# Hydrological Summary *for the United Kingdom*

December 2021

## General

Overall December was typical, with a period of calm weather bookended by unsettled conditions, although unseasonably warm temperatures (16.5°C was recorded on the 31st at Bala, Gwynedd) featured in the last week. Rainfall for the UK was near-average, although this masked drier conditions in western Scotland and parts of northern and southern England. Correspondingly, river flows were generally in the normal range although with some above normal flows in Northern Ireland, central England, and East Anglia. Small soil moisture deficits remained in parts of eastern England, and around the Thames estuary. However, recharge occurred at most groundwater index sites, except for a few in the Chalk of southern England. By month-end most boreholes had levels within the normal range, with a few above normal. Reservoir stocks rose at most impoundments in December and following a relatively average December, the water resources situation remains healthy as winter progresses and latest outlooks suggest rainfall and river flows are likely to be normal over the coming months.

## Rainfall

November's unsettled weather continued into December and dominated the first week, culminating in storm 'Barra'. Pressure fell rapidly on the 7th and frontal rain and high winds approached from the west and on the 8th, 52mm was recorded at Llysdinam (Powys). Efforts to reconnect the remaining properties, which had lost power during storm 'Arwen' 11 days earlier, were hampered. Travel disruption, fallen trees, further losses of power and coastal flooding were reported in Scotland, Northern Ireland and East Anglia but despite the unsettled conditions in the UK, this was a much more extreme storm for Ireland, with Met Éireann issuing a rare red warning for wind. Mid-month brought anti-cyclonic conditions, with dry weather and persistent cloud. From the 20th onwards, low pressure systems returned bringing frontal rainfall, wintry or heavy at times. On the 26th, roads in Cumbria and North Yorkshire were shut due to snow, and in Consett (County Durham) 1,600 homes and businesses lost power. As well as heavy rain – 90mm was recorded at Capel Curig (Conwy) on the 30th – the end of December featured unseasonable mildness, with widespread overnight temperatures above 13°C. The UK as a whole received near-average December rainfall, although less than 70% of average was registered in north-west Scotland (with less than 50% in the far north) and north-west and southern England. In contrast, parts of Wales, central and north-east England registered more than 130% of average. Over the last two months (November-December), rainfall for the UK was below average (81%), with regions in southern England recording around half the average (e.g. Southern, Thames); it was the seventh driest November-December on record for Wessex (in a series from 1910). Rainfall for 2021 overall (January-December) was just below average (96%) with areas of western Scotland and Northern Ireland recording less than 90% of average.

## River flows

Flows continued to increase and peaked above average during the first week of December in most catchments in England and Northern Ireland, and the third highest December peak flow was recorded on the Coquet on the 4th (in a series from 1966). Following the passage of storm 'Barra' on the 8th, recessions commenced reaching a minimum at most sites around mid-month. As the weather became more unsettled closer to month-end responses occurred across the country with flows in many catchments ending the month above average. England outflows for December were decidedly average, with monthly mean flows generally in the normal range. However, notably high flows were recorded on the Coquet, Weaver and Mersey (the latter registering its third highest December monthly flows in a series since 1976). Further south, isolated below-normal flows were recorded on the Coln and Tone – both registered two-thirds or less of their respective averages for December. Flow accumulations for November-December show a similar picture, albeit with below normal flows in more catchments in southern England (e.g. Dart, Exe) but also in isolated areas of central and northern England (e.g. Soar, Tees). River flows for 2021 (January-December) were generally above normal across England, notably so on the Coquet, Weaver and Itchen, and exceptionally so on the Stringside which recorded 163% of average and its second highest January-December flows after 2001 (in a series from 1965). Conversely in Northern Ireland, 2021 mean flows were normal or below normal.

## Groundwater and soil moisture

Soil moisture responses in December were mixed, but there were some sharp increases at month-end in response to rainfall in the last week e.g. at Redhill. Soils were normal to notably dry, with exceptionally low soil moisture recorded at Hollin Hill, North Wyke and Harwood Forest. Groundwater levels generally rose in the Chalk, rising from mid-month at West Woodyates Manor and Ashton Farm, but continued to recede at Westdean No.3 and in the slow responding Chipstead, Stonor Park and Therfield Rectory. At month-end, levels were in the normal range, except at Washpit Farm which remained above normal. Levels rose in the Jurassic limestones and remained in the normal range, and in the Magnesian limestones levels rose at Aycliffe and stabilised at Brick House Farm. Levels at Alstonfield in the Carboniferous Limestone rose becoming notably high. In the Permo-Triassic sandstones, levels rose at Weir Farm (remaining notably high) and Bussels No.7a (dropping into the normal range) but fell at Nuttalls Farm (remaining average for December). Levels fell overall at Lime Kiln Way (Upper Greensand) and rose at Royalty Observatory (Fell Sandstone) with both notably high for the time of year.

*Note that due to issues with data access, no data are available for Scotland and Wales.*

National Hydrological Monitoring Programme | UK Centre for Ecology & Hydrology | BGS British Geological Survey

# *Rainfall . . . Rainfall . . .*

Met Office

## Rainfall accumulations and return period estimates

Percentages are from the 1981-2010 average.

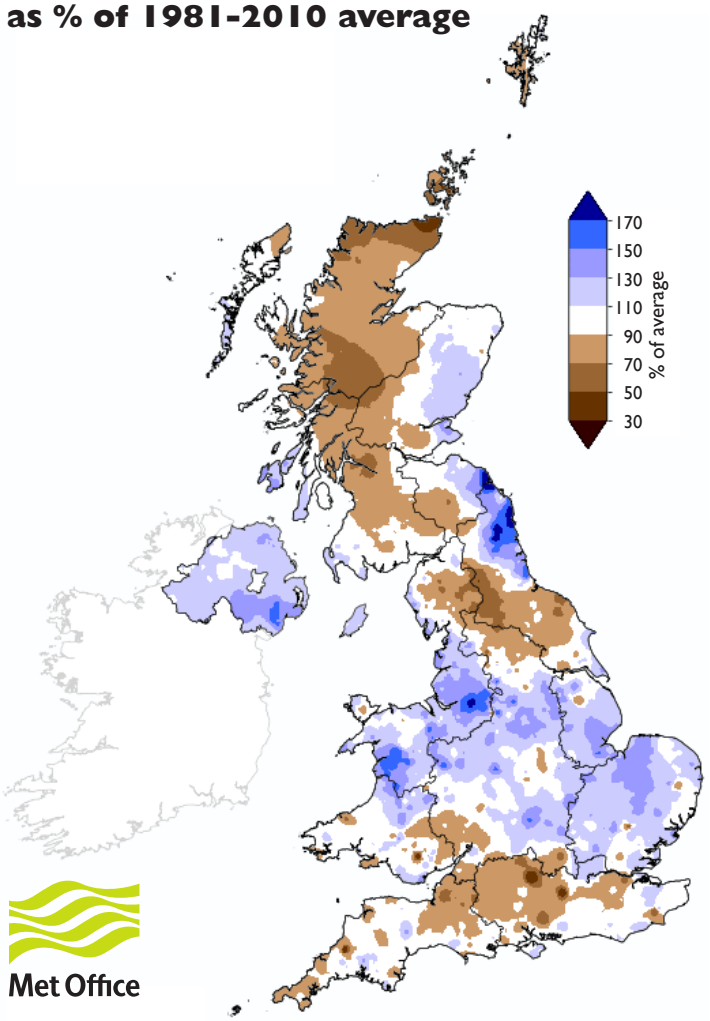
| Region | Rainfall | Dec 2021 | Nov21 – Dec21 | RP | Oct21 – Dec21 | RP | Jul21 – Dec21 | RP | Jan21 – Dec21 | RP |
|---|---|---|---|---|---|---|---|---|---|---|
| United Kingdom | mm | **115** | 190 | | 353 | | 569 | | 1075 | |
| | % | **98** | 81 | 2-5 | 98 | 2-5 | 93 | 2-5 | 96 | 2-5 |
| England | mm | **89** | 128 | | 252 | | 436 | | 853 | |
| | % | **103** | 74 | 5-10 | 96 | 2-5 | 94 | 2-5 | 101 | 2-5 |
| Scotland | mm | **137** | 274 | | 493 | | 748 | | 1350 | |
| | % | **87** | 86 | 2-5 | 101 | 2-5 | 91 | 2-5 | 89 | 2-5 |
| Wales | mm | **184** | 253 | | 462 | | 734 | | 1453 | |
| | % | **115** | 80 | 2-5 | 96 | 2-5 | 93 | 2-5 | 103 | 2-5 |
| Northern Ireland | mm | **137** | 206 | | 332 | | 568 | | 1048 | |
| | % | **120** | 91 | 2-5 | 96 | 2-5 | 92 | 2-5 | 92 | 2-5 |
| England & Wales | mm | **102** | 145 | | 281 | | 477 | | 935 | |
| | % | **106** | 75 | 2-5 | 96 | 2-5 | 94 | 2-5 | 102 | 2-5 |
| North West | mm | **141** | 227 | | 445 | | 711 | | 1319 | |
| | % | **107** | 88 | 2-5 | 113 | 2-5 | 104 | 2-5 | 108 | 2-5 |
| Northumbria | mm | **93** | 161 | | 283 | | 456 | | 900 | |
| | % | **108** | 92 | 2-5 | 108 | 2-5 | 96 | 2-5 | 103 | 2-5 |
| Severn-Trent | mm | **91** | 122 | | 221 | | 395 | | 781 | |
| | % | **118** | 81 | 2-5 | 96 | 2-5 | 94 | 2-5 | 100 | 2-5 |
| Yorkshire | mm | **78** | 132 | | 234 | | 432 | | 877 | |
| | % | **90** | 78 | 2-5 | 94 | 2-5 | 96 | 2-5 | 105 | 2-5 |
| Anglian | mm | **65** | 93 | | 164 | | 292 | | 603 | |
| | % | **121** | 82 | 2-5 | 93 | 2-5 | 86 | 2-5 | 97 | 2-5 |
| Thames | mm | **66** | 82 | | 193 | | 362 | | 721 | |
| | % | **95** | 57 | 8-12 | 87 | 2-5 | 93 | 2-5 | 101 | 2-5 |
| Southern | mm | **84** | 98 | | 239 | | 412 | | 799 | |
| | % | **96** | 55 | 8-12 | 87 | 2-5 | 93 | 2-5 | 100 | 2-5 |
| Wessex | mm | **85** | 104 | | 253 | | 441 | | 839 | |
| | % | **87** | 53 | 10-15 | 86 | 2-5 | 91 | 2-5 | 95 | 2-5 |
| South West | mm | **139** | 192 | | 390 | | 646 | | 1233 | |
| | % | **97** | 68 | 5-10 | 93 | 2-5 | 96 | 2-5 | 101 | 2-5 |
| Welsh | mm | **172** | 237 | | 442 | | 707 | | 1401 | |
| | % | **112** | 78 | 2-5 | 95 | 2-5 | 93 | 2-5 | 103 | 2-5 |
| Highland | mm | **147** | 356 | | 590 | | 860 | | 1514 | |
| | % | **76** | 92 | 2-5 | 101 | 2-5 | 89 | 2-5 | 84 | 2-5 |
| North East | mm | **93** | 179 | | 326 | | 581 | | 1017 | |
| | % | **101** | 89 | 2-5 | 102 | 2-5 | 104 | 2-5 | 100 | 2-5 |
| Tay | mm | **123** | 203 | | 383 | | 654 | | 1248 | |
| | % | **92** | 74 | 2-5 | 90 | 2-5 | 91 | 2-5 | 93 | 2-5 |
| Forth | mm | **110** | 174 | | 364 | | 601 | | 1129 | |
| | % | **92** | 73 | 2-5 | 98 | 2-5 | 92 | 2-5 | 94 | 2-5 |
| Tweed | mm | **103** | 169 | | 358 | | 551 | | 1067 | |
| | % | **99** | 82 | 2-5 | 113 | 5-10 | 98 | 2-5 | 104 | 2-5 |
| Solway | mm | **155** | 248 | | 536 | | 779 | | 1425 | |
| | % | **97** | 78 | 2-5 | 110 | 5-10 | 94 | 2-5 | 96 | 2-5 |
| Clyde | mm | **171** | 307 | | 570 | | 830 | | 1535 | |
| | % | **90** | 81 | 2-5 | 97 | 2-5 | 83 | 2-5 | 85 | 2-5 |

*% = percentage of 1981-2010 average* *RP = Return period*

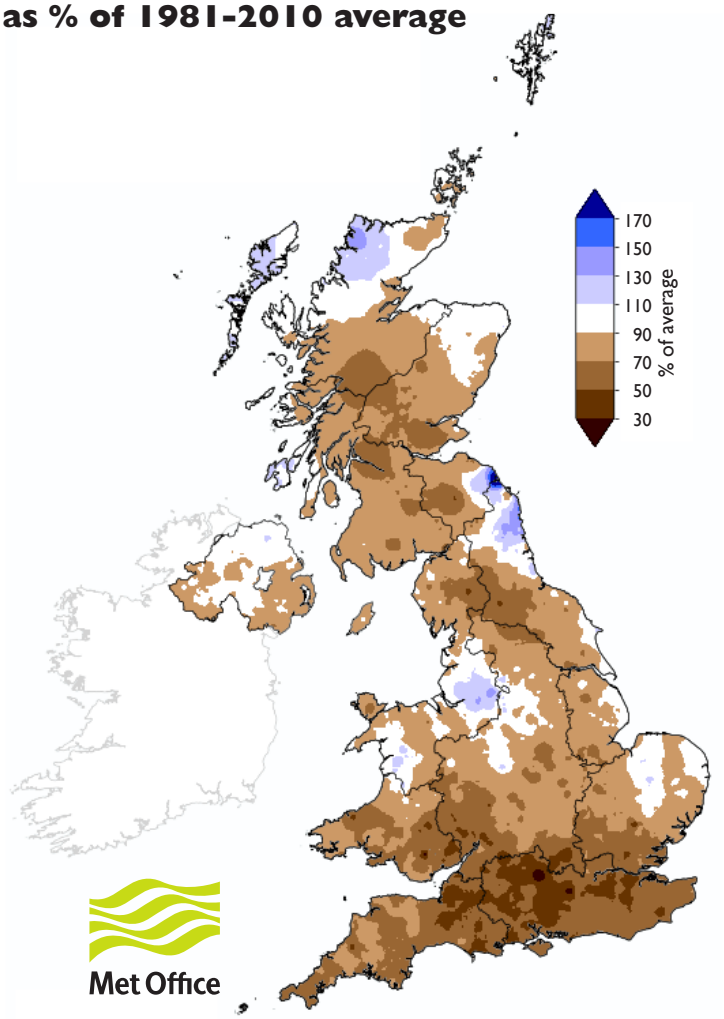
**Important note:** Figures in the above table may be quoted provided their source is acknowledged (see page 12). Where appropriate, specific mention must be made of the uncertainties associated with the return period estimates. The RP estimates are based on data provided by the Met Office and reflect climatic variability since 1910; they also assume a stable climate. The quoted RPs relate to the specific timespans only; for the same timespans, but beginning in any month the RPs would be substantially shorter. The timespans featured do not purport to represent the critical periods for any particular water resource management zone. For hydrological or water resources assessments of drought severity, river flows and/or groundwater levels normally provide a better guide than return periods based on regional rainfall totals. Note that precipitation totals in winter months may be underestimated due to snowfall undercatch. All monthly rainfall totals since January 2018 are provisional.

# *Rainfall . . . Rainfall . . .*

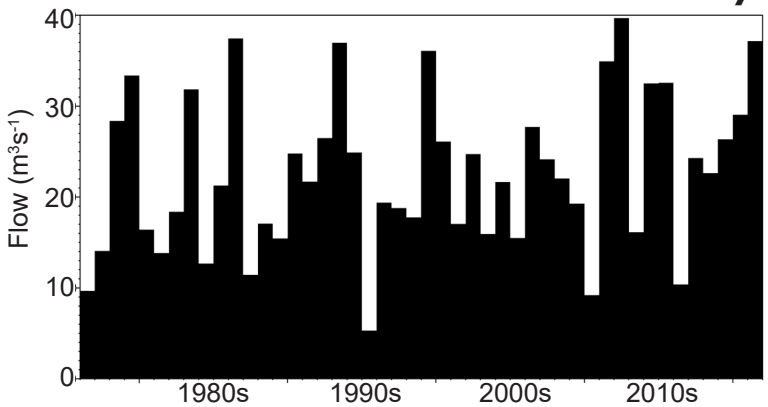
**December 2021 rainfall as % of 1981-2010 average**



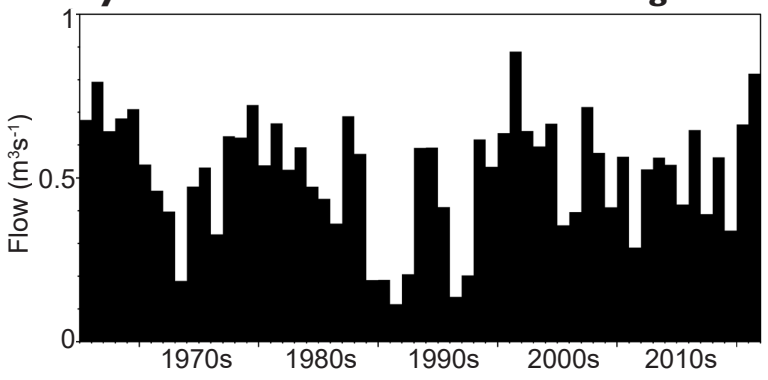

**November 2021 - December 2021 rainfall as % of 1981-2010 average**




**December mean river flows for the Mersey**




**Yearly mean river flows for the Stringside**




## Hydrological Outlook UK

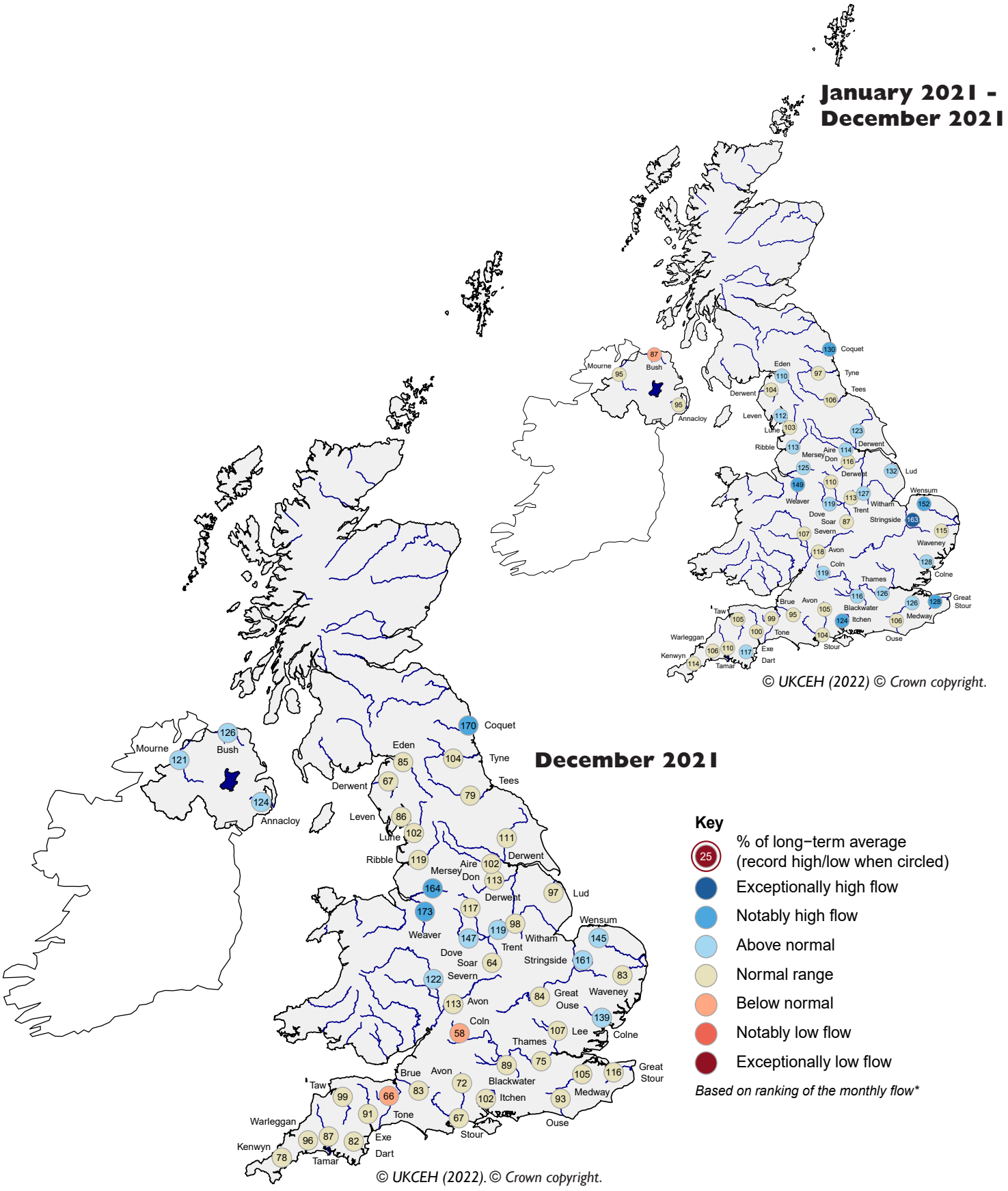
The Hydrological Outlook provides an insight into future hydrological conditions across the UK. Specifically it describes likely trajectories for river flows and groundwater levels on a monthly basis, with particular focus on the next three months.

The complete version of the Hydrological Outlook UK can be found at: www.hydoutuk.net/latest-outlook/

**Period:** **from January 2022**
**Issued:** **11.01.2022**
**using data to the end of December 2021**

River flows in January, and the three month period to March, are likely to be in the normal range throughout the UK, with some possible exceptions. Groundwater levels are likely to be normal to above normal during January, and this will continue to be the case in most areas over the period to the end of March, although with some fall in level in the Chalk of north London perhaps to below normal.

# River flow . . . River flow . . .

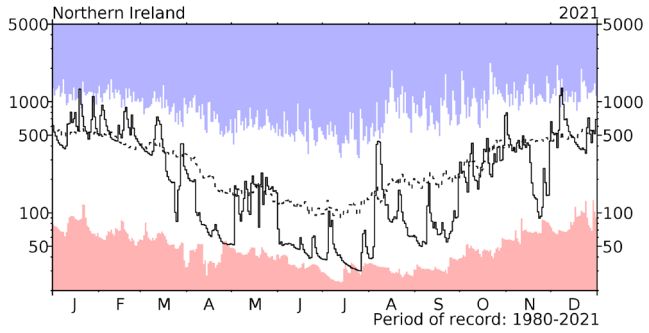


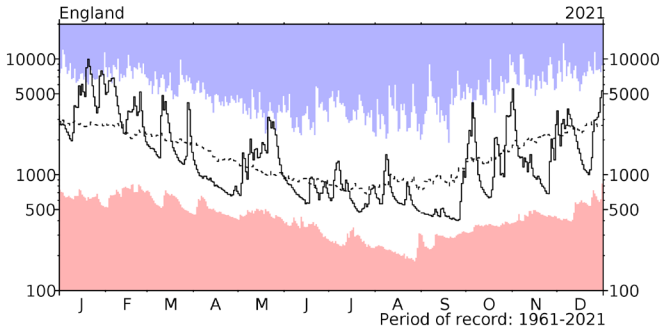

## River flows

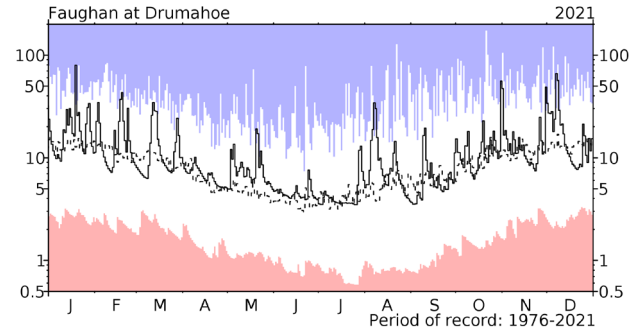
*Comparisons based on percentage flows alone can be misleading. A given percentage flow can represent extreme drought conditions in permeable catchments where flow patterns are relatively stable but be well within the normal range in impermeable catchments where the natural variation in flows is much greater. Note: the averaging period on which these percentages are based is 1981-2010. Percentages may be omitted where flows are under review.

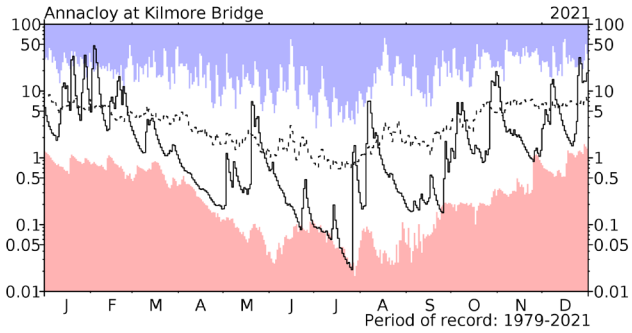
*Note that due to issues with data access, no data are available for Scotland and Wales.*

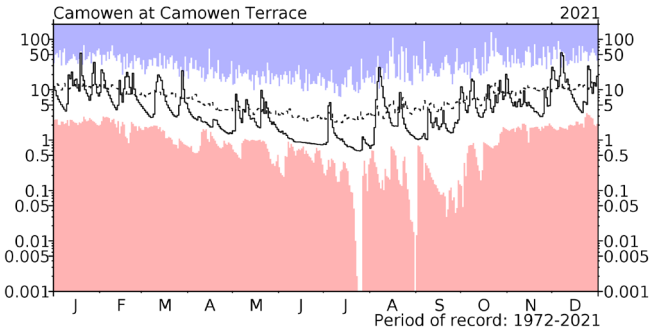
# River flow . . . River flow . . .

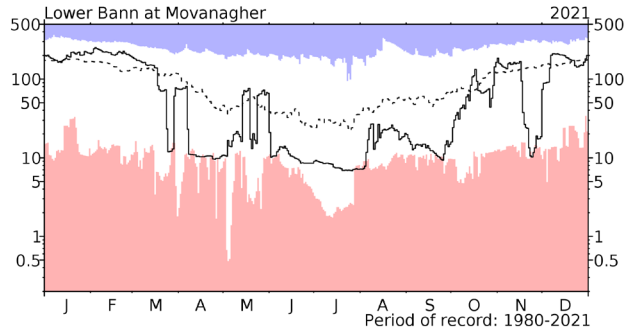


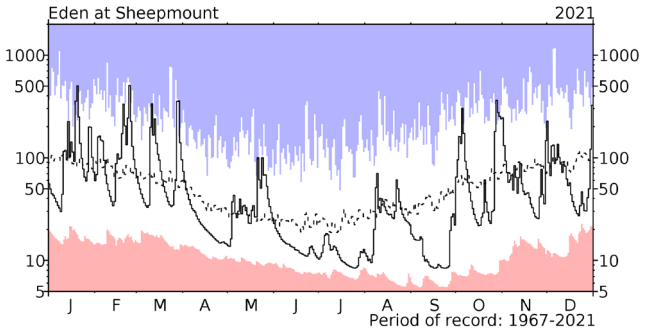



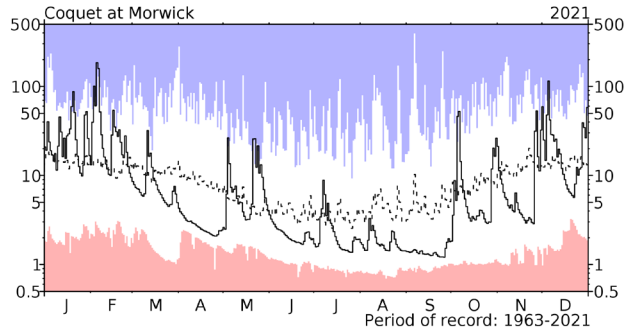



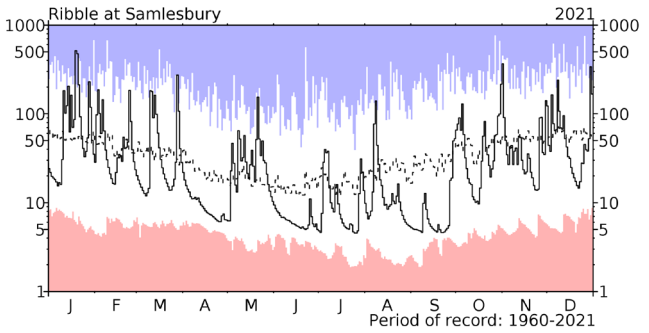



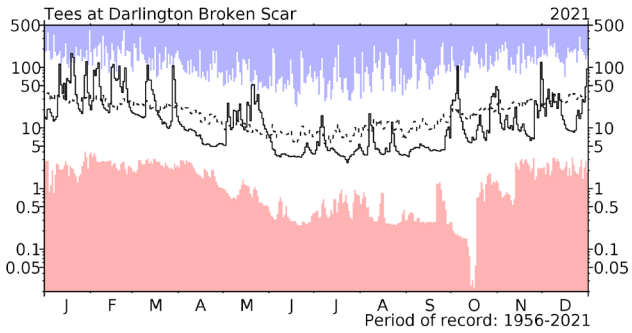



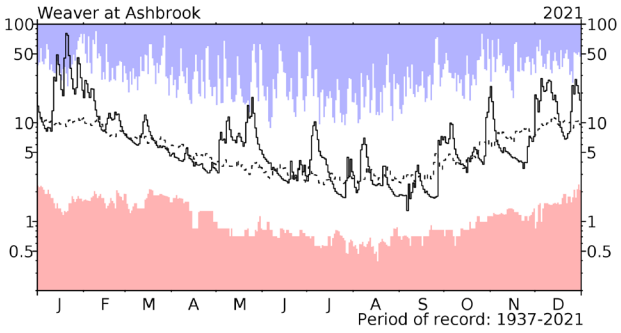



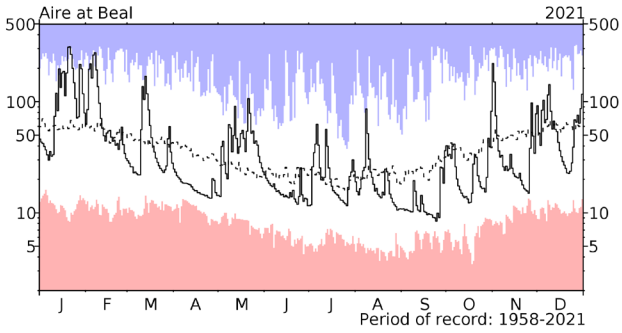



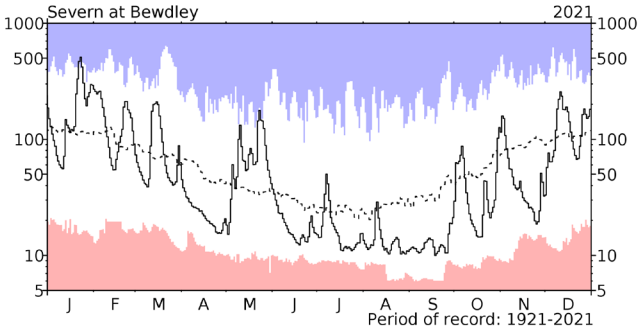

## River flow hydrographs

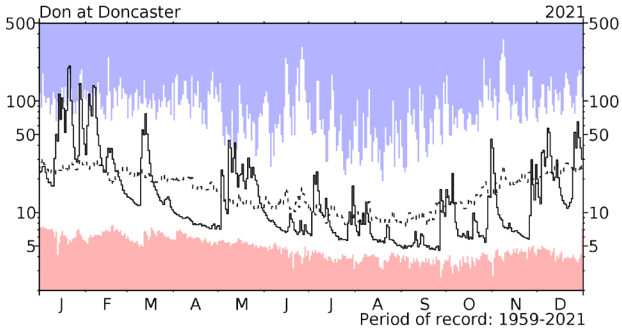
*The river flow hydrographs show the daily mean flows (measured in $m^3s^{-1}$) together with the maximum and minimum daily flows prior to January 2020 (shown by the shaded areas). Daily flows falling outside the maximum/minimum range are indicated where the bold trace enters the shaded areas. The dashed line represents the period-of-record average daily flow.

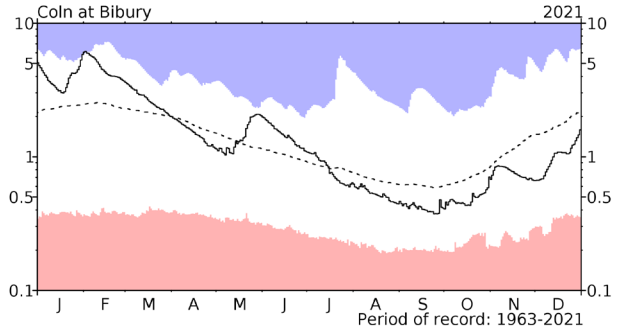
# River flow ... River flow ...

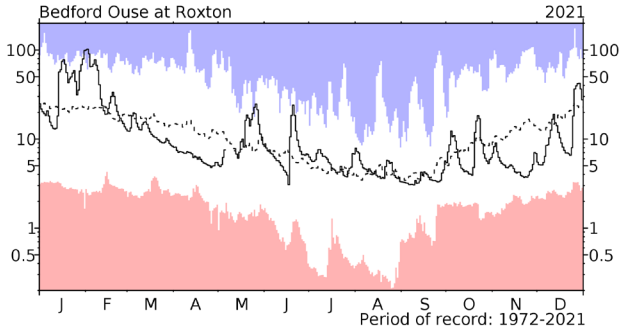


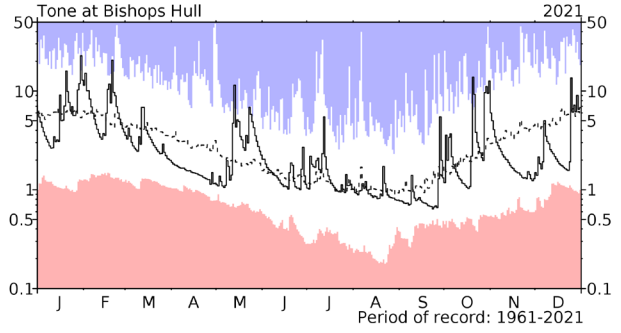



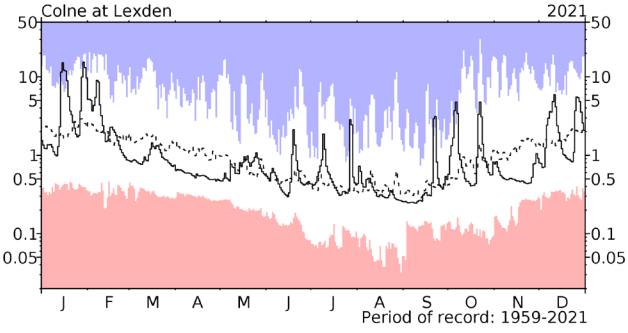



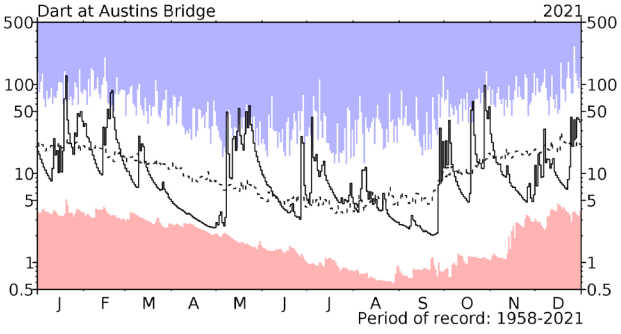



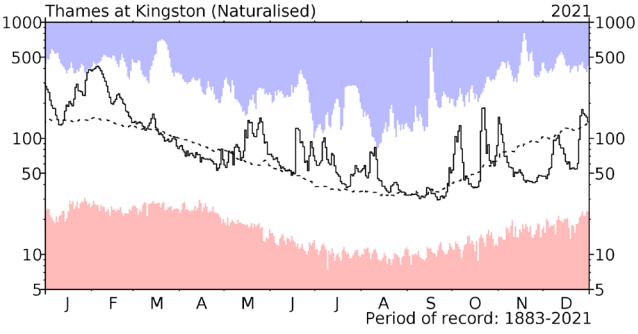



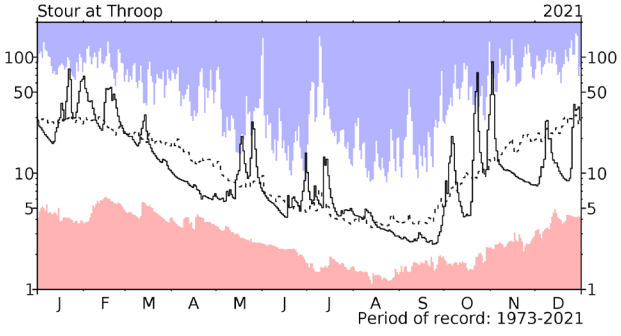



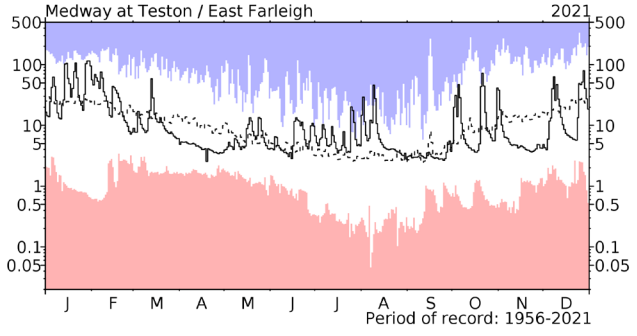



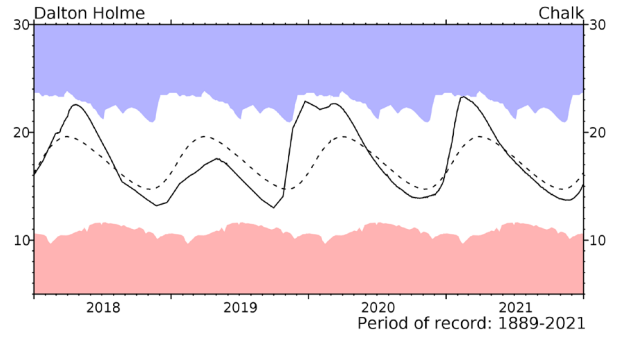



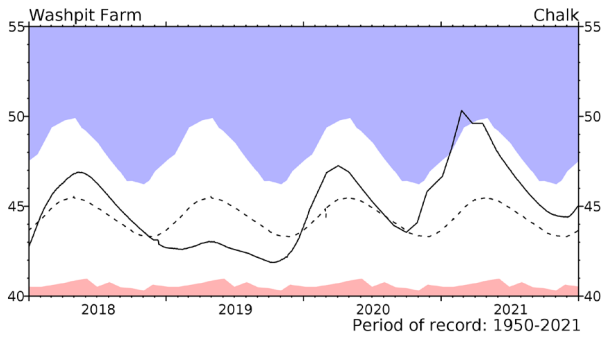



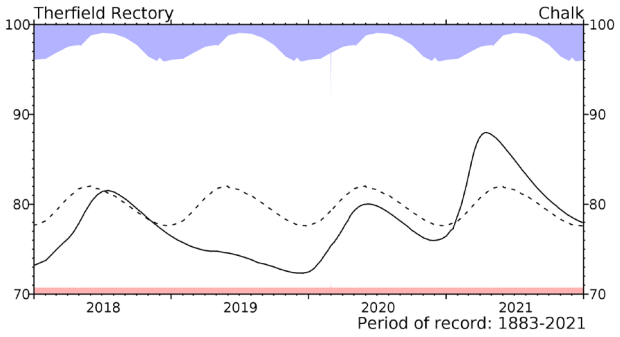



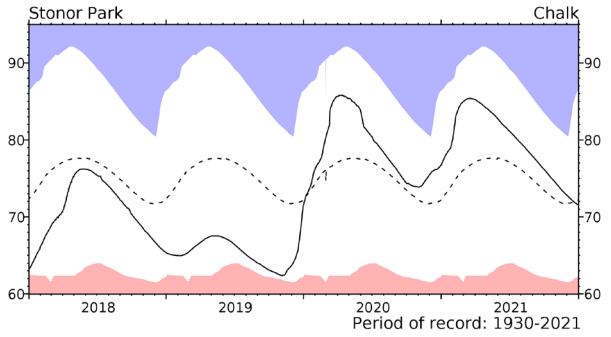



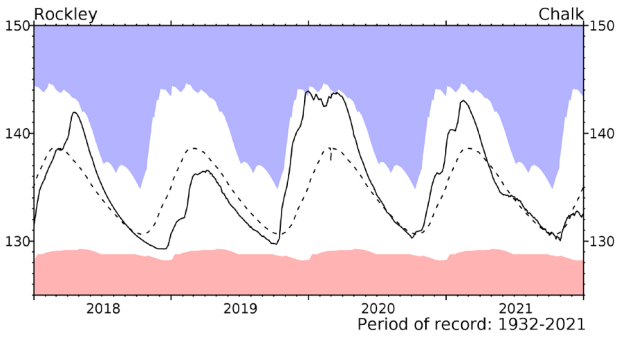
# Groundwater…Groundwater

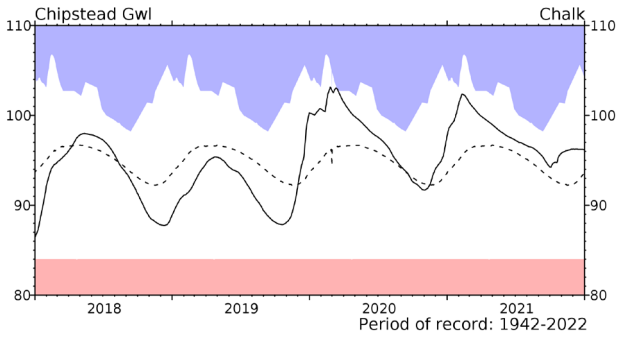


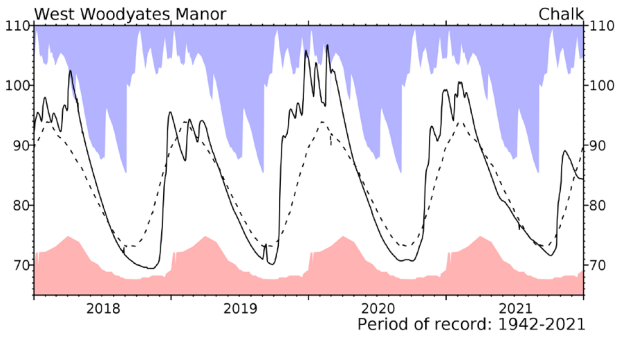



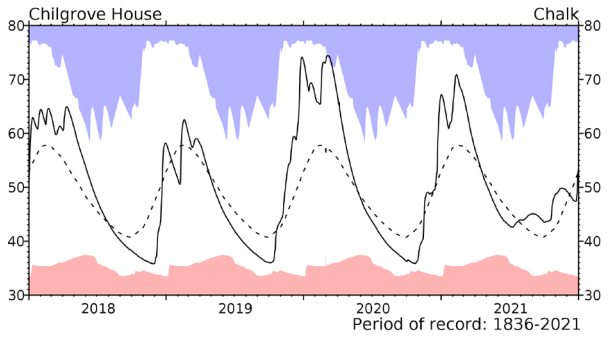



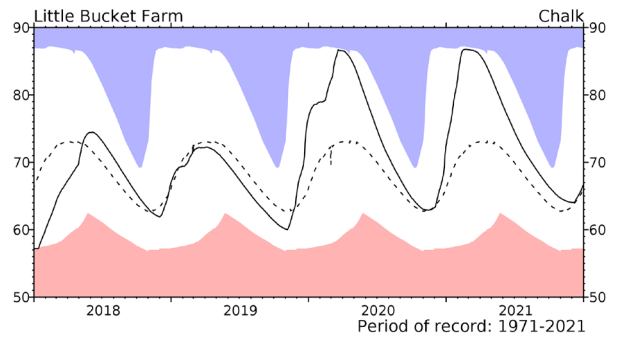



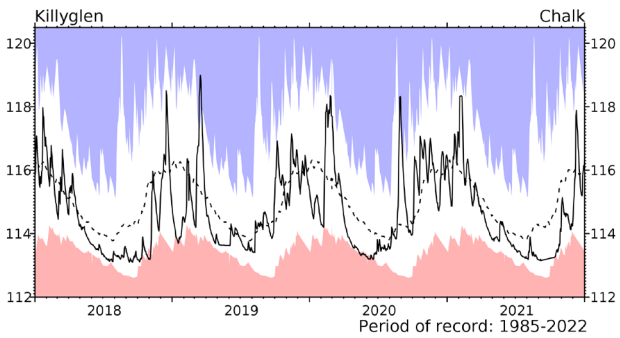



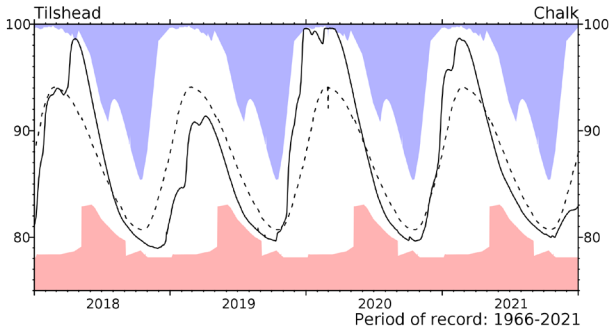



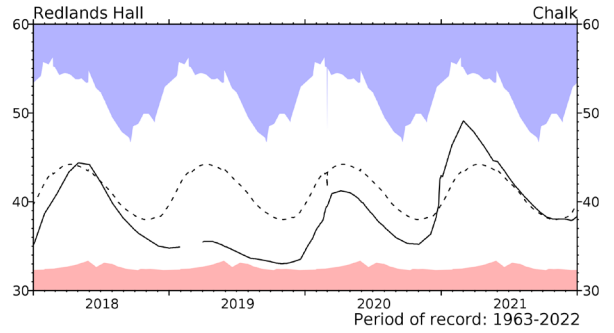



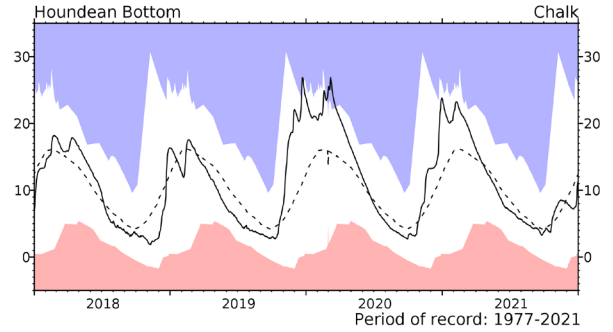



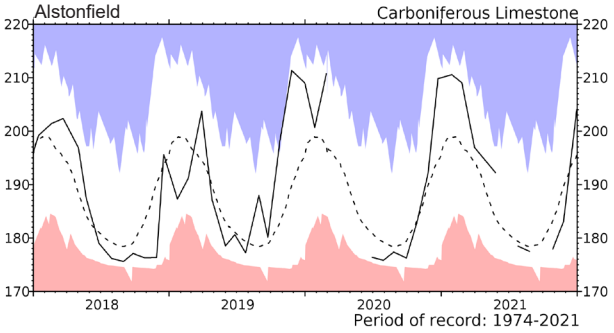

Groundwater levels (measured in metres above ordnance datum) normally rise and fall with the seasons, reaching a peak in the spring following replenishment through the winter (when evaporation losses are low and soil moist). They decline through the summer and early autumn. This seasonal variation is much reduced when the aquifer is confined below overlying impermeable strata. The monthly mean and the highest and lowest levels recorded for each month are calculated with data from the start of the record to the end of 2017. Note that most groundwater levels are not measured continuously and, for some index wells, the greater frequency of contemporary measurements may, in itself, contribute to an increased range of variation.

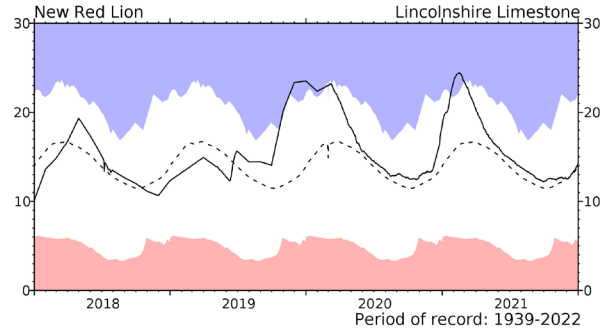
# Groundwater…Groundwater

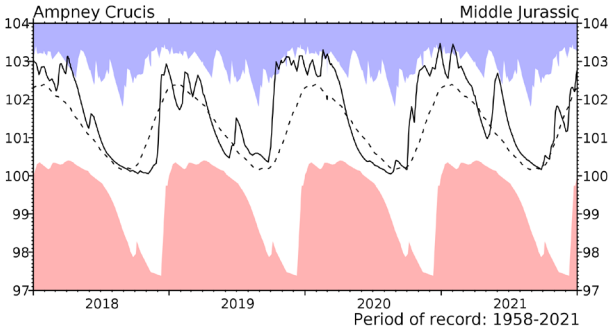


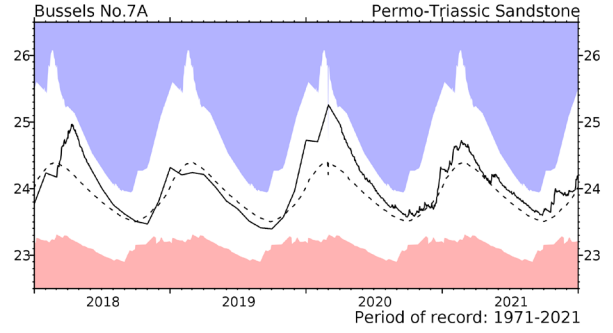



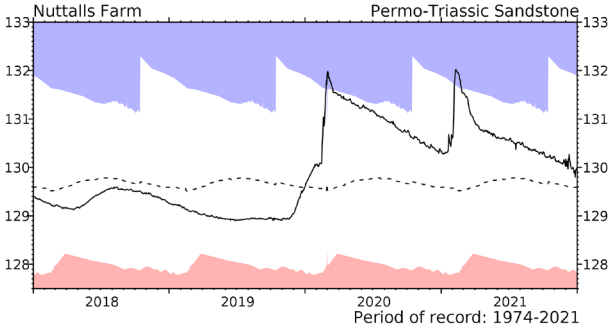



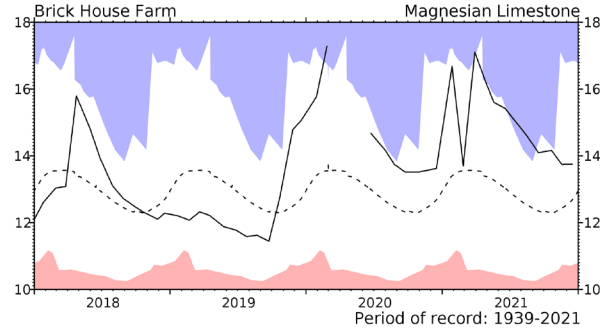



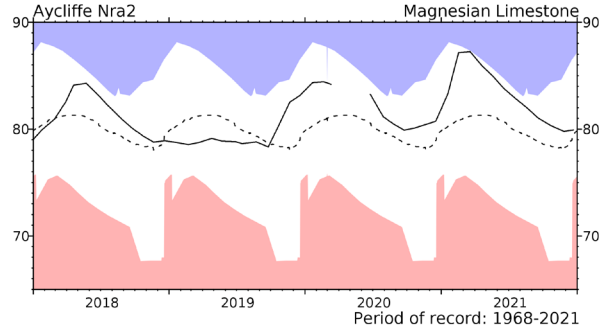



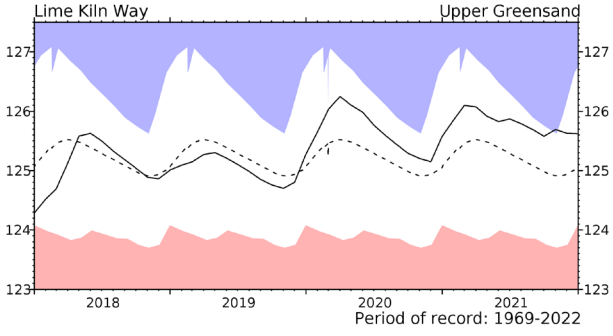



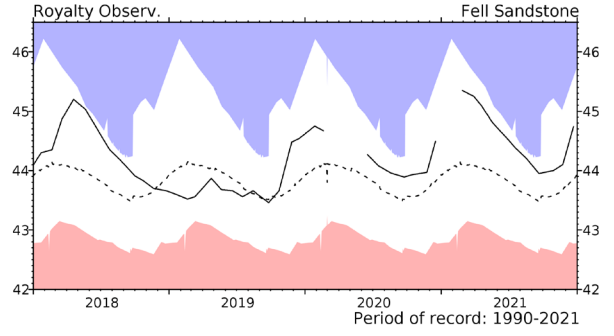



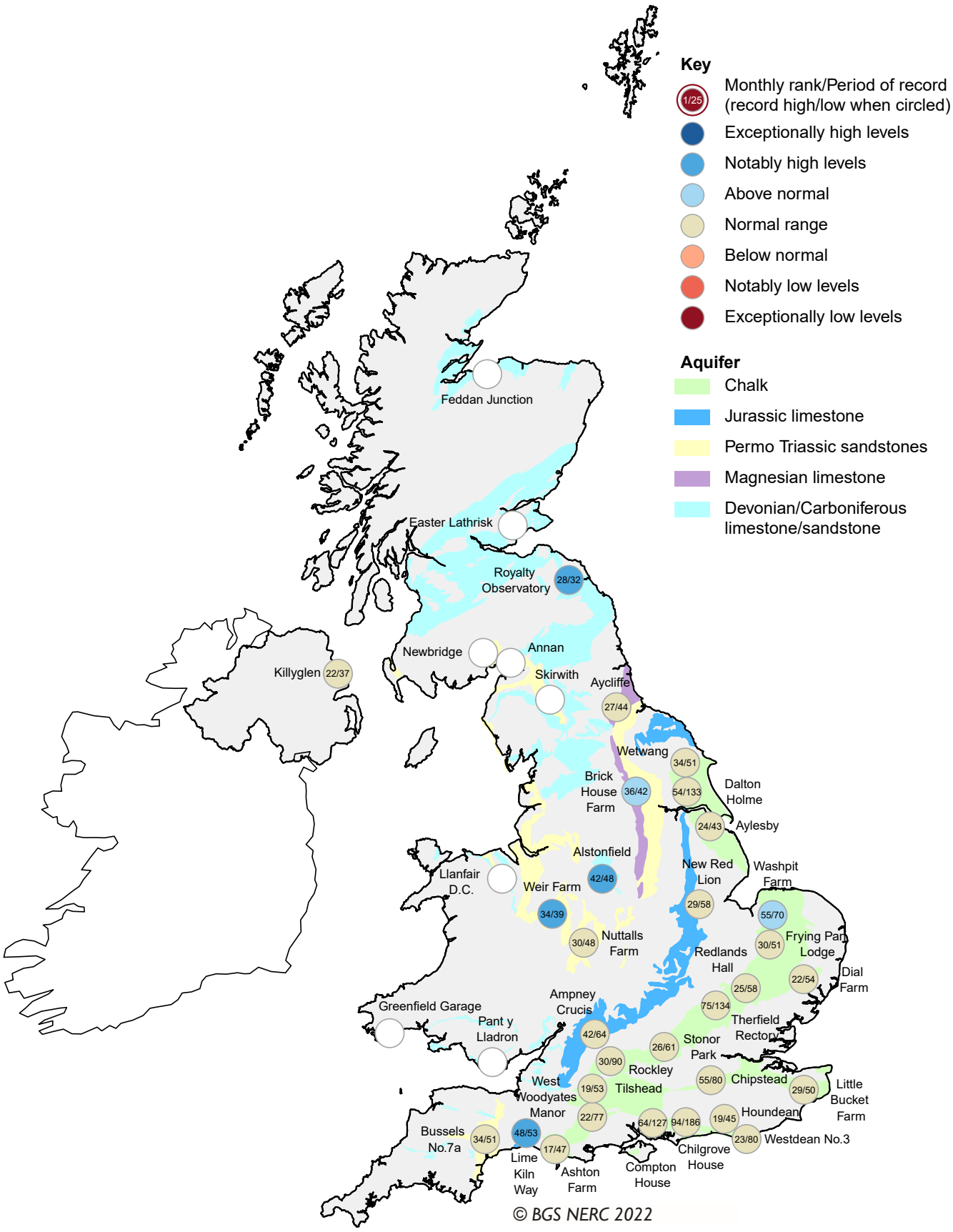





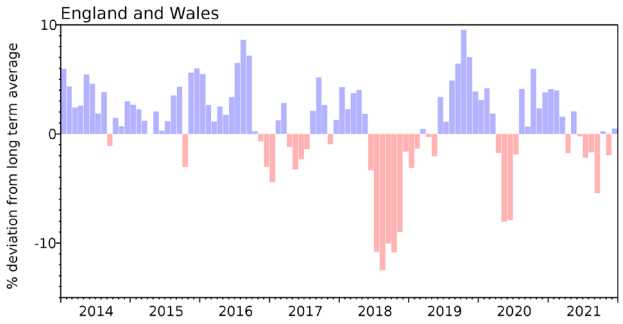

## Groundwater levels - December 2021

The calculation of ranking has been modified from that used in summaries published prior to October 2012. It is now based on a comparison between the most recent level and levels for the same date during previous years of record. Where appropriate, levels for earlier years may have been interpolated. The rankings are designed as a qualitative indicator, and ranks at extreme levels, and when levels are changing rapidly, need to be interpreted with caution.

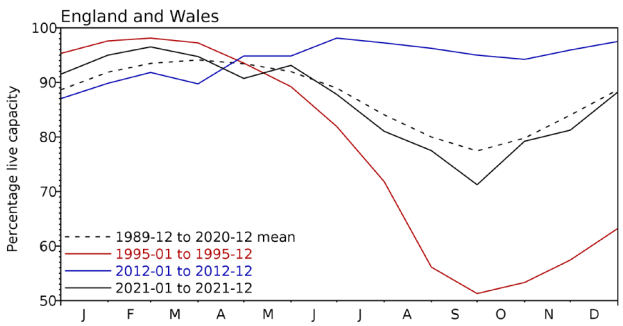
*Note that due to issues with data access, no data are available for Scotland and Wales.*

# Reservoirs . . . Reservoirs . . .

## Guide to the variation in overall reservoir stocks for England and Wales*




## Comparison between overall reservoir stocks for England and Wales in recent years*




*Note: Due to data access issues, the England and Wales stocks for December do not include the Northern Command Zone group or Vyrnwy

## Percentage live capacity of selected reservoirs at end of month

| Area | Reservoir | | Capacity (Ml) | 2021 Oct | 2021 Nov | 2021 Dec | Dec Anom. | Min Dec | Year* of min | 2020 Dec | Diff 21-20 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Northumbrian | Teesdale | • | 87936 | 69 | 75 | 83 | -8 | 41 | 1995 | 94 | -12 |
| | Kielder | | (199175) | 81 | 85 | 87 | -4 | 70 | 1989 | 89 | -2 |
| Severn-Trent | Clywedog | | 49936 | 88 | 88 | 89 | 4 | 54 | 1995 | 89 | 0 |
| | Derwent Valley | • | 46692 | 51 | 63 | 99 | 9 | 10 | 1995 | 100 | -1 |
| Yorkshire | Washburn | • | 23373 | 73 | 76 | 88 | 1 | 23 | 1995 | 98 | -10 |
| | Bradford Supply | • | 40942 | 66 | 68 | 87 | -4 | 22 | 1995 | 100 | -13 |
| Anglian | Grafham | | (55490) | 94 | 94 | 90 | 6 | 57 | 1997 | 87 | 3 |
| | Rutland | | (116580) | 80 | 76 | 77 | -6 | 60 | 1990 | 87 | -10 |
| Thames | London | • | 202828 | 82 | 82 | 85 | -2 | 60 | 1990 | 86 | -1 |
| | Farmoor | • | 13822 | 90 | 93 | 91 | 1 | 71 | 1990 | 78 | 13 |
| Southern | Bewl | | 31000 | 74 | 72 | 76 | 4 | 34 | 2005 | 74 | 2 |
| | Ardingly | | 4685 | 96 | 100 | 100 | 15 | 30 | 2011 | 87 | 13 |
| Wessex | Clatworthy | | 5662 | 78 | 85 | 91 | 0 | 54 | 2003 | 100 | -9 |
| | Bristol | • | (38666) | 67 | 72 | 75 | -5 | 40 | 1990 | 100 | -25 |
| South West | Colliford | | 28540 | 64 | 65 | 72 | -7 | 46 | 1995 | 80 | -8 |
| | Roadford | | 34500 | 87 | 89 | 96 | 18 | 20 | 1989 | 90 | 7 |
| | Wimbleball | | 21320 | 74 | 76 | 86 | 3 | 46 | 1995 | 100 | -14 |
| | Stithians | | 4967 | 56 | 62 | 71 | -10 | 33 | 2001 | 100 | -29 |
| Welsh | Celyn & Brenig | • | 131155 | 80 | 85 | 98 | 5 | 54 | 1995 | 95 | 3 |
| | Brianne | | 62140 | 100 | 97 | 99 | 1 | 76 | 1995 | 98 | 1 |
| | Big Five | • | 69762 | 78 | 80 | 90 | 0 | 67 | 1995 | 94 | -4 |
| | Elan Valley | • | 99106 | 80 | 81 | 100 | 3 | 56 | 1995 | 100 | 0 |
| Scotland(E) | Edinburgh/Mid-Lothian | • | 97223 | 85 | 88 | 89 | -2 | 60 | 1998 | 98 | -9 |
| | East Lothian | • | 9317 | 100 | 100 | 100 | 4 | 48 | 1989 | 100 | 0 |
| Scotland(W) | Loch Katrine | • | 110326 | 71 | 92 | 96 | 4 | 75 | 2007 | 100 | -4 |
| | Daer | | 22494 | 100 | 100 | 100 | 2 | 83 | 1995 | 98 | 2 |
| | Loch Thom | | 10721 | 75 | 83 | 100 | 3 | 80 | 2007 | 92 | 8 |
| Northern | Total+ | • | 56800 | 75 | 74 | 89 | -1 | 61 | 2001 | 100 | -11 |
| Ireland | Silent Valley | • | 20634 | 68 | 65 | 89 | 3 | 39 | 2001 | 99 | -10 |

( ) figures in parentheses relate to gross storage

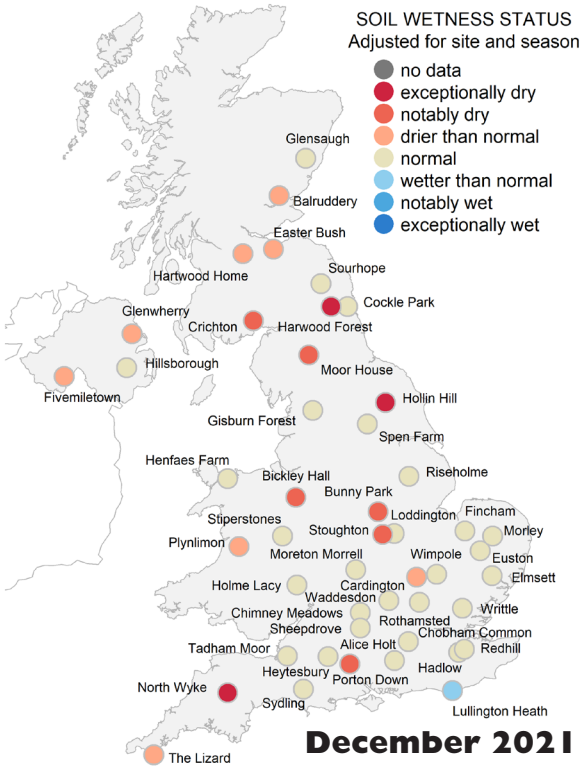
• denotes reservoir groups

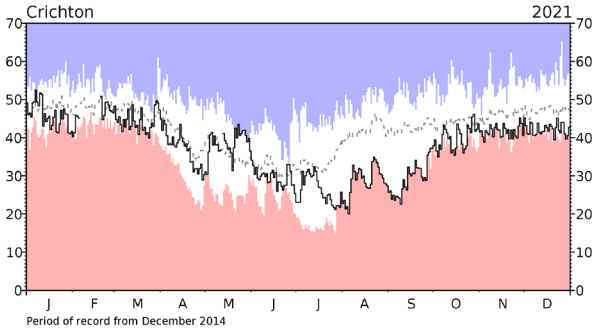
*last occurrence

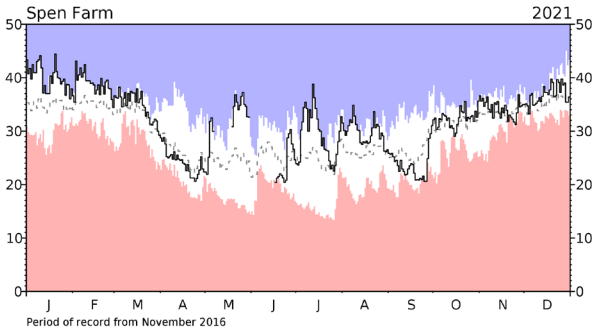
+ excludes Lough Neagh

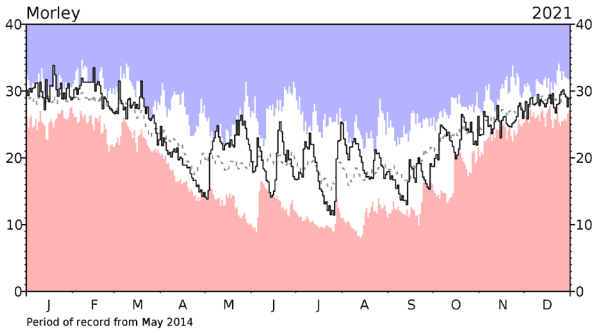
Details of the individual reservoirs in each of the groupings listed above are available on request. The percentages given in the Average and Minimum storage columns relate to the 1988-2012 period except for West of Scotland and Northern Ireland where data commence in the mid-1990s. In some gravity-fed reservoirs (e.g. Clywedog) stocks are kept below capacity during the winter to provide scope for flood attenuation purposes. Monthly figures may be artificially low due to routine maintenance or turbidity effects in feeder rivers.

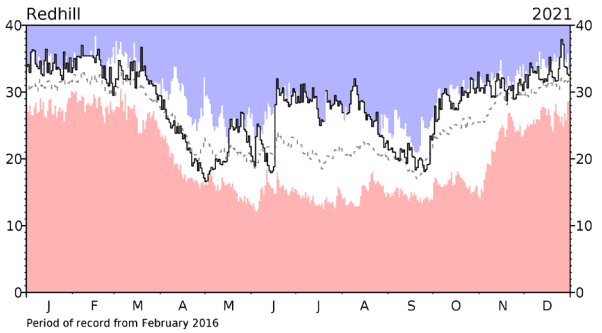
# Soil Moisture . . . Soil Moisture

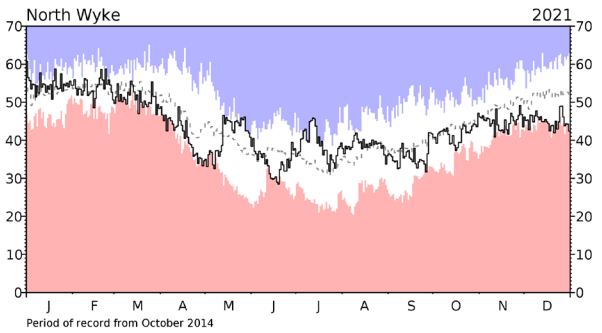



In December soil moisture is expected to be close to, or above, field capacity. At sites that have had recent rainfall soil moisture was in fact above field capacity, whereas at sites that have had little recent rainfall, and a spell of uncharacteristically warm weather at the end of the month, soil moisture was slightly below field capacity. The map above shows this, and also that there was no clear regional pattern to soil wetness.

These conditions were in some cases drier, or perhaps more correctly not as wet, as normal since in some winters heavy rainfall will cause soils to become saturated. Crichton and North Wyke are examples of where soils were drier than expected for the time of year.

Elsewhere, soils hovered around normal soil wetness with short-term increases to above normal conditions in response to rainfall events, as seen at Redhill and Spen Farm.

Some sites have seen soil moisture track in the normal range for several months (e.g. Morley).

## Soil moisture data

These data are from UKCEH's COSMOS-UK network. The time series graphs show volumetric water content as a percentage in black together with the maximum and minimum daily values for the period-of-record of the sites. The dashed line represents the period-of-record mean VWC. For more information visit cosmos.ceh.ac.uk.

## NHMP

The National Hydrological Monitoring Programme (NHMP) was started in 1988 and is undertaken jointly by the UK Centre for Ecology & Hydrology (UKCEH) and the British Geological Survey (BGS). The NHMP aims to provide an authoritative voice on hydrological conditions throughout the UK, to place them in a historical context and, over time, identify and interpret any emerging hydrological trends. Hydrological analysis and interpretation within the Programme is based on the data holdings of the National River Flow Archive (NRFA; maintained by UKCEH) and National Groundwater Level Archive (NGLA; maintained by BGS), including rainfall, river flows, borehole levels, and reservoir stocks.

The Hydrological Summary is supported by the Natural Environment Research Council award number NE/R016429/1 as part of the UK-SCAPE programme delivering National Capability.

## Data Sources

The NHMP depends on the active cooperation of many data suppliers. This cooperation is gratefully acknowledged. River flow and groundwater level data are provided by the Environment Agency (EA), Natural Resources Wales - Cyfoeth Naturiol Cymru (NRW), the Scottish Environment Protection Agency (SEPA) and, for Northern Ireland, the Department for Infrastructure - Rivers and the Northern Ireland Environment Agency. In all cases the data are subject to revision following validation (high flow and low flow data in particular may be subject to significant revision).

Details of reservoir stocks are provided by the Water Service Companies, the EA, Scottish Water and Northern Ireland Water.

The Hydrological Summary and other NHMP outputs may also refer to and/or map soil moisture data for the UK. These data are provided by the Meteorological Office Rainfall and Evaporation Calculation System (MORECS). MORECS provides estimates of monthly soil moisture deficit in the form of averages over 40 x 40 km grid squares over Great Britain and Northern Ireland. The monthly time series of data extends back to 1961.

Rainfall data are provided by the Met Office. To allow better spatial differentiation the rainfall data for Britain are presented for the regional divisions of the precursor organisations of the EA, NRW and SEPA. The areal rainfall figures have been produced by the Met Office National Climate Information Centre (NCIC), and are based on 5km resolution gridded data from rain gauges. The majority of the full rain gauge network across the UK is operated by the EA, NRW, SEPA and Northern Ireland Water; supplementary rain gauges are operated by the Met Office. The Met Office NCIC monthly rainfall series extend back to 1910 and form the official source of UK areal rainfall statistics which have been adopted by the NHMP. The gridding technique used is described in Perry MC and Hollis DM (2005) available at https://doi.org/10.1002/joc.1161

Long-term averages are based on the period 1981-2010 and are derived from the monthly areal series.

The regional figures for the current month in the hydrological summaries are based on a limited rain gauge network so these (and the associated return periods) should be regarded as a guide only.

The monthly rainfall figures are provided by the Met Office NCIC and are Crown Copyright and may not be passed on to, or published by, any unauthorised person or organisation.

For further details on rainfall or MORECS data, please contact the Met Office:

Tel: 0870 900 0100
Email: enquiries@metoffice.gov.uk

## Enquiries

Enquiries should be directed to the NHMP:

Tel: 01491 692599
Email: nhmp@ceh.ac.uk

A full catalogue of past Hydrological Summaries can be accessed and downloaded at:

http://nrfa.ceh.ac.uk/monthly-hydrological-summary-uk

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