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EDITORIAL

Fostering industry collaboration for a better water future for all

The urgent need for seamless, efficient and environmentally focused service delivery has reached unprecedented levels for the UK water sector as we grapple with the complexities of ageing infrastructure, competing resources and the escalating impact of climate change. Collaboration is the key to meeting these challenges head-on to find the right solutions.

The need to intensify collaboration to deliver the programme of works in AMP8 – the asset management plan period covering 2025–30 – was one of the themes discussed at British Water's first annual conference, which took place in Manchester on 21 November 2023. Conference participants from across the water sector, government, non-governmental organisations and the supply chain reflected on how nurturing partnerships was critical to fostering a synergy of collective expertise, enabling the sharing of best practice and consolidating resources. Throughout the day participants heard about how collaboration cultivated an environment of innovation, creativity and continuous improvement – paving the way for a more efficient and cost-effective approach to service delivery.

Earlier this year, a strong performance on contractual approach, collaboration and communication catapulted Scottish Water to the top of British Water's annual water company survey. As the survey results show, water companies that embed cultures to foster a healthy ecosystem in which supply chain companies can operate – and innovate – effectively leads to the best solutions for customers and the environment. However, despite some strides forward for water companies in the last few years, we continue to see low scores for innovation, procurement and communication – a clear indication that work still needs to be done as we approach AMP8.

These areas are where collaboration is vital for fostering a culture of innovation and creativity and developing groundbreaking solutions that address the sector's most pressing challenges. By pooling knowledge and expertise, diverse stakeholders can devise innovative approaches to water management and conservation.

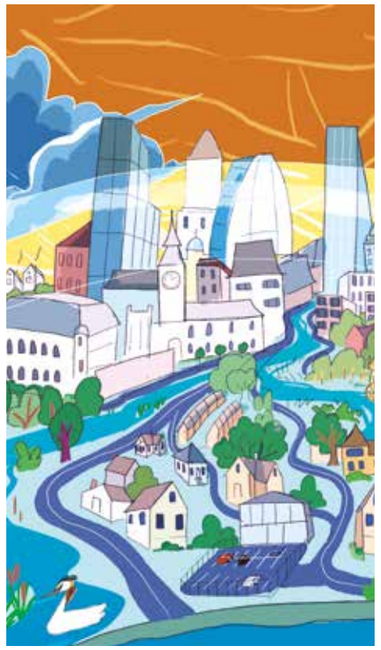
Building skills in collaboration also eliminates silos and streamlines processes, leading to increased efficiency and cost savings. By sharing resources and expertise, organisations can avoid duplicating efforts and optimise their operations, ultimately benefiting sector professionals and the environment.

Collaboration is not just a buzzword; it is a strategic imperative for the UK water sector. By embracing a collaborative approach, the industry can harness the collective power of its stakeholders, ensuring a secure and sustainable water future for generations to come. This unified effort is crucial to unlocking the vast potential of AMP8 and driving transformative change.

Lila Thompson is CEO of British Water, a not-for-profit, dynamic membership organisation that provides leadership, support and best practice and addresses the challenges faced by the UK water sector through its technical and international forums and its independent subsidiary, the Water Industry Forum. Lila is responsible for British Water's strategic direction, raising the profile of the supply chain of the water, wastewater and wider industry for the benefit of customers and the environment. Lila was formerly responsible for British Water's international services and led business development visits to a range of markets across the globe. She has over 20 years' experience of driving business growth, developing policy and engaging with stakeholders in a variety of sectors.

Cover design: Lily Padula is a multi-disciplinary illustrator, animator, and artist based in Brooklyn, New York. She loves to create work about emotional experiences, environmentalism/nature, and abstract scientific ideas. www.lilypadula.com

CONTENTS



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The environmental SCIENTIST provides a platform to discuss key issues within the environmental sciences, hosting original articles written by professionals, academics and experts working across the sector.

INTRODUCTION

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Water: the challenges and opportunities facing the sector

Nicci Russell examines the sector's complexities and considers the ways in which it can contribute to tackling the climate emergency.

THE CHALLENGE WITH WATER

Water is essential to life. We cannot live without it – humans, animals, plants and the world in general. No part of the economy can function without water – schools, hospitals, transport networks, industry, shops, data centres, offices and many others – and without it society would collapse. The UK's National Health Service, for example, uses an estimated 40 billion litres of water a day.[1] Water is also essential to human spirits and wellbeing: a relaxing bath, an invigorating shower, a refreshing swim in open water, a cool glass of water, a picnic by a river. But in the UK water is not given the respect it warrants: it is treated as having a lower priority than carbon and energy bills (despite the fact that water

efficiency, for example, can reduce both of these); it gets polluted and wasted; and, while less attention-grabbing but just as important, the water sector does not benefit from the joined-up, efficient governance and political attention it needs. Water is a precious resource, but it is a complicated issue.

These issues are not exclusive to the UK. Waterwise's report with the British Standards Institution earlier this year shows the scale of the global challenge: the United Nations (UN) reports that a quarter of the world's population already lives in countries that are under water stress and over 3.5 billion people have inadequate access to water for at least one month per year.[1] The challenges we face are numerous and multifaceted: around 90 per cent of disasters are water related; there were 45 major drought events in Europe in the past century affecting millions; and 1.43 billion people were affected by drought between 2000 and 2019.[2]

The UK has a huge amount to do to get it right, so it is timely that this edition of Environment Scientist focuses on water. The issue has been informed by the IES's recent launch of the Foundation for Water Research (FWR) Community: a cohesive, innovative and independent-thinking community of water professionals offering guidance and strategic thought leadership on the IES's water activities. The Community was launched after the IES inherited the FWR's mission in 2022, and uses an integrated, systems-thinking approach to address water issues and their interactions with land and air. As we already know, there are solutions, which like the FWR's cross-disciplinary focus must be collaborative, as the challenges are multifaceted.

WHO IS IN CHARGE IN THE UK?

When the Water Act 2014 was approved by the UK parliament, updating previous legislation to introduce competition into the water industry in England and allow business customers to choose their supplier for the first time, it was the most complicated piece of legislation the House of Lords had seen.[3] Stakeholders new to the UK water sector often comment on the vast number of stakeholders. To illustrate this, over a hundred organisations contributed to Waterwise's *UK Water Efficiency Strategy to 2030*.[4] Waterwise is involved in numerous water-efficiency networks – which itself is a subset of a wider water network – but does not focus on other issues such as leakage, wastewater, carbon or customer service (see **Figure 1**).

Water, unlike energy, is also devolved. England, Northern Ireland, Scotland and Wales have political and ministerial control over their respective water legislative and policy frameworks. Two regulators – Ofwat, the economic regulator, and the Drinking Water Inspectorate – cross boundaries, covering England and Wales; otherwise, each devolved administration has its own economic, environmental and drinking water quality regulator, and its own minister. This gives a total of nine direct water sector regulators in the UK and does not factor in others such as regulators responsible for health and safety and financial probity.

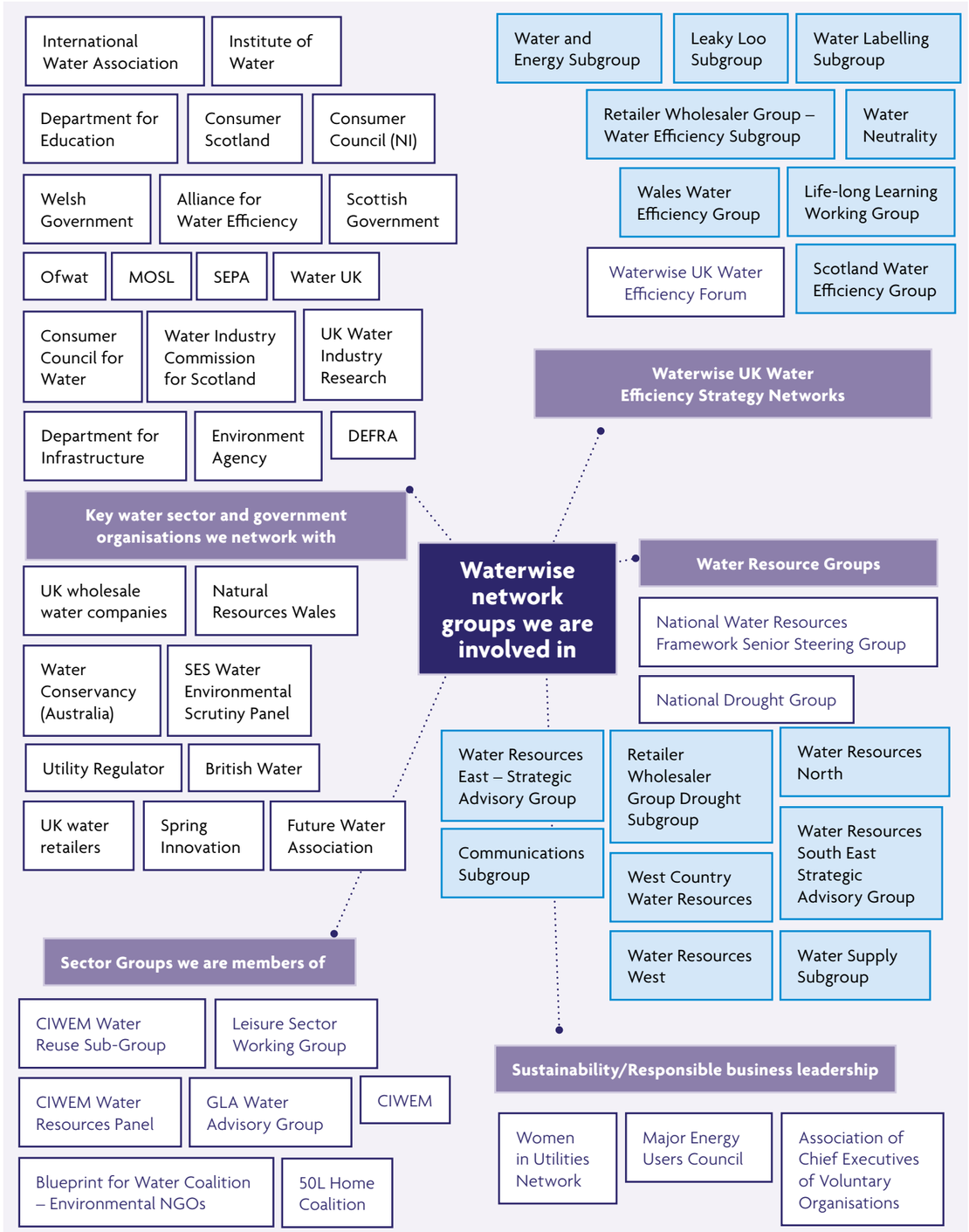
Unsurprisingly, the difference in political governance across the UK reflects a difference in how the water sector is set up. In England, the Conservative Government privatised municipal water companies in 1989 – a model that remains unique in the world. In Wales, the water company supplying almost all businesses is a mutual company, which returns profits to customers rather than shareholders. In Scotland and Northern Ireland there is a single water company in each nation, and both have remained in public ownership.

Even the most avid supporter of the UK water sector setup would agree that this complexity is not always efficient. Legitimacy can also be affected – in other words, customers' trust in the industry and how it operates. The reasons for this are complex: they include the profits and dividends made by water companies and their owners in England, the amount of water leakage from ageing infrastructure, and the raw sewage in waterways and on beaches.

This complexity is supported by data. In the summer of 2023, three UK water companies were in the top-five-performing utility providers for customer satisfaction, with all either on a par with or beating the national average score.[6] Yet a couple of months earlier, the Consumer Council for Water released research findings for England and Wales. These showed that fewer than half of customers had positive associations with their water provider, and a third had negative associations. While trust in water companies to provide reliable services fit for the future and to keep consumers well informed was fairly high, consumer trust in water companies to protect the environment was the lowest of all aspects measured.[7]

WHY DOES IT MATTER WHAT PEOPLE THINK?

Taking water scarcity as an example, challenges such as leakage, pollution and legitimacy mean customers are not keen to change their behaviour to drive water efficiency.[8] Waterwise runs campaigns throughout the year on water efficiency – for example, Water Saving Week every May regularly reaches around 4 million people – and has created a downloadable playlist to encourage shorter showers. Waterwise's independence helps these messages land.[9,10] But the 'noise' around the water industry is a challenge. And yet, behaviour change is essential to make ends meet in terms of water: for the environment, society and the economy. Even if all water company leaks were fixed and planned new supply-side measures all came online, there would still be a gap that water efficiency in homes and businesses must fill.



▲ **Figure 1: The UK water sector networks Waterwise is involved in. (Source: Waterwise[5])**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Equally seriously, public antipathy, or lack of trust in water companies, means that infrastructure schemes seeking to close the gap between supply and demand can face such local opposition that they are unable to proceed.[11]

WATER SCARCITY AND POPULATION GROWTH

In the UK, awareness of water scarcity is very low – despite the recent heatwaves and droughts that have shown this to be an issue, including in areas that are considered very wet, such as Scotland, north-west England, Wales and Northern Ireland. Report after report shows a huge gap in the coming decades between the amount of water available for supply and the expected demand for it; a gap that is already apparent.[12,13] The UK also experiences far more frequent droughts than previously.

Downplaying water scarcity is also a feature of the approach of governments, regulators and industry. Despite more positive messaging and policy and legislative changes in recent years across the UK, the investment in demand management is miniscule compared to supply-side measures. For example, the most recent water companies' 25-year resource management plans for England show that a total spend of about £200 million a year on water efficiency – less than what one water company would spend on a single supply-side scheme, such as a reservoir. Alongside this, the UK population is growing. It increased by approximately 11.1 million (19.8 per cent) in the last 50 years and by around 3.7 million (5.9 per cent) in the past decade.[14] And on average each person in the UK uses more water than before as our water-use behaviour changes to reflect our changing lifestyles – double the per capita consumption of 50 years ago – with daily (at least) showering, garden sprinklers, hot tubs and paddling pools.

The UK is making progress on issues such as mandatory water-efficiency product labels, which can also be linked to standards for new homes and buildings, and a statutory demand-reduction target for England. But water scarcity still does not get a seat at the table, where big decisions are made on economic and housing growth, energy policy and net zero targets. Cambridge is an example of where government money and focus are being invested, as water scarcity is already limiting economic growth, but this needs to be more mainstream.[15]

Waterwise's water efficiency strategy sets out the scale of the challenge and the opportunities attached to it:[5]

- Climate change and population growth are putting increasing pressure on water availability;
- The health of the water environment urgently needs improvement;
- The UK's water resources are under growing pressure; and
- Water use per capita is increasing over time.

Using water more efficiently can help the UK to:

- Secure future water supplies and adapt to climate change – water companies are already struggling to supply water during heatwaves and droughts;
- Enable future growth – new residential developments are already being refused planning permission due to water scarcity;
- Improve the natural environment – nearly a fifth of surface waters in England and over a quarter of groundwaters do not have enough water to protect the environment and meet the needs of fish and other aquatic life;[16]
- Reach net zero – saving hot water reduces energy bills in homes and buildings, and saving all water reduces the need for the industry to pump and treat water and wastewater;
- Save money and help support people facing affordability issues – reducing water and energy bills; and
- Deliver on UN Sustainable Development Goal 6 to 'ensure access to water and sanitation for all'.[17]

The strategy aims for a UK in which all people, homes and organisations are water efficient (see **Figure 2**).

The water industry in the UK is committed to halving water leakage. However, as trade body Water UK said in 2022: 'Leakage rates may be as low as they've ever been, but we are still losing the equivalent of 1,245 Olympic swimming pools per day'.[18] Again, extremes of weather exacerbate the challenge of tackling leakage.

CARBON AND ENERGY

Around 5–6 per cent of the UK's total greenhouse gas emissions come from household water supply and use. The UK water industry has set out plans to reach net zero, but this does not capture the approximately 90 per cent of water-related carbon emissions that result from how we use water at home for heating and washing; it only covers how water companies are supplying water and dealing with wastewater.[19]

Modest reductions in household water use of 5–6 per cent could deliver big annual carbon emissions savings – a bigger saving than was achieved in the entire UK residential sector in 2017–18 or in 2018–19. And just as crucial, particularly in the current cost of living crisis, is that hot-water efficiency reduces energy bills for homes and businesses.

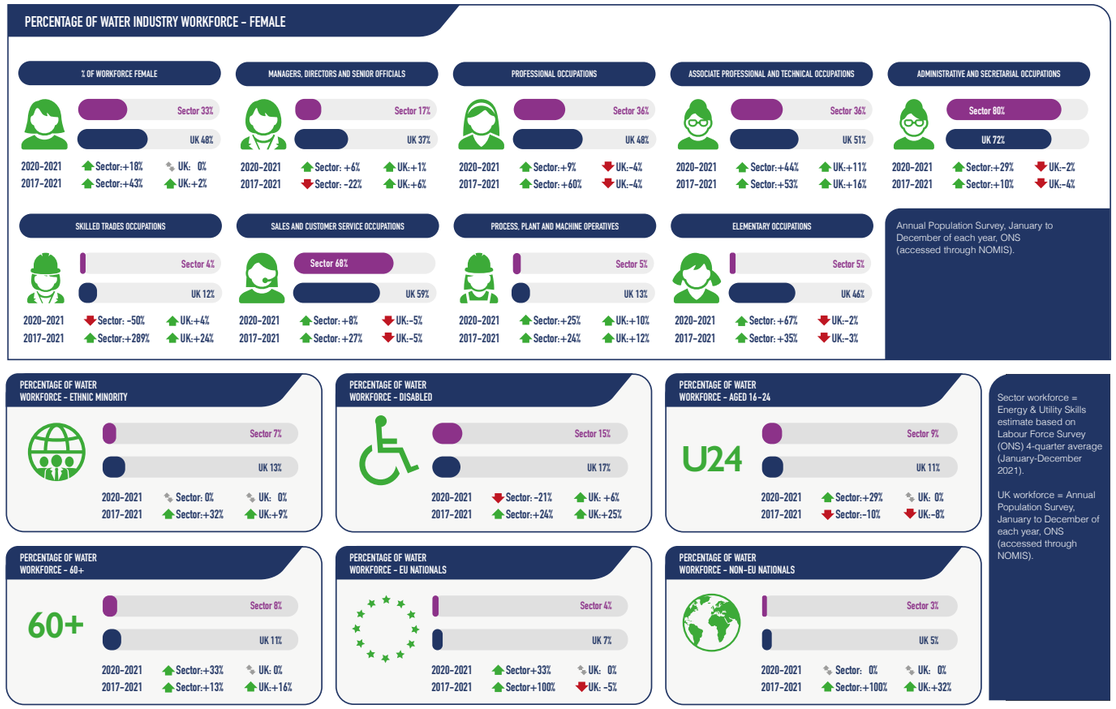
POLLUTION

Ageing infrastructure, company errors and more frequent extreme weather events have also led to significant anger over rivers and beaches being polluted by human excrement. In its November 2023 response to the House of Commons Public Affairs Committee's inquiry into the work of Ofwat, the Blueprint for Water environmental non-governmental organisation coalition stated that:

> 'The state of the water environment is critical. 0% of waterbodies in England are considered to be in good overall health, with both people and nature suffering the synergistic impacts of agricultural run-off, wastewater pollution, toxic chemical cocktails, and unsustainable abstraction.'[20]

Pollution of rivers and beaches has been a national headline on many occasions in recent years. In March 2023, the BBC reported that in 2022 'sewage entered rivers and seas on average 825 times a day'.[21] River

▲ **Figure 2: Strategic objectives of the UK water efficiency strategy. (Source: Waterwise[4])**



▲ **Figure 3: Water industry demographics. (Source: Energy & Utility Skills[24])**

Action UK was launched in 2023 with an animation called This is Sh*t, supported by celebrities such as actor and broadcaster Stephen Fry, who said:

> 'Rivers are a nation's priceless couriers of life, health and beauty. Whether it is swimming, rowing a boat, dipping a hand into the current, playing Pooh sticks over a bridge or sitting on the banks and watching the mayflies and dragonflies dance in the air, rivers and streams bring us all solace and enchantment. To befoul them … is a desecration of everything we should hold dear. We've been here before. The Great Stink of 1858 caused such a stench in the River Thames that plans were made to move Parliament out of London.'[22]

Ministers have called water companies to account and the political parties are competing to outdo each other on how they will tighten requirements on reducing sewage spills. Water companies argue that the investment levels allowed by the regulator are not enough to update ageing infrastructure – much of which was designed in the 18th century to divert flooding from homes and buildings during extreme rainfall, long before the climate emergency was established.

Water companies, governments and regulators are working hard to improve this and end pollution, but campaigners and many members of the public strongly feel it is too little too late.

SKILLS

The water sector is critical to the UK economy; its workers play an essential role in delivering environmental improvements and safe drinking water to millions every day and in removing and treating wastewater. During the Covid-19 pandemic, water company staff were classified as keyworkers, permitting them to work as normal during lockdowns and indicating how essential their work is to society and the economy. However, the UK water sector is facing a substantial skills shortage due to industry changes and a need for new skills; an ageing but experienced workforce; concerns about the legitimacy of the sector; and systemic bias against diversity, which while common across the economy is heightened in the water sector.

Organisations like the Institute of Water, Energy & Utility Skills, and the Chartered Institution for Water and Environmental Management are doing excellent work in promoting and upskilling the sector, and water companies have comprehensive apprenticeship programmes and schemes linked to schools and universities as well as some diversity targets. But more needs to be done.

Yet despite the challenges the water sector needs to tackle and the ongoing work it needs to continue delivering, over 20 per cent of the industry's skilled workforce is expected to retire in the coming decade;[23] just 9 per cent of the workforce is aged under 24 years compared to 11 per cent in other sectors. And 93 per cent of the sector workforce is white compared to 87 per cent in the wider UK workforce, while only 33 per cent are women against 48 per cent for all sectors (see **Figure 3**).

SOCIAL JUSTICE, DIVERSITY AND INCLUSION

Equity, diversity and inclusion are as essential for the water sector as they are elsewhere in the face of systemic and historical biases against groups of people. Without significant progress on this, the UK will not achieve climate justice. When Cape Town, South Africa, was running out of water in 2018 after three consecutive dry winters, for example, it reinforced existing inequalities.[25]

Measurement of equity, diversity and inclusion to inform future work and targets is key to understanding baselines and setting ambitions. The IES agreed for the first time to survey the diversity characteristics of all contributors to this journal – a welcome commitment that will inform its future work. ES

Nicci Russell is CEO of Waterwise, the UK's not-for-profit campaigning organisation on water efficiency. Nicci has chaired and participated in groups on demand management for the Defra Secretary of State, and as a Defra Special Adviser advised previous Secretary of State Margaret Beckett on environmental issues. As an Ofwat director, she led work on resilience and independent regulation. Nicci is an Honorary Fellow of the Chartered Institution of Water and Environmental Management and a longtime industry awards judge. She has received awards for Outstanding Contribution to the Water and Wastewater Industry, and for championing diversity and inclusion and water efficiency. Nicci is chair of national young people's development charity Power2 and a school governor.

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Water, water (not) everywhere...

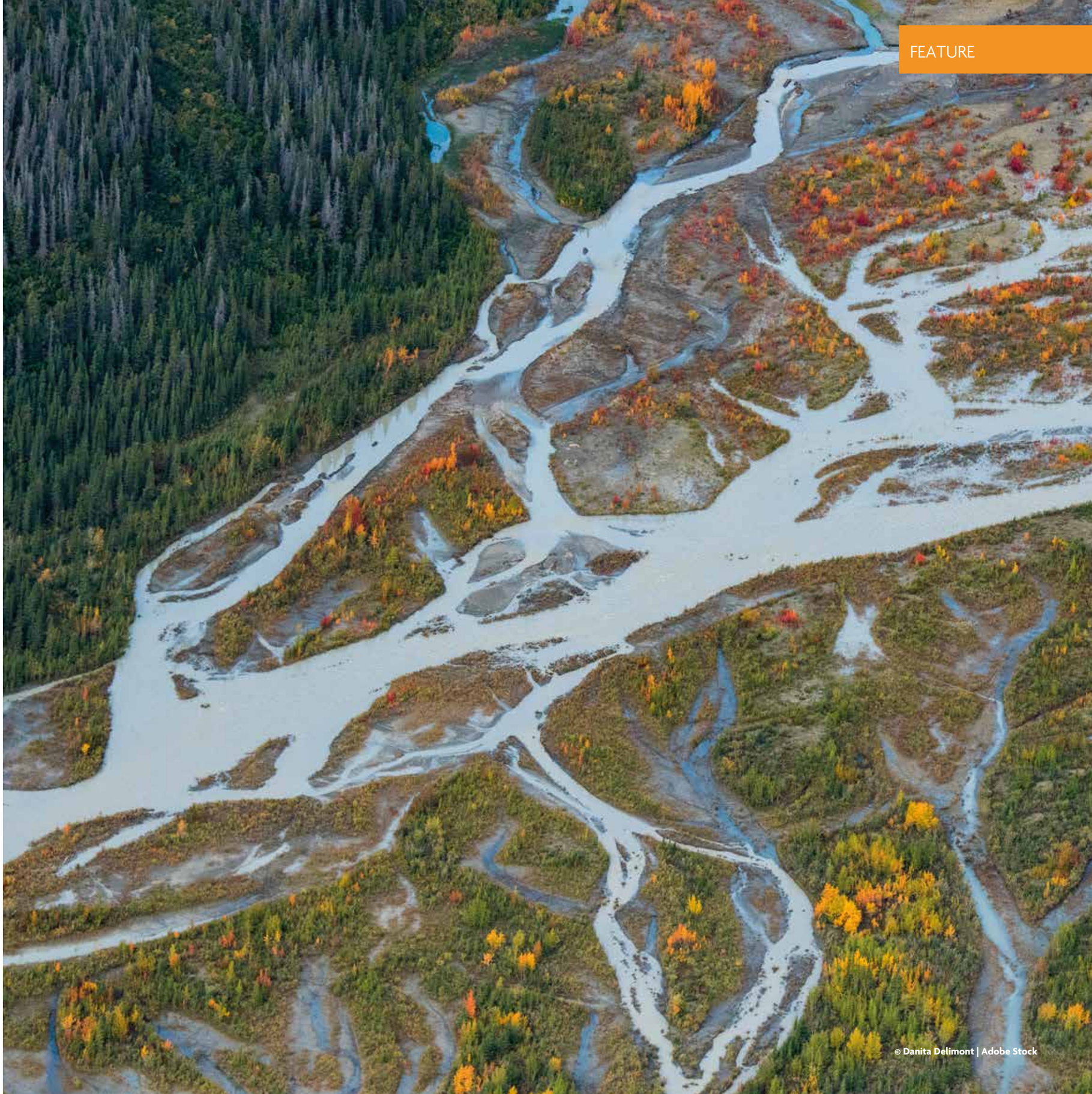
Mark Everard explores the consequences of human-made changes to our river catchments and how we can bring them back to a more natural state.

Our neolithic ancestors (let alone Coleridge and his poorly misquoted Ancient Mariner[1]), if teleported into contemporary British and lowland European landscapes, would wonder where all the water had gone.

THE NATURAL STATE OF RIVERS

European landscapes and riverscapes in pre-human times differed greatly from those we inhabit today, and indeed prior to the Agricultural Revolution with its subsequent enclosures and land use intensification. It is not just the widespread impoundments, bridges and bank reinforcement affecting river channels. More profoundly, it is the wholesale drainage of a formerly heterogenous landscape and the constraining of channels that characterise this marked difference. Rivers formerly comprised ever-morphing, braided systems with multiple channels actively migrating in floodplains. Obstructions and diversions of water flows, particularly as trees fell with age and instability but often through the actions of widespread European beavers, scoured new pathways and opened dynamic floodplain landscapes that were grazed by aurochs and other herbivores.[2]

FEATURE



FEATURE

Active and continuous successional processes would form braids of diverse surface water channels with varied flow regimes, connected with disparate and dynamic wetland types bounded by drier hillsides.[3] All these wet habitats were interconnected: laterally across broad landscapes; longitudinally with heterogeneous flow regimes supporting diverse species and life stages; and vertically into the underlying gravels, groundwater and other bed strata. This geomorphologically active world was the ecosystem within which much of our wildlife evolved, its characteristics supporting the needs of fish, plants, invertebrates and other organisms that evolved within them.

THE UNNATURAL STATE OF RIVERS

The catchment landscapes that we accept as normal today – drained and converted floodplains, armoured banks, dredged channels, weirs and other impoundments, weed cutting, grazing and tilling up to the channel edge, for instance – are the product of thousands of years of intensifying human engineering and other interventions for agriculture, settlements, industry and associated infrastructure.

These direct systematic pressures are compounded by the progressive eradication of nature's ecosystem engineers: species with a disproportionately high influence on habitat creation, modification, maintenance or destruction. We have lost large carnivores, such as wolves and lynx that drove grazing animals from river valleys and controlled their numbers. We have also lost larger grazers such as aurochs that cropped swards and maintained exposed riparian grassland, and beavers that had a radical influence on hydrology and wetland habitat diversity. These direct and indirect pressures progressively disconnected channels from dynamic floodplains and the natural wetland continuum to constrain them into narrow conduits; these constraints were conceptual, too, limiting our perception of what is normal and natural.

One indicator of these long-term and radical mass ecosystem changes, many driven by agricultural intensification, is the eventual loss of the burbot (*Lota lota*: freshwater fish) across eastern England in the latter part of the 20th century. Burbot depend on inundated floodplains in midwinter for their spawning and nursery needs, but were finally extirpated through progressive drainage and disconnection of riparian wetlands. While aurochs and large predators such as lynx and wolves were persecuted to extinction, the burbot was a more passive victim of widespread systemic change – the metaphorical canary in the coalmine of ecosystem damage through progressive habitat drainage and fragmentation – and not, as is often lazily repeated, a consequence of climate change.[4]

WHAT IS A RIVER?

River connectivity – laterally, longitudinally and vertically – matters not just for the daily and seasonal needs of fish for feeding, spawning, nursery, and refuge from spate flows and predation, but for so many other river and riparian organisms. It also matters for wider ecosystems, including biota across all taxa as well as, critically, the multiple beneficial ecosystem services that support and enrich humanity.[5] Biodiversity loss is the ultimate indicator of disintegrating human security and opportunity.

Today, we tend to conceptualise rivers as water flows obediently remaining within channels cut through 'dry land'. This dry land either side of the main stem of the river is often under separate ownership and subject to economic uses, with river channels forming boundaries and lines on maps between fixed parcels of land identified as someone's property. Protection of buildings and farms and other assets has consequently often resulted in engineering to immobilise naturally dynamic ecosystems, to the extent that the media sounds an alarm when rivers burst their banks – in other words, predictably occupy floodplains formed by natural hydrological processes, albeit often amplified by upstream engineering. Societal expectations that rivers belong in discrete, single channels rather than segueing into dynamic and heterogeneous ecotones – across a continuum from fully wet to fully dry hinterlands – is the result of shifting baseline syndrome (a psychological phenomenon of shifting perceptions of environmental conditions) that resets what we accept as the normal structure, ecology and functions of river systems.

HALTING AND REVERSING DECLINING TRENDS

In the industrial era, and with increasing evidence of our overt negative impacts on nature, we began to instigate a range of environmental protection measures. These included pollution controls, the creation of reserves for the most obviously threatened species and, more latterly, the management of selected river reach structures. We also initiated controls on certain invasive and disruptive alien species, such as floating pennywort (*Hydrocotyle ranunculoides*) and signal crayfish (*Pacifasctacus leniusculus*), though generally only once they had taken hold rather than with foresight of their potential impacts. But the language of protection suggests that river systems are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external to humanity rather than living, critical resources underpinning many of our needs.

Some more systemically aware thinking is emerging as the western world moves into post-industrial times. As one example, we are tinkering with concepts often aggregated somewhat uncritically into umbrella terms such as rewilding, re-naturalising or restoring.

Restoration to a truly wild riverscape is an unattainable short-to-medium-term goal in today's highly populated and exploited world where the underpinning geomorphological, ecological and climatic driving forces are so profoundly changed. But a clear-sighted and scientifically founded view of what 'natural' means is essential if we are to halt, and ideally reverse, damage to critical natural assets such as river systems.

Replication of desirable river forms alone without a functional context is naive. If we are to address the restoration of rivers and the multiple hydrological, geochemical, ecological and aesthetic benefits they confer on society on a strategic basis, we need a conceptual reset about what a river is. Our communication about rivers needs to recognise that they are more than blue lines on maps constrained by contemporary land drainage and bank reinforcement. A richer dialogue is required to address the ecological basis of healthy and self-sustaining fishery ecosystems, natural regulation of flood and drought, the cycling of carbon and nutrients, replenishment of soil fertility, and culturally valued aspects provided by healthy catchment systems; equally important is stimulation of dialogue around the costs that result from their degradation.

River restoration science and practices have evolved to their current, albeit knowingly imperfect, state. But geomorphologists, ecologists and geochemists, among other disciplines, concur that 'messy rivers are healthy rivers'.[6] It is the inherently chaotic interactions of natural processes that characterise rivers: unpredictable erosion, deposition of woody matter and sediment, and variable flow regimes, channel width and other structures that denote a system that is functionally active and multi-beneficial to society. Embracing chaos in its scientific sense – unpredictable outcomes albeit driven by deterministic laws – lies at the root of this messy perception of the health of river systems as a fuzzy-edged whole that comprises the channel, floodplain and linked wetlands, hyporheic zone (subsurface flows) and groundwater connections. To this, we must add shaping forces flowing downstream from often extensive catchments that bring formative flows of energy, water, sediment and propagules (seeds, cells or structures that can spread and grow into new organisms).

This approach to river restoration may be hard to conceptualise, let alone act upon, in inherently feudal landscapes of fragmented ownership and assumed rights. But a focus on processes, driving the outcomes from which so many societal benefits flow, gives us better chances of regenerating these vital life-support systems. A functional approach to river restoration might mean that positive management interventions can be located at the origins of its driving forces – such as a groundwater recharge zone that may be nowhere near where the river flows – accruing multiple benefits to people and ecosystems.

Legislation has yet to catch up with this functional approach; legacy regulations are more often focused on the attainment of baseline ecological, chemical and geomorphological status, and often in the channel only. The reality is that the processes matter more than the form, although the latter is an indicator of success. From the current starting point of a world rooted in many unsustainable norms, it is a challenge to convert a generalised vision of a wetter, more complex landscape reticulated by cleaner water across a continuum of linked habitats into operational reality. But recognition and communication of the numerous benefits that healthy and functional ecosystems confer, underpinning future needs spanning disciplinary interests more sustainably, gives us useful language for influencing perceptions and norms.

THE ART OF THE POSSIBLE

As well as benefits there are limitations on the practical potential for restoration of natural landscape hydrology – for instance, land ownership and embedded rights, siloed regulations, and lost keystone species. Not all such constraints are bad. For example, we do need to use land for food production. However, with some strategic insight, we can see the rationale and economic benefits of giving rivers more room for their natural beneficial functions to reassert themselves, albeit in a narrower way than their original corridors.

This transition does require challenging some assumed rights and the perverse economic drivers behind them. One such driver is converting valuable semi-natural riparian wetland habitat for intensive maize cultivation. This form of floodplain conversion robs river systems and society of a wealth of beneficial ecosystem services: the system is transformed for biomass production systems that are rewarded by markets – though this is achieved at massive cost to a wide range of ecosystem services – resulting in multiple and net adverse societal and ecological consequences.[7] This is one of many pressures contributing to the 90 per cent of floodplains across England now being so severely changed that they no longer function properly for flood regulation, the 65 per cent of floodplain extent modified to create smoother surfaces, and the 9 per cent lost entirely to urban and suburban developments; this leaves just 0.5 per cent of natural extent occupied by wetland.[8]

The good news is that we can change with sufficient insight and motivation. In County Waterford, Ireland, wetland recreation has rehydrated whole catchments and, through this, regenerated the river in the Anne Valley. This has led to the return of salmon, sea trout, otters, and traditional and aesthetic landscapes.[9] Farmers in the catchment wonder where all the water came from; it is amazing what happens when water in the landscape is treated as an asset rather than a threat to be pushed out to sea as rapidly as possible.

Where strategic interventions at catchment scale have been successful in safeguarding or rebuilding ecosystem function, rather than narrowly exploiting it, a wealth of societal benefits can occur.[10] Where we allow natural processes to reassert themselves, it is surprising what benefits can re-emerge. The concept of rewilding and the water cycle can include interventions – more to the point, reduction or cessation of destructive land management – to enable natural processes, such as regeneration of natural vegetation to enhance soil hydrology, and wider changes in river networks that are beneficial to people and nature.[11]

It all comes down to what future we want: one of greater security and opportunity, or one increasingly constrained by the consequences of narrow, short-term exploitation that creates so many of today's existential threats. Our cumulative activities have created the Anthropocene; so the power to change course also lies within our hands and in how we respect and regenerate the rivers and other crucial ecosystems that support and enrich our lives. **ES**

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ANALYSIS

Urban drainage in the UK: a water industry in crisis

Richard Ashley and **Brian Smith** confront the wastewater problems we face and look at ways to improve our sewerage infrastructure systems.

Since time immemorial, society has faced, and continues to face, countless challenges and crises. The water industry is no exception. Water is vital to life, yet in this water-constrained world we are often careless with it. In the UK today water is mostly only thought about when there is either too much in the wrong place (flooding or puddles) or not enough (water stress or drought). Recent public and political attention has been drawn to polluted water bodies, largely due to the failure of those responsible for managing our wastewater systems, and considerable media interest has raised awareness about the seemingly uncontrolled discharge of untreated sewage from wastewater treatment plants and sewer overflows. As just one example, there were 342,346 spills from the 9,240 monitored overflows into rivers in England in 2020.[1]

THE WATER INDUSTRY TODAY

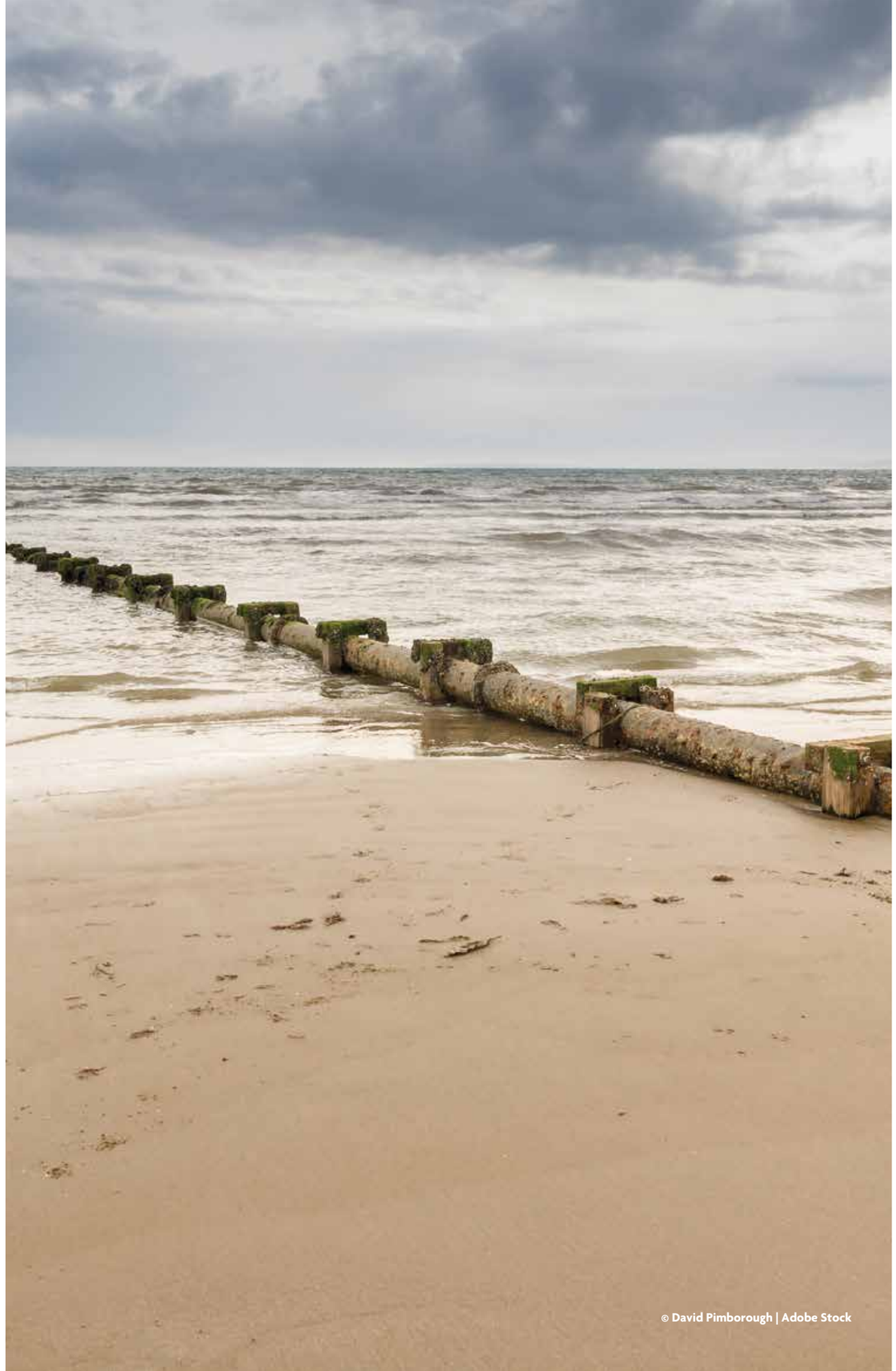
The water industry has been shaped by the Industrial Revolution, urbanisation and increasing demand driven by economic development and ever-higher environmental standards. The champions of the sanitary revolution in London from 1848–60 were John Snow, who showed that cholera was spread by water, and Edwin Chadwick, who came up with the idea of sewage disposal and of piping water into homes.[2] This facilitated the uptake of the ubiquitous WC.[3]

Sir Joseph Bazalgette, in planning and delivering major intercepting sewers, was responsible for the main drainage system we see in London today. This model changed the way we managed wastewater in towns and cities by collecting waste flows from any combination of domestic, institutional, commercial or industrial activities, along with rainfall running off paved surfaces, into a single set of pipes. Much of these combined sewage flows were conveyed into water bodies. As rainfall occurs intermittently, most of the time these combined sewers convey only foul or sanitary flows. However, when it rains the flows increase, typically by at least 30 times the dry weather flow, imposing stress on the sewerage network. This necessitated the use of combined sewer overflows (CSOs): structures designed to limit flow during rainfall events, thereby relieving pressure on combined sewer systems. In mainland UK there are some 26,000 CSOs spilling into rivers and the sea.

Highway authorities transfer most of the costs of dealing with rainwater runoff from roads onto sewerage customers. In 2009, the Walker Report recognised the need for highway authorities to reduce the volume of highway drainage runoff to sewerage systems and seek alternatives, including nature-based systems.[4] The situation will deteriorate further as the climate brings more intense storms, urbanisation continues to pave over absorbent surfaces, and population continues to swell, in turn increasing water use.

Since the 1960s, sewers in the UK comprise separate networks of pipes for surface water and premises drainage: so-called separate sewered systems. However, most separate systems connect at some point into the existing combined sewer network. Significant issues exist with these separate systems, such as wrongly connected drains where sanitary drainage is often connected into surface water systems and vice versa.[5] Untreated surface water discharges are toxic and damage the environment. Separated sewers are not the panacea promoted by the media, and separation of the UK's combined sewers would be prohibitively expensive.[1]

The independence of England's water industry regulators (Ofwat and the Environment Agency) was intended to allow the industry to deliver on its obligations, free from political interference, and to create a stable operating



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environment for investors.[6] However, the industry is no longer meeting those obligations and the current issues it faces around storm overflows and a lack of investment have brought this approach into question. The primary focus on capital rather than operational maintenance has also resulted in a big gap in the investment needed to maintain our sewerage infrastructure.

The 'economic gaming' of water company owners to maximise shareholder dividends has led to huge debt and preferential investment in large capital assets, many of which are not the best available technology but instead deliver the greatest financial returns at minimum risk.[7] The new super-sewer in London is the most obvious example of this, using 150-year-old technology to address the problems of overflows by dealing with the symptoms rather than the cause: river impacts, not rainfall and runoff.[8]

In Wales, Scotland and Northern Ireland, despite different business models for service providers, the outcomes are no better, at least for poorly managed CSOs. In each case, the business models are largely not fit for purpose. Industry professionals, environmentalists and other commentators are now calling for reform of the business model used in England, and of the way water companies are regulated.[6] In a survey of professionals, the Chartered Institution of Water and Environmental Management determined that most respondents believed that either the not-for-profit model of Welsh Water (35 per cent) or the nationalised model of Scottish Water (29 per cent) would deliver a better service.[9] There is also support for reforming the current operating model (23 per cent). In other surveys – for example, one done on behalf of Ofwat in February 2023 – public trust in water service providers in England was at an all-time low. Similar issues have also been raised by the public in Wales.

TOMORROW'S WATER INDUSTRY?

Although there are public and political concerns over how future stresses on water resources will be addressed, the scrutiny is now on the UK's wastewater systems, with a spotlight on pollution caused by sewage discharges. The Government has determined that improvements can be delivered within existing business models and by setting clearer targets.[10] At a cost of £60 billion over the next 25 years, these targets include no discharges into designated bathing waters, which will ultimately add £45 annually to household water bills.

This is not the first time such an initiative to control CSOs has been launched. Since 1991, the UK has strived to comply with the EU's Urban Wastewater Treatment Directive, which introduced controls on CSOs, achieving high levels of compliance. The UK has now seceded from these and other directives, replacing them with watered-down procedures and unclear targets, expressed mainly in aspirational terms.[11]

There is a failure to recognise that the CSO problem is but one part of how best to manage the water cycle in its entirety.

So what are the technology issues? Since the 1990s CSO spills in the UK have been managed by providing large underground storage tanks to hold back the water until the storm recedes. This is still how many engineers think about solutions and what led to the construction of the Thames Tideway Tunnel, which is a £7 billion 25 km long storage tank. At the same time as building this shiny, brand-new asset, Thames Water has been developing desalination plants in London, as there is 'too little rainfall' for security of supply. The company has also begun preparing the public for the recycling of treated sewage, as done in Singapore.[12]

In contrast, in many parts of the world, water falling on towns and cities is seen as an opportunity to be used before it enters drainage systems. In Australia, an 11-year drought prompted the development of the Cities as Water Supply Catchments programme.[13] Key elements include nature-based systems (known as sustainable drainage systems, or SuDS) and multifunctional infrastructure – in other words, not dealing with a single problem like sewer overflows but addressing the key issues in an integrated way.

WHY CAN THIS NOT BE DONE IN THE UK?

The essential barriers relate to the beneficiaries. The water cycle is split into many jurisdictions, despite water service providers bearing the most responsibility. Local authorities' responsibilities to communities include aspects of flood risk management. Numerous other primary agents impinge on aspects of the water cycle.[14] Managing water effectively in urban areas requires focused town planning.[2] Green and blue infrastructure take up valuable land space, whereas pipes and sewers are out of sight and can be built over, leading to the need for integrated town planning with the water cycle, like in Australia.[13]

Various pressure and affected groups also have significant and variable influence on policy. Housebuilders have a major voice, being at the forefront of developments. Efforts to ensure that systems to manage stormwater in new developments are as sustainable as possible have been thwarted in England since the non-implementation of Schedule 3 of the Flood and Water Management Act 2010, which specifies the use of SuDS. An important feature to drainage system practice in England is that developers and housebuilders have an absolute right to connect their properties into the public drainage system. This has traditionally made it very difficult for water companies to control flows, particularly of surface water into their networks, with the control of the flows being determined as part of the planning process.

The planning-led approach has not materially reduced the volumes of surface water entering the sewer system. The right to connect means that water companies do not have overall control of the inputs to their network but are nonetheless responsible for the outputs. This can affect how legal compliance is maintained and the resilience of sewerage networks to deal with future demands. The right to connect has already been removed in Northern Ireland. At the time of the proposed introduction of the act, the Government's growth strategy was based on housebuilding. The Homebuilders Federation effectively influenced government not to commence Schedule 3 by stating that there could either be affordable housing or sustainable drainage, but not both. To keep its growth strategy on track, the Government opted to support the development of affordable housing.[15,16] There is an apparent Government commitment to introduce regulations to compel the use of SuDS in England to alleviate flooding and reduce pollution, but it appears that once again these efforts have been delayed.[17] This is despite SuDS being used effectively in Scotland and Wales.

WHAT COULD OR SHOULD BE DONE?

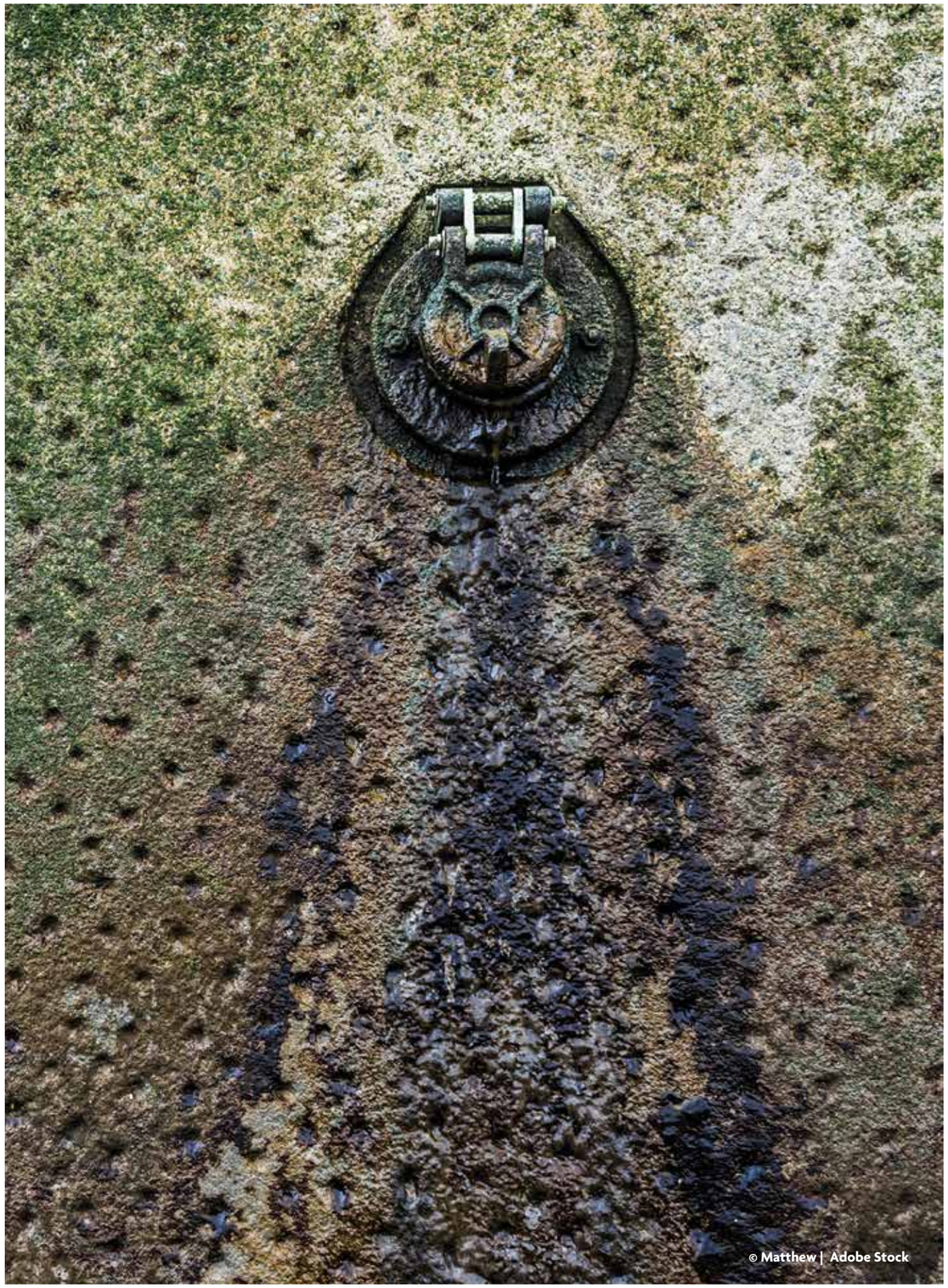
To meet current and future challenges, these systems and their management must clearly be improved. The key issues are not technical, but systemic and institutional. Although there is a technological innovation deficit and a need to embrace a suite of new technologies to improve operation and performance of our networks, this needs to be properly targeted to address potential barriers to implementation and uptake and requires transition management spanning long time frames – potentially several decades.

The way the water sector in England operates today will need to change. The current business model is septic and has run its course. There is a lack of entrepreneurial drive or activity because of the business model, regulation, financing and return on investment. Continuing to work in the same way and hoping that outcomes will improve will simply not work. The current business model does not serve the environment or society well and is no longer fit for purpose. After three decades, since privatisation, there is a need to review the ability of the water industry, as currently configured and regulated, to meet the needs of the environment and society, which are considerably different and in certain contexts more acute to those which existed 30 years ago. The necessary components to effect improvements and increase resilience of controlling sewage discharges, include the following.[14]

1. Developing effective and integrated policies and regulations with clear targets and penalties for ineffective services. This can be achieved by:
   - Establishing a new finance and business model and a better way of regulation, with stricter economic and environmental regulatory controls, to reflect more fully the public policy challenges of the next 50 years;
   - Addressing the levels of debt and gearing ratios of water companies, and the risk these pose to their viability;
   - The commencement of Schedule 3 of the Flood and Water Management Act 2010;
   - Implementing legislation to remove the automatic right of developers to connect surface water to sewers. This would solve so many problems, help promote sustainable drainage and lead to more effective and cost-efficient control and management of stormwater, thereby reducing the impacts it has on CSO spills, the environment and society;
   - Introducing a more robust planning and investment process that prioritises service not businesses and includes effective operation and maintenance budgets;
   - Making water companies statutory consultees in the town planning process; and
   - Transferring highway drainage costs to local highway authorities to create incentives to seek alternative receptors, including the use of nature-based solutions.

2. Taking an integrated approach to the entire water cycle, necessitating institutional reform to make it work. This can be done by:
   - Encouraging the development of integrated water management strategies to support local planning policy and site allocation;
   - Source control to manage rainfall close to where it falls and use it as a resource;
   - Developing long-term drainage infrastructure planning to increase resilience and manage future shocks;
   - Increasing operational maintenance and routine sewer cleaning, reducing blockages and premature operation of CSOs, in parallel with engaging the public – for example, to stop the flushing of wet wipes; and
   - Implementing the optimum combination of above- and below-ground infrastructure, focused on nature-based systems as the default technology.

3. Developing better knowledge of the issues through monitoring to identify sources of pollution and enabling source apportionment and integrated solutions. Techniques such as microbial source tracking can be used to identify whether pollution is chemical, biological, or human or animal faeces and apportion responsibilities and allocate funding accordingly.



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4. Improving skills and identifying capacity deficits. Water companies are resistant to adopting emerging and new technologies, such as in-line energy recovery. There is an inertia, where water companies operate in a perceived relatively stable state without understanding the need for continuous innovation. This can be addressed by:
   - Identifying the gaps in the UK's skills and experience and planning for continuous innovation to provide a resilient service and infrastructure for future generations in light of the water sector's ageing workforce;
   - Reviewing the workforce's age and skills profile to identify gaps and for succession planning, alongside tackling the industry's five-year business cycle to minimise workforce disruption (hire and fire);
   - Developing multi-disciplinary skills to enable improved cross-project and cross-sector working; and
   - Future-proofing the industry by undertaking the retraining and skills development needed for integrated water management and distributed water re-use, which are critical requirements in the industry and supports continuous improvement, transformation and long-term economic growth.

This all requires leadership, and now is the time for government and industry to lead the charge for a better, more resilient future. ES

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Brian Smith has a career spanning more than 47 years providing strategic intelligence on matters relating to sewerage, the environment, and strategic planning and development to the water sector. As Drainage Strategy Manager, he represented Yorkshire Water at a national level on technical, regulatory and legislative matters and was the national and international interface on policy and standards development.

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A further ten years of water pricing: what progress have we made?

Ali Morse looks at the role of nature-based solutions in improving water management as part of the latest price review.

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OPINION

This is my third Price Review (PR), the process through which regulators approve the five-year business plans developed by water companies and which sets the prices that customers will be charged to pay for their delivery. The current review, PR24, is due to conclude in 2024, ready for the plans to be delivered during 2025–30. The following cycle will be PR29. In 2012, in the build-up to PR14, I started to work with Blueprint for Water – a collective of over 20 environmental non-governmental organisations (eNGOs) working together on water policy issues. We published our *Blueprint for PR14*, an environmental manifesto for the Price Review, which set out what companies should act on through their PR14 plans – for example, reduce abstraction to sustainable levels, make improvements around nutrient-rich wastewater discharges and help customers to save water.[1]

WATER SECTOR PRESSURES AND CHALLENGES

I was relatively new to the PR process, learning from my environmental non-governmental organisation (eNGO) colleagues about the repeating cycles of the government's strategic steer, business plan development by water companies, stakeholder and regulator scrutiny, and ultimately delivery – largely funded through customer bills. From the start it struck me that a system that *sounds* as though it should deliver an increasingly improved environment was full of tensions – not least that to make environmental improvements required someone to propose (or mandate) work, others to agree to it and others still to agree to pay for it. The costs and benefits of any proposals rightly form a key part of the decision-making process, to protect customers, but the value of a healthy water environment did not feature as highly in these negotiations as it should have.


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The manifesto showed that sewage spills were a concern, but not a very pressing one, among all the other pressures to which the water sector contributes. Yet even then, Blueprint members highlighted the importance of ensuring that spills were tackled in a cost-effective and nature-positive way. A case study featured in the manifesto proclaimed:

'Thames Water's Counters Creek trial in West London is investigating the effectiveness of retrofitted SuDS [sustainable drainage systems] to reduce flood risk in a combined sewer catchment. Analysis so far suggests that property-level and highway SuDS could be retrofitted to help reduce flood risk to 7,000 households. The company hopes that results will inform PR14, allowing a wider programme of retrofit SuDS to be rolled out in the future.'[1]

Fast-forward and, over a decade on, we still face the challenge of how best to resolve overflowing sewers. We are in a better position in that we have a far greater understanding of the extent of spills, if not their environmental impact. We also have public outrage and political interest. But even with all this, it would not be surprising to be sitting here in another ten years writing about failed ambitions.

Storm overflows, along with other challenges, mean that PR24 will be significantly pressured. There are spill reduction targets put in place through the Government's storm overflows discharge reduction plan, which will ultimately see storm overflow discharges that cause adverse ecological impacts ended by 2050 – and although many do not believe the targets go far and fast enough in environmental terms, they are clearly going to be challenging for companies to meet.[2] There are requirements to upgrade wastewater treatment works in areas subject to nutrient neutrality rules to reduce nitrogen and phosphorus pollution of protected sites. There is a binding target created under the Environment Act 2021 requiring companies to reduce phosphate loads from wastewater treatment works by 80 per cent by 2038, which will entail significant expenditure during the forthcoming Asset Management Period (AMP), the five-year delivery period covered by the plans.[3] And Water Framework Directive targets mature during the next AMP too, in 2027, requiring expenditure to tackle the sector's contributions to current failures caused by wastewater (treated and untreated), abstraction or other operations.

This crowded list of priorities saw the Environment Agency write to companies asking them to consider ways of making the next AMP more affordable for customers, including by using less cautious predictions of climate change and population growth and phasing non-statutory expenditure into future periods. This is clearly an approach that will perpetuate the harms caused by a lack of appropriate investment. When capital was cheap and communities were wealthier, the sector failed to invest. A lack of investment in resilient water management means we are now facing the consequences. In playing catch-up, we now expect to see record water bill increases. So how can we ensure that this investment delivers the greatest possible benefits?

NATURE-BASED SOLUTIONS

Looking back at the PR14 manifesto is a reminder that this is not a new problem. It has long been recognised that nature-based solutions (NbS) could play a role in better water management, and the struggle to make this a reality continues.

Plans being developed for PR24 should in theory see a significant increase in the use of NbS. Defra's steer to Ofwat (and therefore to the water companies) through the Strategic Policy Statement says that companies should significantly increase their use of nature- and catchment-based solutions, delivering multiple benefits for the environment and public, and contributing towards the Government's target to raise over £1 billion in private finance for nature recovery.[4] The updated methodology for PR24's water industry national environment programme (WINEP) – which sets out the action companies will take to meet their legal environmental obligations – states that it will bring 'real changes to the options proposed by water companies to address environmental challenges', including through 'a greater use of nature-based solutions'.[5] WISER, the water industry strategic environmental requirements, which sets out how companies should do this, is also peppered with expectations and encouragements around NbS. Policy all seems to be pulling in the same direction.[6]

Yet scrutiny of draft plans reveals that NbS forms only a small portion of proposed delivery, and where we cannot yet see the detail, such as on WINEP schemes, it appears that unofficial ambitions on the extent of NbS are far from being met.

"...to see the water sector where we all want to see it... is going to take all the solutions we can throw at it."

The benefits of NbS could be multiple. They are often cheaper. For example, the UK's first catchment nutrient balancing trial on the River Petteril in Cumbria saw United Utilities working with landowners across the catchment to reduce phosphate pollution to the river. By combining catchment delivery with improvements to wastewater treatment works, phosphate reduction targets were exceeded, and costs to customers were £7 million lower compared to using conventional engineered solutions.[7] Beyond simply 'reduced spend', the benefits of NbS can include lower carbon costs, biodiversity enhancements, community buy-in and supply chain diversification (the value of which should not be underestimated in an AMP that will see unprecedented demand for conventional materials and contractors).

With expertise in developing and delivering treatment wetlands – wildlife-rich sites that use natural processes to further strip pollutants from treated wastewater before it is discharged – sustainable drainage schemes, and other solutions that work with nature, Blueprint members are well placed to help the sector deliver. While it is easy to demonise water companies, any realistic solution to the country's water management challenges recognises that no one organisation alone can implement a sustainable water management regime. It will require collaboration on skills, financing and building trust.

The eNGO sector will be accused of selling out, of assisting with greenwashing, and of convincing communities to accept and support schemes that some may consider inferior to engineered solutions. That is a deeply flawed criticism. Because to see the water sector where we all want to see it – at the heart of delivering sustainable water management – is going to take all the solutions we can throw at it. ES

Ali Morse is Water Policy Manager at The Wildlife Trusts, working at a national level on issues from pollution to flooding to species conservation. As Chair of Blueprint for Water she works with a coalition of environmental groups to champion a healthy water environment; a key goal is to influence the Price Review process to ensure that water companies' environmental ambitions are as high as possible.

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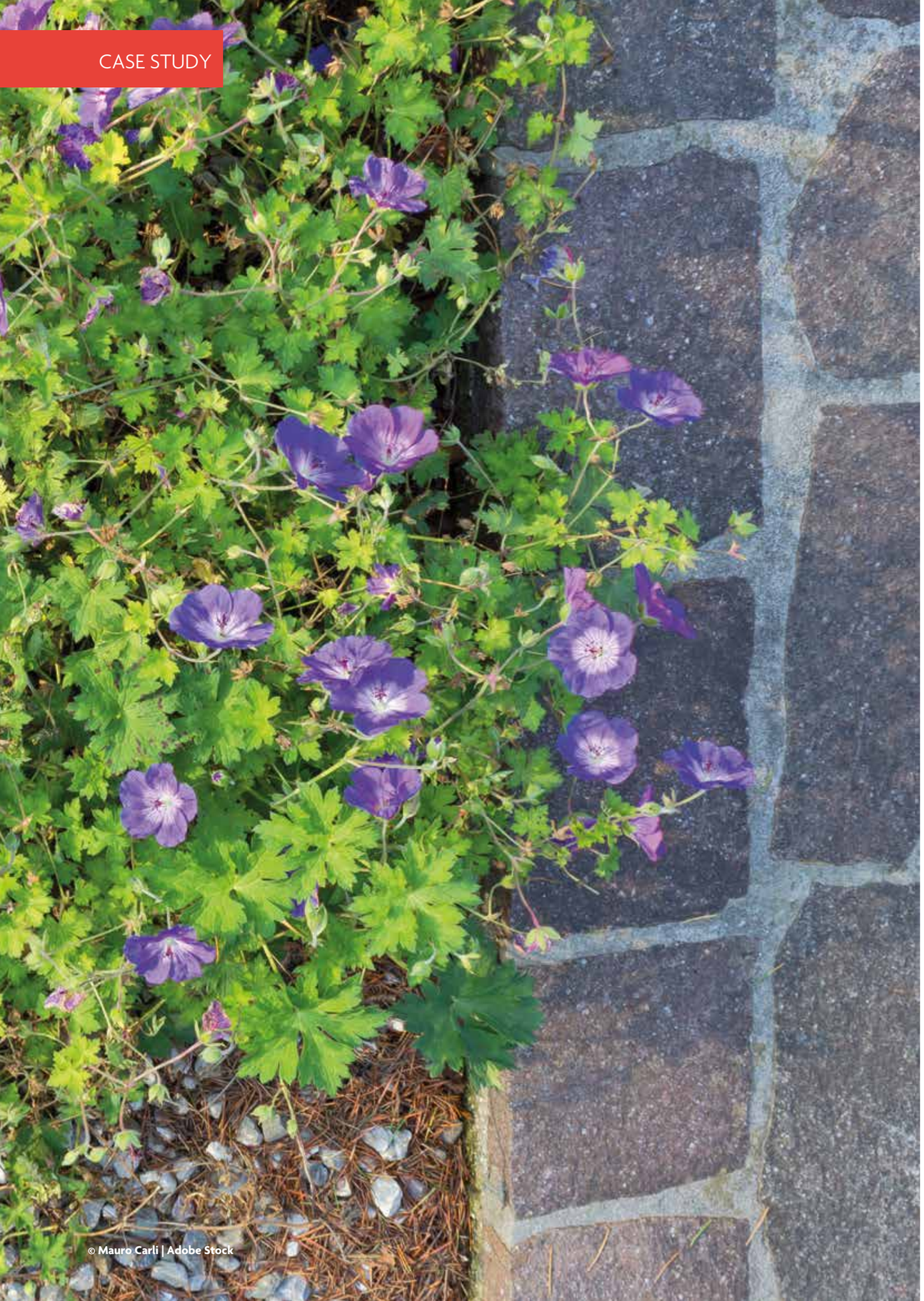

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CASE STUDY

SuDS+: a new approach for communities to benefit from sustainable drainage systems

Mark Davinson, Caitlin Rogers, Ed Rollason and **Eleanor Starkey** review the process being developed and tested in Stanley, County Durham.

Surface water flooding can, and does, cause significant damage and disruption to communities, and ultimately endangers lives. In England approximately 800,000 properties are at a medium or high risk of surface water flooding, with this number projected to grow due to climate change and urbanisation.[1] Sustainable drainage systems (SuDS) are an established technique that manage surface water by mimicking natural drainage processes. The planned 2024 implementation of Schedule 3 of the Flood and Water Management Act (2010) should increase the use of SuDS by mandating their usage in all major new developments (i.e. those over 10 homes).[2]

However, this legislation does not cover retrofit SuDS that are installed in existing developments and environments. By their nature, retrofit SuDS impact local communities because they alter the use, character and amenity of familiar landscapes. This provides an opportunity to test how these impacts could be beneficial by directly involving the local community in the design, monitoring and adoption of SuDS to meet their specific, multiple needs.

To explore this, the Defra-funded five-year (2022–7) SuDS+ Community-Led Futures (SuDS+) innovation project is underway in the town of Stanley, County Durham, to develop and test the SuDS+ approach.[3] The project is part of the £150 million flood and coastal resilience innovation programmes, managed by the Environment Agency, to develop and test new approaches to resilience that are tailored to local communities.[4]

THE SUDS+ APPROACH

The SuDS+ approach de-prioritises drainage as the primary driver for the implementation of SuDS; instead, it considers drainage on a par with the suite of other potential benefits (e.g. for community resilience, amenity, health and wellbeing, biodiversity, education, employment and housing) to create a co-benefit framework to inform SuDS development.[5] These benefits extend significantly beyond the traditional four pillars of SuDS – water quantity, water quality, amenity and biodiversity – which are the mainstay of current SuDS benefit assessment.[6] The participation of communities is integral to SuDS+ because their needs and aspirations underpin the co-benefits framework for local SuDS implementation. The SuDS+ approach consists of four phases:

1. Vision setting. The community identifies the key challenges it faces, its goals and its aspirations. These inform the co-benefits framework and ultimately guide the design and delivery of the SuDS interventions.

2. Opportunity mapping and prioritisation. The community identifies opportunities for improvement and investment (locations and ideas for new infrastructure, resources and activities not limited to SuDS) that will deliver multiple co-benefits aligned to the benefits framework. A prioritisation exercise identifies which community opportunities can be delivered as SuDS schemes.
3. Designing interventions together. The community and specialists co-design the SuDS schemes to achieve the co-benefits, and monitoring is established to ensure robust evaluation.
4. Legacy. Establishing ongoing community participation in SuDS maintenance and monitoring to create sustainable co-benefits.

The SuDS+ approach is multifaceted and involves the complex network of stakeholders typical of surface water management schemes. It is therefore being delivered by a partnership of local county council, academia, rivers trust, Environment Agency, Defra, and design, modelling and innovation consultants in conjunction with a wide range of community groups and local stakeholders that may not be familiar with flood risk management.

SUDS+ IN THE STANLEY COMMUNITY

The SuDS+ study area of Stanley South is approximately 7 km^2 and located to the south of the town of Stanley in the north of County Durham. It is a collection of former mining settlements and includes the urban areas of South Stanley, South Moor and East Stanley and the semi-rural villages of Craghead, Quaking Houses and The Middles (see **Figure 1**). The network and type of communities, mix of urban and available green space, and risk of surface water flooding in Stanley South provide the right conditions to develop, test, monitor and evaluate the SuDS+ approach.

The study's four sub-areas represent semi-independent hydrological catchments and distinct urban areas. Although featuring areas of high-density urbanisation, the study area has significant areas of green open space and woodland (see **Figure 2**). The legacy of coal mining is evident through urbanisation: the area was transformed from mostly agricultural land use to an industrial centre in the 19th century and infill development was required to meet housing demand in the 20th century.[3]

The increased urbanisation reduced the natural drainage capacity of the catchment; Stanley South has been affected by flooding several times in the last decade after heavy rainfall, which has impacted property, public spaces and local roads. Currently there are 429 properties at risk of flooding.[7]

The electoral divisions covering the study area were identified as two of 225 'left behind' neighbourhoods across England.[8] Left-behind areas have much worse socio-economic outcomes than comparable deprived areas. The key metrics are similar to the themes for improvement identified by residents in connection with SuDS+: health, employment, education, skills and household income.

THE SUDS+ PROCESS IN ACTION

Phase 1 (vision setting) was completed in 2023. Through a series of interviews, workshops, surveys and information points in community centres, seven vision statements were created, validated and prioritised by the community (from highest to lowest priority):[3]

1. Help create local job opportunities and support existing and new businesses;
2. Support affordable living costs and improve quality of housing;
3. Provide training and education for workplaces of the future;
4. Create a sense of pride and ownership over the local environment;
5. Create beautiful, vibrant and diverse public spaces accessible to all;
6. Strengthen local community-led networks, groups and services; and
7. Enhance community resilience to flooding.

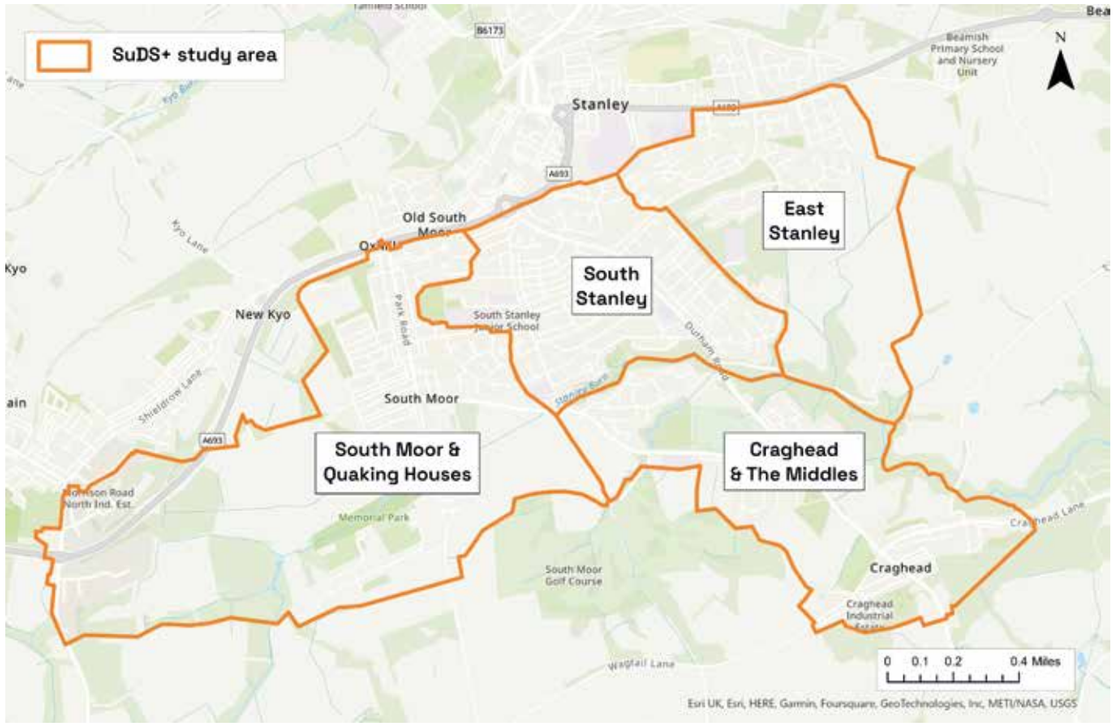
In phase 2 (opportunity mapping and prioritisation), using walking tours, workshops and in-person mapping exercises, the community identified 383 opportunities for investment (see **Figure 3**). The ideas included creating parks and green spaces, improving existing outdoor spaces, reducing litter, planting wildflowers, developing forest schools, and improving community-led facilities and activities for all.

From the 383 identified opportunities, a shortlist of 12 SuDS+ concepts was determined using the SuDS+ filter methodology that applied criteria such as idea frequency, land use, land ownership and flood risk reduction potential (see **Figure 4**).

The community vote on these 12 SuDS+ concepts is due to be completed in December 2023 and will prioritise the concepts to be taken forward to phase 3 (designing interventions together) and phase 4 (legacy) in 2024. The challenge in the design phase is to create SuDS+ schemes that provide the co-benefits desired by the community and that are adoptable. The legacy phase will create a vehicle for ongoing community participation and lasting co-benefit creation.

While it may not be possible for all the co-benefits embodied in the SuDS+ concepts to be delivered as an output of capital investment, they could be achieved by delivering that investment. For example, involving local community-led networks in the design and monitoring of SuDS+ provides opportunities for knowledge boosting

CASE STUDY



▲ **Figure 1. The SuDS+ study area of Stanley South consisting of four sub-areas. (Source: SuDS+ project partnership)**

▲ **Figure 2. The urban and rural characteristics in and around the SuDS+ study area. (© Lewis Christie)**

and education activities, which are a common theme of the SuDS+ concepts; it also aligns with one of the community vision statements to strengthen local community-led networks, groups and services.

A key finding in Stanley South is that flooding is not a priority for residents, despite ongoing fluvial, surface water and sewer flooding issues in the study area. Their top priorities are job opportunities and affordable homes. The opportunity mapping exercise also identified a wide range of community ideas, most outside of the context of flooding. This validates the need for a SuDS+ approach that considers these types of aspirations as equal, not additional, to flood risk reduction, and not only enables community-led flood resilience but also provides multiple co-benefits to residents.[5] ES

Mark Davinson from the Wear Rivers Trust is the SuDS+ Engagement Facilitator. He has over 30 years' experience of working on a wide variety of projects in the community and voluntary sector especially in Stanley, North Durham. His particular interests are reducing fuel poverty, increasing aspiration among deprived communities and building the capacity of residents to make decisions affecting their area.

Caitlin Rogers from Isle Utilities is the SuDS+ Innovation Lead, with a current focus on identifying practical ways for innovation to drive flood resilience. She has experience of applying global water sector innovation to improve environmental, financial and social performance.

Dr Ed Rollason is an interdisciplinary geographer based at Northumbria University. His research explores the intersection between physical water systems and society, with a particular focus on participatory water management. He is the SuDS+ Research Lead for community engagement and visioning.

Dr Eleanor Starkey from Northumbria University is the SuDS+ Research Lead. She is a hydrologist with interests and expertise in flood risk management, water quality, monitoring, citizen science, community engagement and nature-based solutions. She has been involved in a range of catchment-based participatory projects, both inside and outside academia.

The SuDS+ project partnership consists of Durham County Council, Northumbria University, Wear Rivers Trust, the Environment Agency, Defra, Viridian Logic, Arup, Northumbrian Water, Isle Utilities and Teesside University. To learn more about the project or if you are interested in participating in the design and monitoring phase please contact us.

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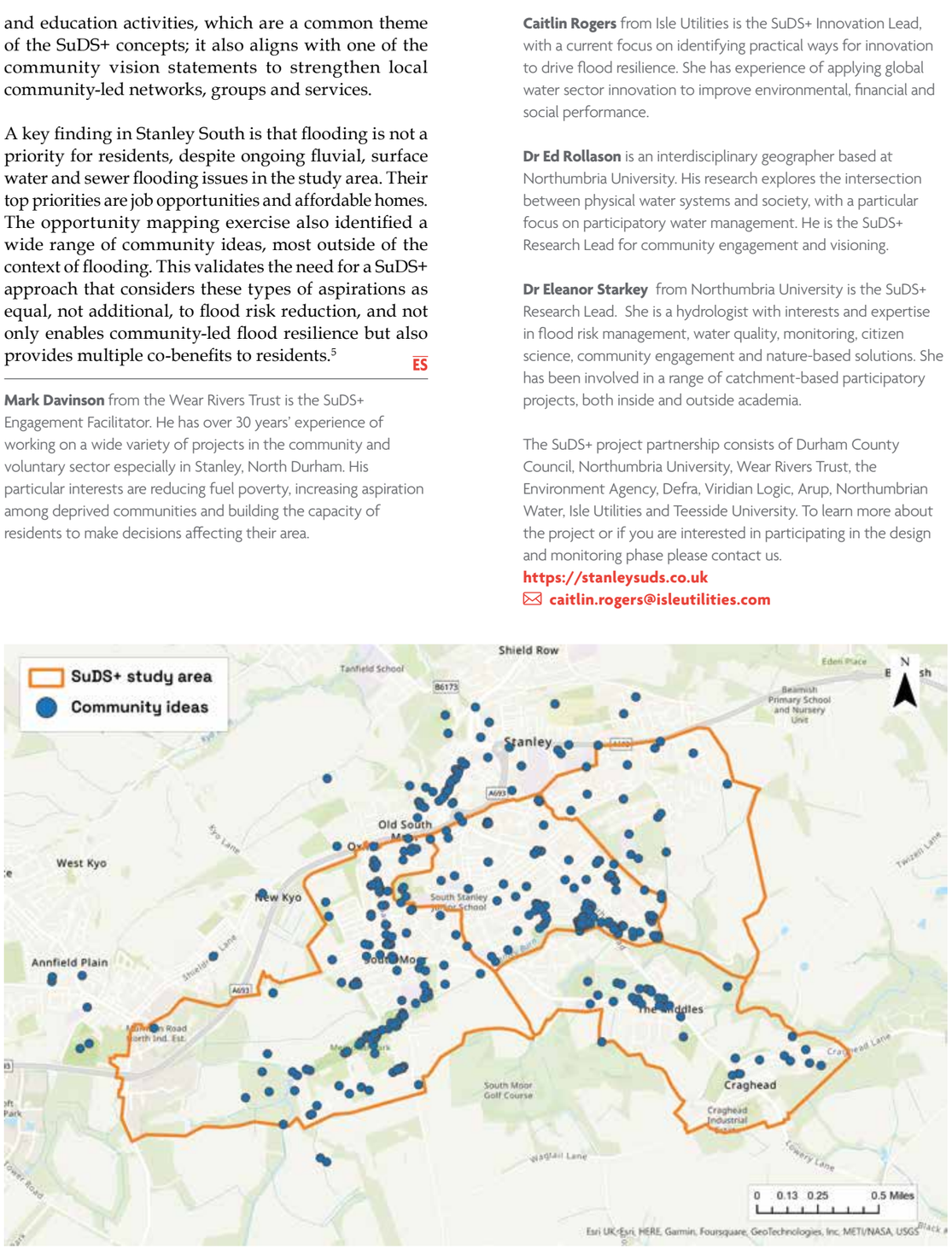
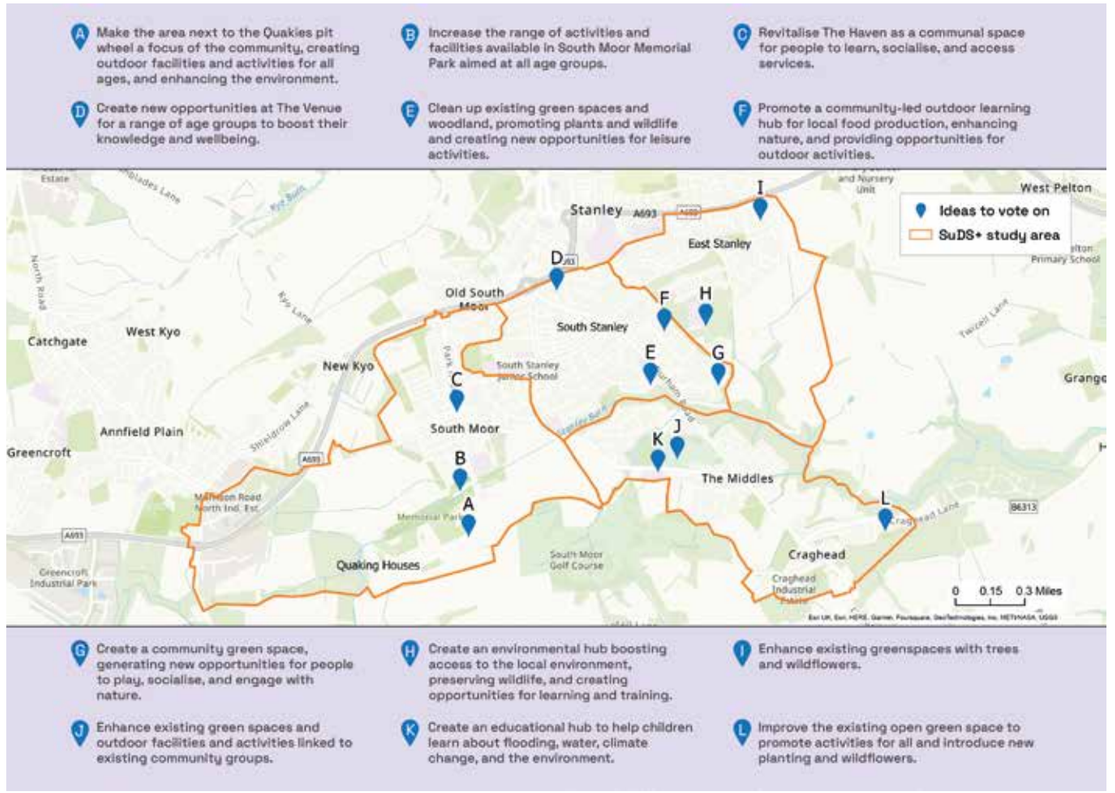


▲ **Figure 3. The SuDS+ community opportunity map. An interactive map is available on the project website. (Source: SuDS+ Community-Led Futures[9])**



▲ **Figure 4. The 12 SuDS+ concepts incorporating multiple co-benefits. (Source: SuDS+ project partnership)**

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Nidderdale ponds: a case study from an important freshwater landscape

Kate Wright outlines an exciting collaborative project to enhance wetlands across an Area of Outstanding Natural Beauty.

INTRODUCTION

Freshwater ecosystems are in trouble worldwide. Yet while pollution of our oceans and rivers has become a matter of public debate, the fate of smaller waterbodies is largely overlooked. Ponds and wetlands comprise around 80 per cent of the global freshwater environment.[1] In the UK, these are known to be declining in quality – the Countryside Survey of ponds across Great Britain showed that two-thirds of high-quality ponds have lost plant species over a 24-year period.[2] However, unlike rivers and streams, these waterbodies are not routinely monitored or systematically protected.

Paradoxically, small waterbodies include many of the best remaining freshwaters. Their small catchments are more likely to be non-intensive, with negligible nutrient inputs and, at a landscape scale, ponds have been shown to support greater biodiversity than larger waterbodies

CASE STUDY

such as rivers or lakes.[3] This means that small habitats can provide rapid, cost-effective, nature-based solutions to address the freshwater biodiversity crisis. Over the last 25 years, a growing body of evidence has begun to point to the need to protect *all* kinds of freshwaters for biodiversity, and to recognise that investment in smaller habitats – and landscapes that give equal profile to all types of freshwaters – is required to prevent continued biodiversity loss.

The vision of Freshwater Habitats Trust and partners is to reverse the decline of life in freshwaters by establishing a new national Freshwater Network comprised of healthy, unpolluted and interconnected landscapes. It will be built around the existing hotspots for freshwater biodiversity and include newly created and restored habitats.

SAVING NIDDERDALE'S PRIORITY PONDS

Situated in North Yorkshire, Nidderdale National Landscape (the new name for Nidderdale Area of Outstanding Natural Beauty) covers an area of 233 square miles. It is located on the eastern flanks of the Pennines and encompasses varied habitats – from high moorland to more fertile agricultural lowlands. It sits largely within the Yorkshire Dales and Forest of Bowland important freshwater landscape – one of 24 of the most critical landscapes for freshwater biodiversity in England and Wales, identified using robust species and habitat data (see **Figure 1**).[4]

A partnership between Nidderdale National Landscape, Freshwater Habitats Trust and Yorkshire Water ran for 18 months from October 2021 to March 2023 and was one of the first collaborations to adopt the Freshwater Network approach. It built on the success of previous projects including Nidderdale's The Wild Watch project (2017–19), which identified high-status ponds in the area.[5] While ponds generally are on the list of priority habitats in England, only around 20 per cent are believed to be priority ponds – those with high conservation or ecological value (see **Box 1**).[6]

The principal aim of the project was to survey and map the pond network, validate existing data and identify new priority ponds in the designated Area of Outstanding Natural Beauty, with the results used to improve the pond network through habitat management and creation. The project also included a large element of education and awareness raising so that members of the public and landowners could better understand the importance of freshwater habitats, specifically ponds, and be more amenable to conservation action.

To achieve this, the Saving Nidderdale's Priority Ponds project carried out an inventory of ponds using volunteers and citizen science to identify those with clean-water status and breeding populations of priority species, such as the common toad (*Bufo bufo*). Alongside this, a range of events and initiatives was held to raise awareness of the value of ponds and the wildlife they support. These included sessions delivered to local schools and youth groups around container-pond building, as well as online modules aimed at both the public and professionals.[7]

BOX 1: PRIORITY PONDS

It is estimated that around 20 per cent of the UK's 500,000 ponds (excluding garden ponds) will meet one or more of the criteria; however, only a small proportion of sites has been identified nationally. The Saving Nidderdale's Priority Ponds project was one of the first to undertake this landscape-scale review. Priority ponds are identified and categorised under the UK Biodiversity Action Plan as:

1. **Habitats of high conservation importance.** Ponds with specialist habitats that meet criteria under Annex 1 of the Habitats Directive.
2. **Ponds supporting species of high conservation importance.** These are Red Data Book species, Biodiversity Action Plan species, species fully protected under the Wildlife and Countryside Act 1981 Schedule 5 and Schedule 8, Habitats Directive Annex II species, a nationally scarce wetland plant species, or nationally scarce aquatic invertebrate species.
3. **Ponds with exceptional populations or numbers of key species.** This is based on:
   (i) criteria specified in guidelines for the selection of biological Sites of Special Scientific Interest (currently amphibians and dragonflies only); and
   (ii) exceptionally rich sites for plants or invertebrates (supporting 30 or more wetland plant species or 50 or more aquatic macroinvertebrate species).
4. **Ponds of high ecological quality.** These are ponds classified in the top category for ecological quality (a score of 75 per cent or more), as assessed by the standardised method for assessing the biological quality of still waters in England and Wales – the Predictive System for Multimetrics.
5. **Other important ponds.** These are individual ponds or groups of ponds with a limited geographic distribution that are recognised as important because of their age or rarity of type or landscape context (e.g. pingos, duneslack ponds, machair ponds).

RESULTS

More than 60 volunteers supported the project, carrying out water quality testing on 150 ponds, equivalent to 12.5 per cent of the 1,194 standing water bodies identified in Nidderdale. Rapid colour-change kits were used to identify levels of nitrate and phosphate pollutants. The Packtest kits used can quickly identify areas of clean water – defined as those having little or no nutrient pollution – providing a cost-effective way of giving a fast, broad assessment of the extent of pollution across a wide area.[8] The surveys identified clean water in 84 per cent of ponds tested in Nidderdale.

Nidderdale scores highly compared to other project areas using the same methodology. It is second only to the New Forest National Park, which is considered one of the most important areas for freshwater biodiversity in the UK. The proportion of clean-water ponds in a national Clean Water for Wildlife survey was 66 per cent, dropping to 36 per cent in more built-up areas such as Greater London.

Sightings of protected amphibian species (e.g. common toad and great crested newt) were identified in 42 new priority ponds, taking the total number for Nidderdale to 80. There are believed to be many more waiting to be discovered: based on the clean-water test results, an estimated two-thirds of ponds within Nidderdale could be priority ponds.

The first phase of the project has paved the way for new ponds and habitats to be protected and created in the most appropriate areas, strengthening connectivity across the landscape to benefit freshwater diversity.

▲ **Figure 1. Important freshwater landscapes in England and Wales, showing the Nidderdale National Landscape boundary in relation to the Yorkshire Dales and Forest of Bowland important freshwater landscape. (Adapted from Biggs and Dunn[4])**

CASE STUDY

Curlew feeding | © Barry Carter

HABITAT OPPORTUNITY MODELLING

Results from phase 1 of the project were fed into a significant piece of work to map habitats and identify areas for enhancement and expansion. Nidderdale has developed nature recovery maps that use the location of existing habitats to strategically identify areas that offer the greatest opportunity to restore and create grassland, woodland, moorland and wetland habitats. These incorporate modelling done by the UK Centre for Ecology & Hydrology to estimate foraging toad population size and distribution.[9]

The nature recovery maps identify landscape-scale clusters of freshwater core habitat and suggest buffers and linkages to these areas – places where new ponds and wetlands would be most successfully placed. The maps present a persuasive long-term strategy for freshwater habitat creation that could facilitate species movement and provide local mitigation for climate change.

NIDDERDALE WETLAND CREATION PROJECT

In response to the above two projects and as part of its long-term management plan, Nidderdale is now running a new project in collaboration with Freshwater Habitats Trust and funded by Defra's Farming in Protected Landscapes programme.[10] Using outputs from the nature recovery modelling, the project aims to deliver habitat improvements strategically, so that these have the best outcome at a landscape scale.

This second phase of work runs for 18 months from October 2023 to March 2025. Unlike other schemes that focus on single species (such as great crested newt mitigation ponds), the Nidderdale Wetland Creation project has the flexibility to design bespoke solutions for specific sites. A number of sites within the highest-opportunity areas have now been identified and initial site surveys carried out. Subject to further investigations and planning permission, new waterbodies will be created in the summer and autumn of 2024.

Ponds are normally dug into terrestrial habitats of low ecological value, such as species-poor grassland. Long-term research and monitoring by the Freshwater Habitat Trusts' Water Friendly Farming initiative found that adding clean-water ponds can have substantial benefits – increasing total catchment richness by 26 per cent and the number of rare plant species by 181 per cent within five years, outweighing any short-term disturbance.[11] Amphibians and aquatic insects can move into new ponds within months.

Machinery will inevitably cause some temporary disturbance to the vegetation around waterbodies. It is preferable to allow this to regenerate naturally, as colonising plants will be adapted to the local conditions. However, if appropriate, pond margins can be re-seeded with a grass or wildflower mix to help plants establish more quickly.

Clean-water ponds provide habitat for a huge range of wetland plants and animals – up to two-thirds of freshwater species. When placed in semi-natural habitats or where they are fed from locally clean sources, such ponds can provide essential clean-water refuges for freshwater plants and animals that are sensitive to water

Common toad | © Barry Carter

quality, including many of our most threatened species. Plants such as stoneworts and aquatic insects such as mayflies and caddis flies are examples of pond-dwelling species with a low tolerance of nutrient pollution.[12,13] Ponds also provide key stepping stone connections across the landscape, linking habitats and enabling species to disperse.

A wetland mosaic comprises multiple waterbodies of different sizes, depths and sometimes even water sources (ground and surface water). The aim is to provide a variety of habitats with clean water, complex topography, and long, shallow drawdown zones (areas of bare mud and stone at the pond margin, caused by a water-level drop of up to half a metre during the summer months) to benefit the widest range of species. As many freshwater species like to move between waterbodies depending on seasonal conditions, having a range of available habitats increases population resilience to local extinctions.

Scrape habitats – shallow areas of water with expanses of bare mud – deliver a perfect habitat for wetland invertebrates and provide wading birds with valuable feeding opportunities.[14] Therefore, Nidderdale can support other projects, such as those aimed at protecting the declining curlew (*Numenius arquata*).

Nidderdale's wetland creation project has the flexibility to deliver bespoke solutions. At a site level, we can engage landowners by designing a pragmatic scheme to assist with natural flood management, as well as deliver benefits for species present on their farm. At a landscape scale, we are aiming for heterogeneity: having a diverse range of waterbodies to benefit a wide range of species. Liaising with other delivery bodies has allowed us to work more strategically and maximise the benefits for the wider environment.

The project has built on a wealth of experience of Freshwater Habitats Trust staff and projects around the country. More information on how landowners can help to reverse the decline in freshwater biodiversity by restoring and creating ponds can be found in a new free guide on the Freshwater Habitats Trust website, based on the latest science from the trust and University College London's Pond Restoration Research Group.[15] ES

Kate Wright, BSc (Hons) MSc ACIEEM, joined Freshwater Habitats Trust in 2021, a national organisation delivering practical conservation in partnership with local stakeholders in areas that are strategically important for freshwater biodiversity. Kate has a broad ecological background with a special interest in wildlife conservation and has experience of surveying for great crested newt among other species. She has an honours degree in environmental science from the Open University and an MSc in Biodiversity and Conservation from the University of Leeds.

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New members and re-grades

Fellow is for esteemed individuals in environmental science and sustainability who are held in high regard by their peers.

Vera Jones – Associate Director

Member is for those individuals who have substantial academic and work experience within environmental science.

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Kenneth Nnanna Aroh – Environmental Scientist/Analyst
Ali Aslam – Environmental Specialist
Kevin Barber – Cultural Heritage Consultant
Victoria Broucke – Senior Environmental Consultant
David Calder – Technical Director
Shuk Kwan Cheung – Senior Environmental Consultant
Daniel Clampin – Senior Air Quality Consultant
Jennifer Clements – Senior Environmental Specialist
Lauren Cullivan – Senior Environmental Consultant
Holly Diggins – Environmental & Sustainability Consultant
Rachel Edworthy – Environmental Consultant
Leire Egia Albizuri – Geo-environmental Consultant
Natalie Espelid – Senior Air Quality Consultant
Dominic Farmer – Director
Lowri Feighoney – Senior Geotechnical Engineer
Jason Ferns – Graduate Air Quality Consultant
John Fitzgerald – Geo-environmental Engineer
Amy-Louise Flynn – Environmental Coordinator
David Gemmell – Director
Kaitlyn Goudge – Assistant Consents & Environment Manager
Richard Greenhalgh – Principal Consultant
Lee Hall – Managing Director
Iain Hall – Senior Geo-environmental Engineer
Robert Hester – Specialist Advisor - Air Quality
Richard Hossack – Principal Investigations Officer
Robert Jones – Remediation Engineer
Sarah Kirkman – Senior Air Quality Consultant
Victoria Kocollari – Senior Technician - Lighting
Maureen Lynch – Environment & Sustainability Advisor
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Jack Mather – Senior Project Engineer
Walter Mochama – Environmental Engineer
Lynn Morrissey – Senior Environmental Consultant
Abdul Hafeez Nasir – Director
Christopher Oliver – Consultant Geo-environmental Engineer
Samuel Paine – Consultant
Benjamin Pender – Environmental Protection Officer
Roman Puotkalis – Environmental Consultant
Keith Raine – Environmental Manager
Elizabeth Ryder-Humphries – Geo-environmental Consultant
Malcolm Sangster – Technical Director - EIA & Consenting
Grace Sibley – Senior Project Manager
James Slade – Technical Manager
Victoria Thomson – Senior Air Quality Consultant
Annie Trevis – Senior Air Quality Consultant
George Vann – Senior Consultant - Nature Advisory
Maria Vigano – Senior Environmental Scientist
Gordon Walker – Environmental Manager
Elizabeth Warner – Senior Consultant
Daniel Wicker – Senior Air Quality Consultant
Timothy Williams – SHEQ Manager
Mark Wilson – Senior Geo-environmental Consultant

Associate is for individuals beginning their environmental career or those working on the periphery of environmental science.

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Niamh Brotherton-Baker – Environmental Advisor
Callum Cecil – Graduate Air Quality Consultant
Jonathon Cook – Senior Environmental Advisor
Samuel Curr – Environmental Scientist
Matthew Earp – Geo-environmental Consultant
Daniel Evans – Geo-environmental Scientist
Beth Gill – Environmental Consultant (Contaminated Land)
Patrick Harland – Air Quality Consultant
Eliah Hunter-Dixon – Graduate Aboricultural Consultant
Matthew Johnson – Graduate Environmental Consultant
Jekabs Jursins – Air Quality Consultant
Megan Lowe – Graduate Environmental Consultant
Ryan MacNeil – Assistant Design Technician
Liana Malynczakova – Graduate Consultant
Olivia Marron – Graduate
Euan McAlister – Hospitality Agency Worker
Alex Michaels – Graduate
Olaleye Olaniyan – Science & Engineering Graduate
Chetna Patil – Graduate Environmental Consultant
William Pitman – Graduate
Kirsty Price – Business Owner
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Daniel Robinson – Geospatial Advisor
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David Scott – Technician
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Daisy Skipper – Student Outreach Ambassador
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Affiliate is for individuals with an interest in environmental issues but who don't work in the field, or for students on non-accredited programmes.

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ANALYSIS

Chemical pollution of our freshwaters

Rob Collins, Anneka France, Josh Jones and **Emma Adler** investigate what needs to be done to tackle the issue.

CHEMICALS: UBIQUITOUS IN OUR WATERS

Chemical substances are an essential part of our daily lives and bring important benefits to society. The global chemicals industry was valued at over US$5 trillion in 2017 and this is projected to double by 2030.[1] However, many chemicals are hazardous, raising concerns for human health and the environment. Emissions of hazardous substances can occur at every stage of the chemical life cycle – production, processing, manufacturing, use and eventual disposal – and from a wide range of sources including agriculture and aquaculture, industry, mining, transport, waste disposal and our own homes.

Hundreds of chemicals are found in our rivers, including industrial chemicals, pesticides, metals, personal care products, pharmaceuticals and plastics. Some run off fields, others are washed into watercourses from roads and pavements. Others still, end up in wastewater treatment plants where they are partially treated before being discharged to rivers or applied to agricultural land within sewage sludge. The sewerage system is overloaded and unable to cope with the increasing pressures of housing development, heavier rainfall and a profusion of non-biodegradable waste clogging it up. Consequently, storm overflows also discharge hazardous substances to rivers.

IMPACTS ON AQUATIC LIFE

Currently, not a single UK river is in good chemical status as defined by regulatory standards, and many of the chemicals found in our fresh and coastal waters are persistent, bioaccumulative and toxic.[2] A wealth of research has shown that their presence has detrimental effects on aquatic life, including on growth, reproduction and immunity. Substances with endocrine-disrupting properties (i.e. interfering with hormones in the body) have been shown to impair reproduction in fish, raising concerns for fertility and population survival.[3] Neonicotinoid insecticides have been found in UK rivers at concentrations that exceed regulatory guidelines and known to be highly toxic to a wide range of invertebrates.[4,5] Pharmaceuticals too are widely found in UK freshwaters and are known to give rise to both chronic and acute effects on aquatic life.[6] Several of these toxic chemicals bioaccumulate, building up at greater concentrations in animals higher up the food chain – for example, in otters and marine apex predators.[7,8]

IMPLICATIONS FOR HUMAN HEALTH?

Freshwater recreation has never been more popular. However, swimmers, paddlers and other water users are all potentially exposed to hazardous chemicals, as well as sewage, while the potential for contamination of fish and shellfish is also concerning. Additionally, some hazardous chemicals are retained in sewage sludge and subsequently applied to agricultural land without any requirement for sludge to be routinely tested to determine levels of contamination.[9] While scientific knowledge of potential impacts is scarce, it is speculated that these exposure pathways could raise implications for human health.

Antimicrobial resistance poses a major threat to human health around the world and, troublingly, our rivers are reservoirs for antibiotic-resistant bacteria[10,11] prescribed antibiotics pass through the body and into the sewer system to be discharged to rivers in treated effluent – along with bacteria. Our beaches and coastal waters present a similar risk, with surfers three times more likely to carry drug-resistant bacteria than non-surfers.[12]

PFAS – PERSISTENT CHEMICALS

A particularly worrying type of chemical pollution comes in the form of per- and poly-fluorinated alkyl substances (PFAS). PFAS include thousands of industrial chemicals found in everyday products from frying pans to bike oil and even our toiletries, including toilet roll. They pose a serious pollution risk, given they are readily released to the environment, but also because they can take over a thousand years to degrade; consequently, they are known as forever chemicals. PFAS have been used since the 1940s and are now so widely dispersed that they can be found in air, soil, water and in our bloodstream. Unfortunately, we are only just beginning to understand their health impacts and environmental toxicity: the compounds that have been studied to date have been shown to cause harm to humans and wildlife.[13,14]

Recent research by The Rivers Trust and Wildlife and Countryside Link has illustrated just how widespread PFAS are in England's rivers. An analysis of the Environment Agency's database found that 81 of the 105 English river sites where PFAS substances were detected contained levels that would not meet a tougher proposed EU environmental quality standard (EQS) (see **Figure 1**).[15] Additionally, 44 sites exceeded this level by more than five times, with some breaching it by 10 or 20 times, demonstrating how dire the situation is.

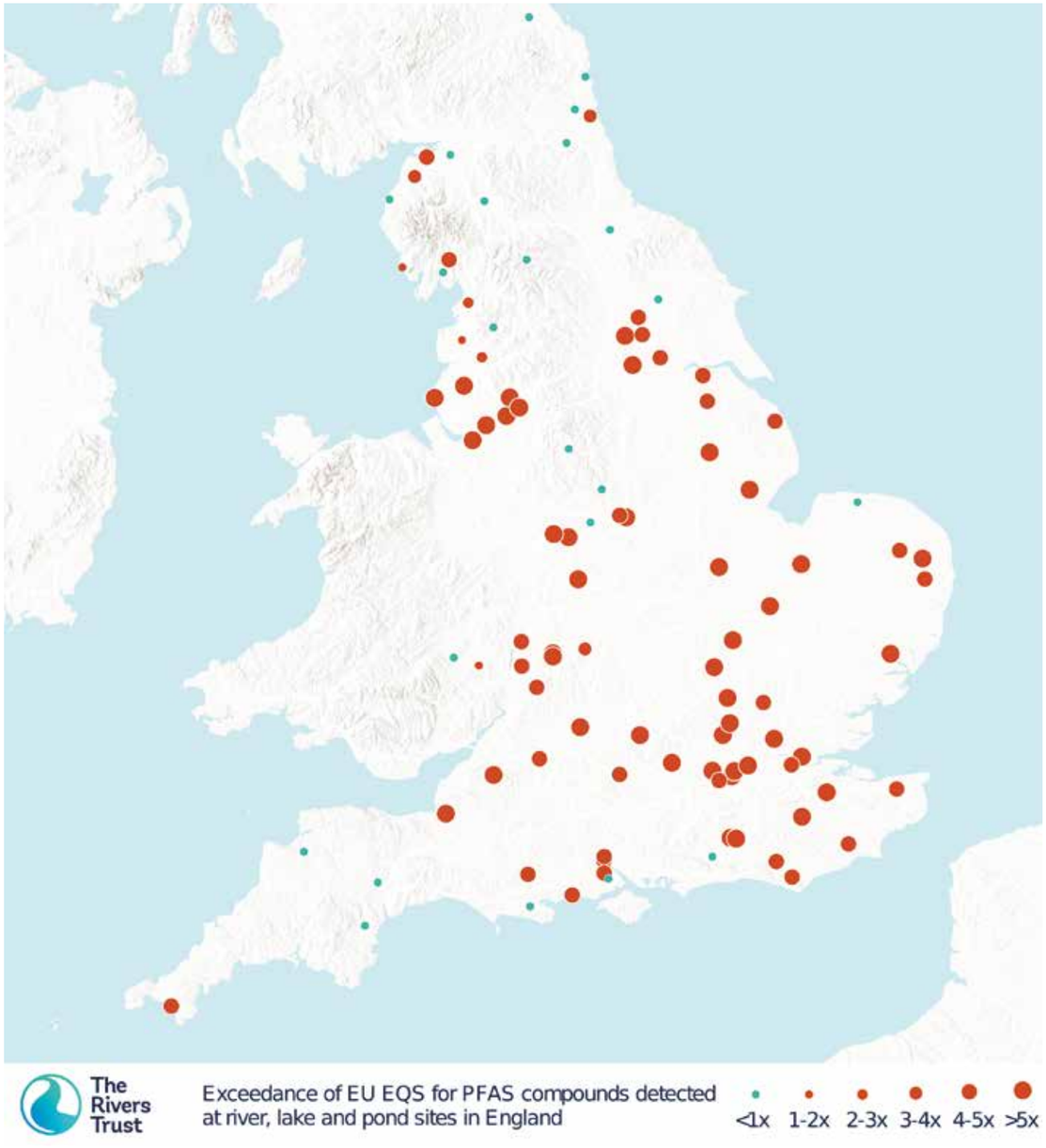
The pervasive nature of PFAS in our freshwaters has led to recent calls for more stringent drinking water standards to protect human health.[16] Currently the UK's thresholds are much more lenient than those of the EU and USA, and the Royal Society of Chemistry is pushing for a tenfold reduction of the current cap per individual PFAS type – from 100 nanograms per litre (ng/L) to 10 ng/L – as well as an overall limit of 100 ng/L for the total amount of PFAS.[17] In the US state of Maine, concerns over the health impacts of PFAS have led to a ban on sewage sludge applications to agricultural land.[18]

Notably, leading investors are increasingly concerned with respect to the harm arising from PFAS and are urging businesses to rethink their use. In September 2022, 47 investors managing a combined US$8 trillion in assets, wrote to 54 of the world's biggest chemicals companies urging them to phase out forever chemicals. The investors cited a range of risks, including an increased threat of litigation.[19]

PET PARASITICIDES

Pesticides used in tick, flea and worm treatments for dogs and cats find their way into rivers from various routes, including contaminated household wastewater from washing treated pets, their clothes and bedding, wash-off of urine and faeces, and treated dogs swimming in rivers and lakes.

Recent analysis shows that three insecticides used widely in these treatments – fipronil, permethrin, and the controversial neonicotinoid imidacloprid – are present in English rivers in concentrations that exceed accepted safe limits for aquatic life.[20] Fipronil was found to be the most pervasive, found in 105 (37 per cent) river sites tested and each time exceeding the predicted no-effect concentration – the level above which adverse effects for aquatic life can be expected. Several sites were at over 100 times this level. Imidacloprid was detected at 34 (12 per cent) sites, and at just over half, the concentration was above the EU's proposed EQS, set to protect aquatic life. Permethrin was found at just four sites, but all had between three and seven times the 'safe' level defined by the proposed EQS.



▲ **Figure 1. Minimum annual average concentrations, expressed as perfluorooctanoic acid (PFOA) equivalent, compared to the proposed EU environmental quality standard of 0.0044≅g/l. Derived from Environment Agency semi-quantitative data. Concentrations are based on the detection limit of the analytical method used and only tested for 14 out of the 24 PFAS substances listed under the proposed standard. Therefore, this is only indicative of actual PFAS concentrations and may underestimate the true environmental burden. (Contains Environment Agency information © Environment Agency and/or database right)**

▲ **Figure 2. River, lake and pond sites in England where one or more of the five chemical cocktails were found. Derived from Environment Agency semi-quantitative data. Compounds included in these known harmful mixtures were ibuprofen, perfluorooctanoic acid (PFOA), 2,4-Dichlorophenoxyacetic acid, perfluorooctane sulfonate (PFOS), perfluorobutane sulfonate (PFBS) and perfluorohexane sulfonic acid (PFHxS). (Contains Environment Agency information © Environment Agency and/or database right)**

Despite each of these chemicals being deemed to be too toxic to be used in agriculture, sales for veterinary use rocketed between 1997 and 2017, increasing over forty-fold in the case of imidacloprid.[21] There are two reasons for this marked increase: a rise in the number of pets in the UK and more frequent preventative dosing.

CHEMICAL COCKTAILS

Monitoring of UK freshwaters shows that aquatic organisms are often exposed to a mixture of hazardous substances in their natural environment. Multiple chemical exposures can combine, reinforcing and augmenting their toxicity and, therefore, negative impacts on aquatic life. Because of these chemical mixtures, or cocktails, the actual risks to aquatic environments could be underestimated. Unfortunately, under current chemical legislation, hazardous substances are tested and their risk assessed as single entities, not as the mixtures in which they occur in the environment.

Recent analysis of Environment Agency datasets by The Rivers Trust and Wildlife and Countryside Link has quantified the prevalence of five chemical cocktails known to be toxic to aquatic life (see **Figure 2**).[22] Within these cocktails, the presence of six different chemicals was explored: four forever chemicals (PFOS, PFOA, PFBS and PFHxS), the pesticide 2,4-Dichlorophenoxyacetic acid, and the commonly used painkiller ibuprofen. In specific combinations, these chemicals are known to have increased harmful impacts on a range of species including amphibians, fish, insects, nitrogen-fixing bacteria and algae.

Across England, at least one of the cocktails was found in 814 river and lake sites (out of 1,006 sites with data – 81 per cent) and in 805 groundwater sites (out of 1,086 sites with data – 74 per cent). Around 54 per cent of these sites contained three or more of the five harmful chemical cocktails investigated. Moreover, up to 101 chemicals were identified in river samples, with sites along the rivers Mersey, Stour, Colne, Thames, Trent, Yare, Irwell, Medway, Humber and Avon among those containing the highest number of chemicals.

REGULATION REMAINS LIMITED

Only 50 or so chemicals are assigned a regulatory standard against which observed concentrations in rivers can be compared to determine whether levels are unsafe and therefore likely to harm aquatic life. Addressing thousands of other chemicals of concern, some still emerging, remains a huge challenge. In England, the Environment Agency has developed a prioritisation and early warning system (PEWS) for emerging chemicals that applies a risk assessment, accounting for factors such as use, fate (i.e. where they end up and in what form), ecotoxicology and monitoring data.[23] Chemicals can be prioritised for environmental regulation if a sufficient level of risk is determined. With over 150,000 chemicals registered for production and use, the need to manage these and to monitor our rivers at sufficient spatial and temporal resolution remains paramount.

TACKLING THE ISSUE

With the Government publication of a new chemicals strategy overdue (the last one dates to 1999), there are several key actions that need to be taken, society-wide, to address chemical pollution of our rivers and wider environment. These include:

- Phasing-out harmful chemicals except for the most essential uses, the use of less-harmful substitutes, and the adoption of the precautionary principle where evidence is incomplete; tackling chemical pollution at source is vital.
- The need to put human and environmental health first in the new model for registering chemicals in the UK and to ensure, as a minimum, it aligns with the EU's REACH scheme and follows its restrictions as standard.[24]
- New legislation to address chemical mixtures with the potential to apply mixture assessment factors to the chemical cocktails found in UK rivers.[25]
- A substantial increase in resources to ensure we monitor chemicals in water as well as in soil and air with sufficient rigour to provide an alert system, integrated with PEWS, to trigger action. We have very limited information with which to quantify the emissions of hazardous chemicals to the environment, which can preclude identification and targeting of the most effective mitigation measures. Action is therefore urgently needed to improve quantitative understanding of sources and emissions.
- Greater investment in wastewater treatment and the tackling of storm overflows is required. For the latter, widespread implementation of sustainable urban drainage schemes, including nature-based solutions such as wetlands, is needed to intercept runoff before it reaches sewers, thereby reducing the frequency and severity of storm overflows and the pollutants they carry. Similarly, a step-change in tackling road runoff is required to prevent, for example, metals and hydrocarbons from polluting our urban rivers. Again, nature-based solutions are proven and cost-effective.
- Support, including incentives to farmers to ensure that pesticides are used in a sustainable and targeted manner, providing benefits for the farm business and the environment.
- Creating greater public awareness of the issue to encourage more sustainable use and disposal of chemicals from our homes, gardens and businesses. This encompasses medicines, including antibiotics; few people are aware that unwanted drugs can be returned to a pharmacy rather than being disposed of inappropriately (e.g. by flushing them away). The England-wide Catchment Based Approach partnerships provide a mechanism to undertake such community engagement.[26]

- Coordinated action across the pharmaceutical, healthcare and environmental sectors to reduce pharmaceutical pollution from human healthcare.[27]
- Creating greater awareness of chemical-free alternatives for the prevention and treatment of fleas on pets.

With toxic chemicals building up in our rivers and posing risks for nature and, potentially, public health, it is critical that the Government acts now to create a bold and ambitious chemicals strategy that is fit for purpose. ES

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ANALYSIS

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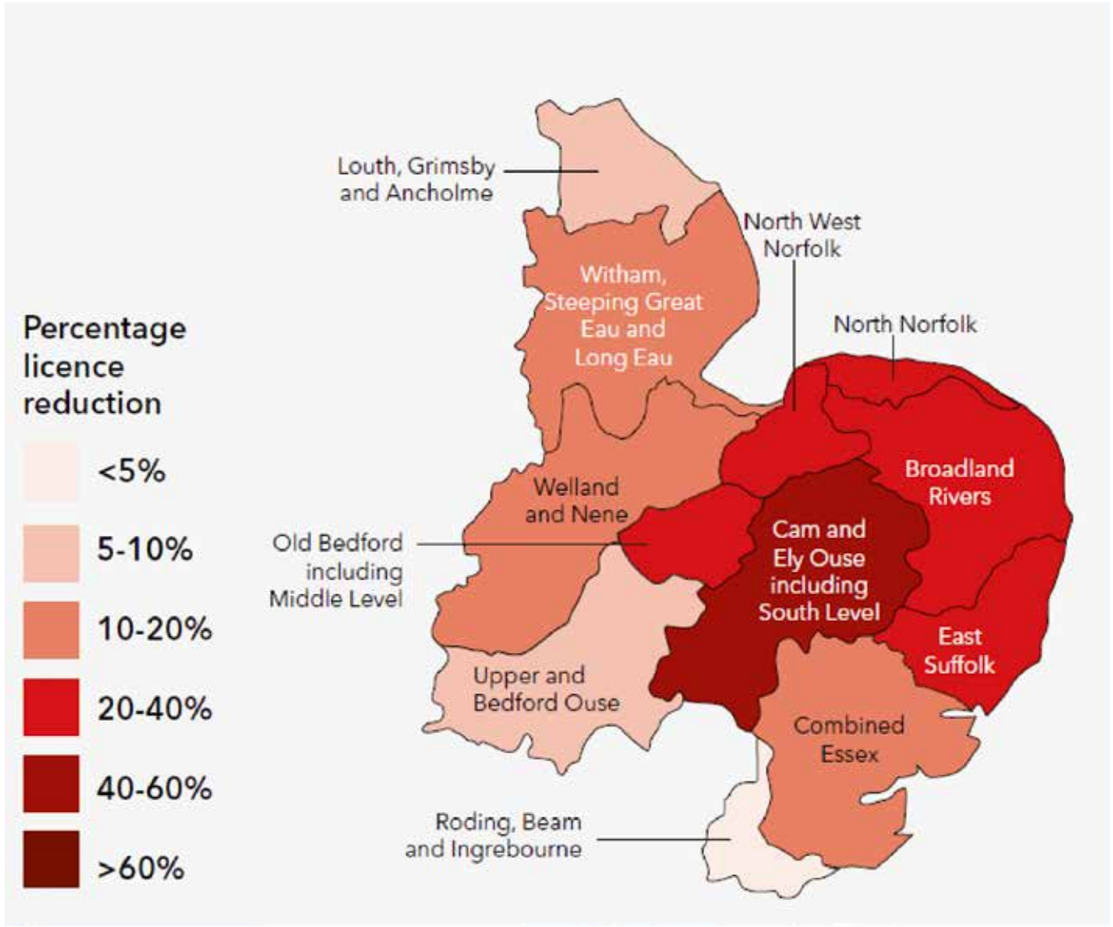
Unlocking water supply constraints on growth

Daniel Johns investigates the benefits of strategic water resource planning for new development.

ANALYSIS

Cheap and readily available water supplies have been taken for granted in England for a long time. Attitudes must now change, and rapidly, to protect the environment in a changing climate. Even 'permanent' abstraction licences – allowing water companies, farmers, businesses and others to draw water from boreholes and rivers in perpetuity – are being withdrawn particularly in water-stressed regions like the East of England. As a result, housing, hospitals and other development projects in the east are on hold. New businesses cannot secure the water they need, and farmers and growers are being left with dwindling, less reliable supplies (see **Figure 1**).



▲ **Figure 1. Projected reductions in licenced abstraction volumes for irrigation by 2050. (© Water Resources East)**

Eastern England – a region broadly encompassing the whole of East Anglia plus Bedfordshire, Northamptonshire and Lincolnshire – is the driest in the country and one of the fastest growing from a housing and economic perspective. It is blessed with once-abundant groundwater sources supporting flows in some of Europe's finest chalk rivers and freshwater habitats, such as the rivers Lark, Nar and Wensum, along with the Norfolk and Suffolk Broads. It encompasses the Fens, critical to UK food production, but whose remaining drained lowland peat soils are rapidly being lost to wind and rain. There is a climatic as well as an economic imperative to manage water in this landscape much more intelligently for the benefit of people, industry, nature and the atmosphere (see **Figure 2**).

Five regional planning groups spanning England and the Welsh Borders play a critical role in the coordination effort to manage water resources sustainably. Water Resources East (WRE) is one of them. WRE's regional water resources plan for eastern England demonstrates the importance of all sectors using water more efficiently, and sharing it more routinely, while water companies and other abstractors bring forward the new water supply infrastructure we will need in future.[1] In the east, that includes billions being spent on two new reservoirs, the expansion of regional transfers, treated effluent reuse schemes and, by the 2040s, significant desalination capacity (see **Figure 3**).

HOUSING GROWTH AMBITIONS ON HOLD

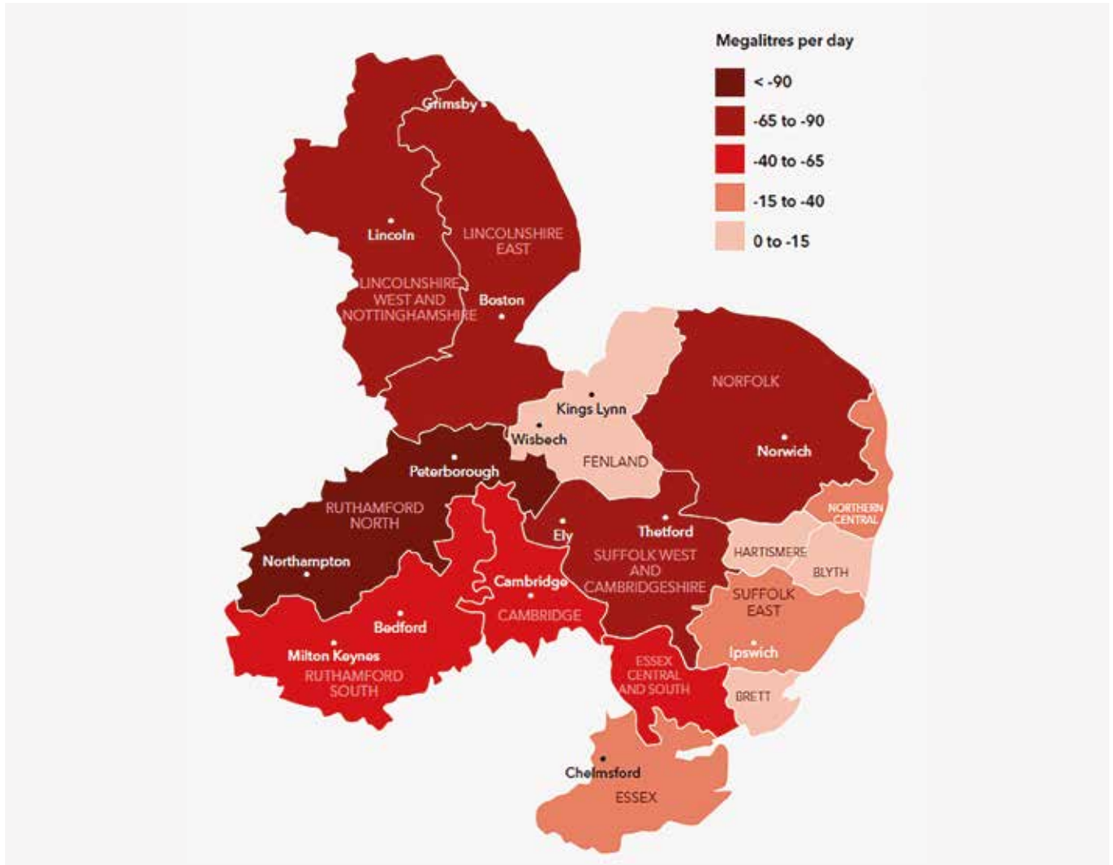
The water scarcity challenge is starting to come to a head as growth ambitions come into conflict with the environmental protections the UK retained when it left the EU. Both Natural England and the Environment Agency – as guardians of the Habitats Directive and Water Framework Directive, respectively – are stepping in due to the risk that already over-abstracted ground and surface waters as well as protected sites will be further harmed by new development (see **Figure 4**).

Natural England has intervened in Sussex to ensure new housing does not lead to even more abstraction where protected sites are at risk.[2] This means developers in several of the area's local authorities must demonstrate that their proposals are water-neutral.[3] The Environment Agency recently took the unprecedented step of objecting to planning applications involving thousands of new homes around Cambridge due to a deterioration risk to chalk aquifers.[4] This objection also affects much-needed infrastructure projects including a proposed cancer hospital.[5] These examples are symptoms of a much wider malaise: a systemic lack of regard for water within the national planning framework.

There are now even greater growth ambitions for Greater Cambridge. Michael Gove, Secretary of State for Levelling Up, Housing & Communities, announced a new long-term plan for housing in July 2023. This would see 'Cambridge supercharged as Europe's science capital' with hundreds of thousands more homes than those in the existing local development plan. Gove's statement recognised that water scarcity is a constraint. A Cambridge Water Scarcity Working Group has therefore been formed to address this. WRE is a member of this group advising the Government alongside regulators, water companies and academics.[6]

JOBS AND THE ECONOMY ARE AT RISK

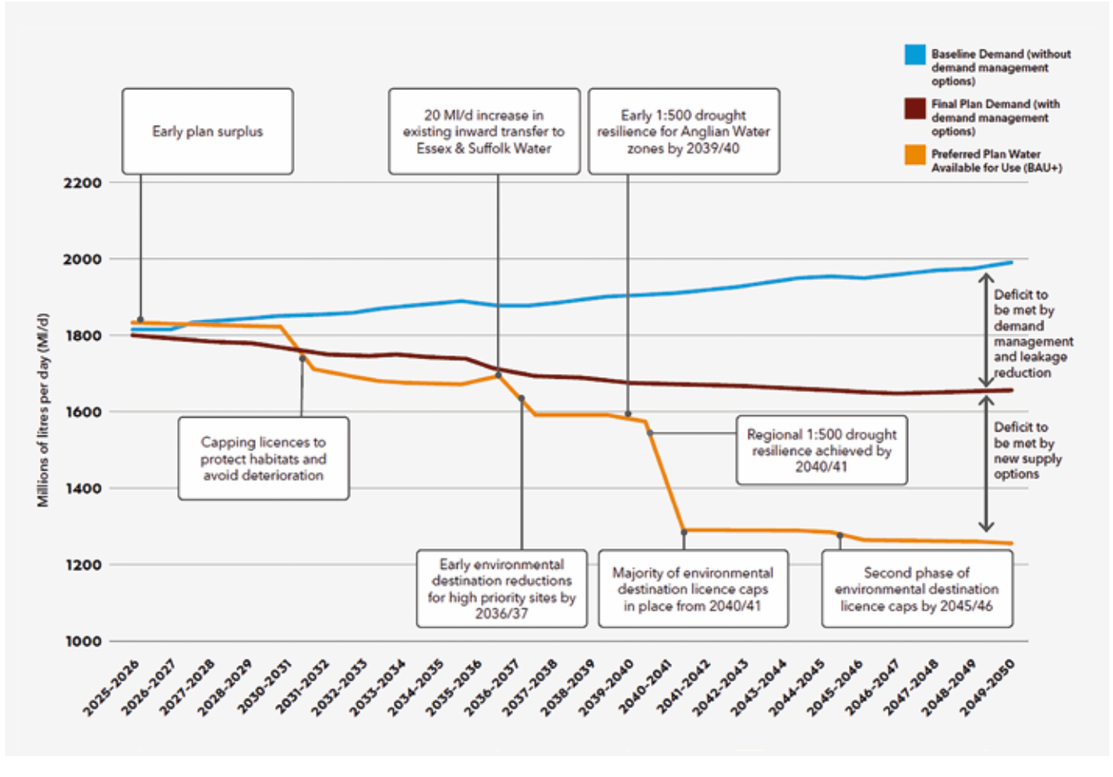
The challenge runs beyond housing and into other sectors such as farming and food production, manufacturing and heavy industry. Energy production can also be a water-intensive process, and a lack of available water could hold back the transition to net zero – for example, freshwater is needed to produce green hydrogen using electrolysis. While the Covid-19 pandemic initially depressed water consumption in the non-household sector, this has since bounced back and accelerated in eastern England. The pandemic is partly to blame for this, with Cambridge becoming a globally significant centre for vaccine research and innovation. Leaving the EU has since encouraged some companies to bring their manufacturing facilities and supply chains back



▲ **Figure 2. Do-nothing scenario for projected supply–demand deficits in 2050. (© Water Resources East)**

ANALYSIS

▲ **Figure 3. Location of significant supply-side options proposed within Water Resources East's regional plan. (© Water Resources East)**



▲ **Figure 4. Do-nothing scenario projections for public water supply deficit 2025–50. (© Water Resources East)**

to the UK. Existing businesses are also requesting new supplies from water companies in response to their own abstraction licences being capped and reduced for environmental reasons.

Not all this extra demand for water can be satisfied. While water companies have a legal duty to supply new households, they have no obligation to meet non-household needs. Water companies will meet new demands where they can, but the volumes currently being requested are far beyond those anticipated by water companies when they last developed their water resource management plans in 2019. This means that requests must be considered on a case-by-case basis, and many must be declined. While there is only one formal moratorium on new non-household water use in East Anglia — in Suffolk's Hartismere zone — more water elsewhere in the region is extremely hard to find.

STANDING UP FOR THE ENVIRONMENT

Faced with these challenges to economic growth, ministers may be tempted to try to erode environmental safeguards. This would be a mistake and would store up even greater problems for the future. It would not be straightforward either: a recent attempt by the Government to abolish nutrient neutrality rules was widely criticised by many, including the independent environmental watchdog, the Office for Environmental Protection, before being rejected by the House of Lords.[8,9] As with water neutrality, nutrient neutrality safeguards became necessary due to decades of weak and poorly enforced policy that allowed impacts and externalities from growth to build up over time. We must learn from this experience and encourage the Government to address the policy failures in water quality and water resources management rather than further weaken safeguards.

WATER EFFICIENCY AND DEMAND MANAGEMENT

Finding new water supplies to support housing growth will not be easy in an already severely water-stressed region – a problem that will only be exacerbated through climate change. All significant ground and surface water sources are already at, or beyond, sustainable abstraction limits. New supply options are possible and are being brought forward as quickly as they can. But reservoirs, reuse schemes and desalination plants have long development lead times and can encounter significant planning hurdles. These options will also have environmental impacts of their own that will need to be minimised and mitigated. Reservoirs are generally net positive from an environmental perspective, achieving significant biodiversity net gain when designed appropriately. But desalination is energy intensive, and the resulting concentrated brine will need careful management if released into sensitive estuarine and coastal waters.

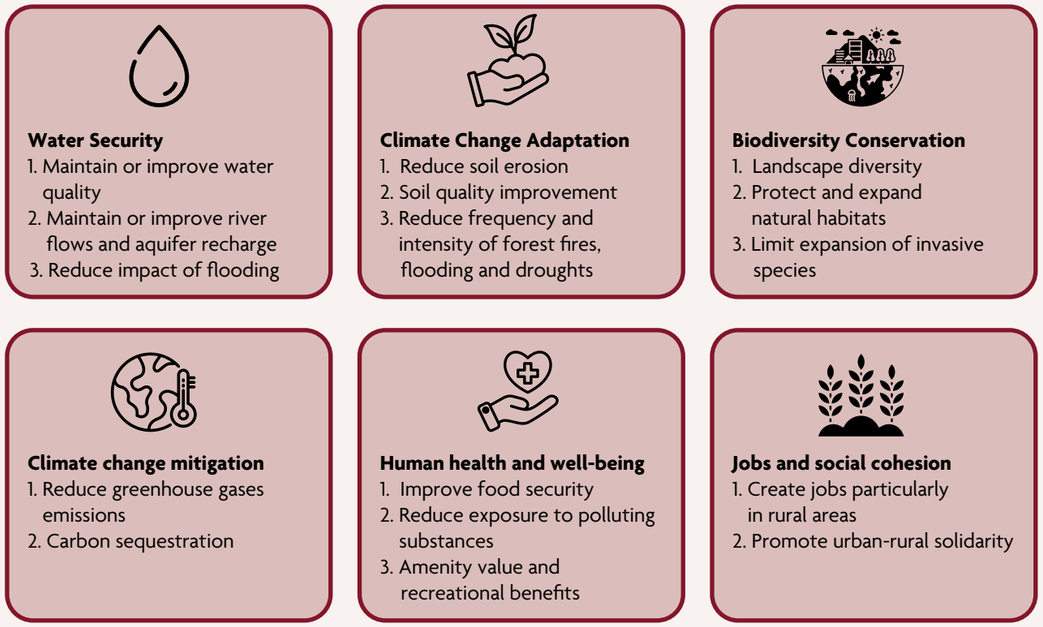
In the short term, the way forward should centre on water efficiency and demand management. This includes leakage control strategies; however, given historic pressures on water resources, easy and cheap options to reduce leakage have already been exhausted in the east. Whether at home or at work, using water more efficiently saves money, including on energy bills: over half of water used at home is heated.

All four water companies serving eastern England have submitted ambitious demand management strategies as part of the latest five-yearly round of water resource planning. Their proposals include achieving the near-universal roll-out of smart water meters within 10 years in homes and businesses.[10] These meters provide hourly readings to customers and allow homeowners and water companies to identify leaks: repairing a leaky toilet can save as much as 400 litres per day and is a quick and easy fix.[11] Water companies also propose to trial innovative tariffs that would price water dynamically according to its availability, as some smart energy tariffs already do.

But even if these latest water company investment plans – aiming to reduce leakage by a further 40 per cent in the east and household consumption by around 20 per cent[1] – are fully funded, new plans for growth could continue to be held back, at least until the next planning round, which completes in five years' time. More needs to be done, and urgently.

STRONGER GOVERNMENT POLICY IS NEEDED

Water companies can only achieve so much, even when working together with water retailers and other partners. Tap water is cheap, costing around £1.25 a day for the average UK household. This means the financial incentive to reduce water use is weak, even when energy savings are factored in. Encouraging restraint and behaviour change will be important, but water-saving action by customers is hard to sustain over time. This is where the Government needs to step forward: it holds most of the important policy levers that would reduce water consumption in existing communities and for new development.



▲ **Figure 5. Potential benefits from nature-based solutions for water security. (Source: Trémolet et al.[16])**

After years of pressure from academics, the water industry and environmental groups, the Government has confirmed it will introduce a mandatory water efficiency labelling scheme for taps, showers and other water-using products in 2025.[12] The Government estimates that in time, this measure alone could save 1.2 billion litres of water per day – equivalent to the yield of a dozen major reservoirs.[13] But to realise the full benefits of the scheme, the Government should use it to underpin minimum product standards so that the most water-wasteful products cannot be sold.

The Government also needs to tighten building regulations, so that new homes use less water, and to ensure these standards are checked and enforced. Once a water label is in place, developers should only be allowed to install the most water-efficient, A-rated products. Local authorities should be able to set even tighter new-build standards in water-scarce areas. Various councils have tried to do this but have been blocked by the Planning Inspectorate, based on a 2015 ministerial statement that favoured weaker national standards being applied consistently.[14] This statement should be withdrawn.

Drinking water regulations also need to be clarified so that communal rainwater harvesting systems can be installed to displace unnecessary potable water use in new homes, such as for flushing toilets. Standards for bathroom fittings need to be tightened to prevent poor-quality dual-flush toilets, whose drop-valves leak continuously and often soon after being installed, from reaching the market.

The Government has promised to look at all these things, but progress has been painfully slow. While the Environmental Improvement Plan 2023 includes a roadmap for water-efficient new development, there are no milestones for its delivery.[15]

THE IMPORTANCE OF STRATEGIC PLANNING

WRE was formed in 2014 to develop a collaborative, cross-sector systems approach to water resources planning in eastern England. It became an independent, not-for-profit company in 2019 with a multi-sector board of directors, recognising the shared challenge of securing sustainable water resources in a changing climate. Working closely with sector leads, WRE has created a plan to meet the region's long-term water resource needs while restoring waterbodies, wetlands and river systems to good health.[1]

While WRE's core role focuses on water resources, its vision is much wider: for the region to be an international exemplar of collaborative, integrated water management. The organisation is working with The Nature Conservancy, Anglian Water and Norfolk County Council to create a Norfolk Water Fund that will blend public, private and philanthropic funding sources to invest in nature-based solutions at scale. Measures such as sustainable drainage systems and run-off attenuation features offer the potential to deliver more cost-effective benefits for water resources than traditional approaches, while achieving improvements in water quality, flood risk, carbon sequestration and biodiversity (see **Figure 5**).

WRE is working with the Cambridge Delivery Group to meet the Government's growth ambitions while returning to the environment the water necessary for nature to thrive. WRE is also working with farmers and abstractor groups to explore water sharing and trading opportunities, as well as local resource options such as winter storage, managed aquifer recharge and effluent reuse. Finally, the organisation has also been working with Net Zero East to investigate options that could help industry and the energy sector to transition to net zero.

A much greater focus on sustainably managing water resources is needed. Freshwater is a common resource that no one 'owns'. Therefore, it follows that sustainable water resources management is a challenge that no single actor, sector or regulator can achieve alone, and all sectors and tiers of government need to work together on this shared endeavour. The five regional planning groups have shown the importance of long-term strategic, collaborative planning focused on addressing the failures of the past. Maybe this regional, catchment-based approach could help resolve other systemic environmental challenges too. ES

Daniel Johns is Managing Director of WRE, the independent not-for-profit membership organisation tasked by the UK Government to create a long-term water resources plan for eastern England.

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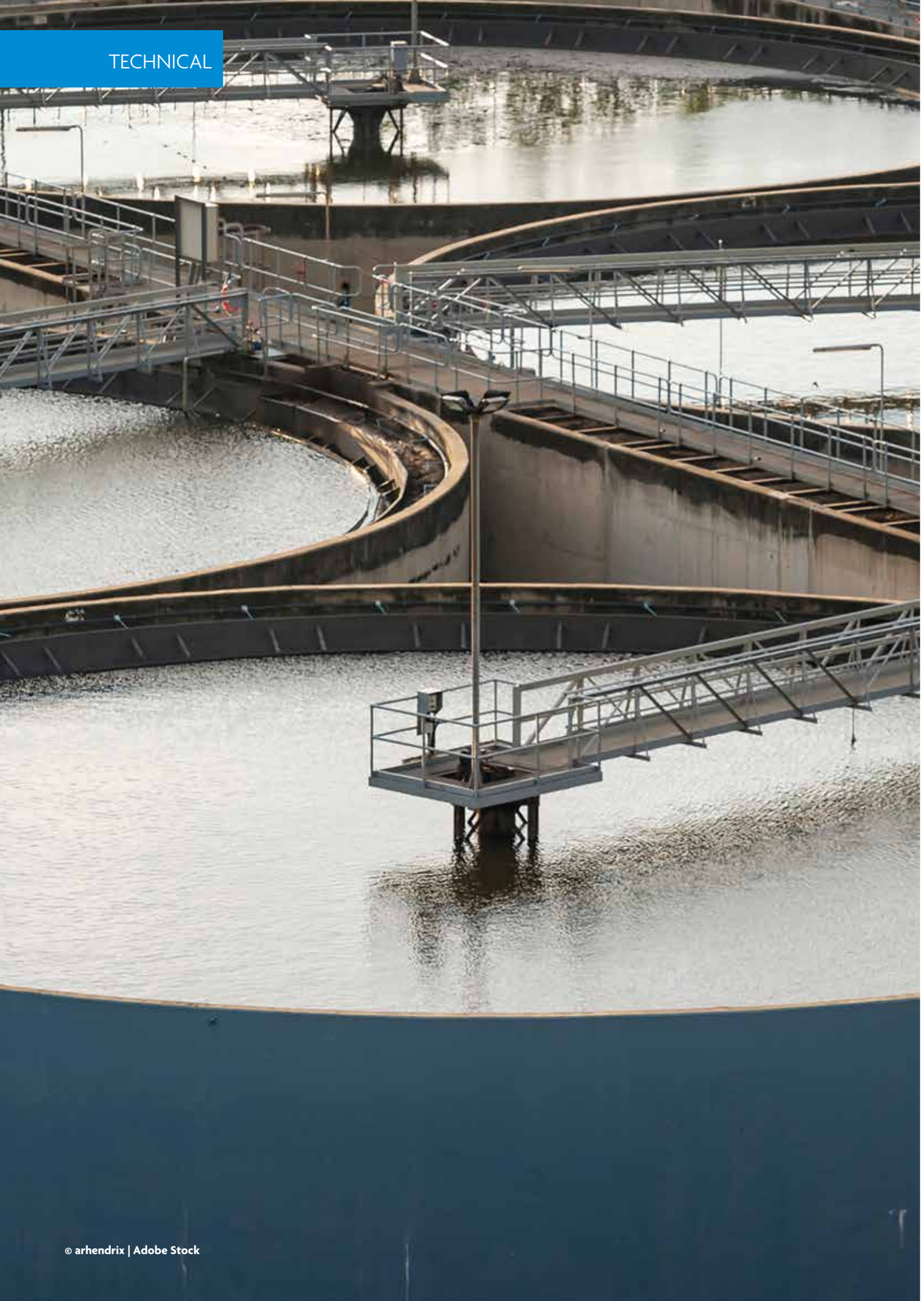

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TECHNICAL

Digital transformation and wastewater net zero

Oliver Grievson considers how the industry can use digital technology to reduce its carbon emissions.

The climate crisis and net-zero target involve the water industry, which is directly affected by changing weather and its effects: on water resources through drought, and by adding pressure to wastewater collection systems and treatment works. In the UK we see the problems the industry faces with storm overflows that are partly due to climatic changes, which stress wastewater systems.

There is a drive by the water industry towards achieving net zero; but what is that in real terms exactly? The United Nations (UN) defines it as 'cutting greenhouse gas emissions to as close to zero as possible, with any remaining emissions re-absorbed from the atmosphere, by oceans and forests for instance'.[1]

The UN goes on to define why this is so important:

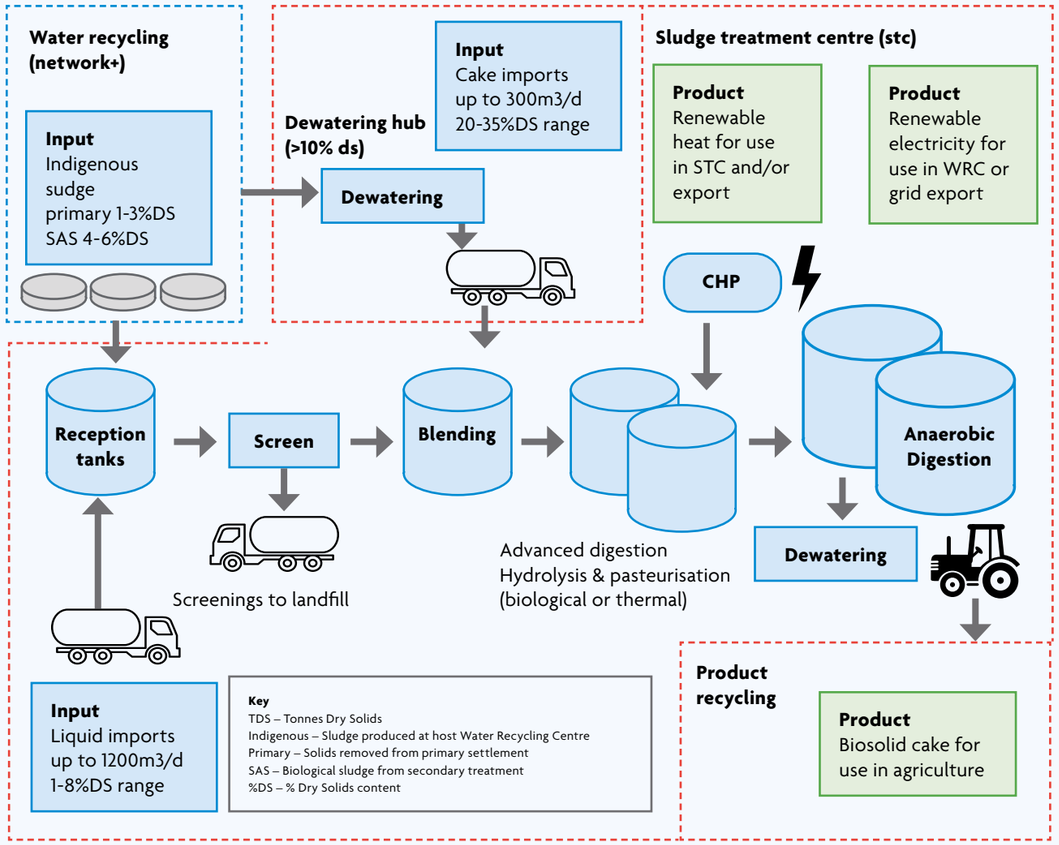
> 'The science shows clearly that in order to avert the worst impacts of climate change and preserve a liveable planet, global temperature increase needs to be limited to 1.5°C above pre-industrial levels. … To keep global warming to no more than 1.5°C – as called for in the Paris Agreement – emissions need to be reduced by 45% by 2030 and reach net zero by 2050.'[1]

In 2021, UK water companies united to join the Race to Net Zero, with each producing a roadmap estimating investments of £2–4 billion.[2] Each water company had a different strategy and produced its own plan on how it was going to achiever this. However, carbon emissions were central to all plans and used the standard scope definitions (see **Box 1**).

BOX 1: CARBON EMISSIONS SCOPE DEFINITIONS

The Greenhouse Gas Protocol, which provides the most widely recognised accounting standards for greenhouse gas emissions, categorises carbon emissions into three scopes:

- Scope 1: Emissions from sources that an organisation owns or controls directly – for example, from burning fuel in a fleet of vehicles;
- Scope 2: Emissions that a company causes indirectly related to where the energy it purchases and uses is produced; and
- Scope 3: Emissions that are not produced by the company itself and are not the result of activities from assets it directly owns or controls, but that it is indirectly responsible for across its value chain.[3]



▲ **Figure 1. Activities in the bioresources price control, which is the measure used to demonstrate compliance to the regulator. (Source: Anglian Water[5])**

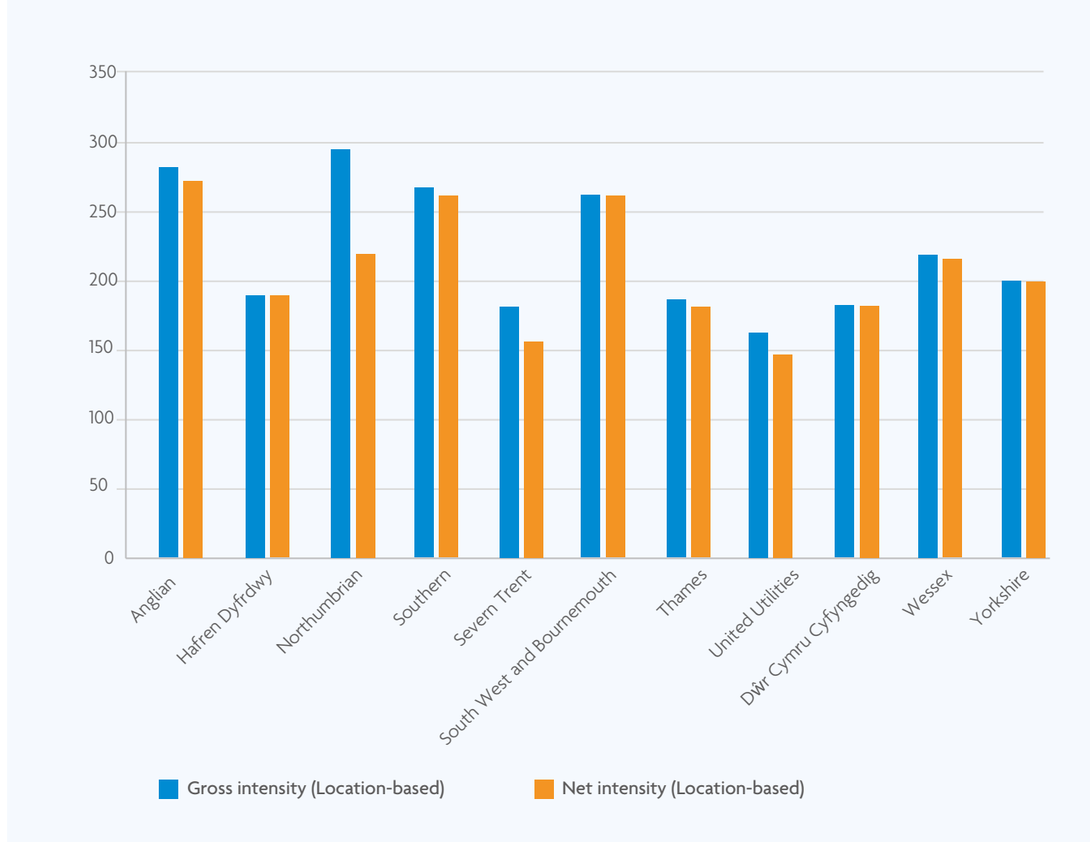
THE INDUSTRY AND CARBON EMISSIONS

With the spotlight on the three scopes of carbon emissions in the wastewater industry, there is significant improvement potential.

Under Scope 1, the main consideration is the amount of road transportation that is involved within the industry: taking sludge from wastewater treatment plants to treatment centres and then transporting the treated sludge for use on agricultural land. The number of tanker movements is extensive and, therefore, so are the resulting emissions. Looking at the geographical spread of one water company, the distance from the southernmost to the northernmost sludge treatment centre is approximately 200 miles. As Anglian Water's centres treat around 180,000 tonnes of dry solids a year, this leads to hundreds of daily tanker movements, and transport emissions alone equate to 21,380 tonnes of carbon dioxide equivalent (CO_2e). For context, the amount of sludge produced in England in 2020 was 807,882 tonnes (see **Figure 1**).[4]

It is within Scope 2 emissions where there is significant improvement potential for the wastewater industry. On average, it takes between 250 kg and 300 kg CO_2e to treat 1,000 m^3 of wastewater. This includes fugitive emissions, comprising nitrous oxide; however, this process is still a developing science that is not yet fully understood and depends on the CO_2 emissions calculation method (see **Figure 2**).

Considering the UK treats around 10 billion litres of wastewater every day, this equates to approximately 1 per cent of the average daily consumption of electricity across the UK.[7] However, this is balanced by the energy that water companies produce. For instance, in 2020 Thames Water generated approximately 476 giga watts per hour (GWh) of renewable electricity.[8] This



▲ **Figure 2. Location-based methodology for gross and net greenhouse gas emissions from wastewater treatment for 2020–21 in kilograms of carbon dioxide equivalent per million litres. (Source: Water UK[6])**

comes from the production of methane through the anaerobic digestion of sewage sludge and its subsequent combustion in combined heat and power engines.

Scope 3 emissions are influenced by the efficiency of capital schemes for the reduction of embodied carbon. The water industry has proposed a total investment of £96 billion for the 2025–30 period, which is a large increase over current plans, leading to the potential for an increase in Scope 3 emissions.

There is a significant emissions reduction potential within the industry to reduce its operational carbon emissions by optimising the wastewater treatment processes. However, this is unlikely to completely offset carbon emissions from operations. In this case, it is possible to offset the remaining carbon emissions either by purchasing green electricity or for water companies to produce increasing amounts of renewable energy themselves.

The first area that can be examined is fugitive emissions from wastewater treatment. It is now well understood that wastewater treatment produces a large amount of nitrous oxide – greenhouse gas with 300 times the impact of CO_2 – due to the denitrification process, especially in activated sludge plants and particularly where plants are operating sub-optimally. The amount of nitrous oxide produced can be controlled through advanced wastewater treatment practices using a combination of real-time control and multivariate process-control strategies.

CONTROL OF FUGITIVE SCOPE 1 EMISSIONS

Real-time control of wastewater treatment plants is a well-established process, particularly for activated sludge. Around 378 wastewater treatment plants in the UK, or 6 per cent, treat 80 per cent of the wastewater load; this means that the industry must concentrate on controlling this process for the greatest reduction of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fugitive emissions. Therefore, real-time control of these wastewater treatment plants is essential.

Some water companies have already implemented this to reduce the amount of electricity they use, and the technology is under development for application to and control of fugitive nitrous oxide emissions. However, this requires research, development and innovation to improve the underpinning models, as well as additional strategies to reduce power consumption. This is a change in focus for the industry and may alter the fundamental design of wastewater treatment works, which would have a knock-on effect of creating a legacy issue for managing existing assets.

This is only one potential control strategy. Another, more fundamental option is to better manage the balance of flow into the wastewater treatment works and by extension the treatment load. Wastewater treatment typically peaks twice a day (morning and evening) – known as the diurnal profile. Engineering design allows for this with a peaking factor, where the treatment processes (mainly aeration blowers) enable up to 40 per cent more power. During the night, when we are asleep, the flow and load coming in are at their lowest levels. This means that there is a dip in both. If flows were more balanced over a 24-hour period the treatment process would be more stable, which would create a more balanced power consumption and minimise emissions while the process operates more efficiently.

DIGITAL TRANSFORMATION AND NET ZERO

Real-time control using a model-and-monitoring approach is the first step towards a digital twin wastewater treatment plant and contributing collection network, which would allow differing operational strategies depending on conditions. For instance, in storm conditions plants would operate at a maximum level with little or no control of process emissions; conversely, during quieter conditions an active control strategy would be possible, limiting both process emissions and power consumption while maximising power generation.

However, one of the first limitations is the measurement of fugitive emissions. There are numerous ways of doing this. Scottish Water is trialling the use of fourier-transform infrared spectroscopy to measure large areas of a wastewater treatment plant, scanning for nitrous oxide, methane and carbon dioxide emissions and studying the role treatment works play in their emission.[9] There is also the Unisense measurement technology, directly measuring nitrous oxide in the liquid phase of the activated sludge plant, developed by Danish specialists.[10]

SCOPE 3 EMISSIONS FROM INFRASTRUCTURE

There is always a need to build more plants, creating more Scope 3 emissions through the use of energy-intensive construction materials. Water companies continually need to expand their asset base to serve their increasing populations. The design and build of wastewater treatment plants and collection networks are energy-intensive processes that lead to indirect carbon emissions. Certain techniques can be used to minimise this, such as the use of low-carbon-impact materials and technologies that minimise design and construction impacts.

It is rare nowadays for large wastewater treatment plants to be built from scratch, with the expansion of existing assets more likely instead. However, as many are decades old and design drawings are not always available, advanced surveying techniques using laser scanning are becoming increasingly popular. These highly accurate digital representations have a high enough resolution to enable design too. They allow for more efficient asset retrofitting, for the integration of models into asset data systems, and for the inclusion of digital twin treatment systems. Where these asset plans do not already exist, a digital representation can be created to allow water operators to refine designs before building anything. This promotes design efficiency and enables consideration of more suitable materials for greater efficiency and lower carbon intensity.

By adding an instrumentation layer onto a construction digital twin that has been created as part of a construction project, it also becomes an operational digital twin of the wastewater treatment plant. As such, it enables efficiencies in both the short-term construction process as well as in the long-term operations.

CONCLUSION

The wastewater industry is a significant greenhouse gas contributor; the race to net zero and mitigation of its carbon impact is still in development. As a relatively new developing area for the industry, new emissions identification opportunities and reduction strategies are being developed. The industry is taking advantage of opportunities to mitigate its environmental impact by addressing areas of inefficiency in operation as well as tackling fugitive emissions.

However, there is a need to race to net zero in the most efficient, ethical and sustainable way possible. Work has already started and while there are initiatives to reach net zero, it will take a lot of research, development and engineering to get there. The wastewater industry face huge challenges, as it is a heavy industry with significant physical infrastructure assets. It is also faced with increasing construction to mitigate issues such as storm overflows, and this contributes to the daily operational carbon that it produces. With the additional pressures of population growth and climate change, it would be easy for the industry to simply do what it can and mitigate the rest through carbon offsetting.

We all produce wastewater every day and while the industry is in place to protect public health, there is also a need, under sustainability principles, to protect the environment too. The race may be slow and the journey long. But the fundamental culture must change, and the industry will get to net zero in the end. ES

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Improving water monitoring through citizen science

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CASE STUDY

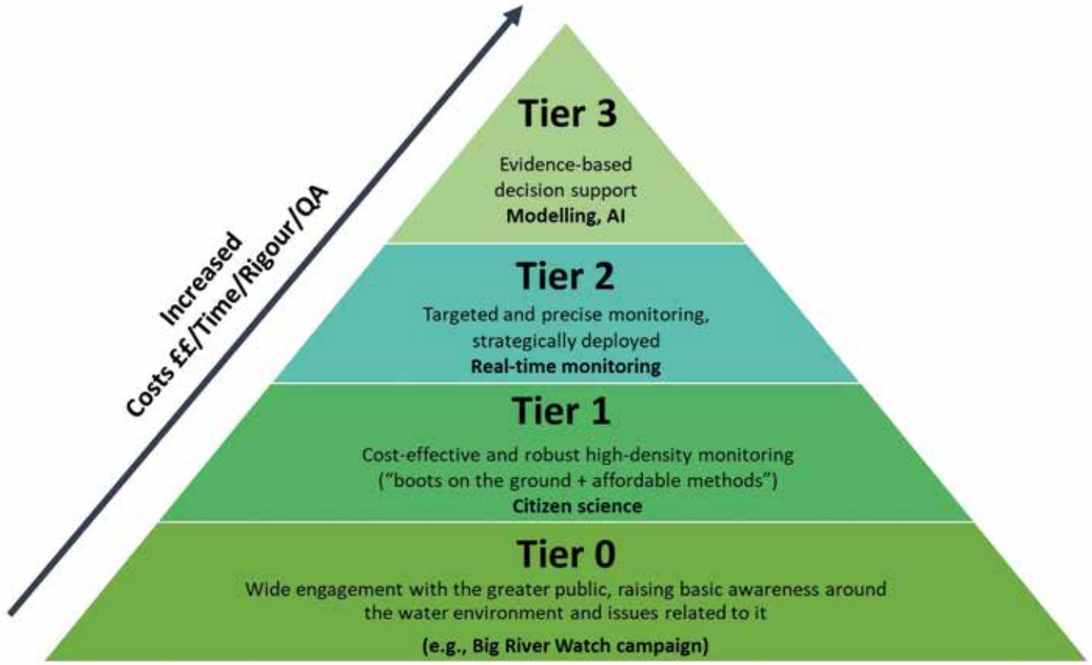
The Rivers Trust takes a deep dive into how communities can get involved in river and catchment monitoring and data collection.

Growing risks related to climate and biodiversity crises and human activities mean that more than ever better information is needed on how the natural environment, such as river catchments, is coping and how to make it more resilient.

CURRENT CHALLENGES IN RIVER MONITORING

Data are some of the most valuable means at our disposal to improving our understanding of the state of the natural environment. The ability to easily share large amounts of information and to combine monitoring data and observations from different sources can greatly extend the reach and understanding of how environmental decision-makers can prioritise appropriate responses and reduce risks.

Natural systems such as river catchments are complex, making it difficult and expensive to monitor them and often resulting in catchment-data gaps related to water quality, pollution sources and flooding impacts, and in poor understanding of how rivers are performing ecologically. The problem is exacerbated by cuts in monitoring budgets, a lack of transparency, and limited collaboration in data collection and management, leading to fragmented decision-making and slow action.[1] Therefore, progress also remains slow: for example, only 14 per cent of England's rivers were classified as having a Good Ecological Status in 2016 – one of the worst records in Europe, where the average was around 40 per cent.[2]



▲ **Figure 1. The proposed Catchment Systems Thinking Cooperative framework takes an integrated and tiered approach to catchment monitoring and data management. (Source: CaSTCo)**

At the same time, there has been a steep increase in public awareness around issues related to freshwater bodies, such as for rivers and lakes, and a rise in the number of people volunteering for citizen science monitoring activities.[3] Although popular in other environmental areas, particularly academic research, the application of citizen science in water monitoring is relatively recent.[4] With citizen science, the public can play a key role in driving better monitoring and data collection and be empowered to work side by side with others to plan, gather, interpret and share reliable data to drive concerted efforts to improve rivers.

Two recent studies are examples of where The Rivers Trust is working with others to build momentum around citizen science as a valuable engagement, monitoring and data-gathering tool: the Catchment Systems Thinking Cooperative (CaSTCo) and the Big River Watch.

CATCHMENT SYSTEMS THINKING COOPERATIVE

To understand how best to improve the state of our freshwater bodies, we must first address the biological, chemical, ecological and environmental factors that affect water quality and quantity across catchments. This requires more joined-up monitoring and the integration of different methods such as citizen science, low-cost sensors, real-time monitoring and remote sensing.[5]

This approach needs to be:

- Independent and robust;
- Easily accessible and widely shared;
- Open and transparent;
- Trusted by all stakeholders who interact with catchments – from catchment partners to water companies, government bodies, communities, scientists, businesses and landowners; and
- Collaborative in its approach.

Such an approach can resolve a lot of the issues around data gaps and inadequate monitoring and provide greater insights into the state of river catchments. However, catchment monitoring remains fragmented and siloed, with many datasets not being used, trusted or have limited access, which can lead to blind spots in decision-making.[6] CaSTCo can address some of these.

CaSTCo is a £7.1 million national project, funded by Ofwat's Innovation Fund, to create the first national, standardised, tiered framework to better integrate catchment monitoring and data management (see **Figure 1**).[7] This will help to improve trust, transparency, data sharing and collaboration across all those in the catchment, including surrounding communities.

It is a highly collaborative and innovative project, co-led by The Rivers Trust and United Utilities, with over 30 organisations and communities represented across England and Wales, including water companies, environmental non-governmental organisations, academia, catchment partners, local communities, government bodies and citizen science volunteers working in regional demonstrator areas (see **Figure 2**).

One of the project's main ambitions is for citizen science to be widely accepted and applied as a valid and robust method and to be used alongside other monitoring

▲ **Figure 2. The Catchment Systems Thinking Cooperative demonstrator areas (shaded in blue) across England and Wales. (Source: CaSTCo)**

CASE STUDY

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methods. To increase the range and density of data collection through citizen science, CaSTCo is growing public outreach and participation, by:

- Engaging the public in simple, fun and accessible citizen science activities such as the Big River Watch;
- Training volunteers in innovative (e.g. Water Rangers, eDNA) as well as standardised monitoring methods (e.g. traditional sampling of nutrients such as phosphorus) that are easy to use and can produce reliable data; and
- Creating local volunteering networks with catchment partnerships as the focal points and dedicated volunteer coordinators to recruit citizen scientists and keep them engaged, ensuring that the data they are collecting matters and will be used.

The project is also using citizen science as a social engagement tool to:

- Improve health and wellbeing by connecting people to nature;
- Increase community understanding of the issues affecting their local rivers, looking to drive action and change behaviour; and
- Train people in monitoring and analytical methods that can lead to upskilling and potentially expand job prospects.

"...there is growing public demand for a better deal for rivers, as well as more tangible ways for communities to get involved."

CaSTCo is engaging with people from all walks of life – across rural and urban areas – ensuring that equality, diversity and inclusion (EDI) are at the heart of its approach. This includes the establishment of an EDI working group, with experts drawn from across all partners to investigate, improve and embed EDI practices into project delivery (such as the project charter) and public engagement as the project evolves. A core CaSTCo aim is to be inclusive in how communities access, are involved with and champion river health.

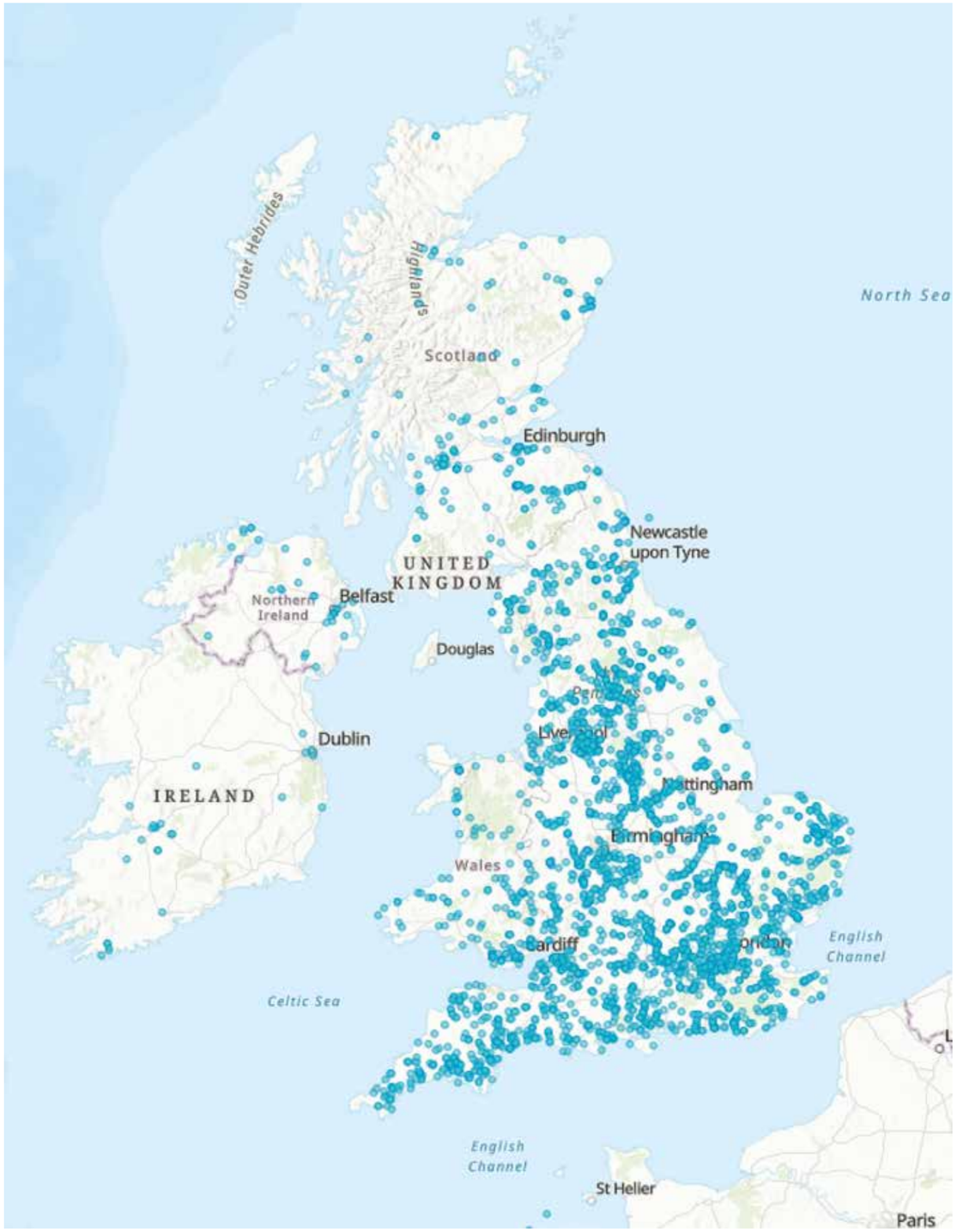
As well as improving catchment monitoring and data capabilities, CaSTCo also aims to demonstrate the wider socio-economic and reputational benefits of collaboration through citizen science, which can open up new ways of engaging the public and creating lasting, positive changes for communities and rivers alike.

THE BIG RIVER WATCH

The Big River Watch is a Tier 0 approach to monitoring and data collection (see **Figure 1**).[8] It is a citizen science monitoring tool, and at its core offers an opportunity for widespread public engagement with both river health issues and the role that citizen science plays in wider environmental change.

The Big River Watch invites communities to engage with their local rivers through a free app (developed alongside the CaSTCo demonstrators) containing a simple survey. Anyone in the UK and Ireland who can access a river can participate – all they need to do is spend 15 minutes watching their local watercourse and answer some simple questions based on what they can see. Questions include how fast the river is flowing, whether there are barriers in the river, if any wildlife or litter are visible, and if the water is clear or has an odour.

Considering the increased focus on river pollution – from sewage to plastics and nutrients – there is growing public demand for a better deal for rivers, as well as more tangible ways for communities to get involved. The Big River Watch app was designed to be an accessible and easy-to-use tool that can serve as a user's first experience of citizen science, yet still suit the needs of more experienced users. The Big River Watch approach also provides a route to connect communities with their local river trusts and an opportunity to continue their



▲ **Figure 3. Mapped dots of the areas surveyed by the public during the Big River Watch campaign on 22–24 September 2023. (Source: The Rivers Trust[3])**

citizen science journey by signing up to other monitoring schemes in their local area.

The app is available in English and Welsh and can be used without any citizen science experience or training. Citizen scientists can either participate independently or as part of events such as nature walks, outdoor classes or volunteer activities. Twice a year, Big River Watch Weekends are held as part of a communications and engagement campaign, and the public is encouraged to take part. This allows for seasonal and annual data collection and comparisons.

Over the weekend of 22–24 September 2023, 5,871 people participated across the UK and Ireland, with The Rivers Trust receiving over 3,600 surveys (see **Figure 3**).

Of those who participated:
- 60 per cent said that they were new to citizen science;
- 73 per cent reported that their local river looked healthy, while 17 per cent said their local river appeared unhealthy; and
- 54 per cent spotted at least one sign of river pollution, including sewage (5 per cent).[3]

As part of the survey, people were also asked about how their local river made them feel. This resulted in varied answers depending on whether a watercourse looked healthy or unhealthy, and descriptions ranged from calm, happy and relaxed to sad, disappointed and angry.

CONCLUSION

Threats such as climate change are putting more pressure on rivers, and there is a growing need for more data to better understand how to address them. This requires coordinated, cost-effective collaboration, high-density deployment of monitoring capabilities and widespread public engagement. Citizen science can address this need, both as a cost-effective monitoring method to fill in gaps in current knowledge, and as a social engagement tool, connecting people with nature, increasing awareness of their local watercourses and improving analytical skills. With frameworks like CaSTCo, citizen science can play a key role in driving evidence-led decision-making and targeted actions to make rivers more resilient to current and future threats. ES

The Rivers Trust is the charitable, national umbrella organisation for a movement of 65 member Rivers Trusts across the UK and Ireland, comprised of catchment conservation experts with a wealth of data and expertise. The Rivers Trust movement uses this collective expertise and knowledge in its work with farmers, local communities and a wide range of organisations, providing advice and resources to deliver improvements to realise its shared vision of wild, healthy, natural rivers valued by all.
https://theriverstrust.org

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OPINION

Taking an ecosystem approach to water management

Laurence Couldrick reviews one organisation's use of nature-based solutions in south-west England.

With such a complex and devolved water sector in the UK, one of the key challenges for non-governmental organisations, government and the private water sector is to develop a cohesive approach to governance and management: one that recognises the importance of ecosystem approaches and integrates catchment-based thinking into the development of new guidance, projects and collaborative efforts. This holistic approach, appreciating the interconnectedness of catchments, ecosystems and society, is one that the Westcountry Rivers Trust (WRT) adopted early on in its efforts to improve the state of rivers in south-west England.

This past year has been an extraordinary one for the water industry. With extensive media coverage and public outrage around rising water bills, sewage spills and climate change impacts, these issues are at the forefront of many people's minds. Yet there have been plenty of things to celebrate in 2023, particularly in the south-west. Here, WRT has overseen delivery of project outputs and outcomes. Such projects include improvements for fish passage at several key rivers in the south-west, including the Water for Growth (funded by the Structural Investment Fund) that removed, eased or adapted 17 barriers to support river ecosystems.

While this project ended in 2023, others will continue at pace into the new year. These include the Upstream Thinking project, which is funded by South West Water and has been running for 15 years, designed to improve drinking water quality by introducing novel ways of slowing and storing water.

In 2023, WRT launched a new Ofwat-funded project called Water Net Gain to tackle drought. This looks at the use of pond and lake networks to capture, divert and store surface water runoff during floods by using nature-based solutions (NbS) to slow water. Similar NbS projects that are continuing into 2024 include the Environment Agency-funded Rapid Response Catchments – operating in Devon to support communities in catchment areas that are more likely to flood quickly[1] – and the Shared Prosperity-funded Resilient Catchment Communities scheme, which will install six demonstration sites across Cornwall to showcase the density, diversity and interconnectedness of NbS methods needed to attenuate flood peaks. While these projects tackle specific elements of water-related pressures, WRT has always sought to combine these actions into an integrated systems approach.

THE ECOSYSTEM APPROACH

WRT operates a wide range of projects and has always taken an ecosystem approach. This approach was first developed at the Convention of Biological Diversity, part of the 1992 Rio Summit, and is just as relevant 30 years later. Its 12 guiding principles have underpinned the work of many environmental organisations, and the founders of the ecosystem approach were closely involved with the development of WRT in 1994 (see **Box 1**).

OPINION

BOX 1: THE 12 GUIDING PRINCIPLES

The guiding principles of the ecosystem approach are as follows:

1. The objectives of management of land, water and living resources are a matter of societal choice.
2. Management should be decentralized to the lowest appropriate level.
3. Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.
4. Recognizing potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem-management programme should:
   - **a.** Reduce those market distortions that adversely affect biological diversity;
   - **b.** Align incentives to promote biodiversity conservation and sustainable use;
   - **c.** Internalize costs and benefits in the given ecosystem to the extent feasible.
5. Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach.
6. Ecosystems must be managed within the limits of their functioning.
7. The ecosystem approach should be undertaken at the appropriate spatial and temporal scales.
8. Recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term.
9. Management must recognize that change is inevitable.
10. The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity.
11. The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.
12. The ecosystem approach should involve all relevant sectors of society and scientific disciplines.

OPINION

Some of the key translations of the ecosystem approach into delivery are, first, where WRT seeks to work with communities and partners to understand and explore the catchment ecosystem both spatially (where things are done) and temporally (the time it takes for things to come into effect). This is evident in the Catchment Partnerships that WRT attends and hosts for the region, as well as in the Regional Flood and Coastal Committee, Local Nature Partnership and West Country Water Resource Group. All these groups emphasise the siloed nature of the environmental sector, for which the ecosystem approach, pulling together funding, partnerships and management, can create sustainable climate change resilience within communities.

The second key translation of the 12 principles is that management of these issues (flooding, drought, pollution and biodiversity loss, alongside food and energy) needs to be balanced with interventions delivered at the lowest appropriate level (i.e. work undertaken directly by farmers rather than managed through government bodies). That means developing trusted and long-term relationships with farmers and landowners. Since its inception, WRT has worked with hundreds, if not thousands, of farmers, and always from a perspective of understanding their business models and adapting them to help farmers save money or diversify their income to include payments for ecosystem services.

Therefore, the needs of society can be managed and balanced through a deep-seated understanding of ecosystem scale, function and limits by working directly with land managers, as well as in partnership with relevant sectors and stakeholders, and using a wide set of information and data to recognise gains and the trade-offs of different water management pathways. As the future of freshwater enters deeper uncertainty, this approach is crucial.

NATURE-BASED SOLUTIONS

While many of WRT's projects are supported from specific funding streams, the organisation works to integrate them where possible. For example, the trust has brought together three key projects in one area of natural flood management (see **Figure 1**).

1. Upstream Thinking[3]	South West Water-funded project to improve raw water quality.
2. Resilient Catchment Communities[4]	Shared Prosperity Fund project, which demonstrates the density, diversity and interconnectedness of natural flood management measures to reduce flooding.
3. Water Net Gain[5]	Ofwat-funded project to store water in smart ponds and lakes to increase farm water resilience and manage drought.

▲ **Figure 1. Nature-based solution projects.**

It would be easy to run these projects in isolation, an approach that has been the norm for decades. To counteract this, the trust has been designing schemes with farmers to slow down water movement through good soil management, to detain surface water in the short term in runoff attenuation features, and to divert that water to clay-lined ponds for long-term storage. This means that water carrying with it lots

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of contamination no longer leaves the catchment too quickly. These are the issues that lead to flooding and sediment and nutrient pollution during heavy rains, along with low-flow drought and pollution due to a lack of dilution in the summer months. The water within these newly implemented systems now runs more slowly and with less contamination. The beneficiary of this new approach – alongside famers, water companies and wider society – is the biodiversity in the river, which can flourish in a more stable, resilient habitat.

WATER NET GAIN

Water Net Gain is just one of the WRT's projects that seeks to create further payments for ecosystem services schemes: payments to landowners who manage their watershed or land in an ecologically positive way.[6] Such schemes allow private investment into catchments to protect water resources, delivering wide co-benefits, and are funded alongside existing government schemes and water company programmes for flood and pollution control.

The narrative that there is a tsunami of green finance on the horizon is accurate, but this investment requires a payback and return on investment. So the real question is: who are the actual buyers of the future? Water companies will always need to invest in plentiful supplies of clean water and are likely to be responsible for the environmental health of many of the river systems where they manage wastewater. But other buyers are appearing: developers interested in offsetting nutrients or biodiversity loss; businesses interested in demonstrating their environmental sustainability governance credentials (carbon or otherwise); and insurers interested in reducing business risk, including in relation to flooding. These all need to be considered alongside any government support or subsidy scheme to ensure a climate change-resilient catchment and society. ES

Dr Laurence Couldrick is CEO of the Westcountry Rivers Trust and has been pioneering catchment management for 20 years. Over that time he has developed several multimillion-pound projects and long-term funding streams to deliver improvements across multiple catchments, including developing payments for ecosystem service schemes for water quality, flood risk and carbon offsetting. Alongside this he has pushed to explain the complex problems society faces as a way of uniting the myriads of partnerships and interest groups.

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