# Briefing Note: Severity of the February 2020 floods -- preliminary analysis

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## Preamble

The purpose of this briefing note is to highlight some of the key points from the monthly Hydrological Summary, and to provide some additional context beyond the space and format constraints of the Summary. Neither the Hydrological Summary nor this Briefing Note provide a fully comprehensive review of the severity of the February 2020 floods. Both documents are based on currently available information and analysis conducted as part of routine reporting by the National Hydrological Monitoring Programme (NHMP), in collaboration with the Environment Agency, Natural Resources Wales, the Scottish Environment Protection Agency and the Department for Infrastructure – Rivers. We wish to thank these Measuring Authorities for their support in providing information at short notice during ongoing flood incident response. More comprehensive analysis of the meteorology, hydrology and impacts of the flooding in February 2020 (which continued into early March) will be conducted over the coming months by the NHMP and partner organisations.

This note was published online on 17th March 2020.

## Introduction

February was a truly remarkable month in hydrological terms, with record-breaking rainfall and river flows and significant flooding. After a somewhat more settled first week, successive low pressure systems brought bands of heavy rain and three named storms, 'Ciara' on the 8th/9th, 'Dennis' on the 15th/16th and 'Jorge' on the 28th/29th. The total monthly rainfall was a new UK maximum for February and anomalies exceeded three and a half (and locally four) times the long term average over upland areas of central and northern England and Wales. With soil moisture deficits near-zero, river flows were highly responsive to the rainfall, and many new February peak flow records were established. Monthly mean flows were notably or exceptionally high across most of the UK, with numerous new February maxima contributing to the highest total outflow from England in any month on record. Whilst flood protection schemes were effective for many thousands of homes, the duration and severity of the high flows resulted in extensive property flooding, most notably from the rivers Calder, Aire, Teme, Wye, Severn and Taff.

## Rainfall and soil moisture deficits

At the national scale, February 2020 was the wettest February in a series from 1910, receiving more than twice the average rainfall, and the fourth wettest of any month in that same timeframe. In parts of Wales and central and northern England, rainfall exceeded three and a half times the average, influenced by some exceptional rainfall totals delivered by individual storms (e.g. 184mm over two days on the 8th-9th from 'Ciara' at Wet Sleddale Reservoir, Cumbria; 148mm over two days on the 15th-16th from 'Dennis' at Maerdy, Mid Glamorgan; and 180mm on the 19th at Honister Pass, Cumbria).

The sequencing of these notable rainfall events was an important factor in the resulting river flows and impacts. Each heavy rainfall was delivered in quick succession over saturated catchments to rivers that had yet to recede from previous events.

The wet conditions in the months leading up to February 2020 may have also contributed to the extensive flooding seen. Persistent and heavy rainfall has been prevalent for much of the last nine months. Rainfall accumulations over the June 2019-February 2020 timeframe (Figure 1) were around 130% of the long-term average across the majority of the UK, and more than 150% for Severn-Trent

region. The flooding of February 2020 was the latest (and most widespread) in a series of flood episodes resulting from heavy rainfall, for example in Lincolnshire in June 2019, the Peak District in July/August 2019, South Yorkshire and central England in November 2019.

This rainfall over the last nine months acted to saturate catchments and enhance flood risk. Soil moisture deficits (SMDs) for the UK have been near-zero for five consecutive months through the winter half-year so far (October 2019-February 2020).

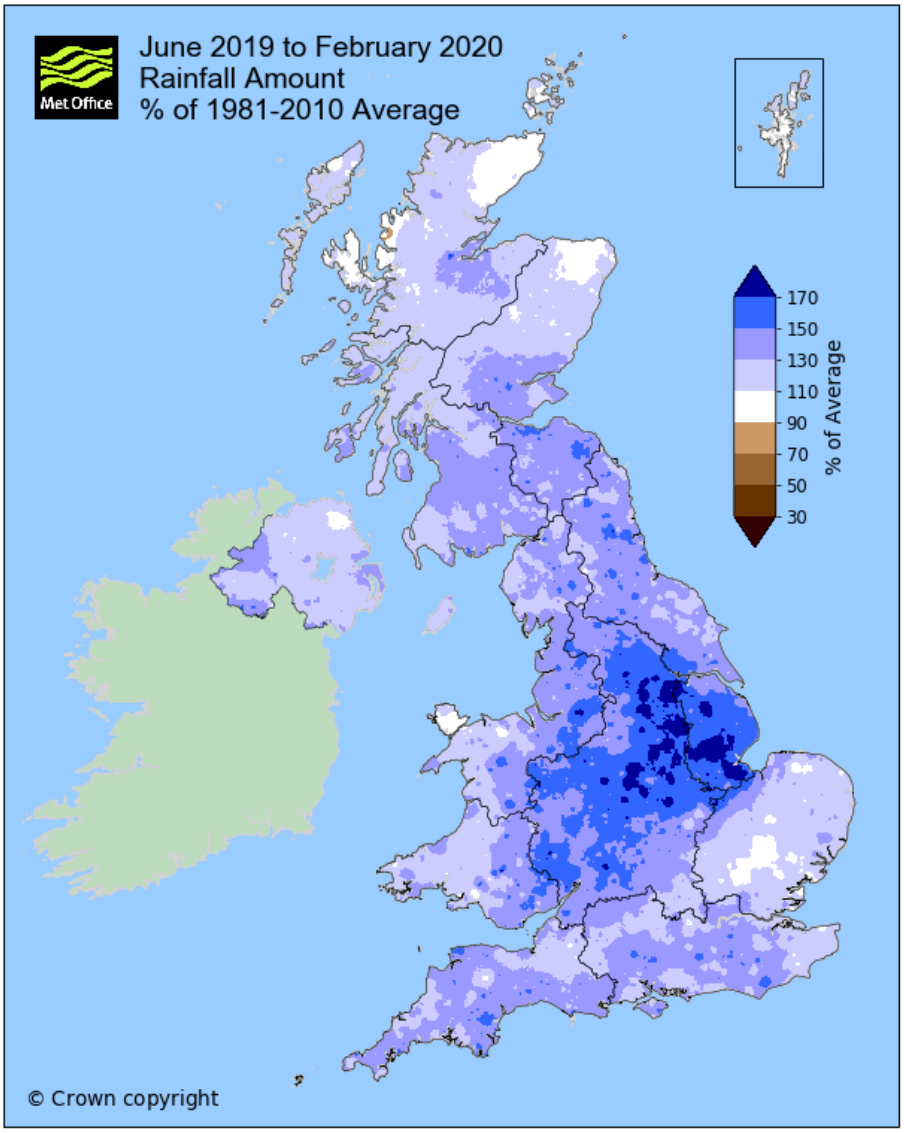


*Figure 1 Rainfall anomalies (% of 1981-2010 average) for the nine month period from June 2019 to February 2020*

## River flows

Persistent heavy rainfall resulting from storm 'Ciara' triggered exceptionally high peak flows, most notably across northern England (impacting many of the same areas that suffered from flooding in November 2019 and winter 2015/2016). Seven days later, storm 'Dennis' generated similarly extreme high flows, predominantly impacting Wales and central England. A barrage of additional rainfall from a succession of frontal systems through the final fortnight kept flows high in a number of large catchments (e.g. the Yorkshire Ouse, Trent and Severn), with the highest peak flows registered towards the end of the month.

Table 1 provides a summary of the peak flows recorded in February, the location of these catchments is shown in Figure 5. The highest February peak flows on record were established for a range of catchments in south Wales, northern England, southern Scotland and Northern Ireland. Even more notably, the Cynon and Wye recorded their highest peak flows on record (i.e. for any month), and second or third highest flows on record were widespread across northern and western Britain. Some of the new maximum flows were in rivers with very long flow records – for the Wye at Belmont, the peak flow of 689 cumecs exceeded the previous maximum by more than 10% in a series spanning more than 100 years. In some instances, February peak flows were comparable with the previous highest flows on record, such as December 2015 in northern England (on the Irwell and Ribble).

Care must be taken when considering the relative magnitude of peak flow events due to the inherent uncertainties involved in gauging such volumes of water. Record lengths which generally span 50 years may not capture substantial flood episodes which pre-date modern river flow recording (e.g. Macdonald & Sangster, 2017). Specifically in relation to February 2020, peak flows are the current best estimates of the Measuring Authorities and are subject to change following more comprehensive reviews in the months ahead.

In order to provide a rapid, broad-scale assessment of event severity across the UK, we have computed provisional return period estimates using the standard Flood Estimation Handbook (FEH) enhanced single site method, applied to the February 2020 peak flow data provided by the Measuring Authorities and the NRFA Peak Flows Dataset V8. The initial estimates shown in Table 1 will undoubtedly be superseded by more comprehensive, locally-informed assessments of event severity when available.

We have assigned ranges to the return periods we have calculated. To do this we applied a simulated bootstrap method. We use the L-moments of the AMAX record to parameterize a Generalized Logistic (GLO) distribution, then produce 5000 simulated records. Each simulated record is sampled from the parameterized GLO distribution and contains as many samples as there are AMAX in the original record. We then fit a GLO distribution to each of the 5000 simulated records and find the return period of the event according to each simulated GLO distribution. The reported return periods are the interquartile range of the 5000 estimated return periods. The majority of peak flows in February have return periods of less than 50 years, meaning that there is more than a 2% chance of similar flows occurring in any given year. However, the return period for peak flows on the Wye at Belmont ranged between 150-480 years meaning flows were large enough to have less than 1% chance of occurring in a given year.

The highest daily mean flows registered in February 2020 were within the top 10 ever recorded for many catchments in Wales and northern and central England (Figure 2), with the highest daily mean flows recorded in catchments in south Wales and central England. To put this into context, a daily flow amongst the top 10 in a 50-year record (the typical length of river flow series in the UK) is higher than 99.95% of daily flows ever recorded at that location. Some of the catchments in Figure 2 have even longer records, making this feat all the more notable.

Whilst February 2020 was clearly a significant event in terms of flow magnitude, it was also exceptional in terms of the spatial extent of the high flows and this can be shown using the regional and national outflows (aggregations of flows from many individual rivers). On the 16$^{th}$ February, outflows from England and Wales registered the highest daily value in a series from 1961 (Figure 3), and monthly total outflows for February from England were the highest on record over this same timeframe. Very high flows were spatially widespread, exceeding the extent of regional flood events in 2007, 2009 and

2013/2014, and comparable with some of largest footprint flood events of last 20 years (e.g. 2015/2016), though falling short of impacting as substantial an area as 2000/2001 or 2012 (Figure 2).

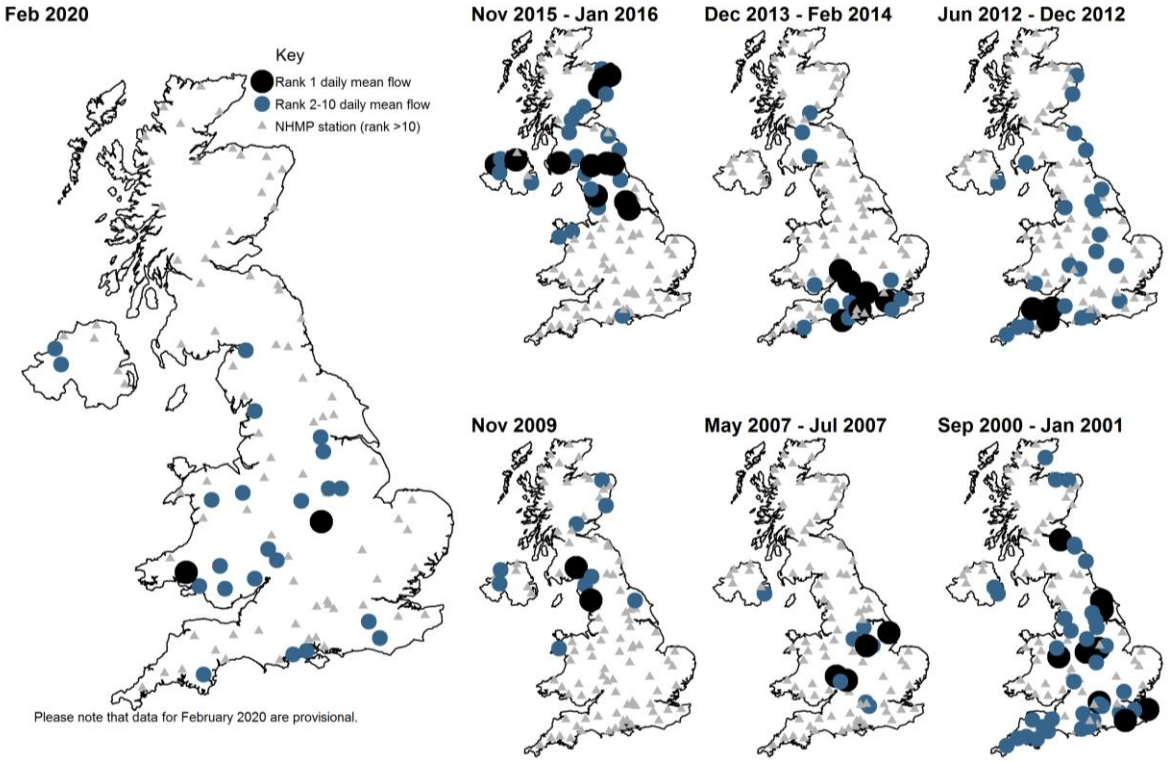


*Figure 2* Maps showing the rank of the highest daily mean flow in the respective February 2020 records of NHMP gauging stations (left, using provisional data), and those of six previous large-scale flood events (right, using National River Flow Archive data).

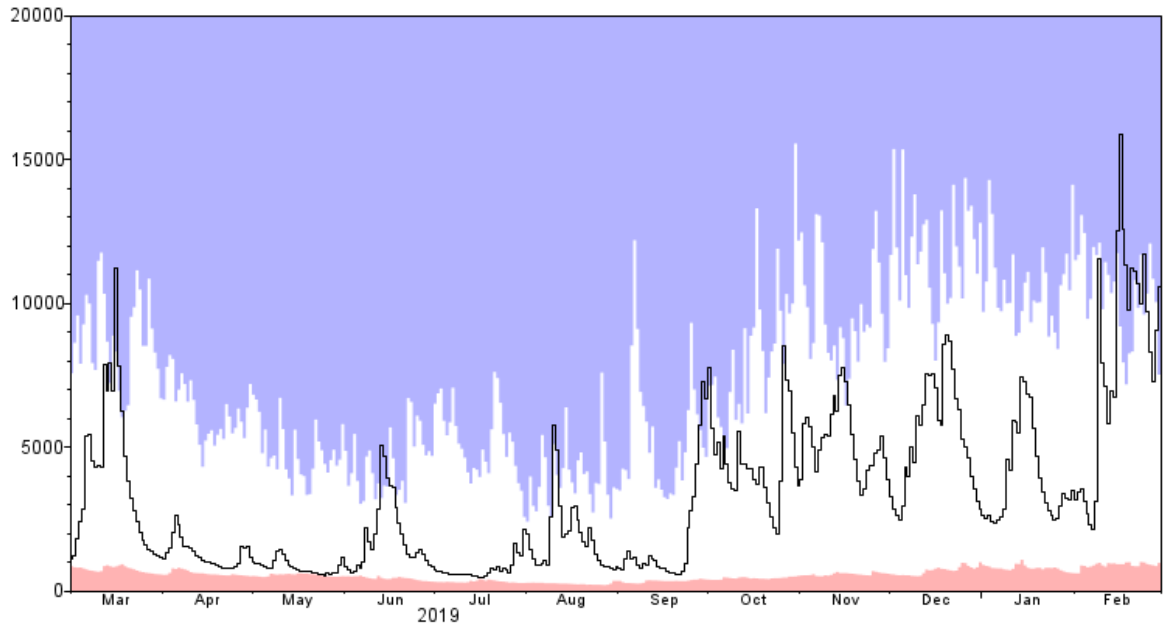


*Figure 3 Daily outflows from England and Wales from March 2019 to February 2020*

The duration of very high flows was also a defining characteristic in February 2020. The persistent wet weather and rapid-fire sequencing of named storms was a key factor in maintaining high flows between events, particularly in larger catchments (e.g. Severn, Trent and Yorkshire Ouse) which are slow to respond, but similarly slow to recede, resulting in prolonged high flows. The Severn at Bewdley remained above 220 cumecs throughout the period from 11th February and only fell below this threshold on 5th March (Figure 4). This is the longest period of consecutive daily flows above this threshold in an almost 100-year series. To put this amount of water into context, sustained exceedance of 220 cumecs is the equivalent to the volume of more than 100 London double-decker buses passing through Bewdley every minute for 24 days.

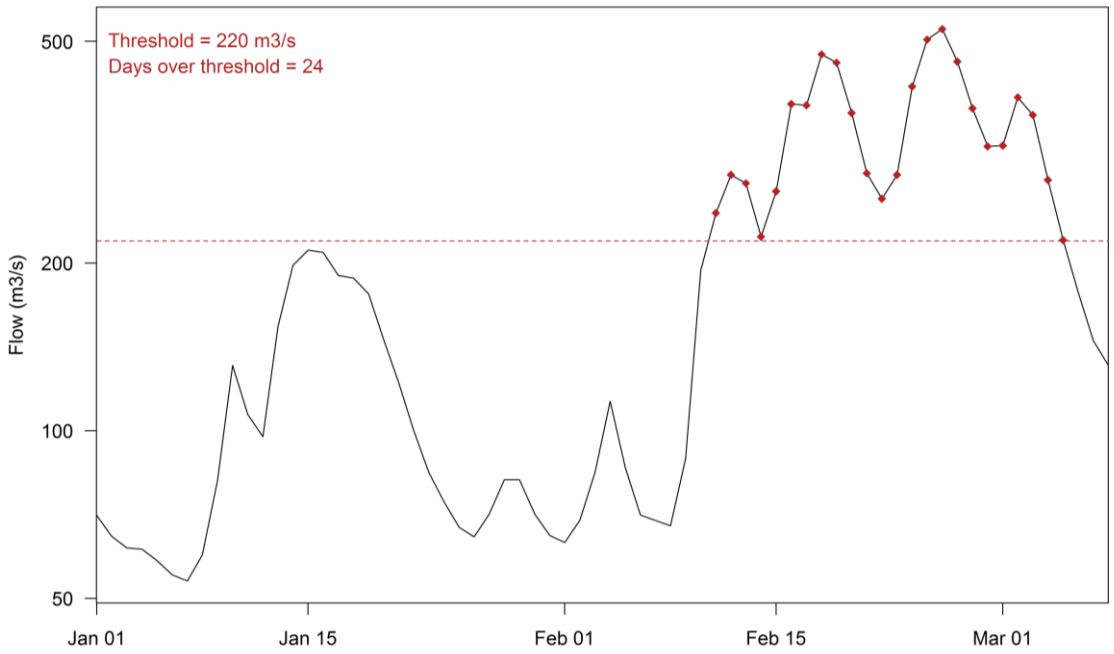


*Figure 4 Gauged daily flows for the Severn at Bewdley (54001) from 1st January 2020 to 8th March 2020, highlighting the number of days above a threshold of 220 cumecs. Note that data for March is from the Environment Agency Hydrology Data Service and is unchecked.*

Taken together, the events of February 2020 were a remarkable combination of long duration and high flows across substantial parts of England and Wales (Figure 2), whilst also registering as a top 5 peak flow event in numerous individual river flow records (Table 1). The sheer volumes of water pooled along the length of major rivers were monumental and (though the situation is now improving) persisted through the first half of March (for example, Flood Warnings remaining in place along the entire length of the Severn and encompassing the Aire Washlands towards mid-March), causing substantial disruption.

## Impacts

It is challenging to collate information on impacts during extreme events, and more comprehensive assessments will certainly follow in the months ahead. Nevertheless, it is clear that the flooding of February 2020 had substantial and protracted impacts in many parts of the country.

Impacts of flooding from storm 'Ciara' were felt strongly along the Calder, Ribble, Irwell, Eden and Conwy, whilst flooding associated with storm 'Dennis' significantly affected south Wales, Herefordshire, Worcestershire and Shropshire. Exceptionally high river levels on the Wye and Severn caused significant flooding in Hereford, Bewdley and Montford, and some flood defences in

Shropshire and Worcestershire were breached. Rhonda County in Wales was also significantly affected by 'Dennis' with around 1,000 properties flooded and large areas of Pontypridd were inundated; parts of Northern Ireland and the Scottish Borders were also impacted by flooding. The emergency services and the Army were deployed in parts of Wales and England to help with flood relief and defences. Initial estimates indicate that as a result of the two storms, more than 3,300 properties flooded in England (in addition to many in Wales), resulting in widespread damage to businesses, shops and homes. To put this number into context with other widespread flood episodes, this compares with 16,000 properties in winter 2015/16 (Marsh et al. 2016), 8,000 properties in 2012 (Marsh et al. 2013), and 55,000 properties in summer 2007 (Marsh & Hannaford, 2007). It is important to note that more than 128,000 properties were protected by flood defences in England in February 2020.


*Figure 5 Location of catchments shown in Table 1*

Ground saturated by rainfall over the last nine months and persistent heavy rainfall in February resulted in a substantial number of landslides, particularly affecting Wales and northern England. There were 42 landslides reported in Great Britain in response to precipitation associated with storms 'Ciara', 'Dennis' and 'Jorge'. Many of these have been reported across the UK on natural slopes as well as man-made slopes, disrupting travel. One area particularly affected was the South Wales Coalfield that has one of the densest concentrations of landslides in the UK. The landslides reported are typical of those that respond quickly to intense rainfall events i.e. shallow (less than 5-10 metres deep) or on

man-made slopes, such as the one at Tylorstown, described to be a landslide in coal spoil. As such, it is likely that further landslides in early March were the result of the heavy rainfall over the final fortnight of February.

There was widespread travel disruption as a result of flooding, particularly across England and Wales. Many flights and ferry services were cancelled as a result of the extreme weather conditions. Both storms caused difficult driving conditions and many roads were blocked by flooding. For only the second time in its history the Humber Bridge was closed to all traffic on the 9th. A number of rail firms were affected by delays and cancellations because of flooding and debris on the tracks. Strong winds caused many fallen trees across the country, and damage to homes and businesses. Hundreds of thousands of homes were left without electricity and several sporting events were cancelled (including Women's Six Nations and Premier League football matches on the 9th).

Due to the flooding of many rural areas, there were widespread agricultural impacts. Large areas of farmland were inundated, many farm buildings were damaged as a result of flooding and strong winds, and rural roads were impassable due to fallen trees. Flocks of animals in Wales had to be rescued after being stranded in flooded fields. There will have undoubtedly been further impacts on agricultural communities as a result of the flooding which put livestock and property at risk.

## Further information

- The February 2020 Hydrological Summary for the UK
- The Hydrological Outlook UK highlights impact of February 2020 on medium-term prospects for UK hydrological status
- A discussion of the changing severity of floods in the UK and the attribution of these trends
- A preliminary account of the major flooding episodes in November 2019 that provided backdrop to the flooding in February 2020
- NHMP reporting on previous flood events

## Acknowledgements

The credibility of any examination of a major hydrological episode is heavily dependent on the availability and quality of hydrological data. The assistance of all involved in the UK Measuring authorities (Environment Agency, Natural Resources Wales, Scottish Environment Protection Agency and the Department for Infrastructure – Rivers) is gratefully acknowledged.

## References

Macdonald, N. and Sangster, H.: High-magnitude flooding across Britain since AD 1750, Hydrology and Earth System Sciences, 21, 1631–1650, https://doi.org/10.5194/hess-21-1631-2017, 2017.

Marsh, T., Kirby, C., Muchan, K., Barker, L., Henderson, E., Hannaford, J.: The winter floods of 2015/2016 in the UK - a review. Centre for Ecology & Hydrology, Wallingford, 2016.

Marsh, T., Parry, S., Kendon, M., Hannaford, J.: The 2010-12 drought and subsequent extensive flooding: a remarkable hydrological transformation. Centre for Ecology and Hydrology, Wallingford, 2013.

Marsh, T. and Hannaford, J.: 2007. The summer 2007 floods in England and Wales – a hydrological appraisal. Centre for Ecology and Hydrology, Wallingford, 2007.

*Table 1– Peak flow records established in February 2020 for catchments in the UK, those in bold are rank 1 events in the period of record.* ***Please note that all data for February 2020 are provisional and may be revised by Measuring Authorities when data have been quality controlled. These initial return period estimates will undoubtedly be superseded by more comprehensive, locally-informed assessments of event severity when available.***

| River (Station) | AMAX record start | February 2020 | | | | Historical record AMAX 1 | |
|---|---|---|---|---|---|---|---|
| | | Feb 2020 Peak Flow (cumecs) | Date (Feb 2020) | Rank in AMAX record | Return period range | Flow | Date |
| Wear (Witton Park) | 1974 | 322 | 9th | 2 | 15-40 | 353 | Jan-1995 |
| Ure (Kilgram) | 1967 | 360 | 9th | 4 | 15-35 | 380 | Feb-1995 |
| Aire (Armley) | 1960 | 240 | 9th | 2 | 30-75 | 344 | Dec-2015 |
| Wharfe (Addingham) | 1973 | 387 | 9th | 4 | 10-20 | 413 | Jan-1982 |
| Roch (Blackford Bridge) | 1948 | 144 | 9th | 2 | 60-170 | 192 | Dec-2015 |
| Irwell (Bury Ground) | 1973 | 267 | 9th | 2 | - | 284 | Dec-2015 |
| Ribble (Samlesbury) | 1960 | 1110 | 9th | 2 | 35-85 | 1113 | Dec-2015 |
| Calder (Whalley Weir) | 1970 | 423 | 9th | 2 | 50-170 | 501 | Dec-2015 |
| Eden (Sheepmount) | 1966 | 1070 | 9th | 4 | 10-20 | 1677 | Dec-2015 |
| Ballinderry (Ballingderry Bridge) | 1969 | 184 | 9th | 3 | 20-45 | 208 | Oct-1987 |
| Colebrooke (Ballindarragh Bridge) | 1975 | 144 | 9th | 3 | 15-30 | 159 | Oct-1987 |
| Teviot (Hawick)** | 1963 | 315 | 15th | 3 | - | 356 | Oct-2005 |
| **Cynon (Abercynon)**** | **1961** | **-** | **15th** | **1** | **-** | **181** | **Dec-1979** |
| Teme (Knightsford Bridge) | 1970 | 266 | 16th | 3 | 15-30 | 315 | Jul-2007 |
| Usk (Chainbridge)** | 1957 | - | 16th | 2 | - | 819 | Dec-1979 |
| **Wye (Belmont)** | **1908** | **689** | **17th** | **1** | **150-480** | **608** | **Oct-1998** |
| Severn (Saxon's Lode)* | - | 490 | 17th | 3 | - | 545 | Jul-2007 |
| **Wye (Redbrook)**** | **1969** | **-** | **17th** | **1** | **-** | **821** | **Feb-2002** |
| Trent (Colwick) | 1958 | 730 | 18th | 6 | 10-20 | 1018 | Nov-2000 |
| Severn (Haw Bridge) | 1972 | 766 | 19th | 5 | 15-25 | 1210 | Jul-2007 |
| Severn (Bewdley) | 1923 | 535 | 26th | 5 | 25-50 | 604 | Mar-1947 |
| Severn (Buildwas)* | - | 546 | 26th | 3 | - | 575 | Nov-2000 |

Historical records have been taken from version 8 of the National River Flow Archive Peak Flow Dataset. With data ending in September 2018.

*Stations not in the Peak Flow Dataset therefore unable to calculate return periods. Rankings and historical AMAX provided by Measuring Authority.

**Ranks confirmed by the Measuring Authority