Climate Change Adaptation

Update Report

September 2016

South Staffs Water

incorporating

CAMBRIDGE WATER COMPANY

Contents

Climate Change Adaptation - Update Report

1 Scope

This report has been produced for the purpose of providing South Staffs Water's update on climate change adaptation in response to the Government's second call to report under the Adaptation Reporting Power.

In October 2011, Cambridge Water was acquired by the South Staffordshire Group. The acquisition was referred to the Competition Commission, which determined that the merger of Cambridge Water and South Staffs Water could go ahead without impact to customers. On 1 April 2013 the Company was merged in to South Staffordshire Water PLC, but continues to trade under the name of Cambridge Water. This report provides a combined update for both South Staffs Water and Cambridge Water as the approach and processes involved are common across the two regions of operation.

2 Background

The UK Climate Change Act 2008 gave the Secretary of State power to require companies to report on their preparedness for climate change, under the Adaptation Reporting Power (ARP).

The ARP was first exercised in 2010 when sectors responsible for National Infrastructure were required to report on adaptation to climate change. The first climate adaptation reports for South Staffs Water and Cambridge Water were published in 2011.

In 2014 the Secretary of State invited companies to submit an update on climate change preparedness. This report provides that update and Appendix 1 provides the explicit responses in line with DEFRA's Guidance Document *(Climate Change Adaptation Reporting Power – How to report your progress in planning for climate change Dec 2013)*

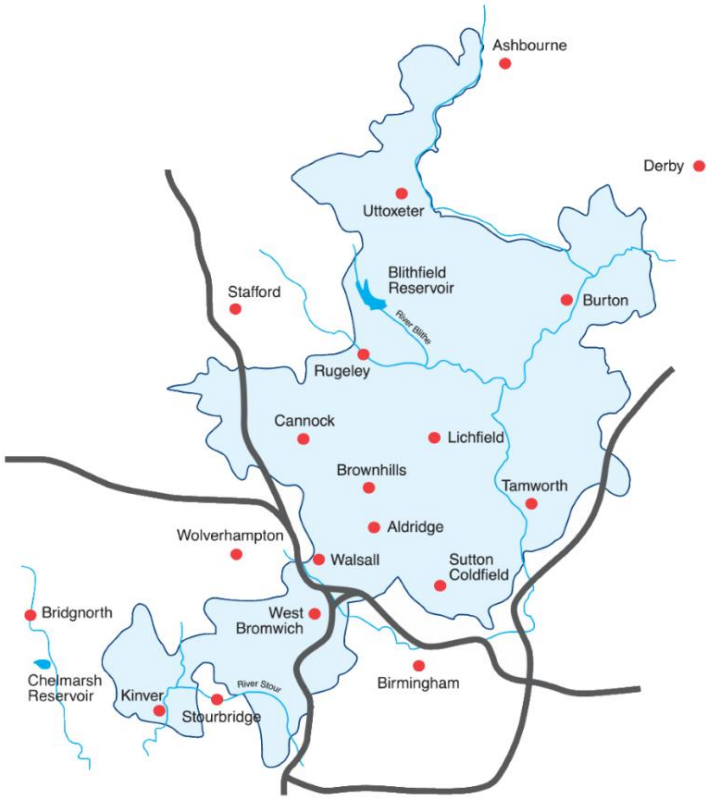
3 Company Information

3.1 South Staffs Region (SST)

South Staffordshire Water was formed in 1853 and supplies an area of almost 1,500 square kilometres with a population of nearly 1.32 million. The Company's area of

supply stretches from the edge of Ashbourne in the north, to Halesowen in the south, and from Burton on Trent in the east to Kinver in the west. The Company's area of supply, shown in Fig 1, contains 550,000 domestic households and 35,000 institutional, industrial and commercial properties.

Figure 1 SST supply area



Groundwater is abstracted from over 60 boreholes at 27 source pumping stations. Two large surface water treatment works, one of which takes water from the River Severn and the other from an impounding reservoir at Blithfield provide about half of the Company's supply. Water is then delivered to customers via 6000km of water distribution pipe work; 51 booster pumping stations; and 33 drinking water storage reservoirs. The total average demand from its customers, including a large bulk supply to an adjacent water company, is around 330Ml/d and this is forecast to remain reasonably stable over the next 25 years.

The Company overcomes considerable challenges in supplying water to its customers, mainly from topography and the extent of urbanisation. Approximately 30% of the Company's source water comes from outside its area of supply and its

water production sites lie within largely rural regions. The majority of customers live within the area to the north of Birmingham known as the Black Country on an elevated part of land known as the Midlands Plateau, which is between 100m and 300m above sea level.

3.2 Cambridge Region (CAM)

Cambridge Water is the water undertaker supplying wholesome potable water to a population of 333,000 in Cambridgeshire and Huntingdonshire, an area that includes Cambridge city and extends to Ramsey in the north, Gamlingay in the west, Balsham in the east and Melbourn in the south, shown in Figure 2.

Customers are currently supplied from groundwater sources in the chalk aquifer. The underground chalk strata is generally a robust water storage aquifer, recharged by rainfall mostly during the winter months each year. Water is abstracted using boreholes sunk into the ground, at 23 sites across the area. There are also a number of small bulk imports and exports with neighbouring water supply companies, which have been in operation for a number of years at the periphery of the Company's supply area.

Figure 2 CAM supply area

4 Key Risks

As part of this update all of the risks identified in the Company's responses to the first ARP in 2011 have been reassessed for each operational area and have been found to remain valid. Tables A, B and C provide an updated assessment of the risks considered. No new risks have been identified.

Climate change adaptation is embedded in Company planning processes and this update report highlights links to those Company processes which ensure that climate adaptation is kept under regular review. In particular, a number of the climate change risks are those around water resources and our ability to continue to supply water to our customers. These risks are routinely investigated as part of our water resources planning process and have been documented in our Water Resources Management Plan (WRMP) 2014.

5 Water Resources Management Plan

Every 5 years water companies are required by law to draw up, consult on and adopt a WRMP which sets out how they will manage resources to meet demand in accordance with the requirements of the Water Industry Act 1991. WRMPs must be prepared in line with the Environment Agency's Planning Guideline.

The current WRMP (WRMP14) covers the period 2015 to 2040 and takes into account factors such as population growth and climate change. A WRMP includes a forecast of the demand for water against the forecast of the amount of water available for use. There is a buffer called 'headroom' added to demand which accounts for uncertainty in the various elements of the forecasts.

The impact of climate change on both the demand for, and availability of, water in the future is considered. The Plan is subject to annual review and a new plan must be prepared every five years. The WRMP14 for both South Staffs Water and Cambridge Region both show that there is no deficit in the supply demand balance over the planning period. Therefore, no specific measures to address the impacts of climate change are currently required.

The following sections (5.1 - 5.5) summarise the assessment of climate change impacts included in the WRMP14.

5.1 Impact of Climate Change on Supply in SST

In order to assess the impacts of climate change on the Company's water supply the methods in the Environment Agency guidance *Climate change approaches in water resources planning – Overview of new methods* (EA, 2012) have been applied. This guidance explains how to make use of the latest climate change projections published by Defra in June 2009 (*Adapting to climate change – UK climate projections 2009*), otherwise known as UKCP09.

The climate change methodology consists of the following steps:

- A climate change vulnerability assessment
- Identification of appropriate assessment approach
- Calculation of river flows
- Calculation of deployable output in the 2030's
- Scaling of impacts of climate change and determination of headroom uncertainty

The Company carried out an initial vulnerability assessment in order to determine how vulnerable the Company water resource zone is to the effects of climate change. This concluded that the Company's vulnerability should be assessed as low to medium. However, due to the interactions with the surrounding Severn Trent Water supply system it was decided to adopt a medium to high vulnerability approach as this was the vulnerability assessment for their Strategic Grid Resource Zone.

This involved application of Approach 2.2 (targeted sample of UKCP09 based on DI analysis) which required undertaking a drought indicator analysis, in order to determine the sensitivity of the system to water availability in drought.

The Company Aquator model was used to investigate the UKCP09 climate change prediction scenarios. Models were run over the 1921-2010 period to evaluate the impact of climate on deployable output under existing Company levels of service (an average of one temporary use ban every 40 years). The results consistently showed that in the majority of future scenarios there will be a reduction in deployable output by the 2030s but there is considerable variation in the volume of this reduction. The

dataset has been used to determine the most likely reduction in baseline deployable output by 2030 and the probability distribution for headroom uncertainty.

Predicted 2030 scenario	Change to dry year annual average DO	Change to dry year critical period DO
Scaled reweighted		
Baseline DO	-5.20	-6.45
Dry (relative to baseline)	-11.18	-13.86
Wet (relative to baseline)	10.63	13.18

The planning guidelines stipulated how 2030/31 values are to be applied across the planning period between 2011/12 and 2039/40. This is applied by means of a scale factor. The SST dry year annual average (DYAA) supply demand balance includes a reduction in deployable output (DO) of 5.55Ml/d by 2039/40 and 6.88Ml/d for peak week. The uncertainty around climate change impacts on supply has been included in headroom.

5.2 Impact of Climate Change on Supply in CAM

For the CAM region the Company undertook a vulnerability assessment of the impact of climate change on supplies. Our assessments indicate that, at the Company deployable output and water resource zone level, there is an aggregate low vulnerability to climate change. The expected impacts have been determined through the following staged approach:

- Determination of vulnerable sources
- Regression analysis of groundwater level and rainfall
- Evaluation of climate change projections
- Application of climate change to predict groundwater levels
- Vulnerability and impact assessment

A vulnerability assessment was undertaken for the WRMP14 alongside a review of Source Reliable Output (SRO) assessments. The SRO studies identify the constraints on deployable output at each source, and those sources where the deployable output is constrained by yield or Deepest Advisable Pumping Water Level (DAPWL) which could potentially see changes in deployable output due to climate change.

Of the 28 groundwater sources where the Company is licensed to abstract water, eight were identified through the vulnerability screening as requiring further assessment. This is based on the principal constraint on the deployable output being climate related, and availability of data.

The impact of climate change on sources is a function of the change in recharge, and minimum groundwater levels. In order to simulate future rainfall and recharge effects on the eight sources, the UKCP09 climate projections for Cambridgeshire were used to develop 15 scenarios. These were selected to include the low, medium and high emission future climate scenarios, for the 2030s, 2050s and 2080s. The predicted change in minimum groundwater level was then assessed at each source for the emissions scenarios.

Results of the assessment on the eight sources indicated that three sources fell into the medium – high vulnerability category, as defined by the Environment Agency Water Resources Guidelines approach. The remaining five sources were assessed as low and considered to be within the range of uncertainty in the model.

Overall, the Company's water resource zone has a low vulnerability to climate change impact on the total deployable output. The three sources identified as medium-high vulnerability only have a small net impact on the available deployable output through the planning period. The worst case is less than 1Ml/d, and this is attributable mainly to 2 medium-high vulnerable sources which provide only 2.3% of total deployable output at annual average. The impacts of climate change on supply have been explicitly included in our supply forecast.

The uncertainty associated with the climate change impacts on supply used in our plan has been included in the target headroom assessment, in accordance with the

guidelines. We have applied a minimal allowance for uncertainty as we do not believe that the impacts would be significant.

5.3 Impact of Climate Change on Demand for Water in SST

For the SST region the Company has included a small estimate for the uncertain impacts of climate change in its headroom assessment based on the draft outputs of 'Impact of Climate Change on Demand for Water' (UKWIR, 2013). No direct impact on the demand for water has been included within the baseline demand forecast.

5.4 Impact of Climate Change on Demand for Water in CAM

For the CAM region the Company has included a very small increase (estimated to be 0.6% of household demand by 2030) in demand due to the impacts of climate change in its baseline forecast. This increase was derived using the UKWIR 13/CL/04/12 methodology.

The uncertainty associated with the demand side climate change assumptions has been included in the target headroom assessment, in accordance with the guidelines. We have applied a minimal allowance for uncertainty as we do not believe that the impacts would be significant.

In recent years the increase in demand in the short-term in response to dry warm weather has been more pronounced than in the past. It is not clear whether this is a change in customer behaviour driven by climate change or by some other influencing factor. It is important for us to understand the drivers for changes in demand, particularly for peak and drought periods and we will review our approach to identify if improvements can be made for the next WRMP.

5.5 Future Climate Change Work

For the SST region we intend to apply a similar approach in the draft WRMP19 to that used for the WRMP14 for supply but will update assumptions to reflect changes in our asset base.

For the CAM region we intend to more fully assess the impacts of climate change on supply by building on the vulnerability assessment completed so far. It is likely that we will adopt the low vulnerability approach set out in *Climate change approaches in water resources planning – Overview of new methods* (EA, 2012).

The Company used UKCP09 in its assessment of climate change impacts on water resources for the WRMP14. We will review the availability of later UK Climate Projections and where appropriate use these in further work to update assessments for the WRMP19

We will review our approach to assessing the impact of climate change on the demand for water and will aim to approach this in a consistent manner across both regions of operation.

There are a number of other pressures on the availability of supply and demand for water which will be reassessed for WRMP19 alongside the impacts of climate change. If, as a result of this reassessment there is a deficit in the supply demand balance over the next planning period (2020 to 2045) then options to redress the imbalance will be identified in accordance with industry methodologies and Environment Agency guidance. In this way the Company continually adapts its supply and demand strategies incorporating the impacts of climate change.

6 Drought Plan

Following the Water Act of 2003 drought plans are statutory documents, which are submitted to the Secretary of State (DEFRA). They must be prepared in line with the Environment Agency's Planning Guideline. A Drought Plan should be reviewed annually and previously a revised plan would be submitted to the Secretary of State every three years or more frequently where there are material changes. This timescale has now been amended and plans are to be brought into line with Water Resources Management Plans and completed every five years.

Drought Plans set out how a water company will respond to the challenges of increasing demand for water in hot dry weather and the corresponding reduction in water availability. All droughts will be unique in terms of the exact impact on the Company but plans are tested against droughts of differing severity.

Climate change has the potential to increase the frequency and or severity of droughts and drought plans need to consider this.

The Company is commencing a review of its current drought plan and this will include a review of the severity, duration and frequency of drought we plan for.

During 2016 Water UK undertook a project to develop a framework for water resources planning in the UK over the long term. The project considered the impacts of climate change, growth and sustainability reductions on the availability of resources to meet demand over the next 50 years. There are a range of key messages from the project for a range of stakeholders to consider and take forwards. One of these is that arising from climate change there is a significant risk from more severe droughts in the next 25 years. Defra has committed to reviewing this project and issuing guidance (possibly in the form of a Direction) regarding the level of resilience to drought which companies should plan for. The timing of this guidance is unknown and may not be in time for inclusion in the next Drought Plan or WRMP updates. However, the Company will be considering its level of resilience as part of these ongoing reviews anyway.

7 Drinking Water Safety Plans

Climate related risks, such as flooding; changes in the quality of our groundwater sources; and changes in the catchment, are included in the Company's source to tap risk assessments under the auspices of Regulation 28 of the Water Supply (Water Quality) Regulations 2016. The Company reviews its risk assessments on a regular basis and will notify the Drinking Water Inspectorate (DWI) of any significant changes in catchment risk as part of the DWI monthly returns process. Internally, any significant risks are reported monthly by Water Quality & Compliance to Board level via the Company's Compliance Database. As most of the Company's sources are groundwater derived, aside of Seedy Mill and Hampton Loade surface water treatment works, the catchments for the Company's abstractions can be found in the Environment Agency's Groundwater Protection Zones.

8 Flooding

As part of the National Flood Resilience Review 2016 all of our operational sites have been risk assessed for flooding using Environment Agency 2016 flood maps and flood depth data. Two sites in the Cambridge region and two sites in South Staffs region have been identified as being at risk of flooding in a 1:1000 year flood and are also critical for maintaining a water supply to our customers. Permanent flood defences are already installed at one site and proposals are being prepared for the three remaining sites. Flood risk data is regularly reviewed as part of the Drinking Water Safety Plan updates.

9 Emergency Planning

The Company's emergency planning arrangements provide the mechanism for responding to unplanned events and incidents. Emergency plans ensure that the impact of a major emergency are minimised; that normal levels of operational activity are resumed as quickly as possible and that the requirements of the Security and Emergency Measures Direction (SEMD) and Civil Contingencies Act 2004 are met. Events which may arise due to climate change, such as loss of supplies to our customers, will be managed by an incident team whose responsibilities are clearly outlined in the Company's Emergency Planning Procedures.

In order to achieve its purpose the Emergency Plan:

- Promotes preparedness by all participants in the incident team, identifying their roles and responsibilities.
- Establishes a team dedicated to resolving all difficulties presented by a major emergency including command and control arrangements for a multi-agency event.
- Establishes a team, which is fully prepared to respond to major emergencies at any time.
- Ensures the most effective and efficient management of response to major emergencies.
- Maintains a dedicated team who will co-ordinate the activities of all parties, and others with a role to play in response to major emergencies.
- Lists plans and / or responses to identified incidents and support the activities of all participants.
- Identifies outside organisations and services and pursue co-operation with all engaged in preparation for and the response to major emergencies.
- Promotes the health, safety and welfare of all those engaged in the response to major emergencies.

An incident is defined as an event which affects, or is likely to affect, the supply and quality of water services so as to jeopardise public health or concern, or endanger the continued operation of the Company. Such incidents may arise due to the impact of climate change and the plans are sufficiently robust and flexible to deal with a wide

variety of events. Emergency Plans are regularly updated and are audited by an external auditor as part of the annual SEMD audit for DEFRA.

10 Business Continuity Plans

The *Business Continuity Management Process* (BCMP) aims to mitigate the impacts of a disaster by ensuring that alternative business-critical capability is available when a disaster strikes. The BCMP is the framework used to ensure that Business Continuity Planning is supported at a senior level in the organisation and that Business Continuity Plans (BCP's) are embedded into the culture of the organisation and are regularly reviewed, updated and exercised. The BCMP also provides the framework for effective disaster management through the provision of Incident Management and Recovery Management Teams.

The aim of *Business Continuity Planning* is to ensure, that following a disruption, essential services are maintained whilst normal services are resumed. Essential in this context is the provision of; customer support activities, including billing and telecommunications; defined IT systems; financial and procurement services (to ensure ongoing essential supplies); staff sufficiency; security of sites and assets; and the continuation of Control Room facilities.

This BCP process follows recognised guidance and best practice as demonstrated in the Business Continuity Institute 'Good Practice Guidelines', 'Implementing Turnbull' and following BS 25999 Business Continuity Management – Part 1:Code of Practice.

The BCMP identifies critical activities for each Division within the Water Company and the risks associated with these critical activities, including climate risk. Risk mitigation measures are applied and if the risk cannot be removed BCP's are prepared to ensure an effective response should the risk be realised and a disaster occurs. BCP's cover the immediate response to an event typically in the first 24-72 hours and longer term >3-7days.

Business Continuity Planning includes responses to climate change risks such as loss of power (such as arising from storms and extreme events) and are regularly updated and audited by an external auditor as part of the annual SEMD audit for DEFRA.

11 Winter and Summer Action Plans

The Winter Action Plan (WAP) and Summer Action Plan (SAP) compliment the Emergency Planning procedures and link into emergency planning arrangements should the need arise. These plans ensure that the supply of water from production facilities (Treatment Works, Source Stations, Boosters, Service Reservoirs and Water Towers) is sufficient to meet the forecasted demand within the SST and CAM regions. The plans focus on supply continuity rather than water resource position as the resource position is covered within the Drought Plan.

The WAP and SAP identify triggers which will invoke actions, together with the escalation criteria. The plans identify both the appropriate levels of resource and other mitigating actions targeted at maintaining supplies to customers and keeping customers informed. The plans are reviewed regularly to take into account both long and short term weather forecasts and what resources are planned to be in supply at times of exceptional demand.

12 Risk Based Asset Management

Risk based asset management is based on our ability to assess the probability of asset failure and effectively quantify the consequences, including the severity of what happens when those assets fail. Our assets' performance can be responsive to weather, especially the underground pipe network, so we use climate data to support the understanding of future probability of failure occurring.

When forecasting how our assets will perform in the future, based on asset cohort information and historic performance, we can then overlay weather scenarios to see how extreme events can affect our predictions. We use historic data to understand how extreme events have affected the pipe network performance and assess the impact of these weather extremes happening either concurrently or more frequently to assess how they would impact on our ability to maintain service to our customers.

One example of asset management where we assess the potential impacts of climate change is the development of our leakage management strategy.

12.1 Leakage Strategy

When predicting future leakage levels a range of climate scenarios are modelled; weather events, from cold freeze thaws to prolonged dry summers can affect the

distribution system. These events can lead to ground movement which in turn can cause pipes and fittings to move, causing either a catastrophic failure or smaller harder to detect weeps.

Historic weather data extremes are used to model the impact of these events happening concurrently to predict how the distribution system would behave in the event of climate change bringing more frequent extreme weather conditions. This assists with identifying the most robust leakage management strategy for the Company.

13 Power Generation

Climate change impacts include the potential for more frequent stormy weather conditions. Experience shows the power network becomes unreliable during such periods. We address the risk arising from this by ensuring we have our own onsite generation to maintain the production of water.

The Company has the capability to generate 100% of electrical capacity required at both our surface water treatment works and around 55% of the groundwater sources.

We are proposing to increase our groundwater pumping stations generation capacity to enhance resilience and secure customers supplies further. Customers that require the water to be boosted due to the zonal topography are all supported by onsite generation.

14 Summary

Since our first climate change adaptation report in 2011 we have continued to build climate risks into our existing planning processes rather than creating a separate overarching Climate Adaptation risk matrix. We recognise that climate change is a significant long term environmental challenge for us and that we need to continue to focus on climate adaption requirements as part of our business as usual (BAU) activities across the business.

Our knowledge of climate adaptation within the business has increased through participation in Industry Networks and the use of existing data and new research. Climate change risks have been recorded on our Compliance Register which is subject to monthly review by our Senior Management Team and climate effects have

been included in our Water Resources Management Plan 2014 and latest Drought Plan.

We have experienced extremes of weather which have confirmed the resilience of some of our sites to flooding and we have used new EA flooding data to assess other sites where we intend to install permanent flood defences.

We recognise that there are some challenges ahead as we plan for long term adaptations. Under current regulatory processes adaptation schemes require customers' support for funding. It can be difficult to gain customers' support for investment associated with risks with significant uncertainty. Engaging customers and gaining their support for investment in this area may be challenging. As and when we identify the need for significant investment driven by climate change impacts we will engage with customers to explain the risks and uncertainties.

Internally we recognise the importance of understanding the impacts of climate change and extending our planning horizons to ensure that impacts are managed and minimised. A Climate Adaptation Steering Group has been formed to ensure that climate risks are regularly reviewed and adaptation schemes are proposed.

Appendix 1 DEFRA Guidance Responses – How to Report Progress in Planning for Climate Change

1. Understanding Climate Risk

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

Since the first round of reporting the Company has identified that the risks presented by climate change are considered in many business as usual activities which have been highlighted in this report (Sections 5 to 13).

The Company has also updated its Water Resources Management Plan (WRMP) 2014 which used the methods in the Environment Agency guidance *Climate change approaches in water resources planning – Overview of new methods* (EA, 2012) to assess the impacts of climate change on the Company's water supply. This guidance explains how to make use of the latest climate change projections published by Defra in June 2009 (*Adapting to climate change – UK climate projections 2009*), otherwise known as UKCP09.

The Company has also been involved in the UKWIR project – *Long Term Water Resources Planning Framework*, which considers the impacts of extreme drought conditions and longer term (50 year) planning horizons.

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

UKCP09 has been used as the core dataset for the second round of reporting and for the WRMP 2014. The WRMP 2014 applies various future climate scenarios to model the effects of climate change on reliable output from abstraction sources. The Weather Generator and threshold tools have also been used to gain a better understanding of maximum and minimum temperature occurrence and longevity, as these are key parameters for climate change effects on our operations, such as peak demands and leakage control.

In the Cambridge Region (CAM) a risk screening of sources susceptible to flooding was undertaken in February 2014. This assessment was to understand the risks to raw water quality from such events following intensive rainfall events. Both fluvial, pluvial and run off flooding risks were included, together with geological, hydrogeological and topographical parameters.

In June 2016 all of the Company's operational assets in both the CAM and SST Regions (CAM and SST respectively) were additionally risk assessed against new EA Flood Maps as part of the National Flood Resilience Review and a recommendation was made for the installation of flood protection at three critical sites (two in CAM and one in the SST).

1.3 Has your understanding of thresholds of climate impacts advanced to better pinpoint organisational vulnerability?

Our understanding of climate impact thresholds that relate to vulnerabilities in our organisation has not changed since the first reporting round. We are aware of key climatic thresholds that impact our operations and UKCP09 data has been used to evaluate these. Thresholds and vulnerability will be re-evaluated once UKCP18 datasets are available, and this will include intense rainfall event thresholds, if the spatial scale that can be applied is appropriate.

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

The risk assessment methodology used in the first round of reporting has been used in this round and the risks have been reviewed and mitigation measures have been linked to business as usual (BAU) processes. Appendix 2 of this report provides a summary of the identified risks, adaptation capacity and adaptation measures. BAU processes have also been further developed and improved since the last round of reporting and a Compliance Database has been created to ensure that actions identified are progressed. The Compliance Database is subject to regular monthly review by the Executive Management Team.

2 Understanding Uncertainties

2.1 What uncertainties remain in monitoring and evaluating climate risks to your organisations functions?

The uncertainties identified in the first round of reporting remain;

- Magnitude of climate change effects due to various future emissions scenarios, beyond the 2020s
- The range of probabilities for the change of climate variables in UKCP09 for the possible future climate.
- Climate model uncertainty in the estimation of frequency and magnitude of future extreme weather events.
- The natural variability of localised weather change and unpredictability of modelling at the regional scale.
- Interdependencies and the interaction with externalities outside the control of our business, such as communications and transportation.

We believe there is a possibility that a minor increase in raw water quality issues in CAM may be due to climate change, as a consequence of intensive rainfall events, however it is too early to determine whether these are climate trends that will continue. The UKCP18 data will be used when available to gain a better understanding of climate risks.

2.2 What new uncertainties have come to light

There is uncertainty around how the Regulatory Framework and applications for funding via Business Plans Submissions will support climate adaptation measures.

2.3 What further implications do uncertainties have on actions your organisation has taken or plans to take

The current investment planning processes do not allow for long term planning for climate change adaptations. Submissions to OFWAT are made every 5 years and must be supported by our customers using 'willingness to pay' criteria. With a high level of uncertainty around climate change impacts and extended planning horizons (50 years - Long Term Water Resources Planning Framework) customers are unlikely to want to pay for significant investment in the short term. The current Regulatory framework does not support long term horizon planning scenarios required for climate adaptation schemes.

2.4 What progress have you made to address information gaps

The Company will continue to use up to date climate data gained through participation in Industry Networks for climate change; emergency planning and security; water resources; and flooding. Regular flooding reviews, using the most recent EA flood maps will be undertaken, and new data within the UKCP18 report will be used to address information gaps.

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

The risks identified in the first round of reporting are unchanged and the methods used to analyse the impacts are based on UKCP09 predictions; company expertise and knowledge of assets; and EA flood plans.

3 Addressing barriers and understanding interdependencies

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

As part of the flood risk assessments the Company identified power assets that are at risk of flooding and provide power to critical water supply sites. However these assets would not necessarily trigger a requirement for protection by the power company as they serve relatively low population numbers. This is an example of how the lack of knowledge of interdependencies may hinder actions to reduce climate risk in the future. In this case the electrical asset will be protected within the Company's planned permanent flood protection project.

3.2 What were the main barriers to implementing action and Why?

The greatest barrier for climate adaptation plans and implementing actions is the uncertainty around impacts and the long term planning horizons that are provided by climate change data. Customer 'willingness to pay' may be less likely when impacts cannot be accurately quantified and, have elongated timescales which are much greater than the traditional 5 year planning periods used for Business Plan submissions. The current regulatory framework and business planning processes do not adequately support funding for adaptations for climate.

3.3 Have new barriers been identified? Are these being addressed? If so How?

Both external and internal awareness of climate change and its impacts needs to continue to be raised and the integration, and identification, of climate change risks into existing Company processes and risk matrices will ensure that awareness is increased.

A Climate Adaptation Steering Group will convene regularly to review the risk matrices and ensure that all risks are considered.

4 Monitoring and Evaluating

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

Climate change risks are considered and embedded into many well established Company processes; Water Resources Management Planning; Drinking Water Safety Plans; Emergency Planning; Business Continuity Planning; Winter and Summer Actions Planning; Asset Management Planning and Leakage Strategies, providing a robust mechanism for addressing climate change risks.

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

Climate adaptation is included within the Company Compliance Database which records all risks and is updated on a monthly basis and reviewed by the Executive Management Team to ensure that adaptive responses are on track.

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

Recent extreme weather events resulted in minor water quality issues in both regions which did not affect the Company's ability to supply wholesome water to its

customers. Flooding events have confirmed that some sites are very resilient to rising water levels and that others are not. The flood review completed as part of the National Flood Resilience Review identified three sites that require flood protection against a 1 in 1000 year flood but none of these sites have been affected by flood water in recent years.

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

The benefits of adaptation schemes that have been implemented have not been quantified.

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

The Company has ensured that all climate risks identified are considered in already established Company processes detailed in 4.1. This flexible approach ensures that adaptation to climate change is built into future planning horizons.

Appendix 2 Adaptation Measures to Identified Key Risks

Table A Climate Hazard: Drought (decrease in rainfall, reduced groundwater levels, dry summers, increased SMD)

Ref	Asset Business Area Affected	Strategic Risks	Adaptation Capacity	Adaptation Measures
DR1	Water Resources	Increased probability and severity of droughts, caused by delayed winter recharge from high SMD in summer, poses risk of reduced supply availability.	Drought plan and schemes, drought indicators/monitors, water efficiency measures, metering programme, Flood and Water Management Act 2010.	Options to address a supply demand deficit arising from a reduction in water availability or a rise in demand include all demand side management options (increase meter penetration, reduce leakage, increase water efficiency, variable tariffs, water recycling and re-use), operational options (reduce treatment works losses and operational use of water) and supply side options (new resource development, winter storage reservoir schemes, water trading, resources sharing). The Company's Water Resources Management Plan (WRMP) looks at the demand for water and the availability of supplies over a 25 year planning period. Climate change risks on supply availability are comprehensively assessed in the WRMP last published in 2014. The impact of climate change on demand is also considered within the WRMP but the uncertainty around this is much greater The Company's Drought Plan assesses risk from historic drought and was last published in 2013. It includes a suite of short term demand side and supply side measures to allow customer supplies to be maintained. Work has commenced on a revised plan to be published in 2018. This will consider more extreme drought events under Climate Change. Our Summer Action Plan (SAP) and Emergency Procedures provide detailed operational responses in the event of drought impacts and are considered alongside the Drought Plan. Summaries of how climate change is considered within our WRMP and Drought Plan can be found in sections 5 and 6. A summary of how the SAP and Emergency Procedures co-ordinate with the Drought Plan can be found in sections 9 and 11.
DR2		Lower average river flows and reduced aquifer recharge leads to lower borehole yields and surface water storage, impacting supply demand balance	Source yields monitored and reviewed every five years as part of WRMP review using latest available information and methodologies including use of the water resources model Aquator in SST.	
DR3		Lower yields leads to loss of sources or reduced output, and licence restrictions leading to reduction in headroom, reducing supply demand balance	SRO updates. WRMP review, water resources model	
DR4		Increase in evapotranspiration and SMD trigger drought actions more quickly	Drought indicators/monitors periodically reviewed in Drought plan.	
DR5		Increased demand at daily & annual peak demand periods impacts supply demand balance	WRMP & supply demand balance review/update, water efficiency measures, metering programme	
DR6		Increase in demand for water & water intensive products and activities.	Water efficiency measures and targets , metering programme and increased meter penetration, variable tariffs, WRMP review, Flood and Water Management Act 2010 - guidance on restrictions on use of water in water shortages.	
DR7	Water Quality	Low aquifer and river flow leads to reduced raw water quality.	DWSP, Water Framework Directive (WFD) and Asset Management Plans. Monitor trends and use groundwater models	Surface water catchment management activities in conjunction with current operating practices will assist in controlling levels of pollutants in surface waters. The Company's Drinking Water Safety Plans (DWSP) approach includes a comprehensive environmental aspect and impact assessment of baseline situations of areas such as drought and reduced groundwater levels. These hazards are risk assessed for their potential impact on water quality and are reported frequently to both internal and external stakeholders via a formal risk assessment process (developed by the Industry in conjunction with the Drinking Water Inspectorate (DWI)). Any hazards deemed in the assessment as an unacceptable risk are reported formally to the Company Executive, the DWI and Environment Agency. The DWSP approach is fundamental in supporting any relevant mitigation required to reduce risk. The frequency of DWSP assessments is annually for all major catchments (with historical high to medium risks) and every two years for lower risk catchments.
DR8		Less infiltration and dilution leading to reduced water quality requiring additional treatment.	Raw water and treated water sampling regime, R&D WFD.	
DR9		Deeper water table pumping deteriorates raw water quality.	SRO updates, WRMP, DWSP	
DR10		Supply losses leading to mains failures increase contamination risks in supply network	Mains failure procedures, DWSP	
DR11		Increased vulnerability to pollution events due to reduced dilution within surface waters and reservoirs.	Raw water and treated water sampling regime, R&D, WFD.	

DR12	Network infrastructure	Increase in SMD - Dry ground and shrinkage leads to greater incidence of pipe failure.	Mains failure procedures operational response, DMA & network monitoring.	Utilisation of operating policies and procedures to ensure impacts of mains failures are managed and impacts on customer service are mitigated as much as possible. Longer term appraisal of asset specific deterioration models to ensure the impacts of all variables are adequately reflected in modeling techniques. This will ensure that expenditure to manage mains bursts is assigned to the most cost effective assets, to proactively manage the impacts of climate change by replacing those assets most likely to fail. All approaches to Asset Management are documented within our ISO 550001 accredited Asset Management Strategy documentation.
DR13		Increased pipe failure leads to serviceability failures.		
DR14		Poor serviceability performance can impact on performance commitments.		
DR15		Peak demands require increased pumping in network, leading to increased risk of pressure surge failures.		
DR16	Production Infrastructure (surface and groundwater)	Increased treatment increases chemical and carbon use/costs.	Treatment optimisation	R&D, new treatment technologies & solutions, alternative power sources, adaptive plan for treatment measures. Long term plan to address quality and quantity issues at surface water sites being developed which will include climate hazards to be assessed and planned for. Alternative power sources, emergency response plans, adaptive response procedures, asset life and performance models. Appropriate resilience measures including duty / standby / duty assist, and strategic pump stock backed-up by parent Group engineering workshop and workforce. Opportunities to implement measures to reduce or rest borehole abstractions reviewed.
DR17		Pumps working harder to meet high demands, increased risk of failure and high power consumption.	Power and pumping optimisation, operational response, proactive maintenance	
DR18		Abstraction pumps working harder to abstract from deeper water level, increased risk of failure and high power consumption.	Power and pumping optimisation, operational response, proactive maintenance	
DR19	Customer Impact	Restrictions imposed on water use.	Drought Plan, Flood and Water Management Act - guidance on restrictions on use of water in periods of water shortages. Demand management strategy.	Metering strategy, water efficiency measures & targets, customer communications promoting behavior change, variable tariffs, water-reuse technologies and initiatives.
DR20		Increased demand for water based leisure activities impacts on supply demand balance.	Drought plan, Flood and Water Management Act - guidance on restrictions on use of water in periods of water shortages. Demand management strategy.	

Table B Climate Hazard: Increase in summer & winter rainfall (floods high groundwater levels & greater storm intensity)

Ref	Asset Business Area Affected	Strategic Risks	Adaptation Capacity	Adaptation Measures
RI1	Water Resources	Sewer flooding poses risk of contamination to groundwater and supply demand balance.	Drinking Water Safety Plan (DWSP) site audits and actions, proactive maintenance and operational policies and procedures.	Drinking Water Safety Plans assess risks to all sources and identify mitigation actions. Asset protection measures are identified and implemented as part of this process. Mitigation measures at Treatment Works include flood alarms, man-made bunds and two-stage chlorination systems. Catchment management activities identifying surface water catchments vulnerable to flashy conditions and pollution events to target activities to mitigate this. Catchment Advisors in both regions assess relevant data and undertake catchment audits to identify any potential risks. Risks to loss of source output considered as part of the WRMP and included within the headroom component. Emergency Response plans deal with the impact of loss of supply for whatever reason.
RI2		Flood water infiltration around source protection zones deteriorates raw water quality reducing supply demand balance.	DWSP, risk analysis using flood databases, operational response, proactive maintenance.	
RI3		Flood water infiltration causes severe pollution of aquifer and source cannot be used, impacting supply demand balance.	DWSP, Flood and Water Management Act 2010, risk analysis using flood databases, operational response, proactive maintenance.	
RI4		Increased rainfall causes erosion of soil, increased leaching of agrochemicals into surface water and / or aquifer and flushing of pollutants from unsaturated zone.	DWSP, catchment modelling.	
RI5		Flooding of pumping station infrastructure causes power loss and inability to use sources, impacting supply demand balance	Flood and Water Management Act 2010, risk analysis using flood databases, operational response, proactive maintenance	
RI6		More intense rainfall events, increasing run-off proportion, thereby reducing recharge of aquifers and reducing supply demand balance.	See DR2	
RI7	Water Quality	Heightened risk of flood water infiltration into pipelines increases water quality risks.	DWSP, Flood and Water Management Act, analyse risk using EA Flood Databases (Jan 2016), flood databases operational response.	Drinking Water Safety Plans assess risks to all sources and identify mitigation actions. Asset protection measures are recommended as part of the DWSP process. The process includes; sewer surveys, run to waste systems, physical protection (i.e. barriers, bunds, etc.), drainage maintenance, etc. In the event of flood waters affecting the outer catchment and therefore the raw water quality then other mitigation measures are considered. These include additional treatment processes installed at a treatment works (i.e. super and de-chlorination, UV Irradiation, etc.).
RI8		Direct flooding causes contaminants to enter pipelines increasing drinking water quality risk.		
RI9		Sewer flooding poses risk of contamination to groundwater raw water quality.		
RI10		Increased flood water run-off introduces additional pollutants into source, requiring additional, increased treatment.		
RI11		High winter soil moisture increases leaching, reducing raw water quality.		
RI12		Flood water infiltration around source protection zones deteriorates raw water quality requiring additional treatment.		
RI13		Increased storm frequency increases frequency of power loss, causing treatment service failure.		
RI14	Network infrastructure	Direct asset flooding cuts access to assets, increased H&S risk to staff.	Sites are risk assessed using EA Flood data. Last updated in 2016.	Consequence of failure analysis includes an appraisal of flooding issues for strategic assets. This includes analysis of assets at risk of flooding, but also impacts of mains failures that could cause flooding issues. This information is used when prioritising expenditure.

RI15	Source pumping stations	Increased storm frequency increases frequency of interruptions to power loss, potential of temporary asset loss.	Analyse risk using EA flood databases updated in 2016. Operational responses.	Flood hazards are included in the DWSP risk assessment process. The hazards are coded as either a high, medium or low risk. The ranking is based on the risks to both water quality and the possibility of a source pumping station not able to supply water. Supporting information is also used in the DWSP process and is provided by external bodies including the Environment Agency in the form of GIS Mapping. The mapping data is regularly updated by the EA and this enables the flood elements of the DWSP to be regularly reviewed. Emergency Planning procedures provide the mechanism to respond to a flooding event should it impact on the availability and quality of water.
RI16		Direct asset flooding causes service failure from temporary asset loss.		
RI17		Increased storm frequency and flooding of power supply infrastructure increases frequency of power loss, causing service failure.		
RI18		Direct flooding leads to submersion of electrical assets, increasing risk to operatives of electrocution, endangering H&S of site staff.		
RI19	Operations	Increased storm frequency increases frequency of interruptions to power loss, potential of temporary asset loss.		
RI20		Direct asset flooding causes service failure from temporary asset loss.		
RI21		Direct asset flooding cuts access to assets, endangering H&S of site staff.		
RI22		Direct flooding leads to submersion of electrical assets, increasing risk to operatives of electrocution endangering H&S of site staff.		
RI23		Flooding causes loss of SCADA and / or telemetry causing a service loss.		
RI24	Customer Impact	Possible loss of supply due to asset failures, cascaded impacts.	Operational response procedures.	Emergency Planning procedures provide the mechanism to respond to an asset failure that may impact on the supply or sufficiency of water.

Table C Climate Hazard: Temperature Rise (increases in average and seasonal peak temperatures, increased evaporation/evapotranspiration)

Ref	Asset Business Area Affected	Strategic Risks	Adaptation Capacity	Adaptation Measures
TR1	Water Resources	Population redistribution from tourism increases seasonal demand and causes a reduction in supply demand surplus.	Demand monitoring studies and latest population growth figures used in WRMP review, water efficiency measures, metering programme..	Options to address a supply demand deficit arising from a reduction in water availability or a rise in demand include all demand side management options (increase meter penetration, reduce leakage, increase water efficiency, variable tariffs, water recycling and re-use), operational options (reduce treatment works losses and operational use of water) and supply side options (new resource development, winter storage reservoir schemes, water trading, resources sharing). The Company's Water Resources Management Plan (WRMP) looks at the demand for water and the availability of supplies over a 25 year planning period. Climate change risks on supply availability are comprehensively assessed in the WRMP last published in 2014. The impact of climate change on demand is also considered within the WRMP but the uncertainty around this is much greater. The Company's Drought Plan assesses risk from historic drought and was last published in 2013. Work has commenced on a revised plan to be published in 2018. This will consider more extreme drought events under Climate Change. Our Summer Action Plan (SAP) and Emergency Procedures provide detailed operational responses in the event of drought impacts and are considered alongside the Drought Plan. Summaries of how climate change is considered within our WRMP and Drought Plan can be found in Section 4. A summary of how the SAP and Emergency Procedures co-ordinate with the Drought Plan can also be found here.
TR2		Daily and peak domestic and commercial demand increases, causing a reduction in supply demand surplus.	WRMP review, water efficiency measures, metering programme.	
TR3		Higher temperatures and longer growing season causes increase in agricultural demand and impacts on supply demand balance.		
TR4		Redistribution of permanent population in response to temperature rise affects demand and impacts on supply demand balance.	Latest population growth figures used in WRMP updates, water efficiency measures, metering programme.	
TR5		Increased probability and duration of droughts, by delayed winter recharge from high SMD in summer poses risk of reduced supply demand balance.	WRMP & SRO, DO reviewed and updated every five years using latest available information and methodologies. Water resources model Aquator used in SST.	
TR6		Increased summer peaks of demand drawsdown surface and groundwater storage reducing supply capacity.	Demand monitoring studies and source yields DO reviewed and updated every five years for WRMP using latest available information and methodologies. Water Resources model Aquator used in SST.	
TR7	Water Quality	Increased algal growth and risk of microscopic organisms within the water supply system increases drinking water quality risk.	DWSP.	Catchment risk assessments are undertaken as part of the DWSP process. Temperature related risks such as algal and microbiological growth are listed as hazards within the catchment risk assessments. Seasonal algal growth within both the Blithfield and River Severn catchments results in frequent sampling of those surface waters to assess algal blooms. Surface water mitigation has included the use of barley straw on the surface of Blithfield Reservoir. The straw inhibits the growth of algae. Downstream of the catchment and treatment works, Trihalomethane (THM's) levels are monitored within distribution. THM's can form as a result of parameters such as temperature and residual chlorine reacting with organic compounds (that occur naturally in surface waters).
TR8		Higher temperatures reduce raw water quality and increase drinking water quality risk.		
TR9		Increased rate of micro-biological growth increases risk of residual chlorine depletion and contamination of supplies, increasing drinking water quality risk.		
TR10		Higher average and peak temperatures cause an Increase in incidence of water & wetland associated disease, thus risk of contamination of raw water.		
TR11	Network infrastructure	Greater extremities in wetting and drying cycles lead to greater soil movement, causing pipe systems to move increasing burst frequency	Mains failure procedures operational response, DMA & network monitoring	Asset Management Strategy (ISO 550001 accredited) – documents approach to asset management interventions and data analysis. Risk based asset management plan, renewals including asset upgrades, adaptive response procedures, contingency measures, response and recovery plans, improved leakage detection. Utilisation of operating policies and procedures to ensure impacts of mains failures are
TR12		Dry ground increases number of identified leaks requiring repair/investigation		

				managed and impacts on customer service are mitigated as much as possible. Longer term appraisal of asset specific deterioration models to ensure the impacts of all variables are adequately reflected in modeling techniques. This will ensure that expenditure to manage mains bursts is assigned to the most cost effective assets, to proactively manage the impacts of climate change by replacing those assets most likely to fail.
TR13	Source pumping stations	Increased peaks of demand lead to greater storage requirements reducing security of supply, increasing pumping required.	Operational response, monitor trends, impacts and failures with proactive maintenance strategy.	Asset protection, risk based asset management plans, contingency measures, response and recovery plans, adaptive asset replacement and working practices. The Company has developed an approach, undertaken in Spring and Autumn, evaluating the trigger levels, operational preparedness, action plans and learning points from previous experiences, that is routinely implemented for the Summer and Winter demand periods.
TR14		Higher average and peak temperatures affect buildings, control systems, pumps and equipment working life, causing increase in failures.	Operational response, monitor trends, impacts and failures with proactive maintenance strategy.	
TR15		Higher average and peak temperatures affect buildings, control systems, pumps and equipment working life, causing accelerated asset deterioration.	Operational response, monitor trends, impacts and failures with proactive maintenance strategy.	
TR16	Operations	Higher average and peak temperatures affect buildings, HVAC plant, control systems working life, causing increase in failures affecting operations.	Monitor trends, impacts and failures with proactive maintenance strategy	Asset protection, risk based asset management plans, contingency measures, response and recovery plans, adaptive asset replacement and working practices. The Company has developed an approach, undertaken in Spring and Autumn, evaluating the trigger levels, operational preparedness, action plans and learning points from previous experiences, that is routinely implemented for the Summer and Winter demand periods.
TR17		Higher average and peak temperatures affect buildings, HVAC plant, & control systems working life, causing accelerated asset deterioration.	Monitor trends, impacts and failures with proactive maintenance strategy	
TR18		Higher levels of UV increase the risk of sun-related injury, endangering H&S of site staff.	Risk assessment	
TR19				
TR20		Higher average and peak temperatures cause an increase in incidence of water & wetland associated disease, possibly affecting access to sites.	DEFRA controls	
		Higher temperatures cause increased vegetation growth at sites requiring management.	Risk assessment and site maintenance strategy	
TR21	Customer Impact	Restrictions imposed on water use.	Model and monitor network flow and pressure.	Manage customer expectations. Metering strategy, water efficiency measures & targets, customer communication promoting behavior change, potential for variable tariffs, water-re-use technologies and initiatives.
TR22		Increased demand for water based leisure activities impacts on supply demand balance.	Water efficiency measures and targets, metering programme and increased meter penetration, variable tariffs, WRMP review, Flood and water management Act 2010 - guidance on restrictions on use of water in water shortage.	
TR23		Increased seasonal demand causes pressure and supply levels of service failures and supply demand balance impacts.	Model and monitor network flow and pressure. Demand management strategy.	