Water today, water tomorrow

Ofwat's climate change adaptation report – supporting process document

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About this document

This document provides more detail about our processes required in order to fulfil the requirements of the direction.

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1. Our approach to adaptation

1.1 Corporate structure

We explain our overall corporate structure – including where responsibility for climate change policy lies – on our website. We have dedicated climate change policy staff, whose remit includes climate change adaptation issues.

Our strategy and forward programme contain more information on our corporate processes. Every year, we report on the work we have done in our annual report.

1.2 Relationships with stakeholders

We do not act in isolation. The response of our stakeholders to climate change adaptation has an impact on us. The means that engagement and collaboration with our stakeholders is central to an effective response to climate change adaptation. Figure 1 (see page 4) provides a simple illustration of the key relationships across stakeholders in the water and sewerage sectors in England and Wales.

It is the companies we regulate that deliver water and sewerage services to consumers. Physical adaptation to climate change will only occur if the regulated companies identify their own risks proactively and accurately, and take appropriate adaptation actions.

Our job is to:

- set an effective and efficient regulatory framework;
- promote competition where appropriate; and
- hold the companies to account if they fail to meet their obligations.

If the companies' objectives are not fit for purpose, if they fail to assess risks correctly and fail to consider adaptation as an embedded part of their business or they cannot make adequate business cases, it affects our success.

The decisions of the UK Government – Defra in particular – are very important for us. The Government will continue to set the policy context and boundaries under which we regulate to deal with future climate change risks. We think our legal functions are generally fit for purpose under a changing climate. But the nature and implementation of existing and future legislation will have a large influence on how well the sectors adapt. For example, the way the provisions of the Flood and Water Management Act 2010 are implemented will influence how well the sewerage system will cope with climate change.

The companies we regulate also operate under the regulation of other organisations, primarily the Drinking Water inspectorate (DWI) and the Environment Agency. The decisions of these regulators can influence strongly successful adaptation in the sectors. Examples of these issues include:

- changes in policy on coastal and flood defences;
- implementation of European directives;
- the ownership and maintenance of sustainable urban drainage systems; and
- the abstraction licence system.

We consult with all our stakeholders on major regulatory issues. For example, before starting this risk assessment, we organised a three-day seminar with the Met Office that focused on collaborative adaptation in the sectors. Representatives from almost every water and sewerage company, Defra, the UK Climate impacts programme (UKCIP), the DWI, the Met Office and the Environment Agency attended the event. The discussions and presentations were a key starting point for this report. We were also part of Defra's working group, which considered how the Reporting Powers were to be applied.

Figure 1 Stakeholders in the water and sewerage sectors

We carry out various degrees of consultation with stakeholders for different decisions and proposals. In most cases, we consult stakeholders informally. For example, we have recently published a number of discussion papers, with the aim of getting feedback on how we might set future price limits. In general, we will base formal consultations around a proposal – such as our proposed framework for the next price review. When we formally consult, we do so in line with our code of practice on consultations. We will also consider our policy on impact assessments. The actions we describe in our report will be subject to different degrees of consultation as they progress.

While a formal consultation on this report was not appropriate, we engaged a range of organisations on our intended approach. For example, we have discussed, and provided comments on, the adaptation report assessment framework with Cranfield University's risk assessment team, and discussed parts of our approach at the National Climate change Risk Assessment workshops held in 2010. We have also discussed our approach in meetings with Defra's Adapting to Climate Change team and the Adaptation Sub-Committee of the Committee on Climate Change.

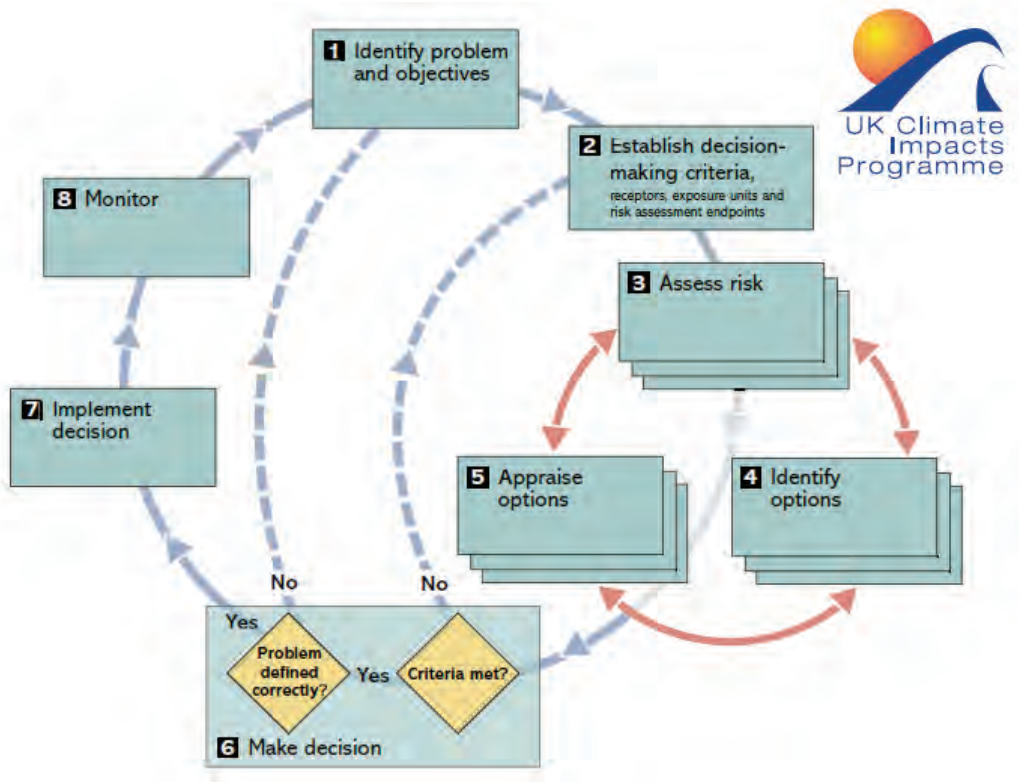
We engaged with the water companies on our approach to this report, for example at meetings of the Water UK Adaptation Network. We have also made an open offer to the companies to discuss their adaptation reports – which some of them took up.

1.3 Our overall approach to climate change risks

The approach we have used to assessing risks and determining actions is based on 'Climate adaptation: risk, uncertainty and decision-making process'[1], developed by UKCIP (UK Climate Impact Programme) and advocated in the statutory guidance. This approach was designed specifically to support good decision-making in the face of climate change risks. The approach is illustrated in figure 2 below.

[1] 'Climate adaptation: risk, uncertainty and decision-making', UKCIP technical report, May 2003. Available from http://www.ukcip.org.uk.

Figure 2 Framework to support decision making in the face of climate change risks



A key feature of this process is that it is designed to be flexible. For example, it is possible to revisit previous steps as new information becomes available. We have retained this flexibility in applying this process. We also plan to reassess our conclusions and actions over time as information improves.

A second reason why we employed this approach is that it can be applied for climate-influenced actions; as well as purely climate-driven actions. Most of our decisions are likely to be climate-influenced, rather than climate-driven. We make decisions in circumstances of significant uncertainty on many things, not just the future climate.

Our overall approach to climate change risks needs to be sustainable and flexible. We explain what we mean by this below.

1.4 Sustainable adaptation

Without sustainable adaptation to climate change, it would be impossible to achieve our strategic vision. It is clear that adapting to climate change is a long-term process, and many of the actions needed to deal with the risks will have significant, wide-ranging, and long-term consequences.

In order to help achieve sustainable adaptation in the sectors, we have had regard to our five principles of sustainability in determining our action plan. These five principles help us guide our decisions to help meet our strategic vision.

1. A safe and reliable water and sewerage service for consumers that minimises the impacts on the environment now and in the future.
2. Consumers continue to get a fair deal and receive a level of service that consistently meets their needs.
3. Financially robust sectors that are able to meet consumers' needs at a fair cost, into the future.
4. Companies that remain accountable to their consumers.
5. Using the best available information to support decision-making.

We set out these principles and discussed our approach to ensuring sustainability in more detail in 'Water today, water tomorrow – Ofwat and sustainability', which we published in March 2009.

We want adaptation actions that minimise their overall environmental impact – for example, any impacts on water quality or greenhouse gas emissions resulting from adaptation measures must be considered. Adapting in the context of reducing emissions is a particular problem, because nearly all construction and operational activity in the sectors will cause some emissions. We explained our overall approach to reducing emissions in the sectors in 'Playing our part – how can we cut greenhouse gas emissions in the water and sewerage sectors', which we published in July 2010. We made it clear that the sectors we regulate must play their part in mitigating climate change by reducing their emissions.

We expect the companies to take the impact of emissions into account across all their activities, including adaptation. We recognise that in some cases adaptation and mitigation are complementary actions – catchment management solutions, for example. We are developing our policy on mitigation further ahead of the next price review.

1.5 Flexible adaptation

Our approach to regulation must take into account the:

- long lifetimes associated with many assets in the sectors;
- long timescales over which climate change will occur; and
- inherent uncertainty about the future impacts of climate change.

Decisions on adaptation investments can leave the companies locked in to a particular approach for a long time. For this reason, our regulatory framework and future regulation programme aim to promote measures that are either robust to the range of potential future climates, or flexible enough so that we can respond as the climate changes.

2. Risk assessment process

Under our direction to report, we must show:

> **"the methodology used to assess the current and predicted impacts of climate change in relation to [our] functions"**

In this chapter, we explain the methodology we used to do this, from identifying potential impacts on our functions to the assessment of the risks.

Our risk assessment decision-making criteria were based broadly on those given in UKCIP's 'Climate adaptation: risk, uncertainty and decision-making process,. We also built on our existing internal risk management processes.

It is important to note that our risk assessment has assessed the risks to us, as economic regulator for the sectors across England and Wales. This means that we have not made distinctions in our assessment between different areas of the country on the basis that if one or more regions are materially affected, then this will affect our functions. It is not our role to carry out individual assessments for each area. Different companies will bear different levels of climate change risk – it is for the individual companies to understand what those risks are.

We have assessed the probability and impact of each of the risks we identified for three different timescales. To do this, we relied on the information provided by UKCIP in the UKCP09 scenarios. So, a key assumption is that this is a reliable basis for a risk assessment.

In assessing risks, we usually focus on a 25-year time horizon. Because of the nature of climate change impacts, the timescales of this risk assessment go much further into the future than we typically consider. The timescales we have used for our risk assessment align with the decadal projections available from the UKCP09 projections.

The periods we have considered represent three different 30-year climate averages, centred on the 2020s, 2050s and 2080s. This allowed us to base our assessment on the UKCP09 key findings. We also considered the fact that many of the key sources used in our assessment are based on these timescales.

The timescales we considered are 2010 to 2040, 2040 to 2070 and 2070 to 2100. It is necessary to focus on these long timescales as the operational lifespan of many assets in the sectors can be in the region of 100 years or more. It can take decades to complete some schemes. In some cases, it is difficult to quantify accurately effects without long periods of monitoring. Also, regulatory incentives and reforms can take time to have the desired effect. For these reasons, it is important to consider as far

ahead as possible. Not doing this could present a threat to service and increase costs unnecessarily.

We have set out a summary of the process we applied in the diagram below. We describe each step in turn in the sections that follow.

Figure 3 Risk assessment process

2.1 Step 1 – reviewing the evidence base

The statutory guidance states that our risk assessment should be "based on the current best evidence and projections". To ensure we did this, the first stage of the process involved researching available evidence on potential climate change impacts to produce a bibliography of useful sources that we could use throughout the risk assessment. This is the underpinning evidence for the risk assessment.

As an economic regulator, we conduct little primary research on climate change impacts ourselves. Instead, we rely on work that other organisations have carried out. It is important that we have a good understanding of the available evidence and its depth and quality in order to regulate effectively. Our review covered a range of sources, including:

- work on climate change impacts from other public sector bodies (such as Environment Agency science reports and Defra publications);
- relevant academic research papers;
- research and work that the companies commissioned;
- commercial research (primarily from the UKWIR research programme, such as the Water UK climate change planning tool[2]); and
- available adaptation frameworks and approaches (such as those produced by UKCIP).

The bibliography (see page 41) is a key resource used in the assessment and has been updated throughout the process. It includes a list of the key sources we used.

2.2 Step 2 – identifying possible risks and defining their impacts

To identify the possible climate change risks to achieving our objectives, we began by considering and listing out all the possible risks of climate change associated with the sectors that we and our stakeholders have identified. We based this, in the first instance, on the risks identified in our climate change policy statement and in an internal risk scoping exercise carried out in 2009.

[2] WaterUK, 2008; available at: http://www.water.org.uk/home/policy/publications/archive/industry-guidance/asset-management-planning

We then considered:

- possible threats and opportunities raised in meetings and presentations, including the workshop we ran with the Met Office in 2010;
- risks raised in the companies' strategic direction statements and business plans, and from the literature; and
- the list of risks identified by the National Climate Change Risk Assessment team and shared with us as part of their stakeholder engagement.

We then consulted internally with the aim of capturing all credible possible risks.

We assessed as a risk any plausible means by which the projected changes in climate could impact upon our ability to successfully fulfil our functions. For each possibility identified in this way, we first set out a brief explanation of what that risk would entail and then collated together the available information relevant to that risk.

We then defined more clearly the causal relationship between the relevant climate change variables, the water and sewerage services and Ofwat. Almost all of the identified risks do not affect Ofwat directly, but will impact upon the companies or other stakeholders, which has a resulting consequence for us.

2.2.1 Defining the causal relationships

To define the precise causal relationships between climate change and a risk to our functions, we began by identifying the basic climate variables that drive each identified risk. This includes temperature changes, sea level rises or changes in rainfall patterns. We then identified the specific relevant effect that the climate variables were expected to have in each case – such as reducing flow levels in rivers, or reducing the number of days of sub-zero temperatures.

The next step was to identify how this specific effect impacted on the companies' operations. For example, reduced river flow threatens a company's ability to abstract water from rivers while reduced frost days affect the pattern of pipe bursts and leaks.

The final step was to determine how the impact on the companies would cause a resultant impact on Ofwat and our functions. A consequence for Ofwat will occur where there is a material change in the companies' ability to provide existing levels of service or a change in the economic or environmental cost of providing those services. When we had established in what ways this impact might be felt, we tested this against our defined impact threshold, which we discuss later in the document.

2.2.2 Grouping

In some cases, we grouped a number of risks together where the nature of the consequence was similar. We did this to ensure that our assessment was proportionate to our needs. For example, for raw water quality issues, there are potentially separate risks associated with levels of phosphorus, nitrogen, toxins, soil content and dissolved oxygen. We have chosen to assess these together. Identifying the nature of different threats to water quality will be critically important for a company and will impact directly on its business plans. But the precise cause of the issue will have a smaller impact upon whether or not and how our functions are affected.

We maintained distinctions between risks where the consequences or magnitudes related to each risk are markedly different. As an example, the overall balance of supply and demand could be defined as a single risk. But we have chosen to separate risks to a limited degree according to how different sources of supply may be affected by climate change. We would expect the companies to carry out analysis on a more detailed and granular level than we have. This is appropriate because the specific details of how a risk impacts on a company's operations is less important to us than to a water and sewerage service provider.

2.2.3 Threats/opportunities

Most of the risks we identified are threats to the successful achievement of our functions. But we have also assessed risks where a climate variable may result in beneficial impacts. The type and nature of the opportunity was identified in each case and assessed in the same way.

2.3 Step 3 – assessing evidence for each risk

For many of the risks there was significant uncertainty regarding the level of probability and/or the extent of the impact. This was often because of the limited evidence available on the risk, which prevents us from having high confidence in the resulting assessment. In other cases, although the evidence was stronger, there was significant uncertainty about how readily the companies can deal with the risk, and how this would translate to an impact upon us as a result. Considering the nature of the uncertainties associated with a risk is useful in the process of identifying and evaluating adaptation options.

For each of the risks we assigned a pedigree score based on the nature of the evidence available to assess that risk. Our scoring system is a simplified version of the system employed in the National Climate Change Risk Assessment. The score reflects the amount and quality of supporting evidence. It also takes into account the degree of agreement in the sources. We have set out the pedigree scoring system we used in the table below.

Table 1 Scoring system for risk pedigree

Score	Description
4	Strong evidence base comprising multiple peer-reviewed sources and strong agreement on the nature of the risk.
3	Multiple reliable sources. Evidence of peer review. General agreement on the nature of the risk.
2	Based on expert testimony, but there is a lack of academic rigour or peer review; or there are multiple reliable sources, but significant disagreements or uncertainties in the evidence base.
1	Non-expert opinions or suggestions.

We recognise that for many risks there may be significant additional research that we have not had the resources to cover or which is unavailable to us. It is partly for this reason that no risks were given a pedigree score of 4. We expect the companies to explore the impacts upon their own systems in detail, and to consider the best available evidence. We will consider new information in future where it is proportionate to do so.

The pedigree score gives us a sense of the levels of uncertainty inherent in each of our assessments. This has informed the actions that we take in response to each of the risks. For example, where risks have very low pedigree scores the most appropriate actions are likely to be about improving understanding, including by recommending and supporting areas for research. We have set out the pedigree scores we have assigned to each risk in the table below.

Table 2 Pedigree scores for each risk

Risk	Pedigree
A1 Reduction in surface water resource yields in summers	3
B1 Increases in single year droughts	3
B3 Increased risk of company assets flooding	3
E2 Increased sewer flooding	3
A2 Reduction in groundwater resource yields in summers	2
A3 Increase in demand for potable water	2
B2 Increases in multi-year droughts	2
C1 More soil moisture deficit (SMD) driven leaks and bursts	2
C2 Fewer frost-driven bursts and leaks	2
C4 Increased risks of coastal flooding of company assets	2
C5 Reduced river flows require increased discharge constraints	2
D1 Increased pollution in raw water sources	2
E1 Increases in combined sewer overflow (CSO) discharges	2
F1 Increased risk of power outages	2
F2 Increased raw water demand	2
D3 Increased algal blooms	2
C6 Accelerated asset deterioration	1
C3 Increase in sewage treatment efficiency	1
D2 Increases in diseases	1
E3 Increased sewer blockages due to low flows	1
C9 Increased risk of fires	1
C8 Changes in water available for hydropower generation	1
C7 Increased odour problems	1
A4 Increased potential for surface water storage in winters	1

Significant uncertainty remains for all the climate change risks we identified, not all of which can be attributed to the inherent uncertainties associated with the climate projections. All stakeholders across the sectors need to continue to develop their understanding.

To understand fully the climate change risks to service and cost requires a detailed understanding of the relationship between weather and the system of assets and processes involved in delivering the service. More than this, those relationships need to be explored with the projections for climate change in the specific geographic regions concerned. We cannot replicate this understanding and we have not tried to. The companies must develop this understanding themselves.

2.4 Step 4 – risk screening

We removed a number of possible risks from the final assessment. The reasons for this included:

- if there is no reliable basis on which to assess the risk;
- if the risk might be affected by climate change but will be primarily driven by other factors; and
- if the risk assessment showed the risk was below our impact threshold.

2.4.1 Impact threshold

An impact threshold is the level of impact above which a materialising risk will have a noticeable effect on an organisation. This level will differ from organisation to organisation depending on its objectives. For us, the threshold above which our functions are noticeably affected is where one or more of the companies we regulate are affected by climate change in a way that has a material effect on service or cost.

Where a risk, if it materialised, could affect service or cost to the extent to which we have to make or alter regulatory decisions and establish or reappraise regulatory approaches; that risk surpasses our impact threshold. We take cost to mean primarily financial cost to existing and future customers; but also the cost to the environment, for example in greenhouse gas emissions. We take service to mean not only the reliable supply of clean water and the removal of wastewater, but also the services to society and the environment that the companies are legally required to provide. For example, sewerage companies must treat effluent adequately before it is discharged to the environment.

2.4.2 Risks which were excluded

We excluded the following risks from our assessment.

- Potential for low flows into wastewater treatment facilities disrupting their operation. We removed this risk because of the lack of any supporting evidence.
- Climate change driven demographic change – for example, where climate change directly encourages migration to the UK, increasing pressure on resources. This risk is too unpredictable and reliant on external factors to bear sensible assessment alongside other climate change risks.
- Changing agricultural patterns driven by climate change with impacts on raw water quality – for example, because of changing pesticide use. This is similar to many other risks in that it is highly reliant on external factors (such as commodity prices or technological changes), but remains too unpredictable to be assessed sensibly.
- The impact of climate change on dam risk and reservoir operation – for example, through increased siltation. Currently, we have found no evidence that climate change presents a significant additional problem in this area, but there is evidence that extreme rainfall events can cause dam failure. This is mainly because of design shortcomings and is an existing asset management issue. Design standards and asset management in this area is based on a conservative approach to risk.
- Hotter, drier conditions may lead to increased demand for water by fire fighting services, especially during long-term droughts. It is very unlikely that this will have a material impact on total demand under the range of climate scenarios investigated. The impacts of this can be integrated into the assessment of aggregate demand change rather than as a separate risk.

For many of these risks, there is no appropriate way to assess the additional climate change risk to our functions. But as time goes on and we improve our knowledge, we will continue to consider these risks. We will assess the validity of any new evidence that arises. We will also consider any suggestions that arise using the same process applied in this risk assessment.

We have taken these possibilities into account in deciding our action plan. Our plan for re-evaluating risks is set out in the main report.

We also considered the risk to company financeability. We excluded this from the full risk assessment because it is determined inherently by relatively short-term changes to regulatory decisions and economic circumstances, rather than longer-term changes in any particular climate variables. But risks associated with financeability remain a very important consideration for us, and we discuss this issue in more detail in the main report.

After screening out these risks, we then assessed the likelihood and impact of each of the remaining risks.

2.5 Step 5 – likelihood

Climate change will only have an impact in the sectors if the climate variable that drives the risk changes to such an extent that our impact threshold is surpassed. As the UKCP09 projections give a probabilistic range of possible climate impacts, we have based our assessment of likelihood on an assessment of the range of scenarios for each time period where the impact threshold may be surpassed.

Our assessment of likelihood for each risk is based on the scenarios under which the relevant climate variables for that risk change to a material extent. The UKCP09 key findings we used present changes in climate variables in terms of a range for a given probability level, rather than a value. For example "a rise of between 0 and 1^{o}C".

For each risk, we assessed the range of scenarios for that time period under which the relevant climate variables that are identified as having an effect on service or cost, change significantly. In most cases, this is the point at which some additional impacts on us in terms of necessary decisions should be seen. Many risks are driven by multiple climate variables. In these cases, we considered the scenarios under which all of these variables changed significantly and in the relevant direction.

Some changes, such as an increase in annual average temperature, are supported by almost all of the climate projections, with different projections differing only in the degree of the increase. Others have a much wider range of potential changes. For example, under the medium emissions scenario, some of the climate models predict small increases in summer rainfall by the middle of the century, which most of them predict a decrease.

We have used the ranges of UKCP09 probabilities as the basis of our scoring of the risk likelihoods. We considered each of the three emissions scenarios for the 10%, 33%, 50%, 66% and 90% probability levels for each relevant variable for the 2020s, 2050s and 2080s.

We used the categorisations presented in the table below to score the likelihood of each risk.

Table 3 Scoring system for risk likelihood

Score	Description
4	Impacts predicted even below the 10% probability level (very unlikely to be less than).
3	Impacts predicted at or above the 33%-66% probability level.
2	Impacts predicted only at or above the 90 % probability (very unlikely to be more than) or only under high emissions scenarios.
1	Impacts predicted only under high++ scenarios

It is not appropriate for us as an economic regulator to carry out a more detailed and complex analysis of the climate scenarios. This is because our precise knowledge of the types of possible failures and existing thresholds present in the water and sewerage systems is inherently incomplete. The companies have the knowledge and understanding in these areas. So, we used broad categorisations of probability based on the UKCP09 key findings. There are a number of advantages to this approach.

- It gives us an appropriate level of understanding for our decision-making on the relative likelihood of different consequences.
- It allowed for a relatively efficient assessment process.
- It allows for straightforward replication of our assessment – aiding transparency.
- Broader conclusions reduce our margin for error.
- It minimises false expectations about the levels of certainty we have.

Because our impact threshold will be exceeded in cases where one or more companies are affected, it may be passed even when only parts of England and Wales are likely to see significant climate change impacts.

In some cases, the UKCP09 projections do not give sufficient information to judge the likelihood of an impact. As an example, droughts are caused by long periods with little or no rainfall. The UKCP09 projections themselves do not give direct information about how the frequency of these dry periods is expected to change. In these cases, we have used specific supplementary work on the effects of climate change rather than relying on the UKCP09 projections themselves. Often this supplementary work is not probabilistic in its conclusions. For these, we replaced the categorisations in table 3 with the broader categorisations outlined in the table below.

Table 4 Alternative scoring system for risk likelihood

Score	Description
4	Almost certain – all or almost all projections indicate impacts will occur in the period.
3	Likely – most projections indicate impacts will occur in the period.
2	Possible – some of the projections indicate impacts may occur in the period.
1	Only the most extreme projections indicate impacts will occur in the period.

2.5.1 Relationships between impact and likelihood

In some cases, our subsequent assessment of the magnitude of impact indicated that even though some impact is likely, those impacts would be marginal. For example, the fire risk at company assets is unlikely to be substantially greater even though summers are quite likely to be drier and hotter. Where this is the case, it is reflected in a low impact score rather than the probability score.

2.6 Step 6 – impact

To assess the magnitude of the impacts for each risk we considered both the magnitude of the possible financial impacts and the impacts on service. We also considered the possible extent of environmental impact.

For financial impacts, we have generally assumed that the impact on us and our duties (especially our role to protect the interests of consumers) will be roughly proportional to the magnitude of the financial impact on a company. But it is worth reiterating here that we have assumed that external circumstances other than climate remain broadly the same. Not doing so would go beyond the scope of our assessment. For example, we have assumed there will be no dramatic change in the economics of leakage control through radical technological innovation. In these circumstances, it is unlikely that adaptation measures that require additional activity in order to maintain the same levels of service will be possible without additional cost.

In judging the nature of the impact we considered:

- the financial size and historic scale of investment in each of the relevant activities;
- regional differences in the projections;
- the nature of the service affected by each risk;
- estimates from relevant sources and academic studies; and
- indicative costs of potential solutions where possible.

Collating and discussing this information allowed us to establish a general assessment of the impact for each risk. The scale of the impact was subject to sense-checking across the organisation.

We have set out the scoring system we used for magnitude of impacts in the table below.

Table 5 Scoring system for risk impact

Score	Description
4	Some companies may fail to be able to supply clean drinking water or dispose of sewage, or may significantly damage the natural environment, even with emergency measures. Catastrophic financial impacts – that is, significant affordability/financeability issues would arise to address the impacts (>20% total annual turnover in a five-year period).
3	Some companies cannot meet serviceability/environmental standards or must carry out significantly more reactive work than planned. Service may be substantially affected. Significant capital works or increases in operational or maintenance costs may be required (>10% total annual turnover in a five-year period).
2	Marginal deterioration in service or increased reactive cost relative to business-as-usual. Non-trivial capital works or increases in operational or maintenance costs (>2% total annual turnover in a five-year period).
1	Minor impacts that do not affect day-to-day business substantially. No significant alteration in budgets or planning because of climate change is necessary (<2% total annual turnover in a five year period).
0	Trivial impacts that Ofwat is unlikely to see any noticeable effect of in cost or service terms. Impacts typically can be accommodated by existing systems and assets or with investment or additional costs well below 1% of total annual turnover in a five-year period.

We have sought to align the measures of impact with those used in our existing organisational risk assessment process. We have also considered the thresholds used in the interim determination process[3] on triviality and materiality.

The 'type' of impacts actually incurred resulting from the risk (that is, whether they are service impacts, environmental damages or additional financial costs to customers) will be hugely dependent on actions of companies in the sector. Broadly, costs could be either:

- additional costs incurred directly because of climate change; or
- additional costs incurred in order to pre-emptively deal with an expected climate change impact.

In most cases, we have made a judgement based on current understanding and circumstances about whether the costs are likely to be in terms of:

- actual harm;
- reactive costs;
- pre-emptive protective measures; or
- a mixture of these.

We have usually scored according to whichever of the two (cost to mitigate or impact of not mitigating) has the highest associated risk magnitude and so represents the greatest potential effect. For risks that involve potential additional environmental damage, we have focused on the costs of maintaining current levels of environmental impacts.

In the long term, there will be an increasing difference between the impacts of a risk depending upon whether any action has taken place to mitigate it. The impact of risk mitigation costs spread over 50-70 years may not be too severe. But if no risk mitigation was carried out before then, the potential impacts in 2060-90 could be very large. We cannot predict the extent and effectiveness of the adaptation that will actually occur. So, for longer-term risks, we have assumed that there has been little or no mitigation of the risk in the preceding periods.

[3] Our latest guidance on this subject is set out in 'RD 13/10: Interim determinations 2010-15' (October 2010) available at: http://www.ofwat.gov.uk/publications/rdletters/ltr_rd1310idok

Because we have assumed no change in external circumstances and no significant advances through technological innovation, in some key respects our assessment of impact may over-estimate the risks. In reality, we expect the sectors to take efficient, incremental action to deal with climate change risks. But we think that this is an acceptable approach to assessing risk given the nature of our duties and the importance of the services we are dealing with. Our approach allows us to identify and prioritise the key risks.

It is important to reiterate that because of the nature of our assessment, the sum of these magnitudes will not represent the total potential impact to the sectors as a whole. Most of the risks have significant regional variations. Because of this, a risk that has a high impact in one region of the country may have less or no discernible impact elsewhere.

We multiplied the likelihood and impact scores together to calculate a gross risk. We have used this as a preliminary indication of priority – in determining adaptation responses we have considered the impact, pedigree and probability of each risk rather than the gross score alone.

2.7 Step 7 – external interactions

Climate change is not the only risk faced by the sectors. There are a number of other short- and long-term risks that will affect the sectors and our ability to fulfil our functions. A good example is demographic change. We and the companies are already aware of many of these risks and most are incorporated into planning.

In order to meet the requirements of the guidance, in assessing risk we have focused on the **additional** risks that climate change presents. In many areas, this has been difficult because the effect of climate change is to exacerbate weather-related risks that already exist (such as the risk of droughts and extreme precipitation events).

Other circumstances will also change in the future. These add even greater uncertainty to our assessment. As an example, we do not know the extent to which population growth will increase the demand for water in different areas. Population projections themselves are highly uncertain and we do not know how effective demand management actions will be. The structure of the sectors and expectations of service might also change.

In assessing the risks from each climate variable, we have assumed little or no change in these key interactions. For example, we have assumed that increased costs to deliver the service are ultimately passed on to customers in some way and that planning objectives are to maintain service at current levels. We recognise that future reforms and changes could affect the validity of this assessment.

For each risk, we have set out the key interactions that might affect it. Consideration of these key interactions features in our monitoring plan, which is set out in the main report. So, the assessments of climate change risk need to be set alongside comparable assessments of different risks that also impact on our decision-making. We recognise that in some areas, climate change is not the biggest risk to our functions.

2.8 Step 8 – early warning indicators

For each risk we also set out a number of early warning indicators that we can use to re-evaluate our risk assessment in the future. These indicators comprise both monitoring actions that we can carry out and the results of work that external groups have carried out. These early warning indicators form a part of our monitoring plan.

2.9 Step 9 – quality assurance

In order to ensure our assessment of risks was robust, we carried out each one separately, twice (although the second assessor had sight of the previous assessment). The assessors then discussed the differences between assessment scores, and further investigation was carried out if needed. We then consulted internally on the full assessments made for each risk.. In particular, we made sure that individuals from the most relevant policy area considered each risk. We discussed any issues and questions before reaching our conclusions. By the end of the assessment, the assessors and other teams had reached a full agreement.

We reinforced this at an internal seminar for Ofwat staff. Here, we presented our conclusions to the whole organisation. We also made the assessment freely available on our intranet. Executive team had sight of the risk assessment at an early stage. This process served two purposes. We used it as a method of improving the accuracy and robustness of the risk assessment, and to raise awareness of the climate change risks across the organisation. We subjected our processes to internal audit. Following submission of the companies' reports, we also sense checked the conclusions of our assessment with the companies' own adaptation reports.

2.10 Step 10 – conclusions

The final step was to present our conclusions and then prioritise the risks. We discuss our risk assessment in more detail in the following chapter.

We have plotted the climate change risks into three matrices, one for each time period, using the impact and probability scores assigned to each risk. The higher a score, the more serious its impact and the more likely it is to occur.

The completed risk matrices are given in figures 4, 5 and 6 below. We have colour-coded the risks by category. We have also highlighted areas of the grid in accordance with our prioritisation of the risks into high, medium and minor risks.

Figure 4 Climate change risks 2010-40

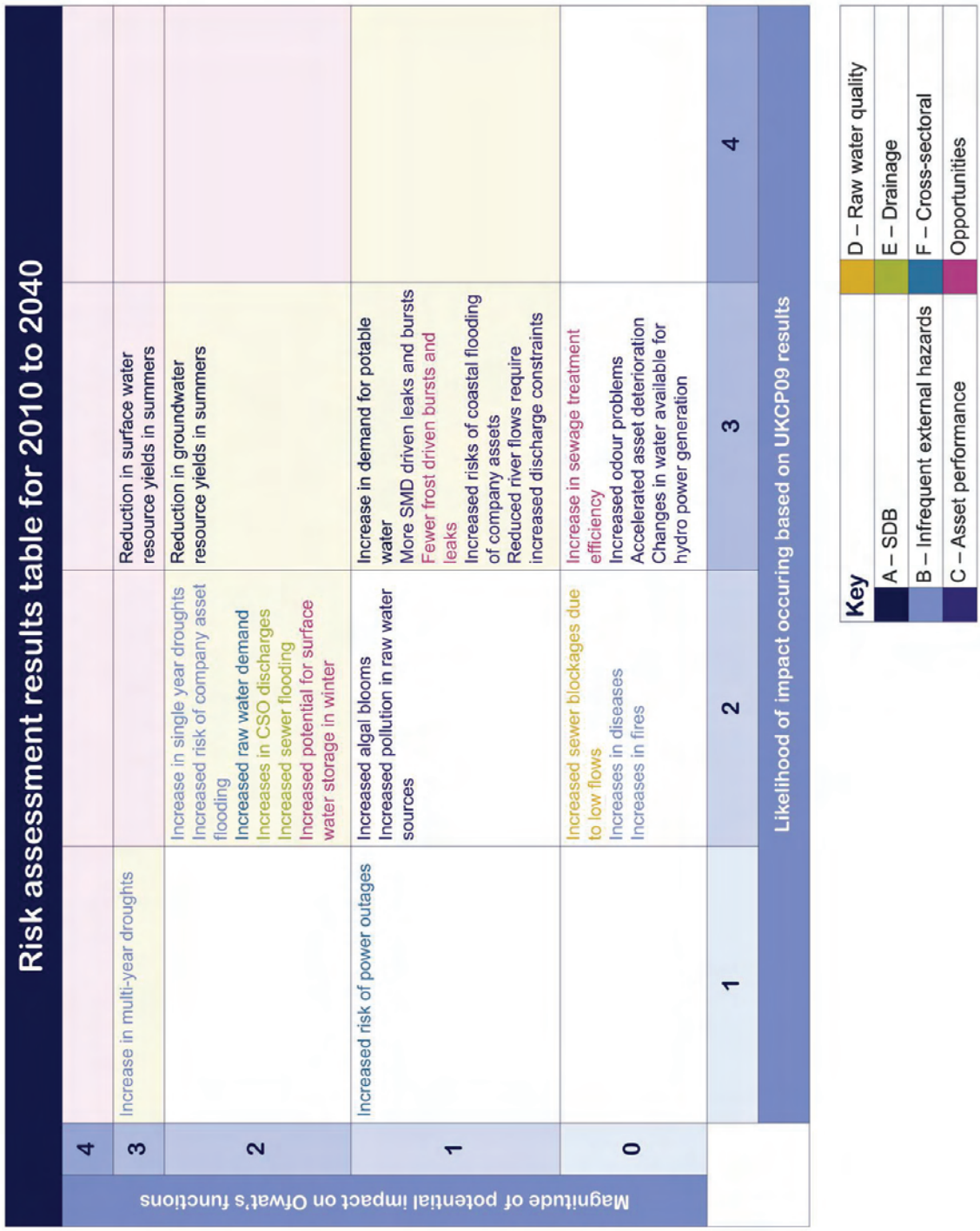
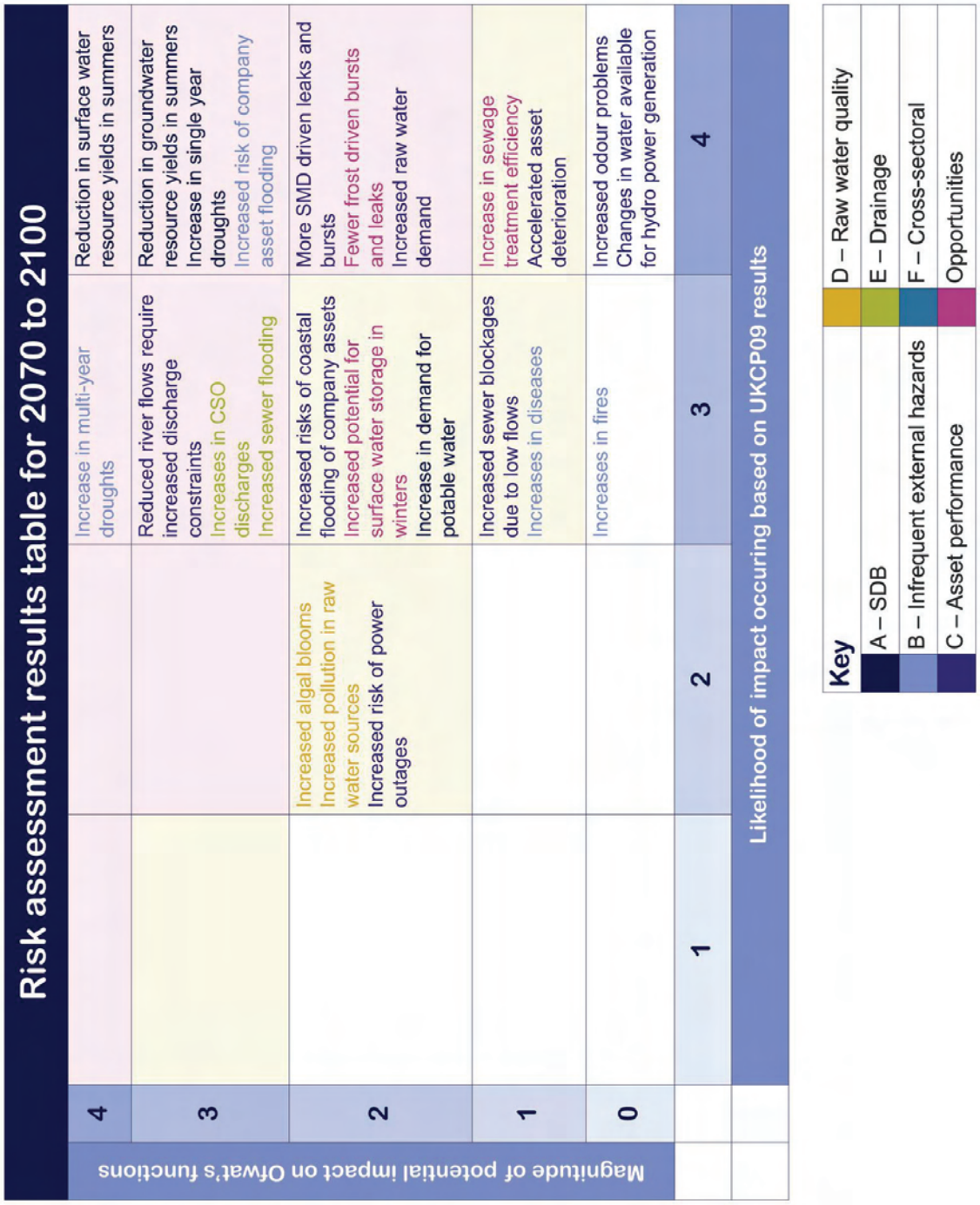


Figure 5 Climate change risks 2040-70

Figure 6 Climate change risks 2070-2100



2.11 Residual risks

The assessments presented above represent the gross, additional climate change risks to the successful achievement of our functions. As such, it does not present a picture of 'residual risk' remaining after existing and future regulatory actions are taken into account. In practical terms, we make a judgement on residual risk at each price review. At each review, we consider all the risks the companies face and arrive at price limits that reflect the level of residual risk we believe is appropriate over the price limit period.

At this point, we have judged the residual risks in a qualitative way as part of our process to establish our adaptation action plan. We did not calculate the residual risks on the same basis as the gross risks because we have no reliable assessment of how effective our future regulation and the companies' plans will be in mitigating each of those risks. This is mainly because of the long timescales and the fact that climate change is just one of the risks that the sectors face. We set out our current qualitative assessment of residual risks in our summary of actions in the main report. We will update our understanding as information improves and circumstances change.

2.12 Corporate risk assessment process

Organisational risks are those that are driven partly or in whole by the actions of other stakeholders, and that may affect our work within the next five years. Many of these risks arise from the response of other organisations to climate change impacts and their perceptions of risk. Neither the likelihood nor the magnitude of these risks can be assessed in the same way as the longer-term indirect climate change risks.

We have also assessed our organisational risks using our existing corporate risk assessment process. This process is designed to assess these types of risks and is applied to other, similar risks we face. Tables 6 and 7 below present the scoring system we used to assess organisational risks.

Table 6 Scoring system for organisational risk likelihood

Likelihood	
Likelihood	**Criteria**
High 4	Almost certain (the risk is likely to occur this year or at frequent intervals).
Medium 3	Likely (the risk is likely to occur more than once in the next three years).
Low 2	Possible (the risk may occur in the next three years).
Very low 1	Rare (the risk may occur in exceptional circumstances).

Table 7 Scoring system for organisational risk impact

Impact	
Magnitude	**Criteria**
High 4	Huge financial concern; death; key deadlines missed; very serious legal concerns (for example, high risk of successful legal challenge, with substantial implications for Ofwat); major environmental impact; loss of public confidence.
Medium 3	Major financial concern; significant public health effects; outputs cancelled or delayed; potentially serious legal implications (for example, risk of successful legal challenge); significant environmental impact; longer-term damage to reputation.
Low 2	Medium financial concern; minor or reversible health effects; reprioritising of outputs required; minor legal concerns raised; minor impact on the environment; short-term reputation damage.
Very low 1	Low financial concern; no public health effects; service delivery unaffected; no legal implications; unlikely to affect the environment; unlikely to damage reputation.

We completed an assessment of organisational risks based predominantly on internal consultation. In some cases, our assessment is quite robust, based on our understanding of stakeholders' attitudes and timescales. But in others our assessment is necessarily quite speculative. The risks we identified in this process have informed our corporate risk management and are included in our internal risk register.

3. Detailed assessment of each risk (zoom for detail; not printable)

									2010-40			2040-70			2070-2100					
High level risk area	Code	Climate variable	Specific effect of variable	Impacts on water companies	Possible consequences for Ofwat	Likely future threats/opportunities	Key Information used in assessment	Pedigree	Likelihood of impact	Magnitude of consequence	Gross Risk	Likelihood of impact	Magnitude of consequence	Gross Risk	Likelihood of impact	Magnitude of consequence	Gross Risk	Early warning indicator(s)	Consequence entails regulatory policy decision?	Key interactions
MANAGING THE SUPPLY/DEMAND BALANCE	A1	Increased annual temperatures Changing precipitation patterns. Rise in potential evapotranspiration which follows from a temperature rise.	Impacts on surface water resources (rivers and reservoirs). Reduced yield, particularly in summer. Impacts on the environment drive action from companies and regulators. Focus on incremental effects here rather than the changing risk of drought frequencies (explored as a seperate risk).	Reduced WAFU threatens supply/demand balance. Decreased security of supply and erosion of existing headroom - making service more vulnerable. Increasing risks of necessary supply restrictions or even service failures. System solutions necessary - drive changing opex costs (e.g. for increased abstraction) and/or capital solutions (e.g. to develop new water resources). Increases risk of breaching existing environmental limits; also may prompt more stringent limits in future. [2/3 of supply from these sources, lesser proportion in the south-east, can identify the companies most vulnerable from this risk]	Companies progressively fail to meet security of supply targets and outputs. Customers see more restrictions and/or interruptions. Damage to the environment from over-abstraction. **Companies propose significant additional activity to increase headroom or reduce risk of SD deficit.** **Necessitates policy decisions - including on how best to incentivise companies to deal with the problem and how to balance the service risks and costs between company and customers. Many of these are existing challenges.** Political and public pressure (e.g. on the environmental damage of over abstraction or arising from supply restrictions). Note primary responsibility for managing national water resources sits with EA.	Predominantly threat May provide more impetus for greater water efficiency (with multiple other benefits including for cc mitigation)	Many sources: 401, 304, 303, 105, 106, 402, 403, 206, 107, 110, 411, 309, 311, 323, 123, 316, 315, 135 FBP information, supplementary information from companies. Existing SOS information.	3	3 towards the end of this time frame it is highly likely to have an impact such that some of the identified consequences are seen for one or more companies. It may be difficult to separate climate change driven impacts from other pressures and changes to supply and/or demand.	3 Judging from provisional projections made by several companies on the possible extent of work necessary and the number/size of companies affected. Costs could manaifest in various measures e.g. more leakage control, more resources, more metering. The costs to develop resources would be very high in some regions and leakage control costs diverge from linear.	9	4 All projections show some impact on rainfall and temperature in this period during summers.	3 Assuming existing capital and operating costs to maintain supply demand balance, cope with growth and manage leakage remain stable cost will be expected to increase, particularly where forecasts indicate demand exceeding supply without additional pre-emptive measures. There is also a possibility of costs increasing non-linearly where solution options are more constrained, for example if absolute environmental limits become more stringent.	12	4	4 Additional impact by this period if there is no incremental adaptation in preceding periods could be very high.	16	Company SDB issues arising and service levels (tracked at least annually). Water resource management plans. Companies flag concerns in Business Plans and ad-hoc. Tracking of numbers of events such as drought orders. Monitoring of weather data, hydrological summaries and longer-term trends.	Likely.	Interacts with other SDB risks. Existing 'over-abstraction' and 'over-licencing' already presents a problem. Primarily interacts with drought risks - actions to manage aggregate SDB are with reference to dry year and security of supply targets. Population change (growth and movement) and demand fluctuation. Success and economics of solutions - particularly the economics of leakage reduction and demand management. EA's approach to water resources - e.g. licence changes, actions on WRMPs. Any EA abstraction constraints (e.g. sustainability reductions as part of the Restoring Sustainable Abstraction project). Changes in raw water quality or quality standards also affects supply availability and cost. Increased surface water abstraction will have some impact on river water quality also.
	A2	Increased annual temperatures Changing precipitation patterns. Rise in potential evapotranspiration which follows from a temperature rise. Sea level rise	Impacts on groundwater resources; shortened recharge periods and increased potential for saline intrusion reduces total yields. Focus on incremental effects here rather than drought frequencies (explored as separate risk).	All the above risks. 1/3 of supply from these sources. (and a larger proportion in south east, most small WOCs in SE rely on groundwater predominantly)			322, 419, 402, 403, 405, 414, 417 FBP information, supplementary information from companies. Existing Security of supply information.	2	3 As above UKCP09 scenarios and available evidence suggest that some impacts in this area are likely.	2 This is assigned a lower score than impact for surface water resources due to the relatively less marked impacts of weather on groundwater resources. Impact is on recharge. Increased saline intrusion risk in the medium term is expected to be low.	6	3	3 Available research suggests groundwater impacts could be significant from 2050s to the end of the century. This would significantly affect some companies.	9	4	3 Under 'high' emission scenario, modelling predicts reductions in groundwater recharge of up to 7-40% depending on the region (322).	12	As above, also: Quality indicators have some bearing. Potential for tipping points from saline intrusion into some groundwater sources. Others such as estuary sources will be able to monitor a gradual change to brackish water.	As above	
	A4	Changing precipitation patterns. Wetter winters and possibility of wetter autumns. Greater frequency of extreme rainfall events.	Changing precipitation patterns increase potential and priority of storage.	Systems alterations to store more water in winter to deal with drier summers. Changes are required to cope with extreme events in winter whilst storing for drier summers.	Possible investment cases e.g. for increased storage capacity or network alterations.	Presents an opportunity to offset negative impacts to the SDB but at a cost.	NCCRA, 315	1 Logical. Recognised by some sources but little research directly on this.	2 Some increase in winter mean is forecast but this could also be negative.	2 not in itself a significant danger to service and can be seen as an opportunity, but could drive investment proposals and necessitate decisions.	4	3 Likely increase in mean precip in winter by 2050s but could be a marginal change.	2	6	3 Highly likely by 2080s but could still be marginal change.	2 Increases in winter rainfall of 10 to 30% are predicted across most of the UK. This represents a significant increase in the amount of water that could be stored during winters without adversely impacting the environment.	6	Company plans and business cases.	Possibly	Interacts with nature of other SDB problems and viability of solutions as above. Not possible in some regions. Increased temperatures increase the rates of evaporation from uncovered surface water storage systems Increased winter storage may have additional benefits to downstream flooding control. Storage of water to release in summers helps to address some environmental problems and increases the potential for dilution of pollutants by rivers
	A3	Increased annual temperatures. Increased summer peak temperatures. Reduced precipitation in summer	Impacts on patterns of demand for PWS from water customers (domestic and non-domestic). Primarily the expectation is that demand will increase due to temperature increases and reduced precipitation in summer. Industries most important are soft drinks and breweries. Drier, hotter conditions will likely lead to increases in water required for fire fighting activities.	Increases to demand threaten the supply/demand balance, particularly at peaks. Environmental pressure from increased abstraction.	Threatens achievement of primary and secondary duties. Necessary activity on SDB to be looked at/funded. More pro-active demand management necessary. Policy decisions to make on how to handle demand rise and particularly peaks - e.g. through tariffs. Political and public pressure. May offset the benefits of demand reduction programmes. More difficult to meet target of reducing household consumption to 130 l per day.	Predominantly a threat	105, **305**, 206, 110, 211 WRMPs; BPs; JR Data	2 Many sources conclude the general relationship will occur but future attitudes/usage and demand is highly unpredictable.	3 Some increase is likely since some level of temperature increases are predicted under all scenarios by 2020s.	1 Roughly calculated to have up to 2-3% increase in demand by this period. This is assigned a lower score because the effects of climate changes are strongly outweighed by the effects of population change and variation. Also offset to some extent by increasing efficiency in the non-domestic sectors and the existing drive to reduce demand through more metering and other means. Fire fighting represents arounds 1% of demand for potable water in a typical year. Increased fire fighting demand is unlikely to have a significant impact on total demand.	3	3	2 Impacts by 2050s are higher but the effects of mitigating measures and social/demographic changes by this time make this impact highly uncertain. Upper limits of the estimates indicate a 5% increase in demand due to climate.	6	3	2	6	SDB issues arising (tracked annually through JR Table 10 particularly). WRMPs Companies flag concerns in BPs and ad-hoc. Research activity - e.g. by waterwise.	Unlikely in isolation - demand fluctuates anyway and for other reasons.	Vital interaction with other pressures on SDB. Demand changes are broadly assessed as of less importance from CC perspective but without dealing with all the SDB issues any increase in demand could cause significant impacts. Most sources recognise key demand drivers are population and behavioural change rather than climate change driven. Incidental adaptation is likely to be most important to manage this risk. Demand also driven by changing technology trends and will be affected by trends in the replacement of housing.
INFREQUENT EXTERNAL HAZARDS	B1	Changing precipitation patterns. Increases in average temperature	Increased severity and frequency of single-year hydrological droughts (above and beyond the problems of maintaining average year balance of supply and demand, coping with incremental climate change).	CC exacerbates existing drought risk. Impacts companies' ability to maintain balance of supply and demand during a drought. Higher frequency of supply restrictions, planned and unplanned. Short term emergency measures are necessary and/or long-term planning and investment is necessary to mitigate the risk. Environmental damage resulting from maintaining the public supply during droughts.	Threatens service. Prospect of increased drought frequency necessitates emergency planning and headroom building or increase in risks of supply interruptions for consumers. Decisions to make about acceptability of risk and companies' approaches and proposals. Criticism in the event/necessary reactions. Note direct role for us during drought events is relatively minor.	Threat	401, 301, 302, 104, 110, 105, 405, 127, 314, 316, 128, **326**	3	2 Drought risk already exists and it is not clear that climate change will materially drives this up within the next 20 year period. Note some models (314) predict a decrease in drought risk in some areas (N).	2 Service disruption and additional cost of droughts can be substantial but it's not clear we will see any more of these due to CC in the short term. Increasing risk of drought in the medium term is likely to drive some pro-active measures. Combines with the risk of additional demand. Increases in forefighting should not materially impact demand even during droughts.	4	3 There is likely to be some increase in single-year hydrological drought frequency by 2050s considering the precipitation decreases at and above the 33% probability level and models for 3-12 month droughts. More certainty for SE than other regions.	3	9	4	3	12	Drought orders and supply restrictions. Weather forecasting and hydrological summaries.	Possible - few significant decisions are required from us *during* a drought.	risk determined by sdb situation and system resilience. Increases in drinking water demand from households, non-household water customers and from other users of raw water will increase the severity of drought impacts on supply security.
	B2	Changing precipitation patterns. Increases in average temperature	More frequent severe hydrological droughts (droughts lasting over 12 months).	As above but with longer-lasting and more serious consequences.	As above; Threatens service over a long period.	Threat Some models predict that multi-seasonal droughts will reduce in frequency, which would represent an opportunity rather than a threat	As above	2 A problem lies in the fact that we don't understand low-frequency variability. Best estimates indicate a range of possible situations ranging from no change in frequency to 1/100->1/10 projections by 2100. Some older sources predict a reduction in frequency	1 No clear certainty on multi-year drought frequencies (particularly ahead of 2050s). Rarity makes these difficult to predict in any case. There already is the existing possibility of severe drought - CC is unlikely to be an additional change above the current probability in this period. Some sources predict multi-year events become less severe by the middle of the century (due to progressively wetter winters) but this is by no means certain.	3 Multi-season drought has potential to disrupt service substantially and/or require very significant mitigation measures such as developing new water resources. Particularly two consecutive dry winters - this significantly impacts ground and surface water resources. Costs will escalate with the length of the drought.	3	2 No clear certainty on drought frequencies and not an output of UKCP09. Rarity makes these difficult to predict in any case. More existing models than not project more frequent droughts by 2050s but this is not to be taken as probabilistic.	4	8	3 More likely than not (judging from spread of model results considered to be of equal probability) that multi-year drought frequency is higher by end of the century.	4	12	Single-year droughts and forecasts indicate these continue.		
	B3	Precipitation patterns - specifically more high intensity rainfall events. Heavy winter rainfall events are projected to become more frequent than currently. Impact on summer rainfall events however remains a large area of uncertainty.	Flooding of water company assets.	Flooding of company assets or other disruption (such as flooding of crucial suppliers or transport links that threaten the operation of company assets) which creates risks to supply. (note we cover the risks associated with drainage and sewer flooding separately).	Incidents of supply disruption for consumers increase. Quality threats. Potential (but empirically minimal) impacts on the environment of sewage works failure. Companies increasingly bear repair, remediation and cleanup costs. Companies propose capital solutions to reduce risk. (asset and network resilience) Criticism and political pressure on the sectors. Potential for excessive de-risking at customer expense. Serviceability issues.	Threat	324, 209, 104, 103, 202, 101, 110, 406, 119, 316, 323, 134 MO return periods project for Ofwat	3 Strongly recognised by most as a current and future risk. Credible investigations into how return periods may change do exist (applying a range of scenarios including UKCP09). But fundamental uncertainties around climate impacts on extreme weather events remains. Many companies have undertaken flood risk screening of their assets already - we have some of this information.	2 There is likely to be some change in the likelihood of extreme events due to climate change, but in this period the changes are unlikely to be noticeably 'additional' above the current levels of variation.	2 Projections for changes in flows of the same return periods are up to 5% for 2020s. 55% of company assets are in natural flood plains (obvious reasons). Indications are that expenditure on resilience solutions may remain significant within this period but note this investment and/or damage costs are unlikely to be entirely climate change driven. Political impetus has kept this on the agenda. Therefore assessed as material but not significant.	4	3 Likely in most of the scenarios.	3 Likely impacts on service without mitigating measures in the interim could be signficant. From the 2050s, the extent of climate change may begin to exceed current precautionary planning assumptions. We can assume that resilience activity and incorporation of consideration of flooding into asset management will work to mitigate the impact (in terms of necessary work and costs and service impacts) in the long term. However this is highly uncertain because it is difficult to ascertain the efficacy of resilience investment	9	4 Central estimates are for heavy rain days (rainfall greater than 25 mm) over most of the lowland UK to increase by a factor of between 2 and 3.5 in winter, and 1 to 2 in summer by the 2080s under the medium emissions scenario. Best estimates show even precautionary planning assumptions are exceeded from this period.	3	12	Company risk assessments (business plans and elsewhere). Warnings. Actual impacts of extreme events on service.	Yes - on approach to resilience, balance of risk and investment cases. Move towards looking at resilience of networks as opposed to individual assets.	Primarily with existing flood risk. Decisions about defences and response (e.g. EA flood defence budgets) Policy decisions (from us and others e.g. the EA/Cabinet office) on resilience approaches (absolute standards, precautionary planning approaches etc).

Detailed assessment of each risk continued (zoom for detail; not printable)

ASSET PERFORMANCE	C9	Increases in average annual temperature Changing precipitation patterns.	Reduced rainfall and increased temperatures increase fire risks.	Harm and costs to consumers where emerging threats are not identified and dealt with by companies. Increased threat of fires to company assets, (but note in most cases companies have robustly reduced fire threat).	Fires temporarily interrupt water company services or uncontrolled fires require partial/total rebuild of company asset.	Threat	No research on this. Some risk assessments by e.g. local authorities and fire services.	1	2 Small increases in temperature are highly unlikely to have a material affect above the current impacts in either case. Large natural variability in these threats will mean small average increases will be lost in the 'noise' of yearly change.	0 Fires are an existing threat that companies are prepared for under the current climate. There are currently few major incidents and costs of these incidents are a small fraction of cost. Countries with comparable climates for possible futures manage without everything catching on fire all the time. Largest risk may be secondary fire risk in some areas (e.g. grasslands).	0	3	0	0	3	0 Increased temperatures will still be well below those faced in comparable European countries under the current climate. Their clear ability to withstand the additional risks of fires and disease imply the UK should manage.	0	Increases in health and safety incidents. increases operating costs for companies (e.g. for insurance).	None	Climate is only one element of these risks. Increased digestion and use of bio-gas and increased use of advanced treatment such as ozone from pure O_2 driven by quality requirements will affect the potential for fires and explosions at assets.
	C1	Changing precipitation patterns. Increase in average annual temperature and increase in summer temperatures. - Affects SMD.	Reduction in soil moisture levels in summer and increases in winter. More soil movement.	Distribution system impacts - more bursts and leaks	Increased levels of company service failures Exacerbates any existing and future climate change pressures on balance of supply and demand in all regions. May affect leakage targets and business case assumptions. Changes the targetting patterns and affects optimal level of leakage control. May affect the validity and cost of maintenance assumptions (e.g. on pipe materials). Companies will need to understand effects when looking at infrastructure renewal and construction.	Threat	410, 107, company information	2	3 Not seen under 'wet' scenario	1 Magnitude is not well understood according to EA. Systems are already well in place to deal with bursts & leaks. Impact changes depending on soil type - SE more vulnerable where movement is already more of a problem.	3	3	2 Estimates from expert opinion put the potential impact of SMD on bursts/leakage at around 20-50% which impacts SDB and mains replacement strategies	6	4	2	8	Changes in historic trends in leakage expenditure and achieving leakage targets Reductions in summer rainfall volumes	CM implications. Affects optimal leakage and may affect targets.	Location. Less frost days decrease leakage while increased soil moisture extremes increases it. Overall balance of supply and demand Company pipe replacement strategies - The impacts will be different depending upon materials and location. Surface cracking can also increase the amount of pollutants entering groundwater sources.
	C2	Increased annual temperatures.	Fewer frost days	Distribution system impacts - less bursts and leaks. Note: many of the significant unplanned supply interruptions >12 hours over the last few years have been due to frost-related bursts in winters. Impact in 09-10, 10-11 winters suggests companies are able to cope but service and supply can be impacted; particularly where vulnerable supply pipes are affected.	Fewer service failures (DG3/DG2) due to frost impacts. Reduction in company leakage Impacts context for decisions on leakage management spending by companies and on supply demand balance issues.	Opportunity	410, 420, weather data, DG data back to 90s	2	3 Minimum temperature increases in all scenarios. Company specific study sees reductions in frost days under all climate change scenarios	1 UKWIR modeling of bursts approximately predicts a 10% reduction in total bursts if all frost days are eliminated and in the absence of other changes. In this time period frost day reductions will be much smaller than this.	3	3	1 Frost days have reduced over the last 40 years. Continuing this trend will give around a halving of frost days during this period - Rough macro-estimates indicate this could lead to a material decrease in bursts/leaks (particularly on vulnerable supply pipes) with no other external changes.	3	4	2 broad estimates from recent data indicate average number of frost days could be reduced by 2/3 meaning a material reduction.	8	Changes in historic trends in leakage expenditure and service targets. Reductions in the numbers of days of sub-zero temperatures.	CM implications. Re-assessment of approaches to leakage and supply.	Location. Less frost days decrease leakage while increased soil moisture extremes increases it. Overall balance of supply and demand Company pipe replacement strategies - The impacts will be different depending upon materials and location.
	C3	Increases in average temperature	Affects the operation and efficiency of treatment processes which are temperature sensitive [e.g biological filtration, ion exchange, AD] and water stability.	Impacts treatment process operation and cost and design. Predominantly the impact of temperature rise is positive (i.e. will tend to increase efficiency of existing process).	Potential savings windfalls for companies. Impact may figure in long term business planning.	Opportunity: Reduced company expenditure on treatment.	404, 118 literature on treatment processes	1 No specific study of the climate change impacts is known but biological and chemical reaction rates increasing with temp is well understood.	3 Temperature increases are found under all scenarios although the difference at 2020 is likely to be minimal	0 Water and sewage treatment account for about a quarter of all annual expenditure, but there is no clear indication that temperature will affect this cost above or below the current in the short term. Likely to be in the noise in terms of impact for us.	0	4 Material mean temperature rise by 2050s is highly likely.	1 In the longer term we may see some impact on operation and cost in longer-term trends.	4	4	1	4	This should be a continuous increase with no particular tipping points or jumps to indicate the effect is beginning.	On whether this is a company efficiency - how should any savings resulting be passed on to customers?	Highly dependent on external factors. Other impacts on water treatment costs and processes are likely to affect or offset the extent of this saving.
	C7	Increases in average temperature	Temperature impacts upon sewage treatment processes - increased rate of biological processes	Odour problems Increased pests such as flies	Customer complaints and other pressure (e.g. from MPs) Increased odour control spend in business plans Companies have more difficulties getting planning permission for new treatment facilities	Threat: To consumer satisfaction and may impact bills.	None	0 Issue has been suggested from several sources and general effect of temperature on odour is understood, but no study of potential changes with climate change are known.	3 Temperature increases are found under all scenarios although the difference at 2020 is minimal	0 Odour complaints are a tiny fraction of customer complaints and are very localised. Solutions exist and recent price reviews have included ongoing work to solve existing problems. Yearly expenditure on odour control is currently around £25m across the sector. Additional cost on top of this due to climate change is assessed as very low.	0	4 The climate driver (temp) will certainly increase, although whether this will cause a noticable impact on odour is unknown	0	0	4	0	0	Volume of odour related compalints. Business cases for odour control.	No	Odour control issues relate to people's willingness to pay to address them, hence the state of the economy is likely to influence customers demand for odour reduction Demographic change may increase the number of odour control projects
	C6	Changing precipitation patterns. Increases in average temperature	Higher temps increase asset deterioration (affecting life of plant) Reduced rainfall drives increase in buildup of H_2S and sediments in sewers and pumps. Reduced extemes in cold weather could reduce asset deterioration (e.g. of electronics).	Increased asset deterioration. Requires appropriate asset management responses.	Increased rate of asset replacement may impact both future business plans and require re-assessment of existing asset management strategies	Threat: Increased asset failure Opportunity: Some asset lives may increase (e.g. due to reduction in frost days)	109, 404	0 Issue has been suggested from several sources, but few studies of CC impacts on maintenance regimes exist.	3 Temperature increases are found under all scenarios although the difference at 2020 is minimal.	0 Reductions in asset lifetimes have a potential to increase costs on companies, and increase service failures if impacts are not forseen. Increases in temperature in this period are low so impacts on asset lifetimes are not expected to be significant. Given uncertainty this is unlikely to be a significant driver in maintenance regimes.	0	3	1 Warmer countries can deal with this issue without incurring large additional costs , but there is a potential for some additional costs over the medium-term, especially as assets have life-times up to 100 years.	3	4	1	4	Serviceability monitoring. Drivers in capital maintenance. Comparison to water industry asset lifetimes and replacement strategies in countries with higher average temps than the UK could be undertaken now and should give an indication of the severity of this impact	Possibly - If impacts on asset management are significant.	Other maintenance drivers are by far more important (e.g. fundamental breaking points) Changes in rainfall and water demand may also have some impact on asset deterioration as assets come under increasing or decreasing useage
	C4	Sea level rise Changing precipitation patterns Changes in wind patterns	Coastal changes: Sea level rise, changes in storm surges, changes in coastal errosion patterns etc.	Increased risks to water sector infrastructure near the coast.	Service failures and complaints where impacts are in terms of low-frequency events (such as flooding). Risk to assets due to coastal errosion may require urgent action and investment to reduce. Assets may require relocation (at a cost). Companies may include increased erosion and potential for storm surges as reasons to replace infrastructure before the end of its operational life as a resiliance measure as erosion conditions change.	Threat: Service failures and reputational consequences could result. Necessity for increased cost to solve/prevent (e.g. non-optimal replacement or relocation).	109, 408	2 UKWIR study indicates increases in the threats from storm surges. The CCRA water sector pilot rank the pedegree as 3 out of 4	3 UKCP09 predicts some rise in sea levels under all climate change scenarios. Climate change impacts on wind speeds and storms are not understood sufficiently in UKCP09 to determine their impacts	1 Most water industry assets are away from the coast although there are around 1,100 outflow pipes and several sewage treatment works at some potential risk of coastal flooding or erosion. Coastal erosion and flooding is already an issue, climate change will add to this existing risk. Also some sources flag boreholes as at risk of saline intrusion - substantive evidence that this is a very material problem is lacking though.	3	3 UKCP09 predicts rises in sea levels under all climate change scenarios. Climate change impacts on wind speeds and storms are not understood sufficiently in UKCP09 to determine their impacts	1	3	3 UKCP09 predicts rises in sea levels under all climate change scenarios. Climate change impacts on wind speeds and storms are not understood sufficiently in UKCP09 to determine their impacts	2 Impacts more severe by this period.	6	EA consultations on flood defence policies will give warnings of potential changes in coastal defense strategies. EA coastal flooding maps	No	The EA currently determine coastal defense policies. They may decide to abandon some defenses that protect water company assets for various economic, social and environmental reasons. Links with risk to effectual drainage, particularly CSOs on the sea. If the customers that are served by coastal assets are forced to relocate, destroyed assets may not require replacement.
	C8	Precipitation and temperature	Reduced flows available for hydropower generation in summer. Increased in winter.	Changing patterns of hydro-power outputs	Impacts on opex efficiency and viability of hydro schemes. Impacts to energy generation outputs.	threat/opportunity	Company information.	1	3	0 Hydro is only a very small proportion of energy generation. Costs associated are low and companies are expected to deal with this in operational.	0 Likely to see some effects but low impact for us.	3	0	0 Likely to see some effects but low impact for us.	4	0	0	Reports in JR GHG reporting.	Unlikely - unless its on the viability of hydro as regulated business (since it affects risk balance).	Extent to which companies prioritise hydro options. Carbon mitigation policies and the strength of incentives. Demand level, population increase and volume of run-off entering sewers may impact the number of high volume-low head hydro generators at WWTW outflows.
	C5	Increases in average temperature, Changing precipitation patterns (particularly drier summers)	Reduced flow in rivers reduces ability to dilute pollution	Increased levels of Ww treatment required and/or increased number of pollution incidents	Companies wastewater treatment costs increase as the discharge constraints become higher. Increased failures of environmental standards have reputational impact on Ofwat	Threat.	121, 105, 408, 321	2 Reduced river flows is a widely accepted impact of reduced rainfall with consequent impacts on pollution levels. Impact of this on required effluent treatment is not as well understood, but it is expected to increase.	3 Likely to see some impact on river flows in summer by 2020s.	1 The actual reduction in precipitation is low in this time period and it is unclear what the impact of this on river flows ability to cope with pollution would be.	3	3	2/3 EA predicts drops in summer flows of up to 80% in some areas and the combined water and sewage treatment is 23% of industry turnover. Environmental protection could be a big driver for spend on this issue if a demonstrable problem materialises.	6 / 9	3	3 EA predicts drops in summer flows of up to 80% and the combined water and sewage treatment is 23% of industry turnover	9	EA water resource information is expected to monitor trends in river flows. Changes in the numbers of environmental consent failures Increases in industry expenditure on treatment above expected levels	Ofwat may need to be involved in policy decisions with the EA/Defra on discharge consents, catchment management and abstraction policies to cope with this risk	Decreases in raw water quality from changes in micro-bilology, run-off from agriculture and urban areas. Reliant on compliance limits and whether these alter to include some climate change assumption. Changes in levels of abstraction due to changing demand (population and agriculture changes) UK and EU drivers to improve water quality

Detailed assessment of each risk continued (zoom for detail; not printable)

RAW WATER QUALITY	D3	Increases in average temperature Changing precipitation patterns Sea level rise	Direct ecological changes significantly alter raw water quality - e.g. Increased algal blooms.	Increased raw water treatment required. Primarily affects surface water resources. Increased algal blooms may increase threats of pumps being blocked	Companies ask for money (capital or operational) to increase raw water treatment processes to deal with reduction in raw water quality. Potential for drinking water quality issues which hold a reputational impact on Ofwat or require a reactive policy response.	Threat: 1) Increased costs for consumers. 2) Increased industry GHG emissions from increased treatment. 3) Potential impact on drinking water quality	121, 309, **320**, 321	2 Several studies have been carried out The general conclusion is that temperature rises and reduced flow rates will promote algal blooms	2 Blooms are seen to increase with temperature and reduced flows, but when this begins to have a noticed impact on companies is unknown	1 Water treatment is around 8% of industry spend. This is one of many existing water quality issues that has moderate to little predicted increase in the short term	1	2 Blooms are seen to increase with temperature, but when this begins to have a noticed impact on companies is unknown	1 Water treatment is around 8% of industry spend. This is one of many existing water quality issues that has moderate to little predicted increase in the short term	2	2 Blooms are seen to increase with temperature, but when this begins to have a noticed impact on companies is unknown	2 Water treatment is around 8% of industry spend. This is one of many existing water quality issues that has moderate predicted increase in the long term as total blooms are ultimately limited to nutient levels	4	DWI or Companies raise as an issue.	Potentially yes. Primarily relating to catchment management and funding routes and validity of various quality drivers and schemes.	Algal blooms depend upon levels of N & P in watercourses which means runoff will influence this risk as will the EA response to the WFD limits Residence time is the other influence on this risk which has some dependence on abstraction
	D2	Increases in average annual temperature Changing precipitation patterns. Reduction in frost days (rising average minimum temperatures in winter)	Increased biological activity increases prevalence of disease (particularly water bourne diseases). Increased runoff can increase the amount biological agents such as cryptosporidium in raw water which is difficult to remove.	Harm and costs to consumers where emerging threats are not identified and dealt with by companies. Increasing operating costs to cope (e.g. through rising levels of sickness or necessary health and safety measures)	Increased staffing and Health and Safety costs in business plans Failure of duties to ensure safe service if sicknesses of company staff increase, especially in the case of a major disease outbreak.	Threat	210	1	2 Small increases in temperature are highly unlikely to have a material affect above the current impacts in either case. Large natural variability in these threats will mean small average increases will be lost in the 'noise' of yearly change.	0 Water bourne diseases are an existing threat that companies are prepared for under the current climate. There are currently few major incidents and costs of these incidents are a small fraction of industry turnover.	0	3 Some increase more likely	1 Assume within existing coping standards and risk averse approach in this area should minimise threat.	0	3	1	0	Increases in health and safety incidents. increases operating costs for companies (e.g. for insurance).	None	
	D1	Changing precipitation patterns, specifically more heavy rainfall events (in winter and possible in summer).	Changes runoff patterns (more dry weather buildup washed off during rainfall periods): Increases in N, P, toxins, dissolved organic material and suspended solids washed into raw water sources.	Increased raw water treatment required. Primarily affects surface water resources.	Companies ask for money (capital or operational) to increase raw water treatment processes to deal with reduction in raw water quality. Potential for drinking water quality issues which hold a reputational impact on Ofwat or require a reactive policy response. Achieving our duties requires us to get increasingly involved in diffuse pollution legal issues.	Threat: 1) Increased costs for consumers. 2) Increased industry GHG emissions from increased treatment. 3) Raises risk to drinking water quality	121, 126 408, 321, 309, 317	2 Several studies have been carried out. Generally conclusions agree that water quality will decline, but results are very location specific.	2 Although impacts are widely predicted, the magnitude will be regionally varied and difficult to predict. Few significant impacts are forecast in by 2020s.	1 This is an existing issue that, while uncertain, is expected to see at most a small increase under short term climate changes impact of runoff on WwT is currently assessed as limited. This is likely to be more important in terms of companies' own operating procedures and practices - less so in terms of an impact on our functions.	1	2 Although impacts are widely predicted the magnitude will be very regionally varied and is difficult to predict	1 Water treatment is around 8% of industry spend. The decreases in quality are fairly unknown but companies typically have reasonable treatment headroom to cope with minor changes under BAU. Modelling shows changes in pollutions loads of around 5-10%, but results depend strongly upon the specific catchment area. Changes in water quality (N & P) are expected to be generally below 5% in 2050.	2	2 Although impacts are widely predicted the magnitude will be very regionally varied and difficult to predict	2 Water treatment is around 8% of industry spend. The decreases in quality are fairly unknown but companies typically have reasonable treatment headroom to cope with minor changes under BAU	4	Changes in OPEX spent on treatment processes over time, especially processes that are only used when needed such as ozone treatment. Companies or DWI raise as an issue.		Dependent on changes in diffuse pollution from agriculture. Implementation of the WFD & EA approach. Changes in industrial discharges Significant influence from reduction in river flow volumes Changes in CSO spills number and volumes may have a direct impact on water quality in some areas. Surface soil cracking may increase infilatration of pollutants into groundwater sources.
DRAINAGE	E1	Wetter winters. More extreme rainfall events.	Increased occurances of heavy downpours, increased rainfall in winters, more surface water enters combined sewer systems.	More difficult to manage surface water within the existing sewer network. Increased pumping costs. Increased CSO spill volumes and to a lesser extent, increases in CSO spill frequency. Increased occurances of heavy downpours after prolonged dry periods lead to 'first flush' CSO spills which can carry a higher pollution load.	Increased pollution incidents as combined sewers overflow into watercourses - reputational impact for Ofwat. Potential political pressure as CSO discharges impact on WFD targets. Increased company spend to address issues, cope with increased flow and adapt the network to cope.	Threat: 1) Increased pollution incidents 2) Increased company spend to address problems	206, 107, 209, 202, 110, 121, 318, **408**	2 An existing threat. UKCP09 scenarios show the causes of CSO discharges will increase. UKWIR research project is the main study of these impacts	2 In winter rainfall when CSO outflows are most often UKCP09 predicts 20% increases in rainfall in some regions at 90% probability level. Greatest impact of CSO discharges are in summer when river flows are lowest. UKCP09 predicts increases in rainfall intensity in summers, but a reduction in total rainfall, so the summer impacts will be fewer but bigger overflows	2 Pollution impacts are difficult to estimate as CSO outflows are not directly measured in terms of frequency or volume and their importance is highly dependant on the nature of the receiving water. 'Additional' CC impact is therefore hard to guage. The costs associated with climate change impacts will depend upon EU legislation over what levels of outflows are acceptable, currently there is little or no impact on companies if their CSO discharge more frequently that expected. Number of CSO discharges will not vary linearly with changes in rainfall, it will depend upon the available headroom in each area.	4	3 Winter increases in rainfall are predicted, but summer increases in rainfall intensity are only predicted at 90% proability under medium emissions scenario	3 Based on EU enforcing more stingent regulation of CSO discharges - this will cause increased environmental consent failures and require very significant costs to solve. 2 Based on current UK policy towards CSO discharges. UKWIR research predicts that even small increases in rainfall can require significant works in order for sewerage system to maintain LOS.	6/9	3	2/3 CSO spill volumes predicted to increase 2.8 times current levels by 2080 in some areas (408). To maintain current levels of spill volume will require up to 10 times more storage volume than maintaining the levels of spill frequency. Maintaining current numbers of spills could require up to 7 fold increases in storage volume.	6/9	Decision by the EU on CSO discharges is likely to occur well before the impacts of climate change are seen. EA's Sewerage Management and Intermittent Discharges Project	Sustainable drainage project is investigating policy issues relating to drainage.	Sewer serviceability and maintenance regimes. Feasibility and cost of solutions such as upsizing/interception. Increases in river flooding and sea level rises at storm surges may increasingly block sewer outflows, causing additional sewer flooding. Increased population will both increase the volume of sludge flushed into the system and more importantly may increase the area of impervious land from new developments. Changes in demand for drinking water will have some impact on maximum sewer flows. Reaction of developers and urban planning bodies to this threat. The extent to which surface water into sewers (particularly at key points) can be reduced. [illegible]
	E3	Changing precipitation patterns.	Decreases in summer rainfall and the amount of surface water entering combined sewer systems.	Impacts the operation of sewer systems (e.g. by resulting in blockages from decreased flow in summer)	Increased sewer blockages generate complaints and increased company service failures. Increase in operating activity and investment to deal with issues reactively and proactively.	Threat: increased service failures and generated complaints	206, 408	1 No reliable study of this effect has been identified	2 Some decrease in rainfall is predicted but no significant change	0 Blockages are current and temporary issues - additional effects are unlikely to require significant additional expenditure to solve. Groundwater infiltration into sewers is not expected to significantly change	0	3	1 Groundwater infiltration is not expected to significantly change (408)	3	3	1	3	None	No	Changes in demand for potable water will impact upon sewer flows Also offset by population increases, which will increase sewer flows Increased temperatures and CO2 may promote tree growth and lead to more blockages being caused by tree roots.
	E2	Wetter winters. More extreme rainfall events. Sea level rise	Increased occurances of heavy downpours and increased rainfall in winters results in more surface water entering combined sewer systems. Sea level rise and high river flows in winters increase the frequency of sewer outflows being blocked (This particularly magnifies problems where this is at the same time as heavy downpours).	Increased risk of sewer flooding, both external and internal.	Sewer flooding incidents - a serious service failure. Increases sewer flooding risks to consumers - companies fail to meet outputs or maintain standards. Increased company spend to remove properties from risk register. Reputational impact and increased political pressure.	Threat	206, 107, 209, 202, 110, 121, 318, 408	3 UKCP09 predicts heavier downpours and sewer flooding is an existing problem; particularly during extreme rainfall events. UKWIR modelling suggests this is a likely impact.	2 Extreme downpours are mentioned specifically by UKCIP as increasing. Changes in wettest days of winter are not seen under most scenarios in the near term though	2 Although sewer overflows are a serious threat, the additional impacts due to climate change in this period are expected to be relatively small due to the small changes predicted by UKCP09. It is noted that the costs of flooding are not linearly dependent upon flooding magnitude. Increased severity of flooding can rapidly increase costs. Proactive expenditure to resolve potential future issues is expected in this time period but is not entirely climate change driven.	4	3	3 Although in terms of population affected additionality due to CC may be relatively small SF is a very severe service failure. Yearly expendature on sewer flooding is currently around £230 m per year. This is a significant cost (2.9% of industry CAPEX+OPEX). This cost is almost certain to increase as rainfall in winters and intensity of downpours increase. UKWIR modelling suggests that even small increases in winter rainfall will require significant works to maintain current levels of service. Again, not all the cost in this area would be driven by climate change.	9	3	3 The issue is likely to be exacerbated by changes in population number, migration and demand. UKWIR modelling suggests that storage volumes may need to increase by 100% in the long term to avoid additional property flooding.	9	Increases in at risk flooding registers in JRs Increased sewer flooding incidents reported, GSS payments. Stakeholder input during sustainable drainage project.	Likely	
CROSS-SECTORAL	F1	All In all of these risks the predominant driver for risks is the effect of and response to climate change in other sectors. The risks presented here are therefore highly dependent on future courses in other sectors, which we cannot reliably assess. We have attempted to set out our understanding on the degree to which the water and sewerage activities are affected by potential changes in other sectors.	All climate change related risks to the energy sector (e.g. storm and temperature impacts on the distribution system, political drivers on the generative capacity). See Ofgem-provided list for all basic risks.	Reduces the security of supply of energy. Failing energy supplies can seriously threaten a water or waste company's ability to provide services.	Risk of service failures as a direct result of outages. Increased costs to companies and consumers to provide backup generation or react to outages.	Threat	Ofgem feedback.	2 Good evidence that risks to the energy sector have been investigated but this has not been the subject of our review. Understanding of risks to companies' service from power outages is not clear to us.	1	1	1	2	2	4	2	2	4	Energy failures, press and media attention. Ofgem warning.	Possible - dependent on success in other sectors.	All massively reliant on external changes Energy sector resilience. [judging from adaptation reports in that sector they are confident - main risk in the long term might be generating capacity - assume water is prioritised] Resource availability and speed of transition to renewable generation. Rate at which companies can increase their generation of renewable energy (note there are fundamental limits associated with this).
	F2		Increase in the demand on water resources or other temporal or regional changes in demand for water from energy, industry, agriculture, firefighting and the environment (as represented by the EA).	Environmental damage of over-abstraction. Possibility of 'demand-led droughts'. Companies have to restrict their abstraction or pay more to abstract in the face of increased competition for resources. Requires operational changes, development of resources or more stringent demand management measures.	Erosion of headroom in supply-demand balance - increased risk of supply interruptions and increased costs to companies or consumers. Damage to the environment from over-abstraction.	Threat Does present a driver for more efficient allocation and use.	agriculture: 105, 305, 325 energy: 206, 305	2 Mentioned and explored in limited papers.	2 Likelihood uncertain due to dependence other factors. Relationship between demand for irrigation is generally clear and projected as + up to 20% by 2020s under medium scenarios. *where nothing else changes.*	2 Potentially commensurate to the impact from 'pure' climate impacts on customer demand, but significantly more uncertain and subject to political and social changes. of all regions, ANH is apparantly highest risk. Increased consumption is concentrated in summer when SD balance is already stressed under current climate Impact in UK is generally lower than other countries because of relative proportions of water used for public supply vs energy/agricultural uses and power station locations near the sea,	4	3 Likelihood fairly high of some changes to competing direct demand on water resources.	2 Energy - over the long term we should see reduced demand on water resources (excepting the sea). However this is uncertain and some studies (SNIFFER) suggests relocating new/replacement power generation away from coastlines to mitigate risks of sea level rise. This could increase resource stress. Agriculture highly unpredictable and reliant on external factors. Projected increases in agricultural use of up to 20%-26% from current by 2050s	6	4	2	8	Annual monitoring. headroom against licences. EA should raise concerns and engage with the water sector when significant changes begin to occur. WRMPs should raise. SDB impacts	Likely - nature of SDB cases and WR planning.	Material changes in the agricultural sector e.g. crops grown, regional shifts in farming types. Political changes which affect this. Material changes in the energy sector which affects demand for cooling water such as move towards renewable generation - more likely acting to reduce demand. Political decisions on hierarchy of needs/compensation is vital. If reform resolves abstraction rights into an economic competition this will mean increased cost to customers. Changes in abstraction costs will impact the economic level of leakage.

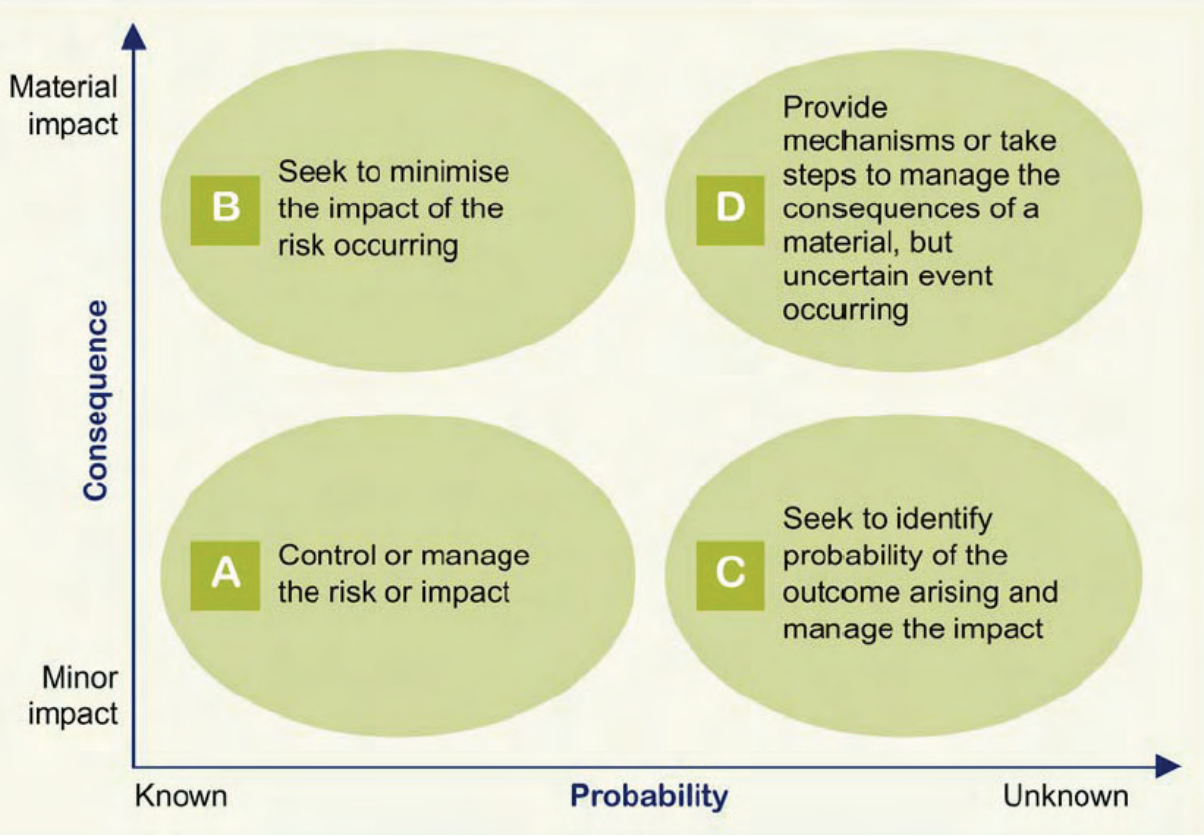
4. Method for determining priority risks

4.1 Risk appetite

Understanding risk appetite is important in order to prioritise risks. For example, a tolerant approach to risks (that is a high-risk appetite) might mean we need take no further actions.

In 'Allocating risk and managing uncertainty in setting price controls for monopoly water and sewerage services – a discussion paper', which we published in October 2010, we explained that a range of factors need to be considered in order to determine how to deal with specific risks. For example, the consequence of some risks is so material that, even though there is a great deal of uncertainty about how likely the risk is, action still needs to be taken. This is represented in the diagram below.

Figure 7 Overall spectrum between risk, uncertainty and materiality



Our prioritisation should reflect the risk appetite among our stakeholders and particularly consumers. We operate in an industry where the repercussions of service failures, such as customers experiencing extended periods of restricted water supplies or river pollution, can be very significant for society and the environment. For this reason, we think that planning for climate change risks in the water and sewerage sectors is more long term relative to other sectors of the economy. As an example, it is appropriate that the companies plan to manage their supply/demand balance over at least a 25-year timescale and that they clearly present their overall strategic direction over the same period. Many other sectors do not carry out this kind of long-term risk planning systematically.

The regulatory framework as it stands, already has significant capacity to deal with some of the risks. Existing mechanisms already provide incentives (and reduced uncertainty) to encourage companies to adapt. As a result, the companies we regulate already have the capacity to deal with many low impact risks without it affecting our duties.

4.2 Risk priorities

Our climate change risk appetite distinguishes between three types of risk.

- High risks – which we believe require mitigation.
- Medium risks – which should be minimised as far as possible.
- Minor risks – which we are willing to accept at the current time.

We used the basic probability impact grid shown in figure 8 below to categorise the risks we identified. Each cell in the grid contains a value calculated by considering the impact and probability assessments for each risk (derived from the definitions explained in chapter 3). We did not use the simple 0-4 scoring system shown in figures 11-13 as this did not represent accurately the changes in scale between impact categories. Instead, we mapped the 0-4 scale onto a non-linear scoring system. The combined risks scores in figure 5 are multiplied by 100 for presentational reasons.

Figure 8 Probability impact grid used for prioritisation

Magnitude of Potential impact on Ofwat	0.25	1.25	2.5	12.5	22.5
	0.15	0.75	1.5	7.5	13.5
	0.02	0.1	0.2	1	1.8
	0.01	0	0.1	0.5	0.9
	0	0	0	0	0
		0.05	0.1	0.5	0.9
		Likelihood of impact occurring based on UKCP09 results			

Many of the risks we have identified are either highly unlikely to occur or have such a low predicted impact that we do not believe it is proportionate for us to take adaptation action. We have included risks with a probability impact score of 0.1 or below in this category. We consider such risks to be minor and do not prioritise them in the adaptation action plan. We consider risks with scores above 0.1 but below or equal to 1 to be medium risks. These are risks that have the potential to affect the achievement of our duties if not dealt with properly. Risks with scores higher than 1 are considered high-priority risks.

Unless there are obvious and low-regret risk mitigants, we expect the companies to be able to deal with minor risks within their capacity. For medium and high risks, we judge that we should have some policy or action in place that helps mitigate that particular risk.

As well as threats, we have considered potential opportunities from a changing climate. In the case of opportunities, we judged that we would simply accept them in all cases but not rely on them. As with other risks, any material benefits from these opportunities will be shared between customers and companies through the regulatory system.

We applied this approach to each of the three time periods in order to determine which risks move from minor to medium or from medium to high in the future. This helps us to determine which adaptation actions need to be implemented now, within the next five years or where we are likely to need to take action over a longer period of time. We have used the results from the 2050s risk assessment as the main indication of priority risks for our organisation.

4.3 Risk allocation

Identifying and understanding where risks should be allocated is an important step in understanding what adaptation actions to take. We seek to set an appropriate balance of risk between consumers and the companies we regulate.

For efficient and effective management of risks, the impacts should rest with the party most able to manage them. And adaptation is more likely to be most effective and efficient when actions are made by those with the best information on the systems concerned and the local circumstances and challenges. The nature of the risks we identified means that these risks should sit with the companies.

Identifying who is best able to control or manage the likelihood or consequence of a risk is an important part of our role as economic regulator. But it is not straightforward. In 'Allocating risk', we explained that the ability to manage or control a risk may lie with one party (for example, the agricultural or water and sewerage sectors) but the consequences of the risk fall elsewhere (for example, on the environment or on water customers). In these cases, incentives are needed which encourage the party that is best placed to control that risk to act. Equally, it may be that more than one party has a role to play in managing a risk. We need to understand this in each case in order to identify what actions need to be taken to ensure that adaptation is effective, efficient and equitable.

4.3.1 Low-regrets actions

The UK Government's Adaptation Sub-Committee has stated that the minimum it expects from organisations that are adapting well is that they are implementing low-regrets adaptation options.

In the near term, we expect the focus of adaptation actions to be in areas where there are existing weather-related risks – such as flooding and to the supply of water available for use, or clear benefits to reducing the risks – such as reduced resource requirements through demand reduction. These are the areas where low-regrets actions are most likely to be found. In many of these areas, we have already seen progress in the sectors over the past 20 years. Such areas include:

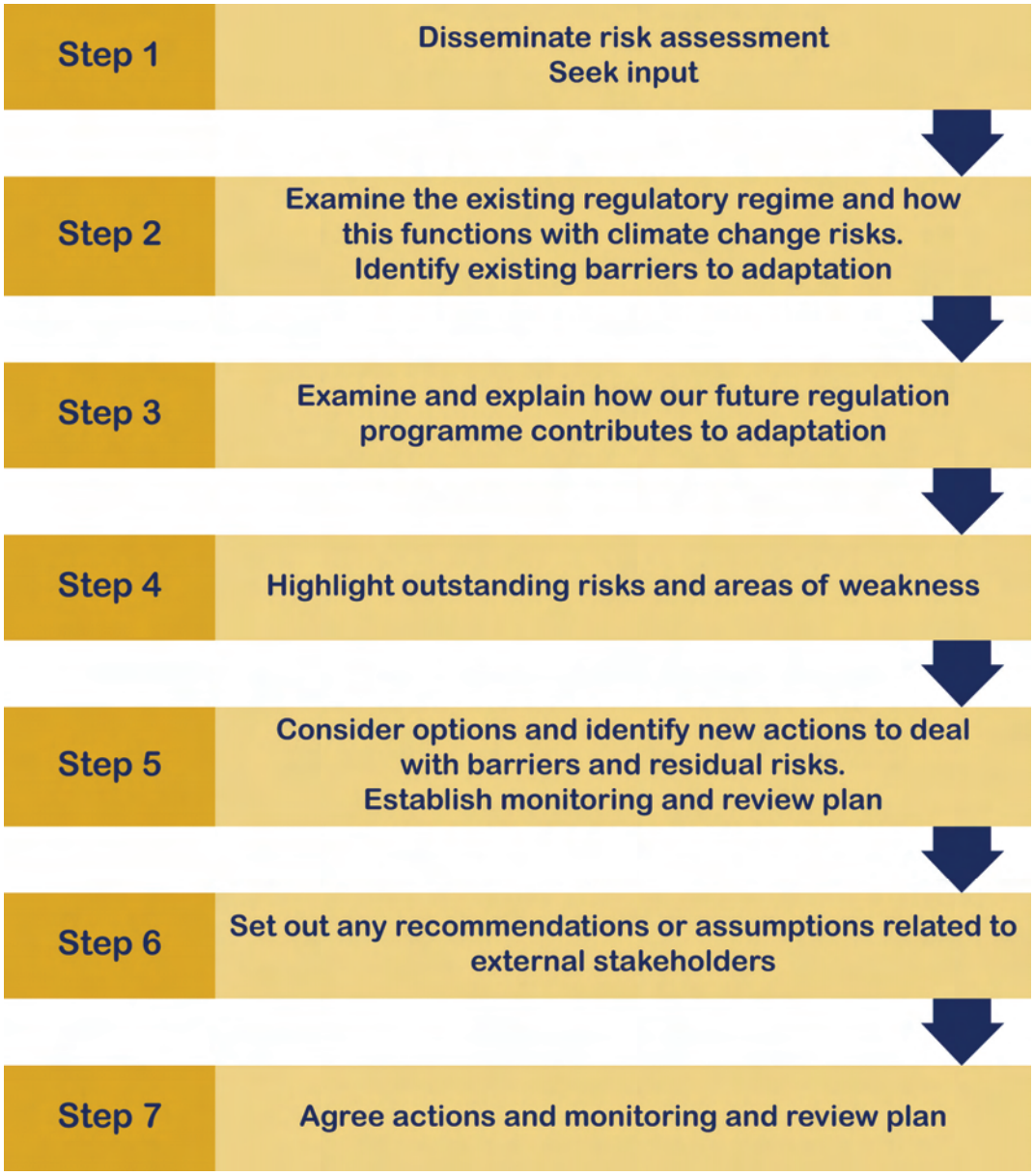
- reducing the amount of water wasted;
- increasing the amount of water available for use;
- increasing resilience of service;
- increasing network interconnection;
- increasing the flexibility of and control over networks;
- reducing, or slowing down, surface water going into the sewers;
- reducing diffuse pollution; and
- planning for emergencies.

These help to set our agenda and understand low-regrets options. They also provide an indication of the types of areas to consider when assessing how well-adapted the sectors are. Choosing the right adaptation actions is always a context-specific process.

5. Process for identifying adaptation actions

In order to arrive at an adaptation action plan that addresses the priority risks we identified, and that meet the aims and principles of adaptation outlined above, we followed the process illustrated below.

Figure 9 Process for identifying adaptation actions



The aim of this process was to ensure we appraised our current approach to regulation critically and could arrive at improvements where necessary. We explain the conclusions of this process and our action plan in the main report. We explain each of the steps in turn below.

5.1 Step 1 – disseminate risk assessment

Our first step was to disseminate the conclusions of the climate change risk assessment and develop ideas on how we can mitigate those risks with others across Ofwat. We did this at both a policy and project level, and overlapped it with the risk assessment quality assurance process. At this point, we also used a decision flowchart to help our thinking on climate change risks and adaptation in different policy areas.

5.2 Step 2 – examine the existing regulatory system and identify barriers

We then examined in detail how the existing regulatory system does and does not enable or incentivise adaptation. This included identifying existing barriers to adaptation in the sectors caused both by our existing system of regulation and by other regulatory and legislative constraints.

We identified these through consultation across the organisation and by considering the views of our stakeholders expressed in workshops, conferences and published documents. As part of this, we also considered our own adaptive capacity and areas where this could improve. 'Adaptive capacity' means the extent of our understanding about climate change risks and our ability to respond to these. This step included further discussions with all relevant policy teams. We then listed and examined the barriers we identified.

5.3 Step 3 – examine and explain our future regulation programme

As part of our future regulation programme, we have a number of projects under way that are considering topics such as future price limits, sustainable drainage and market reform. These projects all have climate change as a key driver and consideration in their work programmes. But as with all our work, climate change is not their only consideration. So, for the purposes of our adaptation report, we explained in detail how the products of those projects may affect (both positively and negatively) the ability of the sectors to adapt to climate change.

5.4 Step 4 – highlight outstanding risks and areas of weakness

Following our review of existing systems and future regulation, we then considered the areas in which further action was required. This meant considering the barriers to adaptation we had identified and understanding which of the priority risks are not dealt with adequately through existing mechanisms.

5.5 Step 5 – establish action plan

We then considered a range of options and established a list of actions to address barriers and outstanding risks. This included a number of internal actions that were driven in part by a self-assessment on adaptive capacity which we carried out. At this point, we also established our plans to monitor and review adaptation in the sectors and to keep the risks under review.

5.6 Step 6 – recommendations or assumptions related to external stakeholders

The penultimate step was to explain our assumptions with regard to other regulators and legislative bodies. In some cases, we also identified specific areas where we rely on the actions of other stakeholders. We identified this as a necessary step because of the complex and inter-related nature of the sectors.

5.7 Step 7 – agree actions

The final stage involved agreeing our report and actions with each of the policy and project teams and with our Board and Executive team.

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