



Environment
Agency



Chief Scientist's annual review 2021

Chief Scientist's Group report

February 2022

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 & 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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Welcome

Welcome to the Environment Agency's first Chief Scientist's Annual Review. In a year when science has again touched all our lives during the Covid19 pandemic, it is timely to acknowledge the value of our scientists and the work they do to help us understand, protect and improve the environment. Whether it's tackling climate change, moving to net zero, understanding the risks posed by chemicals, or managing scarce resources, the challenges we face all require science to inform how we respond.

This review shows the quality of science and evaluation we do in the Environment Agency and the impact it has on our work, particularly in achieving the Environment Agency's 5-year action plan (EA2025) and the Government's 25-year Environment Plan. Many of the areas in our remit have very broad reach across society. I am mindful of our work with colleagues in Operations on monitoring Covid19 in wastewater and the role that plays in managing the pandemic.

The review contains case studies highlighting the role of the Chief Scientist's Group and of science and evaluation more widely. These case studies include our leadership of science within the Environment Agency, how science supports the business, how we use data analysis and evaluation to improve decision making and our future facing work. The review doesn't cover everything we do, and I hope to share even more stories from across the organisation about the fantastic work our teams produce in the future. In the meantime, please have a look at the list of published work and peer reviewed papers produced in 2021 at the end of the review.

Science and evaluation are embedded within many parts of the Environment Agency and this review contains examples of environmental, social and flood science from across the organisation. Science is a team effort; we recognise the value of working with others and have forged partnerships across the Defra network and academia to bring together the best skills and experience. We have an eye to the future and are developing the next generation of scientists. We support a network of over 50 PhD students from 25 universities on topics that span the breadth of our research interests. We also work closely with UK Research Councils to shape and deliver research Fellowships. We have an established programme providing summer work placements for Year 12 students and academic interns. I am always delighted at the enthusiasm that young people bring and the positive impact they have on the teams they work with.

Looking forward to 2022 my ambition is to ensure that we retain a balance in our work. We must continue to underpin the daily work of the Environment Agency and beyond, but also ensure that we scan the horizon and prepare for future challenges. There is a need to focus on the here and now but our investment in the future ensures that we have the right people, skills and knowledge when they are most needed. I hope you enjoy reading the review.



Dr Doug Wilson OBE

Chief Scientist and Director of Chief Scientist's Group, Environment Agency

Introduction

Who we are

The Chief Scientist's Group's purpose is to put strong science and rigorous analysis at the heart of the Environment Agency's work to create a better place for people and wildlife and support sustainable development. There are around 150 people in the Chief Scientist's Group, working in research, innovation, evaluation, data analysis and reporting, and horizon scanning. We work very closely with the Flooding and Coastal Risk Management Research Team and the Social Science Team, both in the Environment Agency's FCERM Directorate. Through our Chemicals Assessment Unit, we provide specialist advice to Defra and the Health and Safety Executive on chemical toxicity. We lead for the Environment Agency on statutory reporting on environmental standards. Our "State of the Environment" reports provide assessments of environmental problems. We lead for the Environment Agency on natural capital accounting and are developing the methods and approach that will be used for the Government's Natural Capital Ecosystem Assessment (NCEA). We have strong links with the Defra Chief Scientific Adviser and other science groups across Defra bodies and across Government, as well as with the Devolved Administrations in Wales, Scotland and Northern Ireland. We work with universities and research establishments across the UK and internationally. We have recently become a Public Sector Research Establishment, which means we are eligible for research funding from UK Research and Innovation (UKRI).

Our ambition

- Deliver expert specialist scientific analysis
- Provide transformational science now and for the future
- Help the Environment Agency make confident evidence-based decisions
- Through rigorous evaluation help the Environment Agency understand the effectiveness of interventions
- Solve new and complex scientific problems quickly and effectively
- Support incident management with excellent scientific analysis and advice.

Our people

Our talented and experienced people are the Chief Scientist's Group's main asset. Between them our 150 people hold PhDs in disciplines including physics, chemistry, biology, geomorphology, hydrology and ecology. Our team contains many leading experts with an extraordinarily diverse range of specialisms: air quality, water quality, waste and recycling, climate change, groundwater, hydrology, geomorphology, fisheries science, ecosystems, data science, ecotoxicology and science communication. We run our own

development network to build our talent and hold regular science webinars with internal and external speakers. We co-supervise 15 PhD students and run a very successful annual conference for all the PhD students supported by the Environment Agency. We offer 3-to-6-month placements for our PhD students, giving them experience of working in a scientific environment beyond academia. We use apprenticeships to bring in new staff and are proud to have one of the Environment Agency's first Kickstarter employees. We support the Nuffield Placement scheme for sixth formers from disadvantaged backgrounds who want to pursue a career in science.

We also support the many Environment Agency scientists working in other parts of the organisation by leading the Environment Agency's Science Profession. This powerful network runs regular science webinars and brings together groups with specialist scientific interests. We are developing specialist training and support for working scientists, including a mentoring scheme and support for those pursuing membership of professional groups.

Our annual review

Our annual review is organised under five themes. We start with the Covid pandemic, which has affected all of us in so many ways over the last two years. Our second theme is developing our people, we then cover our contribution to the 3 long term goals of EA2025 and the Environment Agency's priorities to 2025 and finish with our look to the future. We illustrate each theme with just a few examples of the work we're doing in each area.

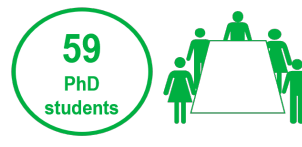
The Chief Scientist's Group year in numbers



have incident roles, supporting the Environment Agency's response to flood and environment incidents



of the Science Profession, launched April 2021



from across the Environment Agency in our PhD network



views of the research reports we published in 2021



delivered to internal Environment Agency staff



additional science and research project funding secured in 2021

Covid 19

Covid has touched every part of our work. Like so many other people we suddenly started working from home in March 2020, and for most of our staff this hasn't changed throughout the pandemic. Our people have found new ways of working together, through email, filesharing and video conferencing. This hasn't always been easy, but the Chief Scientist's Group has risen to the challenge and has remained highly productive and innovative throughout this difficult period. Our teams have also risen to the challenge of supporting pandemic actions, with scientific briefings on the risks of transmission through water and on the challenges of disposing of contaminated materials. Several people, including our Chief Scientist, supported the Government Office of Science (GO-Science) in pandemic response.

Our contribution to managing Covid 19

Early in the outbreak of Covid-19, several scientific reports showed that it was possible to detect the SARS-Cov-2 virus in wastewater, sometimes several days before clinical cases were detected. This meant it was also possible to predict the development of the disease in populations. At the time, the possible testing facilities were abroad or in academic or commercial laboratories.

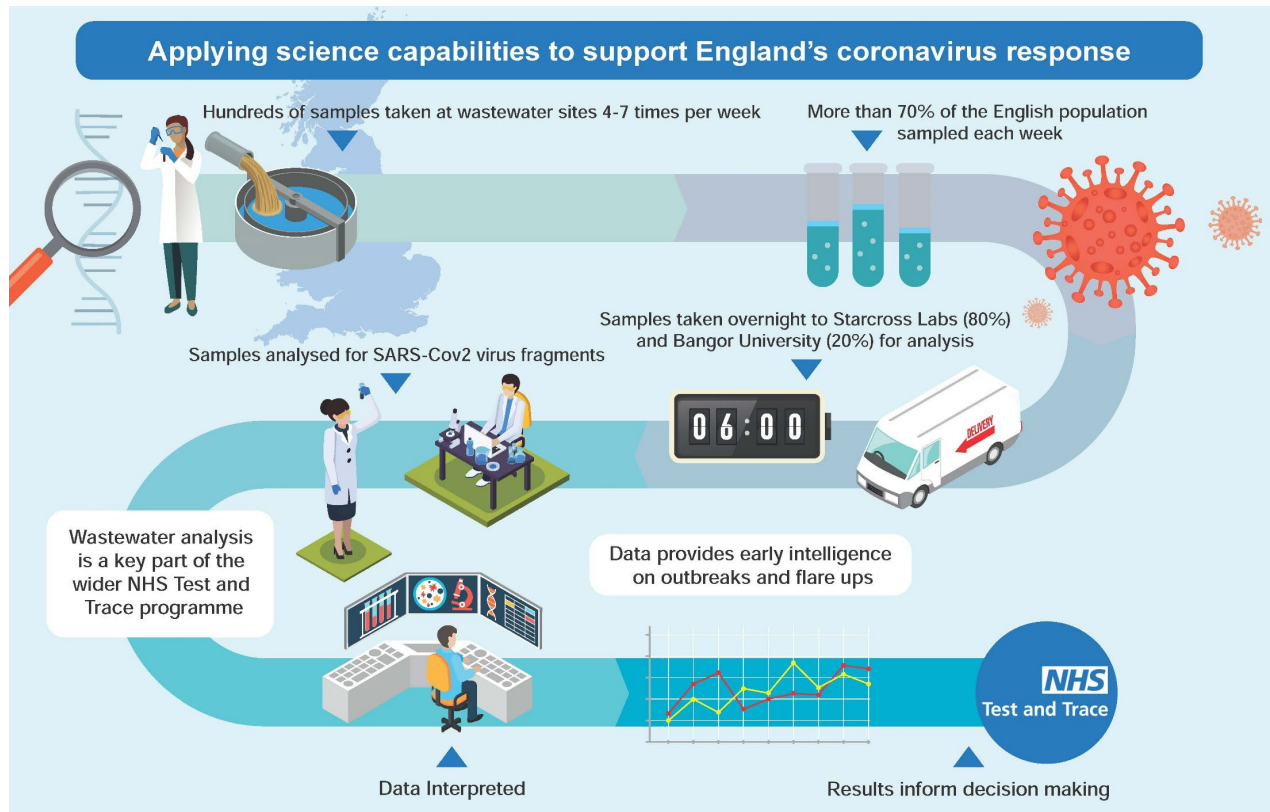
In April 2020, the UK Health Security Agency (UKHSA), the Environment Agency and Defra began developing sewage surveillance for SARS-Cov-2. A team from the Environment Agency including our National Laboratory Service set up a dedicated laboratory in Exeter to handle wastewater. Sampling began in July 2020 at 44 sewage works across England, covering 30% of the population. This capacity was then expanded to cover 80% of England, with 450 sites and 2800 samples analysed a week. This work provides both numbers of viral genes present and RNA for external sequencing of variants. The results of this work go to the Scientific Advisory Group for Emergencies (SAGE) and then on to the NHS area planners.

Wastewater testing can offer different perspectives from clinical data on the course of SARS-Cov-2, including:

- early detection of infections in a population before clinical cases show, or where people have no symptoms
- insight into populations where access to, or uptake of, clinical testing and healthcare is limited
- monitoring large groups of people at much lower cost than testing a similar number of individuals

The UKHSA combines the results of wastewater testing with other clinical and test data, and this can inform government responses at both the local level and national modelling.

While the current focus is on supporting the SARS-Cov-2 response, perhaps the best use will come as low cost, non-intrusive monitoring in more normal times. This will not be our last pandemic; we must make sure we remember what SARS-Cov-2 is teaching us for the future.



Working across Government and with the 9 water companies in England

For more information regarding this project, contact [Alwyn Hart](#)

Visits to nature during the first year of the pandemic

How did the pandemic and the associated lockdowns affect how people visited nature? And what did this mean for our role as agencies managing and regulating sites used for outdoor recreation? Through our work with the Natural Environment Social Research Network, we had a chance to collaborate with Natural England, Forest Research, Natural Resources Wales and NatureScot to get an evidence-based view of how people engaged with nature during the pandemic in 2020 in England, Scotland and Wales. The Environment Agency's Social Science Team managed and led the project.

We found a polarised picture across the 3 nations of Great Britain, where some people had visited nature more than before the pandemic, while others had visited less or not at all. This was partly due to government restrictions and some outdoor spaces being closed. Factors like socio-economic status, age and health also affected peoples' ability to make visits. Existing inequalities in visiting nature seemed to have been reinforced as, for

example, people on lower incomes made fewer visits due to Covid-19, while those in higher income groups were able to visit more than usual.

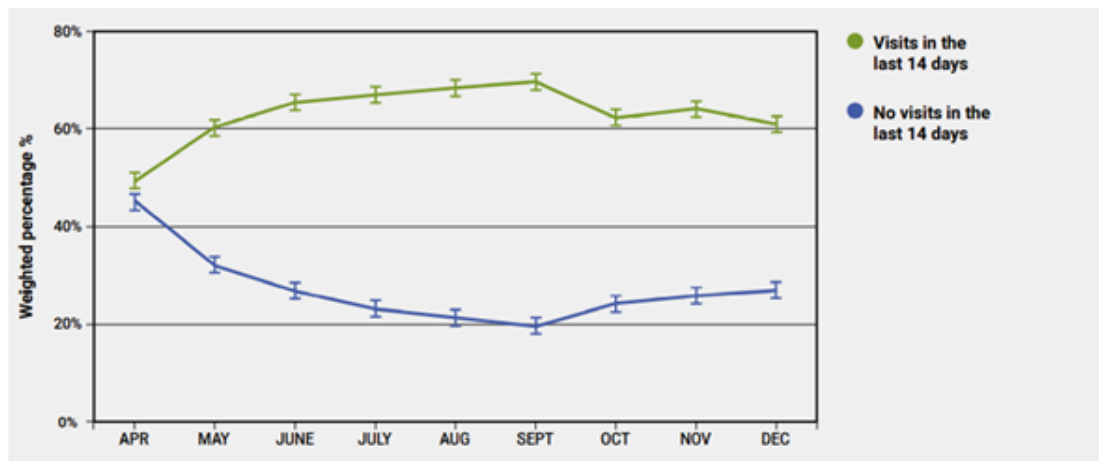


Figure notes: **Source: People and Nature December 2020 Monthly Indicator Report**

Question: *How many times, if at all, did you make this type of visit to green and natural spaces in the last 14 days?*

Some people who visited nature in England reported that they took more time to notice everyday nature, like birdsong, than before the pandemic, while in Scotland, there was an increase in participation in nature-based activities such as watching wildlife. As more people visited nature after the lockdown restrictions eased, some places became popular ‘hot spots’ for recreation. This, in turn, posed a challenge in managing sites, with issues ranging from littering and overcrowding to negative impacts on wildlife.

The project was a really positive experience of working together to share knowledge across the 3 nations of Great Britain. The final publication is available here: [Why society needs nature.](#)

For more information regarding this project, contact [Anna Lorentzon](#)

People

Our scientific and technical staff are at the heart of the work we do to support EA2025. We support scientists across the organisation, and our team leads the Science Profession providing a community for the development and promotion of scientific expertise. We value the development of our next generation of scientists and offer opportunities through PhDs, research Fellowships and work placements to develop their skills and enable them to learn more about what the Environment Agency has to offer.

Inspiring the scientists of the future

As part of our commitment to the EA2025 People Plan, the Chief Scientist's Group set ourselves the objective to inspire and develop the next generation of scientists and reach a broad cross-section of society. To meet this objective, we have set up a programme that provides summer work placements for Year 12 students and academic interns, supervision of PhD students and hosting Research Council Fellowships.

We work closely with the Nuffield Foundation to provide opportunities for talented Year 12 science, technology, engineering and maths (STEM) students from disadvantaged backgrounds, engaging them in the science we do and helping them to explore their potential. To date, we have hosted 16 students and this summer, despite Covid-19, we were able to host 2 virtual placements. The students' work in evaluating the existing evidence on green ammonia and river restoration effectiveness so impressed the Nuffield Foundation that they invited the students to present their projects at the Foundation's autumn celebration event.

We normally host up to 4 undergraduate or recent graduate interns over the summer. We paused this programme during the pandemic, but to date have hosted 14 students from 9 universities. Nearly half of them have gone on to secure permanent jobs in the organisation.

We support a network of over 50 PhD students from 25 universities on topics that span the breadth of our research interests. We are currently supervising 15 of these students, one of whom completed a placement with us this year to progress our net zero research agenda. We also work closely with UK Research Councils to shape and provide research Fellowships. We helped to provide 7 Research Council Fellowships this year, progressing research on a range of topics. These included natural capital approaches to coastal management and understanding the environmental dimensions of antimicrobial resistance.

These opportunities help us to fill gaps in evidence and allow us to access new skills, think differently and develop new ideas and ways of working.



Some of our current PhD students and their supervisors

For more information regarding this project, contact [Pete Drury](#)

Creating a community of scientists

The Environment Agency's success is very much dependent on the success of its people and through the Science Profession we want to promote a community of scientific disciplines that will break down barriers and broaden horizons.

Through the Science Profession we want to raise the profile of science within the Environment Agency and acknowledge the contribution our scientists make. The Environment Agency has a large number of scientists working in nearly all parts of the organisation. Science is absolutely fundamental in helping us understand the environment and underpins so much of what we do that gives us our authoritative voice. The profession has created a place of belonging for our scientists that provides opportunities to find out more about what we all are doing across the organisation, share ideas and good practice, and enhance their professional development.

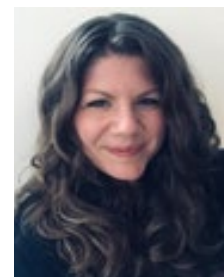
The Science Profession is open to anyone with a background in science, they don't have to be working in a science-based role. So far, we have around 600 members and the activities that we offer are based on what the members said they wanted. We produce a quarterly newsletter called 'Science Matters' to which members contribute and share their science stories. This allows scientists to share their expertise and interests to help them connect with one another. We also run a series of science seminars, led by internal or external speakers on a wide range of topics from sustainable chemistry to the rise of microplastics.

During 2022, we will be launching a mentoring scheme to help members tap into the wealth of experience and knowledge that exists. We also plan to launch more communities of practice (we already have an ecology community and a DNA knowledge transfer group) to harness the collective power of our scientists from across different disciplines and parts of the organisation to resolve challenges or issues.

For more information regarding this project, contact [Susan Tate](#)

I'm Charlotte (Charlie) Hutton and I'm a Research Officer in the Research Hub. I lead on our Nuffield Placements Programme, working with STEM Learning and different teams across the Environment Agency. We provide talented A-level students from disadvantaged backgrounds with no family history of higher education the opportunity to use their skills to carry out meaningful projects and to help make a difference to the work we do.

These experiences encourage students to fulfil their potential in science, technology, engineering and maths and motivate them to pursue environment-related university degrees and careers. Along with our undergraduate internships, PhD supervision and Knowledge Exchange Fellowships, these placements have a positive impact on our own staff and help develop a more diverse and inclusive community of scientists for the future.



Healthy air, land and water

Clean air, land and water are critical for our health, they sustain wildlife and provide essential services that support our lifestyles and our economy. The Chief Scientist's Group play an important role in providing the science and underpinning evidence to support the organisation in protecting and improving air, land and water. Our teams cover a huge variety of topic areas from the impact of agriculture on the environment to identifying ways of managing the risks posed by chemicals. We work closely with others across the Environment Agency to ensure our decisions are evidence based. Our teams are often at the forefront of applying science, developing novel technologies and approaches to improving our understanding of the environment, and meeting future challenges.

How we use the data from bathing waters.

The Chief Scientist's Group plays a warning and informing role for beachgoers. Each year we use sampling data from the Environment Agency's laboratories to assess the number of harmful waterborne bacteria at 417 locations that are designated for public bathing. We classify each location at the end of the bathing season (May to September) to determine the long-term condition of that bathing water, giving it a categorisation of either excellent, good, sufficient or poor. This dataset forms one of the government's official statistics.

Over the last few years, we have used knowledge of how rainfall flushes bacteria from drainage and farmland into these bathing water locations to introduce a bathing water forecasting capability. We now offer this capability at 177 locations across England: bathers are informed in real-time of daily changes to the risk of bacterial pollution. We use the [Swimfo](#) website to distribute these warnings which are used by local beach managers and displayed on signs at the entrance to beaches. This is a great example of an evidence base that is simultaneously used for informing the public, targeting investment in drainage and water company assets and assessing government performance.



Taken from the Swimfo, Swimfo allows you to look up details of a designated bathing water by name or location.

Article by **Owen Lewis**.

For more information regarding this project, contact research@environment-agency.gov.uk

Regulating chemicals

The Chemicals Assessment Unit builds the evidence base and identifies appropriate ways of managing the risks posed by chemicals.

Since the repatriation of EU laws on 1 January 2021, we have taken on a range of new activities. One of these involves classification, labelling and packaging; working with chemical companies to make sure chemicals are correctly identified and mistakes aren't made. We now have more flexibility about how we work with the chemicals industry; although we have a regulatory role, we also have a responsibility to protect the environment, so we want to pre-empt any avoidable problems through dialogue.

Chemicals are registered by manufacturers and importers who have to gather information so hazards and risks can be identified and managed. If we think the companies aren't doing enough to limit the risks, we can propose conditions on the supply and use of chemicals which may result in outright bans. We're currently drafting a proposal to restrict the use of lead ammunition in hunting and sports shooting on the grounds that there's no safe level of lead exposure for wildlife or people who eat game meat.

We also deal with persistent organic pollutants (POP). In April 2021, under the UN Stockholm Convention, we nominated medium chain chlorinated paraffins as a POP. This is the first time the UK has made a nomination of this type, and our goal is for this substance to be phased out globally.

We are also working on a group of chemicals known as poly- and perfluoroalkyl substances (PFAS). PFAS are found in all sorts of products, they are widely detected in water, air, fish, and soil, and many are harmful. We are trying to establish what type of risk management will be proportionate to limit risks for future generations without undermining important benefits such as in medical applications.

For more information regarding this project, contact [Steve Dungey](#)

Improving our understanding of the environment using eDNA

During the last 10 years, we've been evaluating how best to use advances in DNA technology to better understand how ecosystems are changing. We've been looking at what works, what data it will give us, how operational teams might use it, and how this will help us as an organisation to protect the environment.

We have carried out large-scale studies using eDNA (a generic term for DNA isolated from environmental samples) combined with cutting edge DNA sequencing technology to develop community-based methods for routine ecological assessment. We are working with the National Laboratory Service (NLS) to develop and validate new eDNA methods for the surveillance of invasive and protected species.

Having established a UK DNA Working Group, which brings together UK government agencies and leading academic researchers, we have continued to build influential networks and collaborations. Together with other government agencies, we recently established a new Defra Centre of Excellence (CoE) for DNA to build capacity and capability across the Defra Group to support the development of priority initiatives for the 25 Year Environment Plan.

In 2021, we published a compilation of academic papers on 'Understanding ecosystems and resilience using DNA'. These describe different approaches that could transform how we monitor the environment and improve our understanding of ecosystem responses to future pressures like climate change and a wide range of human activities. This work is shaping the future vision for DNA. It is directing our priority research activities to enhance our capability and speed up the implementation of DNA methods.

At the same time, we are working to raise awareness, excite people and make the information accessible to a wide range of audiences. We recently produced a YouTube video, called 'What lives below: an eDNA story', which will be used as part of a STEM 'Learn Live'.

I'm Kerry Walsh and I work alongside some great people in the Climate Change and Resource Efficiency team. I've worked for the Environment Agency for nearly 18 years, usually on something to do with DNA! DNA holds all the genetic information on how organisms develop, function and respond to a changing environment and a big part of what I do is to help us understand how using DNA technology can provide practical monitoring methods to detect organisms – from the small things we can't see to the big things we can – so we can better understand their responses to change to guide management actions.



For more information regarding this project, contact [Kerry Walsh](#)

Improving the land

Since 2005, Defra, Natural England and the Environment Agency have worked together to promote Catchment Sensitive Farming (CSF). The CSF partnership advises farmers on how best to protect the environment, including signposting them to available financial incentives.



The partnership's annual budget rises from £8 million to £15 million from 2022/23. Natural England employ CSF officers who talk directly with farmers across the country. The Chief Scientist's Group's role is to evaluate the effectiveness of the partnership. We receive 10% of the CSF budget to do this. Our evaluation is based on surveying farmers' attitudes and awareness; recording changes in farming practices; environmental modelling, and long-term water quality monitoring. This evaluation directly helps improve CSF delivery; for example, identifying geographic areas and specific farms where CSF advice will provide the greatest potential environmental benefit.

The expansion of the partnership to cover most of England, and the broadening of advice to include air quality as well as water quality and to promote natural flood management, is largely the result of our evidence of the effectiveness of CSF. Our latest evaluation report is available here: [CSF Evaluation Report: Water Quality Phases 1-4 \(2006-2018\)](#).

We are now entering a period of 'Agricultural Transition', when untargeted Direct Payments gradually reduce and the money that is freed up will support agriculture in different ways. Environmental Land Management (ELM) schemes, including the Sustainable Farming Incentive (SFI), Local Nature Recovery and Landscape Recovery will

pay farmers to improve the environment, improve animal health and welfare, and reduce carbon emissions. Alongside this, -long term targets for reducing agriculture's (and other sectors') environmental impact are being developed under the Environment Act. The need for evidence on the effectiveness of policy interventions has never been greater. We are working to ensure the long-term datasets, capabilities and evidence from CSF play a pivotal role in shaping the future.

For more information regarding this project, contact [Phil Smith](#)

A nation resilient to climate change

The impacts of climate change are core to the work of the Environment Agency and particularly our management of water. One of the Chief Scientist's Group aims is to make the scientific information on climate change accessible and available to enable people to take actions to manage and respond to future changes. We also want to create new knowledge. The Government have ambitious targets to reduce greenhouse gas emissions across the economy to reach net zero by 2050. Our teams look at the potential impacts on the environment and society from the introduction of new technologies to reach this target and from our own operational activities.

Coping with climate change



A dry stream channel signifying increased drought

We create and share knowledge about climate change that enables people to prepare for the future. Our activities revolve around water. Problems arise when there's too much leading to flooding, too little resulting in drought, or when it warms up, and affects the quality of water in rivers, lakes and wetlands.

We use the projections for climate change from global climate modelling to assess how these alter the water environment and translate that scientific data into practical guidance for a range of people. These include water companies, local authorities, planners, the construction industry, our own staff and the government. This year our science has driven updated guidance to planners on [future flood risk](#). We've also developed a method to work out how river temperature may change paving the way for a more informed picture of

future rivers. This will help water quality managers appreciate the scale of change and test possible responses.

We are working with the Department for Business, Energy and Industrial Strategy (BEIS) looking at the government's goal of net zero for the low carbon economy. The problem is that many low carbon energy solutions require a lot of water. So we are providing scientific evidence on water availability to avoid any unintended consequences. We're talking to people in the energy sector to identify how we can make it easier for them to use the data and understand what it shows.

Resilience is a word that has become widely used in environmental policy, plans and strategies in recent years. It is often connected to preparing for extreme events and climate change. We've explored the concept of resilience particularly in managing river catchments, where we need to balance competing objectives and demands, while continuing to maintain water quality for people and ecosystems. We have proposed a framework and conducted trials, as discovering what wouldn't work is as important as discovering what would. We call this 'stress testing'; testing vulnerabilities, identifying where an approach would fail, so people can prioritise the actions they need to take.

Visualising the future and identifying the gaps in our knowledge about this changing landscape will put us in a better position to regulate activities and protect the environment.

Article by **Harriet Orr**.

For more information regarding this project, contact research@environment-agency.gov.uk

Net zero – how do we regulate the new technologies?

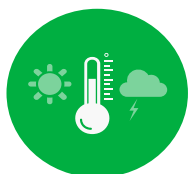
The government's commitment to reduce greenhouse gas emissions to reach net zero by 2050 will involve far-reaching change across the economy, together with the rapid deployment of a wide range of technologies at a scale and in combinations we've not seen before.

Some of the technologies are known to us, but others are completely new. We need to better understand their potential impacts on the environment and society, identify the gaps in evidence and address them. We are working with the Department for Business, Energy and Industrial Strategy (BEIS), Defra and various steering committees to explore the range of potential innovative technologies. We are also starting to flag to UK Research and Innovation (UKRI) important research areas on which to focus funding.

Our research into understanding the environmental risks of onshore oil and gas has enabled us to challenge preconceptions and show that certain risks, such as leaks from decommissioned wells thought to be a significant risk for groundwater contamination, are

much lower than previously thought in England. This has helped focus our efforts on other potential challenges, such as greenhouse gas emissions from industry and repurposing wells.

Novel technologies will help us reach net zero by emitting less greenhouse gas emissions (using geothermal energy, hydrogen storage, compressed air energy storage), or, through the long-term storage of carbon dioxide in the subsurface. We have recently completed work that has identified potential environmental impacts from these technologies. We need to understand more about these impacts and this is shaping our own and broader UK research programmes. We are helping a range of industries reduce their methane emissions (we work with the National Physical Laboratory to produce a framework for monitoring methane) and mapping wider evidence needs.



We help people and wildlife adapt to climate change and reduce its impacts.



We improve the quality of our water, land, and air by tackling pollution.



We work as part of the Defra group to create a better place for people and wildlife.

How the Environment Agency is contributing to net zero goals

For more information regarding this project, contact research@environment-agency.gov.uk

Net zero – a review of the evidence behind potential carbon offsetting approaches



The UK has set a target to achieve ‘net zero’ carbon emissions by 2050. ‘Net zero’ means achieving a balance between the amount of greenhouse gas emissions (GHGs) produced and the amount removed from the atmosphere. To achieve this, annual emission rates will need to be cut to less than 90 million tonnes (Mt) of CO₂e (carbon dioxide equivalent) by 2050 (2019 levels = 260 Mt CO₂e).

The Environment Agency’s own net zero target, set for 2030, includes reducing emissions by 45%, and using best practice carbon offsetting techniques to address remaining emissions.

While approaches to reducing carbon dioxide (CO₂) emissions in the UK are reasonably well documented and understood, those that enable offsetting of residual emissions have been less thoroughly explored. We reviewed the evidence behind 17 different carbon offsetting approaches. This included mainly nature-based solutions and a smaller number of built environment approaches. Each was reviewed against the following criteria:

- readiness for implementation
- speed and scale
- longevity (impact is not reversed)
- leakage (reduction in emissions in one area leads to increase in another)
- additionality (reductions that would not have happened otherwise)
- co-benefits for example, biodiversity benefits as well as carbon reductions
- confidence in the science
- measuring impact
- risks and barriers
- costs

This review will help us understand which carbon offsetting approaches we may want to focus on the most when developing our offsetting strategy.

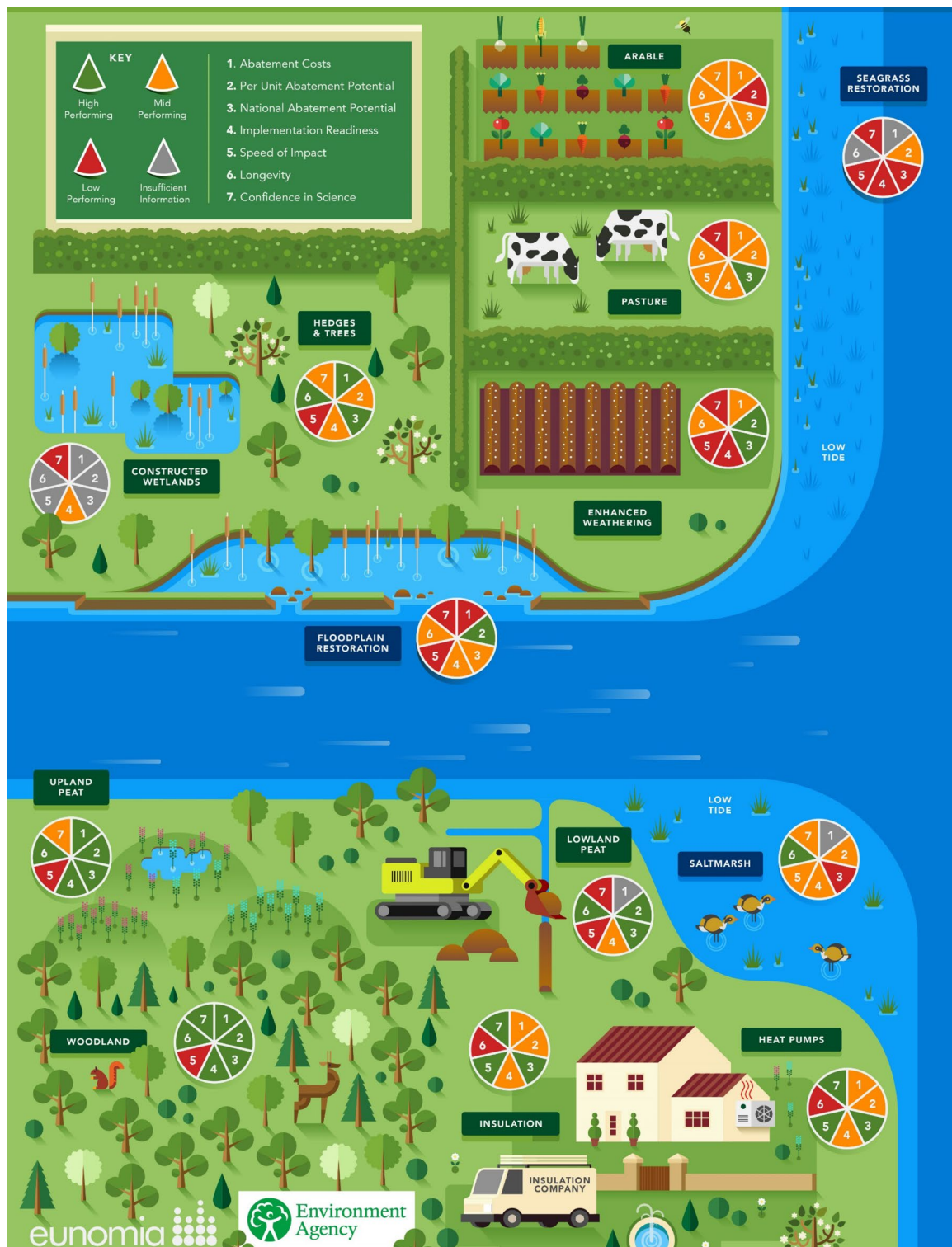
We have also undertaken some research work to investigate and develop a roadmap to inform and help decarbonise our FCRM Capital construction programme. We are now piloting new processes for carbon budgeting across our 6-year programme and

implementing mechanisms to ensure our construction optioneering and business case approaches maximise carbon reduction opportunities. We are also developing proposals that will bring forward new technologies, materials and construction approaches to trial over the next 3 years to accelerate their application across the current and future FCRM 6-year capital programme that reduce our carbon footprint. Themes selected for the trials include assessments of low carbon concrete materials, reinforcement and applications, low carbon steel, earthworks optimisation, methods of modern construction and operation and maintenance aspects.

Article by **Eleanor Heron and Andy Guffogg**

For more information on this project, see our [news story](#) and the [evidence base, which includes a literature review and summary infographic](#). For more information on our floods research programme contact: fcerm.evidence@environment-agency.gov.uk.

Achieving Net Zero – a summary of the evidence behind potential carbon offsetting approaches



This infographic summarises the findings from the Environment Agency research project FRS19213 Achieving net zero – a review of the evidence behind potential carbon offsetting approaches | This summary is based on a review of relevant publications, including peer reviewed and grey literature. We assessed the strength of evidence provided in the literature across 7 different indicators. | Infographic produced by Eunomia Research and Consulting, 37 Queen Square, Bristol, BS1 4QS | Published in May 2021 v8.0 | For further information contact: fcerm.evidence@environment-agency.gov.uk

Green growth and a sustainable future

Meeting the challenge of achieving economic growth and a high-quality environment is an important part of our work. The Chief Scientist's Group excel at providing the evidence that both highlights and drives the changes needed to meet this ambition. Our teams evaluate multiple data sources to present compelling information about a range of topics that are central to sustainable growth. We have produced state of the environment reports, evaluated industry performance and reviewed our own activities. We are preparing the organisation to embed new tools that will prioritise funding and encourage private sector investment in natural resources, and material issue assessments to help us manage strategic risks.

Do we give value for money?

The government is keen to make sure that all the organisations it funds give value for money. It uses an approach called the Public Value Framework. Everything we do comes from, and feeds back into this framework.

Our work supports the business cases that make up the spending review; we need to increasingly show the return on investment for our work. During 2021, we helped the organisation include evaluation plans in its spending review submissions, showing the full environmental and social value of newly funded projects. We'll be applying a natural capital approach for the next spending review in 2024/5 to gather evidence on levels of investment, environmental assets that have been protected or enhanced, and the flow of ecosystem services.

We need to be able to show the return on investment for our regulatory work too; evaluation provides the evidence for this. Evidence from our evaluation of the Extended Producer Responsibility Strategic Review of Charges has shown us that we can further improve the impact of our regulation. We provided evidence for the corporate 'Review of Regulation' and we're now looking at how we can better regulate persistently poor performing sites.

We also work with Operations to help improve the impacts, and better understand the consequences, of its work. We produced a report this year as the result of a national waste crime survey, which suggests that one quarter of all waste is illegally managed. We're working with the new Joint Unit for Waste Crime to show its impact in tackling this.

Hello, I'm Jon Greaves and I lead the Evaluation Team in the Chief Scientist's Group. Our work applies formal evaluation to help build a robust, evidence-based picture of 'what works' and question how effective our interventions at achieving the environmental and societal outcomes we want? We use this information in two ways, firstly to improve how our organisation works, and secondly to show both Treasury and our charge-payers that we and the environment are a great investment. One of my first big jobs in the Environment Agency was to clear up after one of our interventions had failed to deliver the desired outcomes – so now I help others to avoid the same trap.



For more information regarding this project, contact [Jon Greaves](#)

Regulating for people, the environment and growth (RPEG)

The RPEG report presents a national picture of our regulation and contains the main statistics, trends and messages relating to the performance of regulatory activities during the year.

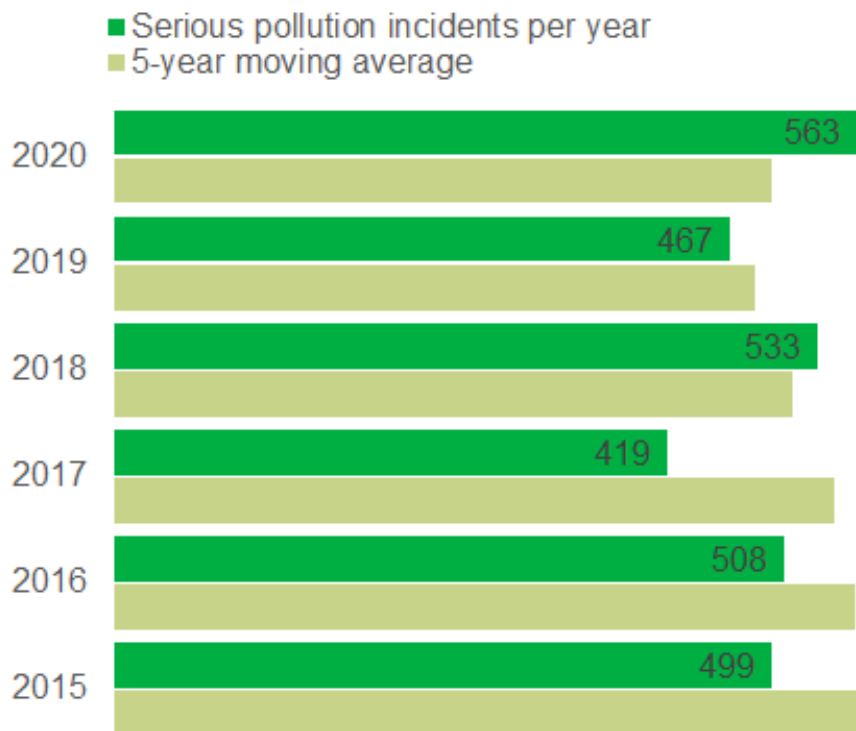
The report is produced for important decision makers, including our Environment Agency Chief Executive, Chair and Board, wider Environment Agency leadership teams, government and industry leaders. It provides succinct evidence and clear business messaging on regulated businesses to support the activities of this group. It demonstrates that we are an efficient and effective regulator, influencing government and industry to support progress in achieving agreed outcomes and addressing future challenges.

The 2020 report shows many improving trends in environmental compliance, pollution incidents, crime, and emissions. It also highlights how we are helping the nation become a climate resilient, net zero nation through our regulatory activities. The report was featured in trade and environmental publications and was promoted on social media. Ultimately, the RPEG report is about providing and publicising the evidence to persuade businesses to improve their performance and achieve a cleaner environment.

Article by **Anna Cowlard**.

For more information regarding this project, contact research@environment-agency.gov.uk

The number of annual serious pollution incidents remains high



Serious pollution incidents between 2015 and 2020

Natural Capital

We're preparing the organisation to embed natural capital (NC) by developing a practical framework to manage nature as an asset, so that it can continue to provide services that benefit people. We use this approach to prioritise funding, encourage private sector investment in natural resources, and to promote a sense of shared stewardship. But to do this, we need evidence and tools; to make sure the natural assets are fit for purpose we need to trial them and give staff the skills they need to use them in their work.

Measurement is crucial. We've developed an NC register and accounting tool to identify the value of the benefits from natural assets in a specific location. We're working with the Water, Land and Biodiversity team and Ofwat to develop wider metrics for water companies to include in their appraisal methods. This will become formal guidance. We've also developed an NC metrics catalogue to clarify the links between asset condition, ecosystem services, benefits and monetary value. These tools are supporting the organisation in choosing the right metrics to reflect environmental, social and economic benefits and in linking them to Environment Agency, partner and government priority outcomes.

We're also working with the Flood and Coastal Erosion Risk Management (FCERM) team to embed natural capital in their supplementary appraisal guidance on valuing our natural

and historical environment. We encourage Area teams to use NC tools and evidence, and we are producing case studies to highlight the benefits of this approach. For example, evidence on natural assets and their benefits will be included in the Local Outcome Plans. This will help prioritise actions and, working with the Future Funding team, start the process of generating private sector investment. But we recognise that this is a new approach, so we've developed introductory eLearning modules, and are seeking feedback from users to find out what they need.

Our natural capital work develops and collates evidence and tools. It also builds capability to empower staff to apply economics to the nature and climate emergencies. Our evidence synthesis work on the risks of chemicals to the aquatic environment is helping to support the organisation in developing regulatory management approaches and to inform future government policy decisions on chemicals.

We use firm and engaging evidence to inform policy and decision makers on some of the most significant water challenges we face. In a fast moving and creative field, this outstanding team leads the way on natural capital, and was shortlisted for the Environment Agency's Innovation & Risk Award.

The topics we work on are important and have a positive impact on the environment. We love to collaborate with others from across our organisation, along with the water and conservation sectors, building ideas together, and promoting the success of others.



For more information regarding this project, contact [Ruth Jones](#)

Material issues assessment

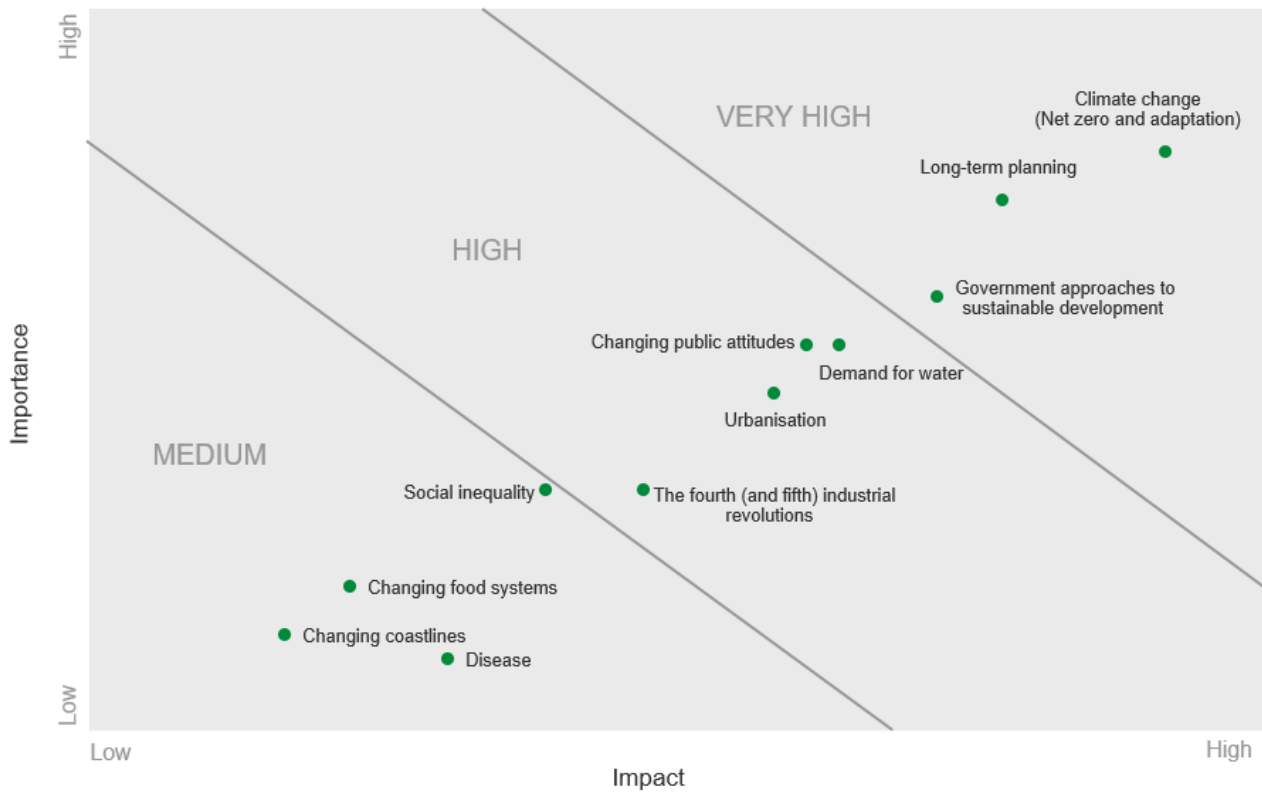
Material issues are the big, longer-term changes that shape the context in which the organisation works. Many private sector organisations already use a material issues approach to anticipate the strategic threats and opportunities for their business; assessing how global influences and pressures will impact on their brand, reputation and profits.

The Environment Agency Board has decided that the organisation should adopt a material issues approach to strengthen the way it too manages strategic risks. We are one of the first public sector organisations to take this approach. Our motive, however, is not to enhance profits, but to ensure that we protect people and the environment.

The Chief Scientist's Group has worked with the Board's Audit and Risk Assurance Committee (ARAC) to identify and assess the impact and importance of 11 material issues relevant to the organisation's goals. These cover long-term, global concerns such as the continuing rise in environmental hazards, declining natural resources, movements of people and environmental inequalities. As part of the approach, we consulted internal experts and 12 stakeholder organisations to understand the impacts, importance and implications of these material issues.

The assessment has generated rich discussion about some of the wider problems the Environment Agency may need to face; from the implications of global food supply chains to the risks and opportunities of new technologies for the environment and how society's expectations drive changes to environmental management. Stakeholders identified that the 3 top issues are climate change (net zero and adaptation), having longer-term planning horizons, and governments' approaches to sustainable development.

ARAC has referred these issues to the Executive Directors' Team to consider as part of its approach to managing corporate risks. ARAC considered our approach and contribution so useful that they have asked for it to become an annual assessment, with the results reported in the Board's Annual Report each year.



11 Material Issues identified by the EA ARAC board

For more information regarding this project, contact [Marie Fox](#)

Shaping the future

In a changing world we cannot sit still and wait for the next set of challenges; we must prepare for them. Science and innovation are an important part of our preparation; we would not have been able to support the pandemic actions without the innovative research we have done over the last 6 years. Our teams use horizon scanning to identify new threats and opportunities, and we work closely with our colleagues and partners to identify gaps in our evidence. This might result in new research or the development of novel technologies.

Saving us from the silent pandemic?

Over 6 years ago we identified a problem of antimicrobial resistance (AMR). We need to take this very seriously, as it's estimated that, globally over the last 5 years, more people have died from AMR than from Covid-19 and the problem is growing.

Although some may see this simply as a health issue, we're exposed to microbes in many different settings. We therefore need to understand the role the environment plays in the development, maintenance, and dissemination of AMR. Over the last 5 years, we have been highlighting this, developing links with academia, government nationally and internationally and through organisations like the United Nations Environment Programme. This has culminated in us working with Defra, the Department of Health & Social Care, UK Health Security Agency (formerly Public Health England) and the Food Standards Agency to successfully submit a proposal for a joint AMR project.

We have secured over £2 million of research funding, and over the next 2 years we will be designing a monitoring programme that will allow us to test for AMR in the environment. A long-term AMR surveillance programme would also help us understand the role the environment plays in this vital area.

I'm Wiebke Schmidt and I'm working on a new project to pilot surveillance for antimicrobial resistance (AMR) in the environment.

AMR exists in natural environments, but as human, animal, and agricultural activities are increasing, so does the prevalence of AMR, therefore posing a potential health risk to people, animals, food sustainability, and ecosystems. Our team sits within the Research group of the Chief Scientist's Group and brings together a broad range of expertise, which will help us understand the complex role that the environment plays in the development and transmission of AMR both into and within the wider environment.



For more information regarding this project, contact [Alwyn Hart](#)

What's happening with water?

The Environment Agency has a responsibility to report on the state of water in England and how it's changing over time. We want to use the natural capital (NC) approach to look at how we evaluate the water environment. To do this, we need:

- good quality data on the location and condition of our assets and ecosystems in England and how they change over time: where are they, how healthy are they and how are they changing?
- to be able to assess why we're seeing changes – good or bad – and how to react
- standardised information that is available to all, and clarity on where the information has come from

In 2021, we were successful in bidding for £3.6 million to design some prototype outputs under the Natural Capital Ecosystems Assessment scheme (NCEA). These will be ready by the end of March 2022. Our initial aim is to conduct some pilots testing monitoring network designs to review what works and what doesn't and make improvements to ensure the business is able to use this approach for water management scenario planning.

But this is about more than monitoring. If we want to identify and quantify change, we need to look at the bigger picture: the whole environment and what is affecting it. We need to understand the systems at work and to know how to remedy a particular situation. We need to map everything that influences it and ensure we can achieve a better environment, avoiding any unintended consequences.

For more information regarding this project, contact [Jennifer Taylor](#)

Come and gone with the wind

To protect the environment and people's health from air pollution we need to know something about the air flows that carry it. That can be difficult and expensive in remote or inaccessible places like hilly uplands. Drones can hover even in turbulent conditions so the question was, could we tap into this technology and work backwards to measure the air flows they are hovering in? We are working with experts on flight control systems at Cranfield University to see if we can do just that.

The benefits are far-reaching. For instance, we will be better able to map the movements of harmful reactive nitrogen compounds and determine where they come from, where they end up and the harm they cause to sensitive habitats. These habitats perform a range of important services, such as storing carbon, reducing flooding and providing clean water. By understanding the different contributions from air, land and water, we can act to reduce the amount reaching them. In particular, this project addresses the airflow measurement needs of a much bigger Defra project – the Natural Capital Ecosystem Assessment scheme as described in the previous case study, 'What's happening with water'.

Drones with this capability will also be useful in the built environment, to identify how air pollution disperses and so inform decisions about what action needs to be taken to protect people from its effects. We already use drones to inspect flood defences and our surveillance teams use them in their fight against criminal activity. As with most great innovation, this work aims to apply existing technologies in new ways to give us new information.



Assessing wet and dry deposition of reactive nitrogen in mountainous areas and the potential impact on water bodies. Snowdon, North Wales.

For more information regarding this project, contact [Rob Kinnersley](#)

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Environment first

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Research at the Environment Agency

This report has been produced by the Environment Agency's Chief Scientist's Group.

You can find out more about our current science programmes at

<https://www.gov.uk/government/organisations/environment-agency/about/research>

If you have any comments or questions about this report or the Environment Agency's other scientific work, please contact research@environment-agency.gov.uk.

For more information on our floods research programme contact:

fcerm.evidence@environment-agency.gov.uk.

Publications and peer reviewed papers

Publications 2021 from the Chief Scientist's Group and Flood and Coastal Erosion Risk Management research teams

Research Reports

A nation resilient to climate change

[Scoping a flexible framework for producing river water temperature projections](#) reviewed alternative approaches to modelling future river water temperature for England, helping the Environment Agency to develop temperature projections and inform measures to help adapt to a changing climate.

[Using flood risk information in spatial planning](#) analysed how information on all sources of flooding is used in spatial planning. The findings have already informed guidance for strategic flood risk assessments.

[Understanding river channel sensitivity to geomorphological changes](#) identified ways to assess and predict where river channels are affected by geomorphological change across England and Wales. This research can be used to inform resilient and sustainable channel maintenance.

[Review of groundwater flood risk management in England](#) provided evidence of current approaches to managing groundwater flood risk across England and identified where improvements could be made in practice and skills.

[Understanding effective flood and coastal erosion risk governance](#) assessed the effectiveness of current FCERM governance in England and Wales and whether it is fit for purpose for the future in the face of increasing risks posed by climate change.

[What is a coastal squeeze?](#) re-defined what causes 'coastal squeeze' and assessed the best way of managing its past and future impacts.

[Achieving Net Zero carbon emissions: a review of the evidence behind carbon offsetting](#) reviewed the evidence behind carbon offsetting, helping us to understand which approaches to focus on when developing our offsetting strategy.

[Flood and coastal erosion risk management research and development framework](#) developed a framework to determine the priorities for future research on how to work with communities to manage the risks associated with flooding and coastal erosion.

Healthy air, land and water

[An analysis of national macroinvertebrate trends for England: 1991-2019](#) presented national-scale trends in macroinvertebrate communities of English rivers over 29 years. The findings help in the evaluation of the effectiveness of management actions against the impact of changing environmental pressures.

[Understanding ecosystems and resilience using DNA](#) explored opportunities for applying advances in DNA and RNA technologies to improve understanding of ecosystem function and resilience.

[Linking the presence of invasive non-native species to measures of ecological quality](#) looked at what impact invasive non-native species have on the ecology of sites at which they are recorded.

[Satellite measurements of air quality and greenhouse gases: application to regulatory activities](#) investigated how satellite measurements of air pollutants and greenhouse gases could be applied to the Environment Agency's regulatory activities.

[A systems-based approach to catchment water management](#) explored an innovative, systems-based approach to water management.

[The nitrate leaching tool](#) estimates annual losses of nitrate at the field and farm scale using data provided by farmers during farm visits. The tool helps the Environment Agency and farmers to identify more sustainable farming practices that prevent environmental pollution.

[Poly- and perfluoroalkyl substances \(PFAS\) – sources pathways and environmental data](#) reviewed environmental monitoring data on PFAS in English rivers, estuaries and groundwater. The findings help to inform a future PFAS monitoring strategy.

[Rainfall and river flow ensemble verification - Phase 2](#) has developed a new framework to help interpret ensemble sets of forecasts of rainfall and river flow.

Green growth and a sustainable future

[Methods for sampling and analysing methane in groundwater: a review of current research and practice](#) reviewed the factors that influence variability and uncertainty in measurements of concentrations of methane in groundwater.

[Integrity of decommissioned wells: studies using integrity-related factors and soil gas monitoring](#) used 2 approaches to investigate the long-term integrity of decommissioned onshore oil and gas wells in England.

[Monitoring at shale gas sites: developing environmental quality baselines](#) applied statistical methods to environmental monitoring data from 2 shale gas sites in England to investigate how best to measure and describe the quality of the environment before activities associated with a shale gas site take place.

[Baseline studies for assessing risks to groundwater from onshore oil and gas and other deep subsurface activities](#) investigated the typical ‘baseline’ range of concentrations of substances that could be associated with onshore oil and gas and other deep subsurface activities in 3 aquifers.

[Ambient air monitoring at shale gas sites: framework for design of adaptive monitoring regimes](#) developed a framework for designing ambient air quality monitoring programmes at shale gas sites.

[Geochemical techniques to define deep thermal spring protection zones](#) reviewed the range of geochemical methods that can be used to understand thermal spring systems in the UK.

[Low carbon subsurface technologies: identifying potential environmental impacts](#) examined the potential impact of low carbon subsurface technologies on the environment, providing evidence to help regulate these technologies and prevent unintended environmental impacts in the future.

[Onshore oil and gas monitoring: a structured approach to quantifying whole-site methane emissions](#) investigated how to quantify the total amount of methane being emitted from an onshore oil and gas site.

[National waste crime survey report 2021: findings and analysis](#) provided the Environment Agency with independent metrics on the scale and nature of waste crime.

[Strengthening local investment decisions: a review of skills and guidance in flood and coastal risk management benefit and cost assessment](#) provides guidance to help practitioners undertake meaningful early benefit and cost assessments in flood and coastal risk management investment programmes.

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