Environment
Agency

Chief Scientist's Annual Review 2023

Chief Scientist's Group report

May 2024

We are the Environment Agency. We protect and improve the environment.

We help people and wildlife adapt to climate change and reduce its impacts, including flooding, drought, sea-level rise and coastal erosion.

We improve the quality of our water, land and air by tackling pollution. We work with businesses to help them comply with environmental regulations. A healthy and diverse environment enhances people's lives and contributes to economic growth.

We can't do this alone. We work as part of the Defra group (Department for Environment, Food and Rural Affairs) with the rest of government, local councils, businesses, civil society groups and local communities to create a better place for people and wildlife.

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Foreword

Welcome to this year's annual review of scientific work carried out by the Environment Agency

The science we do is fundamental to supporting our core purpose of improving the environment in the context of sustainable development. This year, to mark the publication of our first science strategy in November, we brought together around 200 scientists from across the organisation to share ideas and build new opportunities to work together. The event drove home to me the diversity and excellence of the science we do, and the breadth of the expertise dispersed across all areas of the country.

Some of that breadth is reflected here. You will read about how our science is not only core to what we do now, but also to our future operations. For example, science is giving us insight right now into how we inspect our flood assets. It is also enabling us to assess the toxicity of chemicals in new and better ways. Looking further forward, through programmes like the Natural Capital and Ecosystem Assessment, science is helping us to understand how the environment is changing and enabling us to evaluate and increase the impact of our interventions. And even further towards the future, science is also helping us to understand and prepare for emerging issues, such as the nature of future droughts and antimicrobial resistance in the environment.

We continue to publish openly the science that we do, both to share our research and to fulfil our statutory reporting duties. We're constantly looking at ever better ways to communicate our science and data to those that need to use it to inform their planning and decisions. This is because the Environment Agency needs a wide range of industry and citizen groups to access that information so that we can work effectively together to achieve the government's challenging long-term statutory environmental targets. Much of the science itself also needs to be carried out in partnership with others – we need to work with the best of academia and industry to create together and implement the science that is needed to meet complex environmental challenges. Publishing our science strategy was a step towards this greater joint working. Over the coming year, I will be supporting the now nearly 1,700 science profession members to engage in more partnership working, within the Environment Agency and Defra organisations, but also across the UK and internationally. We will support more PhD students to build an ever more diverse scientific community, and we will work on more projects with more partners.

I hope this annual review stimulates you to think where you might want to work with us or use our science and expertise in our joint efforts to protect and improve the environment and make better places for people and wildlife, now, and in the future.

Dr Robert Bradburne FRSB
Chief Scientist and Director of the Chief Scientist's Group, Environment Agency

Introduction

The work we do

The Environment Agency is an organisation that has to work over an extremely wide range of timescales. We predict, prepare and respond to environmental emergencies: situations like flooding or releases of chemicals into the environment. This needs immediate action, where hours and minutes make a difference to the impact on people's lives and the health of the environment.

But our response might also be over decades: planning new ways to protect people and property from flooding, regulating in a way that reflects future as well as present societal needs, or regenerating wetland ecosystems to boost their (and our) resilience in a changing climate.

Science is vital to the ability of the Environment Agency to work effectively across these timescales.

On the shortest of timescales, it enables us to be prepared in advance for incident response. Our work on chemicals in the environment helps us to spot where risks are highest to the environment from the use of a wide range of chemicals. That enables us to advise on management strategies so that they can be used in a safe and responsible way as part of our economy, and to respond quickly and appropriately to releases. Our work on hydrology means we are ever more capable of understanding how water moves in our catchments – vital as our weather patterns shift due to our warming climate. This means being better prepared for and able to predict flooding events with greater precision. And understanding how people respond to our warnings enables us to operate more

effectively when an incident does occur, tailoring our responses to the needs of local communities.

Over longer timescales that power of prediction is both important, but often much harder. Our review of the science of droughts, published this year, has shown the complexity inherent in understanding how water supply will be affected by the weather, demand and catchment characteristics over many years. It demonstrated the need to continue to invest in our understanding of several key parts of the drought system if we are to respond appropriately in future.

We are also facing significant transitions in the coming decades. Moving England to a net zero economy will mean new technologies being used in areas across the country. As a potential future regulator of these technologies, science helps us to get ahead of those changes so that we can be ready to regulate in a modern, positive way. This will allow us to support the important transition away from carbon-releasing technologies in a way that protects not just our atmosphere, but the other parts of the environment that might be affected.

This transition will also affect how we use land across the country, with the Committee on Climate Change's modelling suggesting considerable shifts from one land use to another. Our science can help us understand what impact this might have on our air, water and biodiversity. Also, importantly, it can help us understand how we might help those transitions occur in a fair and positive way by working with farmers and other land managers and owners over the coming years.

The publication of the science strategy in November marked an important moment for science in the Environment Agency. It reaffirmed our commitment to growing the scientific talent we have across the organisation so that the scientists working to make better places around the country can access the very best science and technologies to do their jobs really well. It notes the importance of developing the individuals, but also in growing communities to support peer review and learning across different disciplines, and to encourage a culture of innovation and professionalism in all those for whom science is an integral part of their jobs.

The strategy also recognises the importance of our scientific and data assets to the organisation. Again, innovation is crucial here to our ongoing success. We will need to seek out and invest in the most appropriate modern technologies to carry out our science in ever more efficient and effective ways. This may mean developing new protocols for measuring more or different chemicals or pathogens in our laboratories. Equally, it may mean exploring novel ways of collecting, collating, combining, analysing and presenting the wealth

of data that enable us to gain vital insights into the way the environment is changing at different scales. We will need to ensure that our scientists have access to the right equipment and data, and that they are enabled to use it safely and effectively during incidents and their daily operations.

But, perhaps equally importantly, the strategy is about working more in partnership. Combined with this annual review, it demonstrates to our potential partners in academia, industry and abroad where we are most interested in doing and using science. It helps them see where we might work together to understand the future, innovate the way we work in the present, or understand the impacts of our past and current actions.

Science will continue to be vital to our short-term and long-term activities. This annual review celebrates a year of excellent science supporting our work across all those timescales and gives readers an opportunity to engage with the projects and the experts driving them. Working in partnership, we will continue to produce excellent, trusted, applied science for people and the environment.

Our people

The Environment Agency employs thousands of scientists across a wide range of disciplines. They deliver the science, foresight and evidence that is so vital in informing the actions the organisation takes to protect people and the environment.

The far-reaching science we do covers field activities, laboratory work, research, evaluation, analysis and reporting. Our science supports the organisation in several ways.

We drive innovation to advance our work and that of the sectors we work with, progressing potential ideas and research developments into practical applications.

We support policy making and regulation by providing technical advice, by carrying out evaluations to inform the organisation about what works and what doesn't, and by identifying what can be improved on through operational science.

We offer highly specialised science services, such as strategic risk assessment, horizon scanning and forecasting to show the organisation where we are heading and what risks and opportunities lie ahead.

And as new challenges emerge, we need to nurture and develop our scientists, so they can apply their skills and knowledge to inform our response.

The science profession – a thriving community of nearly 1,700 scientists – plays an important role in their development. In November 2023, 200 of those members joined our Chief Scientist to launch our new science strategy and share their knowledge, covering topics as diverse as radiation, ecology and the hydrology of London.

With an eye on the future, we also seek to attract and develop the next generation of environmental scientists through our academic placement programme. As part of our contribution to the EA2025 People Plan, we host interns, PhD students and research fellows to apply the latest developments in environmental science to current and emerging environmental problems. Our 100-strong network of Environment Agency funded or co-supervised PhD students enhances our research and science portfolio and gives developing scientists unparalleled experience in applied science.

In 2024, we want to do more to harness the scientific and technical knowledge of our staff. Our aim is to build greater local scientific leadership in the organisation, develop wider technical leadership through scientific disciplines, and increase the opportunities for skills development to improve the quality of science in the Environment Agency.

Members of the Environment Agency science profession at the Environment Agency science conference.

Case studies

Structure of the Annual Review

This annual review showcases the diverse work of scientists across the Environment Agency in 2023. It is impossible to capture everything we have achieved, so the series of case studies represent some highlights.

This science delivers broadly to the Environment Agency and often beyond. The case studies support multiple aspects of EA2025, and we have shown how our science links closely to all aspects of delivery, including a forward look to our plans for next year.

Reviewing evidence on the condition of England's rivers

Natural capital experts explored how river condition affects vital ecosystem services and identified mapping methodologies to support river management.

The Environment Agency set out to improve our understanding of how the condition of freshwater rivers affects ecosystem services. The project created reusable frameworks for mapping indicators of river condition across England. The review addressed a knowledge gap which will allow us to improve environmental and socio-economic outcomes through planning, operations and investments.

Natural capital is a framework that helps decision-makers account for the value of nature in their decisions. It describes the living and non-living elements of nature (natural assets) that directly or indirectly provide economic, social, cultural or other value to people through the flow of different functions and products (ecosystem services). The quality (condition) and location of natural assets are important factors influencing ecosystem service provision.

Phase 1 of the project summarised the evidence linking the condition of England's rivers and their ability to provide ecosystem services. We explored existing data to see what it could tell us about riverine natural capital condition, as well as approaches to mapping it. Harnessing the team's interdisciplinary expertise and knowledge, we held workshops and completed peer review to develop a protocol for the review and to analyse the evidence.

Outputs included frameworks for reviewing evidence and mapping indicators, a series of data flowcharts showing the flows of ecosystem services and relevant indicators, and a scoping review of the links between river condition and ecosystem services.

The evidence for indicators will be used to better understand and map natural capital condition and ecosystem services. It will help the Environment Agency identify where more research, monitoring or interventions are needed to fill evidence gaps identified.

Phase 2 is now using these outputs to develop and trial prototype riverine condition and ecosystem service mapping for pilot catchments. If useful, future phases will produce national maps to support river management and ensure sustainable, functioning ecosystems that can continue to benefit society.

Links:
Natural Capital and Ecosystem Assessment programme | Environment Agency Natural Capital Condition Indicator Mapping Evidence Review

Contact:
Alice Crouch
(Chief Scientist's Group)

Manifestations

Condition assessment

Perception of beauty

- D50 D56 Perception survey
- T15 Landscape character assessment
- D70 Natural beauty mapping
- Evidence of potential pressure/impact

Aesthetic experience

Enjoyment

- Features that are valued
- D50 D56 Enjoyment survey
- Evidence of potential pressure/impact

Condition assessment items:
- Invasive species — D20
- Litter — D21
- Graffiti
- Physical modifications — D24
- Vegetation — D54
- Landforms — D24
- Geomorphic features — D24
- Habitat designation — D28
- Tranquillity
- Usage vs access

Datasets
D20 - Non-native species surveys - EA
D21 - Pressure from invasive species - JNCC
D24 - River Habitat Survey
D28 - Designated Sites - NE
D50 - Monitoring of Engagement with the Natural Environment - NE
D54 - MoRPh
D56 - People and Nature Survey - NE
D70 - All England Strategic Landscape Mapping Hub - NE

Tools/methods/models
T1 - Tranquillity map
T15 - Landscape Character Assessments

Data flow chart for the aesthetic experience ecosystem service for natural rivers.

I was fortunate enough to join the Environment Agency straight from university in 2005. Since then, I have applied my water and environment management knowledge in data and mapping roles across the organisation. I currently lead on natural capital data and geospatial evidence, contributing to the Natural Capital and Ecosystem Assessment programme.

My love of the natural world motivates me to do what I can to enhance, not deplete, it. The natural capital approach is a fantastic mechanism to manage the environment holistically, delivering wider environmental and socio-economic benefits.

Working here means playing my part in leaving the environment in a measurably better state for future generations. It's a huge challenge, but collectively we have power to enact change!

Alice Crouch | Environmental Scientist

Making data on English rivers accessible

To improve the useability of data on English rivers, Environment Agency scientists have created a platform allowing staff without a specialist background to access and analyse information with ease.

Many Environment Agency river research projects start with taking monitoring data and trying to work out what environmental factors in the catchment have affected each of the sampling sites.

Traditionally, gathering and collating this environmental information takes a lot of data, along with technical skill to interpret and map the data and time. There are multiple different approaches and data sets that may be used, often leading to inconsistent approaches between projects.

To bring together a standardised set of data, tools and techniques, the Analysis Ready Water Network (ARWN) is being created. It helps to provide consistent information about the environment, wider river network and catchment of all stretches of rivers in England.

This approach enables Environment Agency analysts to quickly and easily access a huge range of nuanced environmental information of a river without the need to consult with technical mapping specialists or carry out any additional pre-analysis.

The effectiveness of the ARWN is already being realised in various Environment Agency river projects. For example, it will allow the River Surveillance Network, a new national monitoring network, to understand the state of English rivers over time, and to investigate environmental influences on water quality. Environment Agency researchers are also using it to help predict river temperatures in rivers where we do not routinely collect this information.

There will always be more information that can be added to the ARWN. Environment Agency scientists are currently refining and documenting their approach to add information on land cover and geology of catchments upstream of stretches of rivers. Such additions will continue to allow people without specialist skills to access quickly and consistently current, otherwise difficult to generate, environmental information, enabling the Environment Agency to maintain and improve English rivers.

Contact:
Jessica Swinburne Cloke | **Grant McMellin**
(Chief Scientist's Group)

The Analysis Ready Water Network will help analysts to understand the state of English rivers.

Developing new techniques and working with citizen scientists to tackle sediment pollution

Scientists from the Environment Agency and Rothamsted Research are working with Catchment Sensitive Farming Advisers and citizen scientists to identify and mitigate sources of fine sediment pollution.

Sediment run-off into rivers from across river catchments can affect aquatic ecology and water quality, transport pollutants and increase flood risk. The sources of sediment vary by catchment, but often include agricultural land, eroding channel banks and urban run-off.

Mitigation measures, such as buffer strips (vegetation rich areas which provide a buffer between land and river) advised by the government-led Catchment Sensitive Farming (CSF) partnership can help to reduce sediment pollution but are most effective when targeted.

To help identify sediment sources, the Environment Agency partnered with Rothamsted Research to use sediment fingerprinting, a method which compares the properties of sediment retrieved from a river to its surrounding catchment. The results identified the major sources of sediment across 9 catchments, and are being used by the local CSF Advisers to improve the targeting of advice and selection of mitigation measures.

As part of this project, a novel, rapid-assessment sediment fingerprinting method was developed, which can provide catchment-specific information quicker and at a lower cost. When tested across 4 catchments, this new method was found to be effective. Scientists at the Environment Agency are now working with CSF Advisers to use this approach across more river catchments.

Because of its simpler process, the rapid-assessment method provides opportunities for wider engagement with citizen scientists.

The Environment Agency, Rothamsted Research, CSF and volunteers from the Alconbury Flood Group have been piloting a project to understand how it can be used in this way. The pilot is being run in the headwaters of the Alconbury Brook (Cambridgeshire) where, following training, volunteers set sediment traps and collected source samples from the surrounding catchment. The samples will be analysed in the laboratory to apportion the major sources of sediment. The results will be used to engage with the community, target advice and select mitigation measures to improve water quality and manage flood risk in this catchment.

Links:
[The potential for colour to provide a robust alternative to high-cost sediment source fingerprinting: Assessment using eight catchments in England](#) | [Catchment Sensitive Farming Evaluation Report – Water Quality, Phases 1 to 4 (20062018)](#)

Contact:
Dr Jessica Durkota
(Chief Scientist's Group)

Demonstrating the use of a sediment trap to volunteers.

Drug resistant microorganisms in the environment – our part in their downfall

Environment Agency scientists are working across government and academia to tackle the growing problem of microbes that are resistant to antimicrobial drugs.

Globally, antimicrobial resistance (AMR) is thought to have been responsible for at least 1.27 million deaths in 2019, according to the World Health Organization (WHO). AMR occurs when microbes that cause disease evolve to the point that antimicrobial drugs, like antibiotics and antifungals, no longer work.

AMR is a recognised problem in human and animal health, but it is also an environmental pollution problem. Resistant microbes are released from various human activities, and can spread through air, soil and water. Moreover, antimicrobials present in the environment can drive the evolution of resistant microbes. People and animals can then be exposed to, and infected with, these organisms.

Over the last 2 years, Environment Agency scientists have worked across government and academia as part of the PATH-SAFE research programme to research and pilot approaches for AMR surveillance in river catchments. This was in response to commitments in the government's 5-year AMR National Action Plan, and reflects calls for environmental surveillance from international bodies like WHO and the United Nations Environment Programme.

In 2023, the team published a range of research that supports their environmental AMR surveillance work, including possible ways to detect the presence of resistant microbes in coastal waters and the natural environment generally. They also published research into AMR surveillance opportunities in wild plants and animals, bathing waters and the air, with further publications due in 2024.

Like many environmental regulators beyond the United Kingdom, the Environment Agency does not currently have any statutory duty to monitor AMR in the environment. However, this important research is contributing to the nation's approach to tackle AMR, and places Environment Agency science in the global fight against the problem.

Links:
Antimicrobial resistance surveillance pilot site selection and database extension | Environmental antimicrobial resistance: review of biological methods | Antimicrobial resistance surveillance strategies within wild flora and fauna of England | Shellfish as bioindicators for coastal antimicrobial resistance | Review: approaches to monitoring and surveillance of antimicrobial resistance in bathing waters | Antimicrobial resistance in bioaerosols: towards a national surveillance strategy

Contacts:
Dr Alwyn Hart | **Dr Wiebke Schmidt**
(Chief Scientist's Group)

The role of behavioural science in providing clean and plentiful water

Through engagement and knowledge exchange, we're helping colleagues to consider social science in their water strategy decisions.

The National Social Science team was commissioned to support the Water Strategy team in developing a workstream which explored the role that behavioural science (and broadly social science) could play in helping to achieve the Environment Agency's ambition of clean and plentiful water.

Behavioural science is a multidisciplinary subject exploring the motivations and drivers of specific behaviours, including underlying social and cultural norms, cognitive biases, and views on one's self-efficacy. It provides insights into how and why decisions are made.

We developed a webinar series to share behavioural science knowledge with others in the Environment Agency. The webinars set out to introduce colleagues to behavioural science and social science by providing practical examples of existing work. We aimed to support national and operational teams so they can consider how these concepts can help in their work.

The webinars consisted of a presentation followed by an interactive session exploring the subject matter. The talks drew in external and internal expertise, with speakers including Environment Agency and Natural England social scientists and Defra colleagues. Topics ranged from behavioural science theory and practice through to society's behaviour and engagement with the water environment. Additional literature, case studies and contacts were gathered to develop resources around each topic.

Several behavioural models were explored, such as the individual, social and material behavioural model (ISM) to explore individual behaviours and their social context.

Feedback from staff demonstrated the value of the webinars, and so far, we've heard from colleagues who have started to implement these ideas in their water strategies. For example, our approach to communicating during a drought is being informed by the behavioural science evidence collected over the last 2 years. Behavioural insights will help shape our development of online bathing water quality information. We're now developing a second series of webinars to continue this work.

"Identifying behaviour change as one of the underpinning activities has enabled us to use this as a common discussion point across a wide range of key work areas which are all critical to securing a healthy water environment."
Jeremy Gallop,
(Environment and Business Manager – Water Strategy)

Contact:
Dr Jatinder Singh Mehmi
(Social Science team, part of the Economics, Appraisal and Research team in the Flood and Coastal Risk Management directorate)

Individual

Time and schedules
Objects
Technologies
Infrastructure
Rules and regulations

Social

Network and relationships
Meanings
Tastes
Roles and identity
Norms
Institutions
Opinion leaders

Material

Values, beliefs, attitudes
Costs and benefits
Emotions
Agency
Skills
Habit
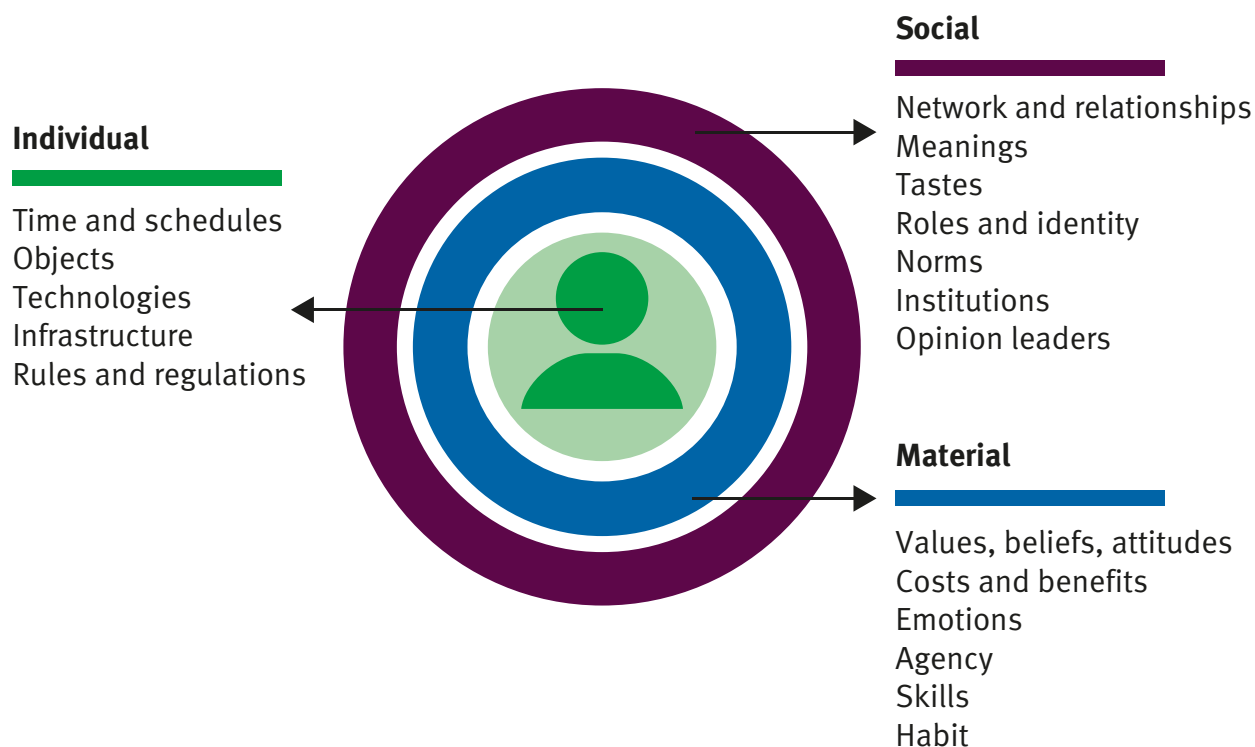
Source: Influencing behaviours: ISM technical guide

I started my career working within the waste management sector and more recently have been involved in sustainable development and climate change work within the Environment Agency at a regional and national level.

Social Science plays a crucial role in understanding the complex relationship between society and the natural environment. I find this area of work very interesting as it involves a multi-disciplinary approach drawing on disciplines such as psychology, sociology, economics and behavioural science.

I'm always learning and collaborating with a wide range of people across the Environment Agency. Together, we are working towards more sustainable practices to benefit people and wildlife.

Dr Jatinder Singh Mehmi | Principal Social Scientist

Revealing the secrets of a cryptic disease in wild salmon

Fish disease specialists are using a range of partnerships alongside innovative laboratory analysis techniques to understand a new disease that has been detected in wild Atlantic salmon populations.

New and emerging diseases pose a significant threat to the health and resilience of our fisheries and the aquatic environment.

The Environment Agency's National Fisheries Laboratory (NFL) is at the forefront of detecting fish diseases and non-native fish species, helping maximise the impact of the organisation's sampling and monitoring activities.

Red skin disease is a newly recorded skin condition of wild Atlantic salmon, first reported from Sweden in 2015. The disease causes Atlantic salmon to develop lesions on the underside of their body, raising concerns over their health, fitness and survival. It has since spread across Northern Europe, but despite concerted efforts the cause of the disease has remained unknown.

Wild salmon exhibiting red marks consistent with red skin disease were first observed in England and Wales in 2021. Over the last 3 years, NFL fish health specialists have been collecting samples, carrying out comprehensive diagnostic testing, and working with and through partners to understand the cause and effect of the disease.

The NFL has worked with anglers and Environment Agency fishery teams to collect data on the visual appearance of salmon to build an understanding of the severity of disease and track its emergence in our rivers. It has also been working with other organisations to develop a severity guide to standardise reporting of the disease across the UK and Ireland, enabling the characterisation of the disease in the absence of a known cause.

Most recently, academic and cross-government partnerships have enabled the use of innovative diagnostic approaches to analyse NFL samples, revealing the presence of a new virus. Further investigation is underway to understand the significance and relevance of this finding to wild salmon populations.

Through partnerships and growing in-house molecular capabilities, Environment Agency scientists are continuing their efforts to piece together the increasingly large body of information to understand this unusual and challenging disease.

Links:
Red skin disease in wild atlantic salmon –
a severity field guide

Contact:
Dr Chris Williams
(Operations, Regulation Monitoring and Customer)

Wild salmon showing ventral red marks consistent with red skin disease.

Biosecurity and invasive non-native species: a permanent solution to water primrose

Creating a permanent solution to an invasive non-native plant.

Environment Agency staff assist with the removal of remaining water primrose.

Water primrose, Ludwigia grandiflora, is an invasive non-native aquatic plant, found in wetlands, ditches, ponds, lakes and watercourses. It forms dense carpets of growth, excluding native biodiversity, increasing flood risk, and degrading amenity use such as angling or swimming. If water primrose was allowed to fully establish in the wild, a 2010 economic assessment determined a potential cost of £242 million to eradicate it from Great Britain.

Water primrose was first recorded in the wild in Great Britain in 1998. In 2009, the Environment Agency was tasked by Defra with eradicating it after a non-native species risk assessment determined a high risk of major effect were it allowed to establish in Great Britain. We have established a network of co-ordinators who provide technical support and funding to help landowners control the plant.

The network trials management techniques and shares good practice, seeking to empower landowners to take ownership of the issue. This approach has gained worldwide recognition for its effectiveness in eradicating water primrose in England. The benefits were particularly apparent during the COVID-19 pandemic when landowners felt sufficiently able to continue to implement their management plans despite Environment Agency staff being unable to visit.

To date, over 50% of sites in the network have eradicated the plant entirely, with the remaining sites only having small amounts of regrowth. It has also been prevented from spreading further beyond the sites. When compared to other countries, like Japan and in Northern Europe, where the plant has established itself in their waters and who continue to experience issues, the Environment Agency's approach has successfully protected England's aquatic environment. It is hoped that it will eventually result in the eradication of water primrose from the country.

Links:
The economic cost of invasive non-native species on Great Britain | The economic cost of invasive non-native species on Great Britain: Headline figures | What kind of legislation can contribute to on-site management?: Comparative case studies on legislative developments in managing aquatic invasive alien plants in France, England, and Japan

Contact:
Trevor Renals
(Environment and Business, Water Land and Biodiversity)

Water primrose.

I joined the water industry in 1989 and spent 15 years leading the Freshwater Ecology team in Cornwall. My interest in managing invasive non-native species progressed into a national technical role.

Invasive non-native species are one of the top 5 causes of biodiversity loss and I am in a privileged position to be able to contribute towards reducing that pressure. I love the rich tapestry of diverse, healthy and resilient habitats. Those we have left are too precious to lose. Invasive species are, by definition, spread by people, but people are also the solution if we can influence behaviour and motivate change.

Trevor Renals | Invasion Biologist

Phosphorus levels in Lake Windermere

By quantifying the sources of phosphorus pollution in Lake Windermere, Environment Agency scientists are helping to drive more targeted efforts to improve water quality.

Phosphorus and nitrogen are 2 nutrients that enter the lake from a variety of sources. They have a similar effect to fertiliser, providing a food source for plants and algae. These nutrients come from wastewater, septic tanks, boats, waterfowl, grazing animals and fertiliser, and from the sediments in lake beds.

To improve our understanding, scientists from the Environment Agency's local team in Cumbria worked with colleagues in our national specialist water quality modelling team to explore possible phosphorus sources in Lake Windermere. Windermere is an icon locally, nationally and internationally due to its cultural, economic and environmental significance – all part of the Lake District's United Nations Educational, Scientific and Cultural Organisation's designation.

The project aimed to quantify the different sources of phosphorus pollution in Windermere, looking at where phosphorus came from both geographically and from different human activities. We also explored the effect that phosphorus had in different parts of the lake so that we can be more targeted in our efforts to improve water quality.

We sourced the latest data and used SAGIS (Source Apportionment Geographical Information System) and SIMCAT (Simulation of water quality in Catchments) models to assess river and lake water quality using various data sets. We also adjusted the models to reflect the local knowledge gathered on Lake Windermere from external stakeholders, including the latest evidence of phosphorus in the area.

The updated modelling showed possible phosphorus sources in Lake Windermere's north and south basins. In the north basin, the modelling showed that 52% of the phosphorus came from point sources (such as sewage) and 48% from diffuse sources (such as run-off from both built up and rural areas). In the south basin, it showed that 59% of the phosphorus comes from point sources and 41% from diffuse sources. These numbers allow us to target our actions and reduce the amount of nutrients entering the lake.

The team aims to update the model when new data and research becomes available. We are also exploring further research to understand the future risks to the lake from climate change and tourism. Through this increased understanding, the Environment Agency and others can work to mitigate these risks and achieve a resilient, healthy lake.

Links:
New data identifies amount of pollution from different sources in Windermere | Phosphorus source apportionment data for the Windermere catchment

Contact:
Paul Simmons
(Operations Regulation Monitoring and Customer)

Thinking innovatively to understand complex groundwater catchments

Environment Agency scientists explored the role of rivers in reducing legacy pollution from coal mines.

Mining for coal in North East England took place for over 7 centuries. When the mines were active, pumping took place to artificially lower groundwater levels and keep work areas dry. Pumping stopped with the closure of mines, allowing water levels to recover.

However, water levels rose uncontrollably after the closure of Durham coalfield's last mines. In the coal-bearing rock (Coal Measures) beneath the Skerne catchment, groundwater rose by up to 200 metres. This allowed poor quality water to flow into the overlying Magnesian Limestone, which is used for public water supply, resulting in a mine water pollution plume.

Over the past 15 years, the mine water plume has travelled past monitoring boreholes. Its exact position and extent are currently unknown. The Environment Agency, Coal Authority and Anglian Water Services agreed on a 40-year management plan to assess the plume's risks to public water supply abstractions.

The Environment Agency's groundwater specialists initiated a project to understand the role of the River Skerne in capturing the plume. The river and many of its tributaries are located in between monitoring and abstraction boreholes. The team identified where groundwater flows into the river. At these locations, the British Geological Survey (BGS) monitored the temperature and chemistry of the river, riverbed (hyporheic zone) and surrounding groundwater at different depths.

The analysis identified mine water entering the river and showed the important role of the hyporheic zone in reducing pollution risks to both surface and groundwater. For example, the organic rich silty sediments, low in oxygen, in the zone reduce sulphate to sulphide, which is of lower concern. BGS carried out a second phase of work to understand how the role of the hyporheic zone changes over time and during different water levels and flow.

The project also confirmed that the greatest risk was elevated sulphate, a mineral both carried by the plume and naturally present in the Magnesian Limestone. To determine remedial actions and responsibilities, the Environment Agency is working to distinguish between naturally occurring sulphate and mine water pollution. This will enable us to stop the movement of sulphate and reduce the plume's impact.

One of the sampling sites in the River Skerne showing the organic rich silty sediment of the hyporheic zone, riverbed.

Links:
[Characterising the hyporheic zones in the Skerne catchment](#) | [A hydrochemical assessment of groundwater-surface water interaction in the Woodham Burn, a Magnesian Limestone catchment in County Durham](#)

Contact:
Diane Steele
(Operations, North East Area Groundwater and Contaminated Land)

I have worked for the Environment Agency for the past 20 years, focusing on the protection of groundwater quality and resources, catchment management and the mineral and heat sectors.

I am passionate about raising awareness of groundwater as an essential source of water which requires protection. I am motivated to help people by simplifying complex problems and identifying more efficient, innovative solutions to protect and improve the water environment.

For me, creating a better place means considering all the needs of society in every piece of work I undertake – economic, social and environmental – to bring about catchment improvements in a thought-out, reasoned way.

Diane Steele | Hydrogeologist (Groundwater Specialist)

Developing cost-effective solutions for a sustainable agriculture sector

Environment Agency scientists used a digital tool to assess current agricultural pollution and inform future policy.

The Environment Agency provides evidence and technical advice to Defra, Natural England and water companies on the environmental impact of agricultural activities and their effective mitigation. This evidence supports current and future national policy, as well as local catchment planning.

The Farmscoper decision support tool enables scenario testing of the impact of a wide range of mitigation measures to address water and air pollution from farming activities. It predicts the loads of different pollutants and the costs and benefits of mitigation measures at farm, catchment and national scales.

Farmscoper has been developed by the consultancy ADAS, with scientific input, advice on design features and funding from Defra, the Environment Agency and Natural England. Freely available to use, it has become the leading policy tool for exploring agricultural pollution management scenarios in England. It has been used to carry out various pollution mitigation projects, including:

Quantifying the benefits of improved slurry storage

The Slurry Infrastructure Grant enables farmers in England to improve or expand their slurry storage capacity, in turn improving organic nutrient use. Farmscoper was used to estimate possible ammonia emissions and other pollutants released following slurry storage infrastructure changes.

Reviewing the impacts of farm inspections

The Agriculture Regulatory Taskforce project aims to positively improve compliance with environmental regulations in targeted catchments. Farmscoper enabled the estimation of catchment-scale water quality benefits of farm actions advised during visits, and the potential future impact of expanding the inspections across targeted catchments.

Nitrate Vulnerable Zones

Farms that fall within (or near) a European site (important conservation site) and are within a Nitrate Vulnerable Zone can apply for an exemption from the rule restricting stocking rates. Farmscoper was used to determine if granting the exemption is likely to have a significant adverse effect on the designated features of the European site through the additional nitrogen load.

Links:
Farmscoper

Contact:
Dr Rachael Dils | Dr Caroline Starr
(Chief Scientist's Group)

A tractor in a bare field towing a machine that is performing sub-soiling.

Reducing the use of animals in chemical safety testing

Working with international partners, Environment Agency chemical assessment experts are leading research into the reduction, refinement and replacement of animals in laboratory tests.

The Chief Scientist's Group's Chemicals Assessment Unit (CAU) works across government to implement the UK REACH (Registration, Evaluation, Authorisation and restriction of Chemicals) Regulation. UK REACH provides the information companies use to assess the hazards of their chemicals, which typically involves various laboratory tests, using fish and, occasionally, amphibians.

Some toxicity tests assess lethality over short periods of exposure to a chemical, whereas others assess non effects on growth, development and reproduction over longer timescales. Animal tests are also used to understand whether a chemical has potential to accumulate in an animal's tissues over time, known as bioaccumulation, and what impact this has.

The legal definition of 'animal' covers vertebrate species after their early embryonic life stage. UK law and government policy state that vertebrate testing must be 'a last resort' and the reduction, refinement or replacement of animals in testing, known as the '3R principles', should always be considered. CAU scientists are working with industry scientists, regulatory bodies, advocacy groups and academia to develop ways to implement the 3Rs in chemical hazard assessment.

As a member of the UK National Centre for the Replacement, Refinement and Reduction of animals in research (NC3Rs) ecotoxicity group, CAU scientists are working to increase uptake of non-animal methods (for example, tests using fish embryos or fish cells) and refinement options

(for example, using fewer fish) when there is no alternative to using an 'animal'. The team is also exploring non-animal methods and using invertebrates, for example, Daphnia magna (water flea) instead of fish to assess the potential of chemicals to bioaccumulate.

Links:
Key Opportunities to Replace, Reduce, and Refine Regulatory Fish Acute Toxicity Tests

Partners:
The Chemical Assessment Unit is a partner in an industry and NC3Rs £800,000 research project called Crack-It SAFE (Safety Assessment of Fish adverse Effects) to develop a completely non-animal, cell-based method to assess long-term toxicity to fish.

We are also working with multi-national organisations such as:

- The Organisation for Economic Cooperation and Development to develop new approaches to assess chemical hazards without generating new in vivo data, and new non-animal test methods.

- The Health and Environmental Sciences Institute (HESI) to develop best practice communities and weight of evidence examples where in vivo fish testing is not required.

- The European Chemical Industry Council (Cefic ECETOC) on the SwiFT tool which uses a probabilistic model to predict acute fish toxicity

- Partnership for the Assessment of Risks from Chemicals (PARC) to develop non-animal methods to assess environmental hazard.

Contact:
Audrey Pearson
(Chief Scientist's Group)

The 3Rs of animal testing

Replace

Reduce

Refine
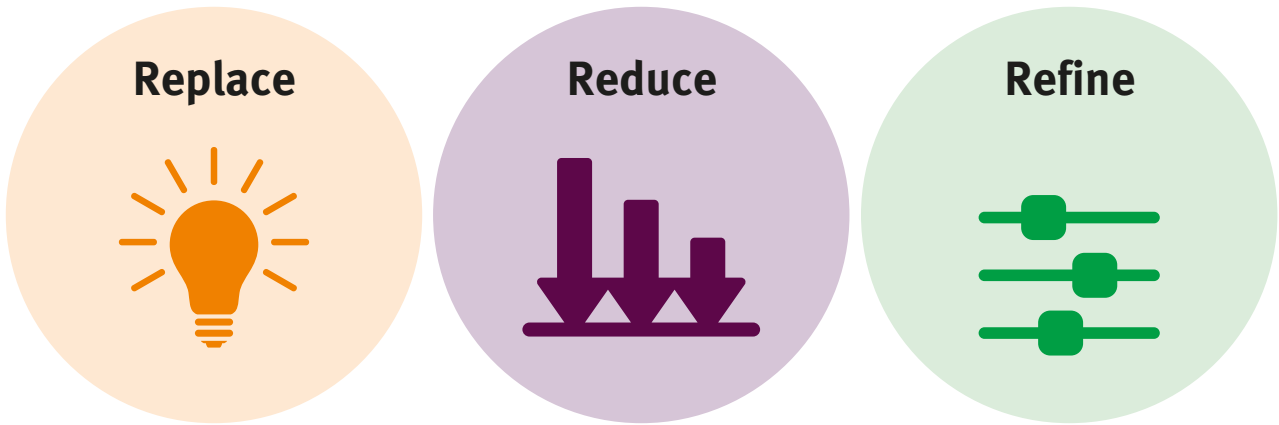
A diagram showing the 3Rs of animal research.

How much natural flood management is enough?

The Environment Agency has developed a simple but expansive tool to help local communities become more resilient to flood risk.

The Environment Agency's Flood Risk Strategy sets out to increase awareness of the risk of flooding that climate change brings, and to help the nation become more resilient to that risk. Natural flood management (NFM) interventions, which use natural processes to reduce the risk of flooding, are an important part of the organisation's ambition.

Communities who experience frequent flooding often have a strong desire to contribute to a solution and can provide useful information to help identify suitable locations for NFM interventions. But to help direct resource and manage expectations, we needed to understand which interventions could work in different areas.

The Environment Agency's Greater Manchester, Merseyside and Cheshire Area team developed a tool to estimate the volume of NFM required at a given location to reduce the risk of flooding. Funded by Flood Risk Innovation, the tool used the standard UK method for estimating flood flows (the Flood Estimation Handbook). Working with

industry experts and the Environment Agency's National Hydrology team, we combined the flood hydrology data with the community at risk locations to determine the size of the flood risk problem. By then applying the current standard of protection, we could estimate the volume of floodwater that would need to be stored upstream to prevent flooding and determine how much NFM intervention would be needed.

The tool can be used by other area teams, using the built-in functionality that allows them to enter Flood Estimation Handbook data manually for their own community at risk.
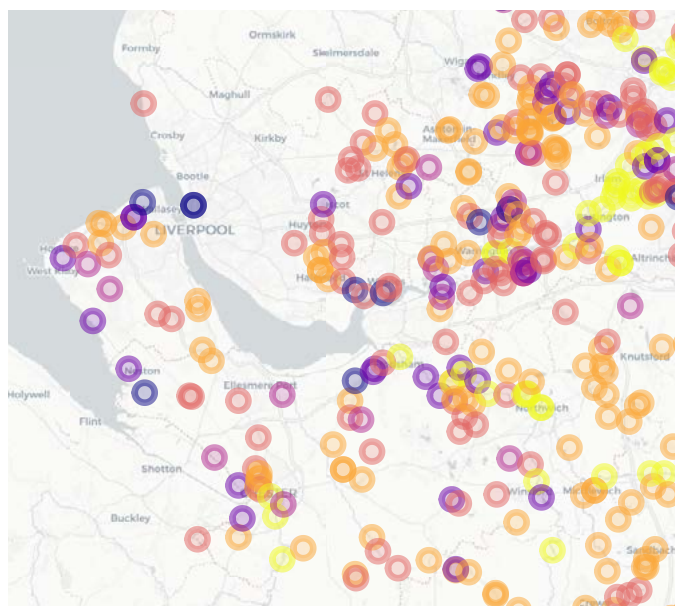
Hydrographs at selcted catchment

Flow, cumecs

Leaflet (https://leafletjs.com) © OpenStreetMap
(https://www.openstreetmap.org/copyright)
contributors © CARTO (https:// carto.com/attributions)
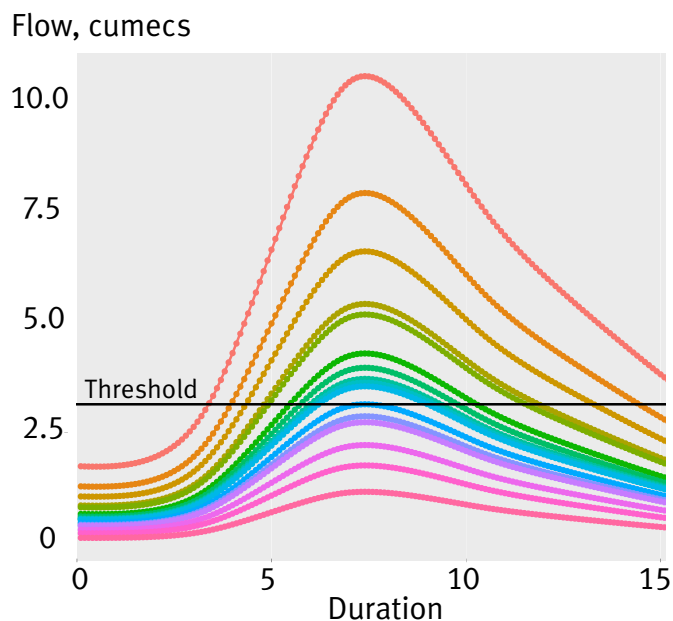
Values	
Unique_ID	75
Easting, Northing	348550, 358350
Community	Old Mill Place, Tattenhall
Watercourse	Mill Brook
Catchment Area	10.9
SoP, Threshold	RP5, 1.844

Flow		Present Day Storage Volumes	
RP2	1.25	RP2	0.00
RP5	1.84	RP5	0.00
RP10	2.30	RP10	0.00
RP20	2.81	RP20	0.00
RP30	3.22	RP30	0.00
RP50	3.62	RP50	2635.00
RP75	4.04	RP75	7508.00

A graph showing storm hydrographs and a table with NFM storage volumes.

I am a Chartered Scientist and Environmentalist via the Chartered Institution
of Water and Environmental Management. My background is hydrology and
geomorphology, with over 25 years in the water industry.

In the Environment Agency, I have a varied and rewarding role that spans flood
risk appraisal, natural flood management, and working with partners to reduce
flood risk. I like problem-solving and am always surprised by the complexities
that each individual flood event brings.

I'm motivated by the climate crisis to do all that I can to find sustainable,
affordable solutions to flooding that enhance our environment. It's not always
easy, but when we get a successful result, it feels great.

Dr David Brown | Senior Flood Risk Advisor

Heat pumps: Low carbon but at what cost?

As part of its net zero research programme, the Chief Scientist's Group worked to understand what the increased use of heat pumps might mean for the wider environment.

Heat pumps can reduce carbon emissions by up to 70% compared to gas boilers. To help reach its net zero goals, the UK government aims to increase the number of heat pumps installed every year from 25,000 to 600,000 by 2028.

Some of these installations will be ground source heat pumps. These systems take advantage of the Earth's relatively constant temperature to transfer heat to or from the ground. This can cause the area underground to become cooler or warmer. In 2023, heat was included as a pollutant in groundwater in the Environmental Permitting Regulations, so it's important that we understand how temperatures could change and manage any impacts on the environment.

The Research team from the Chief Scientist's Group carried out a series of workshops with experts from the Environment Agency, industry, academia and consultants. The group's expertise included aquatic ecology, groundwater ecology, geoscience, water resources and beyond. The workshops aimed to understand the full range of environmental processes – plus the plants, animals, habitats, and connected ecosystems (receptors) – that might be affected by temperature changes.

We used the findings from the workshops and a literature review to create a 'systems' map of the receptors that might be sensitive to temperature changes from ground source heating and cooling. Such effects could be direct (for example, on spawning temperatures of salmon) or indirect (for example, through changing the water quality) through changes in environmental processes. Our interactive systems map shows detailed information about these systems and processes.

The work highlighted many of the complex environmental processes that might be affected by temperature change. For example, we identified possible changes in floral and faunal community composition, movement of contaminants, and the physical and chemical composition of groundwater and connected surface water. The Environment Agency and people installing heat pumps can use this knowledge to identify and protect the areas that could be most sensitive to, or at greatest risk of, temperature change within the ground.

Contact:
Dr Sian Loveless
(Chief Scientist's Group)
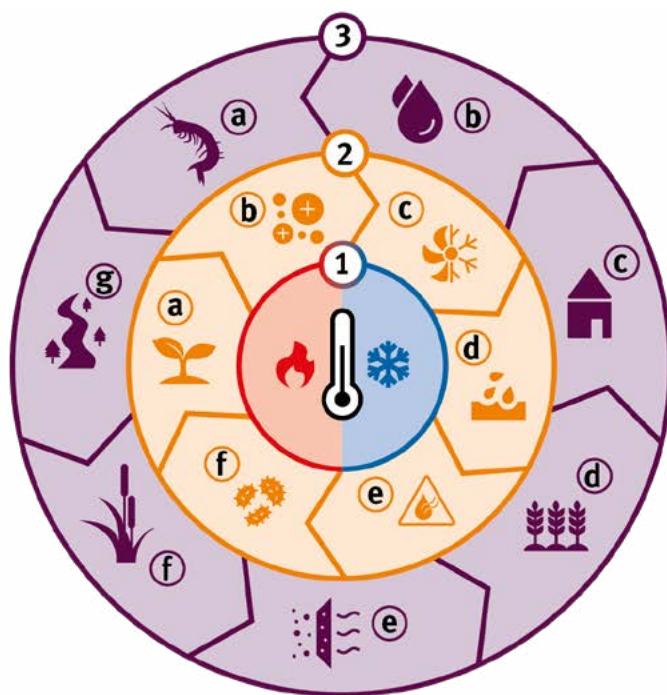
1 Heating or cooling from GSHC system

3 Receptors impacted by process or temperature changes

2 Environmental processes impacted by temperature changes

(a) Decomposition of organic matter
(b) Mobilisation of contaminants
(c) Temperature increase or decrease
(d) Physical and chemical properties of water
(e) Chemical precipitation/dissolution
(f) Pathogen growth

(a) Groundwater (including flora and fauna)
(b) Water quality and resources
(c) Buildings and other infrastructure
(d) Soils and geomorphology (including crops, flora and fauna)
(e) Other ground source heating and cooling systems
(f) Wetlands and springs (including flora and fauna)
(g) Surface waters (lakes, rivers, canals) (including flora and fauna)

A diagram showing the different environmental processes and receptors potentially impacted by ground-source heat pumps.

I am a geoscientist with a background in geothermal energy and groundwater science. I joined the Environment Agency 5 years ago to research onshore oil and gas and groundwater. I now focus on emerging net zero technologies and their potential impact on the environment.

I provide research and evidence to colleagues who make decisions on topics that are evolving rapidly. Our big challenge for net zero is providing the evidence needed for regulation to have the right balance between tackling climate change and protecting the environment.

A better place to me means that my children can experience an environment with abundant biodiversity, safe from the impacts of climate change and free from harmful chemicals.

Dr Sian Loveless | Senior Specialist / Principal Scientist / Geoscientist, Research
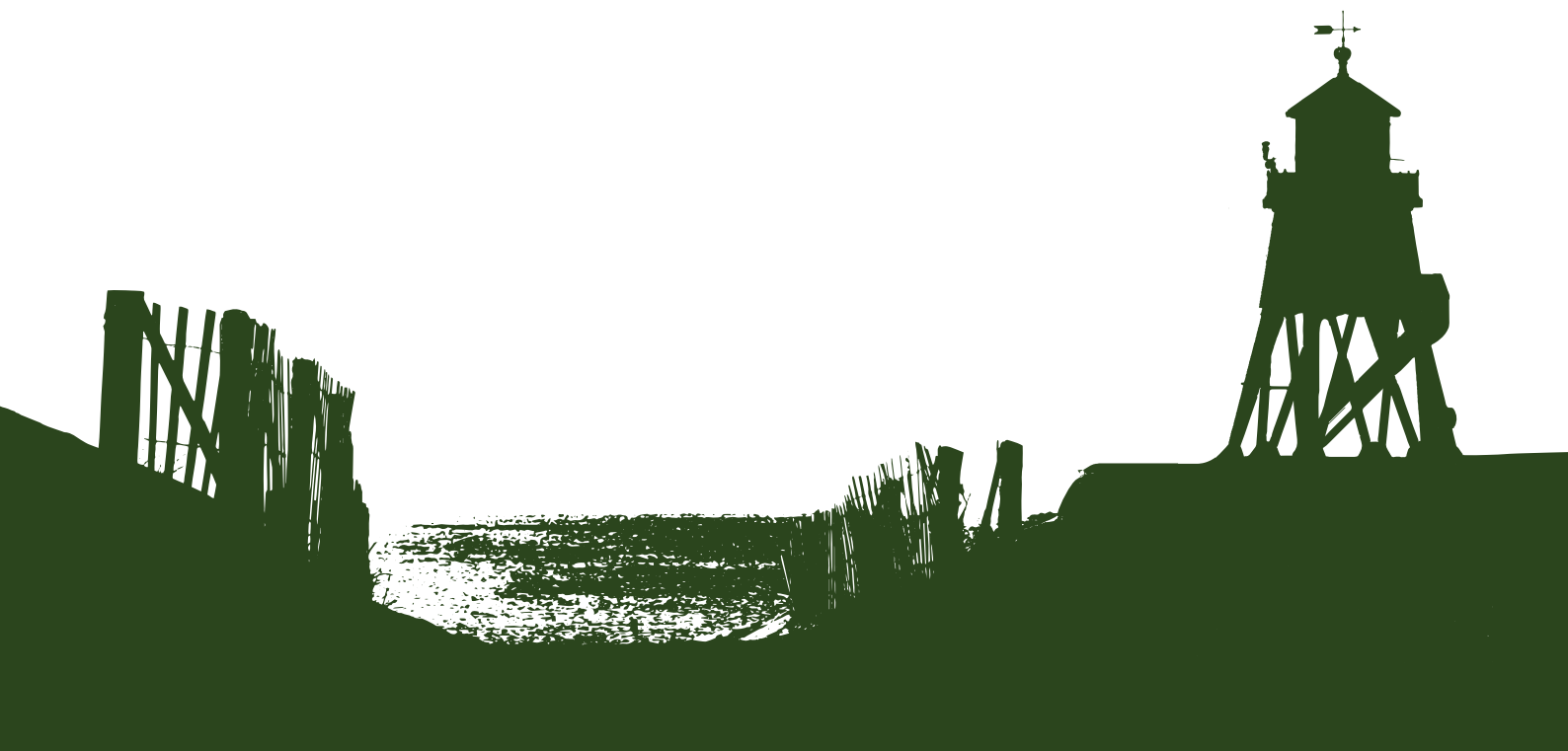
Improving how we inspect flood defences

The Environment Agency developed new tools and resources to help flood risk management authorities spot potential weaknesses that could affect flood defence performance.

The connections between bordering flood defences – or pipes going through flood defences – are called transitions. Irregularities in transitions can increase the chance of those defences weakening or failing.

Current guidance for inspecting and managing flood defences does not account for checking the potential effects of transitions. This means inspectors could miss the risks transitions can cause to the defences performing well.

To update the guidance, the Environment Agency's Flood and Coastal Erosion Risk Management Research team gathered evidence from international experts and carried out pilot studies. The project identified the potential issues causing risks to flood defence performance and the mechanisms that would cause the defences to fail.

We found 4 potential issues affecting transitions. These included certain properties of transitions, such as differences in their geometries (for example, the shape, size and proportions of connecting defences) and materials present (for example, the growth of grass along the transition). It also included obstacles to carrying out construction and maintenance (for example, poor access and visibility) and deterioration of

transitions (for example, damage caused from animal burrows) as possible issues. These issues can cause flood defences to fail.

The project concluded that these issues need to be identified during flood defence inspections and then addressed through maintenance. Where possible, they need to be avoided when designing new flood defences.

Working closely with people who inspect and maintain flood defences, we used these findings to create new tools and guidance documents. A new design and management guide will enable flood defences to be designed in a way that reduces potential failure at transitions, and transition issues to be fixed with retrofitted solutions.

These resources will help risk management authorities identify and prioritise which transitions to inspect, carry out onsite inspections, and quantify the probability of defence failure, so they can manage the risks associated with transitions, ensuring our flood defences continue to perform well.
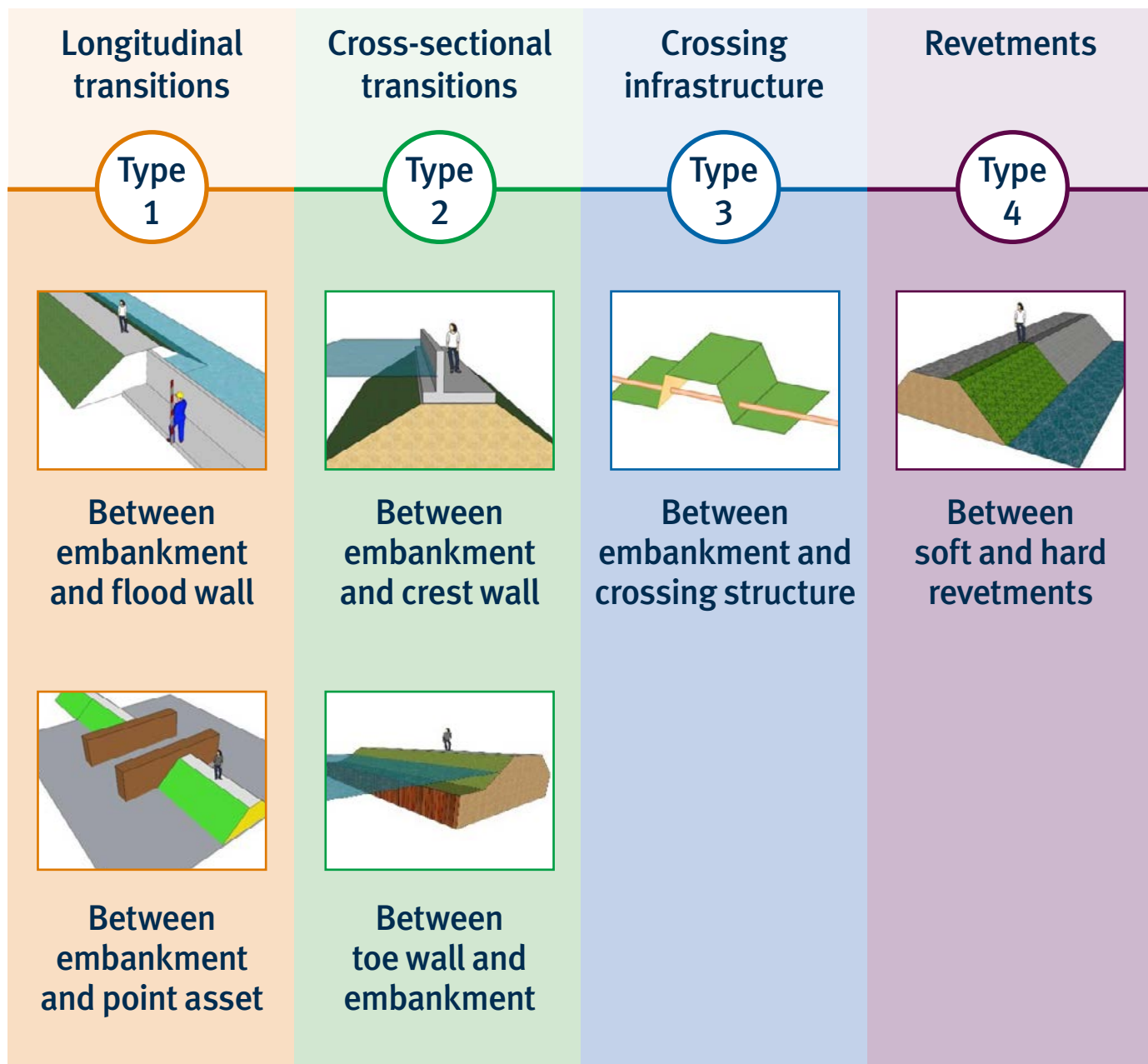
Links:
[Identifying and managing risks arising from defence structure transitions](#)

Contact:
Dr Sarah Twohig
(Flood Research team, part of the Economics, Appraisal and Research team in the Flood and Coastal Risk Management directorate)

Longitudinal transitions	Cross-sectional transitions	Crossing infrastructure	Revetments
Type 1	**Type 2**	**Type 3**	**Type 4**
Between embankment and flood wall	**Between embankment and crest wall**	**Between embankment and crossing structure**	**Between soft and hard revetments**
Between embankment and point asset	**Between toe wall and embankment**		

A diagram showing transition types and examples.

Using research to reduce flood and coastal erosion risk

The Environment Agency is co-ordinating research to manage flood and coastal erosion risk in England and Wales.

Scientific research is crucial to creating a nation that is resilient to flooding and coastal erosion.

By using partnerships with Defra, Welsh Government and Natural Resources Wales, the Environment Agency plays an important role in coordinating the Flood and Coastal Erosion Risk Management (FCERM) research and development programme.

The programme supports the Flood and Coastal Erosion Risk Management Strategies for England and Wales. The FCERM strategy for England has an ambition for the nation to be recognised as a world leader in researching and managing flooding and coastal change. By working with academic communities, including UK Research Councils and other academic institutions, Environment Agency experts commission innovative research into future flooding and coastal changes caused by climate change.

For example, we are involved in a significant funding opportunity this year from UK Research and Innovation (UKRI) that will provide research to support coastal risk management and improve national resilience.

Areas of research interest include research into understanding risks, managing flood defences well, and supporting communities when flooding happens. Resilience and adaptation, and sustainability topics are also covered to meet government commitments to achieving a 'net zero' carbon emissions nation by 2050. It will also concentrate on incorporating new technology, developing a skill across FCERM.

This collaborative research aims to help England and Wales prepare for flooding and coastal erosion by enabling science-led, sustainable responses to managing flooding and coastal erosion, while

supporting ambitions for the UK to achieve net zero carbon emissions. The programme is addressing the areas of research interest through funding research projects, partnerships and building connections across government, industry and academia to create and use the best science available.

UKRI Resilient UK coastal communities and seas (£11.5 million fund) mission statement

The Resilient UK coastal communities and seas programme is jointly funded by central funding from UKRI, the Arts and Humanities Research Council (AHRC), the Economic and Social Research Council (ESRC), Defra and the Natural Research Council (NERC).

The programme aims to harness the full power of the UK's research and innovation system to tackle large-scale and complex challenges. Using a place-based approach, with research that spans many disciplines, it will transform our understanding of UK coastal communities and seas. And by working with stakeholders, this research will enable transformative decision-making, enhance community knowledge mobilisation and improve resilience.

You can read more about this funding opportunity on the Resilient UK coastal communities and seas.

Funded by: ESRC, AHRC, NERC, UKRI

Links:
www.gov.uk/government/publications/flood-and-coastal-erosion-risk-management-areas-of-research-interest | Flood and Coastal Erosion Risk Management Research and Development Programme

Contact:
Hayley Bowman
(Flood Research team, part of the Economics, Appraisal and Research team in the Flood and Coastal Risk Management directorate)

Exploring the science of droughts

The Environment Agency completed its largest ever consultation of drought experts, helping to keep England at the forefront of resolving complex issues in the face of a changing climate.
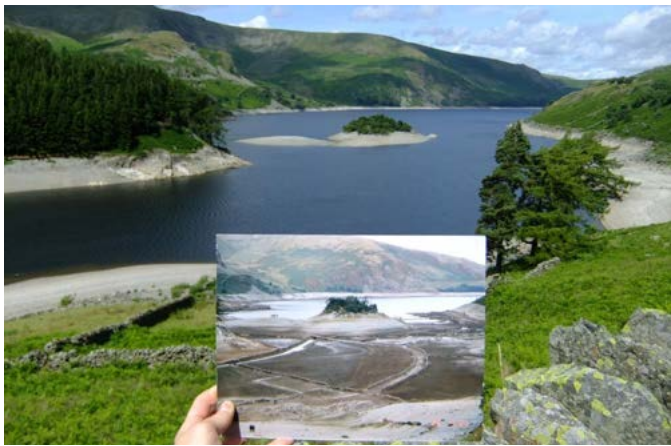
Past drought conditions at Haweswater Reservoir

Researchers from the Environment Agency carried out a review of the current scientific knowledge about drought in the UK. The project provided invaluable insight into drought to inform approaches to research, planning and management both now and into the future.

Droughts – when we don't have enough water to meet all our needs in an area – are complex events that can vary in duration, time of year, location, severity, and society's preparedness and response. The infrequency of droughts means there is limited data and experience of them. This is further complicated by uncertainty in how climate change may affect drought.

Consequently, the current understanding of drought – and ability to manage or respond to it – is limited. The Environment Agency's review aimed to increase knowledge to improve this.

The review focused on 3 themes: the physical processes that drive droughts, the effects of droughts, and the management of droughts. Each theme was further divided into separate topics – for example, rainfall within physical processes, and ecology within impacts – and an expert in each topic carried out a review.

We worked with over 40 experts from 13 different universities, research institutes and consultancies. Authors reviewed existing literature and objectively commented on what is known and not known about drought for their specialist topics. We held a workshop to share information among the group, promote discussion and develop consensus.

The review successfully drew together the current body of knowledge on drought. The improved understanding – including evidence on how drought may alter due to climate change and what the implications are for both the catchment environment and the way water resources are managed – is important for both the Environment Agency and those we regulate. Identifying gaps in knowledge also provides a basis for future research, improving how we can work with others to enable change going forward.

Links:
Review of the research and scientific understanding of drought

Contact:
Stuart Allen
(Chief Scientist's Group)

Seagrass: a blue carbon habitat

Environment Agency marine scientists are mapping and monitoring seagrass habitats in England to understand their effects on climate change.

Seagrass (Zostera marina and Zostera noltii) are the only flowering plants able to live in our estuarine and coastal waters. They are considered to be 'ecosystem engineers', with the ability to create a complex habitat that can alter water movement, stabilise sediment, act as nursery sites for juvenile fish, such as cod, and improve water quality. They are also a blue carbon habitat, and can absorb CO_2, mitigating effects of climate change.

At least 40% of England's seagrass habitats have been lost since the 1930s, with only approximately 35km2 remaining. Surprisingly, there is not a complete map of seagrass across the country. Having this would enable better understanding of the environmental, social and economic benefits of seagrass beds, management to prevent further loss of existing beds, and national opportunities for restoration.

To address this, the Environment Agency's Monitoring Survey Estuarine and Coastal Operations team has been surveying seagrass in areas on the south coast of England as part of the organisation's Natural Capital Ecosystem Assessment programme.

Using underwater images and echosounder data from estuaries and coasts around areas like Portland, Torbay, Plymouth, Falmouth and Salcombe, the team has been able to build an up-to-date map of seagrass habitats. In certain places, large areas of seagrass were able to be mapped for the very first time, including over 1.5 hectares in Swanage alone – an area roughly equivalent to the size of 2 football pitches.

To understand the health of the seagrass habitats, the Environment Agency's Coastal and Estuarine Assessment team has combined the new survey data with existing Environment Agency data sets to produce a comprehensive National Seagrass Extent map that will be published in collaboration with Natural England.

The project has received funding to continue monitoring into 2024 to map new seagrass beds in the South and South West of England. It will also help to establish a monitoring method to understand the extent and density data for kelp beds in the South West and North East of England.

Links:
National opportunities for restoration | National seagrass extent map

Contacts:
Luke Martina | **Kieth McGruer**
(Operations, Regulation Monitoring and Customer)
Dr Ben Green
(Environment and Business, Water Land and Biodiversity)

Seagrass (Zostera marina and Zostera noltii)

Forward look

Environmental science has never been more in the public eye, with extreme weather, 'forever chemicals' and river water quality all in the news throughout 2023. Our scientists will continue to support the Environment Agency's understanding of the state and pressures on the environment and will work to find solutions to some of the pressing environmental problems we face. Our planned highlights include:

1. Strengthening the Science Profession

We will continue to develop the Environment Agency's science profession, helping our scientists with their professional and technical development and building greater local scientific leadership throughout the organisation. As well as our successful scientific seminar series, we will develop guidance to help scientists assure the quality of their work. Our communities of practice continue to grow, and we will use these to develop wider technical leadership in the many scientific disciplines covered by our work.

2. Keeping people informed about their environment

In 2024 we will publish a number of annual statutory reports, including urban wastewater treatment compliance, shellfish and bathing waters. We will continue to publish new state of the environment reports and other assessments of our changing environment. We have begun preparations for a new comprehensive assessment of England's waters in 2025/26.

3. Innovating the way we understand our environment

We will embark on a new programme to design and implement ever more insightful ways of understanding our changing water environment this year. This will consider how we collect data ourselves and with our partners, and how we build capacity to bring it together and analyse it in more efficient and powerful ways. This will work closely with the Natural Capital Ecosystem Assessment programme, which is innovating how we assess the wider water system, our streams, rivers, lakes, coastlines, estuaries and groundwaters. We are investing in new analytical methods to understand the pressures that these environments are under and to gain a better sense of the value of the natural capital that we protect.

4. Supporting efficient and effective operation of the Environment Agency

We will evaluate the effectiveness of interventions in a number of areas. We will publish a review of activities regulated by the Environment Agency, such as data on the percentage of instances where operators are compliant with their environmental permits, as part of a suite of insights that are created by carrying out rigorous data-led evaluation of the effectiveness of our operations and interventions. In our scientific role as part of the UK Chemicals Agency we will continue to work on restrictions on the use of per- and polyfluoroalkyl substances (PFAS) in fire-fighting foams, and on the aquatic risk from road vehicle tyre additives.

5. Novel science for now and the future

We will publish the remaining reports from our HM Treasury-funded project looking at how to monitor antimicrobial resistance in the environment, and we will start a wider survey of antimicrobial resistant organisms in water bodies. We will report on new work on understanding microbial biodiversity in English river biofilms and publish new water temperature projections for England. Other research work includes a review of the use of satellite data for understanding air pollution, and work on the vulnerability of English estuaries to climate change.

We will horizon scan and analyse emerging issues to enable the Environment Agency to anticipate risks and opportunities for the environment and our work.

Publications and peer reviewed papers

Research publications from the Chief Scientist's Group and Flood and Coastal Risk Management Research teams in 2023.

Chemical assessment

Lipid normalisation in the OECD 305 dietary test explored the currently accepted calculations in the main test method used to understand how chemicals accumulate in fish.

Environmental risk evaluation reports: Per- and polyfluoroalkyl substances (PFAS) reported on the environmental hazards and risks from certain PFAS being made or used in the UK.

Water quality

Using DNA to understand river diatom communities applies recent developments in DNA data analysis to help our understanding of river diatom communities.

Air quality

Options for air quality research: drivers of future changes identifies significant drivers of future changes in air quality that are likely to affect regulation by the Environment Agency.

Options for air quality research: monitoring, modelling and integration reviewed current methods for monitoring and modelling air quality and ways of integrating these to best effect.

Drought

Review of the research and scientific understanding of drought conducted a review of the current scientific knowledge about drought in the UK.

Methane

Quantifying methane emissions using inverse dispersion modelling investigated how a technique known as inverse dispersion modelling can be used to estimate the amount of methane released from industrial sites.

Field-scale evaluation of collection methods for dissolved methane samples in groundwaters investigated field methods for sampling methane concentrations in groundwater under different conditions.

Antimicrobial resistance

Shellfish as bioindicators for coastal antimicrobial resistance developed a suite of testing approaches to assess the presence and identity of antimicrobials and resistant microorganisms in marine shellfish.

Review: approaches to monitoring and surveillance of antimicrobial resistance in bathing waters improves our understanding of antimicrobial resistance in relation to human exposures via bathing waters.

Antimicrobial resistance surveillance strategies within wild flora and fauna of England reviewed potential antimicrobial resistance surveillance strategies for wild flora and fauna.

Environmental antimicrobial resistance: review of biological methods reviewed methods for the detection of environmental microorganisms that have become resistant to the effects of antimicrobial compounds.

Antimicrobial resistance in bioaerosols: towards a national surveillance strategy considered the decisions that must be made in designing a national surveillance strategy for antimicrobial resistance in bioaerosols.

Waste crime

National waste crime survey 2023 presents the results of the Environment Agency's waste crime survey for 2023.

State of the environment

State of the environment: the coastal and marine environment provided an evidence-based overview of the pressures, state and trends in England's coastal and marine environments, including estuaries.

Natural capital

Natural capital register and account tool helps users establish a baseline of the natural assets in a place and the services they provide.

Environment Agency natural capital condition indicator mapping explored the natural capital condition and ecosystem service evidence base to support mapping.

Flood and coastal risk management

The Natural Flood Management (NFM) manual provides information to help practitioners select and implement natural flood management measures.

Scoping research to improve dam and levee breach prediction gives an overview of levee and soil-based dam breaches to identify future research needs.

Identifying and managing risks arising from defence structure transitions provides consistency in risk assessment guidance associated with flood defence asset transitions.

Climate change and fluvial flood peaks updates river flooding projections using the latest climate change evidence.

Working together to adapt to a changing climate – flood and coast explores how authorities work with communities on future planning and decision-making to help reduce flood and coastal erosion risk.

Chief Scientist's Group reports

A Science Strategy for the Environment Agency outlines the strategy for Environment Agency science, our scientists, and our scientific research.

Chief Scientist's Annual Review 2022. The Environment Agency's Chief Scientist's Annual Review for 2022.

Academic journal articles by Chief Scientist's Group research staff

Bhui K, Newbury J B, Latham R M, Ucci M, Nasir Z A, Turner B, O'Leary C, Fisher H L, Marczylo E, **Douglas P**, Stansfeld S, Jackson S K, Tyrrel S, Rzhetsky A, **Kinnersley R**, Kumar P, Duchaine C, Coulon F, 2023 – Air quality and mental health: evidence, challenges and future directions. The British Journal of Psychiatry Open, 9(4) https://doi.org/10.1192/bjo.2023.507

Brooks H, Moeller I, Spencer T, Royse K, 2023 – Shear strength and erosion resistance of salt marsh substrates: Which method to use? Estuarine, Coastal and Shelf Science, 292: 108452 https://doi.org/10.1016/j.ecss.2023.108452

Collard M, Camenzuli L, Lyon D, Saunders D, Vallotton N, **Curtis-Jackson P**, 2023 – Persistence and Mobility (defined as organic-carbon partitioning) do not correlate to the detection of substances found in surface and groundwater: Criticism of the regulatory concept of Persistent and mobile substances. Science of The Total Environment, 865: 161228. https://doi.org/10.1016/j.scitotenv.2022.161228

Ficklin D L, Hannah D M, Wanders N, Dugdale S J, **England J**, Klaus J, Kelleher C, Khamis K, **Charlton M B**, 2023 – Rethinking river water temperature in a changing, human-dominated world. Nature Water 1: 125–128.
https://doi.org/10.1038/s44221-023-00027-2

Green C, Bilyanska A, Bradley M, **Dinsdale J**, Hutt L, Backhaus T, Boons F, Bott D, Collins C, Cornell S E, Craig M, Depledge M, Diderich B, Fuller R, Galloway T S, Hutchison G R, Ingrey N, Johnson A C, Kupka R, Matthiessen P, Oliver R, Owen S, Owens S, Pickett J, Robinson S, Sims K, Smith P, Sumpter J P, Tretsiakova-McNally S, Wang M, Welton T, Willis K J, and Lynch I, 2023 – A Horizon Scan to Support Chemical Pollution–Related Policymaking for Sustainable and Climate-Resilient Economies. Environmental Toxicology and Chemistry, 42 (6): 1212-1228
https://doi.org/10.1002/etc.5620

Haase P, Bowler D E, Baker N J, Bonada N, Domisch S, Garcia Marquez J R, Heino J, Hering D, Jähnig S C, Schmidt-Kloiber A, Stubbington R, Altermatt F, Álvarez-Cabria M, Amatulli G, Angeler D G, Archambaud-Suard G, Arrate Jorrín I, Aspin T, Azpiroz I, Bañares I, Barquín Ortiz J, Bodin C L, Bonacina L, Bottarin R, Cañedo-Argüelles M, Csabai Z, Datry T, de Eyto E, Dohet A, Dörflinger G, Drohan E, Eikland K A, **England J**, Eriksen T E, Evtimova V, Feio M J, Ferréol M, Floury M, Forcellini M, Forio M A E, Fornaroli R, Friberg N, Fruget J F, Georgieva G, Goethals P, Graça M A S, Graf W, House A, Huttunen K L, Jensen T C, Johnson R K, Jones J I, Kiesel J, Kuglerová L, Larrañaga A, Leitner P, L'Hoste L, Lizée M H, Lorenz A W, Maire A, Manzanos Arnaiz J A, McKie B G, Millán A, Monteith D, Muotka T, Murphy J F, Ozolins D, Paavola R, Paril P, Peñas F J, Pilotto F, Polášek M, Rasmussen J J, Rubio M, Sánchez-Fernández D, Sandin L, Schäfer R B, Scotti A, Shen L Q, Skuja A, Stoll S, Straka M, Timm H, Tyufekchieva V G, Tziortzis I, Uzunov Y, van der Lee G H,

Vannevel R, Varadinova E, Várbíró G, Velle G, Verdonschot P F M, Verdonschot R C M, Vidinova Y, Wiberg-Larsen P, Welti E A R, 2023 – The recovery of European freshwater biodiversity has come to a halt. Nature, 620: 582–588
https://doi.org/10.1038/s41586-023-06400-1

Hart A, **Warren J**, **Wilkinson H**, **Schmidt W**, 2023 – Environmental surveillance of antimicrobial resistance (AMR), perspectives from a national environmental regulator in 2023. Euro Surveillance 28(11).
https://doi.org/10.2807/1560-7917.ES.2023.28.11.2200367

Kreibich H, Schröter K, Di Baldassarre G, Van Loon A, Mazzoleni M, Abeshu G W, Agafonova S, AghaKouchak A, Aksoy H, Alvarez-Garreton C, Aznar B, Balkhi L, Barendrecht M H, Biancamaria S, Bos-Burgering L, Bradley C, Budiyono Y, Buytaert W, Capewell L, Carlson H, Cavus Y, Couasnon A, Coxon G, Daliakopoulos I, de Ruiter M C, Delus C, Erfurt M, Esposito G, François D, Frappart F, Freer J, Frolova N, Gain A K, Grillakis M, Grima J O, Guzmán D A, Huning L S, Ionita M, Kharlamov M, Khoi D N, **Kieboom N**, Kireeva M, Koutroulis A, Lavado-Casimiro W, Li H, LLasat M C, Macdonald D, Mård J, Mathew-Richards H, McKenzie A, Mejia A, Mendiondo E M, Mens M, Mobini S, Mohor G S, Nagavciuc V, Ngo-Duc T, Nguyen H T T, Nhi P T T, Petrucci O, Quan N H, Quintana-Seguí P, Razavi S, Ridolfi E, Riegel J, Sadik M S, Sairam N, Savelli E, Sazonov A, Sharma S, Sörensen J, Souza F A A, Stahl K, Steinhausen M, Stoelzle M, Szalinska W, Tang Q, Tian F, Tokarczyk T, Tovar C, Tran T V T, van Huijgevoort M H J, van Vliet M T H, Vorogushyn S, Wagener T, Wang Y, Wendt D E, Wickham E, Yang L, Zambrano-Bigiarini M, Ward P J, 2023 – Panta Rhei benchmark dataset: socio-hydrological data of paired events of floods and droughts (version 2). GFZ Data Services.
https://doi.org/10.5880/GFZ.4.4.2023.001

Lu S E, Morris A, Clinton-Bailey G, Namiq M, Gow P C, **Birchill A**, Steigenberger S, Wyatt J, Forrester R, Mowlem M C, Warwick P E, 2023 – Rapid prototyping Lab-on-Chip devices for the future: A numerical optimisation of bulk optical parameters in microfluidic system. Sensors and Actuators A: Physical, 359: 114496
https://doi.org/10.1016/j.sna.2023.114496

Martin I, Hart A, 2023 – Antifungal medicines in the terrestrial environment: Levels in biosolids from England and Wales. Science of the Total Environment, 870: 161999.
https://doi.org/10.1016/j.scitotenv.2023.161999

Pawlowski S, Aicher L, Berends A, **Curtis-Jackson P**, Häner A, Hollender J, Jene B, Jenner K, Redman A, Sanders G, Vallotton N, Wang N, Wheeler J R, 2023 – Mobility in the context of exposure-based assessment of chemicals for drinking water resource protection. Integrated Environmental Assessment and Management, 19(3): 775-791.
https://doi.org/10.1002/ieam.4705

Potts D A, **Timmis R**, Ferranti E J S, Vande Hey J D, 2023 – Identifying and accounting for the Coriolis effect in satellite NO2 observations and emission estimates. Atmospheric Chemistry and Physics, 23(7): 4577-4593.
https://doi.org/10.5194/acp-23-4577-2023

Sellers G S, Jerde C L, Harper L R, Benucci M, Di Muri C, Li J, **Peirson G**, **Walsh K**, Hatton-Ellis T W, Duncan W, Duguid A, Ottewell D, Willby N, Law A, Bean C, Winfield I, Read D, Lawson-Handley L, Hänfling B, 2023 (submitted) – Optimising species detection probability and sampling effort in lake eDNA surveys.
https://doi.org/10.3897/arphapreprints.e105785

Solan M, Spencer T, Paterson D M, Unsworth C A, Christie E K, Blight A J, Brown J, **Brooks H**, Dougal Litchman I, Wei X, Li X, Thorne P, Leyland J,

Godbold J A, Thompson C, Williams M E, Plater A, Moller I, Amoudry L O, 2023 – Biological-physical interactions are fundamental to understanding and managing coastal dynamics. Royal Society Open Science, 10 (7): 230155
https://doi.org/10.1098/rsos.230155

Soto I, Ahmed D A, Beidas A, Oficialdegui F J, Tricarico E, Angeler D G, Amatulli G, Briski E, Datry T, Dohet A, Domisch S, **England J**, 2023 – Long-term trends in crayfish invasions across European rivers. Science of the Total Environment, 867: 161537.
https://doi.org/10.1016/j.scitotenv.2023.161537

Ward S, **Forrow D, Kirk S**, Worthington R, Paling N, Stacey F, Brunt O, 2023 – Visualising, Illustrating and Communicating Future Water Visions to Support Learning and Sustainability Transitions. Water 2024, 16 (1): 14
https://doi.org/10.3390/w16010014

Watts G, 2023 Global Environmental Pressures. In: Krause S, Hannah D M, and Grimm N B. (eds.) Ecohydrological Interfaces, John Wiley & Son.

Whiteman M, Farr G, Haslam A, Train C, **Kieboom N**, Farrell R, Davison P, Williams H, Tang S, Hall J, Jones L, 2023 – Source apportionment of nitrogen pressures at a Chalk-fed groundwater dependent wetland. Geological Society London, Special Publications.
https://doi.org/10.1144/SP517-2020-209

Wyatt N J, **Birchill A**, Ussher S, Milne A, Bouman H A, Troein E S, Pabortsava K, Wright A, Flanagan O, Bibby T S, Martin A, and Moore C M, 2023 – Phytoplankton responses to dust addition in the Fe−Mn co-limited eastern Pacific sub-Antarctic differ by source region. Proceedings of the National Academy of Sciences 120 (28)
https://doi.org/10.1073/pnas.2220111120

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