Tackling the Climate Emergency

Wessex Water's **climate change adaptation** report 2021

Wessex Water
YTL GROUP

FOR YOU. FOR LIFE.

About this report

This report sets out how we plan to adapt to climate change. It covers the climate-related hazards that could affect us, the level of risk that they pose for our business, and the adaptation options that we have in place or propose.

It is published as our third report under Defra's adaptation reporting power that was introduced with the Climate Change Act 2008, and provides updates to the previous edition in 2015.

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Wessex Water and our region

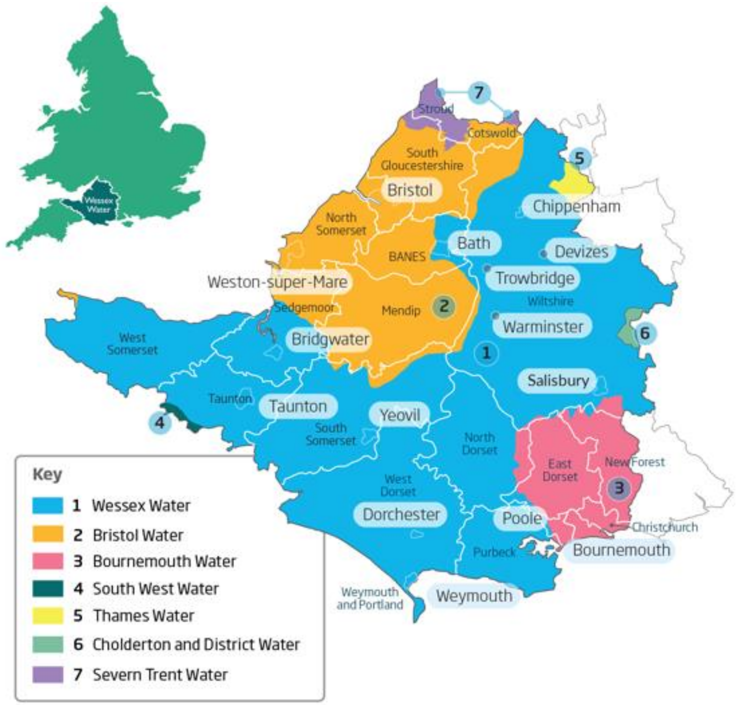
Our company and our region

Wessex Water is the regional water and sewage treatment business serving a 10,000 square kilometre area of the south west of England, including Dorset, Somerset, Bristol, most of Wiltshire and parts of Gloucestershire and Hampshire. The company is a wholly owned subsidiary of YTL Power International of Malaysia.

Our purpose is to support our customers' health and wellbeing, and enhance the environment and the diverse communities we serve. We aim to:

1. provide reliable, affordable services for all customers and communities
2. Deliver a better environment for nature and people
3. Be a great place to work
4. Be a trusted, financially strong company

We treat and supply	We take away and treat
Over 286 million litres of water a day to 1.3 million customers and 45,000 businesses (on average over a ton of water to every customer weekly)	958 million litres of wastewater from 2.8 million customers and 57,000 businesses every day
We have	**We have**
271 water sources & water treatment centres 233 booster pumping stations 314 service reservoirs and water towers 12,055 kilometres of water	34,500 kilometres of sewers 400 water recycling centres 2,129 sewage pumping stations



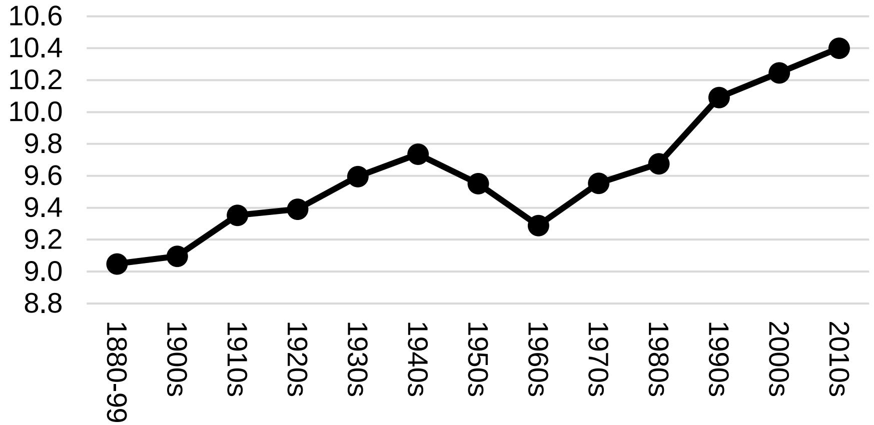
Wessex Water is one of the leading water and sewerage companies for customer service and satisfaction, as judged by standards set by our regulators, and is committed to delivering the highest levels of customer service and environmental performance at a price that customers can afford. We continually seek new and innovative ways of working, while continuing to deliver a quality service and experience for our customers, staff and stakeholders. We are a long-term business that is committed to reducing our environmental impact. This includes our support for the Government's net zero by 2050 target; we are committed to achieving net zero operational emissions by 2030 and net zero total emissions by 2040. Alongside mitigation, we recognise the importance of preparing for climate change and having a business resilient to any potential impacts. Adaptation to a changing climate is integral both to our long-term vision and our business plan, and to subject-specific exercises such as our water resources planning process.

Our climate and extreme weather

Long-term trends
As our services and operations are affected by weather patterns, climate change needs to be accounted for in our long-term planning.

The warming trend since the end of the nineteenth century has been unequivocal. As the chart below shows, annual average temperatures in central England have risen by approximately 1.4 degrees centigrade since the 1880-99 'pre-industrial' period, ahead of the 1.1 degrees rise in global average temperatures over the same period.

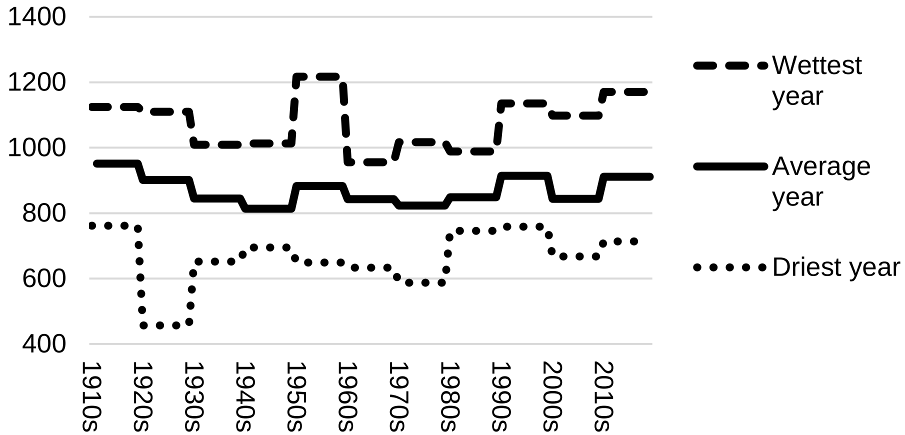
Central England (HadCET) annual average temperature*



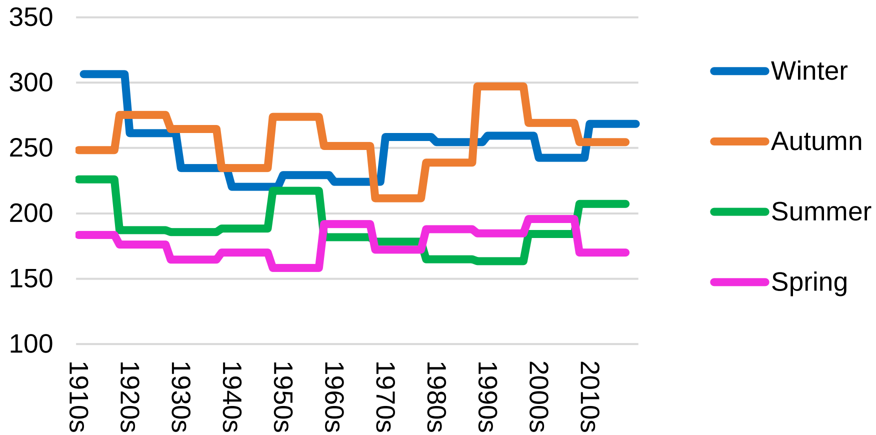
*This is the nearest continuous long term temperature record to our region.

Monthly rainfall records, measured by the Environment Agency's gauges spread across our region, allow us to compare current weather with long term averages, and provide context for the projected effects of climate change. Annual average precipitation in our region is 871mm for 1911-2020 and 838mm for 1961-1990 – one of the periods used for UK Climate Projections to represent the baseline climate. The graphs below show annual and seasonal rainfall by decade since the 1910s; further detail is provided in appendix 2.

Annual precipitation (mm) by decade



Seasonal average precipitation (mm), by decade

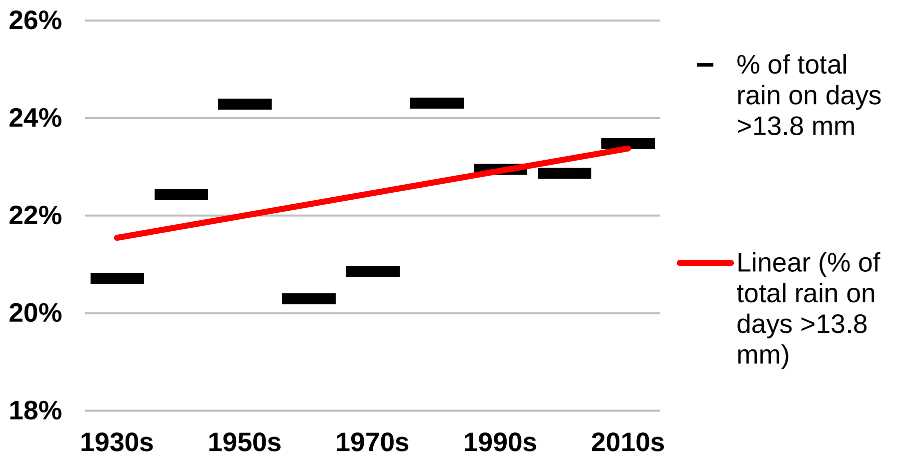


Extreme events – wet and dry

Water and wastewater services are adversely affected by extreme weather conditions. An example of how climate change might influence this is the projected increase in rainfall intensity; one way to assess this is to quantify how much of a year's rain has occurred on days with unusually heavy rainfall.

The graph below does this with daily precipitation data from Wales and south west England (source Met Office, HADUKP), showing the percentage of total annual rainfall that happened on days with more than 13.8mm (which is the 95th percentile for all days with any measurable amount of rain during the baseline period of 1961-1990).

Percentage of total rain on days >13.8mm



There is a moderate rising trend for the years since 1931, which is the start year in this dataset.

Precipitation data do not yet indicate unusually dry seasons (i.e. below the10th percentile) or wet seasons (i.e. above the 90th percentile) becoming much more frequent since 1990, compared with the 1961-1990 reference period. However, since the late 1980s we have experienced extreme wet and dry periods that have tested our resilience – as noted in the following tables.

Extreme wet events		Rainfall compared to 1961-90 average
Winter 1989-90	Heavy rainfall	188%
Winter 1993-94	Heavy rainfall	167%
Winter 1994-95	Heavy rainfall	171%
Autumn 2000	Heavy rainfall, flooding	184%
Summer 2007	Heavy rainfall	160%
April 2012 to Winter 2012-13	Heavy rainfall	154%
Winter 2013-14	Heavy rainfall, flooding	200%
Autumn 2019 to winter 2019-20	Heavy rainfall	162%

The prolonged rainfall of summer 2007 required widespread emergency response, including our assistance to Severn Trent Water under the mutual aid scheme. This event led to a fundamental national review of surface water management under Sir Michael Pitt.

The heavy rainfall of 2012 included the wettest summer since 1911, followed a year later by the wettest three-month period since 1911 from December 2013 to February 2014. This period saw extensive impacts and responses in our region:

- We saw nitrate levels rise significantly at number of sources in 2012 and again in the winter, which led to 23 sites taken out of supply (at varying times) until nitrate levels reduced. Some customers experienced restricted wastewater service and extensive work was needed to keep this to a minimum; for example by removing rainwater from sewers which had been overwhelmed through groundwater infiltration. We had to tanker the contents of sewers to other catchments at 46 locations and overpump to watercourses at 12 locations in order to protect properties from flooding internally
- Soils in many parts of our region became saturated, which limited the capacity of on-farm storage for treated sludge cake.
- We experienced localised flooding of some sites. The flooding of the Somerset levels in 2014 was the largest flood event in the area since records began in the 1600s.

Autumn 2019 and winter 2020 was the third wettest autumn to winter period since 1911.We saw a significant increase in external flooding in 2019-20 due to heavy rainfall over that period:

- There were 2166 external flooding incidents (inside property boundaries)
- In addition to heavy rainfall throughout the winter period, flooding in the winter is also a result of an accumulation of back-to-back events causing high ground water levels and ground saturation leading to smaller rainfall events causing flooding
- Despite the weather throughout this period, there was a decrease in the number of internal flooding incidents reported
- The vast majority of these would be attributed to sewers partially blocked due to sewer misuse rather than the sewer not having adequate hydraulic capacity

The above events are mainly those that occurred over a month or more. Our ability to track extremely wet rainfall at the daily or hourly scale is less advanced, and it is clear that more acute events can be extremely localised and take place in short periods of time. It is projected that the risk of these occurring will increase with global warming, as a warmer atmosphere can hold water vapour in larger quantities.

	Extreme dry events	Rainfall compared to 1961-90 average
Summer 1995	Drought	22%
October 2010 to March 2012	Environmental drought	75%

In terms of dry extremes, 1995 was (and remains) the driest summer since 1911 and the driest three-month period since 1938. Efforts to reduce leakage were stepped up following this event, leading to annual leakage targets overseen by Ofwat; leakage from our network has me than halved since then. While this and the eighteen months to March 2012 were classed as drought events, we have not imposed water use restrictions in our supply area since 1975-76, and this period remains the benchmark for our water resources planning.

Extreme events – temperature

The February to March 2018 ‘Beast from the East’ cold wave and the subsequent thaw caused widespread outbreaks of leaks and pipe bursts. While over 60,000 customers across England and Wales were without water for more than 12 hours, Wessex Water was the only company to have no customers experiencing water supply interruptions exceeding four hours. This was achieved through discussions with Bristol Water about potential impacts and bulk water transfer arrangements before the event hit; use of our new water supply grid to move water to where it was needed most; and use of leak detection and pinpointing technology. We subsequently changed our adverse weather business continuity plan, including earlier notification of potential events before red weather warnings are issued.

The 2018 heatwave also led to changes in business continuity practices, including a direct link into national heat alerts.

Extreme temperature events		Min / max temperatures*
Summer 2003	Heatwave	32.4 deg.C
Summer 2006	Heatwave	35 deg.C
Winter 2010	Cold snap	-15 deg.C
Feb-Mar 2018	Cold wave	-6.4 deg.C
Summer 2018	Heatwave	30.5 deg.C

*As recorded at RAF Yeovilton

Future climate change risk and adaption in the UK

Global, UK and regional climate change hazards
August 2021 saw the publication of the latest Intergovernmental Panel on Climate Change working group 1 report on the physical science basis of our understanding of climate change, produced as part of the IPCC's sixth assessment report. This is the most recent comprehensive overview of the scientific basis of climate change, potential impacts, and options for limiting concentrations of greenhouse gases in the atmosphere. Its headline conclusions include the following:

- "It is unequivocal that human influence has warmed the atmosphere, ocean and land. Widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred."
- "The scale of recent changes across the climate system as a whole and the present state of many aspects of the climate system are unprecedented over many centuries to many thousands of years."
- "Human-induced climate change is already affecting many weather and climate extremes in every region across the globe. Evidence of observed changes in extremes such as heatwaves, heavy precipitation, droughts, and tropical cyclones, and, in particular, their attribution to human influence, has strengthened since the Fifth Assessment Report (AR5)."
- "Global surface temperature will continue to increase until at least the mid-century under all emissions scenarios considered. Global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in CO2 and other greenhouse gas emissions occur in the coming decades."
- "Continued global warming is projected to further intensify the global water cycle, including its variability, global monsoon precipitation and the severity of wet and dry events."

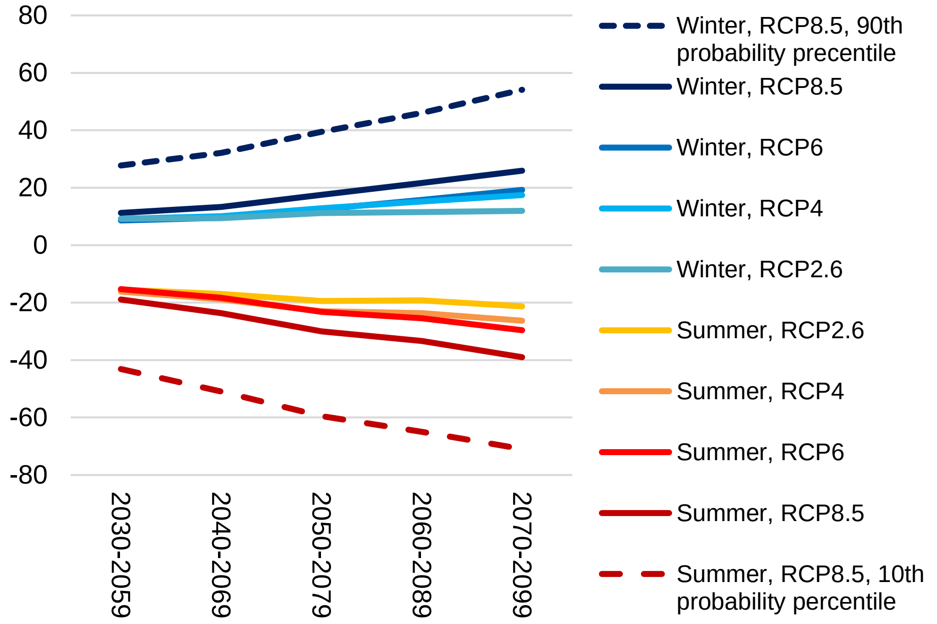
UK Climate Projections

Like other water companies, we use UK Climate Projections to help assess climate risks and plan investment. The 2018 edition (UKCP18) provides the most up-to-date assessment of how the climate of the UK may change over the 21st century. It provides data based on:

- different levels of probability
- four emissions scenarios based on the representative concentration pathways (RCPs) used by the IPCC
- several overlapping time periods to cover the 21st century.

The following chart and tables summarise projected changes (compared with 1961-90) for our region, in an average year, for the most critical parameters. Each value shown is the average of the grid cells in our region, ranging from the most benign emissions pathway (RCP2.6) to the worst (RCP8.5). More detail is provided in appendix 2.

Precipitation: projected % change vs 1961-90 (50th centile for probability and worst-case scenarios)



50th percentile for probability

	2030-59	2050-79	2070-99
Summer (Jun-Aug) precipitation	-15 to -19%	-19 to -30%	-21 to -39%
Winter (Dec-Feb) precipitation	+9 to +11%	+11 to +18%	+12 to +26%
Summer average daily temperature	+1.9 to +2.2°C	+2.1 to +3.6°C	+2.3 to +5.4°C

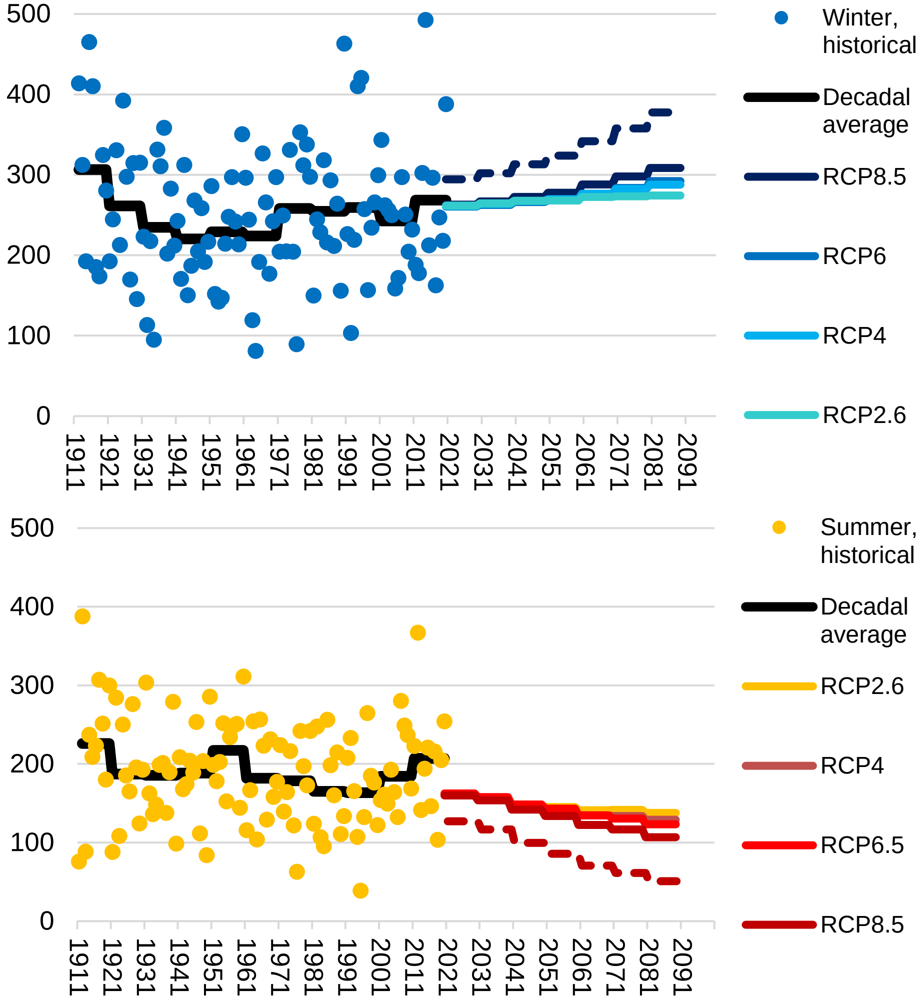
Nb. These ranges align with Ofwat's guidance in its November 2021 document "Long-term delivery strategies and common reference scenarios", i.e. RCP2.6 and RCP8.5, 50th percentile.

Least likely (more extreme) outcomes

	2030-59	2050-79	2070-99
Summer precipitation	-36 to -43%	-43 to -60%	-46 to -71%
Winter precipitation	+24 to +28%	+28 to +39%	+29 to +54%
Summer average daily temperature	+3.1 to +3.6°C	+3.7 to +6.0°C	+4.2.3 to +8.7°C

It is clear that across all scenarios and timescales, the *average* summer will be drier and warmer, and the *average* winter will be milder and wetter. Overlying this gradual trend we can expect a lot of variation from one year to the next, and while changes to averages are important, the resilience of our services is affected more by *extreme* weather events such as heatwaves, droughts, intense storm events and prolonged rainfall – rather than changes to averages. Extreme weather events have happened many times in the past and we have a lot of experience dealing with acute weather-related impacts, which means we can build them into our planning activities and company risk assessments. The following graphs illustrate this with historical winter and summer rainfall in relation to projected changes to average rainfall for those seasons.

Winter and summer rainfall (mm): historical (annual and decadal averages), and projected (decadal averages, from UKCP18)



Note: the future averages shown are at the 50th percentile for probability.

These graphs are purely illustrative; while they demonstrate the variability that we have experienced in past years, future variability may increase. Either way, as background warming takes place, weather events considered extreme or unusual by today's standards are likely to occur more frequently in future. This is the most critical issue for our resilience and adaptability.

UK Climate Change Risk Assessment (UKCCRA) - second round

In 2017 the Government published its second assessment of the risks and opportunities for the UK of the current and predicted impact of climate change, following the first report published in 2012. It draws primarily on an independent report by the Climate Change Committee, which identified six priority areas.

1. Flooding and coastal change risks to communities, businesses and infrastructure
2. Risks to health, well-being and productivity from high temperatures
3. Risks of shortages in the public water supply, and for agriculture, energy generation and industry, with impacts on freshwater ecology
4. Risks to natural capital, including terrestrial, coastal, marine and freshwater ecosystems, soils and biodiversity
5. Risks to domestic and international food production and trade
6. New and emerging pests and diseases, and invasive non-native species, affecting people, plants and animals

Appendix 3 provides further detail on these assessments, focusing on items that are of most direct relevance to our activities, as well as envisaged impacts on the wider water environment.

2018 National adaptation plan

The second National Adaptation Programme (NAP) was published in 2018. As a response to the 2017 UKCCRA it shows the actions government is, and will be, taking to address the risks and opportunities posed by a changing climate. These include responses to the six priority areas shown above, as well as specific groups of actions for the water sector. These come under the following headings:

- water abstraction
- water quality
- water resource management plans
- drought
- strategic policy statement (to Ofwat)
- twin track approach – strengthening the resilience of supply whilst reducing demand
- drainage and wastewater management plans.

Further detail is provided in appendix 3. Our own approach and plans for these headings are provided throughout this report and the supporting information in the appendices.

UK Climate Change Risk Assessment (UKCCRA) - third round

The third edition of the UKCCRA will be published in 2022. It will draw on the updated independent assessment of climate change that was published by the Climate Change Committee in summer 2021. Specific findings of the latter for the water sector were as follows:

- Water infrastructure, such as reservoirs, dams, pipelines, water treatment and recycling centres, are all at risk from the impacts of climate change, especially increases in the frequency and intensity of surface water and coastal flooding.
- Water infrastructure assets represent a key element of the UK infrastructure system and could affect, or be affected by, failures of other assets due to extreme weather, such as energy systems, transport and information and communications technology (ICT).
- There are also risks to buried infrastructure, such as water pipelines, with damage potentially becoming more frequent in future due to flooding and subsidence.
- More frequent flooding could impact water treatment facilities leading to potential reductions in water quality, in turn impacting upon health.
- Future projections of more frequent and intense dry periods lead to concerns around the availability of water supplies in future, especially in England and parts of Wales.
- Aquifers near the coast could be at greater risk from saltwater intrusion due to sea level rise, though the risk is thought to be low in places where aquifers are important water sources.

The independent assessment also updates the areas for action or investigation for the water sector:

More action needed	• Risks to infrastructure networks (water, energy, transport, ICT) from cascading failures • Risks to infrastructure services from river, surface water and groundwater flooding
Further investigation	• Risks to infrastructure services from coastal flooding and erosion • Risks to subterranean and surface infrastructure from subsidence • Risks to health from poor water quality and household supply interruptions
Sustain current action	• Risks to public water supplies from reduced water availability
Maintain a watching brief	• Risks to aquifers and agricultural land from sea level rise, saltwater intrusion

Our main climate-related risks

Understanding climate risk
Providing water and wastewater services involves many risks related to climate change. Understanding and assessing these involves concepts that apply in risk management more widely, including:

- Hazards - events or trends that may cause loss of life, injury, health impacts or damage. These can be gradual (stresses) or more sudden (shocks), and those related to climate change include drought, heatwaves, intense rainfall and sea level rise
- Exposure - the presence of things in places that could be adversely affected by hazards
- Likelihood - the probability of a hazard occurring within a particular time period
- Consequence - the severity of the impact if the hazard should occur.

Together, these give a picture of the sensitivity or vulnerability or organisations like ours to both general changes that we expect to see or very specific issues. More information is given in appendix 5.

Our climate risk assessments
We carry out climate risk assessments at various levels, as described in the following pages. In each case we consider the likelihood and consequence of various exposures to hazards. For likelihood we consider the probability of impacts occurring over different timescales - certain effects of climate change might be unlikely in the next few years but likely in the long term. For consequence or severity we use the various aspects in our corporate risk assessment system, including health and safety, public health, customer service, environmental impacts, reputation, legal and regulatory issues and financial or commercial consequences.

Overall, we plan using the best available evidence and our current view of the best responses, incorporating good quality information from outside our company as well as the accumulated knowledge of our own staff. However, we also acknowledge that climate change projections and responses involve uncertainties, including:

- the future return period of extreme weather events such as multi-season droughts, which are highly unpredictable
- future emissions, concentrations of greenhouse gases in the atmosphere and the pace of climatic changes
- the specific influence of climate change for issues such as flooding and water demand where there are many factors involved
- the costs and benefits of adaptation options and the suitability of the measures we choose
- the potential appearance of some entirely new issues.

High-level assessment
This year, we reviewed our broader, higher level assessment using the 2012 HR Wallingford / UKWIR climate risk assessment tool produced for the UK water sector. The following tables show the hazards in its inventory that we judge in our 2021 assessment as posing medium to high risk i.e., those scoring 12 or more out of 25. The risk scores shown are based on our position without *additional* risk reduction measures i.e., beyond those already in place or planned.

Of the significant climate-related risks shown in the tables, it is clear that heat, drought and heavy rain are each important, and that each poses difficulties for both water supply and wastewater activities. Also, it is generally the case that the services we provide are more sensitive to extreme events, rather than gradual increases to average temperatures – although the latter increases the likelihood of the former.

Climate change impacts and risk scores (out of 25): water supply

Change / hazard	Effects on assets & services		Risk score 2015	Risk score 2021
Higher temperatures	Quantity	Increased daily and peak demand leading to larger volumes requiring treatment & storage	**12**	**20**
	Quantity	Increased seasonal demand and risk of reduced or removed abstraction licences	**9**	**16**
	Quality	Discolouration and taste issues, increasing complaints / compliance risk	**20**	**20**
	Quality	More microbiological growth (algae, microorganisms), increasing treatment requirements	**20**	**15**
	Quality	Accelerated chlorine depletion leading to increased compliance risk	**9**	**15**
Drought	Quantity	Shorter groundwater recharge periods, leading to reduced yields in the summer	**9**	**20**
	Quantity	Lower reservoir yields, affecting security of supply	**8**	**16**
	Quantity	Increased demand increasing volumes needing treatment	**12**	**15**
	Quantity	Political pressure for prioritising essential water use, affecting security of supply	**16**	**16**
	Quantity	Lower groundwater yields / low river flows / changing habitat conditions, resulting in reduced or removed abstraction licences	**16**	**16**
	Quality	With more storms alongside, reducing raw water quality, increasing drinking water quality risk	**20**	**16**
	Quality	Deposition of sediment in raw water, which is remobilised after heavy rain	**4**	**12**
More intense / prolonged rainfall	Quality	Turbidity affecting quality of surface water or raw water quality of groundwater	**20**	**15**
	Quality	Runoff causing increased levels of sediment and suspended solids	**20**	**15**
	Quality	Soil erosion leading to siltation in reservoirs and lower raw water quality	**9**	**12**
	Quality	Increased risk of cryptosporidium affecting drinking water quality	**20**	**12**
Cold wave	Quantity	Extreme freeze thaw events leading to increased leakage and pipe bursts	**16**	**12**
Combinations	Quantity	Drought / heatwave increasing demand leading to increased treated volume requirement	**12**	**20**

Climate change impacts and risk scores (out of 25): sewerage, sewage treatment & sludge

Change / hazard	Effects on assets & services		Risk score 2015	Risk score 2021
Higher temperatures	Sewerage	Increased septicity in sewerage, leading to corrosion, increased toxicity, odour complaints	**9**	**12**
	Treatment	Increasing odour and pest risks at water recycling centres and sludge sites, affecting local people	**16**	**20**
	Treatment	Increased seasonal demand (including from tourism), increasing volumes needing treatment	**12**	**15**
	Treatment	Increased odour complaints linked to water recycling centres	**16**	**12**
Drought	Sewerage	Low flows in sewers leading to sedimentation, increasing the risk of blockages leading to customer flooding; hydrogen sulphide and subsequent deterioration of sewerage assets; pollution incidents	**6**	**16**
	Sewerage	Lower flows in sewers leading to blockages, resulting in property flooding	**12**	**16**
	Sewerage & treatment	Settlement / sedimentation in sewers, leading to subsequent shock loads following rainfall, affecting treatment processes	**16**	**16**
	Treatment	Lower flows, leading to longer retention times in settlement tanks, resulting in increased septicity and odour problems	**16**	**15**
	Other	Lower river flows resulting in less dilution of effluent and increased risk of consent failure	**12**	**12**
More intense / prolonged rainfall	Sewerage	Increased storm water volumes overwhelming combined sewers and sewerage pumps, leading to flooding and more spills affecting watercourses	**20**	**20**
	Sewerage	Heavy rain and sewer blockages caused by customers' sewer misuse, leading to spills and / or sewer flooding	**12**	**20**
	Sewerage	More infiltration of groundwater into sewers, increasing flood risk	**20**	**20**
	Sewerage & treatment	Heavy rain leading to more spills affecting bathing waters	**20**	**16**
	Sewerage	Increased volumes to be pumped, accelerating asset deterioration and increasing power use	**15**	**12**
	Sewerage	Flooding of sewerage assets leading to potential failures	**12**	**12**
	Sludge	Increased risk of spoiling sludge stockpiles		**15**

All services

Change / hazard	Effects on assets & services		Risk score 2015	Risk score 2021
Higher temperatures / drought	Quantity	Increased demand (including from tourism), increasing volumes needing treatment and storage requirements	**12**	**16**
More intense / prolonged rainfall	Other	Flooding of sites, leading to equipment outages, elevated safety risk	**20**	**12**
	Other	Increased public expectation for hard defences to prevent site flooding	**16**	**8**
	Other	Flooding and inundation affecting transport routes/access to assets	**16**	**10**
	Other	Asset flooding leading to submersion of electrical assets	**8**	**12**
	Other	Storm events affecting power supplies and damage to assets at sites	**20**	**12**

Risks to customers, communities and the environment
Our understanding of risk has a dual focus. Firstly, we must understand how hazards can affect the reliability and quality of the services we provide to the people we serve. Secondly, we know that climate change will place greater stress on the wider environment, e.g. rivers and streams suffering more often during very warm or dry weather conditions. This in turn will likely lead to greater pressure on our activities e.g. reduced abstraction, or tighter end-of-pipe standards at water recycling centres.

Regarding **water quantity**, our high-level risk assessment summarised above picks out how long-lasting drought and acute heatwaves would both affect demand. Droughts also reduce overall yields from groundwater and reservoirs, and lead to pressure to reduce abstraction to protect the freshwater environment due to the risk oof low river flows. Much more detailed climate risk assessments are carried out for our Water Resources Management Plans, for which climate change scenario are an integral part. The current edition was published in August 2019 and two climate change sections are included here, verbatim, in appendix 6. The first relates to available water supplies, where we consider the impact of changing rainfall, evaporation and temperature patterns and the impact that these may have on river flows, reservoirs, groundwater recharge and ultimately on deployable output. The second section relates to impacts on water demand.

Regarding water supplies, we carry out a vulnerability assessment to determine more detailed analysis that is needed, followed by calculations of river flows and deployable output. The main conclusions include the following:

- the impact of the median impact climate change scenario on deployable output was low for both the dry year annual average and dry year critical period scenarios.
- The baseline impact of climate change in the 2080s is estimated at -3.69 Ml/d on average (1% of base year deployable output) and +1.07 Ml/d for the peak scenario (0.2% of base year deployable output).
- By 2045, the increase in overall consumption resulting from climate change amounts to 1.7 Ml/d representing a very small proportion of overall distribution input (c. 0.5%).
- We are supporting research projects to improve our modelling of the relationship between weather and demand. Such models may be driven with climate forecast changes to weather conditions in the future, leading to revised predictions of climate change impacts on demand.

Climate-related risks for **water quality** come in the form of extreme wet conditions as well as warm or dry. Warmer summers are likely to bring reductions in quality due to biological activity. Our experience also shows that heavy rainfall – both in prolonged episodes or short, sharp spells – can result in contaminants being washed into reservoirs or groundwater sources. Past episodes have given rise to high levels of nitrates, as noted earlier in relation to extremely wet autumn and winter conditions.

Regarding **sewerage, sewage treatment and sludge**, the highest risks relate to inundation of sewers during intense or prolonged rainfall, with adverse impacts on customers and receiving watercourses. Others include odour during warm weather; reduced dilution in receiving waters during drought; and sedimentation in sewers, also due to drought. Because of these risks, climate change impact assessments are increasingly used in wastewater investment planning, such as the drainage and wastewater management plans Overall, with a changing climate and an increase in impermeable areas connected to the sewer system, we need to make sure that our pipes have sufficient capacity to cope.

More information is provided in appendix 5.

Our actions to adapt to climate change

Responding to climate-related risk
Resilience is our ability to maintain continuity of high quality, reliable and secure services for our customers and to protect the natural environment in the face of disruptive challenges, and ensure the long-term viability of those services against a backdrop of strategic change and the changing external environment. It depends on critical natural resources, our assets and systems and fundamentally on our people and their skills and expertise in planning, developing, operating and maintaining the resources, assets and systems on which those services depend.

Whenever we identify a risk to the services we provide and our business more widely, we aim to manage it to an acceptable level. For climate-related risks there is a range of options include building physical assets or improving systems; managing water supply and river catchments; improving co-operation with other organisations; and encouraging helpful behaviour among users of our services. The table below. which draws on *Keeping the Country Running: Natural Hazards and Infrastructure* (Cabinet Office, 2011) provides examples.

The pages that follow and appendix 5 give more details of our work that is relevant to climate adaptation or resilience. It should be noted that climate change risk is not an explicit driver for the large majority of these activities; typically, other reasons are given by our regulators and other stakeholders for each area of investment. However, much of what we do increases the resilience of our services and the environment in which we operate, and can therefore be described as climate change adaptation by default.

Approach	Examples
Redundancy: backup installations or spare capacity that enable operations to be modified in the event of disruptions	• Maintaining water supply-demand surpluses • Ensuring that communities have back-up water sources • Adding storage in sewers and at water recycling centres • Reciprocal arrangements with neighbouring water companies • Allowance for outages, standby units for critical plant
Resistance: preventing damage or disruption, by providing strength or protection to resist a hazard or its primary impact	• Flood defences • Changing land use to cope with weather extremes • Ensuring design standards are appropriate
Reliability: infrastructure that can operate under a range of conditions, limiting damage or loss from an event	• Routine maintenance • Refurbishment / replacement of assets
Recovery / response: fast and effective response to, and recovery from, disruptive events.	• Early warning systems, telemetry, real-time monitoring • Emergency planning, business continuity

Water supply - quantity

Established ways of working

- Drought plans that set out how we manage water resources during extended periods of dry weather
- 25-year Water Resources Management Plans, incorporating climate change scenarios in their assessment of available water sources and customer demand, which in turn informs our business plans for future investment
- Maintaining a stable risk profile for dams and impounding reservoirs
- Reactive mains repair or replacement, such as bursts caused by ground movement from severe cold weather (freeze thaw cycle) or long hot summers (ground shrinkage).
- Reducing leakage through a range of techniques for detection, pinpointing and rapid repair.
- Encouragement of efficient use of water through promoting metering and other measures amongst customers.

Further work and delivery during 2015-20

- We updated our drought plan in 2017
- We published our updated Water Resources Management Plan in 2019, including the latest available climate change scenarios
- Completion of our integrated water supply grid which reduced the number of customers reliant on a single source; allowed us to accommodate abstraction licence reductions required by the Environment Agency to improve flows in some rivers and protect their ecology; and enables use of surplus water in the event of outages (such as those caused by the Beast from the East).
- Reduced leakage and supply interruptions through a combination of mains replacements and smarter network operation.

Planned actions and delivery for 2020-2030

- Continuation of established activities to protect and manage water sources and treatment facilities
- Updating our Water Resources Management plan in 2024
- With the West Country Water Resources Group, to develop a regional plan with a long-term vision of water resilience and investigate strategic regional resource options to enhance supplies across companies.
- Keeping track of emerging monitoring technologies improve, allowing more rapid analysis of water quality, as well as real time monitoring of water volumes in the distribution network.
- Adopting new and innovative technologies to enhance the operation of our network to deliver excellent service to our customers
- Continued engagement with customers to deliver our water efficiency targets
- Our long-term plan is to have zero interruptions of more than three hours. We will continue to replace older mains which, in the long term, will reduce the number of bursts and therefore the likelihood of supply interruption events. Prioritisation of water mains bursts will take into account the various potential drivers such as interruptions, leakage, mains bursts and water quality.

Water supply - quality

Established ways of working

- Online water quality monitoring and regular sampling of the water we supply means that sources can be taken offline if a risk to water quality is identified
- Catchment management: working with land users to reduce contamination of raw water sources by fertiliser and pesticides. This can increase the resilience of our sources in the face of more extreme rainfall events and limits further deterioration in raw water quality. This approach is also more sustainable and by improving the natural resilience of the ecosystem it provides increased resilience at least cost.
- Continuous monitoring of water quality, allowing sources to be taken offline in the event of a failed sample or a material threat
- Switching sources or blending water from different nearby sources in the event of shorter-lived problems
- Source to tap risk assessments and Drinking Water Safety Plans as the main route for prioritising investment to maintain drinking water quality

Further work and delivery during 2015-20

- We extended catchment management methods to protect water sources at eight sites in relation to nitrates and two sites in relation to pesticides; and started for a further eight water sources (six for nitrates and two for metaldehyde), while leading wider efforts in the Poole Harbour catchment.
- We reconfigured Durleigh water treatment centre to deal with deteriorating water quality, where various upstream issues were causing problems for a range of quality parameters in the reservoir.
- We carried out water quality improvements at a range of sites to ensure they are resilient and available at all times.
- The integrated supply grid enables alternative water supplies to be delivered to areas that are currently supplied by sources at risk of breaching the nitrate limit, reducing the need for additional treatment

Planned actions and delivery for 2020-2030

- Further action against rising nitrates and pesticides in the raw water at our sources
- Reducing contacts about water colour / appearance: we will continue to replace mains in areas that give rise to elevated numbers of contacts.
- A dedicated team for identifying and prioritising appropriate interventions to reduce customer contacts
- We track progress against our water quality related performance commitments; Water quality compliance, Events Risk Index, Water quality in the home and workplace, and lead communication service pipes replaced

Sewerage

Established ways of working

- Emergency tankering and over-pumping during intense and prolonged rainfall events, to protect properties from flooding internally.
- Reducing infiltration of groundwater into private drains and public sewers, e.g. by lining sewers
- Maintaining sewer capacity and condition through inspections, jetting, tree root cutting, relining, and raising public awareness about what can cause blockages in sewers, 89% of which are caused by sewer misuse
- Installing spill monitors at storm overflows (SOs) - which act as relief valves for the sewerage network during times of heavy rain - to better understand the frequency of their operation
- Investing proactively in sewerage capacity where cost-beneficial, including schemes that improve capacity across the region
- Separating surface water from combined systems to create space in the combined sewer and reduces overflow volumes
- Close work with the lead local flood authorities and the Environment Agency, e.g. sharing asset data and hydraulic models to assist in the development of surface water management plans and infiltration reduction plans.

Further work and delivery during 2015-20

- We invested in improvements at coastal sites where there is a link between SOs and coastal water quality.
- We continued to look for sustainable solutions using integrated urban drainage management, sustainable urban drainage systems and active system control.
- 200 new models built and circa. 420,000 model runs assessing the impact of growth, urban creep and climate change on the risks of flooding and pollution
- Circa. 400 pumping station and overflow surveys and 3,000 manhole surveys completed
- Circa. 170 storm overflow investigations progressing
- We maintained a stable level of total flooding risk, including external area flooding
- We addressed smaller non-specific investment needs as they materialised during the period

Planned actions and delivery for 2020-2030

- Publication of our Drainage and Wastewater Management Plan including:
  - modelling climate change impacts on rainfall, and options to maintain current levels of service or remove problems.
  - categorising catchments by performance, assessing ~200 catchments.
  - considering sustainable and traditional solutions to deliver resilient drainage and wastewater infrastructure
  - working with stakeholders to develop partnership schemes to deliver integrated flood risk management
- Improvements at 13 frequent spilling overflows during 2025-30 as well as additional flow and spill monitoring, with more improvements in 2025-2030
- A multi-track programme of customer engagement, jetting of sewers, additional monitoring and analytics to reduce the number of pollution incidents.
- Meeting performance commitments regarding sewer flooding incidents, sewer collapses and population at risk of sewer flooding in a storm.

Sewage treatment

Established ways of working and actions

- Detailed odour management plans, enabling operational improvements and good housekeeping
- Monitor the performance of our odour control plants and carry out maintenance and improvement work as and when required.
- Upgrading treatment processes to maintain capacity and meet environmental quality standards, increasing the resilience of the watercourses into which treated effluent is discharged.
- Continuous maintenance to ensure compliance with discharge permits

Further work and delivery during 2015-20

- We developed catchment permitting for phosphorus reductions as a method of more flexible management of water recycling
- We made improvements to river and bathing water quality, including through transferring flows from smaller water recycling centres for treatment at larger sites
- We achieved a fall in the number of odour complaints related to our wastewater assets

Planned actions and delivery for 2020-2030

- Flood protection at one of our major water recycling centres Providing additional capacity across water recycling centres that are overloaded, or aligning with enhancement schemes where flow and permit limits are being tightened
- Enhancements at water recycling centres including removal of a further c.300 tonnes of phosphorus per year by 2025 - through sewage treatment improvements and, catchment interventions
- Delivering the Water Industry Strategic Environment Requirements, including 100% compliance with environmental permit conditions

Sludge management

Established ways of working and actions

- Forecasting sludge production and the need for additional capacity.
- Managing sewage sludge - including stockpiles on farmland - so as not to cause pollution to land, surface water or groundwater
- Offsite storage of biosolids, prior to delivery to landbank locations

Further work and delivery during 2015-20

- We constructed two barns for winter storage of sludge cake to mitigate against slumping of stockpiles during wet weather.
- We carried out major maintenance and upgrades of anaerobic digesters at two sites to provide additional capacity and resilience

Planned actions and delivery for 2020-2030

- Major maintenance and upgrades of anaerobic digesters at one site to provide additional capacity and resilience.
- Upgrading our Bioresource Centres to ensure compliance with the Industrial Emissions Directive.
- Reviewing implications arising from changes to sludge quantity and make-up as a result of new or additional phosphorus removal from sewage effluent.
- Reviewing implications, and making improvements and wholesale changes as appropriate, on sludge treatment and disposal given forecast reduction in availability of landbanks for nutrient-rich sludge.

Flooding of sites, coastal squeeze

Established ways of working and actions

- Reviewing flood risks at our operational sites
- Improvements at specific sites that are at a higher risk of flooding e.g. installation of bunding; flap valves; alarms; drainage improvements; replacing above-ground pump motors with dry well submersibles; raising electrical equipment above possible flood levels.
- Assessing risk in relation to assets or sites in the areas covered by shoreline management plans

Further work and delivery during 2015-20

- Ensuring all new (critical) electrical plant and equipment is above the 1 in 200-year flood plain level.
- We continued monitoring the vulnerability of sites to flooding
- We reviewed the impact of shoreline management plans on our sites.

Planned actions and delivery for 2020-2030

- Ongoing monitoring of medium to long term flood risk, with appropriate action to be taken at sites where risks have become unacceptable.
- Building a perimeter flood wall / bund around Portbury Wharf water recycling centre (in 2022), where the current sea bank is at increasing risk of overtopping during spring high tides, exacerbated by climate change
- Ongoing review of sites covered by shoreline management plans

Wider environmental work

Established ways of working and actions pre-2015

- Biodiversity Action Plan aims to contribute to regional and national initiatives and projects for biodiversity delivery to include building resilience to, mitigation and adaptation to adverse anthropological impacts on biodiversity including climate change
- Hosting or supporting catchment partnerships, which oversee projects that deliver a range of benefits and increase environmental resilience

Further work and delivery during 2015-20

- We pioneered market-based methods for environmental delivery, e.g. EnTrade
- We introduced Water Guardians – training local volunteers to monitor watercourses, identify possible pollution incidents and report them to us for further investigation

Planned actions and delivery for 2020-2030

- Promotion of outcomes-based environmental regulation
- Expansion of market-based approaches to environmental improvements and promotion of nature-based solutions
- Supporting four projects through our Biodiversity Action Plan Partners Programme during 2020-2025
- A range of measures to achieve net zero operation emissions.

Business continuity (applicable to all services), support services, and Wessex Water employees

Established ways of working and actions

- Ensuring that we can respond to unforeseen, acute situations such as extreme weather events – as well as gradual stresses
- Business continuity arrangements and emergency planning procedures in each business areas
- Following Cabinet Office good practice guidance for integrated emergency management, with three response levels: operational, tactical, strategic
- Active participation in responses to incidents involving multiple agencies, where our involvement is required and contributes to external debriefing
- Using weather forecast and weather warnings from the Met Office, enabling advance planning for coming weather e.g. ensuring additional resources are available; rearranging non-essential planned works
- Adverse Weather Continuity Plans - reviewing our overall preparedness, ensuring appropriate stocks of rock salt and grit, 4x4 vehicles.
- Back electricity generators: 114 for water supply sites, 251 for wastewater sites.

Further work and delivery during 2015-20

- We continued review and updating of business continuity arrangements
- We strengthened our working relationships with local resilience forums
- Response to the 'Beast from the East': allocated additional resources to manage the expected increase in workload; proactive communication with customer through social media on preparation in the home for freezing weather
- We developed an Emergency Tactical Planning Group with leads from across the business, to respond to a range of emergency issues. By taking an integrated view it is able to address concurrent risks and cascading failures.
- We implemented staff risk assessments across the organisation for working in adverse weather

Planned actions and delivery for 2020-2030

- Regular review of business continuity arrangements developed by the various business areas

Public engagement

Established ways of working and actions	
• Promoting a range of water saving behaviours to customers through official communication channels (i.e., social media and customer magazine) and at public events • Home Check: technicians installing water saving devices and providing tailored advice in customer homes • Schools education service that informs pupils about water and wastewater issues through classroom sessions, assemblies and site visits • Localised community-based engagement projects to increase participation • Raising awareness about blockages and pollution incidents causes by wet wipes and cooking oil and fat in sewers	
Further work and delivery during 2015-20	***Planned actions for 2020-2030***
• We carried out over 20,000 Home Check visits in customer homes • We distributed free water saving devices packs to customer homes • We worked with schools and businesses to support water demand reductions • In 2019-20, we saved 3.3 Ml/d through water efficiency promotion • Our water citizenship project in Chippenham involved engagement with people and communities on the local water environment and multiple issues linked to the sustainability of the water system • We collected data when sewer blockages occurred to identify ‘hot spots’ where targeted customer engagement could be beneficial • We campaigned against misuse of sewers that causes blockages, and encouraged the correct disposal of wet wipes and fats, oils and grease.	• Enhancing our Home Check service to target households that use the most water and providing leaking toilet fixes • The launch of GetWaterFit – a digital water use calculator tool – to help customers understand their usage, compare it with other households like theirs, receive tailored behavioural nudges and order free water saving devices • Building our understanding of customer behaviours including a novel project looking into garden water use behaviours that will be used to shape future campaigns • Incorporating behavioural science into communications materials to encourage pro-environmental actions – including increasing the uptake of metering and reducing wet wipes • Increasingly targeted campaigns in sewer blockage hotspots including door-knocking to advise when an issue occurs, coupled with the launch of a new blockage reduction free pack of devices to encourage customers to think about what they flush and pour down the sink, plus engagement through letters and social media • Exploration of collaborative working with water retailers to drive non-household demand reductions • We aim to continue to meet demand without restrictions in the event of a drought that matches 1975-76.

Other considerations

The success of our adaptation work will be judged on our ability to continually meet the wide-ranging expectations of our diverse stakeholders, at the same time as the stresses and shocks of climate change taking effect. Consequently, planning for climate change is not an optional add-on but is embedded in our work, for example:

- it is an explicit part of our risk management framework
- it is integral to technical work such as water resource planning and sewer design standards
- we participate in UKWIR projects that incorporate UKCP18 projections and consider various potential impacts in depth
- we employ technical specialists who are able to translate climate risk into practice.

However, it is not simply a straightforward process by which evidence and modelling leads seamlessly to investment and other adaptation work. There are a range of technical, organisational, economic, and policy considerations that need to be taken into account.

Monitoring
It is important to monitor the gradual impacts of climate change and evaluate the success of our adaptation. For water supply, we review forecasts of source yields (include the effects of climate change) at least once every five years as part of the business plan and water resources management plan processes. For sewerage and sewage treatment, we review the performance of our assets during more extreme rainfall events and assess causes and possible alleviation of new flooding. We are also installing event duration monitors at storm overflows to record the frequency and duration of spill events; this in turn will help us to assess any deterioration in the performance of these assets.

Flexibility
Our adaptation plan and work are not fixed in perpetuity. Adaptation must be flexible as new data emerges or risk assessments change. This is partly enabled by the cyclical nature of some of our asset planning exercises which involve revisiting current climate change projections. Work to deal with flood risk also responds to recent weather events, local floods and the effectiveness of surface water management plans. We also look for opportunities to trial innovative approaches that might improve our resilience, and through initiatives such as Wessex Water Marketplace, to be open to a wider range of solution providers.

Interdependencies and multi-agency cooperation
It would not make sense for us to attempt to adapt to climate change in isolation. We are reliant on services provided by others and some issues involve shared responsibility with others who are affected by extreme weather or a changing climate. Examples include:

- surface water management, involving liaison with councils, Internal Drainage Boards and the Highways Agency and emergency response.
- the water sector's protocol for sharing resources and its mutual aid scheme through which companies co-operate during emergencies.
- customers, who have important roles to play in terms of using water wisely (especially during prolonged dry weather) and not causing blockages by flushing wet wipes or pouring way cooking oil and fat – and the media in helping us to raise awareness of these points
- community groups and individuals that are able to keep an eye on their local water environment and inform us of problems with water supplies or sewerage
- work with land users, especially for protecting drinking water sources that are vulnerable to a combination of farm inputs (e.g. nitrates and pesticides) and heavy rain.
- dialogue with government and our regulators in relation to both our day-to-day activities and longer-term planning.

- our own use of other utilities, in particular electricity and telecommunications. Their reliability is very important to us and interdependencies between utilities have been very evident during past extreme weather events. Information on power outages comes directly into our control room to ensure a managed response from the centre.

We have been doing more in recent years to ensure that we can cope with acute events, especially where there is a risk of cascading failures across a number of utilities or aspects of critical infrastructure.

Under the Civil Contingencies Act we are designated as category 2 responders, although we work closely with category 1 responder agencies via three local resilience forums (LRF). These provide a structure for agencies to work together on planning and in tactical and strategic response to incidents, using facilities such as dedicated teleconferencing to share information and warnings and agree external messaging.

Wessex Water sits on the LRFs' adverse weather groups, which cover plans for responding to events such as flooding and heatwaves.

Our work on interdependencies is developing further under the review of the critical national infrastructure that we rely on, linked to the Security and Emergency Measures Direction. This will be informed by our experience of COVID-19 and the appearance of concurrent disruptive events.

Thresholds

We use certain *weather events* such as the 1975-76 drought and 1 in 30-year storms as reference points or benchmarks for action or investment. However, we have not identified specific threshold points in the *climate* itself, such as average annual or seasonal temperature or rainfall above which particular impacts move up from one level of risk to another. Nevertheless, the water sector should in future consider the implications of the global or UK climate passing particular points and the effects of this on its activities.

Cost-benefit analysis

Cost benefit analysis is integral to the five-year business plans that we submit to Ofwat. We set out the costs that we estimate for delivering outputs and clearly explain the benefits that we expect to be gained as a result. The principal benefit provided by measures with an explicit climate change driver to date has been reduction of the risk of disruption from operational sites being flooded. The benefits of other 'complimentary adaptation' work mainly involve reduced disruption or nuisance to customers; maintaining operational flexibility (such as the number of water sources that we can use); limiting adverse impacts on the environment during drought or heavy rainfall, and generally maintaining our ability to provide expected standards of service in the face of more extreme weather events.

Barriers

The main barriers to climate change adaptation are financial, regulatory and technical. Examples include:

- the upfront cost of capital-intensive engineered measures;
- uncertainty and the limits of existing knowledge;
- delayed action due to complexity (particularly where agencies with varied funding arrangements and cycles are involved);
- insufficiently clarity over responsibilities where there is more than one potential lead organisation;
- potential unintended consequences of adaptation measures such as changes in movement of excess water.

These issues can be addressed in part by improved evidence or risk assessments that indicate the highest priorities for action funding and closer co-operation between interdependent organisations to identify cost savings and risk reduction measures. Changes in economic regulation of the water sector also offer the potential for a wider suite of measures to be pursued.

Regulation

Since 2011 there have been some changes in the water sector that are relevant to climate change adaptation. Firstly, the 2014 Water Act gave Ofwat and the Defra Secretary of State a duty to secure resilience of water supply and sewerage systems in the face of environmental pressures, population growth and changes in consumer behaviour. This provides policy context for thinking on, and investment for, climate change adaptation. Secondly, the 2014 periodic review of prices saw two notable developments. One was the emphasis on beneficial outcomes for customers and environment (one of which for Wessex Water is 'resilient services') as opposed to 'outputs' in the form of a list of activities to be undertaken by water companies. The other is the emphasis on 'totex' (total expenditure), with solutions chosen based on their wholelife cost. This was intended in part to equalise the incentives for less capital-intensive solutions (such as catchment management, sustainable urban drainage systems, or behavioural measures) and conventional investment in larger physical assets. The implication for work related to climate change adaptation is there will likely be more emphasis on 'flexible adaptation' and a more diverse blend of measures overall.

However, regulation in the water sector is not yet providing the space or incentives to choose solutions that deliver the biggest environmental benefit at the lowest societal costs. Indeed, investment tends to be dominated still by capital intensive methods focused on single issues. Meanwhile, uncertainties about the timing and extent of climate change impacts limits the regulatory appetite for investment except where the benefits of acting very clearly outweighs costs. Moreover, the prospect of investment to reduce the sectors carbon footprint while also adapting to climate impacts threatens to place upward pressure on bills, at a time when household budgets are stretched.

One potential way to address these challenges is to place even greater emphasis on outcomes, and we are advocates of an approach termed outcomes based environmental regulation (OBER). OBER involves setting outcomes-based targets that allow companies to choose solutions that deliver the biggest environmental benefits (across a range of dimensions) at the lowest costs. It therefore unlocks the inefficiency with the current approach to environmental regulation. OBER is a flexible approach that can first be introduced in the water sector to learn important lessons and could then be rolled out more widely. Successfully implementing OBER requires a number of conditions to be met such as a strong monitoring framework, enabling partnerships, listening and engaging with communities and creating appropriate incentives in the economic regulation of water companies

Climate change mitigation

By 2030, we aim to achieve net zero operational carbon emissions. These are our annual emissions linked to our energy use and transport, plus other greenhouse gases that are emitted from sewage and sludge treatment processes. However, our goal does not end there. We also aim to achieve net zero total carbon emissions by 2040 at the latest. This includes our operational emissions outlined above, plus emissions linked to construction materials, and consumables such as treatment chemicals.

Background reductions in the UKs carbon footprint, such as the growth in renewable energy generation, will mean that our energy and transport emissions will fall by around one third from our current position. We therefore need to take concerted action between now and 2030.

We will do this through a range of readily-available options including:

- emissions avoidance measures, such as reducing water use and leakage; increasing the use of lower carbon transport; and promoting nature-based solutions that avoid energy use
- optimisation measures, such as energy efficiency work and systems for monitoring and controlling nitrous oxide from sewage treatment
- renewable energy – increasing the amount of biogas that we generate from anaerobic digestion and pursuing opportunities for wind and solar power, either as generators or as the end-user.

However, reductions in background emissions and the most readily-available options will not be sufficient to achieve our goal of net zero carbon. We will need to pursue more innovative options involving emerging science and technology, such as turning sewage sludge into biochar, as well as promoting nature-based solutions. While these methods are not yet well-established, we are assessing their maturity and availability and will take part in trials where appropriate.

Overall, the entire transition to a low carbon economy presents opportunities and challenges to businesses such as ours, as it brings changes to policy, fiscal mechanisms, energy and fuel prices, regulation, technology and stakeholders' views. While we are a large energy user, we believe that we are well-positioned to perform well through this process.

Conclusions

Climate change is our biggest long-term environmental challenge.

Our work to adapt has evolved since our first adaptation report. Our largest investment scheme – the integrated supply grid – has already shown how it can help us maintain continuous service during extreme weather events such as the Beast from the East, as well as reinforcing our long-term resilience. We have carried out work at sites at risk of flooding to ensure that they can continue to operate during flood events. We are actively promoting ways to improve the resilience of the environment around us through nature-based solutions and catchment level interventions, rather than relying solely on hard-engineered methods. We have continued to build climate change considerations into our planning, including the use of UK Climate Projection scenarios in our water resource management plants, and will do similar in the development of our drainage and wastewater management plans.

As climate change adaptation is part of our overall sustainability, we will continue to:

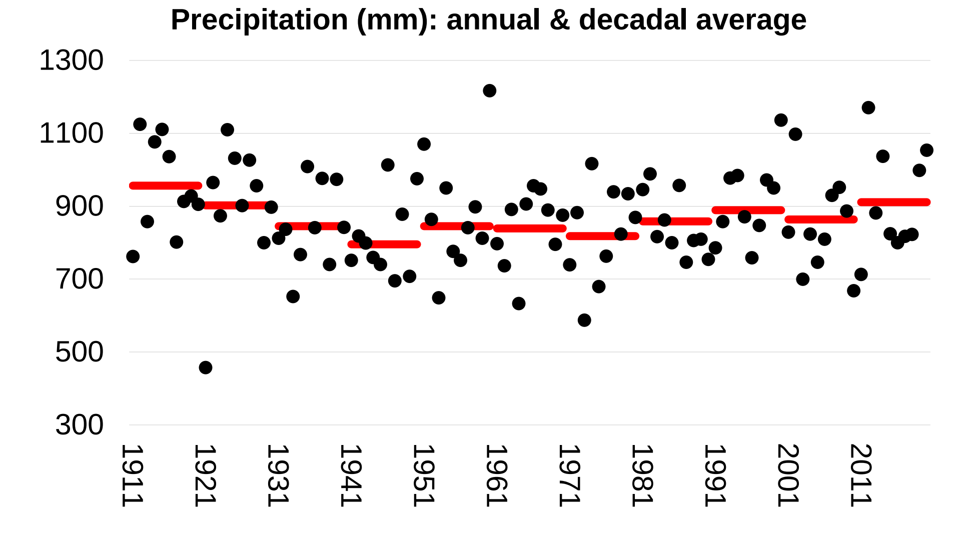
- improve our assessment of how climate change will affect the services we provide
- use this knowledge to prioritise investment and wider work to keep risks to an acceptable level
- use a range of measures including smart asset optimisation, nature-based solutions, partnership approaches, and behavioural interventions as well as conventional investment in physical assets
- integrate these efforts with our wider resilience work, including connections with other infrastructure operators
- communicate progress outside the formal requirements of the adaptation reporting power, under which this report has been produced.

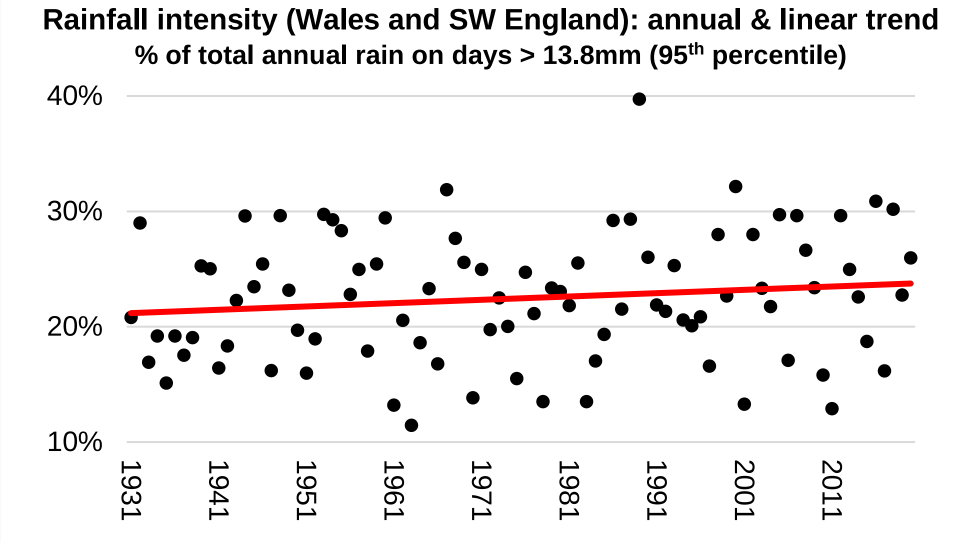
PART 2 SUPPORTING INFORMATION

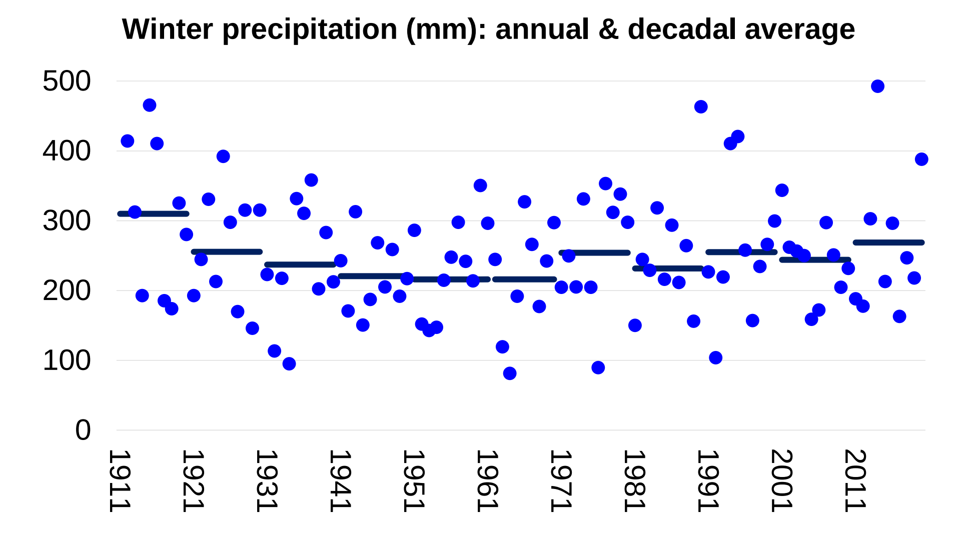
Appendix 1	Historical precipitation
Appendix 2	UK climate projections
Appendix 3	UK climate risk assessment
Appendix 4	Our approach to resilience
Appendix 5	Responding to climate change risks
Appendix 6	Water resources management planning and the impacts of climate change
Appendix 7	Other considerations (additional information)
Appendix 8	UKWIR climate change adaptation projects
Appendix 9	Related information

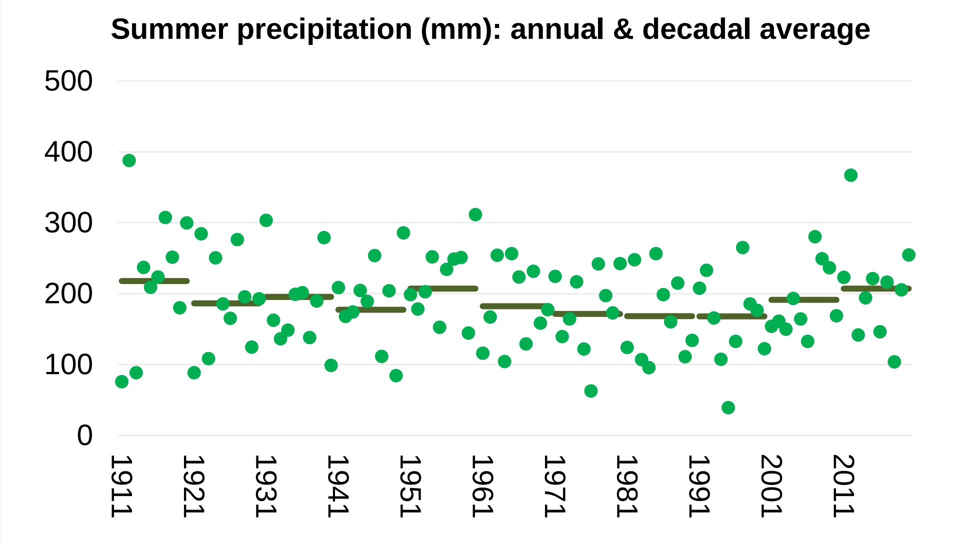
Appendix 1: Historical precipitation

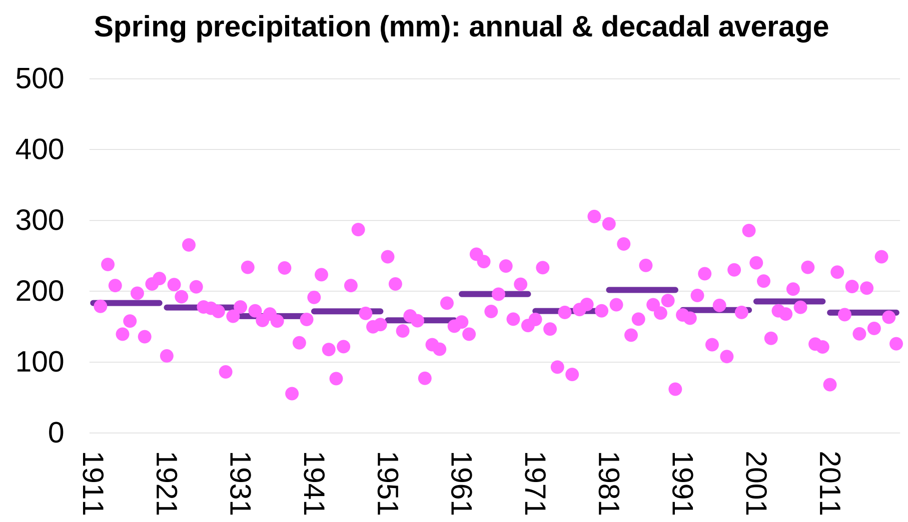
The following charts show historical precipitation from rain gauges spread across our region that are maintained by the Environment Agency.

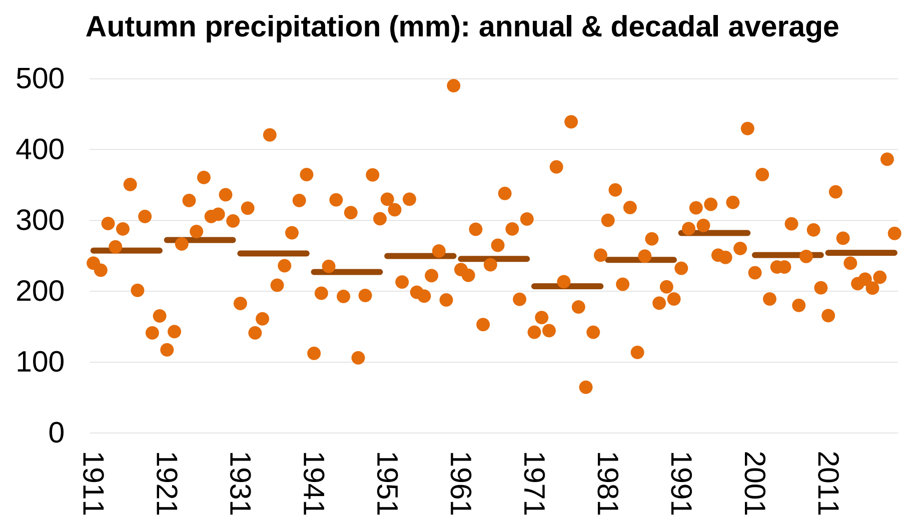









Spring precipitation (mm): annual & decadal average
500
400
300
200
100
0
1911
1921
1931
1941
1951
1961
1971
1981
1991
2001
2011


Autumn precipitation (mm): annual & decadal average
500
400
300
200
100
0
1911
1921
1931
1941
1951
1961
1971
1981
1991
2001
2011

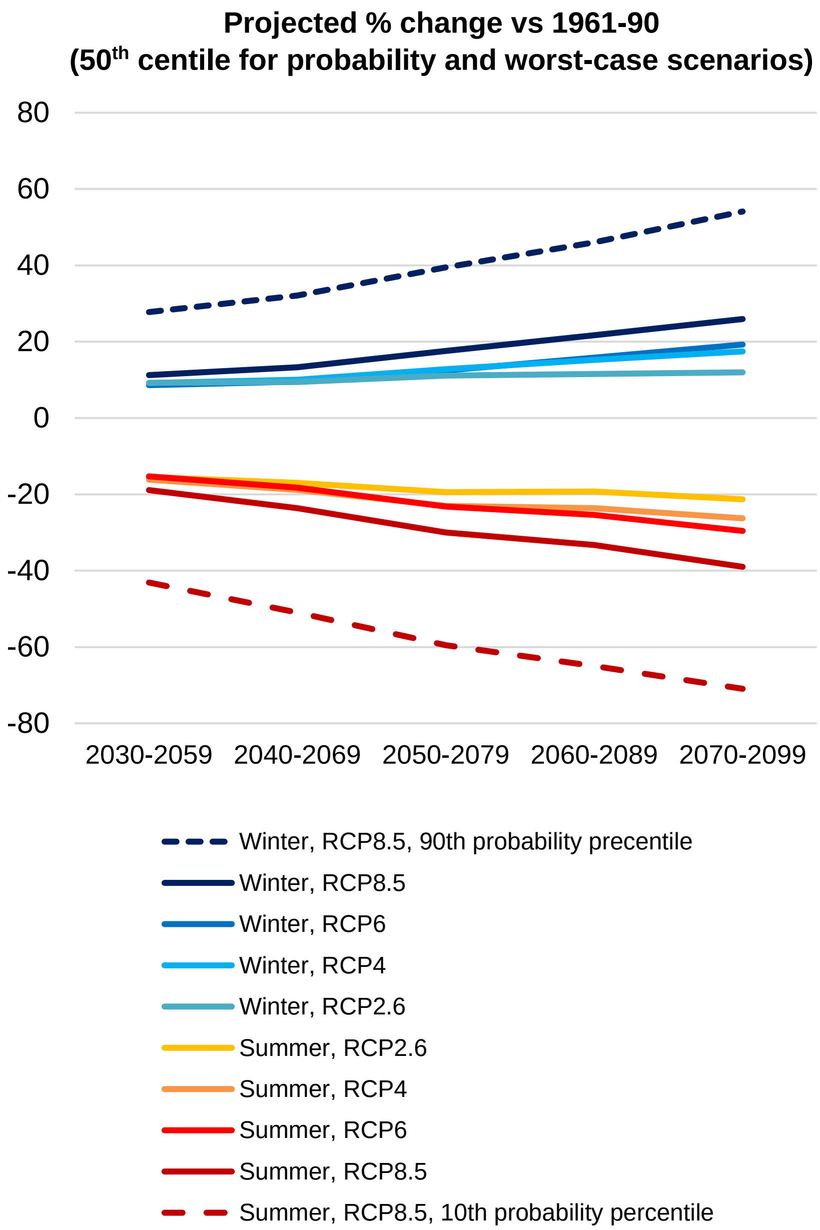
Appendix 2: Climate projections and forecasts

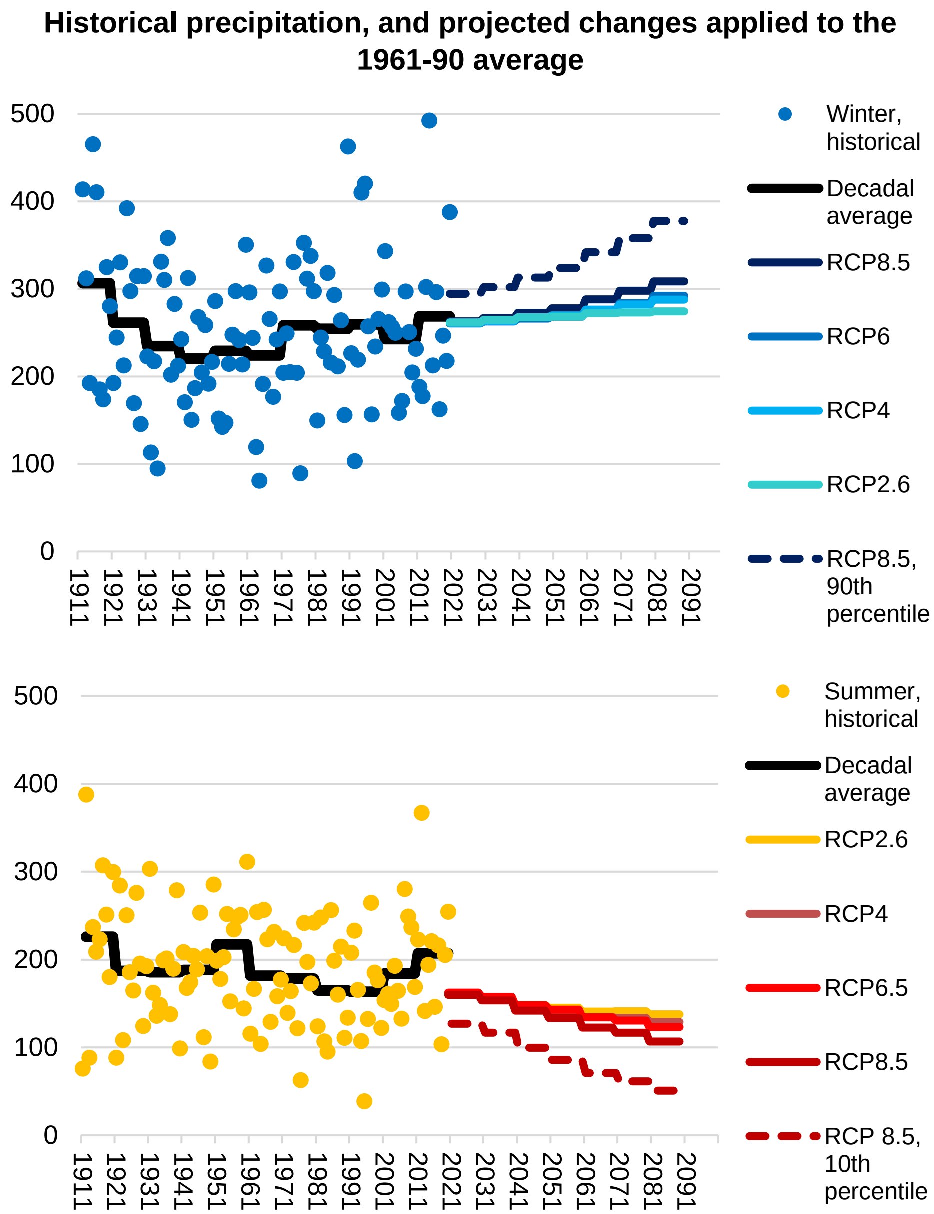
UKCP18 projections for the Wessex Water region

Changes to an average year in future decades (relative to 1961-1990), for four emissions scenarios

	50th percentile (the central estimate across all models)				**10th percentile** (10% probability that the outcome is less than the value shown)				**90th percentile** (90% probability that the outcome is less than the value shown)			
	RCP2.6	**RCP4**	**RCP6**	**RCP8.5**	**RCP2.6**	**RCP4**	**RCP6**	**RCP8.5**	**RCP2.5**	**RCP4**	**RCP6**	**RCP8.5**
Summer rain % change												
2020-2049	-11	-11	-10	-12	-30	-30	-29	-33	10	10	11	10
2030-2059	-15	-16	-15	-19	-36	-38	-37	-43	8	8	8	7
2040-2069	-17	-19	-18	-24	-39	-43	-42	-51	8	8	8	5
2050-2079	-19	-23	-23	-30	-43	-49	-49	-60	8	6	6	2
2060-2089	-19	-24	-25	-33	-43	-51	-53	-65	9	5	5	1
2070-2099	-21	-26	-30	-39	-46	-54	-58	-71	6	3	2	-3
Winter rain % change												
2020-2049	8	8	7	9	-3	-4	-4	-3	21	21	20	23
2030-2059	9	9	9	11	-3	-4	-4	-3	24	24	22	28
2040-2069	9	10	10	13	-4	-5	-4	-3	25	26	25	32
2050-2079	11	13	12	18	-3	-4	-3	-2	28	31	30	39
2060-2089	12	15	16	22	-2	-2	-1	2	27	34	35	46
2070-2099	12	17	19	26	-2	-1	0	0	29	38	41	54
Summer temperature												
2020-2049	1.7	1.4	1.3	1.7	0.8	0.4	0.3	0.6	2.8	2.4	2.3	2.8
2030-2059	1.9	1.7	1.6	2.2	0.8	0.5	0.4	0.8	3.1	3.0	2.8	3.6
2040-2069	2.0	2.1	2.0	2.8	0.7	0.6	0.5	1.0	3.5	3.7	3.6	4.7
2050-2079	2.1	2.5	2.6	3.6	0.6	0.8	0.7	1.4	3.7	4.5	4.5	6.0
2060-2089	2.2	2.9	3.2	4.4	0.4	0.8	0.8	1.6	4.0	5.2	5.6	7.4
2070-2099	2.3	3.5	4.0	5.4	0.6	1.2	1.4	2.3	4.2	5.9	6.7	8.7

The figure shown is the average for the 25km grid squares in the Wessex Water region

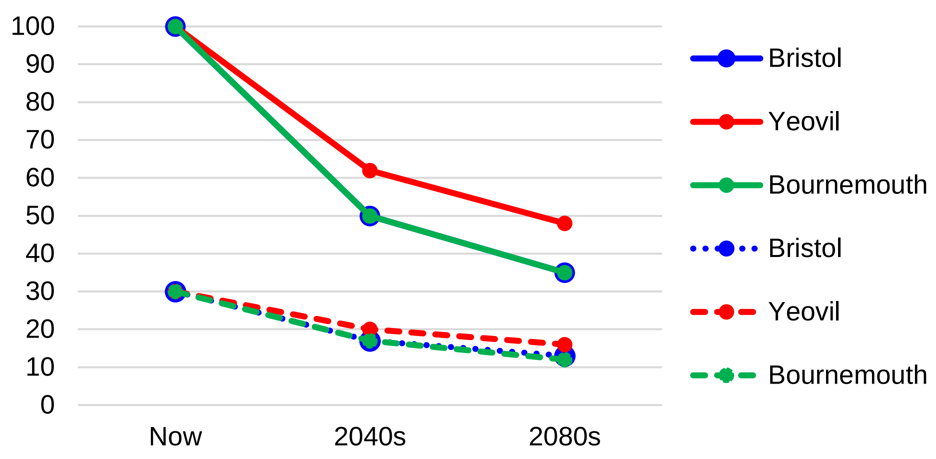

Projected % change vs 1961-90
(50th centile for probability and worst-case scenarios)
80
60
40
20
0
-20
-40
-60
-80
2030-2059
2040-2069
2050-2079
2060-2089
2070-2099
Winter, RCP8.5, 90th probability precentile
Winter, RCP8.5
Winter, RCP6
Winter, RCP4
Winter, RCP2.6
Summer, RCP2.6
Summer, RCP4
Summer, RCP6
Summer, RCP8.5
Summer, RCP8.5, 10th probability percentile


Historical precipitation, and projected changes applied to the 1961-90 average
500
400
300
200
100
0
1911
1921
1931
1941
1951
1961
1971
1981
1991
2001
2011
2021
2031
2041
2051
2061
2071
2081
2091
Winter, historical
Decadal average
RCP8.5
RCP6
RCP4
RCP2.6
RCP8.5, 90th percentile
Summer, historical
Decadal average
RCP2.6
RCP4
RCP6.5
RCP8.5
RCP 8.5, 10th percentile

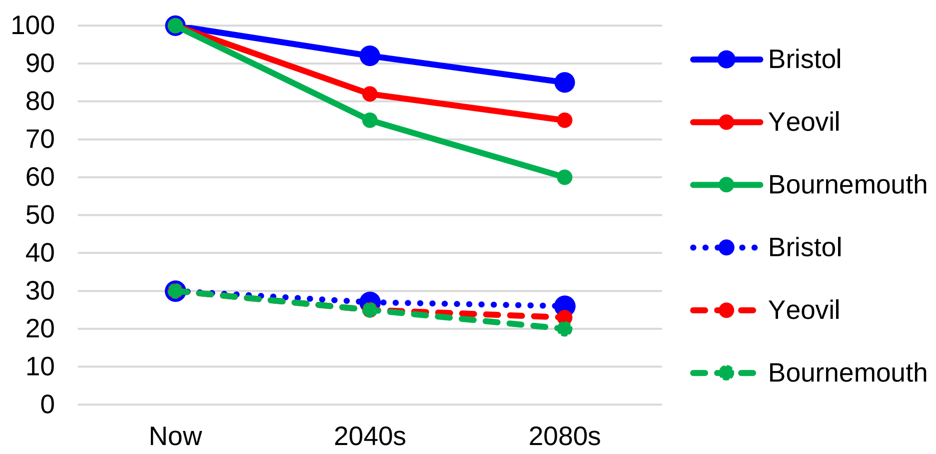
Changing occurrence of major storms (Met Office for Ofwat, 2010)

	Storms of the intensity currently expected to occur once every…	by the 2040s, will be expected to occur once every…	and by the 2080s, will be expected to occur once every…
Winter storms			
Bristol	10 years	6 years	5 years
	30 years	17 years	13 years
	100 years	50 years	35 years
Yeovil	10 years	7 years	5 years
	30 years	20 years	16 years
	100 years	62 years	48 years
Bournemouth	10 years	7 years	5 years
	30 years	17 years	12 years
	100 years	50 years	35 years
Summer storms			
Bristol	10 years	9 years	8 years
	30 years	27 years	26 years
	100 years	92 years	85 years
Yeovil	10 years	9 years	8 years
	30 years	25 years	23 years
	100 years	82 years	75 years
Bournemouth	10 years	8 years	7 years
	30 years	25 years	20 years
	100 years	75 years	60 years

Winter storms (Y axis = return period in years)



Summer storms (Y axis = return period in years)



Source: Met Office (2010) Changes in the frequency of extreme rainfall events for selected towns and cities (report for Ofwat)

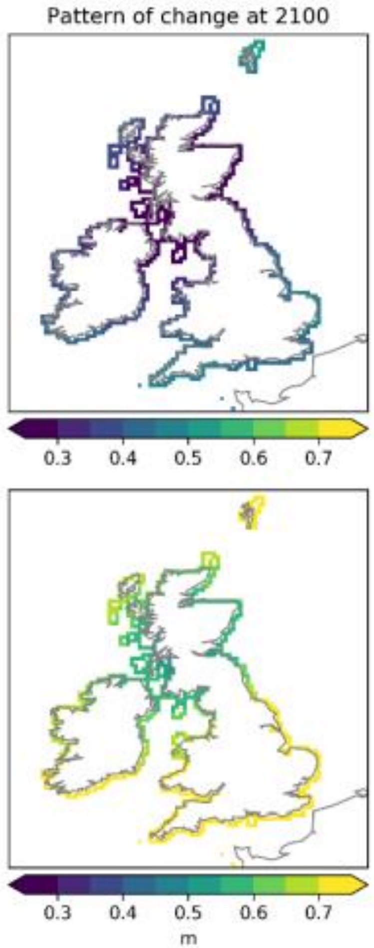
Coastal impacts

UKCP18 Key Findings

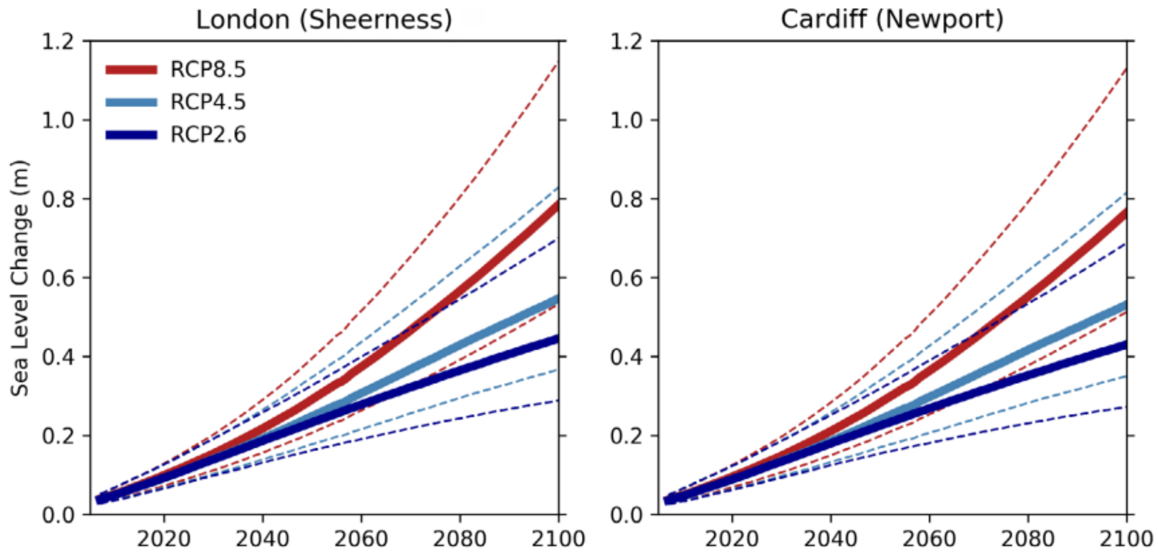
UK coastal flood risk is expected to increase over the 21st century and beyond under all climate change scenarios. Mean sea level (MSL) rise is the dominant factor and varies by location and climate change scenario. Storm surge and wave changes are up to ~10% of the MSL signal, but larger changes cannot be ruled out. Future ice loss from Antarctica remains a major uncertainty, particularly for post-2100 time horizons

Sea level change (m) at 2100 relative to 1981-2000 average (5th and 9th probability percentile)

	London		Cardiff	
	5th	**95th**	**5th**	**95th**
RCP2.6	0.29	0.7	0.27	0.69
RCP4.5	0.37	0.83	0.35	0.81
RCP8.5	0.53	1.15	0.51	1.13



Projected ranges of sea level rise relative to a baseline period of 1981-2000



Source: Palmer et al (2018), UKCP18 Marine report

Appendix 3. UK Climate Risk Assessment and National Adaptation Programme

The Government's first two assessment of the risks and opportunities for the UK of the current and predicted impact of climate change were published in 2012 and 2017. They drew primarily on an independent Evidence Report commissioned by the UK and the Devolved Governments from the Climate Change Committee's Adaptation Sub-Committee.

The 2017 Evidence Report sets out six urgent priorities for action:

Figure 2: The Adaptation Sub-Committee's assessment of the top six areas of inter-related climate change risks for the UK

Individual risks and opportunities identified in the Adaptation Sub-Committee's evidence reports inform the Government's subsequent formal risk assessments. The table below shows those highlighted in the 2017 and 2021 evidence reports which are most relevant to our activities, and the following table summarises our position for each and links to more detailed information.

	2017 evidence report	2021 evidence report
In1: Risks of cascading infrastructure failures across interdependent networks	More action needed	More action needed
In2: Risks to infrastructure from river, surface/groundwater flooding	More action needed	More action needed
In3: Risks to infrastructure from coastal flooding & erosion	More action needed	Further investigation
In4: Risks of sewer flooding due to heavy rainfall	More action needed	
In5: Risks to bridges and pipelines from high river flows / erosion	Research priority	
In8: Subsidence risks to buried / surface infrastructure	Watching brief	Further investigation
In9: Risks to public water supplies from drought and low river flows	More action needed	Sustain current action
In 14: Benefits for infrastructure from reduced extreme cold events	Sustain current action	
PB13: Risks to health from poor water quality	Sustain current action	Further investigation
PB14: Risk of household water supply interruptions	Sustain current action	Further investigation
Bu1: Risks to business sites from flooding	More action needed	
Bu3: Risks to business operations from water scarcity	Sustain current action	
Ne6: Risks to agriculture & wildlife from water scarcity & flooding	More action needed	
Ne11: Saltwater intrusion risks to aquifers, farmland & habitats	Sustain current action	Maintain a watching brief

Legend	Natural environment and natural assets	Infrastructure	People and the built environment	Business and industry

Wessex Water: examples of response to the 2017 UK Climate Change Risk Assessment (most relevant individual risks and opportunities)

	Likelihood of risk	Impact on service	Risk under-standing	Controls (examples)	Actions (examples)	Metrics/ reporting (examples)	Further information in this report
MORE ACTION NEEDED							
Ne6: Risks to agriculture & wildlife from water scarcity & flooding	H	M	H	• Drought planning • Water resource planning to address long term change • Dialogue with regulators on abstraction	• Abstraction reduction at sensitive sites • Integrated supply grid to allow transfers within the region	• Water supply restrictions	Appendix 5: water resources; wider environment; Appendix 6
In1: Risks of cascading failures from interdependent infrastructure networks	H	M	M	• Following Cabinet Office good practice guidance for integrated emergency management • Emergency Tactical Planning Group • Incident management procedures • Involvement in Local resilience forums • Back-up generators	• Continued review of business continuity arrangements • Emergency planning; emergency simulation exercises	• Water supply interruptions	Appendix 4: our approach to resilience Appendix 5: Business continuity and cascading failures
In2: Risks to infrastructure services from river, surface water and groundwater flooding	H	M	H	• Adapting maintenance plans • Water supplies: ability to rezone; blend water sources; move water via our integrated grid • Response and recovery plans • Site flood risk assessments; designation of sites needing defences / alterations • Monitoring of vulnerability of sites and assets	• Water supplies: rezoning; blending; transfers via our integrated grid • Investments in bunding, flap valves, alarms and drainage improvements at high-risk sites • Moving electrical equipment above flood levels	• Various resilience metrics	Appendix 5: flooding of operational sites and assets

	Likelihood of risk	Impact on service	Risk under-standing	Controls (examples)	Actions (examples)	Metrics/ reporting (examples)	Further information in this report
In3: Risks to infrastructure services from coastal flooding and erosion	L	M	H	• See In2 • Assessed as low likelihood for our sites	• See In2	See In2	Appendix 5: flooding of operational sites and assets
In4: Risks of sewer and surface water flooding due to heavy rainfall	H	H	H	• Drainage and wastewater management plans • Infiltration reduction plans • Modelling sewer catchments • Topographic mapping; rainfall modelling. • Monitoring networks and overflows • Work with lead local flood authorities on surface water management • Promoting sustainable drainage methods • Property level protection	• Sewer sealing to reduce groundwater infiltration • Sewer maintenance e.g. jetting • Improvements at individual storm overflows (SOs) • Behavioural engagement to reduce sewer blockages • Sewer separation where possible and effective	• Internal flooding per 10,000 connected properties • External flooding per 10,000 connected properties • Properties at risk of sewer flooding • Sewer flood risk score	Appendix 5 Sewerage and surface water management
In9: Risks to public water supplies from drought and low river flows	L	M	H	• Water resource planning to address long term change • Drought planning • Dialogue with regulators on abstraction	• Publication of plans, following detailed analysis of risk and stakeholder engagement • Promotion of water efficiency	• Compliance with abstraction licences • Water restrictions • Avoided water use from water efficiency measures	Appendix 5 Water supply - quantity
Bu1: Risks to business sites from - flooding	H	M	H	• See In2	• See In2	See In2	Appendix 5: flooding of operational sites and assets

	Likelihood of risk	Impact on service	Risk under-standing	Controls (examples)	Actions (examples)	Metrics/ reporting (examples)	Further information in this report
RESEARCH PRIORITY							
In5: Risks to bridges and pipelines from high river flows and bank erosion	L	M	M	• Water supply rezoning	• Watching brief	• Water supply interruptions	Appendix 5: flooding of operational sites and assets
SUSTAIN CURRENT ACTION							
Ne11: Saltwater intrusion risks to aquifers, farmland & habitats	L	L	H	• Our water sources do not include coastal aquifers at risk of saline intrusion	• Not applicable	• Not applicable	Appendix 5 Water supply - quality
In14: Potential benefits to water, transport, digital and energy infrastructure from reduced frequency of extreme cold events	M	L	M	• Levels of benefit not assessed • Extreme weather business continuity arrangements • Response to future cold wave events informed by learning points from the 2018 ‘Beast from the East’	• No action linked to reduced frequency	• Water supply interruptions	
PB13: Risks to health from poor water quality	L	H	H	• Continuous monitoring of water supplied from our sources • Source to tap risk assessments; water safety plans • Investment in infrastructure and systems to limit the number of customers reliant on a single source	• Rezoning in the event of failing samples • Catchment management to protect drinking water sources • Blending water supplies when required • Additional treatment where necessary to keep risk to a satisfactory level	• Water quality compliance; Events Risk Index; water quality customer contacts	Appendix 5 Water supply - quality

	Likelihood of risk	Impact on service	Risk under-standing	Controls (examples)	Actions (examples)	Metrics/ reporting (examples)	Further information in this report
PB14: Risk of household water supply interruptions	M	M	M	• Network monitoring, leakage detection • Intra-regional water movements via the integrated supply grid during extreme weather event • Water resource planning to address long term change	• Replacement of older water mains • Completion of integrated supply grid	• Water supply interruptions • Leaks repaired within 24 hours	Appendix 5 Water supply - quantity
Bu3: Risks to business operations from water scarcity	L	M	H	• Water resource planning to address long term change • Drought planning • Networks management to maintain resilience • Dialogue with regulators on abstraction	• Publication of plans, following detailed analysis of risk and stakeholder engagement • Promotion of water efficiency	• Compliance with abstraction licences • Water restrictions • Avoided water use from water efficiency measures	Appendix 5 Water supply - quantity
WATCHING BRIEF							
In8: Risks to subterranean and surface infrastructure from subsidence	L	L	L	• Proactive network monitoring inspections • Reactive responses	• Reactive maintenance in the event of sewer collapses	• Sewer collapses per 1,000km	Appendix 5 Water supply – quantity; sewerage

2018 National Adaptation Programme
The National Adaptation Programme sets out the actions that government and others will take to adapt to the challenges of climate change in the UK. The following are key points related to our activities.

Water abstraction
- The government's abstraction plan sets out how it will improve the way it manages water abstraction, to protect the environment and improve access to water. The plan has three main elements:
  - addressing unsustainable abstraction: the EA will change abstraction licences to protect the environment where there is the greatest impact
  - stronger catchment focus: bringing together the EA, abstractors and catchment groups to develop local solutions to existing pressures and to prepare for the future
  - modernisation: making sure all significant abstraction is regulated and bringing regulations in line with other environmental permitting regimes; improving the online service provided to abstractors to reduce administrative burdens and provide real-time information about the availability of water for abstraction

Water resource management plans (WRMP)
- In 2016 Defra strengthened the WRMP guidance to water companies to reflect the need for greater resilience as a result of the changing climate and growing population.
- This new guidance requires companies to take a longer-term strategic approach to protecting and enhancing resilient water supplies, covering a minimum period of 25 years. The extension of time frames obliges companies to consider more thoroughly what actions they need to take in the short term to minimise risks to water supply in the long term.
- Companies are expected to properly examine the value of resilience with their customers and be more transparent about levels of service. This enables customers to understand and express their views on a potential trade-off between securing long term resilience to drought and potential water use bans, versus a potential increase in bills.

Drought
- Water companies have a statutory obligation to produce drought plans every five years which set out the short-term operational actions a company will take during a drought period to maintain supplies to customers. These plans are tested annually to ensure that they remain fit for purpose.
- As part of the WRMP process water companies are required to plan how they will work to increase resilience against drought and ensure security of supply.
- The Government is working with water companies to further improve the level of resilience against drought and will work with other sectors to understand their drought risks and how these can be mitigated.
- If a heatwave coincides with a drought there will be restrictions on how much (and potentially if any) water can be used to maintain green infrastructure.
- During drought, the priority will be maintaining the public water supply for public health and critical national infrastructure.

Twin track approach – strengthening the resilience of supply whilst reducing demand

- The Government wants water companies to develop and implement robust long-term plans that use this ‘twin track’ approach to improve the resilience of water supplies when faced with a changing climate.
- It emphasises ambitious initiatives to reduce demand for water, and bold strategic decisions to secure new water supplies, such as new reservoirs and water transfers.

Drainage and wastewater management plans (DWMPs)

- Water UK’s 21st Century Drainage Programme is driving work to improve long term planning of drainage and wastewater services with the development of a number of tools, including DWMPs.
- DWMPs will
  - help provide a more consistent basis for planning across the sector, enabling companies to target investment on drainage and wastewater more effectively and provide customers with better information about these services.
  - help water companies manage their assets over the long-term and ensure that they are resilient to climate change.
  - contribute to improving surface water management, as part of a mix of solutions to meet current and future water management needs.

Water quality

- Natural England will implement Site Improvement Plans (SIPs), including actions arising from the climate change theme plan developed for Natura 2000 sites.
- Work to restore natural processes within river systems, enhancing water storage capacity to buffer against drought and provide semi-natural habitat with a valuable role to play in increasing resilience of wildlife to a changing climate.
- The EA will continue working with external partners (particularly catchment partnerships) to ensure that third cycle RBMPs take account of pressures from long term climate change, and try to ensure that projects delivered in second cycle plans are also resilient to long term climate change.
- Work with industry in the agricultural sector to encourage the use of low-emissions fertiliser. Smarter targeting of fertiliser type and application will reduce the potential for negative impact on water quality and air quality.

The Climate Change Committee's 2021 evidence report on climate change risk

The 2021 Advice Report is the Adaptation Committee's statutory advice to Governments on priorities for the forthcoming national adaptation plans and wider action. The headline points include the following:

- The gap between the level of risk we face and the level of adaptation underway has widened. Adaptation action has failed to keep pace with the worsening reality of climate risk.
- The UK has the capacity and the resources to respond effectively to these risks, but it has not yet done so. Acting now will be cheaper than waiting to deal with the consequences. Government must lead that action.
- The Committee identifies eight risk areas that require the most urgent attention in the next two years.

1. Risks to the viability and diversity of terrestrial and freshwater habitats and species from multiple hazards.
2. Risks to soil health from increased flooding and drought
3. Risks to natural carbon stores and sequestration from multiple hazards, leading to increased emissions
4. Risks to crops, livestock and commercial trees from multiple climate hazards
5. Risks to supply of food, goods and vital services due to climate-related collapse of supply chains and distribution networks
6. Risks to people and the economy from climate-related failure of the power system
7. Risks to human health, wellbeing and productivity from increased exposure to heat in homes and other buildings
8. Multiple risks to the UK from climate change impacts overseas

- These have been selected on the basis of the urgency of additional action, the gap in UK adaptation planning, the opportunity to integrate adaptation into forthcoming policy commitments and the need to avoid locking in poor planning, especially as we recover from the COVID-19 pandemic.

The Committee also reports on the full set of 61 risks and opportunities and ten principles for good adaptation planning to be considered and / or incorporated in the next set of National Adaptation Plans, due from 2023.

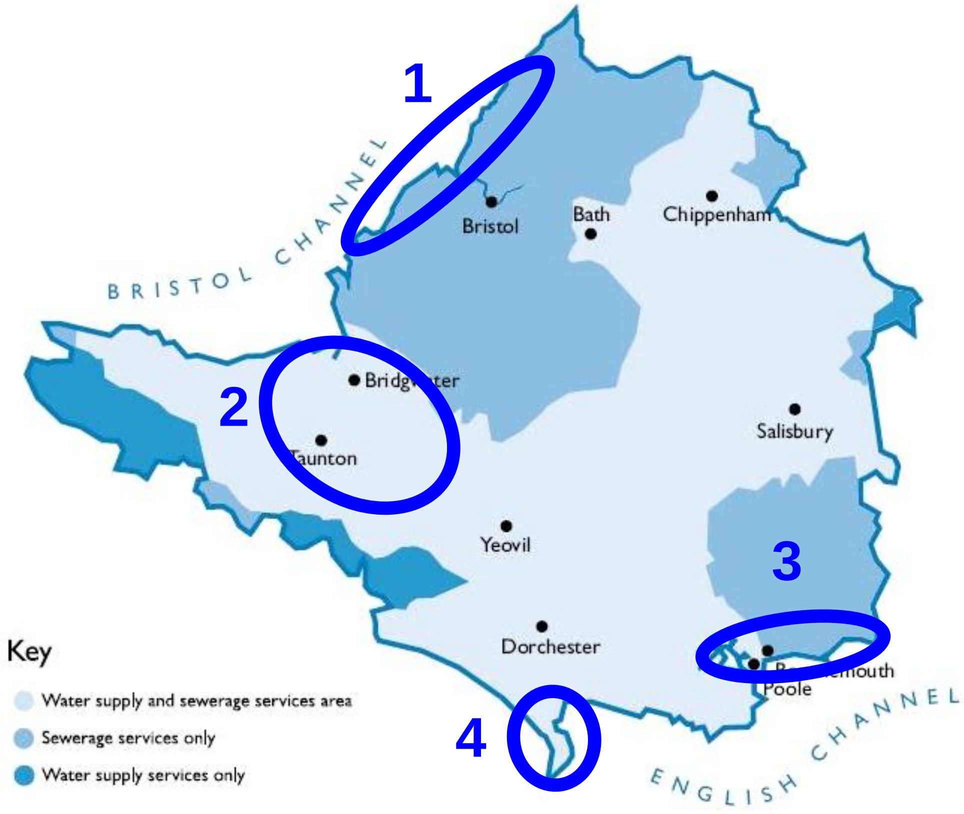
The 2021 evidence report provides a set of key messages for the water sector:

- Water infrastructure, such as reservoirs, dams, pipelines, water treatment and recycling centres plants and sewage treatment plants, are all at risk from the impacts of climate change, especially increases in the frequency and intensity of surface water and coastal flooding.
- Water infrastructure assets represent a key element of the UK infrastructure system and could affect, or be affected by, failures of other assets due to extreme weather, such as energy systems, transport and information and communications technology (ICT)
- There are also risks to buried infrastructure, such as water pipelines, with damage potentially becoming more frequent in future due to flooding and subsidence.

- More frequent flooding could also impact on water treatment facilities leading to potential reductions in water quality, in turn impacting upon health.
- Future projections of more frequent and intense dry periods lead to concerns around the availability of public water supplies in future, especially in England and parts of Wales. Private water supplies are also at risk.
- Aquifers near the coast could be at greater risk from saltwater intrusion due to sea level rise, though the risk is thought to be low in places where aquifers are important water sources.

Additionally, low summer river flows and increases in river water temperature, leading to algal blooms and habitat degradation, is assigned a high-risk rating for 2080.

South West Regional Flood Risk Appraisal (2007): regionally significant flood risk areas



	Groundwater	Fluvial	Tidal	Coastal
1		▪	▪	▪
2			▪	▪
3	▪	▪	▪	▪
4			▪	▪

Appendix 4: Our approach to resilience

Our business plan 'For you, for life' recognises the important responsibility we have in providing essential public services to customers and in managing the natural environment, both now and for future generations. Our activities are fundamental to the health and well-being of our communities, environment and economy. As such, maintaining and strengthening our resilience is critical to ensuring we can continue to deliver high-quality and reliable services to customers and enhance the environment, particularly in the face of acute shocks and chronic stresses.

Our understanding of resilience aligns with Ofwat's 'Resilience in the Round' – our resilience relies on the resilience of our corporate, financial and operational systems, and understanding the interdependencies between our internal and external systems. We recognise that our resilience affects our ability to maintain high-quality and reliable services for our customers, protect the natural environment and ensure the long-term viability of our services.

Maintaining and strengthening our resilience is critical to ensuring we can continue to deliver reliable and trustworthy services to customers and support the long-term prosperity of our society and environment, particularly against a landscape of on-going change coupled with strategic pressures. To be truly resilient and fit for the future, we recognise we must take a long-term view in our plans and procedures, with an aim to anticipate likely changes and actively respond or adapt as they occur.

It has been over 40 years since we had a hosepipe ban and we are recognised for our industry-leading resilient services and environmental stewardship. In the last few years, we have had to deal with various shocks and stresses, including the 'Beast from the East' in 2018, the dry summer that followed, and storms in early 2020. Also in 2020 we were able to react quickly and change our working practices to mitigate the impacts of Covid-19 during one of the driest periods on record. We met all of these challenges with no loss of supply to our customers. Despite our track record of performance, recent experiences have shown that more extreme shocks and stresses appear to be occurring more frequently. We must both learn from our and others' experiences and continue to improve our integrated resilience framework.

Our approach

We are developing a system-based resilience framework with the aim of embedding resilience thinking into our business and ensuring a line of sight from risk to our package of outcomes. Our systems-based resilience framework will help us to evaluate the resilience of our activities through a robust, evidence-based framework to inform our decision making. The framework builds on our existing resilience activities and risk management approach, as well as water industry and international best practice, including:

- Ofwat's latest guidance on resilience, including PR19 Final Methodology and 'Resilience in the Round'
- UK Water Industry Research (UKWIR) Good Practice Guide on Resilience Planning
- UKWIR Framework for Expenditure Decision Making
- Rockefeller Foundation, The Resilience Shift, Arup and SIWI, City Water Resilience Approach
- Arup City Resilience Index
- Cabinet Office guidance on Critical Infrastructure Resilience
- British Standard for Organisational Resilience
- University of Cambridge Centre for Risk Studies taxonomy of threats

Our resilience Action Plan outlines our approach to risk-management and how we will develop and embed a systems-based approach to resilience and an integrated resilience framework, into our existing risk management procedures. The plan has been approved by our Audit &

Risk Committee on behalf of the Board and audited by Mott MacDonald.

The key elements of this framework are as follows.

1. **Risk to resilience**

It is important that our systems-based resilience framework complements our current risk management approach and is integrated into existing processes. Horizon scanning is in place to support the identification of emerging shocks and stresses, ensuring that we are always responding and planning for the most informed and relevant list of shocks and stresses. Our existing risk management process manages risk at three levels – strategic, tactical and operational levels. To complement this, we have developed resilience assessments at three levels:

- ***Strategic***: We have categorised our business activities into 16 individual corporate, financial and operational systems. A resilience maturity assessment has been undertaken on these systems and quantitative resilience metrics are being developed to understand our baseline resilience and identify opportunities for improvement at a strategic level.

- ***Tactical***: Our Water Resource Management Plan (WRMP) and Drainage and Wastewater Management Plan (DWMP) will allow us to manage and respond to shocks and stresses (e.g. population growth, extreme weather events) at an asset portfolio level.

- ***Operational***: We will use interdependency mapping to highlight and prioritise low likelihood, high impact risks against which improvement may be required at an asset level.

Our approach aligns with Ofwat's concept of 'Resilience in the Round' and considers the resilience of our operational, corporate and financial systems. Our resilience approach will allow us to focus our effort on the areas where improvement is needed to maintain or strengthen our resilience.

2. **Planned mitigations**

We have a hierarchy of interventions to systematically encourage the development of mitigations which (1) tolerate the risk, (2) improve operations, (3) collaborate with stakeholders and customers to address the root causes (4) optimise existing assets using new technologies or (5) build smarter solutions (TOCOB).

To inform the optimisation of mitigations, we propose to evaluate the mitigations using the five qualities of resilience (5Rs) as well as a capitals-based service measures framework (SMF), which we have developed to capture the risk to service and value of investing to our customers, environment and operations.

3. **Package of outcomes**

Our integrated risk and resilience management approach and the optimisation of mitigations through the 5Rs and a capitals-based SMF will ensure that our investment decisions can deliver against our Performance Commitments and resilience metrics. We have incorporated a review process to evaluate the outcomes delivered by our mitigations after implementation. Any learning will feed back into our risk and resilience assessments and the development of mitigations.

4. **Corporate Governance Framework**

Our Framework will be incorporated into our governance by expanding our risk management process to cover resilience – ensuring an aligned approach between these closely related activities. Our Board is ultimately responsible for our risk and the Audit & Risk Committee of Non-Executive Directors is responsible for the review and challenge to our assurance arrangements. The Director of Risk & Investment manages our systems-based resilience framework with two committees: Risk Management Group who manage the overall risk and resilience process; and the Investment Solutions Group who review and approve mitigations to ensure we continue to improve our resilience.

Appendix 5: Responding to climate change risks for water and wastewater

Overview
We aim to reduce climate-related risks across our services to an acceptable level, such that we can continue to provide expected levels of service as the climate changes over time.

This appendix explains the various ways in which we do this for each of the main aspects of our work.

We have a major programme of investment in our physical assets and systems, helping us accommodate changing volumes of water and sewage as well as changing customer expectations and regulatory requirements regarding quality. However, climate change is not an always an explicit driver for the large majority of this investment, at the level of individual schemes - other reasons given by our regulators and other stakeholders are typically the primary justification for our work.

Nonetheless, climate change is recognised as part of the context for our investment, much of which will help us to be more resilient to the gradual stresses of a warming world and the shocks that come in the form of extreme weather events. As such, much of what we do could be described as 'climate change adaptation by default'. In our sector, increasing attention is being given to the concept of resilience.

It would not make sense for us to attempt to adapt to climate change in isolation. For example, a good proportion of our adaptation work for drainage requires collaboration and partnership working with Lead Local Flood Authorities, other Flood Risk Management Authorities and stakeholders (including catchment partnerships, infrastructure and utility providers). Similarly, our water resource planning involves extensive consultation with other interests and our business continuity work relies on close working with other service providers.

Over time, that pace and intensity of climate changes may become more or less clear, extreme weather events might highlight vulnerabilities of which we were previously not aware, and alternative adaptation methods might become available. For these reasons, our adaptation measures will themselves need to be flexible and able to change.

Water supply and the water environment - quantity

UK Climate Change Risk Assessment 2017	**MORE ACTION NEEDED**	Ne6: Risks to agriculture & wildlife from water scarcity & flooding
		In9: Risks to public water supplies from drought and low river flows
	SUSTAIN CURRENT ACTION	PB14: Risk of household water supply interruptions
		Bu3: Risks to business operations from water scarcity

Challenges
Within our service region we are experiencing above-average population growth, which during higher temperatures in the summer months can lead to an increased daily and peak demand and larger volumes of water requiring treatment and storage. Dry conditions can present a range of local implications from the impacts of abstraction where droughts lead to shorter groundwater recharge periods, resulting in reduced yields. Consequently, we face the potential need to reduce water abstraction licences in order to protect river ecology, at the same time as meeting demand. Combined with changing weather patterns due to climate change, maintaining a positive supply-demand balance will be challenging.

	Summary of our main risks	2021 Risk score
Higher temperatures	Increased daily and peak demand leading to larger volumes requiring treatment & storage	**20**
	Increased seasonal demand and risk of reduced or removed abstraction licences	**16**
Drought	Shorter groundwater recharge periods, leading to reduced yields in the summer	**20**
	Lower reservoir yields, affecting security of supply	**16**
	Increased demand increasing volumes needing treatment	**15**
	Political pressure for prioritising essential water use, affecting security of supply	**16**
	Lower groundwater yields / low river flows / changing habitat conditions, resulting in reduced or removed abstraction licences	**16**
Cold wave	Extreme freeze thaw events leading to increased leakage and pipe bursts	**12**
Combinations	Drought / heatwave increasing demand leading to increased treated volume requirement	**20**

Summary of action

Previous and ongoing work	Additional actions from 2020 onwards
Forward planning • Alternative or relocated sources if yields change • Altering existing assets to optimise use of resources • Our updated drought plan was published in 2017 • We published our updated Water Resources Management Plan in 2019 **Investment schemes and ongoing operations** • Completion of our integrated supply grid • Reduced leakage and supply interruptions through a combination of mains replacements and smarter network operation **Work with others** • Metering domestic properties, behavioural measures. • Carrying out Home Check visits in customer homes • Distribution of our free pack of water saving devices posted to customer homes • Work with schools and businesses to support water demand reductions in workplaces • Consultation on plans and studies	• Updating our Water Resources Management plan in 2024 • Developing a regional plan with a long-term vision of water resilience with the West Country Water Resources Group, and investigating strategic regional resource options to enhance supplies across companies. • Keeping track of emerging monitoring technologies improve, allowing more rapid analysis of water quality, as well as real time monitoring of water volumes in the distribution network. • Continued replacement of older mains to reduce the likelihood of supply interruption events. • Adopting new and innovative technologies to enhance the operation of our network to deliver excellent service to our customers • Continued engagement with customers to deliver our water efficiency targets. • Digital water use calculator tool • Building our understanding of customer behaviours • Meeting performance commitments for reducing leakage and supply interruptions
Risk mitigation benefits • Drought plan and historical water resources planning helped limit the impact of dry weather in the last ten years • In 2019-20, we saved 3.3 Ml/d through water efficiency promotion • Supply-demand balance surplus forecast to be maintained up to at least 2040 • Reduced disruptions to supply and reduced risk to quality from water mains	

Our overall diagnosis
The investments we have previously made in our strategic network infrastructure have created a resilient water supply system. Households and businesses in the Wessex Water region have enjoyed supplies without restriction for more than 40 years.

In our last published drought plan in 2017, we confirmed that our services are resilient to a repeat of any of the drought events experienced in the last 100 years without the need to require customers to restrict their use. Therefore, we would not expect to impose temporary use restrictions (hosepipe bans) on average more than once every 100 years or to impose non-essential use bans for commercial customers more than once in every 150 years on average.

We are currently developing a new Water Resources Management Plan, which indicates a number of pressures to the amount of water available to meet demand over the next 40 years, including climate change, population growth, and the need to give more water back to the environment, for example, to protect Chalk streams. We will continue to work with our customers and local communities so that together, we can reduce the water we take from the environment, improve the resilience of our services and support areas of the west country where water scarcity is a growing problem. We'll also continue to work with partners at a catchment level to help safeguard the resilience of the ecosystems that provide us with our raw water supplies

Water resource management planning
In our last published Water Resources Management Plan in 2019, we included the latest available climate change scenarios available at the time; see appendix 6 for a detailed account of how we integrate climate change scenarios into our water resource management plans.

We are committed to working with other members of the West Country Water Resources Group (WCWRG) to undertake regional water resource planning to identify solutions across company boundaries. During 2020-25 the WCWRG will develop a regional plan with a long-term vision of water resilience. The regional plan will then be used to inform our next WRMP, which will be published in 2024

Integrated grid
We completed the development a more integrated water supply grid in 2017/18, which allows us to deal with a number of water volume issues simultaneously:

- It has improved the security of supply to customers, allowing us to meet our customers' demand for water and providing full connectivity of demand and resources throughout our water supply area. Specifically, it means that the number of customers reliant on a single source has been reduced.
- It complements existing bulk supply agreements with neighbouring water companies.
- It allows us to accommodate abstraction licence reductions required by the Environment Agency to improve flows in some rivers and protect their ecology. The reductions required total 33.5 megalitres / day in daily abstraction licence limits across eight sources. It also helps us to substitute for smaller sources that have been abandoned due to cryptosporidium risk.
- It enables surplus water to be used in the event of outages. (such as those caused by the Beast from the East);

While the main drivers for this scheme were *not* directly related to climate change, it improves our resilience against the main climate change pressure categories outlined above. As a result, our supply network is better able to cope with extreme weather events.

Reducing leakage

Reducing leakage is an important part of our efforts to maintain a healthy surplus of available water supplies compared to demand, including during hot and dry weather conditions. We have halved leakage since 1994-95, and always met our leakage target despite severe weather and met our challenging leakage reduction target for the last five years 2015 to 2020. We are well on the way to meeting our target to reduce leakage by a further 15% by 2025. We are looking at a wide range of asset management and innovative technologies for reducing leakage from supply pipes.

There are a number of factors that influence mains repairs and replacement, such as the age and material of pipes. Extreme weather impacts can play a part in the number of bursts which can be caused by severe cold weather (the freeze thaw cycle causing ground movement). Through improved prioritisation of work and introduction of real-time control (using sensors in the water network) we plan to keep the mains replacement rate stable in the next five years and maintain the current level of unplanned interruptions.

We will continue to replace older mains which, in the long term, will reduce the number of bursts and therefore the likelihood of supply interruption events. Prioritisation of water mains bursts will take into account the various potential drivers such as interruptions, leakage, mains bursts and water quality. We are adopting new and innovative technologies to enhance the operation of our network to deliver excellent service to our customers and oour long-term plan is to have zero interruptions of more than three hours.

Managing demand

We will continue to manage water supply by continuing to reduce leakage (by 15% by 2025) and supporting customers to manage household demand by promoting metering and water efficiency through behavioural engagement.

Behavioural measures such as encouraging greater water efficiency will also be important for coping with extreme weather events. Our water efficiency strategy actively seeks to help customers use water wisely and avoid waste through a range of education, information and device measures, while showing the links between weather, climate, water resource availability and the environment. During 2015-20 we carried out over 20,000 Home Check visits in customer homes; we distributed free water saving devices packs to customer homes; and we worked with schools and businesses to support water demand reductions. Overall, between 2015-16 and 2019-20, we saved 3.3 Ml/d through water efficiency promotion

More recently, we have launched GetWaterFit – a digital water use calculator tool – to help customers understand their usage, compare it with other households like theirs, receive tailored behavioural nudges and order free water saving devices. We are also building our understanding of customer behaviours including a novel project looking into garden water use behaviours that will be used to shape future campaigns.

Beyond 2020, in addition to the above we are enhancing our Home Check service to target households that use the most water and providing leaking toilet fixes. We are also exploring collaborative working with water retailers to drive non-household demand reductions. Between 2020-21 and 2024-25 we are aiming to save 5.0 Ml/d.

Water supply - quality

UK Climate Change Risk Assessment 2017	**SUSTAIN CURRENT ACTION**	PB13: Risks to health from poor water quality
		Ne11: Saltwater intrusion risks to aquifers, farmland & habitats

Challenges
With the impacts of climate change resulting in a shift in weather patterns, water sources will be vulnerable to extreme rainfall which could increase contamination by sediment, pesticides and nutrients, leading to additional treatment requirements. This can happen by leaching into groundwater or runoff into reservoirs. Higher temperatures present the heightened risk of algal blooms, discolouration and taste issues, resulting in increased compliance challenges and customer complaints. Periods of dry weather followed by heavy rain events can result in reduced raw water quality, also requiring increased treatment to maintain excellent drinking water quality.

	Summary of our main risks	**Risk score 2021**
Higher temperatures	Discolouration and taste issues, increasing complaints / compliance risk	**20**
	More microbiological growth (algae, microorganisms), increasing treatment requirements	**15**
	Accelerated chlorine depletion leading to increased compliance risk	**15**
Drought	With more storms alongside, reducing raw water quality, increasing drinking water quality risk	**16**
	Deposition of sediment in raw water, which is remobilised after heavy rain	**12**
More intense / prolonged rainfall	Turbidity affecting quality of surface water or raw water quality of groundwater	**15**
	Runoff causing increased levels of sediment and suspended solids	**15**
	Soil erosion leading to siltation in reservoirs and lower raw water quality	**12**
	Increased risk of cryptosporidium affecting drinking water quality	**12**

Summary of action

Previous and ongoing work	Additional actions from 2020 onwards
Forward planning • Modelling flows and water quality, water safety plans • Water network service plan • Water Safety Plans are in place at all supply sites **Investment schemes and ongoing operations** • Completed the development of a more integrated water supply grid • Reservoir inspections and desilting • Continuous monitoring • Catchment management via a team of catchment advisors and local agreements for source protection • Reconfiguring Durleigh water treatment centre **Work with others** • Consultation on plans and studies • Catchment management to protect groundwater and watercourses • Presenting evidence, priorities, strategies and plan to policy makers, regulators and other interests	• Continuous development & maintenance of Water Safety Plans • Extending catchment management work for drinking water sources • Watching brief for new monitoring technologies • Reconfiguration of one surface water treatment centre • Further action against rising nitrates and pesticides in the raw water at our sources • We track progress against our water quality related performance commitments; Water quality compliance, Events Risk Index, Water quality customer contacts, tackling water quality in the home and workplace, and lead communication service pipes replaced.
Risk mitigation benefits • Water safety plans provide source-to-tap management system. • An auditable database of actions and risk scores; prioritising investment and operational interventions. • Catchment management contributes to maintaining compliance and deferring additional water treatment for nitrates and pesticides • Compliance maintained at >99.95%	

Water Safety Plans

Following their introduction in 2006, water safety plans are firmly embedded as a central tool for managing water supply risk. Our water safety plans comprise a detailed site-by-site risk assessment. For each supply system these cover the four stages from source to tap (catchment, treatment, distribution and customer); public health, compliance and serviceability; risk scoring of hazards and mitigation actions for each hazardous event. As a legal requirement we have a plan for every source and their routes to customers' taps. The resulting water safety plans are not static documents, as knowledge is constantly evolving about hazards and risks. Thus, we will continue to develop and maintain our water safety plans.

Catchment management
For the last ten years we have developed an active programme of catchment management. By working with land users, we can tackle problems at source to limit deterioration of raw water rather than removing contamination through additional treatment. This approach is considered to be viable where there are clear risks to drinking water quality and reasonable certainty of the timescales involved to address the problem. The rate of increase in nitrate levels has been slowed at a number of sources and metaldehyde risk has been greatly reduced at one of our surface reservoirs (ahead of a total ban on metaldehyde that comes into effect in March 2022). Catchment actions are likely able to help the resilience of our sources in the face of more extreme rainfall events and can limit further deterioration in raw water quality. However, the high nitrate levels seen as a result of the extremely wet conditions in 2012 and winter 2013-14 showed that catchment management does not eliminate risk altogether, nor the need for comprehensive treatment processes. Nonetheless, we are extending this approach to rivers and estuaries as well as drinking water sources, leading multi-agency collaborations in the Bristol Avon and Frome & Piddle / Poole Harbour catchments.

During 2015-20, we used catchment management methods to protect water sources at eight sites in relation to nitrates and two sites in relation to pesticides; and started for a further eight water sources (six for nitrates and two for metaldehyde), while leading wider efforts in the Poole Harbour catchment. This work has been extended through our pioneering work on market-based methods for environmental delivery, e.g. through our environmental trading platform, EnTrade. Post 2020, we are taking further action against rising nitrates and pesticides in the raw water at our sources, through catchment-based measures.

Monitoring sources
Our extensive sampling allows continuous monitoring of the quality of water supplied from our sources. This means that sources can be taken offline if needed in the event of a failed sample or a material threat to quality. In futures years we can expect to see monitoring technologies improve, allowing more rapid analysis of water quality, as well as real time monitoring of water volumes in the distribution network. We also have a dedicated team for identifying and prioritising appropriate interventions to reduce customer contacts related to water quality.

Integrated grid
In addition to the water quantity benefits offered by our new integrated water supply grid, it enables alternative water supplies to be delivered to areas that are currently supplied by sources at risk of breaching the nitrate limit in drinking water. Together with catchment management, this delays the need for construction of additional resource development, although this will be kept under review in the light of potential future reductions to the amount of what that we are permitted to abstract at certain sites.

Reservoir desilting
We intend to maintain a stable risk profile for our dams and impounding reservoirs, principally to ensure on-going compliance with the Reservoirs Act 1975. Sedimentation in reservoirs can eventually affect raw water quality, as can dredging or desilting work that can mobilise sediment into the water column. The main activity planned in the next five years is continuation of routine scouring, which involves opening a pipe at the base of a reservoir dam, resulting in the release of fast flowing water and sediment with it. We will also assess the sediment trapping ability of the inflow wetland area constructed at Durleigh Reservoir

Enhanced treatment

Our preferred course of action for tackling sub-standard raw water is not additional treatment. Instead, we aim to manage the issue at source if possible, for example through catchment management, which can have a significantly lower whole-life cost than additional treatment. Also, there is the option to switch sources or blend-in suitable water from nearby in the event of shorter-lived problems such as elevated nitrates caused by wet weather.

During 2015-20 we commenced a major rebuild of our Durleigh water treatment centre to deal with deteriorating water quality, where various upstream issues were causing problems for a range of quality parameters in the reservoir.

Sewerage and surface water management

UK Climate Change Risk Assessment 2017	**MORE ACTION NEEDED**	In4: Risks of sewer flooding due to heavy rainfall

Challenges
Heavy rain and storm events present a significant risk to sewerage and surface water management. Increased storm water volumes from heavy rainfall events can overwhelm combined sewers and sewerage pumps leading to flooding and / or spills from storm overflows, affecting watercourses and bathing waters. The issue of sewer blockages due to sewer misuse by customers remains an ongoing challenge and combined with more intense and prolonged rainfall events, it adds to the high risk of spills or sewer flooding. Additionally, there is a risk of flooding with more infiltration of groundwater into sewers following heavy rainfall. Prolonged periods of dry conditions can also present challenges such as sedimentation in sewers, which can affect treatment processes due to shock loads following rainfall.

	Summary of our main risks	Risk score 2021
Higher temperatures	Increased septicity in sewerage, leading to corrosion, increased toxicity, odour complaints	**12**
Drought	Low flows in sewers leading to sedimentation, increasing the risk of blockages leading to customer flooding; hydrogen sulphide and subsequent deterioration of sewerage assets; pollution incidents	**16**
	Lower flows in sewers leading to blockages, resulting in property flooding	**16**
	Settlement / sedimentation in sewers, leading to subsequent shock loads following rainfall, affecting treatment processes	**16**
More intense / prolonged rainfall	Increased storm water volumes overwhelming combined sewers and sewerage pumps, leading to flooding and more spills affecting watercourses	**20**
	Heavy rain and sewer blockages caused by customers' sewer misuse, leading to spills and / or sewer flooding	**20**
	More infiltration of groundwater into sewers, increasing flood risk	**20**
	Heavy rain leading to more spills affecting bathing waters	**16**
	Increased volumes to be pumped, accelerating asset deterioration and increasing power use	**12**
	Flooding of sewerage assets leading to potential failures	**12**

Summary of action

<table>
<tr><th>Previous and ongoing work</th><th>Additional actions from 2020 onwards</th></tr>
<tr><td>Forward planning
• Infiltration reduction plans
• Odour management plans in place
• Modelling sewer catchments
• Topographic mapping for flood risk
• Rainfall modelling.

Investment schemes and ongoing operations
• Flood alleviation schemes, including sewerage capacity investment
• Separation of surface water and foul sewers
• Promotion of sustainable solutions using integrated urban drainage management, sustainable urban drainage systems and active system control
• Installation of spill monitors at storm overflows
• Improvements at specific storm overflows, particularly where there is a link to coastal water quality
• Reducing infiltration of groundwater into sewers
• Ongoing sewer maintenance such as sewer sealing
• Operational improvements for odour control and management
• Pumped overflows during river flooding

Work with others
• Collaborative work with Lead Local Flood Authorities (LLFA) and other agencies on surface water management
• Developing infiltration reduction plans
• Collaborative catchment management work</td><td>• Publication of our Drainage and Wastewater Management Plan
• A multi-track programme of customer engagement, jetting of sewers, additional monitoring and analytics to reduce the number of pollution incidents.
• Improvements at 13 frequent spilling overflows during 2020-2025 as well as additional flow and spill monitoring, with more improvements in 2025-2030.</td></tr>
<tr><td colspan="2">Risk mitigation benefits
• Reduced risk of sewer flooding for properties (internally and externally), and avoidance of restricted toilet use
• Limiting overflows from combined sewers and overwhelmed water recycling centres
• Reduction in flood risk and pollution incident risk due to clearance of blockages in sewers
• Reduction in odour nuisance risk for our neighbours</td></tr>
</table>

Assessing risks
Links between climate change and our sewerage services are already recognised. For example, the UK climate change risk assessment identifies a significant risk of increased flooding of properties from sewers, and a 2011 study by Mott MacDonald for Ofwat concluded that climate change is likely to increase flooding volumes by 27% up to 2040. Our DWMP will confirm the Wessex region uplifts when the draft is published in the Summer 2022.

Part of this concern relates to the view that weather events viewed historically as ‘extreme’ will occur more frequently. 2012 and winter 2013-14 demonstrated the effects of extreme rainfall within the context of a changing climate. 2012 saw unprecedented total rainfall depths from prolonged downpours caused by convective rainfall. The high groundwater levels led to 50,000 properties in Dorset and Wiltshire being at risk of groundwater flooding and the Centre for Ecology & Hydrology stating that there was no close modern precedent for the extraordinary switch in river flows during spring 2012. The saturated ground meant permeable areas responded as if they were impermeable and the consequential number of flooding incidents from the sewer network reached an all-time high. We saw exceptionally high groundwater levels and extensive fluvial, pluvial, groundwater and sewer flooding, plus restricted toilet use in some cases for several months. There was a sharp increase in recorded sewer flooding incidents and the number of properties at risk of flooding.

UKCP09 predicted a 20% uplift in rainfall on our south coast. This prediction may have already been proven to be correct, as the Bournemouth and Poole conurbations have both seen four ‘severe’ rainfall events in the last decade. Our customers in some locations have suffered 2-year flood return periods, whereas our historical analysis of rainfall classifies these events as 1 in 20 year or even 1 in 150-year return period events.

The water industry has been investigating the effects of climate change for over a decade, over which time weather patterns appear to have shifted. Currently, the ConVex project (http://research.ncl.ac.uk/convex/) is trying to improve prediction of convectional rainfall patterns. The UKWIR project *Planning for the mean or planning for the extreme* is using the UKCP09 and ConVex data to consider how climate change will affect rainfall intensities and hence flood risk. Predictions show that with an uplift in rainfall of 30% by 2030 in our region, annual flooding volumes would potentially double. As such, today’s extremes could become the futures mean. The water industry has been establishing more consistent long-term planning guidance, such as the Drainage Strategy framework in 2013 and the Drainage and Wastewater Management Plan framework in 2018. Wessex Water has been heavily involved in the steer of these frameworks. Wessex Water is also representing all sewerage companies in Defra’s current Storm Overflow taskforce.

Maintaining resilience
We have a duty “to provide, improve and extend a system of public sewers to ensure that our area is and continues to be effectually drained” (Section 94 Water Industry Act 1991). The sewerage network is required to cope with high volumes associated with prolonged or intense rainfall. Our sewers have generally been designed to provide a 1 in 20-year level of protection against flooding. With a risk-based approach we aim to enhance protection where the impact of any flooding is the greatest. Major investment has already been made to reduce the risk of flooding of properties from sewage and to reduce the impact of overflows from combined sewers into watercourses.

Adding capacity is one method to reduce the risk of flooding, but it is far better to remove the surface water connections from the sewerage system and retain the runoff locally. Investment can either be before flows increase but with a risk that the investment is premature or even unnecessary, or after - which risks customers suffering sewer flooding. We aim to invest appropriately to ensure our service levels remain one of the highest in the industry whilst delivering required capacity as efficiently as possible. With climate change increasing flows and loads through our network and at our water recycling centres (alongside urban creep and new development), we must invest to provide stable levels of service to our customers and the environment.

Sewer flooding attributable to insufficient sewerage capacity occurs during wet weather. Flash floods can occur during intense rainfall or during times of prolonged rainfall due to high groundwater table entering the sewers (such as the 2012 and 2013/14 winters). While prolonged flooding tends to occur during winter months, intense rainfall can occur anywhere, e.g. the village of Chard experienced a 1 in 24-year event in May 2021, a 1 in 34-year event in June 2021 and another significant event in October 2021. These events are a reminder of how variable and extreme weather patterns can be, and as noted earlier can lead to a big increase in flooding incidents and restricted service for some customers.

Drainage and Wastewater Management Planning

Long-term resilience planning for drainage and wastewater is not as advanced as for water supply, partly because of the individual and diverse nature of the wastewater and drainage systems. However, following the work of the 21st Century Drainage Programme, and the water industry publication of the Drainage and Wastewater Management Plans (DWMP) framework, we will publish long-term plans for sewerage investment on our website in the summer of 2022 for the first time. DWMPs will be the wastewater equivalent of the Water Resources Management Plan (WRMP).

DWMPs will include three levels of plan:

- level 1: at the water company regional area, similar to the WRMP
- level 2: strategic planning areas will be based on river basin catchments (four areas in Wessex Water). These are to be relevant for catchment partnerships, which can influence our approaches
- level 3: drainage strategies at treatment works catchment level.

The overall aim is to develop plans for areas that could be at risk of flooding now or in the future, due to intense rainfall, development and other drivers, so that a holistic long-term picture of the ‘sewerage deficit’ can be formed. While DWMPs are not currently a legislative requirement, we will deliver the plans as soon as possible and by March 2023 at the latest, in order to inform PR24.

Wessex Water’s first Drainage and Wastewater Management plan looks at existing risks as well as assessing the potential impact of climate change, growth and urban creep.

DWMPs adopt a risk-based assessment of the hydraulic capacity of the network and treatment works as part of their resilience element. For water recycling centres and significant pumping stations, sites at high risk from flooding have been established and high-level measures to reduce the flood risk will be outlined for potential funding via the PR24 business plan.

The DWMP has also undertaken an assessment of hydraulic capacity risks, where significant impacts of growth, urban creep and climate change are predicted and solutions to reduce flood risk are expected to be complicated. The WRC catchments that are deemed to have a risk have been identified as either ‘standard’, ‘extended’ or ‘complex’. Options for flood risk and storm overflow improvements have been developed for all significant ‘escape of sewage’ risks. Adaptive pathways have been considered for ‘complex’ catchments. Over time, the pace and intensity of climate changes may become more or less clear, extreme weather events might highlight vulnerabilities of which we were previously not aware, and alternative adaptation methods might become available. For these reasons, our adaptation measures will themselves need to be flexible and able to change.

We have models for more than 90% of our foul and combined sewerage system, and plan to complete modelling of our sewer network, and surface water drainage. Our Drainage and Wastewater Management Plan website hosts a long-term sewerage capacity graphical information portal to allow customers and stakeholders to see our long-term Drainage Strategies. Several drainage strategies are already on the portal and more will be rolled out on a catchment-by-catchment basis.

Our Drainage and Wastewater Management Plan will include:

a. modelling climate change impacts of rainfall, and options to maintain current levels of service or remove problems.
b. categorising catchments by performance and complexity, assessing ~200 catchments.
c. considering sustainable (e.g. separation) and traditional (e.g. storage) solutions to deliver resilient drainage and wastewater infrastructure.
d. working with stakeholders to develop partnership schemes to deliver integrated flood risk management.

Subsequent implementation of the plans will come through both investment in physical assets, and work with external organisations and customers. Typically, responses involve reducing the consequences of the main pressures of growth, urban creep and predicted climate change impacts of wetter winters and more intense rainfall. We will continue to work with local lead flood authorities and other stakeholders to identify joint schemes that provide value for money, sustainable solutions to reduce flooding.

Sewer flooding risk

We aim to maintain a stable level of total flooding risk, including external area flooding. Measuring total flooding risk – including external as well as internal flooding risk – is feasible now that we have been collecting external flooding risk data for nearly 15 years. We will continue to focus investment primarily on locations of highest risk and also consequence because flooding inside people's homes and businesses is a high priority from our customer research.

During 2015-20 we invested proactively in sewerage capacity where cost-beneficial, including defined schemes for Bristol and schemes elsewhere that improved capacity. Overall, we maintained a stable level of total flooding risk, including external area flooding and addressed smaller non-specific investment needs as they materialised during the period.

During 2020 – 2025 we continue to invest proactively in sewerage capacity. In 2021 as part of our DWMP, we used 200 hydraulic computer models and carried out circa. 420,000 model runs assessing the impact of growth, urban creep and climate change on the risks of flooding and pollution. We completed circa. 400 pumping station and overflow surveys and 3,000 manhole surveys and have been progressing 170 storm overflow investigations.

It is our intention that the DWMP will inform our plan for increased expenditure beyond 2025.

Dealing with groundwater infiltration

Infiltration of groundwater into private drains and public sewers can be a significant problem in our area due to geology and the prevalence of high water tables. This can lead to restricted toilet use, premature spilling of storm overflows to the environment and hydraulically overloaded water recycling centres. As well as the very wet winters of 2012/13 and 2013/14, the winters of 2019/20 and 2020/2 were also problematic for infiltration inundation, and we had to tanker the contents of sewers to other catchments at locations and over-pump to watercourses at a few locations in order to protect properties from flooding internally.

Historically, infiltration was tackled using gel injection at joints although locations once sealed in this way are now suffering infiltration problems again. Our preferred approach is now epoxy resin lining which, although more expensive than gel injection, is more successful in the long run. Alongside, infiltration reduction plans are developed with the aim of reducing discharges to the environment. We work with the Environment Agency to agree where such plans need to be delivered and help lead local flood authorities to use their powers to enforce private drain maintenance where we can demonstrate that infiltration into these pipes and manholes is affecting downstream capacity. We learned from the floods of 2014 and prepared local emergency plans for over 50 catchments, so we are better prepared should another extreme winter occur. We also work at a national level to raise the profile of groundwater inundation and promote best practice.

Sewer maintenance

Sewers are designed to accommodate flows during wet and dry conditions; however, overflows leading to pollution incidents can occur, usually due to blockages rather than the sewerage itself being too small. We estimate that 89% of blockages are caused by sewer misuse and we will continue to take various measures including inspections, relining, jetting, root cutting, and raising public awareness about what can cause blockages in sewers. We collect data when sewer blockages occur to identify ‘hot spots’ where targeted customer engagement could be beneficial.

Surface water management

Our approach to providing adequate sewerage capacity is not limited to traditional “larger sewer construction”, but includes a suite of delivery options including Sustainable Urban Drainage Systems (SUDS), surface water separation schemes, and real-time control of the network.

Since the Flood and Water Management Act 2010 we have worked more closely with the 10 Lead Local Flood Authorities (LLFAs) in our area. We see continuing co-operation and joint working as a key area for delivering our strategy to address flooding incidents and flood risk. We have shared asset data and hydraulic models with LLFAs and their consultants to assist in the development of their Surface Water Management Plans.

Constructing larger combined sewers is not necessarily the best long-term solution for increasing sewerage capacity. Separating surface water from combined systems has the twofold benefit of releasing headroom in the combined sewer and reducing overflow volumes from storm overflows (SOs). We will continue to look for sustainable solutions using an integrated urban drainage management (IUDM) approach as well as promoting sustainable urban drainage systems and using active system control to ensure adequate capacity is provided. The first two approaches will require partnership working with other risk management authorities. IUDM can also improve water quality and so we will continue applying IUDM techniques in Weston-super-Mare, Highbridge and Bridgwater.

In 2016 we constructed a separation scheme which removes flow from a watercourse that was entering our combined sewer. A new surface water pumping station was built to lift flow into a new above ground storage area. We worked closely with the local council to oversize a pond that they were constructing so we had somewhere to pump the water into. There has also been industry activity to promote sustainable solutions, such as Water UK's Surface Water Separation Project and SusDrain, run by CIRIA.

Improvements at individual storm overflows

Storm Overflows (SOs) act as relief valves for the sewerage network during times of heavy rain to prevent property flooding. They are designed to pass forward polluting loads so that when they do discharge, they do not significantly impact the environment. However, occasionally they operate incorrectly – most often due to downstream blockages - leading to pollution incidents. We have been installing spill monitors at SOs to better understand the frequency of their operation and will continue with this programme with all SOs being monitored by December 2023. We are improving 13 frequent spilling overflows by 2025 and are also improving 3 coastal sites where there is a link between SOs and coastal water quality.

Behavioural engagement

We are building the reach of our campaigns against the misuse of sewers that cause blockages by encouraging the correct disposal of wet wipes and fats, oils and grease. Our water citizenship project in Chippenham in 2018 involved engagement with people and communities on the local water environment and multiple issues linked to the sustainability of the water system. We are now carrying out our increasingly targeted campaigns in sewer blockage hotspots including door-knocking to advise when an issue occurs, coupled with the launch of a new blockage reduction free pack of devices to encourage customers to think about what they flush and pour down the sink, plus engagement through letters and social media.

Sewage treatment and sludge

Challenges

We anticipate that warmer temperatures will increase the risk of odour and pests at sludge sites and water recycling centres, having a resulting impact on residents and businesses in the local area. Additionally, increased seasonal demand during higher temperatures could result in larger volumes of sewage requiring treatment. Periods of prolonged dry conditions can also present challenges to sewage treatment and sludge; for example. lower flows within the system could lead to longer retention times in settlement tanks, which can result in increased septicity and odour problems.

	Summary of our main risks	Risk score 2021
Higher temperatures	Increasing odour and pest risks at water recycling centres and sludge sites, affecting local people	**20**
	Increased seasonal demand (including from tourism), increasing volumes needing treatment	**15**
	Increased odour complaints linked to water recycling centres	**12**
Drought	Settlement / sedimentation in sewers, leading to subsequent shock loads following rainfall, affecting treatment processes	**16**
	Lower flows, leading to longer retention times in settlement tanks, resulting in increased septicity and odour problems	**15**
	Lower river flows resulting in less dilution of effluent and increased risk of consent failure	**12**
More intense / prolonged rainfall	Heavy rain leading to more spills affecting bathing waters	**16**
	Increased risk of spoiling sludge stockpiles	**15**

Summary of action

<table>
<tr><th>Previous and ongoing work</th><th>Additional actions from 2020 onwards</th></tr>
<tr><td>
Forward planning
• Review of treatment options process performance of during extreme weather
• Managing risks to reusing of sludge on agricultural land
• Review of sewage works’ capacity and flow consents

Investment schemes and ongoing operations
• Increasing capacity at sewage works according to changes to incoming flow
• Rolling investment in new assets and investigations of environmental impacts
• Development of catchment permitting for phosphorus reductions as a method of more flexible management of water recycling
• Improvements to river and bathing water quality, including through transferring flows from smaller water recycling centres for treatment at larger sites
• Altering operations and maintenance for changes to sewage received, sludge produced or receiving watercourses
• Monitoring sewage quality, regulating trade effluent
• Review of sludge cake storage facilities and practice
• Managing risks to reusing of sludge on agricultural land
• Reviewing treatment process performance during extreme weather

Work with others
• Negotiations on discharge consents during extreme weather
• Working with farmers to maintain sludge reuse options
</td><td>
• Enhancements at water recycling centres including removal of a further c.300 tonnes of phosphorus per year by 2025 - through sewage treatment improvements and catchment interventions
• Delivering the Water Industry Strategic Environment Requirements, including 100% compliance with environmental permit conditions every year.
• Providing additional capacity across water recycling centres that are overloaded, or aligning with enhancement schemes where flow and permit limits are being tightened
• Major maintenance and upgrades of anaerobic digesters at one site to provide additional capacity and resilience.
• Upgrading our Bioresource Centres to ensure compliance with the Industrial Emissions Directive.
• Reviewing implications arising from changes to sludge quantity and make-up as a result of new/additional phosphorus removal at WRCs in AMP7 and beyond.
• Reviewing implications, and making improvements and wholesale changes as appropriate, on sludge treatment and disposal given forecast reduction in availability of landbanks for nutrient-rich sludge.
</td></tr>
<tr><td colspan="2">
Risk mitigation benefits
• Maintaining compliance with end-of-pipe standards
• Retaining the ability to reuse sludge cake on farmland
</td></tr>
</table>

Sewage treatment - improvements to meet tighter standards
The quality of rivers and streams can be placed under greater stress during very warm or dry weather conditions. With lower flows there is less dilution of effluent, and warmer water holds less dissolved oxygen and is more prone to algal blooms. A warmer climate could see these conditions happening more often, which in turn could mean pressure for tighter end-of-pipe standards at water recycling centres.

Our current extensive programme of work across all the catchments in our region includes new / additional nutrient or ammonia removal, trials of novel treatment technologies, catchment-based consenting and environmental investigations. This is driven by the general condition of watercourses and legislation such as the Water Framework Directive. To date, warmer weather or climate change have not explicitly been cited as contributory reasons for our investment, but it is a factor that could have an influence in the medium to long term.

During 2015-20 our work included the development of catchment permitting for phosphorus reductions as a method of more flexible management of water recycling, as well as improvements to river and bathing water quality more widely, including through transferring flows from smaller water recycling centres for treatment at larger sites. We achieved a fall in the number of odour complaints related to our wastewater assets.

Post 2020 we are providing additional capacity across water recycling centres that are overloaded, or aligning with enhancement schemes where flow and permit limits are being tightened. We are delivering enhancements at water recycling centres including removal of a further c.300 tonnes of phosphorus per year by 2025 - through sewage treatment improvements and catchment interventions.

Maintaining reuse of sludge on land
As we have limited capacity for storing sludge cake, it is normally transferred directly from our bioresource centres (BCs) to on-farm storage areas. The exceptionally wet weather during 2012 to 2014 meant that soils in many parts of our region became and remained saturated, which limited the capacity of on-farm storage for sludge cake. We assessed the need and costs for providing additional cake storage and considered new cake storage slabs at five locations. This led to construction of two barns for winter storage of sludge cake to mitigate against slumping of stockpiles during wet weather.

Regarding other possible measures, we do not favour higher cost methods such as drying sludge where other options are available.

Odour control / mitigation and pests
Our Environmental Odour Policy is based on the Institute of Air Quality Management’s (IAQM) guidance document, EA H4 Odour Management guidance as well as DEFRA’s code of practice for odour control and management. By developing a system of detailed odour management plans we have been able to implement operational improvements and general good housekeeping which has resulted in a fall in the number of odour complaints related to our wastewater assets. We will continue to monitor the performance of our odour control plants and carry out maintenance and improvement works as and when required.

With a changing climate and potential increase in warmer, drier conditions, we anticipate an increase in fly nuisance as well as an increased presence of non-native invasive species. Our approach to fly management is based on guidance on nuisance from insects and flies from Defra and the

Environment Agency. By developing a system of detailed fly management plans, we have been able to implement operational improvements and general good housekeeping, which keeps complaints as low as possible. It is clear that no best practice technique will completely remove all fly larvae and flies from trickling filter beds at water recycling centres, and that not every approach may be suitable for every site. Either way we will continue to monitor sensitive sites as levels of flies and species type may change as a result of climate change.

Flooding of operational sites and assets

UK Climate Change Risk Assessment 2017	**MORE ACTION NEEDED**	In2: Risks to infrastructure from river, surface/groundwater flooding
		In3: Risks to infrastructure from coastal flooding & erosion
		Bu1: Risks to business sites from flooding
	RESEARCH PRIORITY	In5: Risks to bridges and pipelines from high river flows / erosion

Challenges

Prolonged and intense rainfall events can affect our operational sites and assets directly through flooding from rivers or runoff. Particular risks include impacts on power supplies, submersion of electrical assets and transport routes or site access being impaired.

		Summary of our main risks	**Risk score 2021**
More intense / prolonged rainfall	Other	Flooding of sites, leading to equipment outages, elevated safety risk	**12**
	Other	Increased public expectation for hard defences to prevent site flooding	**8**
	Other	Flooding and inundation affecting transport routes/access to assets	**10**
	Other	Asset flooding leading to submersion of electrical assets	**12**
	Other	Storm events affecting power supplies and damage to assets at sites	**12**

Summary of action

<table>
<tr><th>Previous and ongoing work</th><th>Additional actions from 2020 onwards</th></tr>
<tr><td>

Forward planning
- Flood risk assessments
- Adapting maintenance plans

Investment schemes and ongoing operations
- Response & recovery plans for extreme weather events and coastal flooding
- Developing working practices for unusually wet, warm or dry conditions
- Local infrastructure solutions e.g. bunding, flap valves, alarms and drainage improvements
- Continued monitoring of the vulnerability of sites to flooding
- Adapted working practices for health and safety
- Energy self-sufficiency at key sites
- Optimising operating and maintenance regimes

Work with others
- Responding to customers' expectations for improving service levels
- Emergency response strategies

</td><td>

- Ongoing review of risk to sites and assets
- Ongoing monitoring of medium to long term flood risk, with appropriate action to be taken at sites where risks have become unacceptable.
- Building a perimeter flood wall / bund around Portbury Wharf water recycling centre (in 2022), where the current sea bank is at increasing risk of overtopping during spring high tides, exacerbated by climate change
- Ongoing review of the status of affected sites

</td></tr>
<tr><td colspan="2">

Risk mitigation benefits
- Reduced consequence of site flooding
- Avoidance of coastal flooding of operational assets
- Maintained security of supply at two sites, which maintained output during wet weather in 2012-2014

</td></tr>
</table>

Flood risk at water supply sites

Following the flooding in Gloucestershire in July 2007 which shut down a major water treatment centre for an extended period leaving thousands of customers without water, at the 2009 periodic review of prices we recognised the need to carry out flood risk assessments for our water treatment and recycling sewage centres and major pumping stations. Furthermore the Pitt Review published in June 2008 highlighted the need for enhanced resilience of critical assets to flooding.

The guidance provided by OFWAT in June 2008 – Service Risk Framework (SRF) for Flood Hazards included a five-stage process as summarised below:

Risk screening	• Frequency and extent of flooding • Identify assets • Assets 'at risk': the analysis identified water treatment centres that lie within the flood plain or within 50m of it.
Risk analysis	• Flood characteristics • Vulnerability analysis • Modelling - the conclusions of site-specific flood risk assessments were that only two were considered to be vulnerable to significant flooding
Impact of flooding	• The sources of flooding and the impact on the site were assessed
Risk analysis	• The two sites at risk of flooding are critical sites and therefore extended asset failure would cause severe impact to service on the customers
Risk management	• Interventions and risk mitigation: for each site we developed a scope of works for flood protection and flood resilience • Cost benefit analysis: the analysis showed that the projects were cost beneficial

Our assessment in 2008-09 using this methodology led to an initial long list of 24 sites that was narrowed down to two that we deemed to be at genuine risk of flooding. Our subsequent proposals for improvements at the two sites were found by Ofwat to be cost-beneficial and worthy of investment during 2010-15. Then, for 2015-20 we did not propose or carry out any further asset flood resilience schemes as the previous assessments were very comprehensive and still applicable. Our current thinking is that no further work is required in the 2020 to 2025 period.

Flood risk assessment and improvement for wastewater assets and sites

During the 2010-15 investment period, work was carried out at one site involving a sewage pumping station that serves a medium-sized town where we replaced above-ground pump motors with dry well submersibles and raised electrical equipment above predicted possible flood levels. Then, in the light of the exceptional wet weather of 2012 to 2014 we reviewed flood risks at our water recycling centres and records of five fluvial flooding events at one particular site, leading to work to identify and make more resilient critical electrical plant and equipment. This also was to align with our internal design standard which requires all new (critical) electrical plant and equipment to be above the 1 in 200-year flood plain level and/or with appropriate recovery/mitigation measures.

More recently, as part of the Drainage and Wastewater management Plan (DWMP) Resilience Assessment a multifaceted project assessing the resilience of our operational sewerage business has been undertaken including;

- For fluvial and coastal flood risk - 125 water recycling centres & sewage pumping stations assessed with 50 site surveys and modelling completed.

- Coastal erosion risk - 64 sites and circa 2000 lengths of sewer network identified within 20m of mean high tide and risk assessed. Highest risk sites (~1%) surveyed and appraised.
- The current Shoreline Management Plan (SMP) policy has been reviewed to understand the risk of coastal processes on our assets. We will keep the status of these sites under regular review and respond to any developments or revisions to the policies described in the SMPs.
- Communications and power resilience - reviewing the provision and risk within our existing asset base.
- Business resilience documentation & processes assessments.

The outputs of the Resilience Assessment will be contained within the Final DWMP (March 2023), which will inform a programme of resilience works to be considered for funding in the PR24 Business Planning process.

During 2020-25, we are also building a perimeter flood wall / bund around Portbury Wharf water recycling centre (in 2022), where the current sea bank is at increasing risk of overtopping during spring high tides, exacerbated by climate change.

Business continuity and cascading failures

UK Climate Change Risk Assessment 2017	MORE ACTION NEEDED	In1: Risks of cascading failures from interdependent infrastructure networks

Challenges

We are reliant on services provided by others and some issues involve shared responsibility with others who are affected by extreme weather or a changing climate. This means that there is a risk of cascading failures where climate-related problems experienced by other service providers affect us, or vice versa.

Summary of action

<table>
<tr><th>Previous and ongoing work</th><th>Additional actions from 2020 onwards</th></tr>
<tr><td>Forward planning
• Business continuity arrangements and emergency planning procedures in each business areas
• Continued review and updating of business continuity arrangements
• Adverse Weather Continuity Plans - reviewing our overall preparedness, ensuring appropriate stocks of rock salt and grit, 4x4 vehicles

Investment schemes and ongoing operations
• Following Cabinet Office good practice guidance for integrated emergency management, with three response levels: operational, tactical, strategic
• Using weather forecast and weather warnings from the Met Office, enabling advance planning for coming weather e.g. ensuring additional resources are available; rearranging non-essential planned works
• Back electricity generators: 114 for water supply sites, 251 for wastewater sites.
• Implemented staff risk assessments for working in adverse weather

Work with others
• Active participation in responses to incidents involving multiple agencies, where our involvement is required and contributes to external debriefing
• Strengthened our working relationships with local resilience forums</td><td>• Regular review of business continuity arrangements developed by the various business areas
• Ongoing maintenance of generators</td></tr>
<tr><td colspan="2">Risk mitigation benefits
• Back-up power supply in the event of grid supplies being disrupted</td></tr>
</table>

Business Continuity
During 2015-20 we continued to review and update of business continuity arrangements, including strengthening our working relationships with local resilience forums. We developed an Emergency Tactical Planning Group with leads from across the business, to respond to a range of emergency issues. This enables a more integrated view which increases our ability to address concurrent risks and cascading failures. We also implemented staff risk assessments across the organisation for working in adverse weather.

This came into play during the 'Beast from the East' cold wave event in 2018, although much of the response was logistical. We allocated additional resources to manage the expected increase in workload; we carried out proactive communication with customers through social media on preparations that can be made in the home for freezing weather; and we also used our integrated supply grid to move water to locations suffering most from pipe bursts. The net effect was that none of our customers were without water for more than 3 hours during the event.

Future work will be centred on regular review of business continuity arrangements developed by the various business areas, as well as developing the partnership arrangements with other organisations as set out below.

Interdependencies
It would not make sense for us to attempt to adapt to climate change in isolation. We are reliant on services provided by others and some issues involve shared responsibility with others who are affected by extreme weather or a changing climate. Examples include:

- surface water management, involving liaison with councils, Internal Drainage Boards and the Highways Agency and emergency response.
- the water sector's protocol for sharing resources and its mutual aid scheme through which companies co-operate during emergencies.
- customers, who have important roles to play in terms of using water wisely (especially during prolonged dry weather) and not causing blockages by flushing wet wipes or pouring way cooking oil and fat – and the media in helping us to raise awareness of these points
- community groups and individuals that are able to keep an eye on their local water environment and inform us of problems with water supplies or sewerage
- work with land users, especially for protecting drinking water sources that are vulnerable to a combination of farm inputs (e.g. nitrates and pesticides) and heavy rain.
- dialogue with government and our regulators in relation to both our day-to-day activities and longer-term planning.
- our own use of other utilities, in particular electricity and telecommunications. Their reliability is very important to us and interdependencies between utilities have been very evident during past extreme weather events. Information on power outages comes directly into our control room to ensure a managed response from the centre.

We have been doing more in recent years to ensure that we can cope with acute events, especially where there is a risk of cascading failures across a number of utilities or aspects of critical infrastructure.

Under the Civil Contingencies Act we are designated as category 2 responders, although we work closely with category 1 responder agencies via three local resilience forums (LRF). These provide a structure for agencies to work together on planning and in tactical and strategic response to incidents, using facilities such as dedicated teleconferencing to share information and warnings and agree external messaging.

Wessex Water sits on the LRFs' adverse weather groups, which cover plans for responding to events such as flooding and heatwaves. Our work on interdependencies is developing further under the review of the critical national infrastructure that we rely on, linked to the Security and Emergency Measures Direction. This will be informed by our experience of COVID-19 and the appearance of concurrent disruptive events.

We continue to review and update business continuity arrangements and work in partnership with other agencies.

Wider environmental protection

UK Climate Change Risk Assessment 2017	**MORE ACTION NEEDED**	Ne6: Risks to agriculture & wildlife from water scarcity & flooding

Challenges

We expect to see a range of pressures on the natural environment of our region arising from climate change. Less summer rainfall could affect the levels and movement of groundwater and the size and shape of groundwater catchments, affecting flows in rivers and streams that are fed by aquifers. Heatwaves will contribute to algal blooms in lakes, rivers and estuaries, resulting in lower oxygen levels and ecosystem damage. More intense rainfall could lead to more contaminants leaching into groundwater, or being washed directly into surface water. Meanwhile, climate change could result in conditions becoming more suitable to alternative crops but also different parasites and pests, leading to a change in the pesticides used. We also expect further migration into the region of non-native species, including some that are invasive and damaging to existing biodiversity.

Summary of action

Work to date	Further actions 2020 onwards
Forward planning • Environmental investigations to help focus subsequent capital schemes • Developing a routemap to net zero carbon emissions **Investment schemes and ongoing operations** • Delivering improvements to the water environment via regulated upgrades to water resource management, sewerage and sewage treatment • Pioneering market-based methods for environmental delivery, e.g. EnTrade • Investment in renewable energy **Work with others** • Hosting or supporting catchment partnerships, which oversee projects that deliver a range of benefits and increase environmental resilience • Co-delivery of biodiversity improvements • Water Guardians – training local volunteers to monitor watercourses, identify possible pollution incidents and report them to us for further investigation	• Promotion of outcome-based environmental regulation • Expansion of market-based approaches to environmental improvements and promotion of nature-based solutions • Supporting four projects through our Biodiversity Action Plan Partners Programme during 2020-2025 • Working towards achieving net zero operational emissions by 2030 and addressing embodied carbon in construction materials and consumables
Risk mitigation benefits • Improving the resilience of the environment in our region through a range of interventions	

Overview
In addition to our work to limit the amount of water we abstract and to manage and improve effluent discharges, we carry out a range of activities that contribute to the resilience of the environment of our region. Climate change impacts are not always a stated reason for this work; however, it is one of many pressures on the natural environment that underpins our efforts.

Biodiversity action plan
Our biodiversity action plan (BAP) was the first corporate initiative of its kind to be based on the UK biodiversity action plan (UK BAP).
It draws on a long tradition of wildlife conservation work within Wessex Water but has continually adapted to meet the many challenges facing the habitats and species within our region. Our plan has four key themes to help conserve and enhance biodiversity within our own activities and also within our region:

- our partners programme, which provides funding for projects carried out by wildlife organisations across our region
- our environmental assessment work which set out how we avoid or mitigate any impact to the environment from developing our sites or operations
- our conservation, access, recreation work which includes enhancing biodiversity on our land, such as the sites of treatment works
- our catchment biodiversity work, which aims to find both wildlife and water quality solutions to problems in our catchments which are cost-effective and sustainable.

We are actively involved with many of the local conservation groups and organisations across our region, including the Local Nature Partnerships, Environmental Records Centres, Catchment Partnerships and wildlife groups.

Catchment partnerships
We work in partnership with organisations and individuals across our region to protect and restore the water environment as a part of the catchment-based approach. This is a way of working at a river catchment scale to improve the water environment for wildlife and people. By working together, the catchment partnerships aim to share local knowledge and expertise; identify the local challenges; and deliver cost effective solutions with multiple benefits. There are five catchment partnerships, or catchment initiatives, in the Wessex Water region; Bristol Avon, Hampshire Avon, Somerset and under Dorset, Poole Harbour and the Stour. We work with all the catchment partnerships in the region; we host two (Bristol Avon and Poole Harbour), and co-host the Stour catchment initiative with the Dorset Wildlife Trust.

Environmental investigations
We believe our investment should be based on sound science - by gathering data through our scientific investigations we can better understand how our business affects the environment before trialling solutions. We completed over 20 investigations as part of our AMP5 period from 2010 to 2015; the findings from these investigations were reported to the Environment Agency, Natural England and other stakeholders and were fed into our 2015-20 business plan. This programme expanded to 35 investigations during 2015-20, including

- detailed monitoring of chemicals at 30 water recycling centres as part of a national programme
- understanding the effects of our discharges on bathing and shellfish waters at Burnham, Weston-super-Mare, Clevedon and The Fleet (Weymouth)

- monitoring for the presence of eels and identifying improvements to support populations at 10 sites
- trialling different compensation flow and operating regimes at some reservoirs to mimic more natural river flows in downstream watercourses
- a catchment permitting system in the Bristol Avon catchment that allows us to reduce phosphorus from water recycling centres by optimising existing treatment systems and using new technologies and more sustainable solutions
- establishing the impact from our operations upon several Sites of Special Scientific Interest such as the Somerset Levels and Moors, Blagdon Lake and the Moors River
- improvements to our priority wildlife habitats around Clatworthy reservoir and management of non-native invasive species around our business
- understanding the effect of our abstractions on the Water Framework Directive status of streams and rivers in the context of other environmental pressures.

Catchment markets

We are developing catchment markets as a way to demonstrate how high-integrity markets can reduce the costs of nature-based solutions and optimise the multiple environmental services they provide, including carbon sequestration. This will create an attractive economic opportunity for farmers and land managers to use land to plant trees, establish new wetlands and create more biodiverse field systems, building the resilience of our catchments.

These changes in land use create direct benefits for biodiversity, climate resilience and pollution control. They also avoid the carbon impacts of the grey infrastructure solutions that they replace. Modelling of solutions bought in our first catchment market around Poole Harbour, where nature-based projects have been used to avoid infrastructure upgrades and increased chemical usage at Dorchester wastewater treatment works, saving embodied carbon in the process.

Larger scale catchment markets are now also being developed for launch in catchments of the Bristol Avon and Somerset.

Greenhouse gas emissions

By 2030, we aim to achieve net zero operational carbon emissions (i.e. annual emissions linked to our energy use and transport, plus other greenhouse gases that are emitted from sewage and sludge treatment processes); and net zero total carbon emissions by 2040 at the latest. The latter includes our operational emissions, plus those linked to construction materials, and consumables such as treatment chemicals. We have a strong track record of carbon management work including:

- avoiding energy use and emissions generation across company activities, e.g., developing nature-based solutions, innovative infrastructure repair, and reducing the volumes we pump and treat through leakage prevention
- using energy, where required, efficiently by monitoring and using smart controls on equipment
- pioneering work to generate energy from sewage sludge and food waste as we switch our energy use toward renewable sources.

Background reductions in the UKs carbon footprint, such as the growth in renewable energy generation, will mean that our energy and transport emissions will fall by around one third from our current position. We therefore need to take concerted action between now and 2030. We will do this through a range of readily-available options including:

- emissions avoidance measures, such as reducing water use and leakage; increasing the use of lower carbon transport; and promoting nature-based solutions that avoid energy use
- optimisation measures, such as energy efficiency work and systems for monitoring and controlling nitrous oxide from sewage treatment
- renewable energy – increasing the amount of biogas that we generate from anaerobic digestion and pursuing opportunities for wind and solar power, either as generators or as the end-user.

However, reductions in background emissions and the most readily-available options will not be sufficient to achieve our goal of net zero carbon. We will need to pursue more innovative options involving emerging science and technology, such as turning sewage sludge into biochar, as well as promoting nature-based solutions. While these methods are not yet well-established, we are assessing their maturity and availability and will take part in trials where appropriate. We must also address embodied carbon emissions from construction and from the supply chains of goods and services that we use. We are developing a whole-life total carbon approach - which must be central to our decision-making processes - that will necessarily mean challenging assumptions about the best ways to carry out investment for customers, communities, and the water environment.

Performance commitments

	2020-21 performance	2024-25 target
Water supply		
Water quality compliance (CRI) (score)	1.61	0
Water quality event risk index (ERI) (score)	16.766	12.800
Water supply interruptions (mm:ss per property per year)	04:34	05:00
Water per capita consumption (% reduction)	-3.8	0.9
Volume of water saved by efficiency engagement (megalitres per day)	0.7	5
Water supply - unplanned outage (%)	0.57	2.34
Water mains repairs (no. per 1,000 km)	177.7	152.4
Risk of severe restrictions in a drought (%)	0	0
Restrictions on water use (hosepipe bans) (number)	0	0
Wastewater		
Internal sewer flooding (incidents per 10,000 sewer connections)	1.41	1.34
Risk of sewer flooding in a storm (%)	11.82	8.37
Customer property sewer flooding (external) (incidents per 10,000 connections)	19.35	15.68
Treatment works compliance (%)	99.08	100
Other		
Greenhouse gas emissions (KtCO2e)	109	101

Appendix 6: Water resources management planning and the impacts of climate change

This appendix is an extract from our 2019 Water Resources Management Plan (WRMP14), which fed into our business plan for investment during 2020-25.

4.9 Climate change

As a water supply and waste-water treatment business our day-to-day services and operations are affected by weather patterns and so it is important that we account for changes that might be expected to occur to these in our long-term planning. We are a long-term business and adapting to a changing climate is integral to our long-term vision and business plan. Specific risks to our business and our adaptation, mitigation and management strategies were outlined in our 2015 report to Defra under the Climate Change Adaptation Reporting Duty.

Within the context of water resources planning it is particularly important that we consider the impact of changing rainfall, evaporation and temperature patterns and the impact that these may have on river flows, reservoirs, groundwater recharge and ultimately on deployable output. The impact that climate change might have on the demand for water also requires consideration and this is covered in Section 5.5.6 of this Plan.

The most recent information available to water resources planning is the UK Climate Projections outputs from 2009 (UKCP09). The projections incorporate:

- Three different emissions scenarios (low, medium, high)
- Three time periods of the 21st century (2020s, 2050s and 2080s)
- Varying probability based on evidence for different levels of future climate change.

The projections suggest that compared to the baseline period of 1961-1990 the future climate in south-west England is likely to be characterised by drier and warmer summers, milder and wetter winters, and for extreme events to happen with greater frequency.

Table 4-12 shows the most likely 'central case' projections for our region across all three emissions scenarios and three time horizons, which overall suggests a small increase in overall precipitation, with an increase in winter precipitation, and a reduction in summer precipitation. Temperatures are forecast to increase both on an annual average basis, and also during the summer period.

Table 4-12 Overview of UKCP09 projections relative to the 1961-1990 baseline period. Source: Wessex Water (August 2015)

Climate factor/indicator	2020s	2050s	2080s*
Annual mean precipitation	0 to +1%	0	+1 to +2%
Summer (Jun-Aug) precipitation	-5 to -8%	-14% to -20%	-16% to -30%
Winter (Dec-Feb) precipitation	+6 to +7%	+12 to +17%	+17% to +27%
Spring and autumn precipitation	0 to +10%	0 to +10%	0 to +10%
Annual average temperature	+1.4ºc to +1.5ºc	+2.2ºc to +2.8ºc	+2.8ºc to +4.4ºc
Summer mean temperature	+1.5ºc to +1.7ºc	+2.0ºc to +4.0ºc	+3.0ºc to +5.1ºc
Summer mean maximum temperature	+2.0ºc to +2.1 ºc	+3.3ºc to +4.2ºc	+3.9ºc to +6.7ºc

The values shown are those that occur most frequently in our region (i.e. the mode) in the UKCP09 projections. The ranges represent the low and high emissions scenarios.

We have followed the guidance set out in the WRMP19 supplementary information in assessing the impact of climate change on deployable output. Our general approach to the assessment of the impact of climate change on our water resources follows the framework proposed by the joint UKWIR and Environment Agency project 'Climate change approaches in water supply planning – overview of new methods'.

The approach involved a vulnerability assessment (to determine the type of analysis required in the more detailed analysis) followed by a three-stage analysis approach:

- Stage 1 – calculate river flows for a water resource zone in the 2080s
- Stage 2 – calculate deployable output for the 2080s
- Stage 3 – scale the impact determined for the 2080s through the planning period and consider uncertainty

Comments

The analysis undertaken in the vulnerability assessment and during each of the three stages is outlined in sections below.

4.9.1 Vulnerability assessment

The methods used to assess the effect of climate change on deployable output should be proportionate to the risks presented. In accordance with the Guidelines a vulnerability assessment was undertaken to review existing information from previous Water Resources Management Plans, Drought Plans and other relevant data sources to ascertain the level of risk faced and thereby determine a proportionate level of further analysis.

The vulnerability assessment is presented in Table 4-13 and Figure 4-18 and this information was discussed with the Environment Agency and Ofwat during the pre-consultation period.

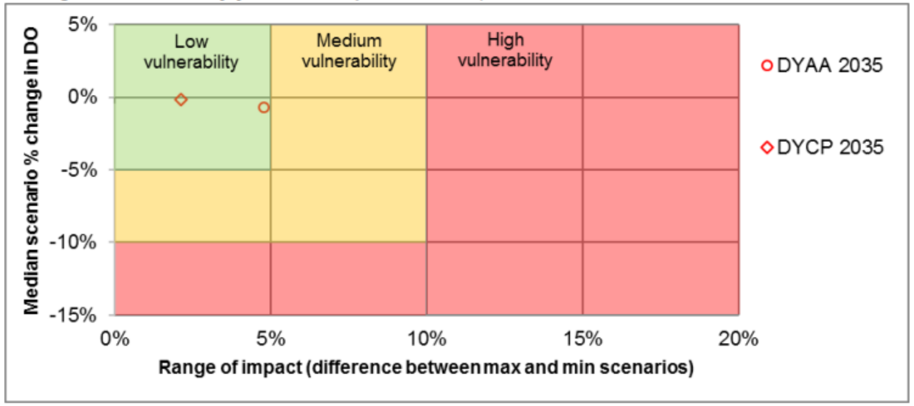
Table 4-13: Climate change vulnerability assessment

Assessment criteria	**Comments**	**Information source**
Critical drought years	1975/76, 1920/21, 1933/34 have been identified as key droughts in studies of historical rainfall records and the analysis of their impact on deployable output. These are the years that we identify the lowest drawdown levels in our single source reservoir model simulations and similarly the lowest simulated groundwater levels in our single point groundwater models.	Analysis of pre-1975 rainfall sequences. Wessex Water, June 2007. Impact of historical droughts on water resource availability. Wessex Water, August 2009. Water Resources Models Data Series Extension Report. Mott MacDonald, March 2009
Period used for analysis (historic flow or groundwater level record)	The critical drought years were identified from rainfall records and reservoir and groundwater level simulations from the 1890s to 2006	Same references as above plus:
Sources	We have over 80 sources. Approximately 75% of the water we supply comes from groundwater and 25% comes from surface water reservoirs. We also have some key imports of water from neighbouring companies which account for c.2% of our distribution input. The development of our integrated grid during AMP5 and AMP6 is connecting communities that are currently stand alone (i.e. can only be supplied by one source) to the wider distribution network thereby increasing their security of supply and making the system more resilient to the potential impacts of climate change.	WRP1 (Baseline Supply), WRP1a (Licences), WRP5 (Final Planning Supply). Water Resource Zone integrity assessment – see Annex B
Supply-demand balance in the base year	The annual review of the Water Resource Management Plan for 2016/17 (the base year) indicated a satisfactory resource position throughout the year. The security of supply index (SOSI) calculation for 2016/17 was 100%.	Annual review of the Water Resource Management Plan 2017

Security of water supply and/or water scarcity indicators	Our investment in a more integrated grid during AMP5 and AMP6 means that we are expecting to forecast supply-demand surpluses throughout the planning period.	Section 4.9
Critical climate variables (e.g. summer rain, winter recharge etc.)	Our supply system is generally most sensitive to multi-season droughts, i.e. the dry summer-dry winter-dry summer drought during 1975/76. Our Drought Plan measures water resource availability against reservoir storage and the use of key annual licences. We also monitor groundwater levels at Allington, Woodyates and Ashton Farm and use these in our monthly supply strategy modelling (using Miser) to optimise source outputs. In 1975/76 summer inflows and groundwater recharge were very low (effectively zero). Climate change therefore cannot make this significantly worse – unless summers become longer (but there is not yet any evidence or data on this from the UK Climate Impacts Programme). Therefore the impact on winter rainfall and infiltration is likely to be more significant, particularly on groundwater recharge (75% of water supplies from groundwater).	Drought Plan (Final Daft, October 2017)
Climate change deployable outputs (dry, mid, wet scenarios from 2013 water resources management plan's)	Overall therefore, the baseline impact of climate change in the 2030s is estimated to be -2.84 Ml/d on average (0.7% of deployable output) and -0.83 Ml/d for the peak scenario (0.2% of deployable output).	Water Resources Management Plan 2013
Adaptive capacity (list of available sources and drought measures)	A list of all our available sources is provided in WRP1a. This table provides information on whether each source is licence, hydrologically or infrastructure constrained. Nearly half of our sources are hydrologically constrained making them particularly susceptible to the impacts of climate change. Appendix 8.3 of our Drought Plan (2017) screened each of our sources for 'adaptive capacity' in terms of whether they would be suitable for drought permit options. This process identified five options in the context of drought planning.	WRP1a (Licences) Appendix 8.3 of Drought Plan – Drought Permit Option Screening
Sensitivity (Low medium or high)	Sources in the south of our area are particularly unaffected by drought as many of the sources are infrastructure or licence constrained (not hydrologically constrained). Reservoirs in the west of our area may be more susceptible to the impacts of climate change. They demonstrated greater variability in the impact on deployable output in climate change scenarios explored in our last Plan	Water Resources Management Plan 2014
Vulnerability classification	The magnitude versus sensitivity plot (see Figure 4-18) suggests our single resource zone is of low vulnerability to climate change	
Identify overall vulnerability and proposed climate change assessment approach	Given our low vulnerability status Tier 1 climate change assessment methods are adequate however, given that we have rainfall-runoff models available be have followed the Tier 2 approach. This method uses the 11 UKCP09 Spatially Coherent Projections to generate monthly climate change factors for precipitation and potential evapotranspiration in the 2080s, which have then been applied to rainfall-runoff model inputs to generate 11 sets of flow sequences and flow factors for each mode.	N/A

Figure 4-19 shows the magnitude-sensitivity plot of information from our previous Water Resources Management Plan – the change in deployable output for the median impact scenario is plotted against the uncertainty as represented by the range of change in deployable output (the difference between the maximum and minimum impact scenarios). The figure shows that the impact of the median impact climate change scenario on deployable output was low for both the dry year annual average and dry year critical period scenarios.

Figure 4-19: Magnitude-sensitivity plot of deployable output to climate change (dry year annual average- DYAA and dry year critical period-DYCP)



Given the evidence presented in Table 4-13 and Figure 4-19 the conclusion of our vulnerability assessment is that the Wessex Water region is at low risk from climate change.

4.9.2 Impact of climate change on river flows and groundwater levels

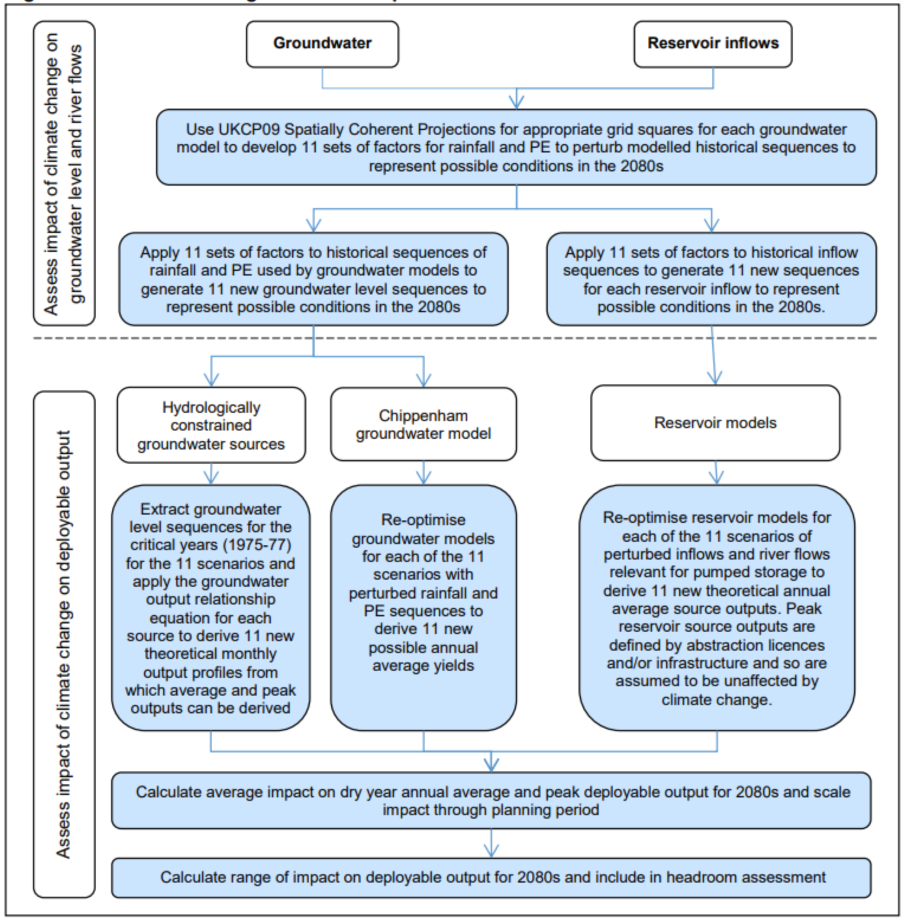
This section covers the assessment of the impacts of climate change on groundwater levels and river flows. Figure 4-32 shows how the analysis undertaken in this stage aligns with the subsequent stage of assessing impacts on deployable output. The impact of climate change is only assessed for sources that are hydrologically constrained; sources that are constrained by licence conditions or infrastructure are not subject to climate change analysis.

The supplementary guidance states that there are three tiers of analysis in order to calculate river flows to input into a water resources model, that may be adopted as a minimum:

- Tier 1 – if the vulnerability is low and there are no rainfall-runoff models
- Tier 2 – if the vulnerability is medium or there are available rainfall-runoff models
- Tier 3 – if there is high vulnerability

Whilst our vulnerability assessment suggests low vulnerability, we have adopted Tier 2, as we have rainfall-runoff models that were developed for inflow sequence calculation (Section 4.2.4). In this tier of analysis, we have used the 11 UKCP09 Spatially Coherent Projections (SCPs) to generate monthly climate change factors for precipitation and PET (potential evapotranspiration) in the 2080s, which have then been applied to rainfall-runoff model inputs to generate 11 sets of flow sequences and flow factors for each model. The ensemble of 11 data sets are all equally likely; they therefore enable us to investigate a range of potential future climates and their possible impact on water resources. The ensemble of 11 data sets are all equally likely; they therefore enable us to investigate a range of potential future climates and their possible impact on water resources. The uncertainty associated with future projections can be considered by evaluating the impacts of all ensemble members. We believe that taking the Tier 2 approach is proportionate for the risks from climate change faced by our supply area. We discussed our vulnerability assessment and proposed analysis methods with the Environment Agency during pre-consultation. This process is set out in Figure 4-19 below.

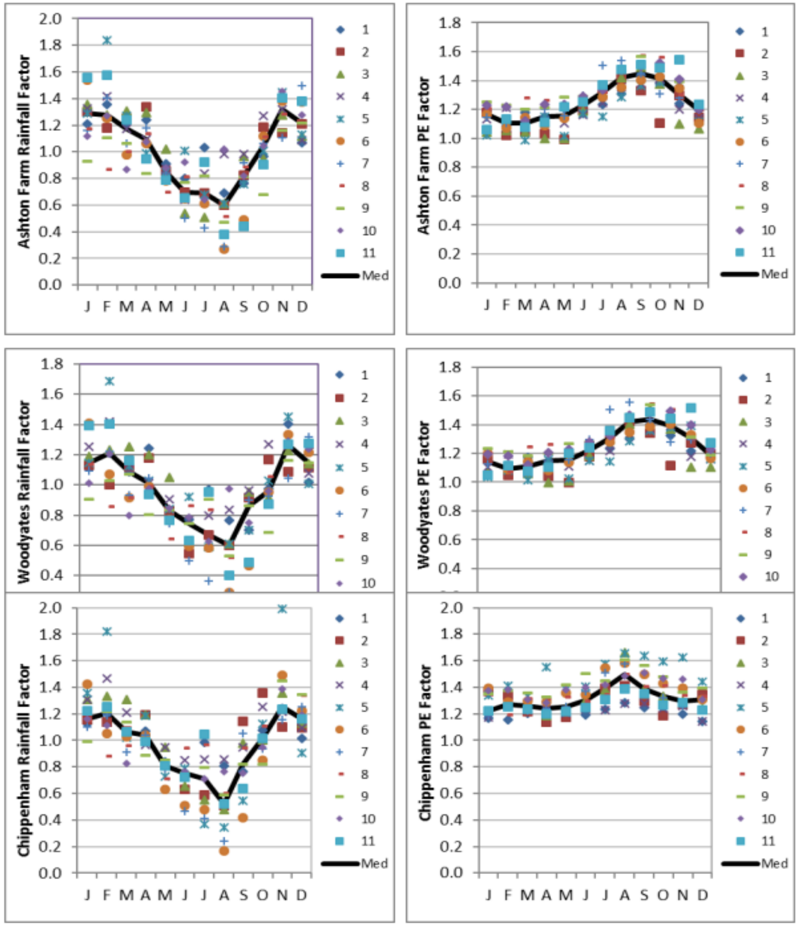
Figure 4-20: Climate change assessment process



Groundwater analysis

In this tier of analysis, we have used the 11 UKCP09 Spatially Coherent Projections (SCPs) to generate monthly climate change factors for precipitation and PET (potential evapotranspiration) in the 2080s. For each groundwater model and catchment model, the appropriate time-series of factors for precipitation and PET for the relevant grid cell(s) were selected from the SCPs and used to perturb model inputs, which were then run to evaluate the impact of climate change on groundwater levels and catchment discharge. Based on data provided in the SCPs, we applied the Hamon equation to derive PET. The rainfall and PET factors for Woodyates, Ashton Farm and Chippenham are shown in Figure 4-21 they indicate that in general (i.e. looking at the median values) the changes in rainfall PE are consistent with the expected warmer drier summers and milder wetter winters.

Figure 4-21: Rainfall and potential evapotranspiration factors for Woodyates, Ashton Farm and Chippenham groundwater models for 11 climate change scenarios



The 11 new groundwater level sequences for the 1975-77 critical period for Woodyates and Ashton Farm are shown in Figure 4-22 and Figure 4-23. The full historical record of groundwater level changes at Woodyates and Ashton Farm suggest that the levels in these locations vary between 67 and 105 mAOD (range of 37 m) and 63 and 72 mAOD (range of 8 m) respectively.

The figures below show that the climate change scenarios suggest the impact on maximum groundwater level in January 1976 may be of the order of magnitude -1 to -5 m for Woodyates (up to 13.5% of the maximum range) and up to -1 m for Ashton Farm (12.5% of the maximum range). There is less variability in the impact of the scenarios on groundwater levels around the critical period (August 1976) and the lowest drawdown point (September/October 1976). Figure 4-22:

Woodyates groundwater levels modelled for 11 climate change scenarios

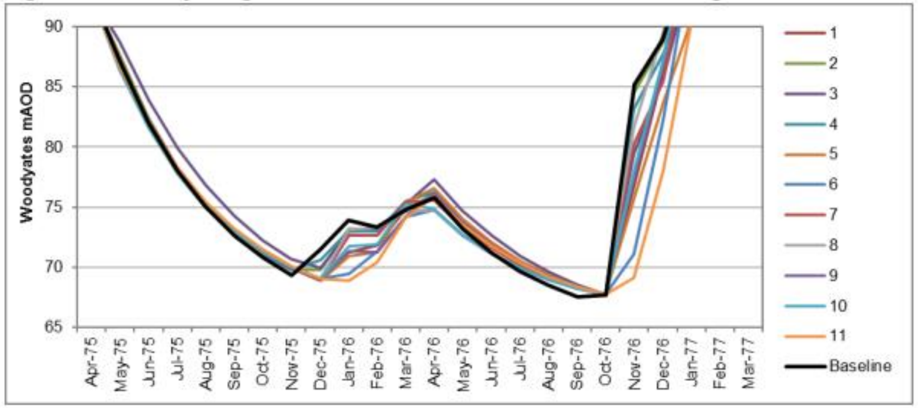
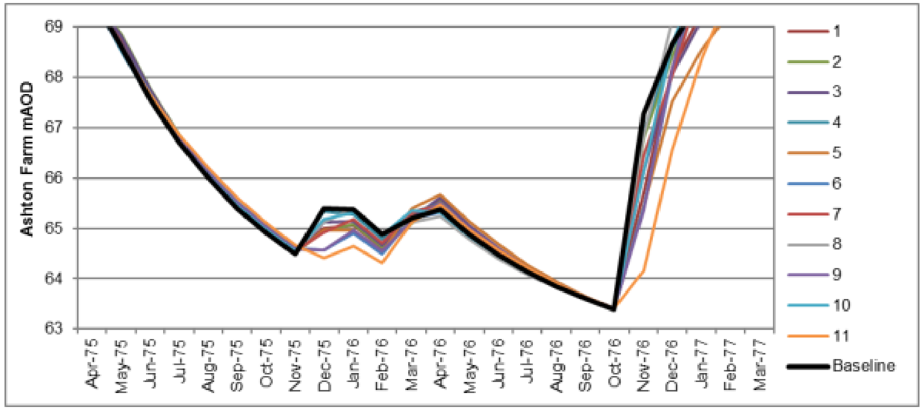


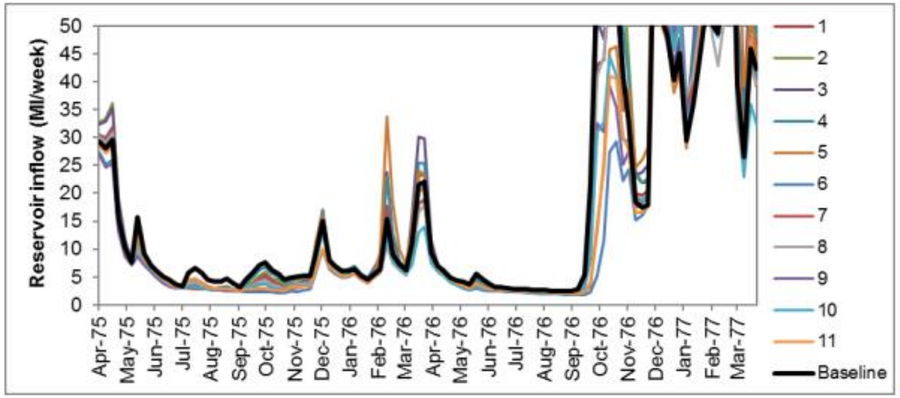
Figure 4-23: Ashton Farm groundwater levels modelled for 11 climate change scenarios



Reservoir inflow analysis

The method for obtaining river flows was the same as that applied as described in groundwater analysis, above. Figure 4-18 below shows the impact of the climate change scenarios on inflows to Durleigh Reservoir during the critical period of 1975-19176.

Figure 4-24: Inflows for Durleigh Reservoir under climate change scenarios



4.9.3 Impact of climate change on deployable output

This element of the climate change analysis uses the outputs of the assessment of impacts on groundwater levels and river flows to examine the potential impacts on the deployable output of the hydrologically constrained sources under the eleven scenarios. The analyses are undertaken as sensitivity tests against a baseline scenario of ‘no climate change’. Baseline deployable outputs are based upon yields available during 1975/76 (see Section 4).

As shown in Figure 4-24, the overall impact of climate change on average and peak deployable outputs are calculated from the combined outputs of three parallel analysis methods, which are applied depending on source type. The three methods are described below:

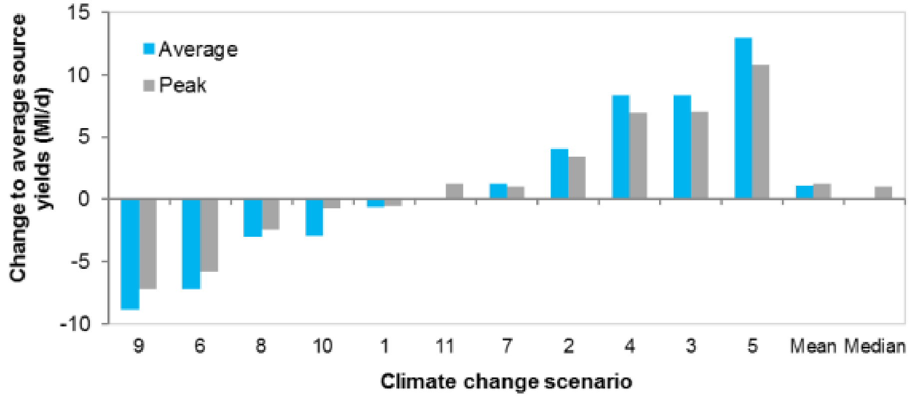
Hydrologically constrained groundwater sources
As outlined earlier in this chapter, 37 of our groundwater sources are hydrologically constrained (accounting for nearly 120 Ml/d and 30% of average deployable output) and their available output can be modelled using their output relationship equation against Woodyates or Ashton Farm (see Section 4.2.3). To assess the impact of climate change on the deployable output of these sources the 11 climate change perturbed groundwater sequences for Woodyates and Ashton Farm were used to calculate average and peak potential yields for the 1975/76 period for each source for comparison against their respective baseline. The ‘peak’ potential yield is that which would have been theoretically possible in August 1976 and the ‘average’ potential yield is the mean theoretically possible yield during the critical summer period (May-August 1976).

Figure 4-25 shows the overall impact on the hydrologically constrained groundwater source yields relative to the baseline condition for each of the 11 scenarios (ranked in order of impact), the mean and median impact.

The magnitude of the impact varies from -8.8 Ml/d to +12.9 Ml/d for average (approximately - 6% to +11% of the potential yield) and from - 7.2 Ml/d to +10.9 Ml/d peak (approximately - 6% to + 9% of the potential yield).

The mean impact of the 11 scenarios is a change in total average deployable output of +1.1 Ml/d and a change in total peak deployable output of +1.3 Ml/d. However, as the impact of the 11 scenarios is not normally distributed, a more representative measure of the most likely impact is given by the median value, which indicates a change in total average deployable output of -0.02 Ml/d and a change in total peak deployable output of -1.07 Ml/d by the 2080s.

Figure 4-25: Summary of impact of climate change scenarios on average and peak yields hydrologically constrained groundwater sources



'note the median change in Average is -0.02 Ml/d, so does not show on the figure

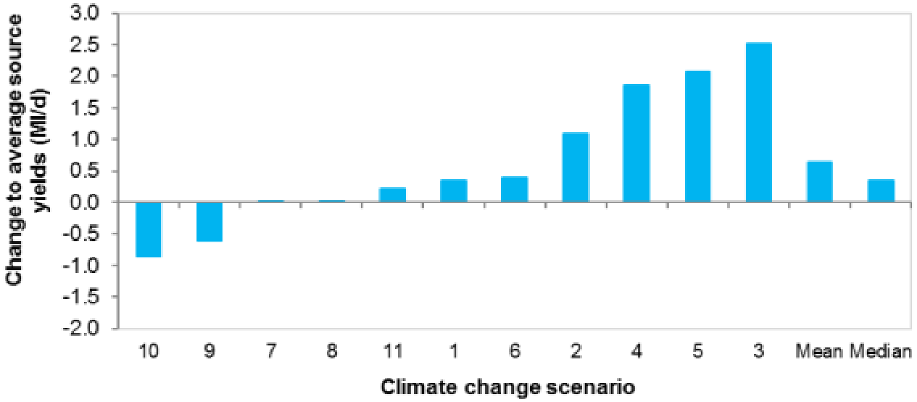
Chippenham groundwater model

Chippenham
Unlike most of our groundwater sources, our abstractions from the Chippenham aquifer can impact on the volume of storage in the aquifer. To model this effect we have a single point groundwater model, which we have used to model the effect of the 11 climate change scenarios relative to the baseline.

Like other 'reservoir' type sources we have assumed that climate change will not impact upon the peak deployable output; it is assumed that we would manage abstraction from the aquifer so that peak outputs in the future are maintained at the current level.

Figure 4-26 shows a summary of the modelling results of the impact on average yields for the 11 climate change scenarios relative to the baseline. It shows that two of the 11 scenarios suggest that the average yield will decline and the other nine scenarios all indicate a net increase in yield which implies the wetter winters will outweigh the effect of drier summers for this aquifer. Overall, the impact varies from -0.9 Ml/d to +2.5 Ml/d, with a mean of +0.60 Ml/d and a median value of +0.3 Ml/d.

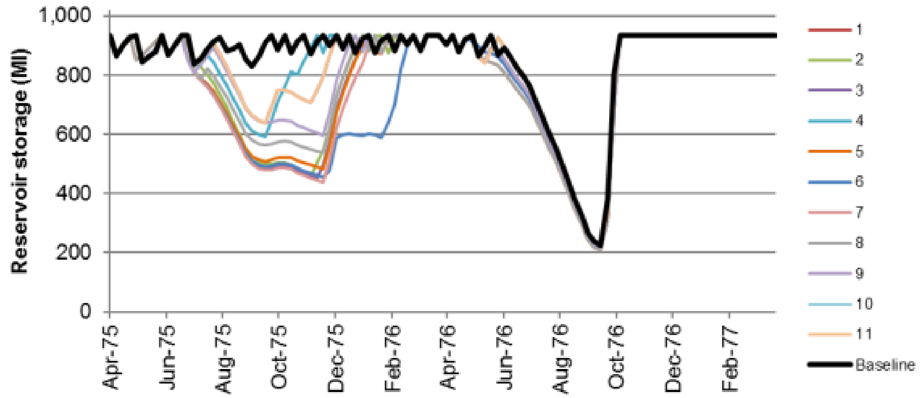
Figure 4-26: Impact of climate change scenarios on the average yield of the Chippenham aquifer sources



Reservoirs
Climate change is assumed to impact only on the average yield of a reservoir source; the peak output of these sources is defined by licence and/or infrastructure constraints which are assumed to remain constant and we would expect to manage abstraction through the year to ensure the peak output would be hydrologically possible.

To calculate the impact of the climate change perturbed inflows on the average yield of our reservoirs we re-optimised each reservoir model for each climate change scenario. The annual average yield is determined against a fixed condition relating to the maximum permitted drawdown (30 days of average yield/pote plus compensation flow). The drawdown profile for Durleigh Reservoir is shown in Figure 4-27.

Figure 4-27: Storage in Durleigh Reservoir under climate change scenarios



Figures 4-27, 4-28 and 4-29 show that under all scenarios and for all reservoirs there is a bias towards a reduction in average yield relative to the baseline. Two reservoirs (Clatworthy and Durleigh) indicate potential increases in yield under some scenarios.

Clatworthy shows the largest absolute yield reduction of up to -3.5 Ml/d under scenario 6, which similarly leads to reductions of -3.0 and -2.7 at Sutton Bingham and Ashford Hawkridge respectively. Durleigh and Fulwood reservoirs indicate lower absolute impacts and a smaller range.

Figure 4-28: Volumetric change in average yield relative to baseline by reservoir for 11 climate change scenarios

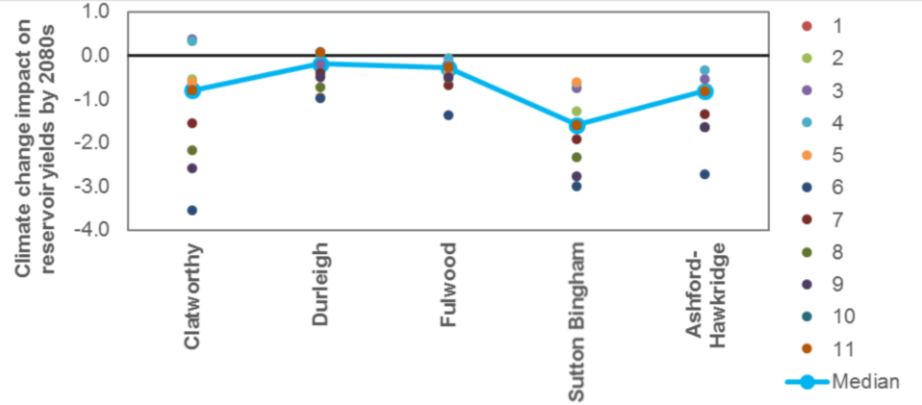


Figure 4-29: Percentage change in average yield relative to baseline by reservoir for 11 climate scenarios

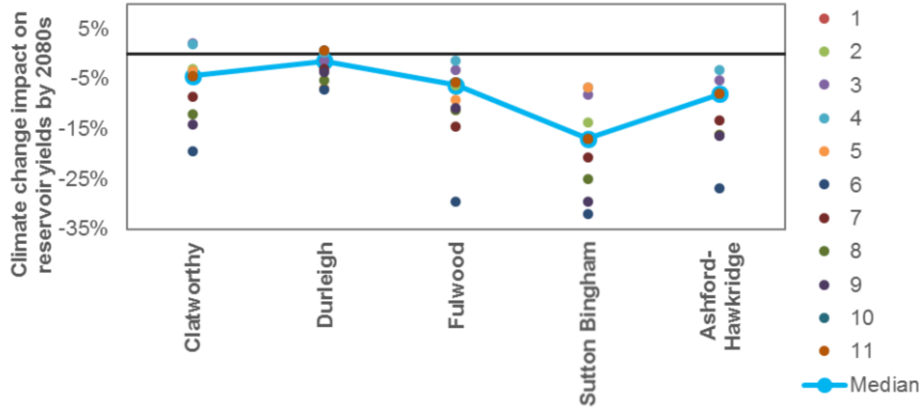
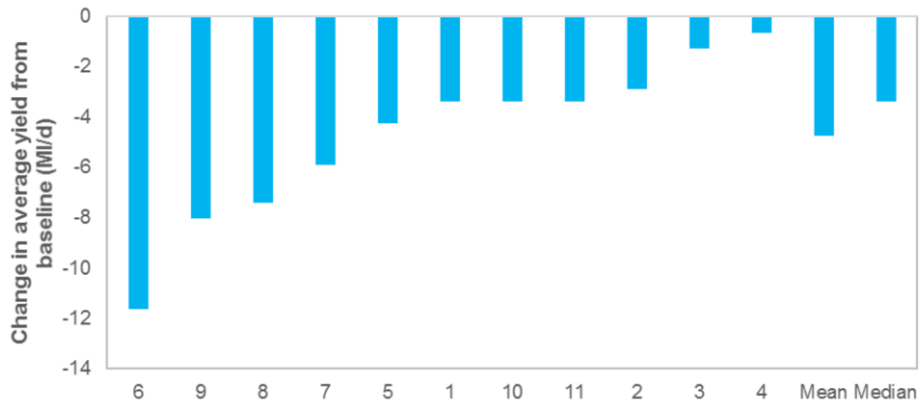


Figure 4-30: Combined change in average reservoir yields relative to baseline for 11 climate change scenarios



Summary of climate change impact on baseline deployable output

The impact of each climate change scenario on groundwater sources and reservoirs for average and peak conditions for the 2080s is shown in Table 4-15.

Scenario	Average				Peak
	Hydrologically constrained groundwater	Chippenham	Reservoirs	Total	Hydrologically constrained groundwater
1	-0.65	0.35	-3.39	**-3.69**	-0.53
2	4.10	1.08	-2.89	**2.29**	3.38
3	8.37	2.52	-1.27	**9.62**	7.02
4	8.33	1.86	-0.65	**9.54**	6.98
5	12.92	2.07	-4.26	**10.73**	10.78
6	-7.17	0.40	-11.64	**-18.41**	-5.81
7	1.29	0.01	-5.92	**-4.61**	1.07
8	-3.03	0.01	-7.40	**-10.41**	-2.46
9	-8.83	-0.60	-8.02	**-17.45**	-7.17
10	-2.95	-0.86	-3.39	**-7.20**	-0.70
11	-0.02	0.21	-3.39	**-3.20**	1.29
Mean	**1.12**	**0.64**	**-4.75**	**-2.98**	**1.26**
Min	**-8.83**	**-0.86**	**-11.64**	**-18.41**	**-7.17**
Max	**12.92**	**2.52**	**-0.65**	**10.73**	**10.78**
Median	**-0.02**	**0.35**	**-3.39**	**-3.69**	**1.07**

The 11 scenarios all have equal probability of occurrence. Given that the range of results are not normally distributed we have chosen to use the median impact of the 11 scenarios for the baseline supply forecast and the variability is accounted for within the headroom assessment.

Overall therefore, the baseline impact of climate change in the 2080s is estimated at -3.69 Ml/d on average (1% of base year deployable output) and +1.07 Ml/d for the peak scenario (0.2% of base year deployable output).

4.9.4 Scaling the impacts through the planning period
The change in deployable output calculated for the 2080s is scaled by generating a multiplier for each year of the planning period that assumes the impact of climate change in 2085 began from a base of no impact in 1975.

The scaled change in deployable output is included in Table WRP2 BL Supply, and summarised in Table 4-16

Table 4-16: Central estimate of the impact of climate change on deployable output

	2016/17	2019/20	2024/25	2029/30	2034/35	2039/40	2044/45
Dry Year Annual Average impact of climate change (Ml/d)	-1.41	-1.51	-1.68	-1.85	-2.01	-2.18	-2.35
Dry Year Critical Period impact of climate change (Ml/d)	0.41	0.44	0.49	0.53	0.58	0.63	0.68

4.9.5 Uncertainty and headroom

The variety in impact shown by the 11 scenarios illustrates that the future impacts of climate change remain uncertain. We have accounted for this uncertainty in our planning by incorporating the impact of all 11 scenarios in our headroom assessment – please see Section 6 for details.

5.5 Household water consumption

5.5.6 Impact of climate change on household demand

The latest UKCP09 forecasts predict that by the 2050s average summer temperatures may be 2-4°C warmer and summer rainfall will be 10 – 30% lower. However, it is also likely from our climate change analysis (Section 4.10) that we will experience wetter winters on average in the future. Whilst the impact of climate change on water consumption is uncertain, the relationship between weather and demand (Section 0), and in particular increased personal washing and garden water use in warmer drier periods, suggests water consumption patterns may alter with climate.

In 2013 UKWIR published a study on the impact of climate change on water demand, which examined the relationships between water use and weather variations for five case studies – including overall household consumption, micro-component consumption patterns and non-household consumption.

Of particular interest for our forecasts were the household water consumption case studies that were developed from household monitor datasets obtained from Severn Trent Water and Thames Water. The weather demand relationships were combined with climate projection data from UKCP09 to develop a set of regionally based look-up tables to estimate the future impacts of climate change on household demand. A range of percentiles were produced for each year between 2012 and 2040 to reflect the uncertainty associated with the climate change projections.

Table 5-12 summarises the outputs from the study for a selection of years through the planning period. Taking the 50th percentile as a central estimate of the impact of climate change suggests that demand will increase by 0.68 % and 0.99% over the planning period as a result of climate change depending on whether the Severn Trent Water or the Thames Water model is used.

Table 5-12: Estimates of climate change impacts on domestic demand (% change relative to base year) for south-west England. Reproduced from UKWIR (2013)

	2011/12	2014/15	2019/20	2024/25	2029/30	2034/35	2039/40
Severn Trent Water model							
P10	0.00	0.04	0.11	0.18	0.24	0.31	0.38
P50	0.00	0.11	0.28	0.46	0.63	0.81	0.99
P90	0.00	0.18	0.47	0.77	1.06	1.35	1.65
Thames Water model							
P10	0.00	0.02	0.05	0.10	0.14	0.17	0.21
P50	0.00	0.07	0.17	0.32	0.44	0.56	0.68
P90	0.00	0.13	0.31	0.58	0.80	1.03	1.25

The two models suggest broadly similar impacts. We selected to use the Severn Trent outputs for our forecasting because they ensure we incorporate the marginally larger factors in our planning.

Our central demand forecast applied the 50th percentile uplift factors to both measured and unmeasured households; the 10th and 90th percentile impacts were used in our headroom analysis to account for the uncertainty around the climate change projections. Whilst these figures were produced for the 2011/12 to 2039/40 period, we have applied them to the 2016/17 to 2044/45.

Table 5-13 presents total and per capita consumption for key years for measured and unmeasured households to demonstrate the impact of climate change being included in the baseline planning forecast. It shows that by the end of the planning period the increase in overall consumption resulting from climate change amounts to 1.7 Ml/d (measured and unmeasured combined) representing a very small proportion of overall distribution input (c. 0.5%).

In accordance with the planning guidelines, no adjustment has been made to peak demands to account for climate change.

Table 5-13: Changes to per capita and overall household consumption (baseline forecast) with climate change. (NYAA = normal year annual average)

Customer type	Demand category	2017/18	2024/25	2044/45
Measured household	NYAA PCC without CC (l/h/d)	120.8	121.5	122.2
	NYAA PCC with CC (l/h/d)	120.9	121.8	123.4
	NYAA consumption without CC (Ml/d)	90.11	118.1	155.3
	NYAA consumption with CC (Ml/d)	90.14	118.4	156.0
Unmeasured household	NYAA PCC without CC (l/h/d)	143.7	146.1	157.5
	NYAA PCC with CC (l/h/d)	143.8	146.5	151.2
	NYAA consumption without CC (Ml/d)	78.5	57.4	31.7
	NYAA consumption with CC (Ml/d)	78.5	57.6	32.1
Total household	Increase in demand due to climate change (Ml/d)	0.0	0.5	1.9

We are currently supporting research projects to improve our modelling of the relationship between weather and demand (Section 12.2). Such models may subsequently be driven with climate forecast changes to weather conditions in the future (e.g. Table 4-13), to revise our predictions of climate change impacts on demand.

Section 9.10 describes that our preferred options for the final planning scenario include leakage reduction, increased optional metering, and water efficiency activities. The impact of climate change on the metering and water efficiency options are inherently accounted for in the percentage uplift that we apply to household demand. The uplift is applied to consumption in both the baseline and final scenarios.

Table 5-14 shows the impact of climate change on each of the final plan demand options. As the baseline demand forecast is larger under a scenario with climate change, so the savings associated with implementing demand reduction options are also larger. Although the impact is very small, with a total difference of -0.05Ml/d. We do not expect any implications of climate change on leakage reduction.

Table 5-14 Impact of climate change on final plan demand options*

Option	Option name	2017/18	2019/20	2044/45
M1a	Enhanced Metering	0.00	0.00	0.00
WE1	Home Check	0.00	0.00	-0.04
WE2	Customer Engagement Dashboard	0.00	0.00	-0.01
ALY	15% reduction in leakage by 2025	0.00	0.00	0.00
Total	Total	0.00	0.00	-0.05

*the impact of climate change in enhanced metering is not zero, but too small to be shown at two decimal places.

Appendix 7 Other considerations (additional points)

Monitoring & evaluation

Water supply data is scrutinised and yield reductions since previous assessments are monitored, but not all changes in yield can or should be attributed to climate change on timescales of only a few decades: weather variability, hydrometric monitoring improvement and data management may also have an influence.

Any new flooding is assessed and the viability of implementing flood alleviation schemes is considered on a case-by-case basis. Linking cause and effect is not straightforward in terms of flooding and sewerage as there are many factors that contribute; for example, land use change, urban development, and maintenance of watercourses as well as weather and climate-related impacts.

Interdependencies

UK infrastructure - energy, transport, information and communications technology (ICT), water and wastewater - is highly interconnected and interdependent. Failures of one type due to extreme weather will have rapid knock-on effects for the others. Similarly, the multi-agency nature of climate risk is very evident for specific issues such as surface water management, which involves liaison with councils, Internal Drainage Boards and the Highways Agency.

We are heavy users of other utilities, in particular electricity and telecommunications. Their reliability is very important to us and interdependencies between utilities were very evident during the 2007 floods. The transmission and distribution sector is working to reduce flood risk among other potential climate impacts and the Committee on Climate Change in 2014 summarised its work and ongoing risks in its report to Parliament on progress in preparing for climate change. Their findings included the following:

- The electricity transmission and distribution companies have agreed business plans with Ofgem to address river and coastal flooding risks by the early 2020s and are transparently taking steps to improve flood protection levels for critical substations
- Five large power stations, 40 electricity transmission substations (9% of the total), and 57 major electricity distribution substations (1% of those with a voltage of between 6.6 to 132 kV), are located in areas at a high likelihood of flooding after accounting for the presence of flood defences.
- Three power stations were shut down during the severe weather in the winter of 2013/14, losing 193GWh of production (less than 0.3% of the power generated over the period). However, power cuts caused by power station outages are rare.
- The number of large power stations in areas of high flood risk is expected to increase to 11 by the 2050s, as a result of climate change. The number of electricity transmission and distribution substations in areas at a high likelihood of flooding is expected to increase by 35% and 77% respectively.

More recently the 2021 independent assessment of climate change risk outlined its view of key risks for other infrastructure sectors, including the following among the key messages:

Energy	Telecoms and ICT	Transport
• All energy-related infrastructure is at risk from the impacts of climate change, especially due to the changing frequency and intensity of surface water and coastal flooding. • High and low temperatures, snow and ice, high winds and lightning can all cause disruption to the energy network. The future risks from wind and lightning are more uncertain than for other hazards. • There are also risks to buried infrastructure such as gas pipelines, with damage potentially becoming more frequent in future due to flooding (affecting bridges that carry pipelines) and subsidence. • The potential for reduced water availability in future could reduce output of thermal power generators and potentially biomass and gas power output.	• There is increasing available evidence of the impacts of weather-related events on ICT and telecoms, including damage to assets, power failures, and poorer performance due to heavy rainfall or temperature extremes and fluctuations. • The risk of telecoms and ICT infrastructure being directly affected by flooding is lower than the risk to other infrastructure types such as energy assets, but disruption caused by flooding of the latter could indirectly cause telecoms and ICT outages. High temperatures are of greater concern.	• Transport regularly faces climate challenges from flooding, heat, erosion, subsidence and extreme weather. As the climate continues to change, the severity of these risks is projected to increase. • The interconnected nature of infrastructure systems means that impacts on transport networks can quickly disrupt other areas, for example by preventing the operation or repair of other critical infrastructure assets • Impacts on other infrastructure sectors can cascade into transport failures.

We have some contingency measures in place, such as our numerous standby power generators which can be deployed at short notice. This includes both permanent generators as key locations and smaller generators which can be moved from one location to another.

Due to these interdependencies, close co-operation is vital. This is well established for emergency response practices - it is important that there are good working relationships with local authorities, emergency services and business partners such as suppliers and contractors, who may themselves be affected by intense weather events. We are an active member of the three Local Resilience Forum groups operating in our region (Avon & Somerset; Wiltshire & Swindon; and Bournemouth, Dorset & Poole), with representation at executive and business management group level. The water sector itself has a protocol for sharing resources and a mutual aid scheme through which companies co-operate during emergencies.

Customers’ needs and expectations are a critical concern and we routinely keep track of how these are evolving. We will be expected to provide excellent service regardless of weather conditions and also to make allowance for climate change in our planning. We need to effectively communicate our approach to dealing with climate stresses and shocks and need the goodwill of our customers and the help of the media to have the greatest chance of successful adaptation.

We continue to build links with land users, particularly through our catchment management work. This is needed especially for protecting drinking water sources that are vulnerable to a combination of farm inputs (e.g. nitrates and pesticides) and heavy rain. Communication to understand each others' activities and needs is important for maintaining the resilience of individual water sources and maintaining security of supply.

Co-operative working relationships with government and our regulators are also essential for our day-to-day activities and longer-term planning alike. This is equally true for climate change – we need to explain our understanding of likely impacts in our region and produce well-reasoned cases for investment where we believe it is necessary.

Barriers

Pricewaterhouse Coopers 2010 report "Adapting to climate change in the infrastructure sectors", found that the main challenge for the water sector is a lack of consensus in how to apply knowledge of climate risks for planning and regulatory purposes. It notes that some adaptation deals with impacts that might not actually occur within a 25-year planning horizon and that it can be difficult to identify the willingness, or obtain the consent, of customers to pay now for future resilience.

Cost and benefits of measures

The agreed costs of adaptation measures are not included in this report for reasons of commercial confidentiality.

Sector policy and regulation

Duties conferred by the 2014 Water Act on Ofwat and the Defra Secretary of State:

- to secure the long-term resilience of water undertakers' supply systems and sewerage undertakers' sewerage systems as regards environmental pressures, population growth and changes in consumer behaviour; and
- to secure that undertakers take steps for the purpose of enabling them to meet, in the long term, the need for the supply of water and the provision of sewerage services to consumers;

including by promoting:

- appropriate long-term planning and investment by relevant undertakers; and
- the taking by them of a range of measures to manage water resources in sustainable ways, and to increase efficiency in the use of water and reduce demand for water so as to reduce pressure on water resources.

This duty provides additional context for further climate change adaptation activity in our sector. How the duty is to be implemented is currently under discussion; it is apparent that Ofwat will look to the water companies to put forward fully evidenced and cost-beneficial plans.

Appendix 8. UK Water Industry Research climate change adaptation projects

2010-11

Water treatment and climate change
An assessment of the impact of climate change on catchment water quality and environmental conditions and the implications that may have for water quality, treatment and treatment processes, optimisation / rationalisation strategies, source protection (quantity and quality) with a view to developing a framework for “no / low regrets”, sustainable asset strategies in the context of developing carbon constraints.

Wastewater treatment and climate change
Transposing the potential effects of climate change into robustly defined impacts on wastewater treatment processes and services, and designing an appropriate response to those impacts for government, the industry, and its regulators.

2011-12

Impact on climate change on asset management planning
The impact of climate change will affect companies’ investment plans. Maintaining the asset performance and customer service will be an issue if like for like replacement continues.

Impact of climate change on source yields
With the Environment Agency, a project to develop the detailed methodologies required for water resources and business plans to produce a methodology that can be used to assess the impact of climate change on source yields.

2012-13

Practical methodologies for monitoring and responding to the impacts of Climate Change on industry treatment processes.
Providing a mechanism by which critical climate sensitive treatment process thresholds may be established, monitored and assessed; and to provide an evidence base from which adaptation actions may be taken that will be justifiable to regulators and other stakeholders.

Updating the UK Water Industry Adaptation Framework
Updating and enhancing the UK water industry adaptation framework, and associated guidance.

2014-15

Rainfall intensity for sewer design
Examined predicted changes in the type of UK rainfall important for sewer design using climate simulations and climate analogues (international locations with current climates similar to the ones predicted for the UK). It recommended uplift factors for current design storms for use in predicting future sewer flooding patterns; examined international sewerage design and stormwater management approaches; and provided guidance on appropriate provision for climate change in any new sewer systems or near-term infrastructure enhancements. Stage 2 (2017) used a new Met Office 1.5km climate length model simulation of the United Kingdom, with a view to resolving convective processes that produce the heavy rain seen in all seasons which affects the functioning of urban drainage systems.

Planning for the mean or planning for the extreme
Established a stronger understanding of the quantitative links between weather – in particular extreme weather events - and a broad range of performance issues, based on present day and historic data.

2017

Drought Vulnerability Framework
Provides a framework of methodologies to enable water companies to better understand the vulnerabilities of their water resource zones to drought. It builds on the concept of the Drought Response Surface (DRS) originally derived for the Environment Agency 'Understanding the Performance of Water Supply Systems during Mild to Extreme Droughts' study.

Resilience – performance measures, costs and stakeholder communication
Focusses on the service provided by the water supply and wastewater sectors and how aspects of resilience of that service could feed into Periodic Review 2019. The work also draws on the parallel work of the Water and Wastewater Resilience Action Group (WWRAG).

2018

Climate change modelling and the Water Resources Management Plans
Demonstrated how new climate change evidence can be considered in a proportionate, targeted and system specific manner. Included an online tool to enable practitioners to quickly evaluate new climate change evidence and identify any scenarios for subsequent analysis, and to rapidly evaluate how the UKCP18 projections compare to the UKCP09 projections in the context of their system's vulnerabilities. It also examined current methods for scaling climate change impacts through the WRMP planning period and recommended their review in advance of WRMP 2024 to better reflect the likely non-linearities of system response to climate exposure.

2019

WRMP 2019 methods – risk-based planning
As part of the UKWIR WRMP 2019 Methods Programme, the Risk Based Methods Project was commissioned to provide practitioners with a new set of tools with which they can evaluate supply, demand and investment risks and incorporate them into the WRMP decision making process.

2020

Developing management strategies for increasingly frequent algal blooms in source waters
Assesses the potential for prediction, the implications of climate change, and potential for better management, through a process of literature review, data collation and analysis, and the investigation of predictive methods. A literature review provided the background for the development of an approach and tools. Data collected from the steering group were analysed and a predictive tool was developed.

Modelling a dynamic and uncertain future – preparing SAGIS for changes in climate, PR24, RBMP Cycle 3 and Brexit
A project to improve confidence in model-based asset planning and decision making by enhancing SAGIS-SIMCAT through scoping studies, research, investigations, and the development of new tools and data to improve the robustness of the modelling system

2021

Integrating UKCP18 with UKWIR tools and guidance: review of existing methods
Identified past UKWIR research which need to be updated following the publication of UKCP18 projections and recommended a programme for those updates. Included a review of UKCP18 projections in the context of water resource planning and drought and surface water management and change in extreme and seasonal rainfall; and a review of existing methods and tools that could be affected by the new projections.

Appendix 9. Related information

Flood zone maps Environment Agency	• Maps indicate the extent of a flood, based on the best estimate of the areas of land at risk of flooding, when the presence of flood defences are ignored • Three flood zones are shown, ranging from zone 1 covering land with a less than 1 in 1,000 annual probability of river or sea flooding, to zone 3 covering land with a 1 in 100 (1%) or greater chance of flooding each year from rivers; or with a 1 in 200 (0.5%) or greater chance of flooding each year from the sea.
Warming to the Idea South West Climate Partnership 2003, 2010	• A scoping study for the region of potential climate change impacts. The second edition was produced to take UKCP09 projections into account.
Regional Flood Risk Appraisal South West Regional Assembly, 2007	• This was required by government guidance PPS25. It aimed to influence housing and employment, identify where flood risk management measures may be functional and direct development away from areas at highest risk of flooding. • The Somerset Levels and Moors, Avonmouth, Weston-super-Mare, Bridgwater, Taunton, Weymouth and Christchurch, Bournemouth & Poole were identified as having significant flood risk.
Water sector climate change risk assessment MWH for Water UK; HR Wallingford / UKWIR 2008, 2012	• This assessment considered temperature, drought, flooding and sea-level rise impacts for the full range of water sector asset types. Climate impacts, associated risks and potential adaptation responses were set out. • This work forms that basis for our high-level climate change risk assessment.
Changes in the frequency of extreme rainfall events for selected towns and cities Met Office for Ofwat 2010	• This study projected changes in the frequency of extreme rainfall events for selected towns and cities. These are based on UKCP09 outputs, using the medium emissions scenario.
Adapting to climate change in the infrastructure sectors PricewaterhouseCoopers 2010	• Explores the implications of climate change impacts for energy, water, transport and ICT, both for existing infrastructure and for future investment. • Examines the role of government and regulators in encouraging action on adaptation to climate change, to maintain robust and resilient infrastructure systems.

Adapting Energy, Transport and Water Infrastructure to the Long-term Impacts of Climate Change URS for Defra 2010	• A vulnerability assessment using the same asset categories as the MWH / Water UK study • Precipitation impacts were highest, with gradual and sudden impacts on water infrastructure expected throughout the 21st century. These include reduced security of supply due to changing precipitation patterns & drought periods; increased fluvial flooding of water supply and wastewater assets; increased pluvial flooding of sewerage; and increased pollution incidents
Future Flows and Groundwater Levels CEH 2010-2012	• An assessment of the impact of climate change on river flows and groundwater levels across England, Wales and Scotland. It used projections from the UK Climate Impact Programme, including the UKCP09 probabilistic climate projections. • FFGWL developed two unique datasets for Great Britain (Future Flows Climate and Future Flows Hydrology) that represent a nationally consistent ensemble of 11 plausible realisations (all equally likely) of almost 150 years of climate, river flow and groundwater regime, and enable investigation of the role of climate variability on river flow and groundwater levels nationally and how this may change in the future.
Keeping the country running: natural hazards and infrastructure Cabinet Office 2011	• The guide for infrastructure owners and operators, emergency responders, industry groups, regulators, and government departments, to work together to improve the resilience of critical infrastructure and essential services. • Advice is provided on risks from natural hazards; standards of resilience; business continuity and corporate governance; guidance for economic regulated sectors; information sharing; and dependencies
Future Impacts on Sewer Systems in England and Wales, Mott Macdonald for Ofwat 2011	• A study of the change in sewer flooding that may result from climate change, increasing drained area (creep), and new population and housing (growth) up to about 2040. It used mathematical models of sewer networks, which the companies use to analyse performance and to inform future investment plans. • The median increase in sewer flooding has a 5% increase attributable to population growth, 12% to property creep and 27% to climate change
UK Climate Change Risk Assessment, UK Government 2012, 2017	• This report fulfils the requirement of the Climate Change Act 2008 for the Government, every five years, to assess the risks for the UK of the current and predicted impacts of climate change. • The 2017 edition outlines the UK and Devolved Governments' views on the key climate change risks and opportunities that the UK faces today - informed primarily by an independent assessment of the available evidence on climate risks and opportunities from the Adaptation Sub-Committee of the Committee on Climate Change (see above).

National Adaptation Programme, UK Government 2013, 2018	• Sets the actions that government and others will take to adapt to the challenges of climate change in the UK. It sets out key actions for the subsequent five years. • The 2018 edition is divided into chapters on natural environment, infrastructure, people and the built environment, business and industry, local government, and adaptation reporting.
5th and 6th assessment reports, Intergovernmental Panel on Climate Change (IPCC) 2014, 2021	• The IPCC prepares comprehensive Assessment Reports about knowledge on climate change, its causes, potential impacts and response options. Projections are based on trajectories for the concentration of greenhouse gases in the atmosphere (Representative Concentration Pathways) • Evidence is assembled by three working groups focused on the physical science basis; impacts, adaptation and vulnerability; and mitigation of climate change.
Independent Assessment of Climate Change Risk, Climate Change Committee (Adaptation Sub-Committee) 2017, 2021	• The second and third reports, which set out the priority climate change risks and opportunities for the UK. The findings act as statutory advice to Governments on priorities for the subsequent national adaptation plans and wider action. • The 2017 Evidence Report sets out six priority areas needing urgent further action. The 2021 report identifies eight risk areas that require the most urgent attention and reports on 61 specific risks and opportunities
Water Industry Strategic Environmental Requirements, Environment Agency & Natural England 2017	• Describes the environmental, resilience and flood risk obligations that water companies must consider when developing business plans • On climate change, includes a) expectations in relation to adaptation reporting and greenhouse gas emissions reduction; and b) good practice in relation to improving understanding of the risks of climate change to the natural assets that water companies rely on; taking into account the impacts of climate change on assets, services and activities; incorporating climate change in water resources management plans and flood risk assessments for new developments; ensuring services are resilient to the increasing frequency of severe weather events; and effective energy management.
UK Climate Projections (UKCP) Met Office Hadley Centre 2009, 2018	• The 2018 projections provided updated and upgraded climate projection tools designed to help decision-makers assess their risk exposure to climate out to 2100. • UKCP18 includes updated projections of how temperatures, rainfall, cloud cover and humidity could change in the coming decades, as well as forecasts for how far sea levels around the UK could rise.
PR24 and beyond: long-term delivery strategies and common reference scenarios Ofwat 2021	• A discussion paper that details Ofwat's approach to long-term delivery strategies at the 2024 Price Review. It sets out Ofwat's expectations for what companies should include in their long-term delivery strategies as part of their business plan submissions • Includes a section on climate change with guidance on planning assumptions to be used by companies (specifically UKCP18 projections under the RCP2.6 and RCP8.5 scenarios, at the 50th probability percentile).