NATIONAL
INFRASTRUCTURE
COMMISSION

Preparing for a drier future

England's water infrastructure needs

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Contents

Foreword

From brushing our teeth to washing our clothes, preparing our food to taking a shower, across industry, agriculture and the environment, the reliable supply of water underpins almost every aspect of human life. Few of us ever question if water will flow when we turn on our taps, and yet without further action there is roughly a 1 in 4 chance over the next 30 years that large numbers of households will have their water supply cut off for an extended period because of a severe drought.

In its interim assessment, published last year, the Commission identified a range of pressures facing the water industry, including climate change, population growth, growing consumer expectations, ageing infrastructure and the need to protect the environment. The Commission also outlined its vision for reducing the risks of drought and managing the UK's water supplies more effectively.

This paper follows that consultation and sets out a range of measures which the Commission believes government, water companies and the regulator should take to increase investment in supply infrastructure and encourage more efficient use of water – halving leakage by 2050, extending metering and developing plans for a national water network.

As the analysis presented in this paper shows, the cost of responding to a severe drought in the UK would likely run into tens of billions of pounds. The case for improving our long-term resilience to drought is therefore compelling.

The current price review being undertaken by the industry regulator – through which companies are considering how they will provide a secure supply of water to homes and businesses in their area – presents an ideal opportunity for improving the long-term planning and coordination of water supply at both regional and national scale.

I am grateful to the many organisations and individuals who have engaged with the Commission's work over recent months and for the continuing dialogue and constructive engagement from all parts of the water sector. I hope that the recommendations contained in this report will now be taken forward as a priority by those with responsibility for ensuring that future generations can continue to access high-quality water.

Sir John Armitt CBE
Chair, National Infrastructure Commission

In brief

A reliable water supply is usually taken for granted but, despite its reputation for rain, England risks water shortages. Climate change, an increasing population (especially in the drier south and east) and the need to protect the environment bring further challenges. The water supply system is already strained and the pressure will only rise over the coming decades.

Concerted action is needed to address these challenges, but conflicting incentives, limited cooperation between water companies and a short-term focus mean that insufficient progress is being made. As a result, in the event of a serious drought, the nation faces an unacceptable risk of severe supply limitations and even homes and businesses being cut off.

This document sets out the National Infrastructure Commission's advice on how to address England's water supply challenges and deliver the appropriate level of resilience for the long term.

The Commission's central finding is that government should ensure increased drought resilience in England by enhancing the capacity of the water supply system. This will require a twin-track approach combining demand management (including leakage reduction) with long-term investment in supply infrastructure.

To achieve this, **the Commission recommends that government ensure plans are in place to deliver additional supply and demand reduction of at least 4,000 million litres per day (Ml/day).** Action to deliver this twin-track approach should start immediately:

- Ofwat should launch a competitive process by the end of 2019, complementing the Price Review, so that at least 1,300 Ml/day is provided through (i) a national water network and (ii) additional supply infrastructure by the 2030s.
- The Department for Environment, Food and Rural Affairs should set an objective for the water industry to halve leakage by 2050, with Ofwat agreeing 5 year commitments for each company (as part of the regulatory cycle) and reporting on progress.
- The Department for Environment, Food and Rural Affairs should enable companies to implement compulsory metering beyond water stressed areas by the 2030s, by amending regulations before the end of 2019 and requiring all companies to consider systematic roll out of smart meters as a first step in a concerted campaign to improve water efficiency.

This document sets out the improvement needed and how it can be achieved.

INCREASING DROUGHT RESILIENCE IN ENGLAND

England faces serious risks of water shortages, especially in the drier south and east. Climate change, an increasing population and the need to protect the environment bring further challenges to an already strained system.

DURING PERIODS OF LOW RAINFALL, WATER SUPPLY COULD BE RATIONED

1 in 4

The chance of a serious drought between now and 2050

4,000

Mega litres[1] per day extra needed

15,000

Mega litres per day

typical volume of water available to supply households and businesses.

THE ECONOMIC CASE FOR BOOSTING SUPPLY RESILIENCE

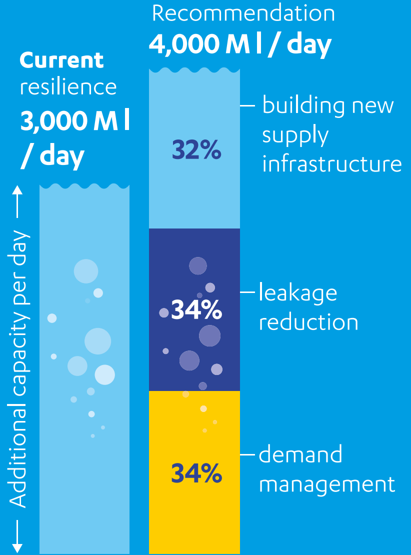
£40 billion

The predicted cost of relying on emergency options such as road and ship tankers over the next 30 years.

£21 billion

The corresponding cost of building resilience over the next 30 years.

ACTION IS NEEDED TO ASSURE LONG-TERM SUPPLY



1 IMPROVE INFRASTRUCTURE

through a **national transfer network** in England and new infrastructure, such as reservoirs and water re-use systems.

2 HALVE LEAKAGE

20% of mains water currently lost each day

1,400 Ml

Saved each day

3 REDUCE DEMAND

from 141 litres per person per day to 118.

▼118 litres

[1] 1 Mega litre = 1 million litres

Sources: Commission calculation using inputs from ITRC, Atkins, REL, Water UK, water companies and Environment Agency.

Background

Water in England is provided by private sector monopoly companies. An economic regulator (Ofwat) sets prices and the Environment Agency and Drinking Water Inspectorate regulate wider performance. Over the past three decades water companies have invested more than £140 billion,[1] principally in response to environmental requirements agreed through the European Union. Drinking water quality is high and there is good public confidence in the public water supply infrastructure.[2]

The investment provided since privatisation has delivered some improvements to existing water supply assets, but little new supply infrastructure has been built. Leakage reductions have largely stalled in the last decade and daily consumption per person has only reduced gradually from 150 litres in 2000 to 141 litres today. This compares with about 115 litres per person per day in Belgium and Denmark, which are amongst the best in Europe.[3]

Water companies' plans for water resources look at least 25 years ahead and are published to coincide with price regulation periods. Final price limits for 2020 – 2025 will be set by December 2019 and water companies are therefore finalising their plans at the end of this summer. In this planning cycle, companies are required to report resilience against a severe drought (0.5% annual probability or about 1 in 7 chance before 2050) and to assess costs of reducing leakage by at least 15%.

'Drought' is defined for this report as a period of such low rainfall that companies have to impose restrictions on households' water supply ('Level 4' restrictions), by providing water only at certain times of the day ('rota cuts') or through temporary taps ('standpipes') in the streets. The likelihood of a drought occurring is measured by its annual probability. Typically, the lower the chance of a drought occurring, the worse the drought is likely to be. The probabilities mentioned in this report are:

- 1% annual probability: 1 in 4 chance of drought by 2050; this is used as a proxy for the worst drought recorded in recent history (also referred to as 'worst historic drought')
- 0.5% annual probability: 1 in 7 chance of drought by 2050 ('severe drought')
- 0.2% annual probability: 1 in 17 chance of drought by 2050 ('extreme drought')

Water companies are currently undertaking public consultations on their Water Resources Management Plans, but the drafts demonstrate limited ambition for improved long-term resilience. This lack of ambition reflects limited public appreciation of the consequences of drought as well as coordination problems and conflicting incentives:

- Because serious droughts are rare events they are hard to 'price' in a system of economic regulation. Customers find it very hard to understand the risk of low probability, high impact events.[4] The costs of resilience are immediate and certain but the benefits are deferred and uncertain.

- Plans are prepared by each water company with little join-up, despite established regional coordination groups and some bilateral operations. Similarly, although the water companies co-operated (through Water UK) to develop a long-term national perspective on water resources[5] in 2016, they have not fully reflected this in their current plans. The water resource planning process does not include an independent analysis to identify strategic options such as transfers between regions.
- Companies benefit from new supply infrastructure, but don't always see incentives to reduce leakage or demand. Some companies perceive regulators to be cautious about agreeing to new supply without action on demand and leakage.

A more comprehensive perspective is required. Companies need to work better with each other and wider stakeholders such as farmers, electricity generators and environmental groups to plan for the long term. Government and Ofwat should ensure that these plans reflect the national strategic requirements to meet the country's future water needs.

This report forms part of the first National Infrastructure Assessment, which will be published in full in summer 2018. This will analyse the UK's long-term economic infrastructure needs, outline a strategic vision for the next 30 years and set out recommendations for how this should be delivered. The full Assessment will consider the links between water supply, drainage and flood risk. This document on water supply is being published in advance so that water companies and regulators can take account of it in the plans currently being finalised. Further details about the National Infrastructure Assessment are available from the Commission's website.[6]

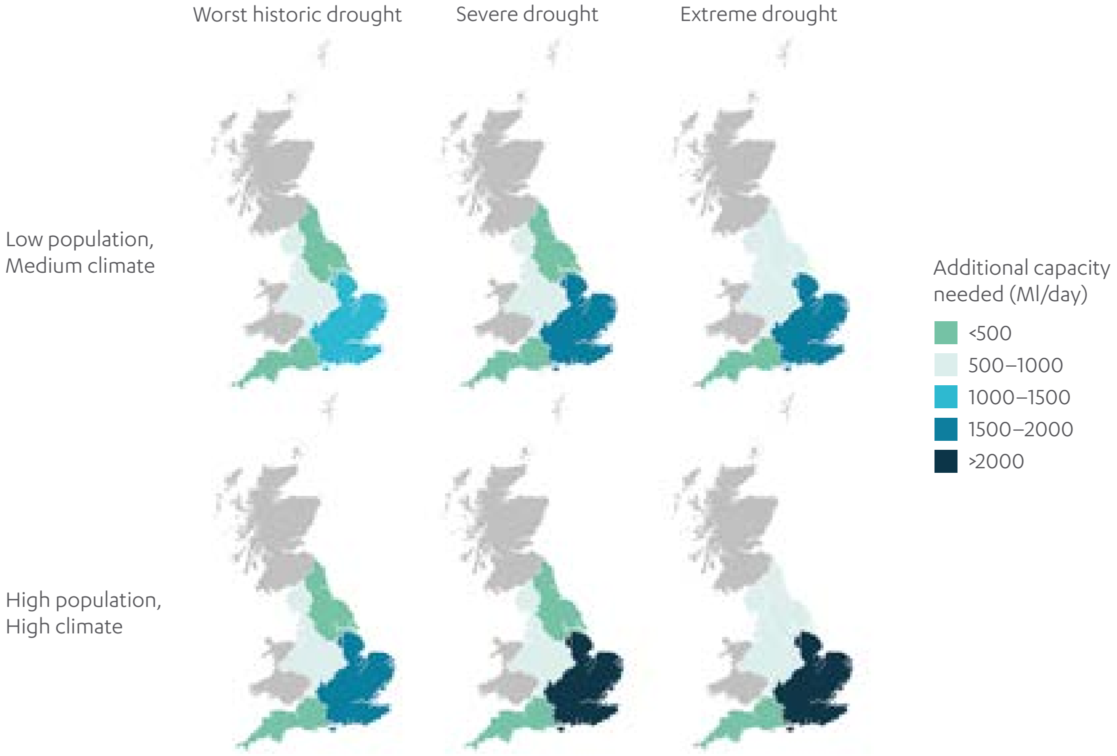
Drought resilience

The risk of households having their supplies rationed because there is not enough water is significant. Large and densely populated parts of England have lower annual rainfall than Sydney and Mexico City.[7] Water companies initially respond to droughts by trying to reduce demand, so that the water available will last longer. If the drought persists, more urgent measures are required, including mobilising emergency supplies and disruptive restrictions on water use. With current plans, there is about a 1 in 4 chance over the next 30 years that large numbers of households will have water supplies cut off for an extended period because of drought. This has been recognised (both government and Ofwat have recent resilience duties) but while water companies plans show some progress in addressing this risk, they fall short of what is needed (see Annex 1).

Current water supply is mostly resilient to the 'worst historic drought', roughly a 1% annual probability. Beyond that, the water companies' plans assume that in the event of more serious and prolonged drought, normal water supplies would be cut off and limited supplies provided (through standpipes or rota cuts). This is unrealistic: rather than cut people off, government and companies would take emergency measures to continue household water supplies for as long as possible, despite very high financial and environmental costs. Thus the appropriate level of resilience should be assessed by comparing the costs of proactive long-term resilience improvements, such as tackling leakage or providing new supply infrastructure, with the cost of these emergency responses (factored by the likelihood of them being needed in the period up to 2050) to maintain water supplies during a drought.

The starting point is to assess the additional capacity that the system needs. Maintaining the current levels of resilience (to the worst historic drought) in the face of rising population, environmental and climate pressures to 2050, would require additional capacity of about 2,700-3,000 million litres per day (Ml/day) in England.[8] This is shown in Figure 1.

Figure 1: Additional water capacity needed in England in case of drought under population and climate scenarios



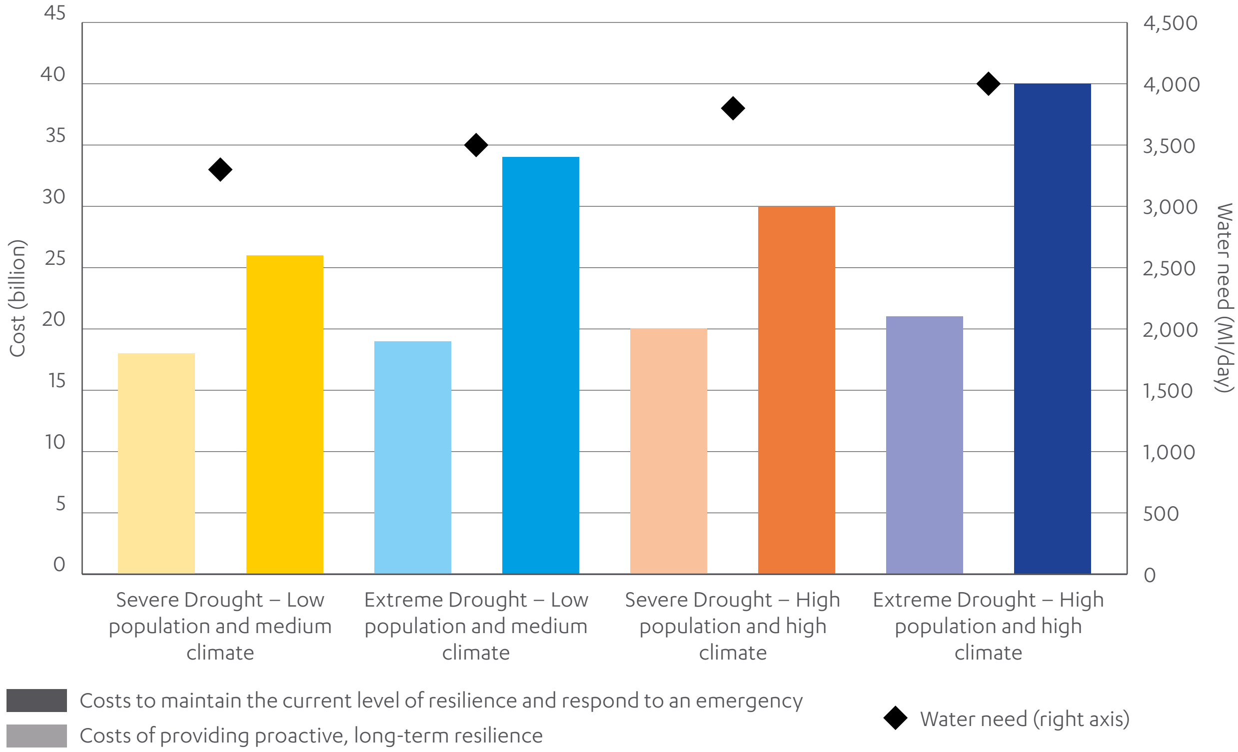
Note: medium climate refers to an average medium emission scenario, high climate refers to a drier, medium emissions scenario with less water in the South East (see Annex 1).

Source: Commission calculations, based on data from Water UK, water companies and the Environment Agency and using the NISMOD model developed by the Infrastructure Transitions Research Consortium.

An additional shortage of between 600 and 800 Ml/day would result from a severe drought (0.5% annual probability), and between 800 and 1,000 Ml/day in an extreme drought (0.2% annual probability). The ranges reflect uncertainty about the impact of changes in population and climate, but the overall additional capacity required is between 3,500 and 4,000 Ml/day.[9] Around 600 Ml/day of the capacity needed is likely to be achieved by efficiency improvements (as modern washing machines and toilets use less water, for example) and a further 400 Ml/day by continuing to roll-out water metering at the current rate.

The short-term emergency costs of providing water during a drought, weighted by their probability of occurrence in the 2020 to 2050 period, are directly comparable with the whole-life costs of building long-term resilience to an equivalent event. Figure 2 shows the comparison between these two costs. Those for maintaining current levels of resilience and relying on emergency measures for more severe droughts are between £25 billion and £40 billion. In simple terms, this is what it is worth spending upfront to avoid the risk of drought, although uncertainty around individual figures is high. There would also be further environmental and public health impacts associated with emergency response. In comparison, the cost of proactive long-term resilience improvements to the same standards ranges between £18 billion and £21 billion (see Annex 2).

Figure 2: Costs of providing proactive, long-term resilience versus relying on emergency response for droughts beyond current resilience levels



Note: Costs are expected present values to 2050 and include maintaining 1% resilience, which is considered to be 'business as usual'.

Source: Commission calculations and analysis, using input from Atkins, Infrastructure Transitions Research Consortium and Regulatory Economics Ltd. See Annex 2 for more details and references.

Whilst the costs of proactive long-term resilience improvements roughly scale with additional capacity, the costs of emergency measures rise more dramatically for the most extreme events. Some of the initial responses (such as abstracting more water from rivers) can be relatively inexpensive, but these have limited capacity. More radical approaches (such as using road or ship tankers to bring in water from elsewhere) have much higher costs, even after allowing for the lower likelihood that they will be needed. This argues for a precautionary approach.

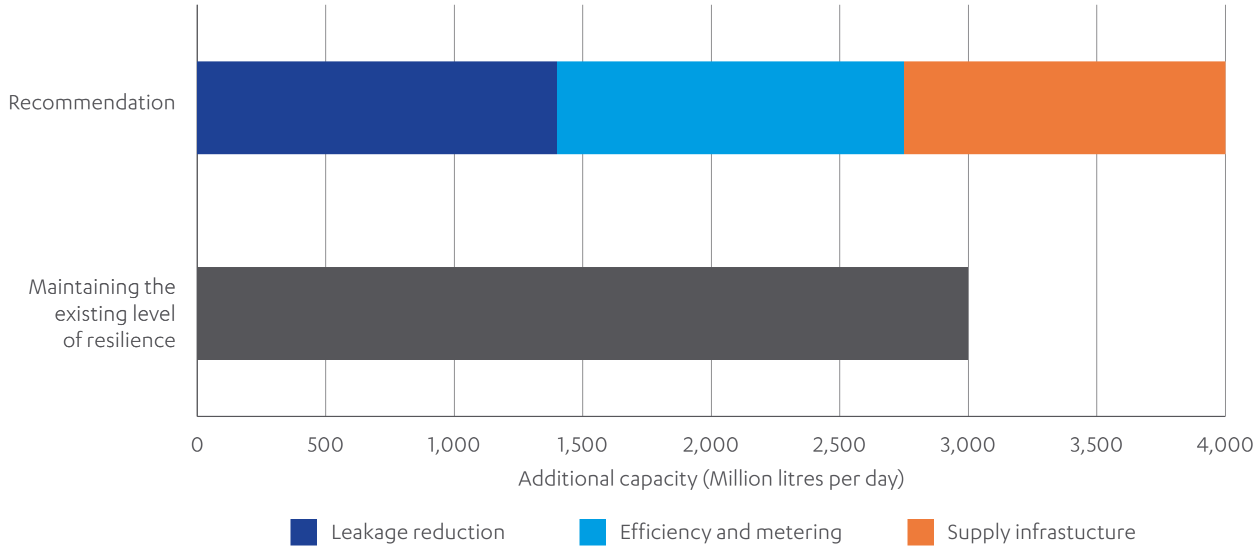
Additional capacity of 4,000 Ml/day should provide resilience to an extreme drought until 2050 even with high climate change and population growth, with most of it likely to be needed by the 2030s. Much of this additional capacity would still be needed even assuming medium climate and low population growth. In any case, the full 4,000 Ml/day is likely to be needed within a few decades of 2050 so can be considered 'low regrets'.

The government should ensure that plans are in place to deliver additional supply and demand reduction of at least 4,000 Ml/day.

A twin-track to deliver resilience

The 'twin-track' approach of reducing demand and increasing supply is widely held to be the lowest cost and most sustainable way to increase resilience. The Commission's analysis supports this and suggests that more ambitious long-term plans are needed, as shown in Figure 3. These should address leakage, enable water companies to undertake more comprehensive water metering and demand management, and ensure that a national water network together with sufficient other options for additional supply infrastructure are delivered.

Figure 3: Twin-track approach addressing demand and supply



Source: Commission analysis, using input from Infrastructure Transitions Research Consortium and Regulatory Economics Ltd, see Annex 3 for more details and references.

Supply

Even with ambitious action to reduce demand, more supply infrastructure will be needed. Aiming for additional capacity of 4,000 Ml/day will require a minimum of 1,300 Ml/day additional supply infrastructure.[10] A range of options are available, including transfers, reservoirs, re-use and desalination. Each has its own advantages and shortfalls, and the choice depends on the particular situation. For example, reservoirs tend to be good value for large volumes of water, but require large areas of land. Desalination makes use of sea water, which is virtually unlimited, but is very energy intensive and produces highly polluting waste. Re-use of waste water is less energy intensive but has more limited availability than desalination. In reality, the best approach is likely to involve a combination of these options and the industry is well placed to determine the exact mix.

The exception is water transfers. A range of studies have all found a positive cost-benefit case for greater transfers and water trading (see Annex 3). However, transfers currently only make up a small proportion of total supply (about 4%). This is likely to be because the incentives in the current system make developing a strategic transfer network difficult, meaning that the decision needs to be made at a different level.

Transfers can move water from areas with surplus to those where it is needed. In addition, they enhance resilience because they increase optionality around further supply options. New storage or other supply could be provided in a wider range of places, which can reduce costs and increase the likelihood of timely delivery. This should encourage a more dynamic and transparent market, allowing a wider range of options to be identified and bringing down costs for customers. However, there are also risks; for example, transfers can enable invasive species and pathogens to spread, so options need to be considered on a case by case basis.

A network of strategic transfers could potentially provide about 700 Ml/day more capacity, at costs comparable with other options and increased adaptability of the overall system. The remaining capacity should be provided by the most cost-effective combination of supply infrastructure.

The scale of this infrastructure goes well beyond that seen in the plans currently proposed by water companies. It is likely to need strengthened regional approaches and perhaps an independent national framework. Ofwat has already developed a 'direct procurement' mechanism for large infrastructure projects which could form the basis of more open and transparent competition ensuring all options for significant additional supply capacity can be considered.

Ofwat should launch a competitive process by the end of 2019, complementing the Price Review, so that at least 1,300 Ml/day is provided through (i) a national water network and (ii) additional supply infrastructure by the 2030s.

Demand

The Commission proposes a package of measures to manage demand for water. The balance between the different measures is pragmatic and may need to be adjusted to cope with changing circumstances. There may be potential to go further in some areas (particularly increasing efficiency through local re-use or 'greywater' schemes, or labelling of appliances and fittings) but evidence on these is currently limited. Water companies should be more ambitious and show what can be achieved. With a national water network, the case for reducing demand is as strong in areas that are in surplus as it is for those experiencing shortages, since the surplus could be transferred.

Around 2,900Ml/day (20%) of water put into the public supply is lost through leakage. Besides the waste of water (and the energy and chemicals used to treat it), leakage affects customer attitudes towards reducing their own consumption and makes supplies less reliable. An ambitious long-term strategy to reduce leakage would help encourage action by customers and incentivise technological innovation, which in turn should drive down the costs of managing leaks (see Annex 3).

Whilst water companies managed to reduce leakage significantly during the 1990s and early 2000s, these improvements have largely stalled. Analysis by water companies and Ofwat suggested that it would be cheaper to use more water than to reduce leakage further. However, this did not account for the full range of benefits from saving water, including those to the environment, or the effect on public attitudes.

The costs of reducing leakage are uncertain, because the condition of the pipe networks is not well understood. Costs are expected to fall with a long-term programme and better use of technology, making halving leakage by 2050 part of the most cost-effective pathway. The water industry needs to seize the opportunity from technological innovation to lower the cost of leakage reduction. This should save over 1,400 Ml/day by 2050, but will need to reflect different company circumstances and provide flexibility as costs become clearer.

The Department for Environment, Food and Rural Affairs should set an objective for the water industry to halve leakage by 2050, with Ofwat agreeing 5 year commitments for each company (as part of the regulatory cycle) and reporting on progress.

Conventional metering can reduce demand by around 15% and smart meters (which provide more frequent readings) are expected to increase this (to about 17%) and help identify leaks. In future, meters are likely to be smart by default. In some areas of water stress companies already use compulsory metering and outside these locations they can introduce meters in limited circumstances such as when the occupier of a property changes, or when requested by customers. About 50% of homes in England are currently metered and this is expected to reach around 80% by 2050, saving around 400 Ml/day. On this basis, nearly all homes would be metered by around 2070.

If companies were able to bring forward the metering more quickly a further 400 Ml/day reduction in demand could be achieved before 2050. There is a good case for enabling more widespread smart metering by the 2030s (see Annex 3). This should be cost neutral, free up water so that it can be transferred to areas that need it and also bring advantages by enabling leakage, including in homes, to be identified and tackled more effectively.

It is important that water companies are able to work with the communities they serve, and particularly customers who might be adversely affected, to manage the transition to more widespread metering. This should help them to maximise the benefits (for example advising customers where leaks are their responsibility as well as fixing those in company networks), secure efficiencies, communicate effectively and target assistance to those who need it most.

The Department for Environment, Food and Rural Affairs should enable companies to implement compulsory metering by the 2030s beyond water stressed areas, by amending regulations before the end of 2019 and requiring all companies to consider systematic roll out of smart meters as a first step in a concerted campaign to improve water efficiency.

Recommendation

The Commission recommends that government should ensure plans are in place to deliver additional supply and demand reduction of at least 4,000 Ml/day. Action to deliver this twin-track approach should start immediately:

- **Ofwat should launch a competitive process by the end of 2019 complementing the Price Review so that at least 1,300 Ml/day is provided through (i) a national water network and (ii) additional supply infrastructure by the 2030s.**
- **The Department for Environment, Food and Rural Affairs should set an objective for the water industry to halve leakage by 2050, with Ofwat agreeing 5 year commitments for each company (as part of the regulatory cycle) and reporting on progress.**
- **The Department for Environment, Food and Rural Affairs should enable companies to implement compulsory metering beyond water stressed areas by the 2030s, by amending regulations before the end of 2019 and requiring all companies to consider systematic roll out of smart meters as a first step in a concerted campaign to improve water efficiency.**

These actions will deliver a more resilient water supply and reduce the chance of expensive and intrusive emergency responses to droughts being required or, worse, homes having their water supply cut off were a prolonged extreme drought to happen. They will also improve the situation for the environment and lessen risks for other users of water, such as agriculture, industry and power generation. The impact of losing access to clean, fresh water for even a short period is unimaginable for many people and, while the risks can never be reduced to zero, much more can and should be done to address them.

Acknowledgements

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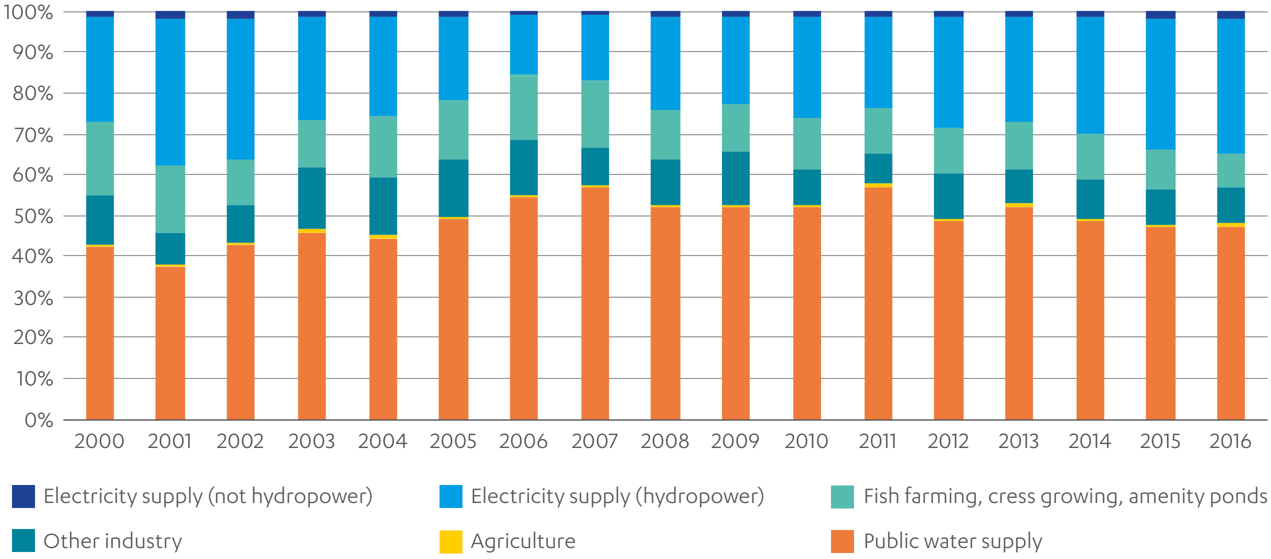
The organisations that submitted responses to the water-related consultation questions and sent representatives to one-to-one meetings and roundtables, including: Affinity Water, Anglian Water, Blueprint for Water, Business In The Community, Campaign to Protect Rural England, Consumer Council for Water, Chartered Institution of Water and Environmental Management, Environment Agency, Greater London Authority, Jacobs, Lincolnshire County Council, Liverpool City Region Combined Authority, Local Government Association, Local Government Technical Advisers Group, London Councils, Luton Council, Mott MacDonald, National Farmers Union, Natural England, Northumbrian Water, Ofwat, Plymouth City Council, Royal Academy of Engineering, Royal Society for the Protection of Birds, Southern Water, Surrey County Council, Thames Water, The Infrastructure Forum, United Utilities, Water Resources East, Water Resources in the South East, Water UK, WSP, WWF UK and Yorkshire Water.

ANNEXES

Annex 1
The size of the problem

Water is essential to people, the economy and the environment. In England,[11] water abstracted from rivers and aquifers is regulated by the Environment Agency. The vast majority of freshwater abstracted in England is used to produce drinking water and for industry (Figure 4).

Figure 4: Freshwater use in England



Source: Environment Agency (2018) ENV15 – Water abstraction tables for England.

Almost half (47%) of the abstraction goes to the public water supply. Water UK in 2016[12] highlighted the challenge of meeting public demand for water during periods of low rainfall. These drought events are increasing in frequency and severity due to climate change, with population growth adding to the challenge. Other abstractors also contribute to the pressure on water resources, although to a lesser extent. Whilst the energy sector accounts for 35% of the freshwater abstraction, most of this (95%) is used for hydropower generation, thus it is not taken away from the environment. Water demand for other types of energy generation would increase only if there is a substantial uptake of carbon capture and storage,[13] and even in this case it would only result in low volumes (a few percentage points) compared with total freshwater use.[14]

The Environment Agency is tasked with ensuring that there is enough water to sustain the environment and the life of waterbodies, supporting water quality and the recharge of aquifers. The Environment Agency revises abstraction limits periodically, issuing sustainability reductions where necessary. Currently the ecosystems of at least one in 10 rivers and more than a third of groundwater bodies in England are under pressure due to water abstraction.[15]

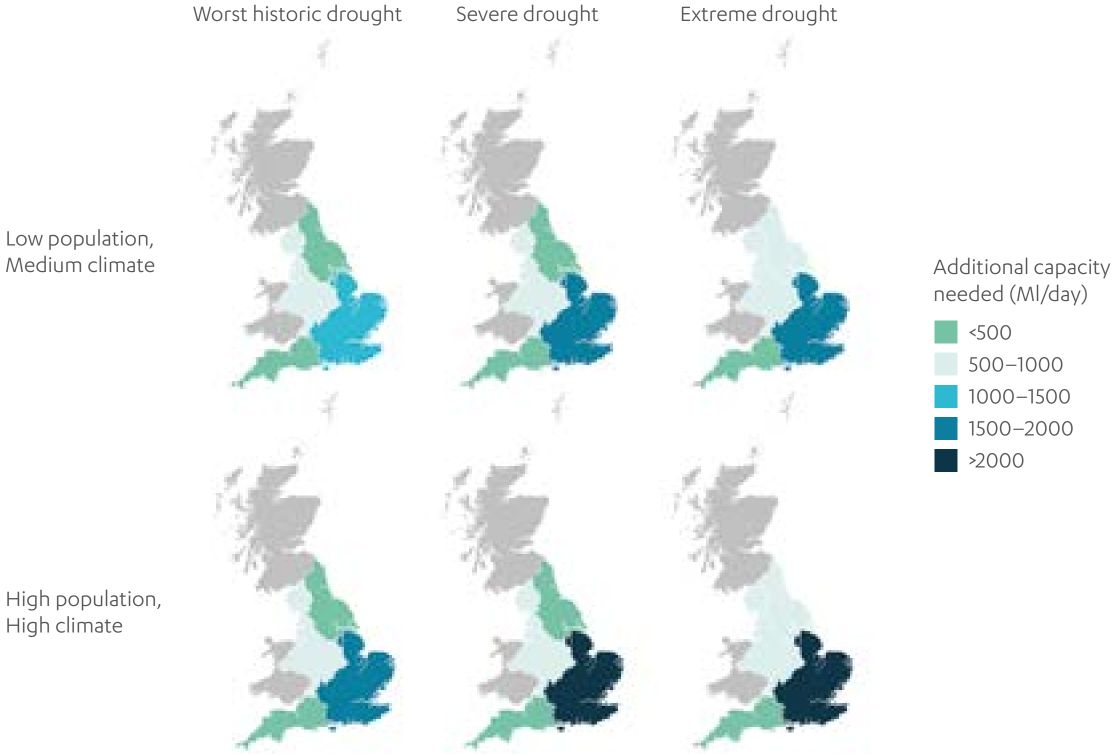
The UK Climate Change Risk Assessment 2017[16] identified a risk to industry from abstraction reform and reduced water availability. This would only materialise if public demand for water is met by increasing abstraction. Managing public demand and creating additional resources to supply water even in periods of drought, whilst maintaining sustainable abstraction limits, should ensure that there is also sufficient water for industry, as well as for the environment. Thus this analysis focuses on public water supply, starting with an independent assessment of the size of the problem.

The Commission calculated future water balances under a range of droughts using the National Infrastructure Systems Model (NISMOD),[17] developed by the Infrastructure Transitions Research Consortium. The analysis assumed no further action beyond those listed in the previous round of Water Resources Management Plans (2014). The baseline demand was assumed to be in line with Water UK's "Business as Usual" scenario, under different scenarios of population growth, climate change and drought.

- **Population growth**
  - Low – ONS 2014-based low migration population projection
  - High – ONS 2014-based high fertility population projection
- **Climate Change**
  - Central – medium emission Future Flows,[18] average water balance scenario
  - Dry – medium emissions Future Flows, with less water in the South East
- **Drought** – drought of different probabilities of occurrence were simulated into the two Future Flows scenarios by the Water UK Long Term Planning Framework project.
  - 1% annual chance, corresponding to a 1 in 4 probability of occurrence by 2050
  - 0.5% annual chance, corresponding to 1 in 7 probability of occurrence by 2050
  - 0.2% annual chance, corresponding to a 1 in 17 probability of occurrence by 2050

The above variables were combined to calculate the supply-demand balance at a company, regional and national scale in England to look at the widest range of results.

Figure 5: Additional water capacity needed in England in case of drought under population and climate scenarios



Source: Commission calculations, based on data from Water UK, water companies and the Environment Agency and using the NISMOD model developed by the Infrastructure Transitions Research Consortium

Six water companies, serving almost 40% of the English population, would experience water deficits during a drought that has a one in four chance of occurring at least once between now and 2050, and ten companies (serving almost 60% of households) during a drought with a one in seven chance of occurring between now and 2050 (Figure 5).

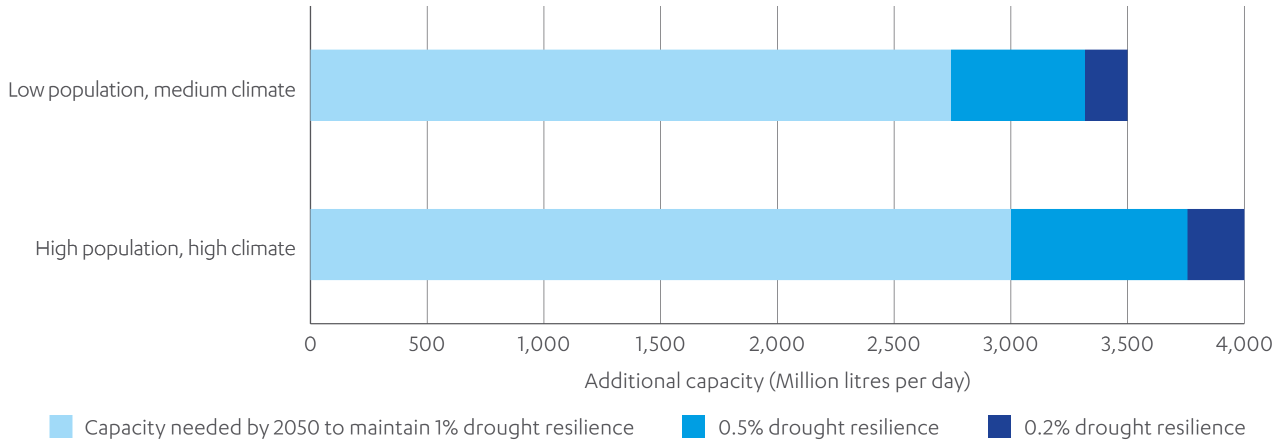
Water companies are required to plan for droughts, but these include imposing emergency restrictions – effectively cutting off supplies to homes and businesses – which are unlikely to be publicly or politically acceptable. It is more likely that emergency action would be taken to sustain near normal supplies for as long as possible. This might include tankering water across the country and removing unsustainable amounts of water from the environment. Most options would incur very high costs and some would result in severe environmental damage and risks to public health.

The Commission calculated the capacity needed to provide water to supply households in periods of drought using the NISMOD model. The capacity calculated represents the additional volume of water needed in each company to respond to drier conditions, beyond that already available within a company (i.e. assuming that internal transfers and investments to maintain or enhance existing capacity take place). It is also assumed that, during these events, some additional capacity is provided by measures that reduce demand but do not restrict essential household water use, such as hosepipe bans and restrictions to some businesses. The calculated capacity needed accounts for interventions in place up to 2020, thus includes those identified in the previous round of Water Resource Management Plans (2014), but excludes additional interventions proposed in the latest draft plans.

In the previous planning cycle companies assessed the amount of water necessary to maintain household supplies during an event comparable with the worst drought experienced by the company. This 'worst historic drought' roughly corresponds to an event with a 1% annual chance of occurring. Maintaining this existing level of resilience to 2050, in the face of population and climate pressures, would require additional demand management and supply for 2,700-3,000 Ml/day (depending on climate and population scenarios).

Over and above this, the Commission estimates that England could face a shortage of between 600 and 800 Ml/day in a severe drought with a 0.5% probability and between 800 and 1,000 Ml/day in a more extreme drought with a 0.2% probability (Figure 6).

Figure 6: Water capacity needed



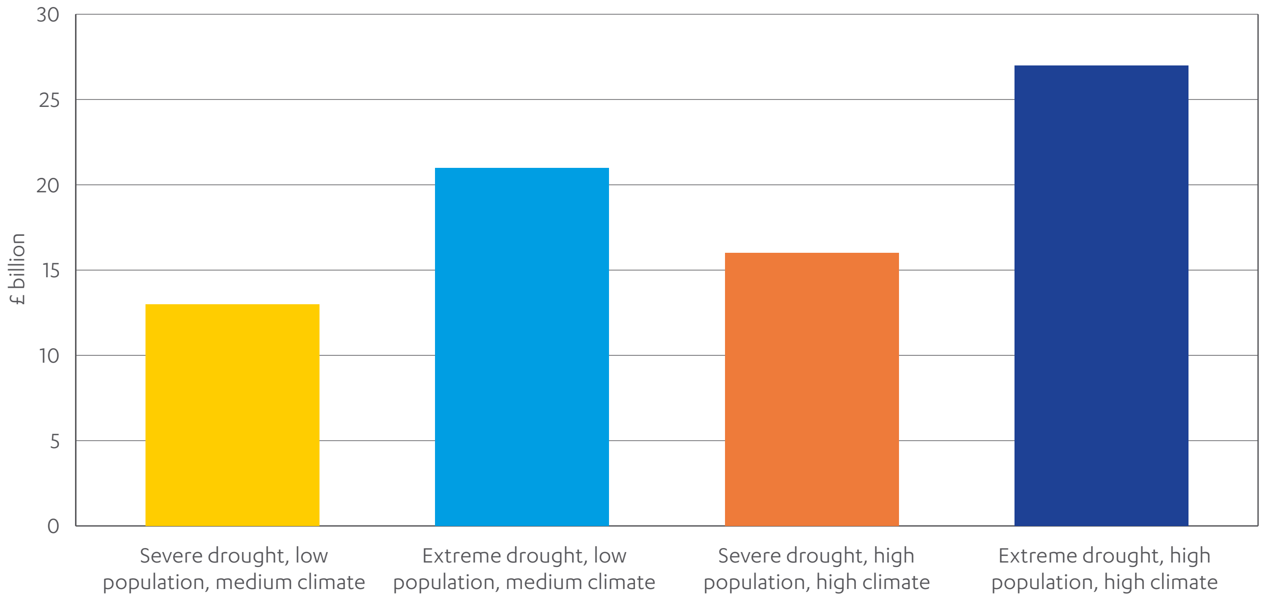
Source: Commission calculations, based on data from Water UK, water companies and the Environment Agency and using the NISMOD model developed by the Infrastructure Transitions Research Consortium

Annex 2 Establishing an appropriate level of drought resilience

To establish the appropriate level of resilience for England, the cost of providing new infrastructure and of reducing water demand and leakage (the 'resilience cost') has been compared to the cost of deploying emergency drought interventions.

The Commission calculated the cost of emergency interventions based on analysis by Atkins.[19] The analysis estimated the costs of supplying water during drought to avoid imposing emergency restrictions to businesses and households on essential use (i.e. rota cuts). It was assumed that every water company is resilient, and will maintain its resilience, to a drought with 1% annual chance of occurrence. Thus, the costs were calculated as marginal costs compared to a 1% drought. The total costs between 2020 and 2050 of implementing emergency measures to provide household water supply during a 0.5% drought, weighted by the probability of occurrence, range between £13 and £16 billion, depending on the assumed climate and population growth (Figure 7). The total costs over the same period of implementing emergency measures against a 0.2% drought range between £21 billion and £27 billion.

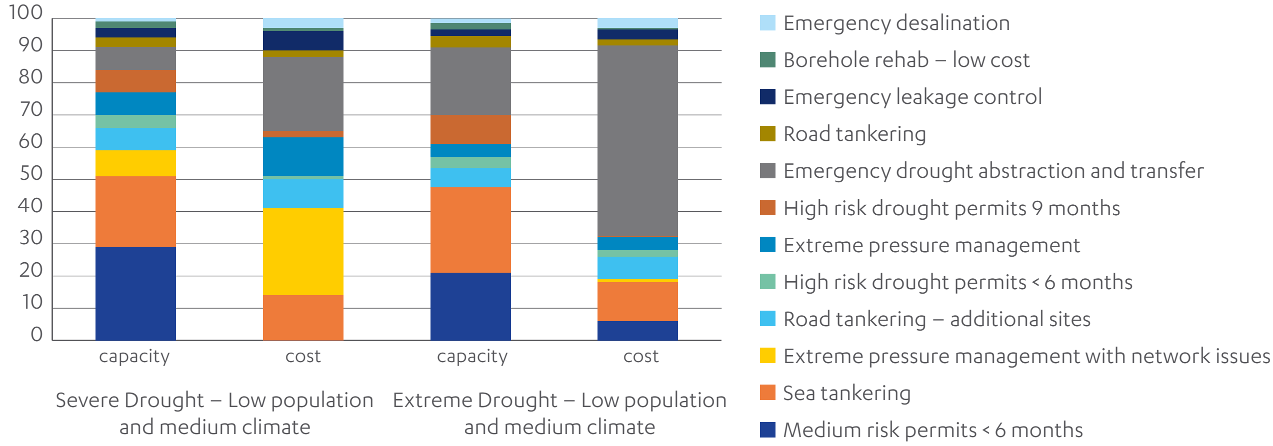
Figure 7: Costs for the period 2020-2050 of supplying emergency measures to provide household water supply during a drought



Source: Commission calculations, based on analysis by Atkins

Note: Costs are on a present value basis weighted by the occurrence probability.

Figure 8: Proportion of the total capacity provided by different emergency measures and corresponding costs



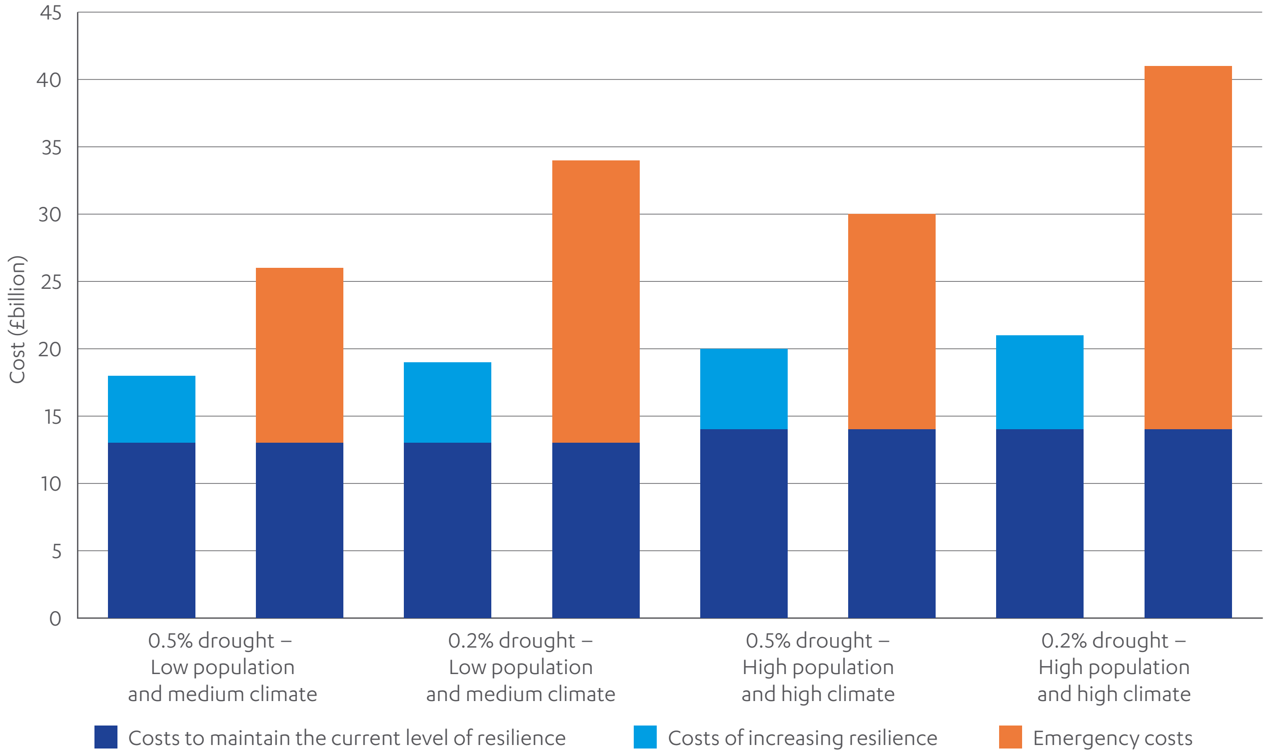
Source: Commission calculations, based on analysis by Atkins

The analysis also shows that to ensure supply during a drought, some costs must be borne in advance of any event occurring. These include the provision of basic connection infrastructure that cannot be constructed in the short timeframe of a drought. On the other hand, extended drought permits can help tackle the deficit during mild drought, but create risks to the environment and might reduce the availability of water to industry. The costs of responding to a mild drought through emergency measures are thus lower when the deficit is met mainly through cheaper but potentially higher-impact measures. The costs increase steeply with the need for more permanent infrastructure to meet the deficit quickly, such as connecting pipes to transfer additional abstracted water ('Emergency abstraction and transfer' in Figure 8) or emergency desalination plants. These interventions make responding to a more extreme drought very expensive which explains why, despite the lower likelihood of a more extreme (0.2%) drought occurring, the weighted present value costs are considerably higher.

The short-term emergency costs of providing water during a drought, weighted by their probability of occurrence in the 2020 to 2050 period, are directly comparable with the whole-life costs of building long-term resilience to an equivalent event. Figure 9 shows the comparison between these two costs, including those of maintaining the current level of drought resilience through proactive long-term measures to manage demand and provide additional supply through infrastructure.[20]

The results show that at a national level, the cost of responding to a drought emergency (Figure 9) are consistently higher than those of building long-term resilience to the same event.

Figure 9: Comparison between emergency costs and resilience costs



Source: Commission calculations and analysis, using input from Atkins, Infrastructure Transitions Research Consortium and Regulatory Economics Ltd.

Annex 3
A twin-track approach to tackling the risk of drought

This annex describes the analysis of demand management (reducing consumption and leakage) and infrastructure options to balance costs, benefits and risks.

Reducing consumption

Increasing the water efficiency of appliances can save considerable amounts of water. For example, modern dual flush toilets use about half of the water of traditional ones, standard showers use about one third the water of a bath, and aerated shower heads further reduce water use.[21] Behaviours are important; for example showering for one minute less each day can save about 3,000 litres of water per year, saving £7 on energy and £12 on water bills.[22] Campaigning and public engagement also play an important role[23] and water labelling would allow consumers to make informed decisions.[24]

Current efficiency initiatives are likely to result in savings of about 400 Ml/day by 2050[25] and new technology would increase this to 600 Ml/day over the same period, in line with the Commission's 'central technology' scenario.[26] There is strong evidence that charging by volume leads to more efficient water use. Standard meters can reduce average consumption by 15% and smart meters[27] by 17%.[28] Smart meters also enable better identification of leaks, help customers understand their consumption, and allow companies to quickly identify and target those struggling to pay their bills.[29]

Water companies can only impose volume-based charges for new homes or occupiers, where households use large quantities of water (e.g. power showers or swimming pools) or in areas classified as seriously water stressed. Despite the constraints, companies are increasing metering, and bills for unmetered customers would go up. Five water companies out of 18 should have near universal metering by 2030, and a further two by 2035.

Universal metering would reduce average water bills but some customers would end up paying more than they do now. Large families may be worse off with a meter[30] but this is consistent with the fact that they consume more water. Universal metering by Southern Water showed a reduction in the average water bill of £6 per year. More than half of households likely to have a lower income saw a reduction in their bill (partly related to reductions in consumption). However the average (mean) bill for households likely to have a lower income rose by around £10 per year. This implies that losses for those households that did pay more outweighed savings among the households that paid less, even though there were more of the latter group.[31] Assistance for lower income households that might be worse off with metering is therefore likely to be most effective if it is well targeted.[32]

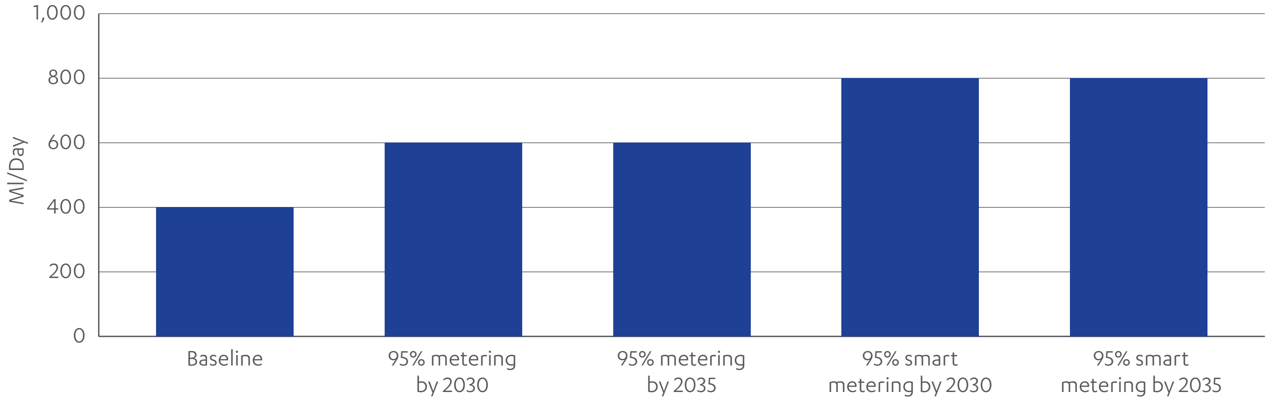
Water companies have a statutory duty to assist vulnerable customers.[33] Smart metering can help companies identify households with the highest water consumption, who might struggle to pay their bills. Smart meters could also enable variable tariffs (recognised in the energy sector as helpful for vulnerable consumers)[34] and more regular and transparent billing (which helps households to budget)[35].

Overall, water bills are not seen as burdensome by customers and stakeholder discussions indicate a generally positive attitude toward metering as observed by Consumer Council for Water research. Companies will therefore need to work with their customers and support them when rolling out compulsory metering.[36]

Commission analysis of the potential benefits of metering compared to a baseline of continuing at the current rate of meter roll-out with near universal conventional and smart metering by 2030 and 2035. The total amount of water that would be saved in 2050 ranges from 400 to 800 Ml/day (Figure 10).

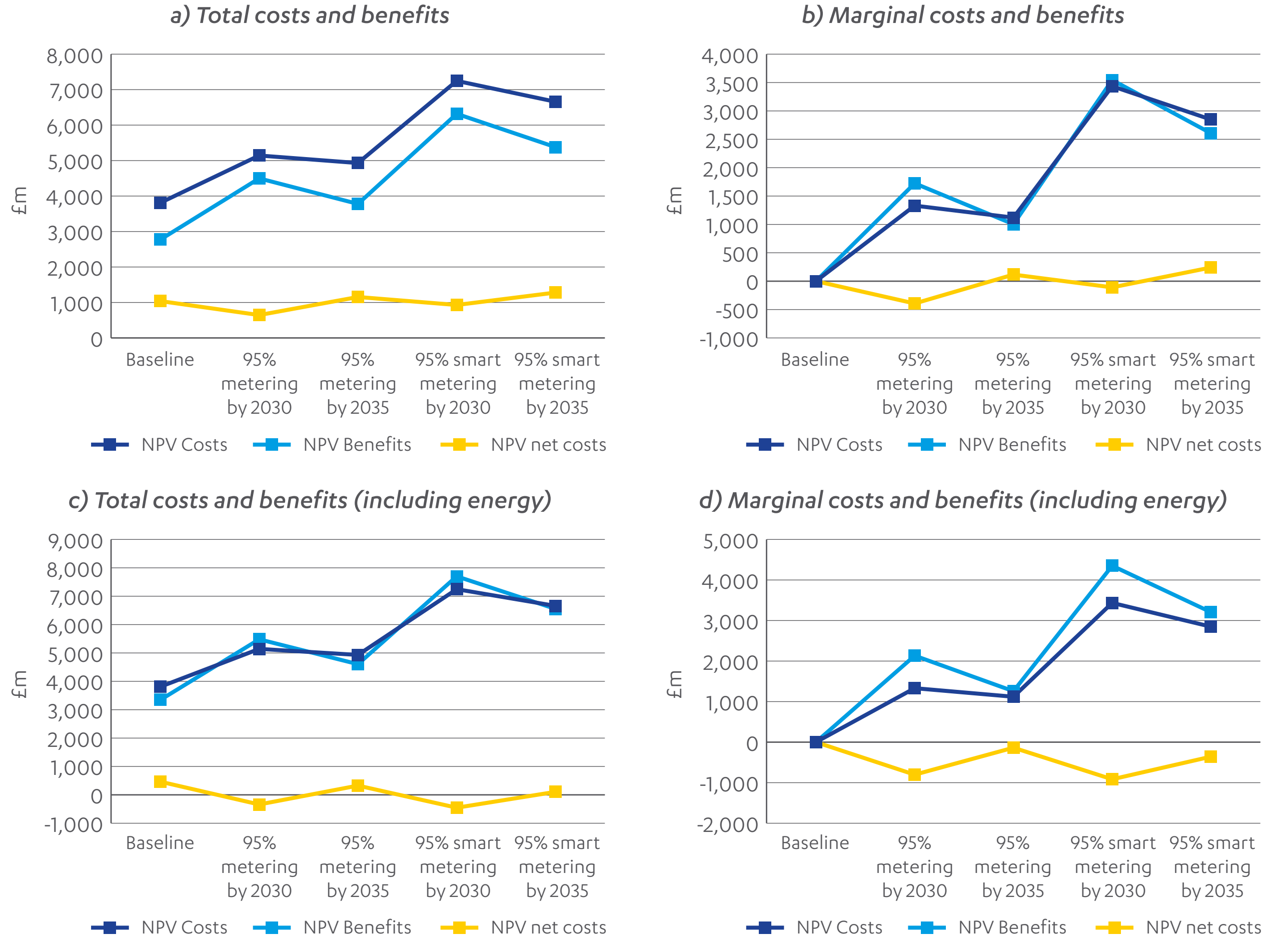
Figure 11 shows the total and marginal costs and benefits of these options. Costs include installation, operation, replacement and carbon costs. Benefits include avoided energy use (from treating and pumping as well as household energy use) and the avoided cost of infrastructure. These results suggest that, if the wider benefits are considered, quicker and more comprehensive smart metering should result in savings and is at worst cost neutral.

Figure 10: Water saved in 2050 under different metering options



Source: Commission calculations

Figure 11: Costs and benefits of metering policies



Source: Commission calculations using input from Regulatory Economics Ltd.

There is evidence that a faster and better planned transition to universal metering could unlock efficiencies and allow for more extensive engagement to help prepare customers.[37] Systematic metering should also help to identify and address water leakage,[38] target financial assistance at those households most in need and provide benefits in all regions in England, regardless of the level of water stress.

Increasing efficiency savings to 600 Ml/day by 2050 and near universal smart metering would reduce average (measured and unmeasured) water consumption in England from the current 141 to 118 litres per person per day, similar to Water UK's most ambitious pathway.[39]

Leakage

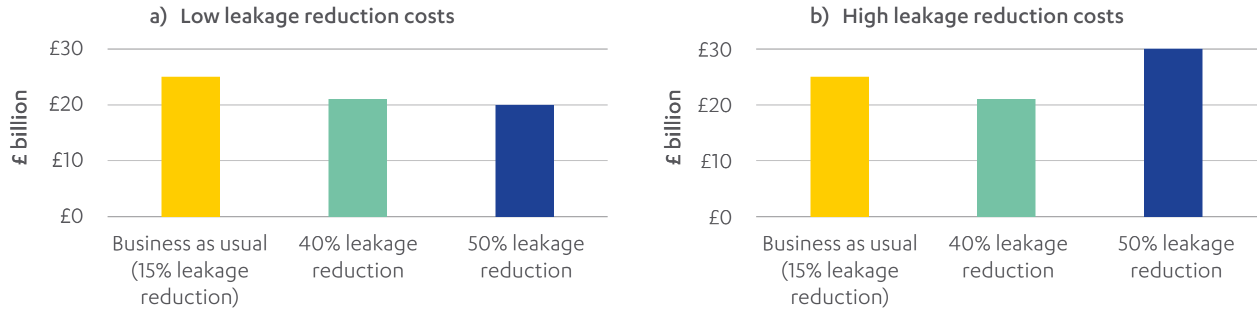
About 20% of the water abstracted from the environment by water companies is lost through leakage. Water companies reduced leakage considerably in the late 1990s, but since 2000 levels have stabilised, possibly because decisions were based on a 'sustainable economic level of leakage'. For Price Review 2019, Ofwat has changed the approach, requiring water companies to consider reduction of at least 15% from the 2020 level, or to the level of the best performing companies (upper quartile, in terms of litres/person/day). There are financial incentives to encourage water companies to reduce leakage.[40]

The Consumer Council for Water reports that leakage is one of the highest concerns for customers,[41] and that companies' performance in managing leakage can have a big impact on their attitude to water saving, as well as their perceptions of water companies. However, reducing leakage levels is expensive, and fewer than a third of the water companies have included a 15% leakage reduction by 2025 in their draft planning tables.[42]

Commission analysis considered the cost effectiveness of different leakage reduction levels. The costs of leakage reduction are uncertain, so the Commission used 'high' and 'low' estimates based on research by Water UK and UK Water Industry Research, the water industry's research body.[43]

These costs were compared with those of providing additional infrastructure to achieve the same level of drought resilience. Figure 15 shows the total costs of providing resilience to a 0.5% probability drought, combining different levels of leakage reduction with additional supply infrastructure and enhanced efficiency and demand reduction (proxied by the cost of extending metering). Additional benefits from leakage reduction, in particular environmental benefits from reduced abstractions, can be substantial but are not quantified in this analysis.

Figure 12: Comparison of the costs of achieving resilience to a 0.5% drought including different leakage reduction policies



Source: Commission calculations and analysis, using input from Infrastructure Transitions Research Consortium and Regulatory Economics Ltd

Supply infrastructure

To meet the Commission's recommendations, at least 1,300 Ml/day of additional supply infrastructure would be needed.

A range of different types of infrastructure can be used to increase water supply and factors such as the volume of water needed, versatility, cost and environmental impact influence the choice:

- Reservoirs have significant capital costs and are generally most cost-effective when large volumes of water are needed. They can also bring environmental benefits (providing habitats for birds and aquatic species), as well as recreational benefits. However, they take up large land areas and can disrupt local communities, especially during construction. Reservoirs must be planned well before they are needed, as it takes around ten years from the decision to build to being able to use the water supplied.
- Transfers can move water from areas with surplus to those where it is needed, using pipelines and pumping stations. In some cases existing infrastructure, rivers or canals could be used to move water. Costs depend on the distance and topography: long or complex transfers can be energy

intensive although Victorian transfers still supply Birmingham and Liverpool from Wales using gravity. There are risks from contamination by pollutants, algae, pathogens or invasive species. A transfer network would also allow other assets, including reservoirs, to be built further away from the areas of highest demand, where land may be more easily available.

- Other options to store water, such as aquifer and surface water storages, are usually less capital intensive but each scheme can only provide a limited volume of water.
- Additional water supply can also be obtained by treating non-potable sources, including sea and waste water. Desalination has the advantage of an effectively unlimited resource, but is very energy intensive and produces highly polluting waste. The potential for re-use (treating waste water to a potable level) is limited by the availability of suitable waste water and public acceptability, but it is less energy intensive than desalination.

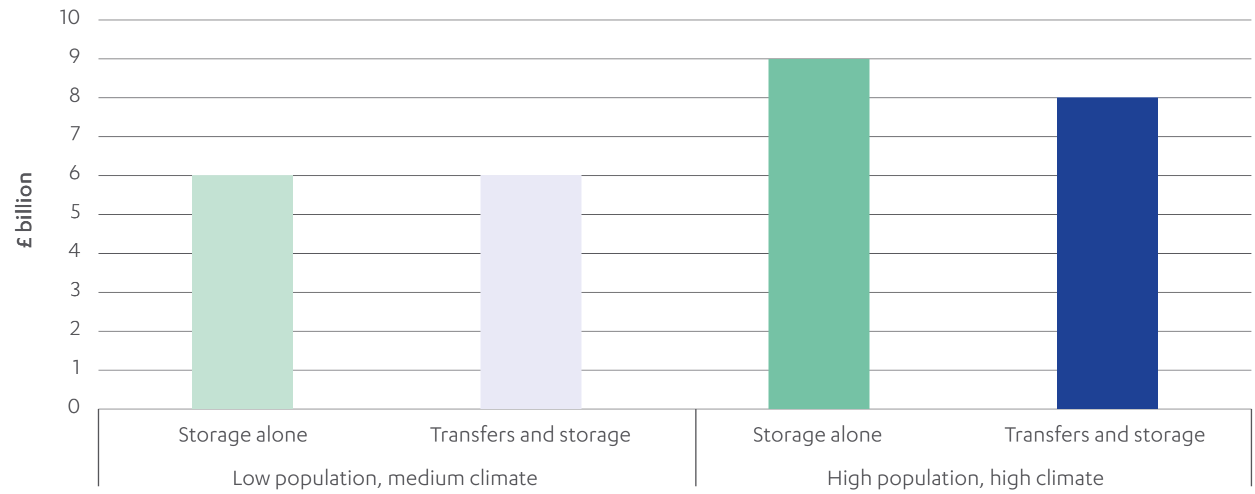
The best approach is likely to involve a combination of these options and the industry is well placed to determine the exact mix. The exception is water transfers. A range of studies have all found a positive cost-benefit case for greater transfers and water trading.[44] However, transfers currently only make up a small proportion of total supply (about 4%). This is likely to be because the incentives in the current system make developing a strategic transfer network difficult, meaning that the decision needs to be made at a different level.

The Commission modelled two different mixes of water supply infrastructure:

- Storage (i.e. non-transfer) infrastructure alone.
- A mix of infrastructure in which transfers are used as far as practical and the remaining capacity is provided through storage infrastructure.

Although precise costs are uncertain, the costs of a combination of a network of transfers, making up one third to a half of the resources needed, with storage infrastructure are comparable with those of non-transfer infrastructure (Figure 13).

Figure 13: Cost of supplying water via transfers and storage infrastructure vs storage alone



Source: Commission calculations and analysis, using input from Infrastructure Transitions Research Consortium and Regulatory Economics Ltd[45]

References

1 Ofwat analysis, in their response to the *Congestion, Capacity, Carbon* consultation
2 BritainThinks for the National Infrastructure Commission (2017) **Phase 1 Social Research**
3 UNDP (2006) **Human Development Report**
4 It is widely recognised that people in general find it very hard to value low probability events. See for example, Kahneman, D (2011) Thinking Fast and Slow
5 Water UK (2016) **Water resources long-term planning framework**
6 **https://www.nic.org.uk/**
7 **https://www.wmo.int/cpdb/ and https://www.metoffice.gov.uk/public/weather/climate**
8 To put this in context, the typical volume of water available to supply households and businesses averages 15,000 Ml each day.
9 This represents the need beyond intra-company transfers and small interventions needed to maintain existing capacity
10 As above
11 This study covers England only, but includes the areas of Wales that provide water to Water Companies whose customers are mostly located in England.
12 Water UK (2016) **Water resources long-term planning framework**
13 Byers, Edward A., Hall, Jim W., and Amezaga, Jaime M. (2014) **Electricity generation and cooling water use: UK pathways to 2050**
14 Environment Agency (2015) **Water supply and resilience and infrastructure**
15 Brown, I., Thompson, D., Bardgett, R., et al. (2016) **UK Climate Change Risk Assessment Evidence Report: Chapter 3, Natural Environment and Natural Assets**
16 Surminski, Style, Di Mauro, Townsend, et al. (2016) **UK Climate Change Risk Assessment Evidence Report: Chapter 6, Business and Industry**
17 Hall, Jim W. et al. (2016) **The Future of National Infrastructure. A System-of-Systems Approach**
18 The **Future Flow** hydrology dataset was created by the Centre for Ecology and Hydrology (CEH) and contains different scenarios of future river flows under climate change conditions.
19 Atkins for the National Infrastructure Commission (2018) Analysis of the cost of emergency response options during a drought
20 The cost of responding to a drought emergency are made up by the cost of maintaining 1% level of resilience to 2050 plus the emergency costs only as shown in Figure 7. The long-term resilience costs include costs of leakage reduction, demand management and infrastructure excluding intra-company transfers and small interventions needed to maintain existing capacity.
21 **http://www.waterwise.org.uk/save-water/**
22 **http://www.energysavingtrust.org.uk/home-energy-efficiency/energy-saving-quick-wins**
23 Consumer Council for Water (2017) Water saving: helping customers to see the big picture
24 Water Label (2015) **The European Water Label Industry Scheme**
25 Water UK (2016) **Water resources long-term planning framework**, "business as usual" scenario.
26 National Infrastructure Commission (2017) **Congestion, Capacity, Carbon: priorities for national infrastructure - Modelling Annex**
27 Smart meters measure and feedback consumption data remotely at the chosen time interval.
28 Pericly and Jenkins (2015) **Smart meters and domestic water usage**
29 Pericly and Jenkins (2015) **Smart meters and domestic water usage**
30 Priestley and Rutherford (2016) **House of Commons Briefing Paper Number CBP06596 Water bills-affordability and support for household customers**
31 Ornaghi and Tonin, **The Effects of the Universal Metering Programme on Water Consumption, Welfare and Equity** and Consumer Council for Water (2016) **Beneath the surface: customers' experience on universal metering**
32 The Consumer Council for Water reports that in England and Wales, current social tariff schemes could support around half a million households, compared with the reported 3 million households that do not consider their bills to be affordable. Smart metering will allow companies to better identify these customers but it is unclear if existing measures are sufficient to help all who need it, regardless of any metering policy.
33 Water Industry (Charges) (Vulnerable Groups) Regulations 1999
34 Ofgem (2017) **Distributional impact of time of use tariffs of gas and electricity markets** and Consumer Council for Water 2017 and CCP (2017) **Price and Behavioural Signals to Encourage Water Conservation**
35 Consumer Council for Water (2016) **Staying afloat: addressing customer vulnerability in the water sector**
36 **https://www.ccwater.org.uk/priorities/your-priorities/working-to-support-customers/compulsory-metering/**
37 Walker, A. (2009) **The Independent Review of Charging for Household Water and Sewage Services** and Angling Trust, WWF-UK and others 2011 **Fairness on Tap, making the case for metering**
38 For example, Berger et al. (2016) **Exploring the Energy Benefits of Advanced Water Metering**
39 For 2040, Water UK's business as usual scenario forecasts average measured and unmeasured per capita consumption of 129 l/person/day (150 unmeasured and 124 measured), and 122 l/person/day (150 measured and about 110 unmeasured) are forecast in the enhanced scenario.
40 Ofwat (2018) **Price Review 2019 methodology**
41 Consumer Council for Water (2016) **Water, water everywhere?**
42 Although half of the companies declare the intention of reaching 15% reduction by 2025 in their planning document.
43 Water UK (2016) **Water resources long-term planning framework** and UKWIR (2011) Long term leakage goals, Report No 11/WM/08/44
44 Deloitte (2015) **Water trading – scope, benefits and options**; Cave, M (2009) Independent Review of Competition and Innovation in Water Markets; Ofwat (2010) A study on the potential benefits of upstream markets in the water sector in England and Wales; Ernst and Young (2011) Changing course through water trading
45 Regulatory Economics Limited for the National Infrastructure Commission (2018) Analysis of the costs of water resource management options to enhance drought resilience

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978-1-5286-0348-5