The state of the environment: water resources

May 2018

Chair's foreword

Since the mid-eighteenth century, England's winter rainfall has increased and summer rainfall has decreased. Climate change, population growth and land use change mean river flows and groundwater levels may decrease in future summers.

The time it takes to refill water supplies, coupled with our variable weather conditions and diverse landscape, means we could increasingly see water shortages in some areas at the same time as flooding in others.

We have good reason to talk about the weather in England, but we need to do more than just talk. If we do not increase water supply, reduce demand and cut down on wastage, many areas will face significant water deficits by 2050, particularly in the south east. The National Infrastructure Commission recently reported that if the water industry does not improve infrastructure and water efficiency we risk a future without enough water for people, business, farmers, wildlife and the environment.

The Environment Agency plays a major role in protecting water resources. We respond to pollution incidents, prosecute offenders and improve water quality along rivers and beaches. We also regulate the abstraction system, which has served us well for over 50 years but now needs reform, introducing greater flexibility to meet the needs of a changing climate.

Current levels of abstraction are unsustainable in more than a quarter of groundwater bodies and up to one-fifth of surface waters, reducing water levels and damaging wildlife. In December 2017, we published a new plan with Defra to address this, making full use of our regulatory powers, local knowledge and partnerships.

Three billion litres of water a day are lost through leakage, equivalent to that used by over 20 million people. Water companies should pursue more ambitious water resource management plans that are resilient to future stresses, develop new resources, support environmental objectives and incorporate better ways to manage and share resources. We will review these plans with Ofwat, Natural England and Natural Resources Wales.

We work closely with water companies and are supporting the development of the national policy statement for water. This will help the development of nationally significant infrastructure by streamlining the planning system, making it easier for water companies to build new schemes such as transfers or reservoirs.

More than a third of freshwater abstracted is used for electricity supply and other industries. All industry should look at cost-effective ways to use water more efficiently, and to invest in resilience to climate change. Climate resilience is not just a necessary precaution, it's an investment. Last month, the Governor of the Bank of England spoke of the major investment opportunity climate change brings in long-term infrastructure. It can also unlock future growth with technical innovation, skills and expertise.

We can all do more. The average person in England uses 140 litres per day, a significant amount is wasted. We will work with government and the water industry to agree a personal consumption target and cost-effective measures to meet it. Right now, you can find simple advice at www.waterwise.org.uk/save-water/.

Thank you to my colleagues for this overview of England's water resources in 2018. By understanding the current state of the environment, we enrich the debates about how to best nurture it in the future.

At the time of writing it is nearly summer, I hope everyone gets enough rain to water the garden this year, but also enough sunshine to go outside and enjoy it.

Emma Howard Boyd, Chair of the Environment Agency

Key findings

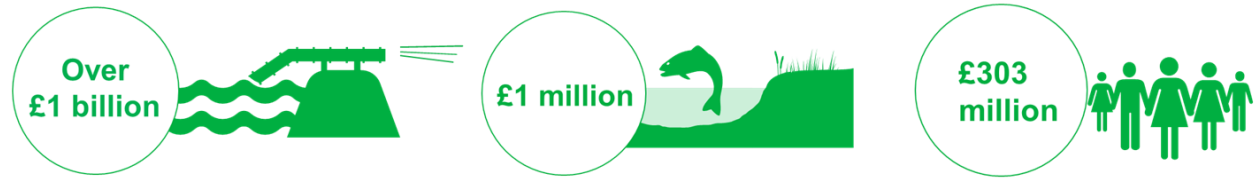
- Impacts of pressures on water resources are evident and will increase with a growing population, changing climate and changes to how we use land.
- Abstraction, drainage and altered water levels are major causes of damage to wetlands.
- In 2017, abstraction from around 28% of groundwater bodies and up to 18% of surface waters was at higher than sustainable levels.
- In 2016, unsustainable abstraction prevented at least 6% and possibly up to 15% of river water bodies from meeting good ecological status or potential.
- Winter rainfall has increased since the mid-18th century; summer rainfall has decreased slightly over the same period.
- High winter river flows have increased over the past 30 years, with a subsequent increase in the frequency and magnitude of flooding.
- There is no clear trend in droughts, but summer river flows and groundwater levels may decrease in the future.

Water resources in England

Water resources management is about balancing the abstraction of water for people to use against the requirements of the natural environment. Water is taken from rivers, lakes, reservoirs, estuaries and groundwater for a wide range of uses. In England, almost 9,500 billion litres of freshwater were abstracted in 2016. That is enough to cover Greater London in nearly 6 metres of water, around the height of a 2-storey house from ground to eaves. Water is neither lost nor gained during its journey through the water cycle. However, the point where it is returned to the water environment can be a long way downstream of the abstraction point or even straight into the sea. Water is a key element of our natural capital - the elements of the natural environment which provide valuable goods and services to people[1] (figure 1).[2]

Figure 1

Annual monetary values of some of the services provided by UK freshwaters (2015)



Value of UK **freshwater abstraction** (excluding groundwaters) in 2015

Value of **fish caught in UK inland waters** in 2015

Value of **time spent at UK freshwater habitats** in 2015

State and trends

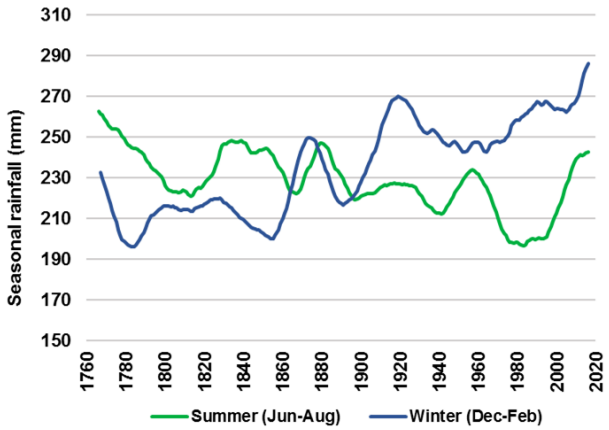
Effective rainfall

Nearly half of all rainfall is lost by evapotranspiration. Evapotranspiration is water leaving the land surface via uptake by plants or by evaporating. The remaining water runs off into rivers and streams or percolates into groundwater. This amount remaining is known as effective rainfall. Effective rainfall varies across England, from more than 2,500mm per year in the Lake District to less than 200mm in parts of eastern England.

Average annual rainfall in England has not changed since records began in the 18th century.[3] This is not the case for seasonal rainfall (figure 2). There has been an increase in winter rainfall and a slightly smaller reduction in summer

Figure 2

Seasonal rainfall in England and Wales, 1766 to 2016



Data source: Kendon, M., McCarthy, M., Sevrejeva, J, and Legg, T. (2016) State of the UK Climate 2016. Met Office, Exeter.

[1] Natural Capital Committee definition (www.gov.uk/government/collections/natural-capital-committee-documents).
[2] All monetary values in figure 1 are from the Office for National Statistics - ONS (2017). Statistical bulletin: UK natural capital: ecosystem accounts for freshwater, farmland and woodland (www.ons.gov.uk/economy/environmentalaccounts/bulletins/uknaturalcapital/landandhabitatecosystemaccounts#ecosystem-accounts-for-freshwater).
[3] Watts, G. and Anderson, M. (eds). (2016) Water climate change impacts report card 2016. Living With Environmental Change (https://nerc.ukri.org/research/partnerships/ride/lwec/report-cards/water/).

rainfall. However, a recent run of wet summers makes the summer trend more difficult to interpret.[4]

Drought can develop during periods of unusually low rainfall, particularly where there is a succession of dry winters.[5] There is no clear trend in the frequency or intensity of droughts.[3] Drought and water scarcity have been of increasing public concern over recent decades.[6]

The consequences of drought for society, the environment and the economy can be severe. Extreme drought would lead to increased pressure on health services and reductions in power generation and agriculture production. Farmers might lose money through crop damage or animal disease and deaths, as well as having to pay extra for access to water.

Human health impacts of drought[7,8] include:

- increased incidence of waterborne diseases such as diarrhoea and gastroenteritis as a result of reduced water for cleaning, sanitation and personal hygiene
- respiratory difficulties caused by reduced air quality from the accumulation of dust, pollen and pollutants that would normally be washed away by rain
- mental health problems caused by stress and anxiety

The environmental impacts of drought include:

- reduced water levels, surface run-off and river flows, which can lead to reduced sediment transport, increased soil desiccation and erosion
- changes in water temperature and nutrient concentrations

The effects on plants and wildlife are wide-ranging and include:

- increased risk of eutrophication - excess nutrient concentrations in water bodies leading to algal blooms and imbalance of ecosystems
- disruption to the breeding cycles of fish, birds and amphibians
- fish kills
- tree and other plant deaths

Additional abstraction is sometimes permitted during a drought, adding to the pressure on the natural environment.

River flows

Trends in river flows and groundwater tell us about changes in the long term reliability of water for people and the environment. Very high river flows also help us to understand the level of short-term flood risk. There is a good historical record of river flows in England. Long term changes can be reliably assessed

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[4] Kendon, M., McCarthy, M., Sevrejeva, J, and Legg, T. (2016). State of the UK Climate 2016. Met Office, Exeter. (www.metoffice.gov.uk/climate/uk/about/state-of-climate).

[5] Droughts are a naturally occurring event characterised by below average environmental water levels, relative to the normal conditions of a specific area. See Van Loon, A.F. and others (2016). Drought in the Anthropocene. Nature Geoscience. 9: 89-91. (http://www.nature.com/articles/ngeo2646).

[6] Cook, C. (2016). Drought planning as a proxy for water security in England. Current Opinion in Environmental Sustainability 21: 65-69. (https://doi.org/10.1016/j.cosust.2016.11.005).

[7] Stanke, C. and others (2013). Health effects of drought: a systematic review of the evidence. PLoS Currents Disasters 5: ecurrents.dis.7a2cee9e980f91ad7697b570bcc4b004. (http://currents.plos.org/disasters/article/dis-13-0001-health-effects-of-drought-a-systematic-review-of-the-evidence/).

[8] Bifulco, M. Ranieri, R (2017). Impact of drought on human health. European Journal of Internal Medicine 46, e9-e1. (https://doi.org/10.1016/j.ejim.2017.08.009).

going back as far as 1960 when the majority of records began.[9] However, human activities such as abstraction and discharges affect the records in many catchments and so care is needed in interpreting long term trends. Available data suggests that:[3]

- since the 1960s annual river flows have increased in parts of the north and west, but not in the south and east
- over the past 50 years, winter flows have increased in the upland catchments of the north and west, and autumn flows have increased in central England
- high winter flows have increased over the past 30 years, with an increase in the frequency and size of floods, especially in the north and west
- there is no clear pattern in summer flows
- these changes in river flows have not been attributed to climate change

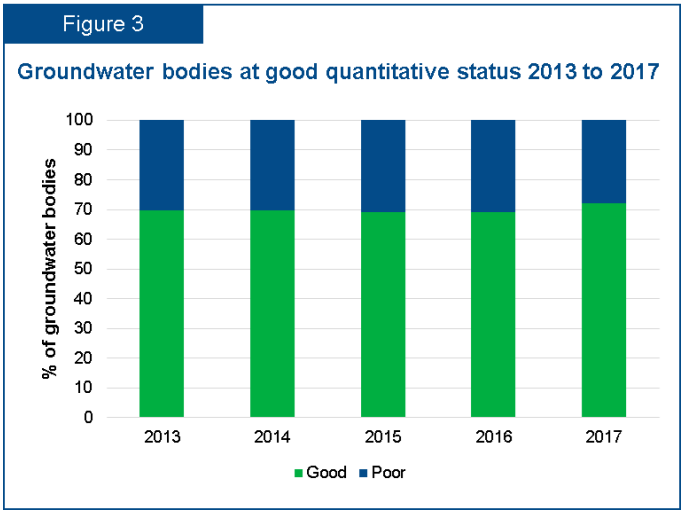
Abstraction and other changes to river flows are putting pressure on the aquatic environment. In some cases, flows are not sufficient to support a healthy ecology. In 2016 unsustainable abstraction prevented at least 6% and possibly up to 15% of river water bodies from meeting good ecological status or potential.[10] Chalk streams are globally important habitats that are often negatively affected by abstraction. Some 75% to 80% of all chalk streams occur in the UK.[11] In 2014, 77% of chalk streams did not meet good ecological status. When a sample of these streams were tested further, abstraction was found to be the primary contributing factor in around a quarter of cases.[12]

Groundwater levels

Groundwater is a major component of ecologically vital flows to certain rivers and wetlands. Groundwater makes up around 30% of England's drinking water supply.[13] Different regions have different proportions of groundwater in the supply. This varies from around 4% in some regions to 100% in others.[14]

In 2017, abstraction in around 28% of groundwater bodies were not at a sustainable level (known as 'good quantitative status'). There has been little change in this figure in recent years (figure 3). Around 15% of groundwater bodies are at risk of

Figure 3



[9] Hannaford, J. (2013). Observed long-term changes in UK river flow patterns: a review. Living With Environmental Change (https://nerc.ukri.org/research/partnerships/ride/lwec/report-cards/water-source02/).
[10] Ecological status is assigned using biological and physico-chemical test results as well as assessments of the degree to which humans have modified the structure of a water body. Some water bodies are heavily modified and will never reach 'good ecological status', but can instead be assigned 'good ecological potential'.
[11] Department for Environment, Food and Rural Affairs (Defra) and Environment Agency (2017). Policy paper: Water abstraction plan: Environment (www.gov.uk/government/publications/water-abstraction-plan-2017/water-abstraction-plan-environment).
[12] O'Neill, R. and Hughes, K. (2014). The state of England's chalk streams. Woking, Surrey: WWF-UK. (www.wwf.org.uk/updates/state-englands-chalk-streams).
[13] UK Groundwater Forum. undated. FAQs: Is the water in my tap groundwater? (www.groundwateruk.org/Is-The-Water-in-my-tap-groundwater.aspx).
[14] British Geological Survey, undated. Current UK groundwater use (www.bgs.ac.uk/research/groundwater/waterResources/GroundwaterInUK/2015.html).

deterioration if abstraction continues to increase within licensed quantities.[11]

Water available for abstraction

Current levels of abstraction often leave little room for possible increases in demand. We determine how much water is available for additional abstraction on a catchment by catchment basis. There are considerable pressures on water resources throughout the country, not just in the drier south-east and eastern areas of England.

There are few parts of the country where additional water is available all the time, after taking existing licences and environmental needs into account (figure 4). This is the case even in areas that are generally thought of as water-rich, such as the north-west and south-west.

We want to end damaging abstraction of water from rivers and groundwater wherever it is cost-effective to do so, as set out in Defra's water abstraction plan.[11]

Although good progress has been made, more needs to be done to maintain and further improve the current situation (table 1).

Figure 4

Percentage of time water may be available for abstraction (produced May 2017)

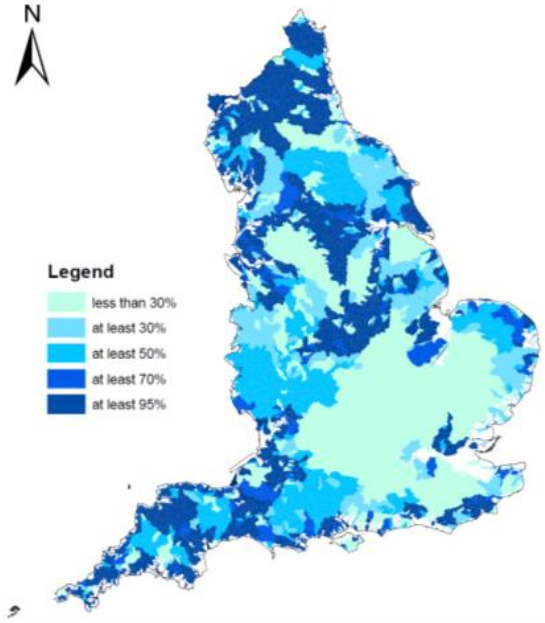


Table 1: Sustainable abstraction in 2017, and ambitions for 2021 and 2027

Water body type	Sustainable for abstraction (% of water bodies)	2021 target (%)	2027 objective[15] (%)
Surface waters	82	90	95
Groundwater bodies	72	77	85

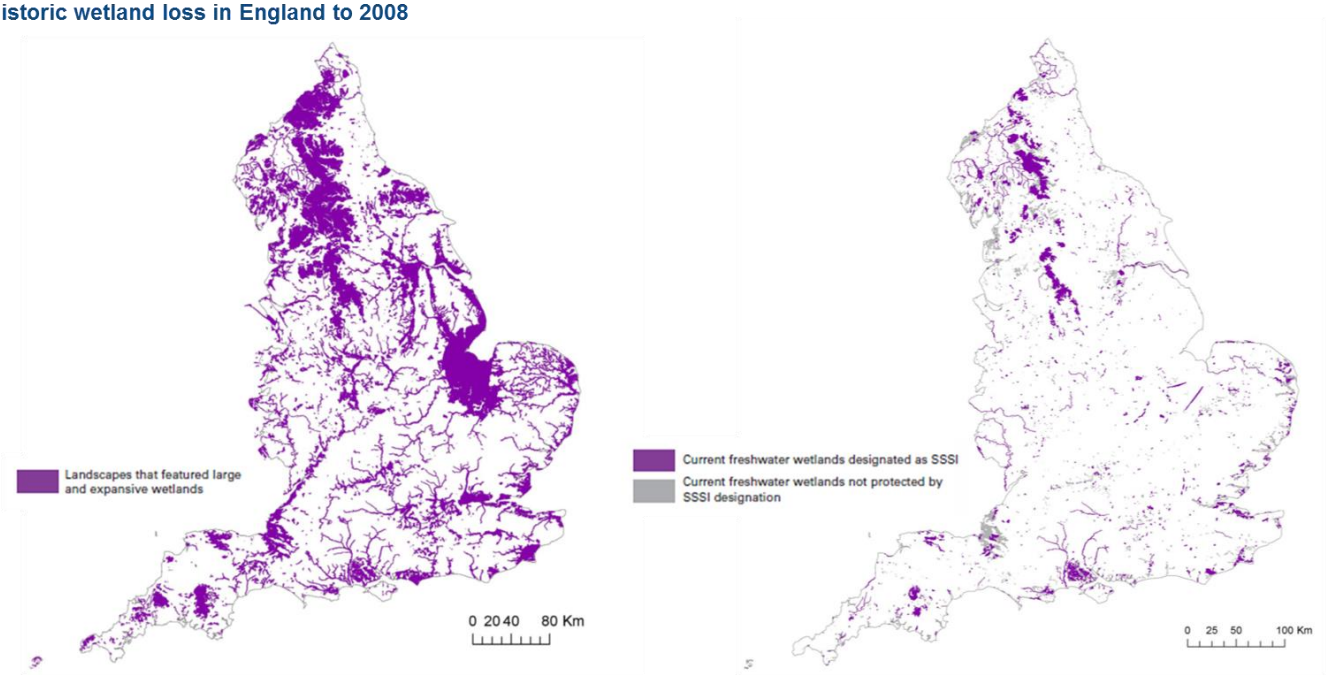
[15] In 2021 the Environment Agency will reclassify water bodies to show where environmental improvements have been made, where improvements are still required before 2027 and where impacts are not yet confirmed. In advance of this reclassification it is not possible to give definitive projections on future improvements.

Wetland extent and condition

Wetlands hold vast numbers of plants and animals including rare and protected species. England's wetlands are recognised for their international importance for birds.[16] Wetland areas also provide a huge range of services to society, including flood management, water treatment and carbon capture and storage.[17] Some 90% of wetland area in England has been lost since Roman times[17] (figure 5). Much of this loss has occurred since the industrial revolution.[17]

Figure 5

Historic wetland loss in England to 2008



Theoretical historic extent of wetlands (indicative map)

Extent of wetlands in 2008 (indicative map)

One of the main causes of loss and poor condition on surviving lowland and upland wetlands is water management. For example, inserting drainage ditches and cutting peat within or around these habitats. Water levels that are too high, low or mismanaged, and excessive surface and groundwater abstraction from underlying aquifers can also damage wetlands.[18] These pressures can alter the availability of water to wildlife and habitats, as well as the water chemistry which can result in changes to wetland type.[19]

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[16] Natural England (2008). State of the natural environment 2008. Chapter 3. Biodiversity. (www.publications.naturalengland.org.uk/publication/31043).

[17] Hume, C. (2008). Wetland Vision Technical Document: overview and reporting of project philosophy and technical approach. The Wetland Vision Partnership (http://www.wetlandvision.org.uk/dyndisplay.aspx?d=downloads).

[18] Joint Nature Conservation Committee, undated. Threats to lowland wetland habitats (www.jncc.defra.gov.uk/page-5856-theme=default).

[19] Mainstone, C. and others (2016). A narrative for conserving freshwater and wetland habitats in England. Natural England Research Reports, NERR064 (http://publications.naturalengland.org.uk/publication/6524433387749376).

For lowland fen, marsh, swamp and bog protected sites, inappropriate water levels account for 3.1% (around 1,100 of 36,000 hectares) remaining in unfavourable or declining condition. In the uplands 0.9% (1,600 of 180,000 hectares) of such habitat area remains unfavourable or declining due to drainage.[20]

Many measures have been put in place to address pressures so that protected site habitats are now recovering or favourable. However, over 11% (24,000 out of 205,000 hectares) of fen, marsh, swamp and bog wetland protected habitats remain under threat from changing water levels.

Lakes and ponds

Lakes and ponds play a critical role in supporting ecosystem services[21] such as:

- intercepting, storing and routing water and nutrients
- transporting and transforming carbon
- supporting biodiversity

Abstraction and drainage can affect the extent, environmental condition and biological assemblages of lakes and ponds.[19] Current assessments show abstraction is not significantly impacting the ecological status of most lakes and ponds. However, we know relatively little about the condition and numbers of ponds in England. Many ponds have been completely lost to drainage and infilling.[17]

Current and future pressures

Abstraction

Abstraction can alter the natural flow regime. This can be directly for surface water flows, or indirectly through groundwater abstraction depleting groundwater levels and consequently affecting flows to springs, wetlands, lakes and rivers. The natural flow regime can also be changed where rivers have been managed or modified for human activities such as navigation, drainage and water storage. The combination of these pressures also reduces resilience to environmental extremes.

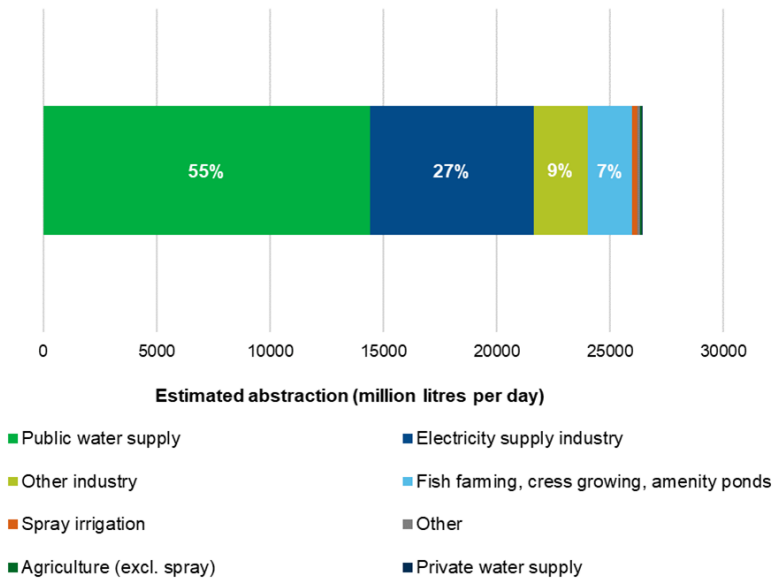
The impact of an abstraction varies depending on when and where it is taken and returned to the environment, as well as the quantities taken and returned. While most water from public supply is returned to the water environment, it can be a long way downstream from the point of abstraction or straight to the sea. It can therefore have a bigger impact on the water environment than other abstractions.

[20] Data provided by Natural England (2018).
[21] Department for Environment, Food and Rural Affairs (2011). The Natural Choice: securing the value of nature [Natural Environment White Paper] (www.gov.uk/government/publications/the-natural-choice-securing-the-value-of-nature).

Water is abstracted by a range of users, including industry, farmers and water companies. In 2016 it is estimated that abstraction by water companies for public water supply used 55% of all water abstracted from freshwater sources (non-tidal surface water and groundwater) (figure 6).

Figure 6

Estimated abstraction from freshwaters (non-tidal) in 2016 by purpose



Climate change

Climate change will affect the amount and timing of rainfall that supports river flows and replenishes groundwater. It will also influence the demand for water and its quality, as well as the way land is used – all of which will put pressure on water resources.[22]

Summers are likely to get hotter, significantly increasing demand for water. Winters are likely to get warmer and wetter. Although average summer rainfall is not predicted to change, more rainfall may come in big downpours.[3] This could lead to droughts and floods, possibly at the same time. This would increase the damage caused and increase the risk of disasters such as wildfires. Increasing frequency of both drought and summer heatwaves could lead to a much higher likelihood of these extreme events occurring at the same time.[23]

River flows are predicted to increase in winter and decrease in summer.[3] Groundwater supplies may decrease over the 21st century.[3] Reduced summer rainfall and increased summer evaporation would negatively affect wetland plant and animal communities, particularly in rain-fed wetlands.[24] Increased areas of stagnant water during droughts, coupled with increased temperatures could lead to the spread of mosquito borne diseases such as dengue fever and West Nile virus.[25]

Treatment plants, pumping stations and sewers that are designed to cope with the past and present climate may no longer be adequate. The reliability of existing reservoirs, groundwater sources and river intakes will change. Some infrastructure, critical for providing water supplies, will be more vulnerable to flooding. Agricultural production may be negatively affected by water shortages during warm, dry summers, particularly in the south and east. Wetter autumns and winters will also reduce productivity by disrupting the timing of farm management activities, and by causing increased flooding in low-lying agricultural

[22] Committee on Climate Change (2017). UK Climate Change Risk Assessment 2017. Synthesis report: priorities for the next five years. London: Committee on Climate Change (www.theccc.org.uk/wp-content/uploads/2016/07/UK-CCRA-2017-Synthesis-Report-Committee-on-Climate-Change.pdf).
[23] Zscheischler, J. and Seneviratne, S. I. (2017). Dependence of drivers affects risks associated with compound events. Science Advances 3(6), e1700263. (http://advances.sciencemag.org/content/3/6/e1700263.full).
[24] Acreman, M. C. and others (2009). A simple framework for evaluating regional wetland ecohydrological response to climate change with case studies from Great Britain. Ecohydrology 2:1-17. (https://doi.org/10.1002/eco.37).
[25] Medlock, J. M. (2015). Effect of climate change on vector-borne disease risk in the UK. The Lancet: Infectious Diseases 15:721-730. (https://doi.org/10.1016/S1473-3099(15)70091-5).

areas.[26] Valuable ecosystem services such as biodiversity and pollination provided by well-managed agricultural land are also threatened by the impact of climate change on water resources.[26]

Population growth

Population growth will continue to be one of the biggest pressures on water resources. The population of England is predicted to increase to 58.5 million by 2026.[27] Many of the growth areas are in places where the water environment and water supplies are already stressed.

Projections suggest that if no action is taken to reduce demand and increase supply of water, most areas will not meet demand by the 2050s under high greenhouse gas emissions and high population growth scenarios. Even low population growth and modest climate change scenarios suggest significant water supply deficits by the 2050s, particularly in the south-east.[28]

Future energy strategies

Energy generation is a major user of water. Different choices of future energy generation and climate change mitigation strategies will therefore affect water resources in different ways.

One study has estimated that scenarios with higher nuclear or renewables investment would have much lower rates of freshwater abstraction and consumption levels by 2050.[29] Scenarios involving increased carbon capture and storage (CCS) would have much higher freshwater abstraction and consumption levels. This is because CCS systems require extra water to function, as well as decreasing the overall efficiency of conventional power plants and increasing the amount of cooling water needed.[30]

Fracking (shale gas extraction) is not likely to be a significant abstractor of water in England, but there could be local impacts in areas that are already water stressed if the industry develops.[31]

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[26] Morison, J. I. L. and Matthews, R. B. (eds). (2016). Agriculture and Forestry Climate Change Impacts Summary Report, Living With Environmental Change (https://nerc.ukri.org/research/partnerships/ride/lwec/report-cards/agriculture/).

[27] Office of National Statistics (2016). National Population Projections: 2016-based statistical bulletin. London: Office for National Statistics (www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/bulletins/nationalpopulationprojections/2016basedstatisticalbulletin).

[28] HR Wallingford (2015). CCRA2: Updated projections for water availability for the UK: Final report. Wallingford: HR Wallingford (www.theccc.org.uk/publication/climate-change-risk-assessment-ii-updated-projections-for-water-availability-for-the-uk/).

[29] Byers, E. A. and others (2014). Electricity generation and cooling water use: UK pathways to 2050. Global Environmental Change 25:16-30. (https://doi.org/10.1016/j.gloenvcha.2014.01.005).

[30] Eldardiry, H. and Habib, E. (2017). Carbon capture and sequestration in power generation: review of impacts and opportunities for water sustainability. Energy, Sustainability and Society. 8:6. (https://doi.org/10.1186/s13705-018-0146-3).

[31] CIWEM, 2016. Shale gas and water (2016). An independent review of shale gas extraction in the UK and the implications for the water environment. London: Chartered Institution of Water and Environmental Management. (www.ciwem.org/wp-content/uploads/2016/02/Shale-Gas-and-Water-2016.pdf).

Land use change

The availability of water and the condition of aquatic habitats is affected by changes in land uses such as:

- urbanisation
- mining
- drainage
- agricultural practices such as afforestation (tree planting), upland grazing, changes in crops

Drainage causes wetlands to degenerate, and has negatively affected most, if not all wetland sites in England.[19] Tree planting is planned to increase in the UK over coming decades.[32] Planting of forests has benefits in reducing downstream flood risk, but needs to be carefully planned as it can reduce local groundwater recharge and therefore also river flows.

Leaks and losses

Treated water leaking from pipes places a significant pressure on water resources and the environment. A certain number of leaks are unavoidable and are allowed for in planning how much water is needed. Although leaked water eventually returns to the natural environment, it adds to abstraction pressures and wastes the energy used in treating and cleaning it.

Over 3,000 million litres per day are lost through leakage in England.[33] This is equivalent to the amount used in homes by over 20 million people (just under a third of the UK population) on an average day. Current leakage volumes, at around 20% of water put into supply, are large enough to have a noticeable effect on the total demand for water.

Substantial volumes of water are also wasted during treatment and in people's homes. In total, one-third of water taken from the natural environment is wasted either through leaky pipes, losses in treatment or in the home.[34]

Looking ahead

The future of water resources in England will be increasingly affected by the pressures of population growth and climate change. Decisions taken in the years ahead on how energy is generated and how land is used will also have large effects on water resources in England. It is not yet clear what the exact extent of some of the impacts will be. However there is strong evidence that action must continue to reduce demand, increase supply and minimise wasting of water to prevent future shortages and limit environmental damage.

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[32] Department for Environment, Food and Rural Affairs (2018). A green future: our 25 year plan to improve the environment. (www.gov.uk/government/publications/25-year-environment-plan).
[33] Consumer Council for Water (2017). Water water everywhere? Delivering a resilient water system (2016-17) (www.ccwater.org.uk/research/water-resilience/).
[34] WWF-UK (2017). Water for wildlife: tackling drought and sustainable abstraction. Woking, Surrey: WWF-UK. (www.wwf.org.uk/updates/water-wildlife).