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Appendices

Executive Summary

This report is South West Water's response to the Secretary of State's instruction to reporting authorities in England and Wales under the Climate Change Act 2008[1]. It has been prepared in accordance with the Defra guidelines[2] and builds upon the work already published by South West Water in the Strategic Business Plan[3] and Water Resources Plan[4]. The structure of this report is based on Box 2 of the Defra guidelines.

1 Information and Organisation

South West Water is the statutory water and sewerage undertaker supplying approximately 1.68 million people and approximately 8 million visitors a year to the South West of England. Our goal is to be recognised by our customers as delivering our objectives of Pure Water, Pure Service and a Pure Environment. One of our challenges is to protect our assets from the effect of climate change whilst ensuring that we minimise our contribution to it.

The predicted changes to the climate have the potential to have a profound impact on all the services we provide. We are committed to ensuring that we can provide a continuous service to our customers by maintaining a number of key service level indicators which include the Security of Supply Index, which is a key investment driver.

2 Business preparedness before Direction to report was received

We have become increasingly aware of the impact of climate change on our business and on our customers. In December 2007 we published our Strategic Direction Statement which looked forward 25 years. In it we acknowledged that climate change will be one of the challenges that we will face and that if we do not plan to address the issue now it could have a major impact on our business, especially water resources and surface water management. Our Strategic Direction Statement therefore included a number of commitments designed to help us cope with the predicted changes, some of which will require investment over a very long period of time to achieve the goals.

Our financial regulator, Ofwat, requires us to review our business plan every five years. During the development of our current plan we examined a number of areas that we felt could be affected by climate change. Some of these were included in our current plan as they were identified as being cost beneficial and the potential effect could be realised during the next five years.

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[1] Letter dated 1st March 2010 from Clare Hawley, Adapting to Climate Change Programme

[2] http://www.defra.gov.uk/environment/climate/legislation/guidance.htm

[3] http://www.southwestwater.co.uk/index.cfm?articleid=6973

[4] South West Water, Final Water Resources Plan November 2009

At the same time as developing our Asset Management Plan we were also drawing together our Water Resource Plan, for the planning period 2010-2035 which also reflects the need to adapt to climate change.

3 Identifying risks due to the impacts of climate change

During the development of our Asset Management Plan for Ofwat we examined a number of areas that our analysis showed could be affected over the next few years by climate change, an example of this is fluvial flooding of our assets. The risk was assessed by referring to flood zone maps that have been produced by the Environment Agency and updated rainfall data.

We prepared an outline of this report based on one-to-one discussions with operational personnel who had an extensive knowledge of the business. We then organised climate change review sessions with acknowledged technical experts. A total of 10 people from across different functions have been involved. In order to provide a framework for the discussions we used the Water UK study, ‘A Climate Change Adaptation Approach for Asset Management Planning’ (2007). The study provides a consistent approach for assessing adaptation risks by highlighting key climate variables for the water industry (drought, flood, sea level rise and temperature rise) and identifying how they may impact our assets and operations in seven key asset based functions.

During the assessment we used the matrix that is described in Section 2.2 of our report to assess the identified risks. The increase in risk was referenced to the UKCP09 climate change projections medium scenario. The risks that received a high score were reviewed to check that relevant factors had been taken into account and to ensure comparability of risk ratings. We estimate that the production of the report has cost our company in excess of £20,000.

4 Assessing risks

We have used serviceability as the measure against which we can quantify the impact of climate change. Ofwat define serviceability as the capability of a system to deliver a referenced level of service to our customers and the environment.

For the indication of risk in this report we used a risk/likelihood matrix to score the relative levels of risk. Our matrix is described in detail in Section 2.2 of our report. Even though the assessments that we have carried out for this report are at a broad strategic level, they have identified where further investigation of potential impacts and mitigation/adaptation measures may be needed.

5 Uncertainties and assumptions

Although there are uncertainties regarding the level of impact and the timing of changes it is evident that change is happening. Even with the level of mitigation that is currently taking place and more stringent mitigation in the future we will still experience ongoing change for the next few decades. We have therefore used the medium scenario of the UKCP09 predictions as we feel that this provides a route which will enable us to track the effects of climate change and easily adapt our approach. However, in certain circumstances it may be necessary to review the use of the medium scenario ranges.

By conducting our assessment at a high level it is hoped that we will be able to identify those areas which are key to our ability to provide a continuous and sustainable service to our customers. One of the key uncertainties is the willingness of our customers to pay for schemes that will take a long time to implement in order for us to protect our assets and customers from the effects of climate change. One such example is keeping sewers for sewage and removing storm and highway drainage.

Whilst customers in the South West show a limited willingness to pay to improve the services they receive and to make further environmental improvements, they are prepared to support investments necessary to maintain current services which include adapting to the impacts of climate change. Mitigation measures, such as carbon reduction, are supported where they reduce bills eg through energy efficiency and generation schemes. Catchment management projects that capture carbon in upland peat bogs and improve water quality and collection are also supported.

We have assumed that certain regulatory reporting requirements and assessments will continue. They are:

- Some form of periodic review process will continue.
- The UKCP09 projections will not change significantly
- The current measures we have in place to help us cope with climate change continue to be viable

6 Addressing current and future risks due to climate change

Our high level risk assessment shows that all of the high levels of risk (6 or 9) to the Consequence for Service are being tackled by Company Adaptive Actions which we already have in place. In fact following adaptive action one of these impacts scores 4 in the 2020s.

Further details of these risks can be found in section 3.1 and appendix A

7 Barriers to implementing adaptation programme

We have identified various barriers in Section 6 of this report and we have included indicative costs for various adaptation measures:

As an example one of the main mitigation measures identified for the Waste Water Networks analysis is the removal of storm and highway runoff. This will leave the sewers to carry the foul flows only. This is captured in our aim of having “Sewers for Sewage”.

Achieving this goal will:

- Protect our sewerage system from the effects of climate change.
- Reduce our carbon footprint by reducing our energy and chemical consumption.
- Eliminate sewer flooding.
- Further protect shellfish and bathing waters by the reduction of CSO spills.

We believe that it is unsustainable to keep on increasing storage capacities which would compromise our ability to deliver to our customers the services they expect at an affordable price. However this is a very time consuming and costly exercise involving the co-operation of a number of agencies.

Through the Periodic Review process Ofwat sets the maximum price limit for water and sewerage services for the coming five year period. Guidance as to the extent that cost benefit driven by customer willingness to pay should determine the level of climate change related expenditure would be helpful.

We are governed by a number of European Environmental Directives. These provide a framework within which we have to work. Sometimes this limits the choices open to us as to which is the best solution to a problem.

Infrastructure outside of our immediate control poses a risk to us which we have not been able to fully assess. This includes our energy supply, delivery of consumables, transport links, information and communication technology. The consequences of the international effects of climate change on our supply chain needs to be further evaluated.

The delivery of some of our adaptation measures, particularly our efforts to improve surface water management, relies on local authorities and agencies playing their full part, especially planning authorities.

8 Report and review

Every five years we have to update our Asset Management Plan and present it to Ofwat. The Plan details the work that we have identified as being necessary to maintain serviceability during the following five years or work that is required to meet new legal obligations. Our plan is carefully scrutinised by independent auditors and the inclusion of schemes and their outputs is verified. One criteria that is considered is the level of customer and stakeholder support for the investment evidenced by cost benefit analysis where appropriate.

When we submitted our current plan in 2009 some of the proposed schemes that we included were derived from an analysis of climate change data.

Each year Ofwat monitors our progress against our five year plan schemes and outputs through the June Return process which again is verified by independent auditors.

As the evidence base on the impact of climate change increases, further guidance on how these impacts should be reflected in cost benefit analysis will be required, particularly if customers do not appreciate the need for immediate action to prevent effects at some distant point in the future.

The monitoring of the effects of climate change and the way the business uses this information is becoming a business as usual approach.

The production of this report has raised awareness of climate change issues within the business and has allowed us to scrutinise the way we monitor the effects of climate change on us and our customers.

9 Recognising opportunities

The predicted change in our climate could give us an opportunity to increase the amount of power we generate from hydro electric turbines.

The warmer climate could also improve the effectiveness of our chemically dependant treatment processes.

We also anticipate that the changes in our climate will reduce the need for us to pump store our impounding reservoirs during the winter months in preparation for us to meet summer demand.

The anticipated increase in tourists visiting the region will increase the demand on our assets during the summer but this should result in a greater income from the increased usage.

1 INTRODUCTION to SOUTH WEST WATER and CLIMATE CHANGE IN THE REGION

1.1 Background to South West Water

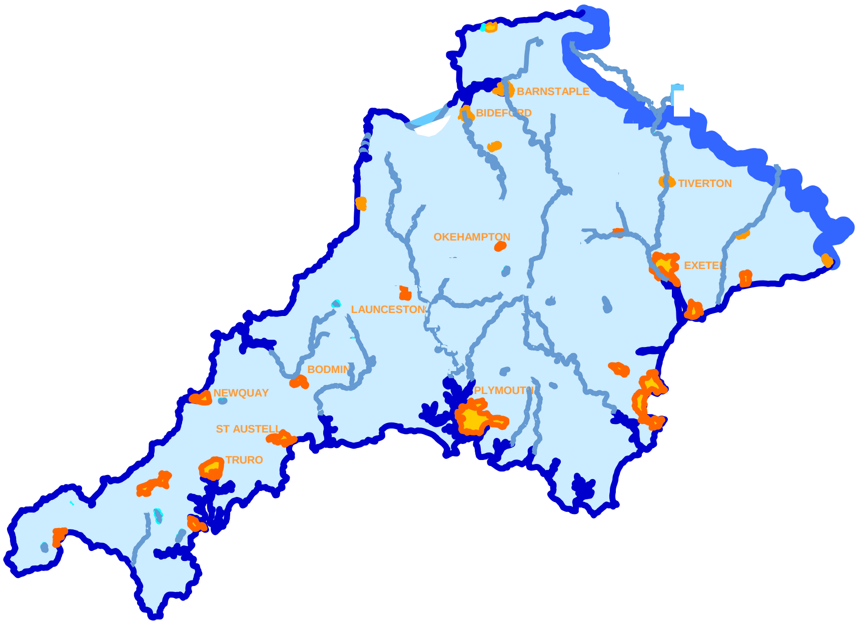
South West Water is part of Pennon Group which operates and invests in water and sewerage services, waste management, recycling and renewable energy. Pennon Group has assets of around £3.9 billion and a workforce of over 4,100 people.

Pennon Group's business is operated through two main subsidiaries:

- South West Water Limited – holds the water and sewerage appointments for Devon, Cornwall and parts of Dorset and Somerset
- Viridor Limited – one of the leading waste management, recycling and renewable energy businesses in the United Kingdom.

We are the licensed water and sewerage service provider for Devon, Cornwall and parts of Dorset and Somerset. The company serves a region of nearly 10,300 square kilometres with over 1.68 million residents. In addition over 39 million visitor nights as recorded by South West Tourism were spent in the region in 2009.

Figure 1: Area supplied by South West Water



1.2 South West Water's functions, mission, aims & objectives

1.2.1 Functions

Our function is to be the licensed provider of water and sewerage services for Devon, Cornwall and parts of Dorset and Somerset.

1.2.2 Mission

Our mission is to deliver **Pure Water, Pure Service and a Pure Environment**

1.2.3 Aims & objectives

Our aims and objectives include:

Drinking water quality
- 100% compliance with the required standards so that our customers will never doubt that it is safe and pleasant to drink.

Water resources and demand
- Always provide enough water for basic sanitation and personal hygiene.
- No water restrictions such as hosepipe bans, except in extreme circumstances.
- We will manage our water resources, leakage control and water efficiency programme in order to avoid building a new impounding reservoir before 2035.
- Pursue the lowest sustainable water losses due to leakage and fix all visible leaks as quickly as possible.
- Concentrate water treatment at key strategic works and improve our ability to move water around the region.
- Be leaders in helping our customers to use water efficiently.
- Further encourage metering as it approaches 100%.

Customer service and choice
- Customers will find it easy to deal with us.
- Resolve contacts first time, by investing in our systems and people.
- Customers can contact us in the way they want, including direct personal contact.
- Treat customers appropriately to their circumstances, especially with regard to affordability and debt.
- Offer choice to customers on services and tariffs.
- Develop tariffs that will encourage water efficiency and assist in delivering a sustainable supply/demand balance.
- Broaden the services we offer, for example grey water re-use and rainwater capture.
- Our services will be constant and reliable.

Sewage collection and treatment
- Services will be odourless and "invisible" to our customers.
- No sewer flooding and zero pollution incidents.
- Prioritise the separation of surface waters from our sewers in order to minimise flooding and pollution risks.
- Sludge recycling undertaken in a sustainable manner, taking into account our carbon footprint.

Sustainability

- Work in partnership with other organisations to manage responsibly river catchments, estuaries and coastline, improving the environment and protecting raw water quality.
- Deliver quality improvements to rivers, bathing waters, shellfish waters and groundwaters, when there is sound scientific evidence of the need, in the most cost effective and sustainable way possible.
- Meet carbon reduction targets.

Efficiency

- Consistently be amongst the most efficient companies in the industry.
- Extend remote site operation and control of our networks without compromising service.

Prices

- As stable as possible for the 2010-2015 period.

Investors and debt providers

- Give a fair return for their investment from a soundly financed business.

1.3 Special characteristics of South West Water and its region

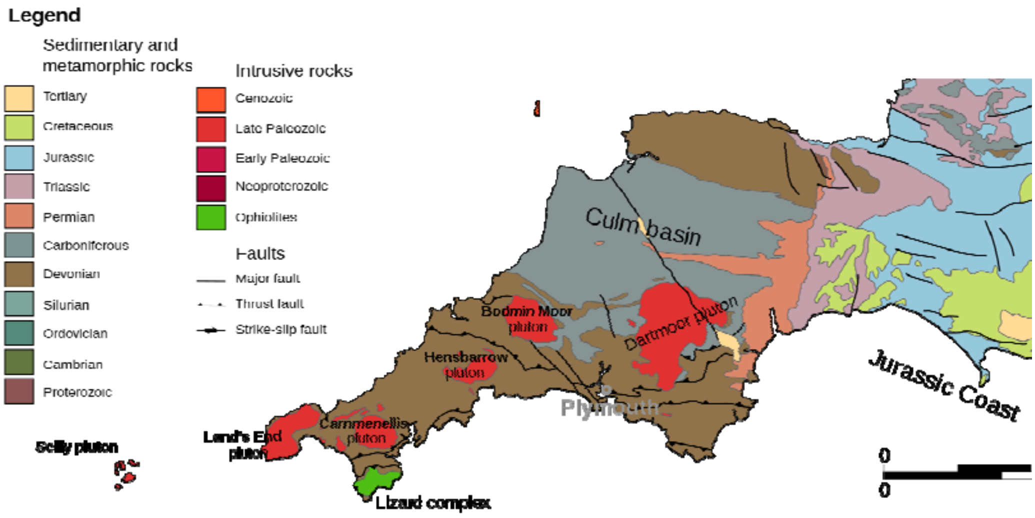
1.3.1 Geology and topography

The coastline, the longest of any water company in England, is divided into a rugged western region characterised by rocky headlands and sheltered coves which contrasts with a more gentle, rolling coastline in the east. This is a product of the geological make-up of the peninsula with hard metamorphic and igneous Palaeozoic rocks west of the river Exe which abut softer Mesozoic sediments further east.

The geological history of the South West has resulted in the region containing rocks from the Pre-Cambrian (The Lizard) right through to Cretaceous deposits (The Blackdown Hills). The west of the region is dominated by Devonian and Carboniferous strata comprising largely sandstones, mudstones, shales and slates that were uplifted and folded during the Hercynian Orogeny. During the Carboniferous a granitic batholith was intruded at depth which has resulted in the region’s characteristic high moorland areas. The post-orogenic, desert landscape in the Permian and Triassic periods generated breccio-conglomerates, sandstones and mudstones infilling low-lying environments around what is now the Exe Valley. A shallow marine transgression occurred across the east of the region in Jurassic and Cretaceous times leading to glauconitic greensands, deeper water mudstones (The Gault Clay) and eventually calcareous oozes (The Chalk).

The water resources potential of the region follows the geological division with only the sedimentary, post-Palaeozoic strata in the east being considered major aquifers that can be exploited for public supply. In the west, the older geology and associated river system lends itself to surface water capture and reservoir development. A simplified geological map is shown in Figure 2.

Figure 2: Simplified geological map of the South West of England



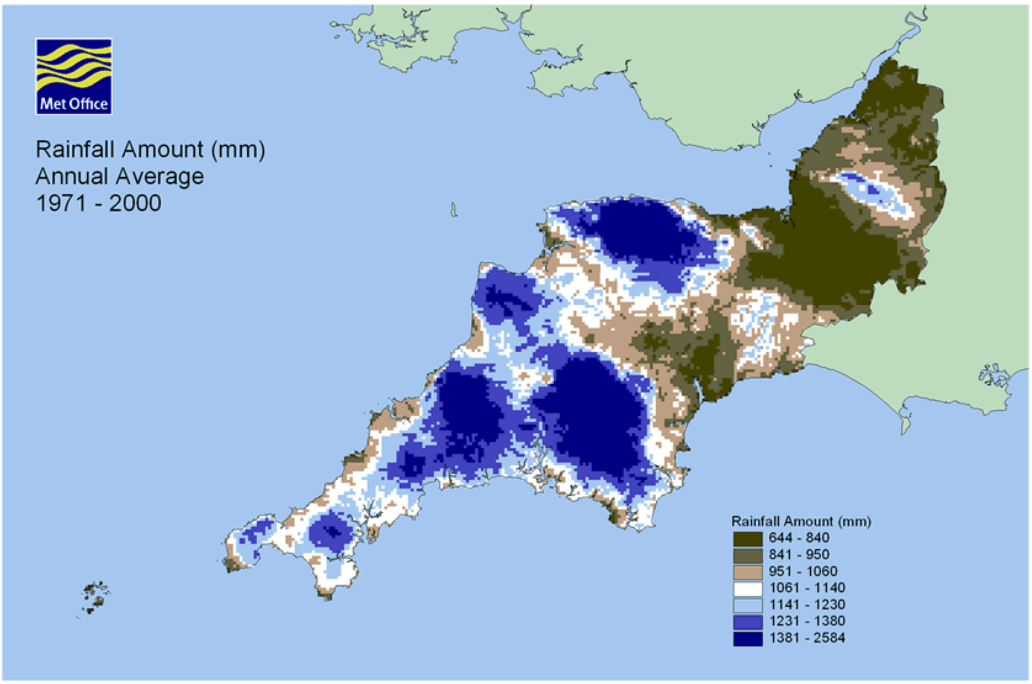
1.3.2 Hydrology

Our region is bounded by the English Channel to the south and the Bristol Channel to the north and west. The climate is mild and moist, having generally mild, wet winters and cool summers, with precipitation throughout the year. The prevailing westerly winds bring large air masses from the Atlantic Ocean. These winds rise over the high moors, causing sharp drops in temperature and increased cloud and rainfall on the high ground. Average annual precipitation ranges from 800 mm or less in the lower reaches of the Exe valley, to over 2000 mm on the moors. Variations in average annual precipitation over the region reflect the relief and the orographic effects caused by the high uplands.

In Devon, the general drainage direction is southwards from Exmoor and the Blackdown Hills towards the English Channel. However, this pattern is interrupted by radial drainage around Dartmoor and the northern route of the Rivers Taw and Torridge as they approach their estuaries at Barnstaple and Bideford. West of the River Tamar the high central spine of Cornwall results in a more evenly distributed flow to the north and south, but with a larger share of the runoff reaching the English Channel. The two largest river systems both flow south across virtually the whole of the peninsula. They are the River Exe, with its main tributaries running off the south eastern part of Exmoor, and the River Tamar with major tributaries joining on the left bank from Dartmoor and on the right bank from Bodmin Moor.

The river valleys of the South West are generally narrow, flanked by steep hillsides and with steep gradients resulting from a combination of high upper catchments and short channel lengths. This results in high flood peaks and low baseflows during periods of drought. Along the lower reaches of the rivers of East Devon and also the Taw and Torridge, flatter gradients and wider alluvial plains prevail. Rivers in East Devon (principally the Rivers Axe, Otter and the Culm tributary of the River Exe) have shallower gradients and higher baseflows. The rainfall for the region is shown in Figure 3.

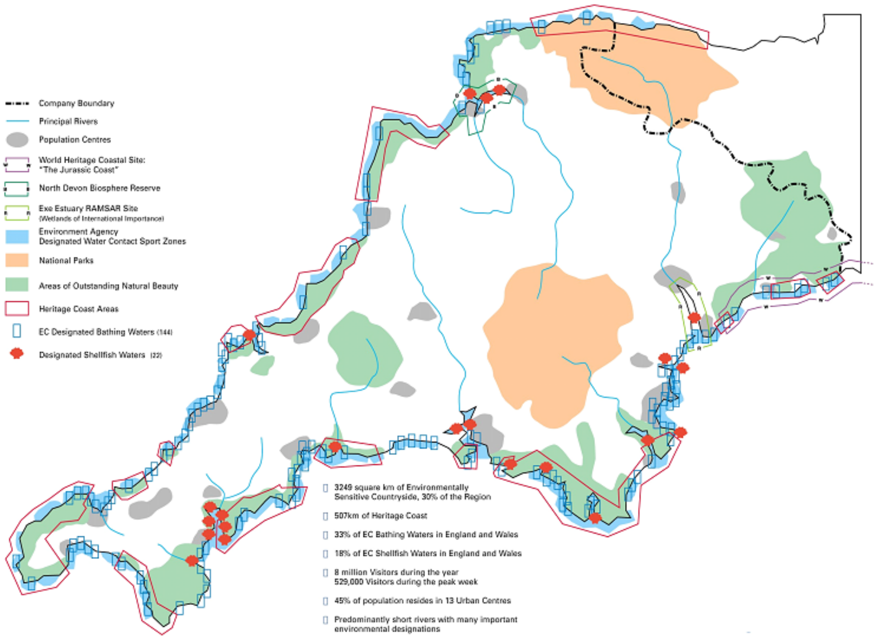
Figure 3: 1971-2000 Annual Average Rainfall (Courtesy of the Met Office)



1.3.3 Environment

30% of our region is designated as being environmentally sensitive and it includes two National Parks, extensive areas of Heritage Coastline and numerous Areas of Outstanding Natural Beauty. These are shown in Figure 4

Figure 4: South West Water – Environmental context



- 3249 square km of Environmentally Sensitive Countryside, 30% of the Region
- 507km of Heritage Coast
- 33% of EC Bathing Waters in England and Wales
- 18% of EC Shellfish Waters in England and Wales
- 8 million Visitors during the year
  529,000 Visitors during the peak week
- 45% of population resides in 13 Urban Centres
- Predominantly short rivers with many important environmental designations

1.3.4 Population, industry and economics

The area that we serve is rural in nature with a low population density in comparison to other parts of England. However, it has one of the highest population growth rates in England, with much of this growth being driven by inter-regional migration. The area has a high proportion of older people. The three major urban areas, Plymouth, Exeter and Torbay are all located in Devon and are home to almost one third of the total population. Outside of these areas the population is spread through many small communities. The resident population of approximately 1.68 million increases during the summer to a peak population of approximately 2.18 million with some popular areas experiencing up to a ten fold increase in summer population.

Both Devon and Cornwall are economically disadvantaged in comparison to other parts of Southern England, following the decline of their traditional industries of fishing, mining and agriculture. Cornwall in particular has been badly affected by this decline and is now one of the poorest parts of the United Kingdom, qualifying for European Community Objective 1 (Convergence) funding, which aims to help the EU’s poorest regions. Many parts of Devon have also qualified for European Community funding through Objective 2, aimed at improving regional competitiveness and employment.

Whilst agriculture still remains an important part of the area’s economy, it is heavily dependent on tourism which is mainly confined to the coast. Due to its perceived higher quality of life, the area has had some success attracting industries which are not heavily dependent on geographic location, illustrated by the 2004 relocation of the Met Office to Exeter and the growth of creative industries in Cornwall. The cities of Plymouth and Exeter play an important role in the economy of the area, with Exeter hosting a strong services sector providing for a large geographical area and Plymouth’s marine sector, particularly Devonport Dockyard being important.

1.3.5 Water supply system

On average each day we distribute over 420 Megalitres (Ml) of treated water through an asset base comprising:

Water distribution mains	15,058 km
Impounding reservoirs	15
Groundwater sources	33
Water treatment works	39

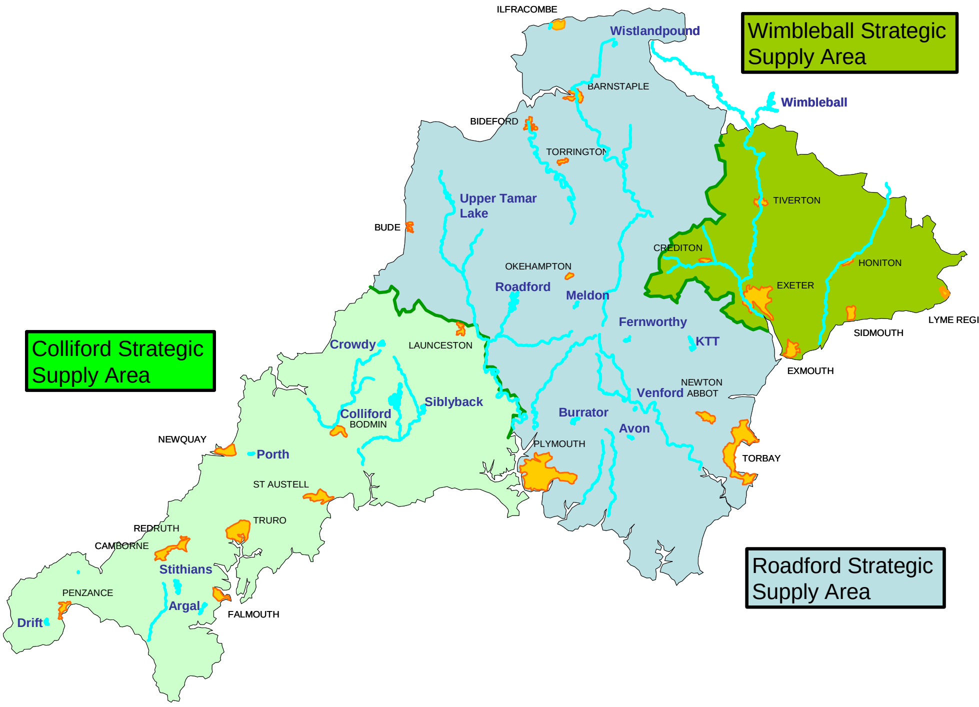
SWW strategic supply areas

Water resource planning is based on resource zones which are defined as the largest possible zone in which all resources, including external transfers, can be shared and hence the zone in which all customers experience the same risk of supply failure from a resource shortfall. We refer to our resource zones as Strategic Supply Areas (SSAs).

We use three SSAs - Wimbleball, Colliford and Roadford - for planning and managing our water resources. These are consistent with the planning framework used by the Environment Agency (South West) in respect of its water resource responsibilities.

Each SSA is served primarily, but not exclusively, by one of the three strategic supply systems: Wimbleball, Colliford and Roadford. For example, customers in the Roadford SSA have a very high proportion of their water supplied by Roadford Reservoir and its associated sources, but a small proportion of their water is provided by transfers from the Wimbleball strategic supply system. The key reservoirs in each SSA are shown in Fig 5 below with their name marked in blue.

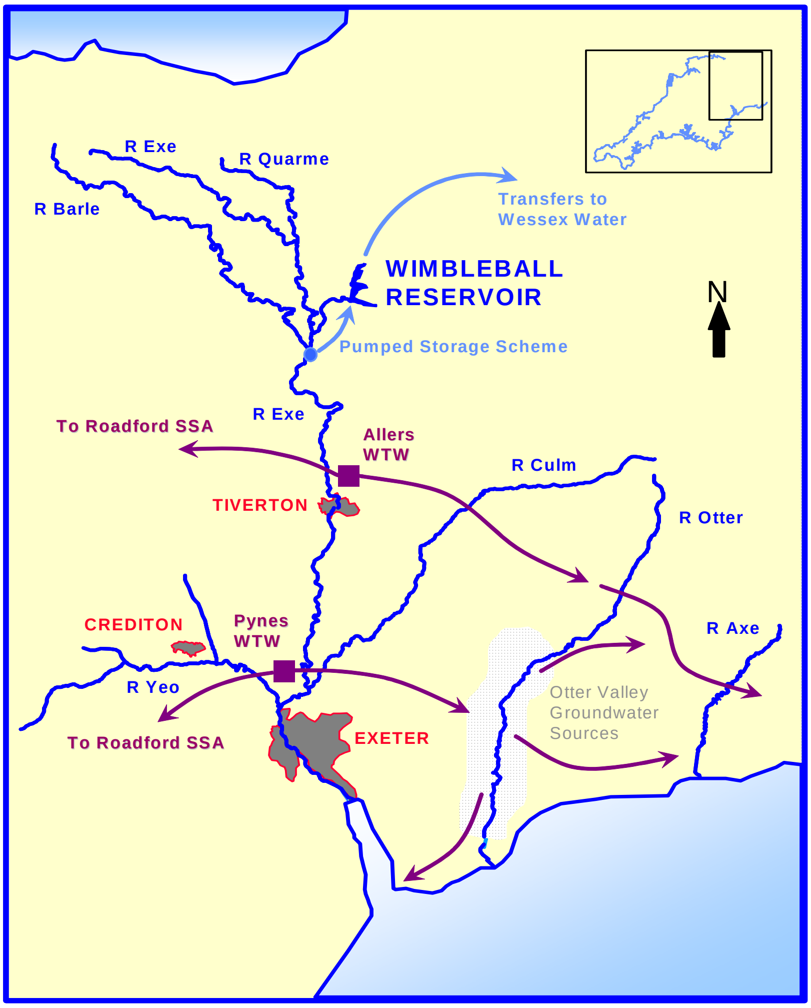
Figure 5: South West Water Strategic Supply Areas



Wimbleball Strategic Supply Area

The Wimbleball SSA stretches from Tiverton in the north to Exmouth in the south and from Crediton in the west to Chardstock and Axminster in the east. The key elements of the Wimbleball strategic supply system are shown in Fig 6.

Figure 6: Key elements of the Wimbleball strategic supply system



Wimbleball reservoir was constructed by South West Water Authority, the predecessor organisation of South West Water, with part of the financing costs being paid by Wessex Water Authority (WWA). We use the reservoir principally for making augmentation releases to the River Exe for subsequent abstraction near Tiverton and Exeter. These releases support abstractions from the natural flow of the River Exe.

Wimbleball reservoir

Wessex Water, the successor to WWA, uses the reservoir for direct supplies.

The Wimbleball SSA is also dependent on the significant groundwater resources of East Devon. The geology of East Devon includes Permian breccias and sandstones, Triassic conglomerates and sandstones, and sandstones of the Lower Cretaceous Upper Greensand. Some Chalk blocks in the extreme east of the catchment have also been exploited historically. Of these strata the Triassic Sandstone Group (the Otter Sandstone and Budleigh Salterton Pebble Beds) of the southern part of the Otter valley is the most significant in terms of public water supply. The typical method of abstraction in this area is from groups of boreholes, such as at Dotton and Otterton.

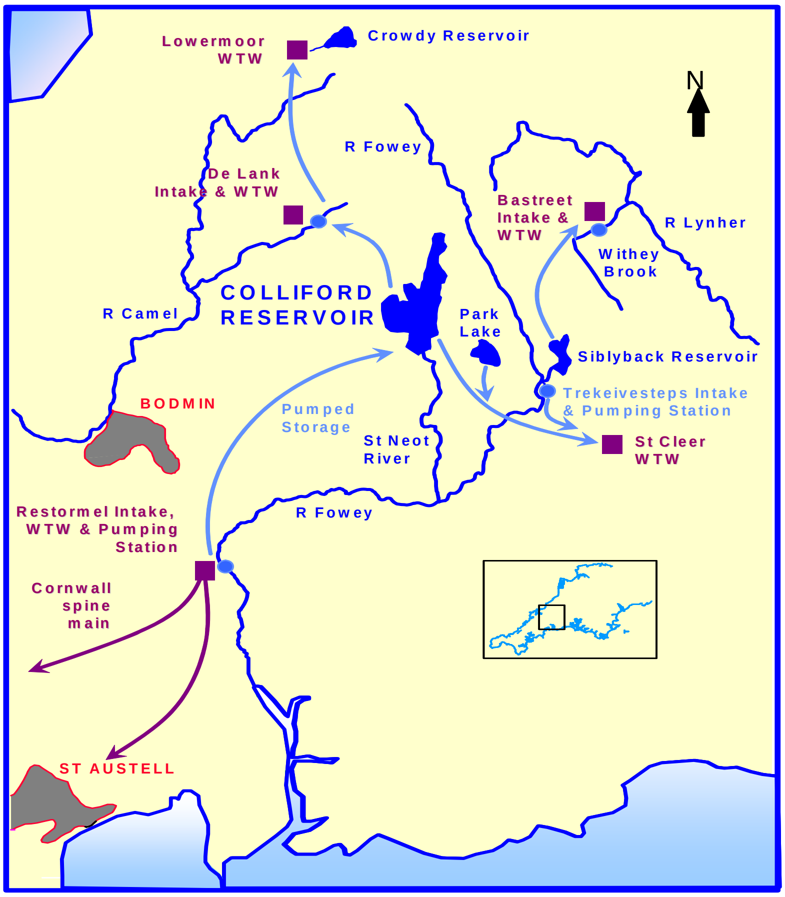
Elsewhere our public groundwater supplies in the East Devon area are more widely dispersed, tapping a range of strata but mostly the Upper Greensand, and Permian sandstones, where significant yields occur as a result of natural fissuring and fracturing. In these cases, the method of abstraction is normally from single boreholes or spring sources.

In order to minimise the need to pump river Exe-derived treated water to supply the eastern fringes of the catchment our strategy is to optimise East Devon groundwater abstractions.

Colliford Strategic Supply Area

The Colliford SSA covers most of Cornwall except the North East of the County. The key elements of the Colliford strategic supply system are shown in Fig 7.

Figure 7: Key elements of the Colliford strategic supply system



We use Colliford Reservoir conjunctively with six impounding reservoirs and six river intakes to form the Colliford strategic supply system. These sources are supplemented by a bulk transfer from the Roadford system of up to 3 Ml/d. The storage of Colliford Reservoir can also be supplemented by pumped transfers from Restormel.

Colliford Reservoir is both a river regulation and a direct supply reservoir and supports supplies in three ways:

- releases to the River Fowey for abstraction and treatment at Restormel WTW
- pumping water direct to De Lank and Lowermoor WTWs
- supplying water, via a gravity pipeline, direct to St Cleer WTW

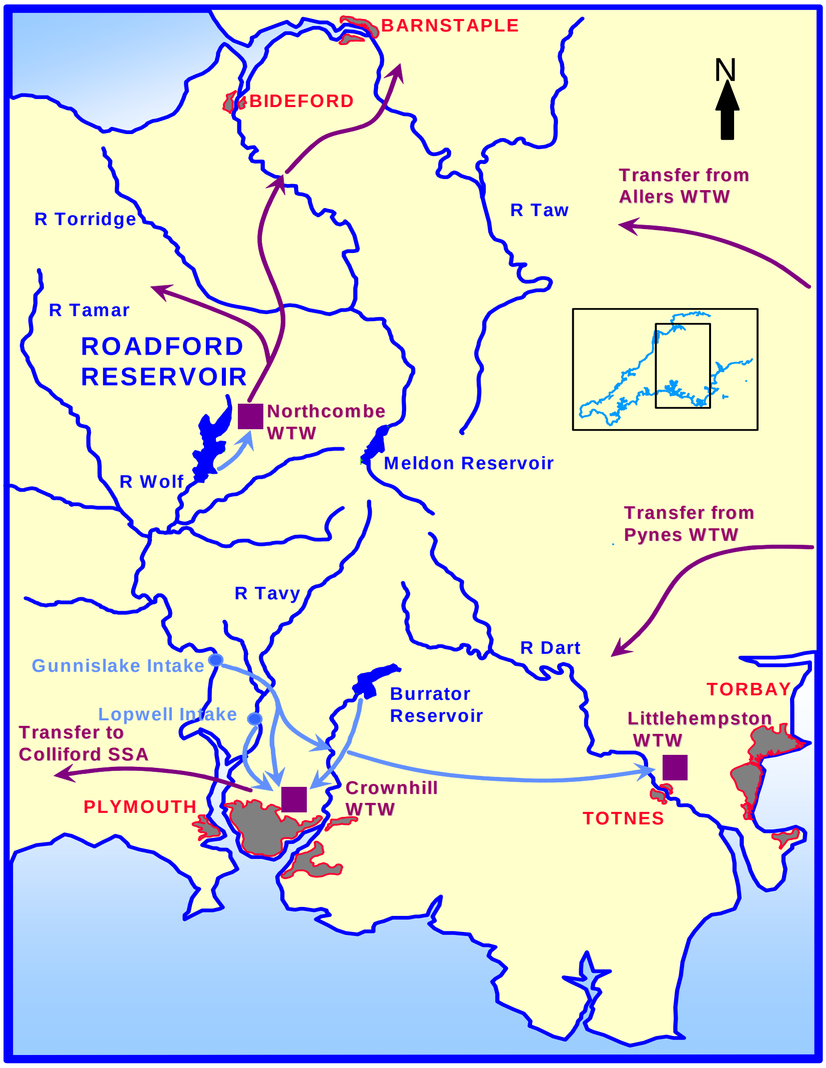
Colliford reservoir

The Colliford strategic supply system comprises a number of supply sub-systems, based on Water Treatment Works which are supported either directly by Colliford Reservoir or indirectly by Colliford Reservoir via Restormel WTW and the Cornwall spine main.

Roadford Strategic Supply Area

The Roadford SSA covers a large part of Devon: from Plymouth, the South Hams and Torbay in the south to Bideford and Barnstaple in the north. It also includes parts of North East Cornwall. The area is served primarily by Roadford Reservoir operating conjunctively with eleven other impounding reservoirs, seventeen river intakes and other sources. The key elements of the Roadford strategic supply system are shown in Fig 8.

Figure 8: Key elements of the Roadford strategic supply system



The most important single source in the area is Roadford Reservoir on the River Wolf, a tributary of the River Tamar. We use Roadford to augment the River Tamar for abstraction downstream at Gunnislake and also for direct supply to parts of North Devon (via Northcombe WTW).

Roadford reservoir

We can pump our abstractions from Gunnislake to Crownhill WTW for use in Plymouth and the surrounding area or transfer them, via the South Devon Spine Main, to Littlehempston WTW at Totnes for use in the South Hams.

Burrator Reservoir on the River Meavy is a direct supply reservoir which supplies water to Crownhill WTW and Littlehempston WTW. We can also use Burrator to support Dousland WTW which is primarily fed by the Devonport Leat (a transfer from the headwaters of the River Dart). The other important source of water for Crownhill WTW is the abstraction from the River Tavy at Lopwell.

Littlehempston WTW is primarily fed directly from the River Dart, riverside boreholes and radial collectors in addition to the transfers from Burrator and Gunnislake. The south of Devon is also supplied by a number of direct supply reservoirs on Dartmoor including Kennick, Trenchford, Tottiford, Fernworthy, Avon and Venford.

In addition to the Roadford water at Northcombe WTW, North Devon is supplied by a variety of local sources including Meldon Reservoir, Upper Tamar Lake and Wistlandpound Reservoir.

Company Level of Service

Our policy is to try to avoid imposing demand restrictions, such as hosepipe bans, or seeking drought orders and in this we have been successful for the last fourteen years. However, for the purposes of planning we use the following Level of Service:

i Customer Level of Service:

- a major publicity campaign requesting voluntary savings of water not more than once in every 10 years on average
- a hosepipe ban not more than once in every 20 years on average, giving a 5% reduction in demand
- 6 month maximum duration of hosepipe ban
- a ban on the non-essential use of water not more than once every 40 years on average, giving a further 5% reduction in demand
- 4 month maximum duration of ban on non-essential use of water
- the use of rota cuts or standpipes is regarded as unacceptable for water resource planning purposes

ii Environmental Level of Service:

- the use of Drought Orders or Drought Permits reducing compensation or prescribed flows not more than once every 20 years on average

Other issues relating to water supply and Level of Service include:

Security of Supply index

The Security of Supply Index assesses the company's ability to supply customers in dry years for both the company's and the reference level of service. It also provides a context for leakage targets and work promoting the efficient use of water by consumers. A Security Of Supply Index of 100 for the Company's level of service shows the Company is able to provide water through the design drought within its level of service definition. South West Water has achieved a value of 100 and it is one of the Company's objectives to ensure that it remains at this level.

Leakage control

South West Water has achieved the mandatory target level of leakage since its introduction 13 years ago. The current level of 84 Ml/d is below the Sustainable Economic Level of Leakage.

Metering

The level of domestic metering in the South West Water area is now 70%, one of the highest levels of any company in England and Wales.

Our customer research showed there is no support for a deterioration in the Level of Service and no desire to pay for an enhanced Level of Service.

1.3.6 Waste water system

On average each day we dispose of around 235 Ml of waste water through an asset base comprising:

Sewers (the transfer of private sewers will add 60% to this figure)	9,288 km
Waste water treatment works, including 55 works with ultra-violet treatment and three with membrane filtration	634
Intermittent discharge points, including 1,029 combined sewer overflows	1,668

Approximately 66300 tonnes of sludge is produced annually.

Along the 625 mile coastline of the region there are currently 144 EU designated bathing waters, almost one third of the total in England and Wales, of which 132 have benefited from the company's marine investment programme. In 1996 only 51% of designated bathing waters in the region complied with EU guideline standards but by 2006 all 144 met the EU mandatory standard and 92% passed the more stringent Guideline standard. There are also 22 designated shellfish waters in the region.

Due to the topography of our region over 1000 pumping stations have an average lift of 160m which is amongst the highest in the industry.

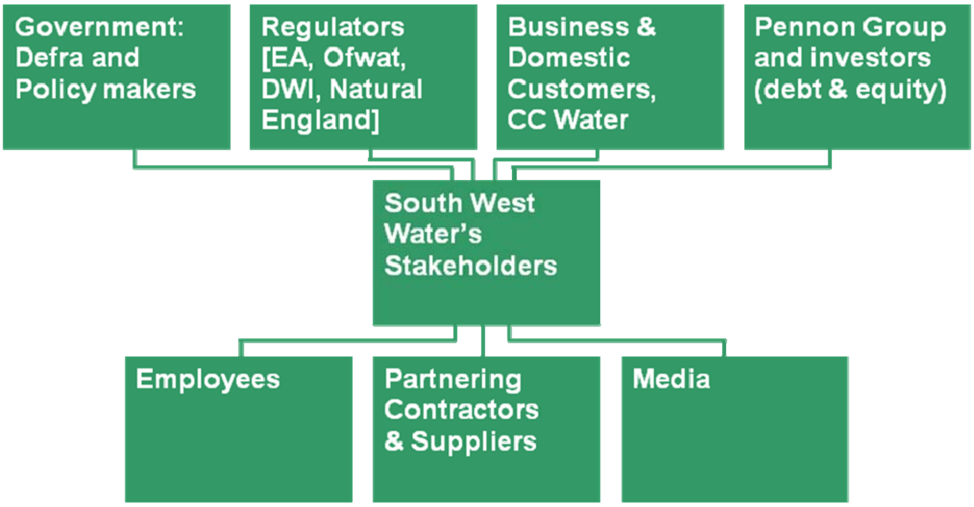
In addition to treating waste from our domestic customers, we also deal with 445 trade effluent discharges

Our river water quality is the best in England as defined by the Environment Agency with over 91% classified as good or very good.

1.4 South West Water's key stakeholders and regulators

1.4.1 Key stakeholders

We have identified our main stakeholders as follows:



We have numerous other stakeholders, some of which are shown below. We work with our stakeholders to ensure their concerns are taken into account when determining our strategy and working practices.

Stakeholder category	Examples
Local Authorities	Planning and Archaeology Departments, Environmental Health Departments, Highways Agencies, Libraries
Community groups	Schools and universities, Citizens Advice Bureaux
Service Providers/ Partnering Contractors/ Suppliers	Power industry – generation & distribution
Workforce representatives	Trade unions, Staff Council, Health and Safety Executive, training bodies eg Energy & Utility Skills
Water UK and other water companies	
Landowners' interests and representatives	National Parks, Duchy of Cornwall, County Land and Business Association, National Farmers Union
Providing our services to businesses	Providing trade effluent discharge consents or services for those who use our accredited laboratory services
Tourism interests	South West Tourism, tourist industry
Research bodies	UKWIR, Water Research Council, Foundation for Water Research, Water Research Centre
Professional bodies	Institution of Civil Engineers, Chartered Institution of Water & Environmental Management, Institute of Water, British Hydrological Society
NGOs, pressure groups	Friends of the Earth, Surfers Against Sewage
Bodies representing wildlife and heritage	Devon Wildlife Trust, Cornwall Wildlife Trust, English Heritage, National Trust
Marine, coastal, estuary and riparian interests	Westcountry Rivers Trust, riparian owners, fishery and shellfish producers
Charities	WaterAid, Devon Air Ambulance

1.4.2 Regulators

Defra

Defra is the UK government department responsible for policy and regulations on the environment, food and rural affairs. Defra's Structural Reform Plan (SRP) lays down three departmental priorities, one of which is to "support a strong and sustainable green economy, resilient to climate change". Defra is responsible for publishing the statutory guidance to reporting authorities[5]

The Water Services Regulation Authority (Ofwat)

Ofwat is the economic regulator of the water and sewerage sectors in England and Wales. It exists to ensure that the companies provide household and business customers with a good quality service and value for money.

Ofwat does this by:

- keeping bills for consumers as low as possible
- monitoring and comparing the services the companies provide
- scrutinising the companies' costs and investment
- encouraging competition where this benefits consumers

If a company falls short of what Ofwat or customers expect it takes the action necessary to protect consumers' interests, which may include legal steps such as enforcement action and fines.

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[5] Defra, "Adapting to Climate Change: helping key sectors to adapt to climate change", 2009

Ofwat works closely with a wide range of other stakeholders including the water quality regulators (the Environment Agency and the Drinking Water Inspectorate) and the Consumer Council for Water.

Ofwat's position on climate change is set out in its publication "Preparing for the future – Ofwat's climate change policy statement" which outlines how the water and sewerage sectors are affected by climate change, and how Ofwat is responding to the challenges and ways in which it expects companies to respond.

Ofwat wants water and sewerage sectors that are sustainable in all respects and believes that the twin challenges of climate change adaptation and mitigation need to be addressed by the water and sewerage sectors in a way which offers value and protection to consumers both now and in the future.

Ofwat expects the water and sewerage sectors to adapt to climate change in a phased, responsible and appropriate manner which means that adaptation plans must be based on sound science and evidence.

On climate change adaptation Ofwat expects:

- that companies will seek to understand and plan for the impact of climate change on both the supply of and demand for water resources
- companies to meet robust leakage targets set as part of a wider long-term strategy to maintain security of supply
- companies to consider carefully the role of water efficiency when planning how to balance supply and demand now and in the future
- companies to understand and act on the impacts that climate change will have on water and sewage treatment
- companies to continue reporting clear and accurate data that shows how their assets are performing and to develop forward-looking asset management plans to maintain serviceability
- companies to take climate change into account when maintaining and building sewerage networks.
- companies to use Ofwat's analytical framework to understand and protect their assets and services.

Environment Agency

The Environment Agency is an Executive Non-departmental Public Body responsible to the Secretary of State for Environment, Food and Rural Affairs and an Assembly Sponsored Public Body responsible to the National Assembly for Wales.

The principal aims of the Agency are to protect and improve the environment, and to promote sustainable development. It plays a central role in delivering the environmental priorities of central government and the Welsh Assembly Government through its functions and roles.

The Agency's corporate strategy, "Creating a better place 2010-2015", sets out its aims for the next five years and describes how it will continue to work with others to tackle society's environmental challenges including climate change, population growth and unsustainable resource.

The Agency aims to realise its vision of "creating a better place for people and wildlife" through:

- Acting to reduce climate change and its consequences
- Protecting and improving water, land and air
- Working with people and communities to create better places
- Working with businesses and other organisations to use resources wisely

The Agency intends to help people and wildlife adapt to climate change and reduce its adverse impacts. It will achieve this by:

- working with local, devolved and central government, and in England regional bodies, to help them embed reducing and adapting to climate change in their policies and plans
- providing advice, guidance and evidence to key stakeholders on adaptation
- working with others to ensure national plans and policies, and business plans for critical infrastructure and essential services, incorporate climate change risks

Drinking Water Inspectorate

The Drinking Water Inspectorate (DWI) was formed in 1990 to provide independent reassurance that water supplies in England and Wales are safe and drinking water quality is acceptable to consumers.

The Inspectorate:

- provides independent scrutiny of water company activities for companies supplying drinking water to consumers in England and Wales
- works with other stakeholders for the improvement of drinking water quality and to secure drinking water safety
- commissions research to build a sound evidence base on drinking water quality
- publishes data on drinking water quality in England and Wales

The Consumer Council for Water (CCWater)

The Consumer Council for Water is a non-departmental public body sponsored by Defra and the Welsh Assembly Government to solely represent the interests of water consumers across England and Wales.

At the time of the recent Price Review CCWater stated that it wanted water companies to carefully assess the risks of climate change to supplies to consumers and to their assets. When planning investment to mitigate the effects of climate change, it wanted companies to:

- Undertake robust cost benefit analysis to ensure that the proposed activity represents good value for money
- Phase remedial works to spread the cost to customers
- Consider which assets can be adapted once they come to the end of their natural life
- Consider sustainable solutions to problems, for example the use of natural processes rather than end-of-pipe solutions
- Clearly outline the benefits to customers and the economy of any proposed investment in their business plans.

Natural England

Natural England is the government's advisor on the natural environment. It provides practical advice, grounded in science, on how best to safeguard England's natural wealth for the benefit of everyone.

Natural England's remit is to ensure sustainable stewardship of the land and sea so that people and nature can thrive. Natural England works with farmers and land managers; business and industry; planners and developers; national, regional and local government; interest groups and local communities to help all of them improve their local environment.

Natural England considers that it is essential that any adaptation action is 'sustainable'. This means that any responses by society should not actually add to climate change, cause detrimental impacts or limit the ability of other parts of the natural environment society or business to carry out adaptation elsewhere.

Natural England was a major contributor to a joint report on how to help the environment to adapt to climate change, published by Defra in 2007. The report identified six key principles to guide conservation practitioners aiming to help wildlife and habitats adapt to climate change. These are:

- Conserve existing biodiversity
- Conserve Protected Areas and other high quality habitats
- Conserve range and ecological variability of habitats and species
- Reduce sources of harm not linked to climate
- Develop ecologically resilient and varied landscapes
- Conserve and enhance local variation within sites and habitats
- Make space for the natural development of rivers and coasts
- Establish ecological networks through habitat protection, restoration and creation
- Make sound decisions based on analysis
- Thoroughly analyse causes of change
- Respond to changing conservation priorities
- Integrate adaptation and mitigation measures into conservation management, planning and practice

1.5 Overview of projected climate change impacts in the South West Water region

1.5.1 Historic changes in climate in the South West[6]

Annual average daily mean temperature in the South West increased by 1.37°C between 1961 and 2006; similar to annual trends in London, South East and East of England. However, this increase has been larger in winter (1.72°C) than in summer (1.41°C). A similar pattern exists for changes in average daily minimum and maximum temperature.

Over the last 250 years, there has been a slight trend for increased rainfall in winter and decreased rainfall in summer, a trend which is in line with the expected changes. All regions of the UK have experienced an increase over the past 45 years in the amount of winter rain that falls in heavy downpours. Severe windstorms

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[6] State of the South West 2010, South West Observatory
http://swo-portal.limehouse.co.uk/portal/sotsw/sotsw2010?pointId=1264606791060#section-1264606791060

around the UK have become more frequent in the past few decades, though not above that seen in the 1920s.

Between 1961 and 2006 there has been increased seasonal and annual total precipitation in the South West, with the largest increase seen in autumn (28.6%). The only exception to this pattern is a small decrease in total precipitation during summer (8.8%). During the same time period the South West has also experienced a small increase in the number of days of rain in autumn and winter and a small decrease in the number of days of rain in spring and summer.

Climate change is expected to increase the risk of river and urban flooding in the South West region. The long, varied coastline will be affected by rising sea levels and more frequent storms with an expected increase in risk of flooding for the low lying coastal communities. Recent years have seen a number of severe flash flooding events in our region including events at Boscastle, Ottery St Mary and South Cornwall. A high proportion of our population and therefore our assets eg terminal pumping stations and waste water treatment works, are located within the coastal strip and are therefore more vulnerable to coastal flooding. Furthermore some of these assets have been found to have performed in a less efficient manner due to saline intrusion and the generation of hydrogen sulphide.

Global sea-level rise has accelerated between the mid 19th and mid 20th century and is now at about 3mm per year. It is likely that human activities have contributed to between a quarter and a half of this rise in the last half of the 20th century. Absolute sea level (ie corrected for land movement) around the South West has risen by around 1 mm/yr over the 20th century[7], and there are indications that the increase has been at a faster rate than this in the 1990s and 2000s. The nature of land movement in the South West (where land levels are generally getting lower through time) is likely to enhance the effect of rising sea levels. This is illustrated below.

Sea level change at Newlyn (Cornwall) since 1946	
Average annual change in mean sea level	1.0 mm / yr
Average annual change in extreme high water level	2.1 mm / yr
Average annual change in extreme low water level	1.3 mm / yr

There is some evidence that annual average extremes in high water are increasing faster than annual average extremes in low water. Sea surface temperature around the UK coast has also risen by 0.7°C in the last 30 years.

1.5.2 Projected climate change in the South West

The latest UK climate projections were published in 2009 (UKCP09). The projections give climate information for the UK up to the end of this century, in relation to 1961 – 1990 baselines. UKCP09 shows three different scenarios representing high, medium and low greenhouse gas scenarios.

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[7] Proudman Oceanographic Laboratory

Key findings from the UKCP09 for the South West region as a whole are set out in Table 1 below and a fuller set including maps can be found in Appendix C. The central estimate under the medium emissions scenario is reported first, followed by the wider range of uncertainty in brackets. The bracketed wider range uses the minimum value at the 10% probability level and the maximum value at the 90% probability level, across all three emissions scenarios[8].

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[8] IPCC SRES: B1, A1B, A1FI

Table 1: Summary of projected climate change in the South West region

Season	2020s	2050s	2080s
Spring			
Mean temperature	Warmer by 1.2^{o}C (0.63 to 1.9^{o}C)	Warmer by 2.1^{o}C (1.0 to 3.6^{o}C)	Warmer by 2.9^{o}C (1.4 to 5.5oC)
Precipitation	Marginally wetter by 0.1% (-7.3 to +8.7%)	Marginally drier by -0.5% (-7.5% to +8.4%)	Wetter by 1.7% (-7.1 to +9.7%)
Cloud cover	Decrease of -2.7% (-6.7 to +2.2%)	Decrease of -3.9% (-8.7 to +0.5%)	Decrease of -4.6% (-11.3 to +1.8%)
Relative humidity	Decrease of -1.2% (-3.8 to +0.9%)	Decrease of -2.0% (-6.2 to +1.0%)	Decrease of -2.5% (-8.6 to +1.9%)
Summer			
Mean temperature	Warmer by 1.6^{o}C (0.5 to 2.7^{o}C)	Warmer by 2.7^{o}C (1.1 to 5.1^{o}C)	Warmer by 3.9^{o}C (1.3 to 7.9oC)
Precipitation	Drier by 8% (-26.6 to +17.5%)	Drier by 20% (-44.5 to 16.1%)	Drier by 24% (-58.5 to 12.9%)
Cloud cover	Decrease of -5.7% (-14.2 to +4.5%)	Decrease of -10.6% (-22.9 to +2.0%)	Decrease of -14.9% (-33.9 to +1.3%)
Relative humidity	Decrease of -3.1% (-8.2 to +2.6%)	Decrease of -5.5% (-13.7 to +1.7%)	Decrease of -7.3% (-19.5 to +1.9%)
Autumn			
Mean temperature	Warmer by 1.5^{o}C (0.77 to 2.5^{o}C)	Warmer by 2.7^{o}C (1.4 to 4.1^{o}C)	Warmer by 3.7^{o}C (1.7 to 6.5^{o}C)
Precipitation	Wetter by 1.5% (-12.1 to +16%)	Wetter by 3.2% (-8.2 to +14.9%)	Wetter by 4.0% (-7.1 to +15.6%)
Cloud cover	Decrease of -2.0% (-6.3 to +1.8%)	Decrease of -4.1% (-9.3 to +0.4%)	Decrease of -5.3% (-5.6 to +0.4%)
Relative humidity	Negligible decrease of -0.5% (-2.3 to +1%)	Decrease of -1.3% (-3.7 to +0.7%)	Decrease of -1.9% (-5.6 to +0.4%)
Winter			
Mean temperature	Warmer by 1.3^{o}C (0.46 to 2.0^{o}C)	Warmer by 2.1^{o}C (0.8 to 3.5^{o}C)	Warmer by 2.8^{o}C (1.4 to 5.1^{o}C)
Precipitation	Wetter by 7% (-3.1 to +19.6%)	Wetter by 17% (0.0 to +40.6%)	Wetter by 23% (5.2 to 73.5%)
Cloud cover	No change (-2.2 to +2.1%)	Negligible increase of 0.4% (-2.0 to +2.8%)	Negligible increase of 0.9% (-1.9 to +3.9%)
Relative humidity	Negligible decrease of -0.1% (-0.6 to +0.5%)	Negligible decrease of -0.1% (-0.8 to +0.6%)	No change (-0.9 to +0.8%)
Annual			
Mean temperature	Warmer by 1.4^{o}C (0.74 to 2.1^{o}C)	Warmer by 2.5^{o}C (1.3 to 4.0^{o}C)	Warmer by 3.5^{o}C (1.6 to 6.3^{o}C)
Precipitation	No change (-4.8% to 6.0%)	No change (-6.0% to +6.4%)	Wetter by 1% (-7.2 to +9.6%)
Cloud cover	Decrease of -2.7% (-6.0 to +0.9%)	Decrease of -5.2% (-10.4 to -0.1%)	Decrease of -6.6% (-15.8 to -0.5%)
Relative humidity	Decrease of -1.2% (-2.9 to +0.4%)	Decrease of -2.4% (-5.6 to +0.03%)	Decrease of -3.1% (-8.3 to +0.1%)

1.6 Functions, mission, aims and objectives which will be affected by the current and possible future impacts of climate change

All key functional areas of our business will be affected to a greater or lesser extent by climate change. These key functional areas are:

- Water resources
- Water treatment
- Water networks
- Wastewater networks
- Wastewater treatment
- Sludge
- Site wide services

In addition, this report will consider the impact of climate change on our key regulators and stakeholders to the extent that it affects the company.

The predictions are for:

- a warmer, drier summer climate which will reduce the flows in the rivers from which we abstract and a likely increase in demand for water.
- a wetter, stormier winter climate which will potentially increase the risk of flooding and change the nature of the recharge of our impounding reservoirs and boreholes.

In some areas climate change is altering the way rainfall runs off the land and this may be responsible for a deterioration in the quality of some of the water we abstract.

Depending on the scale of the change and any change in the population distribution in the UK alternative sources may need to be found which will be more expensive, in financial and/or environmental terms.

In 2007 the flooding of Mythe Water Treatment Works near Gloucestershire left 350,000 people without drinking water and showed the vulnerability of water infrastructure to extreme weather events. Since then we have been working to understand which of our key assets are most at risk of being flooded. When we submitted our business plan to Ofwat in 2009 we included schemes to protect those assets that we had so far identified as requiring protection.

The more frequent intense rainfall that is predicted will put increased strain on our sewerage systems, thus potentially leading to more local flooding and discharges from Combined Storm Overflows (CSOs). It would be impractical, as well as prohibitively expensive; to build ever larger sewers to cope with the increased flows we are likely to experience in the future. We are therefore promoting our “Sewers for Sewage” campaign to find alternative approaches to dealing with storm water, such as removing surface water from sewerage systems by promoting the use of sustainable drainage. To start this process we have a policy of requesting foul only drainage systems when we are approached by developers. However this does not address the problem of the many kilometres of existing combined sewerage systems that we already have.

The changing climate may hamper the day-to-day working of our staff, for example localised flooding and storm damage may prevent staff from being able to reach their workplace. New health and safety issues will need to be considered.

Warmer summers and, in particular, more persistent periods of extreme high temperatures will increase peak demands and put a strain of treated water storage.

We rely on a number of suppliers who provide us with services and products which are essential to the various processes that we rely on to treat water and sewage and maintain equipment to the required standard. Even though we have stockpiles of critical commodities, or standby arrangements, if these supplies are interrupted by the impact of climate change our ability to meet our serviceability standards could be jeopardised. It is essential that we have visibility of their plans to maintain their service to us. It should also be noted that a significant quantity of our essential chemical supplies comes from overseas and is therefore subject to worldwide fluctuations in demand which in turn will be affected by climate change particularly more persistent climatic extremes.

1.7 Assessment of climate thresholds above which climate change and weather events will pose a threat to South West Water

The climate change projections indicate that there will be major changes to the rainfall pattern, temperature and sea level, all of which will have a significant effect on the South West. We must continue to promote schemes to enable us to adapt if we are to continue to be able to deliver our services reliably and without damaging the aquatic environment. We have already started this process through our business plan submission in 2009. We have already noted the effects of climate change in some areas. However, we have many assets and our region is large making it impractical to determine climate thresholds above which climate change and weather events will begin to pose a threat to individual assets. Therefore, at the moment we feel that specific climate change thresholds are best identified at a later stage.

2 APPROACH

2.1 Evidence, methods and expertise used to evaluate future climate impacts

To ensure consistency with our strategic direction statement and Water Resources Plan, the risk assessment in this report primarily covers potential impacts and consequences in the next 25 years (up to year 2035). We have also considered the effects of climate change into the 2080s, but there is greater uncertainty with these assessments

The risk assessment undertaken for this report has been based on a Water UK study, "A Climate Change Adaptation Approach for Asset Management Planning" (2007)[9]. The study identified a common approach for assessing adaptation risks, and their incorporation into asset management planning. It also proposed a set of consistent strategic adaptation response options for the industry.

Key climate variables for the water industry are highlighted in the study. These are drought, flood, sea level rise, and temperature rise. The Water UK study then identified how these variables may impact water industry assets and operations grouped into seven key functional areas:

- Water resources
- Water treatment
- Wastewater networks
- Wastewater treatment
- Sludge
- Site wide services

The risk assessment in this report focuses on maintaining serviceability and considers level of "consequence for service" in combination with the likelihood that the consequence will occur in the next 25 years.

Our assessment of risk has been based on in-house expertise in the seven key functional areas (including that of our partner consultants and contractors) through a series of workshops and discussions. In addition to technical expertise in the functional areas we also have expertise in climate change assessment through active membership of a number of technical groups:

- Membership of Steering Group of Defra CC:Dew climate change & demand project
- Water company representative on Environment Agency Guidelines on water resources and climate change
- Project Manager of UKWIR project: Effect of Climate Change on River Flows and Groundwater Recharge: UKCIP02 Scenarios

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[9] "A climate change adaptation approach for asset management planning" (2008) provided water companies with a consistent set of climate change adaptation information for asset management planning and the 2009 Price Review process (PR09). It also provided information on climate change impacts and adaptation options that can be fed into water companies' 25-year water resource plans, strategic direction statements and business plans where appropriate.

- Membership of Water UK Climate Change Network
- Water Company Technical Lead on joint UKWIR/EA Project: Climate Change in Water Supply Planning
- Water company representative on Environment Agency Climate Change Water resources Forum
- Member of Climate South West Executive and Forum
- Sponsors of climate change related research at University of Exeter

For some asset groups the impact of climate change has been assessed using detailed modelling or calculations further details of which are provided in Appendix D. The outputs from the modelling and calculations have been provided to workshops.

The assessments resulting from our in-house workshops have been compared with those obtained by other water companies and have been informed by discussions held by the Water UK Climate Change Network.

In assessing risks, we also took into account the on-going UK Climate Change Risk Assessment project (CCRA)[10], particularly, the report on Water Resource Sector.

The climate projections we have used for estimating risk are taken from UKCP09[11] and are based on the medium emissions scenario. There are indications that the atmosphere is currently on the medium emissions path in terms of greenhouse gas emissions[12].

2.2 Quantification, estimation and characterisation of the impact and likelihood of risks occurring at various points in the future

2.2.1 Risk quantification

We have used a three by three risk assessment matrix to quantify the level of risk of "consequence for service" derived from the Water UK study. In order to narrow the scale of subjectivity in scoring process, three likelihood levels and three consequence levels have been defined:

Likelihood

1 **Unlikely** the consequence for service will occur by the time being considered.

2 **Fairly likely** the consequence for service will occur by the time being considered. This should be where there is already some evidence from trends and historical data.

3 **Very likely** the consequence for service will occur by the time being

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[10] CCRA first stage produced eleven sector reports. The water sector was included, but the report focuses only on resources, demand and quality of water supply.
[11] A comparison between the results using UKCP09 and the previous scenarios is given in Appendix D.
[12] South West Observatory, State of the South West 2010

considered. This is obviously true where there is evidence of the consequence already happening.

Consequence

1 **Low impact** resulting in possible intermittent impact on service to customers or damage to assets requiring some repair or maintenance.

2 **Medium impact** causing minor loss of service to some customers or damage to assets (eg hosepipe ban, flooding of assets) requiring significant maintenance or replacement work and a review of investment priorities.

3 **High impact** causing major loss of service to customers, significant health & safety issues or damage to assets (eg treatment works unable to function, flooding of several hundred properties).

2.2.2 Risk estimation

Risk = likelihood x level of consequence

For each of the seven functional areas, in-house experts were engaged in the process of estimating risk values for climate change impacts on their functions for the three different time periods: 2020s, 2050s & 2080s

Risk estimation was carried out for two scenarios:

- Firstly, risk value of the impact was estimated without taking into account existing or planned adaptation and mitigation measures. The estimated risk value, therefore, represents level of impact on business function in the absence of any measures.
- Secondly, risk was assessed taking into account all existing and planned adaptation and mitigation measures. This produced a value of the “residual risk” of the impact. Residual risk values highlight areas where new or addition measures are required to further reduce the risk to acceptable levels (a risk value of 1 or 2).

This risk estimation technique identifies the benefits of adaptation and mitigation measures in a simple way. It also provides a great degree of flexibility for the estimation to be revisited when more information and evidence become available in the future.

Detailed risk assessment matrices are included in Appendix A of this report.

2.2.3 Risk values

Estimated residual risk values were used for prioritisation. Potential impacts with residual risk values of 6 or 9 are considered as high priority impacts which urgently require actions to reduce the level of risk.

For impacts with estimated residual risk values of 3 or 4, actions to further reduce the level of risks are required. These have medium priority.

Where residual risk value is estimated at 1 or 2, level of the impact is considered to be acceptable. However, measurement in the form of monitoring plan or a review is required to ensure the risk level continues to be acceptable.

Likelihood				
	3	🟨	🟥	🟥
	2	🟩	🟨	🟥
	1	🟩	🟩	🟨
		1	2	3	Consequence

🟥 urgently requires actions
🟨 action required to reduce risk
🟩 acceptable, monitoring plan required

2.3 Evaluation of the costs and benefits of proposed adaptation options

The industry's asset management planning process already involves cost-benefit analysis as well as risk assessment and costing exercise in setting out our investment programme. This has been based on customer surveys and their willingness to pay. For adaptation actions that are already in place or included in our current asset management plan a cost-benefit analysis was undertaken and only cost beneficial schemes have been included. The current asset management plan commenced in April 2010 and will finish in March 2015. We will be commencing the preparation of our next asset management plan very shortly. This will cover the period 2015 to 2020. All of the data used to carry out the cost benefit analysis will be updated for this next business plan.

For the proposed adaptation options that we have highlighted in this report, we feel further work and guidance from Ofwat is required prior to progressing with cost-benefit analysis of these options. If the guidance is received in time we will carry out any necessary work that will be required in preparation for, and as part of, the next asset management planning process.

Proposed adaptation options for the next asset management plan will not be considered and analysed in isolation in our planning process. They will be considered as part of our whole asset management plan as climate change is one of many risks to our business that we have to take into account.

3 SUMMARY OF RISKS WHICH AFFECT SOUTH WEST WATER

3.1 Likelihood/consequence matrix of South West Water's strategic risks from climate change

Using the approach described in Section 2 of this report, a likelihood/consequence matrix of the risks we may face from climate change has been produced. The full matrix is presented in Appendix A.

From this process high priority impacts (those with a consequence for service risk value of 6 or 9) for each of the seven asset and non-asset based functions have been identified and are summarised in Tables 2-8. These are risks for which new or additional measures may be required to reduce the level of risk to an acceptable level in the future. They will of course be subject to a cost benefit analysis. Through our discussions, we have identified that some risks may remain high even though adaptation measures have been identified. This is where we have to discuss these vulnerabilities with our stakeholders, particularly those supplying power, chemical and transport services. Local authorities will also play a key part in delivering our surface water management strategy.

3.2 High priority climate related risks

The high priority impacts for each of the seven key functional areas resulting from the analysis presented in Appendix A are summarised in the tables below. They show where the consequence for our service was initially assessed as having a value of 6 or 9 and the residual risk to our serviceability following the Company's adaptive action.

Through in-house workshops, high-level adaptive options have been identified for these impacts as they are considered to be urgently requiring action to reduce the level of risk.

Our ability to capture and store raw water is critical to us if we are to maintain our current level of serviceability. We have put a lot of effort into this area. Over the past 25 years we have modelled the availability of raw water and our ability to capture it. Our model takes into account population growth and movement together with a climate change assessment. The risk assessment that was carried out at the last business planning round showed that without adaptation measures the level of risk of impacts on the company's water resource function could be unacceptable.

We have also put considerable effort into identifying assets including assets that may be vulnerable to flooding by using information available from the Environment Agency.

Another priority for us is to ensure that sewers are for sewage. If we can remove surface water from our combined sewers to avoid them from becoming overloaded by the more frequent and intense storms we expect we will reduce the number of internal and external flooding incidents from sewage.

We already have many measures in place that will mitigate the effects of climate change. The high level risks identified in all of our categories are considered to be significantly reduced by existing measures. Going forward we will use our risk assessment to highlight areas that we need to concentrate on in developing new or additional adaptation measures for possible inclusion in our investment strategy in the next asset management plan.

Table 2: Priority impacts on Water Resources

2020

Asset level	Climate Variable/MWH impact ref.	Primary impact of climate variable	Potential impacts on organisation & stakeholders	Consequence for service level of risk	Company residual level of risk
All water resources	F1	Direct asset flooding	Asset loss and service failure	6	3
All water resources	F2	More frequent and power supply flooding	Power outages and service failure	6	3
All water resources	F3	Movement of permanent population (away from flood plains) and tourism due to flooding	Impacts on security of supply	6	3
Storage reservoirs and aqueducts	F6	More intense rainfall events and changes to soil conditions	Service failure, customer flooding and asset loss	6	3
Storage reservoirs and aqueducts	F7	More intense rainfall events	Service failure, customer flooding and asset loss	6	3

2050

Asset level	Climate Variable/MWH impact ref.	Primary impact of climate variable	Potential impacts on organisation & stakeholders	Consequence for service - Level of risk	Company residual level of risk
All water resources	D2	Intake, borehole pump and reservoir draw off levels do not match reduced levels	Service failure	6	4
All water resources	D4	Lower river or borehole yields or reduced water quality	Abstraction licenses reduced or removed, reducing security of supply	6	4
All water resources	D5	Drier conditions	Reduced security of supply	6	4
Storage reservoirs and aqueducts	D6	Lower river flows	Reduced security of supply	6	4
Intake pumping stations	D9	River level falls	Reduced raw water quality	6	4
All water resources	F1	Direct asset flooding	Asset loss and service failure	9	6
All water resources	F2	More frequent and power supply flooding	Power outages and service failure	9	3

All water resources	F3	Movement of permanent population (away from flood plains) and tourism due to flooding	Impacts on security of supply	6	3
Storage reservoirs and aqueducts	F6	More intense rainfall events and changes to soil conditions	Service failure, customer flooding and asset loss	6	3
Storage reservoirs and aqueducts	F7	More intense rainfall events	Service failure, customer flooding and asset loss	6	3
All water resources	T2	Redistribution of/increase in tourism	Reduced security of supply	6	2

2080

Asset level	Climate Variable/MWH impact ref.	Primary impact of climate variable	Potential impacts on organisation & stakeholders	Consequence for service - Level of risk	Company residual level of risk
All water resources	D2	Higher daily and peak demand for garden watering	Reduced security of supply	6	4
All water resources	D3	Intake, borehole pump and reservoir draw off levels do not match reduced levels	Service failure	6	3
All water resources	D4	Lower river or borehole yields or reduced water quality	Abstraction licenses reduced or removed, reducing security of supply	6	4
All water resources	D5	Drier conditions	Reduced security of supply	6	4
Storage reservoirs and aqueducts	D6	Lower river flows	Reduced security of supply	6	4
Intake pumping stations	D9	River level falls	Reduced raw water quality	6	4
All water resources	F1	Direct asset flooding	Asset loss and service failure	9	6
All water resources	F2	More frequent and power supply flooding	Power outages and service failure	9	3
All water resources	F3	Movement of permanent population (away from flood plains) and tourism due to flooding	Impacts on security of supply	6	3
Storage reservoirs and aqueducts	F6	More intense rainfall events and changes to soil conditions	Service failure, customer flooding and asset loss	9	3
Storage reservoirs and aqueducts	F7	More intense rainfall events	Service failure, customer flooding and asset loss	9	3
All water resources	T2	Redistribution of/increase in tourism	Reduced security of supply	6	2

Table 3: Priority impacts on Water Treatment Works

2020

Asset level	Climate Variable/MWH impact ref.	Primary impact of climate variable	Potential impacts on organisation & stakeholders	Consequence for service - Level of risk	Company residual level of risk
Service reservoirs and water towers	D13	Loss of/intermittent supply	Increased drinking water quality risk	6	3
All water treatment	F11	Direct asset flooding	Asset loss and service failure	6	3
All water treatment	F12	More frequent storms and power supply flooding	Service failure	6	3

2050

Asset level	Climate Variable/MWH impact ref.	Primary impact of climate variable	Potential impacts on organisation & stakeholders	Consequence for service - Level of risk	Company residual level of risk
Service reservoirs and water towers	D13	Loss of/intermittent supply	Increased drinking water quality risk	6	3
All water treatment	F11	Direct asset flooding	Asset loss and service failure	9	3
All water treatment	F12	More frequent storms and power supply flooding	Service failure	9	3
Treatment works	T14	More frequent disease increasing drinking water quality risk	Increased drinking water quality risk	6	1

2080

Asset level	Climate Variable/MWH impact ref.	Primary impact of climate variable	Potential impacts on organisation & stakeholders	Consequence for service - Level of risk	Company residual level of risk
Service reservoirs and water towers	D12	Intermittency in supply	Increased drinking water quality risk	6	2
Service reservoirs and water towers	D13	Loss of/intermittent supply	Increased drinking water quality risk	6	3
Service reservoirs and water towers	D14	Loss of supply and depressurisation	More frequent pipe failure and increased drinking water quality risk	6	2
All water treatment	F11	Direct asset flooding	Asset loss and service failure	9	3
All water treatment	F12	More frequent storms and power supply flooding	Service failure	9	3
Treatment works	T14	More frequent disease increasing drinking water quality risk	Increased drinking water quality risk	6	1

Table 4: Priority impacts on Water Networks

2020

Asset level	Climate Variable/MWH impact ref.	Primary impact of climate variable	Potential impacts on organisation & stakeholders	Consequence for service - Level of risk	Company residual level of risk
Distribution storage	F20	Direct flooding	Increased drinking water quality risk	6	3

2050

Asset level	Climate Variable/MWH impact ref.	Primary impact of climate variable	Potential impacts on organisation & stakeholders	Consequence for service - Level of risk	Company residual level of risk
Distribution storage	F20	Direct flooding	Increased drinking water quality risk	6	3
Distribution storage	T22	Higher peak demand	Reduced security of supply	6	2

2080

Asset level	Climate Variable/MWH impact ref.	Primary impact of climate variable	Potential impacts on organisation & stakeholders	Consequence for service - Level of risk	Company residual level of risk
All water networks	D17	Higher daily and peak demand for garden watering	Accelerated asset deterioration	6	4
Distribution networks including ancillaries	D18	Loss of/intermittent supply	Increased drinking water quality risk	6	3
Distribution networks including ancillaries	D19	Loss of supply and de-pressurisation of the supply network	More frequent pipe failure and increased water quality risk	6	3
Distribution storage	D23	Loss of supply or intermittent supplies	Increased drinking water quality risk	6	2
All water networks	F17A	More frequent storms and power supply flooding	Power outages and service failure	6	4
Distribution networks including ancillaries	F18	Flooding	Increased drinking water quality risk	6	3
Distribution networks including ancillaries	F19	Direct flooding	Increased drinking water quality risk	6	3
Distribution storage	F20	Direct flooding	Increased drinking water quality risk	6	3
Distribution networks including ancillaries	T21	Increased micro biological growth	Increased drinking water quality risk	6	4
Distribution storage	T22	Higher peak demand	Reduced security of supply	9	3
Distribution storage	T23	Increased micro biological growth	Increased water quality risk	6	4
Distribution storage	T22	Higher peak demand	Reduced security of supply	9	3

Table 5: Priority impacts on Wastewater Treatment Works

2020

Asset level	Climate Variable/MWH impact ref.	Primary impact of climate variable	Potential impacts on organisation & stakeholders	Consequence for service - Level of risk	Company residual level of risk
Treatment works	S22	Saline intrusion	Accelerated asset deterioration and reduced process performance	6	3

2050

Asset level	Climate Variable/MWH impact ref.	Primary impact of climate variable	Potential impacts on organisation & stakeholders	Consequence for service - Level of risk	Company residual level of risk
All waste water treatment	F33	Direct asset flooding	Asset loss and service failure	6	2
All waste water treatment	F34	More frequent storms and power supply flooding	Power outages and service failure	6	2
All waste water treatment	S19	Direct asset flooding, storm damage, coastal erosion or planned retreat	Asset loss and service failure	6	3
All waste water treatment	S20	Saline intrusion	Accelerated asset deterioration	6	3
Treatment works	S22	Saline intrusion	Accelerated asset deterioration and reduced process performance	9	6

2080

Asset level	Climate Variable/MWH impact ref.	Primary impact of climate variable	Potential impacts on organisation & stakeholders	Consequence for service - Level of risk	Company residual level of risk
Treatment works	D34	Lower average and peak flows	Increased septicity and odour problems	6	2
Treatment works	D35	Lower river flows and increased seasonal variability	Reduced water quality, increased risk of a consent failure / pollution incident	6	2
All waste water treatment	F33	Direct asset flooding	Asset loss and service failure	6	2
All waste water treatment	F34	More frequent storms and power supply flooding	Power outages and service failure	6	2
All waste water treatment	F35	Longer FFT	Increased risk of consent failure	6	2
Site pumping stations	F36	Increased volumes of storm water in combined sewers	Increased pump usage and accelerated asset deterioration	6	2
Treatment works	F37	Longer FFT at WwTW	Accelerated asset deterioration and failure	6	2
Treatment works	F41	Longer retention of water in storm tanks	Reduction in process	6	2

Outfalls	F42	Higher peak levels at discharges	Service failure	6	2
All waste water treatment	S19	Direct asset flooding, storm damage, coastal erosion or planned retreat	Asset loss and service failure	9	3
All waste water treatment	S20	Saline intrusion	Accelerated asset deterioration	9	3
Treatment works	S22	Saline intrusion	Accelerated asset deterioration and reduced process performance	9	3
All waste water treatment	T33	Higher temperatures	Increased H&S risk	6	3
All waste water treatment	T35	Higher temperature	Reduction in treatment process performance and increased risk of consent failure	6	2
All waste water treatment	T36	Higher temperatures	Tighter consents and/or increased H&S risk near discharge points	6	2
Site pumping stations	T37	Greater septicity affecting pumping regimes	Accelerated asset deterioration and increased odour	6	2
Treatment works	T38	Greater septicity in received sewage	Increased odour	6	2
Treatment works	T39	Effluent standards raised to meet temperature affected water quality objectives	Increased risk of consent failure / pollution incident	6	2
Treatment works	T41	Lower summer flows and reduced freezing frequency	Increased environmental health risk	6	2
Treatment works	T43	Greater septicity and use of odour chemicals	Increased health and safety risks	6	2

Table 6: Priority impacts on Wastewater Networks

2020

Asset level	Climate Variable/MWH impact ref.	Primary impact of climate variable	Potential impacts on organisation & stakeholders	Consequence for service - Level of risk	Company residual level of risk
CSOs and overflows	F30	Higher storm intensity	Increased CSO spill frequency and reduced receiving water quality	6	4

2050

Asset level	Climate Variable/MWH impact ref.	Primary impact of climate variable	Potential impacts on organisation & stakeholders	Consequence for service - Level of risk	Company residual level of risk
All waste water networks	F21	Direct asset flooding	Asset loss and service failure	6	2
All waste water networks	F22	More frequent storms and power supply flooding	Power outages and service failure	6	2

CSOs and overflows	F30	Higher storm intensity	Increased CSO spill frequency and reduced receiving water quality	9	4

2080

Asset level	Climate Variable/MWH impact ref.	Primary impact of climate variable	Potential impacts on organisation & stakeholders	Consequence for service - Level of risk	Company residual level of risk
Sewer networks including trunk sewers	D24	Lower precipitation, infiltration and inflows plus water conservation	More frequent sewer blockages and increased customer flooding	6	2
All waste water networks	F21	Direct asset flooding	Asset loss and service failure	6	2
All waste water networks	F22	More frequent storms and power supply flooding	Power outages and service failure	6	2
Sewer networks including trunk sewers	F23	Higher intensity rainfall	Surface flooding and reduced receiving water quality	6	1
Sewer networks including trunk sewers	F24	Increased volumes of storm water	Customer flooding	6	1
Sewer networks including trunk sewers	F25	Higher groundwater levels	Customer flooding	6	4
Pumping stations	F27	Increased volumes of storm water	Service failure and reduced receiving water quality	6	1
Pumping stations	F28	Increased volume of storm water in combined sewers	Increased pump usage and accelerated asset deterioration	6	1
CSOs and overflows	F30	Higher storm intensities	Increased CSO spill frequency and reduced receiving water quality	9	4
CSOs and overflows	F32	More frequent flooding	Increased frequency of failing spills per season consent	6	2
All waste water networks	S12	Direct asset flooding, storm damage, coastal erosion or planned retreat	Asset loss and service failure	6	2
All waste water networks	S13	Saline intrusion	Accelerated asset deterioration	6	2
Sewer networks including trunk sewers	S14	High rainfall adding to high tides	Increased customer flooding and reduced receiving water quality	6	2
Sewer networks including trunk sewers	S15	Saline intrusion	Environmental health risk	6	4
Sewer networks including trunk sewers	S16	Saline intrusion	Accelerated asset deterioration	6	2
CSOs and overflows	S17	Tide locked intermittent discharges	Customer flooding and reduced receiving water quality	6	4

CSOs and overflows	S18	High rainfall adding to high tides	Reduced receiving water quality	6	1
All waste water networks	T25	Higher temperatures	Increased H&S risks	6	3
Sewer networks including trunk sewers	T27	Greater capacity	Accelerated asset deterioration and increased odour	6	2
Pumping stations	T28	Greater septicity affecting pumping regimes	Accelerated asset deterioration and increased odour	6	2
Rising mains	T30	Greater capacity	Accelerated asset deterioration and increased odour	6	2
CSOs and overflows	T31	Greater capacity	Increased toxicity and odour and lower receiving water quality	6	2

Table 7: Priority impacts on Sludge Management

2020

Asset level	Climate Variable/MWH impact ref.	Primary impact of climate variable	Potential impacts on organisation & stakeholders	Consequence for service - Level of risk	Company residual level of risk
Sludge disposal or re-cycling	T53	Higher temperatures	Increased H&S risk	6	3

2050

Asset level	Climate Variable/MWH impact ref.	Primary impact of climate variable	Potential impacts on organisation & stakeholders	Consequence for service - Level of risk	Company residual level of risk
Sludge disposal or re-cycling	D39	Agricultural practice change	Changes in agricultural demand for sludge	6	3
All sludge	F43	Direct asset flooding	Asset loss and service failure	6	2
All sludge	F44	More frequent storms and power supply flooding	Power outages and service failure	6	2
Sludge disposal or re-cycling	F45	Flooding prevents access to fields	Service failure	6	2
Sludge disposal or re-cycling	F46	Flooding of sludge transport routes	Service failure	6	2
All sludge	S25	Direct asset flooding, storm damage, coastal erosion or planned retreat	Asset loss and service failure	6	2
All sludge	T49	Higher average and peak temperatures	Increase in incidence of sludge related diseases	6	3
Sludge disposal or re-cycling	T53	Higher temperatures	Increased H&S risk	6	3

2080

Asset level	Climate Variable/MWH impact ref.	Primary impact of climate variable	Potential impacts on organisation & stakeholders	Consequence for service - Level of risk	Company residual level of risk
Sludge disposal or re-cycling	D39	Agricultural practice change	Changes in agricultural demand for sludge	9	3
Sludge disposal or re-cycling	D40	Low water flow	Increased concentration of toxic compounds in sludge affecting reuse and or incineration.	6	2
All sludge	F43	Direct asset flooding	Asset loss and service failure	6	2
All sludge	F44	More frequent storms and power supply flooding	Power outages and service failure	6	2
Sludge disposal or re-cycling	F45	Flooding prevents access to fields	Service failure	6	2
Sludge disposal or re-cycling	F46	Flooding of sludge transport routes	Service failure	6	2
Sludge disposal or re-cycling	F47	Increased run off from sludge treated agricultural land	Reduced receiving water quality	6	4
All sludge	S25	Direct asset flooding, storm damage, coastal erosion or planned retreat	Asset loss and service failure	6	2
All sludge	S26	Saline intrusion	Accelerated asset deterioration	6	2
All sludge	T49	Higher average and peak temperatures	Increase in incidence of sludge related diseases	6	3
Sludge disposal or re-cycling	T52	Agricultural practice change	Change in agricultural demand for sludge	6	2
Sludge disposal or re-cycling	T53	Higher temperatures	Increased H&S risk	9	3

Table 8: Priority impacts on Site-Wide Services

2020

Asset level	Climate Variable/MWH impact ref.	Primary impact of climate variable	Potential impacts on organisation & stakeholders	Consequence for service - Level of risk	Company residual level of risk
All site wide services		Greater persistence of extreme conditions	Problems in obtaining essential chemicals for water & wastewater treatment	6	3

2050

Asset level	Climate Variable/MWH impact ref.	Primary impact of climate variable	Potential impacts on organisation & stakeholders	Consequence for service - Level of risk	Company residual level of risk
All site wide services	F50	More frequent storms and power supply flooding	Power outages and service failure	6	4
SCADA and telemetry	F52	Flooding	Loss of SCADA / telemetry and service failure	6	3
All site wide services		Greater persistence of extreme conditions	Problems in obtaining essential chemicals for water & wastewater treatment	6	3

2080

Asset level	Climate Variable/MWH impact ref.	Primary impact of climate variable	Potential impacts on organisation & stakeholders	Consequence for service - Level of risk	Company residual level of risk
All site wide services	F49	Direct asset flooding	Reduced access to assets and increased H&S risk to staff	6	2
All site wide services	F50	More frequent storms and power supply flooding	Power outages and service failure	6	4
All site wide services	T51	Direct flooding of electrical assets	Increased H&S risk to staff	6	4
SCADA and telemetry	F52	Flooding	Loss of SCADA / telemetry and service failure	9	4
All site wide services	S27	Direct asset flooding	Asset loss and service failure	6	2
All site wide services		Greater persistence of extreme conditions	Problems in obtaining essential chemicals for water & wastewater treatment	9	6

3.3 Opportunities presented by climate change

The predicted wetter winters could mean that our impounding reservoirs will be full earlier or that the period that they spill for is increased which will allow us to utilise our hydrogeneration equipment for longer. The increase in temperature will almost certainly improve the rates of reaction in our water, wastewater and sludge treatment processes.

Demand may be higher if the climate during the summer is warmer which would result in an increase in revenue received. However this may increase the strain on our infrastructure and make the difference between winter and summer demand more pronounced requiring a different approach to meeting peak summer demand.

If the trend is towards warmer winters there will be less chance of prolonged cold spells which result in an increase in leakage.

The wetter winters will also reduce the need for us to use our pump storage schemes to recharge our impounding reservoirs.

4 ACTIONS PROPOSED TO ADDRESS RISKS

4.1 Adaptation actions for the top priority risks

It is important that the service that we provide is able to deal with incidents and emergencies in an effective manner. Our Emergency Planning Team have developed procedures and plans to help us deal with such events and these are rehearsed, not only internally but also with external agencies.

By their nature some of these plans are generic, so they would be relevant whatever the cause of the emergency. For example we have to produce a drought plan which is agreed with the Environment Agency. We also have procedures in place should there be a pollution incident which could affect one of our abstraction points, or should we be the source of the pollution. We have stand-by generators at our critical assets to provide energy in the event of a power failure. Most projections about the future changing climate anticipate drier and warmer summers, which will put an added strain on water resources. This in turn is likely to increase the priority given to water efficiency. We have met our mandatory annual leakage control target for the last 13 years. The current target is significantly below the sustainable economic level of leakage for our region.

A significant proportion of our assets have a short asset life compared to the timescales involved in climate change. Therefore it is likely that they will be renewed once if not more before the 2080s. During this time designs and our technical standards will evolve to incorporate the effect that climate change will have on such assets. However it is only through the five yearly business plan reviews that we can identify any differences in funding that such changes may require.

For our longer lived assets we may also have to produce programmes of alteration or change which would again be identified through our five yearly asset management plan review.

Our drinking water safety plans will help to identify risks from climate change that need to be evaluated and probable solutions developed which can be promoted through the business plan review. They are based on a comprehensive risk assessment and risk management approach to all the steps in a water supply chain from catchment to consumer.

We have completed the PACT self-assessment which assesses the status of adaptive capacity within our company. The report forms the basis of section 4.5 of this report.

However we need to carry on working towards a greater understanding of the impacts of climate change and where we identify that this presents a major threat to us a scheme to mitigate the problem needs to be included in our business planning process. We have started doing this and some flood resilience schemes are included in our current plan.

4.2 Implementation of adaptation actions

We operate over 600 sewage works, approximately 870 sewage pumping stations and 32 water treatment works. All of these assets have been designed to deliver the outputs required of them given the local conditions that they have to operate in. As the impact of climate change will vary from location to location it would not be effective to design generic solutions to adaptation actions.

This was acknowledged by the Environment Agency in the report (ICF International & RPA, 2007), which accepted that the water industry's assets are difficult to characterise in broad generic terms.

All of the high priority risks that have been identified by our risk assessment will be discussed further with the relevant mangers. It may be necessary to carry out further assessments to identify the particular part of an asset that would be affected by the climate variable and ensure that a suitable plan is drawn up. This can also be included in our asset management plan.

4.3 Cost and benefits of adaptation measures

The process that we have gone through to develop this report has helped to highlight areas where we will need to develop our plans further for inclusion in our business planning process. We will be using this information to promote schemes in our business plan for 2015-2020. We believe that as the evidence base on the impact of climate change increases, further guidance on how these impacts should be reflected in cost benefit analysis will be required, particularly if customers do not appreciate the need for immediate action to prevent effects at some distant point in the future.

Some of the areas where we will need to develop our plans include:

- Our Water Resource Plan has identified that over the next 5 years we do not need to spend any money to maintain headroom and address supply-demand balance issues. However in future planning periods it is likely that we will have to spend money to maintain our level of target headroom.
- Increased rainfall and the change of intensity in some catchments are already affecting the quality of our raw water resources. We have identified an investment of £8.64m in various catchment management schemes to allow better management of some catchments. We are proposing to promote more schemes in our next business plan.
- We are promoting Sewers for Sewage to ensure that our sewers are protected against increased rainfall and more intense storms in the years to come. This is a very long term aspiration that will need careful consideration to ensure that the cost benefit is fully understood by our customers.
- We are incorporating an "Urban Creep" factor into our assessment of the ability of our sewerage systems to cope with the increased run-off from the expansion of impermeable areas within residential and industrial areas.
- We are installing flood resilience schemes for some of our clean water assets at a cost of £1.86m. The assessment of the vulnerability of our assets will be made at each periodic review to check that we are still adequately protected.

- Utilising a similar approach in waste water to that used in water resource planning to improve our strategies for waste water supply and demand planning and inclusion of the effects of climate change.
- Raising awareness among staff, contract partners and suppliers and encouraging them to draw together their own plans.
- Engaging with other stakeholders, such as the Environment Agency, to promote schemes and approaches to solutions for the mitigation of the effects of climate change. Taking part in research through bodies such as UK Water Industry Research (UKWIR) and Water Research Council (WRC).

4.4 Reduction in risk as a result of adaptation measures

Our assessment of the reduction in risk can be seen in the detailed analysis of our risks in Appendix A. A summary of the high level initial risks is shown in section 3. We have estimated that as a result of the measures we are currently taking there are no significant risks that we are exposed to until the 2050s. This position will be reviewed as part of our five yearly business planning process.

4.5 Embedding the management of climate change risks in South West Water

4.5.1 Developing the capacity to adapt to climate change

In order to assess the extent to which the management of climate change risks is embedded within our organisation and to produce a plan for the future, we completed the online PACT Self-Assessment Questionnaire. This questionnaire forms part of a methodology developed by Alexander Ballard Ltd (ABL) to investigate “adaptive capacity”. A report has been produced by ABL on their analysis of our questionnaire and this will contribute to a review of the status of ‘adaptive capacity’ in the UK water sector, which itself forms part of the UK 2012 Climate Change Risk Assessment (CCRA).

The analysis of adaptive capacity in the water sector is being conducted as part of a trial of methods to be used in the CCRA. The definition of adaptive capacity used in the CCRA is as follows:

> *The ability of a system to design or implement effective adaptation strategies to adjust to information about potential climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.*

The management challenge presented by climate change often requires moving on from a ‘business as usual’ mindset and may involve a wide range of participants at different levels in the organisation. The PACT report produced by ABL was designed to provide insights as to where our adaptation programme is strong relative to what is required and also as to where any improvement efforts might best be focused to assist cost-effective progress.

4.5.2 How organisations get better at dealing with climate change

ABL believe that responses to climate change improve in predictable stages. PACT identifies six levels of response, each of which represents an increase in complexity and also the capacity of an organisation to deal with climate change. Organisations become active at different response levels as they develop their understanding of climate change and of how to respond to it. Each higher level of response is built on the foundation of the level below.

The six levels of response

Most organisations of any size would be assessed by PACT as active at the first and second levels of response: **“core business focused”** and **“stakeholder responsive”**. However, many need to be working at the third level of response: **“efficient management.”** This is when climate change becomes rooted in core business processes. The disciplined use of approaches such as carbon management systems and adaptation check lists become standard practice at this level.

A 4th level of response: **"breakthrough projects"** needs activating in order to progress beyond efficient management. This is when senior managers commission projects to explore issues in depth, look beyond the status quo, seek performance breakthroughs and look for insights relevant to the organisation's strategy.

Achieving RL4 should be a staging post towards Response Level 5 **"strategic resilience"** where mainstream focus is on continually building the resilience of organisations and communities both to climate impacts and to a future in which energy could become seriously constrained.

Defining how organisations perform at the highest level, Response Level 6: **"champion organisation"**, is still work in progress since few organisations have managed to consistently operate at this level.

To sustain movement from one level to another requires parallel progress along nine developmental pathways which are summarised below. Our PACT self-assessment review identifies where we currently sit and where the longer term potential could be.

4.5.3 The nine developmental pathways

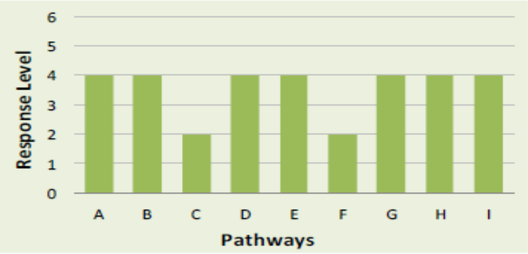
PACT can be described as an organisational development tool because it gathers and organises information about nine organisational capacities or pathways necessary for improved performance. These are:

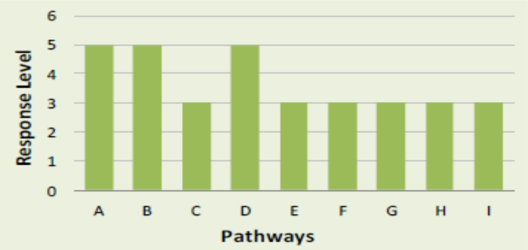
a	**Awareness**	The grasp of what climate change means for society, for the organisation and its mission, and for particular areas of responsibility, now and into the future.
b	**Agency**	The capacity to spot, prioritise and develop opportunities for meaningful and timely action on climate change.
c	**Leadership**	The extent to which a formal leadership team has developed a strategic vision and engages with, supports and legitimises its implementation.
d	**Agents of Change**	How an “ecosystem” or group of champions is identified, developed, empowered and supported so that they can be effective agents of change.
e	**Working together**	The capacity to participate in, learn from, and act in collaborative partnerships with internal and external groups.
f	**Learning**	The extent to which the organisation generates and responds to feedback from innovation, even on a small scale, and makes sense of and communicates new information to improve procedures, strategies and mission.
g	**Managing Operations**	The embedding of procedures to get to grips with climate change in a systematic way to ensure that intentions and policies turn into action.
h	**Programme scope & coherence**	How far projects sit within a strategic programme of action suited to the scope of what the organisation is trying to achieve.
i	**Expertise & Evidence**	Ability to identify, access and deploy the necessary technical and change “know-how” and information to make the biggest difference.

If performance in any one pathway lags behind, it is likely to impair the overall response to climate change. Because the pathways are 'complementary', progress needs to be made along each one at the same rate. So it becomes necessary to understand where each ‘pathway’ stands relative to others

ABL have identified three generic patterns of response, each with its own challenge:

Pattern A: Some lagging pathways. In this pattern, one or two pathways are lagging behind most others. They are likely to be acting as a brake on progress. The payoffs from improving them are likely to be very high – probably higher than trying harder in leading pathways.





Pattern B: Some pathways forge ahead. In this pattern, progress along some pathways is beginning to accelerate. Nobody wants to slow down or stop momentum – and yet there is a great risk that initiatives will fail unless similar progress is made on other pathways. The task is to protect and use leading pathways, as a basis for developing the others.

Pattern C: A stable system. In this pattern, different pathways reinforce each other, making change difficult: whatever happens, it tends to look like more of the same. The task is to unfreeze, change and consolidate. This can happen if there is an opportunity such as a project or working with a single department which allows forward movement on all pathways at the same time.

4.5.4 The response level at which South West Water needs to operate

Following their analysis, ABL have deduced that it is very likely that we need to be able to operate at Response Level 5 "Strategic Resilience". The main reasons for this are that we:

- have ambitions to exist more or less indefinitely into the future; a future that is expected to bring significantly different weather patterns
- are currently responsible for fixed assets that we intend to manage for decades into the future
- are reliant upon global supply chains that may also be affected
- have a policy commitment, or a statutory obligation, to promote sustainable development
- frequently influence decisions that may be expected to have consequences for decades into the future (these are often costly to reverse).

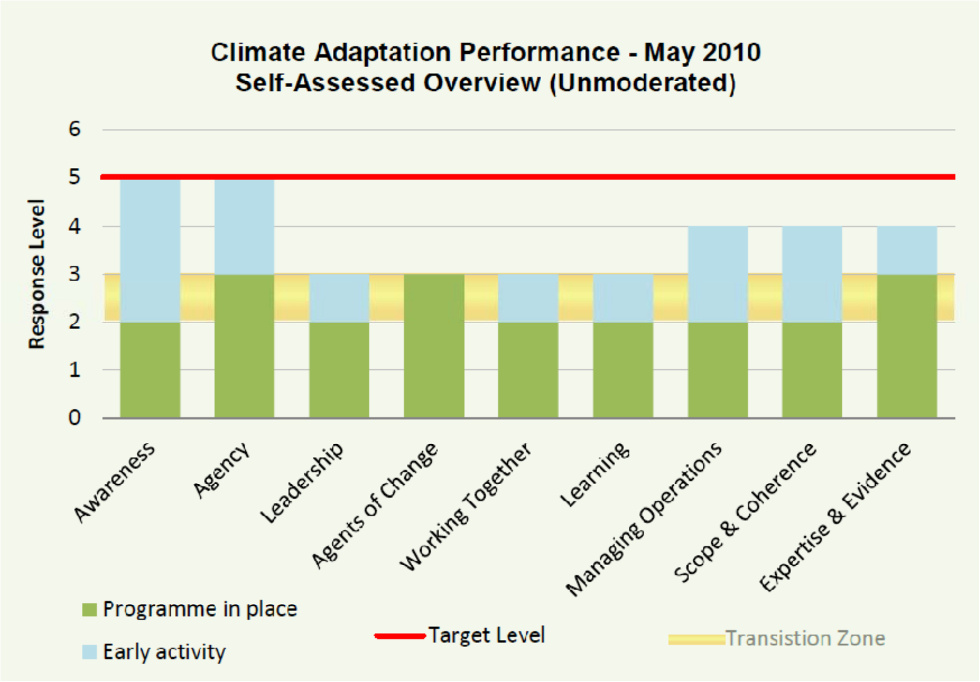
Operating consistently at this target level requires some rare and sophisticated capabilities that very few organisations currently have or even know they need. Working from lower level responses to get to this level may realistically take years to achieve. Developing the capabilities to progress up the response levels requires considerable determination and motivation to achieve, but without developing these skills the organisation will remain vulnerable. ABL noted that they were pleased to see that, unlike many, we are already showing encouraging signs that we understand what Response Level 5 work looks like in some areas.

Society and organisations need to prepare for a radically different and uncertain future. There needs to be an appreciation that addressing climate adaptation means embarking upon a journey of discovery, and ABL noted in their report that they were pleased to see that we acknowledge this.

We believe that we are well on the way to developing a programme on climate adaptation and ABL noted that in some areas progress has been strong. However ABL's analysis suggests that there are other areas where we are not as far forward.

4.5.5 Overview of climate adaptation performance in South West Water

The target response level is shown as a red line on the PACT Overview Graph below.



Green areas represent our current response level on adapting to climate change is solid.

Lighter blue areas represent where there are indications of early activity. While the areas of early activity are not yet solid at the higher level, these represent signs of where we are beginning to move ahead.

The **yellow** area shown as the Transition Zone highlights where the overall system is poised to move to a higher level of response and can be seen as an interim goal for us as it approaches the target level marked in red.

We are engaged in the challenge of the transition from RL2 to RL3. Successfully achieving this will be an important step fro us and will provide a strong foundation from which it will be possible to move forward quickly towards the longer term goals. At RL3, an organisation brings the adaptation agenda into its mainstream operational systems, providing it with similar structures and resources that are provided to other legitimate areas of management activity.

For example, organisational leaders begin to set intermediate goals to improve performance – often 'process goals' to improve systems of management.

Operational systems such as ISO 14001 or ISO 9001 or equivalent are used to ensure that procedures are amended to take account of these goals, that people get the training they need, that learning from activities is used to improve processes, that appropriate expertise is used.

A formal improvement plan is agreed and adequately resourced with professional staff and external experts. Policy begins to be built upon solid foundations of evidence and managers begin to expect that a ‘business case’ can be put together for changes based on this evidence. The issue begins to be addressed in the organisation’s engagement with stakeholders.

Our response pattern is B which means that some pathways are forging ahead, with considerable early activity ahead of the status quo. Although this momentum is good, there is also a risk that these leading pathways will accelerate too rapidly and then stop because there is insufficient progress in other areas to support change. If this pattern is not understood and addressed, people at the leading edge could become disheartened. It is important to learn from the leading pathways in order to bring others up to the same level.

4.5.6 A plan for the future - embedding climate change adaptation in South West Water

In ABL’s report: Part 2 – PACT Pathways Analysis – there is a list of activities that would be expected to be implemented at the next response level. ABL believe that we should give particular focus to the pathways for Leadership, Working Together and Learning, where some work is required to catch up with the other pathways in order to embed RL3 across the whole group. There is also some work required to embed RL3 in the pathways for Awareness, Managing Operations and Programme Scope & Coherence, although to a lesser extent as there are already signs of early activity moving beyond this point.

The leading pathway in which we have clearly already invested considerable effort is Agency, with Awareness almost as far forward. ABL recommends that our emphasis shifts to other pathways so as to provide the support that will be needed to consolidate on progress in this area.

The transition zone is based on the overall pathways pattern as described above (Section 4.5.5). We are facing the challenge of a transition from RL2 to RL3. The analysis provided below looks at specific activities that can be targeted to improve performance and helps enable this transition. Each activity has been put into one of the following classifications according to the amount of progress made:

- IMPLEMENTED
- PARTIALLY IMPLEMENTED
- NOT IMPLEMENTED
- NO EVIDENCE

We consider that our immediate target should be consolidation at RL3 and priority activities to achieve this have been colour coded as follows:

Priority	Classification	Action
High	NO EVIDENCE	Not explored in the report but the activities are important to ensure solid performance and therefore need attention
High	NOT IMPLEMENTED	Activities must be started
Medium	PARTIALLY IMPLEMENTED	Activities need further attention
Low	IMPLEMENTED	Does not require further attention

A) Awareness

Priority activities for RL3

PARTIALLY IMPLEMENTED	▪ Organisation has undertaken short term (up to 10 years) analysis of cost and other risks and opportunities linked to climate impacts (though not necessarily of how these financial implications might change in medium and long term future). ▪ Managers who take decisions are aware of the current climatic conditions that they need to take into account. ▪ Aware of how likely trends in government policy on climate change adaptation might affect organisation over 1 to 5 years.
IMPLEMENTED	▪ Organisation has undertaken study of climate impacts already evident or expected up to 10 years into future - eg drought, subsidence, heat stress. ▪ Members of the organisation have participated in one or several scenario-based studies of how climate change might affect the region and / or industry over future decades. However awareness of possible future impacts may be generic and may not have extended beyond a small group.

Activities to protect for RL4

IMPLEMENTED	▪ The organisation has examined the potential risks and opportunities resulting from climate impacts on the activities and responsibilities of a part of the organisation in some detail over a strategic timescale (more than 10 years, usually a lot more) ▪ Non-specialist managers can identify some but not all strategic risks and opportunities resulting from impacts over medium term (10 to 30 years) and recognise need to know more

In this pathway we are beginning to move a long way ahead and ABL recommend that our priority should be to consolidate at RL3 across the range of pathways before pushing further ahead. This will help to improve progress at the transition zone.

B) Agency

Activities to protect at RL4

IMPLEMENTED	▪ The organisation has identified at least some realistic opportunities to act on longer term (minimum 10 years, often significantly longer) climate related risks. ▪ There has been deeper assessment of longer term climate risks and opportunities to the core activities of the organisation. This would extend beyond 10 years towards the lifespan of major decisions and perhaps longer. But it may not yet be close to comprehensive.

Activities to protect at RL5

PARTIALLY IMPLEMENTED	▪ The organisation has assessed and prioritised longer term (30+ years) climate impact risks and opportunities to its core responsibilities. ▪ The organisation has identified a reasonably comprehensive list of opportunities to act on priority long term (30+ year) climate risks and opportunities ▪ There has been financial analysis of the value of options for addressing climate risk so as to identify optimal paths to affordable risk management over time.

In this pathway we are also beginning to move a long way ahead and ABL recommend that our priority should be to consolidate at RL3 across the range of pathways before pushing further ahead. This will help to improve progress at the transition zone.

C) Leadership

Priority activities for RL3

PARTIALLY IMPLEMENTED	▪ The organisation has defined managerial responsibilities for the climate adaptation agenda at top team level and below.
NOT IMPLEMENTED	▪ The organisation's top management has approved goals for improvement of processes better to handle climate impacts. ▪ The top team formally monitors progress on climate adaptation against policy and goals at least annually.
NO EVIDENCE	▪ There are governance processes to confirm compliance with adaptation policy in decision taking.
IMPLEMENTED	▪ There is broad consensus on the top team that climate adaptation merits organisational attention.

D) Agents of change

In this pathway we are already solid at RL3 and ABL recommend that our priority should be to consolidate at RL3 across the range of pathways before pushing further ahead. This will help to improve progress at the transition zone.

E) Working together

Priority activities for RL3

PARTIALLY IMPLEMENTED	▪ The organisation does the research to identify and then engages with stakeholders who can influence or might be influenced by its adaptation decisions.
NO EVIDENCE	▪ The organisation is engaging with its supply chain and other core business partners to improve processes for adaptation. ▪ The organisation shares its understanding of impacts that require attention with external stakeholders who are closely involved. ▪ The organisation uses a stakeholder engagement process that goes beyond legal requirements in seeking external perspectives to improve adaptation strategies and decisions.
IMPLEMENTED	▪ There is a programme of action to identify and engage with internal stakeholders who are affected by and / or might influence the climate adaptation programme.

F) Learning

Priority activities for RL3

PARTIALLY IMPLEMENTED	▪ The organisation has provided and funded a set of training processes sufficient to meet training needs on adaptation.
NOT IMPLEMENTED	▪ Structured process to identify deviations from adaptation expectations, investigate causes, take corrective action and update processes where appropriate. ▪ At the end of significant adaptation projects, processes are used to draw out the lessons learned and to direct that learning to improve future projects.
IMPLEMENTED	▪ The organisation has investigated the training needs of its staff on climate adaptation issues. ▪ The organisation takes steps to identify and learn from best practice among peer community on climate adaptation. This is an important activity because it helps people to challenge themselves to improve their practices and sometimes also their aspirations.

G) Managing operations

Priority activities for RL3

NOT IMPLEMENTED	▪ The organisation's adaptation goals are incorporated into its project management procedures. ▪ The organisation applies corrective action processes to its actions on climate adaptation. ▪ Adaptation issues are systematically addressed in procurement.
IMPLEMENTED	▪ The organisation has incorporated procedures to address climate adaptation into its core management system ▪ Emergency planners have brought short term (up to 10 years) climate risks into their emergency procedures.

Activities to protect for RL4

IMPLEMENTED	▪ Project processes are biased towards action to innovate for breakthroughs in adaptation performance.

H) Programme scope & coherence

Priority activities for RL3

PARTIALLY IMPLEMENTED	▪ Climate adaptation policy commitments, goals and identified risks are addressed in the organisation's formal action planning.
NO EVIDENCE	▪ As an RL3 programme on adaptation develops it will naturally begin to extend to cover suppliers and other close business partners.
IMPLEMENTED	▪ The adaptation programme changes and develops over time to take account of learning from experience. This includes replicating successes, addressing constraints and barriers limiting previous activities, also taking account of new information on issues.

Activities to protect for RL4

PARTIALLY IMPLEMENTED	▪ Project planning extends several years into the future for some adaptation projects.
IMPLEMENTED	▪ The organisation's core strategy recognises climate impacts as potentially material to its core objectives, and a programme of activity flows from this. ▪ The programme for adaptation includes one or more activities designed to accelerate understanding of the agenda.

I) Expertise & evidence

Activities to protect for RL4

IMPLEMENTED	▪ As the challenges of breakthrough adaptation activity are encountered, project members need to look worldwide to consult leading-edge specialist experts. Eventually, enough 'breakthrough expertise' is gathered within the organisation that publications, etc, often follow. ▪ Breakthrough adaptation activity involves considerable expert input from the primary innovator (often the service provider and / or the adviser providing the innovation), but there is also recognition and willing use of the relevant expertise provided by the eventual end-user, by project participants and by project partners.

Summary of high priority areas for action for RL3

Pathway	Classification	Activity
Leadership	NOT IMPLEMENTED	▪ The organisation's top management has approved goals for improvement of processes better to handle climate impacts. ▪ The top team formally monitors progress on climate adaptation against policy and goals at least annually.
Leadership	NO EVIDENCE	▪ There are governance processes to confirm compliance with adaptation policy in decision taking.
Working together	NO EVIDENCE	▪ The organisation is engaging with its supply chain and other core business partners to improve processes for adaptation. ▪ The organisation shares its understanding of impacts that require attention with external stakeholders who are closely involved. ▪ The organisation uses a stakeholder engagement process that goes beyond legal requirements in seeking external perspectives to improve adaptation strategies and decisions.
Learning	NOT IMPLEMENTED	▪ Structured process to identify deviations from adaptation expectations, investigate causes, take corrective action and update processes where appropriate. ▪ At the end of significant adaptation projects, processes are used to draw out the lessons learned and to direct that learning to improve future projects.
Managing operations	NOT IMPLEMENTED	▪ The organisation's adaptation goals are incorporated into its project management procedures. ▪ The organisation applies corrective action processes to its actions on climate adaptation. ▪ Adaptation issues are systematically addressed in procurement.
Programme scope & coherence	NO EVIDENCE	▪ As an RL3 programme on adaptation develops it will naturally begin to extend to cover suppliers and other close business partners.

5 UNCERTAINTIES and ASSUMPTIONS

5.1 Main uncertainties in the evidence, approach and method used in the adaptation programme and in the operation of South West Water

Because of the probabilistic nature of the UKCP09 data there will always be uncertainty and a range of possible outcomes. This will be translated into the way the risks are identified and dealt with. At the moment UKCP09 looks at the effect of climate change on a single year and does not provide any evidence on cumulative effects. This is of particular significance to us as the critical period for some of our impounding reservoirs is multi-seasonal. At the moment the projections do not allow us to fully consider these impacts. If more information were available on multi season droughts our assessment of the impact of climate change could vary.

Over the next 25 years the choice of which emissions scenario is used to determine our mitigation actions is not critical as the predicted effects of the different scenarios are broadly similar.

In order to try to limit the uncertainty we have chosen to use the medium scenario in our assessment. Knowing exactly how, where and when climate change will affect our assets against a background of a highly variable climate is difficult and inevitably entails a level of subjectivity and expert judgement which is open to challenge.

There are many factors that are outside of our control that will influence the outcome of any scheme designed for climate change adaptation.

Any scheme that is included in our business plan is subjected to a rigorous cost benefit analysis. This is based on our customer's priorities and their willingness to pay for the increased security of the service over the coming years and the risk and consequences of the problem being realised in the light of climate change. At the moment the full cost and benefit to our customers is difficult to predict and demonstrate so many schemes that could mitigate risks further are not seen as being cost beneficial. This could increase risks in coming years as some schemes, such as "Sewers for Sewage" will take a long time to implement.

5.2 Assumptions made when devising the programme for adaptation

We have made various assumptions around the data and analysis during this assessment. We have listed the key assumptions below:

- Climate change predictions continue to remain within the current error bands
- The medium scenario does not change significantly
- The existing periodic review process carries on in a similar manner
- There are no sudden changes in policy from any of our stakeholders eg an Environment Agency policy change on abstraction licensing
- European policy does not impact Water Available For Use

6 BARRIERS to ADAPTATION and INTERDEPENDENCIES

6.1 Barriers to implementing the adaptation programme

We believe that it is difficult to obtain from customers their willing to pay for the protection that will be required to secure the service we provide to them in light of the threat from climate change. As a result we may not be able to promote some schemes that mitigate climate change risk on the grounds of customer cost benefit.

There is also interdependency between our various regulators which requires co-ordination of action to ensure an integrated approach to solutions; this is not always easy to achieve.

Arnell and Charlton[13] have identified nine potential barriers to effective adaptation to potential climate change effects on water supply reliability. Of these nine potential barriers, five are generic and four are specific

6.1.1 Generic barriers

1 The identification of the need for adaptation. This is well-established in the water resources sector, with climate change being recognised as a potential future risk by Government, the regulators, water companies, local councils and the public.

2 The extent to which the need for adaptation can be specified in terms which inform adaptation decisions. This is a function of the climate scenarios and the ability to translate these scenarios into potential impacts on water supply and demand. In general terms this too is not a barrier to adaptation in the water sector as both scenarios of climate change and potential impacts on demand and supply have been modelled with methods and guidelines describing how these scenarios should be incorporated within strategic water resource assessments. A potential barrier in this area relates to the appropriate use of the new UKCP09 probabilistic projections of climate change but research is either on-going or planned to address this.

3 The identification of feasible adaptation options requires sector / institutional competences or preferences. Again, this is not generally a barrier in the water resources sector as many potential adaptation options have been identified by the Government, the regulators and the industry (see section 3 above).

4 The ability to evaluate potential options. This remains something of a barrier to adaptation as such evaluations would generally tend to be risk-based and use multiple scenarios (such as the UKCP09 projections). Methods are being developed to allow these scenarios to be incorporated in water resource planning that currently takes place every 5 years, looking 25 years ahead. Questions are

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[13] Arnell, N.W. and Charlton, M. 2009. *Adapting to the effects of climate change on water supply reliability.* In Adapting to Climate Change: Thresholds, Values, Governance, eds. W. Neil Adger, Irene Lorenzoni and Karen O'Brien. Cambridge University Press.

asked as to whether climate change introduces sufficient (long-term) uncertainty and that this Periodic Review should be extended beyond 25 years.

5 The ability to select and monitor a strategy. Water companies are yet to implement adaptation options, so mechanisms for monitoring such strategies have not been tested.

6.1.2 Specific barriers

1 Physical barriers to adaptation, constraining the performance of an adaptation option. Some such barriers have been identified in the water sector in terms of constraints posed by the conflicting pressures of water supply for domestic, agricultural and industrial use with supplying enough water for the environment. Another physical barrier could be the uncertainty as to whether a new resource scheme (eg reservoir) is sustainable in a changed future climate (for example, could the new reservoir be filled?).

2 Financial barriers refer not only to the absolute cost of an option, but also to the ability to raise funds to cover the costs. The costs of some of the supply-side measures are high and potentially prohibitive. The demand-side options tend to have lower unit costs. The Ofwat Change protocol for 2010-15 describes principles and outline procedures for companies to seek financial adjustments relating to changes to outcomes in the 2010-15 period. This includes “changes that may relate to emerging evidence on climate change impacts, for example in finalising Water Resource Management Plans”.

3 Socio-political barriers include the attitudes and reactions of stakeholders, affected parties and pressure groups to individual adaptation options. There is evidence of public resistance to development of new water supply options (from reservoirs to desalination). The planning process for major works can be very long, creating a barrier to adaptation. Demand-side measures tend to be easier to implement and more flexible, although there can be public resistance to change[14]. There are no real legislative barriers to adaptation, although legislation tends to specify the outcomes of measures rather than the means of achieving it, therefore providing no guidance on the adaptation strategy itself.

4 The characteristics of the individual organisation may affect its ability to implement a specific option, and the regulatory or market context may constrain specific choices. There is a lack of synchronisation and coordination of different policy instruments, for example a mismatch between the Periodic Review cycle and the Water Framework Directive cycle.

In addition to the nine barriers identified by Arnell and Charlton we believe that the following additional barriers also exist:

- Lack of a clear national priority for adaptation.
- Too much emphasis being placed on short-term cost-benefit analysis.

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[14] This has been noted in response to proposals to charge for surface water drainage.

- Too rigid an approach to the Water Framework Directive and daughter directives which could have long-term effects on our ability to protect the environment whilst providing an affordable service to our customers.

- Under S106 of the Water Industry Act a developer or private individual has the right to connect into any part of the public sewerage system without regard to any downstream implications. This was recently reinforced in a Supreme Court judgment (Barratt Homes v Welsh Water) where it was confirmed that a developer has the right to connect into a sewerage system at a point to be determined by the developer rather than the sewerage undertaker, regardless of any adverse impacts. As sewerage undertakers are not statutory consultees this judgement effectively gives control over points of connection into sewerage undertaker's assets to the local planning authority.

- Water and sewerage companies have little ability to influence the growth of impermeable areas resulting from urban creep. The increase in run-off from these areas will exacerbate the effects of climate change in areas of combined sewer systems.

- The UK and Welsh Governments have recently announced plans to transfer the ownership of private sewers in England and Wales to water and sewerage undertakers in October 2011 and privately owned sewage pumping stations by no later than March 2016 . We estimate that this will increase the length of sewer for which we are responsible by approximately 60%. The transferred sewers and pumping stations are unlikely to be constructed to the standards we would normally require and will pose a high risk of causing flooding and pollution.

- There is currently some lack of clarity with regard to responsibility for coastal defences. This is of concern to us as three quarters of our served population live near the coast or estuaries and this will lead to a need to increase maintenance of our coastal assets.

6.2 Addressing the barriers to the adaptation programme

A common approach to problems by not considering risks in isolation can help overcome some of the issues with Defra performing a leadership role and encouraging long term solutions to what are long term problems.

6.3 Interdependencies

We depend on the correct operation of infrastructure provided by the energy, chemical, transport and communication sectors. Without the full functionality of these sectors we would not be able to carry on with our business for very long. Adapting Energy, Transport, and Water Infrastructure to the Long-Term Impacts of Climate Change (2010), a report commissioned by Defra, explores these interdependencies.

The ramifications of changes in the international demand for essential chemicals as a result of climate change are not well understood but clearly could have an impact on us. Increased storage of strategic chemicals will help mitigate this risk.

Water & wastewater treatment and remote control systems are very energy intensive, especially as we have one of the highest pumping heads of all Water and Sewerage providers. This makes us very vulnerable should there be a problem with the energy supply to our sites. That is why we have invested in on-site generation at our critical sites and we have procurement agreements with suppliers of mobile generators. Although this helps mitigate the risk, it does not remove it, especially if the disruption to the service is likely to be long-term.

We also need a functioning transportation network, not only so that our staff can travel to and from sites for routine jobs or to attend breakdowns but also so that we can receive supplies and remove waste products from our sites.

We have taken part in a number of emergency planning exercises which help us to prepare for major service disruptions. This sort of activity also helps us to foster good working relationships with other emergency responders.

7 MONITORING and EVALUATION

7.1 Monitoring the outcome of the adaptation programme

The regulatory periodic review process that is managed by Ofwat on a five yearly basis allows us the opportunity to put forward a business plan that has been based on need and a positive cost benefit analysis. The serviceability outputs from the plan are agreed prior to the start of the asset management plan period, not only with Ofwat but also with other Regulators, and are monitored by auditors on a yearly basis through the June Return process. Failure to achieve the agreed outputs could result in financial penalties.

Over the last few years the level of instrumentation that we have installed at our sites which can send the information to a central control centre has increased enormously, especially on our clean water sites. Therefore we have a lot of data which allows us to examine trends, especially for raw water quality. We have used this information to promote some schemes for catchment management projects which we have called Upstream Thinking. This project aims at reducing pollution from diffuse sources such as farms and will be carried out in conjunction with other stakeholders such as the Environment Agency. The result of this programme should be that the raw water quality improves over time thus reducing the need for expensive and high input processes. We intend to continue monitoring the raw water quality to allow us to track long-term trends.

The Water Resources Plan has a major review every five years. Once it has been agreed progress is monitored through annual updates. These updates are audited to ensure that the trends and outputs that were originally agreed are being realised.

Through our MCERTS programme we are gathering flow information which is allowing us to investigate rainfall patterns and the statistical probability of any climate change effects on our waste water assets

The Water Framework Directive has established the need for River Basin Management Plans and for them to be reviewed on a six yearly cycle. These are prepared by the Environment Agency and should take into account the effects of climate change. The Environment Agency has produced the first set of plans which will be updated in 2015.

We will aim to review our climate change impact risk assessment process at the same time as we are developing our business plan for the next asset management period 2015 to 2020. As more information becomes available the level of confidence in our risk assessment will improve and allow us to articulate the impact of climate change more fully in our business plan.

7.2 How will the thresholds, above which climate change impacts will pose a risk to South West Water, be monitored and incorporated into future risk assessments?

As we currently have not identified any risks that score more then 4 until the 2050s we have not identified any thresholds above which we feel further action is required. As our understanding of the impact of climate change improves we will consider whether it is appropriate to introduce such thresholds.

7.3 Monitoring the residual risks of impacts from climate change on South West Water and stakeholders

We will continue to monitor the overall risk of a decrease or loss in the level of service to our customers through the periodic review process. This takes into account total risk which includes that due to climate change.

7.4 Ensuring that the management of climate change risks is firmly embedded in South West Water

It is our intention to ensure that the recommendations of the PACT assessment will be acted upon and that we will further embed climate change adaptation within South West Water. This will almost certainly require additional staff resources to be dedicated to climate change adaptation.

7.5 Enabling the management of climate change risks to be flexible

As the UKCP09 research has been derived from a statistical analysis of 30 years of weather data we consider that the five yearly periodic review process will provide us with an adequate opportunity to adapt our approach to any changes that may occur from a review or updating of the climate change probabilities.

7.6 Changes in the management of climate risks as a result of the production of this report

The production of this report has given us the opportunity of discussing these issues with a wide section of our business and it has provided a focus.

We intend to keep this report under review, probably at each periodic review so that any changes in the data or our understanding of the potential impact of climate change can be included in our business plan.

We will also examine the outputs of the PACT review and increase the extent to which climate change management is embedded within the organisation.

7.7 Cranfield[15] risk assessment evaluation cross reference

In table 9 below we provide cross references showing where we believe we are working towards the achievement of the sub-attributes. This is not a complete list and our interpretation may differ from what was originally intended.

Table 9: Cranfield risk assessment cross reference

Key Attribute 1

Climate change risk assessment is a clear component of corporate risk appraisal

Sub-attribute	Cross reference
1.1 Climate change demonstrably a key consideration in corporate planning and processes of the Reporting Authority	**1.2.3** Aims and Objectives **1.4.2** Regulators **1.6** Functions, missions, aims, and objectives which will be affected by the current and possible future impacts of climate change **Appendix D** Water Resource and Climate Change modelling
1.2 Reporting Authority presents a clear analysis of climate risks on business operations for specified periods into the future and includes high priority climate related risks and timescales	**1.6** Functions, missions, aims, and objectives which will be affected by the current and possible future impacts of climate change **1.7** Assessment of climate thresholds above which climate change and weather events will pose a threat to South West Water **2.1** Evidence, methods and expertise used to evaluate future climate **2.2.1** Risk quantification **Appendix A** Matrix of South West Water's risks from Climate Change
1.3 Adaptation plan is clearly embedded in the core of the Reporting Authority's business	**1.2.3** Aims and Objectives **2.1** Evidence, methods and expertise used to evaluate future climate **4.5** Embedding the management of climate change risks in South West Water **7.4** Ensuring that the management of climate change risks is firmly embedded in South West Water
1.4 Reporting Authority includes some prior evaluation of how its climate change risks impact upon or are affected by stakeholders	**1.4.1** Key Stakeholders **1.4.2** Regulators **1.5.1** Historic changes in climate in the South West **1.6** Functions, missions, aims, and objectives which will be affected by the current and possible future impacts of climate change **2.1** Evidence, methods and expertise used to evaluate future climate **3.1** Likelihood/consequence matrix of South West Water's strategic risks from climate change **Appendix D** Water Resource and Climate Change modelling
1.5 Reporting Authority considers the existing policies and procedures related to climate impacts, and the effect the weather has on operations and the achievement of the organisation's strategic objectives.	**1.5.1** Historic changes in climate in the South West **2.1** Evidence, methods and expertise used to evaluate future climate **Appendix D** Water Resource and Climate Change modelling

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[15] Evaluating the risk assessments of Reporting Authorities under the Climate Change Act 2008 – August 2010

Key attribute 2

Climate change risk assessment enables the Reporting Authority to make evidence based decisions on adapting to climate change

Sub-attribute	Cross reference
2.1 Reporting Authority adopts a conceptual risk management framework for organisational, rather that locational risk	**1.3.5** Water Supply System **2.1** Evidence, methods and expertise used to evaluate future climate **2.2** Quantification, estimation and characterisation of the impact and likelihood of risks occurring at various points in the future **Appendix A** Matrix of South West Water's risks from Climate Change **Appendix D** Water Resource and Climate Change modelling
2.2 Reporting Authority identifies the key climate variables and their potential impact on the organisation	**1.5.1** Historic changes in climate in the South West **1.5.2** Projected climate change in the South West **Appendix C** Climate change projections for the South West Water region
2.3 Reporting Authority provides clear criteria for likelihood and consequence that are appropriate and specific to their organisation	**2.2** Quantification, estimation and characterisation of the impact and likelihood of risks occurring at various points in the future **Appendix A** Matrix of South West Water's risks from Climate Change
2.4 Reporting Authority's risk assessment quantifies, or otherwise estimates or characterises the impact and likelihood of risks occurring at various points in the future	**2.2** Quantification, estimation and characterisation of the impact and likelihood of risks occurring at various points in the future **3.1** Likelihood/consequence matrix of South West Water's strategic risks from climate change **3.2** High priority climate related risks **Appendix A** Matrix of South West Water's risks from Climate Change **Appendix C** Climate change projections for the South West Water region
2.5 Reporting Authority presents all the organisation's strategic risks from climate change on a likelihood/consequence matrix, where possible including the climate thresholds above which climate change poses a threat to the organisation. Where it is not possible, The Reporting Authority should set out how it will investigate thresholds	**1.7** Assessment of climate thresholds above which climate change and weather events will pose a threat to South West Water **3.1** Likelihood/consequence matrix of South West Water's strategic risks from climate change **3.2** High priority climate related risks **Appendix A** Matrix of South West Water's risks from Climate Change
2.6 Reporting Authority considers short, medium and long term risks of climate change disaggregation into different locations where appropriate, and includes an assessment of the level of confidence in these calculations	**3.1** Likelihood/consequence matrix of South West Water's strategic risks from climate change **3.2** High priority climate related risks **4.1** Adaptation actions for the top priority risks **Appendix A** Matrix of South West Water's risks from Climate Change **Appendix D** Water Resource and Climate Change modelling

Key Attribute 3

Demonstrable use of relevant and appropriate data, information, knowledge, tools and methodologies.

Sub-attribute	Cross reference
3.1 Reporting Authority adopts the latest set of UK Climate Projections (currently UKCP09) or other appropriate scenarios or climate information	**1.5.2** Projected climate change in the South West **2.1** Evidence, methods and expertise used to evaluate future climate **4.1** Adaptation actions for the top priority risks **Appendix B** Summary of UKWIR Climate Change adaptation research since 1997 **Appendix C** Climate change projections for the South West Water region
3.2 Reporting Authority demonstrably assesses using the best evidence suitable to organisational needs	**1.5.2** Projected climate change in the South West **2.1** Evidence, methods and expertise used to evaluate future climate **4.1** Adaptation actions for the top priority risks **4.3** Cost and benefits of adaptation measures **Appendix B** Summary of UKWIR Climate Change adaptation research since 1997 **Appendix C** Climate change projections for the South West

	Water region **Appendix D** Water Resource and Climate Change modelling
3.3 Reporting Authority's risk assessment includes consultation with interested parties or stakeholders	**1.4.1** Key Stakeholders **1.4.2** Regulators **2.1** Evidence, methods and expertise used to evaluate future climate **4.1** Adaptation actions for the top priority risks **Appendix D** Water Resource and Climate Change modelling **Appendix E** Flood resilience and climate change: Water and sewerage services

Key attribute 4

Climate change risk assessment and adaptation measures explicitly consider uncertainties

Sub-attribute	Cross reference
4.1 Reporting Authority's risk assessment includes a statement of the main uncertainties in the evidence, approach and method used in the adaptation plan and in the operation of the organisation	**4.2** Implementation of adaptation action **5.1** Main uncertainties in the evidence, approach and method used in the adaptation programme and in the operation of South West Water **6.1** Barriers to implementing the adaptation programme **6.2** Addressing the barriers to the adaptation programme
4.2 Reporting Authority's adaptation responses explicitly account for uncertainties and interdependencies of actions, including the actions of others on the adaptation plan	**5 Uncertainties and assumptions** **6.1** Barriers to implementing the adaptation programme **6.2** Addressing the barriers to the adaptation programme **6.3** Interdependencies
4.3 Reporting Authority's adaptation plan includes a clear statement of the assumptions which are well evidenced and justified	**5.2** Assumptions made when devising the programme for adaptation **Appendix D** Water Resource and Climate Change modelling

Key attribute 5

Climate change risk assessment generates priorities for action

Sub-attribute	Cross reference
5.1 Reporting Authority provides priority areas for action that are demonstrably linked to the development of a risk based adaptation plan	**4.2** Implementation of adaptation action **Appendix E** Flood resilience and climate change: Water and sewerage services
5.2 Reporting Authority's adaptation plan includes a detailed action plan covering its priority areas. This should ideally include timescales, resources and responsibilities and should be included in the report.	**4.2** Implementation of adaptation action **4.4** Reduction in risk as a result of adaptation measures
5.3 Reporting Authority's risk management actions are targeted to demonstrably reduce risk to be defined (by the organisation) level of residual risk.	**4.4** Reduction in risk as a result of adaptation measures **Appendix A** Matrix of South West Water's risks from Climate Change
5.4 Reporting Authority's adaptation plan is subject to appraisal against sustainability principles, and specifically to an appraisal of costs and benefits	**4.3** Cost and benefits of adaptation measures **6.1** Barriers to implementing the adaptation programme **6.2** Addressing the barriers to the adaptation programme **Appendix E** Flood resilience and climate change: Water and sewerage services

Key attribute 6

Climate change risk assessment identifies opportunities (where applicable)

Sub-attribute	Cross reference
6.1 Reporting Authority's risk assessment allows an evaluation of net benefits and/or opportunities arising from the impacts of climate change	**3.3** Opportunities presented by climate change

Key attribute 7

Clear demonstration of flexible adaptation measures

Sub-attribute	Cross reference
7.1 Reporting Authority's adaptation plan includes strategies to deal with the level of quantified risk and retains flexibility over which future course of action to follow as knowledge improves and projections change	**3.1** Likelihood/consequence matrix of South West Water's strategic risks from climate change **3.2** High priority climate related risks **4.1** Adaptation actions for the top priority risks **7.5** Enabling the management of climate change risks to be flexible
7.2 Reporting Authority's adaptation plan includes a statement of the barriers to implementation and a means of overcoming these	**6.1** Barriers to implementing the adaptation programme **6.2** Addressing the barriers to the adaptation programme **7.5** Enabling the management of climate change risks to be flexible

Key attribute 8

Monitoring and evaluation of adaptation effectiveness

Sub-attribute	Cross reference
8.1 Where possible, the Reporting Authority's report shows progress already made against its adaptation plan	**7.1** Monitoring the outcome of the adaptation programme **Appendix E** Flood resilience and climate change: Water and sewerage services
8.2 Reporting Authority makes clear provision for the evaluation of the effectiveness and viability of its adaptation plan	**7.1** Monitoring the outcome of the adaptation programme **Appendix E** Flood resilience and climate change: Water and sewerage services
8.3 Reporting Authority makes clear provision for monitoring thresholds, above which climate change impacts will pose a risk to the organisation, and their incorporation into future risk assessments	**7.2** How will the thresholds, above which climate change impacts will pose a risk for South West Water, be monitored and incorporated into future risk assessments?
8.4 Reporting Authority makes clear provision for the monitoring of the residual risk from climate change on the organisation and its stakeholders	**7.3** Monitoring the residual risks of impacts from climate change on South West Water and its stakeholders
8.5 Reporting Authority offers evidence that the production of the risk assessment and adaptation plan has led to a change in the organisation's management of climate risks	**7.4** Ensuring that the management of climate change risks is firmly embedded in South West Water **7.6** Changes in the management of climate change risks as a result of the production of this report

APPENDIX A: **Matrix of South West Water’s risks from climate change**

Asset Level 2: Water resources

2020

Level of consequence

1 - **Low impact** resulting in possible intermittent impact on service to customers or damage to assets requiring some repair or maintenance

2 - **Medium impact** causing minor loss of service to some customers or damage to assets (e.g. hosepipe ban, flooding of assets) requiring significant maintenance or replacement work and a review of investment priorities

3 - **High impact** causing major loss of service to customers, significant health & safety issues or damage to assets (e.g. treatment works unable to function, flooding or several hundred properties)

Level of likelihood

1 - **Unlikely** the consequence for service will occur in the 2050s

2 - **Fairly** likely the consequence for service will occur in the 2050s

3 - **Very likely** the consequence for service will occur in the 2050s

2020s

ASSET LEVEL 3	CLIMATE VARIABLE	MHW IMPACT REF.	DESCRIPTION	PRIMARY IMPACT OF CLIMATE VARIABLE	POTENTIAL IMPACTS ON ORGANISATION AND STAKEHOLDERS	Consequence for service			COMPANY'S ADAPTIVE ACTIONS	Company's residual risk			COMPANY'S PROPOSED ACTION TO MITIGATE RESIDUAL IMPACTS
						Level of consequence	Level of likelihood	Level of risk		Level of consequence	Level of likelihood	Level of risk	
All Water Resources	DROUGHT	D1	Reduced available supply causes political pressure for essential water users, e.g. schools and hospitals, and for other customers reduces security of supply	Reduced available supply	Reduced security of supply	2	2	4		2	2	4	

All Water Resources	DROUGHT	D2	Daily & peak demand for 'garden' watering increases, causing a reduction in security of supply	Higher daily & peak demand for garden watering,	Reduced security of supply	2	2	4	Water resource plan includes a CC factor	2	1	2	Continue monitoring and using WR plan
All Water Resources	DROUGHT	D3	Intake, borehole pump and reservoir draw-off levels do not match reduced levels causing service failure	Intake, borehole pump and reservoir draw-off levels do not match reduced levels	Service failure	3	1	3	Water resource plan includes a CC factor	3	1	3	Continue monitoring and using WR plan, consider engineering solution to move draw offs
All Water Resources	DROUGHT	D4	Lower river yields, borehole yields or reduced water quality lead to abstraction licences being reduced or removed, causing a reduction in security of supply	Lower river & borehole yields or reduced water quality	Abstraction licences reduced or removed, reducing security of supply	2	2	4	Water resource plan includes a CC factor	2	1	2	Continue monitoring and using WR plan
All Water Resources	DROUGHT	D5	Increased customer sensitivity to possibility of service failure impacts security of supply.	Drier conditions	Reduced security of supply	2	2	4	Water resource plan includes a CC factor	2	1	2	Continue monitoring and using WR plan
Storage Reservoirs & Aqueducts	DROUGHT	D6	Lower river flows reduce yields and hence increased demand on existing storage, and causes a reduction in security of supply	Lower river flows	Reduced security of supply	2	2	4	Water resource plan includes a CC factor	2	1	2	Continue monitoring and using WR plan
Boreholes / source pumping stations	DROUGHT	D7	Lower groundwater levels reduce borehole yields and causes a reduction in security of supply	Lower groundwater levels	Reduced security of supply	2	1	2	Water resource plan includes a CC factor	2	1	2	Continue monitoring and using WR plan
Raw water pipelines	DROUGHT	D8	Lower flow rates cause deposition leading to reduced raw water quality	Lower flow rates	Reduced raw water quality	2	1	2	WTW process will cope with increased solids level	2	1	2	monitor raw water quality on entry to works
Intake Pumping stations	DROUGHT	D9	River levels fall and they become less reliable sources, reducing security of supply	River levels fall	Reduced security of supply	2	2	4	Water resource plan includes a CC factor	2	1	2	Continue monitoring and using WR plan
All Water Resources	FLOOD	F1	Direct asset flooding causes service failure and asset loss	Direct asset flooding	Asset loss and service failure	3	2	6	Vulnerability reviewed at PR09	3	1	3	Review change in vulnerability at future PR consider improving flood defences
Intake Pumping stations	FLOOD	F10	Greater volumes of storm water cause increased pumping where pumps are part of the infrastructure, leading to increased asset usage and accelerated asset deterioration	More storm water	Increased asset useage and accelerated asset deterioration	1	1	1		1	1	1	
All Water Resources	FLOOD	F2	Increased storm frequency and power supply flooding increases frequency of power loss, causing service failure	More frequent storms and power supply flooding	Power outages and service failure	3	2	6	Standby generation at critical assets already provides adequate level of cover	3	1	3	Possibly investigate provision of lightning protection

All Water Resources	FLOOD	F3	Flooding in certain areas causes redistribution of permanent population (eg away from flood plains) and tourism, which affects demand and impacts on security of supply	Movement of permanent population (e.g. away from flood plains) and tourism due to flooding,	Impacts on security of supply	3	2	6	Existing Monitoring and forecasting of parish population will provide information on migration	3	1	3	continue monitoring parish population liaise with West Country tourism
All Water Resources	FLOOD	F4	The threat of treatment works being flooded (with subsequent service loss) increases customer expectations for visible hard engineering adaptation solutions	The threat of assets being flooded	Increased customer expectations for visible hard engineering adaptation solutions	1	1	1		1	1	1	
Storage Reservoirs & Aqueducts	FLOOD	F5	Increased soil erosion causes the siltation of dams, causing accelerated asset deterioration and asset loss	Increased soil erosion	Accelerated asset deterioration and loss	1	1	1		1	1	1	
Storage Reservoirs & Aqueducts	FLOOD	F6	More intense rainfall events & changes to soil conditions lead to the slippage of soil dams, causing service failure, customer flooding and asset loss	More intense rainfall events & changes to soil conditions	Service failure, customer flooding and asset loss	3	2	6	Regular monitoring of dam condition by qualified dam engineer and through inspecting and supervising engineers visits	3	1	3	Ensure effects of climate change are incorporated into calculations, consider reinforcing structures
Storage Reservoirs & Aqueducts	FLOOD	F7	More intense rainfall events exceed capacity of spillways to deal with increased storm intensity, causing service failure, customer flooding and asset loss	More intense rainfall events	Service failure, customer flooding and asset loss	3	2	6	Regular monitoring of dam condition by qualified dam engineer and through inspecting and supervising engineers visits	3	1	3	Ensure effects of climate change are incorporated into calculations consider altering spillway structure
Boreholes / source pumping stations	FLOOD	F8	More intense rainfall events compact upper soil layers, increasing run-off, reducing recharge of aquifers and reducing security of supply	More intense rainfall compacting upper soil layers	Reduced security of supply	2	2	4	Regular monitoring of borehole levels and recharge rates built into Water resource plan	2	1	2	Ensure effects of climate change are incorporated into calculations
Raw water pipelines	FLOOD	F9	Flood water infiltration into pipelines increases drinking water quality risk	Flooding	Increased drinking water quality risk	2	2	4	On line raw water quality monitoring.	2	1	2	Continue with monitoring
All Water Resources	SEA LEVEL	S1	Direct asset flooding, storm damage and coastal erosion or 'planned retreat' cause service failure and asset loss	Direct asset flooding, storm damage, coastal erosion or planned retreat	Service failure and asset loss	1	1	1		1	1	1	
All Water Resources	SEA LEVEL	S2	Saline intrusion degrades infrastructure, causing accelerated asset deterioration	Saline intrusion	Accelerated asset deterioration	1	1	1		1	1	1	
All Water Resources	SEA LEVEL	S3	Flooding in certain areas causes redistribution of permanent population and tourism (e.g. away from flood plains), which affects demand and impacts on security of supply	Movement of permanent population (e.g. away from flood plains) and tourism due to flooding	Impacts on security of supply	1	1	1		1	1	1	

Boreholes / source pumping stations	SEA LEVEL	S4	Saline intrusion decreases yield, causing a service loss and reduction in security of supply	Saline intrusion	Service failure and reduction in security of supply	2	1	2	Water resource plan includes a CC factor for sea level. Monitoring is taking place	2	1	2	continue to update for CC factor
Intake Pumping stations	SEA LEVEL	S5	Tidal limits move upstream and lead to greater salinity at intakes, causing raw water resource loss and reduction in security of supply	Tidal limits moving upstream and increasing salinity at intakes	Reduced security of supply	1	1	1		1	1	1	
All Water Resources	TEMP. RISE	T1	Higher average and peak temperatures affect structures, buildings, H & V, MEICA plant working life, causing accelerated asset deterioration	Higher average and peak temperatures	Accelerated asset deterioration	1	1	1		1	1	1	
All Water Resources	TEMP. RISE	T2	Redistribution of / increase in tourism increases seasonal demand and causes a reduction in security of supply	Redistribution of / increase in tourism	Reduced security of supply	2	2	4	Water Resource model takes resident population, seasonal variation and CC variation into consideration	2	1	2	Continue to update WR model with latest information and liaise with West Country Tourism
All Water Resources	TEMP. RISE	T3	Daily and peak domestic and commercial demand increases, causing a reduction in security of supply	Higher daily and peak domestic and commercial demand	Reduced security of supply	1	1	1		1	1	1	
All Water Resources	TEMP. RISE	T4	Higher temperatures and longer growing season causes redistribution of / increase in agricultural demand and impacts on security of supply	Higher temperatures and longer growing season	Impacts on security of supply	1	1	1		1	1	1	
All Water Resources	TEMP. RISE	T5	Redistribution of permanent population in response to temperature rise affects demand and impacts on security of supply	Redistribution of permanent population with warmer conditions	Impacts on security of supply	1	1	1		1	1	1	
All Water Resources	TEMP. RISE	T6	Increased customer sensitivity impacts security of supply	Higher temperatures	Impacts on security of supply	2	1	2	Cost benefit analysis carried out at Periodic review time will give customer priorities	1	1	1	Continue with CBA at PR
Storage Reservoirs & Aqueducts	TEMP. RISE	T7	Increased evaporation and evapotranspiration reduce yields, causing a reduction in security of supply	Increased evaporation and evapotranspiration	Reduced security of supply	1	1	1		1	1	1	
Storage Reservoirs & Aqueducts	TEMP. RISE	T8	Increased evaporation and evapotranspiration reduces yield of surface reservoirs and increases demand on groundwater recharge, causing a reduction in security of supply	Increased evaporation and evapotranspiration	Reduced security of supply	1	1	1		1	1	1	

Boreholes / source pumping stations	TEMP. RISE	T9	Increased evaporation and evapotranspiration reduce infiltration, and so borehole yields, causing a reduction in security of supply	Increased evaporation and evapotranspiration	Reduced security of supply	1	1	1		1	1	1	

Asset Level 2: Water resources

2050

1 - **Low impact** resulting in possible intermittent impact on service to customers or damage to assets requiring some repair or maintenance

2 - **Medium impact** causing minor loss of service to some customers or damage to assets (e.g. hosepipe ban, flooding of assets) requiring significant maintenance or replacement work and a review of investment priorities

3 - **High impact** causing major loss of service to customers, significant health & safety issues or damage to assets (e.g. treatment works unable to function, flooding or several hundred properties)

Level of likelihood

1 - **Unlikely** the consequence for service will occur in the 2050s

2 - **Fairly** likely the consequence for service will occur in the 2050s

3 - **Very likely** the consequence for service will occur in the 2050s

2050s

ASSET LEVEL 3	CLIMATE VARIABLE	MHW IMPACT REF.	DESCRIPTION	PRIMARY IMPACT OF CLIMATE VARIABLE	POTENTIAL IMPACTS ON ORGANISATION AND STAKEHOLDERS	Consequence for service			COMPANY'S ADAPTIVE ACTIONS	Company's residual risk			COMPANY'S PROPOSED ACTION TO MITIGATE RESIDUAL IMPACTS
						Level of consequence	Level of likelihood	Level of risk		Level of consequence	Level of likelihood	Level of risk	
All Water Resources	DROUGHT	D1	Reduced available supply causes political pressure for essential water users, e.g. schools and hospitals, and for other customers reduces security of supply	Reduced available supply	Reduced security of supply	2	2	4		2	2	4	
All Water Resources	DROUGHT	D2	Daily & peak demand for 'garden' watering increases, causing a reduction in security of supply	Higher daily & peak demand for garden watering,	Reduced security of supply	2	3	6	Water resource plan includes a CC factor	2	2	4	Continue monitoring and using WR plan review tariff banding
All Water Resources	DROUGHT	D3	Intake, borehole pump and reservoir draw-off levels do not match reduced levels causing service failure	Intake, borehole pump and reservoir draw-off levels do not match reduced levels	Service failure	3	1	3	Water resource plan includes a CC factor	3	1	3	Continue monitoring and using WR plan, consider engineering solution to move draw offs
All Water Resources	DROUGHT	D4	Lower river yields, borehole yields or reduced water quality lead to abstraction licences being reduced or removed, causing a reduction in security of supply	Lower river & borehole yields or reduced water quality	Abstraction licences reduced or removed, reducing security of supply	2	3	6	Water resource plan includes a CC	2	2	4	Continue monitoring and using WR plan
All Water Resources	DROUGHT	D5	Increased customer sensitivity to possibility of service failure impacts security of supply.	Drier conditions	Reduced security of supply	2	3	6	Water resource plan includes a CC factor	2	2	4	Continue monitoring and using WR plan

Storage Reservoirs & Aqueducts	DROUGHT	D6	Lower river flows reduce yields and hence increased demand on existing storage, and causes a reduction in security of supply	Lower river flows	Reduced security of supply	2	3	6	Water resource plan includes a CC factor	2	2	4	Continue monitoring and using WR plan
Boreholes / source pumping stations	DROUGHT	D7	Lower groundwater levels reduce borehole yields and causes a reduction in security of supply	Lower groundwater levels	Reduced security of supply	2	2	4	Water resource plan includes a CC factor	2	1	2	Continue monitoring and using WR plan
Raw water pipelines	DROUGHT	D8	Lower flow rates cause deposition leading to reduced raw water quality	Lower flow rates	Reduced raw water quality	2	2	4	WTW process will cope with increased solids level Update technical standard to cater for this eventuality	2	1	2	monitor raw water quality on entry to works
Intake Pumping stations	DROUGHT	D9	River levels fall and they become less reliable sources, reducing security of supply	River levels fall	Reduced security of supply	2	3	6	Water resource plan includes a CC factor	2	2	4	Continue monitoring and using WR plan
All Water Resources	FLOOD	F1	Direct asset flooding causes service failure and asset loss	Direct asset flooding	Asset loss and service failure	3	3	9	Vulnerability reviewed at PR09	3	2	6	Review change in vulnerability at future PR consider improving flood defences
Intake Pumping stations	FLOOD	F10	Greater volumes of storm water cause increased pumping where pumps are part of the infrastructure, leading to increased asset usage and accelerated asset deterioration	More storm water	Increased asset usage and accelerated asset deterioration	1	1	1		1	1	1	
All Water Resources	FLOOD	F2	Increased storm frequency and power supply flooding increases frequency of power loss, causing service failure	More frequent storms and power supply flooding	Power outages and service failure	3	3	9	Standby generation at critical assets already provides adequate level of cover. Review technical standard for lightning protection	1	3	3	Possibly investigate provision of lightning protection
All Water Resources	FLOOD	F3	Flooding in certain areas causes redistribution of permanent population (e.g. away from flood plains) and tourism, which affects demand and impacts on security of supply	Movement of permanent population (e.g. away from flood plains) and tourism due to flooding,	Impacts on security of supply	3	2	6	Existing Monitoring and forecasting of parish population will provide information on migration	3	1	3	continue monitoring parish population liaise with West Country tourism
All Water Resources	FLOOD	F4	The threat of treatment works being flooded (with subsequent service loss) increases customer expectations for visible hard engineering adaptation solutions	The threat of assets being flooded	Increased customer expectations for visible hard engineering adaptation solutions	1	1	1		1	1	1	
Storage Reservoirs & Aqueducts	FLOOD	F5	Increased soil erosion causes the siltation of dams, causing accelerated asset deterioration and asset loss	Increased soil erosion	Accelerated asset deterioration and loss	1	1	1		1	1	1	
Storage Reservoirs & Aqueducts	FLOOD	F6	More intense rainfall events & changes to soil conditions lead to the slippage of soil dams, causing service failure, customer flooding and asset loss	More intense rainfall events & changes to soil conditions	Service failure, customer flooding and asset loss	3	2	6	Regular monitoring of dam condition by qualified dam engineer and through inspecting and supervising engineers visits	3	1	3	Ensure effects of climate change are incorporated into calculations, consider reinforcing structures

Storage Reservoirs & Aqueducts	FLOOD	F7	More intense rainfall events exceed capacity of spillways to deal with increased storm intensity, causing service failure, customer flooding and asset loss	More intense rainfall events	Service failure, customer flooding and asset loss	3	2	6	Regular monitoring of dam condition by qualified dam engineer and through inspecting and supervising engineers visits	3	1	3	Ensure effects of climate change are incorporated into calculations consider altering spillway structure
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Raw water pipelines	FLOOD	F9	Flood water infiltration into pipelines increases drinking water quality risk	Flooding	Increased drinking water quality risk	2	2	4	On line raw water quality monitoring.	2	1	2	Continue with monitoring
All Water Resources	SEA LEVEL	S1	Direct asset flooding, storm damage and coastal erosion or 'planned retreat' cause service failure and asset loss	Direct asset flooding, storm damage, coastal erosion or planned retreat	Service failure and asset loss	1	1	1		1	1	1	
All Water Resources	SEA LEVEL	S2	Saline intrusion degrades infrastructure, causing accelerated asset deterioration	Saline intrusion	Accelerated asset deterioration	1	1	1		1	1	1	
All Water Resources	SEA LEVEL	S3	Flooding in certain areas causes redistribution of permanent population and tourism (e.g. away from flood plains), which affects demand and impacts on security of supply	Movement of permanent population (e.g. away from flood plains) and tourism due to flooding	Impacts on security of supply	1	1	1		1	1	1	
Boreholes / source pumping stations	SEA LEVEL	S4	Saline intrusion decreases yield, causing a service loss and reduction in security of supply	Saline intrusion	Service failure and reduction in security of supply	2	1	2	Water resource plan includes a CC factor for sea level. Monitoring is taking place	2	1	2	continue to update for CC factor
Intake Pumping stations	SEA LEVEL	S5	Tidal limits move upstream and lead to greater salinity at intakes, causing raw water resource loss and reduction in security of supply	Tidal limits moving upstream and increasing salinity at intakes	Reduced security of supply	1	2	2	Periodic Review process will identify assets concerned	1	1	1	
All Water Resources	TEMP. RISE	T1	Higher average and peak temperatures affect structures, buildings, H & V, MEICA plant working life, causing accelerated asset deterioration	Higher average and peak temperatures	Accelerated asset deterioration	1	1	1		1	1	1	
All Water Resources	TEMP. RISE	T2	Redistribution of / increase in tourism increases seasonal demand and causes a reduction in security of supply	Redistribution of / increase in tourism	Reduced security of supply	2	3	6	Water Resource model takes resident population, seasonal variation and CC variation into consideration	2	1	2	Continue to update WR model with latest information and liaise with West Country Tourism
All Water Resources	TEMP. RISE	T3	Daily and peak domestic and commercial demand increases, causing a reduction in security of supply	Higher daily and peak domestic and commercial demand	Reduced security of supply	1	2	2		1	1	1	
All Water Resources	TEMP. RISE	T4	Higher temperatures and longer growing season causes redistribution of / increase in agricultural demand and impacts on security of supply	Higher temperatures and longer growing season	Impacts on security of supply	1	2	2		1	1	1	

All Water Resources	TEMP. RISE	T5	Redistribution of permanent population in response to temperature rise affects demand and impacts on security of supply	Redistribution of permanent population with warmer conditions	Impacts on security of supply	1	1	1		1	1	1	
All Water Resources	TEMP. RISE	T6	Increased customer sensitivity impacts security of supply	Higher temperatures	Impacts on security of supply	1	2	2	Cost benefit analysis carried out at Periodic review time will give customer priorities	1	1	1	Continue with CBA at PR
Storage Reservoirs & Aqueducts	TEMP. RISE	T7	Increased evaporation and evapotranspiration reduce yields, causing a reduction in security of supply	Increased evaporation and evapotranspiration	Reduced security of supply	1	1	1		1	1	1	
Storage Reservoirs & Aqueducts	TEMP. RISE	T8	Increased evaporation and evapotranspiration reduces yield of surface reservoirs and increases demand on groundwater recharge, causing a reduction in security of supply	Increased evaporation and evapotranspiration	Reduced security of supply	1	1	1		1	1	1	
Boreholes / source pumping stations	TEMP. RISE	T9	Increased evaporation and evapotranspiration reduce infiltration, and so borehole yields, causing a reduction in security of supply	Increased evaporation and evapotranspiration	Reduced security of supply	1	1	1		1	1	1	

Asset Level 2: Water resources

2080

Level of consequence

1 - **Low impact** resulting in possible intermittent impact on service to customers or damage to assets requiring some repair or maintenance

2 - **Medium impact** causing minor loss of service to some customers or damage to assets (e.g. hosepipe ban, flooding of assets) requiring significant maintenance or replacement work and a review of investment priorities

3 - **High impact** causing major loss of service to customers, significant health & safety issues or damage to assets (e.g. treatment works unable to function, flooding or several hundred properties)

Level of likelihood

1 - **Unlikely** the consequence for service will occur in the 2080s

2 - **Fairly** likely the consequence for service will occur in the 2080s

3 - **Very likely** the consequence for service will occur in the 2080s

2080s

ASSET LEVEL 3	CLIMATE VARIABLE	MHW IMPACT REF.	DESCRIPTION	PRIMARY IMPACT OF CLIMATE VARIABLE	POTENTIAL IMPACTS ON ORGANISATION AND STAKEHOLDERS	Consequence for service			COMPANY'S ADAPTIVE ACTIONS	Company's residual risk			COMPANY'S PROPOSED ACTION TO MITIGATE RESIDUAL IMPACTS
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Storage Reservoirs & Aqueducts	FLOOD	F5	Increased soil erosion causes the siltation of dams, causing accelerated asset deterioration and asset loss	Increased soil erosion	Accelerated asset deterioration and loss	1	1	1		1	1	1	

Storage Reservoirs & Aqueducts	FLOOD	F6	More intense rainfall events & changes to soil conditions lead to the slippage of soil dams, causing service failure, customer flooding and asset loss	More intense rainfall events & changes to soil conditions	Service failure, customer flooding and asset loss	3	2	6	Regular monitoring of dam condition by qualified dam engineer and through inspecting and supervising engineers visits	3	1	3	Ensure effects of climate change are incorporated into calculations, consider reinforcing structures
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All Water Resources	SEA LEVEL	S3	Flooding in certain areas causes redistribution of permanent population and tourism (e.g. away from flood plains), which affects demand and impacts on security of supply	Movement of permanent population (e.g. away from flood plains) and tourism due to flooding	Impacts on security of supply	1	1	1		1	1	1	
Boreholes / source pumping stations	SEA LEVEL	S4	Saline intrusion decreases yield, causing a service loss and reduction in security of supply	Saline intrusion	Service failure and reduction in security of supply	2	1	2	Water resource plan includes a CC factor for sea level. Monitoring is taking place	2	1	2	Continue to update for CC factor
Intake Pumping stations	SEA LEVEL	S5	Tidal limits move upstream and lead to greater salinity at intakes, causing raw water resource loss and reduction in security of supply	Tidal limits moving upstream and increasing salinity at intakes	Reduced security of supply	1	2	2	Periodic Review process will identify assets concerned	1	1	1	
All Water Resources	TEMP. RISE	T1	Higher average and peak temperatures affect structures, buildings, H & V, MEICA plant working life, causing accelerated asset deterioration	Higher average and peak temperatures	Accelerated asset deterioration	1	1	1		1	1	1	
All Water Resources	TEMP. RISE	T2	Redistribution of / increase in tourism increases seasonal demand and causes a reduction in security of supply	Redistribution of / increase in tourism	Reduced security of supply	2	3	6	Water Resource model takes resident population, seasonal variation and CC variation into consideration	2	1	2	Continue to update WR model with latest information and liaise with West Country Tourism

All Water Resources	TEMP. RISE	T3	Daily and peak domestic and commercial demand increases, causing a reduction in security of supply	Higher daily and peak domestic and commercial demand	Reduced security of supply	1	2	2		1	1	1	
All Water Resources	TEMP. RISE	T4	Higher temperatures and longer growing season causes redistribution of / increase in agricultural demand and impacts on security of supply	Higher temperatures and longer growing season	Impacts on security of supply	1	2	2		1	1	1	
All Water Resources	TEMP. RISE	T5	Redistribution of permanent population in response to temperature rise affects demand and impacts on security of supply	Redistribution of permanent population with warmer conditions	Impacts on security of supply	1	1	1		1	1	1	
All Water Resources	TEMP. RISE	T6	Increased customer sensitivity impacts security of supply	Higher temperatures	Impacts on security of supply	1	2	2	Cost benefit analysis carried out at Periodic review time will give customer priorities	1	1	1	Continue with CBA at PR
Storage Reservoirs & Aqueducts	TEMP. RISE	T7	Increased evaporation and evapotranspiration reduce yields, causing a reduction in security of supply	Increased evaporation and evapotranspiration	Reduced security of supply	1	1	1		1	1	1	
Storage Reservoirs & Aqueducts	TEMP. RISE	T8	Increased evaporation and evapotranspiration reduces yield of surface reservoirs and increases demand on groundwater recharge, causing a reduction in security of supply	Increased evaporation and evapotranspiration	Reduced security of supply	1	1	1		1	1	1	
Boreholes / source pumping stations	TEMP. RISE	T9	Increased evaporation and evapotranspiration reduce infiltration, and so borehole yields, causing a reduction in security of supply	Increased evaporation and evapotranspiration	Reduced security of supply	1	1	1		1	1	1	

Asset Level 2: Water Treatment Works

2020

Level of consequence

1 - **Low impact** resulting in possible intermittent impact on service to customers or damage to assets requiring some repair or maintenance

2 - **Medium impact** causing minor loss of service to some customers or damage to assets (e.g. hosepipe ban, flooding of assets) requiring significant maintenance or replacement work and a review of investment priorities

3 - **High impact** causing major loss of service to customers, significant health & safety issues or damage to assets (e.g. treatment works unable to function, flooding or several hundred properties)

Level of likelihood

1 - **Unlikely** the consequence for service will occur in the 2020s

2 - **Fairly** likely the consequence for service will occur in the 2020s

3 - **Very likely** the consequence for service will occur in the 2020s

2020s

ASSET LEVEL 3	Climate Variable	MHW IMPACT REF.	DESCRIPTION	PRIMARY IMPACT OF CLIMATE VARIABLE	POTENTIAL IMPACTS ON ORGANISATION AND STAKEHOLDERS	Consequence for service			COMPANY'S ADAPTIVE ACTIONS	Company's residual risk			COMPANY'S PROPOSED ACTION TO MITIGATE RESIDUAL IMPACTS
						Level of consequence	Level of likelihood	Level of risk		Level of consequence	Level of likelihood	Level of risk	
All Water Treatment	DROUGHT	D10	Low flows lead to greater sedimentation, with blockages causing service failure	Low flows	Service failure	2	1	2	Regular cleaning of raw water mains	2	1	2	Continue with cleaning programme
Treatment works	DROUGHT	D11	Reduced raw water volumes reduce dilution and increase drinking water quality risk	Reduced raw water volumes reducing dilution	Increased drinking water quality risk	1	1	1	Upstream management of catchment	1	1	1	
Service Reservoirs & Water Towers	DROUGHT	D12	Loss of / intermittent supply increases risk of contamination from accumulated silt and debris being flushed out of service reservoirs and towers, increasing drinking water quality risk	Intermittency in supply	Increased drinking water quality risk	2	2	4	regular service reservoir cleaning programme	2	1	2	Continue with cleaning programme
Service Reservoirs & Water Towers	DROUGHT	D13	Loss of / intermittent supply increases risk of contamination from external contaminants entering the pipelines, increasing drinking water quality risk	Loss of / intermittent supply	Increased drinking water quality risk	3	2	6	System continuously monitored and integrity checks carried out	3	1	3	Consider Increasing monitoring regime

Service Reservoirs & Water Towers	DROUGHT	D14	Loss of supply and de-pressurisation of pipelines leads to greater incidence of pipe failure with resulting contamination increasing drinking water quality risk	Loss of supply and de-pressurisation	More frequent pipe failure and increased drinking water quality risk	2	2	4	Increase leakage control and system pressure monitoring	2	1	2	Continue with system monitoring
Service Reservoirs & Water Towers	DROUGHT	D15	Inversions occur more frequently in incidences of low water levels; Cryptosporidium accumulation issues increase drinking water quality risk	Inversions occur more frequently with low water levels;	Increased drinking water quality risk	3	1	3	Treatment process removes Oocysts. Sampling confirms efficacy	3	1	3	Continue with system monitoring
Treated water pumping stations	DROUGHT	D16	Loss of supply and depressurisation of the supply system leads to greater incidence of air blockages, causing service failure	Loss of supply and depressurisation of the supply network	Service failure	2	1	2	maintain air valves	2	1	2	Continue with maintenance
All Water Treatment	FLOOD	F11	Direct asset flooding causes service failure and asset loss	Direct asset flooding	Asset loss and service failure	3	2	6	Periodic review process will identify areas of concern	3	1	3	Monitor EA coastal flooding information, consider improving flood defences
All Water Treatment	FLOOD	F12	Increased storm frequency increases frequency of power loss, causing service failure	More frequent storms and power supply flooding	Service failure	3	2	6	Standby generation at critical assets already provides adequate level of cover	3	1	3	Investigate lightning protection for works
Treatment works	FLOOD	F13	Discolouration and odour problems caused by the biological consequences of more intense rainfall events increase drinking water quality risk	More intense rainfall events	Increased drinking water quality risk	1	1	1		1	1	1	
Treatment works	FLOOD	F14	Increased runoff leads to greater sediment levels, which increases drinking water quality risk	Increased runoff	Increased drinking water quality risk	1	1	1		1	1	1	
Service Reservoirs & Water Towers	FLOOD	F15	Direct flooding causes contaminants to enter underground storage tanks increasing drinking water quality risk	Direct flooding	Increased drinking water quality risk	2	1	2	Monitor flood maps produced by EA and integrity checks carried out	2	1	2	Continue to monitor information
Service Reservoirs & Water Towers	FLOOD	F16	Direct flooding causes contaminants to enter pipelines, increasing drinking water quality risk	Direct flooding	Increased drinking water quality risk	2	1	2	Maintain system pressure	2	1	2	Continue to maintain pressure
All Water Treatment	GENERAL	G1	Relocation of permanent and tourist population from drought, temperature rise, flooding or sea level rise (impacts D2, T2, T3, T5, F3, S2) changes supply-demand balance. Response chosen (within WR) impacts WTW requirements and capacity needed.	Relocation of population from weather, flooding, sea level rise	Impacts WTW requirements and capacity and reduced security of supply	2	1	2	Population forecast monitors regional movement liaise with West Country Tourism	2	1	2	Continue to monitor forecasts
Treatment works	SEA LEVEL	S10	Tidal limits move upstream and lead to greater salinity at intakes, causing raw water resource loss and reduction in security of supply	Tidal limits moving upstream and increasing salinity at intakes	Reduced security of supply	2	1	2	Monitor coast line flooding and erosion information from the EA	2	1	2	Continue to monitor EA information

All Water Treatment	SEA LEVEL	S6	Direct asset flooding, storm damage and coastal erosion or 'planned retreat' cause service failure and asset loss	Direct asset flooding, storm damage, coastal erosion or planned retreat	Asset loss and service failure	2	1	2	Monitor coast line flooding and erosion information from the EA	2	1	2	Continue to monitor EA information
All Water Treatment	SEA LEVEL	S7	Saline intrusion in groundwater increases structural attack on infrastructure, causing accelerated asset deterioration.	Saline intrusion in groundwater	Accelerated asset deterioration	2	1	2	Monitoring ground water quality	2	1	2	Continue with monitoring and cleaning programme
All Water Treatment	SEA LEVEL	S8	Sea level rise increases frequency of power loss, causing service failure	Sea level rise	Increased frequency of power loss and service failure	2	1	2	Monitor coastline flooding information from EA and integrity checks carried out	2	1	2	Continue to monitor EA information
Treatment works	SEA LEVEL	S9	Saline intrusion decreases yield, causing a service loss and reduction in security of supply	Saline intrusion	Reduced security of supply	2	1	2	Monitor coastline flooding information from EA	2	1	2	Continue to monitor EA information
All Water Treatment	TEMP. RISE	T10	Increased algal growth and risk of microscopic organisms within the water supply system increases drinking water quality risk	Higher temperatures	Increased drinking water quality risk	2	1	2	Raw water monitoring and in works cleaning programme	2	1	2	Continue with monitoring and cleaning programme
All Water Treatment	TEMP. RISE	T11	Higher average and peak temperatures affect structures, buildings, H & V, MEICA plant working life, causing accelerated asset deterioration	Higher average and peak temperatures	Accelerated asset deterioration	1	1	1		1	1	1	
Treatment works	TEMP. RISE	T12	Higher temperatures reduce raw water quality and increase drinking water quality risk	Higher temperatures	Increased drinking water quality risk	1	1	1		1	1	1	
Treatment works	TEMP. RISE	T13	Higher temperatures impact treatment process improving treated water quality	Higher temperatures	Improved drinking water quality	1	1	1		1	1	1	
Treatment works	TEMP. RISE	T14	Increased incidence of disease leads to introduction of additional potable standards, increasing drinking water quality risk	More frequent disease increasing drinking water quality risk	Increased drinking water quality risk	3	1	3	Change in regulations will trigger investment at works	1	1	1	Monitor proposed changes in regulations
Treatment works	TEMP. RISE	T15	Discolouration and odour problems caused by the biological consequences of higher temperatures increase drinking water quality risk	Higher temperatures	Increased drinking water quality risk	2	1	2	Raw water monitoring for algae is carried out	2	1	2	Continue to monitor raw water
Service Reservoirs & Water Towers	TEMP. RISE	T16	Increased rate of micro-biological growth increases risk of residual chlorine depletion and contamination of supplies, increasing drinking water quality risk	Increased micro-biological growth	Increased drinking water quality risk	2	1	2	Review disinfection policy and investment to avoid reliance on Chlorine	1	1	1	Monitor developments in disinfection techniques
Service Reservoirs & Water Towers	TEMP. RISE	T17	Increased rate of micro-biological growth increases risk of residual chlorine depletion and contamination of supplies, increasing drinking water quality risk	Increased micro-biological growth	Increased drinking water quality risk	2	1	2	Review disinfection policy to avoid reliance on Chlorine	1	1	1	Continue to review developments in disinfection

Service Reservoirs & Water Towers	TEMP. RISE	T18	Greater extremities in wetting and drying cycles lead to greater soil movement, causing pipe systems to move increasing burst frequency	More extreme wetting and drying cycles	Increased burst frequency	1	1	1		1	1	1	

Asset Level 2: Water Treatment Works

2050

Level of consequence

1 - **Low impact** resulting in possible intermittent impact on service to customers or damage to assets requiring some repair or maintenance

2 - **Medium impact** causing minor loss of service to some customers or damage to assets (e.g. hosepipe ban, flooding of assets) requiring significant maintenance or replacement work and a review of investment priorities

3 - **High impact** causing major loss of service to customers, significant health & safety issues or damage to assets (e.g. treatment works unable to function, flooding or several hundred properties)

Level of likelihood

1 - **Unlikely** the consequence for service will occur in the 2050s

2 - **Fairly** likely the consequence for service will occur in the 2050s

3 - **Very likely** the consequence for service will occur in the 2050s

						2050s							
						Consequence for service				Company's residual risk			
ASSET LEVEL 3	Climate Variable	MHW IMPACT REF.	DESCRIPTION	PRIMARY IMPACT OF CLIMATE VARIABLE	POTENTIAL IMPACTS ON ORGANISATION AND STAKEHOLDERS	Level of consequence	Level of likelihood	Level of risk	COMPANY'S ADAPTIVE ACTIONS	Level of consequence	Level of likelihood	Level of risk	COMPANY'S PROPOSED ACTION TO MITIGATE RESIDUAL IMPACTS
All Water Treatment	DROUGHT	D10	Low flows lead to greater sedimentation, with blockages causing **service failure**	Low flows	Service failure	2	1	2	Regular cleaning of raw water mains	2	1	2	Continue with cleaning programme
Treatment works	DROUGHT	D11	Reduced raw water volumes reduce dilution and **increase drinking water quality risk**	Reduced raw water volumes reducing dilution	Increased drinking water quality risk	1	1	1		1	1	1	
Service Reservoirs & Water Towers	DROUGHT	D12	Loss of / intermittent supply increases risk of contamination from accumulated silt and debris being flushed out of service reservoirs and towers, **increasing drinking water quality risk**	Intermittency in supply	Increased drinking water quality risk	2	2	4	regular service reservoir cleaning programme	2	1	2	Continue with cleaning programme

Service Reservoirs & Water Towers	DROUGHT	D13	Loss of / intermittent supply increases risk of contamination from external contaminants entering the pipelines, increasing drinking water quality risk	Loss of / intermittent supply	Increased drinking water quality risk	3	2	6	System continuously monitored	3	1	3	Consider Increasing monitoring regime
Service Reservoirs & Water Towers	DROUGHT	D14	Loss of supply and de-pressurisation of pipelines leads to greater incidence of pipe failure with resulting contamination increasing drinking water quality risk	Loss of supply and de-pressurisation	More frequent pipe failure and increased drinking water quality risk	2	2	4	Increase leakage control and system pressure monitoring	2	1	2	Continue with system monitoring
Service Reservoirs & Water Towers	DROUGHT	D15	Inversions occur more frequently in incidences of low water levels; Cryptosporidium accumulation issues increase drinking water quality risk	Inversions occur more frequently with low water levels;	Increased drinking water quality risk	3	1	3	Treatment process removes Oocysts. Sampling confirms efficacy	3	1	3	Continue with system monitoring
Treated water pumping stations	DROUGHT	D16	Loss of supply and depressurisation of the supply system leads to greater incidence of air blockages, causing service failure	Loss of supply and depressurisation of the supply network	Service failure	2	1	2	Maintain air valves	2	1	2	Continue with maintenance
All Water Treatment	FLOOD	F11	Direct asset flooding causes service failure and asset loss	Direct asset flooding	Asset loss and service failure	3	3	9	Periodic review process will identify areas of concern	3	1	3	Monitor EA coastal flooding information, consider improving flood defences
All Water Treatment	FLOOD	F12	Increased storm frequency increases frequency of power loss, causing service failure	More frequent storms and power supply flooding	Service failure	3	3	9	Standby generation at critical assets already provides adequate level of cover	3	1	3	Investigate lightning protection for works
Treatment works	FLOOD	F13	Discolouration and odour problems caused by the biological consequences of more intense rainfall events increase drinking water quality risk	More intense rainfall events	Increased drinking water quality risk	1	1	1		1	1	1	
Treatment works	FLOOD	F14	Increased runoff leads to greater sediment levels, which increases drinking water quality risk	Increased runoff	Increased drinking water quality risk	1	1	1		1	1	1	
Service Reservoirs & Water Towers	FLOOD	F15	Direct flooding causes contaminants to enter underground storage tanks increasing drinking water quality risk	Direct flooding	Increased drinking water quality risk	2	1	2	Monitor flood maps produced by EA	2	1	2	Continue to monitor information
Service Reservoirs & Water Towers	FLOOD	F16	Direct flooding causes contaminants to enter pipelines, increasing drinking water quality risk	Direct flooding	Increased drinking water quality risk	2	1	2	Maintain system pressure	2	1	2	Continue to maintain pressure
All Water Treatment	GENERAL	G1	Relocation of permanent and tourist population from drought, temperature rise, flooding or sea level rise (impacts D2, T2, T3, T5, F3, S2) changes supply-demand balance. Response chosen (within WR) impacts WTW requirements and capacity needed.	Relocation of population from weather, flooding, sea level rise	Impacts WTW requirements and capacity and reduced security of supply	2	2	4	Population forecast monitors regional movement liaise with West Country Tourism	2	1	2	Continue to monitor forecasts

Treatment works	SEA LEVEL	S10	Tidal limits move upstream and lead to greater salinity at intakes, causing raw water resource loss and reduction in security of supply	Tidal limits moving upstream and increasing salinity at intakes	Reduced security of supply	2	2	4	Periodic review process will identify areas of concern	2	1	2	Continue to monitor EA information
All Water Treatment	SEA LEVEL	S6	Direct asset flooding, storm damage and coastal erosion or 'planned retreat' cause service failure and asset loss	Direct asset flooding, storm damage, coastal erosion or planned retreat	Asset loss and service failure	2	2	4	Identify impact of change at periodic review process	2	1	2	Continue to monitor EA information
All Water Treatment	SEA LEVEL	S7	Saline intrusion in groundwater increases structural attack on infrastructure, causing accelerated asset deterioration.	Saline intrusion in groundwater	Accelerated asset deterioration	2	1	2	Monitor coastline flooding information from EA	2	1	2	Continue with monitoring and cleaning programme
All Water Treatment	SEA LEVEL	S8	Sea level rise increases frequency of power loss, causing service failure	Sea level rise	Increased frequency of power loss and service failure	2	1	2	Monitor coastline flooding information from EA	2	1	2	Continue to monitor EA information
Treatment works	SEA LEVEL	S9	Saline intrusion decreases yield, causing a service loss and reduction in security of supply	Saline intrusion	Reduced security of supply	2	1	2	Monitor coastline flooding information from EA	2	1	2	Continue to monitor EA information
All Water Treatment	TEMP. RISE	T10	Increased algal growth and risk of microscopic organisms within the water supply system increases drinking water quality risk	Higher temperatures	Increased drinking water quality risk	2	1	2	Raw water monitoring and in works cleaning programme	2	1	2	Continue with monitoring and cleaning programme
All Water Treatment	TEMP. RISE	T11	Higher average and peak temperatures affect structures, buildings, H & V, MEICA plant working life, causing accelerated asset deterioration	Higher average and peak temperatures	Accelerated asset deterioration	1	1	1	Company technical standards will be reviewed to take into account climate change factors	1	1	1	
Treatment works	TEMP. RISE	T12	Higher temperatures reduce raw water quality and increase drinking water quality risk	Higher temperatures	Increased drinking water quality risk	1	2	2	Raw water monitoring	1	1	1	
Treatment works	TEMP. RISE	T13	Higher temperatures impact treatment process improving treated water quality	Higher temperatures	Improved drinking water quality	1	2	2	Not required	1	2	2	
Treatment works	TEMP. RISE	T14	Increased incidence of disease leads to introduction of additional potable standards, increasing drinking water quality risk	More frequent disease increasing drinking water quality risk	Increased drinking water quality risk	3	2	6	Change in regulations will trigger investment at works	1	1	1	Monitor proposed changes in regulations

Treatment works	TEMP. RISE	T15	Discolouration and odour problems caused by the biological consequences of higher temperatures increase drinking water quality risk	Higher temperatures	Increased drinking water quality risk	2	2	4	Raw water monitoring for algae is carried out. Any investment identified will be promoted at periodic review	2	1	2	Continue to monitor raw water
Service Reservoirs & Water Towers	TEMP. RISE	T16	Increased rate of micro-biological growth increases risk of residual chlorine depletion and contamination of supplies, increasing drinking water quality risk	Increased micro-biological growth	Increased drinking water quality risk	2	2	4	Review disinfection policy to avoid reliance on Chlorine	1	1	1	Monitor developments in disinfection techniques
Service Reservoirs & Water Towers	TEMP. RISE	T17	Increased rate of micro-biological growth increases risk of residual chlorine depletion and contamination of supplies, increasing drinking water quality risk	Increased micro-biological growth	Increased drinking water quality risk	2	2	4	Review disinfection policy to avoid reliance on Chlorine	1	1	1	Continue to review developments in disinfection
Service Reservoirs & Water Towers	TEMP. RISE	T18	Greater extremities in wetting and drying cycles lead to greater soil movement, causing pipe systems to move increasing burst frequency	More extreme wetting and drying cycles	Increased burst frequency	1	1	1		1	1	1	

Asset Level 2: Water Treatment Works

2080

Level of consequence

1 - **Low impact** resulting in possible intermittent impact on service to customers or damage to assets requiring some repair or maintenance

2 - **Medium impact** causing minor loss of service to some customers or damage to assets (e.g. hosepipe ban, flooding of assets) requiring significant maintenance or replacement work and a review of investment priorities

3 - **High impact** causing major loss of service to customers, significant health & safety issues or damage to assets (e.g. treatment works unable to function, flooding or several hundred properties)

Level of likelihood

1 - **Unlikely** the consequence for service will occur in the 2080s

2 - **Fairly** likely the consequence for service will occur in the 2080s

3 - **Very likely** the consequence for service will occur in the 2080s

2080s

ASSET LEVEL 3	Climate Variable	MHW IMPACT REF.	DESCRIPTION	PRIMARY IMPACT OF CLIMATE VARIABLE	POTENTIAL IMPACTS ON ORGANISATION AND STAKEHOLDERS	Consequence for service			COMPANY'S ADAPTIVE ACTIONS	Company's residual risk			COMPANY'S PROPOSED ACTION TO MITIGATE RESIDUAL IMPACTS
						Level of consequence	Level of likelihood	Level of risk		Level of consequence	Level of likelihood	Level of risk	
All Water Treatment	DROUGHT	D10	Low flows lead to greater sedimentation, with blockages causing service failure	Low flows	Service failure	2	1	2	Regular cleaning of raw water mains	2	1	2	Continue with cleaning programme
Treatment works	DROUGHT	D11	Reduced raw water volumes reduce dilution and increase drinking water quality risk	Reduced raw water volumes reducing dilution	Increased drinking water quality risk	1	1	1		1	1	1	
Service Reservoirs & Water Towers	DROUGHT	D12	Loss of / intermittent supply increases risk of contamination from accumulated silt and debris being flushed out of service reservoirs and towers, increasing drinking water quality risk	Intermittency in supply	Increased drinking water quality risk	2	3	6	increased frequency of regular service reservoir cleaning programme	2	1	2	Continue with cleaning programme

Service Reservoirs & Water Towers	DROUGHT	D13	Loss of / intermittent supply increases risk of contamination from external contaminants entering the pipelines, increasing drinking water quality risk	Loss of / intermittent supply	Increased drinking water quality risk	3	3	9	System continuously monitored with increased instrumentation, integrity checks carried out	3	1	3	Consider Increasing monitoring regime
Service Reservoirs & Water Towers	DROUGHT	D14	Loss of supply and de-pressurisation of pipelines leads to greater incidence of pipe failure with resulting contamination increasing drinking water quality risk	Loss of supply and de-pressurisation	More frequent pipe failure and increased drinking water quality risk	2	3	6	Increase leakage control and system pressure monitoring	2	1	2	Continue with system monitoring
Service Reservoirs & Water Towers	DROUGHT	D15	Inversions occur more frequently in incidences of low water levels; Cryptosporidium accumulation issues increase drinking water quality risk	Inversions occur more frequently with low water levels;	Increased drinking water quality risk	3	1	3	Treatment process removes Oocysts. Sampling confirms efficacy	3	1	3	Continue with system monitoring
Treated water pumping stations	DROUGHT	D16	Loss of supply and depressurisation of the supply system leads to greater incidence of air blockages, causing service failure	Loss of supply and depressurisation of the supply network	Service failure	2	1	2	Maintain air valves	2	1	2	Continue with maintenance
All Water Treatment	FLOOD	F11	Direct asset flooding causes service failure and asset loss	Direct asset flooding	Asset loss and service failure	3	3	9	Periodic review process will identify areas of concern	3	1	3	Monitor EA coastal flooding information, consider improving flood defences
All Water Treatment	FLOOD	F12	Increased storm frequency increases frequency of power loss, causing service failure	More frequent storms and power supply flooding	Service failure	3	3	9	Standby generation at critical assets already provides adequate level of cover	3	1	3	Investigate lightning protection for works
Treatment works	FLOOD	F13	Discolouration and odour problems caused by the biological consequences of more intense rainfall events increase drinking water quality risk	More intense rainfall events	Increased drinking water quality risk	1	1	1		1	1	1	
Treatment works	FLOOD	F14	Increased runoff leads to greater sediment levels, which increases drinking water quality risk	Increased runoff	Increased drinking water quality risk	1	1	1		1	1	1	
Service Reservoirs & Water Towers	FLOOD	F15	Direct flooding causes contaminants to enter underground storage tanks increasing drinking water quality risk	Direct flooding	Increased drinking water quality risk	2	1	2	Monitor flood maps produced by EA	2	1	2	Continue to monitor information
Service Reservoirs & Water Towers	FLOOD	F16	Direct flooding causes contaminants to enter pipelines, increasing drinking water quality risk	Direct flooding	Increased drinking water quality risk	2	1	2	Maintain system pressure	2	1	2	Continue to maintain pressure
All Water Treatment	GENERAL	G1	Relocation of permanent and tourist population from drought, temperature rise, flooding or sea level rise (impacts D2, T2, T3, T5, F3, S2) changes supply-demand balance. Response chosen (within WR) impacts WTW requirements and capacity needed.	Relocation of population from weather, flooding, sea level rise	Impacts WTW requirements and capacity and reduced security of supply	2	2	4	Population forecast monitors regional movement liaise with West Country Tourism	2	1	2	Continue to monitor forecasts

Treatment works	SEA LEVEL	S10	Tidal limits move upstream and lead to greater salinity at intakes, causing raw water resource loss and reduction in security of supply	Tidal limits moving upstream and increasing salinity at intakes	Reduced security of supply	2	3	6	Periodic review process will identify areas of concern	2	1	2	Continue to monitor EA information
All Water Treatment	SEA LEVEL	S6	Direct asset flooding, storm damage and coastal erosion or 'planned retreat' cause service failure and asset loss	Direct asset flooding, storm damage, coastal erosion or planned retreat	Asset loss and service failure	2	3	6	Identify impact of change at periodic review process	2	1	2	Continue to monitor EA information
All Water Treatment	SEA LEVEL	S7	Saline intrusion in groundwater increases structural attack on infrastructure, causing accelerated asset deterioration.	Saline intrusion in groundwater	Accelerated asset deterioration	2	2	4	Changes required to treatment process will be identified and promoted at periodic review	2	1	2	Continue with monitoring and cleaning programme
All Water Treatment	SEA LEVEL	S8	Sea level rise increases frequency of power loss, causing service failure	Sea level rise	Increased frequency of power loss and service failure	2	1	2	Monitor coastline flooding information from EA	2	1	2	Continue to monitor EA information
Treatment works	SEA LEVEL	S9	Saline intrusion decreases yield, causing a service loss and reduction in security of supply	Saline intrusion	Reduced security of supply	2	1	2	Monitor coastline flooding information from EA	2	1	2	Continue to monitor EA information
All Water Treatment	TEMP. RISE	T10	Increased algal growth and risk of microscopic organisms within the water supply system increases drinking water quality risk	Higher temperatures	Increased drinking water quality risk	2	2	4	Raw water monitoring and in works cleaning programme	2	1	2	Continue with monitoring and cleaning programme
All Water Treatment	TEMP. RISE	T11	Higher average and peak temperatures affect structures, buildings, H & V, MEICA plant working life, causing accelerated asset deterioration	Higher average and peak temperatures	Accelerated asset deterioration	1	2	2	MEICA plant monitored to detect deterioration. Asset condition surveys will inform replacement cycle for Periodic review process	1	1	1	
Treatment works	TEMP. RISE	T12	Higher temperatures reduce raw water quality and increase drinking water quality risk	Higher temperatures	Increased drinking water quality risk	1	1	1		1	1	1	
Treatment works	TEMP. RISE	T13	Higher temperatures impact treatment process improving treated water quality	Higher temperatures	Improved drinking water quality	1	3	3	Not required	1	3	3	
Treatment works	TEMP. RISE	T14	Increased incidence of disease leads to introduction of additional potable standards, increasing drinking water quality risk	More frequent disease increasing drinking water quality risk	Increased drinking water quality risk	3	3	9	Change in regulations will trigger investment at works	1	1	1	Monitor proposed changes in regulations
Treatment works	TEMP. RISE	T15	Discolouration and odour problems caused by the biological consequences of higher temperatures increase drinking water quality risk	Higher temperatures	Increased drinking water quality risk	2	3	6	Raw water monitoring for algae is carried out	2	1	2	Continue to monitor raw water
Service Reservoirs & Water Towers	TEMP. RISE	T16	Increased rate of micro-biological growth increases risk of residual chlorine depletion and contamination of supplies, increasing drinking water quality risk	Increased micro-biological growth	Increased drinking water quality risk	2	3	6	Review disinfection policy to avoid reliance on Chlorine	1	1	1	Monitor developments in disinfection techniques

Service Reservoirs & Water Towers	TEMP. RISE	T17	Increased rate of micro-biological growth increases risk of residual chlorine depletion and contamination of supplies, increasing drinking water quality risk	Increased micro-biological growth	Increased drinking water quality risk	2	3	6	Review disinfection policy to avoid reliance on Chlorine	1	1	1	Continue to review developments in disinfection
Service Reservoirs & Water Towers	TEMP. RISE	T18	Greater extremities in wetting and drying cycles lead to greater soil movement, causing pipe systems to move increasing burst frequency	More extreme wetting and drying cycles	Increased burst frequency	1	1	1		1	1	1	

Asset Level 2: Water Networks

2020

Level of consequence

1 - **Low impact** resulting in possible intermittent impact on service to customers or damage to assets requiring some repair or maintenance

2 - **Medium impact** causing minor loss of service to some customers or damage to assets (e.g. hosepipe ban, flooding of assets) requiring significant maintenance or replacement work and a review of investment priorities

3 - **High impact** causing major loss of service to customers, significant health & safety issues or damage to assets (e.g. treatment works unable to function, flooding or several hundred properties)

Level of likelihood

1 - **Unlikely** the consequence for service will occur in the 2020s

2 - **Fairly** likely the consequence for service will occur in the 2020s

3 - **Very likely** the consequence for service will occur in the 2020s

2020s

ASSET LEVEL 3	CLIMATE VARIABLE	MHW IMPACT REF.	DESCRIPTION	PRIMARY IMPACT OF CLIMATE VARIABLE	POTENTIAL IMPACTS ON ORGANISATION AND STAKEHOLDERS	Consequence for service			COMPANY'S ADAPTIVE ACTIONS	Company's residual risk			COMPANY'S PROPOSED ACTION TO MITIGATE RESIDUAL IMPACTS
						Level of consequence	Level of likelihood	Level of risk		Level of consequence	Level of likelihood	Level of risk	
All Water Networks	DROUGHT	D17	Daily & peak demand for 'garden' watering increases, increasing asset use and causing accelerated asset deterioration	Higher daily & peak demand for garden watering	Accelerated asset deterioration	2	1	2	Network modelling and pump efficiency monitoring	2	1	2	Continue with adaptive action
Distribution networks incl. ancillaries	DROUGHT	D18	Loss of supply or intermittent supplies increases risk of external contaminants entering the pipelines, increasing drinking water quality risk	Loss of / intermittent supply	Increased drinking water quality risk	3	1	3	System pressure monitoring and maintain Water Resource plan headroom	3	1	3	Continue with adaptive action consider installing more pressure sustaining valves or isolation valves
Distribution networks incl. ancillaries	DROUGHT	D19	Loss of supply and de-pressurisation of pipelines leads to greater incidence of pipe failure, and resulting contamination during re-pressurisation increases drinking water quality risk	Loss of supply and depressurisation of the supply network	More frequent pipe failure and increased drinking water quality risk	3	1	3	System pressure monitoring and maintain Water Resource plan headroom and reinstatement methodology	3	1	3	Continue with adaptive action consider installing more pressure sustaining valves or isolation valves
Distribution networks	DROUGHT	D20	Loss of supply or intermittent supplies leads to increased risk of mechanical	Loss of / intermittent supply	Increased risk of asset failure and service	2	1	2	Maintenance regime ensures asset operability	2	1	2	Continue with adaptive action

incl. ancillaries			asset failure in PRV's, PSV's, Actuated Valves causing **service loss**		failure							
Distribution pumping stations	DROUGHT	D21	Loss of supply and de-pressurisation of the supply system leads to greater incidence of air blockages, causing **service failure**	Loss of supply and depressurisation of the supply network	Service failure	2	1	2	Air valves are maintained but not on a regular schedule	2	1	2	Create regular maintenance schedule for air valves
Distribution storage	DROUGHT	D22	Lower flow rates cause deposition leading to **reduced raw water quality.**	Lower flow rates	Reduced raw water quality	2	1	2	Regular cleaning is carried out	2	1	2	Continue with adaptive action
Distribution storage	DROUGHT	D23	Loss of supply or intermittent supplies leads to contamination from accumulated silt and debris being flushed out of service reservoirs and towers, **increasing drinking water quality risk**	Loss of supply or intermittent supplies	Increased drinking water quality risk	2	2	4	Regular cleaning and inspection is carried out	2	1	2	Continue with adaptive action
All Water Networks	FLOOD	F17	Direct asset flooding causes **service failure and asset loss**	Direct asset flooding	Asset loss and service failure	2	1	2	Asset vulnerability is reviewed at Periodic review	2	1	2	Continue with adaptive action
All Water Networks	FLOOD	F17 A	Increased storm frequency and power supply flooding increases frequency of power loss, causing **service failure**	More frequent storms and power supply flooding	Power outages and service failure	2	2	4	Standby generators are available for key sites	2	1	2	Lightning protection assessment needed
Distribution networks incl. ancillaries	FLOOD	F18	Flood water infiltration into pipelines **increases drinking water quality risk**	Flooding	Increased drinking water quality risk	3	1	3	Installing more pressure sustaining valves or isolation valves and extending permanent pressure monitoring facilities	3	1	3	Continue with adaptive action
Distribution networks incl. ancillaries	FLOOD	F19	Direct flooding causes contaminants to enter pipelines, **increasing drinking water quality risk**	Direct flooding	Increased drinking water quality risk	3	1	3	System pressure is monitored and maintained	3	1	3	Continue with adaptive action consider installing more pressure sustaining valves or isolation valves
Distribution storage	FLOOD	F20	Direct flooding causes contaminants to enter underground storage tanks **increasing drinking water quality risk**	Direct flooding	Increased drinking water quality risk	3	2	6	Asset integrity is maintained and flood risk is reviewed at Periodic Review	3	1	3	Continue with adaptive action consider installing more pressure sustaining valves or isolation valves
All Water Networks	GENERAL	G2	Relocation of permanent and tourist population from drought, temperature rise, flooding or sea level rise (impacts D2, T2, T3, T5, F3, S2) changes supply-demand balance. Response chosen (within WR) **impacts water networks requirements and capacity needed.**	Relocation of population from weather, flooding, sea level rise	Impacts water network requirements and capacity and reduced security of supply	2	1	2	Water resource plan identifies population migration and hydraulic models identify network restrictions	2	1	2	Continue with adaptive action
All Water Networks	SEA LEVEL	S11	Direct asset flooding, storm damage and coastal erosion or 'planned retreat' cause **service failure and asset loss**	Direct asset flooding, storm damage, coastal erosion or planned retreat	Asset loss and service failure	2	1	2	Flooding instances monitored and system pressure maintained., Reference made to EA coastal flooding assessment	2	1	2	Review vulnerability at Periodic Review
All Water Networks	TEMP. RISE	T19	Higher average and peak temperatures affect structures, buildings, H & V, MEICA plant working life, **causing accelerated asset deterioration**	Higher average and peak temperatures	Accelerated asset deterioration	2	1	2	Asset condition of rotating machinery and other equipment is monitored	2	1	2	Review design spec for equipment and cooling
Distribution networks	TEMP. RISE	T20	Greater extremities in wetting and drying cycles lead to greater soil movement,	More extreme wetting and drying cycles	Increased burst frequency	2	1	2	System being developed to reduce repair time.	2	1	2	More systematic approach to reducing repair time and therefore impact on customer

incl. ancillaries			causing pipe systems to move increasing burst frequency										
Distribution networks incl. ancillaries	TEMP. RISE	T21	Increased rate of micro-biological growth increases risk of residual chlorine depletion and contamination of supplies, increasing drinking water quality risk	Increased micro-biological growth	Increased drinking water quality risk	2	1	2	Chlorine residual monitored at numerous points within the network	2	1	2	Review disinfection policy and investigate methods of more stable disinfection
Distribution storage	TEMP. RISE	T22	Increased peaks of demand lead to greater storage requirements reducing security of supply	Higher peak demand	Reduced security of supply	2	2	4	Hydraulic modelling for each distribution area	2	1	2	Continue with adaptive action
Distribution storage	TEMP. RISE	T23	Increased rate of micro-biological growth increases risk of residual chlorine depletion and contamination of supplies, increasing drinking water quality risk	Increased micro-biological growth	Increased drinking water quality risk	2	1	2	Chlorine residual monitored at numerous points within the network	2	1	2	Review disinfection policy and investigate methods of more stable disinfection

Asset Level 2: Water Networks

2050

Level of consequence

1 - **Low impact** resulting in possible intermittent impact on service to customers or damage to assets requiring some repair or maintenance

2 - **Medium impact** causing minor loss of service to some customers or damage to assets (e.g. hosepipe ban, flooding of assets) requiring significant maintenance or replacement work and a review of investment priorities

3 - **High impact** causing major loss of service to customers, significant health & safety issues or damage to assets (e.g. treatment works unable to function, flooding or several hundred properties)

Level of likelihood

1 - **Unlikely** the consequence for service will occur in the 2050s

2 - **Fairly** likely the consequence for service will occur in the 2050s

3 - **Very likely** the consequence for service will occur in the 2050s

						2050s							
						Consequence for service				Company's residual risk			
ASSET LEVEL 3	CLIMATE VARIABLE	MHW IMPACT REF.	DESCRIPTION	PRIMARY IMPACT OF CLIMATE VARIABLE	POTENTIAL IMPACTS ON ORGANISATION AND STAKEHOLDERS	Level of consequence	Level of likelihood	Level of risk	COMPANY'S ADAPTIVE ACTIONS	Level of consequence	Level of likelihood	Level of risk	COMPANY'S PROPOSED ACTION TO MITIGATE RESIDUAL IMPACTS
All Water Networks	DROUGHT	D17	Daily & peak demand for 'garden' watering increases, increasing asset use and causing **accelerated asset deterioration**	Higher daily & peak demand for garden watering	Accelerated asset deterioration	2	2	4	Network modelling and pump efficiency monitoring	2	1	2	Continue with adaptive action
Distribution networks incl. ancillaries	DROUGHT	D18	Loss of supply or intermittent supplies increases risk of external contaminants entering the pipelines, **increasing drinking water quality risk**	Loss of / intermittent supply	Increased drinking water quality risk	3	1	3	System pressure monitoring and maintain Water Resource plan headroom	3	1	3	Continue with adaptive action consider installing more pressure sustaining valves or isolation valves
Distribution networks incl. ancillaries	DROUGHT	D19	Loss of supply and de-pressurisation of pipelines leads to **greater incidence of pipe failure**, and resulting contamination during re-pressurisation **increases drinking water quality risk**	Loss of supply and depressurisation of the supply network	More frequent pipe failure and increased drinking water quality risk	3	1	3	System pressure monitoring and maintain Water Resource plan headroom and reinstatement methodology	3	1	3	Continue with adaptive action consider installing more pressure sustaining valves or isolation valves
Distribution networks	DROUGHT	D20	Loss of supply or intermittent supplies leads to increased risk of mechanical asset failure	Loss of / intermittent supply	Increased risk of asset failure and service	2	1	2	Maintenance regime ensures asset operability	2	1	2	Continue with adaptive action

incl. ancillaries			in PRV's, PSV's, Actuated Valves causing **service loss**		failure								
Distribution pumping stations	DROUGHT	D21	Loss of supply and de-pressurisation of the supply system leads to greater incidence of air blockages, causing **service failure**	Loss of supply and depressurisation of the supply network	Service failure	2	1	2	Air valves are maintained but not on a regular schedule	2	1	2	Create regular maintenance schedule for air valves
Distribution storage	DROUGHT	D22	Lower flow rates cause deposition leading to **reduced raw water quality.**	Lower flow rates	Reduced raw water quality	2	1	2	Regular cleaning is carried out	2	1	2	Continue with adaptive action
Distribution storage	DROUGHT	D23	Loss of supply or intermittent supplies leads to contamination from accumulated silt and debris being flushed out of service reservoirs and towers, **increasing drinking water quality risk**	Loss of supply or intermittent supplies	Increased drinking water quality risk	2	2	4	Regular cleaning and inspection is carried out	2	1	2	Continue with adaptive action
All Water Networks	FLOOD	F17	Direct asset flooding causes **service failure and asset loss**	Direct asset flooding	Asset loss and service failure	2	1	2	Asset vulnerability is reviewed at Periodic review	2	1	2	Continue with adaptive action
All Water Networks	FLOOD	F17 A	Increased storm frequency and power supply flooding increases frequency of power loss, causing **service failure**	More frequent storms and power supply flooding	Power outages and service failure	2	2	4	Standby generators are available for key sites	2	1	2	Lightning protection assessment needed
Distribution networks incl. ancillaries	FLOOD	F18	Flood water infiltration into pipelines **increases drinking water quality risk**	Flooding	Increased drinking water quality risk	3	1	3	Installing more pressure sustaining valves or isolation valves and extending permanent pressure monitoring facilities	3	1	3	Continue with adaptive action
Distribution networks incl. ancillaries	FLOOD	F19	Direct flooding causes contaminants to enter pipelines, **increasing drinking water quality risk**	Direct flooding	Increased drinking water quality risk	3	1	3	System pressure is monitored and maintained	3	1	3	Continue with adaptive action consider installing more pressure sustaining valves or isolation valves
Distribution storage	FLOOD	F20	Direct flooding causes contaminants to enter underground storage tanks **increasing drinking water quality risk**	Direct flooding	Increased drinking water quality risk	3	2	6	Asset integrity is maintained and flood risk is reviewed at Periodic Review	3	1	3	Continue with adaptive action consider installing more pressure sustaining valves or isolation valves
All Water Networks	GENERAL	G2	Relocation of permanent and tourist population from drought, temperature rise, flooding or sea level rise (impacts D2, T2, T3, T5, F3, S2) changes supply-demand balance. Response chosen (within WR) **impacts water networks requirements and capacity needed.**	Relocation of population from weather, flooding, sea level rise	Impacts water network requirements and capacity and reduced security of supply	2	1	2	Water resource plan identifies population migration and hydraulic models identify network restrictions	2	1	2	Continue with adaptive action
All Water Networks	SEA LEVEL	S11	Direct asset flooding, storm damage and coastal erosion or 'planned retreat' cause **service failure and asset loss**	Direct asset flooding, storm damage, coastal erosion or planned retreat	Asset loss and service failure	2	1	2	Flooding instances monitored and system pressure maintained., Reference made to EA coastal flooding assessment	2	1	2	Review vulnerability at Periodic Review
All Water Networks	TEMP. RISE	T19	Higher average and peak temperatures affect structures, buildings, H & V, MEICA plant working life, **causing accelerated asset deterioration**	Higher average and peak temperatures	Accelerated asset deterioration	2	2	4	Asset condition of rotating machinery and other equipment is monitored	2	1	2	Review design spec for equipment and cooling

Distribution networks incl. ancillaries	TEMP. RISE	T20	Greater extremities in wetting and drying cycles lead to greater soil movement, causing pipe systems to move increasing burst frequency	More extreme wetting and drying cycles	Increased burst frequency	2	1	2	System being developed to reduce repair time.	2	1	2	More systematic approach to reducing repair time and therefore impact on customer
Distribution networks incl. ancillaries	TEMP. RISE	T21	Increased rate of micro-biological growth increases risk of residual chlorine depletion and contamination of supplies, increasing drinking water quality risk	Increased micro-biological growth	Increased drinking water quality risk	2	2	4	Chlorine residual monitored at numerous points within the network	2	1	2	Review disinfection policy and investigate methods of more stable disinfection
Distribution storage	TEMP. RISE	T22	Increased peaks of demand lead to greater storage requirements reducing security of supply	Higher peak demand	Reduced security of supply	2	3	6	Hydraulic modelling for each distribution area	2	1	2	Continue with adaptive action
Distribution storage	TEMP. RISE	T23	Increased rate of micro-biological growth increases risk of residual chlorine depletion and contamination of supplies, increasing drinking water quality risk	Increased micro-biological growth	Increased drinking water quality risk	2	2	4	Chlorine residual monitored at numerous points within the network	2	1	2	Review disinfection policy and investigate methods of more stable disinfection

Asset Level 2: Water Networks

2080

Level of consequence

1 - **Low impact** resulting in possible intermittent impact on service to customers or damage to assets requiring some repair or maintenance

2 - **Medium impact** causing minor loss of service to some customers or damage to assets (e.g. hosepipe ban, flooding of assets) requiring significant maintenance or replacement work and a review of investment priorities

3 - **High impact** causing major loss of service to customers, significant health & safety issues or damage to assets (e.g. treatment works unable to function, flooding or several hundred properties)

Level of likelihood

1 - **Unlikely** the consequence for service will occur in the 2080s

2 - **Fairly** likely the consequence for service will occur in the 2080s

3 - **Very likely** the consequence for service will occur in the 2080s

2080s

ASSET LEVEL 3	CLIMATE VARIABLE	MHW IMPACT REF.	DESCRIPTION	PRIMARY IMPACT OF CLIMATE VARIABLE	POTENTIAL IMPACTS ON ORGANISATION AND STAKEHOLDERS	Consequence for service			COMPANY'S ADAPTIVE ACTIONS	Company's residual risk			COMPANY'S PROPOSED ACTION TO MITIGATE RESIDUAL IMPACTS
						Level of consequence	Level of likelihood	Level of risk		Level of consequence	Level of likelihood	Level of risk	
All Water Networks	DROUGHT	D17	Daily & peak demand for 'garden' watering increases, increasing asset use and causing **accelerated asset deterioration**	Higher daily & peak demand for garden watering	Accelerated asset deterioration	2	3	6	Network modelling and pump efficiency monitoring	2	2	4	Continue with adaptive action
Distribution networks incl. ancillaries	DROUGHT	D18	Loss of supply or intermittent supplies increases risk of external contaminants entering the pipelines, **increasing drinking water quality risk**	Loss of / intermittent supply	Increased drinking water quality risk	3	2	6	System pressure monitoring and maintain Water Resource plan headroom	3	1	3	Continue with adaptive action consider installing more pressure sustaining valves or isolation valves
Distribution networks incl. ancillaries	DROUGHT	D19	Loss of supply and de-pressurisation of pipelines leads to **greater incidence of pipe failure**, and resulting contamination during re-pressurisation **increases drinking water quality risk**	Loss of supply and depressurisation of the supply network	More frequent pipe failure and increased drinking water quality risk	3	2	6	System pressure monitoring and maintain Water Resource plan headroom and reinstatement methodology	3	1	3	Continue with adaptive action consider installing more pressure sustaining valves or isolation valves
Distribution networks incl. ancillaries	DROUGHT	D20	Loss of supply or intermittent supplies leads to increased risk of mechanical asset failure in PRV's, PSV's, Actuated Valves causing **service loss**	Loss of / intermittent supply	Increased risk of asset failure and service failure	2	1	2	Maintenance regime ensures asset operability	2	1	2	Continue with adaptive action

Distribution pumping stations	DROUGHT	D21	Loss of supply and de-pressurisation of the supply system leads to greater incidence of air blockages, causing service failure	Loss of supply and depressurisation of the supply network	Service failure	2	1	2	Air valves are maintained but not on a regular schedule	2	1	2	Create regular maintenance schedule for air valves
Distribution storage	DROUGHT	D22	Lower flow rates cause deposition leading to reduced raw water quality.	Lower flow rates	Reduced raw water quality	2	1	2	Regular cleaning is carried out	2	1	2	Continue with adaptive action
Distribution storage	DROUGHT	D23	Loss of supply or intermittent supplies leads to contamination from accumulated silt and debris being flushed out of service reservoirs and towers, increasing drinking water quality risk	Loss of supply or intermittent supplies	Increased drinking water quality risk	2	3	6	Regular cleaning and inspection is carried out	2	1	2	Continue with adaptive action
All Water Networks	FLOOD	F17	Direct asset flooding causes service failure and asset loss	Direct asset flooding	Asset loss and service failure	2	2	4	Asset vulnerability is reviewed at Periodic review	2	1	2	Continue with adaptive action
All Water Networks	FLOOD	F17 A	Increased storm frequency and power supply flooding increases frequency of power loss, causing service failure	More frequent storms and power supply flooding	Power outages and service failure	2	3	6	Standby generators are available for key sites	2	2	4	Lightning protection assessment needed
Distribution networks incl. ancillaries	FLOOD	F18	Flood water infiltration into pipelines increases drinking water quality risk	Flooding	Increased drinking water quality risk	3	2	6	Installing more pressure sustaining valves or isolation valves and extending permanent pressure monitoring facilities	3	1	3	Continue with adaptive action
Distribution networks incl. ancillaries	FLOOD	F19	Direct flooding causes contaminants to enter pipelines, increasing drinking water quality risk	Direct flooding	Increased drinking water quality risk	3	2	6	System pressure is monitored and maintained	3	1	3	Continue with adaptive action consider installing more pressure sustaining valves or isolation valves
Distribution storage	FLOOD	F20	Direct flooding causes contaminants to enter underground storage tanks increasing drinking water quality risk	Direct flooding	Increased drinking water quality risk	3	2	6	Asset integrity is maintained and flood risk is reviewed at Periodic Review	3	1	3	Continue with adaptive action consider installing more pressure sustaining valves or isolation valves
All Water Networks	GENERAL	G2	Relocation of permanent and tourist population from drought, temperature rise, flooding or sea level rise (impacts D2, T2, T3, T5, F3, S2) changes supply-demand balance. Response chosen (within WR) impacts water networks requirements and capacity needed.	Relocation of population from weather, flooding, sea level rise	Impacts water network requirements and capacity and reduced security of supply	2	2	4	Water resource plan identifies population migration and hydraulic models identify network restrictions	2	1	2	Continue with adaptive action
All Water Networks	SEA LEVEL	S11	Direct asset flooding, storm damage and coastal erosion or 'planned retreat' cause service failure and asset loss	Direct asset flooding, storm damage, coastal erosion or planned retreat	Asset loss and service failure	2	2	4	Flooding instances monitored and system pressure maintained., Reference made to EA coastal flooding assessment	2	1	2	Review vulnerability at Periodic Review
All Water Networks	TEMP. RISE	T19	Higher average and peak temperatures affect structures, buildings, H & V, MEICA plant working life, causing accelerated asset deterioration	Higher average and peak temperatures	Accelerated asset deterioration	2	2	4	Asset condition of rotating machinery and other equipment is monitored	2	1	2	Review design spec for equipment and cooling
Distribution networks incl. ancillaries	TEMP. RISE	T20	Greater extremities in wetting and drying cycles lead to greater soil movement, causing pipe systems to move increasing burst frequency	More extreme wetting and drying cycles	Increased burst frequency	2	1	2	System being developed to reduce repair time.	2	1	2	More systematic approach to reducing repair time and therefore impact on customer

Distribution networks incl. ancillaries	TEMP. RISE	T21	Increased rate of micro-biological growth increases risk of residual chlorine depletion and contamination of supplies, increasing drinking water quality risk	Increased micro-biological growth	Increased drinking water quality risk	2	3	6	Chlorine residual monitored at numerous points within the network	2	2	4	Review disinfection policy and investigate methods of more stable disinfection
Distribution storage	TEMP. RISE	T22	Increased peaks of demand lead to greater storage requirements reducing security of supply	Higher peak demand	Reduced security of supply	3	3	9	Hydraulic modelling for each distribution area	3	1	3	Continue with adaptive action
Distribution storage	TEMP. RISE	T23	Increased rate of micro-biological growth increases risk of residual chlorine depletion and contamination of supplies, increasing drinking water quality risk	Increased micro-biological growth	Increased drinking water quality risk	2	3	6	Chlorine residual monitored at numerous points within the network	2	2	4	Review disinfection policy and investigate methods of more stable disinfection

Asset Level 2: Waste Water Treatment

2020

Level of consequence

1 - **Low impact** resulting in possible intermittent impact on service to customers or damage to assets requiring some repair or maintenance

2 - **Medium impact** causing minor loss of service to some customers or damage to assets (e.g. hosepipe ban, flooding of assets) requiring significant maintenance or replacement work and a review of investment priorities

3 - **High impact** causing major loss of service to customers, significant health & safety issues or damage to assets (e.g. treatment works unable to function, flooding or several hundred properties)

Level of likelihood

1 - **Unlikely** the consequence for service will occur in the 2020s

2 - **Fairly** likely the consequence for service will occur in the 2020s

3 - **Very likely** the consequence for service will occur in the 2020s

						2020s							
ASSET LEVEL 3	CLIMATE VARIABLE	MHW IMPACT REF.	DESCRIPTION	PRIMARY IMPACT OF CLIMATE VARIABLE	POTENTIAL IMPACTS ON ORGANISATION AND STAKEHOLDERS	Consequence for service			COMPANY'S ADAPTIVE ACTIONS	Company's residual risk			COMPANY'S PROPOSED ACTION TO MITIGATE RESIDUAL IMPACTS
						Level of consequence	Level of likelihood	Level of risk		Level of consequence	Level of likelihood	Level of risk	
All Wastewater treatment	DROUGHT	D28	Changes in domestic waste disposal patterns lead to changes in dry weather flow pollutants, affecting treatment process.	Reduced dry weather flow and change in domestic waste disposal	Affects treatment processes	1	1	1		1	1	1	
Site Pumping stations	DROUGHT	D29	Lower average and minimum sewage carry flows reduce quality in rivers reducing environmental water quality	Lower average and minimum sewage flows	Reduced environmental water quality	1	1	1		1	1	1	
Site Pumping stations	DROUGHT	D30	Lower average and peak 'carry' flows lead to settlement in the system, affecting pumping regimes and causing accelerated asset deterioration	Lower average and peak flows	Accelerated asset deterioration	2	1	2	Pump condition is monitored	2	1	2	Continue with adaptive action
Treatment	DROUGHT	D31	Lower average and peak 'carry' flows	Lower average and peak	Accelerated asset	2	1	2	General Maintenance Regime,	2	1	2	Continue with adaptive action

works			lead to settlement in the system, with shock loads affecting process regimes and causing accelerated asset deterioration and H&S risk	flows	deterioration and H&S risk				Planned Prevention Measures				
Treatment works	DROUGHT	D32	Lower average and peak 'carry' flows reduce volumes received at WWTW and affects process regime	Lower average and peak flows	Affects process regime	2	1	2	Periodic review process, final effluent monitoring, PUROS	2	1	2	Continue with adaptive action
Treatment works	DROUGHT	D33	Lower average and peak 'carry' flows reduce wetting rates onto process requiring minimum HLR (e.g. trickling filters), increasing need for recirculation pumping	Lower average and peak flows	Increased need for recirculation pumping	1	2	2	Review whether recirculation is needed. Review process type, introduce recirculation, Consider use of natural media	2	1	2	Continue with adaptive action
Treatment works	DROUGHT	D34	Lower average and peak 'carry' flows increases retention times in settlement tanks leading to increased septicity / odour problems.	Lower average and peak flows	Increased septicity / odour problems	2	1	2	Review tank size and mode of operation - could be a good thing	2	1	2	Continue with adaptive action
Treatment works	DROUGHT	D35	Lower river flows, increased seasonal variability and reduced water quality lead to the tightening of discharge consents, increasing the risk of a consent failure/pollution incident	Lower river flows & increased seasonal variability	Reduced water quality, increased risk of a consent failure / pollution incident	2	1	2	Periodic review process - review treatment process	2	1	2	Continue with adaptive action
Outfalls	DROUGHT	D36	Lower river flows mean effluent is required to maintain river flows, reducing flexibility and increasing the risk of a consent failure/pollution incident	Lower river flows	Reducing flexibility and increased risk of a consent failure / pollution incident	2	1	2	Highly unlikely to be an option as we cannot increase discharge rate	2	1	2	Continue with adaptive action
All Wastewater treatment	FLOOD	F33	Direct asset flooding causes service failure and asset loss	Direct asset flooding	Asset loss and service failure	2	2	4	Reviewed at Periodic review process and vulnerable assets identified	2	1	2	Continue with adaptive action
All Wastewater treatment	FLOOD	F34	Increased storm frequency and power supply flooding increases frequency of power loss, causing service failure	More frequent storms and power supply flooding	Power outages and service failure	2	2	4	Reviewed at Periodic review process and vulnerable assets identified and generator facility installed	2	1	2	Continue with adaptive action
All Wastewater treatment	FLOOD	F35	Increased duration at FFT causes difficulties with managing performance increasing risk of consent failure.	Longer FFT	Increased risk of consent failure	2	1	2	Separate storm flow and create foul only system	2	1	2	Continue with adaptive action
Site Pumping stations	FLOOD	F36	Increased volumes of storm water require increased pumping in combined sewer systems, causing accelerated asset deterioration	Increased volumes of storm water in combined sewers	Increased pump usage & accelerated asset deterioration	2	1	2	Pump efficiency is monitored	2	1	2	Continue with adaptive action
Treatment works	FLOOD	F37	Extended duration of FFT at WwTW due to duration and storage return affects process regime and causes accelerated asset deterioration and asset failure	Longer FFT at WwTW	Accelerated asset deterioration and failure	2	1	2	Pump efficiency is monitored	2	1	2	Continue with adaptive action

Treatment works	FLOOD	F38	Increased intensity rainfall events and higher average flows cause hydraulic overload of treatment process, causing service loss	More intense rainfall and higher average flows	Service failure	2	1	2	Review storm weir settings as part of consent review	2	1	2	Continue with adaptive action
Treatment works	FLOOD	F39	Dilution of, and rapid variations in, influent flows affects process performance efficiency	More dilution / variability in influent flows	Reduction in process performance efficiency	2	1	2	Separate storm flow and create foul only system	2	1	2	Continue with adaptive action
Treatment works	FLOOD	F40	Increased flushing effect (from sewer or PST washout) leads to higher loads to be treated, affecting process performance efficiency and causing service failure	Increased flushing effect (from sewer or PST washout)	Reduction in process performance efficiency leading to service failure	2	1	2	Separate storm flow and create foul only system	2	1	2	Continue with adaptive action
Treatment works	FLOOD	F41	Longer retention of water in storm tanks leads to increased septicity and operational problems, affecting process performance efficiency and increased odour	Longer retention of water in storm tanks	Reduction in process performance efficiency leading to odour problems	2	1	2	Review storm tank policy and potentially de-sludge requirements	2	1	2	Continue with adaptive action
Outfalls	FLOOD	F42	Higher peak levels at the discharge change outfall hydraulics and back up pumps, causing service failure	Higher peak levels at discharges	Service failure	2	1	2	Review storm tank policy and potentially de-sludge requirements	2	1	2	Continue with adaptive action
All Wastewater treatment	GENERAL	G4	Relocation of permanent and tourist population from drought, temperature rise, flooding or sea level rise (impacts D2, T2, T3, T5, F3, S2) changes supply-demand balance. Response chosen (within WR) impacts wastewater treatment requirements and capacity needed.	Relocation of population from weather, flooding, sea level rise	Impacts wastewater treatment requirements and capacity needed	2	1	2	Population forecasting monitors inward migration and liaison with West Country Tourism will identify potential hotspots	2	1	2	Continue with adaptive action
All Wastewater treatment	SEA LEVEL	S19	Direct asset flooding, storm damage and coastal erosion cause service failure and asset loss	Direct asset flooding, storm damage, coastal erosion or planned retreat	Asset loss and service failure	3	1	3	Reviewed at Periodic review process and vulnerable assets identified	3	1	3	Continue with adaptive action
All Wastewater treatment	SEA LEVEL	S20	Saline intrusion degrades infrastructure, causing accelerated asset deterioration	Saline intrusion	Accelerated asset deterioration	3	1	3	Reviewed at Periodic review process and vulnerable assets identified	3	1	3	Continue with adaptive action
Site Pumping stations	SEA LEVEL	S21	Higher receiving water levels leads to increased pumping requirement , causing accelerated asset deterioration	Higher receiving water levels	Increased asset use and accelerated asset deterioration	1	1	1	Reviewed at Periodic review process and vulnerable assets identified	1	1	1	

Treatment works	SEA LEVEL	S22	Saline intrusion increases sewage salinity which impacts on H2S formation, reduces primary and FST sludge settleability, reduces dewaterability of SAS. Potential impact on ASP microbiology due to rate of salinity change, dissolved oxygen saturation causing accelerated asset deterioration and reduced process performance	Saline intrusion	Accelerated asset deterioration and reduced process performance	3	2	6	Identify areas of saline infiltration and target sewer rehab work	3	1	3	Continue with adaptive action
Outfalls	SEA LEVEL	S23	Higher peak levels at the discharge change outfall hydraulics and back up pumps causing service failure	Higher peak levels at discharges	Service failure	2	1	2	Reviewed at Periodic review process and vulnerable assets identified	2	1	2	Continue with adaptive action
Outfalls	SEA LEVEL	S24	Higher sea levels affect dispersion characteristics, leading to different classification, tightened consent, & H+S risk.	Higher sea levels	Different classification, tightened consent and H&S risk	1	1	1	Reviewed at Periodic review process and vulnerable assets identified. Outfall modelling	1	1	1	
All Wastewater treatment	TEMP. RISE	T32	Higher average and peak temperatures affect structures, buildings, H & V, MEICA plant working life, causing accelerated asset deterioration	Higher average and peak temperatures	Accelerated asset deterioration	1	1	1	MEICA plant monitored to detect deterioration in performance and informs replacement cycle. Thermal imaging	1	1	1	
All Wastewater treatment	TEMP. RISE	T33	Higher temperatures lead to greater microbial action, and increased gas production and risk of ignition endangers H&S of site staff	Higher temperatures	Increased H&S risk	3	1	3	Monitor gas levels in buildings, revise PPE needs	3	1	3	Consider using EX rated equipment and increasing ventilation and enclosing process
All Wastewater treatment	TEMP. RISE	T34	Higher levels of UV decrease microbe propagation & survivability, affecting treatment process	Higher levels of UV	Treatment process effects	1	1	1		1	1	1	
All Wastewater treatment	TEMP. RISE	T35	Higher temperatures and septicity levels reduce works performance, increasing the risk of a consent failure	Higher temperatures	Reduction in treatment process performance and increased risk of consent failure	2	1	2	Review chemical needs of treatment process	2	1	2	Continue with adaptive action
All Wastewater treatment	TEMP. RISE	T36	Higher temperatures lead to increased amenity use (e.g. bathing waters) leading to tightened consent and/or increased H&S risk near discharge points	Higher temperatures	Tighter consents and/or increased H&S risk near discharge points	2	1	2	Reviewed at Periodic review process and vulnerable assets identified	2	1	2	Continue with adaptive action
Site Pumping stations	TEMP. RISE	T37	Increased levels of septicity affect pumping regimes and cause accelerated asset deterioration and increased odour	Greater septicity affecting pumping regimes	Accelerated asset deterioration and increased odour	2	1	2	Reviewed at Periodic review process and vulnerable assets identified	2	1	2	Continue with adaptive action
Treatment works	TEMP. RISE	T38	Increased levels of septicity in received sewage causes increased odour	Greater septicity in received sewage	Increased odour	2	1	2	Review chemical needs of process	2	1	2	Continue with adaptive action

Treatment works	TEMP. RISE	T39	Effluent standards raised to meet temperature-affected Water Quality Objectives [O2 etc], increasing the risk of a consent failure/pollution incident	Effluent standards raised to meet temperature-affected Water Quality Objectives	Increased risk of consent failure/pollution incident	2	1	2	Reviewed at Periodic review process and vulnerable assets identified	2	1	2	Continue with adaptive action
Treatment works	TEMP. RISE	T40	Higher rate of biological activity causes change to process efficiency	Higher rate of biological activity	Change to process efficiency	1	1	1	Not considered to need any action	1	1	1	
Treatment works	TEMP. RISE	T41	Lower summer flows and reduced freezing frequency lead to increased insect issues and create an environmental health risk	Lower summer flows and reduced freezing frequency	Increased environmental health risk	2	1	2	Review protective clothing needs and H&S requirements	2	1	2	Continue with adaptive action
Treatment works	TEMP. RISE	T42	Fewer months below critical process temperatures causes increase process efficiency	Fewer months below critical process temperatures	Increased process efficiency	1	1	1	not considered to need any action	1	1	1	
Treatment works	TEMP. RISE	T43	Increased septicity levels and odour chemicals lead to increased health risk	Greater septicity and (use of?) odour chemicals	Increased health risks	2	1	2	Review existing chemical handling procedures	2	1	2	Continue with adaptive action
Treatment works	TEMP. RISE	T44	Increased septicity levels promote growth of undesirable species and inhibit growth of normal aerobic heterotrophs, affecting process performance efficiency	Greater septicity	Reduction in process performance efficiency	1	1	1	Review operational target parameters	1	1	1	Continue with adaptive action
Treatment works	TEMP. RISE	T45	Increased septicity in sewers / primary tanks leads to poor primary settlement and increased load onto secondary process affecting process performance efficiency	Greater septicity in sewers / primary tanks	Reduction in process performance efficiency	2	1	2	Review operational target parameters	2	1	2	Continue with adaptive action
Treatment works	TEMP. RISE	T46	Increased temperatures lead to lower oxygen transfer efficiency in secondary process, affecting process performance efficiency	Increased temperatures	Reduction in process performance efficiency	2	1	2	Review operational target parameters	2	1	2	Continue with adaptive action
Outfalls	TEMP. RISE	T47	Increased levels of septicity lead to increased toxicity, reducing receiving water quality and increasing odour	Greater septicity	Reduced receiving water quality and increased odour	2	1	2	Review operational target parameters	2	1	2	Continue with adaptive action
Outfalls	TEMP. RISE	T48	Reduced oxygen saturation as water temperature increases, increasing the risk of a consent failure/pollution incident	Warmer water leading to reduced oxygen saturation	Increased risk of consent failure/pollution incident	2	1	2	Review operational target parameters	2	1	2	Continue with adaptive action

Asset Level 2: Waste Water Treatment

2050

Level of consequence

1 - **Low impact** resulting in possible intermittent impact on service to customers or damage to assets requiring some repair or maintenance

2 - **Medium impact** causing minor loss of service to some customers or damage to assets (e.g. hosepipe ban, flooding of assets) requiring significant maintenance or replacement work and a review of investment priorities

3 - **High impact** causing major loss of service to customers, significant health & safety issues or damage to assets (e.g. treatment works unable to function, flooding or several hundred properties)

Level of likelihood

1 - **Unlikely** the consequence for service will occur in the 2050s

2 - **Fairly** likely the consequence for service will occur in the 2050s

3 - **Very likely** the consequence for service will occur in the 2050s

2050s

ASSET LEVEL 3	CLIMATE VARIABLE	MHW IMPACT REF.	DESCRIPTION	PRIMARY IMPACT OF CLIMATE VARIABLE	POTENTIAL IMPACTS ON ORGANISATION AND STAKEHOLDERS	Consequence for service			COMPANY'S ADAPTIVE ACTIONS	Company's residual risk			COMPANY'S PROPOSED ACTION TO MITIGATE RESIDUAL IMPACTS
						Level of consequence	Level of likelihood	Level of risk		Level of consequence	Level of likelihood	Level of risk	
All Wastewater treatment	DROUGHT	D28	Changes in domestic waste disposal patterns lead to changes in dry weather flow pollutants, affecting treatment process.	Reduced dry weather flow and change in domestic waste disposal	Affects treatment processes	1	2	2	Routine Sampling, MCERTS Data trend analysis	1	1	1	
Site Pumping stations	DROUGHT	D29	Lower average and minimum sewage carry flows reduce quality in rivers reducing environmental water quality	Lower average and minimum sewage flows	Reduced environmental water quality	1	1	1	Not considered to need any action	1	1	1	
Site Pumping stations	DROUGHT	D30	Lower average and peak 'carry' flows lead to settlement in the system, affecting pumping regimes and causing accelerated asset deterioration	Lower average and peak flows	Accelerated asset deterioration	2	2	4	Pump condition is monitored	2	1	2	Continue with adaptive action

Treatment works	DROUGHT	D31	Lower average and peak 'carry' flows lead to settlement in the system, with shock loads affecting process regimes and causing accelerated asset deterioration and H&S risk	Lower average and peak flows	Accelerated asset deterioration and H&S risk	2	2	4	General Maintenance Regime, Planned Prevention Measures	2	1	2	Continue with adaptive action
Treatment works	DROUGHT	D32	Lower average and peak 'carry' flows reduce volumes received at WWTW and affects process regime	Lower average and peak flows	Affects process regime	2	2	4	Periodic review process, final effluent monitoring, PUROS	2	1	2	Continue with adaptive action
Treatment works	DROUGHT	D33	Lower average and peak 'carry' flows reduce wetting rates onto process requiring minimum HLR (e.g. trickling filters), increasing need for recirculation pumping	Lower average and peak flows	Increased need for recirculation pumping	1	2	2	Review whether recirculation is needed. Review process type, introduce recirculation, Consider use of natural media	2	1	2	Continue with adaptive action
Treatment works	DROUGHT	D34	Lower average and peak 'carry' flows increases retention times in settlement tanks leading to increased septicity / odour problems.	Lower average and peak flows	Increased septicity / odour problems	2	1	2	Review tank size and mode of operation - could be a good thing	2	1	2	Continue with adaptive action
Treatment works	DROUGHT	D35	Lower river flows, increased seasonal variability and reduced water quality lead to the tightening of discharge consents, increasing the risk of a consent failure/pollution incident	Lower river flows & increased seasonal variability	Reduced water quality, increased risk of a consent failure / pollution incident	2	2	4	Periodic review process - review treatment process	2	1	2	Continue with adaptive action
Outfalls	DROUGHT	D36	Lower river flows mean effluent is required to maintain river flows, reducing flexibility and increasing the risk of a consent failure/pollution incident	Lower river flows	Reducing flexibility and increased risk of a consent failure / pollution incident	2	1	2	Highly unlikely to be an option as we cannot increase discharge rate	2	1	2	Continue with adaptive action
All Wastewater treatment	FLOOD	F33	Direct asset flooding causes service failure and asset loss	Direct asset flooding	Asset loss and service failure	2	3	6	Reviewed at Periodic review process and vulnerable assets identified	2	1	2	Continue with adaptive action
All Wastewater treatment	FLOOD	F34	Increased storm frequency and power supply flooding increases frequency of power loss, causing service failure	More frequent storms and power supply flooding	Power outages and service failure	2	3	6	Reviewed at Periodic review process and vulnerable assets identified and generator facility provided	2	1	2	Continue with adaptive action
All Wastewater treatment	FLOOD	F35	Increased duration at FFT causes difficulties with managing performance increasing risk of consent failure.	Longer FFT	Increased risk of consent failure	2	2	4	Separate storm flow and create foul only system	2	1	2	Continue with adaptive action
Site Pumping stations	FLOOD	F36	Increased volumes of storm water require increased pumping in combined sewer systems, causing accelerated asset deterioration	Increased volumes of storm water in combined sewers	Increased pump usage & accelerated asset deterioration	2	2	4	Pump efficiency is monitored	2	1	2	Continue with adaptive action
Treatment works	FLOOD	F37	Extended duration of FFT at WwTW due to duration and storage return affects process regime and causes accelerated asset deterioration and asset failure	Longer FFT at WwTW	Accelerated asset deterioration and failure	2	2	4	Pump efficiency is monitored	2	1	2	Continue with adaptive action

Treatment works	FLOOD	F38	Increased intensity rainfall events and higher average flows cause hydraulic overload of treatment process, causing service loss	More intense rainfall and higher average flows	Service failure	2	1	2	Review storm weir settings as part of consent review	2	1	2	Continue with adaptive action
Treatment works	FLOOD	F39	Dilution of, and rapid variations in, influent flows affects process performance efficiency	More dilution / variability in influent flows	Reduction in process performance efficiency	2	1	2	Separate storm flow and create foul only system	2	1	2	Continue with adaptive action
Treatment works	FLOOD	F40	Increased flushing effect (from sewer or PST washout) leads to higher loads to be treated, affecting process performance efficiency and causing service failure	Increased flushing effect (from sewer or PST washout)	Reduction in process performance efficiency leading to service failure	2	1	2	Separate storm flow and create foul only system	2	1	2	Continue with adaptive action
Treatment works	FLOOD	F41	Longer retention of water in storm tanks leads to increased septicity and operational problems, affecting process performance efficiency and increased odour	Longer retention of water in storm tanks	Reduction in process performance efficiency leading to odour problems	2	2	4	Review storm tank policy and potentially de-sludge requirements	2	1	2	Continue with adaptive action
Outfalls	FLOOD	F42	Higher peak levels at the discharge change outfall hydraulics and back up pumps, causing service failure	Higher peak levels at discharges	Service failure	2	2	4	Review storm tank policy and potentially de-sludge requirements	2	1	2	Continue with adaptive action
All Wastewater treatment	GENERAL	G4	Relocation of permanent and tourist population from drought, temperature rise, flooding or sea level rise (impacts D2, T2, T3, T5, F3, S2) changes supply-demand balance. Response chosen (within WR) impacts wastewater treatment requirements and capacity needed.	Relocation of population from weather, flooding, sea level rise	Impacts wastewater treatment requirements and capacity needed	2	2	4	Population forecasting monitors inward migration and liaison with West Country Tourism will identify potential hotspots	2	1	2	Continue with adaptive action
All Wastewater treatment	SEA LEVEL	S19	Direct asset flooding, storm damage and coastal erosion cause service failure and asset loss	Direct asset flooding, storm damage, coastal erosion or planned retreat	Asset loss and service failure	3	2	6	Reviewed at Periodic review process and vulnerable assets identified	3	1	3	Continue with adaptive action
All Wastewater treatment	SEA LEVEL	S20	Saline intrusion degrades infrastructure, causing accelerated asset deterioration	Saline intrusion	Accelerated asset deterioration	3	2	6	Reviewed at Periodic review process and vulnerable assets identified	3	1	3	Continue with adaptive action
Site Pumping stations	SEA LEVEL	S21	Higher receiving water levels leads to increased pumping requirement , causing accelerated asset deterioration	Higher receiving water levels	Increased asset use and accelerated asset deterioration	1	1	1	Reviewed at Periodic review process and vulnerable assets identified	1	1	1	
Treatment works	SEA LEVEL	S22	Saline intrusion increases sewage salinity which impacts on H2S formation, reduces primary and FST sludge settleability, reduces dewaterability of SAS. Potential impact	Saline intrusion	Accelarated asset deterioration and reduced process performance	3	3	9	Identify areas of saline infiltration and target sewer rehab work	3	2	6	Continue with adaptive action

			on ASP microbiology due to rate of salinity change, dissolved oxygen saturation causing accelerated asset deterioration and reduced process performance										
Outfalls	SEA LEVEL	S23	Higher peak levels at the discharge change outfall hydraulics and back up pumps causing service failure	Higher peak levels at discharges	Service failure	2	1	2	Reviewed at Periodic review process and vulnerable assets identified	2	1	2	Continue with adaptive action
Outfalls	SEA LEVEL	S24	Higher sea levels affect dispersion characteristics, leading to different classification, tightened consent, & H+S risk.	Higher sea levels	Different classification, tightened consent and H&S risk	1	1	1	Reviewed at Periodic review process and vulnerable assets identified. Outfall modelling	1	1	1	
All Wastewater treatment	TEMP. RISE	T32	Higher average and peak temperatures affect structures, buildings, H & V, MEICA plant working life, causing accelerated asset deterioration	Higher average and peak temperatures	Accelerated asset deterioration	1	1	1	MEICA plant monitored to detect deterioration in performance and informs replacement cycle. Thermal imaging	1	1	1	
All Wastewater treatment	TEMP. RISE	T33	Higher temperatures lead to greater microbial action, and increased gas production and risk of ignition endangers H&S of site staff	Higher temperatures	Increased H&S risk	3	1	3	Monitor gas levels in buildings, revise PPE needs	3	1	3	Consider using EX rated equipment and increasing ventilation and enclosing process
All Wastewater treatment	TEMP. RISE	T34	Higher levels of UV decrease microbe propagation & survivability, affecting treatment process	Higher levels of UV	Treatment process effects	1	1	1		1	1	1	
All Wastewater treatment	TEMP. RISE	T35	Higher temperatures and septicity levels reduce works performance, increasing the risk of a consent failure	Higher temperatures	Reduction in treatment process performance and increased risk of consent failure	2	2	4	Review chemical needs of treatment process	2	1	2	Continue with adaptive action
All Wastewater treatment	TEMP. RISE	T36	Higher temperatures lead to increased amenity use (e.g. bathing waters) leading to tightened consent and/or increased H&S risk near discharge points	Higher temperatures	Tighter consents and/or increased H&S risk near discharge points	2	2	4	Reviewed at Periodic review process and vulnerable assets identified	2	1	2	Continue with adaptive action
Site Pumping stations	TEMP. RISE	T37	Increased levels of septicity affect pumping regimes and cause accelerated asset deterioration and increased odour	Greater septicity affecting pumping regimes	Accelerated asset deterioration and increased odour	2	2	4	Reviewed at Periodic review process and vulnerable assets identified	2	1	2	Continue with adaptive action
Treatment works	TEMP. RISE	T38	Increased levels of septicity in received sewage causes increased odour	Greater septicity in received sewage	Increased odour	2	2	4	Review chemical needs of process	2	1	2	Continue with adaptive action

Treatment works	TEMP. RISE	T39	Effluent standards raised to meet temperature-affected Water Quality Objectives [O2 etc], **increasing the risk of a consent failure/pollution incident**	Effluent standards raised to meet temperature-affected Water Quality Objectives	Increased risk of consent failure/pollution incident	2	2	4	Reviewed at Periodic review process and vulnerable assets identified	2	1	2	Continue with adaptive action
Treatment works	TEMP. RISE	T40	Higher rate of biological activity causes **change to process efficiency**	Higher rate of biological activity	Change to process efficiency	1	2	2	Not considered to need any action	1	2	2	
Treatment works	TEMP. RISE	T41	Lower summer flows and reduced freezing frequency lead to increased insect issues and create an **environmental health risk**	Lower summer flows and reduced freezing frequency	Increased environmental health risk	2	2	4	Review protective clothing needs and H&S requirements	2	1	2	Continue with adaptive action
Treatment works	TEMP. RISE	T42	Fewer months below critical process temperatures causes **increase process efficiency**	Fewer months below critical process temperatures	Increased process efficiency	1	2	2	Not considered to need any action	1	2	2	Continue with adaptive action
Treatment works	TEMP. RISE	T43	Increased septicity levels and odour chemicals lead to **increased health risk**	Greater septicity and (use of?) odour chemicals	Increased health risks	2	2	4	Review existing chemical handling procedures	2	1	2	Continue with adaptive action
Treatment works	TEMP. RISE	T44	Increased septicity levels promote growth of undesirable species and inhibit growth of normal aerobic heterotrophs, **affecting process performance efficiency**	Greater septicity	Reduction in process performance efficiency	1	1	1	Review operational target parameters	1	1	1	Continue with adaptive action
Treatment works	TEMP. RISE	T45	Increased septicity in sewers / primary tanks leads to poor primary settlement and increased load onto secondary process **affecting process performance efficiency**	Greater septicity in sewers / primary tanks	Reduction in process performance efficiency	2	1	2	Review operational target parameters	2	1	2	Continue with adaptive action
Treatment works	TEMP. RISE	T46	Increased temperatures lead to lower oxygen transfer efficiency in secondary process, **affecting process performance efficiency**	Increased temperatures	Reduction in process performance efficiency	2	1	2	Review operational target parameters	2	1	2	Continue with adaptive action
Outfalls	TEMP. RISE	T47	Increased levels of septicity lead to increased toxicity, **reducing receiving water quality** and **increasing odour**	Greater septicity	Reduced receiving water quality and increased odour	2	1	2	Review operational target parameters	2	1	2	Continue with adaptive action
Outfalls	TEMP. RISE	T48	Reduced oxygen saturation as water temperature increases, **increasing the risk of a consent failure/pollution incident**	Warmer water leading to reduced oxygen saturation	Increased risk of consent failure/pollution incident	2	1	2	Review operational target parameters	2	1	2	Continue with adaptive action

Asset Level 2: Waste Water Treatment

2080

Level of consequence

1 - **Low impact** resulting in possible intermittent impact on service to customers or damage to assets requiring some repair or maintenance

2 - **Medium impact** causing minor loss of service to some customers or damage to assets (e.g. hosepipe ban, flooding of assets) requiring significant maintenance or replacement work and a review of investment priorities

3 - **High impact** causing major loss of service to customers, significant health & safety issues or damage to assets (e.g. treatment works unable to function, flooding or several hundred properties)

Level of likelihood

1 - **Unlikely** the consequence for service will occur in the 2080s

2 - **Fairly** likely the consequence for service will occur in the 2080s

3 - **Very likely** the consequence for service will occur in the 2080s

2080s

ASSET LEVEL 3	CLIMATE VARIABLE	MHW IMPACT REF.	DESCRIPTION	PRIMARY IMPACT OF CLIMATE VARIABLE	POTENTIAL IMPACTS ON ORGANISATION AND STAKEHOLDERS	Consequence for service			COMPANY'S ADAPTIVE ACTIONS	Company's residual risk			COMPANY'S PROPOSED ACTION TO MITIGATE RESIDUAL IMPACTS
						Level of consequence	Level of likelihood	Level of risk		Level of consequence	Level of likelihood	Level of risk	
All Wastewater treatment	DROUGHT	D28	Changes in domestic waste disposal patterns lead to changes in dry weather flow pollutants, affecting treatment process.	Reduced dry weather flow and change in domestic waste disposal	Affects treatment processes	1	2	2	Routine Sampling, MCERTS Data trend analysis	1	1	1	
Site Pumping stations	DROUGHT	D29	Lower average and minimum sewage carry flows reduce quality in rivers reducing environmental water quality	Lower average and minimum sewage flows	Reduced environmental water quality	1	1	1	Not considered to need any action	1	1	1	
Site Pumping stations	DROUGHT	D30	Lower average and peak 'carry' flows lead to settlement in the system, affecting pumping regimes and causing accelerated asset deterioration	Lower average and peak flows	Accelerated asset deterioration	2	2	4	Pump condition is monitored	2	1	2	Continue with adaptive action

Treatment works	DROUGHT	D31	Lower average and peak 'carry' flows lead to settlement in the system, with shock loads affecting process regimes and causing accelerated asset deterioration and H&S risk	Lower average and peak flows	Accelerated asset deterioration and H&S risk	2	2	4	General Maintenance Regime, Planned Prevention Measures	2	1	2	Continue with adaptive action
Treatment works	DROUGHT	D32	Lower average and peak 'carry' flows reduce volumes received at WWTW and affects process regime	Lower average and peak flows	Affects process regime	2	2	4	Periodic review process, final effluent monitoring, PUROS	2	1	2	Continue with adaptive action
Treatment works	DROUGHT	D33	Lower average and peak 'carry' flows reduce wetting rates onto process requiring minimum HLR (e.g. trickling filters), increasing need for recirculation pumping	Lower average and peak flows	Increased need for recirculation pumping	1	3	3	Review whether recirculation is needed. Review process type, introduce recirculation, Consider use of natural media	2	1	2	Continue with adaptive action
Treatment works	DROUGHT	D34	Lower average and peak 'carry' flows increases retention times in settlement tanks leading to increased septicity / odour problems.	Lower average and peak flows	Increased septicity / odour problems	2	1	2	Review tank size and mode of operation - could be a good thing	2	1	2	Continue with adaptive action
Treatment works	DROUGHT	D35	Lower river flows, increased seasonal variability and reduced water quality lead to the tightening of discharge consents, increasing the risk of a consent failure/pollution incident	Lower river flows & increased seasonal variability	Reduced water quality, increased risk of a consent failure / pollution incident	2	3	6	Periodic review process - review treatment process	2	1	2	Continue with adaptive action
Outfalls	DROUGHT	D36	Lower river flows mean effluent is required to maintain river flows, reducing flexibility and increasing the risk of a consent failure/pollution incident	Lower river flows	Reducing flexibility and increased risk of a consent failure / pollution incident	2	1	2	Highly unlikely to be an option as we cannot increase discharge rate	2	1	2	Continue with adaptive action
All Wastewater treatment	FLOOD	F33	Direct asset flooding causes service failure and asset loss	Direct asset flooding	Asset loss and service failure	2	3	6	Reviewed at Periodic review process and vulnerable assets identified	2	1	2	Continue with adaptive action
All Wastewater treatment	FLOOD	F34	Increased storm frequency and power supply flooding increases frequency of power loss, causing service failure	More frequent storms and power supply flooding	Power outages and service failure	2	3	6	Reviewed at Periodic review process and vulnerable assets identified and generator facility installed	2	2	4	Continue with adaptive action
All Wastewater treatment	FLOOD	F35	Increased duration at FFT causes difficulties with managing performance increasing risk of consent failure.	Longer FFT	Increased risk of consent failure	2	3	6	Separate storm flow and create foul only system	2	1	2	Continue with adaptive action
Site Pumping stations	FLOOD	F36	Increased volumes of storm water require increased pumping in combined sewer systems, causing accelerated asset deterioration	Increased volumes of storm water in combined sewers	Increased pump usage & accelerated asset deterioration	2	3	6	Pump efficiency is monitored	2	1	2	Continue with adaptive action
Treatment works	FLOOD	F37	Extended duration of FFT at WwTW due to duration and storage return affects process regime and causes accelerated asset deterioration and asset failure	Longer FFT at WwTW	Accelerated asset deterioration and failure	2	3	6	Pump efficiency is monitored	2	1	2	Continue with adaptive action
Treatment works	FLOOD	F38	Increased intensity rainfall events and higher average flows cause hydraulic overload of treatment process, causing service loss	More intense rainfall and higher average flows	Service failure	2	2	4	Review storm weir settings as part of consent review	2	1	2	Continue with adaptive action

Treatment works	FLOOD	F39	Dilution of, and rapid variations in, influent flows affects process performance efficiency	More dilution / variability in influent flows	Reduction in process performance efficiency	2	2	4	Separate storm flow and create foul only system	2	1	2	Continue with adaptive action
Treatment works	FLOOD	F40	Increased flushing effect (from sewer or PST washout) leads to higher loads to be treated, affecting process performance efficiency and causing service failure	Increased flushing effect (from sewer or PST washout)	Reduction in process performance efficiency leading to service failure	2	2	4	Separate storm flow and create foul only system	2	1	2	Continue with adaptive action
Treatment works	FLOOD	F41	Longer retention of water in storm tanks leads to increased septicity and operational problems, affecting process performance efficiency and increased odour	Longer retention of water in storm tanks	Reduction in process performance efficiency leading to odour problems	2	3	6	Review storm tank policy and potentially de-sludge requirements	2	1	2	Continue with adaptive action
Outfalls	FLOOD	F42	Higher peak levels at the discharge change outfall hydraulics and back up pumps, causing service failure	Higher peak levels at discharges	Service failure	2	3	6	Review storm tank policy and potentially de-sludge requirements	2	1	2	Continue with adaptive action
All Wastewater treatment	GENERAL	G4	Relocation of permanent and tourist population from drought, temperature rise, flooding or sea level rise (impacts D2, T2, T3, T5, F3, S2) changes supply-demand balance. Response chosen (within WR) impacts wastewater treatment requirements and capacity needed.	Relocation of population from weather, flooding, sea level rise	Impacts wastewater treatment requirements and capacity needed	2	2	4	Population forecasting monitors inward migration and liaison with Wesst Country Tourism will identify potential hotspots	2	1	2	Continue with adaptive action
All Wastewater treatment	SEA LEVEL	S19	Direct asset flooding, storm damage and coastal erosion cause service failure and asset loss	Direct asset flooding, storm damage, coastal erosion or planned retreat	Asset loss and service failure	3	3	9	Reviewed at Periodic review process and vulnerable assets identified	3	1	3	Continue with adaptive action
All Wastewater treatment	SEA LEVEL	S20	Saline intrusion degrades infrastructure, causing accelerated asset deterioration	Saline intrusion	Accelerated asset deterioration	3	3	9	Reviewed at Periodic review process and vulnerable assets identified	3	1	3	Continue with adaptive action
Site Pumping stations	SEA LEVEL	S21	Higher receiving water levels leads to increased pumping requirement , causing accelerated asset deterioration	Higher receiving water levels	Increased asset use and accelerated asset deterioration	1	2	2	Reviewed at Periodic review process and vulnerable assets identified	1	1	1	
Treatment works	SEA LEVEL	S22	Saline intrusion increases sewage salinity which impacts on H2S formation, reduces primary and FST sludge settleability, reduces dewaterability of SAS. Potential impact on ASP microbiology due to rate of salinity change, dissolved oxygen saturation causing accelerated asset deterioration and reduced process performance	Saline intrusion	Accelerated asset deterioration and reduced process performance	3	3	9	Identify areas of saline infiltration and target sewer rehab work	3	1	3	Continue with adaptive action
Outfalls	SEA LEVEL	S23	Higher peak levels at the discharge change outfall hydraulics and back up pumps causing service failure	Higher peak levels at discharges	Service failure	2	2	4	Reviewed at Periodic review process and vulnerable assets identified	2	1	2	Continue with adaptive action
Outfalls	SEA LEVEL	S24	Higher sea levels affect dispersion characteristics, leading to different classification, tightened consent, & H+S risk.	Higher sea levels	Different classification, tightened consent and H&S risk	1	2	2	Reviewed at Periodic review process and vulnerable assets identified. Outfall modelling	1	1	1	

All Wastewater treatment	TEMP. RISE	T32	Higher average and peak temperatures affect structures, buildings, H & V, MEICA plant working life, causing accelerated asset deterioration	Higher average and peak temperatures	Accelerated asset deterioration	1	2	2	MEICA plant monitored to detect deterioration in performance and informs replacement cycle. Thermal imaging	1	1	1	
All Wastewater treatment	TEMP. RISE	T33	Higher temperatures lead to greater microbial action, and increased gas production and risk of ignition endangers H&S of site staff	Higher temperatures	Increased H&S risk	3	2	6	Monitor gas levels in buildings, revise PPE needs	3	1	3	Consider using EX rated equipment and increasing ventilation and enclosing process
All Wastewater treatment	TEMP. RISE	T34	Higher levels of UV decrease microbe propagation & survivability, affecting treatment process	Higher levels of UV	Treatment process effects	1	2	2	Process efficiency is monitored	1	1	1	
All Wastewater treatment	TEMP. RISE	T35	Higher temperatures and septicity levels reduce works performance, increasing the risk of a consent failure	Higher temperatures	Reduction in treatment process performance and increased risk of consent failure	2	3	6	Review chemical needs of treatment process	2	1	2	Continue with adaptive action
All Wastewater treatment	TEMP. RISE	T36	Higher temperatures lead to increased amenity use (e.g. bathing waters) leading to tightened consent and/or increased H&S risk near discharge points	Higher temperatures	Tighter consents and/or increased H&S risk near discharge points	2	3	6	Reviewed at Periodic review process and vulnerable assets identified	2	1	2	Continue with adaptive action
Site Pumping stations	TEMP. RISE	T37	Increased levels of septicity affect pumping regimes and cause accelerated asset deterioration and increased odour	Greater septicity affecting pumping regimes	Accelerated asset deterioration and increased odour	2	3	6	Reviewed at Periodic review process and vulnerable assets identified	2	1	2	Continue with adaptive action
Treatment works	TEMP. RISE	T38	Increased levels of septicity in received sewage causes increased odour	Greater septicity in received sewage	Increased odour	2	3	6	Review chemical needs of process	2	1	2	Continue with adaptive action
Treatment works	TEMP. RISE	T39	Effluent standards raised to meet temperature-affected Water Quality Objectives [O2 etc], increasing the risk of a consent failure/pollution incident	Effluent standards raised to meet temperature-affected Water Quality Objectives	Increased risk of consent failure/pollution incident	2	3	6	Reviewed at Periodic review process and vulnerable assets identified	2	1	2	Continue with adaptive action
Treatment works	TEMP. RISE	T40	Higher rate of biological activity causes change to process efficiency	Higher rate of biological activity	Change to process efficiency	1	3	3	Not considered to need any action	1	3	3	
Treatment works	TEMP. RISE	T41	Lower summer flows and reduced freezing frequency lead to increased insect issues and create an environmental health risk	Lower summer flows and reduced freezing frequency	Increased environmental health risk	2	3	6	Review protective clothing needs and H&S requirements	2	1	2	Continue with adaptive action
Treatment works	TEMP. RISE	T42	Fewer months below critical process temperatures causes increase process efficiency	Fewer months below critical process temperatures	Increased process efficiency	1	3	3	Not considered to need any action	1	3	3	Continue with adaptive action
Treatment works	TEMP. RISE	T43	Increased septicity levels and odour chemicals lead to increased health risk	Greater septicity and (use of?) odour chemicals	Increased health risks	2	3	6	Review existing chemical handling procedures	2	1	2	Continue with adaptive action
Treatment works	TEMP. RISE	T44	Increased septicity levels promote growth of undesirable species and inhibit growth of normal aerobic heterotrophs, affecting process performance efficiency	Greater septicity	Reduction in process performance efficiency	1	2	2	Review operational target parameters	1	1	1	Continue with adaptive action

Treatment works	TEMP. RISE	T45	Increased septicity in sewers / primary tanks leads to poor primary settlement and increased load onto secondary process affecting process performance efficiency	Greater septicity in sewers / primary tanks	Reduction in process performance efficiency	2	2	4	Review operational target parameters	2	1	2	Continue with adaptive action
Treatment works	TEMP. RISE	T46	Increased temperatures lead to lower oxygen transfer efficiency in secondary process, affecting process performance efficiency	Increased temperatures	Reduction in process performance efficiency	2	2	4	Review operational target parameters	2	1	2	Continue with adaptive action
Outfalls	TEMP. RISE	T47	Increased levels of septicity lead to increased toxicity, reducing receiving water quality and increasing odour	Greater septicity	Reduced receiving water quality and increased odour	2	2	4	Review operational target parameters	2	1	2	Continue with adaptive action
Outfalls	TEMP. RISE	T48	Reduced oxygen saturation as water temperature increases, increasing the risk of a consent failure/pollution incident	Warmer water leading to reduced oxygen saturation	Increased risk of consent failure/pollution incident	2	2	4	Review operational target parameters	2	1	2	Continue with adaptive action

Asset Level 2: Waste Water Networks

2020

Level of consequence

1 - **Low impact** resulting in possible intermittent impact on service to customers or damage to assets requiring some repair or maintenance

2 - **Medium impact** causing minor loss of service to some customers or damage to assets (e.g. hosepipe ban, flooding of assets) requiring significant maintenance or replacement work and a review of investment priorities

3 - **High impact** causing major loss of service to customers, significant health & safety issues or damage to assets (e.g. treatment works unable to function, flooding or several hundred properties)

Level of likelihood

1 - **Unlikely** the consequence for service will occur in the 2020s

2 - **Fairly** likely the consequence for service will occur in the 2020s

3 - **Very likely** the consequence for service will occur in the 2020s

2020s

ASSET LEVEL 3	CLIMATE VARIABLE	MHW IMPACT REF.	DESCRIPTION	PRIMARY IMPACT OF CLIMATE VARIABLE	POTENTIAL IMPACTS ON ORGANISATION AND STAKEHOLDERS	Consequence for service			COMPANY'S ADAPTIVE ACTIONS	Company's residual risk			COMPANY'S PROPOSED ACTION TO MITIGATE RESIDUAL IMPACTS
						Level of consequence	Level of likelihood	Level of risk		Level of consequence	Level of likelihood	Level of risk	
Sewer networks, incl./trunk sewers	DROUGHT	D24	Lower precipitation, infiltration & inflow and water conservation lead to lower average and peak 'carry' flows, resulting in greater sewer deposits and more frequent blockages, causing customer flooding	Lower precipitation, infiltration & inflow plus water conservation	More frequent sewer blockages and increased customer flooding	2	1	2	As blockage rates increase more regular and pro-active jetting will be required	2	1	2	Continue with adaptive action
Pumping stations	DROUGHT	D25	Lower average and peak 'carry' flows lead to settlement in the system, affecting pumping regimes and causing accelerated asset deterioration	Lower average and peak flows	Accelerated asset deterioration	2	1	2	Pumps are monitored and maintained on a regular basis	2	1	2	Continue with adaptive action

Rising mains	DROUGHT	D26	Lower average and peak 'carry' flows lead to H2S settlement in the system, causing accelerated asset deterioration	Lower average and peak flows	Accelerated asset deterioration	2	1	2	Reduce size of duty pump so that the pump runs more frequently and keeps the main running more often albeit at a lower velocity	2	1	2	Continue with adaptive action
CSOs and overflows	DROUGHT	D27	Lower average and peak 'carry' flows lead to settlement in the system, with shock loads causing CSO H&S risk and reduced receiving water quality	Lower average and peak flows	Reduced receiving water quality and CSO H&S risk	2	1	2	Jetting on a reactive basis and surface water separation policy.	2	1	2	Continue with adaptive action
All wastewater networks	FLOOD	F21	Direct asset flooding causes service failure and asset loss	Direct asset flooding	Asset loss and service failure	2	2	4	Periodic review process will identify vulnerable areas	2	1	2	Continue with adaptive action
All wastewater networks	FLOOD	F22	Increased storm frequency increases frequency of power loss, causing service failure	More frequent storms and power supply flooding	Power outages and service failure	2	2	4	Periodic review process will identify vulnerable sites. Some sites have standby generation	2	1	2	Investigate lightning protection
Sewer networks, incl./trunk sewers	FLOOD	F23	Higher rainfall intensities lead to runoff exceeding combined sewer capacity, causing surface flooding and reducing receiving water quality	Higher rainfall intensities	Surface flooding and reduced receiving water quality	2	1	2	Review capacities of Foul only system with SuDS for storm flows	1	1	1	Continue with adaptive action
Sewer networks, incl./trunk sewers	FLOOD	F24	Increased volumes of storm water in combined sewers exceeds sewer capacity and causes customer flooding	Increased volumes of storm water	Customer flooding	2	1	2	Review capacities of Foul only system with SuDS for storm flows	1	1	1	Continue with adaptive action
Sewer networks, incl./trunk sewers	FLOOD	F25	Higher groundwater levels cause increased infiltration into sewers, causing customer flooding	Higher groundwater levels	Customer flooding	2	1	2	Increase rehab of sewers	2	1	2	Continue with adaptive action
Sewer networks, incl./trunk sewers	FLOOD	F26	Change in customer behaviour lead to increased instances of sewer misuse (dumping down sewer) leading to blockages which cause sewer flooding and reduce environmental water quality	Increased sewer misuse	Blockages, sewer flooding and reduced environmental water quality	2	2	4	Jetting on a reactive basis. Customer communication plan leading to improved education	2	1	2	Continue with adaptive action
Pumping stations	FLOOD	F27	Increased volumes of storm water exceed pump capacity, causing service failure and impacting on receiving water quality at outfall	Increased volumes of storm water	Service failure and reduced receiving water quality	2	1	2	Surface water separation with Foul only system with SuDS for storm flows	1	1	1	Continue with adaptive action
Pumping stations	FLOOD	F28	Increased volumes of storm water require increased pumping in combined sewer systems, causing accelerated asset deterioration	Increased volumes of storm water in combined sewers	Increased pump usage & accelerated asset deterioration	2	1	2	Pump performance monitoring ,Foul only system with SuDS for storm flows	1	1	1	Continue with adaptive action

Rising mains	FLOOD	F29	Increased volumes of storm water exceed raising main capacity, causing burst and subsequent service failure	Increased volumes of storm water	Increased bursts and service failure	2	1	2	Ensure pump capacity does not exceed main capacity	2	1	2	Continue with adaptive action
CSOs and overflows	FLOOD	F30	Higher storm intensity means CSOs spill more frequently, impacting on receiving water quality	Higher storm intensity	Increased CSO spill frequency and reduced receiving water quality	2	3	6	Re-engineer CSO, surface water separation and delivering system	2	2	4	Foul only system with SuDS for storm flows
CSOs and overflows	FLOOD	F31	Higher winter flows dilute and reduce the effect of spills, reducing impact of spills and improving receiving water quality	Higher winter flows	Improved receiving water quality	1	1	1		1	1	1	
CSOs and overflows	FLOOD	F32	Increased flood incidence increases risk of failure of 'spills per bathing season' type consents.	More frequent flooding	Increased risk of failing 'spills per bathing season' consents	2	2	4	Re-engineer CSO and delivering system	2	1	2	Foul only system with SuDS for storm flows
All wastewater networks	GENERAL	G3	Relocation of permanent and tourist population from drought, temperature rise, flooding or sea level rise (impacts D2, T2, T3, T5, F3, S2) changes supply-demand balance. Response chosen (within WR) impacts wastewater networks requirements and capacity needed.	Relocation of population from weather, flooding, sea level rise	Impacts wastewater network requirements and capacity and reduced security of supply	2	1	2	Water Resource Plan identifies inward migration trends	2	1	2	Continue with adaptive action
All wastewater networks	SEA LEVEL	S12	Direct asset flooding, storm damage and coastal erosion or planned retreat cause service failure and asset loss	Direct asset flooding, storm damage, coastal erosion or planned retreat	Asset loss and service failure	2	1	2	Periodic review process will identify vulnerable sites allowing re-engineering of site	2	1	2	Continue with adaptive action
All wastewater networks	SEA LEVEL	S13	Saline intrusion degrades infrastructure, causing accelerated asset deterioration	Saline intrusion	Accelerated asset deterioration	2	1	2	Periodic review process and increased sewer rehab will identify vulnerable sites	2	1	2	Continue with adaptive action
Sewer networks, incl./trunk sewers	SEA LEVEL	S14	High rainfall and high tides coinciding causes increased customer flooding and reduce receiving water quality	High rainfall adding to high tides	Increased customer flooding and reduced receiving water quality	2	1	2	Reduce infiltration in low lying coastal areas slowing re-engineering of asset	2	1	2	Foul only system with SuDS for storm flows
Sewer networks, incl./trunk sewers	SEA LEVEL	S15	Saline intrusion and subsequent H2S formation in sewer creates environmental health risk	Saline intrusion	Environmental health risk	2	1	2	Increase rehab of sewers in areas of saline infiltration	2	1	2	Improved ventilation at SPS
Sewer networks, incl./trunk sewers	SEA LEVEL	S16	Saline intrusion increases corrosion, leading to accelerated asset deterioration	Saline intrusion	Accelerated asset deterioration	2	1	2	Periodic review process will identify vulnerable sites and allow re-engineering	2	1	2	Continue with adaptive action

CSOs and overflows	SEA LEVEL	S17	Costal estuarine CSO discharges become tide-locked, hindering free discharge and causing customer flooding and reducing received water quality	Tide locked intermittent discharges	Customer flooding and reduced receiving water quality	2	1	2	Re-engineer CSO and delivering system	2	1	2	Foul only system with SuDS for storm flows
CSOs and overflows	SEA LEVEL	S18	High rainfall and high tides coincide and affect CSO discharges, reducing receiving water quality	High rainfall adding to high tides	reducing receiving water quality	2	1	2	Foul only system with surface water sewer for storm flows	1	1	1	Continue with adaptive action
All wastewater networks	TEMP. RISE	T24	Higher average and peak temperatures affect structures, buildings, H & V, MEICA plant working life, causing accelerated asset deterioration	Higher average and peak temperatures	Accelerated asset deterioration	1	1	1	MEICA plant monitored to detect deterioration, asset surveys carried out	1	1	1	
All wastewater networks	TEMP. RISE	T25	Higher temperatures lead to greater microbial action, and increased gas production and risk of ignition endangers H&S of site staff	Higher temperatures	Increased H&S risks	3	1	3	Monitor gas levels in building and sumps and network	3	1	3	Continue with adaptive action
Sewer networks, incl./trunk sewers	TEMP. RISE	T26	Greater extremities in wetting and drying cycles lead to greater soil movement, causing pipe systems to move, leading to accelerated asset deterioration and customer flooding	More extreme wetting and drying cycles	Accelerated asset deterioration and customer flooding	2	1	2	Periodic review will identify vulnerable assets	1	1	1	
Sewer networks, incl.trunk sewers	TEMP. RISE	T27	Increased levels of septicity cause accelerated asset deterioration and increased odour	Greater septicity	Accelerated asset deterioration and increased odour	2	1	2	Consider using chemicals to combat septicity	2	1	2	Continue with adaptive action
Pumping stations	TEMP. RISE	T28	Increased levels of septicity affect pumping regimes and causes accelerated asset deterioration and increased odour	Greater septicity affecting pumping regimes	Accelerated asset deterioration and increased odour	2	1	2	MEICA plant monitored to detect deterioration, asset surveys carried out	2	1	2	Continue with adaptive action
Rising mains	TEMP. RISE	T29	Greater extremities in wetting and drying cycles lead to greater soil movement, causing pipe systems to move, leading to accelerated asset deterioration and customer flooding	More extreme wetting and drying cycles	Accelerated asset deterioration and customer flooding	2	1	1	Periodic review will identify vulnerable assets	2	1	1	
Rising mains	TEMP. RISE	T30	Increased levels of septicity cause accelerated asset deterioration and increased odour	Greater septicity	Accelerated asset deterioration and increased odour	2	1	2	Consider using chemicals to combat septicity	2	1	2	Continue with adaptive action
CSOs and overflows	TEMP. RISE	T31	Increased levels of septicity lead to increased toxicity, reduced receiving water quality and increased odour	Greater septicity	Increased toxicity & odour and lower receiving water quality	2	1	2	Consider using chemicals to combat septicity and re-engineer CSOs	2	1	2	Continue with adaptive action

Asset Level 2: Waste Water Networks

2050

Level of consequence

1 - **Low impact** resulting in possible intermittent impact on service to customers or damage to assets requiring some repair or maintenance

2 - **Medium impact** causing minor loss of service to some customers or damage to assets (e.g. hosepipe ban, flooding of assets) requiring significant maintenance or replacement work and a review of investment priorities

3 - **High impact** causing major loss of service to customers, significant health & safety issues or damage to assets (e.g. treatment works unable to function, flooding or several hundred properties)

Level of likelihood

1 - **Unlikely** the consequence for service will occur in the 2050s

2 - **Fairly** likely the consequence for service will occur in the 2050s

3 - **Very likely** the consequence for service will occur in the 2050s

						2050s							
						Consequence for service				Company's residual risk			
ASSET LEVEL 3	CLIMATE VARIABLE	MHW IMPACT REF.	DESCRIPTION	PRIMARY IMPACT OF CLIMATE VARIABLE	POTENTIAL IMPACTS ON ORGANISATION AND STAKEHOLDERS	Level of consequence	Level of likelihood	Level of risk	COMPANY'S ADAPTIVE ACTIONS	Level of consequence	Level of likelihood	Level of risk	COMPANY'S PROPOSED ACTION TO MITIGATE RESIDUAL IMPACTS
Sewer networks, incl./trunk sewers	DROUGHT	D24	Lower precipitation, infiltration & inflow and water conservation lead to lower average and peak 'carry' flows, resulting in greater sewer deposits and more frequent blockages, causing customer flooding	Lower precipitation, infiltration & inflow plus water conservation	More frequent sewer blockages and increased customer flooding	2	2	4	As blockage rates increase more regular and pro-active jetting will be required	2	1	2	Continue with adaptive action
Pumping stations	DROUGHT	D25	Lower average and peak 'carry' flows lead to settlement in the system, affecting pumping regimes and causing accelerated asset deterioration	Lower average and peak flows	Accelerated asset deterioration	2	2	4	Pumps are monitored and maintained on a regular basis	2	1	2	Continue with adaptive action

Rising mains	DROUGHT	D26	Lower average and peak 'carry' flows lead to H2S settlement in the system, causing accelerated asset deterioration	Lower average and peak flows	Accelerated asset deterioration	2	1	2	Reduce size of duty pump so that the pump runs more frequently and keeps the main running more often albeit at a lower velocity	2	1	2	Continue with adaptive action
CSOs and overflows	DROUGHT	D27	Lower average and peak 'carry' flows lead to settlement in the system, with shock loads causing CSO H&S risk and reduced receiving water quality	Lower average and peak flows	Reduced receiving water quality and CSO H&S risk	2	1	2	Jetting on a reactive basis and surface water separation policy.	2	1	2	Continue with adaptive action
All wastewater networks	FLOOD	F21	Direct asset flooding causes service failure and asset loss	Direct asset flooding	Asset loss and service failure	2	3	6	Periodic review process will identify vulnerable areas	2	1	2	Continue with adaptive action
All wastewater networks	FLOOD	F22	Increased storm frequency increases frequency of power loss, causing service failure	More frequent storms and power supply flooding	Power outages and service failure	2	3	6	Periodic review process will identify vulnerable sites. Some sites have standby generation	2	1	2	Investigate lightning protection
Sewer networks, incl./trunk sewers	FLOOD	F23	Higher rainfall intensities lead to runoff exceeding combined sewer capacity, causing surface flooding and reducing receiving water quality	Higher rainfall intensities	Surface flooding and reduced receiving water quality	2	2	4	Review capacities of Foul only system with SuDS for storm flows	1	1	1	Continue with adaptive action
Sewer networks, incl./trunk sewers	FLOOD	F24	Increased volumes of storm water in combined sewers exceeds sewer capacity and causes customer flooding	Increased volumes of storm water	Customer flooding	2	2	4	Review capacities of Foul only system with SuDS for storm flows	1	1	1	Continue with adaptive action
Sewer networks, incl./trunk sewers	FLOOD	F25	Higher groundwater levels cause increased infiltration into sewers, causing customer flooding	Higher groundwater levels	Customer flooding	2	2	4	Increase rehab of sewers	2	1	2	Continue with adaptive action
Sewer networks, incl./trunk sewers	FLOOD	F26	Change in customer behaviour lead to increased instances of sewer misuse (dumping down sewer) leading to blockages which cause sewer flooding and reduce environmental water quality	Increased sewer misuse	Blockages, sewer flooding and reduced environmental water quality	2	2	4	Jetting on a reactive basis. Customer communication plan leading to improved education	2	1	2	Continue with adaptive action
Pumping stations	FLOOD	F27	Increased volumes of storm water exceed pump capacity, causing service failure and impacting on receiving water quality at outfall	Increased volumes of storm water	Service failure and reduced receiving water quality	2	2	4	Surface water separation with Foul only system with SuDS for storm flows	1	1	1	Continue with adaptive action
Pumping stations	FLOOD	F28	Increased volumes of storm water require increased pumping in combined sewer systems, causing accelerated asset deterioration	Increased volumes of storm water in combined sewers	Increased pump usage & accelerated asset deterioration	2	2	4	Pump performance monitoring ,Foul only system with SuDS for storm flows	1	1	1	Continue with adaptive action
Rising mains	FLOOD	F29	Increased volumes of storm water exceed raising main capacity, causing burst and subsequent service failure	Increased volumes of storm water	Increased bursts and service failure	2	1	2	Ensure pump capacity does not exceed main capacity	2	1	2	Continue with adaptive action

CSOs and overflows	FLOOD	F30	Higher storm intensity means CSOs spill more frequently, impacting on receiving water quality	Higher storm intensity	Increased CSO spill frequency and reduced receiving water quality	3	3	9	Re-engineer CSO, surface water separation and delivering system	2	2	4	Foul only system with SuDS for storm flows
CSOs and overflows	FLOOD	F31	Higher winter flows dilute and reduce the effect of spills, reducing impact of spills and improving receiving water quality	Higher winter flows	Improved receiving water quality	1	2	2		1	2	2	
CSOs and overflows	FLOOD	F32	Increased flood incidence increases risk of failure of 'spills per bathing season' type consents.	More frequent flooding	Increased risk of failing 'spills per bathing season' consents	2	2	4	Re-engineer CSO and delivering system	2	1	2	Foul only system with SuDS for storm flows
All wastewater networks	GENERAL	G3	Relocation of permanent and tourist population from drought, temperature rise, flooding or sea level rise (impacts D2, T2, T3, T5, F3, S2) changes supply-demand balance. Response chosen (within WR) impacts wastewater networks requirements and capacity needed	Relocation of population from weather, flooding, sea level rise	Impacts wastewater network requirements and capacity and reduced security of supply	2	2	4	Water Resource Plan identifies inward migration trends	2	1	2	Continue with adaptive action
All wastewater networks	SEA LEVEL	S12	Direct asset flooding, storm damage and coastal erosion or planned retreat cause service failure and asset loss	Direct asset flooding, storm damage, coastal erosion or planned retreat	Asset loss and service failure	2	2	4	Periodic review process will identify vulnerable sites allowing re-engineering of site	2	1	2	Continue with adaptive action
All wastewater networks	SEA LEVEL	S13	Saline intrusion degrades infrastructure, causing accelerated asset deterioration	Saline intrusion	Accelerated asset deterioration	2	2	4	Periodic review process and increased sewer rehab will identify vulnerable sites	2	1	2	Continue with adaptive action
Sewer networks, incl./trunk sewers	SEA LEVEL	S14	High rainfall and high tides coinciding causes increased customer flooding and reduce receiving water quality	High rainfall adding to high tides	Increased customer flooding and reduced receiving water quality	2	2	4	Reduce infiltration in low lying coastal areas slowing re-engineering of asset	2	1	2	Foul only system with SuDS for storm flows
Sewer networks, incl./trunk sewers	SEA LEVEL	S15	Saline intrusion and subsequent H2S formation in sewer creates environmental health risk	Saline intrusion	Environmental health risk	2	2	4	Increase rehab of sewers in areas of saline infiltration	2	1	2	Improved ventilation at SPS
Sewer networks, incl./trunk sewers	SEA LEVEL	S16	Saline intrusion increases corrosion, leading to accelerated asset deterioration	Saline intrusion	Accelerated asset deterioration	2	2	4	Periodic review process will identify vulnerable sites and allow re-engineering	2	1	2	Continue with adaptive action
CSOs and overflows	SEA LEVEL	S17	Costal estuarine CSO discharges become tide-locked, hindering free discharge and causing customer flooding and reducing received water quality	Tide locked intermittent discharges	Customer flooding and reduced receiving water quality	2	2	4	Re-engineer CSO and delivering system	2	1	2	Foul only system with SuDS for storm flows

CSOs and overflows	SEA LEVEL	S18	High rainfall and high tides coincide and affect CSO discharges, reducing receiving water quality	High rainfall adding to high tides	reducing receiving water quality	2	2	4	Foul only system with surface water sewer for storm flows	1	1	1	Continue with adaptive action
All wastewater networks	TEMP. RISE	T24	Higher average and peak temperatures affect structures, buildings, H & V, MEICA plant working life, causing accelerated asset deterioration	Higher average and peak temperatures	Accelerated asset deterioration	1	1	1	MEICA plant monitored to detect deterioration, asset surveys carried out	1	1	1	
All wastewater networks	TEMP. RISE	T25	Higher temperatures lead to greater microbial action, and increased gas production and risk of ignition endangers H&S of site staff	Higher temperatures	Increased H&S risks	3	1	3	Monitor gas levels in building and sumps and network	3	1	3	Continue with adaptive action
Sewer networks, incl./trunk sewers	TEMP. RISE	T26	Greater extremities in wetting and drying cycles lead to greater soil movement, causing pipe systems to move, leading to accelerated asset deterioration and customer flooding	More extreme wetting and drying cycles	Accelerated asset deterioration and customer flooding	1	1	1	Periodic review will identify vulnerable assets	1	1	1	
Sewer networks, incl.trunk sewers	TEMP. RISE	T27	Increased levels of septicity cause accelerated asset deterioration and increased odour	Greater septicity	Accelerated asset deterioration and increased odour	2	2	4	Consider using chemicals to combat septicity	2	1	2	Continue with adaptive action
Pumping stations	TEMP. RISE	T28	Increased levels of septicity affect pumping regimes and causes accelerated asset deterioration and increased odour	Greater septicity affecting pumping regimes	Accelerated asset deterioration and increased odour	2	2	4	MEICA plant monitored to detect deterioration, asset surveys carried out	2	1	2	Continue with adaptive action
Rising mains	TEMP. RISE	T29	Greater extremities in wetting and drying cycles lead to greater soil movement, causing pipe systems to move, leading to accelerated asset deterioration and customer flooding	More extreme wetting and drying cycles	Accelerated asset deterioration and customer flooding	2	1	2	Periodic review will identify vulnerable assets	1	1	1	
Rising mains	TEMP. RISE	T30	Increased levels of septicity cause accelerated asset deterioration and increased odour	Greater septicity	Accelerated asset deterioration and increased odour	2	2	4	Consider using chemicals to combat septicity	2	1	2	Continue with adaptive action
CSOs and overflows	TEMP. RISE	T31	Increased levels of septicity lead to increased toxicity, reduced receiving water quality and increased odour	Greater septicity	Increased toxicity & odour and lower receiving water quality	2	2	4	Consider using chemicals to combat septicity and re-engineer CSOs	2	1	2	Continue with adaptive action

Asset Level 2: Waste Water Networks

2080

Level of consequence

1 - **Low impact** resulting in possible intermittent impact on service to customers or damage to assets requiring some repair or maintenance

2 - **Medium impact** causing minor loss of service to some customers or damage to assets (e.g. hosepipe ban, flooding of assets) requiring significant maintenance or replacement work and a review of investment priorities

3 - **High impact** causing major loss of service to customers, significant health & safety issues or damage to assets (e.g. treatment works unable to function, flooding or several hundred properties)

Level of likelihood

1 - **Unlikely** the consequence for service will occur in the 2080s

2 - **Fairly** likely the consequence for service will occur in the 2080s

3 - **Very likely** the consequence for service will occur in the 2080s

2080s

ASSET LEVEL 3	CLIMATE VARIABLE	MHW IMPACT REF.	DESCRIPTION	PRIMARY IMPACT OF CLIMATE VARIABLE	POTENTIAL IMPACTS ON ORGANISATION AND STAKEHOLDERS	Consequence for service			COMPANY'S ADAPTIVE ACTIONS	Company's residual risk			COMPANY'S PROPOSED ACTION TO MITIGATE RESIDUAL IMPACTS
						Level of consequence	Level of likelihood	Level of risk		Level of consequence	Level of likelihood	Level of risk	
Sewer networks, incl./trunk sewers	DROUGHT	D24	Lower precipitation, infiltration & inflow and water conservation lead to lower average and peak 'carry' flows, resulting in greater sewer deposits and more frequent blockages, causing customer flooding	Lower precipitation, infiltration & inflow plus water conservation	More frequent sewer blockages and increased customer flooding	2	3	6	As blockage rates increase more regular and pro-active jetting will be required	2	1	2	Continue with adaptive action

Pumping stations	DROUGHT	D25	Lower average and peak 'carry' flows lead to settlement in the system, affecting pumping regimes and causing accelerated asset deterioration	Lower average and peak flows	Accelerated asset deterioration	2	2	4	Pumps are monitored and maintained on a regular basis	2	1	2	Continue with adaptive action
Rising mains	DROUGHT	D26	Lower average and peak 'carry' flows lead to H2S settlement in the system, causing accelerated asset deterioration	Lower average and peak flows	Accelerated asset deterioration	2	2	4	Reduce size of duty pump so that the pump runs more frequently and keeps the main running more often albeit at a lower velocity	2	1	2	Continue with adaptive action
CSOs and overflows	DROUGHT	D27	Lower average and peak 'carry' flows lead to settlement in the system, with shock loads causing CSO H&S risk and reduced receiving water quality	Lower average and peak flows	Reduced receiving water quality and CSO H&S risk	2	1	2	Jetting on a reactive basis and surface water separation policy.	2	1	2	Continue with adaptive action
All wastewater networks	FLOOD	F21	Direct asset flooding causes service failure and asset loss	Direct asset flooding	Asset loss and service failure	2	3	6	Pperiodic review process will identify vulnerable areas	2	1	2	Continue with adaptive action
All wastewater networks	FLOOD	F22	Increased storm frequency increases frequency of power loss, causing service failure	More frequent storms and power supply flooding	Power outages and service failure	2	3	6	Periodic review process will identify vulnerable sites. Some sites have standby generation	2	2	4	Investigate lightning protection
Sewer networks, incl./trunk sewers	FLOOD	F23	Higher rainfall intensities lead to runoff exceeding combined sewer capacity, causing surface flooding and reducing receiving water quality	Higher rainfall intensities	Surface flooding and reduced receiving water quality	2	3	6	Review capacities of Foul only system with SuDS for storm flows	1	1	1	Continue with adaptive action
Sewer networks, incl./trunk sewers	FLOOD	F24	Increased volumes of storm water in combined sewers exceeds sewer capacity and causes customer flooding	Increased volumes of storm water	Customer flooding	2	3	6	Review capacities of Foul only system with SuDS for storm flows	1	1	1	Continue with adaptive action
Sewer networks, incl./trunk sewers	FLOOD	F25	Higher groundwater levels cause increased infiltration into sewers, causing customer flooding	Higher groundwater levels	Customer flooding	2	3	6	Increase rehab of sewers	2	2	4	Continue with adaptive action
Sewer networks, incl./trunk sewers	FLOOD	F26	Change in customer behaviour lead to increased instances of sewer misuse (dumping down sewer) leading to blockages which cause sewer flooding and reduce environmental water quality	Increased sewer misuse	Blockages, sewer flooding and reduced environmental water quality	2	1	2	Jetting on a reactive basis. Customer communication plan leading to improved education	2	1	2	Continue with adaptive action

Pumping stations	FLOOD	F27	Increased volumes of storm water exceed pump capacity, causing service failure and impacting on receiving water quality at outfall	Increased volumes of storm water	Service failure and reduced receiving water quality	2	3	6	Surface water separation with Foul only system with SuDS for storm flows	1	1	1	Continue with adaptive action
Pumping stations	FLOOD	F28	Increased volumes of storm water require increased pumping in combined sewer systems, causing accelerated asset deterioration	Increased volumes of storm water in combined sewers	Increased pump usage & accelerated asset deterioration	2	3	6	Pump performance monitoring ,Foul only system with SuDS for storm flows	1	1	1	Continue with adaptive action
Rising mains	FLOOD	F29	Increased volumes of storm water exceed raising main capacity, causing burst and subsequent service failure	Increased volumes of storm water	Increased bursts and service failure	2	1	2	Ensure pump capacity does not exceed main capacity	2	1	2	Continue with adaptive action
CSOs and overflows	FLOOD	F30	Higher storm intensity means CSOs spill more frequently, impacting on receiving water quality	Higher storm intensity	Increased CSO spill frequency and reduced receiving water quality	3	3	9	Re-engineer CSO, surface water separation and delivering system	2	2	4	Foul only system with SuDS for storm flows
CSOs and overflows	FLOOD	F31	Higher winter flows dilute and reduce the effect of spills, reducing impact of spills and improving receiving water quality	Higher winter flows	Improved receiving water quality	1	3	3		1	3	3	
CSOs and overflows	FLOOD	F32	Increased flood incidence increases risk of failure of 'spills per bathing season' type consents.	More frequent flooding	Increased risk of failing 'spills per bathing season' consents	2	3	6	Re-engineer CSO and delivering system	2	1	2	Foul only system with SuDS for storm flows
All wastewater networks	GENERAL	G3	Relocation of permanent and tourist population from drought, temperature rise, flooding or sea level rise (impacts D2, T2, T3, T5, F3, S2) changes supply-demand balance. Response chosen (within WR) impacts wastewater networks requirements and capacity needed	Relocation of population from weather, flooding, sea level rise	Impacts wastewater network requirements and capacity and reduced security of supply	2	2	4	Water Resource Plan identifies inward migration trends	2	1	2	Continue with adaptive action
All wastewater networks	SEA LEVEL	S12	Direct asset flooding, storm damage and coastal erosion or planned retreat cause service failure and asset loss	Direct asset flooding, storm damage, coastal erosion or planned retreat	Asset loss and service failure	2	3	6	periodic review process will identify vulnerable sites allowing re-engineering of site	2	1	2	Continue with adaptive action
All wastewater networks	SEA LEVEL	S13	Saline intrusion degrades infrastructure, causing accelerated asset deterioration	Saline intrusion	Accelerated asset deterioration	2	3	6	periodic review process and increased sewer rehab will identify vulnerable sites	2	1	2	Continue with adaptive action

Sewer networks, incl./trunk sewers	SEA LEVEL	S14	High rainfall and high tides coinciding causes increased customer flooding and reduce receiving water quality	High rainfall adding to high tides	Increased customer flooding and reduced receiving water quality	2	3	6	Reduce infiltration in low lying coastal areas slowing re-engineering of asset	2	1	2	Foul only system with SuDS for storm flows
Sewer networks, incl./trunk sewers	SEA LEVEL	S15	Saline intrusion and subsequent H2S formation in sewer creates environmental health risk	Saline intrusion	Environmental health risk	2	3	6	Increase rehab of sewers in areas of saline infiltration	2	2	4	Improved ventilation at SPS
Sewer networks, incl./trunk sewers	SEA LEVEL	S16	Saline intrusion increases corrosion, leading to accelerated asset deterioration	Saline intrusion	Accelerated asset deterioration	2	3	6	periodic review process will identify vulnerable sites and allow re-engineering	2	1	2	Continue with adaptive action
CSOs and overflows	SEA LEVEL	S17	Costal estuarine CSO discharges become tide-locked, hindering free discharge and causing customer flooding and reducing received water quality	Tide locked intermittent discharges	Customer flooding and reduced receiving water quality	2	3	6	Re-engineer CSO and delivering system	2	2	4	Foul only system with SuDS for storm flows
CSOs and overflows	SEA LEVEL	S18	High rainfall and high tides coincide and affect CSO discharges, reducing receiving water quality	High rainfall adding to high tides	reducing receiving water quality	2	3	6	Foul only system with surface water sewer for storm flows	1	1	1	Continue with adaptive action
All wastewater networks	TEMP. RISE	T24	Higher average and peak temperatures affect structures, buildings, H & V, MEICA plant working life, causing accelerated asset deterioration	Higher average and peak temperatures	Accelerated asset deterioration	1	2	2	MEICA plant monitored to detect deterioration, asset surveys carried out	1	1	1	
All wastewater networks	TEMP. RISE	T25	Higher temperatures lead to greater microbial action, and increased gas production and risk of ignition endangers H&S of site staff	Higher temperatures	Increased H&S risks	3	2	6	Monitor gas levels in building and sumps and network	3	1	3	Continue with adaptive action
Sewer networks, incl./trunk sewers	TEMP. RISE	T26	Greater extremities in wetting and drying cycles lead to greater soil movement, causing pipe systems to move, leading to accelerated asset deterioration and customer flooding	More extreme wetting and drying cycles	Accelerated asset deterioration and customer flooding	1	1	1	Periodic review will identify vulnerable assets	1	1	1	
Sewer networks, incl.trunk sewers	TEMP. RISE	T27	Increased levels of septicity cause accelerated asset deterioration and increased odour	Greater septicity	Accelerated asset deterioration and increased odour	2	3	6	Consider using chemicals to combat septicity	2	1	2	continue with adaptive action

Pumping stations	TEMP. RISE	T28	Increased levels of septicity affect pumping regimes and causes accelerated asset deterioration and increased odour	Greater septicity affecting pumping regimes	Accelerated asset deterioration and increased odour	2	3	6	MEICA plant monitored to detect deterioration, asset surveys carried out	2	1	2	Continue with adaptive action
Rising mains	TEMP. RISE	T29	Greater extremities in wetting and drying cycles lead to greater soil movement, causing pipe systems to move, leading to accelerated asset deterioration and customer flooding	More extreme wetting and drying cycles	Accelerated asset deterioration and customer flooding	1	1	1	Periodic review will identify vulnerable assets	1	1	1	
Rising mains	TEMP. RISE	T30	Increased levels of septicity cause accelerated asset deterioration and increased odour	Greater septicity	Accelerated asset deterioration and increased odour	2	3	6	Consider using chemicals to combat septicity	2	1	2	Continue with adaptive action
CSOs and overflows	TEMP. RISE	T31	Increased levels of septicity lead to increased toxicity, reduced receiving water quality and increased odour	Greater septicity	Increased toxicity & odour and lower receiving water quality	2	3	6	Consider using chemicals to combat septicity and re-engineer CSOs	2	1	2	Continue with adaptive action

Asset Level 2: Sludge

2020

Level of consequence

1 - **Low impact** resulting in possible intermittent impact on service to customers or damage to assets requiring some repair or maintenance

2 - **Medium impact** causing minor loss of service to some customers or damage to assets (e.g. hosepipe ban, flooding of assets) requiring significant maintenance or replacement work and a review of investment priorities

3 - **High impact** causing major loss of service to customers, significant health & safety issues or damage to assets (e.g. treatment works unable to function, flooding or several hundred properties)

Level of likelihood

1 - **Unlikely** the consequence for service will occur in the 2020s

2 - **Fairly** likely the consequence for service will occur in the 2020s

3 - **Very likely** the consequence for service will occur in the 2020s

						2020s							
ASSET LEVEL 3	CLIMATE VARIABLE	MHW IMPACT REF.	DESCRIPTION	PRIMARY IMPACT OF CLIMATE VARIABLE	POTENTIAL IMPACTS ON ORGANISATION AND STAKEHOLDERS	Consequence for service			COMPANY'S ADAPTIVE ACTIONS	Company's residual risk			COMPANY'S PROPOSED ACTION TO MITIGATE RESIDUAL IMPACTS
						Level of consequence	Level of likelihood	Level of risk		Level of consequence	Level of likelihood	Level of risk	
All Sludge	DROUGHT	D37	Change in domestic waste disposal patterns leads to change in dry weather flow pollutants affecting composition of sludge	Change in domestic waste disposal	Changed composition of sludge	1	1	1		1	1	1	
Sludge treatment	DROUGHT	D38	Increase in the generation of dust causes accelerated asset deterioration and endangers H&S of site staff	More dust	Accelerated asset deterioration and impacts on H&S	2	1	2	Rotating machinery is monitored for wear and tear. Raise awareness of problem with staff and issue appropriate PPE	2	1	2	Continue with adaptive action
Sludge disposal or re-cycling	DROUGHT	D39	Agricultural practice change affects sludge demand and affects agricultural demand for sludge	Agricultural practice change	Changes in agricultural demand for sludge	3	1	3	Develop alternative disposal routes or change treatment process	3	1	3	Continue with adaptive action

Sludge disposal or re-cycling	DROUGHT	D40	Lower water flow increases concentration of toxic compounds in sludge, affecting sludge reuse and/or incineration and leading to waste disposal issues	Lower water flow	Increased concentration of toxic compounds in sludge affecting reuse and/or incineration	2	2	4	Monitoring and control at source of sludge composition will highlight any significant trends, develop alternative treatment process	2	1	2	Continue with adaptive action
All Sludge	FLOOD	F43	Direct asset flooding causes service failure and asset loss	Direct asset flooding	Asset loss and service failure	2	2	4	Periodic review process will highlight vulnerable sites	2	1	2	Continue with adaptive action
All Sludge	FLOOD	F44	Increased storm frequency increases frequency of power loss, causing service failure	More frequent storms and power supply flooding	Power outages and service failure	2	2	4	Periodic review process will highlight vulnerable sites. Critical sites have standby generation installed	2	1	2	Investigate provision of lightning protection at sites
Sludge disposal or re-cycling	FLOOD	F45	Flooding prevents access to fields causing service failure	Flooding prevents access to fields	Service failure	2	2	4	Periodic review process will highlight vulnerable sites and identify alternative disposal routes and on site undercover storage	2	1	2	Continue with adaptive action
Sludge disposal or re-cycling	FLOOD	F46	Flooding cuts sludge transport routes causing service failure	Flooding of sludge transport routes	Service failure	2	2	4	Periodic review process will highlight vulnerable sites	2	1	2	Continue with adaptive action
Sludge disposal or re-cycling	FLOOD	F47	Increased run off rates from sludge treated agricultural land reduce receiving water quality	Increased runoff from sludge-treated agricultural land	Reduced receiving water quality	2	1	2	Review no spread zone around watercourses and on site undercover storage requirements and risk assessments	2	1	2	Develop alternative disposal routes or application methods and storage
All Sludge	GENERAL	G5	Relocation of permanent and tourist population from drought, temperature rise, flooding or sea level rise (impacts D2, T2, T3, T5, F3, S2) changes supply-demand balance. Response chosen (within WR) impacts sludge treatment, storage and disposal requirements and capacity needed.	Relocation of population from weather, flooding, sea level rise	Impacts sludge treatment, storage and disposal requirements and capacity needed	2	1	2	Water Resource Plan identifies inward migration changes along with liaison with West Country Tourism	2	1	2	Continue with adaptive action
All Sludge	SEA LEVEL	S25	Direct asset flooding, storm damage and coastal erosion cause service failure and asset loss	Direct asset flooding, storm damage, coastal erosion or planned retreat	Asset loss and service failure	2	1	2	Periodic review process will highlight vulnerable sites	2	1	2	Continue with adaptive action
All Sludge	SEA LEVEL	S26	Saline intrusion degrades infrastructure, causing accelerated asset deterioration	Saline intrusion	Accelerated asset deterioration	2	2	4	Periodic review process will highlight vulnerable sites	2	1	2	Continue with adaptive action

All Sludge	TEMP. RISE	T49	Higher average and peak temperatures cause an increase in incidence of sludge related disease	Higher average and peak temperatures	Increase in incidence of sludge related disease	2	1	2	Pathogen monitoring of sludge and site management to control dust levels	2	1	2	Continue with adaptive action
All Sludge	TEMP. RISE	T50	Higher average and peak temperatures affect structures, buildings, H & V, MEICA plant working life, causing accelerated asset deterioration	Higher average and peak temperatures	Accelerated deterioration of assets	1	2	2	MEICA plant monitored to detect deterioration. Asset condition survey will inform replacement cycles	1	1	1	Continue with adaptive action
Sludge treatment	TEMP. RISE	T51	Higher average temperatures reduce heating requirement for sludge digestion and affects performance	Higher average temperatures	Reduced heating requirement for sludge digestion	2	1	2	Temperature will be maintained by automated system	2	1	2	Continue with adaptive action
Sludge disposal or re-cycling	TEMP. RISE	T52	Agricultural practice change affects agricultural demand for sludge	Agricultural practice change	Change in agricultural demand for sludge	2	1	2	Develop alternative disposal routes or change treatment process	2	1	2	Continue with adaptive action
Sludge disposal or re-cycling	TEMP. RISE	T53	Higher temperatures lead to greater microbial action, and increased gas production and risk of ignition in storage endangers H&S of site staff	Higher temperatures	Increased H&S risks	3	2	6	Issue protective clothing, site management, H&S awareness training, monitor gas levels in buildings	3	1	3	Continue with adaptive action and link with S26 actions
Sludge disposal or re-cycling	TEMP. RISE	T54	Higher temperatures lead to increased insect issues and create an environmental health risk	Higher temperatures	Increased insect problems	2	1	2	Issue protective clothing, site management, H&S awareness training, or alternative treatment methods and recycling practices	2	1	2	Continue with adaptive action

Asset Level 2: Sludge

2050

Level of consequence

1 - **Low impact** resulting in possible intermittent impact on service to customers or damage to assets requiring some repair or maintenance

2 - **Medium impact** causing minor loss of service to some customers or damage to assets (e.g. hosepipe ban, flooding of assets) requiring significant maintenance or replacement work and a review of investment priorities

3 - **High impact** causing major loss of service to customers, significant health & safety issues or damage to assets (e.g. treatment works unable to function, flooding or several hundred properties)

Level of likelihood

1 - **Unlikely** the consequence for service will occur in the 2050s

2 - **Fairly** likely the consequence for service will occur in the 2050s

3 - **Very likely** the consequence for service will occur in the 2050s

2050s

ASSET LEVEL 3	CLIMATE VARIABLE	MHW IMPACT REF.	DESCRIPTION	PRIMARY IMPACT OF CLIMATE VARIABLE	POTENTIAL IMPACTS ON ORGANISATION AND STAKEHOLDERS	Consequence for service			COMPANY'S ADAPTIVE ACTIONS	Company's residual risk			COMPANY'S PROPOSED ACTION TO MITIGATE RESIDUAL IMPACTS
						Level of consequence	Level of likelihood	Level of risk		Level of consequence	Level of likelihood	Level of risk	
All Sludge	DROUGHT	D37	Change in domestic waste disposal patterns leads to change in dry weather flow pollutants affecting composition of sludge	Change in domestic waste disposal	Changed composition of sludge	1	1	1		1	1	1	
Sludge treatment	DROUGHT	D38	Increase in the generation of dust causes accelerated asset deterioration and endangers H&S of site staff	More dust	Accelerated asset deterioration and impacts on H&S	2	1	2	Rotating machinery is monitored for wear and tear. Raise awareness of problem with staff and issue appropriate PPE	2	1	2	Continue with adaptive action
Sludge disposal or re-cycling	DROUGHT	D39	Agricultural practice change affects sludge demand and affects agricultural demand for sludge	Agricultural practice change	Changes in agricultural demand for sludge	3	2	6	Develop alternative disposal routes or change treatment process	3	1	1	Continue with adaptive action

Sludge disposal or re-cycling	DROUGHT	D40	Lower water flow increases concentration of toxic compounds in sludge, affecting sludge reuse and/or incineration and leading to waste disposal issues	Lower water flow	Increased concentration of toxic compounds in sludge affecting reuse and/or incineration	2	2	4	Monitoring and control at source of sludge composition will highlight any significant trends, develop alternative treatment process	2	1	2	Continue with adaptive action
All Sludge	FLOOD	F43	Direct asset flooding causes service failure and asset loss	Direct asset flooding	Asset loss and service failure	2	3	6	Periodic review process will highlight vulnerable sites	2	1	2	Continue with adaptive action
All Sludge	FLOOD	F44	Increased storm frequency increases frequency of power loss, causing service failure	More frequent storms and power supply flooding	Power outages and service failure	2	3	6	Periodic review process will highlight vulnerable sites. Critical sites have standby generation installed	2	1	2	Investigate provision of lightning protection at sites
Sludge disposal or re-cycling	FLOOD	F45	Flooding prevents access to fields causing service failure	Flooding prevents access to fields	Service failure	2	3	6	Periodic review process will highlight vulnerable sites and identify alternative disposal routes and on site undercover storage	2	1	2	Continue with adaptive action
Sludge disposal or re-cycling	FLOOD	F46	Flooding cuts sludge transport routes causing service failure	Flooding of sludge transport routes	Service failure	2	3	6	Periodic review process will highlight vulnerable sites	2	1	2	Continue with adaptive action
Sludge disposal or re-cycling	FLOOD	F47	Increased run off rates from sludge treated agricultural land reduce receiving water quality	Increased runoff from sludge-treated agricultural land	Reduced receiving water quality	2	2	4	Review no spread zone around watercourses and on site undercover storage requirements and risk assessments	2	1	2	Develop alternative disposal routes or application methods
All Sludge	GENERAL	G5	Relocation of permanent and tourist population from drought, temperature rise, flooding or sea level rise (impacts D2, T2, T3, T5, F3, S2) changes supply-demand balance. Response chosen (within WR) impacts sludge treatment, storage and disposal requirements and capacity needed	Relocation of population from weather, flooding, sea level rise	Impacts sludge treatment, storage and disposal requirements and capacity needed	2	2	4	Water Resource Plan identifies inward migration changes along with liaison with West Country Tourism	2	1	2	Continue with adaptive action
All Sludge	SEA LEVEL	S25	Direct asset flooding, storm damage and coastal erosion cause service failure and asset loss	Direct asset flooding, storm damage, coastal erosion or planned retreat	Asset loss and service failure	2	3	6	Periodic review process will highlight vulnerable sites	2	1	2	Continue with adaptive action
All Sludge	SEA LEVEL	S26	Saline intrusion degrades infrastructure, causing accelerated asset deterioration	Saline intrusion	Accelerated asset deterioration	2	2	4	Periodic review process will highlight vulnerable sites	2	1	2	Continue with adaptive action
All Sludge	TEMP. RISE	T49	Higher average and peak temperatures cause an increase in incidence of sludge related disease	Higher average and peak temperatures	Increase in incidence of sludge related disease	3	2	6	Pathogen monitoring of sludge and site management to control dust levels	3	1	3	Continue with adaptive action

All Sludge	TEMP. RISE	T50	Higher average and peak temperatures affect structures, buildings, H & V, MEICA plant working life, causing accelerated asset deterioration	Higher average and peak temperatures	Accelerated deterioration of assets	1	2	2	MEICA plant monitored to detect deterioration . Asset condition survey will inform replacement cycles	1	1	1	Continue with adaptive action
Sludge treatment	TEMP. RISE	T51	Higher average temperatures reduce heating requirement for sludge digestion and affects performance	Higher average temperatures	Reduced heating requirement for sludge digestion	2	1	2	Temperature will be maintained by automated system	2	1	2	Continue with adaptive action
Sludge disposal or re-cycling	TEMP. RISE	T52	Agricultural practice change affects agricultural demand for sludge	Agricultural practice change	Change in agricultural demand for sludge	2	2	4	Develop alternative disposal routes or change treatment process	2	1	2	Continue with adaptive action
Sludge disposal or re-cycling	TEMP. RISE	T53	Higher temperatures lead to greater microbial action, and increased gas production and risk of ignition in storage endangers H&S of site staff	Higher temperatures	Increased H&S risks	3	2	6	Issue protective clothing, site management, H&S awareness training, monitor gas levels in buildings	3	1	3	continue with adaptive action
Sludge disposal or re-cycling	TEMP. RISE	T54	Higher temperatures lead to increased insect issues and create an environmental health risk	Higher temperatures	Increased insect problems	1	2	2	Issue protective clothing, site management, H&S awareness training, or alternative treatmetn methods and recycling practices	1	2	2	Continue with adaptive action

Asset Level 2: Sludge

2080

Level of consequence

1 - **Low impact** resulting in possible intermittent impact on service to customers or damage to assets requiring some repair or maintenance

2 - **Medium impact** causing minor loss of service to some customers or damage to assets (e.g. hosepipe ban, flooding of assets) requiring significant maintenance or replacement work and a review of investment priorities

3 - **High impact** causing major loss of service to customers, significant health & safety issues or damage to assets (e.g. treatment works unable to function, flooding or several hundred properties)

Level of likelihood

1 - **Unlikely** the consequence for service will occur in the 2080s

2 - **Fairly** likely the consequence for service will occur in the 2080s

3 - **Very likely** the consequence for service will occur in the 2080s

						2080s							
						Consequence for service				Company's residual risk			
ASSET LEVEL 3	CLIMATE VARIABLE	MHW IMPACT REF.	DESCRIPTION	PRIMARY IMPACT OF CLIMATE VARIABLE	POTENTIAL IMPACTS ON ORGANISATION AND STAKEHOLDERS	Level of consequence	Level of likelihood	Level of risk	COMPANY'S ADAPTIVE ACTIONS	Level of consequence	Level of likelihood	Level of risk	COMPANY'S PROPOSED ACTION TO MITIGATE RESIDUAL IMPACTS
All Sludge	DROUGHT	D37	Change in domestic waste disposal patterns leads to change in dry weather flow pollutants affecting composition of sludge	Change in domestic waste disposal	Changed composition of sludge	1	1	1		1	1	1	
Sludge treatment	DROUGHT	D38	Increase in the generation of dust causes accelerated asset deterioration and endangers H&S of site staff	More dust	Accelerated asset deterioration and impacts on H&S	2	1	2	Rotating machinery is monitored for wear and tear. Raise awareness of problem with staff and issue appropriate PPE	2	1	2	Continue with adaptive action
Sludge disposal or re-cycling	DROUGHT	D39	Agricultural practice change affects sludge demand and affects agricultural demand for sludge	Agricultural practice change	Changes in agricultural demand for sludge	3	3	9	Develop alternative disposal routes or change treatment process	3	1	3	Continue with adaptive action

Sludge disposal or re-cycling	DROUGHT	D40	Lower water flow increases concentration of toxic compounds in sludge, affecting sludge reuse and/or incineration and leading to waste disposal issues	Lower water flow	Increased concentration of toxic compounds in sludge affecting reuse and/or incineration	2	3	6	Monitoring and control at source of sludge composition will highlight any significant trends, develop alternative treatment process	2	1	2	Continue with adaptive action
All Sludge	FLOOD	F43	Direct asset flooding causes service failure and asset loss	Direct asset flooding	Asset loss and service failure	2	3	6	Periodic review process will highlight vulnerable sites	2	1	2	Continue with adaptive action
All Sludge	FLOOD	F44	Increased storm frequency increases frequency of power loss, causing service failure	More frequent storms and power supply flooding	Power outages and service failure	2	3	6	Periodic review process will highlight vulnerable sites. Critical sites have standby generation installed	2	2	4	Investigate provision of lightning protection at sites
Sludge disposal or re-cycling	FLOOD	F45	Flooding prevents access to fields causing service failure	Flooding prevents access to fields	Service failure	2	3	6	Periodic review process will highlight vulnerable sites and identify alternative disposal routes and on site undercover storage	2	1	2	Continue with adaptive action
Sludge disposal or re-cycling	FLOOD	F46	Flooding cuts sludge transport routes causing service failure	Flooding of sludge transport routes	Service failure	2	3	6	Periodic review process will highlight vulnerable sites	2	1	2	Continue with adaptive action
Sludge disposal or re-cycling	FLOOD	F47	Increased run off rates from sludge treated agricultural land reduce receiving water quality	Increased runoff from sludge-treated agricultural land	Reduced receiving water quality	2	3	6	Review no spread zone around watercourses and on site undercover storage requirements and risk assessments	2	2	4	Develop alternative disposal routes or application methods
All Sludge	GENERAL	G5	Relocation of permanent and tourist population from drought, temperature rise, flooding or sea level rise (impacts D2, T2, T3, T5, F3, S2) changes supply-demand balance. Response chosen (within WR) impacts sludge treatment, storage and disposal requirements and capacity needed	Relocation of population from weather, flooding, sea level rise	Impacts sludge treatment, storage and disposal requirements and capacity needed	2	2	4	Water Resource Plan identifies inward migration changes along with liaison with West Country Tourism	2	1	2	Continue with adaptive action
All Sludge	SEA LEVEL	S25	Direct asset flooding, storm damage and coastal erosion cause service failure and asset loss	Direct asset flooding, storm damage, coastal erosion or planned retreat	Asset loss and service failure	2	3	6	Periodic review process will highlight vulnerable sites	2	1	2	Continue with adaptive action
All Sludge	SEA LEVEL	S26	Saline intrusion degrades infrastructure, causing accelerated asset deterioration	Saline intrusion	Accelerated asset deterioration	2	3	6	Periodic review process will highlight vulnerable sites	2	1	2	Continue with adaptive action
All Sludge	TEMP. RISE	T49	Higher average and peak temperatures cause an increase in incidence of sludge related disease	Higher average and peak temperatures	Increase in incidence of sludge related disease	3	2	6	Pathogen monitoring of sludge and site management to control dust levels	3	1	3	Continue with adaptive action

All Sludge	TEMP. RISE	T50	Higher average and peak temperatures affect structures, buildings, H & V, MEICA plant working life, causing accelerated asset deterioration	Higher average and peak temperatures	Accelerated deterioration of assets	1	2	2	MEICA plant monitored to detect deterioration. Asset condition survey will inform replacement cycles	1	1	1	Continue with adaptive action
Sludge treatment	TEMP. RISE	T51	Higher average temperatures reduce heating requirement for sludge digestion and affects performance	Higher average temperatures	Reduced heating requirement for sludge digestion	2	1	2	Temperature will be maintained by automated system	2	1	2	Continue with adaptive action
Sludge disposal or re-cycling	TEMP. RISE	T52	Agricultural practice change affects agricultural demand for sludge	Agricultural practice change	Change in agricultural demand for sludge	2	3	6	Develop alternative disposal routes or change treatment process	2	1	2	Continue with adaptive action
Sludge disposal or re-cycling	TEMP. RISE	T53	Higher temperatures lead to greater microbial action, and increased gas production and risk of ignition in storage endangers H&S of site staff	Higher temperatures	Increased H&S risks	3	3	9	Issue protective clothing, site management, H&S awareness training, monitor gas levels in buildings, review treatment process used and engineering solutions to provide protection	3	1	3	Continue with adaptive action
Sludge disposal or re-cycling	TEMP. RISE	T54	Higher temperatures lead to increased insect issues and create an environmental health risk	Higher temperatures	Increased insect problems	1	3	3	Issue protective clothing, site management, H&S awareness training, or alternative treatment methods and recycling practices	1	2	2	Continue with adaptive action

Asset Level 2: Site-wide services

2020

Level of consequence

1 - **Low impact** resulting in possible intermittent impact on service to customers or damage to assets requiring some repair or maintenance

2 - **Medium impact** causing minor loss of service to some customers or damage to assets (e.g. hosepipe ban, flooding of assets) requiring significant maintenance or replacement work and a review of investment priorities

3 - **High impact** causing major loss of service to customers, significant health & safety issues or damage to assets (e.g. treatment works unable to function, flooding or several hundred properties)

Level of likelihood

1 - **Unlikely** the consequence for service will occur in the 2020s

2 - **Fairly** likely the consequence for service will occur in the 2020s

3 - **Very likely** the consequence for service will occur in the 2020s

						2020s							
ASSET LEVEL 3	CLIMATE VARIABLE	MHW IMPACT REF.	DESCRIPTION	PRIMARY IMPACT OF CLIMATE VARIABLE	POTENTIAL IMPACTS ON ORGANISATION AND STAKEHOLDERS	Consequence for service			COMPANY'S ADAPTIVE ACTIONS	Company's residual risk			COMPANY'S PROPOSED ACTION TO MITIGATE RESIDUAL IMPACTS
						Level of consequence	Level of likelihood	Level of risk		Level of consequence	Level of likelihood	Level of risk	
All Site wide Services	DROUGHT	D41	Exfoliation cracks in storage basin affect coatings/seals, and cause clay liner failure. Accelerated asset deterioration	Exfoliation cracks in storage basin affecting coatings/seals, clay liner failure	Accelerated asset deterioration	2	1	2	Reservoir inspections during significant drawdown	2	1	2	Monitor frequency of significant drawdown

All Site wide Services	DROUGHT	D42	Relocation of permanent and tourist population from drought, temperature rise, flooding or sea level rise (impacts D2, T2, T3, T5, F3, S2) changes supply-demand balance. Response chosen (within WR) site wide services requirements.	Relocation of population from drought	Affects supply-demand balance and other aspects	2	1	2	Water resource plan assess inward migration and headroom	2	1	2	Monitor climate change information
All Site wide Services	FLOOD	F48	Direct asset flooding causes service failure and asset loss	Direct asset flooding	Asset loss and service failure	2	1	2	Periodic review process identifies need	2	1	2	Monitor climate change information
All Site wide Services	FLOOD	F49	Direct asset flooding cuts access to assets, endangering H&S of site staff	Direct asset flooding	Reduced access to assets and increased H&S risk to staff	2	1	2	Periodic review process identifies need	2	1	2	Monitor climate change information
All Site wide Services	FLOOD	F50	Increased storm frequency and power supply flooding increases frequency of power loss, causing service failure	More frequent storms and power supply flooding	Power outages and service failure	2	2	4	Standby generation at key sites	2	1	2	Lightning protection may be needed
All Site wide Services	FLOOD	F51	Direct flooding leads to submersion of electrical assets, increasing risk to operatives of electrocution endangering H&S of site staff	Direct flooding of electrical assets	Increased H&S risk to staff	2	1	2	Periodic review process identifies need	2	1	2	Monitor flood frequency information
SCADA & Telemetry	FLOOD	F52	Flooding causes loss of SCADA and /or telemetry causing a service loss	Flooding	Loss of SCADA / telemetry and service failure	3	1	3	Plants manned 24/7 and contingency plans	3	1	3	Improve flood defences
All Site wide Services	SEA LEVEL	S27	Direct asset flooding causes service failure and asset loss	Direct asset flooding	Asset loss and service failure	2	1	2	Periodic review process identifies need	2	1	2	Continue with adaptive action
All Site wide Services	SEA LEVEL	S28	Direct asset flooding cuts access to assets, endangering H&S of site staff	Direct asset flooding	Reduced access to assets, increased H&S risks to staff	2	1	2	Periodic review process identifies need	2	1	2	Continue with adaptive action
All Site wide Services	SEA LEVEL	S29	Direct storm damage &/or coastal erosion or 'planned retreat' causes service failure and asset loss	Direct asset flooding, storm damage, coastal erosion or planned retreat	Asset loss and service failure	2	1	2	Monitor coast line flooding and review at periodic review process	2	1	2	Continue with adaptive action
All Site wide Services	SEA LEVEL	S30	Saline intrusion degrades infrastructure, causing accelerated asset deterioration	Saline intrusion	Accelerated asset deterioration	2	1	2	Monitor coast line flooding and review at periodic review process	2	1	2	Continue with adaptive action
SCADA & Telemetry	SEA LEVEL	S31	Direct flooding leads to submersion of electrical assets, increasing risk to operatives of electrocution endangering H&S of site staff	Direct flooding of electrical assets	Increased H&S risk to staff	2	1	2	Monitor coast line flooding and review at periodic review process	2	1	2	Continue with adaptive action

All Site wide Services	TEMP. RISE	T55	Higher levels of UV increase the risk of sun-related injury, endangering H&S of site staff	Higher levels of UV	Increased risk of sun-related H&S injuries	2	1	2	Education of workforces and provision of Personal Protective Equipment	2	1	2	Continue with adaptive action
All Site wide Services	TEMP. RISE	T56	Higher average and peak temperatures cause an increase in incidence of water & wetland associated disease	Higher average and peak temperatures	greater incidence of water & wetland associated disease	2	1	2	Education of workforces and provision of Personal Protective Equipment	2	1	2	Continue with adaptive action
All Site wide Services	TEMP. RISE	T57	Higher average and peak temperatures affect structures, buildings, H & V, MEICA plant working life, causing accelerated asset deterioration	Higher average and peak temperatures	Accelerated deterioration of assets	1	1	1	MEICA plant monitored for efficiency and asset condition surveys	1	1	1	
All Site wide Services	TEMP. RISE	T58	Higher temperatures cause increased vegetation growth at sites	Higher temperatures	Increased vegetation growth at sites	1	1	1	Site specific vegetation control measures	1	1	1	
All Site wide services	GENERAL		International climate change effects affecting the procurement of essential supplies	Greater persistence of extreme conditions	Problems in obtaining essential chemicals for water & wastewater treatment	3	2	6	Increase strategic chemical storage	3	1	3	Continue with adaptive action

Asset Level 2: Site-wide services

2050

Level of consequence

1 - **Low impact** resulting in possible intermittent impact on service to customers or damage to assets requiring some repair or maintenance

2 - **Medium impact** causing minor loss of service to some customers or damage to assets (e.g. hosepipe ban, flooding of assets) requiring significant maintenance or replacement work and a review of investment priorities

3 - **High impact** causing major loss of service to customers, significant health & safety issues or damage to assets (e.g. treatment works unable to function, flooding or several hundred properties)

Level of likelihood

1 - **Unlikely** the consequence for service will occur in the 2050s

2 - **Fairly** likely the consequence for service will occur in the 2050s

3 - **Very likely** the consequence for service will occur in the 2050s

2050s

ASSET LEVEL 3	CLIMATE VARIABLE	MHW IMPACT REF.	DESCRIPTION	PRIMARY IMPACT OF CLIMATE VARIABLE	POTENTIAL IMPACTS ON ORGANISATION AND STAKEHOLDERS	Consequence for service			COMPANY'S ADAPTIVE ACTIONS	Company's residual risk			COMPANY'S PROPOSED ACTION TO MITIGATE RESIDUAL IMPACTS
						Level of consequence	Level of likelihood	Level of risk		Level of consequence	Level of likelihood	Level of risk	
All Site wide Services	DROUGHT	D41	Exfoliation cracks in storage basin affect coatings/seals, and cause clay liner failure. Accelerated asset deterioration	Exfoliation cracks in storage basin affecting coatings/seals, clay liner failure	Accelerated asset deterioration	2	1	2	Reservoir inspections during significant drawdown	2	1	2	Continue with adaptive action

All Site wide Services	DROUGHT	D42	Relocation of permanent and tourist population from drought, temperature rise, flooding or sea level rise (impacts D2, T2, T3, T5, F3, S2) changes supply-demand balance. Response chosen (within WR) site wide services requirements.	Relocation of population from drought	Affects supply-demand balance and other aspects	2	1	2	Water resource plan assess inward migration and headroom	2	1	2	Monitor climate change information
All Site wide Services	FLOOD	F48	Direct asset flooding causes service failure and asset loss	Direct asset flooding	Asset loss and service failure	2	2	4	Periodic review process identifies need	2	1	2	Monitor climate change information
All Site wide Services	FLOOD	F49	Direct asset flooding cuts access to assets, endangering H&S of site staff	Direct asset flooding	Reduced access to assets and increased H&S risk to staff	2	2	4	Periodic review process identifies need	2	1	2	Monitor climate change information
All Site wide Services	FLOOD	F50	Increased storm frequency and power supply flooding increases frequency of power loss, causing service failure	More frequent storms and power supply flooding	Power outages and service failure	2	3	6	Standby generation at key sites	2	2	4	Lightning protection may be needed
All Site wide Services	FLOOD	F51	Direct flooding leads to submersion of electrical assets, increasing risk to operatives of electrocution endangering H&S of site staff	Direct flooding of electrical assets	Increased H&S risk to staff	2	2	4	Periodic review process identifies need	2	1	2	Monitor flood frequency information
SCADA & Telemetry	FLOOD	F52	Flooding causes loss of SCADA and /or telemetry causing a service loss	Flooding	Loss of SCADA / telemetry and service failure	3	2	6	Plants manned 24/7 and contingency plans	3	1	3	Improve flood defences
All Site wide Services	SEA LEVEL	S27	Direct asset flooding causes service failure and asset loss	Direct asset flooding	Asset loss and service failure	2	2	4	Periodic review process identifies need	2	1	2	Continue with adaptive action
All Site wide Services	SEA LEVEL	S28	Direct asset flooding cuts access to assets, endangering H&S of site staff	Direct asset flooding	Reduced access to assets, increased H&S risks to staff	2	1	2	Periodic review process identifies need	2	1	2	Continue with adaptive action
All Site wide Services	SEA LEVEL	S29	Direct storm damage &/or coastal erosion or 'planned retreat' causes service failure and asset loss	Direct asset flooding, storm damage, coastal erosion or planned retreat	Asset loss and service failure	2	1	2	Monitor coast line flooding and review at periodic review process	2	1	2	Continue with adaptive action
All Site wide Services	SEA LEVEL	S30	Saline intrusion degrades infrastructure, causing accelerated asset deterioration	Saline intrusion	Accelerated asset deterioration	2	1	2	Monitor coast line flooding and review at periodic review process	2	1	2	Continue with adaptive action
SCADA & Telemetry	SEA LEVEL	S31	Direct flooding leads to submersion of electrical assets, increasing risk to operatives of electrocution endangering H&S of site staff	Direct flooding of electrical assets	Increased H&S risk to staff	2	1	2	Monitor coast line flooding and review at periodic review process	2	1	2	Continue with adaptive action

All Site wide Services	TEMP. RISE	T55	Higher levels of UV increase the risk of sun-related injury, endangering H&S of site staff	Higher levels of UV	Increased risk of sun-related H&S injuries	2	2	4	Education of workforces and provision of Personal Protective Equipment	2	1	2	Continue with adaptive action
All Site wide Services	TEMP. RISE	T56	Higher average and peak temperatures cause an increase in incidence of water & wetland associated disease	Higher average and peak temperatures	greater incidence of water & wetland associated disease	2	1	2	Education of workforces and provision of Personal Protective Equipment	2	1	2	Continue with adaptive action
All Site wide Services	TEMP. RISE	T57	Higher average and peak temperatures affect structures, buildings, H & V, MEICA plant working life, causing accelerated asset deterioration	Higher average and peak temperatures	Accelerated deterioration of assets	1	1	1	MEICA plant monitored for efficiency and asset condition surveys	1	1	1	
All Site wide Services	TEMP. RISE	T58	Higher temperatures cause increased vegetation growth at sites	Higher temperatures	Increased vegetation growth at sites	1	1	1	Site specific vegetation control measures	1	1	1	
All Site wide services	GENERAL		International climate change effects affecting the procurement of essential supplies	Greater persistence of extreme conditions	Problems in obtaining essential chemicals for water & wastewater treatment	3	2	6	Increase strategic chemical storage	3	1	3	Continue with adaptive action

Asset Level 2: Site-wide services

2080

Level of consequence

1 - **Low impact** resulting in possible intermittent impact on service to customers or damage to assets requiring some repair or maintenance

2 - **Medium impact** causing minor loss of service to some customers or damage to assets (e.g. hosepipe ban, flooding of assets) requiring significant maintenance or replacement work and a review of investment priorities

3 - **High impact** causing major loss of service to customers, significant health & safety issues or damage to assets (e.g. treatment works unable to function, flooding or several hundred properties)

Level of likelihood

1 - **Unlikely** the consequence for service will occur in the 2080s

2 - **Fairly** likely the consequence for service will occur in the 2080s

3 - **Very likely** the consequence for service will occur in the 2080s

						2080s							
						Consequence for service				Company's residual risk			
ASSET LEVEL 3	CLIMATE VARIABLE	MHW IMPACT REF.	DESCRIPTION	PRIMARY IMPACT OF CLIMATE VARIABLE	POTENTIAL IMPACTS ON ORGANISATION AND STAKEHOLDERS	Level of consequence	Level of likelihood	Level of risk	COMPANY'S ADAPTIVE ACTIONS	Level of consequence	Level of likelihood	Level of risk	COMPANY'S PROPOSED ACTION TO MITIGATE RESIDUAL IMPACTS
All Site wide Services	DROUGHT	D41	Exfoliation cracks in storage basin affect coatings/seals, and cause clay liner failure. Accelerated asset deterioration	Exfoliation cracks in storage basin affecting coatings/seals, clay liner failure	Accelerated asset deterioration	2	2	4	Reservoir inspections during significant drawdown	2	1	2	
All Site wide Services	DROUGHT	D42	Relocation of permanent and tourist population from drought, temperature rise, flooding or sea level rise (impacts D2, T2, T3, T5, F3, S2) changes supply-demand balance. Response chosen (within WR) site wide services requirements.	Relocation of population from drought	Affects supply-demand balance and other aspects	2	2	4	Water resource plan assess inward migration and headroom	2	1	2	Monitor climate change information

All Site wide Services	FLOOD	F48	Direct asset flooding causes service failure and asset loss	Direct asset flooding	Asset loss and service failure	2	2	4	Periodic review process identifies need	2	1	2	Monitor climate change information
All Site wide Services	FLOOD	F49	Direct asset flooding cuts access to assets, endangering H&S of site staff	Direct asset flooding	Reduced access to assets and increased H&S risk to staff	3	2	6	Periodic review process identifies need	2	1	2	Monitor climate change information
All Site wide Services	FLOOD	F50	Increased storm frequency and power supply flooding increases frequency of power loss, causing service failure	More frequent storms and power supply flooding	Power outages and service failure	2	3	6	Standby generation at key sites	2	2	4	Lightning protection may be needed
All Site wide Services	FLOOD	F51	Direct flooding leads to submersion of electrical assets, increasing risk to operatives of electrocution endangering H&S of site staff	Direct flooding of electrical assets	Increased H&S risk to staff	2	3	6	Periodic review process identifies need	2	2	4	Monitor flood frequency information consider moving critical electrical equipment above flood level
SCADA & Telemetry	FLOOD	F52	Flooding causes loss of SCADA and /or telemetry causing a service loss	Flooding	Loss of SCADA / telemetry and service failure	3	3	9	Plants manned 24/7 and contingency plans and improve flood defences through periodic review process	2	2	4	Further improve flood defences
All Site wide Services	SEA LEVEL	S27	Direct asset flooding causes service failure and asset loss	Direct asset flooding	Asset loss and service failure	2	3	6	Periodic review process identifies need	2	1	2	Continue with adaptive action
All Site wide Services	SEA LEVEL	S28	Direct asset flooding cuts access to assets, endangering H&S of site staff	Direct asset flooding	Reduced access to assets, increased H&S risks to staff	2	2	4	Periodic review process identifies need	2	1	2	Continue with adaptive action
All Site wide Services	SEA LEVEL	S29	Direct storm damage &/or coastal erosion or 'planned retreat' causes service failure and asset loss	Direct asset flooding, storm damage, coastal erosion or planned retreat	Asset loss and service failure	2	2	4	Monitor coast line flooding and review at periodic review process	2	1	2	Continue with adaptive action
All Site wide Services	SEA LEVEL	S30	Saline intrusion degrades infrastructure, causing accelerated asset deterioration	Saline intrusion	Accelerated asset deterioration	2	2	4	Monitor coast line flooding and review at periodic review process	2	1	2	Continue with adaptive action
SCADA & Telemetry	SEA LEVEL	S31	Direct flooding leads to submersion of electrical assets, increasing risk to operatives of electrocution endangering H&S of site staff	Direct flooding of electrical assets	Increased H&S risk to staff	1	2	2	Monitor coast line flooding and review at periodic review process	2	1	2	Continue with adaptive action
All Site wide Services	TEMP. RISE	T55	Higher levels of UV increase the risk of sun-related injury, endangering H&S of site staff	Higher levels of UV	Increased risk of sun-related H&S injuries	1	3	3	Education of workforces and provision of Personal Protective Equipment	2	2	4	Continue with adaptive action consider covering all processes
All Site wide Services	TEMP. RISE	T56	Higher average and peak temperatures cause an increase in incidence of water & wetland associated disease	Higher average and peak temperatures	greater incidence of water & wetland associated disease	2	2	4	Education of workforces and provision of Personal Protective Equipment	2	1	2	Continue with adaptive action

All Site wide Services	TEMP. RISE	T57	Higher average and peak temperatures affect structures, buildings, H & V, MEICA plant working life, causing accelerated asset deterioration	Higher average and peak temperatures	Accelerated deterioration of assets	1	2	2	MEICA plant monitored for efficiency and asset condition surveys	1	1	1	Continue with adaptive action
All Site wide Services	TEMP. RISE	T58	Higher temperatures cause increased vegetation growth at sites	Higher temperatures	Increased vegetation growth at sites	1	2	2	Site specific vegetation control measures	1	2	2	Continue with adaptive action
All Site wide services	GENERAL		International climate change effects affecting the procurement of essential supplies	Greater persistence of extreme conditions	Problems in obtaining essential chemicals for water & wastewater treatment	3	3	9	Increase strategic chemical storage	3	2	6	Continue with adaptive action

APPENDIX B: Summary of the UKWIR[16] climate change adaptation research since 1997

A Scoping Study to Identify Research Requirements to Assist the UK Water Industry in Dealing with Changing Patterns of Drought

00/CL/07/1 - ISBN: 1 84057 187 X

The objective of this project was to determine the requirements for future research into the effects of changes in the occurrence of droughts across the whole range of water industry operations. The project was based on literature review and discussions with a range of experts and academics in the water industry. Fourteen action areas were identified where research is required.

Effects of Climate Change on River Flows and Groundwater Recharge: Guidelines for Resource Assessment

97/CL/04/1 - ISBN: 1 84057 010 5

The project examines the impacts of four climate scenarios on six climatic regions of the UK. Changes in weather parameters such as rainfall, temperature, potential evaporation are given together with the resulting changes in monthly river flows and in groundwater.

Effect of Climate Change on River Flows and Groundwater Recharge UKCIP 02 Scenarios

03/CL/04/2 - ISBN: 1-84057-286-8.

This report presents a procedure for the rapid determination of the effects of climate change by the 2020s on mean monthly runoff and average annual groundwater recharge for strategic scale assessments. The procedure uses three core UKCIP02 scenarios, together with two scenarios characterising the effects of uncertainty and two representing natural climatic variability. Three approaches to translating these scenarios into changes in runoff and recharge are proposed. The report also gives examples of the effect of climate change on Q95; the flow exceeded 95% of the time, for a number of case study catchments.

Effect of Climate Change on River Flows and Groundwater Recharge, A Practical Methodology: Use of Climate Change Scenario Data at a Catchment Level

05/CL/04/3 - ISBN: 1-84057-373-2

This report provides background information on using the United Kingdom Climate Impacts Programme (UKCIP02) climate scenarios (Hulme, et al., 2002) and catchment scale climate scenario data developed as the deliverable from Task 1 of this research project.

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[16] United Kingdom Water Industry Research

An Excel spreadsheet accompanies the report and provides monthly temperature, rainfall and potential evapotranspiration (PET) factors for 190 individual or groups of river catchments in the UK. The catchment boundaries used were Catchment Abstraction Management Strategy (CAMS) areas in England and Wales and Water Framework Directive (WFD) sub-basins in Scotland and Northern Ireland.

The major benefit of the Excel spreadsheet is that it removes the need for individual water resources studies to interpolate the UKCIP02 50km^2 data to derive catchment rainfall and PET climate change factors. It also provides a consistent data set that can be used by UK Water Service Providers and Regulators.

Effect of Climate Change on River Flows and Groundwater Recharge, A Practical Methodology: Trends in UK River Flows 1970-2002

05/CL/04/5 - ISBN: 1-84057-387-2

Since the late 1980s the UK climate has suffered from a series of dry periods, such as the 1995 drought, and a number of severe floods, such as the flash flooding in Boscastle in August 2004. These events have raised concerns that climate change is causing an increase in the frequency and magnitude of extreme hydrological conditions.

The main objective for this report was to detect trends in river flows for the period 1970 to 2002. The report describes an analysis of 47 river flow records and 10 groundwater observational wells that aimed to detect any early signals of climate change due to changes in the seasonal water balance. Some short to medium term upward trends in autumn and winter river flow were identified but it is not possible, at this stage, to attribute these changes to climate change rather than natural climate variability.

The main benefit of the study is that it provides a framework for the water industry to periodically review trends in river flow and compare these with a range of possible future climate scenarios.

Climate Change Uncertainty in Water Resource Planning

05/CL/04/4 - ISBN: 1 84057 389 9

The project investigates uncertainty in the impact of climate change on river flows and water resource. Three sources of uncertainty were considered:

- Uncertainty in climate change projections, due to Global Climate Models (GCM), emission scenarios and downscaling techniques
- Uncertainty in climate variability, including natural variability and reproduction of current climate
- Uncertainty in hydrological modelling, including model parameters and model structure uncertainty

The impact of these uncertainties on the river flow regimes was assessed on thirteen catchments in Britain. Results showed that:

- For the 2020s, uncertainty due to emissions of greenhouse gases is small
- GCM uncertainty is the biggest source of uncertainty. Full impact studies should always consider a range of GCMs
- Downscaling uncertainty is significant but not as great as GCM uncertainty
- Hydrological uncertainty can be significant.

Effect of Climate Change on River Flows and Groundwater Recharge, A Practical Methodology: A Strategy for Evaluating Uncertainty in Assessing the Impacts of Climate Change on Water Resources

05/CL/04/6 - ISBN: 1 84057 396 1

This report develops a strategy for evaluating uncertainties related to assessing the impacts of climate change on river flows and groundwater recharge. The strategy considers the use of different climate models, hydrological models and methods for translating changes at the global scale to catchment scale changes in river flow and recharge. The approaches discussed in the report are being developed further as part of the on-going research project and will form the basis of a practical framework to help water companies and the Environment Agency assess the potential impacts of climate change.

Effect of Climate Change on River Flows and Groundwater Recharge, A Practical Methodology: Interim Report on Rainfall-Runoff Modelling

06/CL/04/7 - ISBN: 1 84057 421 6

This report presents interim results on the impacts of climate change on average monthly river flows and recharge in the UK. It is based on rainfall-runoff modelling of 27 catchments for the 1961-1990 period and for the 2020s and one climate change emissions scenario (A2). This report demonstrates the operation of the methodology for dealing with the uncertainty related to different Global Climate Models (6 GCMs) and hydrological models (2 model structures and large numbers of parameter sets). The modelling results indicate increases in winter flows and reductions in summer flows in the 2020s.

Effects of Climate Change on River Flows and Groundwater Recharge: Guidelines for Resource Assessment and UKWIR06 Scenarios

06/CL/04/8 - ISBN: 1 84057 431 3

This report provides technical guidelines for the assessment of the impacts of climate change on average monthly river flows and recharge in UK catchments for the 2020s based on scenarios derived from six Global Climate models. It builds on previous guidance published by UKWIR for 'rapid determination of the effects of climate change', based on the UKCIP02 climate change scenarios and provides a flexible set of methods for considering the impacts of climate change in Water Resources Plans.

Effect of Climate Change on River Flows and Groundwater Recharge, A Practical Methodology: Recharge and Groundwater Level Impact Assessment

07/CL/04/9 - ISBN: 1 84057 439 9

This report provides tools and guidance on how to estimate changes in recharge and regional groundwater levels based on changes in precipitation and potential evaporation. The report provides a framework for assessing the impacts of climate change on groundwater recharge using three approaches with varying levels of complexity, and provides worked examples of these methods.

In summary these approaches are:

- GR1 - Based on a relationship between antecedent precipitation conditions and minimum groundwater levels at a particular location.
- GR2 - A spreadsheet model which undertakes lumped calculations of recharge and groundwater level.
- GR3 - Utilising existing regional groundwater models.

The methods presented here should enable companies to identify appropriate analytical approaches to assess the impact of climate change. These approaches consider uncertainty and can be used for the PR09 Draft Water Resources Plans.

Effect of Climate Change on River Flows and Groundwater Recharge, A Practical Methodology: Synthesis Report

07/CL/04/10 - ISBN: 1 84057 443 7

This report provides a synthesis of the research outputs of the UKWIR and Environment Agency research project 'Effects of climate change on river flows and groundwater recharge'. A 'Guidelines Report' described a framework and practical methods for use by water companies and the Environment Agency. This 'Synthesis Report' provides an overview of research outputs followed by recommendations for further work to support water companies, 'prepare the ground' for the UKCIP08 scenarios and research studies that continue to improve our understanding of the impacts of climate change on river flows and groundwater recharge.

Climate Change - A Programme of Research for the UK Water Industry: Volume 1 - Summary Report

08/CL/01/7 - ISBN: 1 84057 513 1

This report provides a first climate-related snapshot looking across the UK water industry and out to 2100. It identifies where significant uncertainties in the climate science remain, the nature and extent of impact and business risks, adaptation options, and where there are critical knowledge gaps and capacity within the industry.

A long term, integrated, forward looking programme of climate change research needs is recommended that will allow the industry to put in place a sustainable response to adapting to climate change and for the industry to develop a 'one voice' approach that will underpin the development of strategies by individual companies.

The report is in two volumes: this summary report (Volume 1) of the issues and the proposed programme of research needed to meet those issues; and a detailed technical report (Volume 2) which is attached to Volume 1 on CD-ROM.

Assessment of the Significance to Water Resource Management Plans of the UK Climate Projections 2009

09/CL/04/11 - ISBN: 1 84057 547 6

This report provides a 'rapid assessment' of the UK Climate Projections 2009 (UKCP09), published on June 2009, to determine the headline impacts of river flows and any immediate implications for water company Water Resources Plans (WRPs). It builds on previous work published by UKWIR assessing the impacts of climate change based on global climate change models (UKWIR 07/CL/04/10). The study has developed novel methods for using probabilistic information but otherwise uses a similar modelling approach to provide comparative data and an indication of the impacts of probabilistic projections on future rivers flows. Based on this work a number of research recommendations into the use of UKCP09 have been formulated that will form the basis for developing guidelines and methods for use in future Water Resources Plans.

Climate Change and the Hydraulic Design of Sewerage Systems - Volume I: Climate Change Effects on Rainfall; IA - Climate Change and the Production of FSR, FEH and Year 2080 Rainfall Maps

03/CL/10/1 - ISBN: 1-84057-360-0

This report is part of a major study on the impact of climate change on sewerage hydraulic design. The project was wide ranging, but with a principle focus on the performance of sewerage systems under future (year 2080) rainfall conditions and what changes might be needed in the hydraulic design of sewerage systems to address any problems that climate change might pose. Other issues include a summary of international drainage practice and predicted changes in sea levels and river flows.

This report is one of 13 documents collated in 4 volumes. This document is one of three in volume I - Climate Change Effects on Rainfall. The other reports in volume I cover:

- A sensitivity analysis of the differences between the predictions of the UKCIP98 models and the UKCIP02 models
- A seasonality study on the differences between the rainfall output from UKCIP98 and UKCIP02 models.

This report covers the work carried out on processing rainfall data from the Hadley RCM models and producing climate change maps for the predicted change in extreme rainfall for various durations and return periods. The work was based on the Medium-High scenario UKCIP98 models available at the start of the study. Also available in association with this report are sets of maps to illustrate the differences between FSR and FEH rainfall and the uplift due to climate change. All maps are available as rastser (JPG) images included with the printed document. Digital images (suitable for ArcView) are available separately.

Climate Change and the Hydraulic Design of Sewerage Systems: Volume I - Climate Change Effects on Rainfall; IB Sensitivity Report: Validation of HadRM3 and Comparison with HadRM2

03/CL/10/2 - ISBN: 1-84057-327-9

This report is part of a major study on the impact of climate change on sewerage hydraulic design The project was wide ranging, but with a principle focus on the performance of sewerage systems under future (year 2080) rainfall conditions and what changes might be needed in the hydraulic design of sewerage systems to address any problems that climate change might pose. Other issues include a summary of international drainage practice and predicted changes in sea levels and river flows.

This report is one of 13 documents collated in 4 volumes.This document is one of three in volume I - Climate Change Effects on Rainfall. The other reports in volume I cover: - A report summarising the work carried out by the Met Office in producing predictions for extreme rainfall of the future based on the UKCIP98 Medium-High Scenario and the production of present day and future rainfall maps. Comparison of rainfall from FSR and FEH methods was also carried out. - A seasonality study on the differences between the rainfall output from UKCIP98 and UKCIP02 models.

This report extended the work carried out on processing rainfall data covered by report IA in assessing the differences between the predictions from the HADRM2 model (the UKCIP98 output) and the HADRM3 model (the UKCIP02 output). The findings indicated that the changes in the future may be less extreme in terms of rainfall, but that both models should be considered as realistic scenarios for the future climate in the UK.

Climate Change and the Hydraulic Design of Sewerage Systems Volume I: Climate Change Effects on Rainfall; IC - Seasonality Study

03/CL/10/3 - ISBN: 1-84057-328-7

This report is part of a major study on the impact of climate change on sewerage hydraulic design. The project was wide ranging, but with a principle focus on the performance of sewerage systems under future (year 2080) rainfall conditions and what changes might be needed in the hydraulic design of sewerage systems to address any problems that climate change might pose. Other issues include a summary of international drainage practice and predicted changes in sea levels and river flows.

This report is one of 13 documents collated in 4 volumes. This document is one of three in volume I - Climate Change Effects on Rainfall. The other reports in volume I cover: - A sensitivity analysis of the differences between the predictions of the UKCIP98 models and the UKCIP02 models. - A report summarising the work carried out by the Met Office in producing predictions for extreme rainfall of the future based on the UKCIP98 Medium-High Scenario and the production of present day and future rainfall maps. Comparison of rainfall from FSR and FEH methods was also carried out.

This report extends the work carried out comparing the UKCIP98 and UKCIP02 rainfall data breaking the information down into seasons. This was needed due to the major differences in seasonal rainfall patterns that the later model predicts and the importance of seasonal issues in sewer system performance.

Climate Change and the Hydraulic Design of Sewerage Systems Volume II: Rainfall Data Production & Analysis; IIA - Time-Series and Design Event Update

03/CL/10/4 - ISBN: 1-84057-329-5

This report is part of a major study on the impact of climate change on sewerage hydraulic design The project was wide ranging, but with a principle focus on the performance of sewerage systems under future (year 2080) rainfall conditions and what changes might be needed in the hydraulic design of sewerage systems to address any problems that climate change might pose. Other issues include a summary of international drainage practice and predicted changes in sea levels and river flows.

This report is one of 13 documents collated in 4 volumes. This document is one of two in volume II - Rainfall Data Production & Analysis. The other report in volume II covers: - The development and evaluation of a disaggregation tool to produce high resolution data from an hourly or other coarser resolution series.

This report covers the work carried out on developing a tool (Balerep) for use in generating future rainfall. 100 year time series data output was generated for the present day and 2080 - 2100 Medium-High scenario. Seasonal characteristics of rainfall were considered important to be represented accurately. The use of design storms and the profile to be used for future rainfall is also covered.

Climate Change and the Hydraulic Design of Sewerage Systems Volume II: Rainfall Data Production & Analysis; IIB - Time-Series Rainfall - Disaggregation

03/CL/10/5 - ISBN: 1-84057-330-9

This report is part of a major study on the impact of climate change on sewerage hydraulic design The project was wide ranging, but with a principle focus on the performance of sewerage systems under future (year 2080) rainfall conditions and what changes might be needed in the hydraulic design of sewerage systems to address any problems that climate change might pose. Other issues include a summary of international drainage practice and predicted changes in sea levels and river flows.

This report is one of 13 documents collated in 4 volumes. This document is one of two in volume II - Rainfall Data Production & Analysis. The other report in volume II covers: - The development and evaluation of a time series rainfall tool to produce future rainfall used data from the Hadley model. 100 years of present and future data were produced for 7 regions across the UK.

This report covers the work carried out on developing a tool (Cascade) for use in producing high resolution rainfall data from a time series. This tool uses various measures of rainfall characteristics to produce representative rainfall through the seasons. The tool was compared favourably to StormPac which is the only available tool currently available on the market.

Climate Change and the Hydraulic Design of Sewerage Systems Volume IV: Associated Topics; IVA - A Comparison between SOIL and HOST; Implications for Urban Drainage Design

03/CL/10/10 - ISBN: 1-84057-331-7

This report is part of a major study on the impact of climate change on sewerage hydraulic design The project was wide ranging, but with a principle focus on the performance of sewerage systems under future (year 2080) rainfall conditions and what changes might be needed in the hydraulic design of sewerage systems to address any problems that climate change might pose. Other issues include a summary of international drainage practice and predicted changes in, sea levels and river flows.

This report is one of 13 documents collated in 4 volumes. This document is one of four in volume IV - Associated Topics. The other reports in volume IV cover: - A summary of drainage design practices and the future direction of drainage - An overview of high intensity spatial rainfall and the issues relating to climate change and drainage system evaluation

This report addresses the issue of urban runoff models being based on FSR and the implications of the trend to using FEH. Recommendations are made as to how to apply current tools using FEH descriptors. In general this is not seen as causing a major difficulty for sewerage design and simulation tools.

Climate Change and the Hydraulic Design of Sewerage Systems Volume III: Sewerage System Modelling; IIID Increase in Mean and Extreme Sea Levels around the UK

03/CL/10/9 - ISBN: 1-84057-345-7

This report is part of a major study on the impact of climate change on sewerage hydraulic design The project was wide ranging, but with a principle focus on the performance of sewerage systems under future (year 2080) rainfall conditions and what changes might be needed in the hydraulic design of sewerage systems to address any problems that climate change might pose. Other issues include a summary of international drainage practice and predicted changes in sea levels and river flows.

This report is one of 13 documents collated in 4 volumes. This document is one of four in volume III Sewerage System Modelling. The other reports in volume III cover: - Evaluation of the changes in the performance of sewerage systems due to climate change using 5 models of selected drainage systems applied to 4 climate regions - Use of simple models to evaluate changes in runoff and water quality for 7 climate regions - A summary of the predicted changes in river flows over the next century.

This report reviews the available information on mean and extreme sea levels around the UK and the potential impacts of climate change on design conditions for sewerage systems.

Climate Change and the Hydraulic Design of Sewerage Systems Volume IV: Associated Topics; IVC - Spatial High Intensity Rainfall
03/CL/10/12 - ISBN: 1-84057-346-5

This report is part of a major study on the impact of climate change on sewerage hydraulic design The project was wide ranging, but with a principle focus on the performance of sewerage systems under future (year 2080) rainfall conditions and what changes might be needed in the hydraulic design of sewerage systems to address any problems that climate change might pose. Other issues include a summary of international drainage practice and predicted changes in sea levels and river flows.

This report is one of 13 documents collated in 4 volumes. This document is one of four in volume IV - Associated Topics. The other reports in volume IV cover: - An evaluation of the different parameters used in FSR and FEH and their implications with regard to sewerage system design and simulation - A summary of drainage design practices and the future direction of drainage.

This report addresses the difficult issue of the limited spatial extent of extreme rainfall and the likely increase of more extreme rainfall events in the future. The report highlights the limitations of current practice in this area.

Climate Change and the Hydraulic Design of Sewerage Systems: Summary Report
03/CL/10/0 - ISBN: 1 84057 361 9

This report provides an overview of the findings from this major study on the impact of climate change on sewerage hydraulic design. In addition to this Summary Report there are 12 other reports collated in 4 volumes.

The investigations ranged widely, but with a principle focus on the performance of sewerage systems to future (year 2080) rainfall and what changes might be needed in the hydraulic design of sewerage systems to address any problems that climate change might pose. Other issues include a summary of international drainage practice and predicted changes in, sea levels and river flows.

The findings of the project as a whole were that, while there are significant uncertainties in the prediction of changes in rainfall over the next century the analysis carried out under this project indicates that for many areas of the UK rainfall events are likely to become more extreme. This would result in a significant reduction in sewerage systems performance particularly in respect of flood protection and CSO discharges and suggests the need for changes in the design of sewerage systems.

A set of national rainfall maps in digital or and paper form have been produced to present the results of the rainfall analysis and illustrate the differences between FSR to FEH and the possible changes to extreme rainfall over the coming century.

Climate Change and the Hydraulic Design of Sewerage Systems Volume III: Sewerage System Modelling; IIIA -A Changes in the Performance of Sewerage Networks

03/CL/10/6 - ISBN: 1 84057 362 7

This report is part of a major study on the impact of climate change on sewerage hydraulic design The project was wide ranging, but with a principle focus on the performance of sewerage systems under future (year 2080) rainfall conditions and what changes might be needed in the hydraulic design of sewerage systems to address any problems that climate change might pose. Other issues include a summary of international drainage practice and predicted changes in sea levels and river flows.

This report is one of 13 documents collated in 4 volumes. This document is one of four in volume III - Sewerage System Modelling. The other reports in volume III cover: Use of simple models to evaluate changes in runoff and water quality for 7 climate regions

- A summary of the predicted changes in sea level over the next century
- A summary of predicted changes to river levels and flows around the UK.

This report summarises the results from using 5 quality assured drainage models run with both present and future rainfall for 4 representative regions across the UK.

The work involved looking at the change in flooding response and the extent of the drainage system modifications needed to return the performance of the systems to their present day performance. In addition to flooding, the performance of overflows and the change in river water quality were also investigated. The report resulted in a number of suggestions where current practice and criteria might need to be changed.

Climate Change and the Hydraulic Design of Sewerage Systems Volume III: Sewerage System Modelling; IIIB - Changes in Sewerage Run-off and Water Quality

03/CL/10/7 - ISBN: 1 84057 363 5

This report is part of a major study on the impact of climate change on sewerage hydraulic design The project was wide ranging, but with a principle focus on the performance of sewerage systems under future (year 2080) rainfall conditions and what changes might be needed in the hydraulic design of sewerage systems to address any problems that climate change might pose. Other issues include a summary of international drainage practice and predicted changes in sea levels and river flows.

This report is one of 13 documents collated in 4 volumes. This document is one of four in volume III - Sewerage System Modelling.

The other reports in volume III cover:

- Evaluation of the changes in the performance of sewerage systems due to climate change using 5 models of selected drainage systems applied to 4 climate regions
- A summary of the predicted changes in river flows over the next century
- A summary of the predicted changes in sea level over the next century

This report documents the use of the time series rainfall data produced for present and future rainfall from 7 sites across the UK to look at the performance of overflow structures (spill frequency and volume) and water quality impact of spills in rivers using simple simulation models. Annual and seasonal runoff was also assessed. The rainfall data was also evaluated and certain modelling parameters quantified.

Climate Change and the Hydraulic Design of Sewerage Systems Volume III: Sewerage System Modelling; IIIC - Changes in River Levels and Flows around the UK

03/CL/10/8 - ISBN: 1 84057 364 3

This report is part of a major study on the impact of climate change on sewerage hydraulic design The project was wide ranging, but with a principle focus on the performance of sewerage systems under future (year 2080) rainfall conditions and what changes might be needed in the hydraulic design of sewerage systems to address any problems that climate change might pose. Other issues include a summary of international drainage practice and predicted changes in sea levels and river flows.

This report is one of 13 documents collated in 4 volumes. This document is one of four in volume III – Sewerage System Modelling. The other reports in this volume cover:

- Evaluation of the changes in the performance of sewerage systems due to climate change using 5 models of selected drainage systems applied to 4 climate regions
- Use of simple models to evaluate changes in runoff and water quality for 7 climate regions
- A summary of the predicted changes in sea level over the next century

This report summarises the information currently available on the probable changes to river flows over the coming century. It recommends that sensitivity analysis should be applied to sewerage design when the river characteristics are important due to the uncertainty of the flow rate changes. Emphasis is placed on the likely water quality impact due to the prediction of drier summers and reduced flows in rivers.

Climate Change and the Hydraulic Design of Sewerage Systems Volume IV: Associated Topics; IVB - International Drainage Practices

03/CL/10/11 - ISBN: 1 84057 365 1

This report is part of a major study on the impact of climate change on sewerage hydraulic design The project was wide ranging, but with a principle focus on the performance of sewerage systems under future (year 2080) rainfall conditions and what changes might be needed in the hydraulic design of sewerage systems to address any problems that climate change might pose. Other issues include a summary of international drainage practice and predicted changes in sea levels and river flows.

This report is one of 13 documents collated in 4 volumes. This document is one of four in volume IV - Associated Topics. The other reports in volume IV cover:

- An evaluation of the different parameters used in FSR and FEH and their implications with regard to sewerage system design and simulation

- An overview of high intensity spatial rainfall and the issues relating to climate change and drainage system evaluation.

This report provides a summary of current best drainage practices and the possible future direction that drainage design might take is considered.

Uncertainty & Risk in Supply/Demand Forecasting - Volume A
03/CL/09/1 - ISBN: 1-84057-284-1

Two Volume Report (Volume B supplied free of charge with Volume A)

The report presents guidelines on how uncertainties in the individual elements of supply and demand can be brought together in an integrated way. The guidelines offer a hierarchical approach that allows the practitioner to select the most appropriate method for a given spatial area. At the simplest level the approach uses data from standard Water Resource Plan Tables, becoming progressively more complex requiring Monte Carlo simulation and then full simulation of the supply-demand balance at a weekly time step. The report also reviews the economic literature and provides guidance on how to interpret uncertainties and improve the process by which investment decisions are made.

Uncertainty & Risk in Supply/Demand Forecasting - Volume B
03/CL/09/2 - ISBN: 1-84057-285-X

Sold with Volume A - 03/CL/09/1

The report presents guidelines on how uncertainties in the individual elements of supply and demand can be brought together in an integrated way. The guidelines offer a hierarchical approach that allows the practitioner to select the most appropriate method for a given spatial area. At the simplest level the approach uses data from standard Water Resource Plan Tables, becoming progressively more complex requiring Monte Carlo simulation and then full simulation of the supply-demand balance at a weekly time step. The report also reviews the economic literature and provides guidance on how to interpret uncertainties and improve the process by which investment decisions are made.

Review of River and Reservoir Water Quality Models for Predicting Effects of Climate Change
00/CL/06/1 - ISBN: 1 84057 188 8

A review was carried out of existing calibrated water quality models of rivers and reservoirs. A number of river models were identified as suitable candidates to predict the impact of climate change on water quality. These included Thames, Trend, Aire, Wharfe, Wye and Almond. Few reservoir quality models have been applied to UK reservoirs. The only models identified as suitable candidates to predict the impact of climate changes were two models of Wraysbury Reservoir: SULIS to predict water quality and PROTECH to predict any changes in dominant algae.

Modelling the Effects of Climate Change on Water Quality in Rivers and Reservoirs

01/CL/06/2 - ISBN: 1 84057 247 7

Models of 5 rivers and 1 reservoir were used to determine whether they are capable of assessing changes in water quality under likely climate change scenarios. All of the models used suggest that no significant effects on water quality would result. However, it is not valid to conclude that significant effects will not occur. The reasons are found in the nature of the models used, in the way changes were assumed to happen and in the nature of the climate change scenarios themselves.

Effects of Climate Change on River Water Quality Phase 3 - Scoping Study

03/CL/06/3 - ISBN: 1-84057-290-6

This is a scoping study for the third phase of investigations into the effects of climate change on river water quality. It firstly investigates what water quality parameters are of concern to the water industry, how they may be affected by climate change, and if this subsequent impact would then be significant. Consideration is then given to modelling approaches; including data issues that would be needed to develop catchment based water quality models to represent the above, along with identification of catchments on which a completed modelling framework can be used.

Effects of Climate Change on River Water Quality

05/CL/06/4 - ISBN: 1 84057 402 X

The potential impact of predicted climate change on water quality in UK rivers, and its implications to the UK water industry, was investigated using a newly developed, fully distributed catchment-scale hydrological and water quality model, CAS-Hydro. The model has been developed at the landscape scale, allowing an improved representation of how material is processed and transported across the landscape and into the river channel network.

Modelling of the River Derwent (Yorkshire) and a simulated catchment in southern England demonstrated a risk of climate-induced hydrological and water quality impacts on UK rivers, for the UKCIP 1998 medium-high emissions scenario in the 2080s.

Climate Change, the Aquatic Environment and the Water Framework Directive

07/CL/06/5 - ISBN: 1 84057 434 8

This project examined the likely effects of climate change on UK water industry compliance with the Water Framework Directive (WFD), set in the context of other expected changes, such as demographic shifts or changes in land-use.

A range of other drivers were identified - changes in energy prices, new regulatory targets for energy efficiency, water conservation and flooding, demographic and land use changes, and new environmental legislation that are likely to directly or indirectly affect the water industry.

The report proposes a Conceptual Assessment Framework to identify linkages between different drivers and industry operations and specific aspects of performance. The framework of drivers and effects was then used to assess the effects of the WFD, climate change and other drivers, which, with further development, could be used by water companies to identify appropriate responses.

APPENDIX C: Climate change projections for the South West Water region

Notes:

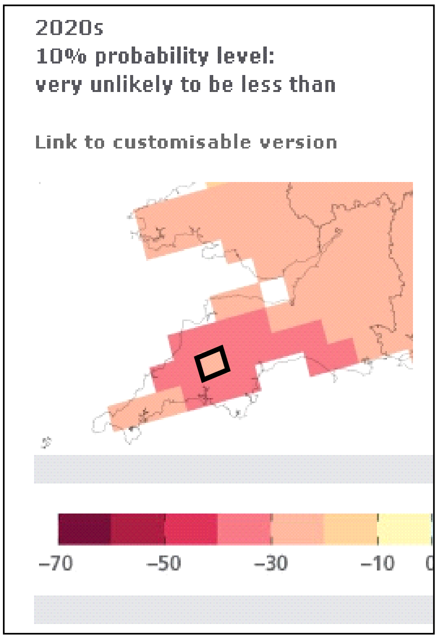
1 The first part of this Appendix contains maps taken from UKCP09 of projected changes for the following climate variables for both low and high emissions scenarios:

- Mean temperature change 2020s Winter
- Mean temperature change 2020s Summer
- Mean temperature change 2050s Winter
- Mean temperature change 2050s Summer
- Mean temperature change 2080s Winter
- Mean temperature change 2080s Summer
- Precipitation change 2020s Winter
- Precipitation change 2020s Summer
- Precipitation change 2050s Winter
- Precipitation change 2050s Summer
- Precipitation change 2080s Winter
- Precipitation change 2080s Summer

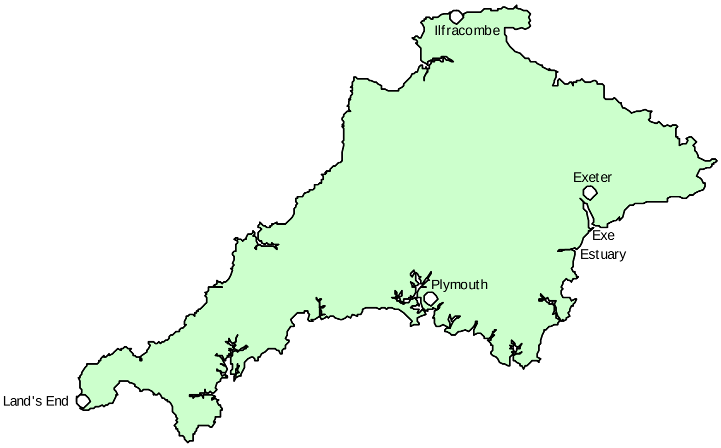
2 The following pages show data for the South West Water region in tabular form for all three emissions scenarios:

- Winter rainfall change
- Summer rainfall change
- Annual Average Daily Temperature oC
- Summer Average Daily Temperature oC
- Relative Sea Level Rise (cm) with respect to 1990

The 25km square shown by the black box on the adjacent map is the cell used to represent the "centre of the SWW Region":

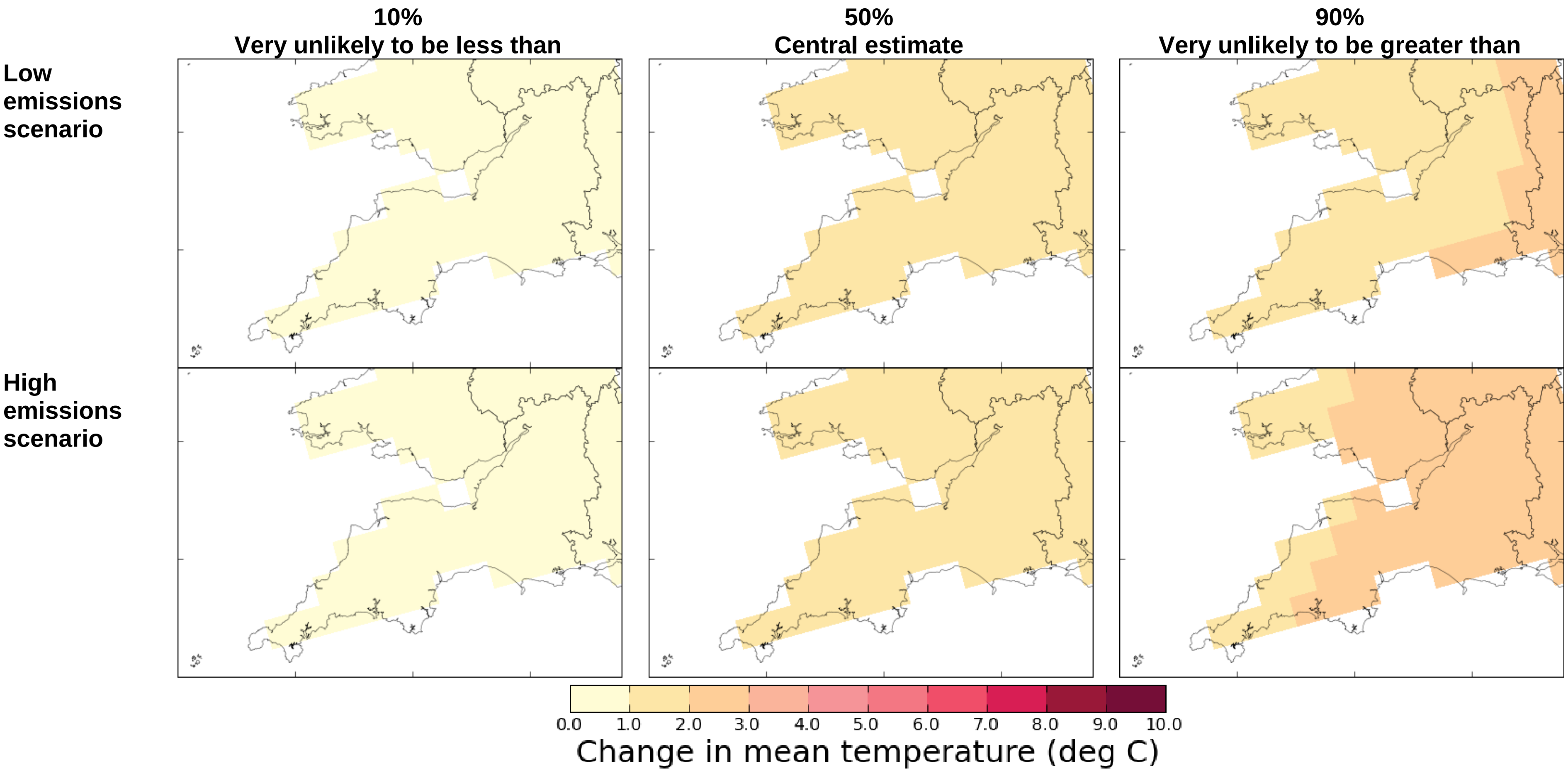


3 The extent of the SWW region is shown in the map to the left. Relative sea level rise forecasts are given for the coastal areas off Ilfracombe, Land's End and the Exe Estuary.)



4 This report has been based on the use of the medium emissions scenario and so the final set of tables shows the same table as listed in note 2 above but just for the medium emissions scenario

Mean Temperature Change 2020s Winter



10%
Very unlikely to be less than

50%
Central estimate

90%
Very unlikely to be greater than

Low emissions scenario

High emissions scenario

Mean Temperature Change 2020s Summer

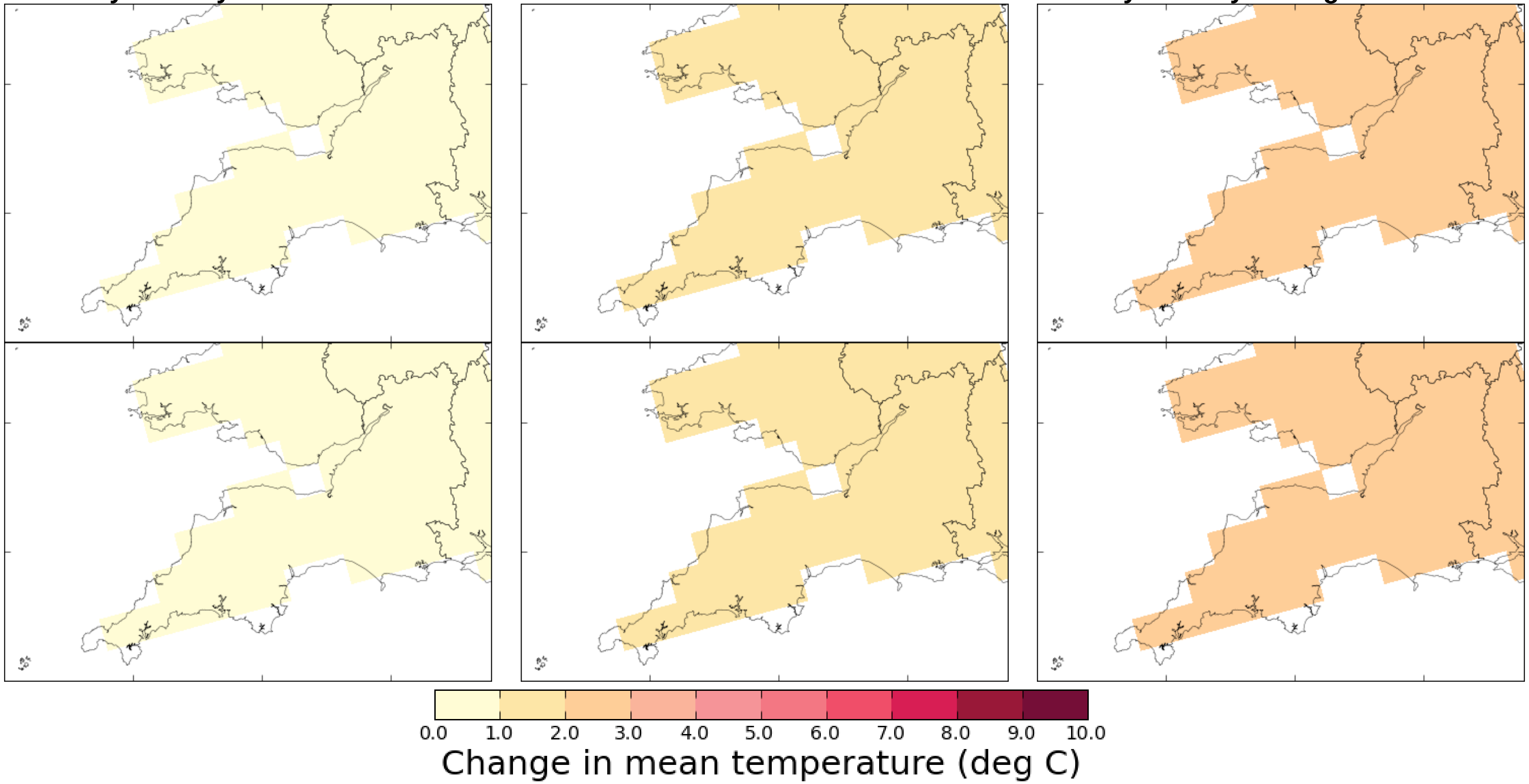
10%
Very unlikely to be less than

50%
Central estimate

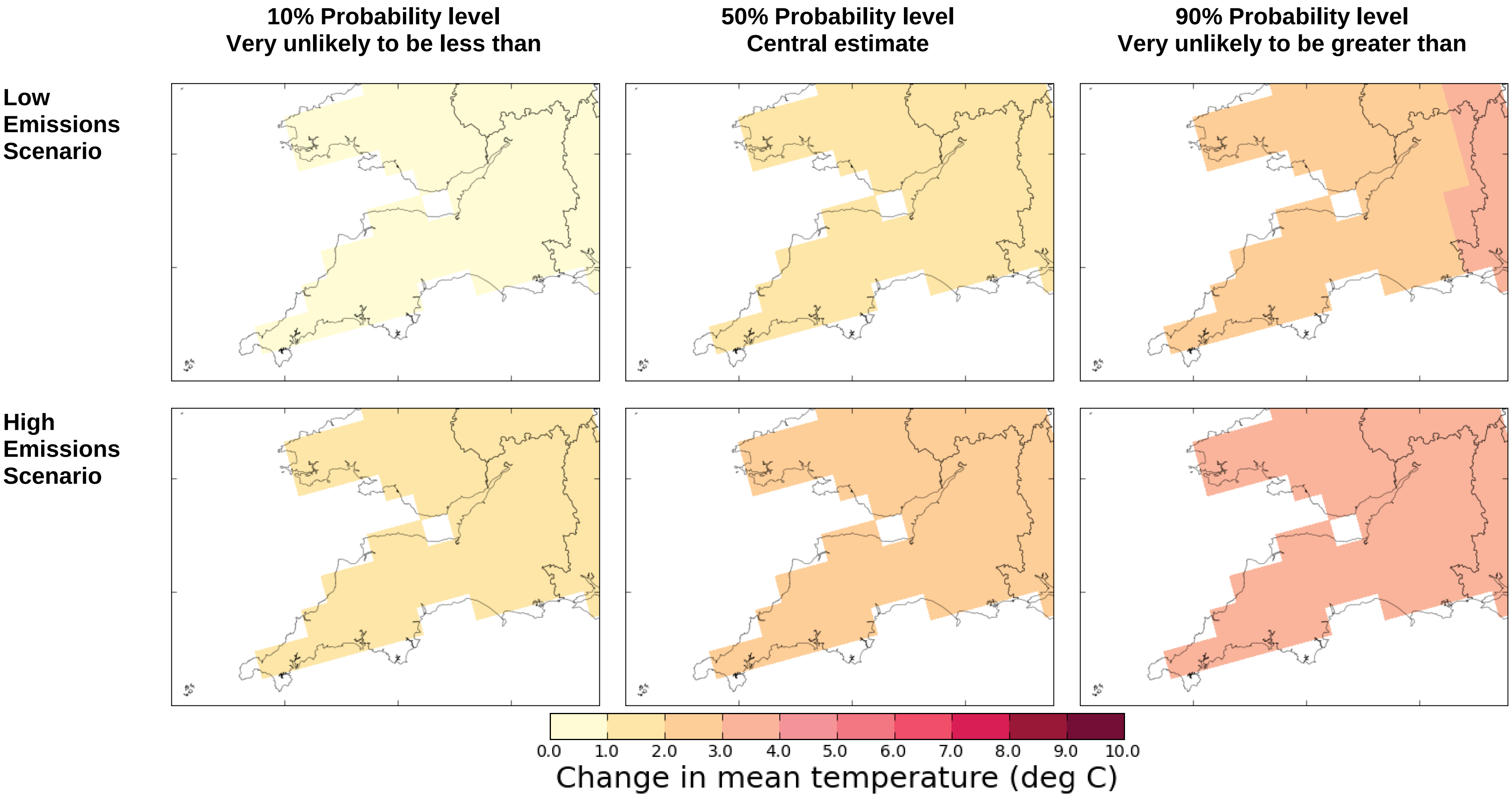
90%
Very unlikely to be greater than

Low emissions scenario

High emissions scenario



Mean Temperature Change 2050s Winter



10% Probability level
Very unlikely to be less than

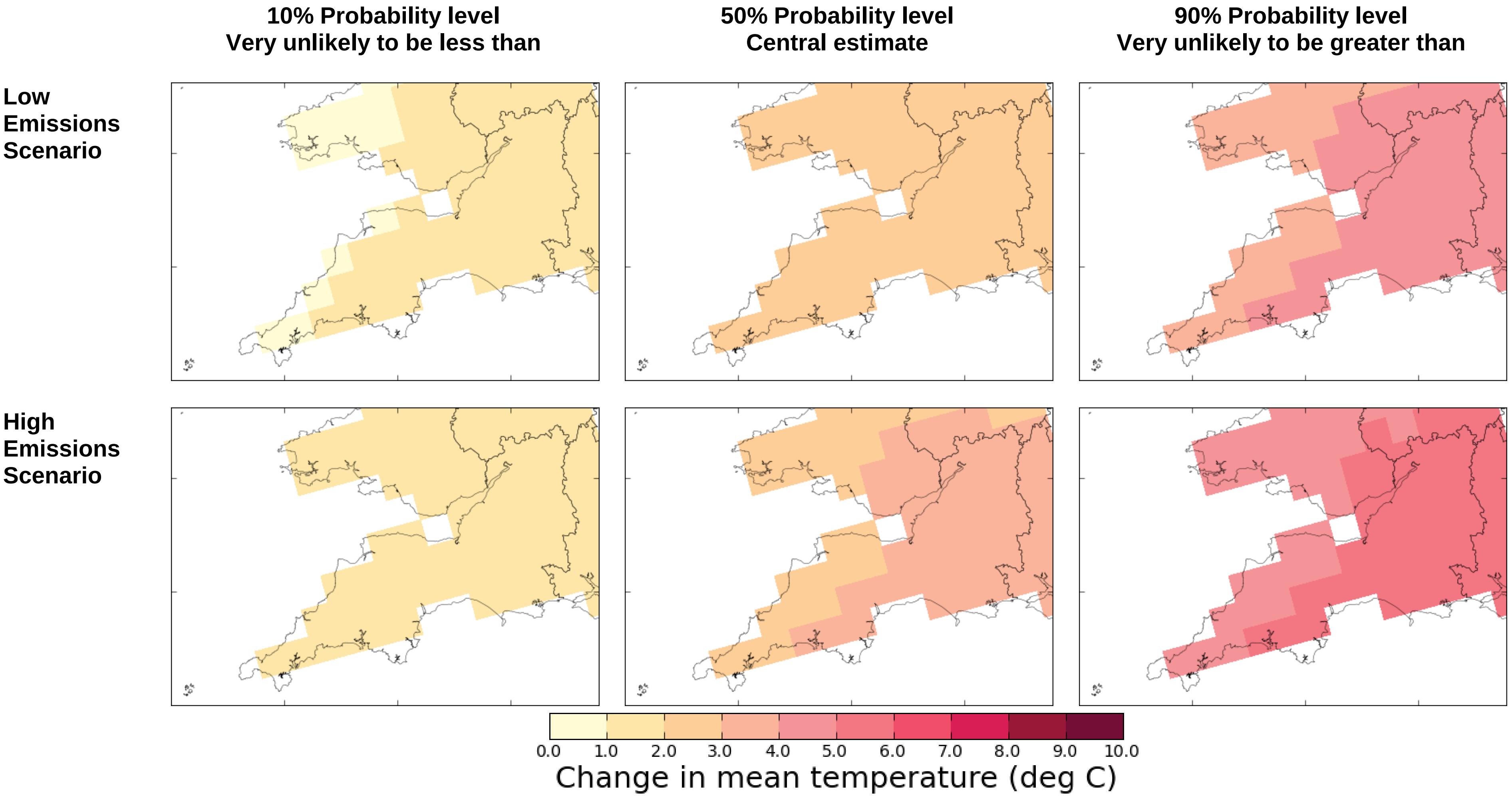
50% Probability level
Central estimate

90% Probability level
Very unlikely to be greater than

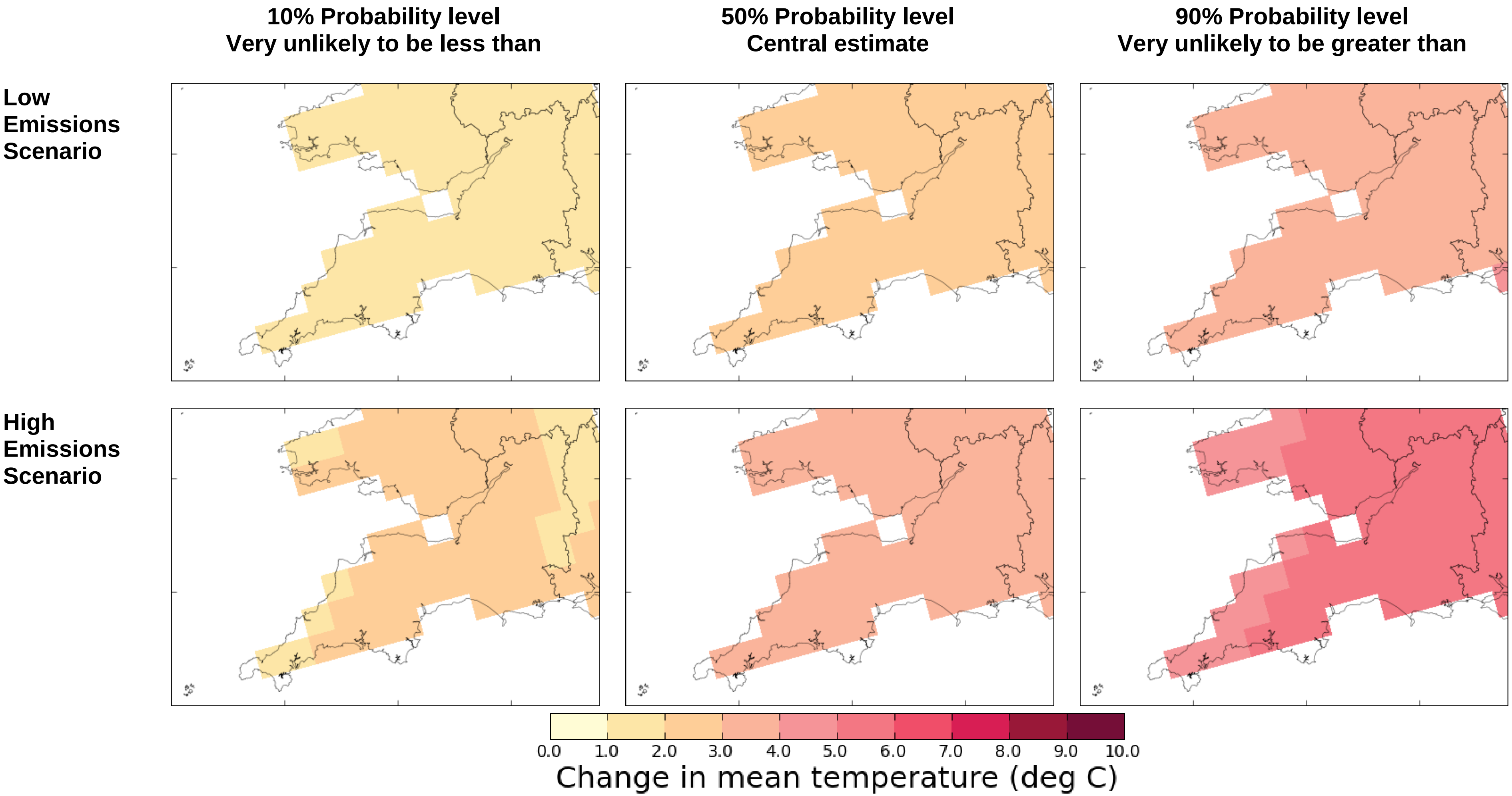
Low Emissions Scenario

High Emissions Scenario

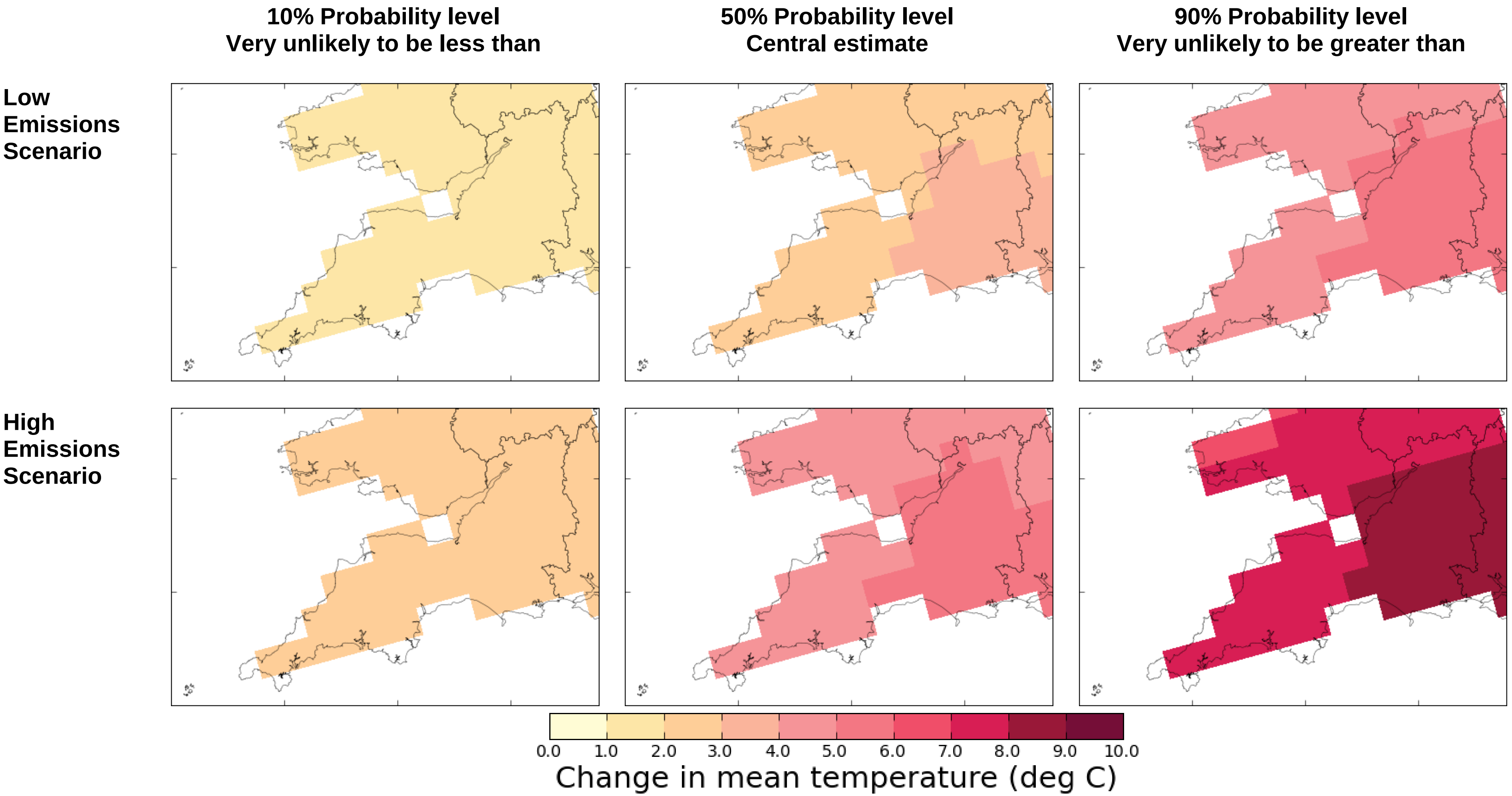
Mean Temperature Change 2050s Summer



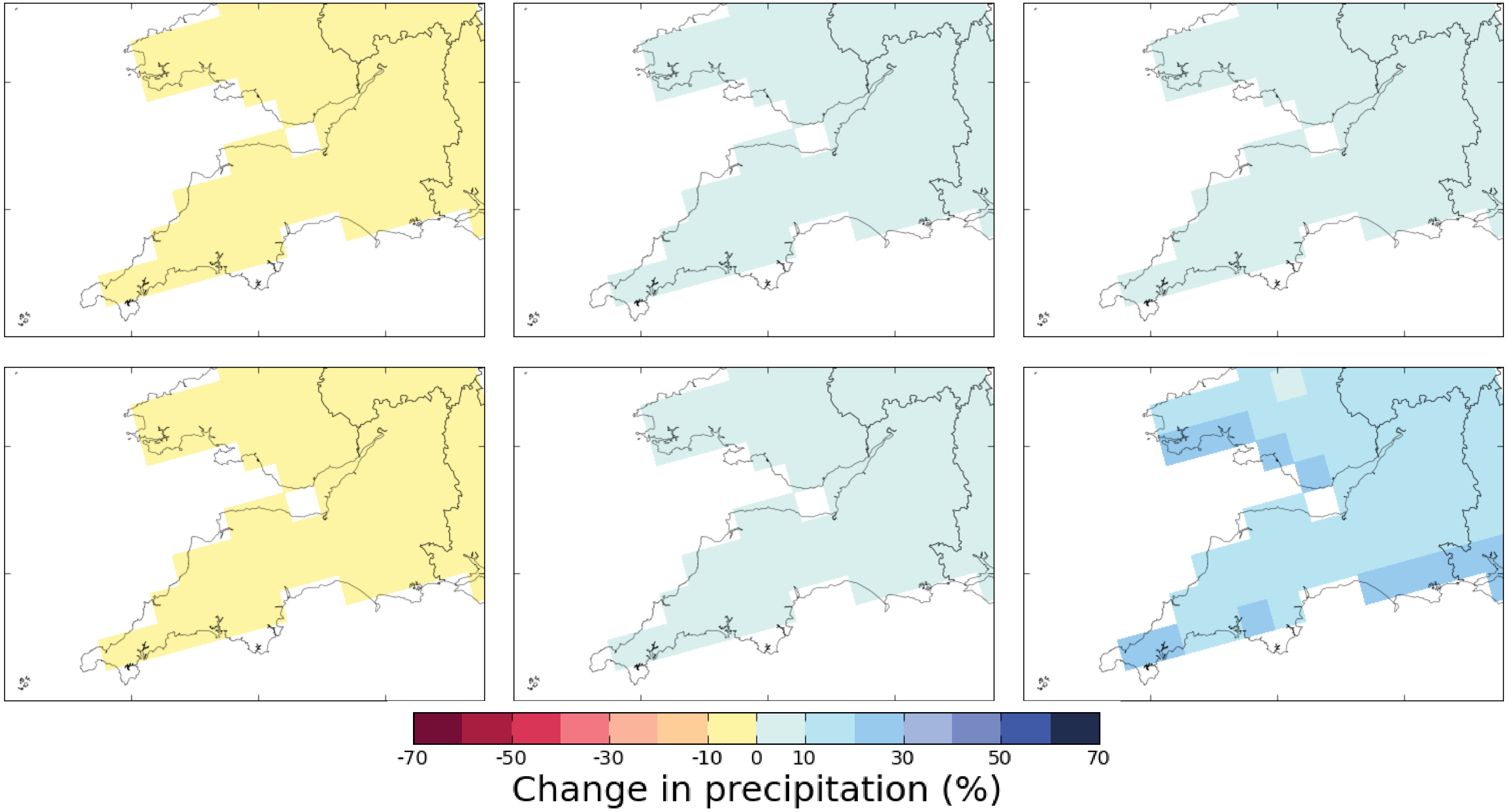
Mean Temperature Change 2080s Winter



Mean Temperature Change 2080s Summer



Precipitation Change 2020s Winter



10% Probability level
Very unlikely to be less than

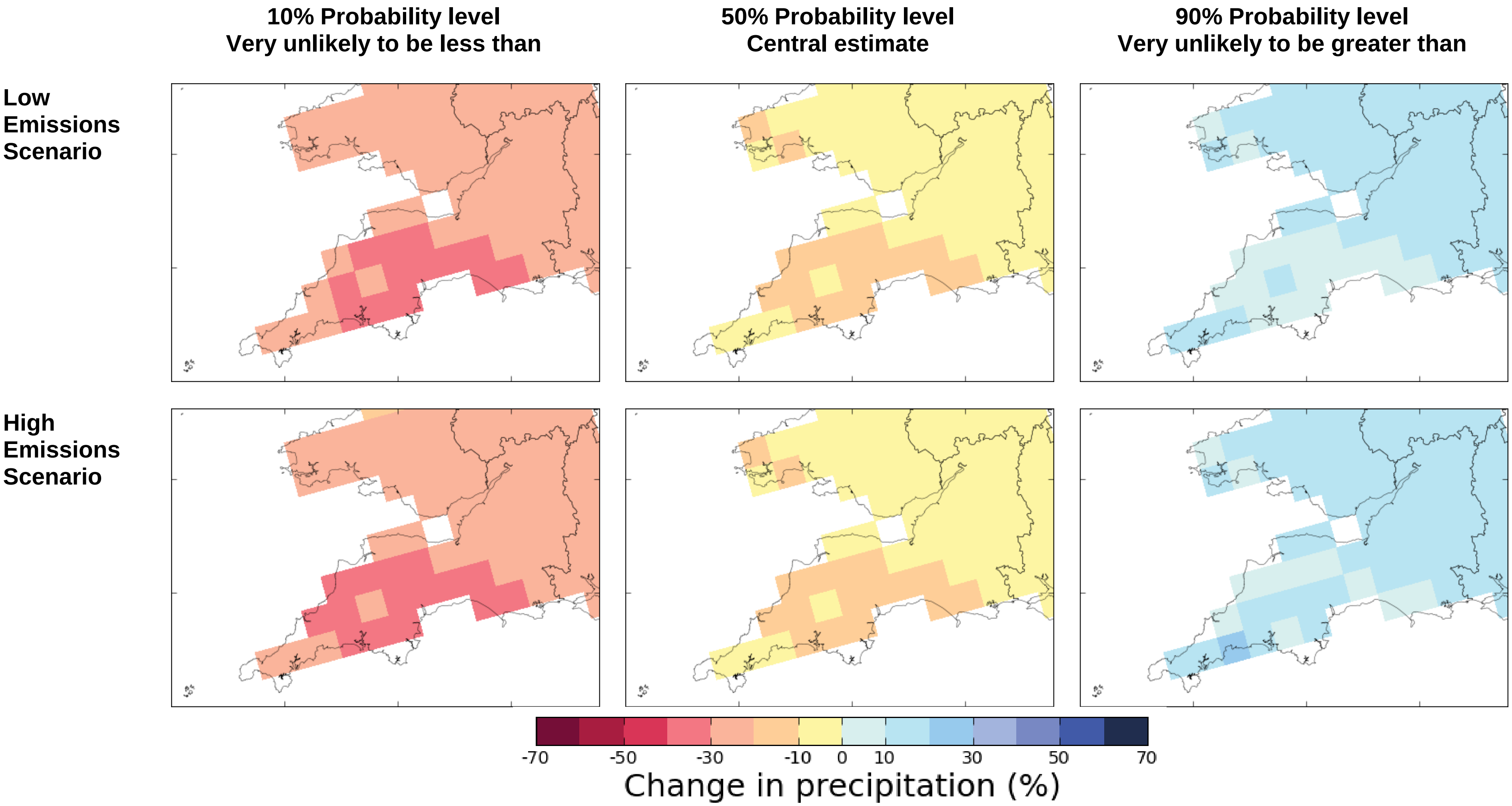
50% Probability level
Central estimate

90% Probability level
Very unlikely to be greater than

Low
Emissions
Scenario

High
Emissions
Scenario

Precipitation Change 2020s Summer



10% Probability level
Very unlikely to be less than

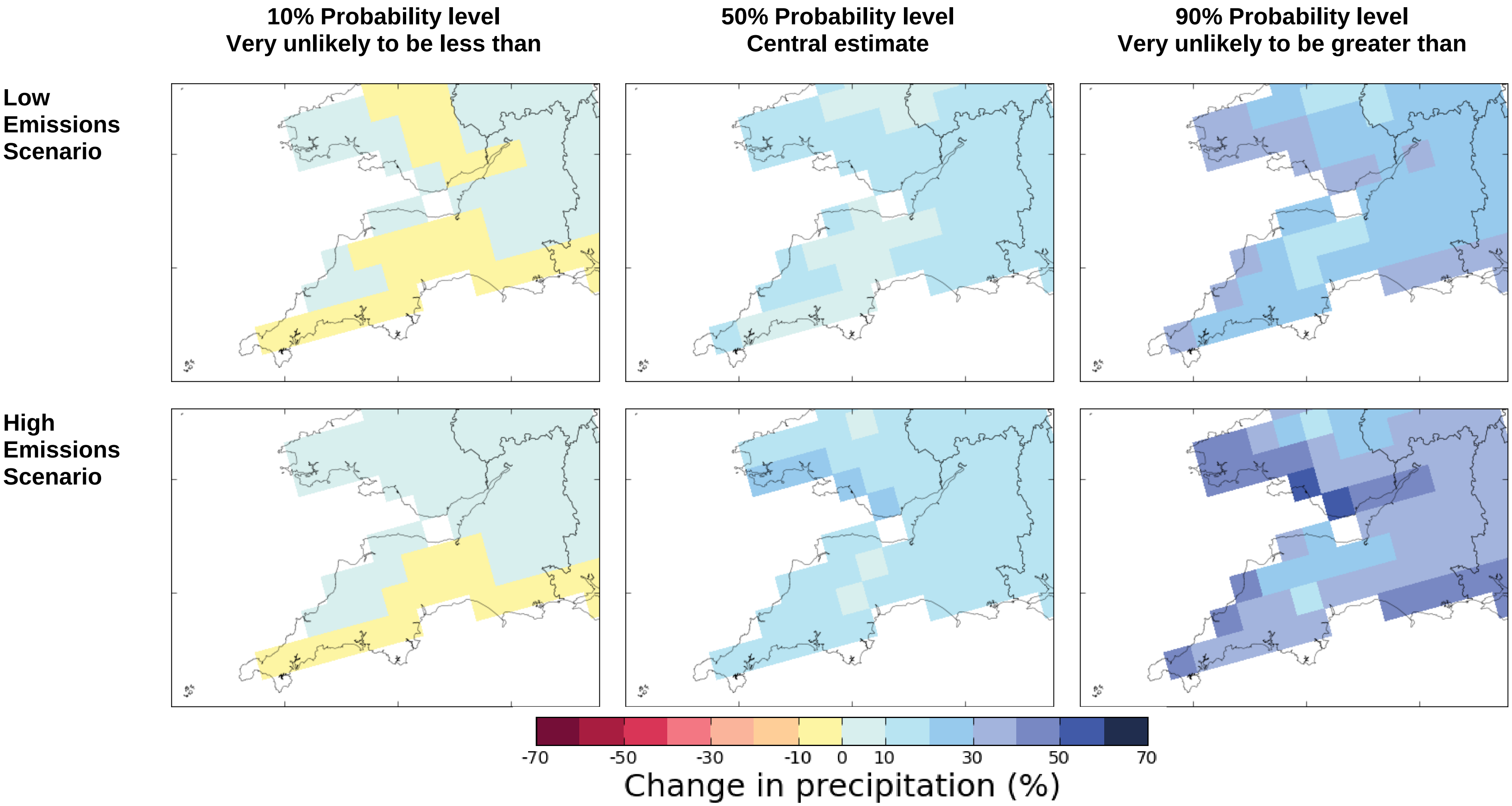
50% Probability level
Central estimate

90% Probability level
Very unlikely to be greater than

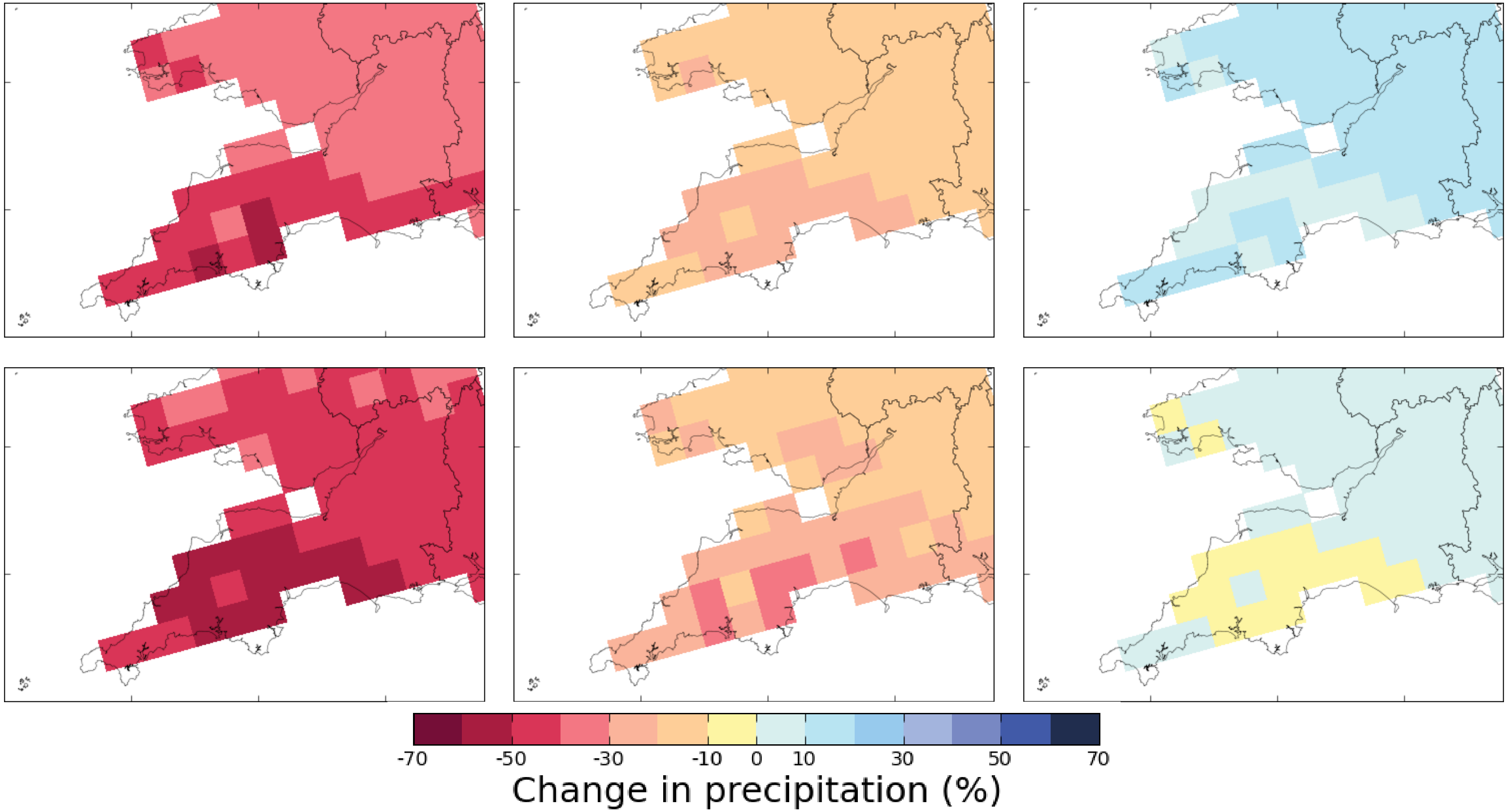
Low Emissions Scenario

High Emissions Scenario

Precipitation Change 2050s Winter



Precipitation Change 2050s Summer



10% Probability level
Very unlikely to be less than

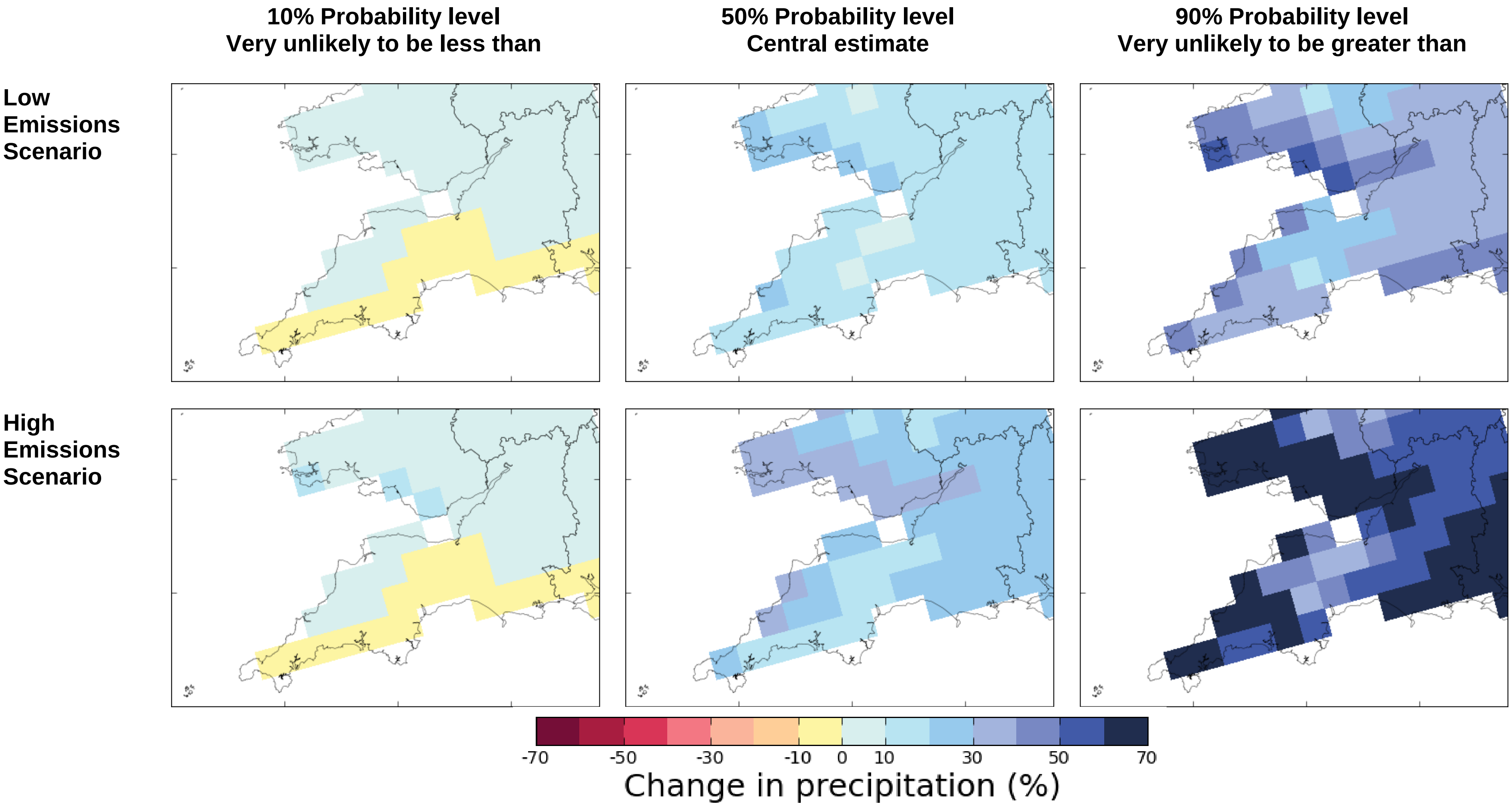
50% Probability level
Central estimate

90% Probability level
Very unlikely to be greater than

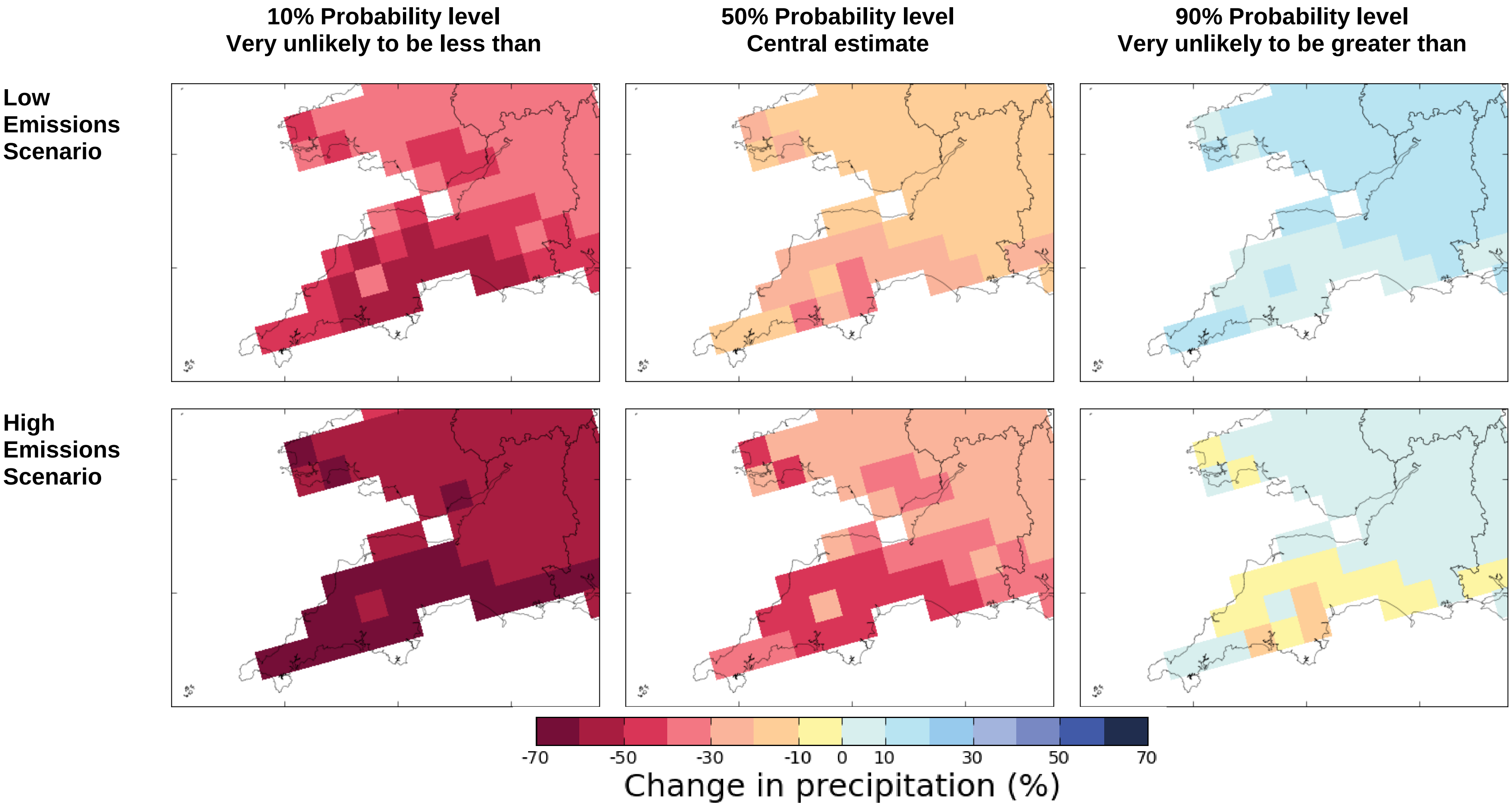
Low
Emissions
Scenario

High
Emissions
Scenario

Precipitation Change 2080s Winter



Precipitation Change 2080s Summer



Winter rainfall change

CENTRE OF SWW REGION

			2020s			2050s			2080s		
			Emissions scenario			Emissions scenario			Emissions scenario		
			Low	Medium	High	Low	Medium	High	Low	Medium	High
Probability	10%	(very unlikely to be less than)	0 to -10%	0 to -10%	0 to -10%	0% to +10%	0% to +10%	0% to +10%	0% to +10%	0% to +10%	0% to +10%
	33%	(unlikely to be less than)	0% to +10%	0% to +10%	0% to +10%	0% to +10%	+10% to +20%	+10% to +20%	+10% to +20%	+10% to +20%	+10% to +20%
	50%	(central case)	0% to +10%	0% to +10%	0% to +10%	+10% to +20%	+10% to +20%	+10% to +20%	+10% to +20%	+20% to +30%	+20% to +30%
	67%	(unlikely to be greater than)	0% to +10%	0% to +10%	0% to +10%	+10% to +20%	+20% to +30%	+20% to +30%	+20% to +30%	+20% to +30%	+30% to +40%
	90%	(very unlikely to be greater than)	+10% to +20%	+10% to +20%	+10% to +20%	+20% to +30%	+30% to +40%	+30% to +40%	+30% to +40%	+40% to +50%	+60% to +70%

WETTEST IN SWW REGION

			2020s			2050s			2080s		
			Low	Medium	High	Low	Medium	High	Low	Medium	High
Probability	10%	(very unlikely to be less than)	0 to -10%	0 to -10%	0 to -10%	0% to +10%	0% to +10%	0% to +10%	0% to +10%	0% to +10%	0% to +10%
	33%	(unlikely to be less than)	0% to +10%	0% to +10%	0% to +10%	0% to +10%	+10% to +20%	+10% to +20%	+10% to +20%	+10% to +20%	+20% to +30%
	50%	(central case)	0% to +10%	0% to +10%	0% to +10%	+10% to +20%	+10% to +20%	+10% to +20%	+20% to +30%	+20% to +30%	+30% to +40%
	67%	(unlikely to be greater than)	+10% to +20%	+10% to +20%	+10% to +20%	+10% to +20%	+20% to +30%	+20% to +30%	+20% to +30%	+30% to +40%	+40% to +50%
	90%	(very unlikely to be greater than)	+20% to +30%	+20% to +30%	+20% to +30%	+30% to +40%	+40% to +50%	+40% to +50%	+40% to +50%	+60% to +70%	+60% to +70%

LEAST WET IN SWW REGION

			2020s			2050s			2080s		
			Low	Medium	High	Low	Medium	High	Low	Medium	High
Probability	10%	(very unlikely to be less than)	0 to -10%	0 to -10%	0 to -10%	0 to -10%	0 to -10%	0 to -10%	0 to -10%	0 to -10%	0 to -10%
	33%	(unlikely to be less than)	0% to +10%	0% to +10%	0% to +10%	0% to +10%	0% to +10%	0% to +10%	0% to +10%	0% to +10%	0% to +10%
	50%	(central case)	0% to +10%	0% to +10%	0% to +10%	0% to +10%	0% to +10%	0% to +10%	0% to +10%	+10% to +20%	+10% to +20%
	67%	(unlikely to be greater than)	0% to +10%	0% to +10%	0% to +10%	0% to +10%	+10% to +20%	+10% to +20%	+10% to +20%	+10% to +20%	+10% to +20%
	90%	(very unlikely to be greater than)	+10% to +20%	+10% to +20%	+10% to +20%	+10% to +20%	+10% to +20%	+10% to +20%	+10% to +20%	+20% to +30%	+30% to +40%

NOTES

http://ukclimateprojections.defra.gov.uk/content/view/1488/499/

Annual Average Daily Temperature

CENTRE OF SWW REGION

			2020s			2050s			2080s		
			Emissions scenario			Emissions scenario			Emissions scenario		
			Low	Medium	High	Low	Medium	High	Low	Medium	High
	10%	(very unlikely to be less than)	0 to +1	0 to +1	0 to +1	+1 to +2	+1 to +2	+1 to +2	+1 to +2	+2 to +3	+2 to +3
	33%	(unlikely to be less than)	+1 to +2	+1 to +2	+1 to +2	+1 to +2	+2 to +3	+2 to +3	+2 to +3	+2 to +3	+3 to +4
Probability	50%	(central case)	+1 to +2	+1 to +2	+1 to +2	+2 to +3	+2 to +3	+2 to +3	+2 to +3	+3 to +4	+4 to +5
	67%	(unlikely to be greater than)	+1 to +2	+1 to +2	+1 to +2	+2 to +3	+2 to +3	+3 to +4	+3 to +4	+3 to +4	+4 to +5
	90%	(very unlikely to be greater than)	+2 to +3	+2 to +3	+2 to +3	+3 to +4	+3 to +4	+3 to +4	+3 to +4	+4 to +5	+6 to +7

WARMEST IN SWW REGION

			2020s			2050s			2080s		
			Low	Medium	High	Low	Medium	High	Low	Medium	High
	10%	(very unlikely to be less than)	0 to +1	0 to +1	0 to +1	+1 to +2	+1 to +2	+1 to +2	+1 to +2	+2 to +3	+2 to +3
	33%	(unlikely to be less than)	+1 to +2	+1 to +2	+1 to +2	+1 to +2	+1 to +2	+2 to +3	+2 to +3	+3 to +4	+3 to +4
Probability	50%	(central case)	+1 to +2	+1 to +2	+1 to +2	+2 to +3	+2 to +3	+2 to +3	+2 to +3	+3 to +4	+4 to +5
	67%	(unlikely to be greater than)	+1 to +2	+1 to +2	+1 to +2	+2 to +3	+2 to +3	+3 to +4	+3 to +4	+4 to +5	+4 to +5
	90%	(very unlikely to be greater than)	+2 to +3	+2 to +3	+2 to +3	+3 to +4	+3 to +4	+4 to +5	+4 to +5	+5 to +6	+6 to +7

LEAST WARM IN SWW REGION

			2020s			2050s			2080s		
			Low	Medium	High	Low	Medium	High	Low	Medium	High
	10%	(very unlikely to be less than)	0 to +1	0 to +1	0 to +1	+1 to +2	+1 to +2	+1 to +2	+1 to +2	+2 to +3	+2 to +3
	33%	(unlikely to be less than)	+1 to +2	+1 to +2	+1 to +2	+1 to +2	+2 to +3	+2 to +3	+2 to +3	+2 to +3	+3 to +4
Probability	50%	(central case)	+1 to +2	+1 to +2	+1 to +2	+2 to +3	+2 to +3	+2 to +3	+2 to +3	+3 to +4	+4 to +5
	67%	(unlikely to be greater than)	+1 to +2	+1 to +2	+1 to +2	+2 to +3	+2 to +3	+2 to +3	+2 to +3	+3 to +4	+4 to +5
	90%	(very unlikely to be greater than)	+1 to +2	+2 to +3	+1 to +2	+2 to +3	+3 to +4	+3 to +4	+3 to +4	+4 to +5	+5 to +6

NOTES

East / southeast part of SWW region generally warmer.

http://ukclimateprojections.defra.gov.uk/content/view/1482/499/

Summer rainfall change

			2020s			2050s			2080s		
			Emissions scenario			Emissions scenario			Emissions scenario		
CENTRE OF SWW REGION			Low	Medium	High	Low	Medium	High	Low	Medium	High
	10%	(very unlikely to be less than)	-20% to -30%	-20% to -30%	-20% to -30%	-30% to -40%	-40% to -50%	-40% to -50%	-30% to -40%	-40% to -50%	-50% to -60%
	33%	(unlikely to be less than)	-10% to -20%	-10% to -20%	-10% to -20%	-20% to -30%	-20% to -30%	-20% to -30%	-20% to -30%	-30% to -40%	-30% to -40%
Probability	50%	(central case)	0 to -10%	0 to -10%	0 to -10%	-10% to -20%	-10% to -20%	-10% to -20%	-10% to -20%	-20% to -30%	-20% to -30%
	67%	(unlikely to be greater than)	0 to -10%	0 to -10%	0% to +10%	0 to -10%	-10% to -20%	-10% to -20%	0 to -10%	-10% to -20%	-10% to -20%
	90%	(very unlikely to be greater than)	+10% to +20%	+10% to +20%	+10% to +20%	+10% to +20%	0% to +10%	0% to +10%	+10% to +20%	0% to +10%	0% to +10%

DRIEST IN SWW REGION											
	10%	(very unlikely to be less than)	-30% to -40%	-30% to -40%	-30% to -40%	-50% to -60%	-50% to -60%	-50% to -60%	-50% to -60%	-60% to -70%	-60% to -70%
	33%	(unlikely to be less than)	-20% to -30%	-20% to -30%	-20% to -30%	-30% to -40%	-40% to -50%	-40% to -50%	-30% to -40%	-40% to -50%	-50% to -60%
Probability	50%	(central case)	-10% to -20%	-10% to -20%	-10% to -20%	-20% to -30%	-30% to -40%	-30% to -40%	-30% to -40%	-30% to -40%	-40% to -50%
	67%	(unlikely to be greater than)	0 to -10%	0 to -10%	0 to -10%	-10% to -20%	-20% to -30%	-20% to -30%	-20% to -30%	-20% to -30%	-30% to -40%
	90%	(very unlikely to be greater than)	0% to +10%	0% to +10%	0% to +10%	0% to +10%	0 to -10%	0 to -10%	0% to +10%	0 to -10%	-10% to -20%

LEAST DRY IN SWW REGION											
	10%	(very unlikely to be less than)	-20% to -30%	-20% to -30%	-20% to -30%	-30% to -40%	-40% to -50%	-40% to -50%	-30% to -40%	-40% to -50%	-50% to -60%
	33%	(unlikely to be less than)	-10% to -20%	-10% to -20%	-10% to -20%	-20% to -30%	-20% to -30%	-20% to -30%	-20% to -30%	-30% to -40%	-30% to -40%
Probability	50%	(central case)	0 to -10%	0 to -10%	0 to -10%	-10% to -20%	-10% to -20%	-10% to -20%	-10% to -20%	-20% to -30%	-20% to -30%
	67%	(unlikely to be greater than)	0 to -10%	0 to -10%	0% to +10%	0 to -10%	-10% to -20%	-10% to -20%	0 to -10%	-10% to -20%	-10% to -20%
	90%	(very unlikely to be greater than)	+10% to +20%	+10% to +20%	+20% to +30%	+10% to +20%	0% to +10%	0% to +10%	+10% to +20%	0% to +10%	0% to +10%

NOTES

http://ukclimateprojections.defra.gov.uk/content/view/1485/499/

Summer Average Daily Temperature

			2020s			2050s			2080s		
			Emissions scenario			Emissions scenario			Emissions scenario		
CENTRE OF SWW REGION			Low	Medium	High	Low	Medium	High	Low	Medium	High
	10%	(very unlikely to be less than)	0 to +1	0 to +1	0 to +1	+1 to +2	+1 to +2	+1 to +2	+1 to +2	+1 to +2	+2 to +3
	33%	(unlikely to be less than)	+1 to +2	+1 to +2	+1 to +2	+1 to +2	+2 to +3	+2 to +3	+2 to +3	+3 to +4	+3 to +4
Probability	50%	(central case)	+1 to +2	+1 to +2	+1 to +2	+2 to +3	+2 to +3	+2 to +3	+2 to +3	+3 to +4	+4 to +5
	67%	(unlikely to be greater than)	+1 to +2	+1 to +2	+1 to +2	+2 to +3	+3 to +4	+3 to +4	+3 to +4	+4 to +5	+5 to +6
	90%	(very unlikely to be greater than)	+2 to +3	+2 to +3	+2 to +3	+3 to +4	+4 to +5	+4 to +5	+4 to +5	+6 to +7	+7 to +8
WARMEST IN SWW REGION											
	10%	(very unlikely to be less than)	0 to +1	0 to +1	0 to +1	+1 to +2	+1 to +2	+1 to +2	+1 to +2	+2 to +3	+2 to +3
	33%	(unlikely to be less than)	+1 to +2	+1 to +2	+1 to +2	+2 to +3	+2 to +3	+2 to +3	+2 to +3	+3 to +4	+4 to +5
Probability	50%	(central case)	+1 to +2	+1 to +2	+1 to +2	+2 to +3	+2 to +3	+3 to +4	+3 to +4	+4 to +5	+5 to +6
	67%	(unlikely to be greater than)	+2 to +3	+1 to +2	+1 to +2	+3 to +4	+3 to +4	+3 to +4	+3 to +4	+4 to +5	+6 to +7
	90%	(very unlikely to be greater than)	+2 to +3	+2 to +3	+2 to +3	+4 to +5	+4 to +5	+5 to +6	+5 to +6	+6 to +7	+8 to +9
LEAST WARM IN SWW REGION											
	10%	(very unlikely to be less than)	0 to +1	0 to +1	0 to +1	0 to +1	+1 to +2	+1 to +2	+1 to +2	+1 to +2	+2 to +3
	33%	(unlikely to be less than)	+1 to +2	+1 to +2	+1 to +2	+1 to +2	+1 to +2	+2 to +3	+2 to +3	+2 to +3	+3 to +4
Probability	50%	(central case)	+1 to +2	+1 to +2	+1 to +2	+2 to +3	+2 to +3	+2 to +3	+2 to +3	+3 to +4	+4 to +5
	67%	(unlikely to be greater than)	+1 to +2	+1 to +2	+1 to +2	+2 to +3	+2 to +3	+3 to +4	+3 to +4	+4 to +5	+5 to +6
	90%	(very unlikely to be greater than)	+2 to +3	+2 to +3	+2 to +3	+3 to +4	+4 to +5	+4 to +5	+4 to +5	+5 to +6	+7 to +8

NOTES

East / southeast part of SWW region generally warmer.

http://ukclimateprojections.defra.gov.uk/content/view/1058/499/

Relative Sea Level Rise (cm) with respect to 1990

Off the Exe Estuary (Grid square 25728)

			2020s			2050s			2080s	
		Emissions scenario			Emissions scenario			Emissions scenario		
		Low	Medium	High	Low	Medium	High	Low	Medium	High
	5% (very unlikely to be less than)	0 to +10	0 to +10	0 to +10	+10 to +20	+10 to +20	+10 to +20	+10 to +20	+10 to +20	+20 to +30
Probability	50% (central case)	0 to +10	+10 to +20	+10 to +20	+10 to +20	+20 to +30	+20 to +30	+30 to +40	+30 to +40	+40 to +50
	95% (very unlikely to be greater than)	+10 to +20	+10 to +20	+10 to +20	+20 to +30	+30 to +40	+40 to +50	+40 to +50	+50 to +60	+60 to +70

Off Land's End (Grid square 26930)

			2020s			2050s			2080s	
		Emissions scenario			Emissions scenario			Emissions scenario		
		Low	Medium	High	Low	Medium	High	Low	Medium	High
	5% (very unlikely to be less than)	0 to +10	0 to +10	0 to +10	+10 to +20	+10 to +20	+10 to +20	+20 to +30	+20 to +30	+20 to +30
Probability	50% (central case)	0 to +10	+10 to +20	+10 to +20	+20 to +30	+20 to +30	+20 to +30	+30 to +40	+40 to +50	+40 to +50
	95% (very unlikely to be greater than)	+10 to +20	+10 to +20	+10 to +20	+20 to +30	+30 to +40	+40 to +50	+40 to +50	+50 to +60	+70 to +80

Off Ilfracombe (Grid square 24080)

			2020s			2050s			2080s	
		Emissions scenario			Emissions scenario			Emissions scenario		
		Low	Medium	High	Low	Medium	High	Low	Medium	High
	5% (very unlikely to be less than)	0 to +10	0 to +10	0 to +10	+10 to +20	+10 to +20	+10 to +20	+10 to +20	+10 to +20	+10 to +20
Probability	50% (central case)	0 to +10	+10 to +20	+10 to +20	+10 to +20	+20 to +30	+20 to +30	+30 to +40	+30 to +40	+40 to +50
	95% (very unlikely to be greater than)	+10 to +20	+10 to +20	+10 to +20	+20 to +30	+30 to +40	+40 to +50	+40 to +50	+50 to +60	+60 to +70

NOTES

For 2020s, relative sea level rise for the year 2020 has been given.
For 2050s, relative sea level rise for the year 2050 has been given.
For 2080s, relative sea level rise for the year 2080 has been given.

Winter rainfall change - medium emissions

			2020s	2050s	2080s
CENTRE OF SWW REGION					
	10%	(very unlikely to be less than)	0 to -10%	0% to +10%	0% to +10%
	33%	(unlikely to be less than)	0% to +10%	+10% to +20%	+10% to +20%
Probability	50%	(central case)	0% to +10%	+10% to +20%	+20% to +30%
	67%	(unlikely to be greater than)	0% to +10%	+20% to +30%	+20% to +30%
	90%	(very unlikely to be greater than)	+10% to +20%	+30% to +40%	+40% to +50%
WETTEST IN SWW REGION					
	10%	(very unlikely to be less than)	0 to -10%	0% to +10%	0% to +10%
	33%	(unlikely to be less than)	0% to +10%	+10% to +20%	+10% to +20%
Probability	50%	(central case)	0% to +10%	+10% to +20%	+20% to +30%
	67%	(unlikely to be greater than)	+10% to +20%	+20% to +30%	+30% to +40%
	90%	(very unlikely to be greater than)	+20% to +30%	+40% to +50%	+60% to +70%
LEAST WET IN SWW REGION					
	10%	(very unlikely to be less than)	0 to -10%	0 to -10%	0 to -10%
	33%	(unlikely to be less than)	0% to +10%	0% to +10%	0% to +10%
Probability	50%	(central case)	0% to +10%	0% to +10%	+10% to +20%
	67%	(unlikely to be greater than)	0% to +10%	+10% to +20%	+10% to +20%
	90%	(very unlikely to be greater than)	+10% to +20%	+10% to +20%	+20% to +30%

NOTES

http://ukclimateprojections.defra.gov.uk/content/view/1488/499/

Summer rainfall change - medium emissions

CENTRE OF SWW REGION

			2020s	2050s	2080s
	10%	**(very unlikely to be less than)**	-20% to -30%	-40% to -50%	-40% to -50%
	33%	**(unlikely to be less than)**	-10% to -20%	-20% to -30%	-30% to -40%
Probability	**50%**	**(central case)**	0 to -10%	-10% to -20%	-20% to -30%
	67%	**(unlikely to be greater than)**	0 to -10%	-10% to -20%	-10% to -20%
	90%	**(very unlikely to be greater than)**	+10% to +20%	0% to +10%	0% to +10%

DRIEST IN SWW REGION

			2020s	2050s	2080s
	10%	**(very unlikely to be less than)**	-30% to -40%	-50% to -60%	-60% to -70%
	33%	**(unlikely to be less than)**	-20% to -30%	-40% to -50%	-40% to -50%
Probability	**50%**	**(central case)**	-10% to -20%	-30% to -40%	-30% to -40%
	67%	**(unlikely to be greater than)**	0 to -10%	-20% to -30%	-20% to -30%
	90%	**(very unlikely to be greater than)**	0% to +10%	0 to -10%	0 to -10%

LEAST DRY IN SWW REGION

			2020s	2050s	2080s
	10%	**(very unlikely to be less than)**	-20% to -30%	-40% to -50%	-40% to -50%
	33%	**(unlikely to be less than)**	-10% to -20%	-20% to -30%	-30% to -40%
Probability	**50%**	**(central case)**	0 to -10%	-10% to -20%	-20% to -30%
	67%	**(unlikely to be greater than)**	0 to -10%	-10% to -20%	-10% to -20%
	90%	**(very unlikely to be greater than)**	+10% to +20%	0% to +10%	0% to +10%

NOTES

http://ukclimateprojections.defra.gov.uk/content/view/1485/499/

Annual Average Daily Temperature - medium emissions

CENTRE OF SWW REGION

			2020s	2050s	2080s
	10%	(very unlikely to be less than)	0 to +1	+1 to +2	+2 to +3
	33%	(unlikely to be less than)	+1 to +2	+2 to +3	+2 to +3
Probability	**50%**	**(central case)**	+1 to +2	+2 to +3	+3 to +4
	67%	(unlikely to be greater than)	+1 to +2	+2 to +3	+3 to +4
	90%	(very unlikely to be greater than)	+2 to +3	+3 to +4	+4 to +5

WARMEST IN SWW REGION

			2020s	2050s	2080s
	10%	(very unlikely to be less than)	0 to +1	+1 to +2	+2 to +3
	33%	(unlikely to be less than)	+1 to +2	+1 to +2	+3 to +4
Probability	**50%**	**(central case)**	+1 to +2	+2 to +3	+3 to +4
	67%	(unlikely to be greater than)	+1 to +2	+2 to +3	+4 to +5
	90%	(very unlikely to be greater than)	+2 to +3	+3 to +4	+5 to +6

LEAST WARM IN SWW REGION

			2020s	2050s	2080s
	10%	(very unlikely to be less than)	0 to +1	+1 to +2	+2 to +3
	33%	(unlikely to be less than)	+1 to +2	+2 to +3	+2 to +3
Probability	**50%**	**(central case)**	+1 to +2	+2 to +3	+3 to +4
	67%	(unlikely to be greater than)	+1 to +2	+2 to +3	+3 to +4
	90%	(very unlikely to be greater than)	+2 to +3	+3 to +4	+4 to +5

NOTES

East / southeast part of SWW region generally warmer.

http://ukclimateprojections.defra.gov.uk/content/view/1482/499/

Summer Average Daily Temperature - medium emissions

CENTRE OF SWW REGION

			2020s	**2050s**	**2080s**
	10%	**(very unlikely to be less than)**	0 to +1	+1 to +2	+1 to +2
	33%	**(unlikely to be less than)**	+1 to +2	+2 to +3	+3 to +4
Probability	**50%**	**(central case)**	+1 to +2	+2 to +3	+3 to +4
	67%	**(unlikely to be greater than)**	+1 to +2	+3 to +4	+4 to +5
	90%	**(very unlikely to be greater than)**	+2 to +3	+4 to +5	+6 to +7

WARMEST IN SWW REGION

			2020s	**2050s**	**2080s**
	10%	**(very unlikely to be less than)**	0 to +1	+1 to +2	+2 to +3
	33%	**(unlikely to be less than)**	+1 to +2	+2 to +3	+3 to +4
Probability	**50%**	**(central case)**	+1 to +2	+2 to +3	+4 to +5
	67%	**(unlikely to be greater than)**	+1 to +2	+3 to +4	+4 to +5
	90%	**(very unlikely to be greater than)**	+2 to +3	+4 to +5	+6 to +7

LEAST WARM IN SWW REGION

			2020s	**2050s**	**2080s**
	10%	**(very unlikely to be less than)**	0 to +1	+1 to +2	+1 to +2
	33%	**(unlikely to be less than)**	+1 to +2	+1 to +2	+2 to +3
Probability	**50%**	**(central case)**	+1 to +2	+2 to +3	+3 to +4
	67%	**(unlikely to be greater than)**	+1 to +2	+2 to +3	+4 to +5
	90%	**(very unlikely to be greater than)**	+2 to +3	+4 to +5	+5 to +6

NOTES

East / southeast part of SWW region generally warmer.

http://ukclimateprojections.defra.gov.uk/content/view/1058/499/

Relative Sea Level Rise (cm) with respect to 1990 - medium emissions

Off the Exe Estuary (Grid square 25728)

			2020s	2050s	2080s
	5%	(very unlikely to be less than)	0 to +10	+10 to +20	+10 to +20
Probability	50%	(central case)	+10 to +20	+20 to +30	+30 to +40
	95%	(very unlikely to be greater than)	+10 to +20	+30 to +40	+50 to +60

Off Land's End (Grid square 26930)

			2020s	2050s	2080s
	5%	(very unlikely to be less than)	0 to +10	+10 to +20	+20 to +30
Probability	50%	(central case)	+10 to +20	+20 to +30	+40 to +50
	95%	(very unlikely to be greater than)	+10 to +20	+30 to +40	+50 to +60

Off Ilfracombe (Grid square 24080)

			2020s	2050s	2080s
	5%	(very unlikely to be less than)	0 to +10	+10 to +20	+10 to +20
Probability	50%	(central case)	+10 to +20	+20 to +30	+30 to +40
	95%	(very unlikely to be greater than)	+10 to +20	+30 to +40	+50 to +60

NOTES

For 2020s, relative sea level rise for the year 2020 has been given.
For 2050s, relative sea level rise for the year 2050 has been given.
For 2080s, relative sea level rise for the year 2080 has been given.

APPENDIX D: Water resources & climate change modelling

1 Introduction

We are active participants in climate change work at both regional and national levels and have sponsored academic research on the topic. The water industry has played a leading role in climate change research in recent years and a list of projects completed since 1997 is included in Appendix B to this report.

We keep abreast of the latest developments in climate change and keep our supply/demand computer models are regularly updated. The water resources modelling we carried out for our Water Resources Plan[17] incorporated climate change effects based on the latest scenarios available at the time, which were the UKWIR06 scenarios (based on the UKCIP02 outputs). However, since publication of the Plan the UKCP09 scenarios became available. The water industry commissioned a project to develop “Quick Look” mean climate change factors which would enable companies to see if there were any significant differences emerging between the new scenarios and those used previously.

In Section 2 of this Appendix we present our assessment of the impacts of climate change on WAFU as published in our Water Resources Plan. We analysed the effect on surface sources, groundwater sources and demand.

Section 3 of this Appendix uses the “Quick Look” factors to see if the projected impact of climate change on water resources has changed significantly with the publication of UKCP09. It should be noted that the impact on demand was not reanalysed for the new scenarios as it was most unlikely to have a material effect on the results. Section 3 examines each of our three strategic supply areas separately.

2 Assessment of impact climate change on WAFU based on UKWIR06 scenarios and presented in the Water Resources

2.1 Climate change impacts on supply

2.1.1 Surface water

In estimating the impact of climate change on the surface water sources, we followed the guidance report and methodology provided by the Environment Agency[18]. This guidance is based on the methods detailed in the UKWIR CL04 surface water report[19] and uses the UKWIR06 climate change scenarios and the

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[17] South West Water, Water Resources Plan, November 2009

[18] Environment Agency Supplementary Guidance to Chapter 8, Nov 2007, Climate change implications in estimates of water resource zone Deployable Output, N. Arnell and N. Reynard

[19] UKWIR, 2007, Effects of climate change on river flows and groundwater recharge: guidelines for resource assessment and UKWIR06 scenarios. UKWIR Report CL04/. UKWIR Ltd London

spreadsheet model (Integrated Spreadsheet V5.xls) provided by the Environment Agency.

In line with the guidance, we used the UKWIR CL04 (flow factor) methods 1a and 1b, as catchment rainfall-runoff models were not available. Method 1a was selected where the flow site being considered was within, or similar to, one of the 70 catchments already modelled in the UKWIR06 study. Method 1b was used in areas where method 1a flow factors were not available.

The methodology identifies three climate change scenarios: dry, mean and wet. For each of these scenarios monthly flow factors were obtained using either the methods 1a or 1b as detailed above. In line with the Supplementary Guidance Note provided by the Environment Agency, the monthly flow factors for each of the scenarios were applied to the whole of our historic naturalised flow sequences to create flow sequences characteristic of possible conditions in 2025. Although it is possible that flows in the 1990s already include some impact of climate change and hence there could be potential for 'double-counting', this does not affect us for the purpose of defining Deployable Output/WAFU, as for all three resource zones, the design drought uses pre 1990s records.

2.2.2 Groundwater

We undertook an assessment of the impact of climate change on the groundwater sources using the same Environment Agency guidance and UKWIR methodology as used for surface water sources. In the case of groundwater the methodology describes three methods:

Method GR1: Using regression equations between local values of precipitation and minimum annual groundwater level

Method GR2: Using a spreadsheet-based lumped parameter, catchment-wide groundwater model to estimate the effect of perturbations to rainfall and potential evaporation on groundwater recharge

Method GR3: Using a catchment groundwater model

Method GR1 can be used to estimate declines in groundwater level from reduced rainfall whilst GR2 and GR3 produce an estimate of the change in recharge, which in turn is used to predict potential changes in local groundwater levels. Irrespective of the method used it is necessary to transpose general water level change estimates into changes in groundwater level at abstraction sites and to infer what these changes would mean for the Deployable Output of the source.

We reassessed groundwater source Deployable Outputs in 2007 and the individual constraints on output were identified. Where groundwater Deployable Output is constrained by source performance and groundwater level there is potential for the reduction in groundwater level from climate change to reduce Deployable Output.

Table D1: SWW Groundwater sources at risk from climate change impacts

Licence Group	DO Constraining Factor	Aquifer Body
Dotton Boreholes 1,2,3,7	Source performance	Triassic Otter Sandstone unit
Colaton Raleigh Boreholes 2,4	Licence flow constraint	Triassic Otter Sandstone unit
Otterton Boreholes 1A	GW licence constraint on 1A	Triassic Otter Sandstone unit
Greatwell Boreholes 1,2,3	Source performance	Triassic Otter Sandstone unit
Greatwell Borehole 4	Source performance	Triassic Otter Sandstone unit
Greatwell Borehole 5	Source performance	Triassic Otter Sandstone unit
Kersbrook	Source performance	Triassic Otter Sandstone unit
Duckaller	GW level constraint on licence	Permian Sandstone
Vennbridge	GW level constraint on licence	Permian Sandstone
Wilmington	Spring flow	Upper Greensand
Littlehempston GW sources	Source performance	Totnes River Gravels

Otter Valley Sources

The majority of groundwater sources “at risk” of impact from climate change occur in the Otter Valley. Hydrogeologically, these sources can be described as occurring in similar groundwater environments, dominated by the properties of the Triassic Otter Sandstone aquifer. The Otter catchment possesses a number of monitoring observation boreholes maintained by the Environment Agency but the majority are heavily influenced by abstractions or have short records. The lack of long term, non abstraction-influenced monitoring points prohibits the investigation each source separately. Instead the site we identified as at most risk was investigated in detail and the results assumed to apply to all the Otter Valley Triassic sandstone sources. We judged this source to be the Otterton 1A production borehole.

The Otterton 1A borehole is licensed to abstract up to 4 Ml/d. However, the abstraction licence includes a provision that the watertable at a local monitoring borehole (known as S1) shall not be drawn down to lower than 0.5 mAOD. The purpose of this constraint is to provide protection against possible saline intrusion as the borehole is a coastal source. We have assessed the current Deployable Output as 2.5 Ml/d based on historical levels reached in S1 during drought periods.

We commissioned an external consultancy (Entec UK) to investigate the impact of climate change on abstraction. The assessment employed both the GR1 and GR2 methodologies but the GR3 approach was not possible due to the absence of a good groundwater model. In addition to the risk of reduced recharge producing lower groundwater levels, a further consideration was the effect of rising sea level.

The ENTEC report reached two conclusions:

- That a best estimate of groundwater level decrease was approximately 0.1 m
- That the sea level could rise be estimated to be 0.12 m
- That an effective water level change of 0.22 m would produce a reduction in abstraction capability of up to 1 Ml/d

The report caveats the impact of sea level rise by stating that the coast groundwater system lies to some extent on top of the saline water system hence any rise in sea level would be expected to be mirrored in a rise in groundwater level. On this basis the impact of sea level rise could be ignored. However, the minimum groundwater level permitted on the licence at S1 is given in mAOD which is a fixed height, therefore, it is considered that any rise in sea level is likely to have a direct impact upon the level in the monitoring borehole and compromise the ability of Otterton 1A to abstract.

For water resource modelling purposes, we have therefore assumed that the groundwater source Deployable Output could decrease from 2.5 Ml/d to 1.5 M/d by 2025. We have changed the abstraction profile using in the conjunctive water resource modelling of the Wimbleball SSA to reflect this.

Given the aquifer characteristics of the Otter Sandstone aquifer system, the location of the sources and the limited data available, we think that a decline in the order of 0.1 m is the best estimate of the potential groundwater fall in the Otter Valley due to climate change. As such a small change is within the level of accuracy of the Deployable Output assessments of the Otter Valley sources, we do not think those boreholes identified as “source constrained” will suffer any significant impact on Deployable Output due to climate change over the planning period.

We carried out further investigations on the Colaton Raleigh boreholes which are constrained by a stream flow constraint on their abstraction licence. They have an assessed Deployable Output of zero but their Deployable Output profile does assume some pumping in the winter and spring, therefore these sources are at risk of some further loss of abstraction capability due to climate change effects on surface water flows. We applied flow factors to the stream flow record using the UKWIR methodology to perturb the flow sequence. Our conclusion from this analysis is that climate change impacts cause a greater flow reduction in the summer months (when the boreholes are already assumed to be off) but the length of the switch-off period does not significantly increase. Therefore in this case the Deployable Output remains zero and the Deployable Output profile we used in water resources modelling remains unchanged.

Permian Sandstone Sources

The Permian aquifer system on which the Duckaller and Vennbridge boreholes are situated is very similar to the Otter Sandstone aquifer system with similar aquifer and recharge characteristics. As such it is reasonable to apply the same estimated fall in groundwater level of 0.1m. These boreholes are restricted in output by levels in local monitoring boreholes and flows in neighbouring streams. As in the Otter Valley, a 0.1m drop is not significant in terms of the accuracy of the Deployable Output assessments of these sources therefore no Deployable Output change is applied due to climate impacts on groundwater level. In the case of stream flow reduction, no impact on abstraction capacity is assumed as stream flow is protected by the use of compensation boreholes to top up the stream flow as necessary.

Upper Greensand Spring Source

The outputs at Wilmington Springs WTW are frequently reduced due to declining spring flow in the summer and autumn. This is accentuated during a drought period. Due to the poor availability of groundwater level records, we have undertaken a simple analysis to identify the correlation between spring flow and the water level record from the nearest monitoring point. We used a reduction of 0.1m in groundwater level due to climate change (as calculated from the Otter Valley climate change analysis) to estimate the potential impact on spring flow. We identified a correlation which translated a fall of 0.1m in local groundwater level into a decline in spring flow of up to 0.2 Ml/d. We applied this decline in Deployable Output to the 2025 yield profile of the source.

River Gravel Sources

We have not undertaken a detailed assessment of the climate change impact on the Littlehempston groundwater sources which abstract from recent river gravel deposits, in view of the nature of the aquifer system. These sources abstract from a shallow river gravel aquifer underlying the River Dart. Groundwater levels are highly influenced by river levels but these do not change sufficiently to have an impact on the abstraction capacity of the sources. Rather, the Deployable Output is controlled by the performance of the sources themselves. Any changes in river level as a consequence of climate change are likely to be in the order of centimetres, at most, and this would have no appreciable affect on the ability of the sources to abstract.

2.2 Climate change impacts on demand

2.2.1 Household demand

Results from the CCDeW report[20], which uses the UKCIP02 medium-high climate change scenario in conjunction with the world markets socio-economic scenario, suggest that the increase in demand in our Region due to climate change will be 1.4% by the 2020s.

We have applied this figure to both the measured and unmeasured demand forecasts, for both normal and dry years. The factor was applied to the year 2025, and scaled linearly between 2007 and 2025. We used the same rate of increase between 2025 and 2034. The increase has been divided between the components thought to be most sensitive to climate change in the proportions suggested by the report:

Garden Watering	25%
Personal Washing	70%
Other (Clothes Washing)	5%

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[20] Downing, T.E et al, (2003) *Climate Change and the Demand For Water*, Research Report, Stockholm Environment Institute Oxford Office, Oxford, February 2003.

Table D2: Household PCC increase due to climate change

Year	2007/08	2009/10	2014/15	2019/20	2024/25	2029/30	2034/35
PCC increase	0.0%	0.1%	0.5%	0.9%	1.4%	1.7%	2.2%

2.2.2 Non-household demand

We have built climate change into the forecast by applying the factors from the CCDeW report[21]. The forecast effect of climate change is to increase non-household demand by 3.2% by 2024/25 and 4.3% in 2034/35. This effect has been scaled linearly between the intervening years.

Table D.3: Non-household 'dry' year demand increase due to climate change

Year	2007/08	2009/10	2014/15	2019/20	2024/25	2029/30	2034/35
Demand increase	0.0%	0.4%	1.3%	2.3%	3.2%	3.8%	4.3%

2.3 Calculation of Deployable Output and WAFU

Although the guidance recommends adjusting Deployable Outputs to take into account the effect of climate change, our calculations have focused on the impact of climate change on Water Available For Use (WAFU), in order to take account of climate change on the imports and exports between the resource zones. We have assumed that the outage allowance is the same with and without climate change.

Hence, using the information detailed above for both the surface and groundwater sources, we calculated the WAFU for each resource zone using our water resource simulation model for the "no climate change" scenario, as well as the dry, mean and wet climate change scenarios. As described above, the climate change calculations were assumed to represent the effect in 2025 and therefore we used the spreadsheet model provided by the Environment Agency to interpolate between the present day and 2025.

The results of the impact on WAFU under the mean climate change scenario for each of the resource zones in the tables below:

Table D4: Impact of Climate Change on WAFU in 2025 under the Mean Climate Change Scenario

	Resource Zone		
	Colliford	**Roadford**	**Wimbleball**
Estimated Change in WAFU (%)	-1.53	-1.86	-0.59

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[21] Downing, T.E et al, (2003) *Climate Change and the Demand For Water*, Research Report, Stockholm Environment Institute Oxford Office, Oxford, February 2003.

Table D5: Impact of Climate Change on WAFU under the Mean Scenario, for each Forecast Year (interpolated)

Year	Resource Zone		
	Colliford	Roadford	Wimbleball
2006/07	159.08	258.86	92.57
2007/08	159.08	258.86	92.57
2008/09	158.90	258.51	92.53
2009/10	158.73	258.17	92.49
2010/11	158.56	257.82	92.45
2011/12	158.38	257.48	92.42
2012/13	158.21	257.14	92.38
2013/14	158.03	256.79	92.34
2014/15	157.86	256.45	92.30
2015/16	157.68	256.10	92.26
2016/17	157.51	255.76	92.22
2017/18	157.34	255.41	92.18
2018/19	157.16	255.07	92.14
2019/20	156.99	254.72	92.11
2020/21	156.88	254.52	92.08
2021/22	156.83	254.42	92.07
2022/23	156.79	254.32	92.06
2023/24	156.74	254.23	92.05
2024/25	156.69	254.13	92.04
2025/26	156.64	254.04	92.03
2026/27	156.59	253.94	92.02
2027/28	156.54	253.84	92.01
2028/29	156.49	253.75	92.00
2029/30	156.44	253.65	91.98
2030/31	156.40	253.55	91.97
2031/32	156.35	253.46	91.96
2032/33	156.30	253.36	91.95
2033/34	156.25	253.26	91.94
2034/35	156.20	253.17	91.93

It should be noted that although climate change causes an adverse effect on WAFU throughout the planning period, infrastructure constraints may influence this impact. The tables above assume the infrastructure that will be in place at the start of AMP5 (2010/11).

In accordance with the guidance, the calculations of WAFU we have presented in the baseline and final planning scenarios of this plan have assumed the mean climate change scenario.

2.4 Uncertainty in climate change

In the consideration of climate change there is inevitably a degree of uncertainty. This is accounted for within the target headroom calculations, using the wet and dry climate change scenarios identified above.

3 Reassessment of impact climate change on WAFU based on UKCP089 “Quick Look” flow factors

3.1 Aim of the reassessment

To identify whether the UKCP09 ‘Quick Look’ climate change flow factors have any different impact on Water Available for Use (WAFU) in Wimbleball, Roadford and Colliford Strategic Supply Areas (SSA) compared to the UKWIR06 climate change factors used to derive values for WAFU in the Strategic Business Plan (SBP) and Water Resources Plan (WRP).

3.2 Reassessment of Wimbleball SSA

3.2.1 Assumptions

The work assumes no change to AMP5 climate change groundwater yield assumptions at Wilmington and Otterton 1A.

The UKCP09 ‘Quick Look’ flow factors only provide figures for 70 modelled catchments. In AMP5 the climate change flow factors for Wimbleball SSA were based on UKWIR06 method 1b – Exe catchment 74 and local Base Flow Index figures. It is not possible to calculate comparable changes in flows using UKCP09. Instead, the Taw at Taw Bridge has been chosen from the list of 70 modelled catchments as the best representation for the Exe catchment of the South West catchments modelled[22].

The factors used for the AMP5/WRP work were UKWIR06 probability factors whereas the UKCP09 ‘Quick Look’ factors are only available as percentile factors. In order to maintain a direct comparison between Miser[23] runs the AMP5/WRP original Wimbleball climate change run was rerun using the UKWIR06 Taw at Taw Bridge method 1a percentile factors. This was compared against the UKCP09 Taw at Taw Bridge ‘Quick Look’ percentile factors. Results from these runs were compared against each other and against the originally reported AMP5 climate change results.

Comparison charts of the AMP5/UKWIR06 and UKCP09 mean, dry and wet climate change factors are shown below.

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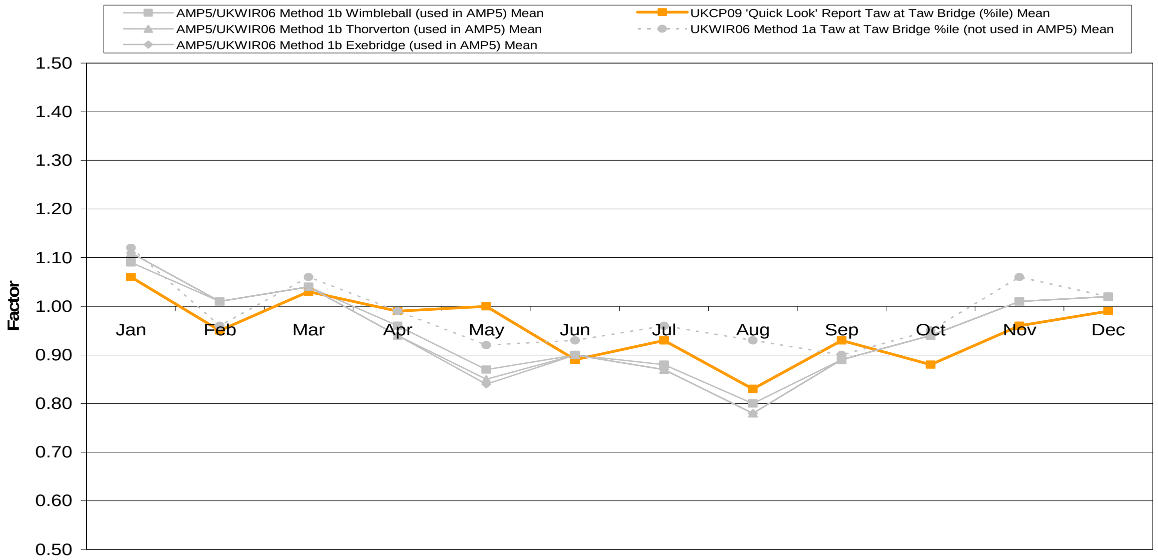
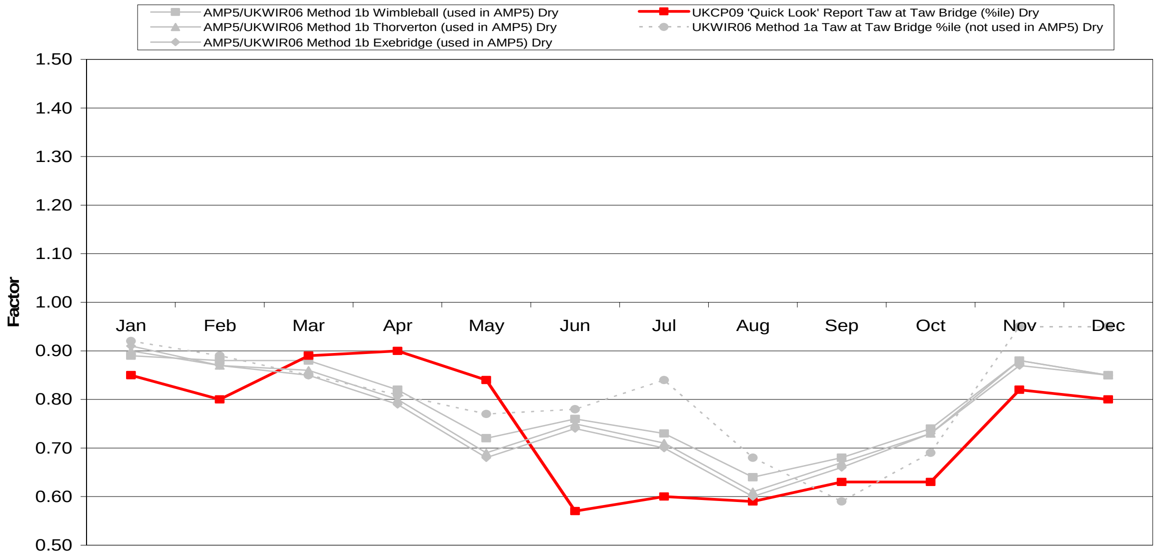
[22] South West catchments covered within the 70 modelled catchments are; Avon at Amesbury, Tamar at Gunnislake, Tiddy at Tideford, Warleggen at Trengoffe, Taw at Taw Bridge, Currypool Stream at Currypool Farm, Wellow Brook at Wellow.

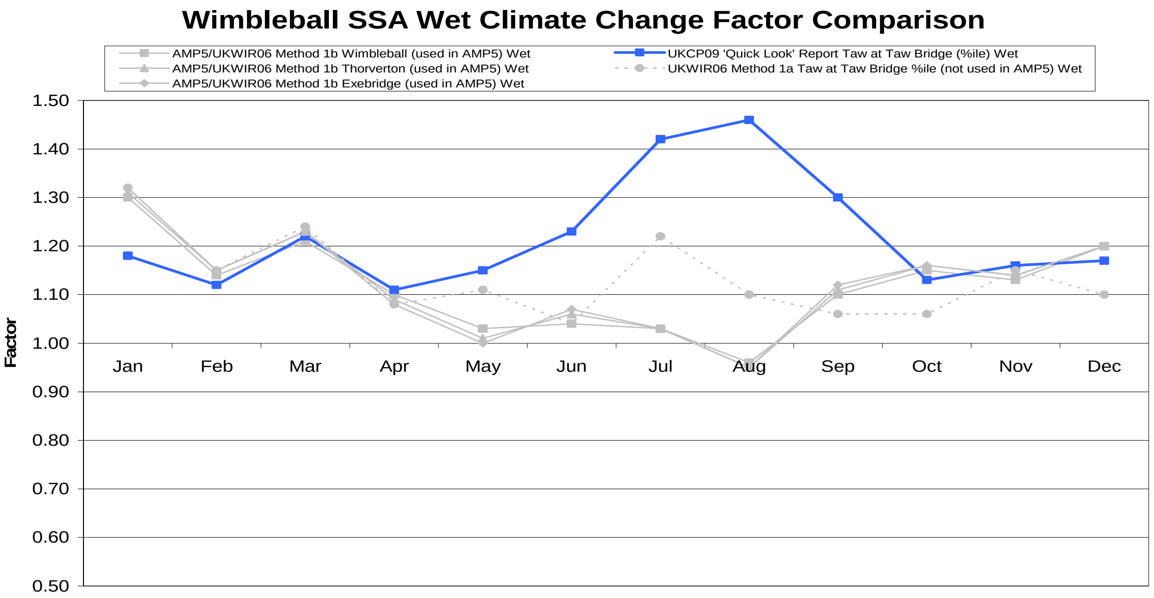
[23] Miser is the computer simulation water resources model used by SWW to calculate WAFU.



Wimbleball SSA Mean Climate Change Factor Comparison

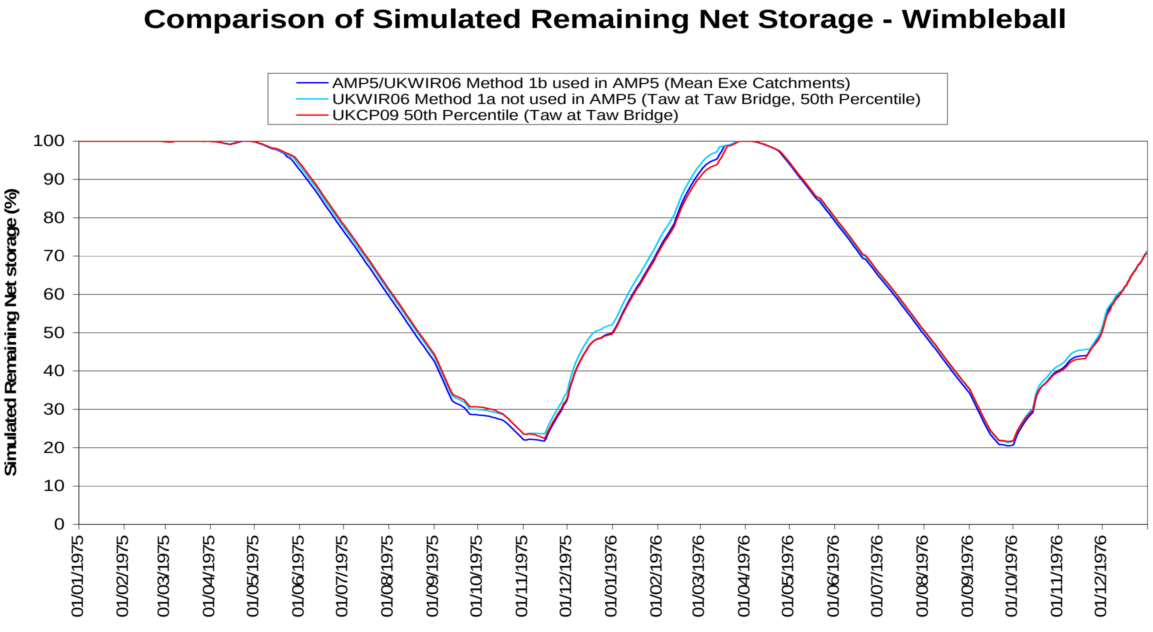


Wimbleball SSA Dry Climate Change Factor Comparison

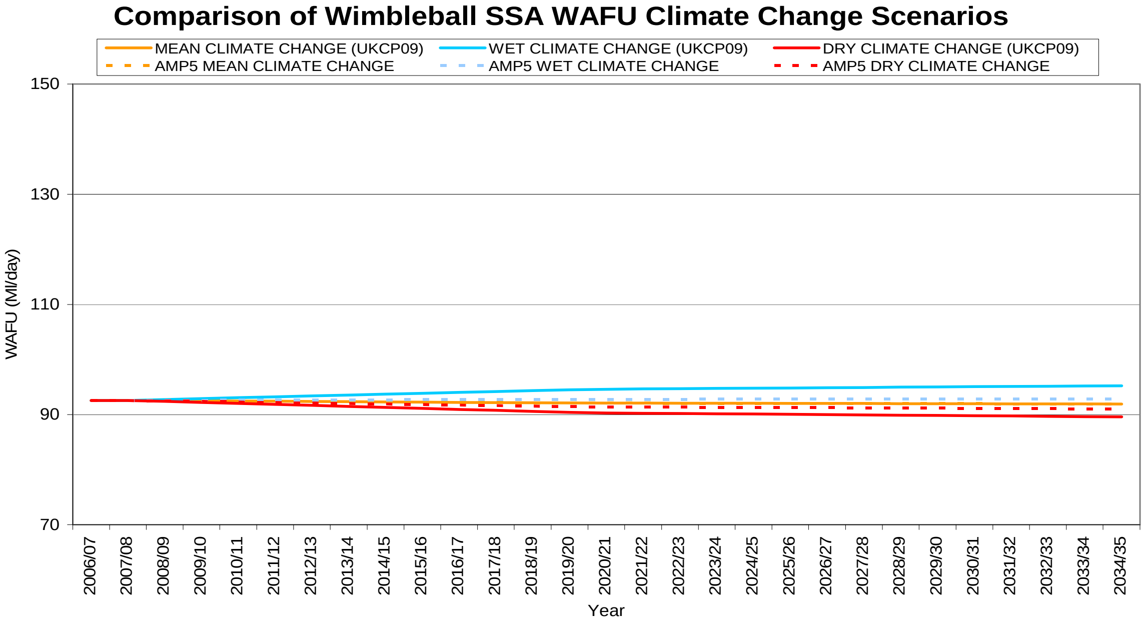


3.2.2 Results

Running Miser with the UKCP09 mean climate change factors does not alter the change in WAFU reported in the SBP and WRP as a result of climate change. This is because the constraint remains the distribution system (White Cross). As shown below, the difference in Wimbleball reservoir storage modelled under each scenario is minimal.



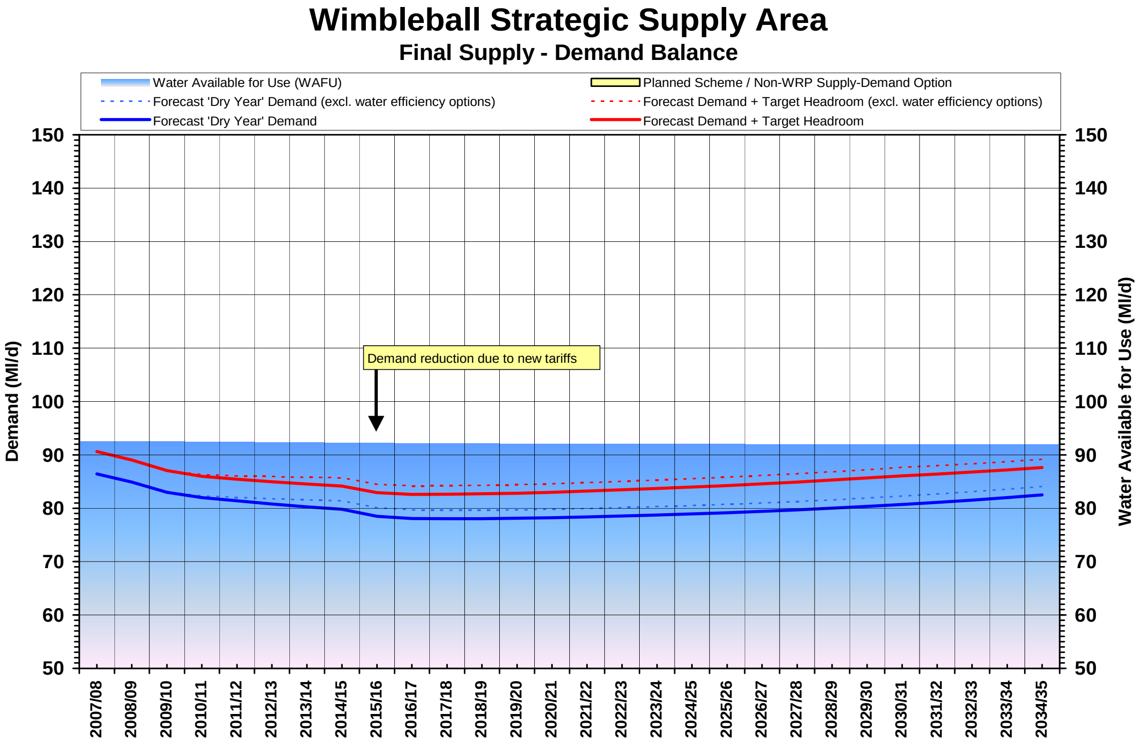
A comparison of the impact of AMP5/UKWIR06 and UKCP09 mean, dry and wet climate change scenarios on WAFU is shown in the chart and summary table below.



Estimated change in WAFU based on the different climate change scenarios.

WIMBLEBALL SSA	Estimated Change in WAFU % (MEAN)	Estimated Change in WAFU % (DRY)	Estimated Change in WAFU % (WET)
AMP5/UKWIR06 Reported in SBP/WRP (Method 1b Exe Catchment)	-0.59	-1.41	0.26
UKWIR06 Percentile (1a Taw at Taw Bridge)	-0.59	-2.62	0.97
UKCP09 Percentile (Taw at Taw Bridge)	-0.59	-2.73	2.45

As shown in the chart below, the UKCP09 ‘Quick Look’ mean climate change scenario does not alter the outcome of the Wimbleball SSA supply-demand balance reported in the SBP and WRP.



3.2.3 Conclusions

- The UKCP09 ‘Quick Look’ mean climate change factors do not alter the change in Wimbleball SSA WAFU reported in the SBP and WRP as a result of climate change. The estimated change in Wimbleball SSA WAFU as a result of mean climate change remains -0.59%.
- However, the UKCP09 dry scenario factors do alter the Wimbleball SSA dry scenario WAFU from that calculated using the UKWIR06 climate change factors. The estimated change in WAFU as a result of the dry climate change scenario has increased from -1.41% to -2.73%.
- The UKCP09 wet scenario factors also alter the Wimbleball SSA wet scenario WAFU. The estimated change in WAFU as a result of the wet climate change scenario has increased from 0.26% to 2.45%.

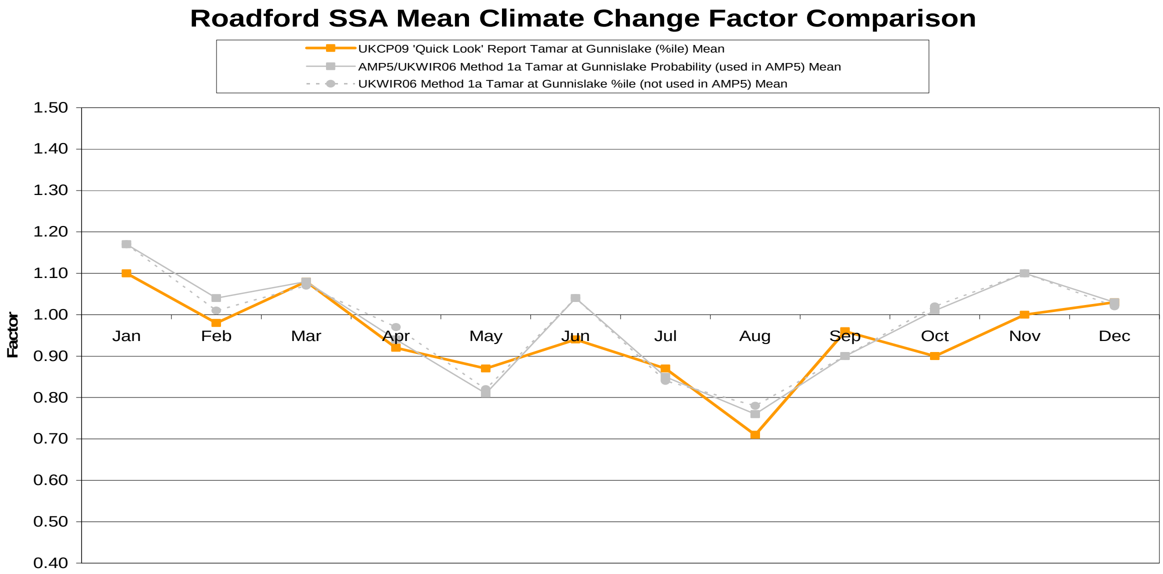
3.3 Reassessment of Roadford SSA

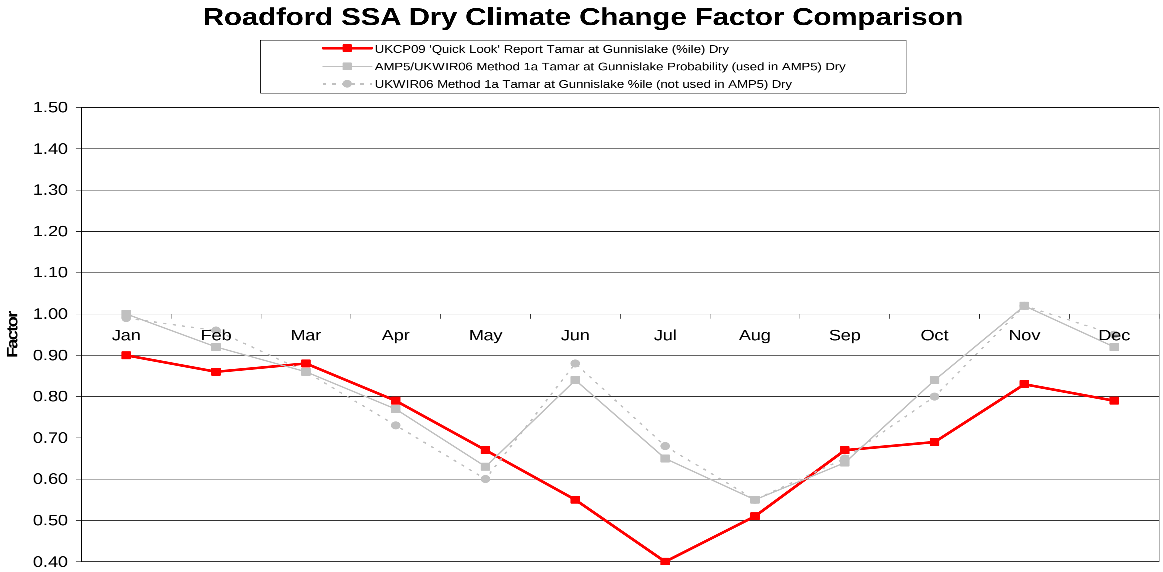
3.3.1 Assumptions

The UKCP09 ‘Quick Look’ flow factors only provide figures for 70 modelled catchments. In AMP5 the climate change flow factors for Roadford SSA were based on UKWIR06 method 1a – Tamar at Gunnislake.

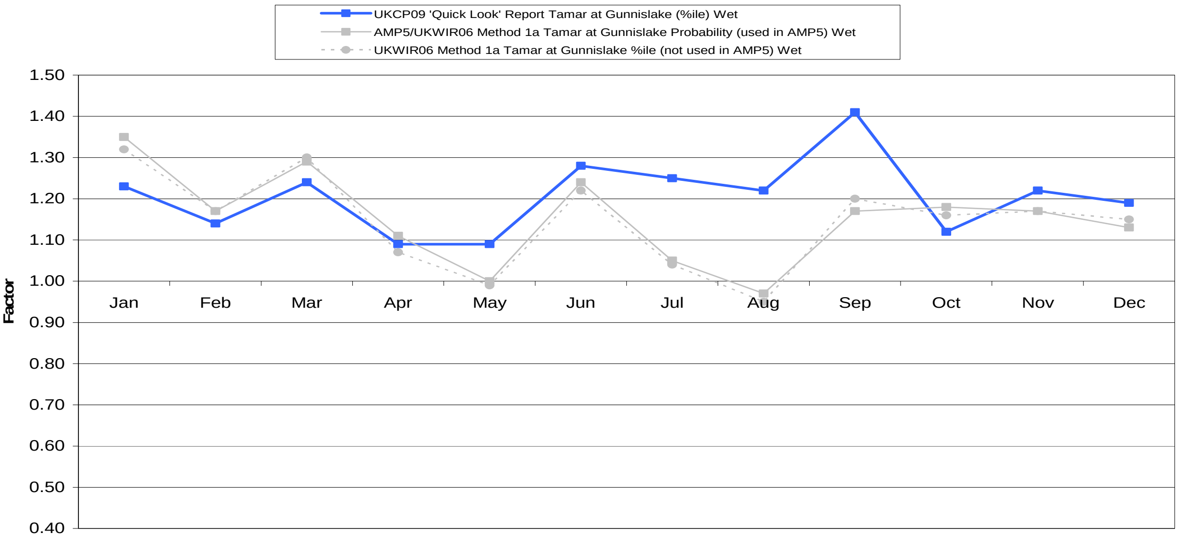
The UKWIR06 factors used for the AMP5/WRP work are probability factors whereas the UKCP09 'Quick Look' factors are only available as percentile factors. However, the differences between AMP5/UKWIR06 Tamar at Gunnislake probability mean and percentile factors are negligible. Miser was run for the UKCP09 Tamar at Gunnislake 'Quick Look' percentile factors and compared against the originally reported AMP5 climate change results.

Comparison charts of the AMP5/UKWIR06 and UKCP09 mean, dry and wet climate change factors are shown below.





Roadford SSA Wet Climate Change Factor Comparison

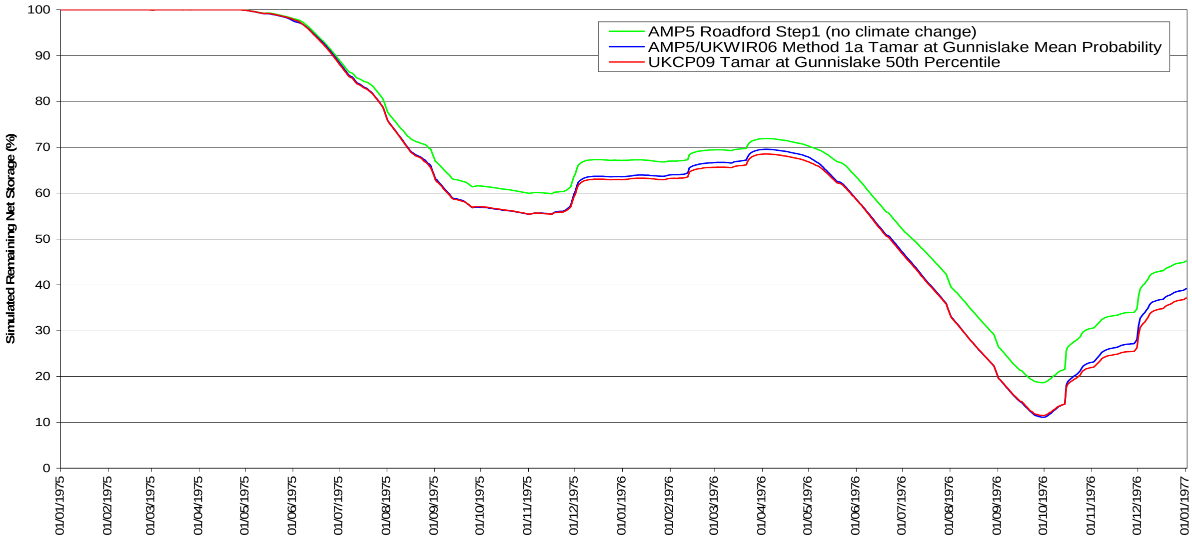


3.3.2 Results

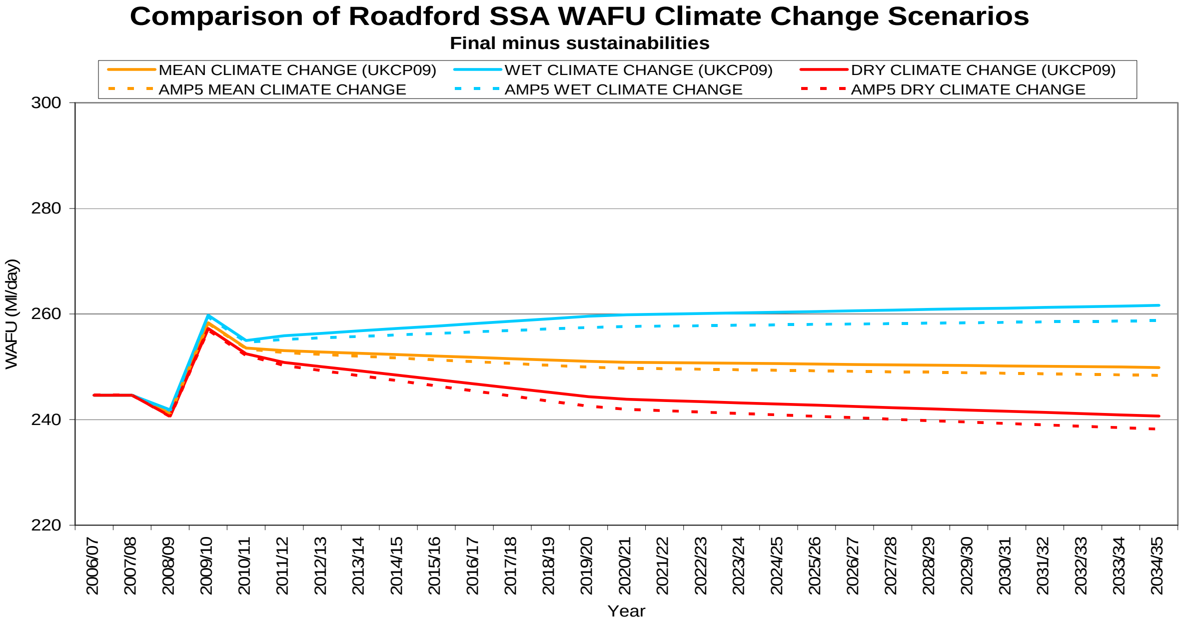
Running Miser with the UKCP09 mean climate change factors does alter the change in WAFU reported in the SBP and WRP as a result of climate change. The constraint is Roadford SSA total raw water storage.

Comparison of Simulated Remaining Net Storage - Roadford

AMP5 and UKCP09 Mean Climate Change Runs with AMP5 No Climate Change



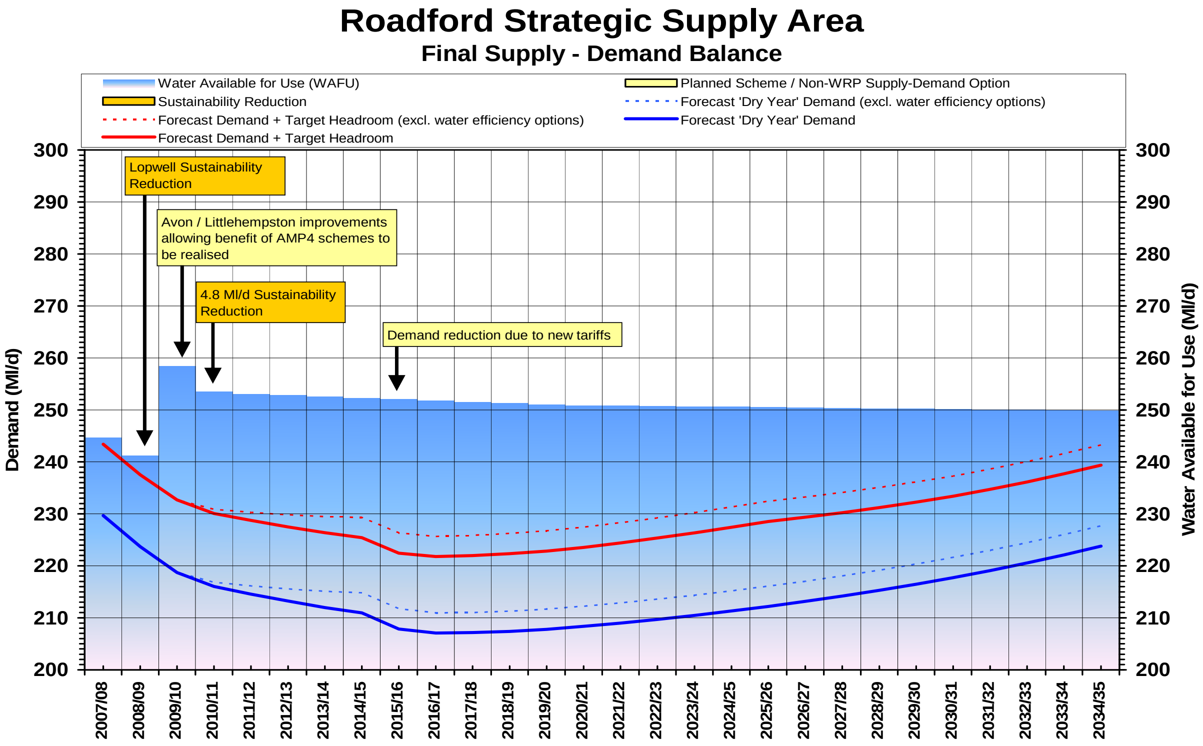
A comparison of the impact of AMP5/UKWIR06 and UKCP09 mean, dry and wet climate change scenarios on WAFU is shown in the chart and summary table below.



Estimated change in WAFU based on the different climate change scenarios.

ROADFORD SSA	Estimated Change in WAFU % (MEAN)	Estimated Change in WAFU % (DRY)	Estimated Change in WAFU % (WET)
AMP5/UKWIR06 Reported in SBP/WRP (Method 1a Tamar at Gunnislake	-1.86	-5.20	1.53
UKCP09 Percentile (Tamar at Gunnislake)	-1.37	-4.39	2.48

The UKCP09 mean climate change scenario does alter the WAFU reported in the SBP and WRP as a result of climate change. However, as shown in the chart below, this change is small and does not alter the outcome of the reported Roadford SSA supply-demand balance.



3.3.3 Conclusions

- The UKCP09 ‘Quick Look’ mean climate change factors do alter the change in Roadford SSA WAFU reported in the SBP and WRP as a result of climate change. The estimated change in Roadford SSA WAFU has altered from -1.86% to -1.37%. This change is small and does not affect the outcome of the supply-demand balance.
- The UKCP09 dry scenario factors also alter the Roadford SSA dry scenario WAFU from that calculated using the UKWIR06 climate change factors. The estimated change in WAFU as a result of the dry climate change scenario has decreased from -5.20% to -4.39%.
- The UKCP09 wet scenario factors also alter the Roadford SSA wet scenario WAFU. The estimated change in WAFU as a result of the wet climate change scenario has increased from 1.53% to 2.48%.

3.4 Reassessment of Colliford SSA

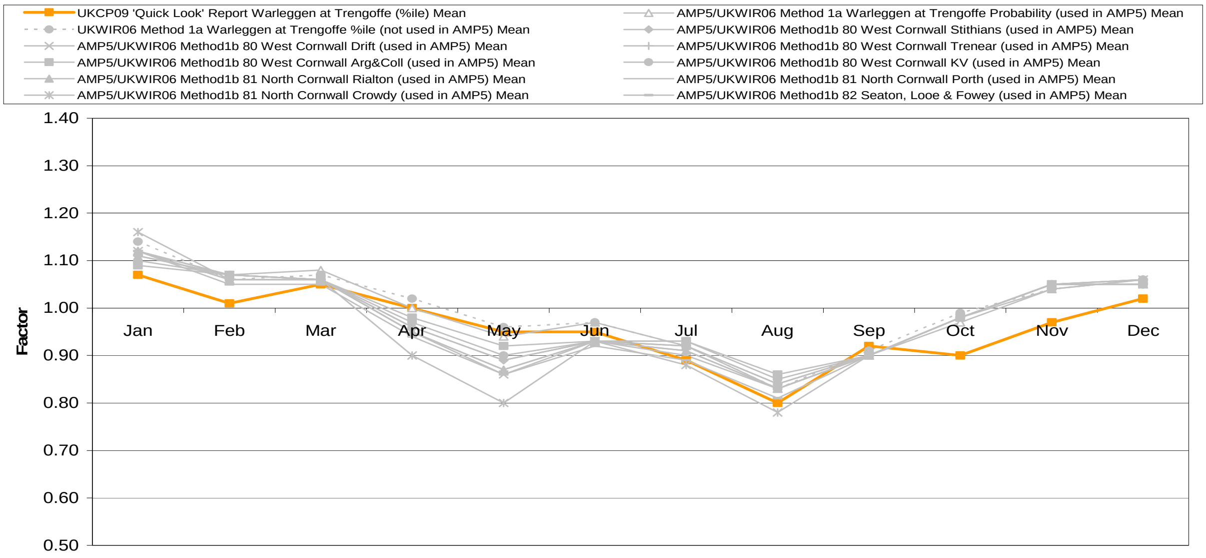
3.4.1 Assumptions

The UKCP09 ‘Quick Look’ flow factors only provide figures for 70 modelled catchments. In AMP5 the climate change flow factors for Colliford SSA were based on UKWIR06 methods 1a – Warlegggan at Trengoffe and 1b - catchments 80 (West Cornwall), 81 (North Cornwall) and 82 (Seaton, Looe at Fowey) with local site Base Flow Index figures.

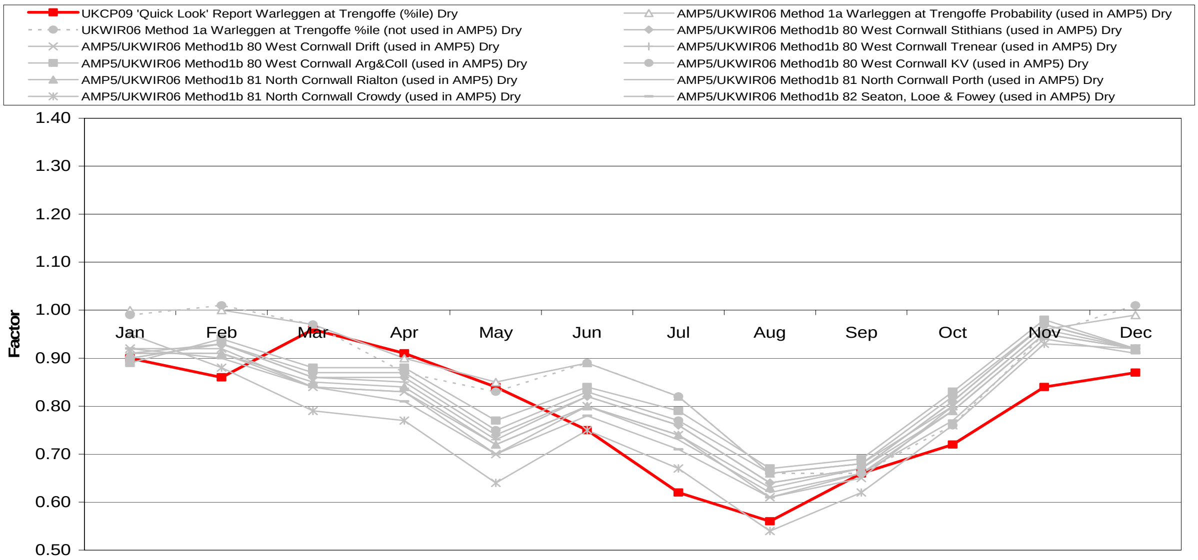
The UKWIR06 factors used for the AMP5/WRP work are probability factors whereas the UKCP09 'Quick Look' factors are only available as percentile factors. The AMP5/WRP original Colliford Climate change Miser run was rerun using the UKWIR06 Warleggan at Trengoffe method 1a percentile factors and compared against the UKCP09 Warleggan at Trengoffe 'Quick Look' percentile factors. Results from Miser were also compared the originally reported AMP5 climate change results.

Comparison charts of the AMP5/UKWIR06 and UKCP09 mean, dry and wet climate change factors are shown below.

Colliford SSA Mean Climate Change Factor Comparison

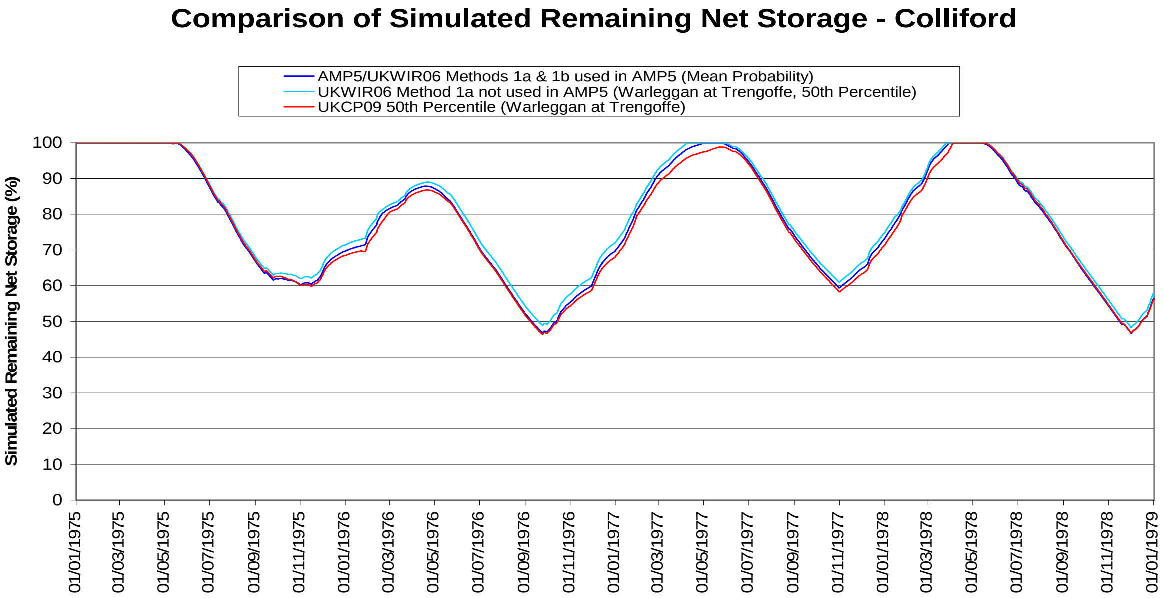


Colliford SSA Dry Climate Change Factor Comparison

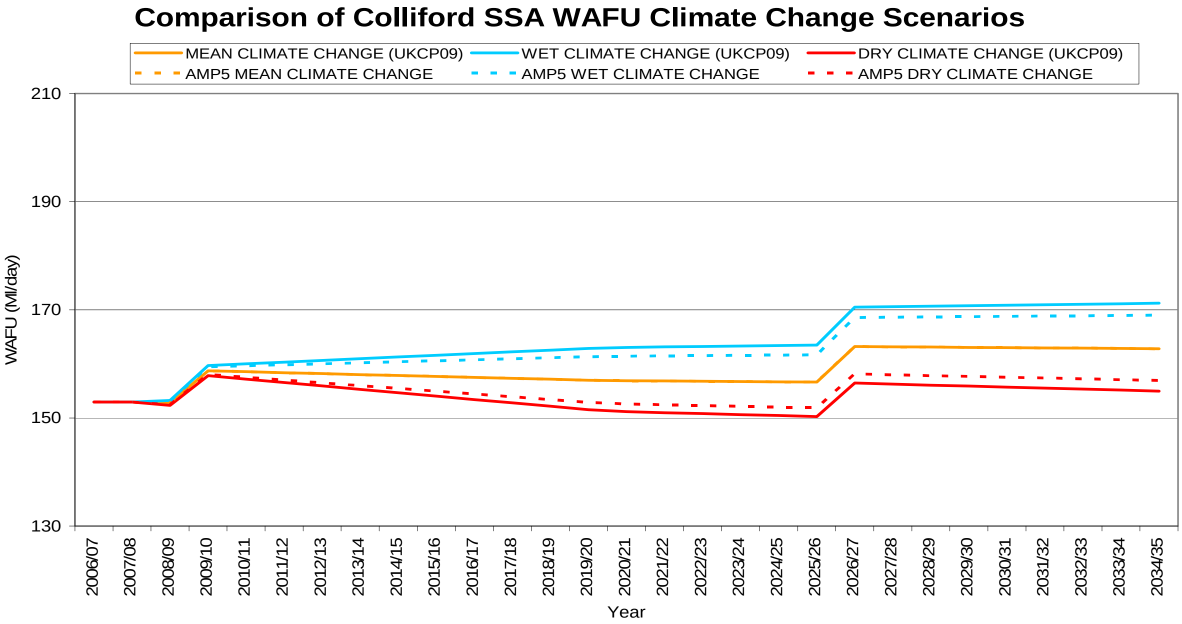


3.4.2 Results

Running Miser with the UKCP09 mean climate change factors does not alter the WAFU reported in the SBP and WRP as a result of climate change. The constraint remains the maximum water treatment works output available during the peak demand period. As shown below, the difference in Colliford reservoir storage modelled under each scenario is minimal.



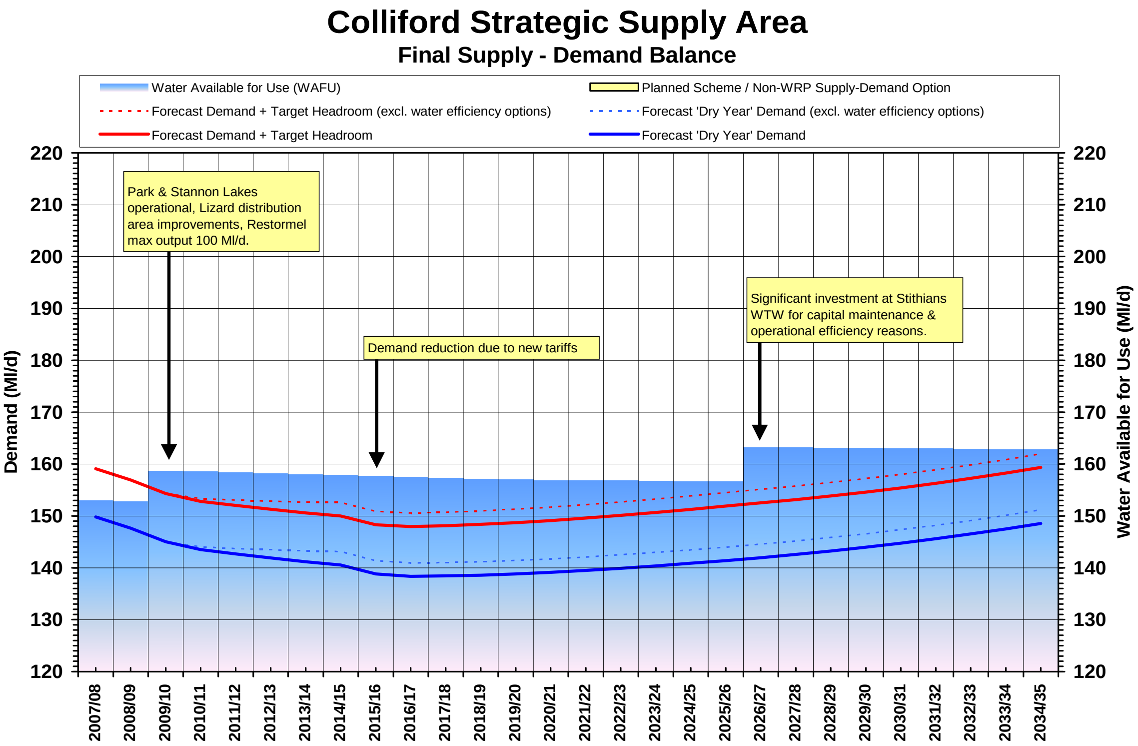
A comparison of the impact of AMP5/UKWIR06 and UKCP09 mean, dry and wet climate change scenarios on WAFU is shown in the chart and summary table below.



Estimated change in WAFU based on the different climate change scenarios.

Colliford SSA	Estimated Change in WAFU % (MEAN)	Estimated Change in WAFU % (DRY)	Estimated Change in WAFU % (WET)
AMP5/UKWIR06 Reported in WRP	-1.53	-4.53	1.64
AMP5/UKWIR06 Percentile (1a Warleggan at Trengoffe)	-1.53	-5.89	1.44
UKCP09 Percentile (Warleggan at Trengoffe)	-1.53	-5.53	2.77

As shown in the chart below, the UKCP09 ‘Quick Look’ mean climate change scenario does not alter the outcome of the Colliford SSA supply-demand balance reported in the SBP and WRP.



Park & Stannon Lakes operational, Lizard distribution area improvements, Restormel max output 100 Ml/d.

Demand reduction due to new tariffs

Significant investment at Stithians WTW for capital maintenance & operational efficiency reasons.

3.4.3 Conclusions

- The UKCP09 ‘Quick Look’ mean climate change factors do not alter the change in Colliford SSA WAFU reported in the SBP and WRP as a result of climate change. The estimated change in Colliford SSA WAFU as a result of mean climate change remains -1.53%.

- However, the UKCP09 dry scenario factors do alter the Colliford SSA dry scenario WAFU from that calculated using the UKWIR06 climate change factors. The estimated change in WAFU as a result of the dry climate change scenario has increased from -4.53 to -5.53%.

- The UKCP09 wet scenario factors also alter the Colliford SSA wet scenario WAFU. The estimated change in WAFU as a result of the wet climate change scenario has increased from 1.64% to 2.77%.

APPENDIX E: Flood resilience & climate change: water and sewerage services

1 Introduction

As part of the AMP5 business planning process we have undertaken a comprehensive review of the resilience of our assets and services. This was prompted by the extreme flood events that have occurred in the our region in recent years, the severe and widespread flooding that occurred throughout the country during the summer of 2007 and the projected impacts of climate change.

The review took into account the findings of the Pitt Review[24] in which it was observed that "higher levels of protection for critical infrastructure are needed to avoid loss of essential services such as water and power". Recommendation 52 of the Review states: "In the short-term, the Government and infrastructure operators should work together to build a level of resilience into critical infrastructure assets that ensures continuity during a worst-case flood event".

Our approach to flood resilience follows Ofwat guidance[25] that "long-term asset planning should take appropriate account of emerging guidance and evidence on the impact of climate change on assets and service delivery", together with more specific guidance[26] developed by Halcrow for Ofwat.

Our investment programmes for flood resilience have been demonstrated to be cost beneficial and supported by customer willingness to pay and were therefore placed in the service enhancement part of our Final Business Plan.

It should be noted that our assessment of resilience was based upon the later climate change scenarios available at the time which were the UKCIP02 scenarios. We do not believe that the UKCP09 scenarios will make a significant difference to our analysis. However, it is our intention to carry out a reappraisal of the work using UKCP09 in the near future.

2 Flood risk assessment

We have followed the three stage methodology for assessing flood risk outlined in Ofwat (Halcrow) guidance and shown schematically below.

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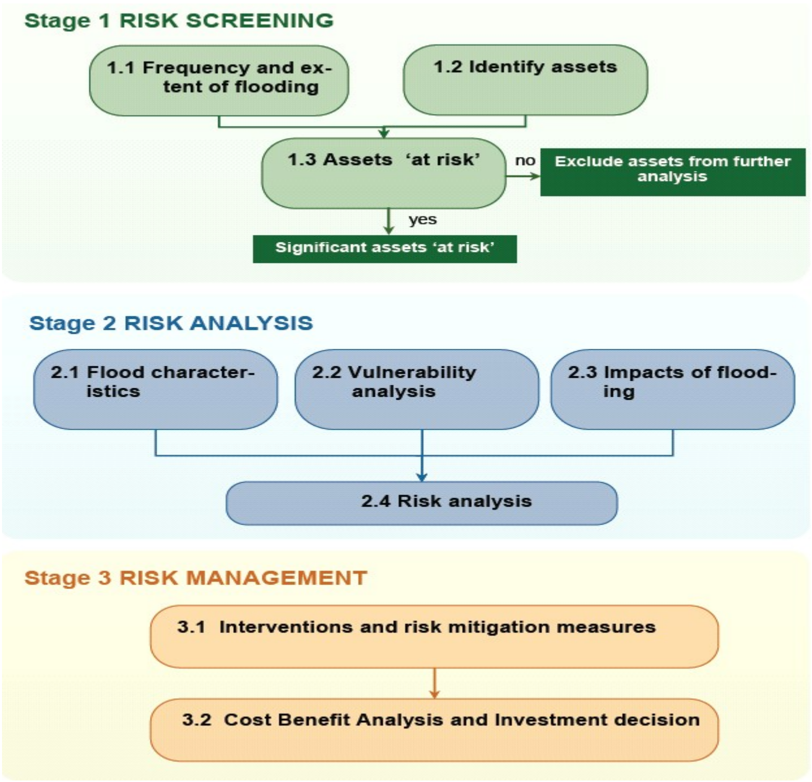
[24] "The Pitt Review: Lessons learned from the 2007 floods", Cabinet Office, 2008
[25] "Setting price limits for 2010-15: Framework and approach", Ofwat, March 2008
[26] "Asset resilience to flood hazards: Development of an analytical framework", Halcrow, June 2008



2.1 Stage 1: risk screening

The key steps of our risk screening were:

1. An initial list of sites at risk of flooding was identified by mapping EA Flood Zone data into our GIS system. Flood Zone 3 was used as the indicator of flood risk in accordance with Defra guidance[27].

2. Each site at risk was evaluated by inspection of asset records supplemented by site surveys where those records were incomplete or insufficiently detailed. All sites at risk in the water service, 51% of wastewater treatment works and 19% of sewage pumping stations were surveyed. The site evaluation work identified:

   - sources of potential flooding
   - critical assets (failure causes partial or full loss of service)
   - consequences of flooding on asset performance and service
   - potential risk mitigation options

3. Sites were removed from the at risk list where one or more of the following criteria applied:

   - Site located outside of 1:100 (fluvial) or 1:200 (tidal) flood plain when compared to more detailed information than the EA Flood Zone maps

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[27] "Planning Policy Statement 25: Development and Flood Risk - Annex D", Defra, 2006

- Critical assets located in a section of the site outside of 1:100 or 1:200 flood plain when compared to best available data
- Assets within floodplain but raised above predicted flood level
- Steep floodplain, inaccurately represented by EA data with site high above watercourse (above predicted flood level)
- Existing flood defences protect site from design flood

4. All sites on the at risk list were assigned a priority using a scoring system based on the impact of asset flooding.

A risk score for water service assets was generated by aggregating scores for each criterion in the following risk matrix (Table E1):

Table E1: Risk matrix for water service assets

Risk criterion	**Impact score**				
	1	**2**	**3**	**4**	**5**
Flood depth at asset	<0.3m	0.3-0.6m	>0.6m	n/a	n/a
Flood zone	Zone 1	Zone 2	Zone 3	n/a	
Current flood protection	Raised ground Raised electrics	Raised electrics	No protection	n/a	n/a
Strategic importance	Low usage Pop. <1,000 Alternative source capacity >50%	Regular usage Pop. <25,000 Alternative source capacity >50%	Regular usage Pop. <25,000 Alternative source capacity <50%	Regular usage Pop. >25,000 Alternative source capacity >50%	Regular usage Pop. >25,000 Alternative source capacity <50%

A risk score for sewerage service assets was generated by combining asset size (population equivalent of wastewater treatment works or installed power of sewage pumping station) with scores for environmental impact from the following matrix (Table E2):

Table E2: Risk matrix for sewerage service assets

Risk criterion	**Impact score by distance from site**				
	Immediate vicinity	**<0.5 km**	**0.5-1 km**	**1-2 km**	**2-5km**
Water supply intake	10	8	6	4	2
Bathing waters	10	8	6	4	2
Shellfish waters	10	8	6	4	2
Areas of Outstanding Natural Beauty	5	4	3	2	1
Important Bird Areas	5	4	3	2	1
Local Nature Reserves	5	4	3	2	1
Marine Nature Reserves	5	4	3	2	1
National Nature Reserves	5	4	3	2	1
Nitrate Sensitive areas	5	4	3	2	1
Ramsar Sites	5	4	3	2	1
RSPB Reserves	5	4	3	2	1

Sites of Special Scientific Interest (SSSI)	5	4	3	2	1
Special Areas of Conservation (SAC)	5	4	3	2	1
Special Protection Areas (SPA)	5	4	3	2	1
World Heritage Sites	5	4	3	2	1

2.2 Stage 2: risk analysis

Predicted flood levels for a range of return frequencies were determined by hydraulic modelling using best available data from the following range of sources (Table E3):

Table E3: Data sources

Data Type	Data / Information	Data Source
Desktop	Flood Depth Grids from J-Flow Models	EA
	River Flow / Flood Level Nodes	EA
	HECRAS hydraulic models	Developed by consultants based on river surveys and LiDAR
	LiDAR topographic data	EA and Channel Coastal Observatory
	Hydrological data - FEH Catchment Descriptors	Flood Estimation Handbook , CD-ROM
	Hiflows river gauge data	EA
	Tidal Flood Levels and Return Periods	EA - South West Region Report on Regional Extreme Tide Levels
	Predicted impact of climate change on flood levels	From PPS25 based on DEFRA guidelines
	Site plans and topographic surveys	SWW and consultants databases
	Details of existing and planned flood defences in vicinity of the sites	EA
	Mapping - SWW Strumap GIS, Qmaps, OS maps, Magic Maps and Flood Maps	Downloaded from SWW Intranet, consultants databases and the Internet
	DSEAR SPS Reports - Including photographs at many SPS	SWW
Information from site	River / floodplain surveys	Consultants Site Visit
	Details of historic flooding in the vicinity of the sites	EA and Operator Questionnaires
	Details of flood mechanism in the vicinity of the sites	Site Visits / OS mapping / EA
	Estimated Flood Levels (derived from flood photographs / surveys)	Operators / EA photos
	Anecdotal information on flooding/flood risk and consequences in the vicinity of the sites	Operators / Meetings with local EA officers

The impact of climate change on flood risk was incorporated in the analysis by considering the increase in flood levels to 2050. This time horizon aligns with the 40 year horizon for cost benefit analysis used in our Investment Optimisation process. Our assumptions for climate change allowances are based on the Defra guidance:

- Tidal flooding: 280mm allowance (to 2050) derived from sea level rise associated with climate change in south west England (taking into account isostatic rebound):

Table E4: Sea level rise

Net Sea Level Rise Relative to 1990 (mm/year)			
1990 to 2025	2025 to 2055	2055 to 2085	2085 to 2115
3.5	8.0	11.5	14.5

- Fluvial flooding: 20% additional flow allowance on 1 in 100 year flood flow

At water service sites, design flood levels were assessed from published data for 1 in 1000 years flood level data as an alternative to making site specific assessments of climate change.

From the risk screening and risk analysis processes, sites and assets were prioritised as high, medium, low or no risk and a programme was developed to improve flood protection to maintain stable service risk.

Table E5: Risk screening summary – Water service

Risk category	WTW & Intakes	WPS	SR
Initial list of sites at risk in Flood Zone 3	10	7	1
High and medium risk sites included in AMP5 programme	8	4	1
Low risk sites not requiring further mitigation	2	3	-

Table E6: Risk screening summary – Sewerage service

Risk category	WWTW	SPS
Initial list of sites at risk in Flood Zone 3	116	233
High risk sites included in AMP5 programme	22	25
Medium risk sites included in AMP6 programme	-	123
Low risk sites mitigated by temporary measures	61	51
Low risk sites not requiring further mitigation	33	34

2.3 Stage 3: risk management

2.3.1 Intervention options

Where sites were assessed to require protection from flooding, mitigation measures were designed on the basis that critical assets should be fully protected at the predicted flood levels, including appropriate allowances for climate change.

A range of mitigation options was considered for each site including:

- relocating assets out of the floodplain and into a low-risk area
- improving the robustness of flood defences through permanent or temporary defences

- increasing resilience of assets through waterproofing key components or by raising assets above design flood levels

A combination of different approaches was selected at many sites according to the nature and configuration of the particular assets at risk (see Tables E12 and E14).

In order to rationalise the number of options considered at each site, the cost of wholesale relocation of assets was tested for a sample of sites and it was established that local measures to increase flood protection of assets are invariably more cost effective. However, it may be cost effective to relocate individual assets within a site and this option was considered in appropriate cases.

Table E7: New build/local measures cost comparison

Example site	Size (population equivalent or kW installed)	Cost to build new works £k	Typical cost of local measures to protect assets	
			£k	**Site**
WWTW 1	1,000 p.e.			Dulverton WWTW (1327 p.e.)
WWTW 2	5,000 p.e.			Horrabridge WWTW (3893 p.e.)
SPS 1	20 kW			Cross Street SPS
SPS 2	100 kW			The Ham SPS

The level of protection afforded by existing flood defences (bunds or flood walls) was assessed against the design flood levels, and enhancements were proposed where a deficiency was found.

Proposals for bunds or flood walls for protection against fluvial flooding were confirmed by site surveys to improve the accuracy of hydraulic models and costings. EA development officers were involved in site surveys wherever possible.

Large scale temporary (dismountable) flood defences are not considered to be an appropriate solution because sufficient manpower could not be mobilised to install defences when a flood warning is issued. We have assessed grouping of assets by catchment or coastal zone and up to 25 sites could be damaged in a single event. Temporary solutions are therefore limited to simple stop logs or floodgates.

Electrical equipment and control kiosks are inherently vulnerable to flooding and these are some of the key assets which require protection. Raising these assets above the design flood level is invariably a cost effective mitigation measure.

The risk assessment of Pynes WTW was extended to cover a range of flood return frequencies (1 in 200, 500 and 1000 years), since the cost of flood protection at this site is disproportionately expensive. The optimal flood protection was selected as 1 in 200 years on the grounds of best benefit cost ratio and overall value (Table E8).

Table E8: Intervention alternatives at Pynes WTW

Flood risk return frequency (years)	Intervention capex £m	Whole life cost £m	Whole life Benefit £m	Benefit cost ratio
200				
500				
1000				

2.3.2 Cost estimates and cost benefit analysis

Capex cost estimates for interventions were prepared by a cost consultant[28] based on schedules of work and drawings provided by engineering consultants. Standard on-costs were applied and all costs were adjusted to price base 2007-08.

It is noted that some inaccuracy in Capex estimates of individual projects is introduced by applying standard on-costs for all sizes of project. Thus smaller projects will tend to be underestimated and larger projects will tend to be overestimated, however, the total cost of the whole package is robust.

All investments in the AMP5 programmes were individually scoped and costed. Our approach for the AMP6 programme of the sewerage service is more generic due to the large number of sites. A representative sample of 17 sites were assessed and extrapolated to 108 other sites.

The AMP5 and AMP6 programmes of work do not generate any additional Opex costs.

The cost benefit of flood resilience investments has been assessed in accordance with our approach set out in our business plan, and incorporates environmental/ societal costs, company costs and customer willingness to pay. The particular benefit measures (Operational Performance Measures) and benefit values applied to flood resilience investments are summarised in Tables E8 and E9:

Table E9: Benefit measures used in CBA – Water service

OPM			Unit Benefit £k			
Ref	**Description**	**Unit**	**Willingness to pay**	**Environmental /societal**	**SWW**	**Total**
5.2	DWI prosecution Supply water unfit for human consumption	No of incidents				
6.2	Water quality failure Biological Major incident causing some illness (not crypto)	No of properties				
9.4	Unplanned supply interruption >24 hrs	No of properties				

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[28] EC Harris

27.1	SWW Other avoided costs (incl maintaining supplies from an alternative source or tankering, and repair or replacement of damaged assets)	£k				

Table E10: Benefit measures used in CBA – Sewerage service

OPM			**Unit Benefit £k**			
Ref	**Description**	**Unit**	**Willingness to pay**	**Environmental /societal**	**SWW**	**Total**
12.1	EA prosecution Breach of consent	No of incidents				
13.1	Waste water Quality Compliance failure (PCV)	p.e. of failing works				
14.1	Waste Water Flow Compliance failure	Failure days per works				
25.1	Biodiversity/Heritage	No of sites protected				
27.1	SWW Other avoided costs (incl repair or replacement of damaged assets)	£k				
28.2	Pollution incidents Category 2	No of incidents				
31.1	Bathing water	No of failures				
32.1	Shellfish	No of failures				

In our cost benefit analysis, probability of failure values were assigned to each OPM based on the flood return periods determined for each site before and after improvement.

All projects included in our AMP5 programme were cost beneficial and none cost beneficial projects are excluded from the programme. Benefit cost ratios of projects in the AMP5 water and sewerage programmes are summarised in Tables E12 and E14.

3 AMP5 enhancement programme - Water service

For our water service, we propose in our business plan a programme of work to increase resilience to flooding of all critical water treatment works, intakes, water pumping stations and service reservoirs, where existing flood protection was below our service standard for flood risk. This aligns with our vision to have no unplanned interruptions to supply and 100% compliance with drinking water quality standards, as articulated in our Strategic Direction Statement.

The total AMP5 investment proposed was £xxm at 11 sites:

Table E11: AMP5 flood resilience summary – water service

Installation	AMP5	
	No	Capex £m
Water treatment works and intakes	8	
Water pumping stations	2	
Service reservoirs	1	
Total	11	

More detail of this programme of work is summarised in Table E12 below. The projects shaded in green were accepted by Ofwat in the price determination

Table E12: AMP5 Programme for flood resilience – water service

Project ID	Site	Worst case flood	Service level - Flood risk return frequency in years		Capex £m	Benefit cost ratio	Completion Date	Summary of mitigation measures
			Before intervention without climate change allowance	After intervention with climate change allowance				
D1F5003	Littlehempston WTW	Tidal	2	200			2014-15	Dart intake: Raise controls and seal low level openings. Ranney 1 PS: Flood embankment. Ranney 2: Flood embankment and flood gate
D1F5005	Northbridge Intake	Fluvial	100	100			2012-13	Raise controls and seal low level openings. Raise access road.
D1F5006	Restormel Intake	Fluvial	100	100			2012-13	Raise controls
D1F5007	Trenear Intake	Fluvial	100	100			2014-15	Flood embankment and sluice gates
D1F5009	Bolham Leat	Fluvial	20	100			2012-13	Flood embankment
D1F5010	Gunnislake Intake	Fluvial	200	100			2012-13	Replace sluice gates and install auto shutdown
D1F5011	Bastreet Intake	Fluvial	100	100			2013-14	Flood embankment and flood wall
D2F5013	Avon Treated Water Reservoir	Pluvial	20	100			2014-15	Reinforce hedge and seal manholes
D2F5030	Pynes WTW	Fluvial	10	100			2011-12	Flood embankment, sheet pile wall and sluice gates. Raise access road into site. Seal surface water drainage.
D8F5008	Uplowman Booster Pump Station	Fluvial	20	100			2014-15	Reinforce hedge and seal manholes.
D8F5012	Fatherford Booster Pump Station (Okehampton)	Fluvial	100	100			2012-13	Seal all external manholes

Our service standard is 1 in 100 year protection for assets at risk of fluvial or pluvial flooding and 1 in 200 year protection for assets at risk of tidal flooding.

Existing flood risk for each site is reported without a climate change allowance as an indicator of the current risk level to maintaining service in flood conditions. Existing flood risk ranges from 1 in 2 years to 1 in 200 years return frequency.

All projects in the programme are cost beneficial. Our customers have expressed willingness to pay for flood risk improvements through their support for avoiding interruptions to supply.

4 AMP5 enhancement programme - Sewerage service

In our wastewater service, we proposed a programme of work to increase the resilience to flooding of all critical wastewater treatment works and sewage pumping stations where existing flood protection is below our service standard for flood risk. This aligns with our vision to be environmental leaders in our region and to achieve full compliance with discharge consents and no pollution incidents, as articulated in our Strategic Direction Statement.

The AMP5 investment is £2.267m at 47 sites and AMP6 investment is £0.625m at 123 sites (Table E13):

Table E13: AMP5 flood resilience summary – sewerage service

Installation	**AMP5**		**AMP6**	
	No	**Capex £m**	**No**	**Capex £m**
Wastewater treatment works	22		-	-
Sewage pumping stations	25		123	
Total	47		123	

The AMP5 programme will address all high risk wastewater treatment works and sewage pumping stations with a high impact score and/or large capacity (STW population equivalent > 500 and sewage pumping stations >100kW installed power). Medium risk sites were deferred to AMP6 to enable more specific risk assessments to be undertaken.

For low risk sites, our flood mitigation strategy is to restore asset operation after a flood event using temporary hired equipment as required. We have identified 48 wastewater treatment works and 49 sewage pumping stations that are low risk and will be managed by this approach.

Our proposed AMP5 programme of work is summarised in Table E14. The projects shaded in green were accepted by Ofwat in the price determination

Table E14: AMP5 Programme for flood resilience - Sewerage service

Project ID	Site	Worst case flood	Service level - Flood risk return frequency in years		Capex £m	Benefit cost ratio	Completion Date	Summary of mitigation measures
			Before intervention without climate change allowance	After intervention with climate change allowance				
D5J0001	Countess Wear Exeter WWTW	Tidal	20	200			2012-13	Bund, raise walls, raise controls
D5J0003	Dulverton WWTW	Fluvial	18	100			2012-13	Bund
D5J0004	Ivybridge WWTW	Fluvial	20	100			2013-14	Protect sump pump, stop logs, seal vents and services ducts
D5J0005	Kilbury WWTW	Fluvial	2	100			2010-11	Raise assets - SAS/RAS PS, Humus PS, Filter Feed PS, Final Efflent PS, Oxygen system
D5J0007	Marsh Mills WWTW	Tidal	17	200			2012-13	Bunds, flood wall, raise access road, raise control panels
D5J0008	St Columb WWTW	Fluvial	15	100			2011-12	Bund
D5J0010	Totnes WWTW	Fluvial	10	100			2013-14	Bund, flood wall and flood gate
D5J0012	Branscombe WWTW	Fluvial	10	100			2014-15	Relocate generator
D5J0014	Calstock WWTW	Tidal	10	200			2014-15	Protect pumps, level sensors
D5J0017	East Ogwell WWTW	Fluvial	5	100			2013-14	New culvert, door log, seal vents
D5J0019	Fluxton WWTW	Fluvial	20	100			2014-15	Raise panels, door log, seal services ducts
D5J0022	Horrabridge WWTW	Fluvial	9	100			2013-14	Bund, raise generator and controls
D5J0023	Lodgehill WWTW	Fluvial	16	100			2011-12	Bund and flood wall
D5J0024	Lostwithiel WWTW	Tidal	7	200			2012-13	Raise assets - Control panels, generator, electrics, pump
D5J0027	Moretonhampstead WWTW	Fluvial	10	100			2013-14	New door and log, raise power supply
D5J0028	Mylor Bridge WWTW	Fluvial	20	100			2014-15	Raise wall for UV equipment, stoplog door, seal vents and services ducts
D5J0029	North Molton WWTW	Fluvial	20	100			2014-15	Raise control electrics, waterproofing
D5J0031	Porthtowan WWTW	Fluvial	10	100			2014-15	Flood channel, kiosk door log
D5J0032	Sampford Peverell WWTW	Fluvial	10	100			2014-15	Door log; seal vents and services ducts of control building
D5J0033	Seaton South WWTW	Tidal	10	200			2013-14	Bund
D5J0037	West Charleton WWTW	Tidal	10	200			2014-15	Bund, door log, seal vents and service ducts
D5J0038	South Molton WWTW	Fluvial	2	100			2014-15	Raise switches, control panels and chemical dosing equipment
D9J0046	Hele Bay SPS	Tidal	57	200			2013-14	Door logs, seal vents and services ducts
D9J0047	Mayors Avenue SPS	Tidal	40	200			2013-14	Door logs, seal vents and services ducts
D9J0048	North Sands SPS	Tidal	44	200			2013-14	Door logs, seal vents and services ducts
D9J0055	Shutterton SPS	Fluvial	40	100			2013-14	Door logs, seal vents and services ducts
D9J0057	Totnes Town SPS	Fluvial	10	100			2013-14	Door logs, seal vents and services ducts
D9J0062	Axmouth SPST Axmouth	Tidal	95	200			2014-15	Raise kiok on slab
D9J0063	Bowling Green Marsh SPS Exeter	Tidal	10	200			2011-12	Spare pumps and starters for rapid restart
D9J0064	Cockwood SPS Dawlish	Tidal	20	200			2014-15	Spare pumps and starters for rapid restart
D9J0065	Cofton SPS Dawlish	Tidal	59	200			2013-14	Raise control kiosk and telemetry outstation
D9J0066	Cross Street SPS Combe Martin	Tidal	5	200			2014-15	Sealable doors on kiosk, seal vents and services ducts
D9J0067	Exton South SPS Exmouth	Tidal	10	200			2013-14	Spare pumps and starters for rapid restart
D9J0068	Gales Hill Low SPST Teignmouth	Tidal	14	200			2014-15	Raise control panels and generator
D9J0069	Generals Lane Terminal SPST	Tidal	35	200			2013-14	Raise incomer mains switch

Our service standard is 1 in 100 years protection for assets at risk of fluvial or pluvial flooding and 1 in 200 year protection for assets at risk of tidal flooding.

Existing flood risk for each site is reported without a climate change allowance as an indicator of the current risk to maintaining service in flood conditions. Existing flood risk ranges from 1 in 2 years to 1 in 95 years return frequency.

All projects in the programme are cost beneficial. Our customers have expressed willingness to pay for flood risk improvements through their support for avoiding pollution incidents and protecting bathing waters and biodiversity/ heritage areas.

A provisional programme of work for AMP6 was developed using a generic approach based on extrapolation from the AMP5 programme. This AMP6 programme is summarised in Table E15.

Table E15: AMP6 Programme for flood resilience - Sewerage service

Project ID	Site	Worst case flood	Service level - Flood risk return frequency in years		Capex £k	Benefit cost ratio	Completion Date
			Before intervention without climate change allowance	After intervention with climate change allowance			
D9J0081	Flood mitigation for small SPS 1 (25 sites)	Fluvial	10	100			2015-16
D9J0082	Flood mitigation for small SPS 2 (25 sites)	Fluvial	10	100			2016-17
D9J0083	Flood mitigation for small SPS 3 (25 sites)	Fluvial	10	100			2017-18
D9J0084	Flood mitigation for small SPS 4 (25 sites)	Fluvial	10	100			2018-19
D9J0085	Flood mitigation for small SPS 5 (25 sites)	Fluvial	10	100			2019-20

However, further information and analysis is likely to lead to a significantly increased number of projects.