TW-RR-A1

Resilience

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Section 1

Introduction

A Purpose of this document

1.1 The purpose of this document is to explain our risk-based approach to improving our corporate, operational and financial resilience.

1.2 In this document we set out:

- How we have developed our resilience ambition – 'being able to manage all forms of disruption to the continuity and quality of our service and the quality of the environment';
- How we have used the best available evidence to objectively assess and prioritise risks, considering challenges to our corporate, operational and financial resilience over the short, medium and long-terms;
- How we have considered a wide range of solutions, including markets, partnerships and 'soft' solutions in response to the risks we face; and
- How the actions we propose are the best value for money, have customer support and are linked to stretching incentives.

1.3 We more fully explain the activities, both changes in the way we do things and the investment we need to make to increase our resilience to these, and wider, risks. Through challenges raised in the IAP feedback, we have reviewed our plan and have subsequently reduced the cost of our resilience investment plan by £250m, from £2.11bn in our September submission[1], to £1.86bn[2].

B Structure of this document

1.4 This document is composed of four sections:

- Section 1: Introduction
- Section 2: Corporate resilience
- Section 3: Operational resilience
- Section 4: Financial resilience

1.5 This section sets out the structure for this document and explains how resilience is integrated into our plan.

[1] Thames Water, Appendix 4 – PR19 – Resilience, September 2018
[2] See Section 3, Part D of this Appendix

1.6 Section 2 sets out our customers' expectations on the resilience of our services and how we have incorporated their expectations and needs to define our resilience ambition. It then explains our corporate processes that enable us to systematically assess and prioritise risks, and identify and optimise solutions. It also explains how we are increasing the resilience of our services through our people, our stakeholders and our supply chain.

1.7 Section 3 describes our operational resilience, explaining how we manage the health of assets, how we respond to emergencies, how we plan to improve our operational resilience through 11 key programmes of investment and how we will increase our resilience through improving the environment and our supply chain.

1.8 Section 4 summarises how we have considered the financial resilience of our April submission and references where further information can be found.

C Overview

1.9 We believe that to be truly resilient, corporate, operational and financial resilience must be considered in a holistic way, as each reinforces the others. Through this document we demonstrate how we have taken an integrated approach and how the proposed activities, including our £1.86bn operational resilience investment plan, stem from the expectations of our customers and address our prioritised risks to build a resilient, sustainable service for customers today and for future generations.

1.10 In developing our plan, we have considered all seven resilience planning principles and highlight through this document where and how they are addressed:

1) Considering resilience in the round for the long term (see Section 2)
2) A naturally resilient water sector (see Section 3, part E)
3) Customer engagement in resilience (see Section 2, parts C and E)
4) Broad consideration of intervention options (see Section 2, part E and Section 3, Part D)
5) Delivering best value solutions for customers (see Section 2, part E)
6) Outcomes and customer-focused approach (see Outcomes chapter of TW-RS1-Building a Better Future: Response to Ofwat's IAP and TW-OC-A1 Outcomes Supporting Evidence document)
7) Board assurance and sign-off. (see TW-CA-A1).

Section 2

Corporate resilience

A Introduction

2.1 Corporate resilience is the ability of an organisation's governance systems and assurance processes to avoid, limit, cope with and recover from disruption. It also is the organisation's ability to anticipate trends and variability in external and internal factors that may affect the need for and delivery of services, including protecting the environment. Having a clear strategic direction that is supported by customers, employees and stakeholders is an important component in enabling corporate resilience. As such, corporate resilience is the foundation for operational and financial resilience.

2.2 The purpose of this section is to explain how we define our resilience ambition. We also set out the systems and processes applied to prioritise and manage risks. This section is in six parts:

- The governance of resilience at Thames Water
- How do we define our resilience ambition?
- How do we identify, assess and prioritise risks?
- How do we identify, assess and optimise resilience actions?
- Resilience through customer and stakeholder engagement
- Summary.

B The governance of resilience at Thames Water

2.3 Our Board has ultimate responsibility for maintaining a sound system of risk management and internal control. This includes determining the level of appetite for the principal risks we face and are willing to take to achieve our strategic objectives, and for ensuring that an appropriate risk management culture has been embedded throughout the organisation.

2.4 At the heart of the process, the Board and its Committees:

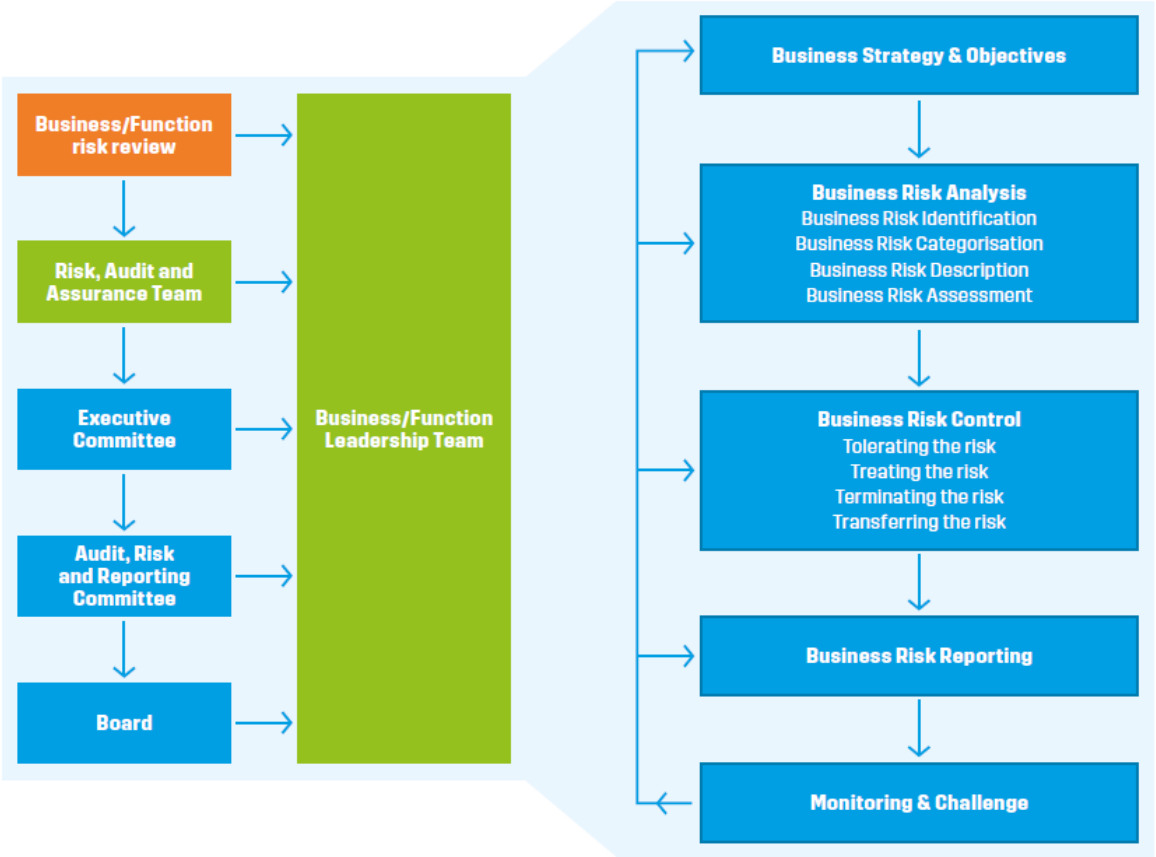
- Articulate and endorse risk management policy;
- Ensure alignment of risk management objectives with the strategies and objectives of the Company;
- Oversee legal and regulatory compliance;
- Assign management accountabilities and responsibilities at appropriate levels within the Company; and,
- Ensure that necessary resources are assigned to achieve a balanced and transparent approach to the management of risks facing our operations, and to measure the effectiveness of the key controls in place to manage them.

2.5 The work of the Board and its Committees is underpinned by delegations of authority and policies and procedures covering key areas of our operation.

2.6 Risk management is a fundamental element of this framework and helps to ensure that risks are identified and assessed and that risk responses are appropriate. This is achieved across the Company through policies, procedures, systems, monitoring and reporting tools, and the core risk management competencies of all staff. Key aspects of the risk management reporting and oversight process are in Figure 1 below. Risks are identified and analysed at four senior management levels:

- Business / Function leadership;
- Executive;
- Non-Executive; and
- Board.

Figure 1: Key aspects of our risk management process



Source: Thames Water: CSD021 – Annual report and annual performance report 2017-18, Page 65

2.7 At all four levels, risks are regularly reviewed in terms of their potential impact on our business. The key steps of our risk management process are detailed below. Risk analysis and control is recorded via an electronic risk management software tool, which helps improve our risk management consistency and performance. The Audit, Risk and Reporting Committee ('ARRC') evaluates the effectiveness of our overall risk management framework and makes recommendations for improvement.

2.8 Section 2 of our Core Supporting Document *'CSD032 – Our approach to risk'* from our September submission sets out in further detail of how the Board, and its supporting Audit, Risk and Reporting Committee, is underpinned by delegations of authority and policies and procedures covering key areas of our operations. Further information is also provided in our Annual Report and Performance Report 2017-18[3].

C How do we define our resilience ambition?

2.9 We considered a wide range of issues in developing our resilience ambition:

- Our customers' needs and expectations;
- Our experience of events that have impacted on our services;
- Our own extensive knowledge and experience, drawn from across our employees, partners and expert panels (e.g. WRMP expert advisory panel);
- Good practice and lessons learnt by other utility companies (for example, the 2007 floods);
- Our resilience maturity assessment; and
- The experience and ambitions of our investors and Board.

2.10 Our plan is a customer-led plan. The starting point for defining our resilience ambition was, therefore, to understand our customers' needs and expectations regarding the resilience of the services we provide them. To do this, we undertook extensive research[4] which told us that our customers:

- See the provision of water and wastewater as essential services;
- Expect our systems to be resilient to risks within our control and for us to have plans in place for risks that are not;
- Expect us to plan for the future and implement measures that make our services resilient to reasonably foreseeable challenges;
- Prefer that we invest to avoid impacts that significantly affect our services, rather than respond to them; and
- Believe that we are the experts and trust us to plan and act appropriately.

2.11 To be able to understand these headlines in greater detail we undertook 'deep dives' into operational, corporate and financial resilience[5,6,7], intergenerational fairness[8] and long-term water resource planning[9]; This research identified our customers' appetite for risk using our service-level 'willingness to pay' research[10]; and ongoing customer journey research[11] to develop mitigations for the short-term manifestation of some of our resilience challenges.

[3] Thames Water, CSD021 – Annual report and annual performance report 2017-18 (pages 64-78)
[4] Thames Water, CSD002-PR-19 What Customers Want
[5] Thames Water, GRF0510 – CR52 Resilience Deep Dive (February 2017),
[6] Thames Water CR66 Corporate and Financial Responsibility Deep Dive (July 2018)
[7] Thames Water, Putting the Sector Back in Balance Deep Dive (August 2018)
[8] Thames Water, CR19 Intergenerational fairness deep dive (October 2016)
[9] Thames Water, CR29 WRMP Research (October 2016)
[10] Thames Water, CSD019 – Triangulation Report – Customer and societal values (eftec and ICS Consulting)
[11] Thames Water, TSD019 – PR19 – Customer research, consultation and operational data analysis report

2.12 During our three Operational Resilience deep dives, customers selected and ranked six key resilience challenges as set out in Table 1. This research highlighted the priority risks that customers expect us to plan for and address in our business plan.

Table 1: Customer Prioritisation of Operational Resilience Challenges

Flooding	Sustained Cold	Drought / Extreme Heat	Cyber-Crime / Terrorism	Severe Storms	Power Failure
Most Severe	High Severity	Moderate Severity	Most Severe	Moderate Severity	Moderate Severity
Very Likely	Very Likely	Moderately Likely	Relatively Unlikely	Relatively Unlikely	Moderately Likely

Source: Thames Water, GRF0510 – CR52 Resilience Deep Dive (February 2017)

2.13 Listening to customer feedback, we understand that resilience means being able to deliver the outcomes our customers want consistently, now and in the future. We therefore define our resilience ambition as '**being able to manage all forms of disruption to the continuity and quality of our service and the quality of the environment'**. This supports our overall corporate ambition of being 'Here for our customers'. Our business plan sets out a clear strategic direction, defined under five objectives and the investments that are necessary to achieve this.

Resilience Maturity Assessment

2.14 Our resilience ambition has also been informed by an independent assessment of the 'maturity' of our systems and processes for resilience. We developed, with the consultants Arup, a framework of indicators[12] covering corporate, financial and operational resilience, as shown in Table 2. Arup assessed the evidence for each indicator across three different timeframes – 'current', 'AMP7' and 'AMP8 and beyond', and rated them one (leading) to five (unaware). The findings provided us with a systematic view of how effective our current and planned systems and processes are at identifying and responding to resilience challenges. It helped us to benchmark our systems against industry best practice in the UK, and abroad, and identified areas of relative lower performance, which we used to further develop our plan improve our resilience rating.

[12] Thames Water, CSD007-PR19-Resilience Assessment (2018)

Table 2: Resilience Maturity Assessment (2018)

Corporate	Current and ongoing activity	Planned for AMP7	Planned for beyond AMP7
Clear strategic direction	3	4	4
Effective governance and assurance processes	3	4	4
Effective business continuity planning	2	4	4
Comprehensive horizon scanning	3	4	4
Inclusive customer engagement and co-creation	3	4	4
Engaged stakeholders	2	4	4
Active role in the community	3	3	3
Comprehensive health, safety and wellbeing	4	4	4
Collaborative, adaptive organisational culture	2	4	4
Financial			
Financial viability	3	4	4
Protected finances for the regulated business	4	4	4
Sustainable long-term financial planning	3	3	4
Accessible financial reporting	3	4	4
Robust financial monitoring	3	4	4
Operational			
Continuity of service to customers	3	4	4
Robust long-term water resource planning	3	4	5
Robust long-term wastewater planning	3	4	5
Reflective approach to asset-based health	3	3	4
Robust, integrated and flexible technology	3	4	4
Innovative, collaborative, naturally resilient approach to risk mitigation	3	3	4
Robust and flexible supply chain management	4	5	5
Diverse, inclusive and future skilled workforce	3	4	4

Scoring Key

5	Leading	Best practice approach with horizon scanning for future changes and clear methods to include these within plans and strategies.
4	Response actioned	Response applied in practice across most of the company, focused on proactive actions to prevent issues before they arise.
3	Response developed	Clear goal with a developed response around most elements. This response has yet to be widely actioned, though pilots may have been undertaken.
2	Aware	Aware of the need to act but actions have not been consistently adopted into process, plans and operational activities. Tends towards reactive action.
1	Unaware	Significant gaps in understanding, processes, plans, strategies and operational activities to achieve this goal.

Source: Thames Water, CSD007-PR19-Resilience Assessment (2018)

D How do we identify, assess and prioritise risks?

2.15 We apply both a 'top-down' and 'bottom-up' approach to identifying and objectively assessing risks, which links both our current and future corporate and operational risks. Both are aligned to ensure we deliver our services to our customers with our operational risk being linked to customer valuations via our asset planning system. We consider risks at each stage of corporate strategy, strategy development, planning, delivery and operations including event learning, as well as the potential interactions between them.

Top-down approach to assessing risks to our resilience

2.16 Our top-down approach includes:

- Leadership and challenge by our Board (as explained in paragraph 2.3);
- Our Risk Management process;
- Our Board-level Audit, Risk and Reporting Committee;
- Our Long-term Viability assessment[13] (see 2.21 and Section 4);
- Our strategies, which are underpinned by long-term forecasts and our decision support tools, which model the condition, performance and deterioration of our assets; and
- Undertaking a systems approach to understanding to risk and resilience.

2.17 Our bottom-up approach includes:

- Identification of risks by operational teams
- Monitoring of current performance and using it to validate our decision support tools and models.

Identification of Corporate Risks

2.18 In order to ensure we consistently assess our resilience challenges in the round, we have used our Risk Management ('RM') process to standardise our approach to risk and resilience challenges across the organisation in line with the Risk Management International Standard, ISO 31000. We focus on four 'Risk Categories' (strategic, operational, financial and compliance risks) on a short- to medium-term and are in the process of integrating our business unit level analysis on catastrophic and long-term sustainability risks into our RM framework to give us a more systemised view of our longer-term resilience challenges.

2.19 In our corporate risk framework we have identified 12 areas of 'Principal Risk', which are separated into the four Risk Categories (with the potential to impact on our strategy in addition to contributing to our business environment). We review the Principal Risks on a quarterly basis. These are set out in Table 3.

2.20 By the end of AMP7, we will have undertaken further work to align our existing detailed processes and current controls which are routinely tested and reported to our ARRC into our risk management process. Our RM process will be informed by detailed process mapping of our organisation, with controls that are routinely tested by the business and checked independently, in place to help enhance the ability of our systems and processes to cope with, and recover from, shocks and stresses.

[13] TW-RR-A2 Finance and Financeability

2.21 Using the 12 Principal Risks, we generated a series of severe but plausible shocks of an extreme but low probability nature that would challenge financial viability, all else being equal. We quantified the individual financial impact of these individually and in combination and the subsequent timing of any cash-flow impact (opex / capex increases, revenue reductions, performance penalties, regulatory fines and / or reputational damage etc.). Our testing indicated we remain financially viable in all scenarios, giving us confidence that our current mitigations are robust and resilient. Further detail is provided in TW-RR-A2 - Finance and Financeability, and page 79 of CSD021 Annual report and annual performance report.

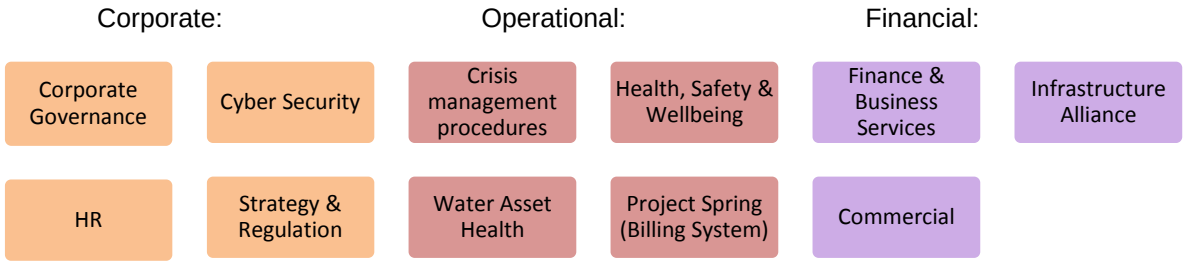
Table 3: 12 Principal Risks

Risk Category	Principal Risk	Description
Strategic	Climate and Societal	Adverse changes and events in the climate and society that risk our security of supply
	Political, Regulatory and Economic Environment	Adverse changes, intervention or a failure to influence change to the political, regulatory or economic landscape
	Trust and Reputation	Risks to the positioning and protection of our reputation
	Business Planning, Forecasting and Execution	Risks to business planning, forecasting, change and strategy execution and achievement of anticipated benefits
Operational	Customer Service	Risks to providing good quality customer service throughout our operations
	People	Risks to the attraction, retention and succession of the right people with the right skills in the right role at the right time
	Asset Management and Performance	Risks to investment, management and performance of our assets
	Supply Chain Management	Risks from the dependency on and management of third parties to deliver products / services
	Health, Safety, Environment and Security	HSES hazards associated with our operations
	Technology Systems & Security	Risks to the effectiveness, availability, integrity and security of our technology and data
Compliance	Legal and Regulatory Compliance	Risk of non-compliance with legal and regulatory requirements
Financial	Credit and Liquidity	Risks to the balance sheet and credit position

Source: Thames Water, CSD021 – Annual report and annual performance report 2017-18

2.22 Over the last two years, the ARRC has undertaken 11 ‘deep dives’ with technical experts and our Executive Management team to understand the scale, root causes and ongoing / proposed mitigation actions and controls of some of our key risks. These are shown in Figure 2. The deep dives enable us to draw upon the expertise of the Board members and their experience from other sectors.

Figure 2: ARRC risk-focussed 'deep dives' between 2016 and 2018

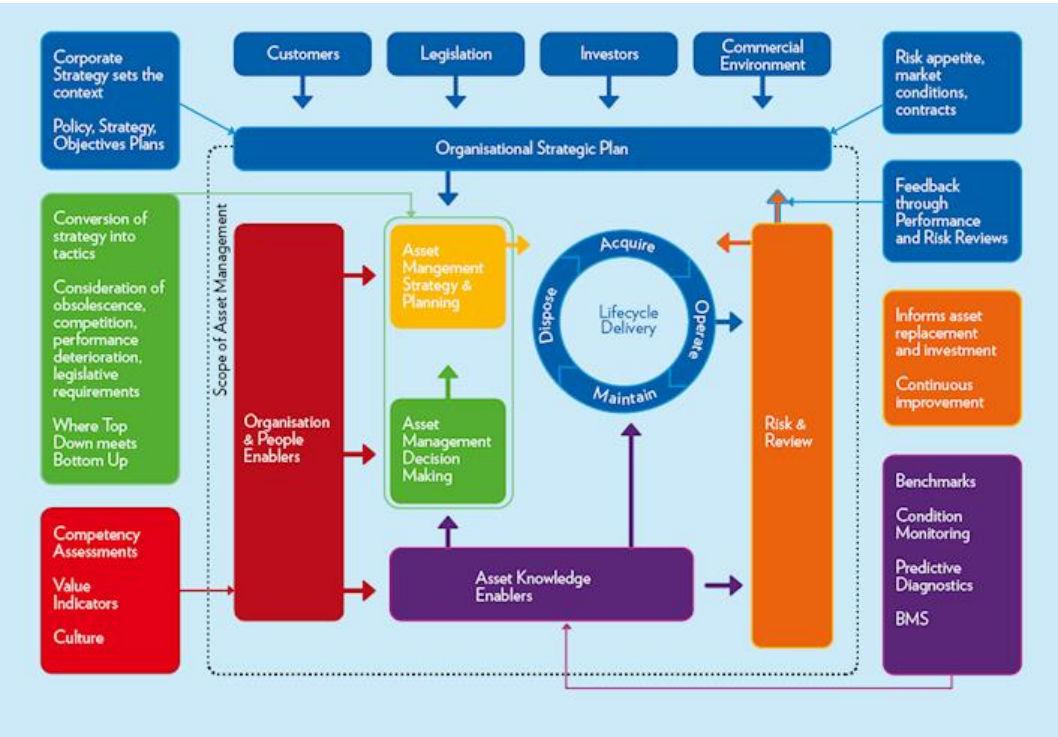


Source: Thames Water

Identification of Operational Risks

2.23 Our operational risk management systems and long-term plans have been developed in alignment with the Institute of Asset Management's asset management framework (see Figure 3) and ISO 55000, which ensures integration of the identification of risks, the strategic monitoring of performance, and our investment and management plans.

Figure 3: Institute of Assessment Management's asset management framework.



Source: Institute of Asset Management

2.24 In its Initial Assessment of our Plan, Ofwat stated that we should commit to provide, by 22 August 2019, *"an action plan to develop and implement a systems based approach to resilience in the round and ensure that the company can demonstrate in the future an integrated resilience framework that underpins the company's operations and future plans showing a line of sight between risks to resilience, planned mitigations, package of outcomes and corporate governance framework*." (Action TMS:LR:A2). We are working towards developing an integrated resilience framework and will provide an action plan setting out the key stages of its ongoing development by the August deadline.

2.25 Our Asset Planning System ('APS') captures all risks that relate to our wholesale performance commitments. Our Investment Management System and decision support tools which are integrated with APS support our operational investment planning through providing multi-criteria optimisation. They use our risk management framework to put a financial value on risk, both now and into the future. This is based on how our customers value our service and how our service impacts on our customers, wider society and the environment. It is made up of three parts:

- An operational risk database (integrating 'top-down' and 'bottom-up' risks);
- A database that stores investment 'needs' and 'solutions'; and
- An advanced optimisation engine.

2.26 Operational risks create a formalised entry point for our operational teams to highlight risks identified through their routine activity. This allows us to incorporate these risks into our investment planning process. The Risk Register uses a simplified version of our risk framework to quantify the value the risk. The register focusses on capital maintenance issues as that is a large portion of the work that our operational teams do, but it also includes resilience, growth, flooding, odour and many other issues.

2.27 The optimisation process considers the costs and benefits of a range of solutions to determine the most effective way to identify appropriate choices, to achieve a specified goal, subject to a series of constraints. For some areas of investment, we use customised optimisation models in an independent software application like Asset Investment Manager ('AIM'). These are loaded into APS as Needs and optimised Solutions and Needs. Within APS there is a detailed optimiser. Optimisations can be run on both cost and/or performance metrics. The optimising process considers:

- The 'need' (the cost of doing nothing);
- Risk values (including cost of failure and customer willingness to pay);
- Financial and service level targets;
- Whole-life costs (Totex, including carbon); and
- Solutions and their residual risk.

Undertaking a 'systems' approach

2.28 When considering our networks, processes and people, we take a 'systems' approach and consider the internal and external interdependencies. As part of our asset planning for example, we have undertaken a system-level analysis of the current and future performance of our water supply networks, from abstraction through treatment to distribution. We have assessed the ability of these systems to maintain the expected levels of service considering growth, climate change and asset health. This analysis has highlighted a number of 'pinch points' where existing vulnerabilities lead to an unacceptable level of risk of prolonged interruptions to supply. In response to these we have prioritised the areas at highest risk and developed long-term (25-year) strategies for each area, starting in our North-East London water supply zone (see Section 3, Part D of this Appendix and the North East London Resilience enhancement case[14] for further information). In developing our Drainage and Wastewater Management Plans, we are taking a similar approach for our wastewater systems.

[14] TW-CE-A7 North East London Resilience enhancement case

Bottom-Up approach to assessing risks to our resilience

2.29 As noted above, our operational teams provide detailed insight on the performance of our assets and potential risks. Their input is captured in APS (see Part E), which ensures bottom-up risks are considered in asset planning.

2.30 For each major water and wastewater site, we have identified the key assets and assessed their relative criticality within the system they operate to delivering our services. For each of the assets, we understand their design load, design life, maintenance schedule and actual workload. This information is integrated to develop a 'criticality model' for each site which we use to identify and prioritise the highest impact points in each system. This insight is used to inform our asset planning process.

2.31 We are planning to increase the digitalisation of our operational technology systems (see 'Improving the resilience of our IT', 3:53-3:57, Section 3, Part D), giving us greater real-time insight and control over our networks and the ability to make more informed decisions about how we operate, maintain and replace our assets.

E How do we select and assess risk management options?

2.32 Within our decision support tools and our APS, which act as our risk prioritisation and optimisation systems, we capture different solution options for addressing risk. Each option is scored pre- and post-risk mitigation, against our risk framework which is aligned to our customer performance commitments. As our customer valuations and cost of failure values are also embedded within these tools, it allows us to compare different options, to see which are the most cost beneficial to customers, which are best value over the long term, and which protect the environment.

2.33 These tools are in use for our water and larger sewage treatment works, our water and waste networks. We also consider solution options from a system perspective as described in the section above.

2.34 For example, in assessing the options for increasing sewage treatment capacity in London as a result of growth, we looked at different types of treatment over both the long and short term and in particular the order in which we implemented changes. Our assessment compared which option would provide the best value to customers over the long term, which would provide a level of headroom, and which would be resilient to significant changes in population growth, while continuing to protect the environment through sewage treatment compliance and avoidance of pollution incidents (see Part D in Section 3).

The Cabinet Office's Four R's

In identifying options to address risk we take into consideration a wide range of options which reflect the Cabinet Office's Four R's[15].

- **Resistance**: preventing damage or disruption by providing the strength or protection to resist the hazard or its primary impact
- **Reliability**: ensuring that the infrastructure components are designed to operate under a range of conditions, and hence mitigate damage or loss from an event
- **Redundancy**: the availability of backup installations or spare capacity which enables operations to be switched or diverted to alternative parts of the network in the event of disruptions to ensure continuity of services.
- **Response and recovery**: enabling fast and effective response to, and recovery from, disruptive events. Effectiveness is determined by the thoroughness of efforts to plan, prepare and exercise in advance of events.

2.35 Not all of our risk interventions result in investment. For example we proactively identify stress points in our network by mapping real-time information from the Met Office, our SCADA[16] system and our network monitoring devices against our system models to determine the location and scale of a potential event. We have developed a number of industry leading tools to help identify and manage situations that are beyond the normal operation of our systems (see case study). This allows us to detect, respond and prevent customers from being impacted.

Case study: Supply and demand tool

2.36 Our bespoke 'supply and demand tool' complements our monitoring systems, providing improved real-time capability to identify significant, local water demand increases, such as experienced during the March 2018 Freeze-Thaw, through tracking the actual supply from a water system against predicted demand. This enables us to rapidly recognise sudden and unusual increases in demand and escalate water production at our supply plants to meet the higher demand.

Water resources planning

2.37 Water resources planning is one example of where we plan for the long-term, developing scenarios to manage the uncertainties associated with climate change, growth and environmental policy.

2.38 We forecast a significant and increasing gap between the demand for and supply of water. This is driven by climate change, population and economic growth, and the need to leave more water in the environment. Our updated revised draft Water Resources Management Plan 2019[17] ('rdWRMP19') looks out to 2100, and proposes a range of supply and demand management options to sustainably balance supply and demand, as well as increasing our resilience to a severe (1-in-200 year) drought by 2030. Because of the uncertainties inherent in planning to the end of the century, we have used an

[15] 'Keeping the Country Running', Cabinet Office, 2011
[16] Supervisory Control and Data Acquisition ('SCADA')
[17] TW-OC-A2-WRMP update

'adaptive pathways' approach, providing a range of potential future pathways and a 'trigger point' where the decision on which pathway to take can be made with the best available information.

2.39 Because these challenges must also to be considered at the strategic (South East England and national) scale, we have been developing our plan with the Water Resources in the South East[18] regional group and are engaged with Water Resources East[19], Water Resources West and the National Framework Group. Our aim is to develop a Water Resources Management Plan that meets the needs of our customers now and in the long-term, whilst supporting greater regional and national resilience.

F Building resilience with our customers and stakeholders

2.40 Our customers and stakeholders provide an important source of insight into current and future challenges, along with the additional capacity to act upon them. Our aim is to work with them to identify shared challenges and work collaboratively to develop and deliver solutions that make us collectively more resilient.

Working with customers

2.41 We recognise that our customers are not just consumers, but active participants in our services. In the past we have been content with being 'invisible', only interacting with our customers when things went wrong. We now know that we need to better understand our customers' needs and priorities to be able to offer them a more individually tailored service. This level of understanding will enable us to identify and better support vulnerable customers and to work with all customers to change unsustainable behaviours.

2.42 We understand that if we want our customers to be motivated to act positively on issues that affect our and their resilience, for example water efficiency, misconnections, sewer abuse and sustainable drainage, then we need them to trust us. In order to build confidence and trust we need to:

- Provide an effortless customer service: We have invested in a brand-new customer relationship management and billing system (CRMB) that is designed to be robust and agile. This will reduce the risk of downtime of the system allowing us to provide a reliable service to our customers. Our system will also increase the accuracy of our billing and allow us to detect unusually high bills, enabling us to proactively contact customers and talk to them about why their bill might be high (e.g. due to a leak on their property);
- Recognise when customers are in vulnerable circumstances and need our support: We have put in a hierarchy of support measures that will allow our employees to identify the right service for a customer needing additional help and offer them services that are tailored to their specific needs (see 'Supporting vulnerable customers' below for further information).
- Be more transparent about what we pay in taxes, dividends and executive rewards, as well as lowering our exposure to financial risk through reducing our gearing, and proactively communicate our actions in these areas: Our targeted research on corporate and financial resilience[20] showed that our customers believe the company is managed in a way that reflects

[18] http://www.wrse.org.uk/
[19] http://www.waterresourceseast.com/
[20] Thames Water, TSD019 - PR19 – Customer research, consultation and operational data analysis reports

their interest. However, they encouraged us to continue to increase our transparency and reduce future exposure to financial shocks through the closure of our Cayman Islands subsidiaries and are particularly interested in reducing the level of gearing in a way that minimises the impact on their bills.

2.43 We have recently launched a number of public awareness campaigns, including our 'Bin it don't block it'[21] and 'Sewper Heroes'[22] campaigns, encouraging our customers to dispose of 'unflushable' items and fats/oils properly. We also launched our first non-drought driven water efficiency campaign[23]. Encouraging our customers to reduce unnecessary demands on our networks, not only improves our resilience and reduces the impact of sewer flooding / droughts on our customers, but also is more cost efficient and sustainable than increasing the size of our systems.

Supporting vulnerable customers

2.44 Some of our customers need more support than others. We believe a responsible company ensures that the level and type of support should be tailored to the individual needs of its vulnerable customers. We make a distinction between customers who may struggle to pay their bills due to external economic factors (affordability) and customers whose characteristics, situation or circumstances mean that they may need sensitive, well-designed, flexible support and services to access, read or understand our information (priority customers). We recognise that some customers may face affordability challenges as well as being priority customers.

2.45 We have used data sources from credit rating agencies and the third sector to design a social tariff that supports those on a lower income to pay their bill. Roughly 330,000 households in our area are estimated to qualify for our social tariff. According to data held by energy utilities, approximately 800,000 households in the Thames region are either permanently or temporarily classed as 'vulnerable' and therefore qualify to be registered on their Priority Services Register (PSR).

2.46 We have therefore developed a 'Vulnerability Strategy' for PR19, as part of our wider Customer Strategy. The Vulnerability Strategy is described in detail in our Retail Price Control[24] and sets out both how we will provide access to financial support for every customer who struggles to pay their bill and to be 'Here for You' for all customers in vulnerable circumstances.

Working with Stakeholders

2.47 Given the geographic spread of our area, from rural to capital, and the wide range of issues that 'water' touches on, we have a considerable stakeholder interest. We believe our relationship with our stakeholders has an increasingly critical role in helping us achieve our shared ambitions. We want our stakeholders to be our advocates.

2.48 We work with our stakeholders to identify and understand our respective concerns and challenges, through a number of industry-leading stakeholder engagement processes:

- For the past four years, we have been convening a Water Resources Forum, bringing together the key local and regional authorities, community and environmental groups, to help develop our Water Resources Management Plan 2019. We believe that this is the most thorough and

[21] https://www.thameswater.co.uk/be-water-smart/Bin-it
[22] https://community.thameswater.co.uk/t5/Thames-Water-Hub/Meet-our-Sewper-Heroes/td-p/49
[23] https://www.thameswater.co.uk/be-water-smart
[24] Thames Water, Section 3, Appendix 3, Affordability and Vulnerability, September (2018)

sustained programme of stakeholder engagement in developing a WRMP for any water company;

- Members of our local engagement team look after geographical portions of the Thames Water region, developing relationships with MPs, local authorities, civic society and community groups. Through these relationships, we are able to better understand local communities' particular needs, and put in place solutions that draw on their knowledge and understanding;
- We have transformed our relationship with the developers in our area. We convene a quarterly Developer Scrutiny Panel, where we co-create and test our policies and procedures with a panel of developers. We also hold an annual Developer Forum and regular 'Ask the Expert' drop-in sessions;
- Our Annual Stakeholder Review brings together around 100 individuals from organisations spanning regulators, national, regional and local government, NGOs and local community groups, and provides an opportunity for us to better understand our stakeholders' priorities, update them on our performance and explain our future plans; and
- We are a leading voice on behalf of the water industry in the development of the Oxford to Cambridge 'growth arc', which proposes the creation of 1.1 million new jobs and 1 million new homes in a severely water stressed area. We have been leading the water sector input into the government's assessment of where, what type and how much new growth should be planned in the growth arc.

Case study: Mayor of London's Infrastructure High-Level Group

2.49 The Mayor of London has brought together the key infrastructure providers in London to identify and overcome the barriers to delivering the infrastructure needed to support his vision of developing 65,000 homes per year.

2.50 We are working with the Mayor's Infrastructure High-Level Group (representing the key utility providers in the capital) to identify where future growth will exceed our water and wastewater systems and to remove barriers to integrated utility working. We have co-developed a GIS platform, called the 'Infrastructure Mapping Application'[25], based on our 'Thames Connect' tool that enables infrastructure providers to share information on their asset locations, delivery programmes and identify opportunities for joint working. This reduces some of the cost of working in London, as well as the associated disruption (re-routing buses, traffic congestion) and pollution.

[25] https://www.london.gov.uk/what-we-do/business-and-economy/better-infrastructure/london-infrastructure-map

G Summary

2.51 In this section we have shown that:

- We consider 'resilience in the round', taking account of corporate, operational and financial resilience;
- We take a top-down and bottom-up approach to identify and prioritise our key risks;
- We use a systems approach to understand the contribution of individual assets within a system to prioritise investment;
- We consider a wide range of options to manage our key risks and use a multi-criteria optimisation process to select the best value, long-term solutions that are supported by customers;
- We proactively work with our stakeholders to understand their needs which feed into our plans; and
- We engage with our customers to understand how we can help them play an active part in building a resilient water industry.

Section 3

Operational Resilience

A Introduction

3.1 Operational resilience is the ability of an organisation to maintain an acceptable level of service to customers, and protect the environment, in all reasonable conditions. It also requires having an effective response and recovery plan for when things go wrong and the ability to apply the lessons learnt from previous emergency events to improve resilience in the future.

3.2 This section provides an overview of the following activities that form our operational resilience plan:

- Improving asset health
- Managing events when things don't go as planned
- Our operational resilience investment plan
- Becoming more naturally resilience
- A resilient supply chain.

B Improving asset health

3.3 Asset health is critical to deliver the services that our customers rightly expect and to protect the environment. As described in the Outcomes chapter of our main document[26], the Outcomes Supporting Evidence document[27] and Section 2 of this Appendix, we have selected a range of asset health performance measures that clearly link to our customers' priorities and are designed to incentivise stretching performance in these areas.

3.4 In the initial assessment of our draft plan, Ofwat recommended that we *'should also provide a commitment to work with the sector to develop robust forward-looking asset health metrics and provide greater transparency of how its asset health indicators influence its operational decision making,*' (Action TMS.LR.A3). We commit to work with the sector to review existing metrics and develop new metrics where appropriate. We are developing a publicly accessible microsite that will provide a dashboard of performance indicators that will be updated regularly. Where appropriate, we will present the asset health metrics to enhance the transparency of our operational performance.

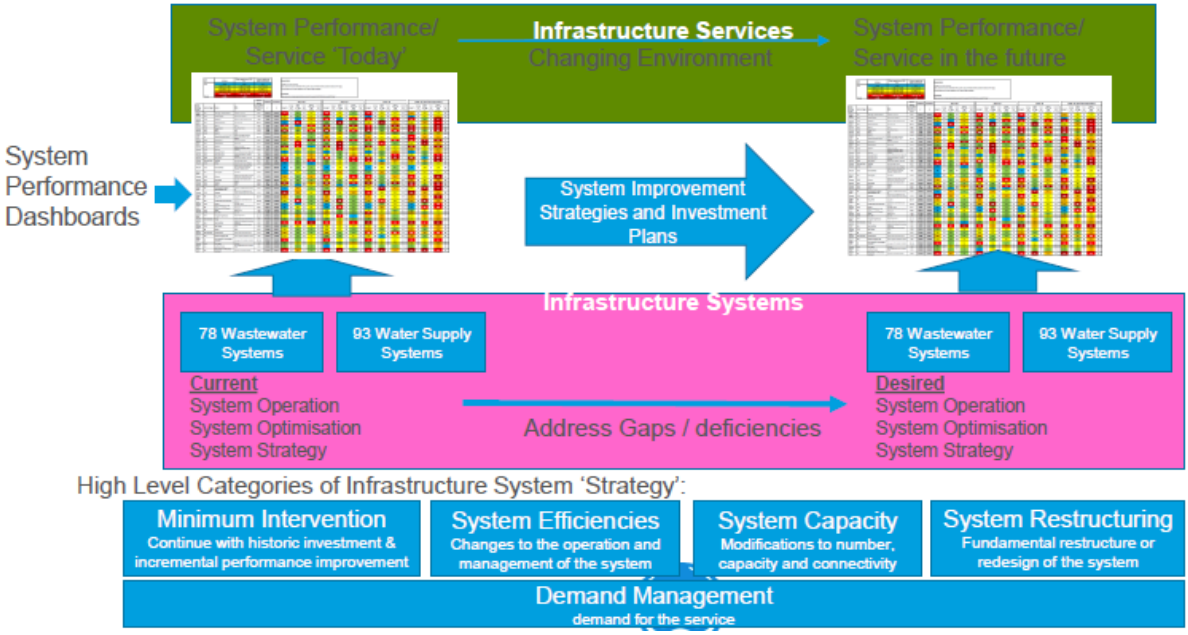
3.5 We have appointed an Integrated Business Planning Manager whose role is to ensure that our long-term objectives are delivered through our annual business planning process. This will involve balancing competing demands from across the company and ensuring our investment and prioritisation of risks are aligned to support the delivery of our corporate objectives. The attainment of

[26] TW-RS1-Building a Better Future: Response to Ofwat's IAP
[27] TW-OC-A1 – Outcomes Supporting Evidence document

our stretching asset health metrics and maintaining a clear line between performance and investment are key components of this role.

3.6 In developing our plan, we have taken a systems approach to understanding the criticality of our assets in delivering our services (see Section 2, Part D). We have divided our area into 93 water supply and 78 wastewater systems. For each system, we are looking at current performance, measured by using a range of indicators and desired future performance, including building in additional resilience to the forecast future challenges. By the end of this AMP we will, for each system, understand the type of intervention required to maintain or improve to the desired standard. This is set out diagrammatically in Figure 4.

Figure 4: Water and wastewater systems analysis and planning.



Source: Thames Water

C Managing events when things don't go as planned

Event Management processes and capabilities

3.7 Thames Water has a robust Event Management process and structure that applies 24/7, 365 days a year. Supported by a comprehensive training portfolio, staff across all levels of the organisation are expected to consider risks, and to raise an event when things are outside of a 'business as usual' position or have the potential to be. Identifying potential events early on and initiating event processes, allows us to respond quickly and put in place early interventions to mitigate the risk and ensure that any disruption to customers is minimised. As the level of risk increases, so does the event level, and the corresponding management level of the individual who is designated as the 'Event Controller'. Our significant events are managed by our Senior Managers, supported by fully-scalable resources from the relevant areas of the business who contribute as required under the Event Management structure established for the event.

3.8 Our Event Management procedures were strengthened following the 'Beast from the East' in March 2018. We defined and embedded a command and control structure which aligns with the approach

used by emergency services and public sector organisations. Where required, a 'Gold Command' structure will be established to make strategic decisions supported by executive-level advisors from the required areas of the business. This will be supported by 'Silver Command' (headed by the Event Controller) who will make tactical decisions to manage the event, supported by an advisory group made up of the relevant areas of the business, and a 'Bronze Command' who oversee the operational response and execute the tactical plan. This team will control and deploy operational resources and co-ordinate activities and actions.

3.9 Response to events is co-ordinated through our Operational Control Centre which maintains a full oversight of all activity across the operational business. It enables our highly competent teams to drive effective resolution of events, supported by a suite of defined business continuity and contingency procedures. Our industry leading Logistics Management Centre supports our rapid and efficient emergency management response arrangements (see Case Study).

3.10 Our operational controllers and event managers have access to our brand new 'Event Viewer' system. This system provides a geospatial view of our network, customer contacts, bottled water stations and current stock levels of bottled water, and can be seen at regional to street-level view. It receives information from the Customer Relationship Manager (CRM), Critical Pressure Points (CPPs) and the Priority Services Register (PSR) with overlays for Flow Monitoring Zones, District Meter Areas and Local Authority areas. Key data is automatically updated every 15 minutes.

Case Study: Logistics Management Centre

3.11 The Logistics Management Centre (LMC) is our in-house, one-stop shop, for managing our operational hardware (e.g. tankers, pumps, portable flood defence barriers), logistical and estates management requirements. The LMC is operated 24/7 from our offices at Kemble Court (Reading) using a sophisticated logistical management software that optimises the provision of resources around availability, cost, priority and demand. In 2016 the LMC won one of the top awards at the UK Supply Chain Excellence Awards.

3.12 From the LMC we are able to coordinate our pool of 400 drivers (trained to manage a range of vehicles), 60 tankers, three storage warehouses, and 12 logistics hubs (increasing to five warehouses and 40 logistics hubs by the end of AMP6).

3.13 In case of an interruption to the water supply, the LMC stores and manages the dispatching of 600 pallets of bottled water. Through the LMC we have access to another 1,000 pallets of bottled water at short notice and the capacity to produce 1 million litres of bottled water from a bottling plant with 48 hours' notice.

3.14 This centralised team delivers efficiencies (time and financial) through effective contract management and the in-sourcing of key activities as defined by the business. Its remit is expanding as the business identifies further opportunities to drive improved performance.

Working in partnership with others

3.15 We are members of each of the ten Local Resilience Fora (LRF) our area covers. The degree of our engagement depends on the proportion of the LRF area we supply and the relative importance of the issues according to the LRF's risk register, to which we contribute. We actively take the lead in London, Surrey and the Thames Valley where we are the largest water and sewerage undertaker, leading on planning for disruption to the water supply, drought and impacts to the water industry of flooding. In London we chair the interruption to water supply and drought planning groups and represent all water companies / all utilities on a number of working groups such as the London LRF Programme Board, Risk Planning and Training and Exercising groups. In Surrey we represent all utilities on the Severe Weather planning group. In the Thames Valley we represent all water companies on the Risk Group and the Training, Exercising and Organisational Learning Group.

3.16 Thames Water has taken a leading role on advising the government on the potential impacts of the water sector leaving the European Union and preparing for a range of scenarios for the UK's departure. We have been working with colleagues from across the UK water industry through the Platinum Incident Management (PIM) to gather information from individual water companies and regional coordinators. This will enable the PIM to take decisive and timely decisions on, among other areas, mutual aid, central and departmental government escalation, and nationally coordinated water activity.

Supporting customers during an event

3.17 We have a 'playbook' that provides the framework for communicating with customers during and after an event. It provides the protocols for the various channels we have to inform our customers, including our website, social media, email, SMS text messages, our contact centre and through trusted stakeholders (for example MPs, local councillors and local authority emergency planners).

3.18 During an event, we proactively contact vulnerable customers on our PSR likely to be affected by the event. Vulnerable customers can access us through a prioritised phone line and our aim is to provide this dedicated channel to all of our customers on our PSR. Through a social media keyword search tool (Lithium), we are able identify customers who have a temporary need for greater support (for example pregnant mothers).

Post event review

3.19 Every event is reviewed to understand the root cause of the event and to identify opportunities for learning, which is fed back into our continuous improvement process. Greater focus is placed on the learning from our significant events with both operational and strategic learning highlighted and actioned, with co-ordination of this sitting within our Incident Management Team.

D Investing in operational resilience

3.20 Many of our systems were not designed for the demands we predict they will face in the future. Challenges such as climate change, population growth, changes to environmental legislation and rising societal (including customer) expectations will mean that simply maintaining our existing systems will increasingly fail to deliver the levels of service our customers expect.

3.21 In our draft plan, we proposed an operational resilience investment plan[28], composed of 11 separate programmes of work. Since our September submission, we have been refining these programmes, working from the premise of delivering the same benefits through being efficient and smart before investing in new measures. We have reduced the costs of our resilience plan by £250m.

3.22 The actions in our resilience investment plan are the culmination of applying the risk prioritisation processes set out in Part D of Section 2, and the optioneering and optimisation processes set out in Part E of Section 2. Whilst they do not represent the entire portfolio of our activities to improve our resilience, they are the key 'big ticket' programmes in our business plan. The programmes in our resilience investment plan are set out in Table 4: Operational resilience investment plan, and each programme is summarised below.

Table 4: Operational resilience investment plan

Programme	£m
Reducing leakage by 15%	357
Additional sewage treatment capacity	394
Upgrading our treatment works	249
Reduce risk of customer flooding in a 1:50 year storm	206
Increasing water resources and capacity of our distribution systems	203
North East London water supply system resilience	181
Improving the security of our sites	27
Improving the reliability of our IT	117
Rehabilitating our water mains and sewers	63
Preparing London Thames Tideway Tunnel to receive storm flow	63
Improving power resilience to critical sites	36
Total	**1,862**

Source: TW-CE-A26- Wholesale Costs Spreadsheet.

3.23 In its initial assessment of our plan, Ofwat stated that, '*The company should ensure that its common and bespoke performance commitments associated with operational resilience are clearly defined, sufficiently demanding for AMP7 and the long term, and supported by the right incentives. We expect the company to satisfy the relevant actions set out in relation in the outcomes areas ensuring a line of sight between risks to resilience and package of outcomes,*' (TMS:LR:A1). In Table 5 below, we set out the performance commitments that map to our resilience programmes, state whether they are

[28] Thames Water, Section 4, Appendix 4 – PR19 – Resilience (September 2018)

common or bespoke, and provide the relevant IAP actions that are covered in our Outcomes Supporting Evidence document[29].

Table 5: Mapping of resilience performance commitments to IAP Actions

PC ref	Performance Commitment Title	Type	IAP Actions
BW01	Asset Health Mains Bursts (no.) per 1000km	Common	TMS.OC.A6-A8
BW02	Asset Health Unplanned Outage	Common	TMS.OC.A9-A12
BW04	Leakage	Common	TMS.OC.A15-A16
BW12	Improving system resilience of North East London water supply	Bespoke	TMS.OC.A49-A53
CS02	Asset Health: Sewer collapses (no.) per 1000km of sewers	Common	TMS.OC.A24
CS05	Sewage pumping station availability	Bespoke	TMS.OC.A54-A55
DS01	Risk of sewer flooding in a storm: 1 in 50 year storm	Common	TMS.OC.A27
DS02	Surface water management	Bespoke	TMS.OC.A56
DW01	Risk of severe restrictions in a drought: 1:200 drought resilience	Common	TMS.OC.A28
DW02	Security of supply index SoSI	Bespoke	TMS.OC.A57
DWS01	Power resilience	Bespoke	TMS.OC.A58-A59
DWS02	SEMD - Securing our sites	Bespoke	TMS.OC.A60-A62
ET01	Readiness to receive tunnel flow at Beckton STW	Bespoke	TMS.OC.A69-A70
ET04	Establish an effective system operator for the London Tideway Tunnels	Bespoke	TMS.OC.A81-A86

Source: Thames Water

Reducing leakage by 15%[30]

Key risk/s	Climate change increasing the risk of drought Population growth increasing demand for water Population growth increasing the number of people affected by leaks/bursts
Investment	£357m
Impact of not investing	More frequent supply interruptions More frequent and longer lasting drought measures Reduced customer uptake for water efficiency

3.24 Our water supplies are under increasing pressure from population growth and the impacts of climate change, and improving the resilience of our ageing water supply network is one of our highest immediate priorities for 2020-2025. Our plan sets out a more ambitious programme to manage demand, including by reducing leakage by 15% by 2025, as part of a commitment to halve leakage by 2050.

3.25 We propose investing more than £900m[31] overall to control leakage. A large part of this spend will prevent leakage from worsening, including through a major programme to find and fix leaks, replace poor performing mains and other associated network maintenance. A further £357m of investment

[29] TW-OC-A1 Outcomes Supporting Evidence document (April 2019).
[30] TW-RS1-Building a Better Future: Response to Ofwat's IAP, 'Delivering better outcomes' section (April 2019)
[31] TW-CE-A26- Wholesale Costs Spreadsheet.

has been included in our plan to go beyond this level and make our water supply network more resilient. To do this we will:

- Use technology to better understand where water is being lost and pinpoint repairs we need to make. This includes installing smart water meters that enable work to find and fix leaks on our and our customers' pipes;
- Invest in how we control the water supply network so that we can better manage pressure fluctuations that place a stress on our ageing network, and lead to leaks and bursts;
- Install new apparatus and digital monitors on our trunk mains and distribution mains to assist in leakage detection and network management; and
- Restore the best achieved leakage performance in areas where leakage has deteriorated over time. We will do this through a combination of increased detection resource, data analytics and technology (including smart meters) and targeted mains replacement.

3.26 Collectively these measures will enable us to achieve our leakage target and support our efforts to encourage customers to reduce their water wastage. Without this investment, we will continue to waste a precious resource, increase the risk of supply interruptions – both temporarily from bursts and prolonged due to drought - as well as undermine customers' confidence in us and the need to be water efficient. Further information can be found in our WRMP Enhancement Case[32] and the Leakage Chapter of the Outcomes Supporting Evidence document[33].

Additional sewage treatment capacity

Key risk/s	Growth increasing production of wastewater
Investment	£394m
Impact of not investing	Increased likelihood of pollution events Local Authorities applying limits on new development

3.27 The population of our region continues to grow at a rate faster than the country as a whole. We can accommodate some growth within existing headroom where possible, but the extent of growth in a number of areas is such that we need to invest to increase capacity at some sites. Our plan caters for this growth by ensuring we have capacity in our wastewater networks and sewage works to provide for an additional 600,000 people. This ensures our works can continue to treat the flows that they receive before effluent is discharged to receiving watercourses; and sludge is produced to the required quality standards before being recycled.

3.28 In London, growth has outpaced historic forecasts and through our work with developers, London Boroughs and the Greater London Authority, we have greater confidence in the growth predictions. Our plan includes major works to cater for growth in the catchments served by Mogden and Beckton (where we have already started procurement), and at Crossness, Long Reach and Riverside sewage treatment works.

3.29 Outside the capital we are currently forecasting the need to invest at 17 treatment works. Changes to future housing delivery and population forecasts could affect the sites in this programme but at this stage, sites where we have most confidence work is needed and it is planned for the first two years,

[32] TW-CE-A9 WRMP Enhancement Case
[33] TW-OC-A1 Outcomes Supporting Evidence document – Section 4.

are Stansted Mountfitchet, Moreton-in-Marsh, Hatfield (Mill Green), Luton (East Hyde), Chinnor and Burstow.

3.30 We monitor and review growth forecasts regularly, using projections from the Office for National Statistics, Edge Analytics and the Greater London Authority, and adjust our plans to accommodate changes in the growth forecasts. This ensures we invest when and where needed to facilitate growth, and minimise the risk of investing too much, too soon.

3.31 Further information on this programme can be found in our Wastewater Network Plus Price Control document[34].

Upgrading our treatment works

Key risk/s	Climate change increasing the risk of drought Climate change affecting raw water quality Population growth increasing demand for water Population growth increasing production of wastewater
Investment	£249m
Impact of not investing	Increased likelihood of unplanned outages and supply interruptions Increased likelihood of pollution events

3.32 Our changing climate and growing population are placing an increasing pressure on the water and wastewater treatment works our customers, and the environment rely on. We need to ensure our treatment works continue to provide high standards of service, and sewage pumping stations maintain their performance, whilst minimising the risk of unplanned outages that interrupt services.

3.33 Investing in our treatment works will create headroom that will enable us to take assets out of service for maintenance and ensure the resilience of the sewage pumping stations that serves them.

3.34 The water treatment works component of this programme includes:

- Improvements to slow sand filters at Ashford, Hampton and Fobney;
- Redesigning ozone treatment plants to include latest efficient generation technologies at Farmoor and Fobney;
- Providing facilities at a number of groundwater works to ensure water quality standards are met; and
- Work to ensure the structural integrity of the raw water tunnels from storage reservoirs (including Queen Elizabeth II Reservoir) which feed water treatment works.

3.35 On the wastewater side, we will:

- Ensure our critical sewage pumping stations continue to safely and reliably operate, preventing the risk of pollution or flooding; and
- Install a new control room at Beckton to accommodate recent and future upgrades, including the operation of the Thames Tideway Tunnel.

[34] Thames Water, PCD2 – Price Control, Wastewater Network Plus (September 2018) – Section 3.3.25 (sewage pumping stations) and 3.3.33 (Tideway Tunnel).

3.36 Further information on this programme of investment can be found in our TW-CE-A13 Unplanned Outage Enhancement Case, the TW-CE-A14 CRI Improvement, and our Wastewater Network Plus Price Control[32].

Reduce risk of customer flooding in a 1:50 year storm

Key risk/s	Climate change increasing the frequency of heavy rainfall events Population growth increasing impermeability of surfaces through new development ('urban creep') Population growth increasing number of people affected by an event
Investment	£206m
Impact of not investing	Increased likelihood and frequency of sewer and surface water flooding Release of un- or partially treated wastewater into the environment

3.37 Without action, population growth, urban creep (the loss of natural permeable surfaces into impermeable hard standing) and climate change will increase the likelihood of sewer flooding of our customers' homes. Our plan will make our sewers more resilient to these risks, including through a step-change in investment in Sustainable Drainage Systems ('SuDS').

3.38 Working in partnership with others, and introducing real-time control of our sewer network, we will introduce smarter ways to operate our network and make better use of existing capacity, contributing to a 20% reduction in internal sewer flooding incidents by 2025[35].

3.39 Our sector-leading work to evaluate sewer capacity, combined with information from extensive installation of monitors measuring the network, is being used to identify and then prioritise areas of our sewer network under the most pressure.

3.40 Our current five-year plan aims to disconnect 20 hectares of impermeable land from London's combined sewers. Our Plan for 2020-25 will more than triple the scale and pace of this work through a programme to disconnect more than 65 hectares by:

- Providing funding to each of the 96 Lead Local Flood Authorities (LLFA) to contribute to SuDS schemes;
- Forming partnerships with three LLFAs to jointly deliver a range of projects;
- Funding third-sector bodies (including schools and environment groups) to deliver SuDS schemes; and
- Installing a range of schemes ourselves in areas with the least available capacity in their sewers.

3.41 We will also take forward the actions identified through the preparation of Drainage Strategies in a number of areas throughout the Thames Valley, including Brent; Bourton on the Water; Charlton on Otmoor; Compton; Didcot; East Shefford; Ramsbury; Reading; Sherbourne St John; Standlake; Witney.

[35] TW-RS1-Building a Better Future: Response to Ofwat's IAP (April 2019) – 'Delivering better outcomes' section.

3.42 Our plan also includes significant contributions to the lower River Thames and Oxford flood alleviation schemes, reflecting the extent to which they will address the risk of floods from public sewers and our desire to develop and deliver solutions in partnership with others. Further information on this programme can be found in our Risk of sewer flooding in a 1 in 50-year storm document[36].

Increasing water resources and capacity of our distribution systems

Key risk/s	Climate change increasing the frequency and duration of low rainfall periods Population growth increasing demand for water Population growth increasing number of people affected by an event
Investment	£203m
Impact of not investing	Increased likelihood, frequency and duration of drought management measures Increased likelihood of supply interruptions.

3.43 Our changing climate, growing population and the need to leave more water in the environment to protect wildlife, are increasing the risk of water supply shortages that could damage the economy, the environment, and society as a whole. This means that on top of our ambitious demand management programme, we need to develop new sources of water to manage these risks.

3.44 To manage the increasing risk of water supply shortages, we plan to strengthen our resilience to drought to withstand a 1-in-200 year event by 2030. To achieve this, our plan includes:

- Funding to initiate our plans for a new reservoir filled from the River Thames near Abingdon in Oxfordshire, shared with Affinity Water, as the best value option to meet our and their customers' long-term needs. This will involve initial planning; engagement and design, with the reservoir ultimately in use by 2037;
- Investment to develop a number of new source of groundwater; and
- An innovative aquifer recharge scheme in South London.

3.45 Our region will see pockets of rapid, concentrated, development that require new water resources supply infrastructure. We also plan to invest in:

- A major project to improve the resilience of water supplies in our Guildford water supply zone by building a new trunk main that can transfer water from the west to the east of the area.
- A number of projects to provide new or improved water distribution networks serving areas where rapid growth is set to outstrip the capacity of the existing systems.

3.46 Further information on this programme can be found in the TW-CE-A9 Water Resources Management Plan cost enhancement document and the updates on our rdWRMP19[37].

North East London water supply system resilience

Key risk/s	Climate change affecting the frequency and duration of algal blooms Population growth increasing demand for water Population growth increasing number of people affected by an event

[36] Thames Water, CSD005-DS01-PR19 Risk of sewer flooding in a 1 in 50-year storm (September 2018)
[37] TW-OC-A2-Water Resources Management Plan updates

Investment	£181m
Impact of not investing	Increased likelihood, frequency and duration of unplanned outages Increased likelihood of supply interruptions.

3.47 We have been using new modelling frameworks and tools to undertake a system-scale review of all our water and wastewater networks. Our North East London water supply zone, which includes the City and Canary Wharf, has been identified as our highest risk zone, with the risk of large-scale interruptions to water supply. This is due to the decreasing raw water quality due to algal blooms, driven by climate change, affecting our Coppermills Water Treatment Works ('WTW'), and a potential single point of failure at Coppermills WTW and in particular the High Lift Pumping Station owing from the original 1960's design. The resilience of the zone is further limited by the lack of interconnections between the strategic mains and other water treatment works, meaning there is insufficient flexibility to manage a reduction in output from the works or the loss of the pumping station.

3.48 In developing the programme, we considered not just the North East London zone as a system, but how the North East London zone operates within the wider London network. We applied a multi-criteria assessment of a wide range of different risk management options and assessed the options individually and as a programme. We undertook extensive customer research which shows strong customer support for the investment. The options in our proposed integrated programme comprises:

- An innovative new pre-treatment process to remove algae from the water taken from our reservoirs;
- A new strategic high lift pumping station; and
- A new water treatment works with associated network storage and strategic trunk mains connections.

3.49 This first phase of work will be completed by 2030 and it lays the foundations for us to initiate wider systems resilience improvements across the rest of London and the Thames Valley. Further information on this programme can be found in the TW-CE-A7 North East London Resilience Enhancement Case.

Improving the security of our sites

Key risk/s	Intentional malicious damage to our systems
Investment	£27m
Impact of not investing	Increased risk of unplanned outage and interruptions to supply Increased risk of sewer flooding and pollution events

3.50 Improving the security of our sites against intruders is a priority and our long-term ambition is for all our sites to be secure against the risk of malicious damage (vandalism and terrorism) and other threats. We are developing a risk-based, prioritised list of sites that we will invest to fulfil our legislative security requirements. We will be able to confirm the work programme once DEFRA's Security and Emergency Measures Directive ('SEMD') guidance is finalised.

3.51 Despite not being able to definitively confirm our work programme, we believe that the performance commitment is stretching due to the geographical and technical complexity of the work. Whilst there is a standardised product base, the application of these measures is unique to each site, requiring individual design and bespoke installation. Delivery is further complicated by a lack of capacity in the supply chain.

3.52 Further information on this programme can be found in the TW-OC-A5 SEMD Performance Commitment update.

Improving the reliability of our IT

Key risk/s	Cyber-threats
Investment	£117m
Impact of not investing	Increased risk of unplanned outage, interruptions to supply Increased risk of sewer flooding and pollution events

3.53 We commenced our digital transformation in 2017 and have focussed on building a modern, scalable and resilient IT and Operational Technology (OT) estate. We have improved the resilience of our data centres and are currently upgrading our IT networks. We are rationalising and standardising our applications estate and have a 'cloud first' strategy which provides a secure, scalable and resilient Microsoft hosted platform for our on-going transformation.

3.54 Improving our OT by employing the Internet of Things is at the heart of our AMP7 digital plans. Firstly, we will continue to address current and upcoming obsolescence in our OT, such as replacing aged telemetry equipment and controllers. This will reduce the likelihood of our IT/OT failure (and therefore customer impact) and will ensure a faster return to service in the event of a failure. We will also reduce the age and historic fragmentation of our SCADA systems and control rooms which will again increase resilience and make it easier for our controllers to operate.

3.55 During 2018, in response to the Beast from the East, we developed a data-led digital tool to monitor supply and demand at a system level (Supply and Demand Tool – see Section 2, Part E). During AMP7 we intend to increase the extent of monitoring across our water and waste water networks, including deploying up to 200,000 sewer monitors. This is primarily intended to address leakage, supply interruptions, blockages and environmental performance but the associated benefit will be that we will develop a much better understanding of network performance, enhance operational performance through insight, and in turn increase resilience.

3.56 Throughout 2018 we have transformed our Information Security function to facilitate improvements in security event detection and response. In AMP7 we will increase active monitoring and detection and data leakage protection. Additional improvements in security operational workflow will reduce the "detect to respond" ratio during security events. As with OT, a reduction in obsolesce will be a major factor in eliminating security vulnerabilities and reducing risk. The integration of next generation technologies will also allow consolidated management of cyber and SCADA vulnerabilities to form a joined up operational view to more quickly react to all threats and reduce overall risk.

3.57 For further information, please see our September 18 Business Plan submission[38].

Rehabilitating our water mains and sewers

Key risk/s	Climate change increasing frequency and intensity of extreme weather event Population growth increasing development near our assets Population growth increasing number of people affected by an event
Investment	£63m
Impact of not investing	Increased risk of unplanned outage, interruptions to supply and

[38] Thames Water, BDP1-PR19-Business Plan Document (September 2018) – Chapter 10

	flooding from burst mains Increased risk of sewer flooding and pollution events

3.58 Our water mains and sewers are ageing, as are some of the key structures that support them where they cross roads, rivers and railways, including the London Underground. There is an increasing risk of catastrophic failure at some locations.

3.59 The number of water mains that burst and sewers that collapse will increase unless we keep up pace with rehabilitation work. We need to spend an additional £63m above historical levels to address this and deliver our commitments on internal sewer flooding, pollution incidents, sewer collapses, sewer blockages, leakage, mains bursts and supply interruptions.

3.60 Without additional investment, water mains will become more fragile and less resilient to severe weather events such as freeze-thaw and during hot weather, when we need to move large quantities of water around to meet demand. Sewers are more likely to block or collapse during wet weather events if they are not maintained.

3.61 Our programme is composed of five key elements:

- Investing in calming our water network and prolonging the life of our water mains by controlling the pressure fluctuations resulting from our water treatment and water pumping activities;
- Improving our ability to detect potential bursts on trunk mains by increasing the coverage of monitoring equipment that can provide early warnings and help us effectively target the rehabilitation of pipes before they interrupt supplies or cause flooding;
- Undertaking surveys and rehabilitation of pipe bridges that cross sensitive locations;
- Maintenance of critical penstocks so that we can safely isolate and inspect large sewers; and
- Replacing a large rising main at Store Road on the Isle of Dogs which is at risk of causing a major pollution incident in the Thames.

3.62 Further information on this programme can be found in TW-CE-A10 Supply Interruptions Enhancement Case and PCD2-PR19 Waste Water Network Plus Price Control.

Preparing London Thames Tideway Tunnel to receive storm flow

Key risk/s	Climate change increasing frequency of heavy rainfall events
Investment	£63m
Impact of not investing	Increased strain on assets (reduced asset life)

3.63 In AMP5 we upgraded our Thames Tideway sites, with a particular focus on Beckton STW, as it receives the flow from the Lee Tunnel and in preparation for the Thames Tideway Tunnel, when it becomes operable. Our experience from pumping out the Lee Tunnel and subsequent studies demonstrated that sustained flow would place unacceptable strain on the inlet works at Beckton STW. We are therefore increasing the resilience of the inlet works through upgrading the grit removal gantries and improving the flow dynamics.

3.64 For further information, see the TTT price control document update[39].

Improving power resilience to critical sites

[39] Thames Water, TW-CE-A17-TTT Price Control Update (April 2019).

Key risk/s	Increasing fragility of the power supply (plus intermittency of renewable energy supply)
Investment	£36m
Impact of not investing	Increased risk of unplanned outage, interruptions to supply Increased risk of sewer flooding and pollution events

3.65 In 2017, 85% of our sites were affected by disturbances or interruptions to the power supply from the power transmission/distribution network. When the power supply fails, customers and the environment are at risk of interruptions to their supply of water, flooding from the sewers, or releases of un- or partially treated wastewater. The frequency of power interruptions is expected to increase as the proportion of power generated from renewable sources, and new demands for power, e.g. charging electric cars, increases.

3.66 We have identified 201 key power dependent sites that need to be made resilient to power supply interruptions and disturbances. By the end of AMP6 we will have upgraded 133 of them. Our AMP7 programme is to make a further 47 sites resilient, with the remaining 21 sites made resilient by the end of AMP8.

3.67 We have defined 'key power dependent sites' as water and sewage treatment works, and sewerage pumping stations with greater than 500kw installed power and water booster stations without standby generation and with greater than 200 directly fed properties. We use a process called "probability of asset failure leading to customer impact" (PAFLI) to prioritise sites. This process identifies and assesses the key components that contribute to the resilience of the system, the number of customers that would be affected by a power outage and the type of impact. We combine these factors to rank the sites by order of customer impact.

3.68 Further information can be found in the Resilience (excluding NE London) Enhancement Case[40].

E Becoming naturally resilient

3.69 We recognise that the quality of our key resource is dependent upon the quality of the environment it is taken from. We also recognise that the quality of the environment can be profoundly affected by the quality and quantity of what we return to the environment. A healthy, naturally resilient, environment is both a benefit to us and an imperative for us to help maintain.

3.70 In this sub-section, we set our how we have used environmental valuation techniques to assess resilience options in our plan and provide examples of where we are increasing natural resilience through using greener options. This approach and these examples align to Resilience Principle 2, 'A naturally resilient water sector'.

Environmental Valuation

3.71 We have used environmental valuation at various stages in the assessment of different options in our plans, including prioritising investment for catchment management (flood risk management and water quality), mains replacement (assessing the potential impact of trunk main bursts on sites of

[40] TW-CE-A12 Resilience (excluding NE London) Enhancement Case (April 2019).

biodiversity interest) and wastewater asset failure (impact of un-or partially treated sewage on watercourses). Our APS tool (see Section 2, Part E) considers the cost of carbon as part of its optimisation process. Our aim is to keep developing these processes and the associated supporting information so that Natural Capital is an intrinsic part or our investment appraisal methodology for our PR24 submission.

Environmental Net Gain

3.72 We have a new performance commitment for 2020-2025 to enhance the biodiversity on our landholdings by five percent, focusing on the 253 sites which have been designated as being a Site of Biodiversity Interest (SBI). We are measuring the biodiversity net-gain using Defra's biodiversity net gain tool and have carried out the baseline survey. The majority of the enhancement will be improving the condition of the existing grassland to attract, for example, species such as bumble bees and butterflies. The five percent enhancement is considered to be stretching as there is no historical precedent to measure enhancements and from the baseline survey, we feel, that this is the maximum we can achieve given pressure from other activities, such as operational activity, growth projects and land sales.

3.73 It is recognised that calculating biodiversity net gain is the basis of the emerging methodology of measuring environmental net gain, as set out in the Government's 25-year environment plan and highlighted by the Secretary of State in his statement on net gain in December 2018[41].

3.74 As the principles of environmental net gain are developed, the measurement will expand to include wider natural capital benefits, such as flood protection, recreation and improved water and air quality. We have identified ten of our 253 SBIs where we will be applying these wider natural capital benefits, for example creating new ponds and wetlands, opening the sites to local communities, planting woodland, in readiness for the implementation of this new calculation.

Smarter Water Catchments

3.75 We believe catchment management has the potential to offer better value or greater benefits than more traditional capital investment solutions. Our plan for AMP7 will see a step change in our approach to catchment management through the co-creation of our 'Smarter Water Catchments' initiative, in partnership with key stakeholders across the industry. By recognising the environment as a system, this initiative will capitalise on opportunities of greater scope and scale, and work together on projects to build better functioning river catchments that, in turn, are better equipped to support water company and ecosystem services.

3.76 Under the Smarter Water Catchments initiative, we have identified three river catchments where we will test the contribution this more holistic approach can make. These catchments have been specifically selected to represent the range of environmental challenges we face across our region. It will challenge the conventional association of catchment management with rural, upland areas through an innovative major project in London, the most challenging and complex of all our urban catchments. The three river catchments are:

- River Crane, West London, working with the Crane Valley Partnership;
- River Chess, Buckinghamshire, working with the River Chess Association and Chilterns Chalk Streams Project; and

[41] https://www.gov.uk/government/news/gove-sets-out-proposals-for-greener-developments

- River Evenlode, Oxfordshire, working with the Evenlode Catchment Partnership.

3.77 In addition to these three rivers, we have also identified three further projects under this initiative that will have a narrower focus and will provide additional evidence and learning that we can apply to other locations. Each of these projects will be designed and delivered in partnership with a key stakeholder, and will encourage innovative ways of improving the water environment across catchment boundaries; they include:

- Working with Action for the River Kennet (ARK) to assess how increased targeted customer and stakeholder engagement across the River Kennet catchment reduces the demand for water, and influences the way people use our sewers;
- Evaluating the impact of increasing environmental resilience with the South East Rivers Trust across varying catchments by proactively improving river habitats to mitigate the impact of abstractions and effluent discharges; and
- A region-wide project with the Environment Agency to investigate the practicability and potential scope for dual-purpose flood alleviation and water storage assets.

Payment for Ecosystem Services

3.78 Alongside the Smarter Catchments programme, the Catchment Control Team has been working for many years, and will continue into AMP7, to work with farmers and land managers across the catchment to protect water quality. Our Payment for Ecosystem Services (PES) projects are about working with farmers to reduce diffuse pollution problems at source, rather than relying on water treatment to remove them, to increase the sustainability of our approach (see case study). Realistically, treatment will always be required for surface water, but decreasing the challenge on the treatment would be desirable and would provide increased resilience, both for the environment and for water quality. These projects are targeted based on water quality risk from historical data and modelling, and the areas where the greatest water quality improvements are likely to be achieved. Our catchment fund will provide additional financial support for farmers in specific high risk areas to put in place significant measures to protect water quality in both surface water and groundwater catchments. We will also be continuing to work with Network Rail on the longstanding agreement for the protection of drinking water sources (see case study: Payment for Ecosystem Services), as we have done for many years, and we will continue to be active members of the Amenity Forum to drive forward the environmental and water protection agenda.

Case study: Payment for Ecosystem Services.

3.79 The River Tillingbourne and River Wey near Guildford, Surrey, are sources of drinking water that can receive levels of metaldehyde that rise above Drinking Water Standards between September and December. In autumn 2015 we started working with three farmers on a ‘payment for ecosystem services’ (PES) trial, where the farmers received payments for helping maintain the quality of the river water throughout the ‘high risk’ season. This involved adopting cultural control methods to create a less favourable environment for slugs and using integrated pest management. The trial provided valuable lessons on the PES approach, and we are now building on the success of the project by scaling up this approach across larger catchments with more farmers. In 2018, we ran 19 PES projects across the Thames Basin and Lea Valley.

Case Study: Working with Network Rail on catchment management.

3.80 One of our first successful catchment management projects involved protecting vulnerable drinking water sources from herbicides used to control weeds on railway lines. We were a founding partner in this project, delivered in collaboration with Network Rail and its predecessors, which became a national agreement administered by the Environment Agency. It is the largest, longest running catchment management project in the country, protecting 75 vulnerable water sources in our region and 550 more elsewhere.

F A resilient supply chain

3.81 Disruption to our supply chain is one of our 12 principal risks. To address this risk, we are developing sophisticated supply-chain forecasting tools to consider the impacts of future trends or scenarios on the availability and cost of goods and materials. We have invested in 'On Track', a tool that provides visibility of forward-looking spend through future demand forecasts. It enables us to identify key areas of business plan expenditure and potential procurement challenges. We are planning to share demand forecasting with our supply chain to increase transparency and encourage innovation. We also use a software tool called 'Curve' to enable us to track commodities and indices in order to understand, from a market perspective, what the impacts are likely to be across the supply chain.

3.82 Our aim in AMP7 is to continue our strong focus on data driven insight and foresight. We are focused on engaging with our delivery partners to understand their levels of exposure to their suppliers' suppliers. As we get a deeper understanding of the links between Tier 2-3 and Tier 3-4 suppliers we will be able to move from a long supply chain tail to a dynamic supply network.

G Summary

3.83 In this section we show that:

- We focus on improving our asset health through taking a systems approach. We are keen to develop forward-looking metrics that better represent the resilience of our services;
- We have tried and tested systems for when things don't go as planned, including how we work with other emergency responders and how we support our customers;
- We have developed a £1.86bn 'resilience investment plan', that addresses our key risks and is supported by customers;
- We use environmental valuation to inform our decision-making and aim to improve and standardise this approach so that it is integrated into our investment appraisal methodology for our PR24 submission;
- We work with a wide range of stakeholders to develop and deliver natural resilience programmes; and
- We are driving resilience through our supply chain and working towards have a dynamic supply network.

Section 4

Section 4: Financial resilience

A Changes to our Plan

4.1 We have considered the financial resilience of our April Submission over a ten-year period, given a range of plausible, but severe downside scenarios appropriate to the business. In doing so, we have adopted an approach consistent with the Long Term Viability Statements ("LTVS") contained in our annual reports. This maintains an assessment period of 10 years. As our audited financial accounts for the year ending 31 March 2018 are only available in July, when we publish our 2018/19 annual report, we have assumed the forward-looking assessment period to be from 1 April 2019 to 31 March 2028. We have concluded that we will be financially resilient and will be able to operate within our financial covenants and maintain sufficient liquidity facilities to meet our funding needs over the ten-year assessment period, even if these downsides were to crystallise.

4.2 We have also considered Ofwat's prescribed downside scenarios which it expects companies to consider in their assessment of financial resilience, as set out in 'Back in Balance'[42].

4.3 The full results of our assessment are set out in the Finance and Financeability Appendix[43] within which we address the additional questions raised by Ofwat in its IAP, considering our ability to maintain our credit rating, the impact of the gear sharing mechanism requirements to refinance subordinated debt and effect of capital raised elsewhere in the corporate group.

[42] https://www.ofwat.gov.uk/consultation/putting-sector-back-balance-consultation-proposals-pr19-business-plans/

[43] TW-RR-A2 Finance and Financeability Appendix, Section 7 (April 2019).