	2	0	9
st-hybrid2035-dy-w1-tree16.05-options-v37-gov-led-hybridb-drpo-v4-2075	9	9	9	9	9	6	1	1	1	0	1	0	0	9
st-hybrid2045-dy-w1-tree16.05-options-v37-gov-led-hybridb-drpo-v3-2075	9	6	9	8	5	1	1	2	0	2	0	0	0	9
st-hybrid2050-dy-w1-tree16.05-options-v37-gov-led-hybridb-drpo-v2-2075	9	5	9	8	5	2	1	2	2	0	2	1	0	9
st-hybrid-dy-w1-tree16.05-options-v37-excl-gov-led-2075	9	9	9	9	6	3	4	2	2	3	0	0	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hydrida-2075	9	9	9	9	5	2	1	2	0	0	2	1	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-2075	9	9	9	9	8	5	0	0	2	0	3	2	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-2075-bvp01_00	9	9	9	9	4	1	2	2	2	0	2	0	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-2075-emsoc-01_00	9	9	9	9	8	4	0	2	2	0	3	0	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-2075-resilience-01_00	9	9	9	9	8	4	1	2	2	0	2	0	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-2100	9	9	9	9	7	4	1	0	2	0	1	3	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-all-stt-2075	9	9	9	9	6	1	0	2	2	0	3	1	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-chingford-2030-2075	9	9	9	9	5	1	0	2	0	0	2	3	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-delay1-beckton-desal-2075	9	9	9	9	6	2	0	1	0	0	3	2	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-delay1-beckton-reuse-2075	9	9	9	9	6	1	0	2	0	0	3	2	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-delay1-sesro-2075	9	9	9	9	4	1	0	2	2	0	3	1	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-delay1-stt-pipe-2075	9	9	9	9	8	5	1	1	1	0	3	1	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-delay1-ted-dra-2075	9	9	9	9	4	4	2	0	1	9	0	1	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-delay3-beckton-desal-2075	9	9	9	9	8	6	2	0	1	0	3	2	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-delay3-beckton-reuse-2075	9	9	9	9	8	6	1	0	2	0	3	2	0	9
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st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-delay3-stt-pipe-2075	9	9	9	9	8	5	1	0	2	0	2	2	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-delay3-ted-dra-2075	9	9	9	9	8	6	2	0	2	9	0	2	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-drpo-v5-2075	9	7	9	8	3	2	0	0	0	0	2	2	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-excl-budds-farm-ht-recharge-2075	9	9	9	9	8	1	0	2	0	0	3	3	0	0
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-excl-guc-2075	0	0	9	9	8	4	1	3	1	2	3	0	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-excl-high-dmp-2075	9	9	9	9	4	2	3	2	0	0	2	0	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-excl-high-medium-dmp-2075	9	9	9	9	4	4	5	2	3	3	0	0	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-excl-media-tubs-neubs-2075	9	9	9	9	5	2	3	2	4	4	1	0	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-excl-sesro-twul-rsr-all-stt-2075	9	0	9	9	6	2	0	7	3	2	4	0	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-excl-sesro-twul-rsr-all-stt-2075-bvp-01_00	9	0	9	9	7	5	2	1	7	3	2	0	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-excl-sesro-twul-rsr-force-stt300-2075	9	0	9	9	6	3	0	9	3	0	1	0	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-excl-sesro-twul-rsr-force-stt300pipe-2075	9	0	9	9	5	2	0	9	3	1	3	0	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-excl-sesro-twul-rsr-force-stt400pipe-2075	9	0	9	9	6	2	1	9	2	2	0	0	0	9
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st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-excl-ted-dra-2075	9	9	0	8	4	1	0	2	9	1	2	0	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-excl-wbgws-2050-2075	9	9	9	8	5	1	0	2	0	2	2	0	0	9
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st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-incl-mendip-rsr-2075-bvp-01_00	9	7	9	8	5	0	2	2	0	1	0	0	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-lon-1in200-2034-2075	9	9	9	2	8	6	1	0	1	0	3	2	0	9
st-hybrid-dy-w1-tree16.05-options-v37-gov-led-hybridb-lidr-2075	9	9	9	9	8	6	1	0	3	0	1	2	0	9

Figure 19. Performance of WRSE schemes according to number of times selected across a range of scenarios, “selection of key schemes across the situations and IVM runs” (WRSE, 2022, p. 17).

The WRSE model is innovative in its approach to addressing the wide uncertainty in future projections by emphasising the selection of schemes that are assessed as optimal across most scenarios. Results (Figure 18 and Figure 19) clearly indicate that some scheme such as the Grand Union Canal (GUC) are selected across different model sensitivity runs and future scenarios indicating these options are robust. Other schemes such as Beckton desalination and recycling are not selected by the investment model consistently across runs indicating they are less robust (WRSE, 2022). However, justifications were primarily based on aggregated least cost and best value scores, and the frequency of selection of options across multiple future scenarios and sensitivity tests, rather than necessarily providing greater detail on practical differences between schemes.

Although the advancements in decision making methodologies such as multi-criteria analysis and robust optimisation are promoted to more explicitly demonstrate the basis for decision-making considering a wider range of objectives and future risks, the

adoption of these more sophisticated and data-heavy tools, and reporting in diverse ways, can undermine the claims of improved transparency and evidenced-based decision-making. The implications of the compromises required for complex decision-modelling can sometimes get hidden (for example, the choice of algorithm, the reasons behind the number of metrics being optimised, the spatial and temporal scales adopted, or the quality and completeness of input data). These choices may be made for practical reasons such as time constraints, computational capability, licencing conditions, and data availability.

5.4.6.2 Regulatory econometric modelling: funding solutions

In producing the final determinations Ofwat uses many models. We will highlight two examples that demonstrate the implications of assumptions (1) unit cost modelling and (2) rate of return.

5.4.6.2.1 Unit cost modelling

Although the assessment of scheme costs involves detailed analysis by companies (a bottom-up approach), the funding allocated by Ofwat follows a more top-down approach. Ofwat establishes categories and thresholds to determine what the regulated allowances will be for particular ‘types of schemes’. Sometimes a benchmarking approach is taken whereby the median cost per megalitre across companies is used to output a unit cost per megalitre for a particular category (**Table 14**). Allowed investment is then calculated according to this median value per megalitre, rather than the proposals in business plans. This approach aims to normalise allowed investments across companies according to the benefits (megalitres) they provide and encourages companies to improve the cost-benefit ratio of seemingly inefficient schemes. The approach expands on the method used for PR19 which used only one category instead of PR24’s five categories (although only four were used in practice as “High Complexity” schemes were assessed separately through the SRO gated process).

Table 14. Price Review Water Supply enhancement expenditure model – unit cost model (cells B101:G:109) *some schemes are redesignated to other categories with various justifications (or no justification) stated including “based on scheme scope”, “base overlap”, “very low capex”

Complexity	Scheme type*	Median unit cost - based on cost /benefit (£m/ML/d) across companies	Number of schemes delivered 100% in 2025-2030 – benefit (ML/d)	Allowance minus company estimated cost (£m): mean, median (min/max)
High	Reservoir Reuse	0 (FD) 12.01 (DD)	No schemes of this type for AMP8 in FD (SROs are considered separately)	0
Treatment	Treatment	4.49 (FD) 5.71 (DD: listed as Base activity schemes rather than treatment)	16 schemes - ranging from 0.2 to 18	-3.86, -4.38 (-36.06 to 26.52)
Medium	Transfer Ground and Surface Water	3.97 (FD) 3.71 (DD)	14 schemes - ranging from 0 to 398	27.64, 1.30 (-37.23 to 365.54)
Low	Licence trading Other	0.71 (FD/DD)	22 schemes - ranging from 0.2 to 26	-1.48, -0.36 (-13.08 5.87)
Very low	1 “Medium” and 5 “Low” complexity schemes redesignated as “Very Low”*	0.071 (FD/DD) Low divided by 10.	3 schemes - ranging from 0.3 to 25	0.003, 0.071 (0 to -0.008)

However, one industry practitioner questioned the seeming arbitrariness of the costing approach as, even with four categories, schemes are inevitably under or overvalued posing a risk that the averaged, allocated costs are a poor match for the reality of costs on the ground which may vary significantly. For example, transfer schemes, groundwater, and surface water schemes are all classified as medium complexity, and based on the median of those proposed costs will receive an allowed expenditure of 3.97 £m per megalitre. However, the costs across even two transfer schemes, or between a transfer scheme and a groundwater scheme will likely vary widely depending on the context. Taking one example, Anglian proposed a new treatment scheme (Hall water treatment works (WTW) surface water enhancement) to cost ~£23m. However, the scheme has an Ofwat modelled cost of £14m. The £14m was calculated as 3.2 ML/d benefit * 4.49 £/ML/d for this type of scheme. The reduction of £9m (~50%) is clearly material. Part of justification of the approach stems for the balancing of wins and losses across the whole price review.

5.4.6.2.2 Rate of return

Investments are financed initially by investors who are repaid by customer bills over time with interest. The allowed return is set by Ofwat which for PR24 was set at 4.03%. This increased from 3.72% set in the draft determinations.

Table 15. Change in return rate between draft and final determinations.

	Draft determinations	Final determinations	Comment
Allowed return on equity	4.8%	5.1%	CEPA recommended 4.63%
Allowed cost of debt	2.84%	3.15%	
Allowed return	3.72%	4.03%	
Average increase in customer bills over 5 years	21%	36%	

Ofwat stated the reason for choosing a higher point in its range was to:

“help to support a level of investment that looks to be higher than any 5-year period since privatisation”,

as well as the inclusion of more credible data, and alignment with:

“likely financing conditions over 2025-30” (p6, Ofwat).

The total expenditure between 2025-2030 is estimated at £104 billion, so in simple terms, this shift represents over £300m. Ofwat linked to several reports highlighting differing views on appropriate methods to calculate returns between consultants representing the water industry, versus consultants commissioned by Ofwat. Debates centre on the balance between historical stability and recent financial fluctuations, as well as critiques regarding the statistical robustness and reliability of alternative methodologies (CEPA, 2024). This example is useful to illustrate that these decisions and the use of modelling are never value-free, possibly reflecting the aims of the actor commissioning the work, requiring judgements based on highly sensitive modelling assumptions linked to the uncertainty and unpredictability of financial markets.

Both examples highlight the significant changes that Ofwat can apply at the end of the process with the aim of encouraging water companies to strive for efficiency, according to median performance across companies (previously upper quartile). The asymmetry of information across the companies and regulators, and profit-motive of companies,

drive regulators concern over companies' incentives to use modelling in ways that delivers maximum profit. Within a privatised industry this tension is inherent, although can be managed, as will be discussed below.

5.4.6.3 Managing uncertainty

Given how the uncertainties propagate through the chain of models across the various stages of planning described above, it is likely an impossible task to ever understand the true range and character of uncertainty we face, illustrated in **Figure 20**.

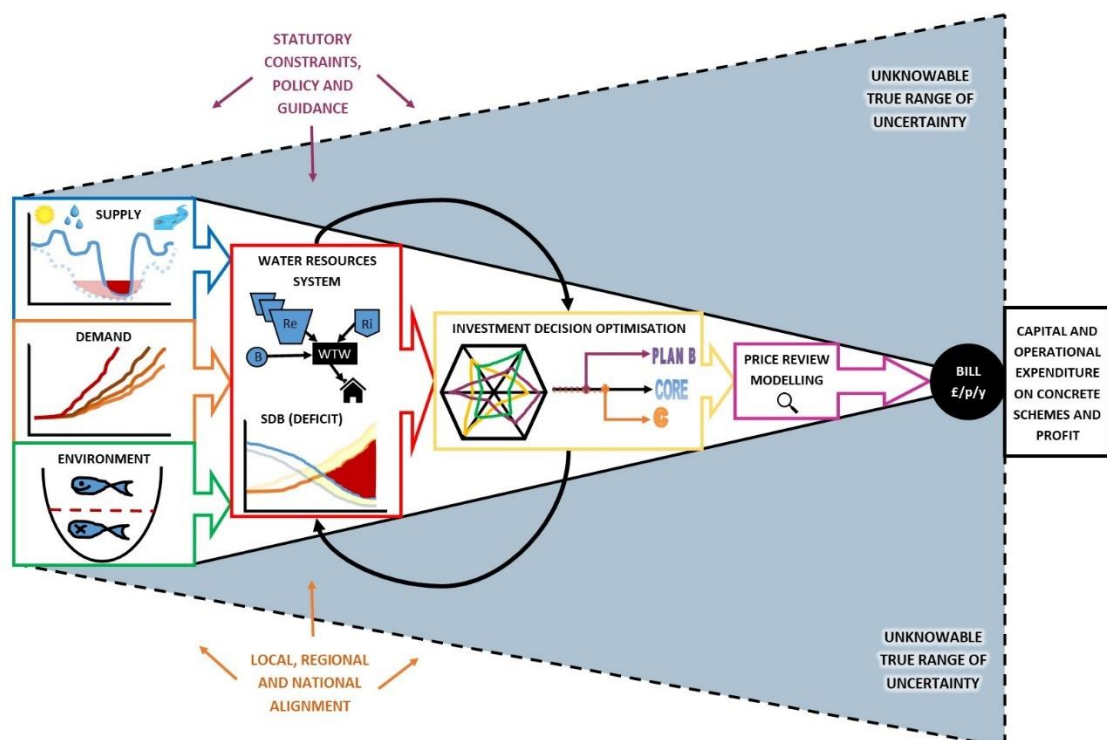


Figure 20. Representation of key stages of modelling for water resources planning investment in England. The figure indicates the unknown/unknownable range of uncertainty (the dashed area) that the final agreed customer bill (for capital and operational expenditure and profit) sits within. Acronyms: Reservoir abstraction, Re; River abstraction, Ri; Borehole yield, B; Supply Demand Balance, SDB; pounds per person per year, £/p/y.

Regulators and companies are aware of the diverse and complex uncertainties surrounding modelling supply demand balances and selecting schemes. In response to this, companies incorporate multiple layers of uncertainty management into their plans which have developed over multiple planning rounds, and which continue to evolve. As previously mentioned, adaptive planning is a recent feature of plans which defines alternative investment strategies triggered at pre-defined points if monitoring indicates that conditions have deviated significantly from the expected pathway. Sensitivity and scenario testing evaluate how plans perform under different assumptions, such as

higher-than-expected growth or higher scheme costs. Target headroom provides a buffer against unexpected deficits accounting for modelled variability in supply and demand factors. Each method is a valuable buffer against risk, though the combination of approaches can obscure the overall picture of how risk is being addressed.

The shift towards a more adaptive approach in the recent planning round is welcome given the range of uncertainties discussed. However, different regions and individual companies are approaching adaptive planning in different ways regarding the scenarios explored, the methods used to assess options to meet different scenarios, and the approach to monitoring progress and trigger points. Ofwat introduced their final guidance on Long Term Delivery Strategies (LTDS) which set out eight mandatory scenarios for testing in April 2022 (Ofwat, 2022), about halfway through the second national reconciliation. However, this was too late for the companies and regions to adopt these strategies in a consistent way. For example, WRSE was the only region to directly encode nine adaptive pathways into their investment model, spanning different futures of need driven by climate change, population and environmental need. The choice of what to reflect across these 9 pathways was made before Ofwat released its strategies.

This somewhat haphazard introduction of guidance, and translation into practice through modelling, characterises the diversity of plans and methods across companies and regions, contributing to overall complexity which can hinder effective scrutiny and agonism.

5.5 Discussion

5.5.1 Inherent planning tensions

Section 5.4 provides an overview of the modelling involved in water resources planning focusing on the 2020-2024 cycle, exploring some of the cases where it has been difficult to balance complexity with trust, due to a wide range of factors, including:

- a high quantity of reporting output,
- non-standard reporting,
- inconsistent modelling methods and assumptions,
- inherently complex and interconnected drivers of supply and demand operating at multiple scales,

- incongruous transposition of subjective value systems into quantified decision-outputs,
- the incentive structure of a privatised and regulated industry, and
- late-stage and uncertain policy introductions.

Looking across these factors over the course of the analysis, we identified eight planning tensions that are particularly relevant to the English case of water planning but may also have wider applications (**Figure 21**).

Planning tensions

Exploration amid uncertainty and ambiguity



Concrete / binary decision making

Planning ultimately involves decision-making, and in the case of large infrastructure, binary choices as to whether to build the scheme or not, and how much to charge to customers each year to deliver plans. This is in tension with the explorative stage which tries to define the problem and find solutions amid an unknowable range of uncertainty. The tension between these two stages is resolved at the point the decision is made, which requires at least one actor to take accountability despite the risks posed by uncertainty.

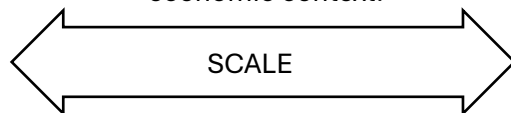
Non-prescriptive



Prescriptive

There is a trade-off between promoting more prescriptive methods (such as by issuing standards) to promote consistency for greater transparency, efficiency, and broad attainment of minimum standards, versus, allowing for greater variation in the hope that diversity and experimentation lead to innovation, and more locally appropriate solutions. Regulators noted that a constraint within the existing framework is that standardising a particular modelling method may give certain consultancies a competitive advantage, at odds with the politico-economic context.

Local



National

National and regional, and company scale, water resources models involve simplification and aggregation. This means they may not be able to capture the true risks posed at an operational level. The data quantity, quality, and consistency, human resourcing, computational limitations, and coordination requirements may impose feasibility constraints as you scale up, while efficiencies, improvements, and risks, may be missed if planning is limited to local scale.

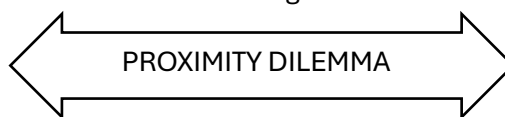
Turbulent



Stable

Planning schemes that have long lead times (e.g. reservoirs) lend themselves towards a more technocratic, long-term, stable planning approach. However, democratic decision-making inherently involves disruption and turbulence as democratic decision-makers (e.g. government and regulators) intervene in the process in response to (shorter-term) political forces. For example, policy can be introduced that means a re-working of previous modelling. This happened several times in the 2020-2024 planning round including the introduction of stricter environmental targets (EA and NE), interim demand and leakage targets (government), and long-term delivery scenarios (Ofwat). These examples may be partly attributable to a lack of coordination but are also partly influenced by top-down policy change.

Regulatory distance for enforcement



Regulatory closeness for understanding

Regulators may be accused of 'capture' if concern of a too close relationship between themselves and those they are scrutinising arises. This may incentivise greater distance. Yet, many duties of the regulators require them to have a detailed understanding of the problems, solutions, and delivery (notably the regulators establish planning objectives and guidance).

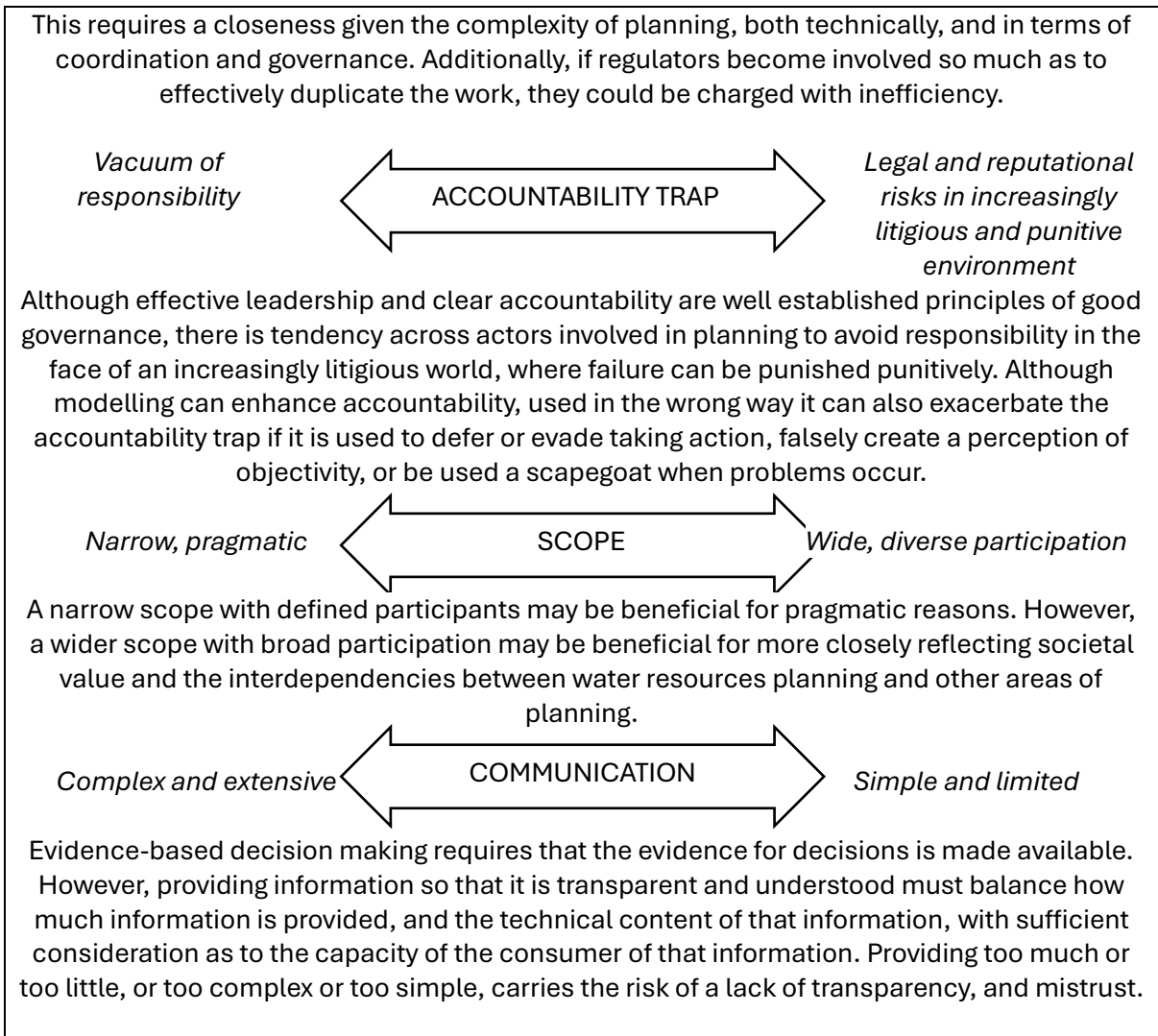


Figure 21. *Inherent planning tensions.*

These tensions and the way they combine with one another and the use of modelling can be problematic for effective planning. However, greater awareness of them can help to diagnose problems and consider possible solutions, as discussed below.

5.6 Discussion and recommendations

The previous sections demonstrate the inherent complexity of modelling and the impact of early-stage assumptions. Practitioners raised the question whether the increased complexity of modelling was having a positive impact. More complexity may not necessarily create better decision-making, particularly if added complexity obscures impactful but uncertain model choices, that result in substantial changes in the level of investment proposed. Modellers must make do with gaps in critical data and understanding, simplifying models within the constraints of what is available and feasible. Computational power remains a major limitation given the vast size of the decision space (despite exponential progress in recent decades). Therefore, outputs will

be couched in the same caveats that the models were built upon (Babel, Vinck and Karssenber, 2019; Sanz *et al.*, 2019; Melsen, 2022). It is possible that some constraints will be resolved with more data, computational power and research, yet, a critical portion stemming from inherent subjectivity and uncertainty will remain (Lane, 2014). This uncertainty, which grows further into the planning horizon, signals the need for decision-makers to not solely rely on the outputs of modelling, but understand the premises they were built upon, and structure the planning framework accordingly. We discuss and propose three recommendations to improve the use of modelling in water resources planning in England.

5.6.1 Embed adaptive planning

Firstly, we believe the adoption of adaptive planning has been a positive development given the wide, and ultimately unknowable range of uncertainty.

One of the notable features of the modelling landscape is the substantial effort that goes into producing the supply and demand balance and associated projected surplus and deficits, spanning supply, demand, environment, and water resources systems modelling. The choices and uncertainty become wrapped up in a baseline time series of supply and demand by water resources zone over at least a 25-year planning horizon, reported to two decimal places. Yet, the precision of the supply demand balance forecast for 2050 appears at odds with the scope of uncertainty (Funtowicz and Ravetz, 1994). We cannot know how accurate the forecasts will be, and we cannot assume that one case of overestimation will be compensated by underestimation in another. It is not possible to predict whether the drivers of change will converge or confound one another in ways that are amelioratory or deleterious. Marchau *et al.* (2019) recommend that problems characterised by high complexity and uncertainty (Level 4 in **Figure 22**) fall under the category of deep uncertainty and require a ‘monitor and adapt’ paradigm which aims to:

“prepare and adapt by monitoring how the future evolves and allowing adaptations over time as knowledge is gained” (p11).


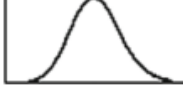

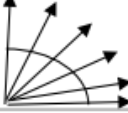
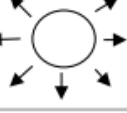
	Complete determinism	Level 1	Level 2	Level 3	Level 4 (deep uncertainty)		Total ignorance
					Level 4a	Level 4b	
Context (X)		A clear enough future 	Alternate futures (with probabilities) 	A few plausible futures 	Many plausible futures 	Unknown future 	
System model (R)		A single (deterministic) system model	A single (stochastic) system model	A few alternative system models	Many alternative system models	Unknown system model; know we don't know	
System outcomes (O)		A point estimate for each outcome	A confidence interval for each outcome	A limited range of outcomes	A wide range of outcomes	Unknown outcomes; know we don't know	
Weights (W)		A single set of weights	Several sets of weights, with a probability attached to each set	A limited range of weights	A wide range of weights	Unknown weights; know we don't know	

Figure 22. Categorising uncertainty according to the knowledge assumed about four aspects of a problem (future context, system, outcomes, weights put on outcomes) between the extremes of complete determinism and total ignorance, “Progressive transition of levels of uncertainty” (Marchau et al., 2019, p. 9).

As mentioned in the introduction, the longevity of the supply demand balance approach is tied to the way it provides a method for companies to meet their legal obligations as stated in Section 37 of the Water Industry Act in 1991:

“for providing supplies of water to premises in that area and for making such supplies available to persons who demand them” (Water Industry Act, 1991).

Despite its flaws, it does provide a testable method for water companies to demonstrate their resilience and tackle areas of risk, with the five-yearly reviews embedding a degree of monitoring and adaptation. However, the multiple compounding uncertainties and high risks involved lend themselves towards a more explicit and active adaptive approach.

There may also be benefits in shifting focus towards identifying and delivering a resilient mix of solutions rather than the extensive modelling involved in pinning down a malleable need (Culley et al., 2016). The shift to adaptive planning will take time to embed and the next round of planning provides an opportunity for planning groups to refine its implementation, such as through aligning scenarios, establishing effective and coordinated monitoring systems, and clarifying funding mechanisms at trigger points.

One approach that complements adaptive planning which is gaining some traction in the industry is the use of ‘storylines’ or ‘tales’ (Hazeleger et al., 2015; Shepherd et al., 2018; Chan et al., 2022). The use of storylines aims to improve decision-making by putting greater emphasis on considering plausible events rather than assigning

probabilities conditional on uncertain historical records and models (Sillmann *et al.*, 2021). It is important to emphasise that a storyline approach does not disavow or reject the use of modelling. In fact:

“models are valuable tools in generating and testing the understanding that helps us to create the storylines. The emphasis is on their use to generate plausible background conditions for weather phenomena consistent with larger-scale changes in the climate system.” (Hazeleger et al., 2015, pp. 111–112).

Allowing for a storylines approach would likely require an evolution of the planning framework as under current arrangements it is easier to make a case based on assigned probabilities and precise deficits rather than a plausible story. An important question is how the current framework could evolve to better recognise and account for the risks involved with relying heavily on modelling alone to provide simple answers to complex, long term planning questions (Workman *et al.*, 2021). How can modelling be used with a more reflective contextualisation against the wider background given hidden risks and simplifications (Thompson, 2022)?

5.6.2 Simplify

We believe that a degree of rationalisation would improve planning. It is important that the use of modelling is continually checked for its appropriateness to the problem, accounting for questions of scale, data availability, tool constraints, and interconnections with other parts of the overall planning problem that may prove material, including, crucially, transparency. As new methods have developed the landscape of modelling has widened, particularly in recent years with the adoption of new climate data, stochastics, optimisation methods, multi-criteria analysis, new approaches to customer research, and adaptive planning. Although this innovation can have benefits, it can also create a resourcing burden for regulators and stakeholders who cannot scrutinise all the modelling choices, even though they can clearly have significant implications on projected deficits, proposed options, and bills. The diversity and overabundance of methods and reporting hinders transparency and can undermine confidence in planning outputs (Weber and Baisch, 2023).

One way to tackle this is to consider aspects of modelling that might benefit from greater standardisation, or that could be commissioned at larger scales, such as

regionally or nationally, such that the plans, and particularly the detailed technical appendices could be simplified. Candidates for such standardised approaches have been proposed by practitioners, including aspects of climate change assessments, demand assessment, environmental assessments, approaches to multi-criteria analysis such as common metrics, and the use of common scenarios for adaptive planning and sensitivity testing. Another proposal is to better standardise certain aspects of the reporting. Having a common presentation of key aspects of modelling outputs would enable more effective scrutiny and hopefully generate greater confidence in plans.

Related to improved transparency and scrutiny is challenge in a wider more integrated sense. Can we develop a common language and “junctions” in modelling approaches and outputs that allow those outside those of the field to interrogate the approach and results to provide respectful challenge (agonism) (Lane, 2014; Krueger *et al.*, 2016; Krueger and Alba, 2022). This will be a core focus if planning is to move to the catchment scale to consider a much wider range of objectives that inevitably brings a wider range of stakeholders into the planning process. This testing against a wider pool may improve robustness. However, it requires much greater focus on the ability to communicate across groups.

5.6.3 Build adaptive governance

Thirdly, we suggest the way to implement recommendations 1-2 is with an adaptive governance approach. As with the adoption of adaptive planning to promote flexible planning in response to new information and change, we believe that the governance structures themselves should embody similar principles (greater responsiveness, self-reflection, openness to challenge, and learning) to continually refine and improve how modelling is being implemented and conducted (Méndez *et al.*, 2012). This is particularly true given the current transitional nature of water resources planning in England since the adoption of the National Framework with raised ambitions, new tiers of planning, new methods, as well as tentative steps towards more integrated planning with other sectors, particularly Energy and Agriculture.

Practitioners reported several signs of positive progress in this regard. Firstly, the development of regional groups allows new platforms and forums for companies, regulators and other stakeholders to convene, share best practice, explore

opportunities, and raise challenges (Leonard *et al.*, 2024). Secondly, a national level Modelling Advisory Group (MAG) was set up to improve modelling involved in WRMPs. The group includes representatives from regions, companies, the Environment Agency, and academics, and was praised for its collaborative spirit embedded into its working practices such as having a rotating chair, open discussion, voting, and feedback.

One thread that runs through all aspects is the question of how the use and evolution of modelling will and should interact with the transition to more integrated planning. This involves on one side greater interaction between the public water suppliers with non-public water suppliers. It also involves integration beyond water resources into other policy areas such as water quality (which as previously discussed directly impacts water resources systems but is often siloed from it in modelling, planning and operations), as well as flooding and drainage, drought planning, habitats and ecosystems, amenity, and so on. Considering the context of existing legal and economic frameworks and how they could evolve, what governance structures, common language approaches, common modelling approaches and use of metrics could be developed to help synchronise these overlapping but often siloed fields of planning. It is likely that as we move further into the future with greater pressures from climate change, for growth and development, and to meet legal environmental and sustainability targets, there will be increasing need for the sometimes quite disparate groups to solve problems collaboratively using common tools and languages. There are considerable obstacles to achieving a more integrated system (Biswas, 2008). However, it is useful to first understand the position we are currently in (siloed) and consider possible next steps to start building the foundations for integration.

5.7 Conclusion

The complexity of water resources planning in England reflects efforts to use quantitative methods to meet regulatory requirements. However, the 2020-2024 planning round has highlighted key tensions between granularity and trust in decision-making. The diversity of modelling approaches across companies and regions, inconsistencies in assumptions and reporting, and the sheer volume of documentation have made scrutiny and transparency challenging. While models serve as essential decision-support tools, the propagation of uncertainties, from climate projections to

investment assessments, raises concerns about how effectively they capture risk and inform investment.

Despite these challenges, the adoption of adaptive planning and increased regional and national coordination indicate progress. Moving forward, there is a need to streamline complexity where it does not serve transparency, improve alignment across planning entities, and embed mechanisms for ongoing review and challenge. While some level of uncertainty is unavoidable, improving clarity and coordination will be critical to ensuring robust, trusted decision-making for the future resilience of England's water resources.

5.8 Signpost to the next chapter

Following the exploration of modelling complexity and its implications for planning legitimacy and decision-making, the next chapter integrates findings from across the thesis to draw out cross-cutting themes.

Chapter 6. Integrated Discussion

This chapter brings together the key findings of the thesis to reflect on how water resources planning in England is evolving in response to complex environmental, institutional, and technical pressures, drawing on the previous three chapters:

- Chapter 3: The Changing Landscape of Water Resources Planning in England
- Chapter 4: Collaborative Multi-Scale Water Resources Planning in England
- Chapter 5: The Complexity of Clarity: Balancing Granularity and Trust in Modelling for Water Resources Planning in England

Building on these three empirical chapters, the discussion synthesises insights into a broader analytical narrative, structured around four cross-cutting themes.

6.1 Cross cutting themes

The following section considers four cross cutting themes:

1. Scale: transition to strategic and multi-scale
2. Institutional context: privatised and regulated
3. What we value: eliciting objectives
4. Uncertainty and complexity: adaptability in a dynamic environment

The chapter proceeds by revisiting each of the four themes in turn, drawing connections across the case study material.

6.1.1 Scale: transition towards strategic, multi-scale planning

One of the key themes prominent throughout this thesis is scale. Scale is a fundamental consideration for planning and institutions (Cash *et al.*, 2006). It can be envisioned along a spectrum. At one pole is top-down, strategic, often national (sometimes international) direction. The other is represented by bottom-up, possibly community-led, local management. In between is punctuated by federal, regional, sub-regional, river-basin, and catchment-based tiers that vary in size and character depending on the context. Advocates and opponents debate the effectiveness of planning at different scales along this spectrum (Watson, 2014). Positions sometimes reflect contentious political ideologies, governance structures and institutional capacities.

Each of the three chapters in this thesis engages with scale from a different perspective. Chapter 3 examines the historical evolution of scale in English water governance, highlighting non-linear shifts from fragmented local planning to regional and national coordination. Chapter 4 explores the real-time implementation of multi-scale governance in England, particularly through the introduction of regional water planning frameworks and the National Framework. Chapter 5 investigates how modelling frameworks struggle to balance national standardisation with local specificity, illustrating a core challenge in multi-scale governance.

6.1.1.1 Politics and neoliberalism

Some have made emotive arguments rooted in deeply entrenched beliefs related to politics and the economy. Friedrich Hayek, a famous and influential Austrian economist often associated with right-leaning politics and neoliberalism, warned that well-meaning spatial planners would be doomed to fail given the inherent complexities of large multifaceted societies. He advocated for small government and market solutions to avoid the rise of authoritarian and totalitarian figures stepping into the void of failure created by mis-matched strategic policy design (Hayek, 2014). This political and economic theory is criticised by others who point to market-failures, inequality, the necessary role of government particularly in crisis, a lack of empirical evidence, oversimplification, and a failure to recognise corporate overreach and unchecked techno-feudalism (Tribe, 2009; Hudson, Hunter and Peckham, 2019; Varoufakis, 2024). In the context of water resources, a purely market-driven system risks neglecting public goods, making some level of strategic coordination essential.

This context is relevant throughout this thesis. Chapter 3 traces how England's water sector transitioned towards privatisation and regulatory oversight, leading to a governance structure where strategic decision-making is fragmented across multiple private actors. Chapter 4 highlights how regional planning attempts to reconcile these tensions, balancing strategic coordination with private sector autonomy. Chapter 5 demonstrates how market-driven decision-making influences technical modelling choices, often prioritising financial efficiency. This political-economic backdrop frames the ongoing debate about the appropriate scale of governance and the role of strategic planning in water management.

6.1.1.2 Top-down planning

Political ideology is one entangled influence amid many others regarding how strategic planning is considered, but it does relate to an overarching criticism that strategic planning results in mismatched, poorly tailored solutions. We can see practical implications of this in Chapter 5 which highlights how simplifications used in long term planning can conflict with operational and drought management and the difficulties of achieving consistent modelling at the national scale due to the complexity and inherent local nature of operations. Other criticisms suggest that strategic planning can result in the discouragement of innovation, and priorities shifting to short-term, measurable outputs (Robins and Kanowski, 2011). Marshall describes challenges faced by taking a higher-level (regional rather than local) approach:

“pressures [exist] on regional bodies to assume responsibilities (e.g. maintaining upward accountability to government investors) that risk them becoming perceived by their constituents as extensions of government. A further challenge follows from increased governmental pressures on regional bodies to invest their funds more strategically, and less on the basis of equity considerations, and the consequent risk that community ownership of regional decisions may be weakened by perceptions of bias or political opportunism” (Marshall, 2009a, p. 43).

The introduction of the National Framework in England (described in chapters 3 and 4) indicates a shift towards more strategic planning, at least relating to national policy and steer. Chapter 5 highlights new national planning groups such as the Modelling Advisory Group (MAG) as an example of a strategic approach to improve and refine use of modelling in a pragmatic way. In England, the central government is not institutionally designed for long term, cross-sectoral resource management. Expertise sits at arm's length within the private sector, regulators, and consultancies. This is intentional; responsibility has increasingly shifted to private actors (Watson, Deeming and Treffny, 2009) considered more efficient since the establishment's adoption of neoliberalism since the seventies. Additionally, culturally and structurally, the civil service is designed to promote the development of 'generalists' such as through frequent, cross-government transfers which promote broad rather than deep expertise. As such, legislation is designed to be flexible to allow regulators to iterate policy based on emerging needs. However, since regulators themselves are also removed from the

operation and planning of water resources networks, such that it is not possible for them to understand all the implications of new policy or react quickly to unintended consequences, policy is designed with caveats that can be vague and ambiguous, for example to meet targets *unless* the costs prove *unjustifiable*:

*“your plan reflects any relevant regional plan, which has been developed in accordance with the National Framework and relevant guidance and policy, **or provides a clear justification for any differences**” (EA, Ofwat and NRW, 2021, p. 9)*

*“Some **flexibility** is possible where costs are exceptionally high locally in comparison to benefits” (EA, 2020b, p. 8)*

Having flexibility makes sense given the distance between policy makers and operation, however, it also creates room for (mis)interpretation, uncertainty and possibly mistrust that caveats create loopholes in policy against the ‘public good’. Interestingly, one practitioner highlighted that in practice the room for flexibility often weakens under political pressure, such that the initially flexible policy becomes increasingly hard and prescriptive. They evidenced the regulatory approach to leakage and demand management targets through the 2020-2024 planning round, which started out as an ‘expectation’ but became more strongly interpreted and eventually legislated over the four years:

*“Regional groups **should**: contribute to a national **ambition** on average PCC of 110 l/p/d by 2050 - this should be reviewed every 5 years; reduce the water lost from networks by 50% by 2050 from a baseline of 2017 to 2018” (EA, 2020b, p. 10).*

*“we **expect** companies to assume they will meet relevant performance commitments and government targets” (Ofwat, 2022, p. 41)*

*“To drive progress to close the gap, we have **set a new legally binding target** under the Environment Act 2021 to reduce the use of public water supply in England per head of population by 20% by 2038. To achieve this we will reduce household water use to 122 litres per person per day, reduce leakage by 37%, and reduce non-household (for example, business) water use by 9% by 31 March 2038. This is part of the trajectory to achieving 110 litres per person per day household water use, a 50% reduction in leakage and a 15% reduction in non-household water use by 2050.” (Defra, 2023a)*

This tension between more or less prescriptive guidance is illustrative of many of the tensions identified in Chapter 5 (particularly standardisation, scale, techno-political stability, proximity dilemma, and the accountability trap), none of which have perfect solutions. In England, there is an ambiguity over who is ultimately accountable for defining the final degree of permitted flexibility. This ambiguity which reflects all these inherent tensions can be navigated more effectively through an active and sustained commitment to close collaboration and problem-solving between regulators and operators.

This active process of implementing strategic planning becomes increasingly difficult given complex, inter-linked sectors. In practice, fragmented central planning arrangements appear common. Some regions, such as California in the United States and Victoria in Australia, reference ‘national water grids’ evoking a single central operating system. However, both are fragmented with notions of a ‘grid’ tending to focus on how to smooth the funding for single, bottom-up infrastructure projects within complex networks (Escriva-Bou, Hanak and Mount, 2019).

Proponents for top-down, broader, strategic planning point to the benefits of economies of scale. Such an approach allows for a clear, long-term vision and greater standardisation through higher-level frameworks and guidance, open-data, methods, and definitions, helping increase transparency and building the foundations needed for cross-actor communication. Marshall (2012) suggests the Netherlands embodies this, pointing to the prominence, particularly in the sixties, of spatial planners in government, “*on a par with the budgeting side*” (p89) and embedded into planning both sectorally and cross-sectorally. He also points to a “*national spatial imaginary*” (p97). The author considers these factors to have had a lasting significant and positive impact on decision-making for strategic water infrastructure planning, supported by indicators including low leakage rates, and safe, unchlorinated drinking water (Smeets, Medema and van Dijk, 2009). Success is partly attributed to strategic planning promoting a:

“long-term time-frame for thinking and discussion, in a sense on a nearly continual loop” (p95), and greater public coherence amid “public debate [that] brings out the zones of tensions and conflict” (p98).

As described, although England is pursuing more strategic aims through the introduction of a National Framework, the country does not have the same history of

promoting planners to a similar level of authority as the treasury, encouraging national public debate around water management, or developing a *national spatial imaginary*. These historical and cultural legacies act as barriers to the implementation of national planning on a par with the Netherlands.

These examples hopefully highlight some of the proposed benefits and limitations of strategic planning and the difficulties and barriers in shifting towards more strategic planning in countries which do not have an already established strategic cultural imaginary.

6.1.1.3 Bottom-up planning

The benefits and weakness of local planning somewhat mirror top-down planning. Advocates highlight that problems can be understood granularly, and solutions tailored, with closer participation and accountability of the people affected who possess deep contextual knowledge. Scale in this sense is deeply connected to questions of accountability, enforcement, responsibility, and clear roles (Porter and Birdi, 2018; Grafton *et al.*, 2020). Considering Australia's experiment with local planning through its Land Care programme, Marshall (2009a, p. 1507) points out benefits of strengthened legitimacy and buy-in of a more local approach, suggesting:

“subregional bodies have an advantage over regional bodies in motivating [behaviour such as voluntary cooperation through reciprocity] from farmers because the former are better positioned to engage them sufficiently to turn around norms of free-riding or opposition”.

Limits of local planning, again reflecting the benefits of more strategic approaches, include a lack of ability to impact broader issues, variability in service, missed opportunities, and insufficient capacity. These limits are demonstrated in Chapter 3 which outlined how England's water sector was historically highly fragmented, resulting in unequal outcomes particularly across the rural and urban divide in the early 20th century. Chapter 4 reveals gaps in planning and potential vulnerabilities for non-PWS and catchment planning. While Chapter 5 highlights how local-scale modelling inconsistencies create challenges in producing coherent national planning outputs. Other limitations of more local approaches include failure to sustain amid political change, dependence on external support and lack of funding, and difficulties dealing

with conflict between competing interests (Ostrom, 2005; Curtis *et al.*, 2014). Additionally, Lopez-Gunn (2003) illustrates variability in success between local approaches by comparing two local water user associations in Spain and noting how success depended on the homogeneity, leadership, and the culture of enforcement within the local associations.

6.1.1.4 Subsidiarity

Both top-down and bottom-up arrangements may be vulnerable to several challenges, including insufficient funding, increased transaction costs, reduced goodwill, and inconsistent commitment. Rather than advocating for either top-down or bottom-up, others promote adhering to the principle of subsidiarity which enshrines designing for decision-making at the lowest level possible (Marshall, 2009a; Moran and Elvin, 2009; Marshall and Smith, 2010). In some cases, this would be local, particularly when problems require fine-grained contextual knowledge or stakeholder trust. However, in others where problems exceed local capacity and cross-boundaries, regional or national structures would be invoked.

The introduction of regional and national planning frameworks in England demonstrates benefits gained from following the principle of subsidiarity where issues can be tackled at the lowest level feasible. For example, the regional group provides a forum that can facilitate joint interactions, such as developing new schemes, communicating with local stakeholders and regulators, developing new methods, and sharing lessons. Such interactions were observed across the five regions, with each region developing their own approach to match the unique problems faced in their area:

- WRE put greater emphasis on developing a multi-stakeholder approach,
- WRSE chose to focus on adaptive pathways in light of uncertainty,
- WRW was attentive to its position as a potential source region and maintaining a coordinated timetable for both sources and recipients of transfers,
- WReN took a looser approach given its more secure position, and
- WCWR took an increasingly coordinated approach as a greater level of risk was recognised.

This flexibility allowed for tailoring to the regional context, encouraged a wider range of approaches to learn from, and avoided enshrining a one-size-fits-all framework that might have proved to be unnecessary and excessive.

The national reconciliations, and the national planning groups (the RCG, SSG, MAG) allowed for issues arising at company and regional levels to be discussed if they had national relevance, for example:

- establishing national standards such as the 1 in 500 drought resilience target,
- agreeing cross-regional schemes such as the Grand Union Canal (GUC), the Derwent Valley Transfer, and the Seven Thames Transfer (STT), and
- developing more consistent approaches such as commissioning Atkins consultancy to develop a library of consistent stochastic data to explore climate change scenarios.

This multi-scale structure following the principle of subsidiarity allows to match problems to their appropriate scale. Studies have similarly indicated benefits (Ostrom, 2012; Garrick, 2018):

- improving fit between governance and problem scale,
- clarifying roles and responsibilities,
- fostering learning within and across regions,
- enabling local innovation,
- addressing cross-border issues,
- enabling decentralisation without losing coherence,
- counterbalancing central authority, and
- enhancing adaptive capacity in the face of uncertainty.

However, studies also point to limitations and barriers:

- complexity and scale mismatches in multi-jurisdictional setting,
- bureaucratic inertia or resistance,
- capacity constraints,
- weakened or ambiguous accountability, and
- inconsistency.

Furthermore, although in theory subsidiarity allows problems to be matched to the right scale, this can be difficult in practice. A key difficulty is determining who decides the appropriate level for a given issue (Schout, 2025). Disagreements may arise over whether an issue should be handled locally, regionally, or nationally. Key questions include:

- how to navigate conflicts in the case of disagreement over which level is appropriate?
- who is the arbitrator of such conflicts and with what authority?
- to which party does the burden of proof lie, should higher levels justify centralisation, or should lower levels prove their capacity to act effectively?

This final question is contentious; benefits of ‘economies of scale’ associated with centralisation may superficially appear more efficient compared to the benefits of fragmented local approaches that offer less tangible benefits linked to building trust, encouraging local innovation, and maintaining closer accountability. How one imagined system fares compared against the other will depend significantly on the approach to evaluation such as choice of metrics and use of quantification versus qualitative assessment and judgement.

Furthermore, while subsidiarity typically regards vertical scale (geographically and hierarchically in terms of governance), it can also apply to horizontal scope, for example, which stakeholders and connected policy areas should be considered within remit (Moroni, 2024). The shift to more integrated multi-sector planning suggests a broadening horizontally which may increase the scale of planning. Yet, this scaling out is subject to the same issues around who decides when or when not the remit should be expanded versus the benefits of keeping the scale smaller. Such issues are pertinent as they intersect with questions of power, legal constraints, and budget allowances. With growing calls for local, regional, and national water resources planning to become multi-sector, designing appropriate governance structures, regulation, and funding becomes critical.

Overall, subsidiarity appears to be a good principle. This research evidences the benefits of following subsidiarity. Increased cross-company collaboration was observed that resulted in proposals for new inter-regional schemes. The process and outcomes

show promising signs of developing trust and improving consistency, while maintaining that decision-making for complex systems such as water resources networks sits better locally with those who understand the operational realities of those systems. However, (like collaboration) continuing to enshrine subsidiarity given calls to expand the remit of water resources planning to better consider other sectors may face difficulties in practice as the theory abuts potentially conflicting or ambiguous legal and economic frameworks and power balances. Ultimately following the principle in practice is more of an ongoing, fuzzy process that requires conversion of multi-scale frameworks into clear roles, remits, accountability, conflict resolution mechanisms, arbitration, understanding of power and participation, funding and legal backing.

6.1.1.5 Bridging scales and the importance of people

In some cases, scalar restructures have demonstrated benefits. Yet, re-scaling is contingent on the constitutional rules which may prohibit and constrain changes in governance (Huang *et al.*, 2022; Wang, van Rijswick and Dai, 2022; Yakubov, 2022). Many barriers face those attempting reform. Thiel (2014) finds evidence that in Spain the entrenched regional hegemony overrode attempted transformations from supra-national European policy. In New Zealand the government attempted to transition to a top-down model, amalgamating 67 authorities into four large districts, in pursuit of economies of scale, better access to capital, greater technical expertise, and improved minimum standards through standardisation. However, several areas of contention arose, such as; how to design co-governance between Māori and councils, the role of privatisation, loss of local control and reduced accountability to communities, and proposals for alternative less radical reforms such as regional cooperation agreements (Chambers *et al.*, 2022). The reform was abandoned after Labour was replaced by a coalition of right-leaning parties following a general election in 2023.

What comes out in discussions around scale is how rather than seeking the ‘correct scale’, greater attentions should focus on allowing sufficiently for interactions, using bridging organisations (Margerum and Robinson, 2015), and trusted intermediaries (Rouillard and Spray, 2017) that are able to build social capital and retain the benefits of local, interpersonal, and flexible planning alongside driving strategic aims (Memon, Painter and Weber, 2010; Curtis *et al.*, 2014; Eberhard *et al.*, 2017).

The effectiveness of any scalar arrangements depends on the competence and social capital of practitioners. As Moss (2012: 9) states:

“[the] interrelationship between agency and institutions [is critical]. How actors interpret institutions, give them meaning through their actions, and adapt to the constraints and opportunities they generate is fundamental to institutional effectiveness.”

Yet,

“even the most imaginative practitioners are constrained by a federal system that places government organizations in conflict with one another and creates an underlying tension as to whether federal, state, regional, or local priorities should govern decision making”
(Imperial, 2005, p. 311).

These quotes highlight how even the best scalar arrangements will be imperfect, overly static and lag behind a dynamic reality, requiring ongoing navigation. Perfect synchrony between local granularity and strategic consistency is impossible, and a balance must be sought that maintains trust and allows skilled practitioners to navigate across scalar boundaries.

6.1.1.6 Summary of the first theme: ‘scale’

Scale is a fundamental consideration in water resources planning, shaping governance structures, institutional responsibilities, and decision-making processes. Case studies demonstrate the ongoing struggle for matching the scale of governance and institutions to reality and the complexities that arise. Rather than serving as a rigid framework for institutional design, scale should be seen as an analytical tool to reveal governance mismatches, institutional boundaries, and opportunities for improved coordination, accounting for political, socioeconomic, and cultural geographies:

“the value of the concept of spatial fit lies less as a normative category for institutional design than as an analytical frame for revealing the multiple geographies of resource management, the problems that these may generate, and options for addressing them.

*Our chapter suggests, first, that future research and policy on spatial fit should be **exploring ways of working with and across boundaries, rather than trying to remove them**. These boundaries, moreover, should not be conceived of as purely physical ones, but should reflect the political, socioeconomic, and cultural geographies of an*

*ecosystem or natural resource. In this context, more work is needed on those boundary organizations that strive to span the various geographies of resource management... we should **avoid negative assumptions about the co-existence of multiple jurisdictions and institutional arrangements and study empirically their relative merits as well as their limitations.*** (Moss, 2012, p. 9).

Governance frameworks should help enable actors to interact across scales, exchange knowledge and understanding, build trust, flag potentially risks, and hold one another accountable when needed. Having a multi-scale framework, with national coordination, regional coordination, and sub-regional coordination, where accountability for decision-making sits where possible with the lowest actors following the principle of subsidiarity, allows for a bottom-up structure whilst also promoting gains from learning, efficiency, standardisation (Chapter 4).

“A core proposition is that in a world increasingly recognized as being multilevel, solutions must be as well. The opposite poles of top-down approaches, which are too blunt and insensitive to local constraints and opportunities, and bottom-up approaches, which are too insensitive to the contribution of local actions to larger problems and the resulting potential for tragedies of the commons, are clearly inadequate in providing both socially robust information (Gibbons 1999) and viable management solutions. A middle path that addresses the complexities of multiple scales and multiple levels is much more difficult, but also what is required” (Cash et al., 2006, p. 10).

This framework is developing (Chapter 3) with the introduction of regional and national planning. Yet, there is room for further consolidation with greater structure and resourcing. A national coordination office could drive the big picture of resilience. The regional planning groups are well placed to identify hot spots and find cross-sector opportunities (Chapter 4). These could include both building up local efforts, such as through multi-sector abstraction groups (MAGs) and Catchment-based approach (CaBA) partnerships, as well as national efforts such as through the exploration of strategic resource options (SROs). Networked structures are required which enable ongoing discussion as to which planning and technical aspects (Chapter 5) are suited to a more top-down, consistent approach and which are suited to local tailoring.

6.1.2 Institutional context: privatised and regulated

The second theme that is drawn out across the three chapters is the critical context of public water resources planning in England happening within a privatised and regulated framework. This sets the basis for funding, regulation, decision-making, investment, and the balance between collaboration, coordination, and cooperation across scales. While privatisation has provided a financial foundation for planning, it has also led to fragmentation, regulatory complexity, and barriers to strategic coordination. This section examines the historical evolution of privatisation, its impacts on planning, and the challenges of collaboration within a competitive framework.

6.1.2.1 Historical development and implications

What is prominent across the research is the mature framework that has developed for public water supply provision (PWS) by water companies, developed through the WRMP process since privatisation. The entrenched legal rules and economic context (constitutional rules), and actors with decision-making responsibilities (collective choice rules), impose constraints and code working practices that materially impact planning (operational rules) (Polski and Ostrom, 2017). As emphasised in Chapter 3, it is important to understand the path dependency of privatisation which signifies the broader neoliberal landscape that has dominated since the seventies and eighties. Some of the consequences of this include:

- the prioritisation of economic efficiency (such as using cost-benefit analysis),
- the growing role of private companies in decision-making and delivery,
- a ‘roll-back’ and ‘roll-out’ regulatory regime caught between deregulation and increasing prescriptiveness (Peck, 2010) aiming to provide checks and balances on private monopolies, and
- a reorientation of the public from a citizen to a consumer (Bakker, 2003).

It is important to understand the incentives and penalties of the institutional setting, which in the case of public water supply planning in England are ultimately driven by private companies aiming to maximise profit under fiduciary duties, while maintaining minimum standards within defined legal and policy constraints. While privatisation ensured long-term financial stability, it also fragmented governance. Unlike in the Netherlands, where national-scale water planning remains a government responsibility

(Marshall, 2012), England's decentralised regulatory model left strategic decision-making to individual water companies. This structural factor underpins many of the contemporary challenges discussed across the three results chapters.

6.1.2.2 Benefits and risks of financial stability in a privatised system

One of the consequences of the system is a long-term secure income, which is essentially ring-fenced, with customer bills relied upon due to the monopoly character of water provision. As outlined in Chapter 5, this provides reliable income for planning, maintenance activities, and capital expenditure, beneficial for long term planning.

The water resources planning framework is predicated on the assumption of secure, predictable, and long-term investment. However, the near-insolvency of Thames Water and the legal appeals by six companies against Ofwat's latest price review (Adie, 2025a, 2025b) point to emerging financial instability within the sector. This has intensified investor concerns and prompted calls for higher returns to reflect growing exposure to risk, including increased regulatory scrutiny, more frequent penalties, and heightened public expectations for service and environmental standards. In response, Ofwat raised the allowed rate of return between the draft and final determinations for PR24 and refrained from placing Thames Water into special administration. Yet, whether these measures are sufficient to restore investor confidence remains uncertain.

At the same time, the political viability of increasing returns is increasingly being questioned, particularly in light of widespread public dissatisfaction with water company performance and growing support for renationalisation (Bayliss, 2024). For example, a YouGov poll in 2024 found that 82% of the public favoured public ownership of water services, up from 59% in 2017 (Smith, 2024). In essence, the current policy trajectory proposes raising financial incentives to encourage long-term investment, even as those incentives are directed toward companies and investors who have become the focal point of public distrust. While some of this distrust may overlook the roles of regulators and shifting public expectations, it nonetheless poses a significant political and reputational challenge to market-based solutions.

These challenges reflect ongoing questions around England's ability to fund strategic, multi-sector water planning. This is even more true in areas beyond public water supply (non-PWS), which currently lack a dedicated funding mechanism. To address this gap,

Chapter 4 suggests exploring sustainable funding options, such as allocating a portion of abstraction license fees to regional and catchment planning. This would provide a parallel funding mechanism for non-PWS, similar to the WRMP structure for PWS. If these areas are to be given material rather than rhetorical attention, securing a sustainable source funding, such as a portion of abstraction licence fees, is crucial.

6.1.2.3 Barriers to collaboration

The privatised system creates institutional and competitive barriers that make cross-company collaboration, standardisation, and transparency challenging. Chapter 5 illustrates difficulties of dealing with uncertainty within a regulatory and financial framework that demands certainty and is risk adverse. Additionally, competition rules limit the sharing of data, modelling methodologies, and strategic planning across companies, which companies and regions navigated through the national reconciliations and planning groups (Chapter 4). Chapter 5 demonstrates that while open datasets and shared models could improve transparency and decision-making, these innovations often conflict with regulatory and financial structures. Thus, there is a trade-off between the perceived efficiency of privatisation and the difficulty of achieving system-wide consistency and scrutiny.

The introduction of regional and national planning reflects an attempt to solve this strategic void. Chapter 4 shows that these frameworks have improved engagement between regulators and practitioners, fostering a more collaborative culture. This collaborative approach is in line with wider literature, for example Marshall, (2009, p. 1519) points out successes of collaborative approaches being:

“economic dividend from increased voluntary adoption of conservation practices under this approach arises from the reduced transaction, political and other opportunity costs of achieving the same result entirely through coercion or financial inducements”.

However, the current system still lacks an independent national coordination forum, and the embedding of regional groups, to align multi-scale planning efforts across companies and sectors. The developing regional groups have potential to help in this space given the significant experience, existing social capital, and developed networks and links into water companies and other stakeholders.

6.1.2.4 Lessons from international case studies

The limited success of collaborative approaches in privatised water systems suggests that voluntary cooperation alone may not be sufficient. Chile, one of the only other countries which has pursued the privatisation of water resources assets to a similar degree to England, has faced persistent failures in integrated planning due to a lack of: financial support, government support, ability to allocate or prioritise between water users, shared vision, human resourcing, legal jurisdiction, role clarity, conflict resolution, and research and learning. The outcome being ongoing water quality deterioration, decline in aquifer levels, conflict among water users, and water deficits (Lostarnau *et al.*, 2011; Donoso, 2014; Valdés-Pineda *et al.*, 2014; Peña, 2018; Galvez *et al.*, 2020). Research suggests that without a strong regulatory framework or independent oversight, privatised systems struggle to balance public and private interests relating to fair water allocation in an efficient and sustainable way.

Similarly, Cuadrado-Quesada and Schwartz (2022) illustrate the collapse of a collaborative governance agreement in the Netherlands, which failed due to the breakdown of shared goals and trust. These examples highlight that without legal mandates, financial resources, and institutional support, collaborative governance initiatives may not be sustainable.

This aligns with arguments that collaboration alone is not a governance solution, or a:

“magical cure for all governance problems” (Imperial, 2005, p. 17).

It requires institutional structures that embed coordination, accountability, and sustainable funding mechanisms (Bodin, 2017). The success of functioning planning frameworks depends on funding, social capital, consistency, communication, and as Ansell and Gash highlight, interdependence:

“many of the cases we read suggest that stakeholders come to recognize their interdependence through the collaborative process” (Ansell and Gash, 2008, p. 568)...“bitter adversaries have sometimes learned to engage in productive discussions” (Ansell and Gash, 2008, p. 561).

6.1.2.5 Recognising different modes for different stages of planning

An aspect that is not as visible in the privatised and regulated framework is the need for different modes in the planning process (Friend and Hickling, 1997), that require

different levels of accountability. This relates to the different roles required, sometimes from the same actors, across the span of the planning period that require characteristically different approaches and levels of openness. These could be categorised into (1) exploration, (2) decision-making, and (3) implementation (**Table 16**).

Table 16. Stages of planning.

Stage	Exploration	Decision-making	Implementation
Actions	Exploring, vision, problem-defining, shaping, solution scoping, designing, understanding trade-offs, negotiating, facilitating	Deciding, balancing trade-offs, compromise, pragmatism, choosing, comparing	Managing, operating, monitoring, evaluating

Planning must balance (1) openness to discussion and exploration, with (2) action and solid decision-making. In the exploration stage, wider participation helps ensure the problem definition is robust and allows for a wide scoping of solutions. When planning moves into the decision-making stage, and also for implementation, clear accountability is needed that recognises the constraints of regulation, scrutiny, and enforcement. This stage requires effective and transparent communication of the justifications behind decision-making, so those (such as regulators) who have participated in the exploration stage, and who must scrutinise outcomes, understand the practical constraints and what is realistic. This is important to maintain trust, especially given that the modelling involved in decision-making involves many uncertainties, as outlined in Chapter 5.

These dynamics are also demonstrated in Chapter 4 through the transposition of exploring options into concrete plans through iterative national reconciliations, and the development of regional plans and WRMPs, with a mix of success as well as signs that trust at certain points faltered.

The difficulties of managing these shifting roles and modes across stages of planning relate to the inherent planning tensions described in Chapter 5, such as the ‘proximity dilemma’, helping illustrate the challenges faced by collaborative multi-scale frameworks:

“multifunctional and multipurpose collaborative networks would need to strike a favourable balance between many ideal, and often contradicting, structural characteristics” (Bodin, 2017).

6.1.2.6 The proximity dilemma; balancing closeness with independence

The regulation of water resources in England reveals a core dilemma in modern governance: how can regulators remain close enough to industry to coordinate effectively, while maintaining enough distance to preserve independence and avoid regulatory capture? This tension is illustrated by the roles of the Environment Agency (EA), Ofwat, and other regulators in long-term water resources planning.

Ofwat in particular have been accused of failing to counter the excesses of water company profiteering (Allen and Pryke, 2013; Christophers, 2020). Critics point to:

- Financial engineering and gearing that allowed value extraction through dividends and left companies vulnerable to increasing interest rates
- The economic level of leakage (ELL) favouring cost savings over resilience
- Cost of capital forecasts that underestimated market conditions resulting in excess profits

At the heart of this lies a fundamental regulatory challenge. Stigler (1971) argued that regulators are vulnerable to “capture”, serving the interests of the industries they oversee rather than the public:

“as a rule, regulation is acquired by the industry and is designed and operated primarily for its benefit” (p.3).

Strong conceptions of capture, whereby the net effect of regulation is counter to the public good, may evoke illegal practices such as bribery and corruption, and the twisting of regulatory design by incumbent market players to favour their interests, such as by erecting barriers to new entrants, reflecting asymmetries across interest groups in their ability to lobby and influence. Yet, more recent empirical studies refute this claim, finding that cases of strong or pervasive capture are difficult to find and likely quite rare, with the reality often much more nuanced (Makkai and Braithwaite, 1992). Recent scholarship emphasises that capture is rarely absolute. Instead, Carpenter and Moss (2013) introduce the idea of “weak capture,” where subtle biases emerge from informational dependence, cultural familiarity, or shared professional norms, but where

the overall benefit of regulation is still assessed as a net public benefit. This counters arguments that deregulation is necessarily always the answer to ‘capture’ and suggests that greater understanding is needed of complex regulated-regulator dynamics to ensure that reforms protect the parts of the system that are robust in resisting strong capture, while targeting the weaknesses in the system.

The relationship will always be dynamic. In fact, studies indicate that in recent years firms may be more likely to seek deregulation itself, rather than actively pursue barriers to entry of their competitors. This highlights how those under regulation will continue to react and adapt. One risk is that industries are advantaged by greater resources.

McCarty (2013) suggests the wage premium on expertise in industry might be so large the government is left at a constant disadvantage, and, thus, advocates more competitive public salaries (while noting this might not be politically tenable).

This nuanced view is crucial in highly technical sectors like water or finance. Regulators may lack the internal modelling capacity or sector-specific expertise to independently challenge firms. Such asymmetries can foster “epistemic” or “algorithmic” capture, where the regulated shape the very tools, models, and assumptions used to govern them (Zingales, 2013).

Authors also point to specialist job pools whereby human capital is highly industry-specific, with many of the best paid jobs in industry. Accusations of a “revolving door” has been levelled at the water sector in England (Ungoed-Thomas, 2023), where people move between jobs in regulation and industry. This is thought to influence regulators incentives, even without direct job offers, to act more favourably to industry. These ideas tie into public choice theory which emphasises that bureaucrats like everyone else act out of self-interest, and that this can shape institutional dynamics (Ostrom, 1975). Other examples include the growth of bias due to close, frequent interaction and access, self-selection processes that may ignore wider perspectives (cultural capture or groupthink), and the dependency of regulators on the regulated for information (Zingales, 2013).

There are unfortunately no simplistic solutions. Fragmenting authority among multiple regulators (such as between Ofwat, EA, Natural England) may reduce the chance of capture through increased checks and balances, but can also produce coordination failures, duplicated effort, and deeper dependence on company-supplied data

(Carpenter & Moss, 2013), particularly if agencies are not given sufficient capacity, mandate, or accountability.

The focus should be on structured proximity: regulators must engage closely with industry but within clear boundaries, supported by institutional design. [Ansell, Boin and Keller \(2010\)](#) show that adaptive governance under uncertainty requires ongoing collaboration and knowledge exchange. But proximity must be balanced by strong public input, transparency, and plural expertise. Reforms might include: open data sharing to reduce information monopolies, standardised models and accounting rules, independent advisory panels to counter bias, mandatory disclosure of revolving door appointments, and enhanced in-house analytical capacity to reduce dependency. These measures do not eliminate the risk of capture but help manage it through transparency, contestation, and accountability.

6.1.2.7 Summary of the second theme: Institutional context

The privatised and regulated framework of England's water sector has ensured financial stability but created institutional barriers to collaboration and long-term strategic planning. Chapters 3, 4, and 5 illustrate how privatisation has embedded a fragmented regulatory system that limits standardisation, coordination, and transparency. While regional planning groups have improved engagement, fundamental governance challenges remain.

To overcome these limitations, England's water governance system requires structural reforms that enhance national coordination, introduce sustainable funding for non-PWS planning, and create regulatory mechanisms that balance certainty with flexibility. Without these changes, the sector may struggle to adapt to long-term challenges such as climate change, population growth, and increasing water scarcity.

6.1.3 What we value: eliciting objectives

The third theme of the research relates to how the approach to planning frames what is valued in decision-making, i.e. what the aims and objectives are. This happens through:

- (1) defining what is encompassed within the problem scope and remit,
- (2) establishing who can participate (who has authority and influence), and
- (3) using methods and tools to model preferences and trade-offs.

This section explores how these processes shape water resources planning in England, highlighting historical path dependencies (Chapter 3), governance structures and stakeholder engagement (Chapter 4), and the role of technical models in prescribing value (Chapter 5).

6.1.3.1 Remit

The boundaries of planning frameworks directly shape what is valued and prioritised. This relates to research on defining the bounds of ‘problemsheds’ (Allan, 1998; Mollinga, Meinzen-Dick and Merrey, 2007) and later, ‘problemscapes’ (Polaine, Nicol, *et al.*, 2022). These approaches recognise that water management involves ‘hard’ hydrological boundaries such as watersheds, catchments, and river basins, as well as ‘soft’ social boundaries such as institutions and complex interdependencies with food, energy, the environment, the economy, technology and so on more (Boelens *et al.*, 2016). Thus, an integrated, multi-disciplinary, and participatory understanding is needed of drivers and networks to avoid planning that is a poor match for reality, resulting in missed opportunities and unintentional consequences. Yet, to stop the problem becoming impractically amorphous, planning requires defining limits. As discussed in relation to scale, in a dynamic environment, all boundaries will be imperfect. However, some will be more suitable than others.

How these are drawn depends on the path dependency of how planning has developed, which in England we have described so far (particularly in Chapter 3) to be scaled according to private companies, overseen by national (and local and regional in the case of the Environment Agency) regulators and Defra. These boundaries have an impact on what the objectives are. For example, in interviews, water company practitioners described how new water supply options within company boundaries are considered preferable to ones outside due to reduced risk and complexity, for example, not needing to work with third parties. This demonstrates how arbitrary historical borders can influence what is valued in decision-making processes.

Additionally, the research reveals how the planning framework is heavily orientated towards public water supplied by private water companies. The established mature and prescriptive planning frameworks provide clear mechanisms for decision-making and investment, and have cultivated a pool of expertise across water companies and regulators. In contrast, planning for other abstractors is far less prescriptive, and the

input of wider stakeholders into the WRMP process largely confined to defined consultation periods. The fact that planning has been designed with a focus on the remit of PWS rather than non-PWS or other related stakeholders sets particular objectives and priorities, while excluding others.

The introduction of regional groups and national planning represented new developments that were initially designed to bridge the gaps of scale and fragmented company boundaries, reflecting the new explicit objective for more strategic planning. As mentioned in Chapter 4, discussion grew over an expanded remit of regional groups to consider non-PWS and more integrated planning beyond water resources into other policy areas, such as water quality, flooding and drainage, drought planning, habitats and ecosystems, amenity, and so on. This would reshape and broaden the objectives and values of the planning framework, likely leading to different solutions. In theory this could help avoid planning mismatches or later conflict and planning appeals. However, there is a risk that planning becomes unwieldy and ineffective. Watson (2015, p. 15) considers this in relation to the implementation of the water framework directive, discussing how policy makers had a:

“choice between developing relatively small and tightly defined groups focused only on water and habitat within the catchment, or to widen the scope to include more issues and attract support from a larger group of interests”.

This reflects the tension between a wide or narrow scope. To what extent should the problem be characterised differently at the outset of planning to include a broader remit, for example regarding affordability constraints, risk appetites, and interdependencies with other policy areas. Furthermore, for planning to be effective, it must materially as well as rhetorically embed ambitions for integrated planning. This brings in the question of what structural changes (e.g., regulatory mandates, funding mechanisms) are needed to make integrated planning a reality.

6.1.3.2 Participation

The remit of planning is intrinsically linked to who is defined as legitimate participants in the process. Effective planning balances diversity with practicality to:

“encourage and enable greater diversity whilst also reducing the risks that collaboration will fail” (Watson, 2015, p7).

Linking with scale, how can participation open a more collaborative model involving local politics, whilst scientifically following effective river-basin integrated management at larger scales. These conflicting paradigms risk paralysed decision-making (Perry and Easter, 2004).

As stated, water resources planning in England has evolved with a focus on private water companies. This process enables participation of other stakeholders and the public through processes of consultation and the elicitation of customer values through water company willingness to pay surveys. Outlined in Chapter 3, this has reorientated public participation towards consumer representation (Bakker, 2003), which can be argued to have increased the number of opportunities, relative to regional planning in the eighties which severed the link between water resource management and local authorities.

6.1.3.3 Role of technical expertise and transparency

However, the extent to which the public can engage in the process is debatable, particularly given low public awareness of water resources planning, the technical nature of modelling involved, and the substantial reporting to parse through (as outlined in Chapter 5). Ideally, everyone would be able to understand the process and the implications of uncertainty, however, maintaining a level of technical ability amongst regulators and policy makers, as well as within companies and consultancies is difficult, let alone across the public and wider stakeholders (Lane, 2014; Krueger *et al.*, 2016). This tension is inherent to interdisciplinary, unwieldy, “wicked” problems; following good or best practice for one field is difficult, following good practice for all fields is much more difficult, particularly where best practice contradicts rather than overlaps.

Yet it is critical that the regulators and policy makers, in charge of setting the vision and scrutinising progress towards it, understand both the robustness of the more detailed and local scale aspects of modelling, as well as how they combine to influence the wider picture. Building transparency and trust in decision-making given complex modelling underpinnings is one of the ongoing challenges outlined in Chapter 5. The complexity of the prescriptive and sophisticated framework, involving a long and complicated chain of modelling, presents a challenge. It raises the question of how the use and evolution of modelling could evolve to become more participatory and integrated.

This may require greater interaction between the public water suppliers with non-public water suppliers e.g. those abstracting water themselves for agricultural and industrial purposes. Which governance structures, common language approaches, common modelling approaches and use of metrics could be developed to allow more people into the process to bridge overlapping but often siloed fields of planning. It is likely that as we move further into the future with greater pressures from climate change, for growth and development, and to meet legal environmental and sustainability targets, there will be increasing need for the sometimes quite disparate groups to solve problems collaboratively using common tools and languages (Walsh *et al.*, 2013; Krueger *et al.*, 2016).

6.1.3.4 Eliciting value

Value is not only determined by path dependencies related to scale and boundaries. In Chapter 5, it is demonstrated how the choice of options is output through a technical and quantified process that prescribes decision-making variables that align with investment strategies, such as approved cost-benefit analysis methods and probabilistic risk modelling. This process twists value into an abstract mathematical exercise. Metric definition and fulfilment risks becoming an end in itself (Nguyen, 2024), however, it can be helpful for transparent, evidenced based decision-making that can be held to account. It is helpful to keep in mind that this approach is pragmatic in nature rather than an accurate reflection of any 'objective truth'. It is difficult to estimate how closely the values prescribed by these metrics and approaches, and fit to the institutional context, match the values of the public, or the company's customer base.

An alternative approach is proposed by Raynor and Cantor (1987), who advocated for integrating trust, liability, and consent-based principles into risk management. This would shift planning away from purely probabilistic risk assessments towards a more socially responsive framework that considers stakeholder confidence and perceptions of fairness:

“as an alternative to using preferences regarding the probabilistic concept of risk, we suggest using the decision maker’s preferences for principles of consent, liability, and trust as underlying determinants of derived risk perceptions... help risk managers construct meaningful possible solutions to be offered in public forums.” (Raynor and

Cantor, 1987)

What could this mean in practice? One emerging field of practice is the use of deliberative mini publics (DMPs) to elicit public preferences. Deliberative mini publics can take various forms (see Figure 23). These forms have evolved over recent decades as DMPs have grown in popularity.

	Developed by (first instance)	No. of members	No. of meeting days	Outcome
Citizens' juries	Crosby (USA, 1971)	12–26	2–5	Collective position report
Planning cells	Dienel (Germany, 1970s)	100–500	4–5	Survey opinions + collective position report
Consensus conferences	Danish Board of Technology (1987)	10–25	7–8	Collective position report
Citizens' initiative reviews	Healthy Democracy (USA, 2008)	20–24	3–5	Citizens' statement
Deliberative polls	James Fishkin (USA, 1994)	100–500	2–3	Survey opinions
Citizens' assemblies	Gordon Gibson (Canada, 2002)	50–160	4–30	Detailed recommendations

Source: Based on Elstub (2014).

Figure 23. Variation in the design of DMPs, source (Farrell and Field, 2022, p. 290)

Citizen's assemblies, typically composed of randomly selected participants representative of the broader population, engage with balanced expert input over structured sessions to develop informed recommendations on complex policy issues:

“through careful and informed deliberation by regular citizens who have no agenda or ulterior motive (in contrast to politicians, whose focus tends to be on re-election)”
(Farrell and Field, 2022, p. 289).

Citizens' assemblies have been used to address topics such as electoral reform in Canada, abortion and marriage equality in Ireland, and climate policy in the UK, and are expanding into many more policy areas (Pal, 2012).

While sometimes portrayed as 'direct democracy', they tend to function as complements to representative institutions, enhancing legitimacy and deepening public input (Nielsen and Sørensen, 2023). Research shows assemblies can combat polarisation, bipartisanship, and short-termism, and promote trust, education, consensus building, policy making, value elicitation, and compromise (Česnulaitytė, 2024).

However, their effectiveness depends on design and follow-through. Key features for success include random, representative selection, clear mandates, political commitment to consider outcomes, well-facilitated, high quality deliberation, neutral expert input, and transparent communication with the public (Sandover, Moseley and Devine-Wright, 2021). The skill of the workshop facilitators is crucial.

There is the risk of disillusionment if recommendations are ignored or diluted (Wells, Howarth and Brand-Correa, 2021). One study noted variation in the success of whether recommendations are implemented.

“[of] 55 of the cases in that study... a little over a third (36 per cent) had all their recommendations implemented; a similar proportion (40 per cent) had half of the recommendations implemented; in just 11 per cent of cases were none of the recommendations implemented” (Farrell and Field, 2022, p. 295).

Some argue for the outputs of citizen juries to be directly become public policy. Others posit that wider structural change is required to shift policy and outcomes to become fairer and more democratic like many decision-making process that involve the distribution of resources.

Democratic forums are inherently at risk of familiar governance challenges related to power. DMPs are not immune from influence from interest groups with differing levels of power and access (Kenyon, 2005). Poorly designed forums risk tokenism and elite capture. These risks are heightened if the process gets captured such that interests overly shape participation, agenda-setting, the selection of experts, and the management of the deliberation process. Without transparency and commitment, assemblies can backfire undermining rather than restoring trust.

The external institutional environment is also critical. Boswell, Dean and Smith (2022) question whether policy recommendations taken at a single snapshot mesh well with the messy reality of policy implementation. Observing that some assemblies evolve into working groups to review government responses to recommendations, publicise outputs, or review implementation, the authors raise questions around the legitimacy of these groups that were initially randomly picked as a representative snapshot of collective public opinion. They highlight the need for greater empirical study of the many and diverse ways that assemblies, and other forms of mini publics, are being run and

become integrated into democratic structures (Huitema, Cornelisse and Ottow, 2010; Wells, Howarth and Brand-Correa, 2021; Boswell, Dean and Smith, 2023).

Yet, despite these risks, the use of assemblies can counter some of the problems of the current system. For example, relating back to water resources planning in England, the model of representative democracy leads to democratic deficits. Elected ministers are not necessarily incentivised to develop a deep understanding of niche policy areas, or the public's true preferences. They are tasked with broad remits, advised by a generalist civil service, and under political pressure to find wins in the short term. Detailed planning gets shifted to the regulators and water companies. It turns into a technocratic exercise conducted by a relatively small and specialised group of people and becomes removed from democratic input, potentially reducing its legitimacy. Citizens' assemblies and other deliberative mini forums may offer to remedy this democratic deficit while maintaining the stability of existing institutions and knowledge.

As relatively new innovations, studies note that practice is outpacing theory given the growth and diversity of mini forums in recent years. Greater research and "cautious experimentation" (Sandover, Moseley and Devine-Wright, 2021, p. 83) is needed on the design, benefits, limitations, and long term impact of mini-publics.

6.1.3.5 Summary of the third theme: Value

Defining planning objectives is not just a technical exercise; it is deeply influenced by governance structures, stakeholder engagement processes, and decision-making tools. Chapter 3 illustrates how historical path dependencies have locked England into a PWS-dominated planning system, shaping priorities and institutional constraints. Chapter 4 highlights the role of stakeholder engagement in defining planning objectives, showing that participation remains limited to predefined consultation mechanisms. Chapter 5 explores how modelling frameworks shape investment decisions, raising concerns about the transparency and accessibility of technical decision-making. Moving forward, planning systems must evolve to integrate broader societal values, strengthen participatory processes, and balance quantitative rigor with qualitative insights. Planning must balance taking an integrated, inclusive, and transparent approach that reflects public values and cross-sector interdependencies, while acknowledging the tension between broadening scope and maintaining practicality and effectiveness in decision-making. Consideration of scale and participation will be central to setting the

boundaries of problems relating to who should be included and how can the format and process be designed to ensure that everyone included at that scale is sufficiently engaged and involved, such as through cross-sector forums led by neutral chairs (Watson, 2004), allowing for clarifications and establishing a common language (Lockwood *et al.*, 2010; Conrad, 2018; Colloff and Pittock, 2019), and considering benefits and risks of standardisation. By addressing these challenges, England's water governance can become more adaptive, inclusive, and responsive to future uncertainties.

6.1.4 Uncertainty and complexity: adaptability in a dynamic environment

The fourth theme that comes out across the three chapters is the dynamism and uncertainty inherent to long term planning, signifying the need for adaptiveness. This section explores how uncertainty is managed at institutional, strategic, and technical levels, examining the tensions between flexibility and regulation, trust in decision-making, and the evolving role of adaptive governance. Chapter 3 introduces the concept of wicked problems with water resources planning being a long-term exercise that involves future uncertainties, subjectivities, complexities, and multi-actor networks operating within dynamic institutional environments. Chapter 4 highlights institutional flexibility and collaboration as tools for navigating uncertainty, while Chapter 5 focuses on the technical challenges of uncertainty propagation, evidence scrutiny, and balancing flexibility with accountability.

6.1.4.1 Designing flexible institutions amid dynamic environments

Long-term water resources planning occurs in an inherently uncertain environment, influenced by climate variability, demographic changes, economic shifts, and policy instability. Chapter 3 illustrates how historically addressing uncertainty has been within a context of institutional fragmentation, evolving in a disjointed yet adaptable manner, particularly with the 5 yearly WRMP and Price Review cycle. Chapter 4 highlights the introduction of the National Framework as a response to the challenge of fragmentation and the need to develop more resilience given wider future uncertainties. Regional planning groups experimented with different styles of national reconciliations and approaches to strategic coordination, fostering social capital and collaborative problem-solving observed through the increased interactions between actors (Lopez-

Gunn, 2003; Memon, Painter and Weber, 2010; Benham and and Beavis, 2014; Eberhard *et al.*, 2017).

This revealed benefits of purposefully designing in flexibility. Practitioners mentioned that greater coordination would have helped improve the process. However, considering this scale of strategic planning across typically siloed actors occurred for the first time, representing a significant step up organisationally and resource-wise, there were several positives gained, including the development of social capital and broad commitment to collaboration. These factors are helpful in an uncertain environment, linking to the discussion on scale on the benefits of bridging and intermediaries, which helps create a more dynamic institutional structure reflecting reality, and build resilience to instability in the wider environment such as political and economic changes (Margerum and Robinson, 2015).

What was clear through Chapter 5 is the that although the new governance arrangements allowed for greater collaboration, they also meant a step up in workload and reporting, and revealed a lack of consistency across foundational assumptions and modelling behind much of evidence base of decision-making (Turner and Jeffrey, 2021). This created difficulties in reconciling strategic national objectives with operational, company-level realities. These factors make the process less transparent and more difficult to scrutinise. Chapter 4 suggests that governance structures must balance flexibility with coordination mechanisms to ensure adaptability without sacrificing accountability (Conrad, 2018).

6.1.4.2 Technical methods for addressing uncertainty and complexity

As Chapter 5 outlines, the complexity and uncertainty of the decision-making process, including the role of technical modelling, create a challenge for those involved to have a clear understanding of the outcomes. A question arises as to whether those scrutinising planning outcomes are confident that the process is robust, relating to problem characterisation, process, outcomes, and the sensitivity of those outcomes to methodological modelling choices, policy choices, underlying assumptions about the physical world, subjective judgements and risk appetites, and other 'black swan' events (the unknown unknowns) (Marchau *et al.*, 2019).

Technical methods are being increasingly employed to tackle the challenge of uncertainty, such as the use of stochastics, adaptive scenarios and robust optimisation modelling, generally considered by practitioners as positive developments (Hall and Borgomeo, 2013; Harou, 2023). The methods are somewhat inconsistently incorporated, making it difficult to match the strategic picture at the national level, with the propagation of uncertainty through multiple models of different types across multiple companies WRMPs, business plans, and Ofwat's final determinations.

Greater consideration of how planning outputs could be simplified possibly with greater standardisation and consistency may help with demonstrating the evidence behind decisions and allowing for more effective scrutiny and trust (Rouillard and Spray, 2017). However, the challenge of striking the right balance between too little information and information overload is difficult and is relatable for many policy areas. In fact, this research itself must navigate this tension in providing sufficient, but not excessive and superfluous, evidence.

6.1.4.3 The Tension Between Adaptive Planning and Regulatory Rigidity

Adaptive planning which incorporates scenario analysis, monitoring, and trigger points, and the concept of 'robustness' can be a practical approach to forward planning that is flexible to a wide range of future scenarios, such as shifting climatological and hydrological conditions, as well as costings and social acceptance (Erfani, Pachos and Harou, 2018; Workman *et al.*, 2021). Nonetheless, England's regulatory framework remains largely static, with set WRMP cycles, prescriptive investment justifications, and stringent financial oversight, which raises the tension between the pragmatic flexibility of this approach, with the rigidity required by the regulatory system, and requirement for clear accountability. The litigious and regulated nature of company expenditure acts as a constraint on the ambition for more adaptive and resilient planning (given uncertainties of factors such as future growth and climate change).

One of the recommendations is to promote not just adaptive planning (in the stricter sense of alternative pathways, trigger points, and monitoring), but adaptive governance. Adaptive governance aims to emphasise the need for critical reflection, learning, scrutiny, participation, and a willingness to reform not just the methods, but the governing rules and interactions between actors (Curtis *et al.*, 2014; Rouillard and Spray, 2017). This reflects this complex landscape of planning where there is no silver

bullet for how to plan well, but rather many ‘*necessary but not sufficient*’ criteria (Baldwin *et al.*, 2018). Many studies have outlined some of the factors that require consideration including leadership, funding and resourcing, knowledge, shared perceptions, homogeneity, political support, transparency, and many others as summarised in Chapter 4. It is difficult to pin down the main barrier to effective planning or the correct mitigation strategy given many aspects that must come together. Having adaptive planning and governance recognises that adjustments will continually be needed, and learning allows the rules, plannings, reporting, methods to evolve with the dynamic environment. Implementing adaptive governance requires evaluation, interaction, open-data and transparency, sufficient funding and resourcing, clear roles and accountability, effective and fair enforcement.

6.1.4.4 Summary of the fourth theme: uncertainty

Managing uncertainty and complexity in water resources planning requires a multi-layered approach, balancing institutional adaptability, technical transparency, and regulatory accountability. Moving forward, governance frameworks must incorporate adaptive planning mechanisms, improve transparency, and build institutional trust. By doing so, England’s water governance can better navigate uncertainty and deliver sustainable, resilient water management strategies.

Chapter 7. Conclusion

Water resources planning in England is undergoing a significant transformation to address growing challenges posed by climate change, population growth, and environmental pressures. Historically fragmented and company-specific since privatisation, the planning framework has evolved towards a more multi-scale governance approach with the addition of national, and regional planning tiers. By analysing England's 2020-2024 water resource planning cycle through qualitative analysis, including semi-structured interviews with industry practitioners, document reviews, and embedded research in planning groups, this research critically examines how historical pathway dependencies have characterised the development of the new arrangements, the embryonic role of strategic coordination, and the balance between granularity and trust in water modelling. Operating within strict economic and legal constraints, though not legislated for itself, the introduction of England's National Framework for Water Resources in 2020 marked a major step toward overcoming company-boundary limitations by fostering regional and national coordination. This study highlights both the successes of the emerging multi-scale governance model, alongside difficulties linked to misalignments and gaps in the framework. This research identifies how adaptive governance, and greater interdisciplinary collaboration can improve trust and clarity in decision outputs.

7.1 Findings of each chapter

This section summarises the core three research chapters and their implications in relation to the overall goals of the thesis. Some aspects are repeated across each chapter to provide important foundational context, for example the regulatory environment and the recent introduction of the non-legislated National Framework and regional planning. Each chapter was original in a particular way; Chapter 3 in its historical-institutional approach, Chapter 4 in its engagement with real-time governance dynamics and planning practice, and Chapter 5 in its interrogation of technical evidence.

7.1.1 Chapter 3: The Changing Landscape of Water Resources Planning in England

Aim: To understand water resources planning in England and how it developed.

7.1.1.1 Background context and history

Chapter 3 outlines how water resources planning in England has evolved from a fragmented, localised approach to a more strategic, multi-scale framework. The concept of path dependency is central to this analysis, as historical decisions around governance structures, regulatory frameworks, and economic priorities continue to shape current planning processes (Sehring, 2009). Early institutional arrangements, such as the division between public and private actors, and the shift from regional water authorities to privatised companies, established entrenched ways of thinking and operating, which persist in contemporary governance challenges. One of the key historical dynamics explored is the tension between economic efficiency and the public good. The neoliberal restructuring of the water sector in the late 20th century introduced competitive market principles that, while driving efficiency, also reinforced siloed decision-making and limited collaborative governance. These inherited structures set the stage for the ongoing difficulties in aligning national, regional, and company-scale planning today (Hall and Lobina, 2008).

7.1.1.2 Linking historical developments to planning today

A key contribution of this chapter is its analysis of how past institutional arrangements continue to shape present-day planning. The introduction of the National Framework in 2020 represents an effort to overcome historical fragmentation by fostering cross-company and regional collaboration in the hope of implementing inter-company and cross-regional solutions that can provide more resilience in the face of future water insecurity. However, the historical tendency towards company-defined planning, embedded through decades of regulatory and economic structures, presents persistent barriers to achieving fully integrated water resources management. These path dependencies influence planning today in several ways:

- Fragmented governance structures; the long-standing division of responsibility between regulators, private companies, the government, and other abstractors and stakeholders poses a barrier to national scale strategic and integrated planning (Marshall, 2012).
- The inertia of rules and decision-making structures established decades ago still guide planning today (Lowndes, 2005), making it difficult to introduce more

adaptive and collaborative approaches that do not interfere with, conflict with, or duplicate the existing framework.

- Embedded economic and legal incentives; the privatised nature of the industry continues to prioritise cost efficiency and return on investment, which some question as being at odds with the ‘public good’, long-term resilience and integrated water management (Chowdhury and Behera, 2022; Zetland, 2023).

7.1.1.3 Lessons for subsequent chapters

By tracing the historical evolution of water resources planning, this chapter lays the foundation for the discussions in Chapters 4 and 5. The governance challenges identified, such as fragmentation and structural dynamics, carry forward into the analysis of real-time collaborative planning (Chapter 4) and the evaluation of technical modelling frameworks (Chapter 5). Specifically, Chapter 4 builds on the findings about historical governance silos and examines whether the introduction of regional planning groups can overcome these institutional constraints. Chapter 5 explores how the legacy of past decision-making frameworks affects the transparency and trust in technical modelling. Thus, this chapter not only provides a historical overview but also establishes the critical institutional constraints that subsequent chapters evaluate in a contemporary context.

7.1.2 Chapter 4: Collaborative, Multi-scale Water Resources Planning in England

Aim: To observe current practice to understand the process of water resources planning in real-time.

7.1.2.1 Background context

Leveraging on the conclusions of Chapter 3, this study situates England’s water resources planning within the broader shift towards multi-scale governance. The effectiveness of this transition depended not just on institutional design but also on how practitioners engaged with and interpreted these new structures in practice. This chapter, therefore, moves beyond policy analysis to a real-time case study of the 2020-2024 planning round, incorporating direct practitioner insights gathered through interviews, workshops, and embedded engagement.

7.1.2.2 Observing real-time planning: practitioner experiences

By actively engaging in the planning process, this case study highlights three key practitioner perspectives that shaped the success and challenges of multi-scale planning:

- Perceived benefits of collaboration: Practitioners widely acknowledged that regional groups improved consistency and knowledge-sharing, particularly in aligning technical methods and planning assumptions (Margerum and Robinson, 2015). Many reported that for the first time, cross-company and cross-regional discussions led to a strategic picture of national water supply risks, rather than company-specific assessments.
- Challenges of institutional misalignment: Despite these benefits, the study identifies persistent tensions between regional collaboration and company-level autonomy. Some water company planners expressed concerns about regulatory uncertainty and late-stage policy changes, which disrupted planning schedules and created inconsistencies in modelling assumptions. Additionally, while the National Framework aimed to increase multi-scale coordination, practitioners often felt that roles and responsibilities remained unclear.
- Role of trust and power dynamics: Interviews, workshops, and observations revealed a collegiate culture and common vision across the sector which provided a strong basis for growing collaboration at regional and national levels (Ahopelto *et al.*, 2024). However, actors were still driven by competitive and regulatory pressures, limiting the extent to which they shared data and engaged in cross-company solutions. This challenge underscores the legacy of the privatised system, as analysed in Chapter 3.

Through iterative engagement with practitioners in real-time, Chapter 4 considers how existing multi-scale structures would benefit from greater coordination, while recognising the inherent constraints of a highly regulated and privatised system, and the barriers of transaction costs. The evaluation leads to the recommendation to embed more explicitly the developing multi-scale framework balancing strategic planning with the principle of subsidiarity (Memon, Painter and Weber, 2010). Chapter 4 posits that having flexible coordination at the national level would prove beneficial, driven by trusted intermediaries able to proactively flag and solve problems rather than encounter

delays and difficulties late in the schedule. Chapter 4 also highlights how embedding flexible regional groups allows for connections vertically and horizontally across scales and actors, providing forums to flag priority issues and promote promising solutions (Huang *et al.*, 2022). This bridging of existing gaps in coordination, particularly at the national level, for non-PWS through regional groups, and at the catchment and local levels of planning helps drive improvements and learning, while maintaining accountability and nurturing the developing social capital and collaborative approach.

7.1.2.3 Linking to broader governance lessons

The practitioner-led analysis in this chapter builds on Chapter 3's findings about historical fragmentation and evaluates whether contemporary reforms are effective in overcoming these institutional legacies. While some improvements in alignment and coordination were evident, challenges related to power dynamics, trust, and policy uncertainty remained significant. Chapter 3 showed how past governance structures created fragmentation. Chapter 4 assesses how regional planning attempts to address these barriers in practice. These findings serve as a bridge to Chapter 5, which further examines how governance structures shape technical decision-making, analysing whether technical modelling frameworks have evolved to reflect this new governance landscape or whether persistent silos still create inconsistencies in decision-making.

This chapter's real-time observations suggest that while regional planning has improved strategic coordination, the persistence of regulatory fragmentation, competitive pressures, and trust deficits continue to hinder fully integrated decision-making. These unresolved governance challenges directly influence the modelling inconsistencies and transparency concerns explored in Chapter 5.

7.1.3 Chapter 5: The Complexity of Clarity: Balancing Granularity and Trust in Modelling for Water Resources Planning in England

Aim: To understand the evidence and justifications of the outcomes of the 2020-2024 planning process since the implementation of the National Framework and regional planning.

7.1.3.1 Background context

Water resources planning in England is underpinned by extensive modelling frameworks, which aim to justify investment decisions and ensure future water supply

resilience. The introduction of new regional and national-scale planning frameworks (as discussed in chapters 3 and 4), created increased requirements for cross-company consistency in modelling assumptions and methods.

However, this shift brought significant tensions to the forefront, revealing the variability and complexity of technical methods across different companies. On the one hand, increased technical sophistication allows for more precise and risk-informed decision-making. On the other hand, greater complexity makes it harder to maintain consistency, and reduces transparency, trust, and accountability, particularly in a highly regulated and privatised environment (Colloff and Pittock, 2019). This chapter critically evaluates how these tensions played out in practice by analysing modelling frameworks, outputs, and practitioner perspectives.

7.1.3.2 Evaluating technical modelling

Through an assessment of planning documents, interviews, and engagement with practitioners, this study identifies several key challenges that emerged in the 2020-2024 planning round.

Firstly, inconsistent modelling standards across companies and regions. Despite efforts to align modelling approaches, practitioners reported that companies continued to use different software, assumptions, and methodologies. These inconsistencies made it difficult to reconcile regional and national plans, leading to uncertainty over investment decisions and regulatory approval processes. Yet, aligning models involves high transaction costs (Garrick and Aylward, 2012) and violates the sunk costs fallacy (Arkes and Blumer, 1985).

Secondly, tension between modelling granularity and decision-making clarity. The emphasis on detailed, high-resolution modelling led to significant variations in outputs, making it harder for regulators and stakeholders to interpret results. Practitioners highlighted the need to balance technical sophistication with clear, interpretable outcomes, particularly in justifying investment to regulators and the public.

Thirdly, lack of trust in modelling outcomes and the role of power dynamics. Water companies, regulators, and regional groups expressed varying levels of trust in each other's modelling outputs, often due to different underlying incentives. Some company practitioners saw the modelling process as overly prescriptive, while regulators were

concerned about transparency and the potential for companies to manipulate assumptions to justify preferred investments.

These findings suggest that while improved modelling techniques offer opportunities for more accurate and risk-informed planning, they also introduce new governance challenges that require stronger coordination and oversight (Godinez-Madrigal, Van Cauwenbergh and van der Zaag, 2020).

Based on this analysis, Chapter 5 identifies eight inherent planning tensions related to designing the planning process:

1. *Ambiguity resolution*: exploration versus binary decision-making
2. *Standardisation*: non-prescriptive versus prescriptive
3. *Scale*: local versus national
4. *Techno-political*: turbulent versus stable
5. *Proximity dilemma*: distance versus closeness
6. *Accountability trap*: vacuum of responsibility versus legal and reputational risks
7. *Scope*: narrow and pragmatic versus wide and diverse
8. *Communication*: complex and extensive versus simple and limited

7.1.3.3 Linking governance and modelling challenges: connections to chapters 3 and 4

The planning tensions identified in this chapter directly stem from the historical and governance issues discussed in chapters 3 and 4. Institutional legacies still influence how modelling is conducted today, as companies prioritise internal modelling frameworks aligned with their own financial and regulatory incentives rather than a unified national approach. Chapter 4 highlighted ongoing governance challenges in regional collaboration, including regulatory uncertainty and competitive pressures. These issues are reflected in the modelling process, where regional and company-specific approaches continue to diverge, despite efforts to promote national consistency. Chapter 5 extends those discussions by examining how these governance tensions translate into technical modelling dilemmas. It demonstrates that without further coordination and trust-building mechanisms, modelling could exacerbate rather than resolve governance challenges (Godinez-Madrigal, Van Cauwenbergh and van der Zaag, 2020).

7.1.3.4 Implications and recommendations: towards a more integrated modelling approach

One question that arises is how to promote trust given increasing complexity and specialisation. A key implication is that a dynamic and specialised environment requires ongoing balancing of granularity and trust. Based on these findings, Chapter 5 proposes three key recommendations:

- (1) Embed adaptive planning approaches: given the uncertainties in forecasting and investment decisions, future planning should integrate adaptive pathways that allow for adjustments as conditions evolve.
- (2) Rationalise and consider standardisation, enhancing transparency: a national-level coordination body could help reduce inconsistencies in modelling approaches, ensuring that assumptions and outputs are more comparable across regions.
- (3) Embed reflective and adaptive governance: to improve decision-making confidence, modelling frameworks should be co-developed, evaluated, and continually improved with input from regulators, water companies, and other stakeholders to foster greater shared ownership of results.

These recommendations emphasise that effective planning is not just a technical exercise but also a governance challenge. The integration of adaptive governance principles, as discussed throughout the thesis, will be essential for balancing modelling complexity with clarity and trust. There are many considerations for implementing these recommendations; how can the process be designed in ways that allows modelling to be better translated to allow people into the process to help identify potential risks and opportunities and enhance robustness? Krueger *et al.* (2016) proposes using common languages, methods, and “junctions” in the process to broaden participation. How can this thinking be implemented within the current siloed and complex economic, legal, and regulatory frameworks than tends to incentivise people to stay within their remits? Regional groups may be well positioned in this space to help bridge siloes in a way that maintains flexibility and pragmatism (Conrad, 2018).

7.2 Disciplinary implications

What this research project has demonstrated is that water resources planning in England is sophisticated and impressive despite its flaws. Noting problematic areas to improve, overall, water resources planning is proactive compared to other areas of planning. The mature framework requires water companies to consider what investment is needed over at least a 25-year period, and the introduction of regional and national tiers have provided platforms for a more strategic collaborative approach between a complex network of actors. This planning results in real outcomes including investment into demand and supply schemes, based on an evidenced-based decision approach that considers uncertainty, and a value system beyond simply lowest cost. Engagement with practitioners at different levels demonstrated a collegiate culture and common vision for resilience and environmental protection. As such, there are many reasons to be optimistic for the future of water resources planning in England.

7.2.1 Future risks and challenges

Noting these positives, there are several areas which could expose the vulnerabilities of the evolving framing, outlined below.

Drought. Drought can provide an impetus for reforming planning; if an event occurs that is outside the range of planning, resulting in unanticipated water shortages, the existing process will likely be called into question. As outlined in Chapter 5, due to uncertainties and nonstationary of future climate and the hydrological response, and the inadequacies of modelling, it is difficult to estimate the size of this risk (Chan *et al.*, 2023). This underlines the need to continually fund the research and improvement of the planning assumptions underlying decision-making. It also underlines the importance of communicating risk and engaging buy in from the public.

Conflict and competition over licence changes. As the Environment Agency (EA) mandates stricter licence reductions to comply with meeting Water Framework Directive objectives and its 'no deterioration' clause, it is possible that conflict may arise among abstractors (such as farmers) and with the EA. Moreover, with a changing climate, habitats, ecosystems, and river systems will change. There is ambiguity over the interpretation of 'no deterioration' in relation to how much change is acceptable with a changing climate change. Should water companies be planning to maintain water

environments in their current state, potentially through increased investment in water resources infrastructure to offset the impacts of a warmer (and wetter) climate, or should the 'baseline' be adjusted, and if so, how would this be defined? Chapter 4 highlights the benefits of collaborative planning, but also the risks of fragmentation and inconsistent engagement. This underlines the need for clear, and early warning of any licence changes and a process for resolving allocation disputes, emphasising narratives that promote shared management of a common resource, over conflict and competition.

Limits to growth. Different sectors may demand more water. With the government promoting growth, such as house building in the OxCam arc, and industries such as data centres, hydrogen production, and other water intensive businesses, there is a risk that these growth ambitions will be restricted by water resource constraints under environmental protections, particularly in the East and Southeast where water is scarcest. There have been indications of this around Cambridgeshire and Sussex where developments have been blocked due to water neutrality regulations (Early, 2024). Therefore, calls for more integrated planning, as discussed in Chapter 4, should be heeded so that interconnected areas of policy, such as spatial planning, energy, food, and water, develop symbiotically rather than antagonistically (planning bottlenecks, project delays, and legal disputes).

Failure to meet demand targets. Reducing water demand rather than building new supplies is an efficient and environmentally friendly way to reduce predicted deficits. However, Chapter 5 raises concerns about how realistic meeting these targets is given unpredictable consumer behaviour, not wholly under the control of companies, and rebound effects (short-term reductions offset by increased demand). Unlike other countries which have managed to drastically reduce water consumption during drought, such as Australia and South Africa (Hemati *et al.*, 2016; Booysen, Visser and Burger, 2019; Brick, De Martino and Visser, 2023), England has a much wetter climate and may well face increasing flooding and wet events alongside increasing drier events. This might dampen the ability to drive reduced consumption, particularly in wetter regions such as in the north and west of the country. Demand policy targets are baked into planning assumptions (daily per capita consumption (PCC) of 110 litres and leakage cut by 50% by 2050 (compared to 2017 baseline)). Yet, there is a risk that if these targets are

not met, deficits will be realised. This is a difficult area for regulators who must balance a strong position on the need for companies to meet the targets, with the need to allow companies to plan for contingencies if targets are not met, and additional supply-side investments are needed to fill the gap. Many practitioners in interviews raised this as a potential concern (Neale et al, 2020).

Unsustainable transfers. Once transfers are built, they entrench economic patterns that are difficult to rescind, even if the background climatology and hydrology changes. This was the case in Spain where long distance transfers, from the centre of the country to support irrigation in the southeast, are no longer viable under EU Water Framework Directive rules. The rules aim to protect source region environments that have seen reduced river flows. This has created a politically sensitive question over who has the right to the water and what should happen to industries dependent on the transfers (Lopez-Gunn, 2009; Hernández-Mora *et al.*, 2014; Marcos Fernández, 2017). Chapter 3 examines historical precedents of infrastructure-driven path dependency, while Chapter 5 highlights the challenge of balancing supply security with sustainability. Future planning must ensure robust mechanisms for reviewing the long-term viability of transfer schemes, including regular re-evaluations of transfer sustainability under changing climate conditions, transparent and participatory decision-making that builds broad support and incorporates trade-offs, and strong accountability frameworks to prevent unsustainable economic lock-in (Méndez, Amezaga and Santamaría, 2019).

7.2.2 Insights from research

Effective institutional design should be guided by principles of good governance, with a strong emphasis on transparency, rigorous monitoring, and learning. While governance frameworks should allow for flexibility in participation strategies and technical approaches, this must be balanced with a structured mechanism for evaluation to ensure coherence across different regions and scales. Bridging organisations and intermediaries play a crucial role in this process, facilitating coordination between fragmented institutions while ensuring that local decision-making aligns with broader national objectives.

At the national level, a cohesive oversight structure should provide strategic direction and policy alignment, ensuring consistency in planning processes while allowing for adaptive, locally led solutions. Meanwhile, regional and local decision-makers should

be actively engaged from the outset, with access to sufficient resources, structured support, and transparent communication channels. Early and continuous engagement is essential to build trust, improve responsiveness, and enhance collaboration across sectors. By integrating top-down coordination with bottom-up empowerment, institutional frameworks can better navigate complex, dynamic challenges while fostering a resilient, adaptable, and inclusive planning process.

7.2.3 Targeted recommendations

7.2.3.1 Industry

1. Continue to work collaboratively with each other, regulators, and policy makers to improve coordination
2. Expand data-sharing initiatives to promote greater transparency and consistency
3. Strengthen innovation efforts in demand reduction, leakage control, and nature-based solutions
4. Enhance engagement with non-PWS sectors to improve cross-sectoral water resource planning
5. Invest in training people to think holistically and work collaboratively with other companies, sectors, stakeholders

7.2.3.2 Regulators

1. Enhance coordination across regulators, and with government and regional groups (considering timetabling, feedback, policy changes, definitions and methods)
 - Establish how to improve coordination across regulators. RAPID was set up to overcome some of the regulatory misalignment for Strategic Resource Options (SROs), consider how it can be developed more broadly, for example used to align and streamline feedback across the EA, Ofwat, and NE to avoid contradictory feedback and policy.
2. Restructure the WRMP cycle timetable to improve change management across key stages of planning (1) problem characterisation and objectives, (2) methods, (3) exploring feasible options, (4) deciding on portfolios of (nationally reconciled) feasible options
3. Establish open access, transparent national databases and improved standardisation

- Drought libraries (joined up research into meteorological, hydrological, geological risk, incorporating climate change)
 - Demand projections (joined up survey of local authorities and ONS)
 - Environmental condition
 - Metrics
 - Performance indicators
 - Reporting standards and formats
4. Communicate performance indicators that reflect outcomes rather than outputs in ways that build public trust
 - Complement cost-benefit analysis with qualitative assessments, social impacts, equity, sustainability, and long-term resilience

7.2.3.3 Policy makers

1. Enhance coordination with regulators and regional groups (considering timetabling, feedback, policy changes, definitions and methods)
2. Establish a cross-departmental group or intermediary to flag synergies and barriers between interdependent areas of planning (water, spatial planning, energy, agriculture, business, the environment, climate change)
3. Secure sustainable funding mechanisms for multi-scale planning, through a sustained, reliable source, such as an abstraction licence fee, for:
 - a. A national coordination office
 - b. Regional groups
 - c. Local and catchment initiatives
 - i. Regional groups may help to prioritise high risk catchments that would benefit from integrated solutions
4. Ensure sufficient funding and resourcing for regulators (especially the EA and NE)
5. Recognise the government's role in taking action to support demand management
 - a. Legislate for comprehensive smart metering that can feed into national monitoring system of progress given significant risks
 - b. Finalise legislation for demand management (water labelling, building regulations)
 - c. Coordinate effort in line with statutory planning frameworks

6. Trial innovative participation strategies such as citizens assemblies to engage the public and better understand the trade-offs involved in water resources management, particularly balancing risk, affordability, environmental protection, growth, and around particular controversial options such as desalination, reservoirs, water re-use.
 - a. E.g. multi-stakeholder forums at key planning stages, led by neutral chairs, to balance technical expertise with broader public input.
7. Clarify governance: review the balance of regulation and legislation and collaboration for planning, considering the requirements be for (1) consultation, (2) documentation, (3) governance and coordination, and (4) funding.
 - a. Consider each of these for relevant actors: PWS, non-PWS, regional groups, catchments groups, and links between existing statutory plans¹.

Moving forward, water governance must evolve to integrate adaptive planning mechanisms, strengthen transparency, and enhance cross-sectoral collaboration. Is there sufficient leadership in government to step into the “accountability trap”? If not, how can existing arrangements be made to work through improved coordination, social capital, and trust building (e.g. better transparency and scrutiny through common reporting). By embedding learning-based governance, the planning framework can become more resilient to climate change, socio-economic shifts, and emerging policy challenges.

7.2.4 Recent developments in policy

7.2.4.1 The Cunliffe Review, interim report published June 2025

Following the election of the Labour government in July 2024, the government commissioned Sir Jon Cunliffe to conduct a review of the water industry. The commission sought views from key stakeholders across the water industry including water companies, regulators, and key water using sectors, and held a public consultation. An interim report was published in June 2025. The final report is due to be published later in the summer 2025.

¹ WINEP / RAPID gated assessments / LROs / DWMP / RBMP / FRMP / CaBA / local plans

The interim report reflects the commissions discussions with and calls for input from selected stakeholders; the report mentions over 150 meetings with those with an interest in the water sector (Cunliffe, 2025). An appendix was published alongside the interim report explaining that the public consultation received over 50,000 responses, which the commission continues to evaluate for the final report, using quantitative analysis and Artificial Intelligence (AI) to pick out themes.

The report presented five themes:

1. National strategy: clear, long-term vision that is regional and multi-sector
2. Legislative framework: streamlined and emphasising science, innovation, and discretion
3. Regulation: strengthened, active and engaged, promoting consumer voice
4. Economics and ownership models: maintain stable long-term investment
5. Resilience: strategically promote long-term infrastructure resilience

The report outlines the spectrum of views it was considering in relation to these themes, without coming down on a particular position yet. The final report may set out a clearer position. However, it is likely that there will still be many aspects still in need of clarification given the broad and complex scope.

I outline a few key points from the review and consider how they compare with some of the discussions in this research.

First theme

The first theme concerns two major aspects of governance:

- National vision
- Regional planning structures

The report advocates for a stronger national vision to guide decision-making and manage trade-offs in planning. This aligns with the recommendation in this thesis to establish a national coordination office. A further development would be the creation of a cross-departmental coordination body to enable integrated planning across government. This is especially important given that many future objectives, such as housing growth, economic development, and the net zero agenda, are inherently interdisciplinary and multi-sectoral. Although the report notes the difficulties of

matching time horizons across different plans and sectors and suggests the need for rationalisation and use of common metrics and standards, it does not make it clear what governance and planning structures would be needed to establish and monitor such an approach. Several practitioners interviewed for this research emphasised that the real value of planning often lies in the process itself, rather than the creation of a national vision as a one-off exercise. To reflect this, the commission could consider establishing a permanent coordination office tasked with convening stakeholders and addressing emerging issues over time, promoting adaptive capacity.

Alongside vision, the report also discusses structures of government noting that it would be beneficial to have a more effective multi-sector regional tier that captures the local voice and has stronger delivery and enforcement responsibility (compared to existing RBMPs). The report suggests the introduction of a regional tier, although it does not reference the existing regional water resource planning groups in this context. Instead, it considers two possible approaches: one based on hydrological catchments, aligned with the Environment Agency's current regional boundaries, and another based on local authority areas. The latter option may be more optimal given the current lack of integration between spatial planning and water resource development; a gap that has already constrained development in areas like Cambridge and North Sussex. With further development planned in the Ox-Cam Arc and other new industrial hubs, this issue will only grow in significance. The report also points to the perceived success of the partnership between the Greater Manchester Authority, United Utilities, and the Environment Agency as a potential model for more integrated water management. Notably, local government is currently fragmented, and this latter option will likely depend on the extension of the combined authority structure across the whole of the country (it currently only exists for a few regions).

Second theme

The second theme relates to the legislative framework. For this theme, the report favours rationalisation, simplification, and flexibility, which mirrors the conclusions of the fifth chapter. The report suggests benefits from reforming the WFD, and introducing constrained regulatory discretion to allow for innovation and nature-based solutions, yet again, the report does not detail the process or structures that would be required to achieve these aims.

Third theme

The third theme is regulatory reform in light of the loss of public trust, which has been eroded by pollution incidents, rising bills, and opaque financial engineering. The report highlights failings including capability deficits, increasingly burdensome administration, a ‘doom-loop’ whereby poorly performing firms receive lower income limiting their ability to recover performance, and too narrow incentives.

The report calls for sustainable funding and expertise within the EA, and greater clarity of remit and coordination among the regulators, which align with this research.

The report suggests that the ‘economic regulator’ (i.e. Ofwat) should take on a more “supervisory” role, giving the specific example that the economic regulator should include tailored price setting for each company, alongside the current benchmarking approach. This also reflects the work in this research where many practitioners felt that Ofwat was at times too distant, and their approach was too coarse to capture the required investment needed for specific infrastructure proposals.

However, there appears to be a tension between the stated aim of simplifying regulation with the recommendation to introduce more tailored, company-specific oversight, which may in fact increase complexity. The report does not yet set out a clear target or mechanism for achieving regulatory simplification. This area will likely require further detailed work and collaborative engagement to streamline processes without compromising necessary oversight. As WaterUK’s response to the consultation notes:

“Importantly, any new approach should not simply add another layer of complexity on top of the existing framework” (Water UK, 2025, p. 9).

Fourth theme

The fourth theme discusses ownership and financial structures and how these interact with long-term performance and the ability to raise capital. While this thesis does not explicitly explore the question of ownership, it recognises that it is the most politically salient and controversial aspect in water governance (alongside water quality). Loss of public trust has played out alongside reduced investor confidence, evidenced by the downgrading of the sector credit rating from AAA (2018) to A (2024) by Moody’s (the

credit ratings agency), with some companies rated lower than investment grade (BBC News, 2024; Moodys Ratings, 2024).

The commission was instructed not to consider nationalisation, despite its broad public support. Rather, the report sets out a narrower spectrum of views, from favouring publicly listed companies (which the report perceives to enable greater transparency), to adopting a not-for-profit model similar to that used in Wales (which the report poses may not be sufficiently incentivised or able to raise sufficient capital). Rather than taking a clear position on ownership, the report emphasises on the need for more stable, long-term investment. It argues that reduced risk and lower profit volatility are more important for attracting capital than the specific ownership model, implicitly supporting the status quo in the hope that a clear national strategy will create the necessary stability. Ongoing reforms are highlighted such as introducing a fit-and-proper test for directors, banning bonuses, mechanisms for the consumer voice on boards, and statements of public good.

Despite referencing international comparisons and competing arguments, this theme would benefit from deeper academic analysis to move beyond ideological positions. Empirical evidence is needed to assess how ownership structures impact performance, accountability, and investment (despite the inherent challenges in achieving objectivity on this topic).

Fifth theme

The final theme relates to the resilience of water assets. The report recognises that the sector has promoted efficiency above resilience, in part led by Ofwat's focus on keeping bills down. Assets are insufficiently mapped and assessed (particularly assets built before 1989 which are legally exempted). Furthermore, the commission recognise the regulatory gap concerning asset condition (the Environment Agency's remit being primarily focused on environmental compliance). Such an approach does not appear sensible in light of multiple risk factors and wider uncertainties (climate change, aging asset base, combined risks).

The report recognises the benefits of redundancy and calls for a shift toward a more forward-looking, prognostic approach, rather than one based on past failures and historic expenditure. It highlights Scotland's success in adopting such a strategy. The

Netherlands use of life cycle assessments is also praised. Additionally, the report promotes the National Infrastructure Commission's (NIC) recommendations to adopt national resilience standards, as well as improved monitoring, and the development of engineering expertise within the regulators. This is closely aligned with the analysis in Chapter Five of this research, which considers the deep uncertainty and cascading risks inherent in long-term water planning. The report's acknowledgment of the need for built-in redundancy and anticipatory planning marks an important step forward.

Overall, the Cunliffe Review interim report shares many of the concerns and priorities identified in this research: regulatory fragmentation, underinvestment in resilience, weak public confidence, and the absence of long-term strategic coordination. However, the interim report often identifies what should change without sufficiently addressing how. Future work should:

- Clarify institutional design for national and regional planning
- Resolve tensions between discretion and accountability
- Examine ownership models through independent, empirical analysis
- Define concrete mechanisms to embed resilience in regulation and governance

7.2.4.2 The National Framework 2025

As well as the Cunliffe review, another central piece of policy was published in June 2025, The National Framework 2025. The new framework builds on the previous; reaffirming the significant need for water resources development and demand reduction given the (even larger) deficits forecast driven by environmental protections, economic growth, and climate change. The report brings in a greater focus on delivering proposed infrastructure projects, continuing to work collaboratively through the regional groups, as well as other sectors, and developing the local tier of water planning (Environment Agency, 2025).

7.3 Strengths, limitations, and suggestions for future research

This thesis provides valuable insights into the governance, decision-making, and technical underpinnings of water resources planning in England, offering a critical assessment of how planning structures have evolved, the effectiveness of collaborative governance, and the role of modelling in shaping investment decisions. However, as with any research, there are limitations that constrain the breadth and depth of analysis,

alongside areas where further research would enhance understanding. This section reflects on the key strengths of the study, acknowledges its limitations, and outlines future research directions.

7.3.1 Strengths of the thesis

A key strength of this research is its examination of England's water resources planning framework within a real-world institutional and regulatory context. Unlike theoretical governance studies, this thesis is grounded in empirical analysis of decision-making processes, practitioner engagement, and evolving governance mechanisms.

The thesis also offers practical insights for policymakers, regulators, and industry stakeholders. The analysis of the National Framework highlights both the successes and limitations of multi-scale governance, while underscoring the tensions between modelling complexity, regulatory scrutiny, and investment decision-making. By bringing these themes together, this research provides a comprehensive overview of England's planning system while also identifying gaps and potential areas for reform.

Furthermore, the engagement with practitioners and direct observation of planning processes add richness to the study. The collegiate culture among practitioners and their commitment to resilience and environmental protection are notable findings, demonstrating that despite structural challenges, there is a shared vision for improving water resource planning.

7.3.2 Limitations of the study

7.3.2.1 Evaluating governance effectiveness

One of the fundamental challenges in assessing governance arrangements is the inability to conduct controlled experiments. Governance models are inherently context-dependent and shaped by historical, political, and economic factors, making it difficult to directly compare alternative governance structures or isolate causal relationships.

While this research analyses governance effectiveness through practitioner perspectives and documentary evidence, it does not include a comparative experimental approach. A potential future avenue could involve structured workshops or simulations, where different groups attempt to develop long-term water resource plans, for example some with access to detailed modelling tools, others without, to

explore how different decision-making environments influence outcomes. Additionally, a comparison of outcomes from the WRMP19 and WRMP25 planning rounds, against proposed solutions by groups posed with similar planning problems could provide further insights into the strengths and weaknesses of the current process.

7.3.2.2 Scope of stakeholder engagement

Although the study engages with water companies, regulators, and key industry stakeholders, it does not extensively incorporate perspectives from opposition groups (e.g., the Group Against Reservoir Development known as GARD) or customer advocacy organisations. Chapter 3 highlights the growing expectation for greater public participation in decision-making, yet the research does not explore in depth how broader stakeholder engagement could be structurally integrated within a highly technical and regulated planning process.

This omission reflects a broader tension in governance: how to incorporate diverse perspectives in a way that is substantive rather than tokenistic. Meaningful participation would likely require reforms beyond the existing framework, as current consultation mechanisms primarily allow for stakeholder input at predefined stages rather than embedding them into decision-making processes.

7.3.2.3 Economic and regulatory constraints

While the thesis examines governance structures and regulatory frameworks, it does not fully explore the economic underpinnings of England's privatised water system. Chapter 5 discusses the role of financial regulation in investment decisions, but deeper questions remain about whether the privatised model remains sustainable in light of financial instability, inflationary pressures, and regulatory interventions. The privatised system has come under attack from accusations of financial mismanagement given recent inflationary pressures that have pushed Thames Water close to bankruptcy, and increasing numbers of companies appealing to the Competition and Markets Authority (CMA) over Ofwat's Final Determinations (six companies appealed at PR24, four companies appealed at PR19, one company appealed at PR14) (Gatt, 2025). Questions remain over whether a nationalised system, particularly under austerity following the financial crash in 2008, would have fared better. These questions raise concerns about the long-term viability of the existing funding model, particularly whether:

- The benefits of financial stability through customer billing are now at risk due to debt exposure and mismanagement.
- Regulatory mechanisms (e.g., Ofwat enforcement, PR24 determinations) are sufficient to prevent financial instability or whether structural reform is required.
- A nationalised model would face similar risks (including under austerity-driven government funding constraints).

While the study assesses planning effectiveness within existing institutional constraints, it does not challenge or reimagine the broader economic structures underpinning the water industry. Future research could explore whether alternative regulatory or ownership models could provide greater financial resilience and public trust.

7.3.3 Areas for future research

7.3.3.1 Assessing the effectiveness of the "best value" approach

The transition from least-cost to "best value" decision-making introduces new complexities in how investment trade-offs are evaluated. While this shift aims to integrate social, environmental, and resilience factors, there is limited analysis of whether this approach meaningfully changes decisions or simply adds procedural complexity. Future research could examine:

- The extent to which "best value" has led to different investment choices compared to traditional cost-benefit methods.
- How weighting across regions is applied in practice, considering consistency.
- Whether additional analytical effort leads to better outcomes or merely adds confusion.

7.3.3.2 Democratic legitimacy and public engagement in water resources planning

The representative model of democracy places the public at a significant distance from planning. This potentially undermines the legitimacy that decision-making is in line with the public's preferences and values, even though they ultimately pay for the outcomes (including the profits earned by the companies who do this work). To combat this democratic deficit, future research could explore the role of citizens assemblies, for example research could:

- Evaluate whether citizens assemblies effectively elicit what the public values at different stages of the planning cycle, including: (1) setting strategy and objectives, (2) defining metrics, (3) testing whether draft decision-making outputs are in line with the public's preferences, and (4) evaluating final plans to inform subsequent iterations.
- Explore how the assemblies integrate with institutional structures and power dynamics, considering the appropriate scale and remit of the problem characterisation, and critically evaluate whether assemblies help fill democratic deficits.

7.3.3.3 Integrating water resources planning with other sectors

As Chapter 3 discusses, water resources planning often remains siloed from other policy areas, despite increasing recognition of the interconnected nature of climate resilience, spatial planning, energy policy, and agricultural water use. Future research could explore:

- How water resource planning could be more systematically integrated with spatial planning, energy infrastructure, and agricultural policy.
- How regional and national governance structures could facilitate better cross-sector coordination.
- International case studies where integrated water-energy-food planning has been successfully implemented (Biswas, 2008; Fritsch, 2017).

7.3.3.4 The role of leadership in governance structures

Chapter 4 highlights the importance of collaboration in regional and national planning, but it does not fully explore the role of leadership in shaping governance effectiveness. Chapter 5 highlights positive feedback about the role of the Modelling Advisory Group's structure having a rolling chair, integrated feedback, and open discussion. Key research questions include:

- Is leadership in water governance random and idiosyncratic, or are there structural factors that foster effective leadership?
- How can leadership functions be institutionalised to ensure continuity in decision-making?

- To what extent do bridging organisations support leadership development and knowledge-sharing?

7.3.3.5 Economic and regulatory reform

Given the growing scrutiny of financial sustainability in the privatised water industry, future research could examine:

- The effectiveness of regulatory enforcement in preventing financial mismanagement.
- Whether more prescriptive regulations (e.g., debt ratio caps, stricter investment oversight) would enhance financial stability.
- Comparisons between privatised, hybrid, and public water ownership models in ensuring long-term financial resilience.
- Examining the broader implications of ‘new’ procurement models for SROs such as Direct Procurement for Customers (DPC), for example the impact on operation flexibility
- The role of governmental departments (DEFRA, Environment Agency, Ofwat) and how their remits could be restructured for better regulatory alignment.

7.3.4 Overall summary

This thesis makes a significant contribution to understanding governance, decision-making, and technical planning challenges in England’s water resources sector. It demonstrates how historical path dependencies shape current governance structures (Chapter 3), how regional and national planning mechanisms have evolved (Chapter 4), and how technical modelling influences decision-making (Chapter 5).

Findings suggest that enhancing coordination and adaptive governance will be crucial for ensuring long-term water resilience. Key recommendations include the establishment of a national coordination office to help with programme management, improved regulatory alignment, and a commitment to open and iterative learning. Ultimately, this research underscores the need for bridging science, governance, and resilience to create a more robust and transparent future for water resource management in England.

While methodological and scope limitations exist, the findings provide a foundation for future governance reforms, regulatory adjustments, and interdisciplinary research. By

addressing the gaps identified, particularly in economic regulation, stakeholder participation, and cross-sectoral integration, future research can help shape a more adaptive, transparent, and resilient water governance framework.

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Appendices

9.1 Documents reviewed for the document analysis

9.1.1 Policy and industry chapters

Appendix A. List of sources used in the document analysis

Title	Date	Authors / organisations	Source (links accessed on 05/03/2025)
The 1984 Drought	1985	TERRY MARSH AND MARTIN LEES. INSTITUTE OF HYDROLOGY.	https://nora.nerc.ac.uk/id/eprint/6953/1/HDdrought84.pdf
The 1988-92 Drought	1994	T.J. Marsh, R.A. Monkhouse, N.W. Arnell, M.I. Lees, & N.S. Reynard. Institute of Hydrology & British Geological Survey.	https://nora.nerc.ac.uk/id/eprint/6952/1/HDUKdrought.pdf
Future Charges for Water and Sewerage Services – The outcome of the Periodic Review	1994	Ofwat	https://www.ofwat.gov.uk/wp-content/uploads/2020/10/PR94-final-determinations-document.pdf
Final Determinations – Future water and sewerage charges 2000-05	1999	Ofwat	https://www.ofwat.gov.uk/wp-content/uploads/2020/10/PR99-final-determinations-document.pdf
Future water and sewerage charges 2005 -10 - Final determinations - Periodic review 2004	2004	Ofwat	https://www.ofwat.gov.uk/wp-content/uploads/2020/10/PR04-final-determinations-document.pdf
THE DEVELOPMENT OF THE WATER INDUSTRY IN ENGLAND AND WALES	2006	Ofwat	https://www.ofwat.gov.uk/wp-content/uploads/2015/11/rpt_com_devwatindust270106.pdf
Do we need large-scale water transfers for south east England?	2006	Environment Agency	https://www.bipsolutions.com/docstore/pdf/14342.pdf
A sustainable water industry – To PR09 and beyond	2006	Ofwat	https://webarchive.nationalarchives.gov.uk/ukgwa/20150603193956/http://www.ofwat.gov.uk/pricereview/pr09phase1/pr09phase1letters/ltr_md219_suswatindpr09bey
T i	Date	Authors / organisations	Source (links accessed on 05/03/2025)

t l e			
Setting water and sewerage price limits: Is five years right?	2006	Ofwat	https://webarchive.nationalarchives.gov.uk/ukgwa/20150603192339/http://www.ofwat.gov.uk/pri cereview/pap_con_lengthpr.pdf
Contributing to sustainable development – a consultation on Ofwat’s approach	2006	Ofwat	https://webarchive.nationalarchives.gov.uk/ukgwa/20150604022944/http://www.ofwat.gov.uk/pri cereview/pap_con_sustainabledev.pdf
Developing our process for assessing capital maintenance requirements	2006	Ofwat	https://webarchive.nationalarchives.gov.uk/ukgwa/20150603232552/http://www.ofwat.gov.uk/regulating/casework/reporting/pap_con_procasscapmtnreq.pdf
Future Water The Government’s water strategy for England	2008	Defra	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69346/pb13562-future-water-080204.pdf
A legal duty to act	2008	The Climate Change Committee	https://www.theccc.org.uk/the-need-to-act/a-legal-duty-to-act/
Independent Review of Competition and Innovation in Water Markets: Final report	2009	Professor Martin Cave	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69462/cave-review-final-report.pdf
Setting price limits for 2010-15: Framework and approach	2009	Ofwat	https://www.ofwat.gov.uk/wp-content/uploads/2015/12/pap_pos_pr09method080327.pdf
Future water and sewerage charges 2010-15: Final determinations	2009	Ofwat	https://www.ofwat.gov.uk/wp-content/uploads/2015/11/det_pr09_finalfull.pdf
Multi-criteria analysis: a manual	2009	Department for Communities and Local Government: London	https://eprints.lse.ac.uk/12761/1/Multi-criteria_Analysis.pdf
INQUIRY into the THAMES WATER REVISED DRAFT WATER RESOURCES MANAGEMENT PLAN 2010-2035	2010	The Planning Inspectorate	https://www.hwa.uk.com/site/wp-content/uploads/2017/12/SWC-D5.1-Inquiry-report-Thames-Water-revised-draft-WRMP-2010-2045.pdf
THE 1975-76 DROUGHT - A contemporary and retrospective review	2011	Rodda, J.C. and Marsh, T.J. Centre for Ecology and Hydrology (CEH)	https://nora.nerc.ac.uk/id/eprint/15011/1/CEH_1975-76_Drought_Report_Rodda_and_Marsh.pdf

T i t l e	Date	Authors / organisations	Source (links accessed on 05/03/2025)
The Natural Choice: securing the value of nature	2011	Defra	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/228842/8082.pdf
Review of Ofwat and consumer representation in the water sector	2011	Defra	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69442/ofwat-review-2011.pdf
The case for change – current and future water availability	2011	EA	https://webarchive.nationalarchives.gov.uk/ukgwa/20140328154328/http://cdn.environment-agency.gov.uk/geho1111bvpe-e-e.pdf
The case for change – reforming water abstraction management in England	2011	Ofwat. EA	https://webarchive.nationalarchives.gov.uk/ukgwa/20140328154328/http://cdn.environment-agency.gov.uk/geho1111bvpe-e-e.pdf
Water for Life	2011	Defra	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/228861/8230.pdf
Water for Life Market - reform proposals	2011	Defra	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69480/water-for-life-market-proposals.pdf
An overview of the 2010-12 drought and its dramatic termination	2012	CEH, Natural Environment Research Council (NERC)	https://nora.nerc.ac.uk/id/eprint/20083/1/2012_Drought_Transformation_FINAL.pdf
The Water White Chapter Second Report of Session 2012–13	2012	House of Commons The Environment, Food and Rural Affairs Committee	https://publications.parliament.uk/pa/cm201213/cmselect/cmenvfru/374/374.pdf
The Water White Chapter Written Evidence	2012	House of Commons The Environment, Food and Rural Affairs Committee	https://publications.parliament.uk/pa/cm201012/cmselect/cmenvfru/writew/water/wwp.pdf
Catchment Based Approach: Improving the quality of our water environment	2013	Defra	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/204231/pb13934-water-

			environment-catchment-based-approach.pdf
T i t l e	Date	Authors / organisations	Source (links accessed on 05/03/2025)
Managing Abstraction and the Water Environment	2013	Defra	https://consult.defra.gov.uk/water/abstraction-reform/supporting_documents/abstractreformconsultmanage20131217.pdf
Environmental Flow Indicator - What it is and what it does	2013	EA	https://webarchive.nationalarchives.gov.uk/ukgwa/20140328104910mp_/http://cdn.environment-agency.gov.uk/LIT_7935_811630.pdf
Making the most of every drop consultation on reforming the water abstraction management system - Summary of consultation responses	2014	Defra	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/328442/abstraction-reform-sum-resp.pdf
A Water Strategy for Wales – Consultation Document	2014	Welsh Government	https://www.gov.wales/sites/default/files/consultations/2018-01/140407water-strategy-consultation-document-en.pdf
Legal Briefing: The Water Act 2014	2014	Michael Barlow and Stephen Lavington	https://www.inhouselawyer.co.uk/legal-briefing/the-water-act-2014/
The UK drought of 2003 an overview – 2nd edition	2014	Terry Marsh. CEH.	https://nora.nerc.ac.uk/id/eprint/510184/1/N510184CR.pdf
The 2004-06 Drought – 2nd Edition	2014	Terry Marsh, Doug Booker and Matt Fry. CEH.	https://nora.nerc.ac.uk/id/eprint/510185/1/N510185CR.pdf
Water Bill - Sustainable Development and Resilience Duties	2014	Defra	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/271334/pb14102-waterbill-sd-rd-note.pdf
Impact Assessment: Ability for ministers to specify a level of service in water	2014	Defra	https://www.legislation.gov.uk/ukia/2013/263/pdfs/ukia_20130263_en.pdf

resources plans to which water undertakers must plan			
Trust in Water - Towards resilience: how we will embed resilience in our work	2015	Ofwat	https://www.ofwat.gov.uk/wp-content/uploads/2015/07/pap_pos20151210towardsresiliencerev.pdf
T i t l e	Date	Authors / organisations	Source (links accessed on 05/03/2025)
Water supply and resilience and infrastructure - Environment Agency advice to Defra	2015	EA	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/504682/ea-analysis-water-sector.pdf
The case for change – reforming water abstraction management in England	2015	Ofwat, the EA	https://www.ofwat.gov.uk/wp-content/uploads/2015/11/pap_pos20111205abstraction.pdf
Updated projections for water availability for the UK	2015	HR Wallingford, The CCC	https://www.theccc.org.uk/publication/climate-change-risk-assessment-ii-updated-projections-for-water-availability-for-the-uk/
Abstraction incentive mechanism (AIM) – Recommendation of the AIM taskforce	2015	Ofwat	https://www.ofwat.gov.uk/wp-content/uploads/2015/10/pap_res201508aimproposal.pdf
Environment (Wales) Act 2016 Factsheet Overview of the Environment (Wales) Act	2016	Welsh Government	https://www.gov.wales/sites/default/files/publications/2019-05/environment-wales-act-2016-overview.pdf
UK Government response to consultation on reforming the Water Abstraction Management System	2016	Defra	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/492411/abstraction-reform-govt-response.pdf
Trust in Water - Guidelines on the abstraction incentive mechanism	2016	Ofwat	https://www.ofwat.gov.uk/wp-content/uploads/2016/02/gud_pro20160226aim.pdf
Creating a great place for living - Enabling resilience in the water sector	2016	Defra	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/504681/resilience-water-sector.pdf

	Strategic water resources planning: “Strategic Water Infrastructure and Resilience” - WT1535	2016	AECOM for EA	https://randd.defra.gov.uk/ProjectDetails?ProjectId=18964
	Water resources long term planning framework (2015-2065)	2016	WaterUK	https://www.water.org.uk/sites/default/files/wp/2018/11/WaterUK-WRLTPF_Final-Report_FINAL-PUBLISHED-min.pdf
T i t l e	Date		Authors / organisations	Source (links accessed on 05/03/2025)
	WRMP 2019 METHODS – DECISION MAKING PROCESS: GUIDANC	2016	UKWIR	https://ukwir.org/WRMP-2019-Methods-Decision-Making-Process-Guidance
	An Overview of the WRSE - An introduction to the Water Resources of the South East group, its purpose and objectives	2017	Water Resources South East (WRSE)	https://www.wrse.org.uk/media/au1n1gbk/wrse_file_278_an-overview-of-the-wrse.pdf
	The Clean Growth Strategy - Leading the way to a low carbon future	2017	Business, Energy and Industrial Strategy (BEIS)	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700496/clean-growth-strategy-correction-april-2018.pdf
	The government’s strategic priorities and objectives for Ofwat	2017	Defra	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/661803/sps-ofwat-2017.pdf
	TAPPED IN From passive customer to active participant	2017	Corporate Culture Group for Ofwat	https://www.ofwat.gov.uk/wp-content/uploads/2017/03/1941_OFWAT_Cust_Participation_Report_final.pdf
	Delivering Water 2020: consultation on PR19 methodology Appendix 2: Delivering outcomes for customers	2017	Ofwat	https://www.ofwat.gov.uk/wp-content/uploads/2017/07/Appendix-2-Outcomes2.pdf
	Delivering Water 2020: Our final methodology for the 2019 price review	2017	Ofwat	https://www.ofwat.gov.uk/wp-content/uploads/2017/12/Final-methodology-1.pdf
	Draft National Policy Statement for Water Resources Infrastructure	2017	Defra	https://consult.defra.gov.uk/water/draft-national-policy-statement/supporting_documents/draftnpwaterresourcesinfrastructure.pdf

Building resilient water supplies – a joint letter	2018	Defra, EA, DWI, Ofwat	https://www.ofwat.gov.uk/wp-content/uploads/2018/08/Building-resilient-water-supplies-letter.pdf
GUIDE TO DEVELOPING THE PROGRAMME BUSINESS CASE BETTER BUSINESS CASES: for better outcomes	2018	HM Treasury	https://assets.publishing.service.gov.uk/media/6644948aae748c43d3793bb9/Programme_Business_Case_2018.pdf
T i t l e	Date	Authors / organisations	Source (links accessed on 05/03/2025)
The long term potential for deep reductions in household water demand	2018	Artesia for Ofwat	https://www.ofwat.gov.uk/wp-content/uploads/2018/05/The-long-term-potential-for-deep-reductions-in-household-water-demand-report-by-Artesia-Consulting.pdf
Consultation : “Board Leadership, Transparency & Governance - Principles”	2018	T. Martin Blaiklock Consultant Infrastructure & Energy Project Finance	https://www.ofwat.gov.uk/wp-content/uploads/2018/07/T-Martin-Blaiklock-Response.pdf
Putting the sector in balance: position statement on PR19 business plans	2018	Ofwat	https://www.ofwat.gov.uk/wp-content/uploads/2018/04/Putting-the-sector-in-balance-position-statement-on-PR19-business-plans-FINAL2.pdf
NATIONAL INFRASTRUCTURE ASSESSMENT	2018	National Infrastructure Commission	https://nic.org.uk/app/uploads/CCS001_CCS0618917350-001_NIC-NIA_Accessible-1.pdf
A Green Future: Our 25 Year Plan to Improve the Environment	2018	Government	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/693158/25-year-environment-plan.pdf
Draft National Policy Statement for Water Resources Infrastructure	2018	Defra	https://consult.defra.gov.uk/water/draft-national-policy-statement/supporting_documents/draftnpswaterresourcesinfrastructure.pdf
Consultation on the draft National Policy Statement for Water Resources Infrastructure	2018	Defra	https://consult.defra.gov.uk/water/draft-national-policy-statement/supporting_documents/npswaterconsultdocument.pdf
Appraisal of Sustainability of the National Policy Statement for Water	2018	Wood for Defra	https://consult.defra.gov.uk/water/draft-national-policy-statement/supporting_documents

Resources Infrastructure			ts/Appraisal%20of%20Sustainability%20Main%20Report.pdf
Appraisal of Sustainability of the National Policy Statement for Water Resources - Appendix B	2018	Wood for Defra	https://consult.defra.gov.uk/water/draft-national-policy-statement/supporting_documents/Appraisal%20of%20Sustainability%20Appendix%20B.pdf
Planning Water Resources in England and Wales	2018	CIWEM	https://www.ciwem.org/assets/pdf/Policy/Reports/Planning%20Water%20Resources%20in%20England%20and%20Wales%20CIWEM%20PPS.pdf
T i t l e	Date	Authors / organisations	Source (links accessed on 05/03/2025)
Improving our management of water in the environment Consultation proposals	2019	Defra	https://consult.defra.gov.uk/water/improving-management-of-water-in-the-environment/supporting_documents/floodwaterconsultation190114.pdf
Improving our management of water in the environment Summary of responses and government response	2019	Defra	https://assets.publishing.service.gov.uk/media/5d3549c1e5274a14eb8e04e8/floods-water-consult-sum-resp.pdf
Abstraction reform report Progress made in reforming the arrangements for managing water abstraction in England	2019	Defra	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/914427/abstraction-reform-report.pdf
National Policy Statement for Water Resources Infrastructure 2018 - Motion to Take Note	2019	House of Lords	https://www.theyworkforyou.com/lords/?id=2019-04-11a.546.0
Improving our management of water in the environment Summary of responses and government response	2019	Defra	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/819372/floods-water-consult-sum-resp.pdf
About RAPID	2019	RAPID	https://www.ofwat.gov.uk/regulated-companies/rapid/about-rapid/
Corrigenda to United Utilities PR19 final determinations: Outcomes	2019	Ofwat	https://www.ofwat.gov.uk/wp-content/uploads/2020/05/PR19-final-determinations-United-Utilities-Outcomes-

performance commitment appendix			performance-commitment-appendix-corrigenda.pdf
About Drought Handbook – Outputs and Impacts – The UK’s Drought & Water Scarcity Programme	2020	UKRI	https://aboutdrought.info/wp-content/uploads/2021/02/about-drought-handbook_FINAL_2020-1.pdf
Meeting our future water needs: a national framework for water resources	2020	EA	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/872759/National_Framework_for_water_resources_main_report.pdf
T i t l e	Date	Authors / organisations	Source (links accessed on 05/03/2025)
Appendix 2: Regional planning	2020	EA	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/872222/Appendix_2_Regional_planning.pdf
Water Company Drought Plan guideline, December 2020 (Version 1.2)	2020	EA	Email correspondence
Deriving a best value water resources management plan	2020	UKWIR for NRW, EA, RAPID	https://ukwir.org/deriving-a-best-value-water-resources-management-plan
Meeting regional and national water resources needs: gap analysis of the current strategic infrastructure scheme portfolio	2020	Jacobs for RAPID	https://www.ofwat.gov.uk/wp-content/uploads/2020/10/RAPID-Water-Resources-Gap-Analysis-report.pdf
Evolving the Water Industry National Environment Programme to deliver greater value	2020	United Utilities	https://www.ofwat.gov.uk/wp-content/uploads/2021/01/UUW-WINEP-review-discussion-chapter.pdf
Policy chapter Water abstraction plan: Environment	2021	Defra	https://www.gov.uk/government/publications/water-abstraction-plan-2017/water-abstraction-plan-environment
Forward programme 2021-22	2021	RAPID	https://www.ofwat.gov.uk/wp-content/uploads/2021/03/RAPID-Forward-programme-2021_22.pdf
Water resources planning guideline	2023	Defra	https://www.gov.uk/government/publications/water-resources-planning-guideline/water-resources-planning-guideline

Anglian Water Services Limited, Bristol Water plc, Northumbrian Water Limited and Yorkshire Water Services Limited Price Determinations Summary of Final Determinations	2021	CMA	https://assets.publishing.service.gov.uk/media/604fa141e90e077fe7a5f45a/-_CMA_water_redeterminations_-_summary_-_online_version_---.pdf
National framework Senior Steering Group summary June 2021	2021	SSG	https://www.ofwat.gov.uk/wp-content/uploads/2021/07/SSG-summary-June-2021.pdf
Title	Date	Authors / organisations	Source (links accessed on 05/03/2025)
Regional Coordination Group (RCG) Alignment & War-gaming Project - Draft report (work in progress)	2021	WRE	Email correspondence
Water supply resilience and climate change	2021	Jade Ward and Jonathan Wentworth for POST	https://researchbriefings.files.parliament.uk/documents/POST-PB-0040/POST-PB-0040.pdf
The government's strategic priorities for Ofwat Draft for consultation	2021	Defra	https://consult.defra.gov.uk/water-services/government-news-consultation/supporting_documents/newstrategicpolicystatementofwatdraftforconsultation.pdf
A water supply-demand model for England and Wales Report to RAPID	2021	Slaughter, A., Harou, J.J., Tomlinson, J., Matrosov, E., Wilson, J., Dennis, J., Read, M., Dunford, T., Stokes, M., O. Walker, A. Widmaier for RAPID	https://www.ofwat.gov.uk/wp-content/uploads/2021/07/University-of-Manchester-and-RAPID-England-and-Wales-supply-demand-modelling-report-2021.pdf
Jan 2022 Regional Reconciliation Process Version 7	2022	Regional groups	https://wre.org.uk/wp-content/uploads/2022/01/Regional_Plan_Reconciliation_V7.pdf
July 2022 Inter-regional reconciliation of regional plans – Spring 2022: Summary report (final report)	2022	Regional groups	https://static1.squarespace.com/static/5e67889204d86850e1fdcece/t/6374aee64a480d58a038f497/1668591338084/Inter-regional+reconciliation+Spring+2022+-+SUMMARY+REPORT+-+v1.0.pdf

Summary of Regional Plans for Water Resources	2022	Regional groups	https://www.wrse.org.uk/media/lulfk0sa/summary-of-regional-plans-for-water-resources-final-21st-nov-2022-published.pdf
Review of the Water Industry National Environment Programme (WINEP)	2022	EA	https://consult.environment-agency.gov.uk/environment-and-business/review-of-the-winep/
PR24 and beyond: Final guidance on long-term delivery strategies	2022	Ofwat	https://www.ofwat.gov.uk/wp-content/uploads/2022/04/PR24-and-beyond-Final-guidance-on-long-term-delivery-strategies_Pr24.pdf
T i t l e	Date	Authors / organisations	Source (links accessed on 05/03/2025)
Inter-regional reconciliation 3: Summary report May 2023 – v1.0 – Final for publication	2023	Regional Groups	https://www.waterresourcesnorth.org/globalassets/wrmp/wren/inter-regional-reconciliation-3---summary-report---v1.0---final-for-publication.pdf
Governance for collaborative national and regional water resource planning Final report	2023	Mott MacDonald for EA	Email correspondence
Review of funding options and potential for multisector water resource planning in regional groups	2023	Arup for EA	Email correspondence
National Policy Statement for Water Resources Infrastructure	2023	Defra	https://assets.publishing.service.gov.uk/media/6437e3a2f4d42000cd4a1a7/E02879931_National_Policy_Statement_for_Water_Resources.pdf
How could water be planned differently and what lessons can we learn from other sectors? RAPID Advisory Panel Request	2023	Crouch and Scarrot for RAPID	Email correspondence
REGIONAL PLANNING FOR THE FUTURE	2023	WRW	https://static1.squarespace.com/static/5e67889204d86850e1fdcece/t/6453f8b2e6bcb049a86955c8/1683224757001/Regional+planning+for+the+future+-+WRW+-+April+2023.pdf

Water Resource Planning – Case for Change	2024	Trevor Bishop for Ofwat	https://www.ofwat.gov.uk/wp-content/uploads/2024/02/Water-resource-planning-case-for-change-independent-report-Jan-2024.pdf
Regional planning – discussion chapter	2024	WRSE	Email correspondence
Strategic infrastructure planning - National Systems Planner	2024	Ofwat	Email correspondence
sswan Sustainable Solutions for Water And Nature A new approach Discussion Chapter	2024	Advisory panel for Wessex Water	https://www.wessexwater.co.uk/media/4popagnb/sswan-discussion-chapter.pdf
T i t l e	Date	Authors / organisations	Source (links accessed on 05/03/2025)
A Fresh Water Future	2024	CIWEM	https://afreshwaterfuture.org/wp-content/uploads/FRESH_WATER_FUTURE_MAIN_REPORT_WEB.pdf
Research and analysis A summary of England’s revised draft regional and water resources management plans	2024	EA	https://www.gov.uk/government/publications/a-review-of-englands-draft-regional-and-water-resources-management-plans/a-summary-of-englands-draft-regional-and-water-resources-management-plans
WRMPs, WRMP data tables (draft, statement of response, revised draft, final, technical appendices) Business plans data tables	2024/2025	English water companies	Company websites
WRMP consultation feedback	2020/2024	Ofwat, EA	Ofwat website, and email correspondence
Price review final determination enhancement models	2024/2025	Ofwat	Ofwat website
Online publications (emerging, draft, statement of response, revised draft, technical appendices, and final plans where available)	2020/2024	Regional planning groups	Regional group websites

9.1.2 Legislation

Appendix B: pieces of legislation with relevance for the evolution of water resources governance and planning in England

Date	Act	Source
1875	Public Health Act	https://www.legislation.gov.uk/ukpga/Vict/38-39/55/contents/enacted
1902	Metropolis Water Act	https://www.legislation.gov.uk/ukpga/Edw7/2/41/enacted
1936	Public Health Act	https://www.legislation.gov.uk/ukpga/Geo5and1Edw8/26/49/part/IV/enacted
1937	Public Health (Drainage of Trade Premises) Act	https://www.legislation.gov.uk/ukpga/Edw8and1Geo6/1/40/contents/enacted
Date	Act	Source
1944	Rural Water Supplies and Sewerage Act	https://www.legislation.gov.uk/ukpga/Geo6/7-8/26/introduction/enacted
1945	Water Act	https://www.legislation.gov.uk/ukpga/Geo6/8-9/42/contents/enacted
1951	Rivers (Prevention of Pollution) Act	https://www.legislation.gov.uk/ukpga/Geo6/14-15/64/enacted
1963	Water Resources Act	https://www.legislation.gov.uk/ukpga/1963/38/section/23/enacted
1968	Water Resources Act	https://www.legislation.gov.uk/ukpga/1968/35/enacted
1972	Local Government Act	https://www.legislation.gov.uk/ukpga/1972/70/contents/enacted
1973	Water Act	https://www.legislation.gov.uk/ukpga/1973/37/enacted
1974	Control of Pollution Act	https://www.legislation.gov.uk/ukpga/1974/40/enacted
1981	Wildlife and Countryside Act	https://www.legislation.gov.uk/ukpga/1981/69/enacted
1989	Water Act	https://www.legislation.gov.uk/ukpga/1989/15/contents
1991	Water Industry Act	https://www.legislation.gov.uk/ukpga/1991/56/contents/enacted
1991	Water Resources Act	https://www.legislation.gov.uk/ukpga/1991/57/contents/enacted
1992	Competition and Service (Utilities) Act	https://www.legislation.gov.uk/ukpga/1992/43/contents/enacted
1994	The Urban Waste Water Treatment (England and Wales) Regulations	https://www.legislation.gov.uk/uksi/1994/2841/made

1995	Environment Act	https://www.legislation.gov.uk/ukpga/1995/25/contents/enacted
1998	Competition Act	https://www.legislation.gov.uk/ukpga/1998/41/contents/enacted
1999	Water Industry Act	https://www.legislation.gov.uk/ukpga/1999/9/contents/enacted
2000	Countryside and Rights of Way Act	https://www.legislation.gov.uk/ukpga/2000/37/contents/enacted
2000	Directive 2000/60/EC of the European Parliament and of the Council	https://www.legislation.gov.uk/eudr/2000/60/contents/adopted
2002	Enterprise Act	https://www.legislation.gov.uk/ukpga/2002/40/contents/enacted
2003	Water Act	https://www.legislation.gov.uk/ukpga/2003/37/contents/enacted
Date	Act	Source
2004	The Environmental Assessment of Plans and Programmes Regulations	https://www.legislation.gov.uk/uksi/2004/1633/contents/made
2006	Natural Environment and Rural Communities Act	https://www.legislation.gov.uk/ukpga/2006/16/section/41
2007	The Water Resources Management Plan Regulations	https://www.legislation.gov.uk/uksi/2007/727/contents/made
2008	Climate Change Act	https://www.legislation.gov.uk/ukpga/2008/27/contents/enacted
2008	Planning Act	https://www.legislation.gov.uk/ukpga/2008/29/part/3
2009	The Eels (England and Wales) Regulations	https://www.legislation.gov.uk/uksi/2009/3344/contents/made
2010	Flood and Water Management Act	https://www.legislation.gov.uk/ukpga/2010/29/contents/enacted
2014	Water Act	https://www.legislation.gov.uk/ukpga/2014/21/contents/enacted
2015	Well-being of Future Generations (Wales) Act	https://www.legislation.gov.uk/anaw/2015/2/contents
2016	Environment (Wales) Act	https://www.legislation.gov.uk/anaw/2016/3/contents
2017	The Conservation of Habitats and Species Regulations	https://www.legislation.gov.uk/uksi/2017/1012/contents/made
2017	The Water Environment (Water Framework Directive) (England and Wales) Regulations	https://www.legislation.gov.uk/uksi/2017/407/contents
2021	Environment Act	https://www.legislation.gov.uk/ukpga/2021/30/contents

2025	Water (Special Measures) Act	https://www.legislation.gov.uk/ukpga/2025/5/contents/enacted
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9.2 Semi-structured interviews

Appendix C. Speech at the beginning of interviews to give background and check participants consent.

Topic	Interview introductory speech and questions
Consent to record and use of data	<p>Thanks for agreeing to participate. There's a couple of things to go through at the beginning, it should be fairly quick.</p> <ol style="list-style-type: none"> 1. First, I want to check that you are happy for me to record the meeting? 2. Also to reassure you: <ol style="list-style-type: none"> a. As a voluntary participant you are free to withdraw at any time b. I will send you a summary afterwards which you can review and adjust as you like to most accurately represent your position, so you will have final review c. With your consent the research data may be published as a report.
Attribution and any questions or concerns	<ol style="list-style-type: none"> 1. Regarding participant attribution, would you be happy to be referred by your organisation/region, or would you rather be completely anonymous. You are also free at any time to change your mind. 2. Do you consent to you anonymised research data being stored and used by others for future research? <p>If you have any questions, or concerns feel free to ask me or contact any of my supervisors.</p>
Project background	<p>I mentioned it in the email but just to explain the project in person:</p> <ol style="list-style-type: none"> 1. The aim of the research project is to investigate the challenge of how to develop an optimal water resource management plan which is aligned across different scales, so from the national level for England and Wales, down to the zonal and catchment level. 2. Part of the research is evaluating how multi-scale water resources planning is developing between 2020 and 2023 under new regulatory expectations, particularly the introduction of regional planning. 3. In line with this, I wanted to capture the views of those involved in the regional reconciliation process before it starts, and hopefully again after, to find out what participants thought went well and if any challenges arose. 4. As someone involved I would like to ask you a few fairly broad questions 5. I plan on constructing an analysis which will hopefully provide some insight as to what went well and what could be improved for next time. Any findings will be shared with everyone who was involved so hopefully there might be some benefit to taking part. 6. Do you have any questions for me?

Appendix D. List of initial interview questions in 2021.

	Topic area	Question
1	Background	Please could you say a little about your background?
2	Reconciliation process	What is your role in the national reconciliation process?
3		What is your understanding of how the iterative reconciliation process will work? How are water companies and other stakeholders involved?
4		How would you define a successful result by December (for your organisation)?
5		Are there any challenges you anticipate?
6	Scale of planning	How do you feel about the balance between a top-down approach (consistency) versus locally tailored approach (right tool for the job, use of local understanding, giving more room for innovation)?
7	Decision making tools and methods	Which tools, methods, datasets does your organisation use to support your decision making?
9		Do you have any comments about regions taking different approaches in their methods/data? How do you think consistency should be managed across regions, in terms of ambitions, general approach, decision making methods etc.?
10	Uncertainty	There is a lot of uncertainty in the deficit numbers - what are your thoughts on planning for the central estimate versus the worst-case scenario?
11	Environmental destination	How does environmental destination impact planning?
12	Best value planning	What constitutes best value planning, and which criteria are weighed particularly highly in your areas, compared to other regions?
13		How does your organisation determine which criteria should be valued/weighted? How are you measuring best value? Which engagement and participation activities are involved?
14	Adaptive planning	What are the challenges and opportunities for integrating adaptive planning into WR planning?
15	Stakeholder engagement	How is stakeholder and customer engagement managed in your organisation?
16	WR planning more broadly	What do you see as the biggest obstacle/opportunity for effective WR planning in England/Wales? What do you think are the main causes of this problem?
17		What do you see as the most promising trends/drivers that could help overcome these?
18		Are there aspects where you think more information is needed, or any actors which could help provide this?
19	Final thoughts	Are there any other points you would like to mention that you think it would be good for me to consider?
20		Is there anyone you recommend for me to interview?

Appendix E. List of initial interview questions in 2022.

	Topic area	Question
1	Background (for those not interviewed before)	Please could you say a little about your background?
2	Progress of reconciliation	If you were to repeat the process so far, what would you keep the same, - anything that has gone particularly well?
3		and what would you change? any particular challenges that have arisen through the process so far?
4		What has the experience regarding your organisations decision making model, and governance structure?
5		What has been your experience of incorporating best value planning and the organisations approach to metrics?
6		What has been your experience of incorporating adaptive planning?
7	Future directions	What do anticipate for the next round of reconciliation, and the publishing of final plans?
8		If you could change anything for next time - (1) your organisation (2) the wider approach?
9		What do you see as the biggest obstacle further along in the process - Ofwat/DCO stages/public enquiry?
10		Do you think regional planning should be made statutory?
11	Final thoughts	Is there anything else you to mention that would be worth me considering?

Appendix F. List of example additional interview questions in 2023-2024.

	Topic area	Question
1	Background (for those not interviewed before)	Please could you say a little about your background?
2	Planning progress	What has been your experience of the current planning round, any positives or negatives?
3	Modelling	What is the role of modelling in your organisation?
4		What are the main opportunities and benefits linked to modelling?
5		What are the main barriers and limitations linked to modelling?
6		Can you provide any specific examples of how modelling is used (either well or poorly)?
7	Governance	How is your team structured, what is the role of consultants in your organisation?
8	Standardisation	What are your thoughts about standardisation and the balance between consistency and local tailored assessments?
9	Policy and guidance	What are the strengths and weaknesses of current policy and guidance?
10		How would you like to see policy and guidance evolve?
11	Reporting	Do you have any comments about the reporting and documentation involved in planning?
12	Final thoughts	Is there anything else you to mention that would be worth me considering?

9.3 Lessons learned reports

Appendix G. Report from the first lessons learned workshop presented to the Regional Coordination Group (RCG) in January 2022.



Report of Reconciliation Lessons Learnt for RCG

Authors: Ali Leonard, Dr Jaime Amezaga

25th January 2022

Context

There has been a recent shift in the scale of water resources governance to **national planning** through five regions akin to the centralised planning of the sixties. This change in approach represents a significant challenge and creates **new requirements for alignment, cooperation, and resourcing**, particularly considering the myriad of drivers and uncertainties amidst a heterogeneous pattern of water supply and demand.

This note gives context to reconciliation of regional plans and reports on a recent lessons learnt exercise between the regional groups. The authors of this note facilitated the exercise.

Policy problem

Since the close imposition of drought measures in 2012 after low rainfall in preceding years there has been a **recognised need to improve drought resilience** through developing large new infrastructure schemes such as new reservoirs and inter-regional transfers alongside demand management and leakage reduction. This has been outlined in reports such as the National Framework. However, **proposed infrastructure schemes have faced difficulties in implementation** prompting decision makers to change governance frameworks to enable assessment of strategic infrastructure.

*"The national framework report marks a move to strategic regional planning. It sets out the principles, expectations, and challenges for 5 regional groups (made up of the 17 English water companies and other water users)."*¹

New regulatory guidance

Recognising a lack of drought resilience and the need to build adequate governance structures to develop solutions **new regulatory expectations** have been introduced for water resources governance in England and Wales.

- Ambitious targets for drought resilience, leakage, demand reduction, environmental destination, and carbon net zero.
- Improving collaboration across zones to meet the national need through regional planning.
- Progressing strategic infrastructure using funding overseen by the Regulators' Alliance for Progressing Infrastructure Development (RAPID).
- New decision-making approaches to aid the selection of new schemes which require justification based on good evidence particularly as they will be funded through customers water bills.
 - Best value planning (multi-criteria decision analysis, MCDA) (transparent)
 - Adaptive planning (scenarios) (flexible)
 - Multi-stakeholder, participatory planning (IRBM) (collaborative)

Initial challenge of regional heterogeneity in supply and demand and in governance

The framework lays out ambitious expectations for the regional plans acknowledging the heterogeneity in supply and demand across the UK due to the different physical, demographic, economic and environmental drivers. Less clearly acknowledged is the heterogeneity in regional governance which has evolved differently in each region.

- Differences in objectives and focus - physical and historical factors influencing regional governance aims and objectives today (Figure 1).
- Differences in information and procedures used to take decisions - tailored technical approaches and models developed by companies and regional groups driven by differences in working practices and cultures, as well as in response to their unique set of challenges.
- Different ways of involving stakeholders – extent to which regions have adopted a participatory multi-stakeholder governance structure.

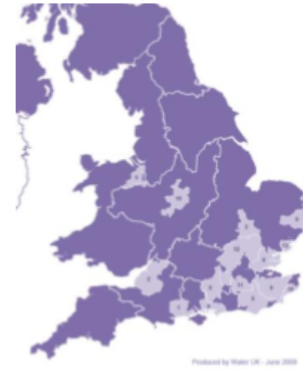


Figure 1: Water company boundaries highlighting a greater legacy of consolidation in the north and west and fragmentation in the south and east. Figure from Water UK, 2009.

These differences impact how regional groups coordinate internally as well as together. However, the ambitious demand and leakage targets that are expected to be met across all regions may delay the need to build new supply infrastructure in the short to medium term. In the meantime, the regions need to find a balance between preserving their inherent diversity and aligning to achieve the level of consistency required to plan nationally. This presents a significant challenge particularly during the transition period where there is still uncertainty over the final regulatory framework.

The introduction of best value planning may help regions to manage this transition if it can enable the regions to tailor best value criteria to their specific needs allowing for flexibility. However, how criteria are compared across regions will require careful consideration.

Region formation and characteristics.	
WRSE (1996):	more fragmented, greatest uncertainty, adaptive planning
WRE (2014):	multi-stakeholder, IWRM
WCWRG (2017):	high level strategic approach
WRW (2020):	bottom-up approach, exporter
WRN (2020):	already integrated/resilient

Positive progress

Although the five regions are stepping into unchartered territory planning at the national level they are working well together. Significant experience has been gained through the maturity of the WRMP process helping build a strong technical foundation for their collaboration. Through the first regional reconciliation process (Sep-Dec 2021) **the five regions showed common understanding of the challenge, worked together effectively, and agreed a joined-up national plan with support from their boards.** This first output represents a substantial achievement for the regional groups. After public consultation, the regions have an opportunity to build on the lessons learned so far through the process in a second round of reconciliation.

Lessons learned

National planning brings a new level of complexity. Coordinating meeting the national need under new “best value” and “adaptive” planning guidelines whilst maintaining operational knowledge at the company resource zone level introduces new requirements for consistency across company borders. This transition is complex and resource intensive. Achieving these changes within the tight planning timelines proved difficult.

Regional coordination requires effective collective leadership and arbitration. Although the regions have developed a positive working culture and shown good collaboration there is room to improve their working practices to encourage one another to set and meet explicit targets. The regions may need to set up new rules of engagement with sufficient standing to hold one another accountable.

The level of technical evidence and detail required should be appropriate to the stage of the planning process and be consistent across regions. Further work is needed to understand where consistency and alignment is essential or unnecessary and to ensure that data processing, modelling, and analysis behind the justification of selected schemes is adequate to support regulatory requirements at WRMP, DCO, and PR24 stages.

Schemes selected in regional plans need to align with the regulatory process. There are cases where regulatory guidance has not been consistent which has generated uncertainty over the standing of regional plans in relation to WRMPs, PR24 and DCOs.

- Consistency is needed as to what should be included in planning baselines across regional plans, WRMPs, and particularly what ultimately gets **funded through Ofwat's assessment in PR24.**
- Uncertain aspects of plans that will not be funded through PR24 (but might be included in future funding rounds) could be included as **alternative scenarios.** For example, enhanced environmental destination could be a scenario until sufficient evidence is gathered to demonstrate that the environmental and societal benefits of abstraction reductions justify the cost and environmental disbenefits of new supply schemes.
- Evidence generated through regional and WRMP planning and consultation should align with the requirements of the **development consent order process** so that appropriate schemes can ultimately be approved.

Regulatory alliances could be useful bridging mechanisms to create consistency across regulatory guidance.

Otherwise, there is a risk the enhanced, best value aspects of regional plans will be dropped at the PR24 or DCO stages, particularly if Ofwat and planning inspectorates use least-cost rather than best value assessments. Unfulfillment of the more enhanced elements that support regional plans and SROs to be best value could create distrust among those who engaged in the regional planning process.

Actions for next reconciliation suggested in the workshop

Aim is to improve the quality of evidence resulting from reconciliation with three complimentary actions:

- a) **Technical water resources planning support** to add more rigour and upfront clarity on goals, process and required outputs. Purpose is to provide sufficient clarity for the regions to hold each other to account for delivery. Particular focus on best value evidence requirements to support WRMPs.
- b) **Economic evidencing support** to ensure that reconciliation provides sufficient evidence to support Ofwat's PR24 assessments and ensure the reconciled schemes can progress to delivery.
- c) **Academic support** to evidence the reconciliation is robust in the context of the established methods for water resources decision making internationally.

Together these actions are intended to add weight to the reconciliation.

RATIONALE

Short term

The regional leads agreed four proposals to improve the delivery of the regional plans and national strategy. Firstly, the leads propose to commission programme management support to coordinate the alignment of inter-regional options through a third reconciliation process that will be run bilaterally between the regions (Proposal 1), and secondly to commission support to help present the key inter-regional aspects of the plans in a consistent way to demonstrate why the final selection is efficient and robust to regulators and stakeholders (Proposal 2). Following the publication of the statements of response, the regional leads agreed that it would be useful to hold a workshop with regulators in the summer to discuss the plans and statements of response, and build confidence that the WRMPs and regional plans fit together and align with the national strategy (Proposal 3). Finally, following publication of WRMPs in autumn 2023, the regional leads agreed that regional plans should be published jointly around December alongside a national event that allows stakeholders to engage with the outputs of the process and demonstrate that positive progress is being made (e.g., increased drought resilience and wider benefits to people and the environment) (Proposal 4).

The regional leads agreed actions to (1) present these proposals to the RCG, and (2) commission support for the third reconciliation to agree and clearly communicate a nationally aligned selection of schemes.

Rationale behind short term proposals and actions

For final plans and schemes to be approved, regulators and stakeholders need to have confidence that the plans are based on fair assumptions, use sensible approaches, and present an efficient and robust selection of options that align across regions. Therefore, a coordinated approach is needed across regions to agree a set of options and transparently communicate the justification for the selection. Having support in the form of programme management and reporting is helpful for such coordination across the regions and the consistent communication of outputs. (Proposal 1 and 2)

Through this coordination, ideally, final plans should be aligned, particularly on core assumptions, and transfer volumes and dates. However, there may be areas where plans are not aligned. For example, some regions/companies may deem adopting core assumptions (e.g. around leakage and PCC) to be unaffordable and present a reasonable justification for their position. Furthermore, perfect alignment of transfer volumes and dates may not be deemed feasible, for example because (1) of late changes to guidance and policy that cannot be accommodated within the remaining planning schedule, (2) of overlapping planning cycles and out-of-sync consultations periods where updated information/decisions cannot be accommodated across all cycles simultaneously, (3) it may not be realistic or sensible to align to precise volumes and dates in the long term in the face of considerable uncertainty, and/or (4) change control processes are difficult to enforce across multiple companies and regions. As such, it may be reasonable to permit some discrepancy between regional/company plans, particularly in the long term.

It would be useful to have a space where regions could engage with regulators to provide confidence around their selection in plans and how they fit with the national strategy, explain the outcomes and approaches, and give reasons for any misalignment. (Proposal 3)

Similarly, it would also be useful to engage with stakeholders at the end of the process to provide confidence that final plans are the right first step, that the process is working to deliver the national strategy, and that the progress made so far will be built upon to improve for the next round of plans. (Proposal 4)

Long term

The regional leads agreed that delivering long term resilience and environmental protection would require a holistic, catchment-focused, multi-sector approach to water resources management (Proposal 1). To fulfil this, a national management structure is needed to coordinate across scales and sectors, communicating national ambitions to the local level, whilst simultaneously understanding the local needs and constraints. Such a structure will require sufficient funding and resourcing (Proposal 2). This position appears to align with regulators thinking, evidenced by a joint letter from regulators published in January 2023.

The regional chairs propose actions (1) prepare a joint response to the regulators letter welcoming this direction, and (2) establish a national tier of programme management for regional planning to deliver holistic, cross sector solutions.

Rationale behind long term proposals and actions

Achieving “good ecological status” of water bodies in line the environmental legislation should be planned in a holistic and catchment-focused way and will require coordination across government, regulators, and across sectors with adequate funding and resourcing.

Key steps to achieve the ambition include: (1) agree the long-term ambition across government, regulators, sectors, stakeholders, (2) determine the condition and true need at the local scale, (3) determine available options that best meet the objectives, potentially involving trialling schemes, and (4) deliver the most effective strategies.

This position appears to align with regulators thinking, evidenced by a joint letter from regulators published in January 2023 which states:

*“Regional groups should show strong leadership in a more **holistic and integrated approach** to water management, exploring opportunities to deliver **cross sector mutual benefits**. In doing so regional groups must be **adequately resourced** and have **appropriate governance**”*

*“Environmental protection ... which ensures the environment is integral to planning future water needs, with **improvements prioritised and agreed collaboratively** [and] addresses environmental pressures proactively before they become a problem and makes sure solutions are sustainable and shaped by a **broad understanding of environmental impacts**.”*

*“Over the coming years we plan to: continue our **open and collaborative approach** to develop the refreshed National Framework for water resources, which aims to **enhance multi-sector planning** alongside improvements in public water supply planning delivered by regional plans”*

*“Review strategic governance arrangements, recognising the continued **need for an independent chair**”*

(EA, Ofwat, and Defra, 2023, A new round of Regional Planning - joint letter)

Both regulators and regional leads recognise certain barriers and the need to reform aspects of governance.

Firstly, there is a lack of alignment across regulators over the long-term ambition for abstraction reductions, and existing frameworks, such as RBMPs, are not driving progress.

Secondly, there are time pressures from statutory and policy drivers that may promote construction of less optimal schemes. Furthermore, the PWS 5-yearly price review is not appropriate for long term environmental destination that must integrate other sectors who do not plan according to rigid investment cycles. Integrating other sectors is more than a timing challenge. Many sectors (particularly energy and agriculture) are fragmented and market driven which does not easily allow for long term strategic planning. However even if these challenges were overcome, fundamentally, there is a lack of understanding at the local level on the condition and needs of water bodies, and available options.

Several steps are required to overcoming the barriers. Regulators (spanning PWS and non-PWS) and government need to consult, agree and communicate a clear direction and strategy. The timeframe to understand and deliver this strategy should not be constrained by the 5 yearly price review, but rather consider a long-term view across all sectors and accommodate an adaptive approach to manage uncertainty. Crucially, investigations and cross-sector scoping studies need to be conducted at the local level to gain a greater understanding of environmental needs and available options. It is likely that a pragmatic approach is needed that prioritises the areas most in need, with trials carried out in a targeted way to drive learning and innovation (Proposal 1).

Finally, no structure or funding exists to coordinate the delivery of meeting objectives in a way that reflects national ambitions and local needs across sectors. Since the introduction of the National Framework, regional groups have demonstrated good collaboration running two national reconciliations to agree a selection of inter-regional transfers. Management support was commissioned by the regions to help structure the second reconciliation. However, the voluntary process has been tested by the constrained timetable and late introduction of new guidance (for example, relating to abstraction reductions and common scenarios). Furthermore, understanding of and input from non-PWS has not been adequate to represent their needs.

A multi-sector/multi-scale management structure is needed to coordinate and share knowledge across sectors, and drive projects to deliver the strategy. This includes national programme management to complement the coordination provided by the regional groups. It will be important that any national resource follows the principle of subsidiarity to preserve local understanding and accountability, as has been maintained so far through regional planning. Necessarily, there needs to be sufficient funding and resourcing for the management structure, and for the delivery of projects (Proposal 2).

Collaborative multi-scale water resources planning in England and Wales



Overview

- We propose the industry adopts a clear multi-scale framework to enable sustained collaborative engagement across regulators, water companies, other abstractors, and wider stakeholders including (1) establish independent national programme management, (2) embed regional groups, (3) support sub-regional and local groups.
- Good progress has already been made towards developing a more collaborative framework via regional planning and national reconciliation work, built on the considerable experience and knowledge of planners in the water industry.
- No similar history or experience exists for non-public water supply abstractors (non-PWS) or catchment planning; these groups require support to develop suitable frameworks as well as freedom to experiment and learn, recognising the different contexts and scales at play.
- Improving collaborative planning both for public water supply (PWS) and non-PWS needs clearer ownership of the facilitation process at and across all scales, requiring adequate staff and resourcing for modern and transparent planning, monitoring, and reporting.

Background

Water regulators in England and Wales have called on water companies to meet higher standards of supply resilience in response to growing pressures from climate change, environmental needs and growth whilst still maintaining affordability. New national and regional governance structures have been established with the aim of enabling better collaboration across regulators, water companies, other abstractors, and wider stakeholders to find and deliver the most efficient and robust water supply infrastructure schemes and demand initiatives.

Method

This report is an output of an ongoing PhD project at Newcastle University focused on engaging with water industry practitioners involved in water resources planning at multiple scales. While the views and recommendations expressed are the authors own, they aim to capture and reflect the expressed opinions and observed experiences of participants involved in the planning process.

The study takes a qualitative approach using data from interviews, workshops, observations, and analysis of published planning documents and the available literature. Twenty-six semi-structured interviews have been conducted with nineteen participants from across the water industry including regional planning leads, regulators, government officials, and water resources planners from water companies and consultancies. Two lessons learned workshops were carried out with six and eight participants (respectively) with the outputs reported back to a national planning group as part of the ongoing planning round. Observations of the planning process drew from placements embedded in the national reconciliation processes and regional and company planning. Policy and planning documents and academic literature were reviewed and analysed. The data was collated and organised thematically to identify successes, limitations, and recommendations. This summary document was discussed in a third workshop with representatives of all the regional groups.

Successes and limitations of the 2020-2024 planning round

Water practitioners reported successes and limitations of the evolving framework (Table 1).

Table 1. Success and limitations of the 2020-2024 water resources planning round in England and Wales

	Successes	Limitations
Objectives	<ul style="list-style-type: none"> - Increasing ambition matches increasing needs (such as being driven by raising resilience standards, meeting environmental targets, climate change, and growth) 	<ul style="list-style-type: none"> - Remaining uncertainty around objectives and trade-offs - Late and changing expectations, disrupting the schedule
Information	<ul style="list-style-type: none"> - Improving consistency and alignment of methods (such as agreeing nationally consistent approach to climate change modelling, using best value and adaptive planning approaches) 	<ul style="list-style-type: none"> - Remaining inconsistency for potentially nationally relevant assumptions and approaches - Lack of knowledge in some areas, particularly non-PWS - Mismatch of some required outputs with the nature of uncertainty in long term - Complexity and opaqueness of methods, alongside excessive reporting/duplication creating difficulties for effective scrutiny, hindering transparency, and lowering confidence and trust

Governance	<ul style="list-style-type: none"> - Improving collaboration across regions, companies, and regulators, and other sectors, opened up discussions and learning - Wider consultation and engagement 	<ul style="list-style-type: none"> - Uncertainty around process (unclear, changing, delayed timetable, deadlines not met, roles unclear) - Difficulties handling new information and change through the process; inconsistencies and misalignments - No equivalent WRMP process for other sectors, and difficulties matching scale between PWS and non-PWS
Outcomes	<ul style="list-style-type: none"> - Agreed national set of transfers with improving consistency and alignment 	<ul style="list-style-type: none"> - No schemes funded for non-PWS (potential for conflict and poor trade-offs between sectors (food-energy-water-industry) during drought) - Limited number/range of options in some areas - Risk of plans not meeting affordability criteria at Price Review 2024

The planning round 2020-2024 saw the initiation of regional planning for the first time nationally alongside the raising of resilience standards, environmental ambitions, and demand and leakage targets. To meet the challenge, guidance was issued at the onset of the planning round, planning approaches proposed by regional groups were reviewed by government and regulators, and the planning timeframe was set.

However, despite these efforts, the planning framework was compromised by several interrelated factors. Firstly, regulatory guidance, expectations and definitions changed throughout the process. Secondly, companies and regions did not meet planning deadlines (with reasons including difficulties meeting the changing regulatory expectations, drought management diverting limited resourcing, and prioritisation of statutory planning requirements). Thirdly, the missed deadlines and delays meant the original planning timetable unravelled, particularly as some companies were issued extensions creating syncing issues across companies with interdependencies, and as the WRMP schedule encroached and overlapped with the business planning timetable. Finally, the risk of challenge and rejection of plans increased; the changing expectations and delays created additional work and problems of consistency, and generally increased uncertainty across companies and regulators as to whether the final plans will meet expectations.

Similar risks continue into the final stages of this planning round. Final determinations on plans are expected in 2024 but there continues to be uncertainty as to how trade-offs should be balanced between meeting resilience standards, meeting environmental ambitions, meeting demand targets amidst significant uncertainty surrounding future changes in water use behaviours, progressing strategic schemes and introduction of government interventions, and crucially meeting the government and Ofwat’s criteria for affordability. There may be a risk that late introduction of affordability constraints (recognising the increasing political attention on water quality and rising interest rates) will limit investment proposals for water resources and therefore void water resources investment planning work across companies and regional groups between 2020 and 2024.

The problems discussed reflect issues of management and coordination, particularly relating to an unclear and unstable vision, and a misunderstanding of the constraints imposed by the statutory timeframe for planners within regional groups and companies. In light of the issues encountered so far during the 2020-2024 planning period, several key lessons learned were identified.

1. Establishing a clear timetable and frontloading work helps mitigate uncertainty, fostering trust and confidence in the process.
2. Change is inevitable, and the process should be adaptable through well-organised collaboration that respects the constraints of stakeholders.
3. Avoiding duplication of (1) technical work, (2) reporting, and (3) consultation across WRMPs, regional plans, SRO planning, and business plans reduces unnecessary workload and enhances effective scrutiny.
4. Ensuring simplicity and clarity through early engagement and agreement on common definitions, methods (including assumptions and modelling) and outputs that can be communicated with all stakeholders is vital for building trust and transparency.
5. Structures that enable ongoing collaboration are essential, as this process is key to achieving better action and implementation, underpinned by trust and transparency.

Consequently, this study proposes that the existing arrangements evolve into an explicit multi-scale framework that recognises the need for and facilitates discussions and decision-making at the appropriate scale (Fig. 1 and Fig. 2).

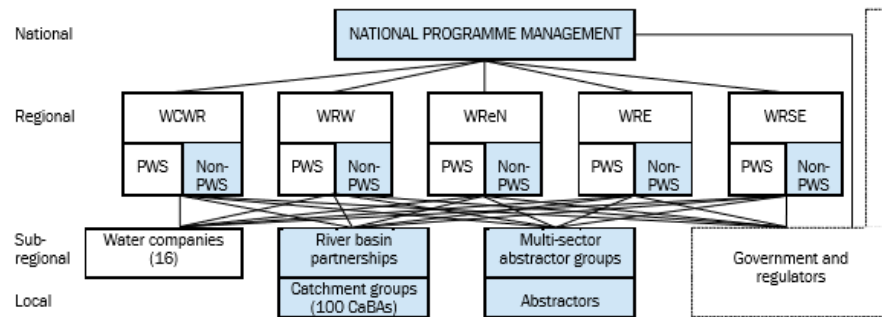


Fig. 1. Proposal for an evolution of the planning framework to make explicit the multi-scale nature of decision-making bodies involved for public water supply (PWS) and non-public water supply (PWS). Blue boxes indicate where a formal investment process is lacking. The dashed border indicates that the government and regulators cross scales.

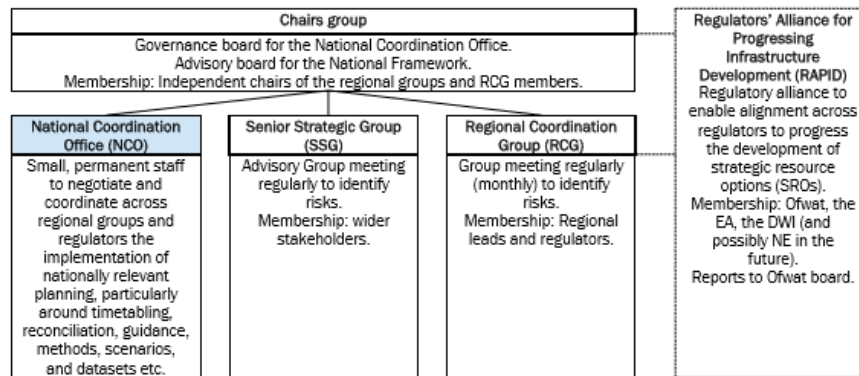


Fig. 2 Proposal for the components of national programme management, with the addition of the National Coordination Office (NCO), highlighted in blue, alongside the existing Chairs group, SSG, RCG, and RAPID.

Clearly, the two schematics provide only a simple overview of a multi-scale water resources governance structure. If new forums are set up to improve water resources planning there are difficult choices at each level regarding form, function and funding that require consideration of trade-offs, possible unintended consequences, and feasibility within the constraints of broader structures of decision-making and politics.

National level coordination

A useful first step is to prioritise the establishment of a national coordination office that can facilitate agreement amongst regional groups (representing both PWS, non-PWS, and wider stakeholders) and regulators on areas of national relevance on a long-term basis.

Seeking agreement across parties following a bottom-up approach, the office could help clarify expectations, common definitions, and methods early on in the process. Furthermore, a crucial function would be to facilitate agreement on and ensure sustained management of a coordinated timetable. The office could hold parties to account as an independent voice by making visible when expectations are not met, backed up by the authority of the chairs group. Additionally, a further role would be to improve national engagement through coordinated reporting and communication.

Having a small team of experienced water resources planners able to negotiate independently across regional groups and regulators to facilitate better coordination amidst the imperfect and changing landscape of planning would smooth the transition to the vision of multi-scale, resilient water resources planning as set out in the National Framework.

Regional coordination

The regional planning groups can play a key role in connecting local constraints and needs up to the national level and national strategies and priorities down to the local level where appropriate. Alongside enabling collaboration vertically, regional groups are well positioned to connect actors across sectors and facilitate the exploration and development of new options across PWS and non-PWS, as well as help to identify critical catchments requiring immediate attention to prioritise for further study due to their importance for supply or particularly difficult trade-offs.

Sub-regional and local

For integrated planning to work effectively, resourcing is needed at sub-regional and local levels to support stakeholders and abstractors as they develop approaches to collaboration and long-term planning. The formation of collectives such as river basin partnerships, catchment groups, and multi-abstractor groups may be useful vehicles for local voices to coordinate and where necessary feed up to higher levels. The emergence of catchment action will help identify and resource those considered critical for regional water resources planning.

Overcoming constraints to enable effective communication across and between scales will be critical to success, else each level or sector risks becoming a silo in itself. These links between scales are therefore crucial and likely work effectively with independent facilitators and when the same practitioners work across levels.

Current practice

Components of this proposed framework exist (water company investment via WRMPs and regional plans) or are already developing (national collaboration via the RCG, SSG, and NF) as illustrated in Table 2. As discussed, these could be clarified and funded on a sustainable basis, alongside the formation of currently missing components (non-PWS investment and greater coordination and investment at the river basin and catchment scale).

Table 2: Framework for delivering WR outcomes, current remit covers investment into PWS schemes. Blue jagged shape represents the process between planning decisions and outcomes (beyond scope of this report).


SCALE	ACTORS	GUIDANCE	PROCESS	PLANS / DECISIONS	OUTCOMES
NATIONAL	Defra, Welsh Ministers Ofwat, EA, NRW, DWI, NE, RAPID, CCW NIC, WaterUK, UKWIR National stakeholders	Legislation: EU, Water Acts, etc. Policy and guidance: NF, WRPG, Welsh Guiding Principles, PR, WISER etc Reports e.g., by UKWIR, NIC, WaterUK etc.	National planning groups (SSG, RCG, RAG, ACWG, MAG, etc.) Gated Process WINEP process	Reconciliation reports Gated decision reports	PWS interregional schemes, including SROs
REGIONAL	5 Regional groups Regional stakeholders		Regional planning	Regional plans	PWS cross company schemes, including SROs
WRZ/ COMPANY BOUNDARY	16 Water companies Consultants WRZ stakeholders		WRMP planning	WRMPs/ Business plans	PWS schemes, including SROs (supply, demand, WINEP)
SUB- REGIONAL AND LOCAL	River Basin Partnerships Local authorities EA Area teams 100 CaBA groups Abstractor groups Local abstractors Local stakeholders				

Table 2 represents the actors, guidance, and processes of planning that allow for decisions to be made on which PWS schemes are required. It is important to note the many critical phases between final plan decisions and the actual operation of schemes including gaining planning consent, detailed scheme design, contracting the relevant supply chains, and construction. Problems may arise that delay or stop schemes at each of these stages. Anticipating these risks and ensuring decisions are built on robust evidence through transparent decision making and wide participation helps to mitigate the risk of schemes falling through at a later point.

As indicated in Table 1, the process is evolving with some successes as well as areas for improvement across objectives, information, and governance. Despite the challenges, the existing WRMP framework for PWS investment does allow for adaptive, long-term planning that enables customer money to be used to meet a range of public goods.

There is no analogous process of long-term planning, investment, and accountability for non-PWS which leaves abstractors vulnerable to water scarcity, particularly in the face of

licence reductions to comply with environmental legislation and increased risk of drought as the climate warms. However the non-PWS framework evolves, it will need to be integrated with PWS at all scales to enable knowledge sharing and learning, reveal and take advantage of collaborative opportunities, build trust and cooperation, and facilitate a collaborative approach to the sharing of a common resource and conflict resolution. It is also important to recognise the diversity of context and scale across non-PWS; a degree of freedom and ownership is required to encourage experimentation, learning, and capacity building to develop planning frameworks that fit needs and capabilities.

Critical issues/analysis

Why a multi-scale framework is needed

Building long term WR planning frameworks for non-PWS raises many questions; how to fund and resource the planning, how to fund and resource investments, how to ensure fairness across a diverse range of abstractors operating across scales with different needs and abilities and capacities to engage, what aspects should be devolved to local groups (such as catchment groups or abstractor groups) and what aspects require greater consistency in approach (such as via national or regional planning)?

There is also the crucial question of whether to better integrate water resources management with related areas of planning (water quality, flooding, drought, land planning, energy, agriculture, ecosystems etc.) at the catchment scale, which may require substantial changes to existing siloed frameworks. In fact, there are many ongoing questions and challenges for water resources management, and it is likely that unanticipated complex issues will continue arise.

Having a multi-scale framework as suggested in Fig. 1 allows for engagement and coordination to begin to explore solutions to these questions. One of the lessons through the recent planning round is that a process that enables collaboration builds human and social capital and reveals inadequacies, with the aim of facilitating better outcomes. Although establishing an integrated multi-scale management structure involves increased transaction costs with additional administrative resources, including experienced staff on a long-term basis, the gains of collaboration in tackling these challenges are worth considering.

Adaptive planning, transparency, and subsidiarity

Decision-makers will always face gaps in understanding, new issues will continue to arise, and approaches and methods will continually evolve, therefore, it is important to build adaptive structures of collaboration and scrutiny that can accommodate the changing and imperfect landscape. Transparency is at the core of this challenge, enabling feedback loops to (1) improve our understanding supported by evidence, and therefore (2) refine our objectives, and (3) the rules and governance required to achieve them.

Keeping in mind the principal of subsidiarity, rather than impose a new top-down structure, a process of information gathering, engagement and trust building is likely needed to bring on board relevant stakeholders. This engagement would provide insight on how best to implement the proposed collaborative multi-scale architecture, and would help clarify (1) the vision, (2) the approach, (3) appropriate metrics, scenarios and performance indicators, (4) a coordinated timetable, (5) the compliance model, and (6) reporting requirements etc.

A stepped approach in the transition to integrated planning

There is wide agreement that to meet future challenges in a holistic and effective way, we will need a more integrated approach to planning that brings together overlapping policy problems including water resources, water quality, flooding, drought planning, etc. However, this would involve transformational change requiring new legislative and policy frameworks, more resources and strong networks built on trust and confidence (requiring higher levels of human and social capital). It may be more effective to first establish multi-scale governance arrangements with a clear remit for water resources planning. As collaborative networks develop, and a greater understanding is developed of areas of priority and potential opportunities, the multi-scale framework could expand to encompass a broader range of objectives.

Summary

Recognising existing gaps and the need to allow learning and adaptation, a stepped approach towards better governance may be wise. A first step should be to establish a national coordination office as part of an explicit multi-scale framework for water resources planning across PWS and non-PWS. This will help initiate trust building and sharing of knowledge to move towards integrated multi-issue planning. As lessons are learnt through collaborative engagement with stakeholders across scales, the framework can be built upon to enable a more informed transition to integrated water management at multiple scales.

Recommendations

The recommendations acknowledge the existing gaps and aim to start framing a collaborative, multi-scale model of planning that starts the process of building a better understanding of water requirements and strategies and managing issues as they arise, recognising that time and resourcing is needed to start building the relationships and levels of trust and confidence required for the long-term goal of truly integrated management.

Recommendations for the next round of water resources planning:

1. Establish an independent national coordination office to structure the process around nationally relevant collaboration and decision-making, particularly for inter-regional reconciliation, alignment, and consistency; regular workshops held early on and throughout the planning cycle to determine needs, current state of knowledge, and appropriate methods to deliver objectives considering scale and the principle of subsidiarity.
2. Progressively align guidance, methods, scenarios, and datasets, creating a shared pool of knowledge that allows for diversity according to local conditions while maintaining consistency and transparency.
3. Develop a joint approach to active adaptive planning at all scales.
4. Embed regional groups as forums for collaboration over issues at the regional level and for feeding up to the national level; streamline existing reporting to reduce duplication with WRMP, SRO, and business planning.
5. Establish a sustainable means of funding to incorporate non-PWS planning alongside PWS decision-making and investment frameworks at the regional and sub-regional/local levels, including greater support and resourcing for multi-sector abstractor groups to widen representation.
6. Establish greater support and resourcing for catchment level and river-basin level environmental investigations and decision-making that can feed up to higher levels where necessary, focusing on identified critical catchments.
7. Ensure sufficient resourcing and transparency for the Environment Agency, Natural Resources Wales, and Natural England across scales, particularly at the local level where there is a need for greater consistency in assessments and better visibility of decision making, alongside a need for setting up modern and transparent monitoring systems to permit effective oversight and evaluation.

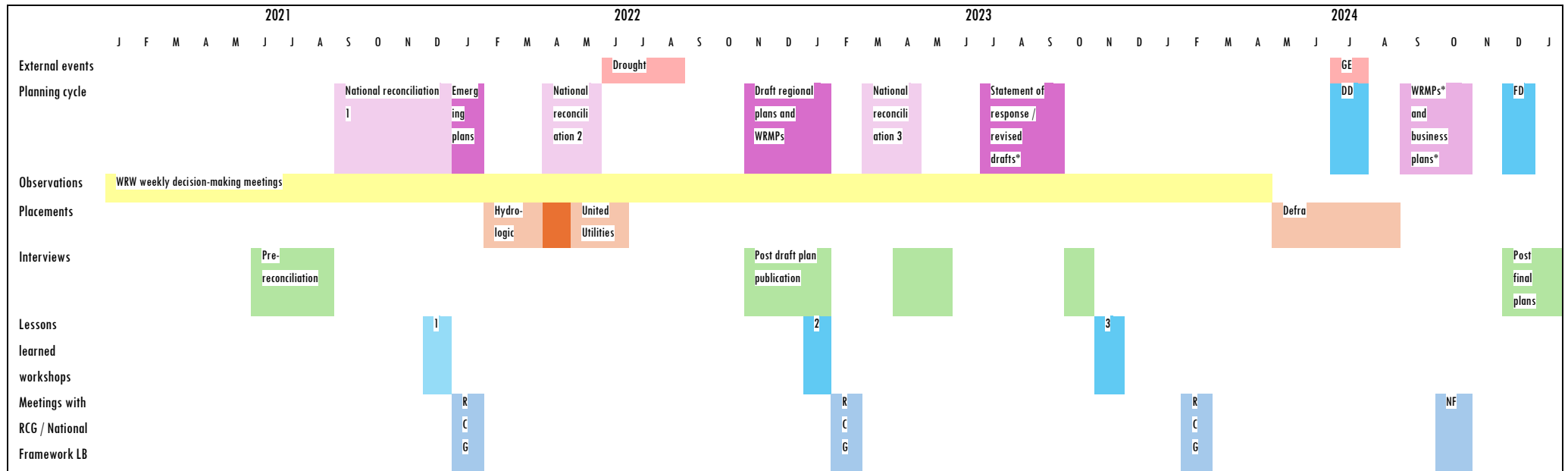
The emerging governance frameworks are attempting to establish and integrate multiple scales for the first time since the sixties in England and Wales, and ultimately will be judged to have succeeded if there is confidence and trust that the process delivered aligned plans across scales that meet long term water supply needs. Success or failure, lessons learned from this transition to a multi-scale approach may provide wider insight for decision makers involved in complex, long-term, multi-stakeholder decision making under uncertainty.

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9.4 Research timeline

Appendix J. Timeline of research activities and wider events



*not all companies and regions published, some plans were delayed

Acronyms: GE = General Election, WRMP = Water resources management plan, DD = Draft Determinations, FD = Final Determinations, WRW = Water Resources West, RCG = Regional Coordination Group, NF = National Framework Leadership Board

9.5 Thematic analysis

Appendix K. Table to demonstrate the data synthesis process, expanding on the results table with additional columns presenting examples of themes, sub-themes and coded data

Limitations	Results table	Themes and sub-themes	Example coded data from interview summaries, meeting minutes, and reconciliation reports
Objectives	Uncertainty around objectives and trade-offs	<ul style="list-style-type: none"> ○ Conflict of objectives and interests, trade offs <ul style="list-style-type: none"> ▪ Trade off affordability with other objectives (resilience, environment, leakage etc) ▪ Competition with wider programmes of spending (e.g. water quality) ▪ Water resources vs flood risk ▪ Environment vs drought resilience ▪ Companies profit driven conflict with EA ▪ CC mitigation vs adaptation ○ Lack of clarity on overall strategy, timing and available funding (prioritisation); ED, scenarios, licence capping, overlapping plans, land management <ul style="list-style-type: none"> ▪ Lack of clarity on whether the best value aspects of regional plans will be funded via the WRMP process ▪ Lack of clarity over (Ofwat) scenarios ▪ Lack of clarity over broader vision; land management and catchment planning ▪ Misalignment of regulators 	<p><u>Interview, water company, July 2021</u> “Meeting the environmental ambition needs to be weighed against cost placed on water bills. There is still a question over whether the right policy approach has been taken regarding getting the balance between drought protection, protecting the environment, and affordability.”</p> <p><u>Interview, regulator, July 2021</u> “There is a challenge managing the trade-off between environmental destination ambition and affordability.” “There is a challenge managing the trade-off between environmental destination ambition and improving drought resilience.” “Water companies are partly profit driven which can conflict with the Environment Agency’s objectives.”</p> <p><u>Interview, regional group, July 2021</u> “There are questions over affordability and investment timelines considering potential consequences for future generations.” “There is a trade-off between water resources management and flood risk management with the former aiming to fill reservoirs to protect against drought and the latter favouring to keep the reservoirs empty to store flood water.” “There will be other drivers on customer bills in the price review, such as combined sewer overflow (CSO) management, which may compete with the water resource programme in the price review. There is a risk that the water resource management plans are deemed unaffordable when considered alongside other programmes of spending.” “Customers value climate change adaptation and resilience to</p>

			<p>drought more highly than mitigation and carbon zero targets.”</p> <p><u>Meeting minutes, May 2022</u></p> <p>“P1: also something interesting that the enhanced had a worse environmental impact than BAU.</p> <p>P2: it’s a summing of options (SEA actions that drive BVP)</p> <p>P1: quite feasible that enhanced is worse than BAU if you have to build a lot of infrastructure, which would be useful to understand</p> <p>P3: we will makes some commentary on that, but who is going to say that a chalk stream in Norfolk is more or less important than a coast line. Into some quite tricky judgements”</p> <p><u>Interview, regional group, July 2021</u></p> <p>“There is uncertainty around the remit of the regional plans particularly regarding environmental destination scenarios and whether these should represent abstraction allocations”</p> <p>“It is difficult to capture catchment scale interventions in regional decision making particularly when they are not optimised and there is no funding mechanism or implementation plan for them yet.”</p> <p><u>Interview, regional group, July 2021</u></p> <p>“There is a risk that the optimal solution set out by the regional plans will start to be unpicked if lack of funding through the business plan process reduces the plans down to what is legally required and least cost stripping away the more enhanced elements and losing the integration across plans.”</p> <p>“There are several plans (catchment partnership groups, river basin management plans, and regional plans) with overlapping jurisdiction and responsibility over the future direction of catchment planning; regulators could help clarify what the broader vision is to help planners understand how changes in land use and management might impact water availability.”</p> <p><u>Meeting minutes, April 2022</u></p> <p>“For the five regions to get clarity around those scenarios, inviting Ofwat to understand where they are coming from, and then have a discussion around how closely the regions will follow that in reconciliation.”</p>
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	Late / changing expectations	<ul style="list-style-type: none"> ○ Lack of clarity on overall strategy, timing and available funding (prioritisation); ED, scenarios, licence capping, overlapping plans, land management <ul style="list-style-type: none"> ▪ Lack of clarity over demand management targets and policy ▪ Lack of clarity over ED policy and licence capping ○ Late and unclear release of guidance or challenge from regulators (room for misalignment between regulators and companies); ED, glidepaths, scenarios, licence capping, water deficits 	<p><u>Interview, regional group, July 2021</u></p> <p>“The Environment Agency are clarifying environmental destination policies in several areas including capping future water abstractions, whether transfers are contingent on water quality status within region, and timings of interventions to improve water quality status for transfers to gain consent.”</p> <p><u>Meeting minutes, April 2022</u></p> <p>“The gov is consulting on targets around demand that will give more confidence around that policy”</p> <p><u>Interview, regional group, November 2022</u></p> <p>“Challenges: Shifting goal posts; particularly definitions and assumptions around environmental destination (ED); and Tight timeframe, hindered by the late agreement of ED and knock-on to modelling work, with the resource crunch rippling into the consultancy sector”</p>
Information	Remaining inconsistency	<ul style="list-style-type: none"> ○ Inconsistencies in approach; undefined terms, language, semantics, definitions <ul style="list-style-type: none"> ▪ Ambiguities with Ofwat's common scenarios, pathways, decisions points etc. ▪ Inconsistent approach to costs and discounting ▪ Inconsistent approach to ED ▪ Inconsistent approach to glide paths ▪ Inconsistent approach to growth projections ▪ Inconsistent approach to metrics ▪ Inconsistent approach to screening uncertain options (SROs) based on confidence in feasibility ▪ Inconsistent approach to the baseline 	<p><u>Interview, water company, June 2021</u></p> <p>“Regions/companies are not taking consistent approaches to environmental destination currently, partly because of perceived lack of data and accuracy of data, which may distort the national picture of needs”</p> <p>“Lining up key assumptions such as those around climate change, decision making, and environmental destination would improve decision making.”</p> <p><u>Interview, regulator, July 2021</u></p> <p>“Undeveloped and inconsistent approaches to data and methods by companies and regions may pose a challenge to the regional planning process”</p> <p><u>Interview, regional group, July 2021</u></p> <p>“Regions are not accounting for environmental destination in a consistent way which needs addressing”</p>

		<ul style="list-style-type: none"> ▪ Importance of having stable baseline and metrics for comparison of plans (not there in reconciliation) ○ Insufficient information on SDB; incomplete and unbalanced understanding (time and funding constraints) <ul style="list-style-type: none"> ▪ Bias one region over another due to insufficient information or unfair assumptions of (true) SDB ▪ Different levels of political pressure has led to different levels of understanding on environment ▪ Lack of time to investigate or evidence to justify environmental destination; feed into next round 	<p><u>Meeting minutes, April 2022</u></p> <p>“We had a conversation around glide paths; when the decision is made, where you end up going to. It comes down to how long the investigations are going to go on to get the data; then confirm the regulatory position</p> <p>“██████████ have completed the template on a different basis.”</p> <p>“There was a question about ONS forecast and which one should be used; WRMP guidance doesn’t specify an ONS variant.”</p> <p>“On abstraction reductions: reflecting feedback that the low scenario wasn’t a plausible extreme as it implied quite large enhancement investment in some regions, we’ve updated the final guidance to “currently known legal requirements to 2050”. This is open to some interpretation.”</p> <p>“We need to really understand what you’re asking for, because interpretations in different ways mean material differences.”</p> <p>“The meaning of locally verified still needs a bit of work, it might be too open- could view it depending on the outcome you want.”</p> <p><u>Reconciliation report, May 2022</u></p> <p>“BAU+ (including WINEP and licence capping), but use local reviews to remove licence reductions with significant uncertainty to represent a realistic plausible low scenario. Regions are in different places regarding progression of local reviews; a key constraint is lack of resource of local EA teams to agree these; regions could themselves define a plausible scenario stating assumptions and caveats.”</p> <p><u>Interview, government, August, 2021</u></p> <p>“There is a question as to where consistency is necessary and to what level of detail”</p> <p><u>Meeting minutes, May 2022</u></p> <p>“Can’t compare metrics to emerging plan (metrics have changed so don’t compare back to January), it’s more useful to compare between the tests that are being done now”</p> <p><u>Meeting minutes, April 2022</u></p> <p>P1: “Metric scoring should be internally consistent. It is not appropriate to compare across regions (even with the normalised</p>
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			<p>scoring) because the ranges are not comparable. If necessary, a qualitative approach can be used to represent the position and facilitate discussion.”</p> <p><u>Meeting minutes, September 2022</u></p> <p>P1: “it's not possible to compare between the regions. It's a vehicle within a region to flush out the changes - benefits and disbenefits. We cant compare one regions metrics to another.”</p>
	<p>Lack of data/ knowledge/ understanding/ inherent uncertainty</p>	<ul style="list-style-type: none"> ○ Barriers to the best value approach to comparing and selecting options <ul style="list-style-type: none"> ▪ Best value approach requires a lot of data input and assessing many combinations of options ▪ Complexity of assigning benefits directly and indirectly to companies or regions ▪ Difficulties comparing options across regions, different levels of complexity (heterogeneity in approach to best value and inevitable subjectivity when valuing the environment, flooding, and cross-sector needs) ▪ Revert to cost analysis; importance of cost in decisions ▪ Option selection sensitivity - closely competing options ○ Uncertainties, errors, lack of data, lack of methods <ul style="list-style-type: none"> ▪ Catchment scale interventions in regional decision making are not captured in regional decision making (not optimised) ▪ Errors can lead to biased decisions (problem with carbon assessment in reconciliation) ▪ Importance of accurate input data to avoid bias (option assessment data e.g. SEA; probabilistic UKCP19 data possible errors; 	<p><u>Interview, regulator, July 2021</u></p> <p>“Following a best value approach requires a lot of data input and involves assessing many combinations of options”</p> <p>“One challenge of water resources planning is its complexity, particularly the heterogeneity in approach to best value and inevitable subjectivity when valuing the environment, flooding, and cross-sector needs”</p> <p><u>Meeting minutes, June 2022</u></p> <p>“Not a full best value plan. Least cost but considering other aspects.”</p> <p><u>Meeting minutes, April 2022</u></p> <p>“MS: understand that people are scared of putting out things that are not finalised, but judgement can be enough”</p> <p><u>Meeting minutes, May, 2022</u></p> <p>“I prefer the more mature schemes coming through - far more comfortable with the uncertain schemes dropping out, and basing around the more mature schemes”</p> <p><u>Reconciliation report</u></p> <p>“It was recognised early in the process that within [REDACTED] modelling there are a number of closely competing options, particularly in terms of cost, making transfer selection and timing very sensitive to change.”</p> <p><u>Interview, consultant, April 2023</u></p> <p>“Decision makers should be careful using models and realise their limitations and constraints. The industry has not yet reached the stage of being able to model simultaneously:</p> <ul style="list-style-type: none"> • all elements of water resource systems at a local scale on a daily timestep, • optimise these based on multiple objectives, • test these portfolios against thousands of stochastically derived drought scenarios.

		<p>choice of emissions scenario, historical record)</p> <ul style="list-style-type: none"> ▪ Important to align the baseline as well as other adaptive pathways, accounting for ED, which adds complexity ○ Insufficient information on options; incomplete and unbalanced understanding (time and funding constraints) <ul style="list-style-type: none"> ▪ Avoiding picking winners (screening out options with uncertainty or less funding), important to keep options on the table ▪ There are many remaining uncertainties, the data is not there in several cases (SROs etc); regions didn't have all the required information and model runs for reconciliation ▪ Uncertainty in feasibility of options; unsure on what timescale uncertainty will reduce (Mendips, Derwent, SESRO, UTVR) 	<p>This would be too computationally expensive, particularly given the limits of statutory timeframes.”</p>
	<p>Limitations of national modelling work</p>	<ul style="list-style-type: none"> ○ Limitations of national modelling work ○ Lack of open data 	<p><u>Interview, water company, November 2022</u> “There are some quite big technical challenges of those national modelling projects, so we're probably not completely comfortable that should be the level of analysis that we would go with to make those decisions” <u>Interview, regulators, October 2023</u> “Need for open data but currently a long way off”</p>
	<p>Outputs mismatch the nature of uncertainty in the long term</p>	<ul style="list-style-type: none"> ○ Models and methods create outputs that do not capture the uncertainty/reality ○ Challenge of yearly dates and volumes in WRMP tables amidst uncertainty ○ Time - future generations; when is the fairest time to deliver investment, how to discount different components of long-life assets ○ Ofwat are only considering a narrow range of future scenarios 	<p><u>Meeting minutes, April 2022</u> “P1: yearly SDB in tables indicating “deficits” in particular years doesn’t necessarily help with long term planning due to huge uncertainty” “The bit that worries me about Ofwat, they are only considering a narrow range of future scenarios around that core path, that will influence the decision making process quite clearly” <u>Meeting minutes, May 2022</u> “P1: trouble is planning to this level of precision at this early stage” <u>Interview, consultant, April 2023</u></p>

			<p>“The EBSD approach:</p> <ul style="list-style-type: none"> ▪ Based on one supply and demand on an annual basis - does not include the constraints of complicated networks; the options may not work in practice in time or space and need to be subsequently tested in a systems model (e.g. pywr) ▪ Fits the tables/spreadsheets, but reality is not linear, and a lot of time is spent talking about how the EBSD outputs are not quite right” <p><u>Interview, regional group, July 2021</u> “██████████ WRMP process explored the impact of discount rates on selected portfolios. There are questions as to whether it is reasonable to discount different components of long-life assets equally”</p> <p><u>Interview, regional group, July 2021</u> “There are questions over affordability and investment timelines considering potential consequences for future generations.” “Question over whether it's reasonable to discount different components of long-life assets equally”</p>
	<p>Complexity and opaqueness of methods, alongside excessive reporting/ duplication creating difficulties for effective scrutiny, hindering transparency, and lowering confidence and trust</p>	<ul style="list-style-type: none"> ○ Lack of time and resources to investigate and assess options and costs; Lack of evidence and assurance could lead to poor or uncredible decision making (lead to loss of confidence in process) ○ Justifying option selection can sometimes be hindered by (black box) sophisticated modelling; it was not always clear through reconciliation why WRSE model out certain configurations ○ Slow technical progress can hinder decision making timeframes ○ Complexity of adaptive approach; exponentially increasing scenarios as regions follow different pathways; scenarios, triggers and branch points, risk and likelihood of scenarios, clear consistent definitions of scenarios 	<p><u>Interview, regional group, July 2021</u> “There is a question as to whether the new modelled outputs for ██████████ are based on fair assumptions such as appropriate choice of emissions scenario and appropriate use of the historical record to generate the stochastic data. Further work is needed to review the results and provide assurance as to their credibility.”</p> <p><u>Meeting minutes, May 2022</u> “P1: From the regulators, the initial view was to get the process going, generate high quality information, then choose options, but the data isn't there or there might be a reason we don't have the information. So, it's a departure from where we thought we'd be. Important to ensure regulators don't lose confidence in the process”</p> <p><u>Meeting minutes, September 2022</u> “P1: I've struggled to follow what ██████████ is doing, with investment model does so much more than everyone else is - the visualiser that you see is the binary outcome - but actually the model underneath is doing so much, so many moving parts, very difficult to explain what's happening because it's just so huge.”</p>

			<p>“P2: no one seems to understand why the model selects anything (black box) churns it out.”</p> <p>“P3: other colleagues who have access to the model landing platform, they're all still in the dark (need a software degree/computing) can't understand why the model is working”</p> <p>“P4: if they are not able to demonstrate it, we're going to end up in a adversarial position next year. Someone will want a print out of the programming.”</p>
Governance	Uncertainty / difficulties around process and disruptions to the schedule	<ul style="list-style-type: none"> ○ Uncertainty and lack of clarity around the process and schedule <ul style="list-style-type: none"> ▪ Late and unclear release of guidance or challenge from regulators (room for misalignment between regulators and companies); ED, glidepaths, scenarios, licence capping, water deficits, ▪ Reluctance of gov and regulators to set guidance (see responsibility with companies) ○ Barriers to cross-company collaboration and more strategic planning <ul style="list-style-type: none"> ▪ Added risk for companies from inter-company transfers; less guarantee of security of supply (legally required) ▪ Challenge of integrating multiple pathways across regions and companies (adaptive planning) ▪ Challenges may arise at planning stages (DCO process); unclear how public enquiries will work ▪ Clash and overlap between planning cycles and frameworks (WRMP, regions, Gates, DWMP, WINEP, best value, AMP, PR etc.); risk of interference, unclear priority and responsibility ▪ Complexity maintaining accountability with multi-scale planning ▪ Concerns over legitimacy 	<p><u>Interview, water company, November 2022</u></p> <p>“It is not yet clear the how the next phase of planning will work, particularly around: (1) how to re-reconcile plans after consultation, (2) when final plans will be published, (3) do WRMPs and regional plans need to be published together, (4) how would public inquiries on WRMPs work, and (5) how will the final sign off on plans and the SRO DCO process work.”</p> <p><u>Meeting minutes, May 2022</u></p> <p>“█ are selecting to stop the transfer in all their scenarios because of the introduction of licence capping”</p> <p>“█ informed us that the groundwater schemes are now going to now be rejected. Given this information about the groundwater and too high a dependency on savings it is likely that this transfer will drop out and STT will come back in.”</p> <p><u>Interview, regional group, July 2021</u></p> <p>“Government may be reluctant to set a better overall integrated planning framework as it could shift responsibility away from the water companies onto themselves bringing greater accountability and an increased risk of being implicated in a failure”</p> <p>“Regional best value planning has not been tried before and it is unclear how the process will balance regions, possibly against each other.”</p> <p>“The timescale is challenging for a new process that involves many policy questions.”</p> <p><u>Interview, regulator, July 2021</u></p> <p>“A challenge that might arise in the regional reconciliation is competition between regions for the same water”</p> <p><u>Interview, water company, July 2021</u></p>

		<ul style="list-style-type: none"> ▪ Heterogeneous regions and companies (organisational); Different approaches across companies and regions create inconsistencies ▪ Information sits at company level ▪ Lack of a national strategy ▪ Lack of standardised costing and competition rules ▪ Local approaches can undermine consistency ▪ Misfit with current legal and governance structures and company practices ▪ Novel ▪ Privatised nature of water industry creates constraint that schemes (transfers) must be profit making and in company interest ▪ Question as to where consistency is necessary and to what level of detail ▪ Question over how to fund schemes ▪ Regions might be in competition; challenge balancing the best overall national strategy ▪ There are legislation differences between Wales and England; environmental legislation, resilience targets, climate policy, biodiversity ▪ Tight planning timeframes ▪ Translating regional plans into WRMPs; aggregating or filtering down; implications for timings, sign off and legitimacy 	<p>“Companies have a legal duty to provide water to their own customers. They face unresolved risks agreeing transfers with other companies because a question remains as to whether security of supply can be guaranteed in future drought conditions”</p>
	<p>Limitations of funding and resourcing</p>	<ul style="list-style-type: none"> ○ Resourcing issues <ul style="list-style-type: none"> ▪ Resourcing and funding issues for regulators, particularly local EA teams ▪ Resourcing and funding issues for regional groups ▪ Resourcing issues for consultancies 	<p><u>Interview, regional group, December 2022</u> “A more structured and better resourced approach would also help regional groups. So far, [REDACTED] has struggled with resourcing and last-minute changes” <u>Interview, regional group, November 2022</u> “Resourcing planning:</p>

		<ul style="list-style-type: none"> ▪ Strategic planning takes up resources which is a particular challenge for smaller companies 	<ul style="list-style-type: none"> • Regional and company planning struggles with a lack of resourcing, both in terms of finances and staffing • Reliant on a small number of specialist WR modellers across companies/regions/consultancies; there is a need for the next generation of water resource specialists to meet the requirements of both regional planning and company level planning” <p><u>Meeting minutes, April 2022</u> “EA confirmed they have no capacity to get involved in this so the “local verification” is not likely to be possible for ██████████”</p>
	<p>Difficulties handling change / new information</p>	<ul style="list-style-type: none"> ○ Change control; new evidence could change option selection; important to draw line in the sand with a process to manage change <ul style="list-style-type: none"> ▪ Important to draw line in the sand to have an aligned plan to consult on alongside alternatives; Regions must reconcile on SROs as they as currently defined despite the likelihood of future changes ▪ Material changes can be managed, significance depends on if they fall within upcoming AMP ▪ New evidence will come into light through further engagement and investigation that could change option selection ▪ Regional heterogeneity in supply and demand balance; E and SE face biggest pressures but pattern of need is continually evolving in all regions; exporters surplus may reduce with ongoing investigations and policy changes 	<p><u>Interview, water company, July 2021</u> “The reconciliation process may indicate previously agreed transfers to be sub-optimal. In particular, long-distance transfers might be challenged if projections are updated to show greater need local to the exporter.”</p> <p><u>Interview, regional group, July 2021</u> “The new modelling may indicate that WRN does not have a surplus to export to support national water trading.” “For consultation to be meaningful it is important to accept it might lead to material changes in the plans.”</p> <p><u>Interview, regional group, July 2021</u> “More detailed analysis through the WRMP process may reveal changes in the availability of water that materially impact the ability of companies and regions to share water.” “There is consensus that the Southeast faces the biggest challenges in water supply. It is possible that the pattern of need may change in the future. In the Southeast region Hampshire and Portsmouth were previously seen as water rich, able to move excess water eastwards into Sussex and Kent. Within a 5-year period, the direction of water need in the Southeast was reversed due to greater emphasis on improving the environment, particularly the chalk streams. Similarly to the Southeast, the perceived pattern of water availability in the other regions may change as planning approaches mature which could compromise the selection of inter-region transfers, and ultimately change the configuration of options.”</p> <p><u>Interview, regulators, July 2021</u></p>

			<p>“Regional plans may need to be reconciled again if material changes happen through consultation and the WRMP process.” <u>Meeting minutes, May 2022</u></p> <p>“P1: what’s been thrown in this week in short notice, we might be in a different situation, we might have a bigger gap to fill because of deficits on the [REDACTED]. It comes back to - where do you draw the line in the sand - or do we take what we know is coming (bigger deficits)?” <u>Interview, regional group, December 2022</u></p> <p>“There was an expectation the process of aligning regional and company plans would run according to a particular timeline with data being locked down early (in May for [REDACTED]). However, in practice late changes made locking down and alignment more difficult, and blurred whether the direction of decision making for some schemes was top down (directed by the region) or bottom up (directed by the companies). In the future we need to get smarter at how we achieve alignment on parallel processes making sure there's a good process where information feeds up.”</p>
	<p>No framework for other sectors</p>	<ul style="list-style-type: none"> ○ Barriers to integrated planning ○ Lack of funding for non-PWS ○ Lack of framework ○ Mismatch in planning timeframes 	<p><u>Interview, water company, November 2022</u></p> <p>“There is potentially a gap having the government and regulatory response to regional plans and evaluation of the SROs resting primarily on Ofwat who’s remit concerns public water supply rather than multi-sector needs, such as agriculture and hydrogen power. This raises a question over whether other governmental policy making bodies should have more of a role in setting out how to plan for other sectors water needs, for example Defra over agricultural water needs and BEIS over hydrogen water needs. The needs of these sectors may impact the evaluation of the portfolio of schemes selected in regional plans.” <u>Interview, regional group, December 2022</u></p> <p>“The other sectors do not have a funded, structured approach around long term planning in the same way that water companies do (with agriculture presenting a particular challenge in this regard).” <u>Interview, government, January 2023</u></p> <p>“In the future, other sectors should be better integrated to make the most of any cross-sector opportunities, particularly considering water companies’ ability to move water around. However, several barriers</p>

			exist (organisational, funding, understanding wider sector needs, mismatched timing, and scales etc).”
	Difficulties matching scale between PWS and non-PWS	<ul style="list-style-type: none"> ○ Complexity of integrated planning ○ Difficulties reconciling granularities due to differences in scale between non-PWS and PWS ○ Catchment scale interventions in regional decision making are not captured in regional decision making (not optimised) 	<p><u>Interview, regional group, July 2021</u> “It is difficult to capture catchment scale interventions in regional decision making particularly when they are not optimised”</p> <p><u>Interview, water company, November 2022</u> “A challenge of the regional simulator approach has been incorporating the requirements of other sectors at the right level of granularity, particularly energy and agriculture, who do not generally plan their long-term water requirements at the same scale and in the same structured way that water companies do (and who are hindered from doing so by barriers to cooperation such as competition laws, siloed working practices, and a lack of long-term forecasting). For example, for agriculture █████ did modelling at the CAMS catchment level but there’s a big difference between the CAMS catchment and an individual farm in terms of how meaningful that is for farmers.”</p>
	Lack of framework for catchment / nature-based / IRBM solutions	<ul style="list-style-type: none"> ○ Catchment and local approaches <ul style="list-style-type: none"> ▪ Catchment planning barrier; difficult to capture in regional decision making, lack of funding mechanism, overlapping jurisdiction, requires clarification from regulators over the broader vision for land use and management ▪ Improving the assessment of catchment schemes with more engagement and collaboration with NGOs and regulators ▪ Holistic (qualitative) approach to ED and ecological outcomes (water quality and hydromorphology) might meet ambitions rather than a focus on flow 	<p><u>Interview, regional group, December 2022</u> “Water companies are keen on promoting nature-based solutions at the catchment scale (which generally focus more on water quality and drainage but could benefit water resources through reducing risk to water quality). However, so far, nature-based solutions have not been included in preferred plans to solve supply and demand deficits due to difficulties with quantifying their water resources benefit. It would be good to include more catchment and nature-based solutions as they can add value.”</p> <p><u>Interview, regional group, July 2021</u> “It is difficult to capture catchment scale interventions in regional decision making particularly when they are not optimised and there is no funding mechanism or implementation plan for them yet. “</p> <p><u>Interview, regional group, July 2021</u> “More engagement and collaboration with NGOs and regulators could enable better assessment of the costs and benefits of catchment schemes.”</p>

	Difficulties of participation and engagement	<ul style="list-style-type: none"> ○ Less engagement from Ofwat through the process compared to the EA ○ Barriers to participation with the public, regulators, and other companies due to complexity ○ Complexity of decision modelling and scenario testing should not undermine the decision making process of ability to communicate outputs ○ Consultation is key to decide between close alternatives ○ Customer demographics, awareness, and perception of water scarcity impact priorities and willingness to engage and reduce demand ○ Important that stakeholders (incl. regulators) understand, trust, and do not lose confidence in the process ○ Important to allow sufficient time for consultation ○ Negative perceptions of schemes (desal and water reuse) may present a barrier to their implementation ○ Perceptions of drought influenced by recent memory in the news ○ Stakeholder advisory board that may not accept the reconciled plan 	<p><u>Interview, water company, June 2021</u> “Customers do not always want to engage with the water companies”</p> <p><u>Interview, water company, July 2021</u> “One challenge is incorporating stakeholders’ views and managing stakeholder’s expectations to keep everyone engaged and supportive of the process”</p> <p>“It is important that the complexity of the decision modelling and scenario testing does not undermine the decision-making process or undermine the ability to communicate the outputs clearly.”</p> <p><u>Interview, regulator, July 2021</u> “People’s negative perceptions of water supply options such as desalination and water reuse schemes may present barriers to their implementation”</p> <p><u>Interview, consultant, April 2023</u> “There are difficulties communicating model outputs and decisions to the public, as well as to regulators and staff within the water companies.”</p> <p><u>Interview, water company, November 2023</u> “There has been less engagement with Ofwat on regional planning compared to the EA who observed the reconciliation process. Ofwat engaged more in the WRMP process through pre-consultation meetings with the water companies.”</p>
Outcomes	No schemes funded for non-PWS	<ul style="list-style-type: none"> ○ No schemes funded for non-PWS ○ Lack of schemes for non-PWS ○ Company technical planning dominates over a truly multi-sector approach 	<p><u>Interview, regional group, December 2022</u> “Although █████ discuss the needs of other sectors in the narrative throughout their draft plan, they are not able to present a non-PWS programme of investment for supply and demand options to meet projected deficits.”</p> <p><u>Governance report</u> “This process is currently dominated by water company considerations and is currently being determined at a technical level. It does not truly reflect a multi-sector approach”</p>

	<p>Limited options in some areas</p>	<ul style="list-style-type: none"> ○ Lack of options ○ Need for large new options to replace lost supply from abstraction reductions and licence capping 	<p><u>Interview, regional group, July 2021</u> “A potential challenge is whether there are sufficient options available to meet the substantial forecast deficit which is driven by unyielding factors such as climate change and population growth.”</p> <p><u>Interview, regional group, July 2021</u> “To prepare for water-poor years with reduced groundwater and river abstraction, there are a limited range of options including increasing storage, water recycling, transfers, and demand and leakage management.”</p> <p><u>Meeting minutes, April 2022</u> “P1: BAU creates significant deficits in [REDACTED] (groundwater dominated – large quantities to reduce), the consequence is the need to increase connections to the grid from surface water upstream where the only available solution is [REDACTED]. This means under the BAU scenario, [REDACTED] would need to make use of both their 2 available options 1) cease the transfer to [REDACTED], and 2) raise the [REDACTED] dam, for use in their own zones. There is no real scope for best value planning (as opposed to simply scoring ‘impacts’) as there are no available alternatives.”</p> <p><u>Meeting minutes, September 2022</u> “P1: fundamental problem with all the plans, not enough choice can't give confidence that they are the best combination of options. Water needs have changed so quickly that the regions haven't got enough options available.” “P2: for the WC, need all their options, impossible to provide a best value plan. Its just the cost, because they need everyone. Haven't done it wrong but there's no element of choice.”</p> <p><u>Reconciliation report</u> “To fill the resulting deficits, [REDACTED] has very limited feasible WRMP options: (1) to utilise the new reservoir enlargement element of the [REDACTED] and (2) to cease the existing transfer to [REDACTED].”</p> <p>“Due to limited alternatives for [REDACTED] the resulting reconciliation position (to cease the existing transfer) is therefore based on need rather than being a BVP decision.”</p> <p><u>Interview, water company, July 2021</u></p>
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			<p>“There has been a growing momentum to reduce abstraction from chalk streams. Large schemes such as transfers will be required to replace the lost supply.” <u>Interview, water company, December 2022</u> “There was not a significant difference between the least cost and best value plans. This may be partly due to insufficient options to choose from. Usually water resources planners aim for three times the number of options as the size of the problem in terms of volumetric benefit, however, this was not possible with the number of options on the table and the size of the deficit. As a result, certain big schemes were always selected to fill the deficits.”</p>
	Risk of plans not meeting affordability criteria at Price Review 2024	<ul style="list-style-type: none"> ○ Price review affordability risks 	<p><u>Interview, government, January 2023</u> “it is not clear what would happen if the cost on customer bills for water resources and quality planning was considered unaffordable; there is a chance that the government would have to revisit the planning approach.”</p>
	Risks with planning and implementation	<ul style="list-style-type: none"> ○ Delivery risks 	<p><u>Interview, water company, November 2011</u> “Big schemes are needed to meet the challenge set out by the NIC in 2018 to improve drought resilience, alongside demand management; the question now is how to deliver them.” <u>Interview, government, January 2023</u> “there is a risk that supply chains will not be able to handle big increases in infrastructure building, which could increase prices.”</p>

Success	Results table	Themes and sub-themes	Examples from interview summaries, meeting minutes, and reconciliation reports
Objectives	Increasing ambition matches increasing needs	<ul style="list-style-type: none"> ○ Recognition of multi-objective problem ○ Protecting the environment ○ Improving resilience ○ Long term strategy to ensure water company abstractions protect the environment ○ Long term planning horizon; projecting deficits over 25 years, 50 years, 60-80 years 	<p><u>Interview, water company, July 2021</u> “The National Framework set an expectation that all regions should aim for the long term environmental destination which is focused on making sure water company abstractions protect the environment and are sustainable.” <u>Interview, regulators, July 2021</u></p>

		<ul style="list-style-type: none"> ○ National Framework aimed to present an objective proposition of investment and DM ○ New framework is helping solve strategic deficits; capturing experience from mature WRMP process and WRSE process; promotes best options based on evidence ○ The planning framework is starting to incorporate scenarios and pathways ○ Ofwat introduced incentives for transfers (export incentive provides a super profit on transfers) ○ Promoting strategic planning ○ What success looks like; overall long term best value options, agreed by all, aligned, affordable, time for consultation to strengthen transparency, balance between local knowledge and clear accountability and national need, less complexity 	<p>“A successful outcome of regional planning would be greater consideration of environmental needs in the longer term in the face of climate change” <u>Interview, regional group, July 2021</u> “there is a move to improve the robustness and resilience of plans by considering future environmental needs alongside a wider range of growth and planning scenarios. The change in planning approach [REDACTED] recognises the widening range of challenges.” “Although events such as drought or a change of government could trigger a change in policy, in general, the strategic direction – more resilient water supplies - in water resources planning is relatively settled.” “A successful reconciliation would be to determine that a certain configuration is possibly the better one evidenced by what-if scenarios whilst recognising the need to continue consulting on alternatives and reconciling and aligning plans when changes are made.” “It would be favourable to have a system that enables robust plans, that deliver the needs of the environment, customers, and stakeholders, to be funded at an economic level with support from the regulators” <u>Interview, government, August, 2021</u> “Although events such as drought or a change of government could trigger a change in policy, in general, the strategic direction – more resilient water supplies - in water resources planning is relatively settled.” “Ministers want to see transparent, integrated, long-term planning enabled by proper engagement and consultation”</p>
<p>Information</p>	<p>Improving consistency and alignment of methods</p>	<ul style="list-style-type: none"> ○ Improving consistency and alignment of methods ○ More sophisticated approaches incorporating stochastic hydrology have been introduced to improve the robustness of plans ○ Reconciliation aims to align plans to provide an optimised solution to meet the national deficit in a consistent and coherent way; more 	<p><u>Interview, regional group, July 2021</u> “The current planning round is the first to use best value criteria in a consistent and coherent way” [REDACTED] companies are working together well to produce a regional plan. The companies are generally in good agreement” <u>Interview, water company, 2021</u> “The Environment Agency is helping to ensure better consistency in approach to long term environmental destination by suggesting scenarios for companies to investigate and base their proposals on”</p>

		reconciliations might needed in the future to re-align plans if changes occur	<p><u>Interview, regulator, 2021</u> “Water industry regulators are working to ensure regional plans are nationally coherent” “The main aim of the regional reconciliation process is to ensure that inter-regional transfers are aligned across the five regional plans based on the same planning assumptions, such as consistent approaches towards drought resilience, demand reduction, and drought measures”</p> <p><u>Interview, government, August 2021</u> “The reconciliation aims to share information and create consistency across the regions where it is necessary at the right level of detail”</p>
	Recognition of the importance of maintaining locally tailored approaches	<ul style="list-style-type: none"> ○ The approach and the complexity of the methods used should be a feature of the complexity of the problem that's being faced ○ Regional diversity exists and different approaches should reflect complexity 	<p><u>Interview, water company, June 2021</u> “There are reasons to maintain a more local approach, particularly regarding decision making tools, though it may undermine consistency.”</p> <p><u>Interview, regional group, July 2021</u> “Every region has a set of unique features, challenges, and opportunities. Reflecting their inherent diversity, regional groups must take different approach. The approach and the complexity of the methods used should be a feature of the complexity of the problem that's being faced.”</p> <p><u>Interview, regulator, September 2022</u> “P1: risk is really important to us. How much time we spend on a time, depends on how much risk there is - more time on the southeast. Don't need to spend so long on a small company with a surplus.”</p>
	Benefits of national modelling work	<ul style="list-style-type: none"> ○ Additional models (e.g. Oxford and Manchester models) can help explore solutions and provide a check on the reliability of industry models 	<p><u>Interview, regulator, July 2021</u> “Understanding divergence between the Oxford model and industry models improves understanding of different assumptions and provides a check on the reliability of how the models are performing.” “RAPID is working with the University of Manchester on high-level water resources modelling exploring hypothetical combinations of options that could be efficient nationally and might be worth investigating further. The modelling work helps shape and challenge water company plans.”</p> <p><u>Meeting minutes, May 2022</u></p>

			<p>“P1: the national simulation modelling might help some info on robustness for configuration P2: hopefully say the same things - which by large i think they do” <u>Emerging regional plan</u> “There are also plans to link household and non-household demand forecasts to the new Met Office weather generator that is being used to determine climate change impacts on our supply systems. Once this is complete, we will have the capacity to produce time consistent weather and climate change adjusted supply and demand forecasts for the whole of the region, both for the Regional Plan and to inform water companies’ WRMP forecasts.” <u>Interview, water company, November 2022</u> “The selection was endorsed by national scale modelling done by the Universities of Manchester and Oxford”</p>
	Reducing uncertainties	<ul style="list-style-type: none"> ○ Benefits of best value; reflect criteria to specific challenges faced by regions according to stakeholder priorities (democratic process) ○ Regional planning is providing a better understanding of regional requirements and available options ○ This planning cycle is a learning process that will hopefully improve over time 	<p><u>Interview, regulator, July 2021</u> “Best value criteria allow regional groups to assign value to traditionally non-financial elements that are difficult to cost like recreation, amenity, and customer preferences” <u>Interview, regional group, July 2021</u> “Regions can use best value criteria to reflect the specific challenges they face and the priorities of their stakeholders and customers, so the process is based democratically in the area they represent.” <u>Interview, government, August, 2021</u> “Best value planning that incorporates natural capital is being promoted in the WRMP guidance over least cost planning to select options that are more integrated.”</p>
Governance	Building on existing mature WRMP framework	<ul style="list-style-type: none"> ○ New planning framework is promoting collaboration building on the existing WRMP framework ○ The companies pick options based on evidence ○ Planning balances meeting the national need, local knowledge, and accountability 	<p><u>Interview, regulator, July 2021</u> “In general, the framework works. The guidance is mature and captures the considerable experience that has been gained through the WRMP process” “The framework is helping to meet the strategic need in the face of future deficits that could not have been solved through the individual company WRMP process.” <u>Interview, government, August 2021</u></p>

			<p>“The water industry is in a good place overall to overcome potential challenge because the process of regional planning and water resource planning is set up so companies must do the hard work to pick the best options, and justify and have confidence to promote those options based on evidence” <u>Interview, regulator, July 2021</u></p> <p>“Water resources planning aims for best value plans that represent an optimal balance between meeting the national need and maintaining local knowledge and clear accountability”</p>
	<p>Improving collaboration opened discussions and learning</p>	<ul style="list-style-type: none"> ○ New planning framework is promoting collaboration to align transfers and adaptive planning to select best value large supply options to meet strategic deficits; learning process that will hopefully improve ○ Regional planning is providing a better understanding of regional requirements and available options 	<p><u>Interview, regulator, July 2021</u></p> <p>“The regional groups consisting of the relevant water companies are working together, learning, and collaborating to develop these plans. The regional process, which is enabling more collaboration between companies, regulators, and government, is improving our understanding of risk in the water industry. A benefit of regional planning is better understanding of regional requirements, sharing and finding solutions that ensure sufficient water for everyone across the regions.” <u>Interview, regional group, December 2022</u></p> <p>“Collaborative, integrated thinking may present opportunities to develop a wider range of innovative solutions, particularly for non-potable uses. One example is the Hydrocycle project in Felixstowe which captured water being drained to sea and piped it back up-catchment into reservoirs for use on farms.” <u>Interview, regional group, November 2022</u></p> <p>“The process has worked, as a result of a huge amount of work over the last six months, shown by the publication of the regional plans in time for consultation, resulting in a better plan than would have been if the companies were working in isolation” <u>Interview, government, January 2023</u></p> <p>“Through the Senior Steering Group, the Regional Co-ordination Group, and other sub groups, the regional groups, other sectors, government and regulators are brought together to oversee how the plans are being developed, if any barriers exist, and what lessons can be learned to improve the process going forward.”</p> <p>“The process has enabled much better collaboration and co-ordination across companies.”</p>

			<p><u>Interview, water company, January 2023</u> “Producing the regional plan allowed for in-region cross-company collaboration. Individuals working in each water company benefitted from additional support as they could talk with their equivalents in other companies, for example about interpreting guidance, or about the different approaches taken and why.”</p>
	Wider consultation and engagement	<ul style="list-style-type: none"> ○ Improving the assessment of catchment schemes with more engagement and collaboration with NGOs and regulators ○ Consultation that is meaningful might lead to change ○ Consultation should treat all stakeholders fairly ○ Consultation is the right way to choose between closely competing options; consultees should be presented with a clear locked down preferred plan alongside alternatives 	<p><u>Interview, regional group, December 2022</u> “A key way regional groups can add value to existing water company planning is by integrating other sectors into planning under a best value framework.”</p> <p><u>Interview, regulator, July 2021</u> “Water companies are expected to engage with wider stakeholders, customers and third parties to seek innovative solutions for both public supply and multi-sector needs.”</p>
Outcomes	Agreed national set of transfers (core pathway and alternative pathways)	<ul style="list-style-type: none"> ○ Process worked, regional plans published, better than isolated planning ○ Agreed adaptive plans ○ SROs agreed through reconciliation process, including inter-regional projects 	<p><u>Interview, regional group, November 2022</u> “The process has worked, as a result of a huge amount of work over the last six months, shown by the publication of the regional plans in time for consultation, resulting in a better plan than would have been if the companies were working in isolation”</p> <p>“Big schemes are needed to meet the challenge set out by the NIC in 2018 to improve drought resilience, alongside demand management; the question now is how to deliver them.”</p> <p><u>Interview, water company, November 2022</u> “The regional planning process has successfully achieved a broader view of water resources planning with a robust outcome, particularly the selection of SROs. The selection was endorsed by national scale modelling done by the Universities of Manchester and Oxford (notwithstanding some technical challenges of modelling at the national scale).”</p> <p><u>Report, Jan 2022</u> “The future is uncertain. Our plan will be able to adapt”</p>

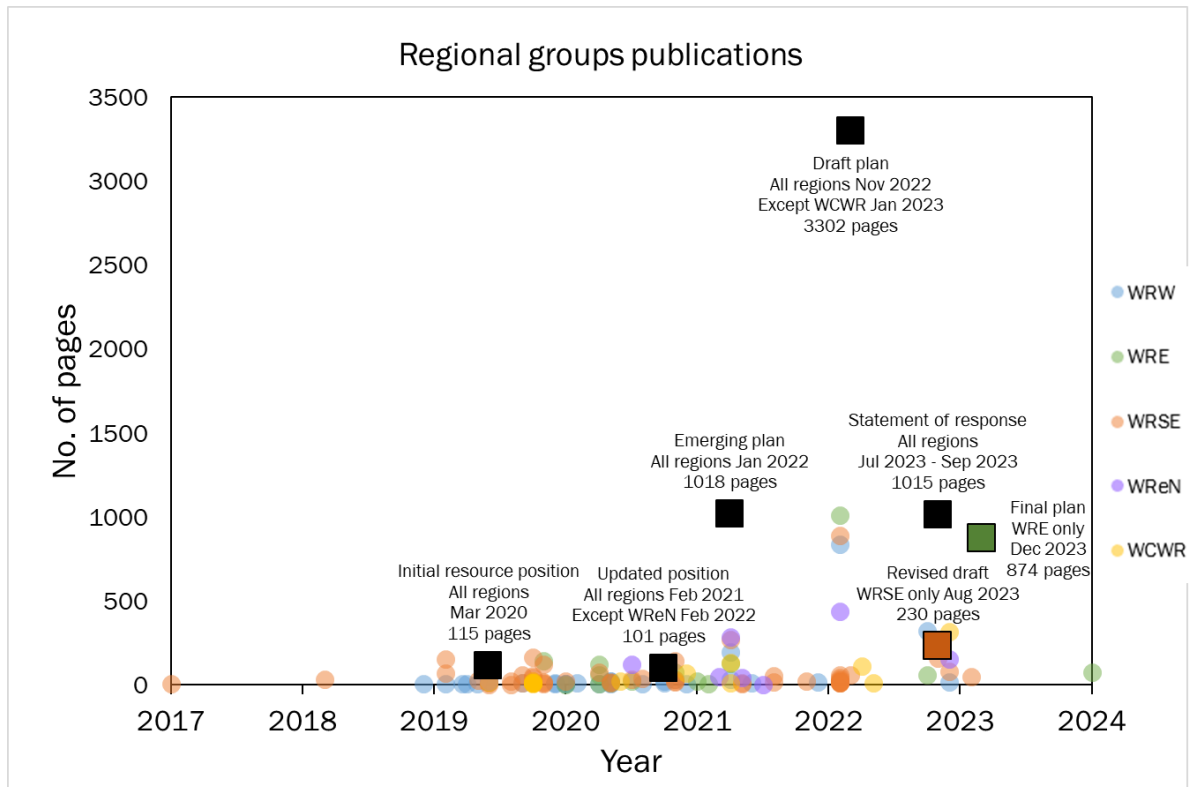
			<p><u>Interview, water company, Jan 2022</u> “adaptive planning allows for phased decisions, such as delaying or advancing investment based on evolving conditions / how scenarios unfold”</p> <p><u>Interview, water company, February 2023</u> “It’s clearly the correct way to tackle that problem because there’s societal value to flexibility”</p>
	Improving consistency and alignment	<ul style="list-style-type: none"> ○ Regional planning allowed for collaboration and brought greater consistency and consensus ○ National expectations drove better alignment ○ Companies were more aligned regionally, and nationally due to improved collaboration, and agreed consistency over assumptions (climate change data sets, population forecasts etc) 	<p><u>Interview, regional group, December 2022</u> “Having clear national expectations cascaded through regional collaboration to the water companies is helpful”</p> <p><u>Interview, regional group, January 2023</u> “The biggest highlight of regional planning has been the collaborative approach that the regional groups have followed, in navigating challenges and problems, to come to a consensus view on priorities and milestones, and ultimately deliver regional plans.”</p>

9.6 Additional information to support Chapter 5

Appendix L. Breakdown of additional appendices into sub-categories.

Plan breakdown totals		Total
No. WRZs		128
No. of customers (million people)		61
DI (Ml/d)		15,283
No. of appendices		510
No. of pages:		
Main plan, summaries, guides		4,664
Additional appendices	Assurance	169
	Problem characterisation, progress since WRMP19, 2022 drought review	407
	Supply modelling	1,527
	Demand modelling	2,582
	Environment modelling	1,287
	WR systems modelling	399
	Managing uncertainty	621
	Options assessment	5,100
	Customer and stakeholder engagement	3,524
	Adaptive planning	125
	Consultation and statement of response	14,090
	Alignment	234
	Environmental assessments	15,102
Total number of pages		49,831

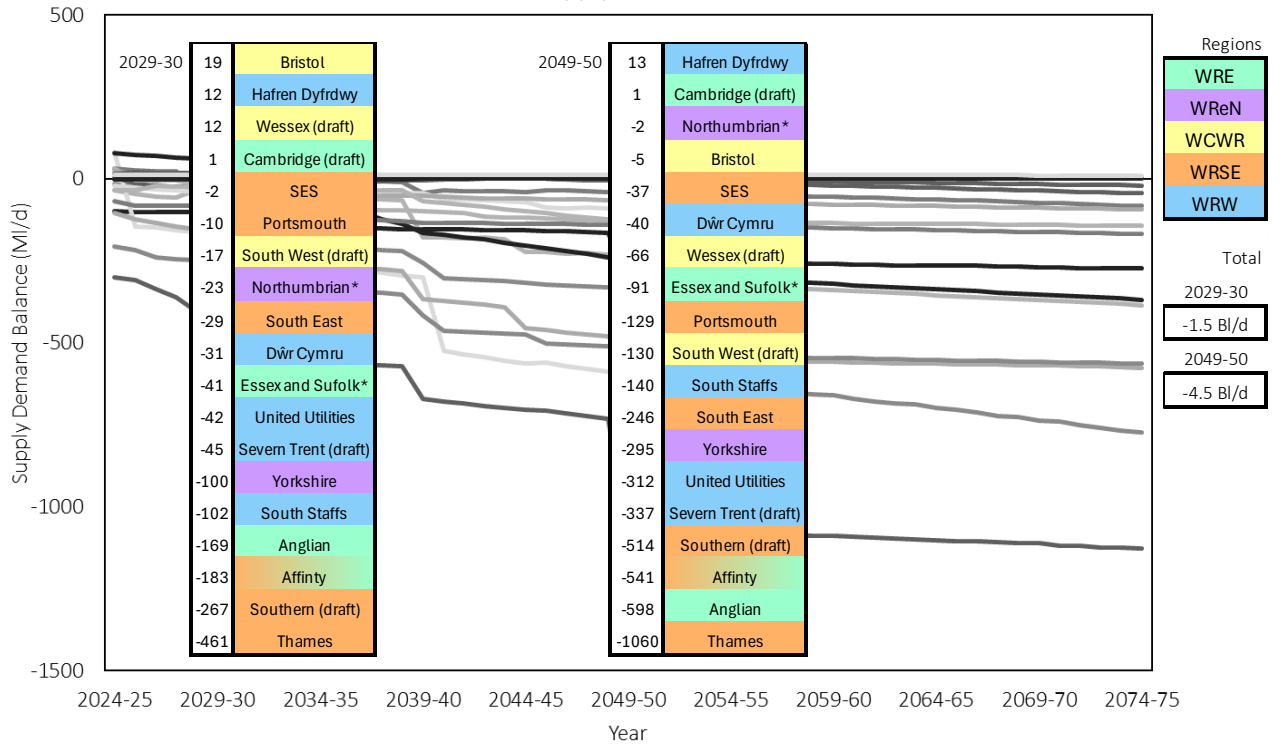
Appendix M. Timeline of regional plan publication by number of pages.



Appendix N. Alternative presentation of Figure 3 in a table, and below two time series graphs presenting supply demand balances for baseline and final year plans. Summary of final outputs across WRMPs, business plans, and final determinations, and customer bills.

DYAA SDB WRMP data tables (Ml/d)				Business plan data tables Totex 2025-2030 (Em)							Price review FD allowances - WRMP water supply enhance totex				Price review FD allowances - Base totex		Customer bills				
Region	Company	2029-2030			2049-2050			WRMP	Water supply enhance:	Water supply enhance:	Water supply base:	Wastewater:	Total:	In business plans	After reallocations	Allowance	Δ	Base	Base after reallocations	E	%
		Baseline	Final plan	Δ	Baseline DYAA	Final plan DYAA	Δ														
WRSE	AWN	-169	41	210	-598	7	605	1,158	341	2,535	5,849	9,335	1,121	1,836	1,828	-7	2,818	2,845	631	29%	
WRW	WSH	-31	80	112	-40	222	262	196	543	1,496	3,304	5,555	73	69	65	-4	1,665	1,678	645	42%	
WRW	HDD	12	14	2	13	22	9	2	14	171	19	206	128	121	119	-2	162	162	557	42%	
WRW/WRE	NES	-64	64	128	-93	197	134	502	388	1,923	2,907	5,716	639	669	596	-73	2,064	2,205	510	21%	
WRW	SVE	-45	144	189	-337	266	604	703	1,167	3,666	6,745	12,086	687	896	957	61	3,940	3,940	583	47%	
WCWR	SWB	-17	25	42	-130	85	216	238	295	900	2,044	3,488	305	399	423	24	1,037	1,037	610	23%	
WRSE	SN	-267	73	340	-514	1	515	553	913	1,127	1,852	4,401	1,168	1,397	797	-600	1,429	1,433	642	53%	
WRSE	TMS	-461	162	623	-1,060	74	1,134	1,544	2,273	6,281	12,771	22,876	1,529	1,520	1,162	-358	6,678	6,693	588	35%	
WRW	NMT	-42	103	144	-312	148	460	442	683	3,025	8,508	12,540	334	326	268	-59	3,355	3,290	585	32%	
WCWR	WSS	12	51	39	-66	49	115	189	125	891	2,409	3,607	154	161	133	-28	885	886	614	21%	
WRW/WRE	YKY	-100	126	226	-295	118	413	272	264	2,552	4,529	7,601	229	250	331	81	2,650	2,667	607	41%	
WRSE/WRE	AFW	-183	5	189	-541	40	581	254	438	1,427	0	2,113	260	266	251	-16	1,525	1,525	241	26%	
WCWR	BR	19	33	14	-5	68	73	57	136	525	0	724	56	59	40	-19	491	494	614	21%	
WRSE	PSI	-10	9	19	-129	0	129	66	56	190	0	311	48	62	64	2	217	217	152	37%	
WRSE	SEV	-39	63	92	-246	23	269	337	442	1,029	0	1,805	307	240	154	-86	1,196	1,218	387	24%	
WRW/WRE	SSC	-101	2	103	-139	14	154	81	69	575	0	699	74	51	68	17	664	664	195	21%	
WRSE	SES*	-2	32	34	-37	9	46	35	24	309	0	378	45	58	70	12	333	333	215	-3%	
Total		-1,479	1,027	2,506	-4,530	1,344	5,719	6,628	8,172	28,623	51,035	94,033	7,157	8,381	7,326	-1,055	31,110	31,288	487	30%	

Baseline DYAA supply demand balance



Final plan DYAA supply demand balance

