WESSEX WATER'S SECOND REPORT TO DEFRA UNDER THE CLIMATE CHANGE ADAPTATION REPORTING POWER

August 2015

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 each poses for our business and the adaptation options that we have in place or propose.

It is published as an update to report that we produced in 2011 under Defra's adaptation reporting power that was introduced with the Climate Change Act 2008. The report is in two main parts: an overview and a set of technical appendices.

Contents

1. Wessex Water, our region and our climate

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 aims are to provide customers with excellent affordable services, to protect and improve the environment, to be a great place to work in which all employees can reach their full potential, and to give our investors a good return.

Wessex Water is the leading water and sewerage company 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.

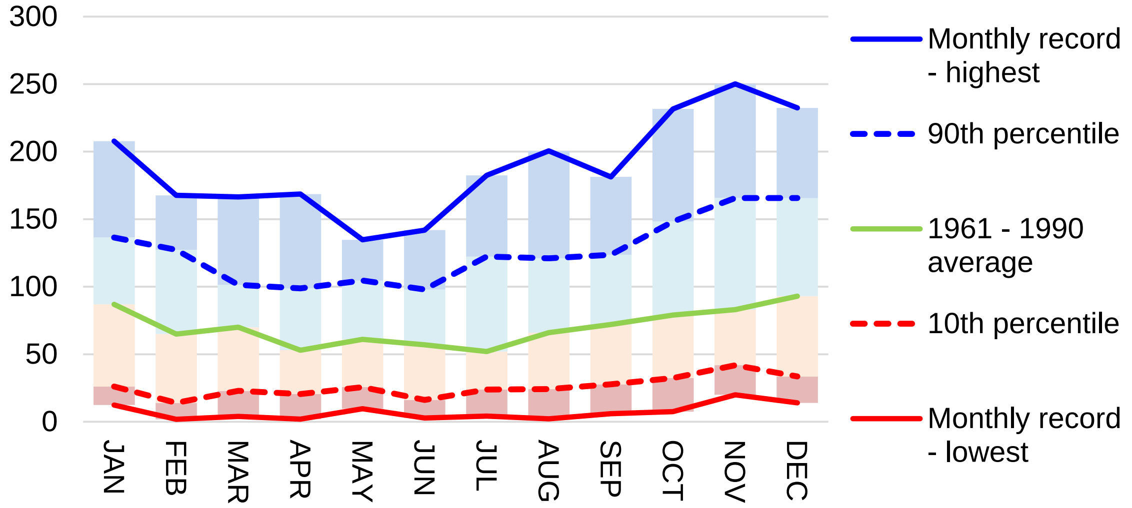
We treat and supply	We take away and treat
280 million litres of water a day to 1.3 million customers (on average over a ton of water to every customer weekly)	470 million litres of sewage from 2.7 million customers every day
We have	**We have**
209 water sources & water treatment works 209 booster pumping stations 300 service reservoirs and water towers 11,600 kilometres of water mains	34,500 kilometres of sewers 407 sewage treatment works 1,600 sewage pumping stations

We are a long term business. This is demonstrated by our sustainability vision which explains what a genuinely sustainable water company would look like in relation to the environment, our stakeholders and our staff, our physical assets and our finances, and our business plan which sets out our strategy to 2020 and beyond for improving our services to customers and the environment. 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.

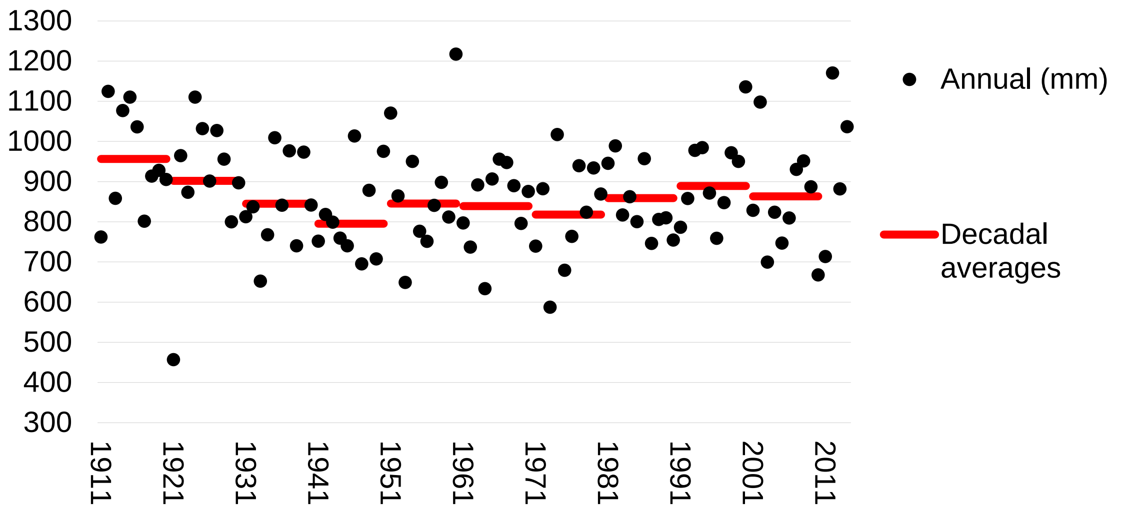
Our climate

As our services and operations are affected by weather patterns, climate change needs to be accounted for in our long term planning. Monthly rainfall records (measured by the Environment Agency's gauges spread across our region) allow us to compare current episodes, such as droughts and prolonged wet weather, with long term averages. They also allow us to compare the projected effects of climate change with past conditions. Annual average precipitation in our region is 870mm for 1911-2014 and 838mm for 1961-1990 - the period used for UK Climate Projections to represent the current average climate. The graphs below show monthly and annual rainfall; seasonal rainfall graphs are shown in appendix 2 of the supporting information.

Monthly precipitation (mm) 1961-1990 average and 1911-2014 range

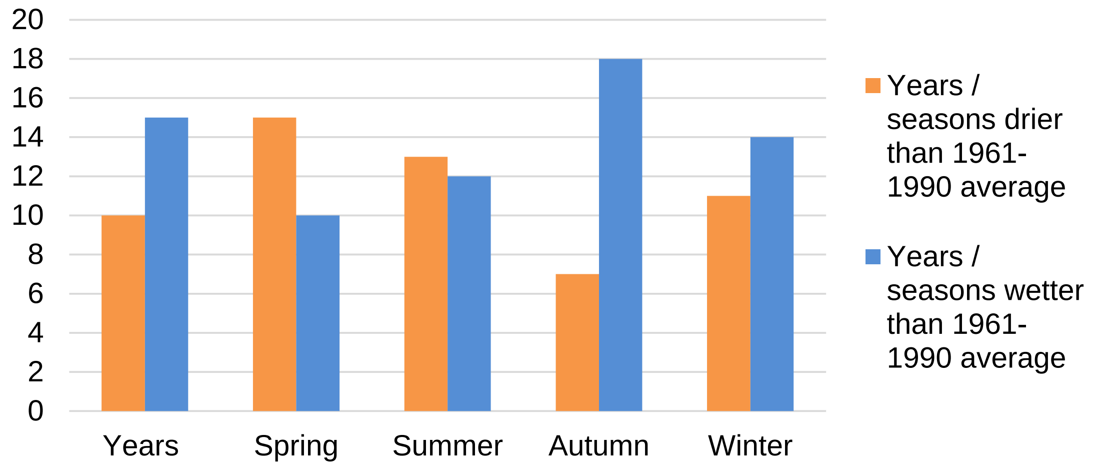


Annual precipitation (mm) since 1911



Comparing seasonal rainfall since 1990 with their respective averages for 1961-1990, the most marked change is the greater frequency of wet autumns. Aside from this, there is no clear sign yet of seasons becoming markedly wetter or drier on average.

1990-2014 years and seasons compared with the 1961-90 reference period



Region-wide seasonal and monthly data does not yet indicate extreme rainfall or dryness becoming more frequent either. This is particularly the case for dry conditions, with only four seasons since 1990 having less than 60% of their 1961-1990 average rainfall. The frequency of wet seasons has not changed notably either compared with the 20th century, although two seasons (autumn 2012 and winter 2013-14) in the last three years had more than double the average of the 1961-1990 period. We acknowledge though that monthly and seasonal data would not necessarily reveal changes to the frequency of extremely wet rainfall at the daily or hourly scale. Either way, during the last four years we experienced a sequence of unusual weather, some of which could be called 'extreme'. A prolonged dry period affected southern England from October 2010 to March 2012, leading to water use restrictions in the south east of the country and an environmental drought in the south west. This was followed by the wettest summer in our region since 1911 and a very wet end to the year. Then, while most of 2013 was not unusual, December 2013 to February 2014 was the wettest three month period in the last one hundred years. These are included in the summary below:

Weather extremes since 1990

Rainfall extremes	Event	Rainfall compared to 1961-90 average
Winter 1989-90	Heavy rainfall	188%
Winter 1993-94	Heavy rainfall	167%
Winter 1994-95	Heavy rainfall	171%
Summer 1995	Drought	22%
Autumn 2000	Heavy rainfall, flooding	184%
Summer 2007	Heavy rainfall	160%
October 2010 to March 2012	Environmental drought	75%
April 2012 to Winter 2012-13	Heavy rainfall	154%
Winter 2013-14	Heavy rainfall, flooding	200%

Temperature extremes	Event
Summer 2003	Heatwave, dry conditions
Winter 2010	Cold snap

No droughts in recent years have led to water use restrictions in our supply area. Indeed, the drought in 1975-76 was the last time that hosepipe bans were imposed in the Wessex Water region, and this period remains the benchmark for our water resources planning. However, concerted responses have been required during or after unusual weather events, for example:

- Efforts to reduce leakage were stepped up following the drought in 1995, leading to annual leakage targets overseen by Ofwat
- The prolonged rainfall of summer 2007 required widespread emergency response and then led to a fundamental review of surface water management
- The heavy rainfall of 2012 and winter 2013-14 led to localised flooding of sites and the need for extensive work to remove rainwater from sewers which had been overwhelmed through groundwater infiltration.

2. Climate change projections

The global picture

The fifth assessment report of the Intergovernmental Panel on Climate Change, produced in 2013-14, 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:

- *"Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased*

- *"Human influence has been detected in warming of the atmosphere and the ocean, in changes in the global water cycle, in reductions in snow and ice, in global mean sea level rise, and in changes in some climate extremes. This evidence for human influence has grown since AR4. It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century."*

- *"Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions."*

- *"Changes in the global water cycle in response to the warming over the 21st century will not be uniform. The contrast in precipitation between wet and dry regions and between wet and dry seasons will increase, although there may be regional exceptions."*

UK Climate Projections

Like other water companies, we use UK Climate Projections (UKCIP02 and UKCP09) to help plan investment in water and wastewater. The 2009 edition gave probabilistic projections for individual 25km squares, using three different emissions scenarios (high, medium, low) across three time periods of the 21st century (2020s, 2050s and 2080s). Appendix 3 shows UKCP09 projections for the Wessex Water region for average winter rainfall, average summer rainfall, annual average daily temperature, average summer mean temperature and sea level rise. The table below shows the most likely 'central case' projections for our region across all three emissions scenarios and three time horizons. Compared with the baseline period of 1961-1990, we can expect the average summer to be drier and warmer, the average winter to be milder and wetter, and for extreme events to happen with greater frequency.

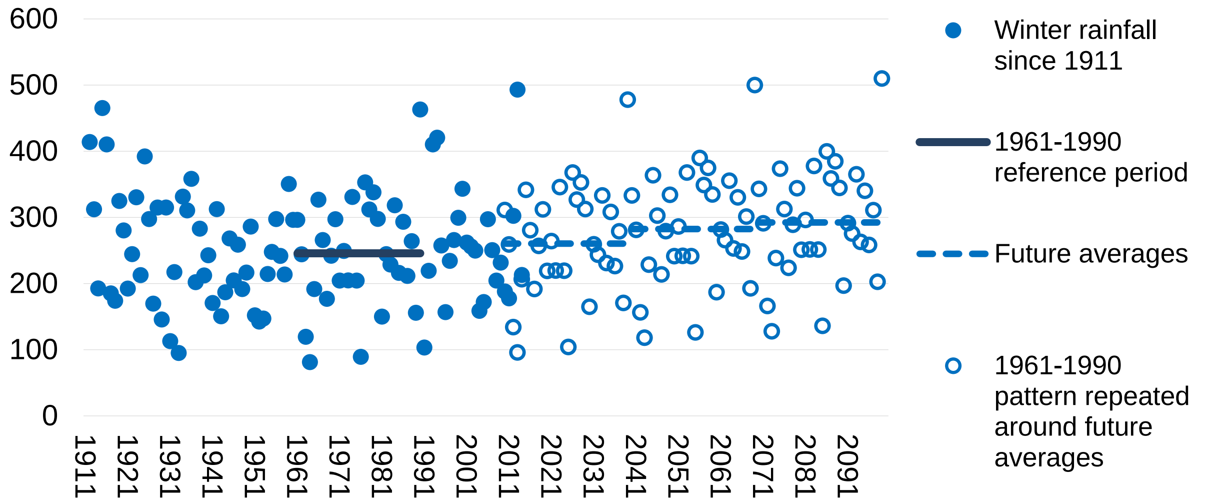
UKCP09 projections future change compared with 1961-1990

	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%
Annual average temperature	+1.4ºc to +1.5 ºc	+2.2ºc to +2.8 ºc	+2.8ºc to +4.4ºc
Summer average daily temperature	+1.5ºc to +1.7 ºc	+2ºc to +4 ºc	+3.0ºc to +5.1ºc
Summer mean maximum temperature	+2ºc 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.

Historically we have had many summers that were as dry as or drier than the forecast future average summer, and winters were as wet as or wetter than the forecast future average winter. The key point is that UKCP09 shows changes to *averages*; we expect plenty of variation from one year to the next, overlying a gradual trend of summers getting drier and winters getting wetter. This is illustrated in the graphs below with a simple scenario in which the rainfall pattern of the 1961-1990 reference period - with its changes from one year to the next - is repeated in the 21st century on top of projected changes to average rainfall. This is purely illustrative - historical rainfall patterns are not reliable guides for what may or may not happen in the future. Plus, future rainfall trends might have abrupt step changes rather than a smooth progression, and annual variability could also change. The critical issue for our resilience and adaptability will be the degree to which historical extreme events become more frequent.

Rainfall since 1911, and the 1961-90 pattern repeated around projected future averages (from UKCP09)



Note: in both graphs the future averages are based on the medium emissions scenario. The difference between the medium and high emissions scenario is very slight in the 2020s and 2050s, but by the 2080s increases to 8% for winter rainfall and 6% for summer rainfall.

Other evidence
In addition to UKCP09 outputs, we have drawn on the findings of a number of reports on climate change impacts and related risks. These include:

- UK-wide risks (UK Government, 2012; Committee on Climate Change (2015)
- General impacts for the region (South West Climate Partnership, 2003)
- Water sector impacts and risks (MWH / Water UK, 2008; HR Wallingford / UKWIR, 2012)
- Impacts on domestic water demand (Defra, 2003)
- Impacts on river flows (Environment Agency, 2008)
- Extreme rainfall events (Met Office / Ofwat, 2010)
- Flood risk and flood zones (Environment Agency, ongoing; South West regional assembly, 2007)
- Impacts on energy, transport and water infrastructure (URS / Defra, 2010)

Appendix 4 gives further information on these reports.

3. Methods for assessing climate change risk

Resilience to the risks posed by climate change centres on our ability to continually provide excellent service for customers and the environment. This is related to:

- our ability to plan ahead and then implement measures needed to increase resilience
- the physical capacity of our assets
- the quality of our emergency response.

While climate projections are often presented in terms of changes to *averages* e.g. average seasonal rainfall, or average temperature, the resilience of our services is affected more by *extreme* weather events such as heatwaves, droughts, intense storm events and prolonged rainfall. As these have happened many times in the past, 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. However, as background warming takes place, weather events considered extreme or unusual by today's standards are likely to occur more frequently in future.

To assess climate-related risks, we consider the likelihood and consequence of a hazard occurring. 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 we consider the geographic scale of impacts and the things that are affected. For example, a drought that does not particularly inconvenience many customers, with no water restrictions being imposed, would have a medium consequence score. By contrast, heavy rain events that cause widespread flooding, placing stress on critical assets and causing sewer flooding or environmental pollution would have a high consequence score.

We have carried out a range of assessments at various levels. For example, in-depth studies of climate change impacts on the yields from water sources are carried out for our water resource management plan. Also, as detailed in this report, we conduct higher level assessments of impacts on the full range of our activities. More details are given in appendices 5-8.

We acknowledge that climate change projections involve uncertainty; this is clearly recognised by the Intergovernmental Panel on Climate Change and UK Climate Projections. Examples of the uncertainties we need to consider include:

- the future return period of extreme weather events such as multi-season droughts
- 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 consequences of climate change for specific aspects of our services, and the accuracy of our risk assessments
- the costs and benefits of adaptation options and the suitability of the measures we choose.

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. To be resilient, we need to plan for the possibility that extreme weather events will become more frequent and more widespread, and also for the potential appearance of some entirely new issues.

4. Our main climate-related risks

A resilient water company is one that can cope with gradual changes to the climate and also extremes of weather.

The impacts of heavy rain dominate our risk assessments compared with warm or dry conditions. This was very noticeable during the extreme weather from 2011 to January 2014: heavy rain over nine months from April to December 2012 and over three months from December 2013 to February was more problematic than the preceding two years of below-average rainfall from spring 2010 to March 2012. Temperature increase is a lesser concern for our operational assets, but could affect peak demand and cause odour problems at wastewater assets. Sea level increase is a lesser risk in the short to medium term but could become more important in the long term in combination with coastal storms. Otherwise, we are pleased that the UK Water Industry Research (UKWIR) risk inventory has been extended to include impacts such as heatwaves on the health and safety of employees and the resilience of our supply chain during extreme weather events.

The following tables, based on the 2012 HR Wallingford / UKWIR climate risk assessment tool, show our most recent view of medium to high risk climate-related hazards i.e. those scoring 12 or more out of 25.

Regarding **water quantity**, our risk assessment reflects detailed work for our Water Resources Management Plan as explained in appendix 7. Our initial assessment showed that our single resource zone (region) is of low vulnerability to climate change, with only the west of our supply region (where the majority of our surface water reservoirs are located) having a medium risk. Elsewhere, sources tend to be constrained by infrastructure or their abstraction license, rather than by hydrology. Overall, the UKCP09 medium emissions scenario suggests changes to summer and winter rainfall in an average year will balance each other to the start of the 2050s.

Water resource quality is more likely to be compromised by climate change in the short to medium to long term, than water quantity. Warmer summers are likely to bring reductions in quality due to biological activity that is triggered also by warm weather. Heavy rainfall – both in prolonged episodes or short, sharp spells – can result in contaminants being washed into reservoirs or groundwater sources.

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.

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

Change / hazard	Effects on assets & services	RS*
Higher temperatures	More microbiological growth (algae, microorganisms), increasing treatment requirements	20
	Discolouration and taste issues, increasing complaints / compliance risk	20
	Increased daily and peak demand - domestic, commercial and tourism	12
Drought	Political pressure for prioritising essential water use, affecting security of supply	16
	Lower river flows resulting in less reliable yields from sources	12
	Lower dilution with reduced raw water volumes, increasing treatment requirements	12
More intense / prolonged rainfall	Flooding of treatment works and supply network sites, leading to equipment outages, elevated safety risk	20
	Storm events affecting power supplies at water treatment sites	20
	Surface water entering groundwater, greater turbidity, affecting raw water quality	20
	Increased risk of cryptosporidium contamination	20
	Discoloration and odour issues, increasing complaints / compliance risk	20
	Runoff causing increased levels of sediment and suspended solids	20
	Increased public expectation for hard defences to prevent site flooding	16
	Flooding and inundation affecting transport routes/access to assets	16
Sea level rise & coastal surge	Flooding and inundation affecting transport routes or access to assets	16
Combinations	More extreme wetting / drying cycles in soil, leading to increased pipe movement and burst frequency	12

* RS = risk score

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

Change / hazard	Effects on assets & services	RS*
Higher temperatures	More septicity at sewage treatment works increasing asset deterioration, toxicity, odour complaints and compliance risk, while reducing receiving water quality	16
	Increasing odour at sewage treatment works and sludge sites, affecting local people	16
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	16
	Lower flows in sewers leading to blockages, resulting in property flooding	12
	Lower river flows resulting in less dilution of effluent	12
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 leading to more spills affecting bathing waters	20
	More infiltration of groundwater into sewers, increasing flood risk	20
	Increased volumes to be pumped, accelerating asset deterioration and increasing power use	15
	Combination of heavy rain and high tides impeding discharges from overflows, risking property flooding	12
	Combination of heavy rain and blockages caused by sewer misuse risking property flooding	12
	Flooding of sewerage assets leading to potential failures	12
	Flooding affecting transport routes into sites	12
	Flooding of agricultural land and transport routes impeding sludge recycling activity	12

* RS = risk score

5. Our adaptation plan

Responding to climate-related risk

Whenever we identify a risk to our business and the services we provide, we aim to manage it to an acceptable level. This is as true for climate-related risks as for any other issue.

This is related to the concept of resilience, which has been given increasing attention in the utility sector in recent years. There are a number of ways to build resilience, as illustrated in the table below which draws on *Keeping the Country Running: Natural Hazards and Infrastructure* (Cabinet Office, 2011):

Approach	Examples
Redundancy Backup installations or spare capacity that enable operations to be switched or diverted to alternative parts of the network in the event of disruptions	• Elimination of stand-alone sources • Twinning critical pipeline crossings • Reciprocal arrangements with neighbouring water companies • IT systems • Demand management • Allowance for outages, standby units for critical plant • Water resource management planning
Resistance Prevention of damage or disruption, by providing strength or protection to resist a hazard or its primary impact	• Flood defences • Security measures • Ensuring design standards are appropriate
Reliability Infrastructure that is designed to operate under a range of conditions and hence mitigate damage or loss from an event	• Routine maintenance • Refurbishment / replacement of assets
Recovery / response Fast and effective response to, and recovery from, disruptive events. This is determined by efforts to plan, prepare and exercise in advance of events.	• Early warning systems, telemetry, real-time monitoring • Emergency planning, business continuity

There are a number of options at our disposal to reduce the likelihood or consequence of a problem occurring. Some options involve building physical assets or improving systems; others are focused on catchment management; others are mainly about co-operation with external organisations and encouraging helpful behaviour among users of our services. Much of this work will help us to cope with the gradual stresses of a warming world and the shocks that come in the form of extreme weather events – we will need to accommodate changing volumes of water and sewage as well as evolving customer expectations and regulatory requirements for water and effluent quality. Indeed, one of the main outcomes that we have defined for our 2015-20 programme is resilient services; specifically, ‘assets and working practices that continue to deliver high quality, reliable services in the face of unusual events such as flooding or droughts’. The targets connected with this outcome are a) no hosepipe bans, b) reduced number of properties experiencing short term interruptions to supply, c) reduced number of properties supplied from a single source of water, d) no increase in water mains bursts, e) no increase in sewer collapses.

While climate change is not an explicit driver for the large majority of individual schemes - other reasons are given by our regulators and other stakeholders for each area of investment - much of what we do could be described as ‘climate change adaptation by default’.

Water supply options

A summary of our work is given below, with a detailed account in appendices 6 and 8.

Flooding of assets and sites

We carried out improvements at two sites during 2010-15, involving installation of bunding, flap valves, alarms and drainage improvements. As the previous flood risk assessments were very comprehensive and still applicable, we are not proposing any further asset flood resilience schemes during 2015-20. However, we will continue to monitor the vulnerability of our sites to flooding in the medium to long term.

Water resources planning & drought planning

Our drought plan, which sets out how we manage water resources during extended periods of dry weather, was most recently used during the dry period that culminated in spring 2012. While our water resource position at the time was satisfactory, there were concerns about flows in some headwater streams. The next version of our drought plan will be finalised in 2018. Our Water Resources Management Plan compares available water sources with demand forecasts over 25 years. Potential impacts of climate change were built into our most recent Water Resources Management Plan (as explained in more detail in appendix 7), which in turn informed our business plan for the investment period 2015-20. Our next Water Resources Management Plan will be published in 2019.

Water Safety Plans

Water safety plans are firmly embedded as a tool for managing water supply risk, with detailed risk assessments for each supply system. Water safety plans are not static documents, as knowledge is constantly evolving about hazards and risks. Thus, we will continue to develop and maintain them for the foreseeable future.

Catchment management

By working with land users we can tackle the root cause of some problems for raw water - 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. Catchment actions are 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, but do not eliminate risk altogether (especially during very wet conditions), nor the need for comprehensive treatment processes. In the next five years we will continue to use catchment management methods at existing sites (eight in relation to nitrates and two in relation to pesticides) and plan to extend it to safeguard a further eight water sources (six for nitrates and two for metaldehyde) as well as leading efforts in the Poole Harbour catchment.

Monitoring sources

Our extensive sampling allows continuous monitoring of the quality of water supplied from the sources we use. This means that they 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.

Integrated grid

We are currently developing a more integrated water supply grid to be completed in 2017/18 which will allow us to deal with a number of issues simultaneously. It will improve the security of supply to customers (specifically, reducing the number of customers reliant on a single source); it will allow us to accommodate abstraction licence reductions required by the Environment Agency to improve flows in some rivers and protect their ecology; it will enable surplus water to be used in the event of outages; and enable 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.

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.

Enhanced treatment
Our preferred course of action for tackling sub-standard raw water is to manage the issue at source if possible, for example through catchment management. There is also the option to switch sources or blend-in suitable water from nearby in the event of shorter-lived problems. During the next five years we are reconfiguring one treatment works to deal with deteriorating water quality, where various upstream issues are causing problems for a range of quality parameters at the site's reservoir. Catchment management in the area has greatly helped reduce pesticide risk but cannot solve all the site's issues.

Water mains – repair & replacement
Extreme weather impacts can play a part in the need for mains renewal or replacement, such as bursts caused by severe cold weather causing ground heave. Through improved prioritisation of work and introduction sensors in the water network, we plan to keep the mains replacement rate at 50km per year in the next five years and maintain the current level of unplanned interruptions. From 2020 onwards, the mains replacement rate will need to rise as pipework ages, and mains rehabilitation designed to improve water quality will also need to continue.

Supply demand balance: reducing leakage and managing demand
Reducing leakage is an important part of our efforts to maintain a healthy surplus of available water supplies compared to demand. We have halved leakage since 1994-95, and always met our leakage target. In the next five years we aim to reduce leakage further to less than 66.5 Ml/day, mainly through increasing household water metering. We are looking at a wide range of asset management and technological methods for reducing leakage from supply pipes. Behavioural measures such as encouraging greater water efficiency will also be important for coping with extreme weather events. Through a combination of measures we aim to further reduce consumption to 131 litres / person / day on average by 2020. Consequently, the water we put into the water supply network is now lower than at any time in the last 25 years and we are able to forecast a surplus of supply over demand for the next 25 years. We are confident that in the event of a drought that matches 1975-76 we can continue to meet demand without restrictions and that our planned investment helps maintain a resilient supply service overall.

Standby generators; response and recovery plans
We need to be able to respond to unforeseen, acute situations such as extreme weather events. The 114 electricity generators we have to provide back-up to water supply sites is one aspect. We also continue to review and update business continuity arrangements and work in partnership with other agencies.

Sewerage, sewage treatment and sludge options

Flood risk to our assets
In 2013 we carried out flood resilience work at a sewage pumping station that serves a medium-sized town, replacing above-ground pump motors with dry well submersibles and raising electrical equipment above possible flood levels. Relatively minor works to improve resilience against flooding were carried out at one other sewage pumping station and three sewage treatment works in 2011 and 2012 respectively. In the light of the exceptional wet weather of 2012 to 2014 we have reviewed flood risks at our sewage treatment works. Consequently, we are carrying out improvements at one site before 2020 with new electrical plant and equipment located at a higher level, above the 1 in 200 year flood plain. Otherwise, we will continue to review the risks associated with flooding of our sewerage assets and take appropriate action should the risks become unacceptable.

Sewerage capacity, condition and maintenance
2012 and the winter of 2013/14 was a reminder of how variable and extreme weather patterns can be and led to a big increase in flooding incidents and restricted service for some customers. Over the next five years we will aim to maintain a stable level of total flooding risk, including external area flooding. Our approach includes a suite of options including sustainable urban drainage systems, surface water separation and real-time control of the network. We will also invest proactively in sewerage capacity during 2015-20 where cost-beneficial, including schemes that improve capacity across the region; smaller non-specific investment needs will be addressed as they materialise during the period.

Dealing with groundwater infiltration
Infiltration of groundwater into private drains and public sewers can lead to restricted toilet use, premature spilling of combined sewer overflows to the environment and hydraulically overloaded sewage treatment works. During 2012-13 and 2013-14, the worst years on record for infiltration problems, 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. As well as repairing sewers we are working with the Environment Agency and lead local flood authorities in the preparation of infiltration reduction plans, which include private drains as well as our sewers.

Sewer maintenance
Sewers are designed accommodate flows 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.

Surface water management
Since the Flood and Water Management Act 2010 we have worked more closely with the 11 Lead Local Flood Authorities in our area. This is a key area for delivering our strategy to address flooding incidents and flood risk. Our contributions include sharing asset data and hydraulic models to assist in the development of surface water management plans. Separating surface water from combined systems creates space in the combined sewer and reduces overflow volumes; for example, we recently constructed a separation scheme which removes flow from a watercourse that was entering our combined sewer. Looking ahead, we will continue to look for sustainable solutions using integrated urban drainage management, sustainable urban drainage systems and active system control.

Improvements at individual combined sewer overflows (CSOs)
CSOs act as relief valves for the sewerage network during times of heavy rain. They are designed to pass forward polluting loads so that when they do discharge they do not 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 CSOs to better understand the frequency of their operation and will continue with this programme in the next five years. We are also investing in improvements at some coastal sites where there is a link between CSOs and coastal water quality.

Odour control / mitigation
By developing a system of detailed odour management plans for our STWs and SPS's, including generic and 30 site specific plans, we have been able to implement operational improvements and general good house-keeping 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.

Quality improvements to meet tighter standards
The quality of rivers and streams can be placed under greater stress during very warm or dry weather conditions. If climate change leads to this happening more often, in turn there could be pressure for tighter end-of-pipe standards at sewage treatment works. Currently our work to improve the quality of effluent from sewage treatment is driven by the general condition of watercourses and European regulation. To date, warmer weather or climate change have not explicitly cited as contributory reasons for our investment, but it is a factor that could have an influence in the medium to long term.

Maintaining sludge to land
The exceptionally wet weather during 2012 to 2014 meant that soils in many parts of our region became saturated, which limited the capacity of on-farm storage for treated sludge cake. We assessed the need and costs for providing additional storage, including new storage slabs at five locations. However, more intense operational management and frequent assessment of the stability of the stockpiles of sludge cake has alloed us to manage the process without needing to create additional storage.

Shoreline management plans (SMPs)
We have 391 significant sewerage assets or sites in the areas covered by SMPs. In the short term (0-20 years) the risk to all these assets from coastal processes is low. However, in the medium term (20-50 years), four assets are potentially at a high risk from coastal processes. 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.

Standby generators; response and recovery plans
We need to be able to respond to unforeseen, acute situations such as extreme weather events. The 251 electricity generators we have to provide back-up to wastewater sites is one aspect. We also continue to review and update business continuity arrangements and work in partnership with other agencies.

6. Other considerations

The success of our adaptation work will be based on our ability to meet standards expected by customers and regulators; to accommodate gradual change such future population growth and increasing flows; and to maintain normal service during extreme weather events. Consequently, planning for climate change is not an optional add-on but is embedded in our risk management framework, in water resource planning and sewerage design, and in water industry research. However, it is not simply a straightforward process by which evidence leads seamlessly to investment; there are a range of technical, organisational, economic, and policy considerations that need to be taken into account.

Monitoring

Ongoing monitoring of climate change impacts and evaluating the success of our adaptation has a number of aspects. 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 combined sewer overflows to record the duration of spill events, which will help us assess any deterioration in the performance of these assets.

Flexibility

Our adaptation plan is not fixed in perpetuity - it is important that adaptation is 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. There will also be opportunities to trial innovative approaches that might improve our resilience.

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. This is very evident for surface water management which involves liaison with councils, Internal Drainage Boards and the Highways Agency and emergency response. The water sector itself has a protocol for sharing resources and a mutual aid scheme through which companies co-operate during emergencies. In some areas such as maintaining sewers we need the goodwill of our customers and the help of the media to have the greatest chance of successful adaptation. Work with land users 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. Co-operative working relationships with government and our regulators are also essential for our day-to-day activities and longer term planning alike.

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 recently summarised its current work and ongoing risks in its report to Parliament on progress in preparing for climate change. For our part we have some contingency measures in place, such as standby power generators which can be deployed at short notice.

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 agencies with varied funding arrangements and cycles are involved); insufficiently clarity over responsibilities where there is more than one potential lead organisation; and 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.

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.

Thresholds

In terms of 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.

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 should mean that incentives to choose less capital-intensive solutions (such as catchment management, sustainable urban drainage systems, or behavioural measures) are at least equal to incentives for conventional investment in larger physical assets.

Climate change mitigation

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. We have a long term aim to be carbon neutral and a carbon management strategy with three main elements: emissions avoidance, increasing efficiency across our sites, and generating renewable energy.

7. Conclusions

Climate change is our biggest long-term environmental challenge. In this report we have set out the main climate-related risks that we face and the work that we are carrying out that will help us manage those risks to an acceptable level and be more resilient overall.

Since our first adaptation report in 2011 we have continued to build climate change considerations into our planning, including the use of UK Climate Projection scenarios to test our future water resource position. We have reinforced sites at risk of flooding and experienced a series of extreme weather events that provided a significant test for our operations. Our largest investment scheme – the integrated supply grid – is well underway and ‘resilient services’ is one of the main outcomes that we aim to deliver for our customers during 2015-20.

As climate change adaptation is part of our overall sustainability we will continue to communicate progress outside the formal requirements of the adaptation reporting power, under which this report has been produced. We will communicate with our stakeholders as knowledge improves, new risks emerge, investment is completed and our strategy develops.

PART 2 SUPPORTING INFORMATION

References	
Appendix 1	Responses to questions in Defra's guidance to reporters
Appendix 2	Historical precipitation
Appendix 3	UK climate projections
Appendix 4	Other relevant evidence / background information
Appendix 5	Climate change risk: an overview of assessment and action
Appendix 6	Water supply: risks related to climate change and resulting action
Appendix 7	Water resources management planning and the impacts of climate change
Appendix 8	Sewerage, sewage treatment and sludge: risks related to climate change and resulting action
Appendix 9	Other considerations
Appendix 10	Recent UKWIR climate change adaptation projects

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Appendix 1: Responses to questions in Defra's guidance to reporters

Understanding climate risk

How has your understanding of climate risks, impacts and their effects on your sector/organisation and stakeholders advanced since your first round report?

Since our first adaptation report in 2011, our understanding of the main climate risks has not advanced significantly. This mainly because our understanding is underpinned by the 2009 UK Climate Projections (UKCP09) which informed our 2011 report and allied work on climate-related risks in the previous two years. Also, the 2012 UK climate risk assessment confirmed what we believed to be the principal risks for our sector and our understanding of the impacts of climate risks on our day-to-day operations was informed further by the extreme weather, and its impacts on the hydrology of our region, between autumn 2011 and January 2014.

What climate change evidence or research have you used to better understand the implications for organisational functions?

We continue to use the outputs of UKCP09, the outputs of specific analytical projects based on UKCP09 (e.g. *Future flows and groundwater levels*), our own records of asset condition and performance and our experience of handling extreme weather events.

Has your understanding of thresholds of climate impacts advanced to better pinpoint organisational vulnerability? If so, how?

Our understanding of thresholds is similar to 2011. The main thresholds used to inform investment decisions are the 1975-76 drought (with regard to water supply) and occurrences of flooding of properties and our own physical assets.

How have you developed your quantified assessment and analysis of risk likelihood and impacts?

We have used the 2012 HR Wallingford / UKWIR climate risk assessment tool that built on the previous MWH inventory that we used to inform our 2011 adaptation report. Further information is given in appendices 5, 6, 7, 8.

Understanding of uncertainties, information gaps and assumptions

What uncertainties remain in monitoring and evaluating climate risks to your sector's/organisation's functions? What new uncertainties have come to light?

We have already experienced many of the risks identified at some point in the past; a notable event that has already happened increases the justification for action. However, uncertainties can remain around how frequently such an event might occur again in the future, or whether the same sites will be affected again. As such it is often a case of 'when / where?' rather than 'if?'. However, if there is significant uncertainty about the timing or location of a hazard, it can be harder to justify upfront action unless the consequences of a hazard are very severe.

What further implications do uncertainties have on action your sector/organisation has taken or plans to take?

Adaptive work is more likely to proceed where the likelihood and / or consequence of a hazard occurring is higher; also where we have greater confidence in our assessment of this risk. Further information is given in appendix 5.

What progress have you made to address information gaps?

The main advances in addressing information gaps is in water resources planning, assisted by research carried out jointly by water companies (further information is given in appendices 6 & 7). For sewerage, we continue to update our knowledge of at-risk locations based on actual events and modelling.

What are the strategic business and methodological assumptions that underpin your analysis of impacts and risks?

We use industry-wide research (such as the 2012 HR Wallingford / UKWIR climate risk assessment tool) to understand the full range of potential impacts, plus the outputs of UK Climate Projections. These are then processed using a high level risk scoring tool (based on likelihood and consequence).

Details of actions: implemented and new

An important part of your progress update is to set out the actions you've taken to address climate change risks or increase resilience.

This includes an assessment of how effective each action has been in:
- ***achieving beneficial outcomes***
- ***mitigating climate change risks***
- ***increasing to your organisation's readiness to respond and recover from impacts***
- ***contributing to sustainable development***

We're also interested in whether each action has been cost effective or resulted in savings. Where you cannot quantify benefits, include a narrative to set out how and what climate change benefits you've realised. Your assessment can include any issues, challenges or negative implications arising from action taken.

Appendices 6 (water supply) and 8 (sewerage, sewage treatment and sludge) explain the main climate-related risks related to our activities and our consequent actions to manage those risks. A short assessment is given for section based on the tabular format proposed in Defra's guidance to reporters. Further information is given in appendices 6 & 8.

Addressing barriers and understanding interdependencies

Where you've identified interdependencies, how have these assisted or hindered actions to address climate risk?

Interdependencies with land users have led to closer collaborative working over the last ten years. The primary focus for this is drinking water protection rather than climate risk *per se*, although extreme weather is a component for the resilience of our water sources. Similarly there is greater recognition now that flooding and surface water management are multi-agency issues.

What were the main barriers to implementing adaption actions and why? Have new barriers been identified? Are these being addressed? If so, how?

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 when agencies with varied funding arrangements and cycles are involved); insufficient clarity over responsibilities where there is more than one potential lead organisation; and potential unintended consequences of adaptation measures such as changes in movement of excess water. Otherwise, no new significant barriers have been identified since our 2011 report.

Monitoring and evaluation

How effectively has consideration of climate change risks been embedded within your sector or organisation?

Climate change impacts is fully embedded in our water resource planning process, where we estimate the impacts of climate change on yields from water sources and customer demand. It is also recognised as one of the main threats for sewerage capacity. Dealing with acute weather events has been a high-profile issue for our operations since 2011 and is one part of our company risk management and business continuity processes.

How effective have organisational monitoring and evaluation processes been to ensure adaptation responses are implemented and on track? If these have not been effective, what barriers prevented this?

Monitoring and evaluation are central to all of our work. We closely monitor customer service and satisfaction, environmental compliance, asset performance and the progress of capital investment among other aspects. This is essential for satisfying regulators, customers and other stakeholder that we are delivering first-class services and are working in an efficient and responsible manner. This applies to all of the activities outlined in this report that contribute to our overall resilience. Further information is given in appendix 9 - managing climate risks.

How effective were monitoring and evaluation processes in determining how the organisation/sector handled recent extreme weather conditions?

Monitoring and evaluation were important for the extreme weather experienced between 2011 – 2014; for example, keeping a close eye on abstraction during dry conditions and nitrate levels in boreholes and sewer flooding incidents during wet conditions. We do not reserve monitoring and evaluation for unusual circumstances; they are part of our routine work.

Has the sector/organisation identified any financial benefits from implementing adaptation actions? Perhaps through cost benefit analysis, fewer working days lost, more efficient operations etc.?

While all of our investment proposals are subject to cost benefit analysis we have not assessed the financial benefits of climate change adaptation *per se*. However, during 2015-20 we will be subject to financial rewards and penalties linked to the outcomes for customers and the environment that we set out in our business plan. As weather can affect our performance for many of the measures of success that we have defined, there is a link to adaptation actions.

Has there been sufficient flexibility in the approach to adaptation within the sector/organisation, which allowed you to pursue alternative courses of action? If not what remedial measures could you take to ensure flexibility?

Across all our activities we have a degree of flexibility about how we achieve the outcomes that are desired for customers and the environment. For actions that could be considered as adaptation work, we employ a mix of asset-based, catchment-based and behavioural solutions. We believe that this provides a suitable degree of flexibility overall.

Opportunities and benefits

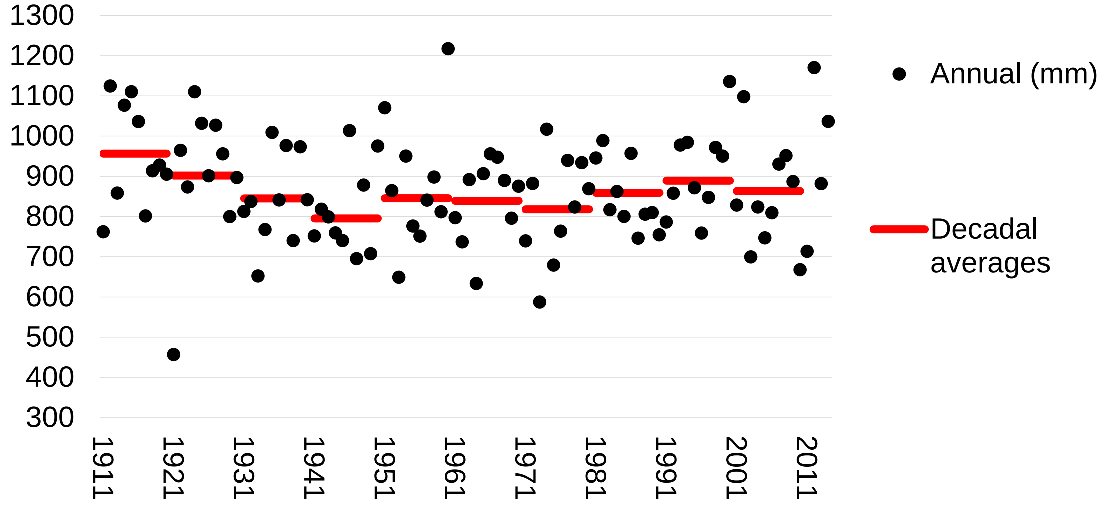
What action have you taken to exploit opportunities? How effective were your efforts?

The HR Wallingford risk assessment for the water sector shows some seasonal effects that might be beneficial, such as improved biological processes in sewage treatment in warmer weather and reduced heating bills with milder winters. However, none have particular strategic implications nor suggest the need to take particular actions to exploit them.

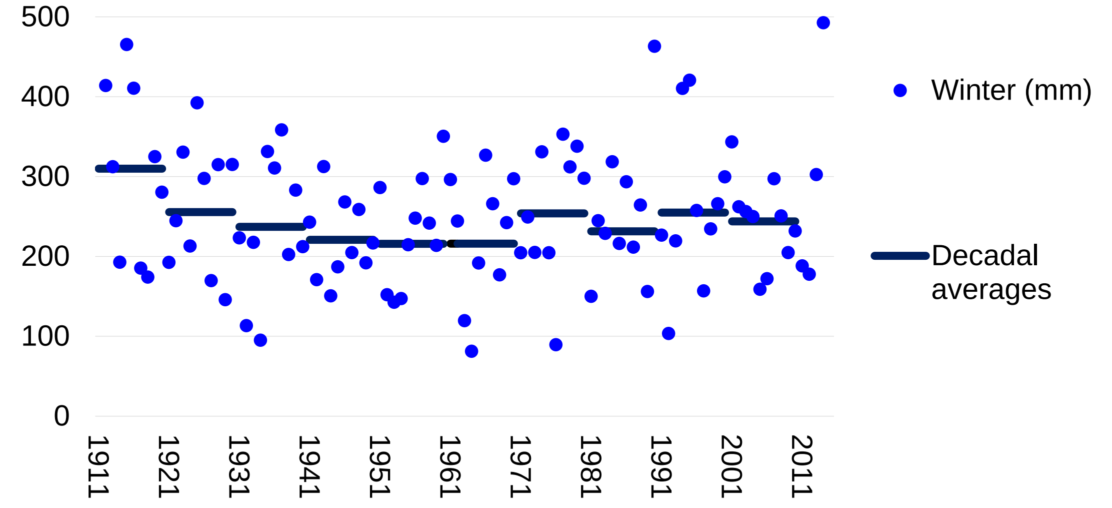
Appendix 2: Historical precipitation

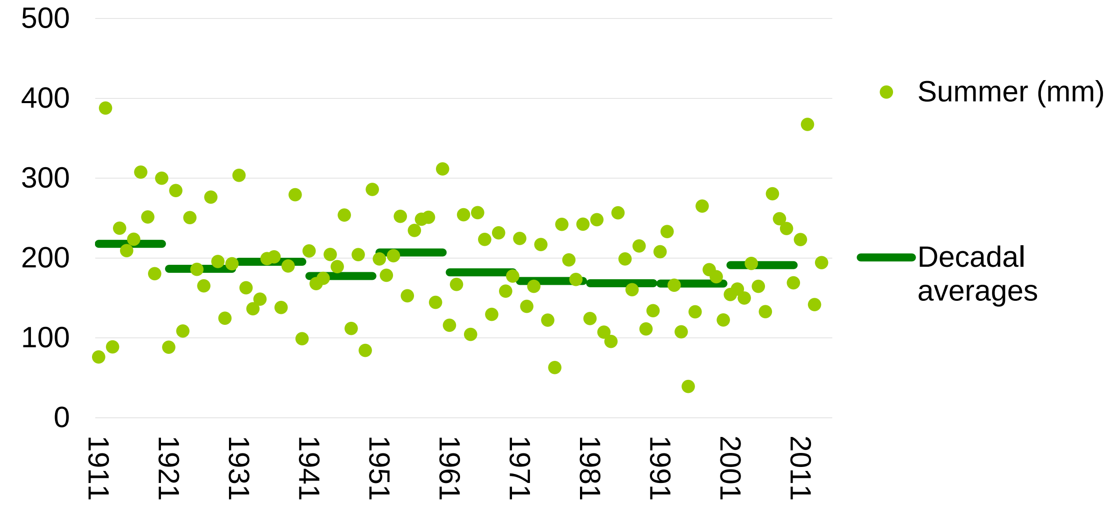
The following charts show historical precipitation from rain gauges spread across our region that are maintained by the Environment Agency.

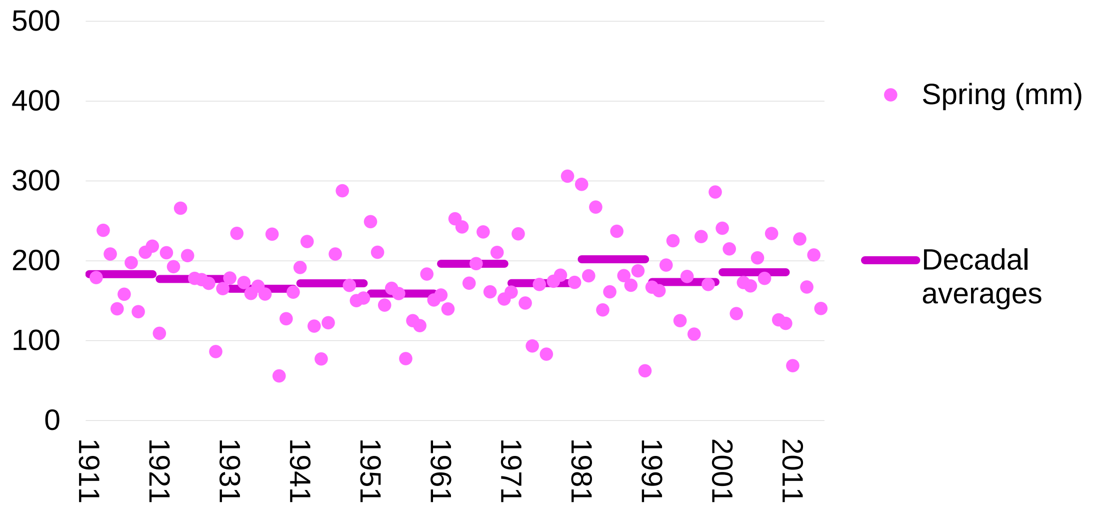
Annual precipitation (mm)

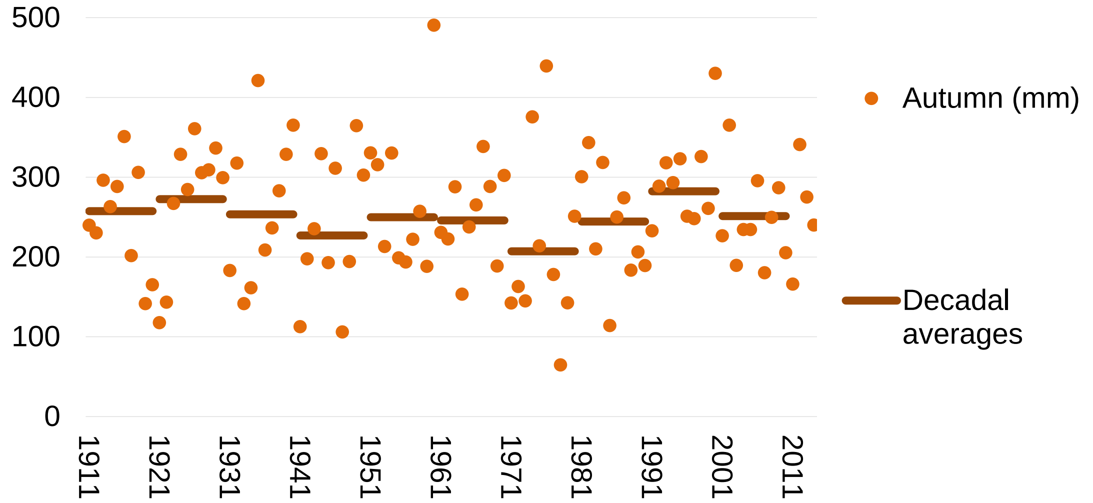


Seasonal precipitation (mm)

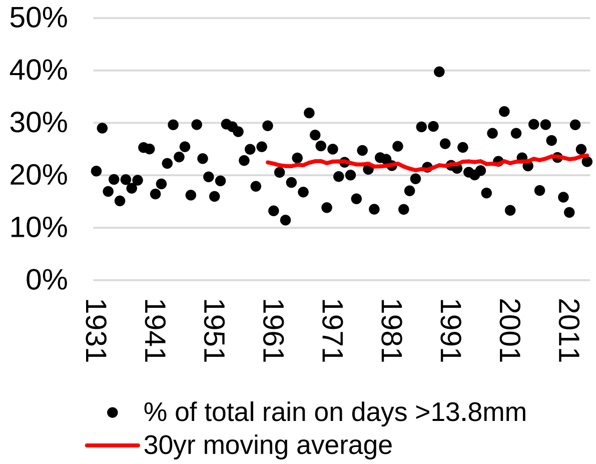


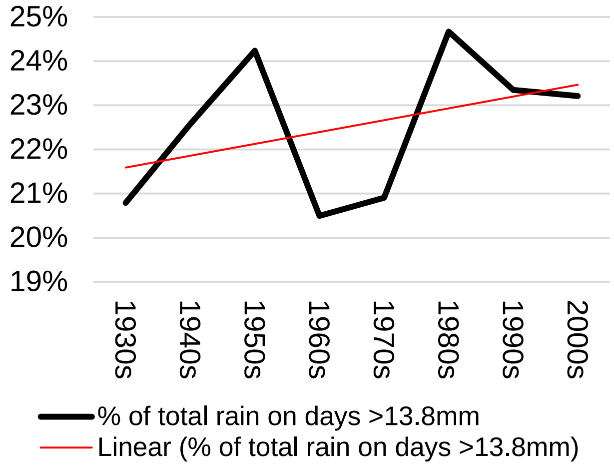






One possible impact of climate change will be an intensification of rainfall patterns. One way to assess this is to calculate how much of a year's total rain fell on heavy rainfall days. We do not have multi-decadal daily rainfall data to do this for our own region, but the Met Office provides daily rainfall data for Wales and south west England that allows this analysis. The 95% percentile of recorded rainfall could be considered to be a threshold for heavy daily rainfall and between 1961 and 1990 this was 13.8mm. The graphs below show the percentage of annual rain falling on days with 13.8mm or more, for each year and each decade, with a very slight increase seen since the 1930s.





Appendix 3: UK climate projections

Like other water companies, we use UK Climate Projections (UKCIP02 and UKCP09) to help plan investment in water and wastewater. The 2009 edition gave probabilistic projections for individual 25km squares, using three different emissions scenarios (high, medium, low) across three time periods of the 21st century (2020s, 2050s and 2080s).

The table below shows UKCP09 projections for the Wessex Water region for a range of rainfall and temperature indicators. It only shows the most likely 'central case' projections, across all three emissions scenarios and three time horizons. Values are available for individual 25km grid squares; the table below shows the value that appears most frequently in our region, i.e. the mode.

From these projections, we can expect the average summer to be drier and warmer, and the average winter to be milder and wetter than the baseline period of 1961-1990. It is also projected that extreme events will happen with greater frequency as the climate warms. The 2009 projections also show some variations within our region. For example, for summer rainfall projections, south and west Dorset have the driest conditions across each time horizon and each emissions scenario. By contrast the biggest increase in winter rainfall appears in different parts of the region depending on the time horizon and emissions scenario selected.

Central case, mode of grid squares in the Wessex Water region.

	2020s Emissions scenario			**2050s** Emissions scenario			**2080s** Emissions scenario		
	Low	Med	High	Low	Med	High	Low	Med	High
Rainfall (% change)									
Average winter rainfall	+6%	+6%	+7%	+12%	+15%	+17%	+7%	19%	+27%
Average summer rainfall	-7%	-8%	-5%	-14%	-19%	-20%	-16%	-24%	-30%
Total rainfall	+1%	0%	0%	0%	0%	0%	+2%	+1%	+1%
Temperature (deg. C)									
Annual average daily temperature	+1.5	+1.4	+1.4	+2.2	+2.5	+2.8	+2.8	+3.5	+4.4
Summer average daily temperature	+1.7	+1.6	+1.5	+2.5	+2.8	+3.2	+3	+4.1	+5.1
Summer mean maximum daily temperature	+2.1	+2.1	+2	+3.3	+3.7	+4.2	+3.9	+5.2	+6.7

The remainder of this appendix has tables and charts showing a) comparison of historical rainfall and future projects averages, and b) coastal impacts.

Driest summers and wettest winters since 1990 compared with the UKCP09 medium emissions scenario

Summer	Winter
Summers that were drier than the UKCP09 medium emissions scenario for average summer rainfall in the **2020s** (161 mm) 1990, 1994, 1995, 1996, 2001, 2002, 2003, 2006, 2013	Winters that were wetter than the UKCP09 medium emissions scenario for average rainfall in the **2020s** (261 mm) 1990, 1994, 1995, 1999, 2000, 2001, 2002, 2007, 2013, 2014
Summers that were drier than the UKCP09 medium emissions scenario for average summer rainfall in the **2050s** (142 mm) 1990, 1994, 1995, 1996, 2006, 2013	Winters that were wetter than the UKCP09 medium emissions scenario for average rainfall in the **2050s** (283 mm) 1990, 1994, 1995, 2000, 2001, 2007, 2013, 2014
Summers that were drier than the UKCP09 medium emissions scenario for average summer rainfall in the **2080s** (133 mm) 1994, 1995, 1996, 2006	Winters that were wetter than the UKCP09 medium emissions scenario for average rainfall in the **2080s** (293 mm) 1990, 1994, 1995, 2000, 2001, 2007, 2013, 2014

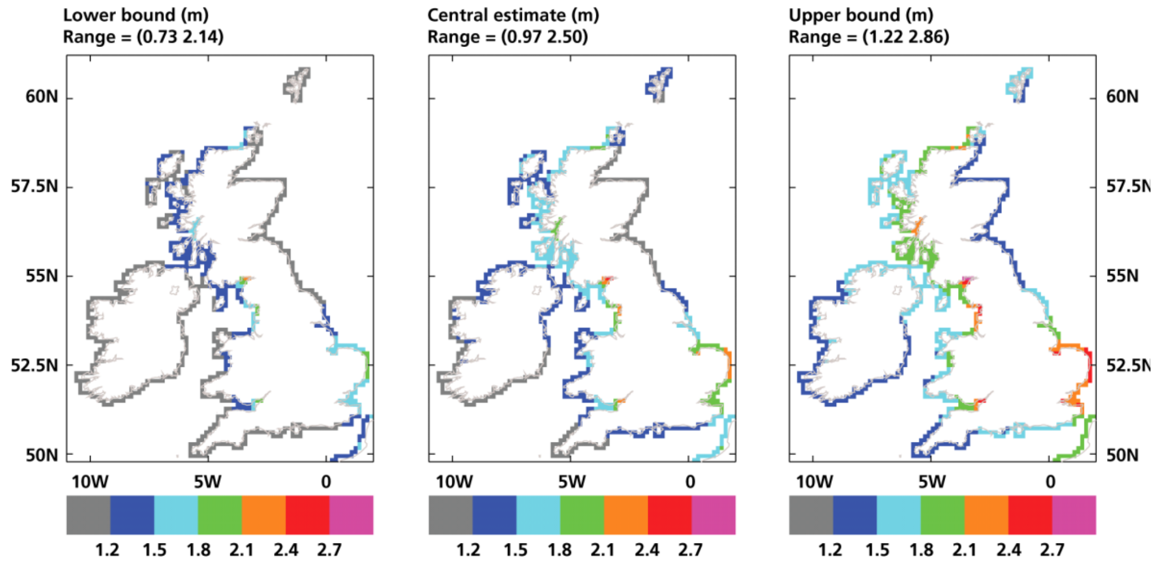
Coastal impacts

i) Sea level rise (cm increase compared with 1990)

	London			Cardiff		
	High	Med	Low	High	Med	Low
2000	3.5	3.0	2.5	3.5	2.9	2.5
2010	7.3	6.2	5.3	7.3	6.2	5.3
2020	11.5	9.7	8.2	11.5	9.7	8.2
2030	16.0	13.5	11.4	15.9	13.4	11.4
2040	20.8	17.5	14.8	20.8	17.5	14.8
2050	25.8	21.8	18.4	25.9	21.8	18.4
2060	31.4	26.3	22.2	31.4	26.3	22.2
2070	37.2	31.2	26.3	37.1	31.1	26.3
2080	43.3	36.3	30.5	43.3	36.2	30.5
2090	49.7	41.6	35.0	49.7	41.6	35.0
2095	53.1	44.4	37.3	53.1	44.4	37.3

Source: Low et al (2009)

ii) Exceedance of present-day astronomical high tides by projected future extreme water 50-yr return levels for 2095 (m).



The central panel shows the estimated central value. Left and right panels show the lower and upper bounds of the 90% confidence interval. Grey shows any value < 1.2 m.

Source: Lowe et al (2009) at http://ukclimateprojections.defra.gov.uk/content/view/1859/500/

Appendix 4: Other relevant evidence / background information

Reports & guidance (chronological)

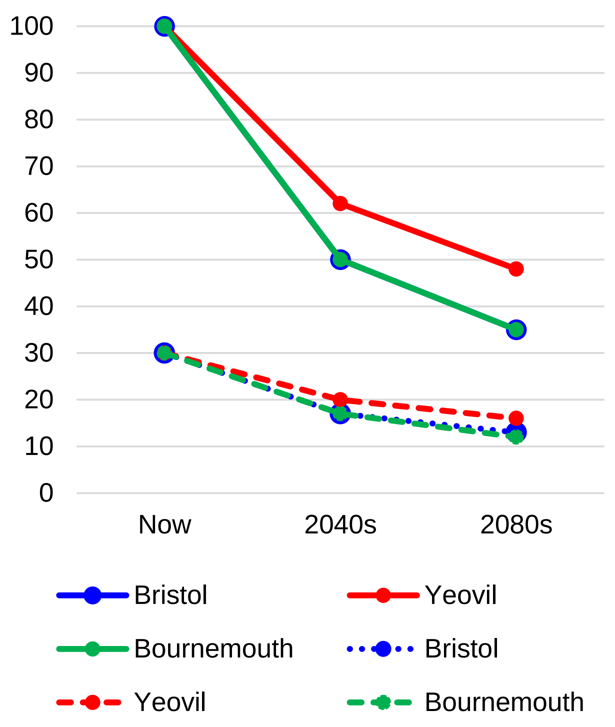
Defra, 2003 Domestic water demand	• Under a medium high emissions scenario, climate change would lead to a 1.2% increase in domestic water demand in south-west England by 2025. • We applied lower and upper increases in demand of 1.0% and 1.4% for supply demand balance calculations in our water resources management plans.
Environment Agency, 2008 River flows	• Under the UKCP 2002 medium-high emissions scenario, total annual flows are projected to drop by 10%-15%. The greatest reductions in flow are projected for September and October. • Sections of the Bristol Avon and the Tone could fall by 50%-80% and catchments in south Wiltshire and Dorset by 30%-50%.
Environment Agency Flood zone maps	• Maps indicate the extent of a flood with a 1% chance of happening in any year for rivers, and 0.5% for coastal flooding; also the extent of an extreme flood from rivers or the sea with a 0.1% chance of happening in any year. • The maps purposefully ignore existing flood defences which can be overtopped by floods that are larger than what the defences are designed to withstand.
South West Climate Partnership, 2003 General impacts and risks	• *Warming to the Idea* - a scoping study for the region of potential climate change impacts. • A later update was produced to take UKCP09 projections into account.
South West Regional Assembly, 2007 Flood risk	• The Regional Flood Risk Appraisal 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.
MWH for Water UK 2008 Water sector impacts and risks	• 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.
Met Office for Ofwat, 2010 Extreme rainfall events	• 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. • Examples for our region of projections (taking the central case for probability) showing the increasing frequency of such events are shown below.

URS for Defra 2010	• *Adapting Energy, Transport and Water Infrastructure to the Long-term Impacts of Climate Change* was a vulnerability assessment using the same asset categories as the MWH / Water UK study • Precipitation impacts are considered to be 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; increased pollution incidents due to changing precipitation patters & drought periods.
UK Government 2012 General impacts and risks	• The UK Climate Change Risk Assessment was published by the government in January 2012, with the next edition scheduled for 2017. • The 2012 assessment set out adaptation priorities for agriculture and forestry; business, industries and services; health and wellbeing; natural environment; and buildings and infrastructure. • Among the largest impacts it identified in relation to the water cycle were increased flood damage and disruption, and pressure on some water resources.
HR Wallingford / UKWIR 2012 Water sector impacts and risks	• This study built upon the work previously carried out by MWH for Water UK.
UK Government 2013 General impacts and risks	• The National Adaptation Programme (NAP) contains a register of actions, showing alignment to risks identified in the Climate Change Risk Assessment. • The NAP is divided into chapters looking at the built environment, infrastructure, healthy and resilient communities, agriculture and forestry, natural environment, business and local government. It looks most closely at the most urgent risks. • The Adaptation Sub Committee of the Committee on Climate Change will assess how well the NAP report has been implemented so far by July 2015.
Committee on Climate Change 2015 Annual report to Parliament	• Reducing emissions and preparing for climate change: 2015 Progress Report to Parliament is covers both progress towards meeting carbon budgets and progress on adaptation to climate change. • It includes the CCC's first ever statutory assessment of the National Adaptation Programme. • With regard to water the report note the resilience improvements made following the 2007 floods, that the new system of rewards and incentives introduced by Ofwat should also encourage water and wastewater companies to achieve reliable services at least cost, and suggests that the new resilience duty under the 2014 Water Act should further strengthen performance when it comes into effect from 2019, provided it is defined and performance is measured in a consistent and robust way.

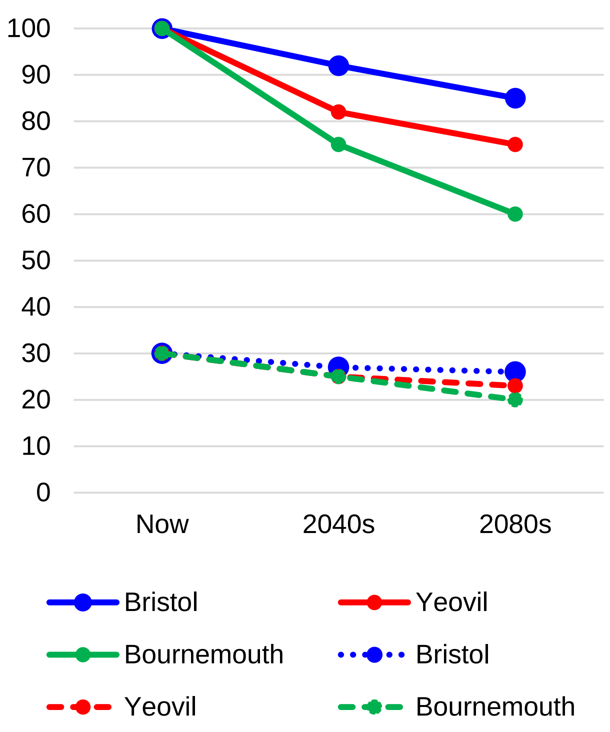
Changing occurrence of major storms (Met Office for Ofwat, 2010)

	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 (1:100 year & 1:30 year)

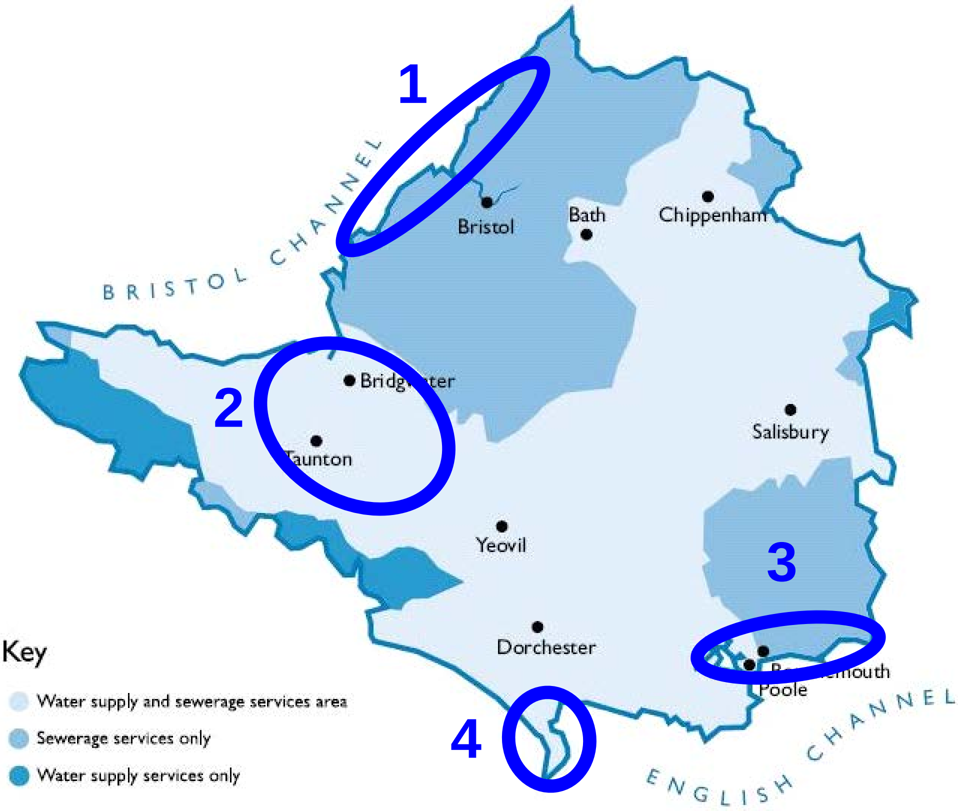


Summer storms (1:100 year & 1:30 year)



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

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



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

Appendix 5: Climate change risk: an overview of assessment and action

Our overall approach

Wessex Water has an all-encompassing framework for risk management. Our Risk Committee and Risk Group keep emergent risks under review, including those associated with climate change. Company business continuity arrangements include procedures for dealing with the impacts of more extreme weather events such as flooding and heat waves. Risk assessments also feed into our five-year business plans, asset management plans and our 25 year Water Resources Management Plan.

Resilience is gaining prominence as an issue for government and regulators and customers place a lot of importance on having reliable water and sewerage services. The resilience of our services is related to our ability to plan ahead and implement necessary measures, the physical capacity of our assets and the quality of our emergency response. Our approach to *improving* resilience of our services is a combination of:

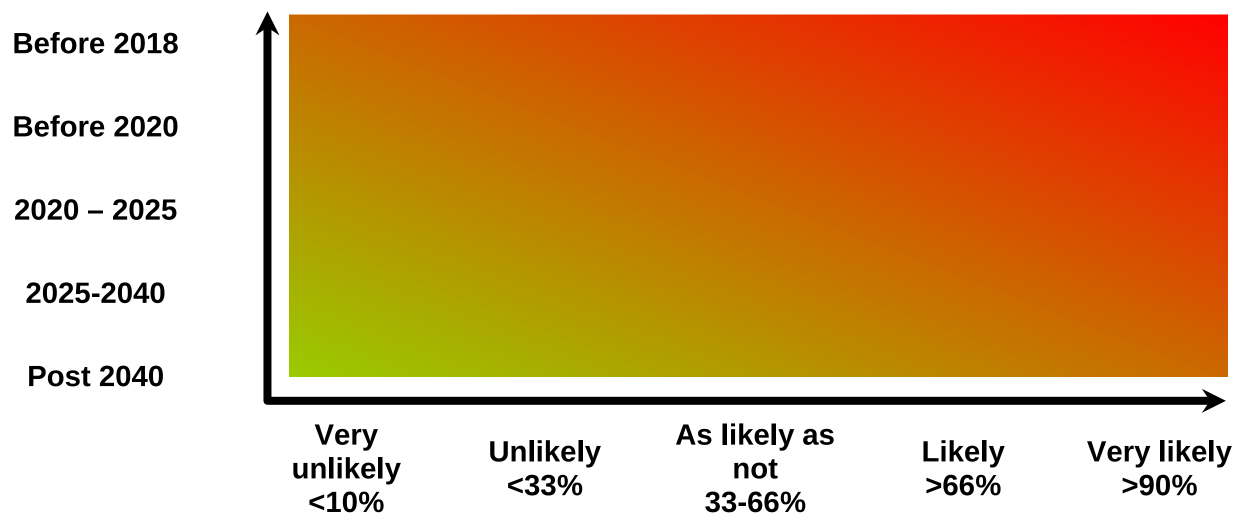
- conventional ways involving building physical assets, such as additional treatment units and protection of assets – to provide resistance and redundancy;
- more innovative approaches such as improved monitoring and systems that provide early warning of problems, and catchment management
- surveys that refine subsequent investment or changes to working practices.

The nature of climate change risk

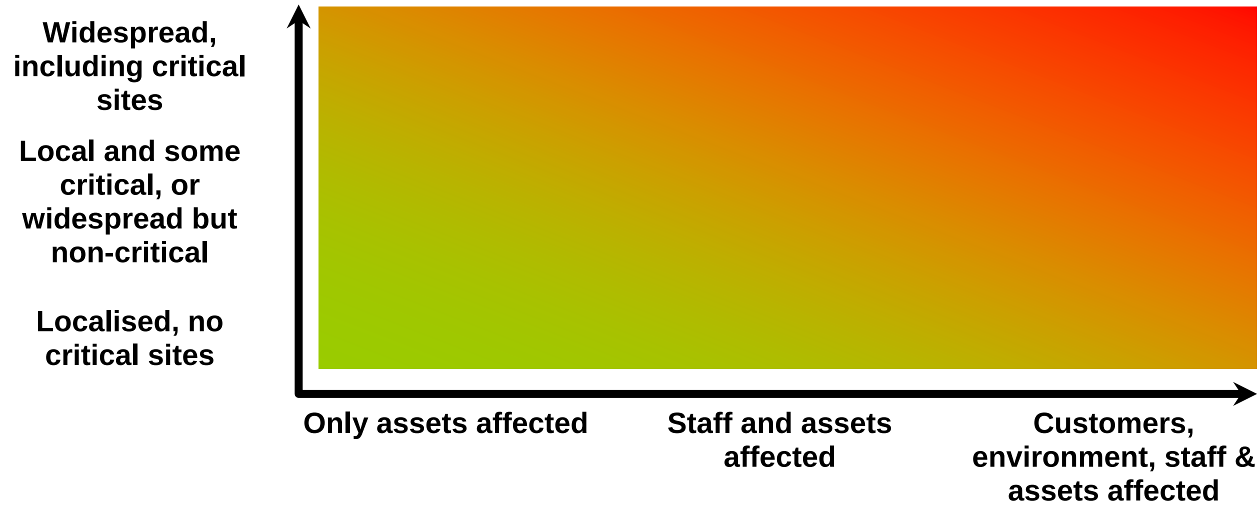
Much of the data provided with UK climate projections concerns changes to *averages* e.g. average winter or summer precipitation, average temperature. This helps us understand how underlying conditions will change gradually over time. However, the resilience of our services is affected more by *extreme* weather events such as heatwaves and drought that elevate peak water demand; or intense and prolonged rainfall that can overwhelm drainage and contaminate water sources. As these have happened many times in the past, we have a lot of experience dealing with acute weather-related impacts. Consequently, they are built into our planning activities and company risk assessments. However, as background warming takes place, weather events considered extreme by the standards of the last thirty years are likely to occur more frequently in future.

Assessing climate-related risk

In common with our other risk assessment work, we consider the likelihood and consequence of a hazard occurring. For **likelihood** we consider the probability of impacts occurring (horizontal axis) over different timescales (vertical axis). For example, certain effects of climate change might be unlikely in the next few years but likely in the long term.



For **consequence** we consider the geographic scale of impacts (vertical axis) and the things that are affected (horizontal axis). For example, a drought that only affects assets and does not lead to water use restrictions would have a medium consequence score. By contrast, a sequence of heavy rain events that causes widespread flooding, placing stress on critical assets and subsequently causing adverse impacts on customers and the environment, would have a high score.



The table below summarises some typical responses across the consequence scores.

Consequence score	Response, adaptation, mitigation
1	A watching brief on local impacts; protection of specific assets to deal with local impacts (e.g. localised flooding); periodic review of assets in the light of gradual change
3	Action needs to be taken. In most cases there are already effective solutions, although individual situations might prove to be testing when they arise.
5	Major investment is likely to be needed for reducing the risk. Reactive mitigation would probably be challenging.

To present our climate change risks in our 2011 adaptation report we used the inventory produced by MWH for Water UK in 2009. Accordingly, we have used the update produced by HR Wallingford for UKWIR in 2012 for this report.

Overall, changes to precipitation – particular heavy rain - dominate our risk assessments. This was very noticeable during the extreme weather conditions experienced from 2011 to January 2014 and is corroborated by other studies e.g. URS review of impacts on energy, water and transport infrastructure. Temperature increase is a lesser concern for our operational assets, but could affect peak demand and cause odour problems at wastewater assets. Sea level increase is a lesser risk in the short to medium term but could become more important in the long term in combination with coastal storms. Otherwise, we are pleased that the UKWIR risk inventory has been extended to include impacts such as heatwaves on the health and safety of employees and the resilience of our supply chain during extreme weather events.

Uncertainties

Climate change projections are inherently bounded by uncertainty – this is recognised by the Intergovernmental Panel on Climate Change, the UK Climate Projections where climate impacts and the UK Climate Change Risk Assessment. While for southern England there is a general narrative of summers becoming warmer and drier on average, winters becoming milder and wetter on average, and stormy conditions becoming more frequent, there are uncertainties that we have to work with. These include:

- the future return period of extreme weather events such as multi-season droughts
- the future trajectory of global emissions, and the greenhouse gas concentration pathway which the world follows
- whether climatic changes happen faster or slower than in current projections
- the specific influence of climate change on issues where there are a number of factors involved. For example, flooding caused by surface water runoff is influenced by the increasing coverage of impermeable surfaces in urban areas, as well as changing rainfall patterns. Similarly, water demand is affected by changes to population and consumption habits as well as the weather.
- the consequences of climate change for specific aspects of our services, and our assessments of risk in which subjective judgements are inevitably brought to bear
- the level of impacts on water availability in the longer term
- the costs and benefits of adaptation options and the suitability of the measures we choose.

So, there is a range of possible outcomes of climate change which itself will tend to amplify or mute other changes. Therefore, we must plan using the best current available evidence and our current view of the best responses, incorporating good quality information from outside our company as well the accumulated knowledge of our own staff.

Responding to climate-related risk

We aim to reduce risk to an acceptable level, such that we can continue to provide expected levels of service, even if in some acute cases this means focused effort and deployment of extra resources. Our responses come through both investment planning and work with external organisations and customers. Typically, responses involve reducing the consequences of an event; for example, it may be difficult to reduce the likelihood of a site being flooded, but we may be able to change the layout of the site to limit the effects of the flooding. Inevitably, we must prioritise risk reduction measures; with limited resources, there may be sites that are vulnerable but have investment deferred as they are lower down the prioritisation.

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 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 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. The table below shows the four main elements to resilience as set out in *Keeping the Country Running: Natural Hazards and Infrastructure* (Cabinet Office, 2011) with examples of adaptive work for each.

Approach	Examples
Redundancy Backup installations or spare capacity that enable operations to be switched or diverted to alternative parts of the network in the event of disruptions	• Elimination of stand-alone sources • Twinning critical pipeline crossings • Reciprocal arrangements with neighbouring water companies • IT systems • Demand management • Allowance for outages, standby units for critical plant • Water resource management planning
Resistance Prevention of damage or disruption, by providing strength or protection to resist a hazard or its primary impact	• Flood defences • Security measures • Ensuring design standards are appropriate
Reliability Infrastructure that is designed to operate under a range of conditions and hence mitigate damage or loss from an event	• Routine maintenance • Refurbishment / replacement of assets
Recovery / response Fast and effective response to, and recovery from, disruptive events. This is determined by efforts to plan, prepare and exercise in advance of events.	• Early warning systems, telemetry, real-time monitoring • Emergency planning, business continuity

It would not make sense for us to attempt to adapt to climate change in isolation. A good proportion of our work requires co-operation and in some cases shared responsibility, with other agencies that are also affected by extreme weather. These include energy and telecoms providers, local authorities, transport providers and those maintaining transport routes, the health service and tourist organisations. More information is given in appendix 9.

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.

Information on how we are responding to specific climate-related risks is given in appendix 6 on water supply and appendix 7 on wastewater services.

Appendix 6: Water supply: risks related to climate change and resulting action

Overview

This appendix firstly explains how we assess climate-related risk for water supply; in detail for water resources planning and at a higher level for the full breadth of activities. We then outline our work carried out over the last five years and planned for the future that will increase our resilience and adaptive capacity, even if climate change is not the primary reason for acting.

Water resources planning

For water supply planning, we are interested in the long-term balance of available water supplies and demand for water. An important consideration is whether our available water resources are sufficient in the event of an 18 month dry period, using the 1975-76 drought as our benchmark. This involved a relatively dry summer in 1975, followed by a very dry winter and a relatively dry summer. We have not imposed any restrictions on water use since 1976; partly due to the absence of such a severe dry winter and dry summer sequence, and partly due to our work to reduce leakage and manage customer demand.

We integrated potential impacts of climate change into our most recent Water Resources Management Plan (as explained in more detail in appendix 7), which in turn informed our 2014 Business Plan for the investment period 2015-20. The first stage is a vulnerability assessment. With information from previous Water Resources Management Plans, Drought Plans and other data we are able to ascertain the level of risk faced, and thereby determine what level of further analysis would be proportionate. We are able to classify our level of vulnerability to future climate change by considering past drought years; our supply sources; the supply-demand balance in the base year (2011-12); security of water supply and / or water scarcity indicators; critical climate variables (such as summer rain, winter recharge); our adaptive capacity (including available sources and drought measures); and the degree to which sources are constrained by hydrology or other factors.

The next stage of assessment was based on the 2011 collaborative *Future Flows and Groundwater Levels* project, which assessed the impact of climate change on river flows and groundwater levels using the UKCP09 projections. These produced 11-member ensemble projections for the 2030s for precipitation, potential evapotranspiration, daily river flow and monthly groundwater levels, under a medium emissions scenario. With the arising data, we were able to perturb historical sequences for groundwater and reservoir inflows within our own models to develop factors for the 2030s. For groundwater, this modelling is consistent with the expected pattern of warmer drier summers and milder wetter winters. Looking at two of our representative groundwater indicator wells, applying the climate change scenarios to the rainfall of winter 1975-76 suggest the impact on maximum groundwater level may be +/- 2 m for Woodyates (4.7% of the maximum range) and +/-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).

For reservoirs, we calculated the impact of the climate change-perturbed inflows on their average yield, by re-optimising each reservoir model for each climate change scenario. The annual average yield relates to the maximum permitted drawdown from reservoirs. Under all climate change scenarios and for all reservoirs there is a bias towards a reduction in average yield relative to the baseline, although for all reservoirs potential increases in yield are indicated under some scenarios. The median overall change in reservoir yields is -2.11 Ml/d.

Our 2014 water resources management plan was subject to regulator, stakeholder and public consultation and was also a key element of the business plan we submitted for Ofwat's 2014 Price Review (PR14).

Flood risk

Following the flooding in Gloucestershire in July 2007 which shut down a major water treatment works 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 and sewage treatment works and major pumping stations. Furthermore the Pitt Review published in June 2008 highlighted the need for enhanced resilience of critical assets to flooding. The approach we adopted complied with the guidance provided by OFWAT in June 2008 – Service Risk Framework (SRF) for Flood Hazards. The methodology followed a five stage process as summarised below:

Risk screening	• Frequency and extent of flooding • Identify assets • Assets 'at risk': the analysis identified water treatment works 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.

Broad risk assessment

The following table, based on the 2012 HR Wallingford / UKWIR climate risk assessment tool, shows our most recent view of medium to high risk climate-related hazards i.e. those scoring 12 or more out of 25.

Regarding water ***quantity***, our risk assessment reflects detailed work for our Water Resources Management Plan as explained in appendix 7. Our initial assessment showed that our single resource zone (region) is of low vulnerability to climate change, with only the west of our supply region - where the majority of our surface water reservoirs are located - having a medium risk. Elsewhere, sources tend to be constrained by infrastructure or their abstraction license, rather than by hydrology. Overall, the UKCP09 medium emissions scenario suggests changes to summer and winter rainfall in an average year will balance each other to the start of the 2050s.

Water resource ***quality*** is more likely to be compromised by climate change in the short to medium to long term, than water quantity. Warmer summers are likely to bring reductions in quality due to biological activity that is triggered by warm weather. Heavy rainfall – both in prolonged episodes or short, sharp spells – can result in contaminants being washed into reservoirs or groundwater sources.

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

Change / hazard	Effects on assets & services	2015	2011
Higher temperatures	More microbiological growth (algae, microorganisms), increasing treatment requirements	20	20
	Discolouration and taste issues, increasing complaints / compliance risk	20	20
	Increased daily and peak demand - domestic, commercial and tourism	12	12
Drought	Political pressure for prioritising essential water use, affecting security of supply	16	-
	Lower river flows resulting in less reliable yields from sources	12	12
	Lower dilution with reduced raw water volumes, increasing treatment requirements	12	12
More intense / prolonged rainfall	Flooding of treatment works and supply network sites, leading to equipment outages, elevated safety risk	20	16
	Storm events affecting power supplies at water treatment sites	20	12
	Surface water entering groundwater, greater turbidity, affecting raw water quality	20	16
	Increased risk of cryptosporidium contamination	20	-
	Discoloration and odour issues, increasing complaints / compliance risk	20	16
	Runoff causing increased levels of sediment and suspended solids	20	16
	Increased public expectation for hard defences to prevent site flooding	16	16
	Flooding and inundation affecting transport routes/access to assets	16	-
Sea level rise & coastal surge	Flooding and inundation affecting transport routes or access to assets	16	-
Combinations	More extreme wetting / drying cycles in soil, leading to increased pipe movement and burst frequency	12	12

Progress since 2011 and plans for 2015-20

In our 2011 adaptation report we set out a number of possible measures to address the medium to high risk climate-related hazards for water supply (see following table). The following pages outline our progress since then and our planned work over the next five years to maintain excellent services in the face of various potential stresses and shocks.

Table 8. High to medium risk impacts and potential adaptation measures

Risk	Potential adaptation measures
Higher temperatures	
Impacts on raw water quality e.g. discolouration and odour caused by growth of microorganisms	• Water Safety Plans, catchment management • Ongoing monitoring; sources taken offline temporarily if levels are exceeded • Enhanced treatment if needed e.g. Granular Activated Carbon
Increasing water demand, reducing security of supply	• Leakage reduction, trials of innovative tariffs, general demand management work, accelerated metering
Drought	
Impacts on raw water quality e.g. lower dilution of contaminants	• Water Safety Plans, catchment management • Ongoing monitoring, sources taken offline temporarily if levels are exceeded • Enhanced treatment if needed
Lower yields from some sources	• Water resources planning & drought planning • Monitoring of general supply-demand balance and availability at particular locations
Lower flows in rivers affected by abstraction	• Ensure rigorous compliance with abstraction licence conditions and continue to review abstraction licence conditions with EA as the climate changes.
Impacts on demand	• Work with customers to reduce their use of water, primarily by promoting metering but supported by information about how to use water wisely and devices that will help them such as cistern displacement devices.
More intense / prolonged rainfall	
Impacts on raw water quality e.g. contaminants washing into water sources	• Water Safety Plans, catchment management • Ongoing monitoring, sources taken offline temporarily or permanently if levels are exceeded • Increased backwashing; enhanced treatment if needed • Reservoir de-silting
Flooding of sites and access routes	• Flood protection: two water treatment works • Ongoing flood risk assessment, review of flooding incidents elsewhere. • Longer term: co-operation with land users upstream, others with interests in flood defence
Loss of power supplies	• Standby generators; response and recovery plans
Combinations	
More extreme wetting-drying cycles, leading to soil movement & pipe bursts	• Reactive repair; mains replacement where justified

Flooding of assets and sites

Following the flood risk assessments outlined above, our proposals for improvements at two sites were found by Ofwat to be cost-beneficial and worthy of investment during 2010-15. In our previous adaptation report we classed this ‘instructed adaptation’ as Ofwat explicitly recognised that climate change was a driver for investment. As the previous flood risk assessments were very comprehensive and still applicable, we are not proposing any further asset flood resilience schemes during 2015-20. However, we will continue to monitor the vulnerability of our sites to flooding in the medium to long term. To date, our flood protection work has been focused principally at the locations of our own assets. Working with land users uphill of our sites, where land management might contribute to flooding, remains an option for the medium to long term depending on how flood risks evolve.

Timescale of actions 2011-2012	**Progress on implementation** Completed: bunding, flap valves, alarms and drainage improvements
Risk mitigation benefits, challenges experienced Maintained security of supply at two sites, which maintained output during wet weather in 2012-2014	**Further actions: risks addressed, timescale** Ongoing monitoring

Water resources planning & drought planning

Our approach to water resources planning is given above, with a detailed account of how we incorporate climate change into the process in appendix 7. Our drought plan sets out how we intend to manage water resources during extended periods of dry weather. Our region experienced an environmental drought during the dry period that culminated in spring 2012, with the greatest concerns focused on streams near Mere at the top of the Stour catchment. Our water resource position however was satisfactory: while groundwater was low, reservoir storage was at 88%. We reached band 2 of our drought plan in February in the north and west and in June in the south. This stage involves initial dry weather actions, such as regular water efficiency communications and the first phase of our resource saving strategy. Overall, stream support was used more heavily than in previous years.

Timescale of actions - Ongoing	**Progress on implementation** - Our most recent drought plan was approved by the Environment Agency and Defra in January 2013 following public consultation.
Risk mitigation benefits, challenges experienced - Drought plan and historical water resources planning helped limit the impact of the 2010-12 drought. - Maintenance of positive supply-demand balance. - Local challenges about impacts of abstraction during dry conditions	**Further actions: risks addressed, timescale** - The next version of our drought plan will be finalised in 2018, and our next Water Resources Management Plan will be published in 2019.

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 for the foreseeable future.

Timescale of actions - Ongoing	**Progress on implementation** - In place at all supply sites
Risk mitigation benefits, challenges experienced - Provide source-to-tap management system. - Compliance maintained at >99.95% - An auditable database of actions and risk scores; prioritising investment and operational interventions.	**Further actions: risks addressed, timescale** - Continuous development & maintenance

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. 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. In the next five years we will continue to use catchment management methods at existing sites (eight in relation to nitrates and two in relation to pesticides) and plan to extend it to safeguard a further eight water sources (six for nitrates and two for metaldehyde).

Timescale of actions - Ongoing	**Progress on implementation** - An established team of catchment advisors - Local agreements for source protection
Risk mitigation benefits, challenges experienced - Contribution to maintaining compliance above 99.95%, among a range of actions specified by the water safety plans for our sources - Deferral of additional water treatment for nitrates and pesticides - Sources remain vulnerable to extreme rainfall	**Further actions: risks addressed, timescale** - Extending catchment management work for drinking water source protection and leading collaborative work for surface water quality.

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.

Timescale of actions - Ongoing	**Progress on implementation** - Continuous monitoring
Risk mitigation benefits, challenges experienced - Early warning system helps maintain supply of wholesome drinking water for customers - Individual sources can be taken out of supply temporarily	**Further actions: risks addressed, timescale** - Watching brief for new monitoring technologies

Integrated grid
We are currently developing a more integrated water supply grid to be completed in 2017/18 which will allow us to deal with a number of issues simultaneously:

- It will improve 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 will be reduced. The grid will also complement existing bulk supply agreements with neighbouring water companies.
- It will allow 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 will also help us to substitute for smaller sources that have been abandoned due to cryptosporidium risk.
- It will enable surplus water to be used in the event of outages.
- It will enable 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 will remove the need for construction of additional treatment plants.

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

Timescale of actions - 2011-2018	**Progress on implementation** - On schedule for completion in 2017-18, with some elements completed
Risk mitigation benefits, challenges experienced - Once completed, will help resolve a number of issues at once (security of supply, single-source properties, nitrate compliance, low river flows)	**Further actions: risks addressed, timescale** - On-going construction work and commissioning.

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.

Timescale of actions - Ongoing	**Progress on implementation** - Regular work
Risk mitigation benefits, challenges experienced - Maintaining raw water quality	**Further actions: risks addressed, timescale** - Continuation of routine scouring

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 the next five years we are reconfiguring one treatment works to deal with deteriorating water quality, where various upstream issues are causing problems for a range of quality parameters at the site's reservoir. While catchment management in the area has greatly helped reduce pesticide risk it cannot solve all the site's issues, hence the need to invest in improved treatment.

Timescale of actions - Ongoing programme according to regulatory requirements	**Progress on implementation** - 2010-15 work completed
Risk mitigation benefits, challenges experienced - Contribution to maintaining compliance above 99.95%, among a range of actions specified by the water safety plans for our sources	**Further actions: risks addressed, timescale** - Reconfiguration of one surface water treatment works

Water mains – repair & replacement
As with raw water quality there are a number of causal factors that influence mains renewal or replacement, such as the age and material of pipes. Extreme weather impacts can play a part, but bursts are more likely to be caused by severe cold weather (causing ground heave) than wetting and drying cycles. 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 at 50km per year in the next five years and maintain the current level of unplanned interruptions. From 2020 onwards, the mains replacement rate will need to rise as pipework ages, and mains rehabilitation designed to improve water quality will also need to continue.

Timescale of actions - Ongoing	**Progress on implementation** - Ongoing implementation
Risk mitigation benefits, challenges experienced - Reduced disruptions to supply and reduced risk to quality from water mains	**Further actions: risks addressed, timescale** - Continuation of mains replacement at current rate during 2015-20.

Supply demand balance: reducing leakage and managing demand
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 the change in target from 74 megalitres per day to 71Ml/day in the last five years. In the next five years we aim to reduce leakage further to less than 66.5 Ml/day, mainly through increasing household water metering. We are looking at a wide range of asset management and technological methods for reducing leakage from supply pipes.

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. Per capita consumption by metered and non-metered customers alike has been falling gradually in the last ten years, and through a combination of measures we aim to further reduce consumption to 131 litres / person / day on average by 2020.

In combination, these measures mean that the water we put into the water supply network is now lower than at any time in the last 25 years and we are able to forecast a surplus of supply over demand for the next 25 years. We are confident that in the event of a drought that matches 1975-76 we can continue to meet demand without restrictions and that our planned investment helps maintain a resilient supply service overall.

Timescale of actions - Ongoing	**Progress on implementation** - Continuous implementation of supply- and demand-side measures
Risk mitigation benefits, challenges experienced - Supply-demand balance surplus forecast to be maintained up to at least 2040	**Further actions: risks addressed, timescale** - 2015-20: further leakage reduction, metering domestic properties, behavioural measures.

Standby generators; response and recovery plans
We need to be able to respond to unforeseen, acute situations such as extreme weather events. The 114 electricity generators we have to provide back-up to water supply sites is one aspect. We also continue to review and update business continuity arrangements and work in partnership with other agencies (as set out in appendix 9).

Timescale of actions - Ongoing	**Progress on implementation** - Operation of generators when required
Risk mitigation benefits, challenges experienced - Back-up power supply in the event of grid supplies being disrupted	**Further actions: risks addressed, timescale** - Maintenance of generators

Appendix 7: Water resources management planning and the impacts of climate change

This appendix explains how we applied climate change factors in our 2014 Water Resources Management Plan (WRMP14), which fed into our business plan for investment during 2015-20. Our general approach follows the framework proposed by the joint UKWIR and Environment Agency project *'Climate change approaches in water supply planning – overview of new methods'*.

This involves a vulnerability assessment followed by a four-stage analysis:

1. assess the impact of climate change on groundwater levels and river flows (for the 2030s)
2. assess the impact of different groundwater levels and river flows on source deployable outputs
3. scale the impact determined for the 2030s through the planning period
4. determine the uncertainty associated with climate change and include in the headroom analysis.

Vulnerability assessment
For the vulnerability assessment we used information from previous Water Resources Management Plans, Drought Plans and other data to ascertain the level of risk faced, and thereby determine what level of further analysis would be proportionate. The main findings are as follows.

Critical drought years and period used for analysis
Studies of historical rainfall records and deployable output show that 1975/76, 1920/21, 1933/34, 1943/44 saw notable droughts. These are the years with the lowest drawdown levels in our single source reservoir model simulations and the lowest simulated groundwater levels in our single point groundwater models. In the 120 years since the 1890s there were five drought events of similar magnitude, extent and duration to the drought of 1975/76, suggesting a 1 in 23 year return period. We aim to maintain unrestricted supplies in a repeat of the 1975/76 drought, which we tend to quote as a 1 in 30 year level of service for customer restrictions.

Sources
We have over 100 sources. Approximately 75% of the water we supply comes from groundwater and 25% comes from surface water reservoirs. We also import water from neighbouring companies, accounting for around 2% of our distribution input. The development of our integrated grid during AMP5 and AMP6 will connect 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.

Supply-demand balance in the base year (2011-12)
The annual review of the Water Resource Management Plan for 2011-12 indicated a satisfactory resource position throughout the year. The security of supply index calculation was 100% and surpluses were 58 Ml/d on average and 68 for the critical period.

Security of water supply and / or water scarcity indicators
Our current investment in a more integrated grid means that we can forecast supply-demand surpluses throughout the 25 year planning period.

Critical climate variables (e.g. summer rain, winter recharge)

Our supply system is generally most sensitive to multi-season droughts akin to the dry summer-dry winter-dry summer drought of 1975-76. Our Drought Plan measures water resource availability in terms of reservoir storage and the use of key annual licences. Groundwater levels at Allington, Woodyates and Ashton Farm are used in our monthly supply strategy modelling to optimise source outputs. In 1975-76 summer inflows and groundwater recharge were very low (effectively zero). Climate change cannot make this significantly worse, unless summers become longer although 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.

Adaptive capacity (available sources and drought measures)
In our previous source yield review approximately half of our sources were judged to be hydrologically constrained, making them particularly susceptible to the impacts of climate change. For our 2011 Drought Plan we screened each of our sources for 'adaptive capacity' i.e. whether they would be suitable for drought permit options.

Sensitivity (low, medium or high)
Sources in the south of our area (formerly our south resource zone) 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 and demonstrate greater variability in the impact on deployable output under the scenarios explored previously for the 2009 WRMP.

Vulnerability classification
Our assessments of changes in deployable output suggest that our single resource zone (region) is of low vulnerability to climate change. When we previously had four water resource zones, only the west zone (where the majority of our surface water reservoirs are located) indicated a medium risk; north, south and east all indicate low risk.

Subsequent analysis
For the next stage of the climate change assessment, the Water Resource Planning Guidelines identifies four suitable approaches in situations where there is a low vulnerability classification.

Given the data available for use and the data requirements of our existing water resource models, we chose to employ approaches 1.3 and 1.4. These use outputs of the 2011 collaborative *Future Flows and Groundwater Levels* project, which itself uses the Met Office Hadley Centre Regional Climate Model which underpins the UKCP09 analyses. The outputs give projections for daily absolute climate (i.e. not climate changes) in individual 25 km grid squares over a continuous time period of 1950-2099, under one (medium) emissions scenario.

Future Flows and Groundwater Levels assessed the impact of climate change on river flows and groundwater levels using the UKCP09 projections, producing two key datasets of use to water resources planning:

- Future Flows Climate (FF-HadRM3-PPE): an 11-member ensemble 1km gridded projection time series (1950-2098) of precipitation and potential evapotranspiration specifically developed for hydrological and hydrogeological application.
- Future Flows Hydrology (FF-HydMod-PPE): an 11-member ensemble projection of daily river flow and monthly groundwater levels time series (1951-2098) for 282 rivers and 24 boreholes in Great Britain.

As all the 11 data sets are equally likely, they 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.

Using 11 transient time series of climate and flow data that were made available, we were able to perturb historical sequences for groundwater and reservoir inflows within our own models to develop factors for the 2030s. We believe these methods are proportionate to the risks from climate change faced by our supply area, and the Environment Agency agreed with this approach also.

Impacts of climate change on river flows and groundwater levels
We only assess the impact of climate change on sources that are *hydrologically* constrained, but not on sources that are constrained by licence conditions or infrastructure.

We contracted consultants Hyder to analyse and process the *Future Flows and Groundwater Levels* data into suites of monthly factors to perturb the historical sequences of rainfall, potential evapotranspiration, river flows and inflows used by our groundwater and reservoir models.

Groundwater
For impacts on groundwater levels, the steps were as follows:
1. Select appropriate grid squares relevant to our groundwater models (Woodyates, Ashton Farm and Chippenham) from the Future Flows climate data
2. Obtain transient rainfall and potential evapotranspiration (PE) for the grid squares covering the period 1950-2098 and develop 11 sets of factors for rainfall and PE that relate the 1961-1990 period (pre climate change baseline) to 2020-2049 (representing the 2030s).
3. Apply these factors to the historical sequences of rainfall and PE in our groundwater models to create 11 new versions of each model that represents the 11 climate change scenarios.

In general, median values of the models suggest changes that are consistent with the expected pattern of warmer drier summers and milder wetter winters. The climate change scenarios suggest the impact on maximum groundwater level in the winter of 1975-76 may be +/- 2 m for Woodyates (4.7% of the maximum range) and +/-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).

Reservoir inflows
For impacts on reservoir inflows, the steps were as follows:
1. Select appropriate ‘donor catchments’ from the Future Flows hydrology data relevant to our reservoirs
2. Obtain transient river flow data for the donor catchment covering the period 1950 – 2098 and develop 11 sets of factors for flows that relate the 1961-1990 period to 2020-2049.
3. Use an equation to relate the donor catchment to the inflow of interest and apply the factors to the historical sequences of reservoir inflows in our reservoir models to create 11 new versions of each model that represents the 11 climate change scenarios.

Impacts of climate change on deployable output
Using the assessment of impacts on groundwater levels and river flows, we can examine potential impacts on the deployable output of hydrologically-constrained sources under the eleven scenarios. Three parallel analysis methods are applied depending on source type, as follows.

Hydrologically constrained groundwater sources
50 of our groundwater sources are hydrologically constrained, accounting for nearly 120 Ml/d and 30% of average deployable output. Their available output can be modelled using their output relationship equation against Woodyates or Ashton Farm sources. Accordingly, 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).

Impacts vary from -5.79 Ml/d to +6.95 Ml/d for average (approx. +/- 5% of the potential yield) and from -4.73 Ml/d to +5.69 Ml/d for peak (approx. +/- 4% of the potential yield). The mean impact of the 11 scenarios is a change in total average deployable output of +0.27 Ml/d and a change in total peak deployable output of +0.24 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. This indicates a change in total average deployable output of -1.17 Ml/d and a change in total peak deployable output of -1.00 Ml/d by the 2030s.

Chippenham and Chitterne groundwater models
Unlike most of our groundwater sources, our abstractions from the Chippenham aquifer can impact on the volume of storage in the aquifer. To reflect this we use a single point groundwater model to model the effect of the 11 climate change scenarios relative to the baseline. Average yields decline in two of the 11 scenarios and increase in the other nine, suggesting that wetter winters will outweigh the effect of drier summers for this aquifer. Overall, the impact varies from -0.50 Ml/d to +1.30 Ml/d, with a mean of +0.40 Ml/d and a median value of +0.22 Ml/d.

In 2011 there was a formal reduction in the annual licence for Chitterne. As yields from this source are constrained by the licence rather than hydrology, its yield is assumed to be unaffected by climate change. Modelling the 11 climate change scenarios using our single point groundwater model for Chitterne shows that under the baseline scenario the modelled theoretical yield of the source exceeds the average daily equivalent annual licence. In none of the 11 scenarios are yields less than the current licence indicating that this source's output will be unaffected by climate change.

Reservoirs
Climate change is assumed to impact only on the *average* yield of a reservoir source; their *peak* output 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/abstraction plus compensation flow). Under all scenarios and for all reservoirs there is a bias towards a reduction in average yield relative to the baseline, although for all reservoirs potential increases in yield are indicated under some scenarios. The median overall change in reservoir yields is -2.11 Ml/d (sum of median change for each reservoir) and the mean change is -1.97 Ml/d.

Summary of climate change impacts on baseline deployable output
The impact of each climate change scenario on groundwater sources and reservoirs for average and peak conditions for the 2030s is shown below:

	AVERAGE				PEAK
	Hydrologically constrained groundwater	Chippenham	Reservoirs	Total	Hydrologically constrained groundwater
Min	-5.79	-0.50	-4.27	-9.56	-4.73
Max	6.95	1.30	0.62	6.90	5.69
Mean	0.27	0.40	-1.97	-1.30	0.24
Median	-0.95	0.22	-2.11	-2.84	-0.83

The Water White Paper and Water Resource Planning Guidelines encourage water companies where appropriate to look beyond the standard 25-year planning horizon, particularly in the context of climate change and resilient infrastructure developments. However, given the relatively small impact of climate change that our assessments forecast and our growing supply demand balance surplus throughout the 25-year period we do not believe that extending our forecasts and planning further into the future is appropriate in the context of our Water Resources Management Plan.

Scaling
As per the Water Resources Planning Guideline the calculated change in deployable output for 2035 is scaled from the base year (zero effect) to 2034/35 and then extrapolated from 2034/35 to the end of the planning period (2039/40), as summarised below

Table 4-15: Best estimate of the impact of climate change on deployable output

	2011-12	2014-15	2019-20	2024-25	2029-30	2034-35	2039-40
Dry year annual average impact of climate change	0.0	-0.30	-1.05	-1.80	-2.54	-2.80	-3.03
Dry year critical period impact of climate change	0.0	-0.11	-0.37	-0.63	-0.90	-0.99	-1.07

Uncertainty and headroom
The variety in impact shown by the 11 scenarios indicates that the impacts of climate change remain uncertain. We have accounted for uncertainty by incorporating the impact of all 11 scenarios in our headroom assessment.

Appendix 8: Sewerage, sewage treatment and sludge: risks related to climate change and resulting action

Overview

This appendix firstly explains how we assess climate-related risk for sewerage, sewage treatment and sludge. We then outline our work carried out over the last five years and planned for the future that will increase our resilience and adaptive capacity, even if climate change is not the primary reason for acting.

Sewerage, sewage treatment and sludge – assessing climate related 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.

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 are suffering a 2 year flood return period, 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. Wessex Water is also heavily involved in the new 21st Century Drainage programme, co-chairing three of the seven workstreams. The intention is to produce a high level framework that enables our sewerage systems to continue to be fit for purpose now and in the future. Ofwat has also recently consulted the industry of resilience of our assets.

The following table, based on the 2012 HR Wallingford / UKWIR climate risk assessment tool, shows medium to high risk items i.e. those scoring 12 or more out of 25. 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.

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

Change / hazard	Effects on assets & services	2015	2011
Higher temperatures	More septicity at sewage treatment works increasing asset deterioration, toxicity, odour complaints and compliance risk, while reducing receiving water quality	16	16
	Increasing odour at sewage treatment works and sludge sites, affecting local people	16	16
Drought	Settlement / sedimentation in sewers, leading to subsequent shock loads following rainfall affecting treatment processes	16	16
	Lower flows, leading to longer retention times in settlement tanks, resulting in increased septicity and odour problems	16	16
	Lower flows in sewers leading to blockages, resulting in property flooding	12	16
	Lower river flows resulting in less dilution of effluent	12	16
More intense / prolonged rainfall	Increased storm water volumes overwhelming combined sewers and sewerage pumps, leading to flooding and more spills affecting watercourses	20	20
	Heavy rain leading to more spills affecting bathing waters	20	20
	More infiltration of groundwater into sewers, increasing flood risk	20	15
	Increased volumes to be pumped, accelerating asset deterioration and increasing power use	15	20
	Combination of heavy rain and high tides impeding discharges from overflows, risking property flooding	12	12
	Combination of heavy rain and blockages caused by sewer misuse risking property flooding	12	9
	Flooding of sewerage assets leading to potential failures	12	12
	Flooding affecting transport routes into sites	12	-
	Flooding of agricultural land and transport routes impeding sludge recycling activity	12	12

There may be some specific benefits from climate change. For example, milder winters would help some sewage treatment processes and reduce heating cost.

Taking action: progress since 2011 and plans for 2015-20

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 – either 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 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 sewage treatment works (alongside urban creep and new development), we must invest to provide stable levels of service to our customers and the environment.

In our 2011 adaptation report we set out a number of possible measures to address the medium to high risk climate-related hazards for wastewater services (see following table). The following pages outline our progress since then and our planned work over the next five years to maintain excellent services in the face of various stresses and shocks.

Medium to high risks as assessed in 2011, and potential adaptation measures

Risk	Potential adaptation measures
Higher temperatures	
Increased septicity and odour problems, affecting sewage treatment performance and causing nuisance	• Local odour control; increased aeration, more efficient management of sludge
Effluent standards tightened due to warmer receiving waters	• Investment if required by environmental regulators and supported by Ofwat
Drought	
Sedimentation in sewerage causing blockages	• Sewer maintenance, cleansing
Longer retention in settlement tanks, odour problems	• Local odour control / mitigation
Lower river flows leading to increased risk of tightening discharge standards over time	• Investment if required by environmental regulators and supported by Ofwat
More intense / prolonged rainfall	
Sewerage overwhelmed, through surface flooding or groundwater infiltration, leading to property flooding or spills that affect rivers and streams	• Work to alleviate sewer flooding of properties • Sealing sewers experiencing groundwater infiltration • Improvements at individual CSOs • Involvement with surface water management plans • Flow modelling to predict local impacts of rain events; drainage area plans
Direct flooding of pumping stations and sewage treatment works	• Raising controls above flood level • Flood risk assessment and review of flooding incidents • Co-operation with upstream land users and others with interests in flood defence
Flooding of transport routes and waterlogging of fields, affecting sludge recycling operations	• Management of sludge cake • Use of portable trackway to access fields • Driers to minimise sludge volumes
Sea level rise and coastal storms	
Combined sewers affected by high tides, leading to customer flooding and unplanned discharges	• Work to alleviate sewer flooding of properties • Surface water management plans with stakeholders in tide-locked catchments • Need for pumped relief discharges
Direct flooding / loss of assets, particularly if coastal realignment was required	• Flood risk assessments; investment to protect sites if agreed by Ofwat; relocation of sites / flows where necessary

Flood risk to our assets

Our 2008 risk assessment started by identifying 84 sewage treatment works and 164 sewage pumping stations that lie in a flood plain. Using the flood risk assessment and prioritisation steps outlined earlier, we reduced this list to eleven sites for improved flood resilience works during the 2010-15 investment period - two sewage pumping stations and nine sewage treatment works. However, Ofwat was unable to support the need for all but one of these schemes, challenging the marginal results of the cost-benefit assessment. The single scheme, involving a sewage pumping station that serves a medium-sized town, was completed in March 2013. We replaced above-ground pump motors with dry well submersibles and raised electrical equipment above predicted possible flood levels. In addition, relatively minor works to improve resilience against flooding were carried out at one other sewage pumping station and three sewage treatment works in 2011 and 2012 respectively.

The flood risk assessments undertaken in 2008 were comprehensive and are still applicable. While it was not necessary to repeat the analysis, in the light of the exceptional wet weather of 2012 to 2014 we have reviewed flood risks at our sewage treatment works. Several of the sites identified in the previous assessment were flooded but had sufficient resilience to quickly recover once flooding subsided. However one site suffered significant damage in its inlet, raising the probability of consequential pollution. We also have records of five fluvial flooding events at this site over the past 8 years. We are therefore carrying out improvements before 2020 with new electrical plant and equipment located at a higher level, above the 1 in 200 year flood plain. Otherwise, we will continue to review the risks associated with flooding of our sewerage assets and take appropriate action should the risks become unacceptable.

Timescale of actions - Risk assessment in 2008 - On-going monitoring	**Progress on implementation** - Comprehensive risk assessment - Flood protection at one major pumping station -
Risk mitigation benefits, challenges experienced - Reduced consequence of site flooding	**Further actions: risks addressed, timescale** - Improvements at one sewage treatment works by 2020 - Ongoing review of risk

Sewerage capacity, condition and maintenance

Sewer flooding attributable to insufficient sewerage capacity occurs during wet weather. 2012 and the winter of 2013/14 was a reminder of how variable and extreme weather patterns can be. As noted earlier this led to a big increase in flooding incidents and restricted service for some customers.

Over the next five years we will aim to maintain a stable level of total flooding risk, including external area flooding. 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. Also, we will measure total flooding risk – including external as well as internal flooding risk – which is feasible now that we have been collecting external flooding risk data for nearly 10 years. We will continue to focus investment primarily on locations of highest risk. We will also invest proactively in sewerage capacity during 2015-20 where cost-beneficial, including defined schemes for Bristol and schemes that improve capacity across the region whilst allowing smaller non-specific investment needs to be addressed as they materialise during the period.

Timescale of actions	Progress on implementation
- Ongoing programme of work	- Extensive investment during 2010-15 on various aspects and approaches
Risk mitigation benefits, challenges experienced	**Further actions: risks addressed, timescale**
- Reducing risk of sewer flooding for properties (internally and externally) - Heavy rainfall in 2012 and 2013-14 caused widespread disruption	- Ongoing programme, including sewer improvements, SUDS, sewer separation, real-time monitoring and control

Dealing with groundwater infiltration

Infiltration of groundwater into private drains and public sewers can be a significant problem in our area due to the prevalence of geology that can have high water tables. This can lead to restricted toilet use, premature spilling of combined sewer overflows to the environment and hydraulically overloaded sewage treatment works. During 2012-13 and 2013-14, the worst years on record for infiltration problems, 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.

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. The last few years has also seen the development of infiltration reduction plans, with the aim of reducing discharges to the environment. We are agreeing with the Environment Agency where such plans need to be delivered and helping 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 have learned from the floods of 2014 and have prepared local emergency plans for over 50 catchments, so we are better prepared should another extreme winter occur. We have also been working at a national level to raise the profile of groundwater inundation and promote best practice.

Timescale of actions	Progress on implementation
- Ongoing programme of work	- Sewer sealing - Development of infiltration reduction plans
Risk mitigation benefits, challenges experienced	**Further actions: risks addressed, timescale**
- Avoidance of restricted toilet use, overflows from combined sewers and overwhelmed sewage treatment works - Prevention of infiltration into private drains is a challenge	- Continual work on our sewerage assets and co-operation with other agencies

Sewer maintenance

Sewers are designed accommodate flows 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.

Timescale of actions	Progress on implementation
- Ongoing programme	- Ongoing sewer maintenance
Risk mitigation benefits, challenges experienced - Clearance of blockages in sewers that could otherwise cause pollution incidents	**Further actions: risks addressed, timescale** - Ongoing inspection and maintenance work, plus public awareness raising about causes of blockages

Surface water management
Since the Flood and Water Management Act 2010 we have worked more closely with the 11 Lead Local Flood Authorities 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. We are currently discussing joint partnership funding with LLFA to address flooding in a number of areas in Bristol, Bath, Bournemouth, and Somerset.

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 CSOs and Settled Storm Overflows (SSOs). 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.

We have recently 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 WaterUK's Surface Water Separation Project and SusDrain, run by CIRIA.

Timescale of actions	Progress on implementation
- Ongoing programme	- Collaborative work with LLFAs and others
Risk mitigation benefits, challenges experienced - Reduction in flood risk	**Further actions: risks addressed, timescale** - Ongoing programme, including sewer separation, integrated urban drainage management

Improvements at individual combined sewer overflows
CSOs act as relief valves for the sewerage network during times of heavy rain. They are designed to pass forward polluting loads so that when they do discharge they do not 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 CSOs to better understand the frequency of their operation and will continue with this programme in the next five years. We are also investing in improvements at some coastal sites where there is a link between CSOs and coastal water quality.

Timescale of actions	Progress on implementation
- Ongoing	- Spill monitors being installed - Improvements at specific CSOs
Risk mitigation benefits, challenges experienced - Reduction in pollution incident risk	**Further actions: risks addressed, timescale** - Continuation of current work

Odour control / mitigation

In AMP5 we developed and introduced an Environmental Odour Policy based on the Institute of Air Quality Management's (IAQM) guidance document as well as DERA's code of practice for odour control and management. By developing a system of detailed odour management plans for our STWs and SPS's, including generic and 30 site specific plans, we have been able to implement operational improvements and general good house-keeping 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.

Timescale of actions	Progress on implementation
- Ongoing	- Odour management plans in place - Operational improvements
Risk mitigation benefits, challenges experienced - Reduction in odour nuisance risk for our neighbours	**Further actions: risks addressed, timescale** - Ongoing monitoring of control equipment

Quality 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 sewage treatment works. However, our ongoing programme of investment to improve the quality of effluent from sewage treatment is driven by the general condition of watercourses and European regulation such as the Urban Waste Water Treatment Directive and the Habitats directive. To date, warmer weather or climate change have not explicitly cited as contributory reasons for our investment, but it is a factor that could have an influence in the medium to long term. Over the next five years we have an extensive programme of work across all the catchments in our region including new / additional nutrient or ammonia removal, trials of novel treatment technologies, trialling catchment-based consenting and environmental investigations.

Timescale of actions	Progress on implementation
- Ongoing	- Rolling investment in new assets and investigations of environmental impacts
Risk mitigation benefits, challenges experienced - Maintaining compliance with end-of-pipe standards	**Further actions: risks addressed, timescale** - 2015-20: additional treatment, technology trials, catchment-based approaches, investigations

Maintaining sludge to land
As we have limited capacity for storing sludge cake, it is normally transferred directly from our Sludge Treatment Centres (STC) 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. However, we have found that more intense operational management and frequent assessment of the stability of the stockpiles of sludge cake allows us to manage the risk of running out of capacity to store cake, without needing to create additional storage at this time. Regarding other possible measures, we do not favour higher cost methods such as drying sludge where other options are available (although we have sludge drying facilities at our disposal).

Timescale of actions - Ongoing	**Progress on implementation** - Review of sludge cake storage facilities and practice
Risk mitigation benefits, challenges experienced - Retaining the ability to reuse sludge cake on farmland	**Further actions: risks addressed, timescale** - Continuation of current practice

Shoreline management plans (SMPs)
We have 391 significant sewerage assets or sites in the areas covered by SMPs. In the short term (0-20 years) we have assessed the risk to all these assets from coastal processes as low. In the medium term (20-50years), four assets are potentially at a high risk from coastal processes – one sewage treatment works, one sewage pumping station and two outfalls. 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. Between 2020-30 we anticipate developing options and plans to improve the resilience of the assets which are at risk.

Timescale of actions - Ongoing	**Progress on implementation** - Assessment of risk to assets in areas covered by SMPs
Risk mitigation benefits, challenges experienced - Avoidance of coastal flooding of operational assets	**Further actions: risks addressed, timescale** - Ongoing review of the status of affected sites

Overview of adaptation measures for impacts of any level of risk

	Forward planning	Investment schemes and ongoing operations	Work with others
All activities	• Flood risk assessments • Asset deterioration models • Adapting maintenance plans	• Response & recovery plans for extreme weather events and coastal flooding • Developing working practices for unusually wet, warm or dry conditions • Local infrastructure solutions • Adapted working practices for health and safety • Energy self-sufficiency at key sites • Optimising operating and maintenance regimes	• Responding to customers' expectations for improving service levels • Emergency response strategies • Discussions on water legislation •
Water resources, treatment and networks	• Alternative or relocated sources if yields change • Altering existing assets to optimise use of resources • Drought planning • Modelling flows and water quality, water safety plans • Water network service plan	• Monitoring processes & water quantity • Reservoir inspections and desilting • Water metering • River flow studies • Leakage reduction measures	• 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
Sewerage, sewage treatment and sludge	• Modelling sewer catchments • Topographic mapping for flood risk • Sewerage capacity investment • Flood alleviation schemes • Rainfall modelling • Review of sewage works' capacity and flow consents • Review of treatment options process performance of during extreme weather • Managing risks to reusing of sludge on agricultural land	• Monitoring run-off and flood flows • Reducing infiltration of groundwater into sewers • Separation of surface water and foul sewers • Pumped overflows during river flooding • Increasing capacity at sewage works according to changes to incoming flow • Altering operations and maintenance for changes to sewage received, sludge produced or receiving watercourses • Monitoring sewage quality, regulating trade effluent • Re-using effluent	• Work with other agencies on Surface Water Management Plans • Developing infiltration reduction plans with regulators • Collaborative catchment management work • Negotiations on discharge consents during extreme weather • Working with farmers to maintain sludge reuse options

Appendix 9 Other considerations

The success of our adaptation work will be based on our ability to meet standards expected by customers and regulators; to accommodate gradual change such future population growth and increasing flows; and to maintain normal service during extreme weather events. Consequently, planning for climate change is not an optional add-on but is embedded in our risk management framework, in water resource planning and sewerage design, and in water industry research. However, it is not simply a straightforward process by which evidence leads seamlessly to investment; there are a range of technical, organisational, economic, and policy considerations that need to be taken into account. This section outlines current efforts to build understanding of climate change into work, as well as consideration of other organisational issues.

Managing climate change risks within Wessex Water

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 into technical work such as water resource planning and sewer design standards
- we participate in UKWIR projects that incorporate UKCP09 projections and consider various potential impacts in depth
- we employ technical specialists who are able to translate climate risk into practice.

Monitoring & evaluation

Ongoing monitoring of climate change impacts and evaluating the success of our adaptation has a number of aspects. For water supply, we review source yields at least once every five years as part of the business plan and water resources plan processes. Actual data is considered and yield reductions since previous assessment will be 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.

For sewerage and sewage treatment, we are monitored against stable levels of service and asset condition such as the performance of combined sewer overflows; as climate change happens we will need to review the performance of these assets during more extreme rainfall events. Any new flooding is assessed and the viability of implementing flood alleviation schemes is considered. We are part-way through a programme of installing event duration monitors at combined sewer overflows to record the duration of spill events, which will help us assess any deterioration in the performance of these assets. However, as for water supply, linking cause and effect is not straightforward in sewerage management as there are many factors that contribute to issues such as flooding; for example, land use change, urban development, and maintenance of watercourses as well as weather and climate-related impacts.

Flexibility

Our adaptation plan and management of climate change risk is not fixed in perpetuity. Although we can set out preferred approaches, it is important that adaptation is flexible as new data emerges or risk assessments change. This is partly enabled by the cyclical nature of some of our asset planning exercises, such as water resources management plans, which involves revisiting current climate change projections every five years at most. Flood risk assessments and associated mitigation work also need to flex, as the impacts of weather events and local floods are reviewed and the success of initiatives such as surface water management plans are evaluated. Furthermore as innovations reach us via various routes there will be opportunities to trial novel approaches that might improve the resilience of individual sites and our overall operations.

Interdependencies

It would not make sense for us to attempt to adapt to climate change in isolation. This partly because we are reliant on services provided by others and partly because much work involves shared responsibility with others that are affected by extreme weather or a changing climate. These include customers, energy and telecoms providers, local authorities, transport providers and those maintaining transport routes, the health service and tourist organisations. There is also an important role played by climate researchers in better understanding and communicating current and future climate risks.

The multi-agency nature of climate risk is very evident for surface water management, which involves liaison with councils, Internal Drainage Boards and the Highways Agency. Similarly, for emergency response practices - it is also 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 in the rural parts of our region, 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.

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 recently summarised its current 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.
- More flood barriers were purchased by National Grid after the 2013/14 winter storms.
- The Environment Agency has assessed water demands for electricity generation through to the 2050s

- Electricity transmission and distribution companies are transparently taking steps to improve flood protection levels for critical substations over the coming decade.
- 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).
- Power cuts caused by power station outages are rare…power can be routed to customers even if individual power stations are forced to cease generation.
- 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.
- Electricity substations serving one million customers are due to benefit from flood protection measures by the end of the decade. However during the 2020s, climate change is expected to mean substations serving around a half a million customers will fall in to the high flood risk category.

We have some contingency measures in place, such as our 365 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.

Barriers

The main barriers to climate change adaptation are financial, regulatory and technical. Examples include the upfront cost of capital-intensive engineered measures and their affordability to those who pay; uncertainty and the limits of existing knowledge (such as those outlined in appendix 5); delayed action due to complexity (particularly agencies with varied funding arrangements and cycles are involved); insufficiently clarity over responsibilities where there is more than one potential lead organisation; and potential unintended consequences of adaptation measures such as changes in movement of excess water.

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.

Any of these factors, individually or in combination, can lead to corrective work being delayed. They 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 (see below).

Cost and benefits of measures

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

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 are varied and explained in appendices 6 and 8. In the main they 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.

Thresholds

We use certain *weather events* such as the 1975-76 drought and 1 in 30 year storms as reference points or benchmarks. However, we have not identified specific threshold points in the *climate* itself, such as average temperature or rainfall above which particular impacts move from one level of risk to another. For example, we do not know the temperature increase that would change the intensity of storms above the level that could be handled by key sewers or pumping stations. Nevertheless this is an area in which the water sector is looking to increase its knowledge, with potential future work looking scenarios in which global or UK climate has passed particular reference points and the effects of this on its activities.

Sector policy and regulation

Since 2011 there have been some sectoral changes that are relevant to climate change adaptation. Firstly, the 2014 Water Act gave Ofwat and the Defra Secretary of State the duty:

- 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.

Secondly, the 2014 periodic review of prices saw two notable developments. One was the emphasis on beneficial outcomes for customers and environment, as opposed to ‘outputs’ in the form of a list of activities to be undertaken by water companies.

Consequently, one of Wessex Water’s outcomes is ‘resilient services’, defined as “assets and working practices that continue to deliver high quality, reliable services in the face of unusual events such as flooding or droughts”. The targets connected with this outcome are a) no hosepipe bans, b) reduced number of properties experiencing short term interruptions to supply, c) reduced number of properties supplied from a single source of water, d) no increase in water mains bursts, e) no increase in sewer collapses.

The other major development is the emphasis on ‘totex’ (total expenditure), so that the solutions are chosen based on their wholelife cost. This should mean that incentives to choose less capital-intensive solutions (such as catchment management, sustainable urban drainage systems, or behavioural measures) are at least equal to incentives for 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.

Climate change mitigation
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. We have a long term aim to be carbon neutral and a carbon management strategy with three main elements:

- emissions avoidance through catchment management, leakage reduction, water demand management
- increasing efficiency across our sites through site audits, real time monitoring and introduction of more efficient equipment
- generating renewable energy principally through anaerobic digestion and resource recovery at sewage treatment works, but also pursuing other opportunities involving hydro, solar and wind.

Appendix 10. Recent UK Water Industry Research climate change adaptation projects

2010-11

Water treatment and climate change
The project aims to assess 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
This project aims to transpose the potential effects of climate change into robustly defined impacts on wastewater treatment processes and services, and seeks to design an appropriate response to those impacts for government, the industry, and its regulators.

Both CL08 and CL12 will look at the potential impact on existing processes and to identify generic sensitivities and thresholds where climate change could have an impact both negative and positive.

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
Following publication of UKCP09, UKWIR are working with the Environment Agency on two projects to assess how climate change may affect the supply demand balance. This is a follow on 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.
The aim of this study is to provide companies with a mechanism by which critical climate sensitive treatment process thresholds may be established, monitored and assessed. This will provide an evidence base from which adaptation actions may be taken that will be justifiable to the regulators and other stakeholders.

Updating the UK Water Industry Adaptation Framework
The overall aim of the project was to update and enhance the UK water industry adaptation framework, with the creation of a practical new framework and guidance

2014-15

Rainfall intensity for sewer design
This project is examining predicted changes in the type of UK rainfall important for sewer design using the latest climate simulations and identifying climate analogues (international locations with current climates similar to the ones predicted for the UK). It will recommend uplift factors for current design storms for use in predicting future sewer flooding patterns; and

will examine and learn lessons from international sewerage design and stormwater management approaches. It will also provide guidance to make appropriate provision for future climate in any new sewer systems or infrastructure enhancements for which investment is needed in the near term.

Planning for the mean or planning for the extreme

This project aims to stablish 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. The knowledge developed will play a central role in allowing the industry to better understand and manage present day climate and weather issues.