

# The case for change - current and future water availability



Report – GEHO1111BVEP-E-E

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# Executive summary

Water is a precious resource that faces increasingly severe and often conflicting pressures. Water resources will become more stressed in future as a result of climate change, increasing demand and changes in lifestyle. Careful planning will be critical to ensure sustainable water supplies for people, businesses, agriculture and the environment. It is important to understand the scale of the challenge now because it takes many years to plan and invest in solutions.

The Environment Agency has a duty to manage water resources in England and Wales. It's our responsibility to decide how much water can be taken from the environment for people and businesses to use, without damaging the environment or compromising existing lawful users. We deal with all aspects of water such as managing abstraction, flood risk and water quality, and are able to look at the water environment in its entirety. To support the government's Water White Paper, we have produced this report which focuses on current and future water resources.

Water is abstracted for many purposes, including public water supply, agriculture, industry and electricity generation. Water resources are already under pressure. Reliable supplies of additional water for abstraction are not available across much of England and Wales. In some places, water bodies<sup>1</sup> are already being damaged by abstraction. We are carrying out investigations to understand the problem and will assess the options needed to improve and protect the environment through our Restoring Sustainable Abstraction programme.

In the future, climate change and population growth will increase the pressure on water availability. Current climate change projections for the UK suggest that by the 2050s, under the medium emissions scenario, summer temperatures may increase and summer rainfall may decrease. Short duration droughts (12-18 months) are likely to become more frequent, so that droughts like 1976 could be more common despite the increased resilience of public water supply and more winter storage.

The population of England and Wales is forecast to increase by 9.6 million people by the 2030s (9.2 million people in England and 0.4 million people in Wales). Population growth means that demand for water is likely to increase. Impacts will vary from place to place. However those areas already experiencing water stress will have a potentially increased population of over 40 per cent (Thames and South East England) which will make the problem worse.

It is important to understand the scale of the impact on water availability now and in the future. We have therefore tried to quantify water availability in the 2050s. The analysis presented in this report uses best available evidence to look at the possible impacts of future pressures which can be used to inform an understanding of the scale of the challenge. We have set out a number of scenarios that include a range of projected futures, taking climate change, population growth, demand changes and environmental requirements into account. The conclusions that can be drawn from this work are:

**Water resource availability in the future is uncertain.** We have not analysed all possible futures but have considered a range of possible outcomes for each river basin district and catchment.

**The water environment will be different from that of today.** Some species will be better suited to future conditions than others. We will need to reconsider the requirements for future water ecosystems and the implications on the water available for abstraction.

The combined impacts of climate change and increases in population show there could be **less water available for people, businesses, agriculture and the environment than today.**

**Future water resource availability pressures will not be limited to the south and east of England.** Under many of the scenarios Wales, south west and northern England are likely to see significant unmet demand in the future.

**Over the longer term climate change could have a bigger impact on water resource availability than population growth.** Unmet demand is more closely linked to the climate change scenarios than the demand scenarios.

**Demand management will have an important role in the future but increased demand and climate change impacts could result in the need for significant new resources to be developed.**

**The scale of the problem needs to be considered at a strategic and local level.** The study shows that the river basin district analysis masks significant local problems.

Climate change, population growth, and changes in lifestyle are likely to impact significantly on water availability in the future. The evidence presented in this report presents an important first step to inform how water resources management may need to adapt. Understanding the likely scale, nature and potential range (including uncertainties) of future impacts is essential to a sound and resilient adaptation strategy.

However it is clear that continuing with the current approach to water resource management will compromise the environment, the economy, or society - singly or in combination. As the severity of pressures on water resources vary across England and Wales, the approach for managing them will need to be adaptive and flexible.

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# 1 Introduction

Water is essential for people and the environment. It is vital to the economy and for health, is used to generate power, run industries and grow food. Access to clean, safe and secure water supplies is fundamental to society.

But reliable supplies are already under pressure in parts of England and Wales. Increases in population and changes in lifestyle, together with climate change are likely to make the situation worse.

Our focus in this report is on water resources, and how the availability of water resources could be limited in the future. But the findings and conclusions must be considered within the wider context of the water cycle. Whatever is done to one part of the water cycle has impacts elsewhere, and elements of the water system must not be managed in isolation. For example, the amount of water that can be used will also depend on water quality. We plan to explore this further in the future.

In this report we set out current evidence on the availability of water now and in the future. We set out the challenges for future water resources and a range of projected futures, taking climate change, population growth, demand change and environmental management pressures into account. By considering those futures, we can begin to understand the scale of the challenge for future water availability, identify areas where we need to do more work to reduce uncertainty and plan for a future that society wants to see, rather than one that may otherwise develop. It is important to understand the scale of the challenge for future water availability now as planning and implementing solutions takes many years.

Section 2 provides background information on **current water availability and use** including evidence on current abstractions across England and Wales.

Section 3 explains the likely **pressures on water resources** in the future including climate change, environmental requirements and population growth.

Section 4 explores pressures on water resources further by **quantifying water availability in the 2050s**. We look at a number of scenarios to understand the scale of the challenge.

Having looked at the pressures and challenges for water availability, Section 5 summarises the **implications for managing water resources in the future**.

This document provides evidence to support Government's Water White Paper covering England and the Strategic Policy Position Statement (SPPS) on water covering Wales. It complements 'The case for change – reforming water resources management in England'.

## 2 Current water availability and use

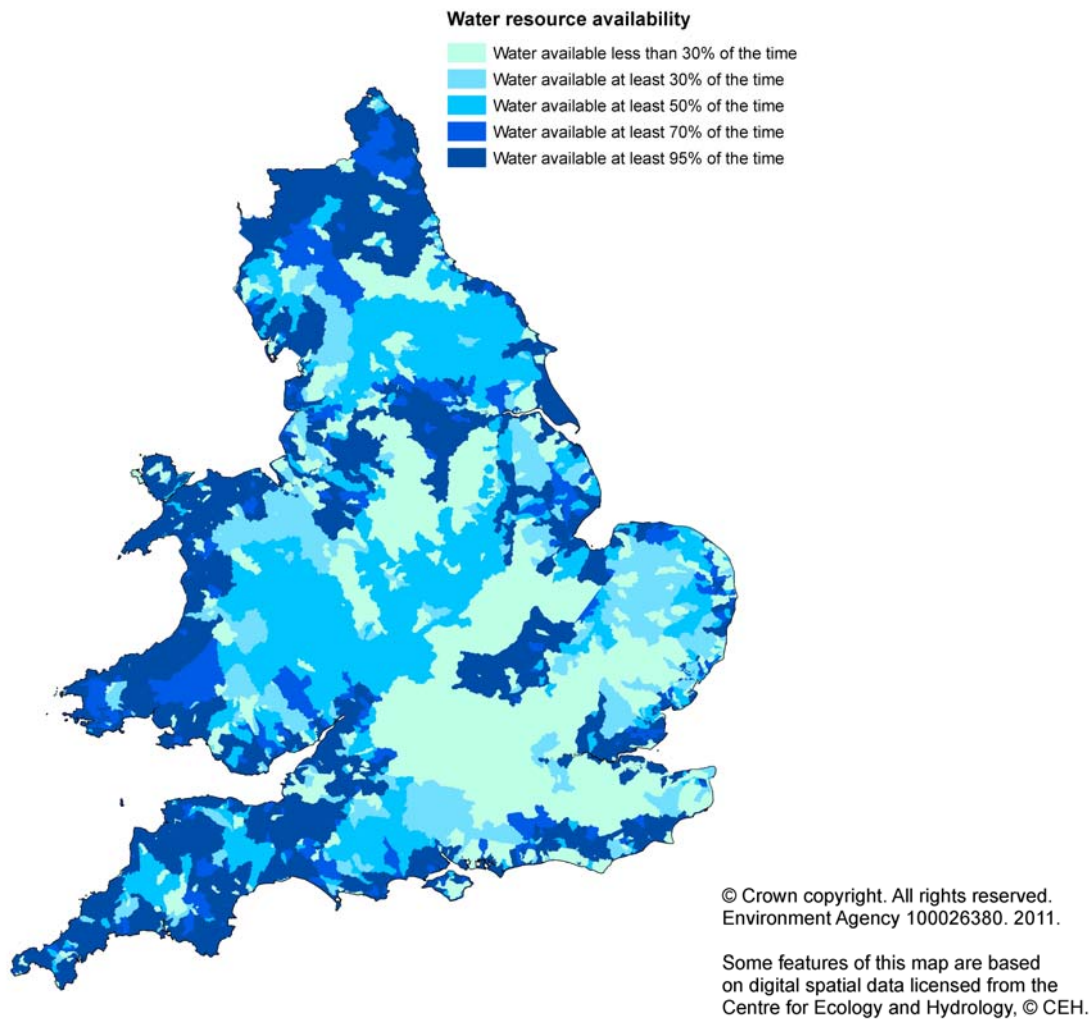
Water is a renewable but finite resource. The amount of water available varies between different places and seasons. The demands on water also vary across England and Wales as it is put to use to support society, the economy and the environment.

### 2.1 Assessing water availability

The Environment Agency is responsible for deciding the maximum amount of water that may be taken from the environment for human and business use, without compromising the environment. We do this by assessing the water available for abstraction through our Catchment Abstraction Management Strategies (CAMS). CAMS show how much freshwater resource is reliably available, how much the environment needs and the amount of water that can be licensed for abstraction.

We split catchments down into smaller areas (water bodies) to look at local impacts and to determine how much water is needed for the environment and how much can be allocated for abstraction. Figure 2.1 shows how reliable new surface water and groundwater licences are, using the CAMS assessment. Reliable supplies of additional water for abstraction are not available across much of England and Wales. A quarter of water bodies in England and seven per cent of water bodies in Wales will provide a reliable source of water for a new consumptive abstraction for less than 30 per cent of the time. Therefore, licences issued in these areas will have a less reliable supply of water than those issued elsewhere.





**Figure 2.1: Water resource reliability: percentage of time water would be available for abstraction for new licences**

## 2.2 Regulating water abstraction

We manage abstraction of water through a licensing system that regulates all abstractors taking more than 20m<sup>3</sup>/d of water (excluding activities currently exempt from licensing). Whether we can grant a licence depends on the amount of water available after the needs of existing abstractors and the environment are met and whether the justification for the abstraction is reasonable.

There are approximately 21,500 abstraction licences in England and Wales<sup>2</sup>. All new licences (since 2001) have an expiry date. Approximately 21 per cent of licences in England and Wales now have time limits<sup>3</sup>. The remaining 79 per cent do not have a time limits.

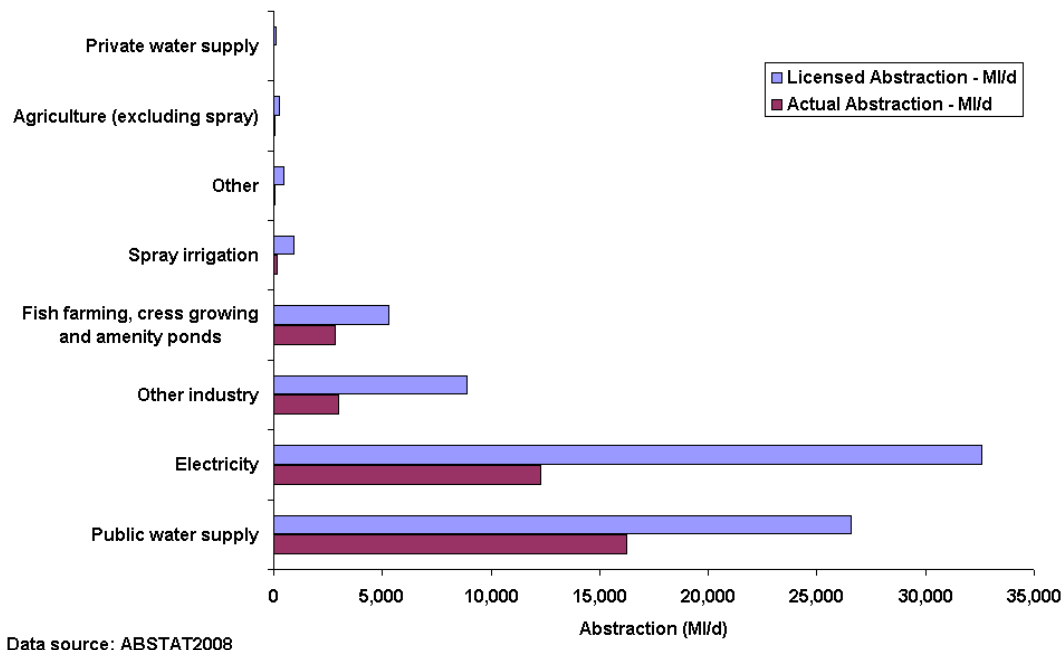
Licences may have conditions that require abstraction to stop or be reduced when a river flow or level falls below a specified threshold. This helps to maintain sufficient flows in rivers to protect the environment, 17 per cent of licences in England and Wales have these restrictive conditions<sup>4</sup>.



## 2.3 Abstraction uses

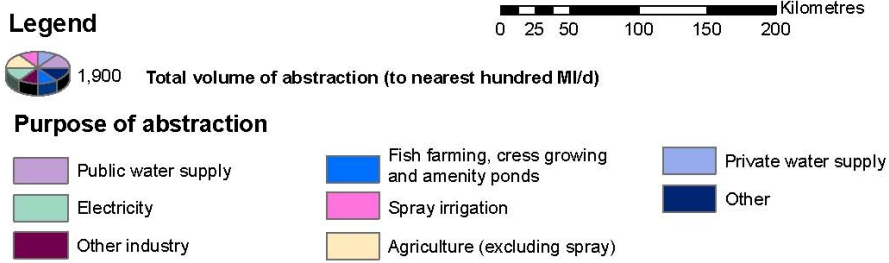
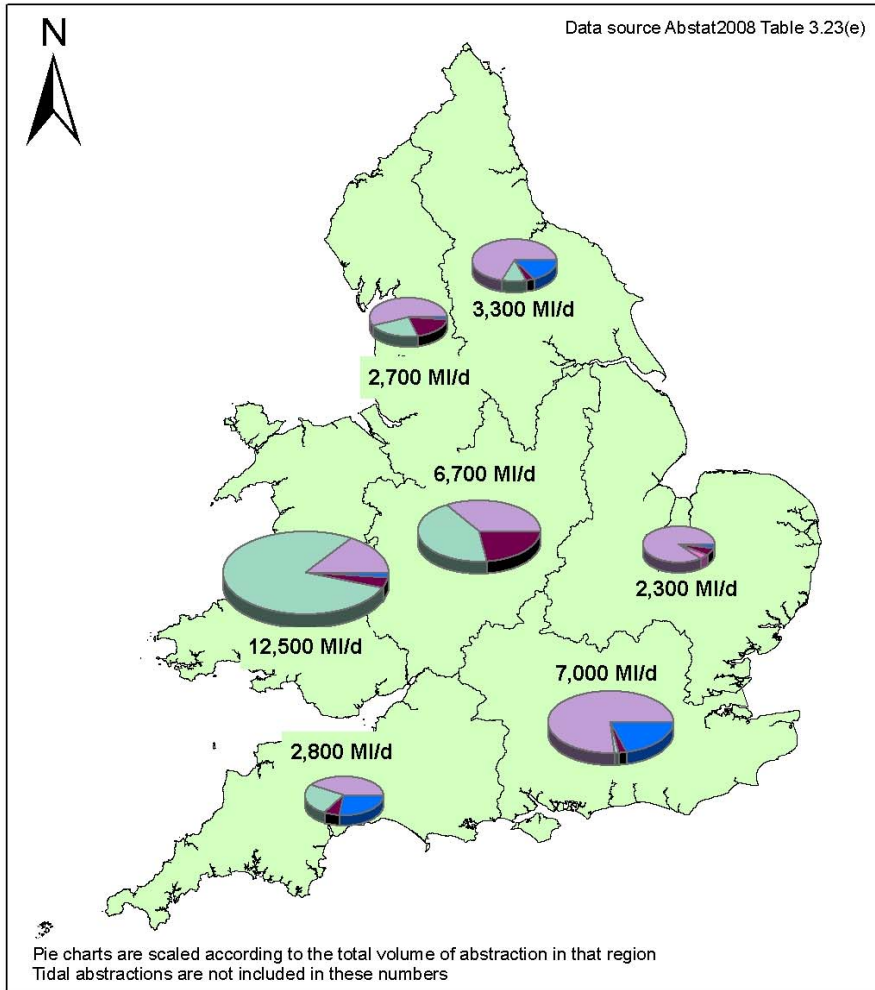
Water is abstracted from freshwater (non-tidal) sources for a wide range of uses in England and Wales (figure 2.2). Not all of the water that is licensed for abstraction is actually abstracted. We licence 75,000 MI/d of water in England and Wales of which just under 34,500 MI/d is abstracted (around 45 per cent)<sup>5</sup>.

Water companies abstract almost half of the total amount taken from non-tidal waters in England and Wales, but return over 70 per cent of this as treated effluent which, unless it is discharged to the marine environment, supports river flows.



**Figure 2.2: Water abstraction from non-tidal waters in England and Wales<sup>6</sup>**

Type of water use varies across England and Wales (figure 2.3 and table 2.1). For example, over 80 per cent of water abstracted in Wales is used to support electricity generation with less than 15 per cent taken for public water supply. The biggest demand for spray irrigation is in East Anglia, where actual abstraction is four per cent of the total for all uses. Water for spray irrigation is required in the summer (when water resources are most scarce) and sometimes more water is used on a hot dry day for spray irrigation than for public water supply. Not all of the water abstracted is used. For example, water can be used in a process, such as power station cooling, but a significant proportion returned back to the environment with little impact on flow volume.



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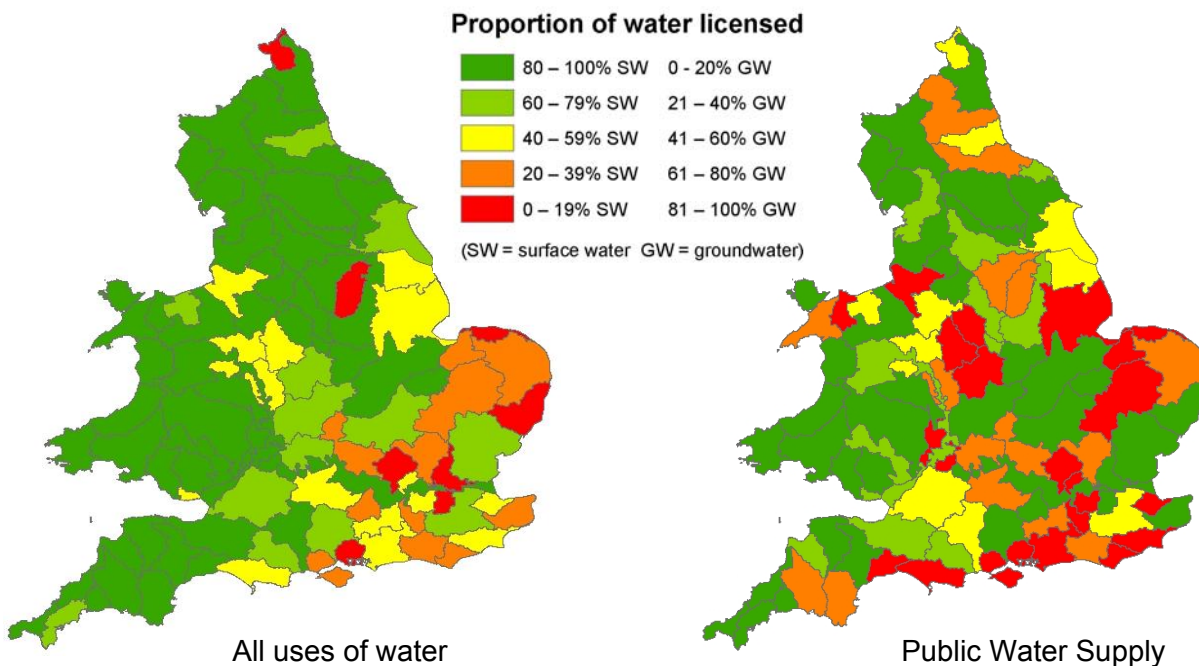
**Figure 2.3: Recent abstraction by sector and Environment Agency region (based on ABSTAT 2008<sup>6</sup>)**

Region	Sector							
	Public water supply	Electricity	Other industry	Fish farming etc	Spray irrigation	Agriculture (excluding spray irrigation)	Private water	Other
North West	1482	694	496	29	1	3	0.2	2
North East	2208	430	120	480	7	4	3	6
Midlands	2418	2742	1469	37	29	4	4	10
Anglian	2032	15	119	56	97	4	5	1
South West	1186	584	226	751	2	9	3	8
South East	5285	103	189	1332	17	11	9	47
EA Wales	1631	10292	377	165	2	3	1	0.6

**Table 2.1 Estimated abstractions (MI/d) from surface water and groundwater sources (based on ABSTAT 2008<sup>6</sup>)**

## 2.4 Sources of water

Most of the water licensed for abstraction (85 per cent by volume) is from surface water but the proportion of water licensed between surface water and groundwater varies across England and Wales. The south and east of England relies on groundwater resource. Public water supply relies more on groundwater resources than other uses of water (figure 2.4).



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**Figure 2.4: Proportion of licensed volume: surface water to groundwater (based on ABSTAT 2008<sup>6</sup>)**

## 2.5 Water and the environment

Many important species and habitats depend on water to thrive. Impacts on surface water and groundwater need to be managed so that there is sufficient quantity and quality of water for rivers and other wetland habitats to thrive. Water also provides opportunities for recreation and supports navigation along rivers, estuaries and canals.

The natural functions of catchment ecosystems provide multiple benefits to society, these benefits are referred to as 'ecosystem services'. These services underpin basic human health and survival needs as well as supporting economic activities and enjoyment of life. Historically, development has largely overlooked or disregarded many of these ecosystem services. But by recognising benefits to society, the services ecosystems provide can be brought into planning and other decision-making processes, linking ecological with social and economic considerations.

### 2.5.1 Improving the current water environment

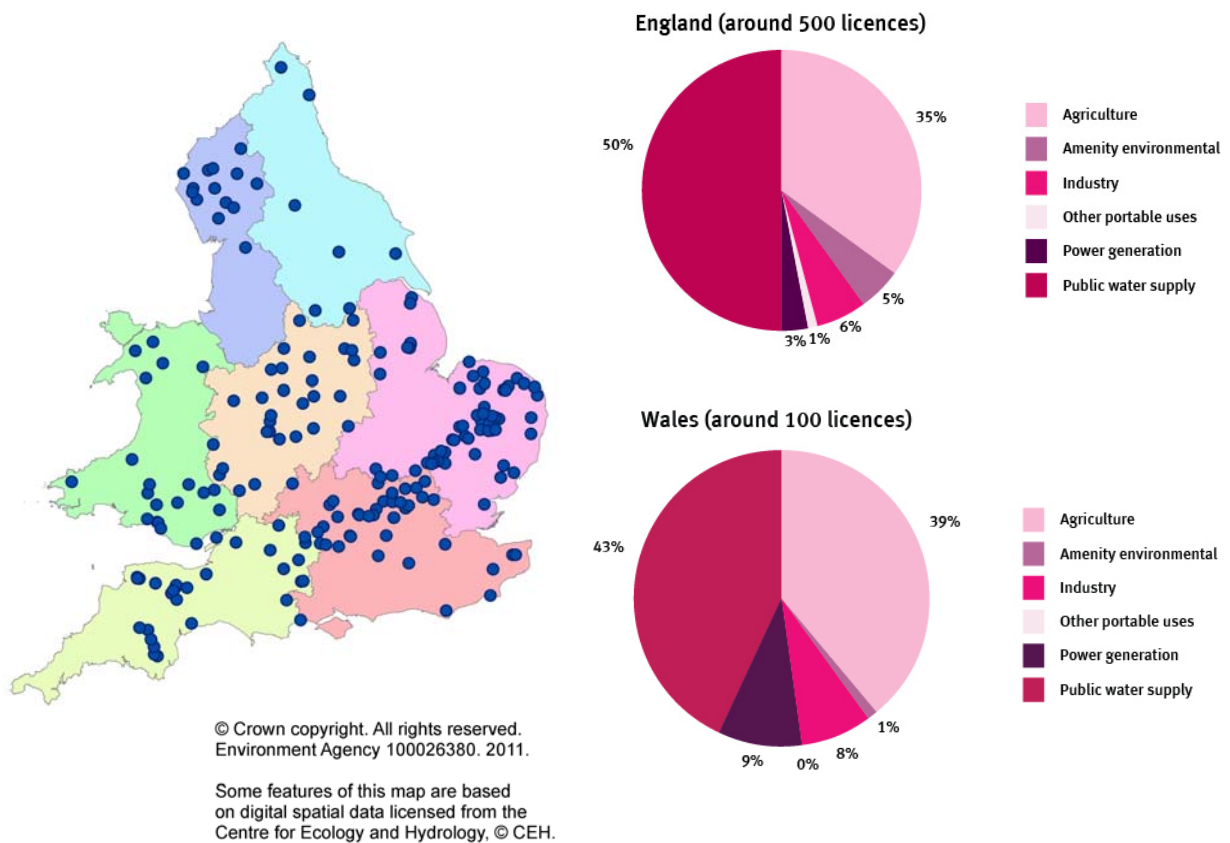
In some places water abstraction licences have been issued that we now understand could be harming nature conservation sites or the ecological health of catchments. We need to take action at these sites to protect and improve the environment.

The Water Framework Directive (WFD) requires Member States to aim to achieve good ecological status and good groundwater quantitative status by 2015 and prevent deterioration in the status of water bodies (subject to certain specific exemptions).

The criteria we use to assess the environmental flow needs of a river are referred to as Environmental Flow Indicators (EFIs). The EFI is adapted from flow standards proposed by the WFD UK Technical Advisory Group (UKTAG) to support good ecological status. If flows are above these thresholds we can be confident that abstractions are acceptable and good ecological status requirements will be met from a flow perspective. If flows are below these thresholds there is a risk of ecological damage. We are investigating such situations and will look to take action where needed.

We have statutory powers and duties to protect, conserve and enhance the environment. Under the Habitats Regulations<sup>7</sup>, we have to act where abstractions have or potentially could damage the environment. We are also responsible for reviewing licensed abstractions that could damage the health of Sites of Special Scientific Interest (SSSIs) and which may be damaging sites of local environmental importance.

Within the Restoring Sustainable Abstraction (RSA) programme, we are currently carrying out investigations into whether existing abstractions are damaging sites; affecting river flows or causing poor groundwater quantitative status, and are taking action to remediate that damage where possible (figures 2.5 and 2.6). This involves collecting evidence on abstraction impacts, assessing all of the options to resolve the problem and agreeing with the abstractors involved on the best course of action. This may lead to changes to abstraction licences, and the way water is managed, although solutions to look at off-setting or mitigating any damage are also considered.



**Figure 2.5: Distribution of Restoring Sustainable Abstraction schemes**

**Figure 2.6: Number of licences (shown as percentage of total number included in the Restoring Sustainable Abstraction programme) broken down by sector of use**

## 2.6 Water resources in the context of wider water management

To manage water resources effectively, we need to consider catchments in their entirety. Elements of the water system must not be managed in isolation. We deal with all aspects of water such as managing abstraction, water quality and flood risk. We also manage water in ways that improve opportunities for water related recreation and public enjoyment. Our priorities for water include improving water quality to protect water supplies, fisheries, and natural habitats; balancing supply and demand, and making sure that water management is resilient to future pressures.

England and Wales have one of the most comprehensive systems in the world for water planning and delivery to protect the environment and provide safe and secure supplies of water. Our Catchment Abstraction Management Strategies (CAMS) allocate a proportion of the available water for the environment and to meet the needs of people, industry and agriculture. Our discharge permitting system ensures that we can regulate the quality of discharges to help protect water quality, the environment and human health. We use the river basin management process to make the links between surface water management, land management (urban and rural), flood risk management and diffuse pollution.

This report focuses on water resources, and how the availability and reliability of resources might change in the future. But the findings and conclusions must be

considered within the wider context of water management. We will do further work to explore the links between water quality and availability in the future.



# 3 Pressures on water resources

Climate change and population growth will be the biggest challenges to ensuring that there is enough water to meet future needs. With changes to the amount and distribution of rainfall and growing water demands, it will be a real challenge to protect the environment, let alone improve it. In this section we set out the potential impacts of future pressures on water resources.

## 3.1 Climate change

Climate change is likely to alter the water cycle significantly in the future. The amount and distribution of rainfall will change, although there are large uncertainties around the extent of the changes. This will affect water availability to support water dependent species and habitats and the availability of water for society and economic growth.

### 3.1.1 Climate change impacts on rivers and groundwater

Our current understanding of the impact of climate change on water resources in England and Wales is based on the latest UK Climate Projections (UKCP09). A recent study<sup>8</sup> provides a national assessment of seasonal changes in river flows and groundwater levels for the 2050s from 11 medium emission<sup>9</sup> Regional Climate Model (RCM) simulations (referenced by the letters A to K) that are one component of UKCP09.

The UKCP09 medium emission projections for the 2050s indicate that changes in summer mean temperatures may be greatest in parts of southern England (between 1.3 to 4.6°C with a median of 2.8°C<sup>10</sup>) and least in the north of England (1.1 to 3.9°C with a median of 2.3°C). In Wales, summer temperatures may increase between 1.2°C to 4.1°C with a median of 2.5°C. There may be little change in average annual rainfall, although summer rainfall may decrease<sup>11</sup>. However, there is a large range of projections for rainfall - including increases as well as decreases for summer - so we have a lot of uncertainty to deal with in planning how to manage water resources.

The percentage changes in mean river flow between the baseline and 2050s are shown in figure 3.1 for four seasons for each of the 11 RCM simulations. The overall pattern is varied, reflecting the complex nature of UK weather patterns and uncertainty in the impact of climate change. No one scenario is more likely to occur than any other.

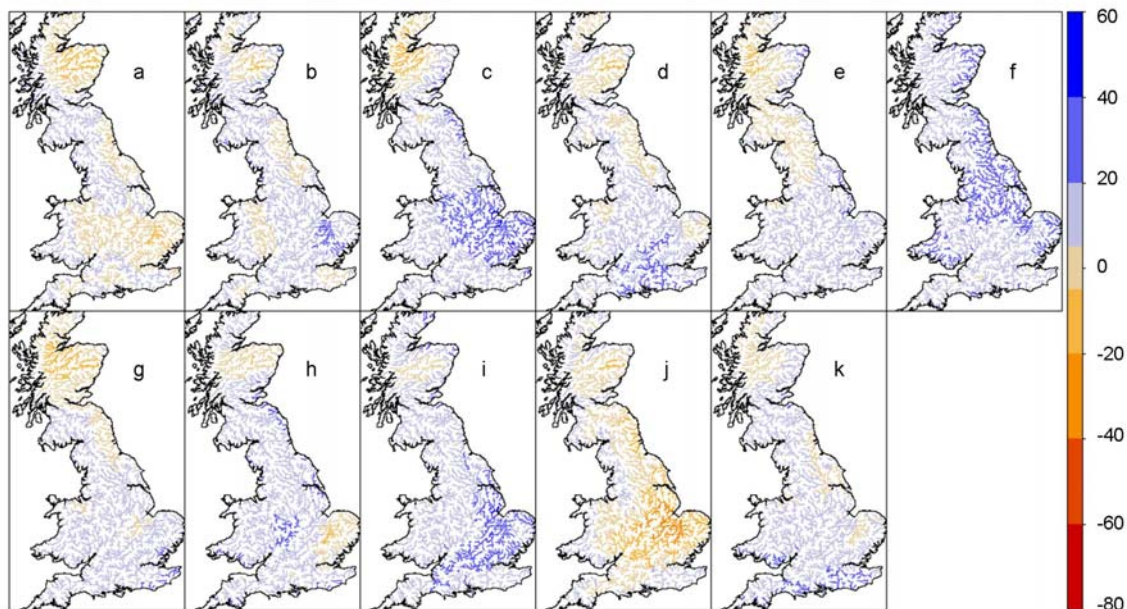
- In winter (December, January, February) there is a mixed picture in England and Wales with drier, similar or wetter patterns, all within +40 per cent to -20 per cent change.
- In spring (March, April, May) more of the scenarios are drier for most of the UK, with decreases of up to 44 per cent. However, for four scenarios central England has increased flows (up to 40 per cent).
- In summer (June, July, August) scenarios predominantly show decreases in runoff through the UK, ranging from +20 per cent to -80 per cent. The largest

percentage decreases are mainly in the north and west of the UK although the range in these areas between scenarios can be large (0 to 80 per cent).

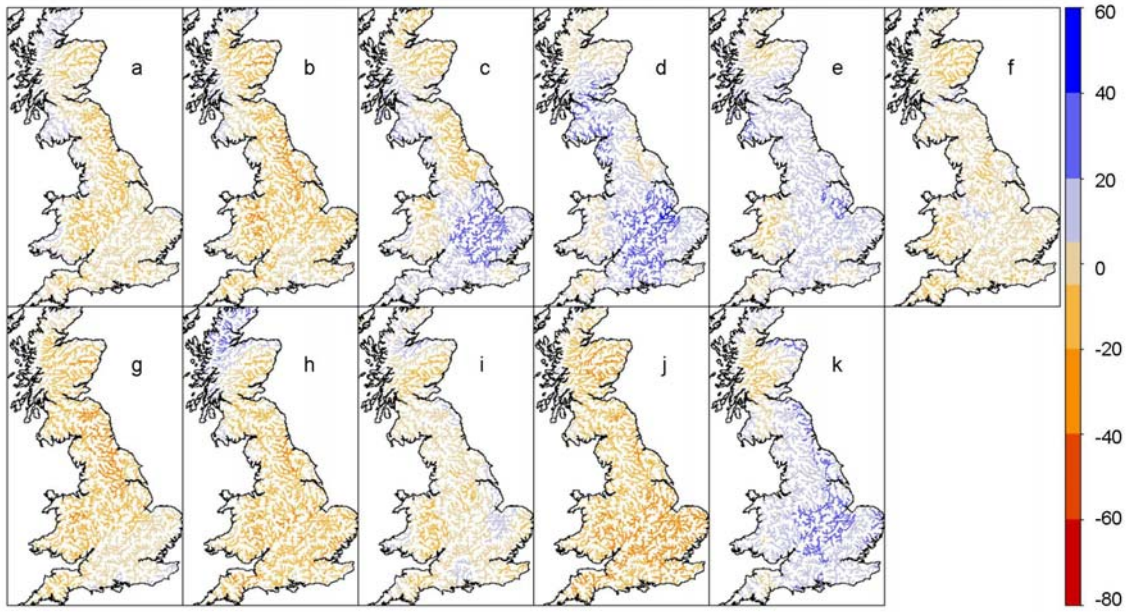
- In autumn (September, October, November) there is a mixed pattern with a wide range of percentage changes (+60 to -80 per cent) across the UK. Most scenarios indicate decreases in flows, especially in the south and east (up to -80 per cent) whilst in the west and north changes can be small. One scenario shows no change or an increase in runoff across the UK.

The scenarios are all different. Autumn and winter are especially mixed, but all scenarios show a decrease in flow in the summer almost everywhere. However, the differences between the scenarios at any location can be significant, especially in spring and autumn.

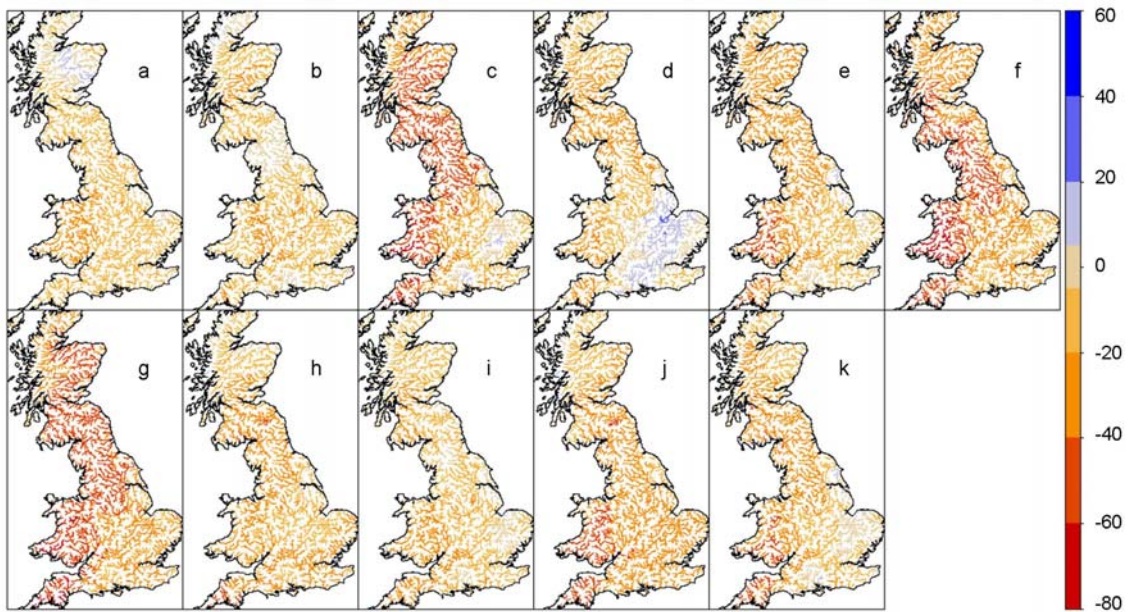
The picture for groundwater is still unclear. Early results suggest that in some climate scenarios increased winter rainfall leads to increased recharge and higher groundwater levels that persist into the summer, but in others recharge reduces, leading to lower groundwater levels and reduced availability of groundwater for abstraction.



**Winter (December, January, February)**

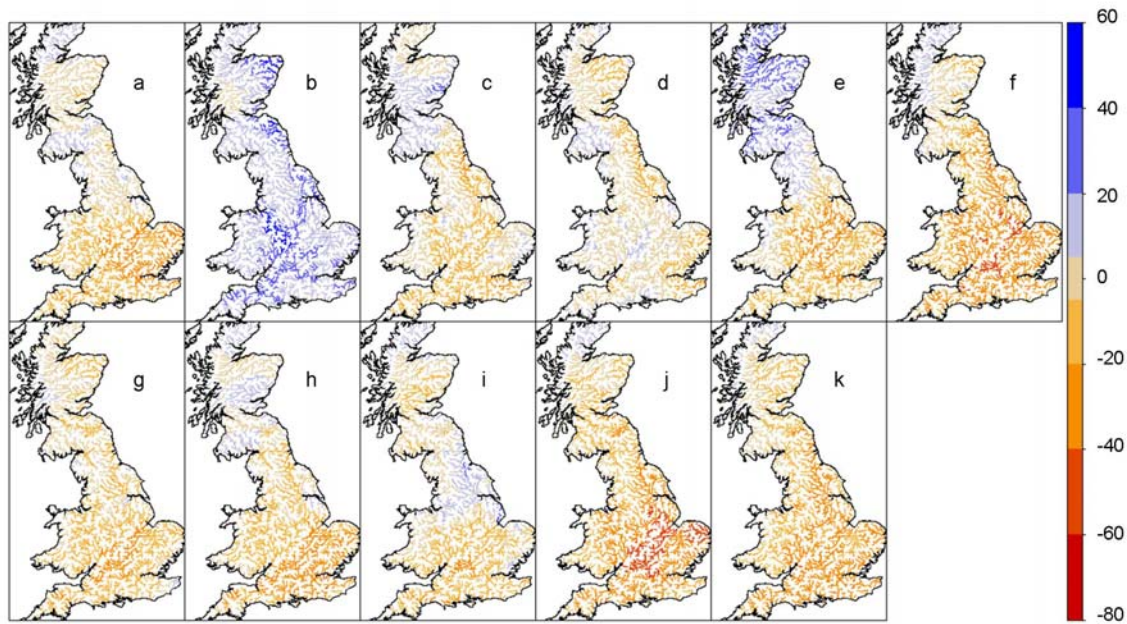


**Spring (March, April, May)**



**Summer (June, July, August)**



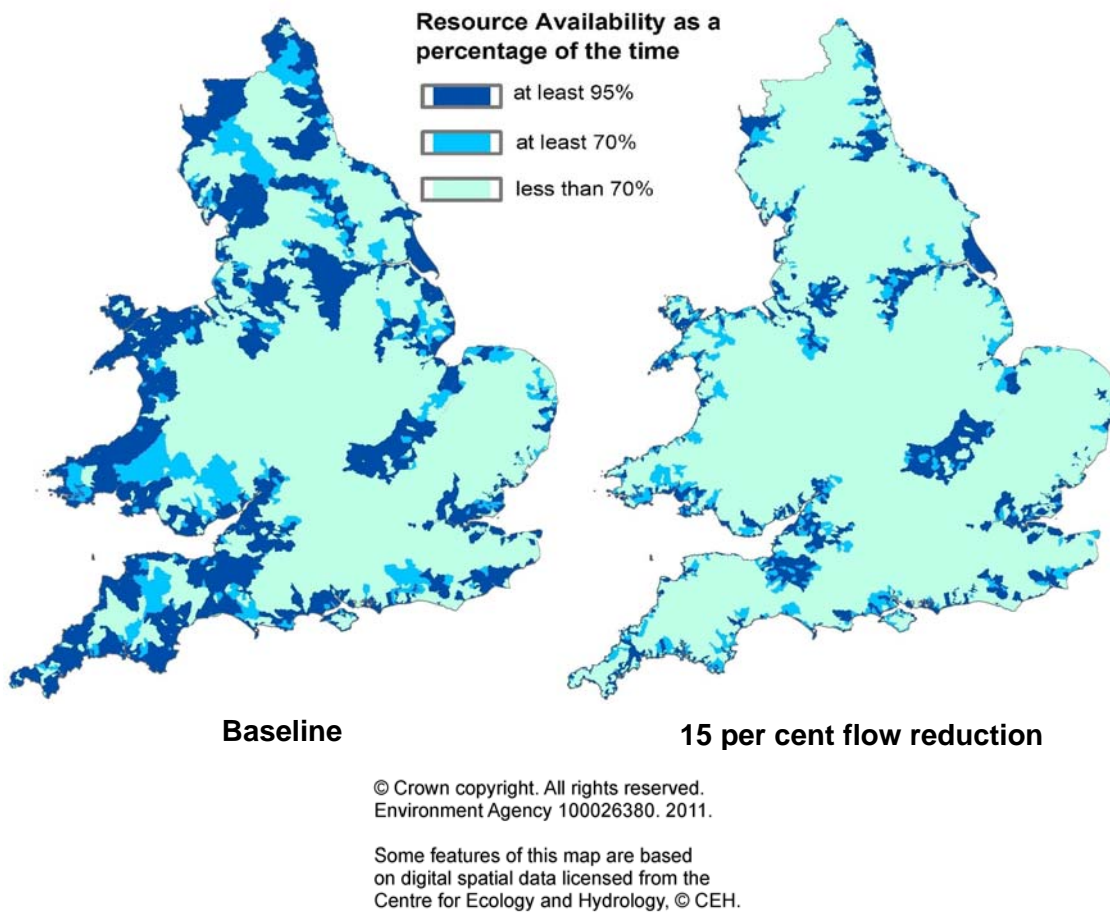


**Autumn (September, October, November)**

**Figure 3.1 Percentage change in mean natural seasonal flows by 2050. Increases in flow are indicated with shades of blue, decreases with shades of yellow/red and no change (-5 per cent to +5 per cent) is shown in buff.**

Climate change is likely to affect the frequency of drought<sup>12</sup> conditions. A Met Office study<sup>13</sup> on how climate change could affect the frequency of extreme droughts in the UK found a range of possibilities - the majority of them showing that droughts, such as the one that occurred in 1976 (one of the most severe droughts on record), will become more common.

To assess how climate change might affect the amount of water available for new abstractions we have analysed the impact of reduced flow on resource reliability. The analysis assumes a scenario where underlying river flows reduce by 15 per cent. This simplification doesn't correspond directly to the climate change scenarios presented in section 3.1.1 but the results can be used to indicate how the current approach to allocating water resources could operate if natural river flows decrease due to climate change. Figure 3.2 compares the current baseline reliability for new licences compared with a 15 per cent flow reduction scenario. As more available water is licensed for abstraction the reliability of further new abstraction will decrease. In drier years, abstractions with the more restrictive hands off flows conditions will have a lower reliability of abstraction and will be prevented from abstracting more often.



**Figure 3.2: Water reliability - percentage of the time water (both surface and groundwater) would be available to abstract for new licences. The reliability of existing licences is defined by licence and physical conditions.**

### 3.2 Protecting the water environment in the future

With changes to the amount and distribution of rainfall and an increase in temperatures, it is inevitable that the water environment of the future will be different to the environment seen today. Some species will be better suited to future conditions and thrive. But there is a risk that some important species and habitats could be lost. Iconic fish species such as Atlantic salmon and brown trout, which need cold water to thrive, may struggle to survive in some rivers. While plants and animals decline in some parts of England and Wales, they are likely to become more prevalent in other areas out competing species and habitats local to the area.

As the water environment changes with changing flow regimes and increased temperatures, we will need to reconsider what environmental flow limits we set (which could mean altering the Environmental Flow Indicators) and the implications for how much water we allow to be abstracted. This involves addressing very challenging questions as our understanding of the water needs of current water ecosystems is still developing. Climate change will create a new level of complexity on top of our current understanding which we have only just begun to tackle. We will need to work to improve our understanding so we can plan effectively for the future and integrate this understanding into future environmental protection standards.

### 3.3 Changing demands

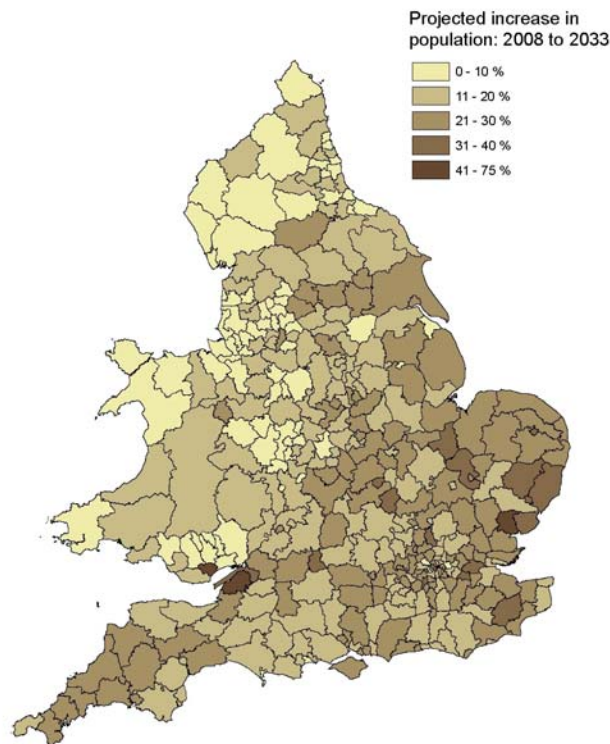
One of the biggest pressures on water resources is the projected population growth. By the 2030s, the total population of England and Wales is expected to grow by an extra 9.6 million people (9.2 million people in England and 0.4 million people in Wales<sup>14</sup>). Figure 3.3 shows that projections vary from place to place with the population in some parts expected to increase by over 40 per cent.

More people and homes in the future mean that household demand for water is likely to increase. Expanding and new communities will need support services, for example schools and shops, which will all need water. Growth will also impact water demand in other sectors. For example more water may be needed to irrigate crops for food production and in new electricity generation cooling processes.

The relationship between growth and forecast demand is complex. Many factors will determine how much water people and businesses will use in the future including the climate, water efficient technology, incentives for people and businesses to use water wisely and regulations. When thinking about the demand for water we have to make assumptions about how people will live and work, the technology that will be available, how people will use their leisure time and how they'll value the environment.

We<sup>15</sup> have looked at the potential effect growth, societal change and climate will have on future demand. It is impossible to know what the future will look like and if we had based our analysis on one possible future then we would almost certainly be wrong. To overcome this, the assessment looks at a range of potential future scenarios (figure 3.4) based on different types of society (conservationist through to consumerist) and governance (growth-focused through to sustainability focused). This identifies an envelope of possible future demands within which the actual future may lie, with no one scenario more likely to occur than any other. We considered the demand from households, from industry and commerce, from agricultural spray irrigation, water company leakage and from power generation<sup>16</sup>.





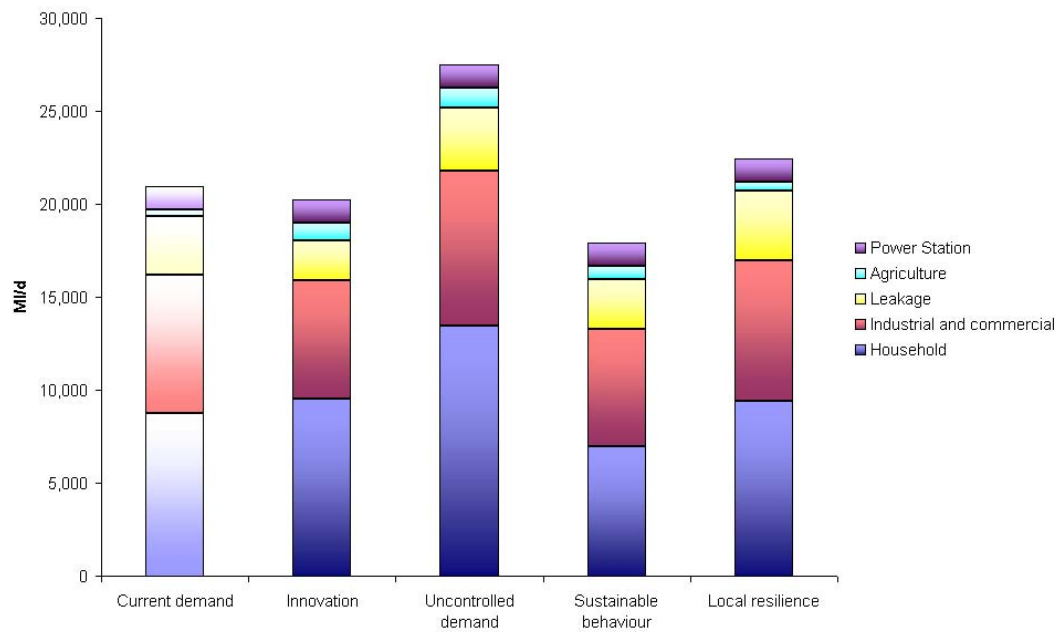
**Figure 3.3: Projected population growth: 2008 to 2033 (Source ONS)**



**Figure 3.4: Future scenarios**

By 2050, total water demand across the four scenarios varies from 15 per cent less than today to 35 per cent more (figure 3.5). The 'Sustainable Behaviour' and 'Innovation' scenarios indicate lower demand where people value water more and adapt to climate change through sustainable policies and substantial advances in technology respectively. The 'Uncontrolled Demand' scenario shows the extent to

which water demand could increase if policy and public attitudes do not focus on sustainable development. Appendix 1 provides details on the four scenarios.



**Figure 3.5: Trends in total water demand - 2008 to 2050 (England & Wales)<sup>17</sup>**

# 4 Quantifying pressures on water availability

The impacts of climate change, population growth and changes in lifestyle discussed in the previous chapter have been used to inform a range of projected futures. We look ahead to predict how much water might be available in the 2050s and how much water would be needed under these scenarios to protect habitats against the needs of a changing environment in the future. It is important that we understand the scale of the challenge for future water availability now, as planning and implementing solutions takes many years.

## 4.1 Developing an assessment of future water availability

We have discussed in section 2.1 how the Environment Agency assesses current water availability through Catchment Abstraction Management Strategies (CAMS). These assessments consider freshwater resources, abstraction demands and environmental requirements. We have used the same framework and tools we use for CAMS to look at a range of potential change around these elements in the 2050s:

- the effect of climate change on available freshwater supplies;
- the assumptions on the flow standards required to protect the environment;
- the likely demand for water from people, businesses and agriculture.

Quantifying water availability in the future is complex. We have had to make assumptions in order to simulate the complex local interactions between available resources and abstraction demands at a national scale. But by using a scenario based analysis on these elements we will indicate how the pressures on the water environment and supply system could increase in the future. Appendix 2 provides more information on the methods and assumptions used.

## 4.2 Available freshwater resources

The CAMS tools look at the amount of water that is available for abstraction. This takes into account natural flows, abstractions, discharges, strategic infrastructure and environmental needs.

We have tested the sensitivity of available resources to climate change by updating the natural flows in the CAMS tools to reflect the scenarios presented in section 3.1.1. We have concentrated our assessment on summer flows. This is defined as Q70, that is, the long-term average flow which is exceeded 70 per cent of the time. Although the availability of water for abstraction varies through the year, the balance between available resource and demand for abstraction is of greatest significance during the summer. This is the period during which the ecological health of rivers is most sensitive to abstraction pressure.

Each of the scenarios, in section 3.1.1 (referenced by the letters A to K), is based on a different combination of meteorological and hydrological conditions, as described in a separate report<sup>7</sup>. The change in flows varies between the scenarios, both quantitatively and spatially,. We have chosen to look at four of the eleven climate change scenarios to reflect a range of the predicted outcomes, from minimal change in flows (scenario A) to greater changes in flows at different locations (scenarios C, G and J; Figure 4.1). Concentrating on just four scenarios means the analysis is more manageable, although the range of outputs will be smaller. The results should be considered within the context of all eleven, and the potential for precipitation changes beyond this range. The maps in figure 4.1 show that the climate change impacts on flow vary throughout England and Wales under the four scenarios.

- Under scenario **A** the biggest impact can be seen in Powys, southern Wales and Essex.
- Under scenarios **C** and **G** Wales, northern and south west England see the biggest reduction in flows. Whilst under scenario C, limited areas (parts of Anglian) see an increase in flows.
- Under scenario **J** central parts of England and Wales, and south east and south west England see the biggest reduction in flows.

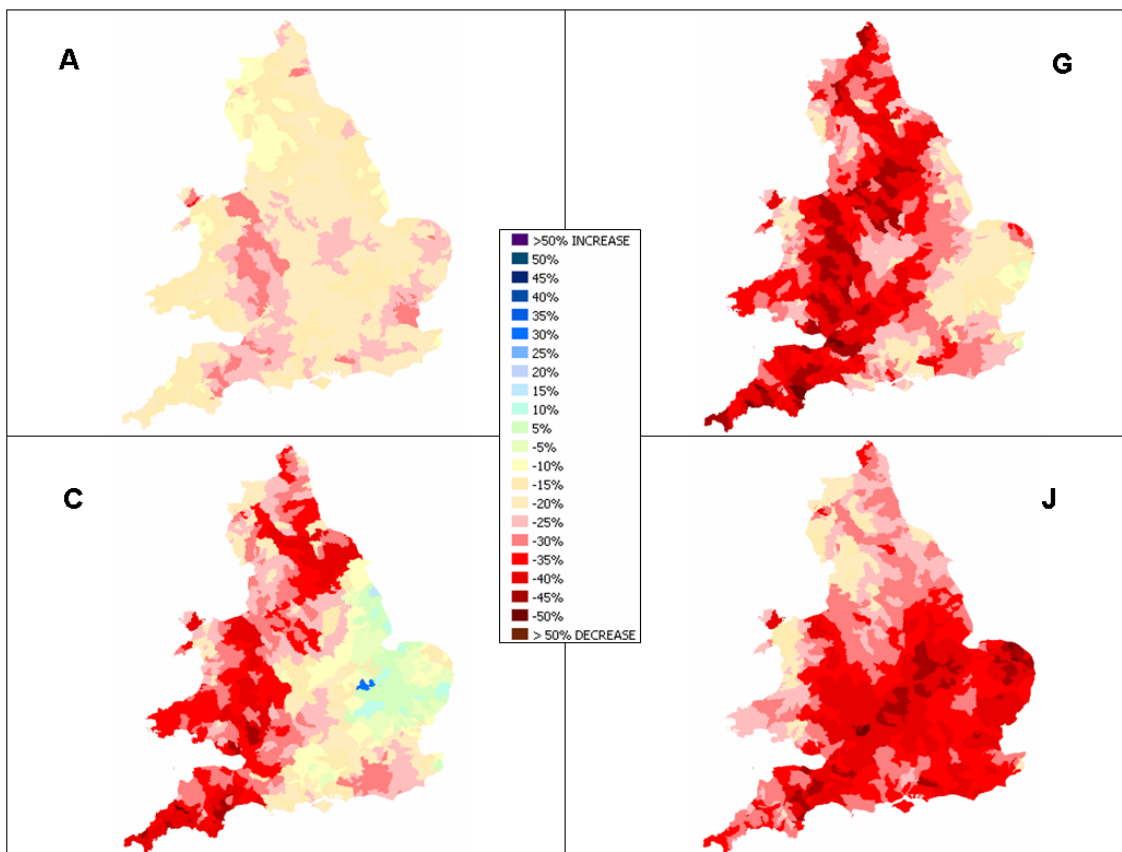


Figure 4.1 Climate change scenarios: changes in flow at Q70

#### 4.2.1 Environmental requirements

To quantify how much water could be available for abstraction in the future under these scenarios we must make assumptions about how much will need to be held back to

protect the environment. Our understanding of the needs of the environment under a changing climate is still developing. We have therefore used two scenarios:

- Using the current Environmental Flow Indicator (EFI) thresholds and assuming that the flow is fixed at those levels to meet environmental requirements including continuing to support WFD Good Ecological Status (GES). There are two big assumptions in using this scenario. Firstly, this does not represent the current status in all water bodies. We believe there may be as many as 1075 water bodies in England and Wales (11 per cent of total) where river flows are at risk of not supporting good ecological status and 35 per cent of groundwater bodies are not achieving good groundwater quantitative status. In some places, the cost of actually achieving GES by ensuring flows meet the EFI thresholds may be disproportionately costly and never achieved. Secondly, until local investigations are completed we cannot be sure that these nationally set indicators are at the right level to mitigate damage to the environment. However, the scenario provides a consistent baseline across all catchments in which to test the pressures of climate change and growth against.
- Using the same percentage deviations from natural flow as the current EFI thresholds, but applying them to a future flow scenario. This keeps the proportion of environmental flow protection the same as it is now, but the volume of water available for abstraction changes to reflect changes in the natural flow.

These are both coarse scenarios but represent the sensitivity of water availability to two very different views of future environment protection.

#### **4.2.2 Abstraction demands**

We have used the scenarios presented in section 3.3 to look at the range of abstraction demands in the future. We analysed all four scenarios but have presented two in this report showing the lowest and highest variability. The scenarios consider demand from households, from industry and commerce, from agricultural spray irrigation, water company leakage and from power generation. We have applied growth (or decline) rates for each of the scenarios to recent actual abstraction to give us predicted abstraction demands for the 2050s. The demands equate to expected abstraction rates at summer flows - to correspond to the assessment of freshwater resources.

### **4.3 Calculating water availability in the 2050s**

We have combined the analysis of available resources, abstraction demands and environmental requirements to test the sensitivity around where there could be unmet demand in the future. The analysis presented here should not be used to drive planning for and management of water resources. Rather, the work uses best available evidence to look at the possible impacts of future pressures which can be used to inform understanding of the scale of the challenge. Water companies manage and plan for supply and demand as part of their long term management plans, however here we consider all types of abstraction and look further to the future.

Increased demand and the effect of climate change on flows could be so great that it could mean that there isn't enough water available for abstraction nor to protect the environment. Some areas in England and Wales that already experience pressures will face even bigger challenges than others in the future. Figure 4.2 shows where this will be a problem at river basin district level. The Thames, Severn and Dee River Basin

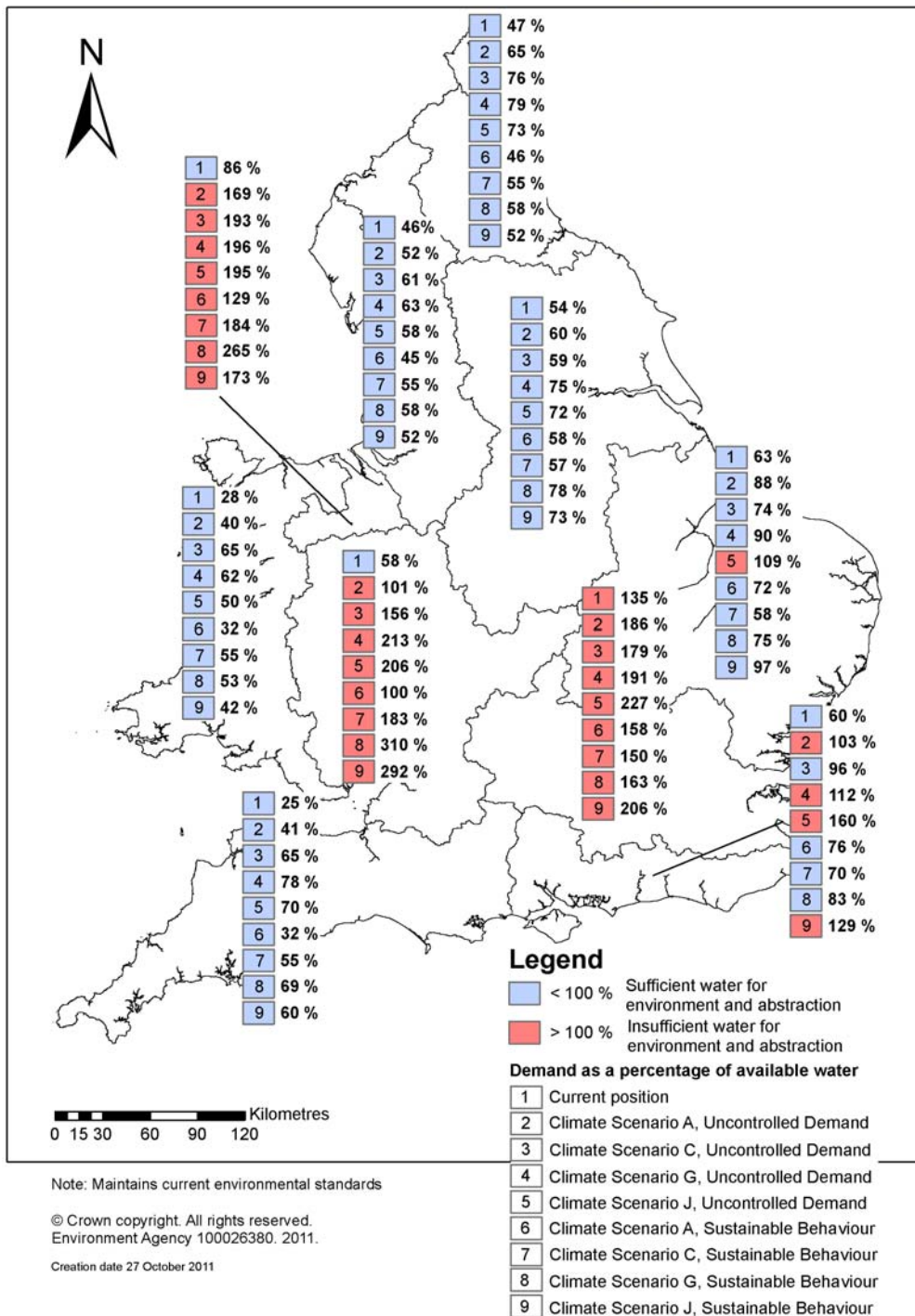
Districts in particular, show unmet demand across almost all scenario combinations. However, not all catchments will experience the same pressures at the same point in time. The analysis is based on Q70 flows and it is unlikely that all parts of England and Wales will be at that level at the same time.

We have also looked at scenarios of unmet demand at a catchment scale to capture local variations (figure 4.3). If climate change reduces summer flows to the extent shown by several of the scenarios, there could be resource shortfalls in around half of the catchments. To understand the possible impact at very low flows, we have also presented results for Q95 (the long-term average flow which is exceeded 95 per cent of the time) in Appendix 3.

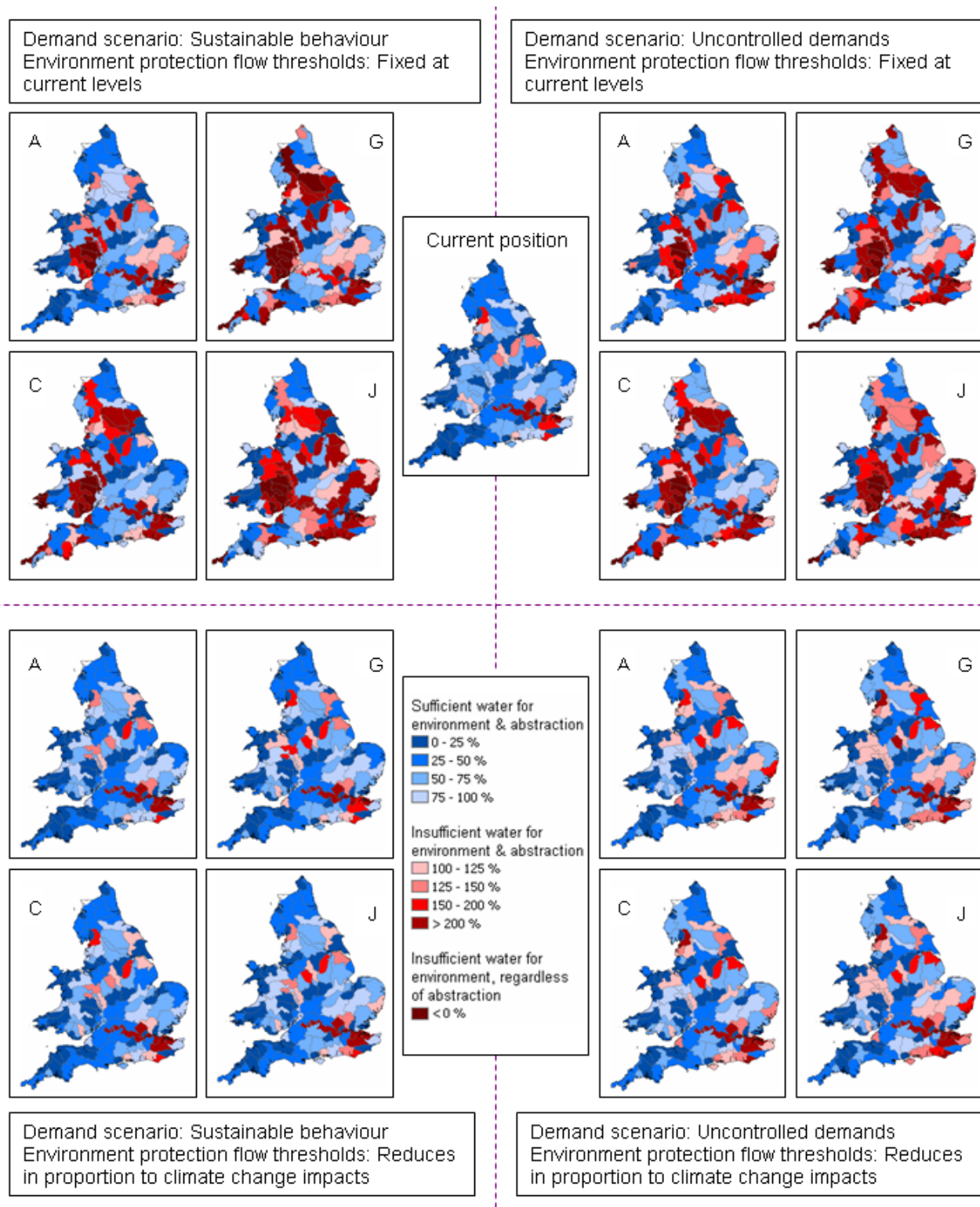
The geographical spread of catchments that won't be able to meet projected future demand is often related to the pattern of climate change impacts in the scenarios A, C, G and J. For example, when looking at scenarios C and G where the biggest reduction in flows due to climate change impacts is predicted for Wales, south west and northern England, these catchments also experience the most unmet demand in the modelling. Catchments with a large predicted reduction in flows are more likely to experience unmet demand.

The situation is projected to change significantly across England and Wales if environmental requirements for water change due to the impact of climate change on flow. Figure 4.3 shows that the number of catchments facing unmet demand for abstraction is much less widespread in the scenarios where water requirements for the environment are allowed to change in proportion to changes in flows due to climate change. Despite the environmental thresholds being met if they were to be lowered in proportion to flow, in absolute terms there will be significantly less water in rivers than the fixed scenario. This is likely to result in greater environmental impacts.





**Figure 4.2: Potential unmet demand in the 2050s at Q70. Results are presented for river basin districts, all results are for fixed current environmental flow standards (100% indicates supply = demand, less than 100% shows supply is greater than demand, more than 100% shows supply is less than demand).**



**Figure 4.3: Potential unmet demand in the 2050s at Q70 (Demand as a percentage of available water). Results are presented by catchment for climate change scenarios A,C,G and J**

## 4.4 Managing water availability

The results show that for many of the scenarios there will be unmet demand. The possibility of unmet demand is a risk which must be managed carefully. To manage the risks to meeting the needs of people, business, agriculture and the environment in the future, action to deliver regulatory reform and to manage supply and demand will be necessary.

Proposing a specific solution to increase water availability for each of the scenario combinations would require detailed investigations. This is not appropriate for this high level assessment and would not be very helpful, as the scenarios are a narrow range of plausible futures. In reality, planning for all uses of water will include many organisations, including regulators, water companies, and abstractor groups.

However, we can assess the relative scale of water that may need to be saved or developed. To test this, we have looked at how demands could be met for one of the scenario combinations that poses a significant challenge to water availability, that is the Uncontrolled Demand scenario and climate change scenario J. This scenario suggests the biggest reductions in flow as a result of climate change in South East England. The scenario also assumes that current EFIs continue and future water ecosystems will still require current water levels to protect them.

To do this we have used the demand scenarios presented in section 3.3 to indicate to what extent water efficiency can help in meeting demand. The Sustainable Behaviour scenario includes strong drivers for reducing demand and the attitude of people and businesses reflects environmental values<sup>5</sup>. We have compared this scenario to the Uncontrolled Demand scenario and assumed that the difference between them shows the possible saving from water efficiency. This is though a very ambitious scenario in terms of improvements in water efficiency.

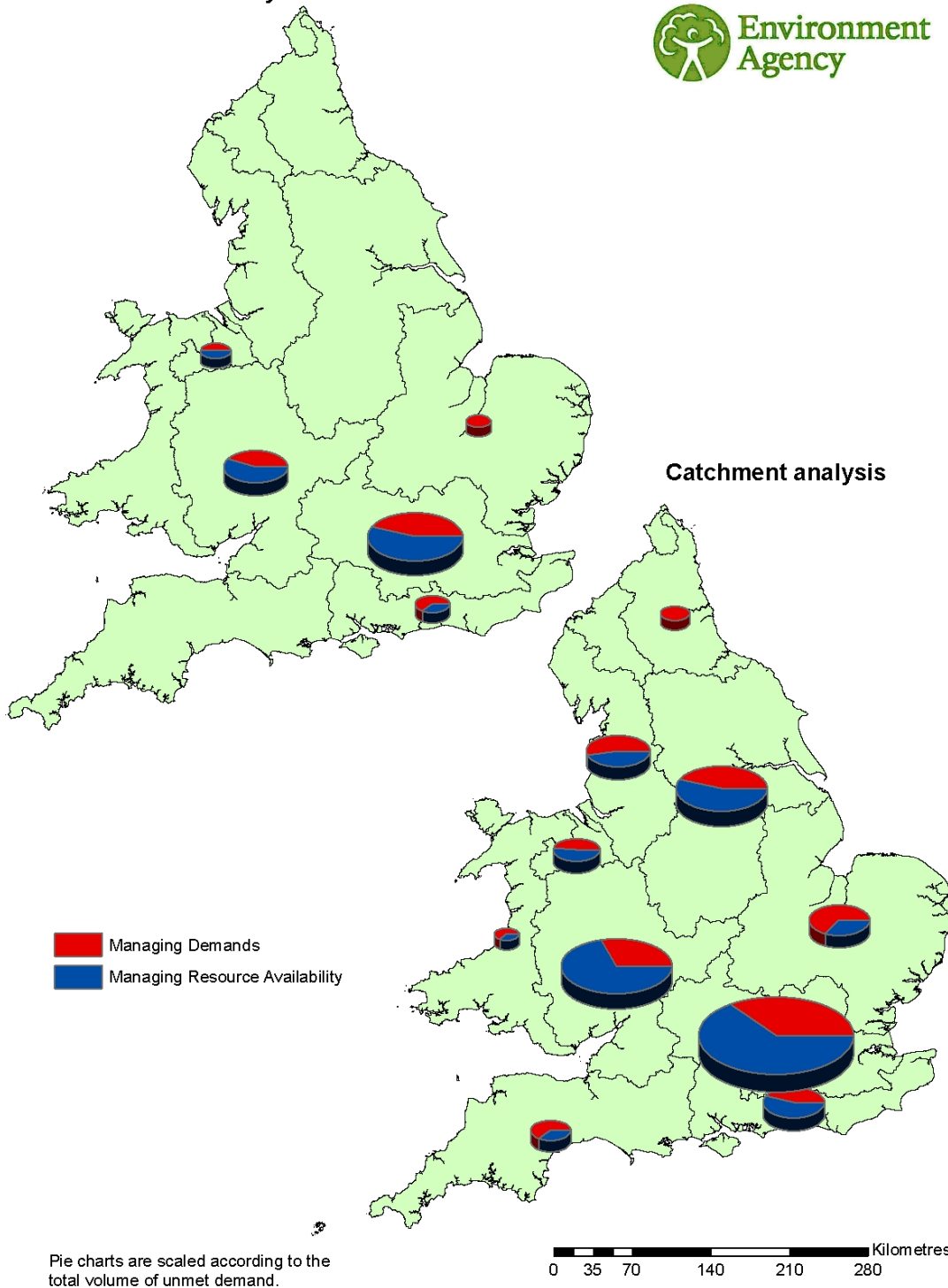
Once we calculated the possible saving from demand management, we then assumed that any remaining shortfall would need to be met by improving infrastructure or developing new resources. We did the analysis at river basin district level and then repeated it for catchments. The results are presented in figure 4.4.

Managing water availability at river basin district level means that any local surplus or deficit could be spread across the region. This represents a situation where resource schemes such as reservoirs could be shared by different sectors and demand management initiatives like water efficiency in homes are implemented without geographical constraints. Across England and Wales under this scenario unmet demand equates to around five times the amount needed to supply homes within greater London.

By contrast, the catchment results show that trying to manage water resources at a catchment level increases the size of the problem. Across England and Wales under this scenario unmet demand equates to around eight times the amount needed to supply homes within greater London.

The results in figure 4.4 are only theoretical to illustrate the significance of the pressures to be managed. In reality, licence controls and infrastructure could be put in place to balance available water and demands in time and space. And the best resource development and demand management balance, with the right level of certainly, costs and benefits, could look quite different to what is presented here.

## River basin district analysis



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**Figure 4.4: Contributions from demand and resource management to ensure there is enough water for people and the environment.**

# 5 Conclusions

We have set out some of the challenges for water resources in this report and looked at the influences of different pressures on future availability.

Quantifying water availability in the future is complex. We have had to make many assumptions about how society will use and value water, how climate change might alter river flows in the future and how that will affect the volume of water that can be abstracted from catchments. We have also made assumptions to simulate the complex local interactions between available resources and abstraction demands at a national scale.

Despite these caveats the analysis is appropriate to show that there are potentially significant pressures for water resources in the future. There are a number of conclusions we can draw from this work:

**Water resources are already under pressure.** Reliable supplies of additional water for abstraction are not available across much of England and Wales. In some places current levels of water abstraction are already harming nature conservation sites or the ecological health of catchments.

**There is uncertainty regarding future water availability.** We have not assessed every possible future. But, we have captured a range of possible outcomes for each river basin district or catchment. The outlook depends on the assumptions we make about climate change impacts; changing demands and water needs for environmental protection. As the severity of pressures on water resources will vary across England and Wales and in order to deal with a wider range of plausible futures than have been considered here, the approach for managing them will need to be adaptive and flexible.

**All of the scenarios we have looked at project a situation with less water available than today.** This includes the scenarios where needs for water ecosystems change in proportion to climate change impacts on flows. Although only a limited number of scenarios have been considered, we believe it would be prudent to put measures in place to address the risk of reduced water availability.

**The challenge of future water resource availability is not likely to be limited to the south and east of England.** Catchments across Wales, south west and northern England are predicted to experience significant unmet demand under many of the scenario combinations we have looked at.

**The water environment will be different from that of today. Some species will be better suited to future conditions than others.** We will need to reconsider environmental needs and implications on water available for abstraction.

**Over the longer term climate change could have a bigger impact on future water availability than population growth and changing demands.** The geographic spread of catchments predicted to face unmet demand is more closely related to the climate change scenario than to demand.

**Demand management will an important role to play in improving water availability in the 2050s. However, demand management alone will not fix the problem,** climate change impacts could result in significant new water resources being necessary.

**The scale of the problem needs to be assessed at both local and strategic levels.** Analysing water availability for river basin districts hides significant local problems. For example, the results show that water is available for abstraction across the Anglian River Basin District in a scenario with low demand<sup>18</sup> as any local surplus is shared out



at this regional scale. But, the catchment analysis shows that eight out of thirteen catchments in this region could face unmet demand under the same scenario. Solutions, such as local trading of licences would be best assessed at a local scale. However, some large scale development solutions, such as new reservoirs **are best planned for at a strategic level**. Interconnectivity of water resources between catchments will be an important part of the solution.

# Appendix 1

## 2050s demand scenarios

The demand scenarios are defined on one axis in terms of societal attitudes and behaviour around consumption, in particular of material goods. At one end of the axis, consumption patterns are constrained. At the opposite end, individuals exist in an intensified 'desire' economy in which there is greater consumption of goods and experiences.

The second axis refers to international governance systems. At one end, governance systems and decision making focus on longer term sustainability concerns, such as climate change and resource depletion. At the opposite end, governance is based on rules concerning competitiveness and open markets, to maximise economic growth.

Total demand under the **Innovation scenario** falls by just under five per cent. The core drivers of demand here are the level of regulation and the resulting technological innovation. This is a world where society expects Government and scientists to solve the problems of climate change and resource shortfalls so they can carry on living their lives as they wish. Although sustainable development is at the core of the scenario, this is delivered through means other than a shift in societal values.

Total demand under the **Uncontrolled demand** scenario rises by about 35 per cent. The focus on growth and consumerism under this scenario is clearly reflected in the water demand figures. The scenario shows what could happen to demand where neither society nor Government takes action to control the demand for water (or many other goods). With the focus on cutting costs, water and energy efficiency measures are often forgotten or are at least given a lower priority. The result is a very large increase in demand.

Total demand under the **Sustainable behaviour** scenario falls by about 10 per cent. Individuals pride themselves in being as efficient as possible and being seen as 'green' is a positive attribute. This drives demand down in most sectors. But as it is primarily achieved through good will, the savings could be seen as more vulnerable than those achieved under some other scenarios.

Total demand under the **Local resilience** scenario rises by about 10 per cent. This scenario is driven by a need to implement efficiency measures in order to get by. The level of efficiency savings that can be achieved are controlled by the limited technology available and by limited funds for investment in the technology that does exist. The Government has neither the capital nor the political will to invest in strong regulation under this scenario and hence the drive to find improvements is limited. In addition to this, because people's drive to use less (of everything) is controlled by the need to survive rather than a desire to protect the environment, the savings they are prepared to achieve are limited.



## 2050s demand scenario assumptions

	Baseline	Innovation	Uncontrolled demand	Sustainable behaviour	Local resilience
Population	53,700,000	<b>73,600,000</b>	<b>78,500,000</b>	<b>66,100,000</b>	<b>64,000,000</b>
Per capita consumption (l/h/d)	155	<b>125</b>	<b>165</b>	<i>110</i>	<i>140</i>
Household (MI/d)	8,500	<b>9,250</b>	<b>13,000</b>	<i>7,250</i>	<b>9,000</b>
		High rates of retrofitting and refurbishment. High efficiency standards for new homes.	Profligate attitudes increase use of high water using goods. Outdoor use high for garden watering and water based recreation.	Reduction in demand primarily due to attitude to efficiency. More composting toilets and rainwater harvesting.	Attitudes shift to saving water but less innovation and inefficient old goods. Leisure time is less important as is outdoor water needs.
Industry and Commerce (MI/d)	7,500	<i>6,250</i>	<b>8,250</b>	<i>6,250</i>	<b>7,500</b>
		Closed loop systems are the norm. Industrial water neutrality.	Drive is to do things cheaply and quickly. Lack of innovation means water use rises.	Reduction in demand primarily due to attitude to efficiency. R&D centrally funded to drive low cost technology.	Reduced demands for goods and services offsets increase in water use per unit from inefficiency
Leakage (MI/d)	3,000	<i>2,250</i>	<b>3,500</b>	<i>2,750</i>	<b>3,750</b>
		Strong regulation drives reduction in leakage. High levels of technology and innovation.	Leakage rises due to weak, inefficient regulation. Small local ownership of networks lacks economies of scale.	Customer expectations drives lower leakage. Good use of technology where available.	Rise in water consumption due to weak regulation. Limited maintenance of networks.
Agriculture (MI/d)	375	<b>950</b>	<b>1,000</b>	<b>725</b>	<b>475</b>
		Lots of choice in smart technology at low cost. High water use efficiency (in terms of 'crop per drop' – and low wastage).	Farming becomes more intensive. Increase in water use because of high quality expectations.	People accept what the climate gives them, rather than irrigate. Farmers are subsidised so efficiency is more widely practised.	Significant increase in area under cereal / vegetable crops. Lack of available technological innovation to reduce water demand.
Total demand (MI/d)	19,250	<i>18,750</i>	<b>26,000</b>	<i>17,000</i>	<b>20,750</b>
(% change from baseline)		<i>-4</i>	<b>35</b>	<i>-10</i>	<b>8</b>

**Bold** is an increase from the baseline  
*Italics* is a decrease from the baseline

Note: Due to evidence limitations, the forecasts for energy generation assume that water demands for this sector remain constant at around 1,250 MI/d (freshwater consumptive use). The data from the baseline year has been carried through the analysis to 2050. We know that the number and location of power stations will change in the future and that their cooling systems will continue to require water. However, we don't yet know how much water will be needed or how much freshwater will be consumed by these systems. We are working with the energy sector to look at this further.

# Appendix 2

## **An assessment of future water availability: method and assumptions**

The assessment of available resource and demand for abstraction scenarios has been undertaken using the Water Resources GIS (WRGIS). This is our primary tool for undertaking national assessments of abstraction pressures to support Catchment Abstraction Management Strategies (CAMS) and the hydrological components of the Water Framework Directive (WFD).

The WRGIS is not a hydrological or hydrogeological model but is based on national datasets of natural river flows and artificial influences, which includes surface water abstractions, groundwater abstractions, discharges and other more complex impacts such as reservoirs and water transfers. The datasets are updated and improved through an iterative process based on Environment Agency local staff knowledge and surface water and groundwater models. The assessment has used the March 2011 edition of the WRGIS which had been updated with improved datasets from approximately 70 per cent of CAMS Catchments, although there are areas where further improvements will be uploaded in 2011/12.

This work concerns understanding the balance between available water resources and the demand for abstraction for both Q70 and Q95 flows and has been reviewed by an independent panel of water resources experts. The components of available resource and demand for abstraction are described below.

**Available Resource:** Water available for abstraction whilst maintaining sufficient flow to support aquatic ecology. There are three components as defined as follows:

The **natural available resource** is the water available for abstraction in a catchment without breaching the Environmental Flow Indicator (EFI) and is calculated as the difference between the natural flow and the EFI in a catchment. In addition to the natural available resource we take account of flow to rivers through discharges and other flow influences. Groundwater also provides an important source of baseflow to rivers and is included in the assessment.

The **discharges** component includes the return of abstracted water to freshwater river reaches where there would be the potential for abstraction downstream.

**Other flow support** is received from reservoir storage and release, inter-catchment transfers and flow augmentation schemes.

**Demand for Abstraction:** The unrestricted demand for abstraction; that is the abstraction that abstractors want to have, rather than the abstraction that regulation or physical conditions would allow.

Abstraction in England and Wales is subject to a licensing system where each licence is limited with respect to the total volume of abstraction, maximum abstraction rates, the months during which pumping is permitted and, in some cases (20 per cent of licences from non-tidal sources) 'hands off flow' conditions that specify river flows below which abstraction is reduced or ceased. As Government has signalled that regulation will be reformed we cannot say how all licences will be regulated or restricted in the future. We have therefore looked at unrestricted demands to understand the scale of the challenge in the future scenarios by removing abstraction limits and hands off flow conditions.

This work has looked at actual abstraction rates and projections from this baseline, rather than annual licensed volumes and assumes that the same sort of abstractions,

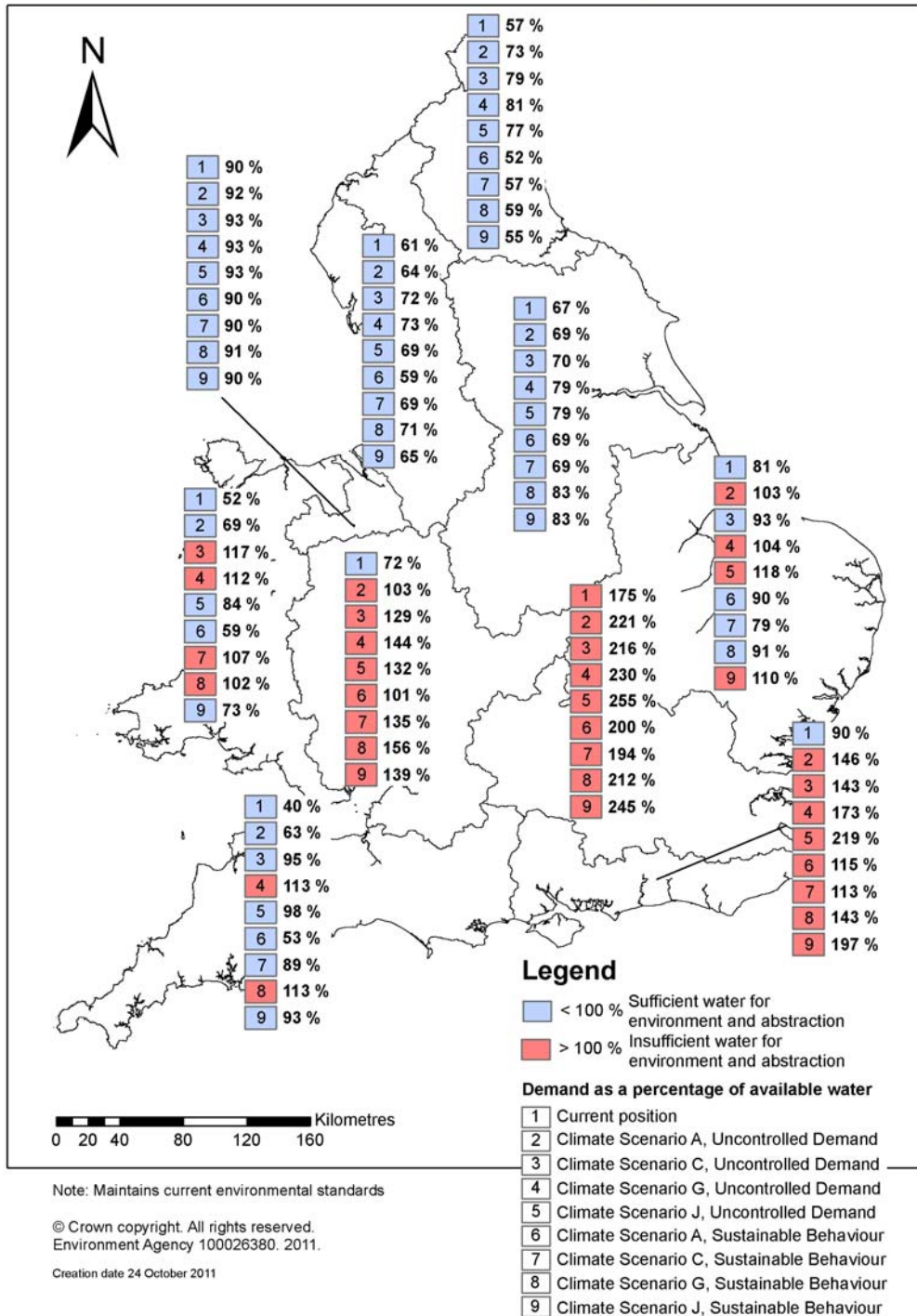
in terms of use and location, will occur across the flow duration curve in the 2050s as they do today.

**Surface water** abstractions have been represented “as pumped” from rivers with impacts summarised across flow duration curves according to the relationship between month of pumping and typical flow distribution through the year. This distribution has been taken from the CAMS datasets held in the WRGIS.

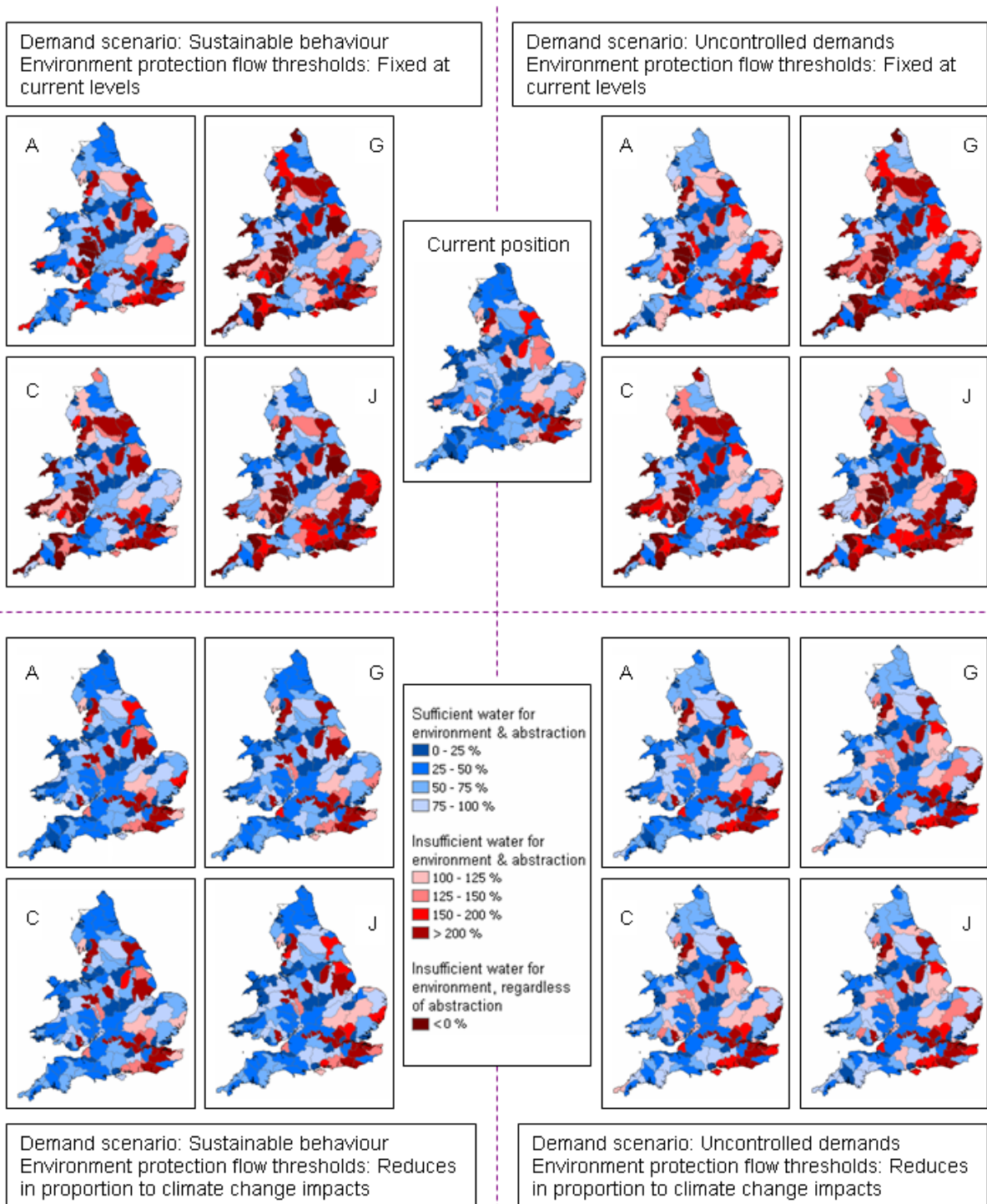
**Groundwater** abstraction impacts have been spread across surface water flow duration curves using factors which take account of the spatial and temporal distribution of abstraction impacts. These assumptions are taken from CAMS datasets in the WRGIS and often draw on understanding from groundwater modelling studies. Hands-off flow thresholds are not applied to groundwater abstractions in the assessment, so it has not been necessary to make any adjustments to the WRGIS groundwater abstractions dataset.

# Appendix 3

## Scenarios of unmet demand at a catchment scale- results for Q95



**Potential unmet demand in the 2050s at Q95. Results are presented for river basin districts, all results are for fixed current environmental flow standards (100% indicates supply = demand, less than 100% shows supply is greater than demand, more than 100% shows supply is less than demand).**



**Potential unmet demand in the 2050s at Q95 (Demand as a percentage of available water). Results are presented by catchment for climate change scenarios A,C,G and J**



# References and endnotes

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<sup>1</sup> A manageable unit of surface water, being the whole (or part) of a stream, river or canal, lake or reservoir, transitional water (estuary) or stretch of coastal water. A 'body of groundwater' is a distinct volume of underground water within an aquifer.

<sup>2</sup> In England there are approximately 20,000 licences and in Wales 1,500 licences.

<sup>3</sup> 21 per cent of all licences in England have a time limit and 15 per cent of all licences in Wales.

<sup>4</sup> In England 17 per cent of all licences have restrictive conditions whilst 19 per cent of all licence do in Wales.

<sup>5</sup> In England, 55,000 MI/d of water is licensed of which 22,000 MI/d is abstracted (around 40 per cent). In Wales, 20,000 MI/d is licensed of which 12,500 MI/d was abstracted (around 65 per cent).

<sup>6</sup> ABSTAT is the Abstraction Statistics report that is prepared by the Environment Agency. It reports estimates of licensed and actual abstraction for each calendar year (1 January to 31 December). Information on ABSTAT is published on the Defra website.

<sup>7</sup> Water companies have a legal obligation to protect sites under the Habitats Directive. Ofwat therefore considers these schemes as part of the Price Review process.

<sup>8</sup> In press, Journal of Hydrological Processes Today.

<sup>9</sup> We have used the medium emissions scenarios as there is a wide range of variability within this emissions scenario similar to that between different scenarios. By looking at the full range of outcomes from the medium emissions scenario, most of the range of the low and high emissions scenarios are also being covered.

<sup>10</sup> The values quoted are the 10th and 90th percentiles: changes are very likely to exceed the 10th percentile and very likely not to exceed the 90th percentile.

<sup>11</sup> In the south of England predicted changes to summer precipitation range from -39mm (10th percentile) to 16mm (90th percentile) with a median of 14mm. In the north of England it ranges from -34mm to 8mm with a median of -14mm. Summer precipitation in Wales may range from -33mm to 13mm with a median of -12mm.

<sup>12</sup> A drought happens when a period of low rainfall creates a shortage of water for people, the environment, agriculture, or industry. Some droughts are short and intense, for example, a hot, dry summer, while others are long and take some time to develop. Indicators of a drought vary across England and Wales because each water body is different.

<sup>13</sup> An extreme value analysis of UK drought and projections of change in the future, Met Office, 2010. Journal of Hydrology.

<sup>14</sup> Based on 2033 projections taken from the ONS: 2008-based National Population Projections Statistical Bulletin – October 2009.

<sup>15</sup> Water in the 2050s, Environment Agency 2011.



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<sup>16</sup> Due to evidence limitations, the forecasts for energy generation assume that water demands for this sector remain constant. The data from the baseline year has been carried through the analysis to 2050. We know that the number and location of power stations will change in the future and that their cooling systems will continue to require water. However, we don't yet know how much water will be needed or how much freshwater will be consumed by these systems.

<sup>17</sup> For demand across the four scenarios in Wales refer to: Water for people and the environment. Water Resources Strategy for Wales. Environment Agency 2009.

<sup>18</sup> Scenario: Sustainable behaviour demands, climate change scenario j, fixed EFIs.

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