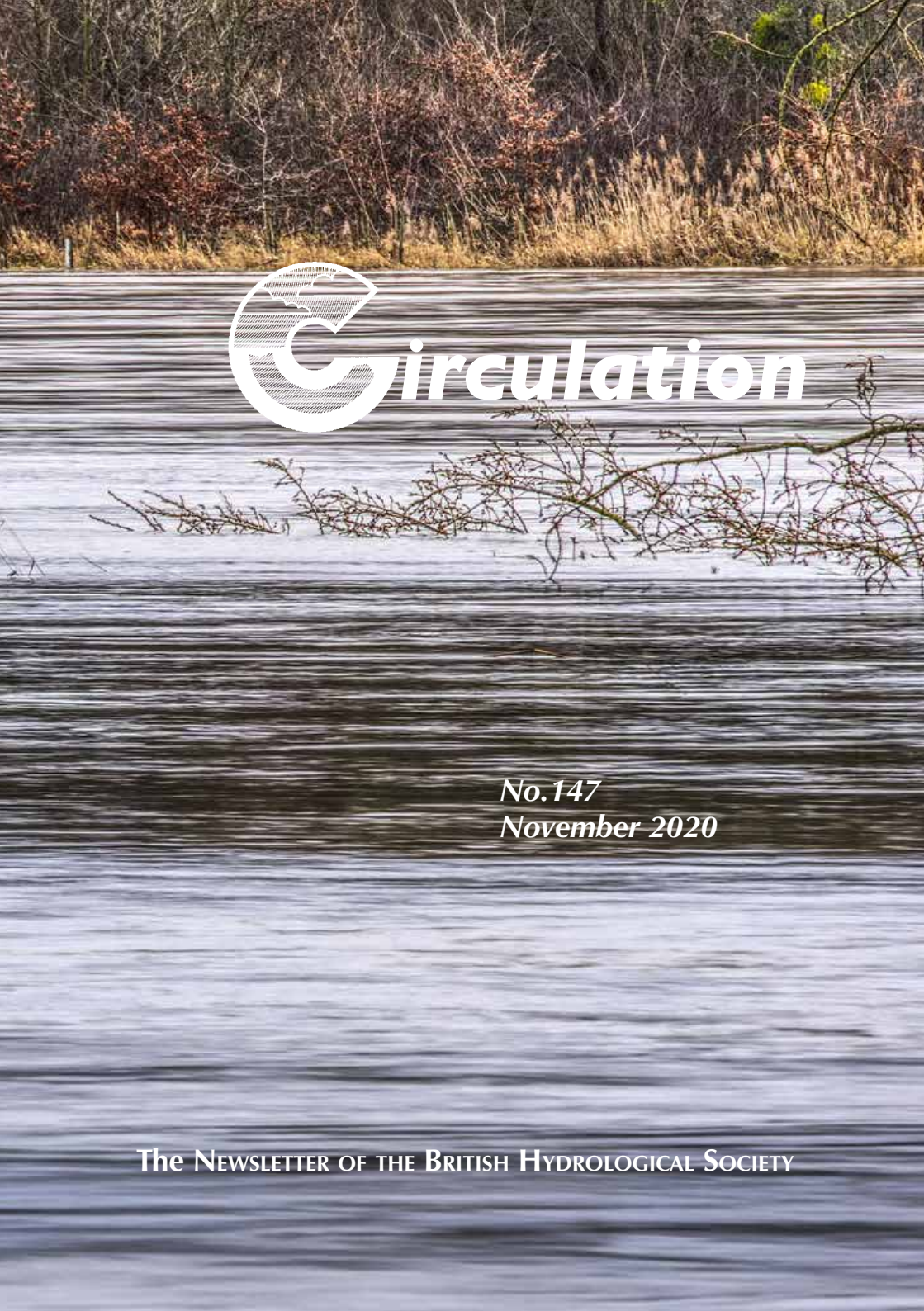


Circulation

No.147
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The Newsletter of the British Hydrological Society

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Hydrological Bulletin : August – October

Copy deadline for Circulation No. 148 6th February 2021

If you attended the webinar 'The Future of Hydrological Forecasting' by Dr Chris White you might have noticed that we did some anonymous polling to find out a bit about the diversity of the audience. We intend to undertake these polls before future events so that we can monitor diversity and inclusion in our activities, and understand if any interventions we make are having an impact, as well as helping to shape future BHS events to improve diversity and inclusion. We will report on the results of these polls in a future edition of *Circulation* alongside an action plan for improving diversity and inclusion within BHS.

BHS Diversity Sub Group

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President's Perspective

Concerns over river water quality

On 16 September, the Environment Agency published the latest data on the chemical and ecological status of rivers in England (Environment Agency, 2020). With only 14% of English rivers achieving 'Good' status for chemical or ecological quality, several NGOs raised major concerns (Wildlife and Countryside Link, 2020). Last year's publication of the 'State of Nature 2019' report (National Biodiversity Network 2019) demonstrated the continued decline in our terrestrial and aquatic ecology since the reference date of 1970. The release of the Living Planet Report 2020 on 9 September (World Wide Fund for Nature, 2020) showed that this 'ecological crisis' is global.

The headline figure of 14% does however mask decades of progress in removing many point sources of pollution to our rivers, the generally higher water quality in headwaters, and the toughening of standards following the work of UKTAG (Water Briefing, 2020a). Huge investment has already been made by water companies in reducing storm-water overflows and phosphorus discharges from sewage treatment works (STWs) with a further £5 billion of investment in water quality planned for the next few years (Water UK, 2019). Further in 2019, in an attempt to reduce agricultural impacts, Government did implement more stringent controls on the more polluting aspects of farming under the 'Farming Rules for Water' (UK Parliament, 2019).

The Government has committed to ensure that 75 % of rivers in England attain good chemical and ecological status by 2027 (The Guardian, 17 Sept 2020). Unprecedented levels of targeted interventions in the water industry, farming sector and elsewhere are going to be needed to transform 14% to 75% in the next 7 years. A 'green revolution' of investment in technological and nature-based solutions is needed to dramatically reduce the amounts of livestock waste, agrochemicals, sewer overflows and urban pollutants from entering the natural environment – if we are to 'bend the curve' of ecological decline (Tricker et al. 2020). There is a key role for the hydrological community in achieving this: first by researching and then informing society of those measures of water quality mitigation proven to be effective at the large-scale, and then by helping to implement schemes across the most intensively managed and populated parts of the country, where the problems are most acute. This will be ever more challenging as we strive to produce more of our food locally and see our population grow, alongside a water industry that is necessarily capital intensive and a farming sector already coping with large uncertainties. Effective technologies continue to be installed at STWs by hydrologists and other practitioners for removing phosphorus (BluewaterBio, 19 Jun 2020), transforming waste to useful biogas (Energy Live News, 14 Aug 2020) and preventing sewer overflows (New Civil Engineer, 18 Aug 2020). However it is considerably more difficult to demonstrate the effectiveness of measures

to reduce diffuse pollution sources at the landscape-scale (Holden et al., 2017) before they are actually deployed at a wide-scale.

The scale of the problem demands a much greater focus by research hydrologists and allied scientists on the science of pollutant transport. Increasingly UK hydrologists are aware that storm periods dominate the migration of chemical, physical and biological pollutants to our rivers: continuous, high frequency monitoring through such events is therefore, needed to quantify what is happening (Rode et al., 2016; Chappell et al., 2017). As a direct corollary, quantifying which local interventions are effective in storm periods also demands high frequency monitoring (Cooper et al., 2020).



Turbid River Kent in Storm Ciara (9 Feb 2020) © NA Chappell

Interventions will need to be intensively applied in particular localities and extensive across the wider landscape to have any discernible effect on the quality of our rivers. This will be costly – so the emerging science must be robust and clear to support the required public expenditure. The Environment Agency are doing their part by publishing their water quality data for all 12,000 monitoring sites, together with planned mitigation measures (see: Environment Agency, 2020). They have also just announced the contractor to deliver £4.5m of high frequency water quality monitoring across the country - well done to Xylem Analytics UK Ltd for winning the tender (Water Briefing, 2020b). In conclusion, restoration of our aquatic ecology needs the expertise of the British hydrological community to identify the most effective ways to mitigate water pollution and then to implement schemes within the built- and natural-environment nationally.

A year of great achievements by the UK hydrological community

The BHS Annual General Meeting on 30 September coincided with the end of the UK Water Year 2019-20. I wish to thank all BHS members for their work contributing to the UK economy, maintaining our water supply, sewerage and flood mitigation infrastructure, enhancing water policies and practice, conducting valuable research, and training the next generation of water scientists and engineers – all at a time of great personal and national challenges.

So many of our community deserve acknowledgement of their achievements. At the AGM we able to acknowledge just a few of you. We awarded John Curtin (Executive Director of Flood & Coastal Risk Management, Environment Agency) the BHS President's Prize 2020 for his visionary and inspirational contribution to the ground breaking 'National Flood & Coastal Erosion Risk Management Strategy for England' (published 14 July 2020). We also recognised early career

hydrologists. We judged that the most outstanding undergraduate dissertation submitted to our annual competition was 'Assessing the transfer of heavy metal contaminants from Yewthwaite lead mine into the Newlands catchment area' by James Lockwood while he studied at Durham University. We had received 15 strong projects for the competition, and felt that the project of Ryan Pigott also showed some outstanding elements. We awarded Ryan the Runner-up prize for his study on 'The effect of broad-crested weir geometry on downstream channel hydraulics: a coupled physical-mathematical modelling approach' while at Leeds University.

Twenty-nine individuals submitted academic cases for financial support for hydrology masters' study at a UK university. The sub-committee, comprising of BHS, Environment Agency and JBA Trust representatives, made awards to 12 individuals: Caitlin Asquith (University of Chester); Amber Bentley (Newcastle University); Ewan Cronin (Lancaster University); Samuel Dickens (University of Birmingham); Adam Hartley (University of Leeds); Lauren Hunt (University of Birmingham); Rachael Hurst (Lancaster University); Eleisha Lord (Newcastle University); Emily Seabrook (Imperial College London); Joshua Thompson (Loughborough University); Megan Trussler (Loughborough University); and Phillip Wadley (Lancaster University). We wish them success in their studies.

Over the last year, officers and representatives of the Society delivered many new initiatives and hard work for our membership - I am indebted to all for their support. In particular, I would like to pay tribute to those completing their term of office for the Society. Thank you to elected committee member Matt James (Stantec UK Ltd) for his valuable contributions including leadership with the undergraduate dissertation competition, and Nick Kettridge (University of Birmingham) for ably representing the Midlands section. Particular appreciation goes to Mike Cranston (Scottish Environment Protection Agency, and formerly RAB Consultants) for working tirelessly as BHS Honorary Secretary, delivering a programme of very rewarding meetings – latterly as the BHS Webinar Series where attendance has exceeded 200.
Peter Ede (Mott MacDonald Group) completes 10 years of leadership within the Society as he finished his term as BHS Past President. I am personally very grateful to Peter for his considerable insight and support during my time on committee.
In recognition of Peter's profound contributions to the Society and our Membership, the BHS Main Committee agreed unanimously to award him BHS Honorary Membership at its meeting on 7 October 2020. Thank you Peter!



We were able to announce at the AGM three new elected members to the BHS Main Committee. We warmly welcome Emily Fowler, a senior flood risk specialist working for Mott MacDonald Group. The Midlands section is again well represented by Emma Neachell of the Environment Agency – welcome Emma. Lucy Barker, a hydrological analyst at the UK Centre for Ecology and Hydrology (UKCEH), was elected as BHS Honorary Secretary building on her already substantial contributions as an elected ordinary member of committee. I am similarly delighted that Hayley Fowler, Professor of climate change impacts at Newcastle University, has been elected to the post of BHS President Elect. Hayley is no stranger to the committee, serving as Hon Secretary from 2006 to 2008.

Lastly, I would like to thank you for your engagement with our BHS Webinar Series, your contributions to BHS Circulation, our mailing list and social media, and of course for your promotion of hydrology and hydrologists nationally and internationally.

Nick Chappell
President
October 2020

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38th Annual General Meeting
30th September 2020
held on-line via Zoom

The 38th Annual General Meeting was held virtually via Zoom and as part of a series of lunchtime webinars. The only apology for absence was from Adam Comerford (CIWEM representative) and no corrections were needed for the report of the 37th AGM published in *Circulation 143*.

President's Report

Dr. Nick Chappell (President) opened this section by highlighting that it's been a challenging six months for members of the society but that the key work performed by hydrologists continues to make a difference. The Society has had to adapt to the postponement of in-person meetings during 2020 and has consequently hosted a series of virtual meetings (see the Honorary Secretary report). Plans for the 14th BHS National Symposium continue with many contributed ideas for sessions. The Symposium will now take place on 7– 9September 2021 at Lancaster University.

Circulation, the Society's newsletter, continues to be published digitally and in print and thanks to all contributors and to the editor Celia Kirby for making this possible. Our partners continue to be the ICE, who provide financial and membership management support, UKCEH, who in 2019 became an independent non-for-profit organisation, and *Hydrology Research*, the Society's journal.

Some initiatives for members over the last 12 months include the re-introduced concessionary membership fee for our highly experienced and valued retired members. This was endorsed by the overwhelming support to change the BHS Statutes (see *Circulation 145*). Entry on the Register of Consultants which is available on the Society's website was also made available for free from 1 January 2020. More enriched education and career pages have been introduced on the Society's website.

The BHS working group on Future of UK Hydrological Research, led by Professor Keith Beven, continues to be active. A paper written by the group on *developing observational methods to drive future hydrological science: can we make a start as a community* was published in the journal *Hydrological Processes* and the next white paper is open for comments by BHS members.

The Society's social media presence continues to grow thanks to committee members Lucy Barker and Michael Pollock. During the past year we have seen the introduction of a new LinkedIn organisational page and a YouTube channel sharing our online webinar meetings.

The Society continue to support MSc/MRes studentships with additional support from JBA Trust and the Environment Agency. This year we received 29 applications and awarded 12 studentships. Once again we also awarded prizes for undergraduate dissertations. This year the first prize is awarded to James Lockwood (Durham University) for his dissertation on assessing the transfer of heavy metal contaminants from Yewthwaite lead mine into the Newlands catchment area. A Runner-up is awarded to Ryan Pigott (Leeds University) for his dissertation on the effect of broad-

crested weir geometry on downstream channel hydraulics: a coupled physical-mathematical modelling approach.

The President's Prize is awarded in recognition of a formative paper, report or work which has advanced hydrology significantly. This year this prize is awarded to John Curtin (Environment Agency) for his contribution to the National Flood and Coastal Erosion Risk Management Strategy for England. John's vision and inspirational leadership in developing and delivering this ground-breaking strategy document was vital.

Honorary Secretary's Report

Michael Cranston (SEPA) reported on the Society's activities in bringing together members in our programme of scientific meetings. The Society's last physical meeting was a one-day conference on flood forecasting: developments in science and application held at the ICE in London. Over 80 delegates from the UK and across Europe attended the meeting which had 14 presentations on science developments, operational aspects and future aspirations.

As highlighted by the President, the Society have had to adapt to the restriction on in-person meetings during 2020. As a result, we have organised a series of four webinars on the future hydrology in a changing environment, taking place monthly throughout the autumn. The first by Nick Everard on hydrometry for a climate emergency was hugely successful and attended by 200 delegates. This new format offers an excellent opportunity for how we may wish to host future meetings of the Society. Looking ahead, we have further themes for webinars in early 2021 including rainfall measurement techniques and citizen science in hydrology.

The 14th BHS national Symposium is set to take place in September 2021 and the Peter Wolf Early Career Hydrologist Symposium is being organised by the University of Strathclyde but no confirmed date as yet.

Honorary Treasurer's Report

Scott McGrane (Strathclyde University) presented the financial activities of the Society. Financially, BHS is as healthy as it's ever been. On the surface, income this year is down significantly on last year. Subscriptions have dropped slightly on last year, but the main factor is loss of income from national meetings and the BHS symposium (which obviously did not take place). The picture is improved significantly by a generous bequest from Janet Wolf early in the 2019/2020 financial year.

An area of concern is the loss of income from job advertisements on the site. This may reflect the changing nature of the way firms recruit and advertise positions, with options that reach wider audiences (e.g., LinkedIn, Twitter, jobs.ac.uk, mailing lists), many of which provide recruiters with free advertising, all compounded by economic devastation in Q1 and Q2 of 2020…..something we may need to address or rethink going forward!

The cancellation of all major national and international events meant no travel grant activity (last awards were made for AGU 2019). Expenses across the board have been significantly reduced. The Committee have moved to online meetings since January, as have all regional and national events. The decision to end paper-inserts with *Circulation* improved our environmental footprint and associated costs. While a programme of events have continued, the overheads associated with in-person events have reduced accordingly.

A key area of investment has been a society-wide licence purchased for Zoom, enabling hosting of regional and national events of up to 500 participants. This will transcend Covid and enable greater access to BHS meetings (including members with caring responsibilities, disabilities, intense workload schedules or no way to finance attendance).

Popularity of the MSc scheme (29 applications), combined with exceptional quality of candidates the meant funding an additional 2 studentships this year (with increased contributions from all 3 partners). In total, 12 awards (£1500 per awardee) were made – congratulations to all the recipients, and on behalf of BHS's membership, may I wish you well in your studies this upcoming academic year! Rachael Hurst (Lancaster University), Ewan Cronin (Lancaster University), Caitlin Asquith (University of Chester), Adam Hartley (University of Leeds), Eleisha Lord (Newcastle University), Emily Seabrook (Imperial College London), Lauren Hunt (University of Birmingham), Amber Bentley (Newcastle University), Megan Trussler (Loughborough University), Joshua Thompson (Loughborough University), Phillip Wadley (Lancaster University), Samuel Dickens (University of Birmingham).

Membership of the BHS Main Committee

The Society gratefully acknowledges the contribution of people completing their terms of office, including: Peter Ede - invaluable contributions & support suring this year as BHS Past President; Matt James providing great leadership with dissertation prizes; Nick Kettridge, Midlands representative replaced by Emma Neachell (Environment Agency) and Michael Cranston – whose term as BHS Honorary Secretary is completed with this meeting.

Michael Cranston
Honorary Secretary 201—202

Changes to the Main Committee

Hayley Fowler, President Elect



Prof Hayley Fowler is Professor of Climate Change Impacts in the School of Engineering at Newcastle University. As a previous Hon. Sec, (2006–8) Hayley is not really a 'New Member', and it is a great pleasure to welcome her back to the Committee. Her research at Newcastle focuses on improved physical understanding of changing precipitation extremes, droughts and floods, and bridging the gap between climate modellers and users of climate scenarios. She is Fellow of the American Geophysical Union (2018) and a Royal Society Wolfson Research Fellow (2014-19). She leads the GEWEX Hydroclimatology Panel sub-daily precipitation cross-cut, is Chief Editor of Frontiers in Interdisciplinary Climate Studies. She is a Contributing Author to the Water Cycle and Extremes Chapters for the WGI IPCC 6th Assessment Report and the UK 3rd Climate Change Risk Assessment.

Lucy Barker, Honorary Secretary



Lucy is a Hydrological Analyst at the UK Centre for Ecology and Hydrology in Wallingford. The main focus of her role is droughts, including drought characterisation and improving drought monitoring in the UK and around the world, working on projects in China, Thailand and India. She is part of the National Hydrological Monitoring Programme, writing and producing the Hydrological Summary for the UK as well as reporting on extreme events, and contributing to the development and update of the UK Water Resources Portal. Lucy is part of the WMO expert network and is contributing to the development of a global hydrological status and outlook product, HydroSOS. Lucy has been on the BHS Committee for the past three years in the position of Ordinary Member, contributing to the communication and diversity sub-groups. She is pleased to be able to continue contributing to the Society in the role of Honorary Secretary as well as taking forwards the positive steps BHS is making to improve both diversity and equality, and engagement and presence on social media.

Emily Fowler, New member



I am a Senior Flood Risk Specialist working for Mott MacDonald, with over 14 years' experience in the flood risk and flood risk management field. I have a particular interest in the development and use of hydraulic and hydrological models for the assessment and understanding of flood risk both present and future, as well as developing sustainable solutions to manage flood risk. A robust hydrological analysis of flood events is fundamental to the understanding and management of flood risk both now and in the future.

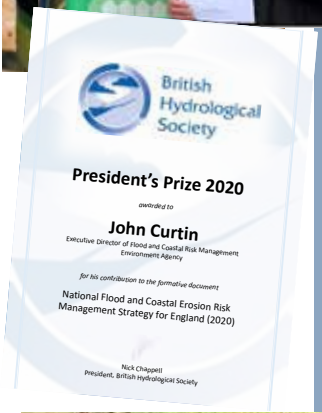
New members

Hayley Carnfield.....Pudsey
Harold Leung.....Preston
Abigail Dent.....Eye
Maria Dancel..... Reading
Rachel Hurst.....Stoke-onTrent

The President's Prize

The award for 2020 went to John Curtin, the Executive Director of the Environment Agency's National Flood Control and Coastal Erosion Strategy in acknowledgement of his leadership and the recently published strategy document with its far-reaching proposals to create a nation more resilient to future flood risks.





This strategy sets out a long-term objective to ensure all infrastructure investment (road, rail, water and power supplie) is resilient to future flooding and coastal change. This includes expert advice on how infrastructure providers can hopefully mitigate disruption to peoples' lives and livelihoods. The Environment Agency is to develop an action plan with partners for taking forward the strategy, to be published by April 2021. The next review of the strategy is planned for 2026.

The Strategy document notes that the UK is a world leader in the research and innovation of flood and coastal risk management, which surely emphasises that there is bright future for hydrologists for many years to come. – Ed.

Congratulations to the winners of our 2020 Student Prize

We are delighted that this year's entries were of the usual high standard. First place was awarded to **James Lockwood** , Geography Department, Durham University for his disseration (see abstract below) on the trasfer of heavy metal contaminants from Yewthwaite Lead Mine into the Newlands catchment area".

The runnerup was **Ryan Pigott** , School ofGeography, Leeds University, considering the effect of broad-crested weir geometry on downstream channel hydraulics using a coupled physical-mathematical modelling approach.



Abstract

Abandoned metal mines contaminate more than 12,000 km^2 of catchments in northern England alone and drive failures in water quality standards across the UK. Historic mine wastes containing

toxic concentrations of heavy metals can remain contaminated for hundreds of years and are often highly vulnerable to erosion, accumulating downstream in rivers and lakes where they damage ecosystems. Although the Environment Agency and the Coal Authority are working to combat this issue though the River Basin Management Plan, thousands of abandoned metal mines continue to disperse potentially harmful elements into aquatic environments.

Yewthwaite Lead Mine is an abandoned mine in the contaminated Newlands Beck catchment of the Lake District National Park, an area with multiple potential point sources of pollution. This study incorporates a pXRF survey, uses time-integrated mass flux samplers, geochemical fingerprinting, Structure-from-Motion photogrammetry, and diffuse pollution risk mapping in order to characterise the nature of contamination at Yewthwaite Lead Mine and establish the impact of downstream heavy metal dispersal on potentially harmful element concentrations in Newlands Beck.

The pXRF survey revealed Pb and Zn concentrations of up to ~35,000ppm and ~55,000ppm respectively, while suspended sediment sampling recorded in-sediment concentrations in excess of 23,000 ppm for Zn; 7,000 ppm for Pb; and 1,400 ppm for As.

These values are up to 245 times greater than current soil and sediment guidelines. Geochemical fingerprinting indicates that the connectivity of contaminated source areas within the study area is highly dependent on flow rates, which leads to a complex relationship between downstream sediment contamination levels and flow rates. However, in-channel sediment contamination remained elevated, in relation to guideline values, at all flow rates during six months of sampling.

The results of this investigation indicate that Yewthwaite Lead Mine is exporting potentially harmful elements at concentrations that elevate downstream contamination in Newlands Beck far beyond the threshold at which adverse biological impacts are expected in aquatic ecosystems.

Authors required!

Dr Harvey Rodda, Director of Hydrology, Hydro-GIS and an Associate Professor at UCL Dept of Earth Sciences, is currently looking for author contributions for a new book 'The impact of climate change on global flood risk' which will be published by World Scientific Publishing. This will be part of a series of review volumes looking at the impact of climate change on natural hazards and intended for undergraduates, post-graduates and researchers. The book length will be approximately 300 pages, each chapter being a specific case study with the aim of including a wide range of studies to give a global coverage.

- Evidence of climate change in recent flood events
- Coastal Flooding
- River Flooding
- Surface Water
- Ground Water Flooding

Anyone interested in this opportunity can complete the contact form on the web page: **Chapter Authors Required - Hydro-GIS** or email at i**nfo@hydro-gis.co.uk.**

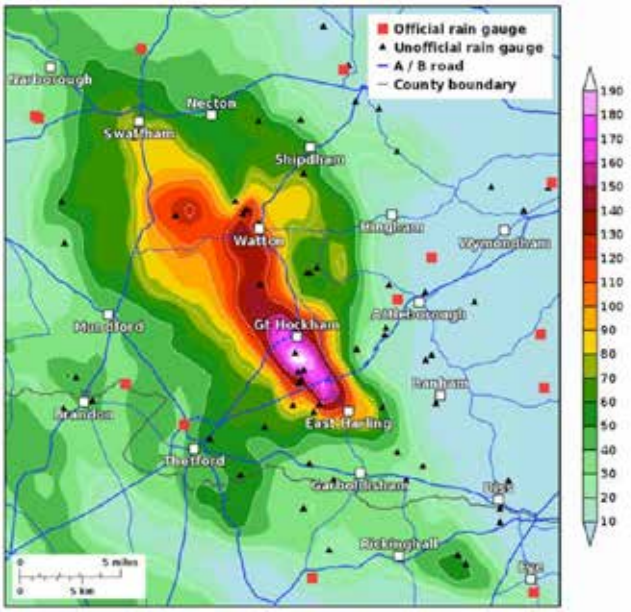
Contributions are requested by January 2021.

South Norfolk Storm of 16 August 2020

by James Dent (Retired Consultant), Dan Holley (Weatherquest) & Colin Clark (Charldon Hill Research Station)

A major storm rainfall event occurred over an area of south Norfolk, east of Thetford, in the afternoon of Sunday 16 August 2020. The storm had a highly active, localised focus near Great Hockham, over an area of largely agricultural land in the Breckland.

A maximum rainfall of 197mm was reported, with at least 10 other measurements exceeding 100mm.



The falls of rainfall were confirmed by radar coverage, which also recorded some extreme rainfall rates. The duration of the heaviest rainfall was about 2.5 hours. The storm therefore ranks alongside previous extreme storm rainfalls that have been noted in published lists of the major events in the UK since the start of the 20th century, seven of which took place in Norfolk.

Apart from reports of bad driving conditions and localised road flooding, there was little in the way of major flood impacts. Marked flood peaks were recorded at nearby river gauges in the upper reaches of the Thet and Little Ouse rivers. These peaks dissipated in a relatively short distance downstream, and no flood damage has been reported in the news media. However, the authors have undertaken their investigation of the event, as they consider it deserves attention on rainfall depth and intensity alone. As well as the absence of any reported physical impacts, heavy falls have not been recorded by the network of "official" rain gauges (Met Office and Environment Agency).

In the past, meteorological considerations would have been sufficient for the event to feature in records such as British Rainfall but today no such unified information source exists. Addition of this event to existing lists of maximum storm events in the UK would be useful in updating drainage and flood protection design.

The authors propose to submit a detailed account of this incident for publication in the refereed literature – Ed.

Measurement of Rainfall Accumulation, Rainfall Intensity and the implications for the UK of New European Standards

Introduction

On 19 August 2019, European Standards were released detailing "the measurement requirements and classification of rainfall intensity measuring instruments". The British Standards Institution (BSI) formally recognised this Standard on November 6th 2019, by publishing an identical text under the auspices of BSI (2019). The document highlights international efforts to deliver an important step change in classifying the accuracy and integrity of rainfall intensity measurements, which are often poorly understood by consumers of rainfall data more accustomed to dealing with rainfall accumulation measurements.

What do the Standards involve?

The new standard outlines a consistent process for classification of catching-type rainfall intensity gauges under laboratory conditions. It will allow users to buy and use a rainfall intensity gauge knowing that it will perform to a specific class of performance before it is deployed in the field. A rainfall intensity gauge shall be attributed a class of A, B, C or '*not classified*', based on how it performs when tested on a dynamic calibration rig, which uses consistent water flows to simulate equivalent rainfall intensities.

The rainfall background: Accumulation *versus* Intensity

There are two primary quantities of interest when measuring rainfall: accumulation and intensity. Rainfall accumulation is historically the most common type of measurement and is typically reported in millimetres. It is useful in many applications, such as water resources management and traditional flood risk management practices. Rainfall accumulation is often measured over timescales ranging from 10-minute totals to monthly. Rainfall intensity is the rate at which accumulation occurs and is reported in mm/hr. In one sense, the intensity can be derived from the measurement of accumulation to produce an averaged rain rate, but this restrictive hypothesis assumes a constant rainfall over the accumulation period. It is not the same as performing a direct measurement of rainfall intensity.

Rainfall intensity varies greatly over short durations in time and space. Accurate quantification of this parameter requires measurements to be reported at a resolution of one minute as recommended in these standards but acquired at even higher resolution timescales, e.g. 1-second. Modern applications increasingly rely on real-time or near-real-time measurements of rainfall. For example, transport safety systems, urban hydrology and flood forecasting in flashy catchments all rely on fine resolution near-real-time rainfall intensity measurements in order to provide or help manage valuable services. Many of the same devices deployed to measure rainfall accumulation, such as the tipping bucket rain gauge, do have the capability to measure rainfall intensity accurately. However, in the absence of any authoritative national or international

guidance documents prior to the publication of these standards, such devices are neither calibrated appropriately, nor is the recording strategy adequate to return accurate measurements.

Why are the Standards necessary, and why now?

The Standards referred to in this article represent the culmination of nearly two decades of work undertaken by National Rainfall Laboratories in France, Italy and the Netherlands. Two rigorous intercomparison campaigns were led by the WMO-supported Lead Centre on Precipitation Intensity based in Genoa, Italy. The reports published from the laboratory and field-based intercomparisons provide the basis from which the European Standards were developed.

Understanding the impact of climate change on rainfall patterns has progressed rapidly over the past two decades. The resulting effects of more intense rain events are being felt in many places around the world, causing an increase in damage and loss of life due to flooding from intense rainfall. This is a driver for the increased scrutiny on short-duration rainfall measurements.

Without international standards directing how rainfall intensity measurements are quality checked, there is legitimate concern over the homogeneity and interoperability of current short-duration rainfall data from around the world. Therefore, when examining historical records great care must be taken to understand the method of data recording, the measurement technology and corresponding error profiles of the instruments used. If these are not properly accounted for, short-duration rainfall intensities may be underestimated or exaggerated with, for example, potentially adverse impacts on design criteria for urban development and flood defence schemes. When unquantified environmental sources of error such as wind-induced undercatch are added to instrumental and calibration errors, there is an additional risk of degrading the quality of the data by an unknown extent (Pollock *et al*., 2018). Errors are inevitable when undertaking any measurement, but the most important issue is to understand the uncertainties that are introduced by the measuring process so that they can be appropriately managed.

What does the future hold?

With rapid advances in sensor technologies, availability of crowdsourced personal weather station measurements and innovative methods of measuring rainfall as a by-product of another service, such as satellite links and car windscreen wipers, there is an opportunity to enrich information provided by existing rainfall networks with a greater depth of spatial and temporal rainfall data. When coupled with advances in data science and computing through machine learning and artificial intelligence, there is great potential to produce more useful rainfall products. However, there are huge challenges with collating, processing, verifying and validating such variable data sources, each having different error characteristics. The only way that this can be done effectively is to create and properly maintain as large a network as possible of reference quality instruments to provide highly accurate and precise rainfall measurements. This involves using the most advanced rainfall sensing technology, calibrated to the highest standards, located in a reference pit with the rain gauge orifice below the ground surface. Note that even with this ideal

configuration, it remains critical to also have a strong understanding of residual errors and uncertainties.

Having made the case for a strong reference network, it is important to outline that it is also necessary to evolve measurement practices to start to assimilate new information. This is particularly important in the context of more extreme rainfalls occurring over increasingly localised areas. The total combined area covered by rain gauges in the world is less than the size of a football (soccer) pitch (Kidd *et al*., 2017), so there is already a high (and increasing) probability that localised storms will not be detected by these devices. There is a resulting demand for additional spatial rainfall information, even if the rainfall quantities measured by different technologies are subject to significant errors.

The impact of improving the spatial extent of rainfall measurements on life-saving applications such as flood warning is likely to be significant, so it is critical that greater effort is invested in mining other sources of data to yield useful rainfall information.

Michael Pollock,
Water Engineer at Arup

References

British Standards Institution (2019) BS EN 17277:2019: Hydrometry. Measurement requirements and classification of rainfall intensity measuring instruments. Available at: https://shop.bsigroup.com/

Hydrological expertise

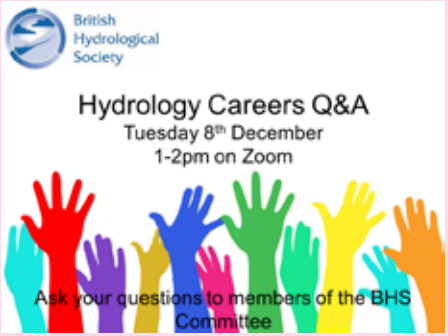
Where do you go to get information and advice on 'things hydrological '?

Enterprising members of the public faced with watery problems do sometimes contact us with queries such as where or how they can respond to requests for hydrological surveys in connection with planning submissions or their concerns over irregular behaviour observed in local small water courses.
General advice and comments are obviously freely given, including pointing to the Consultants page* on the web for professional contacts.

We should like to enlarge the usefulness of this listing for our own community by including links to other organisations that have skills/ services /products relevant to hydrological concerns. Therefore, may we ask members to consider whether their own organisations should be listed and if so, to discuss this with colleagues with a view to submitting some appropriate text.

Celia Kirby

*there is no fee for entries on this page



If you are interested in a career in hydrology, ask our experts for advice on Tuesday 8th December from 1–2pm. There will be short introductions from our BHS committee members whose careers span a wide variety of sectors, from academia to industry followed by a careers advice Q&A where we'll be throwing the floor open to you. Look out for sign up details which will be available soon.

Panel members include:
Prof Hayley Fowler (Newcastle University), Lucy Barker (UKCEH), Dr Michael Pollock (ARUP), Mason Durant (HR Wallingford) and Emily Fowler (Mott MacDonald).

If you would like to submit questions in advance of the session (anonymously if desired), then please email them to Elizabeth Lewis (Elizabeth.lewis2@ncl.ac.uk).



If you missed any of the
"**Future Hydrology in a Changing Environment**"
webinars over the last three months, you can catch up and watch them on our YouTube channel.
We currently have five BHS webinars you can watch:

- Hydrometry for a Climate Emergency – Nick Everard (UKCEH)
- Historic Droughts: Using the past to inform the future – Lucy Barker (UKCEH)
- The Future of Hydrological Forecasting – Dr Chris White (University of Strathclyde)
- BHS Pennines: Overview of the winter 2019-2020 flooding in Yorkshire – Richard Maxted (Environment Agency)
- BHS Pennines: National Hydrological Monitoring Programme Update – Katie Muchan (UKCEH)

These five videos have been viewed a total of 860 times. We will continue to add future BHS webinars to the channel. You can subscribe to the channel to be notified when a new video has been added by clicking 'Subscribe'.

Lucy Barker
BHS Honorary Secretary

BHS Webinars on our YouTube Channel

BHS Webinar: 26 August

"Hydrometry for a Climate Emergency"

Over 200 attendees joined this invigorating presentation emphasising the importance of hydrometry – in life as well as in hydrology! The speaker, **Nick Everard** (UKCEH), delivered an enthusiastic pitch in support of new techniques for measuring river flow to augment established methods. A key takeaway from this presentation was Nick's observation that river flows during extreme events are increasing due to climate change resulting in traditional methods becoming overwhelmed, expounding the need for new thinking in this space.

Nick started the presentation by linking back to last year's "Celebrating Hydrometry" event, held at the headquarters of the Institute for Civil Engineers (ICE) in London. With the provocative line "Have we broken the climate..?", discussion of the apparent increases in extreme flood and drought events throughout 2020 served to emphasise the importance of fresh water in society. Therefore, measuring it accurately is critically important.

The next set of slides showed engaging visuals of instances where traditional flow measurement techniques have become overwhelmed and extremely dangerous to people operating the equipment. This emphasis on a lack of safety led to the advocation of "non-contact" instruments to measure flow, where operators and instruments are not in contact with or near to dangerous water flows.

Image-based velocimetry was discussed, where cameras are used to capture features in successive frames and image processing algorithms are used to calculate the displacement. The surface velocity is calculated from the displacement and the time between successive photographs. Recent innovations include the use of these cameras on drones flying above the river. A range of different software has been developed to process these data and produce surface velocity measurements, with discharge being calculated based on knowledge of the river's geometry. Nick demonstrated user-friendly software produced by Kobe University. The Environment Agency (EA) are working with Newcastle University on a project on flooding from intense rainfall, where eight fixed camera-based monitoring stations have been installed.

Other non-contact techniques discussed included thermal imaging, surface velocity radar, satellite imagery from space. These techniques have potential for accurate measurement but there are technical and cost-related challenges to overcome. Validation of each method using established techniques is also critical. Nick also mentioned some non-contact techniques to measure rainfall, such as using the sensors in cars and from the attenuation between a mobile phone and network mast.

The irreverent delivery style resulted in an engaging presentation on one of the most critical aspects of hydrology. Accurate measurements of flow and rainfall underpin hydrological science and

practice, so this presentation was a refreshing look at new innovations. With a heavy focus on river flow, looking ahead into 2021 perhaps there is both opportunity and interest for a comparable presentation focusing on recent innovations in rainfall measurement…?

Michael Pollock

BHS Webinar: 30 September

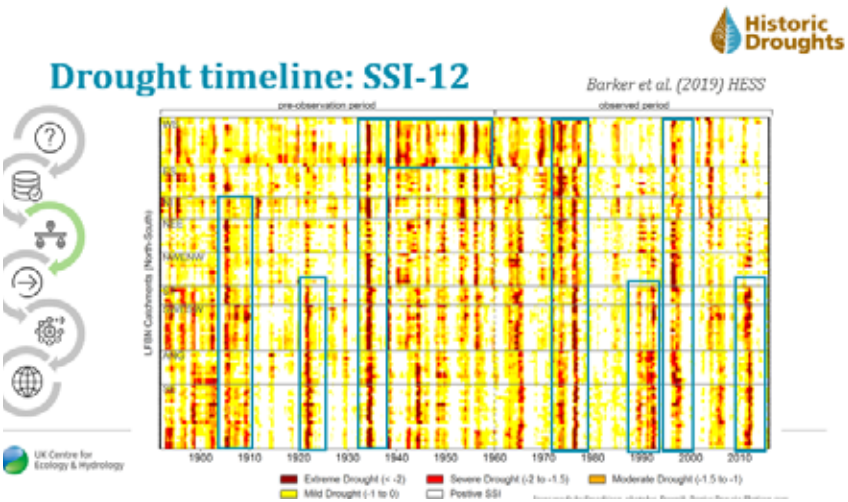
"Historic Droughts: Using the Past to Inform the Future"

The second in the series of BHS lunchtime webinars on Future Hydrology in a Changing Environment preceded the AGM on 30th September 2020, and with over 270 of us virtually tuned in, set a new attendance record at a BHS event! **Lucy Barker**, who is a Hydrological Analyst at UKCEH and Honorary Secretary of BHS, gave an illuminating talk on Historic Droughts: Using the past to inform the future. UKCEH developed hydrological drought reconstructions for the Historic Droughts project, which ran for four years (ending in 2019) with eight contributing institutions.

Droughts are complex, compound events (e.g. meteorological, soil moisture, hydrological, socio-economic) and an ongoing issue, with future projections suggesting they will become more frequent and more severe. To build our resilience, we need to improve our understanding of the variability of hydrological droughts that happened before the development of the flow monitoring network in the 1960s. However, information on such events, such as the so-called Long Drought of 1890–1910, and those in 1921–1922, 1933–1934 and 1959, is limited to documentary sources, a handful of long river flows records and some regional reconstructions, with no consistent catchment-scale historical drought analysis of the UK.

Historical flows were reconstructed using a hydrological model (GR4J) driven by rainfall and potential evaporation (PE) data. Existing rainfall records, starting in 1910 and extended back to 1872 by a Met Office data rescue project, were used to produce gridded datasets of daily rainfall and Standard Precipitation Index (SPI), and gridded daily PE reconstructed for 1891–2015 using temperature-based equations. River flows were modelled for 330 catchments and an ensemble approach taken to account for uncertainty, with the best performing 108 catchments used for flow reconstructions that extended observations by on average 75 years. Model performance was best in the south west, and poorest in north east Scotland and East Anglia due to snowmelt and abstraction, respectively.

Drought events were identified as those in which the Standardised Stream Index (SSI) dropped below a threshold of –1.5 (severe drought) and characterised using four metrics; duration, accumulated deficit (∑SSI), mean deficit (accumulated deficit divided by event duration) and maximum intensity (the minimum SSI during the event). The SSI was calculated for a 12– and 3–month accumulation



period.

The 12-month accumulated deficit for the whole dataset (catchments grouped by region along the y axis) revealed widespread drought in the 1930s, 1970s and 1990s, and regional events, for example, in the south in the 1920s. Shorter, seasonal droughts were seen on similar plots using 3-month accumulation deficits.

The dynamics of the drought events and their regional patterns were revealed by ranking the drought metrics. Across the country as a whole, the Long Drought ranked highly for accumulated deficit, but lower for mean deficit, whilst the 1930s conversely, as a shorter more intense event, ranked higher for mean deficit. Regionally, 1976 was a high-ranking event for accumulated deficit in the south, and 1990–1992 on the east coast. Intensity was highest across the south and east of England in the 1920–1922 drought, and in the west in the 1930s.

The reconstructed SSI time series allows detailed inspection of these early events, tracking the development of droughts with time and across the country, with potential application in the assessment of drought trends & seasonality, spatial coherence and climate change, as well as improving the context for seasonal forecasting and water resources stress testing. More immediately, the methods have been incorporated into the UKCEH Water Resources Portal, to allow comparison of near-real-time rainfall, flows, soil moisture, groundwater level, SSI & SPI with recent events. For example, the hydrological situation in the summers of both 2018 and 2020 drew comparisons with 1976, but were in fact more comparable with 1984.

The data, tools and drought inventory arising from the Historic Droughts project – all openly available – help us as a community to improve our assessment of the current hydrological situation, of future droughts as they develop and of drought risk in a changing world. For more information see the project website https://historicdroughts.ceh.ac.uk/.

Cath Sefton, UKCEH

BHS Webinar: 28 October

"Hydrological forecasting: sharing a vision for the future"

Christopher White, Head of the Centre for Water, Environment, Sustainability and Public Health at the University of Strathclyde provided the third in the series of webinars on future hydrology in a changing environment. Over 200 delegates attended this session by Chris on the future of hydrological forecasting.

With considerable experience of ensemble and impact-based forecasting at the Australian Bureau of Meteorology and more recently research at Strathclyde, Chris provided an insightful introduction to hydrological forecasting. Examples of how ensemble forecasting techniques are applied included the European Flood Awareness System (EFAS) that produces probabilistic streamflow forecasts at the pan-continental scale and the 7-day ensemble streamflow forecasts utilised in Australia.

Chris posed the question of where we might be heading given that hydrological forecasting approaches are now well advanced. He highlighted that some of the current opportunities exist in the sub-seasonal to seasonal (S2S) forecasting range and it is this space which is growing within the scientific community; the 10–30 day forecast range potentially opens up forecasts to new users including those making decisions around humanitarian aid. Additionally, the energy generation sector could benefit from the use of hydrological ensemble forecasting at the sub-seasonal range.

The presentation emphasised that part of the focus should be about bringing together the meteorological and hydrological communities to provide better forecasts and particularly at longer timescales. Also, Chris made the point that for the growth to be successful it is important to understand what decisions could be made and what are the end user requirements.

The point of better decision making made the link to the second area of opportunity for hydrologists in the use of Impact-based forecasting. Chris highlighted that building a risk model that captures exposure and vulnerability or the consequence of an event is key to improved decision making. The concept of end-to-end forecasting for surface water flood forecasting was given as an example and how we need to understand the impacts of our forecasts which are critical to the success of this approach. Chris made the point that as hydrologists we could learn from other hazard forecasting such as for heatwaves where impact-based systems are more advanced.

What approach should we take? In concluding, Chris commented that crucially users need to know when and where impacts will occur; and that we need consistency across hazards, time and space through an interdisciplinary approach.

Michael Cranston,
Flood Forecasting Lead,
SEPA

BHS Hydro Profiles Questionnaires

*Thank you to **Rosanna (Rosie) Lane** for completing a Questionnaire!*



How did you become interested in hydrology?

I first became interested in hydrology during my undergraduate geography degree at the University of Bristol. I found many of the lectures fascinating, and especially enjoyed learning about hydrological modelling. I explored this further in my master's degree, and enjoyed it so much that I decided to continue further with a PhD

What is your current job?

I am a research associate hydrological modeller at the UK Centre for Ecology and Hydrology (UKCEH). I am currently working on multiple projects within this role, including 1) analysing climate change impacts on hydrological extremes across Great Britain, 2) exploring how land-use changes have modified river flows using the CLASSIC hydrological model, and 3) acting as a National River Flow Archive (NRFA) representative which involves validating river flow data before it is uploaded to the NRFA website. As a research associate I also have time to spend on training and development.

What is your dream job?

I would like to say that I am currently in my dream job! I always wanted a role that was varied and challenging, where I was doing something that would have a positive impact. In my current role I am always learning, and I enjoy the variety that I have working on multiple projects. However, if I could change anything then I would love to try out some field work and spend less time behind a computer screen and more protecting the environment. I think I'd always need to do something that has a connection to the natural world.

What, or who, has helped you get to this point in your career?

My PhD supervisors have definitely helped me get to this point. I couldn't have completed my PhD thesis without their guidance and enthusiasm.

Do you have a favourite river? Why is it your favourite?

The River Otter, which runs through my hometown, is my favourite. I have many happy memories of this river from when I was younger; including riverside picnics, wild swimming and spending a day following the river until we reached the coast. The River Otter also has fantastic wildlife with otters, kingfishers and the only licenced population of free-living beavers in England.

Do you have a favourite gauging station? Why is it your favourite?

The Severn at Haw Bridge (54057) has to be my favourite. This was my test catchment for any model developments during my PhD, because it is so large and hydrologically varied. In fact I used it so much that even my partner has the gauge number memorised!

What keeps you busy apart from hydrology?

I love being outside. I spend many of my weekends finding new walks around the Oxfordshire countryside, and over summer I enjoyed socially-distanced kayaking days along the river Thames. I also enjoy a good book – I'm currently reading Once Upon a River by Diane Setterfield. .

Which BHS meeting did you enjoy most?

I have been to two Peter Wolf early career symposiums, hosted by UKCEH in 2017 and the Canal and River Trust in 2018, and they were both excellent. It was great meeting other early-career hydrologists and learning about how their experiences differed from mine. The meetings were both fun and friendly, and a great chance to present my PhD work as well as learning about the work of others.

Describe BHS in three words:

Interesting, inspiring, community

*Thank you also **Michael Pollock** for completing a Questionnaire!*



How did you become interested in hydrology?

I came into hydrology through engineering – building sandcastles, dams and reservoirs on the beach when I was on family holidays as a child (and still…)! I've also always loved walking in the mountains and enjoying water in the landscape. I have fond memories of going camping with friends and jumping into freezing rivers just for the exhilaration. But it was through my Civil Engineering degree at Newcastle University that I really became interested in hydrology as a science. I found a topic I was really interested in (rainfall measurement!) and pursued that first through doing an MSc in Hydrology and Climate Change and then an industry-based PhD.

What is your current job?

I work as a Water Engineering Consultant for Arup, where I am involved in various projects which usually have some link to flooding. Currently I'm really interested in applying an engineering mindset to Natural Flood Management measures and trying to quantify how they work during storm events. Prior to this I worked as a Product Manager for Environmental Measurements Ltd (EML), who specialise in producing Hydro-Met instrumentation and systems, where I developed a real interest in measuring the natural environment.

What is your dream job?

My goal is always that I find my job interesting, that I can keep learning new things and that my role has a positive impact on society and the environment. I also like to get away from my desk and into the natural world as part of it!

What, or who, has helped you get to this point in your career?

My civil engineering lecturer at Newcastle University has had a big impact on my career in hydrology, as well as my former employers at EML. I've met some great people in the profession and I'm looking forward to meeting more!

What keeps you busy apart from hydrology?

Playing sport! I played a lot of hockey and tennis over the years, but lockdown has prompted me to try some new things – open water swimming is next on the list.

What do you like about being a member of BHS?

The sense of community. I enjoy meeting people from lots of different organisations that have wide-ranging interests and engaging in interesting discussions, learning new things. BHS facilitates that through its events, and I enjoy keeping up to date with what's going on the world of UK Hydrology through its publications – like this one!

Describe BHS in three words:

Community, Stimulating, Friendly

UK Hydrological Bulletin: August – October 2020

Rainfall patterns through 2020 thus far have departed markedly from seasonal norms — after the UK's 5th driest spring in a series from 1862, the June–August rainfall was around 30% above average adding to a cluster of west summers in the 21st century. The impact on agriculture was severe in some regions. Generally, September was relatively dry but on October 3rd the passage of Storm Alex resulted in the UK's wettest day on record, flooding was extensive and the risk continued as a sequence of deep Atlantic low pressure systems tracked across the country. Flood warnings were extensive and persistent with surface flooding being particularly severe and resulting in widespread transport disruption. The wet summer and, particularly exceptional runoff during October, resulted in abundant reservoir replenishment with groundwater levels generally entering November appreciably above the mid-autumn range. Correspondingly, the water resources outlook, which was fragile in the early summer, is generally very healthy but, with near-saturated catchments, an enhanced flood risk is likely through the late autumn.

August

Whilst the northern and south-eastern extremities of the UK were relatively dry in August, nationally the rainfall total was around 20% above average. This contributed to an appreciably above average summer rainfall, adding to a cluster — 10 out of last 14 have been wetter than the preceding average for the UK but no overall trend, in a series from 1862, is yet evident (see Fig. 1). The month was punctuated by hot and humid episodes with a correspondingly high frequency of thunderstorms and associated large spatial variations in both rainfall and runoff patterns. Many rivers were in spate by the second week and widespread flood warnings extended across Scotland by the 12th when rainfall totals in the 40–60 mm range triggered a number of landslides. One resulted in a rail derailment near Stonehaven with three fatalities.

The focus of flood risk then moved south: on the 13th a rainfall total of 104 mm was recorded at Hollies (Staffordshire) and three days later an extreme rainfall event occurred over an area of south Norfolk, east of Thetford. The maximum storm rainfall closely approached 200 mm with several other measurements exceeding 100 mm (see page 16) underlining the value of professionally-moderated

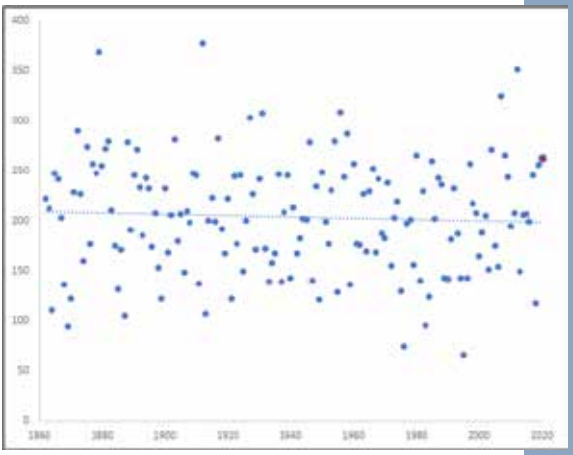


Fig. 1 *Summer (June-August) rainfall totals (mm) for the UK. Data source: Met Office*

informal raingauge catches. The arrival of Storm Francis in the final week resulted in rainfall totals >30 mm in many areas, and >80 mm in parts of the Lake District.

Flood warnings were widespread across the UK with severe flooding in County Down. Some western rivers (e.g. the Lune and Conwy) recorded their highest August runoff on record and the saturated soil conditions – together with the very dry spring – contributed to the worst harvest for a quarter of a century in some regions*. The substantial late-summer rainfall did, however, ensure a rare and substantial overall improvement in reservoir stocks (see Fig. 2).

September was a relatively dry month, particularly across much of the Midlands, southern England and eastern Scotland where rainfall totals were less than half the average. However, some extreme local rainfall accumulations were recorded, particularly in north-west Scotland: over the 11–13th, Archnagart recorded over 200 mm whilst in Norfolk on the 25th a 66 mm total at Houghton Hall triggered a flood Alert on the river Bure.Generally, however the late summer spate conditions were succeeded by sustained flow recessions resulting in very moderate outflows from the UK during the third week of the month, contributing to noticeably depressed runoff totals for September in north-east Scotland.

Fig. 3 illustrates the unusual reversal in outflows from Great Britain over the late-August to late-September period. Despite limited aquifer recharge through the month, September groundwater levels remained mostly in the normal seasonal range but with an expected contrast between seasonally high levels in the slow-responding Permo-Triassic sandstones in the Midlands and depressed levels in a few of the deeper Chalk wells (yet to fully benefit from recharge in the unsaturated zone).

Overall reservoir stocks for England & Wales — at a concerning level in the late-spring — recovered through the summer, a rare circumstance, and were moderately above average in late September (Fig. 2). However, stocks remained below average in some reservoirs in the South West, and below previous late-September minima at the small, but locally important, Ardingly reservoir in West Sussex.

*UKCEH repo rt: https://www.ceh.ac.uk/press/high-tech-data-confirm-record-poor-harvest-after-year-extreme-weather

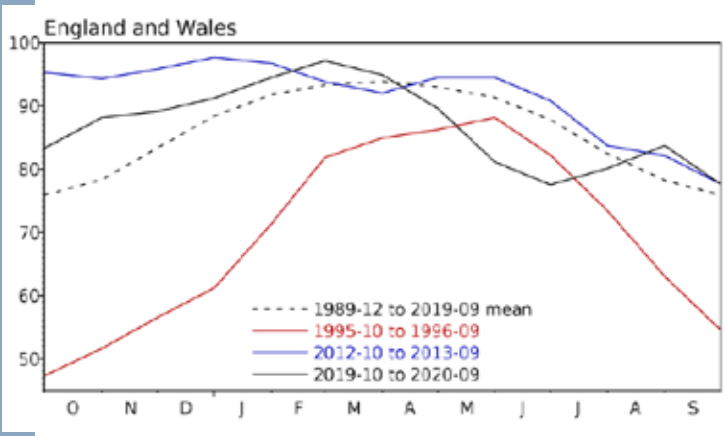


Fig. 2 An index of overall end-of-month reservoir stocks for England & Wales

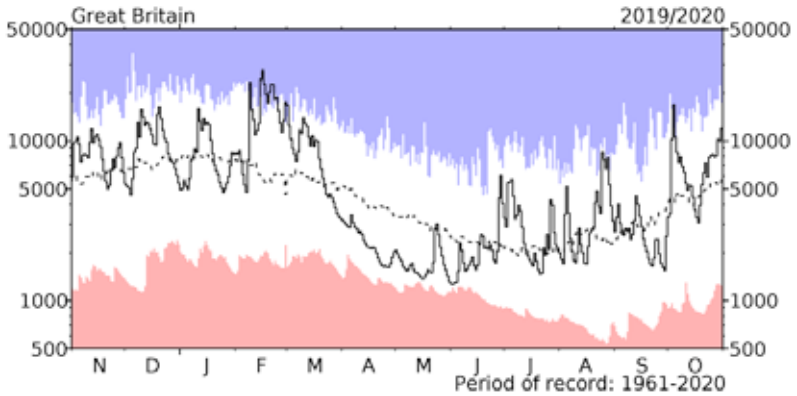


Fig. 3 Daily outflows (m3s-1) from Greater Britain – the blue and pink envelopes show the highest and lowest daily flows in a series from 1961; the dotted trace is the long-term mean

Synoptic patterns throughout most of **October** were very cyclonic – a sequence of deep Atlantic low- pressure systems brought heavy and sustained rainfall to most areas, resulting in the 5th wettest October in the UK series which begins in 1862. Substantial parts of eastern Scotland recorded more than twice the monthly average and anomalies were even greater in much of south-eastern Britain; Oxford recorded its second wettest month in the last 145 years. The passage of Storm Alex on the 2nd/3rd brought particularly extreme rainfall across most of the country. In Northern Ireland, a 24hr rainfall total of 78 mm was recorded at Aboyne whilst in England 48-hr totals of 92 mm and 90 mm were registered at Liscombe (Devon) and High Wycombe (Bucks) respectively. For the UK as a whole, rainfall on the 3rd established a new record — 31.7 mm — in a daily series from 1891. Rainfall intensities greatly exceeded the infiltration capacities of soils over wide areas and surface flooding was both extensive and severe with a major impact on road transport.

River flows increased steeply even in baseflow dominated regimes (e.g. the Itchen in Hampshire) and flows in many rivers approached or exceeded previous maxima for early October. By the 4th, over 50 Flood Warnings and 100 Flood A lerts were in operation across the country and outflows from Great Britain were outstanding (see Fig. 3). However, the ubiquity of exceptional runoff was not accompanied by many extreme flood events in individual catchments. Further active Atlantic low pressure brought heavy rainfall later in the month particularly in western and northern Britain; on the 19th Tiree (western Scotland) recorded 78 mm and Capel Curig (north Wales) 74.0 mm on the 29th. Many rivers remained in high spate with extensive inundation of agricultural land, particularly in Scotland. Locally, heavy autumn leaf-fall, causing drain-blockages, exacerbated the flood risk. The exceptional October rainfall was, however, very beneficial in a water resources context. Despite some drawdown to accommodate forecast heavy rainfall, overall reservoir stocks were well above average entering November.

Terry Marsh
12/11/20

