Hydrological Summary
for the United Kingdom

September 2019

General

With an unsettled start and persistent frontal rain towards the end of the month, it was a wet September across much of the country. Over north-west Scotland, and parts of south-east England, however, rainfall totals were below average, and the UK enjoyed a dry spell mid-month that included some unseasonal warmth (27.7°C in Weybourne, Norfolk on the 22nd). During the last ten days, heavy rain caused travel disruption and localised flooding in England, Wales and Northern Ireland. Flows on many rivers in Wales and northern England were notably or exceptionally high for a second consecutive month, in contrast to notably and exceptionally low flows in parts of the south-east. Soil Moisture Deficits (SMDs) decreased markedly in response to the rainfall and by the end of the month soils were wetter than average across the country. Groundwater levels continued to decline at most sites, however, the overall situation was similar to that seen in August, with below normal or notably low levels in the Chalk, and mainly normal or above normal in other aquifers. Reservoir stocks remained healthy (with notable increases in Yorkshire and Severn Trent), except in the south-west and south-east (including the London reservoirs) where deficits relative to average remained. Whilst the outlook for water resources across much of the UK is healthy, sustained rainfall (following the wet start to October) is needed to return water resources in the south-east to normal over the winter half-year.

Rainfall

Unsettled conditions affected all but southernmost areas during the first week of September with successive westerly fronts. Patchy rain (that was moderately heavy in the west on the 9th and in the north-west on the 14th) gave way to a high pressure system bringing dry conditions across the country from the 16th-20th. The return and intensification of the wet weather brought bands of persistent rain and associated weather warnings and travel disruption across England and Wales that continued until month-end. Heavy rain on the 23rd-24th (66mm at Kingston Maurward, Dorset on the 23rd) affected rail services at four London stations, and on the 28th (when a daily total of 54mm was recorded at Sennybridge, Brecon Beacons), a mudslide covered the railway track between Lancaster and Leeds. September rainfall for the UK as whole was 131% of average, although below average in coastal areas of south-east and north-east England and in central and north-western Scotland, with Highland (at 83%) the driest region relative to its average. Elsewhere, September totals were above average, and North West England, Yorkshire and South West England each received more than 170% of their average rainfall. Following the wet August, two month accumulations were similarly high in North West England, Tweed and in Solway, where it was the third wettest August-September recorded (in a series from 1910).

River flows

Flow responses at the start of September, notably in the north and west, gave way to recessions between the 16th and 21st with new daily minima recorded on the Little Ouse, Colne, Great Stour and Stour. In fact, daily flows on the Little Ouse were lower than the minimum established in August 1976 for nine consecutive days (from 15th-23rd). Subsequently flows increased, sharply in places, and peaked towards month-end. On the 28th, fluvial flooding closed roads in north-east Scotland, and new September peak flow maxima were established on the Tawe and the Dyfi (in records from 1958 and 1963, respectively). Monthly maxima were similarly recorded the following day on the English Don and the Ribble (in records from 1959 and 1960, respectively), and again on the 30th on the Dover Beck (in a record from 1972), by which time more than 70 Flood Warnings were in place across England and Wales. Mean September river flows were normal or above normal in Scotland, Northern Ireland and south-west England, and notably or exceptionally high in northern England and in Wales, where on the Tawe, at 243% of average, they were the second highest on record (in a series from 1958). By contrast, mean monthly flows on many rivers in the south and east were below normal or lower, and the Colne, Lee and Great Stour each recorded their lowest August-September mean flow since 1997. On the Little Ouse, there were new minimum records for monthly mean flow (previously set in 1997), and for the water year (October-September) as a whole (in a series from 1968). The Colne similarly recorded its lowest mean flow for a water year since the drought of 1995-1996. Nevertheless, with two consecutive months of high flows elsewhere (the highest August-September mean on the Welsh Dee since 1974), the Great Britain outflow for August-September was the fourth highest in a series from 1961.

Groundwater

Soils at the end of September were widely wetter than average, with September rainfall sufficient to eliminate SMDs in the Clyde, Solway and North West England regions, although in the south-east they remained substantial. Groundwater levels at most Chalk sites were below normal for September, with exceptionally low levels remaining at Dial Farm and Chilgrove House. Levels continued to decline at the majority of Chalk sites, including Washpit Farm, where they were notably low. Levels at Aylesby and Ashton Farm were in the normal range, while at Killyglen levels were above normal, all increasing categories from the previous month. Levels in the Jurassic limestones remained above normal, while the Magnesian Limestone sites remained normal or below normal. The Carboniferous Limestone sites in south Wales both moved up categories in response to the high rainfall, with a record high level for the end of September observed at Pant y Lladron (in a series from 1995). Levels at Lime Kiln Way in the Upper Greensand continued to recede and remained below normal. The situation in the Permo-Triassic sandstones was very similar to that of the previous month, as levels at the majority of sites remained normal or above. Levels at Royalty Observatory in the Fell Sandstone remained in the normal range.

Centre for Ecology & Hydrology
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British Geological Survey
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Rainfall . . . Rainfall . . .

Met Office

Rainfall accumulations and return period estimates

Percentages are from the 1981-2010 average.

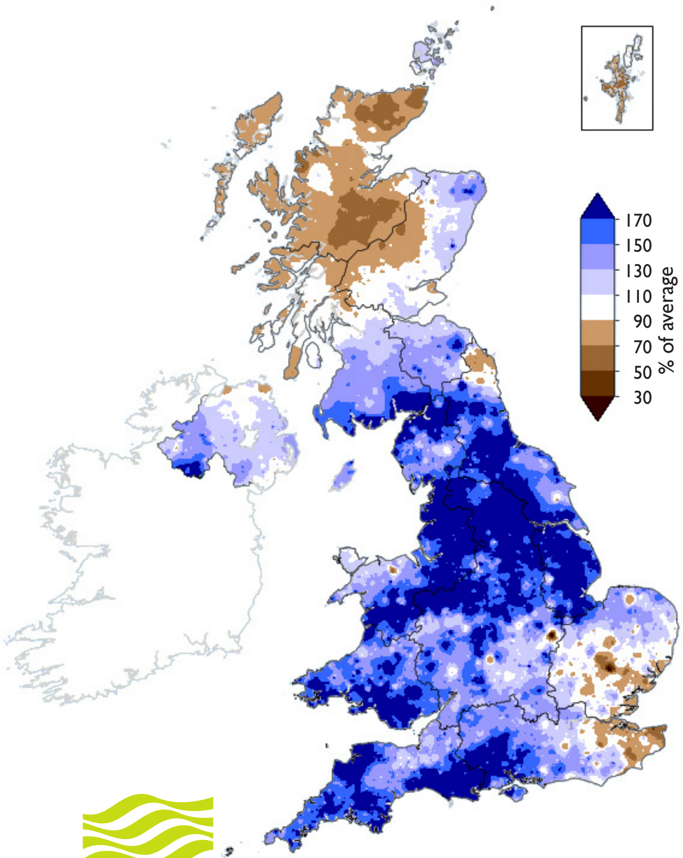
Region	Rainfall	Sep 2019	Aug19 – Sep19	RP	Jun19 – Sep19	RP	Apr19 – Sep19	RP	Oct18 – Sep19	RP
United	mm	**122**	259		459		576		1191	
Kingdom	%	**131**	143	10-20	140	20-30	124	10-20	106	5-10
England	mm	**108**	190		367		449		880	
	%	**157**	139	5-10	142	10-15	120	5-10	104	2-5
Scotland	mm	**132**	354		589		751		1601	
	%	**101**	146	20-30	140	30-50	128	20-30	106	8-12
Wales	mm	**186**	325		539		687		1567	
	%	**166**	151	5-10	139	5-10	123	5-10	110	5-10
Northern	mm	**111**	269		469		606		1217	
Ireland	%	**121**	142	5-10	135	10-15	122	10-15	107	5-10
England &	mm	**118**	208		391		481		975	
Wales	%	**158**	141	5-10	141	10-15	120	5-10	106	2-5
North West	mm	**186**	360		619		735		1427	
	%	**181**	176	25-40	167	50-80	143	30-50	116	10-20
Northumbria	mm	**110**	242		449		556		960	
	%	**154**	166	10-20	161	30-50	140	20-30	110	2-5
Severn-Trent	mm	**106**	185		399		487		852	
	%	**163**	143	5-10	158	25-40	133	10-20	109	2-5
Yorkshire	mm	**123**	198		387		470		883	
	%	**182**	142	5-10	144	10-15	123	5-10	105	2-5
Anglian	mm	**70**	116		267		326		598	
	%	**129**	104	2-5	123	5-10	104	2-5	96	2-5
Thames	mm	**75**	126		264		324		679	
	%	**128**	110	2-5	122	2-5	100	2-5	95	2-5
Southern	mm	**81**	128		263		319		763	
	%	**129**	108	2-5	120	2-5	98	2-5	96	2-5
Wessex	mm	**112**	185		315		401		891	
	%	**164**	140	2-5	128	2-5	110	2-5	101	2-5
South West	mm	**154**	264		422		532		1273	
	%	**171**	153	5-10	132	5-10	112	2-5	104	2-5
Welsh	mm	**178**	312		523		667		1509	
	%	**164**	149	5-10	139	5-10	123	5-10	110	5-10
Highland	mm	**130**	384		628		808		1832	
	%	**83**	137	10-20	133	15-25	122	8-12	101	2-5
North East	mm	**90**	222		412		607		1120	
	%	**102**	133	5-10	133	5-10	137	15-25	110	5-10
Tay	mm	**108**	300		511		678		1392	
	%	**95**	144	8-12	139	10-15	130	10-15	104	2-5
Forth	mm	**115**	295		510		654		1224	
	%	**109**	149	10-15	143	15-25	132	15-25	102	2-5
Tweed	mm	**118**	285		492		615		1133	
	%	**143**	172	15-25	157	20-35	139	15-25	111	5-10
Solway	mm	**197**	446		677		825		1764	
	%	**163**	186	50-80	160	40-60	139	50-80	119	50-80
Clyde	mm	**168**	452		747		890		1921	
	%	**105**	150	15-25	146	30-50	127	15-25	106	5-10

% = 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.

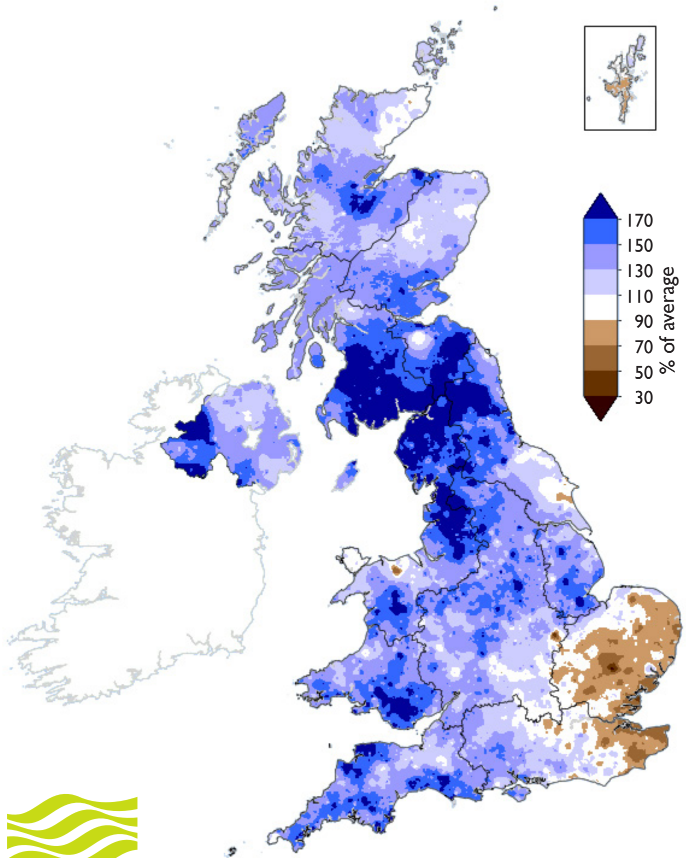
Rainfall . . . Rainfall . . .

September 2019 rainfall as % of 1981-2010 average



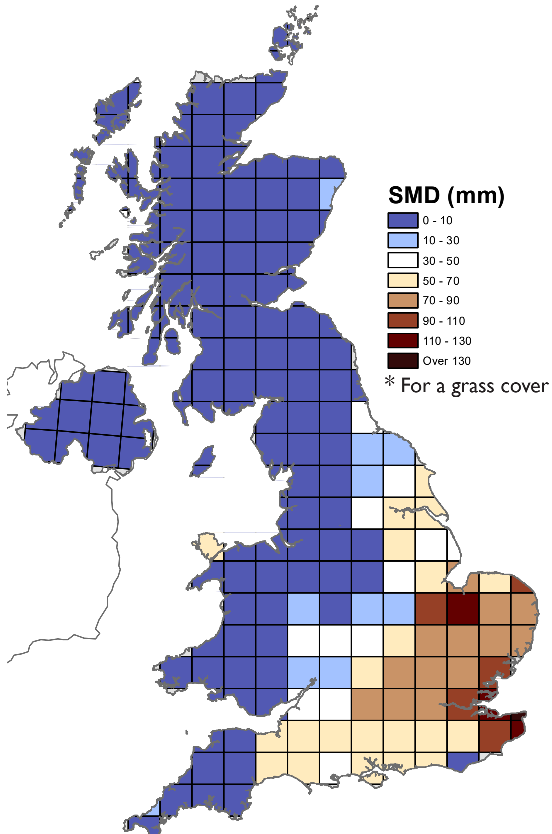
Met Office

August 2019 - September 2019 rainfall as % of 1981-2010 average



Met Office

MORECS Soil Moisture Deficits* September 2019



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.

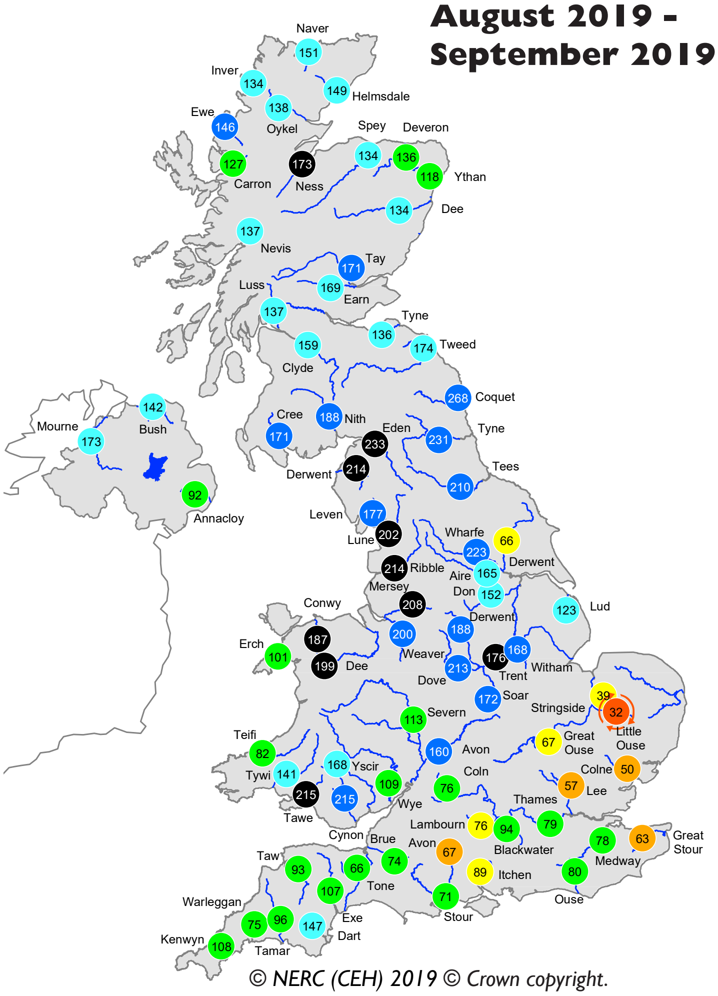
The complete version of the Hydrological Outlook UK can be found at: www.hydoutuk.net/latest-outlook/

Period: **from October 2019**
Issued: **08.10.2019**
using data to the end of September 2019

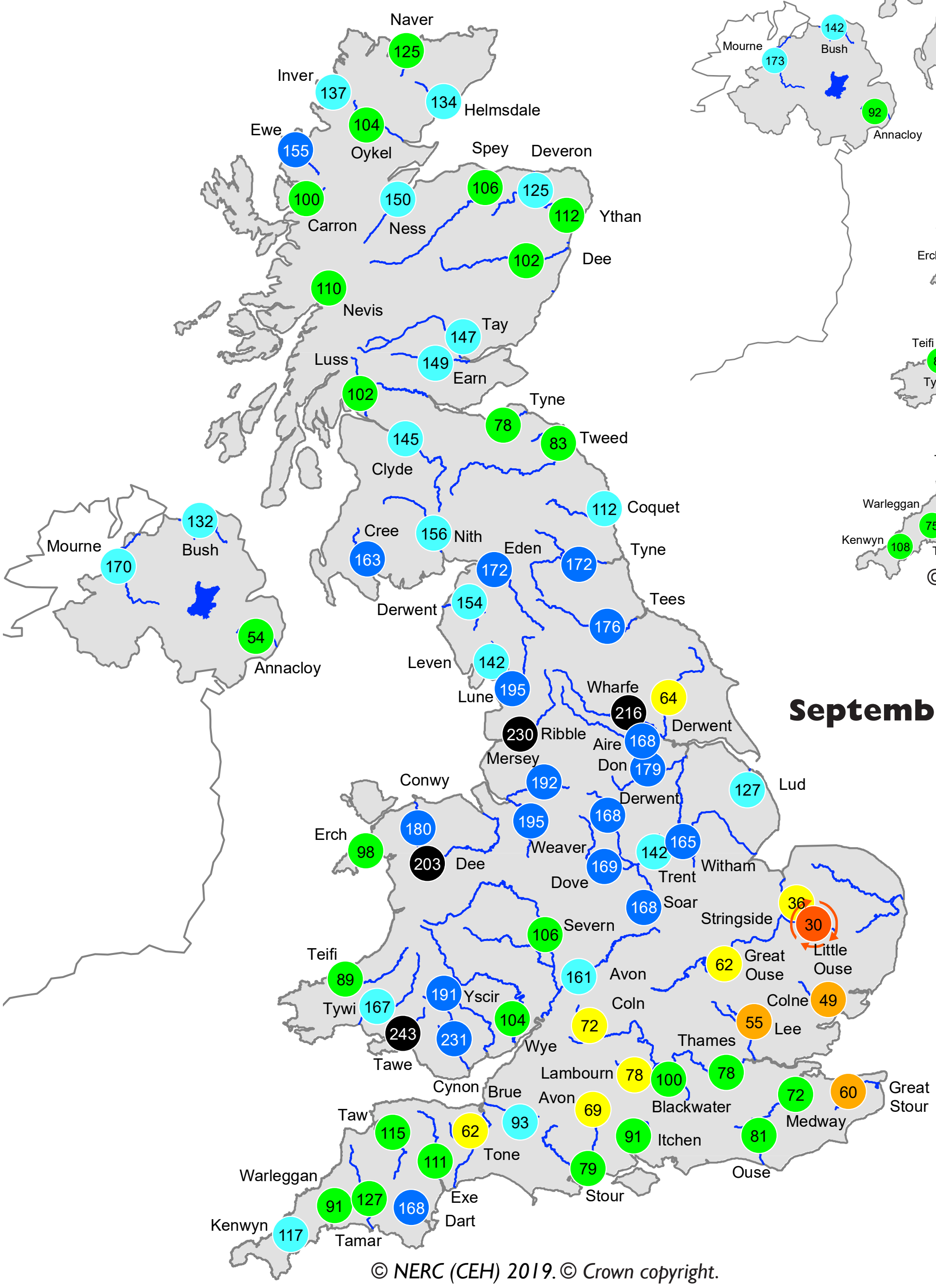
The outlook for October is for normal to below normal river flows in parts of East Anglia and southern central England, with normal to above normal flows elsewhere. A similar pattern is expected to persist for the period to December. Groundwater levels are expected to be below normal in southern and eastern parts of England, and normal elsewhere. Over the period to December it is likely that many groundwater levels will return to normal, with below normal levels persisting in the Chilterns and the Chalk to the north of London.

River flow . . . River flow . . .

August 2019 - September 2019



September 2019



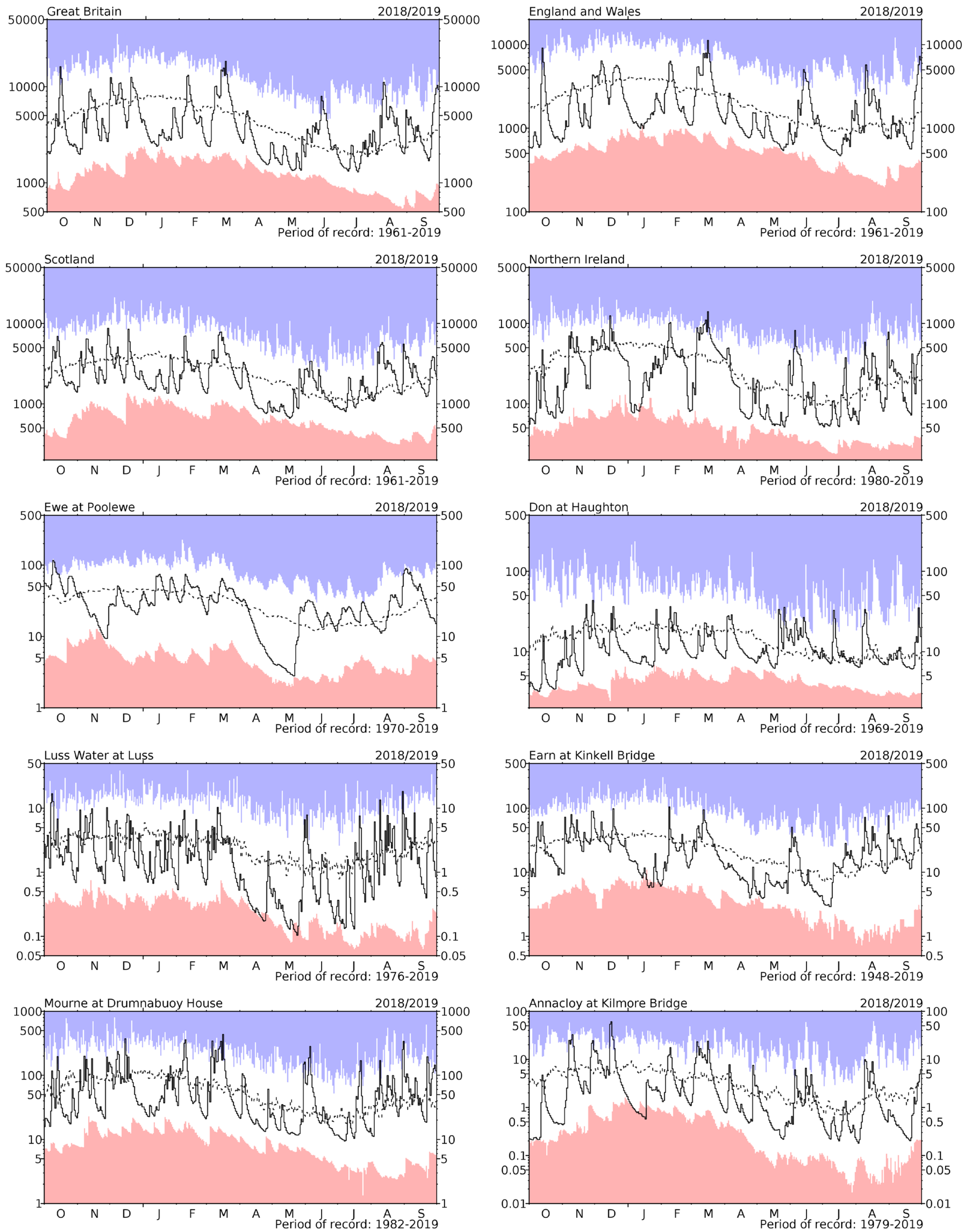
Key

- 25 — % of long-term average (record figure when circled)
- Exceptionally high flow
- Notably high flow
- Above normal
- Normal range
- Below normal
- Notably low flow
- Exceptionally low flow

*Based on ranking of the monthly flow**

River flows

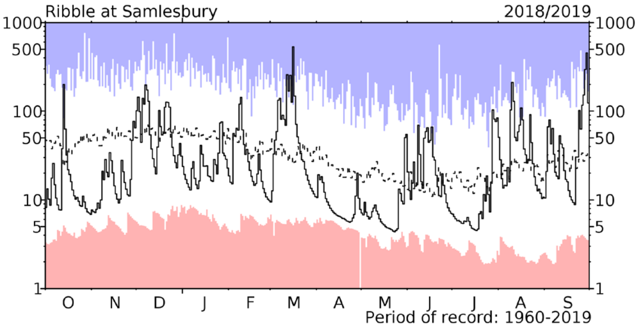
*Comparisons based on percentage flows alone can be misleading. A given percentage flow can represent extreme drought conditions in permeable catchments where flow patterns are relatively stable but be well within the normal range in impermeable catchments where the natural variation in flows is much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

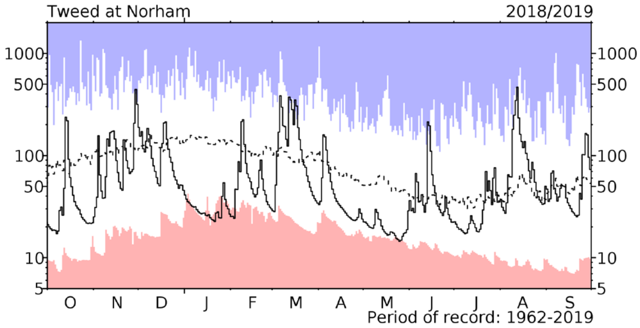


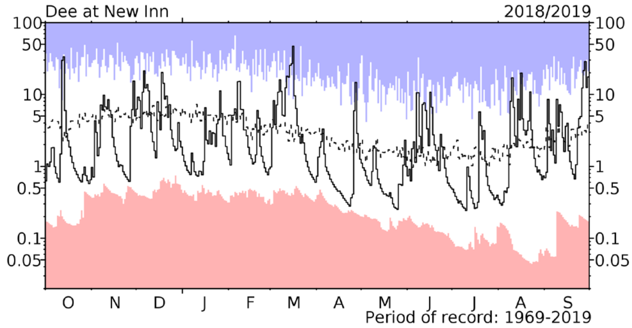
River flow hydrographs

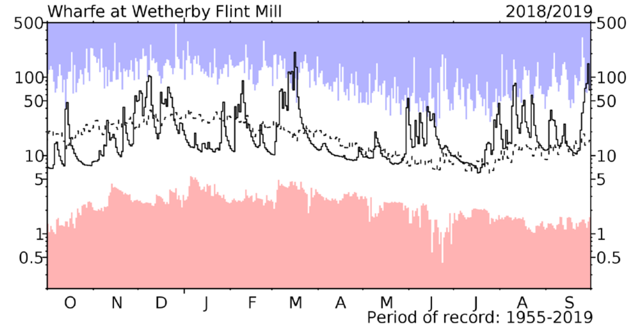
*The river flow hydrographs show the daily mean flows (measured in m^3s^{-1}) together with the maximum and minimum daily flows prior to October 2018 (shown by the shaded areas). Daily flows falling outside the maximum/minimum range are indicated where the bold trace enters the shaded areas. The dashed line represents the period-of-record average daily flow.

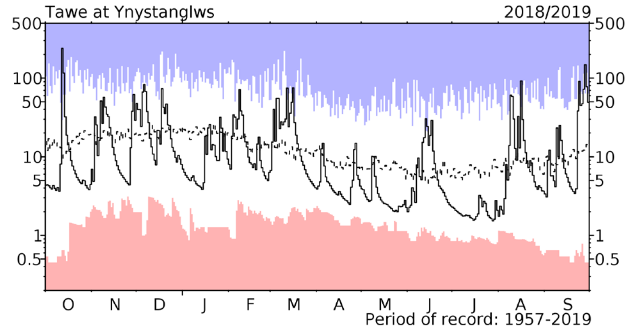
River flow . . . River flow . . .

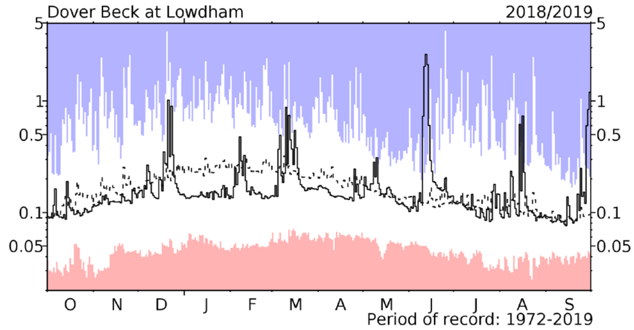


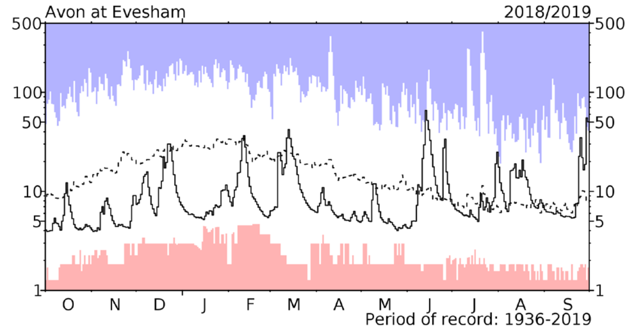


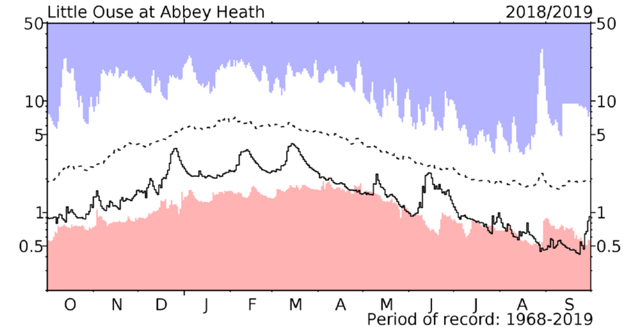


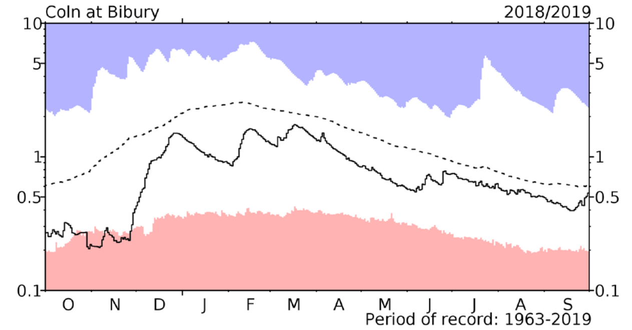


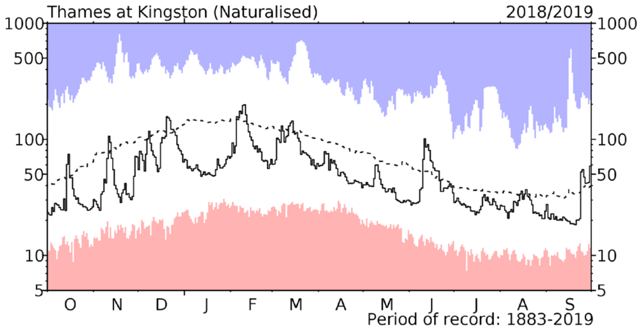


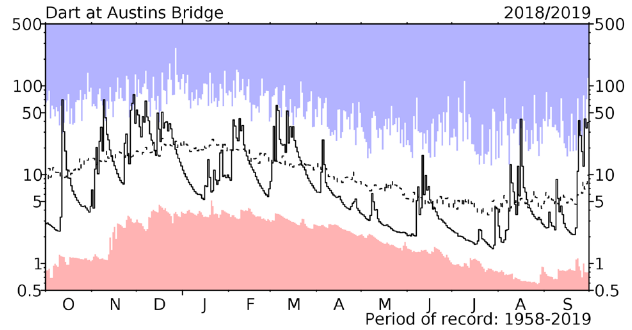


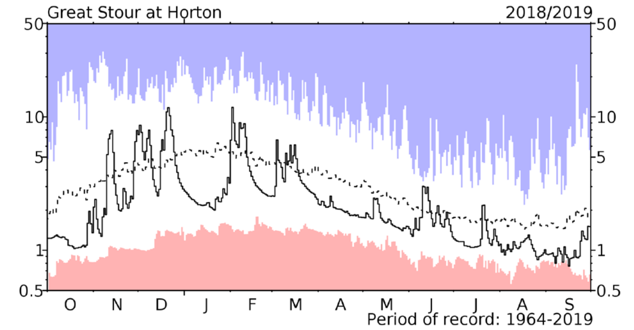




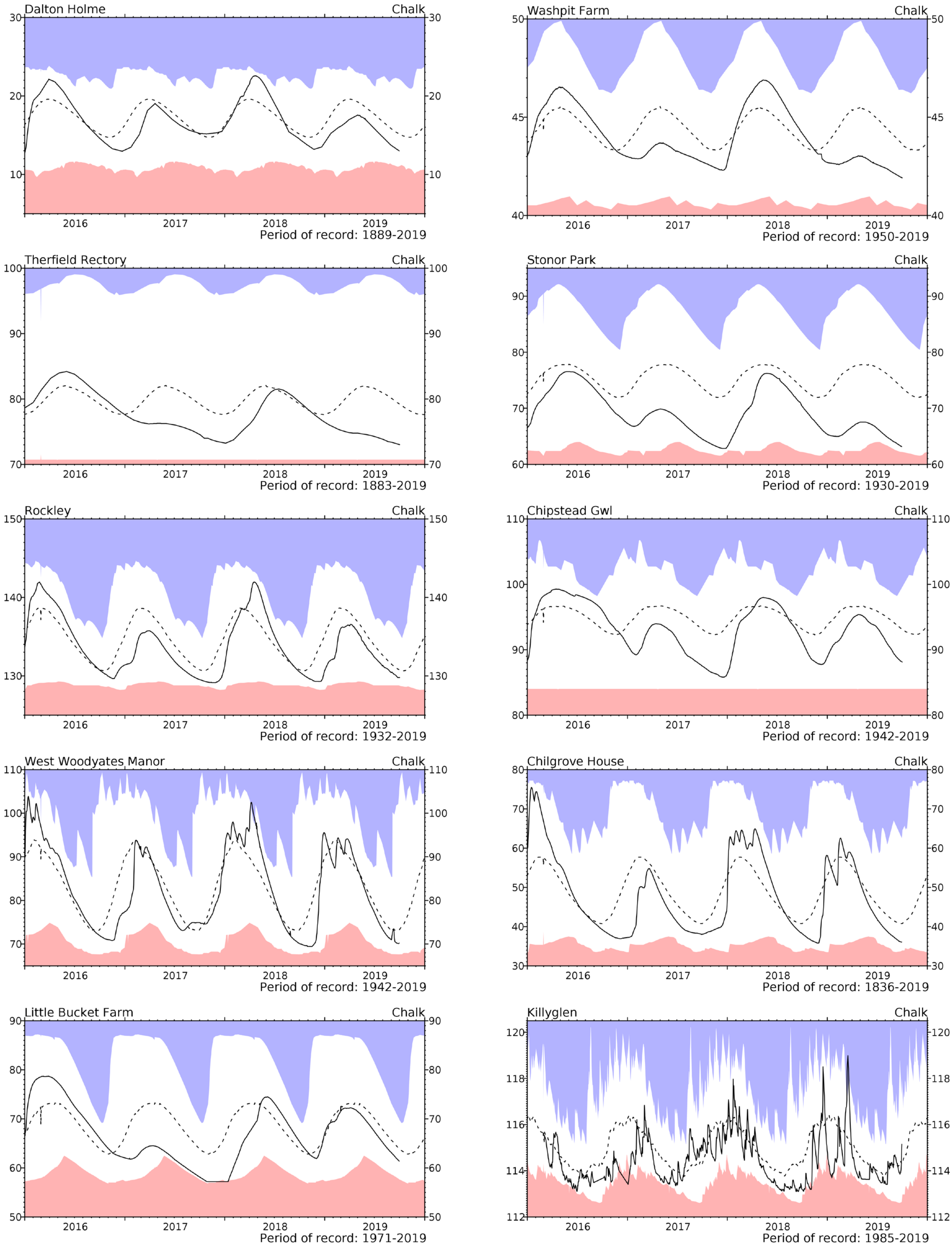




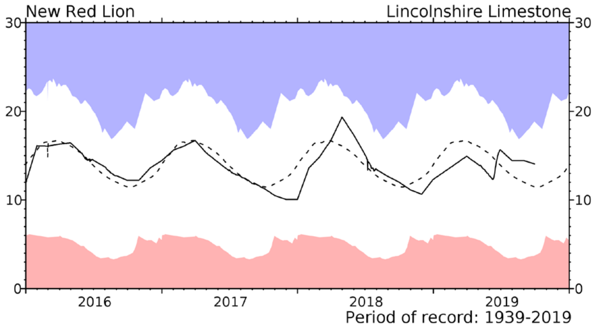


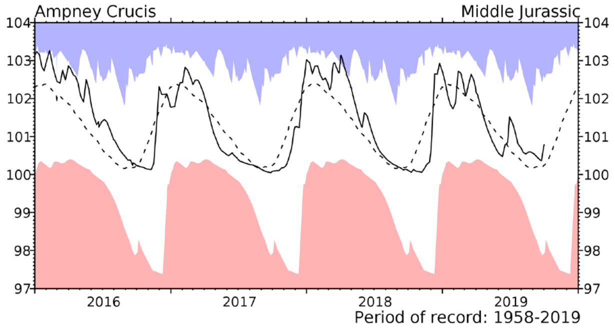


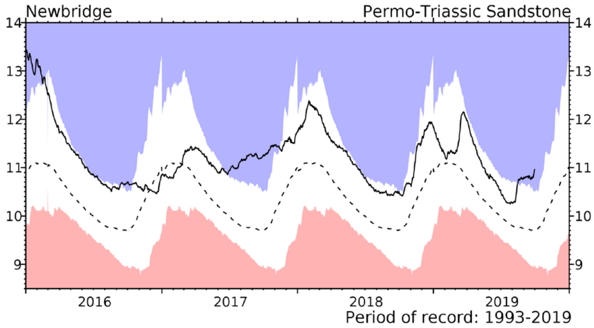
Groundwater . . . Groundwater

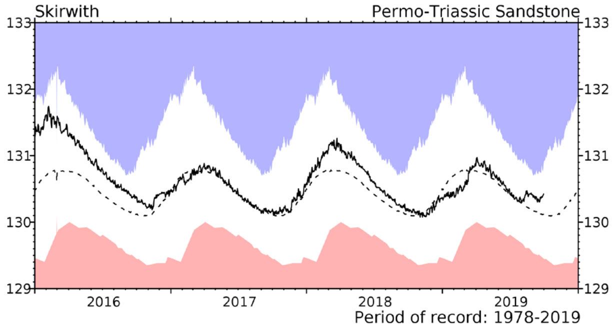


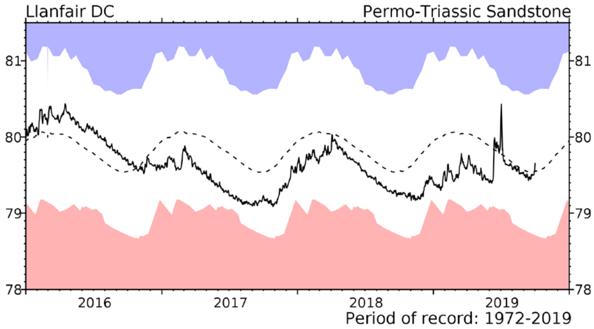
Groundwater levels (measured in metres above ordnance datum) normally rise and fall with the seasons, reaching a peak in the spring following replenishment through the winter (when evaporation losses are low and soil moist). They decline through the summer and early autumn. This seasonal variation is 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 displayed in a similar style to the river flow hydrographs. 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.

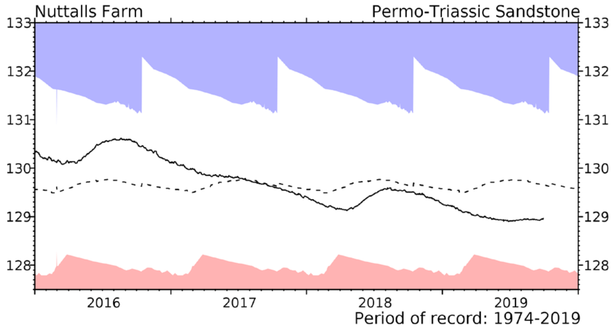

New Red Lion
Lincolnshire Limestone
2016
2017
2018
2019
Period of record: 1939-2019

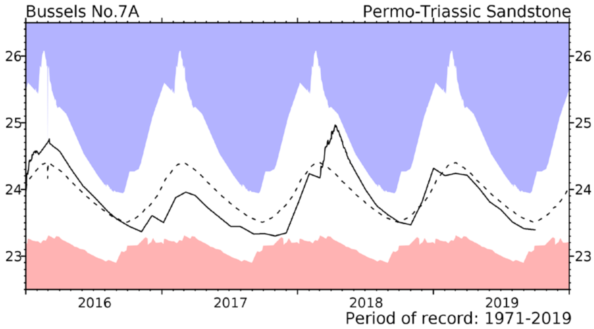

Ampney Crucis
Middle Jurassic
2016
2017
2018
2019
Period of record: 1958-2019

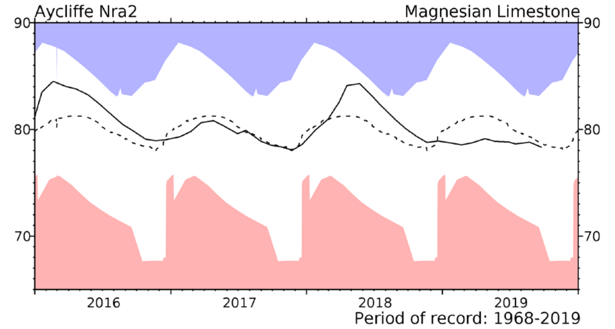

Newbridge
Permo-Triassic Sandstone
2016
2017
2018
2019
Period of record: 1993-2019

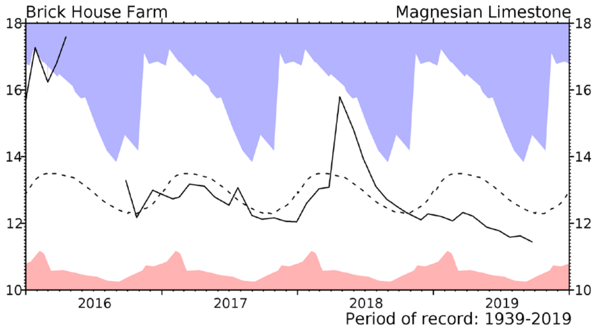

Skirwith
Permo-Triassic Sandstone
2016
2017
2018
2019
Period of record: 1978-2019

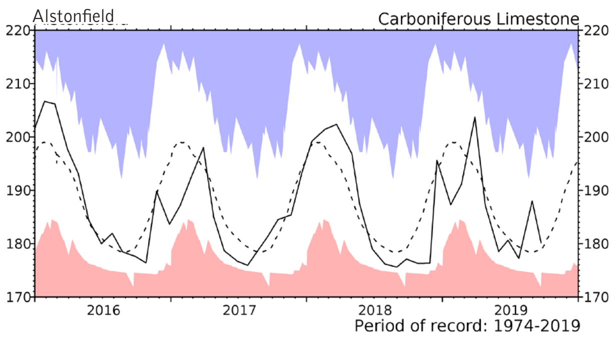

Llanfair DC
Permo-Triassic Sandstone
2016
2017
2018
2019
Period of record: 1972-2019

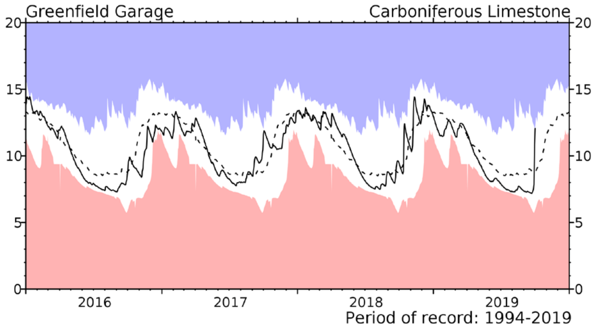

Nuttalls Farm
Permo-Triassic Sandstone
2016
2017
2018
2019
Period of record: 1974-2019

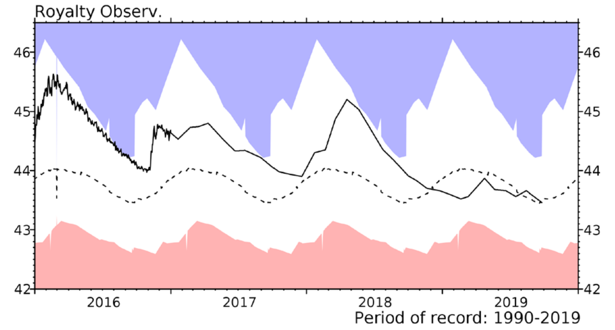

Bussels No.7A
Permo-Triassic Sandstone
2016
2017
2018
2019
Period of record: 1971-2019


Aycliffe Nra2
Magnesian Limestone
2016
2017
2018
2019
Period of record: 1968-2019

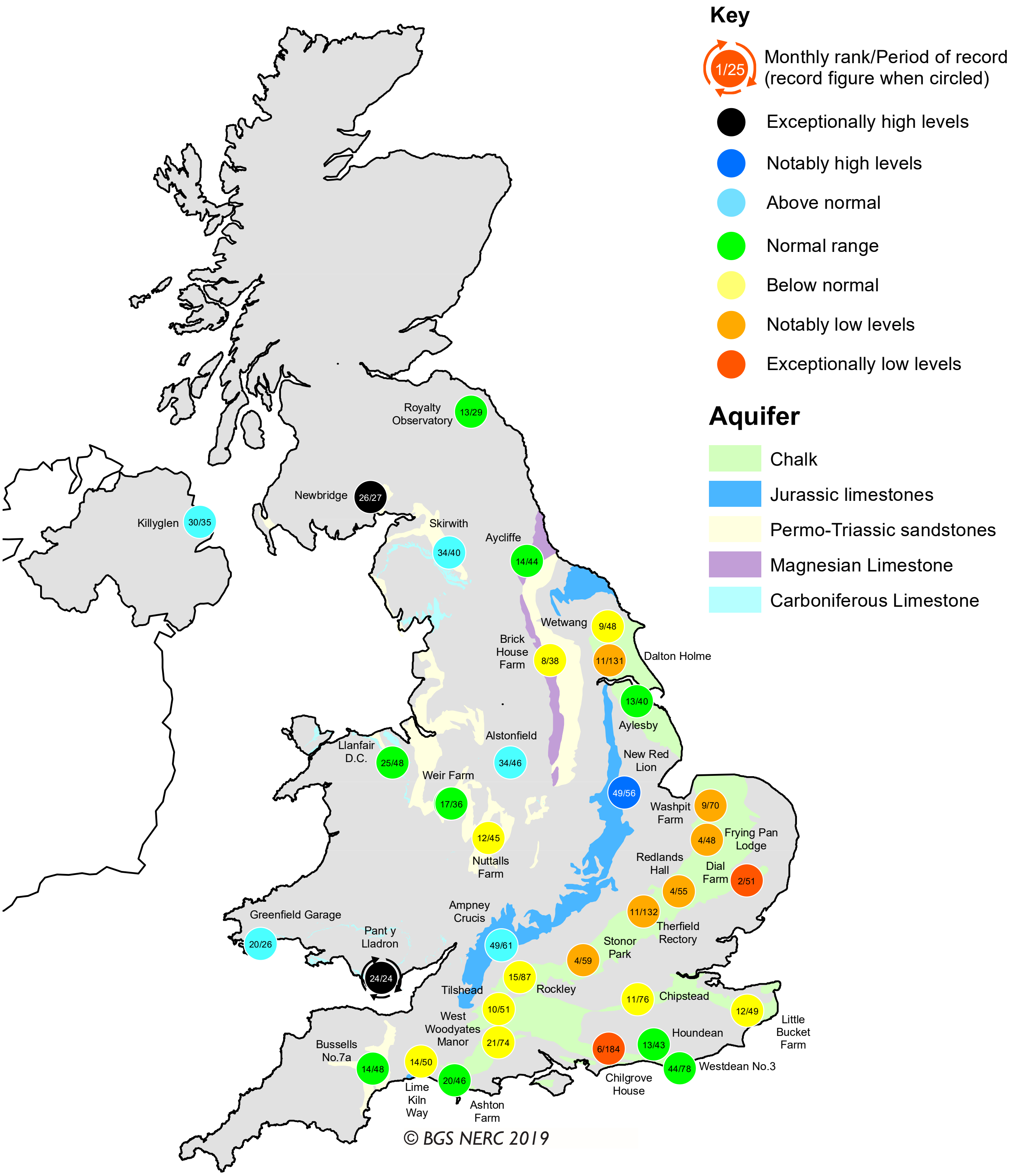

Brick House Farm
Magnesian Limestone
2016
2017
2018
2019
Period of record: 1939-2019


Alstonfield
Carboniferous Limestone
2016
2017
2018
2019
Period of record: 1974-2019


Greenfield Garage
Carboniferous Limestone
2016
2017
2018
2019
Period of record: 1994-2019


Royalty Observ.
2016
2017
2018
2019
Period of record: 1990-2019

Groundwater...Groundwater

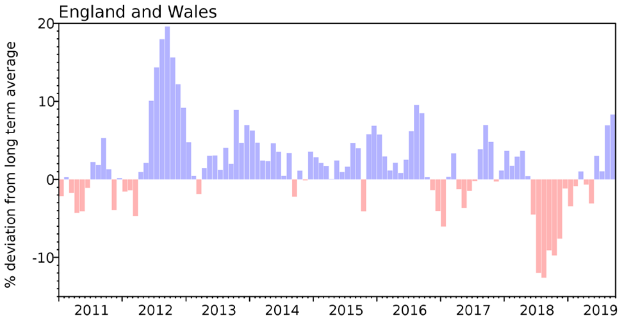


Groundwater levels - September 2019

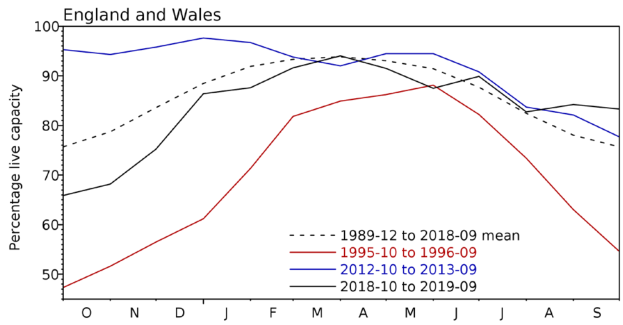
The calculation of ranking has been modified from that used in summaries published prior to October 2012. It is now based on a comparison between the most recent level and levels for the same date during previous years of record. Where appropriate, levels for earlier years may have been interpolated. 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.

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



Percentage live capacity of selected reservoirs at end of month

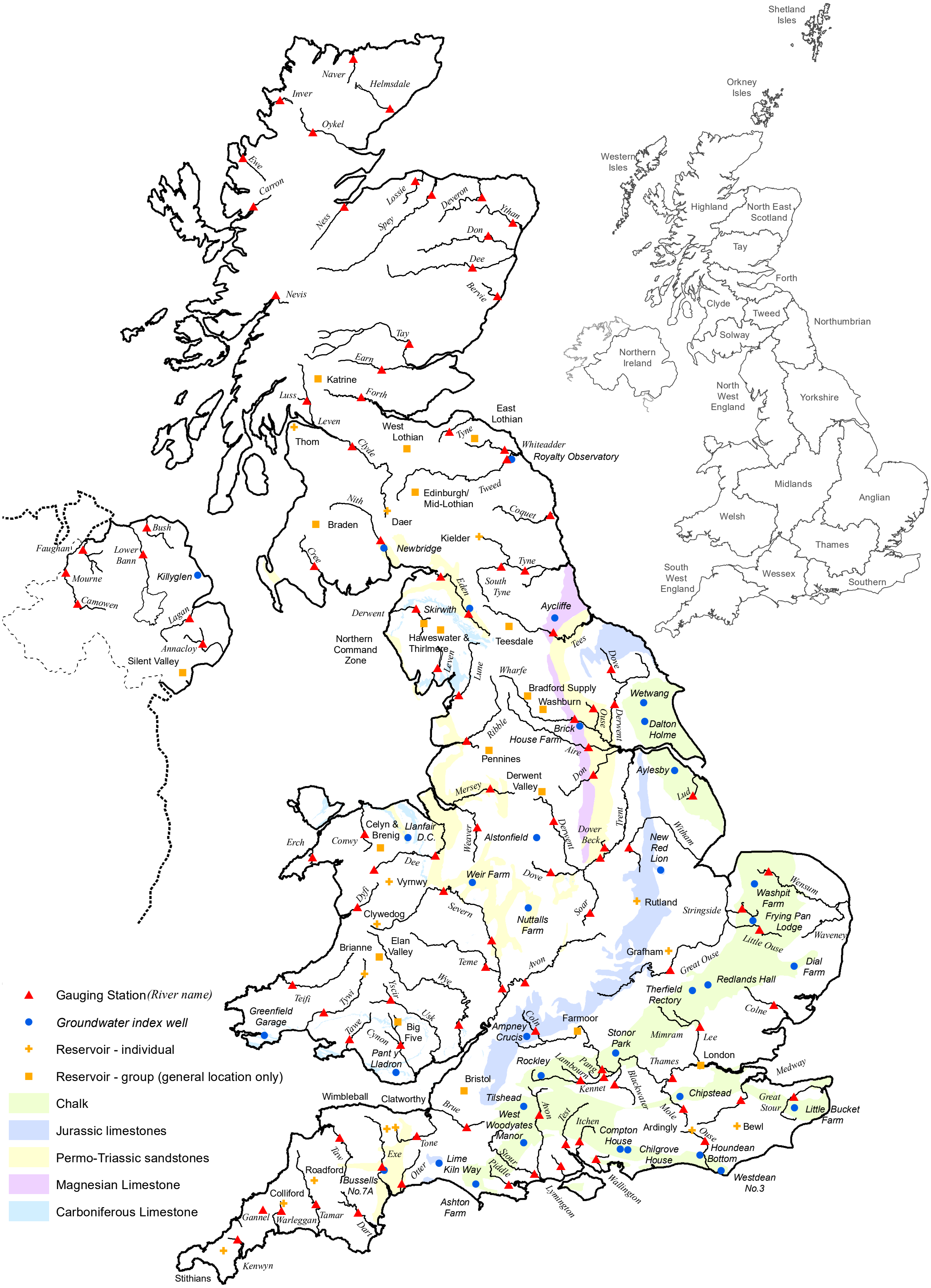
Area	Reservoir		Capacity (Ml)	2019 Jul	2019 Aug	2019 Sep	Sep Anom.	Min Sep	Year* of min	2018 Sep	Diff 19-18
North West	N Command Zone	•	124929	61	80	80	21	13	1995	56	24
	Vyrnwy		55146	91	98	100	29	26	1995	73	27
Northumbrian	Teesdale	•	87936	80	91	98	27	31	1995	66	32
	Kielder		(199175)	90	90	85	0	59	1989	80	5
Severn-Trent	Clywedog		49936	96	95	100	28	24	1989	71	29
	Derwent Valley	•	46692	66	86	95	32	24	1989	41	54
Yorkshire	Washburn	•	23373	81	89	95	29	24	1995	45	51
	Bradford Supply	•	40942	70	83	91	24	15	1995	49	42
Anglian	Grafham		(55490)	86	81	76	-8	46	1997	74	2
	Rutland		(116580)	95	95	93	14	61	1995	82	12
Thames	London	•	202828	84	76	65	-12	53	1997	62	3
	Farmoor	•	13822	99	96	98	8	54	2003	90	9
Southern	Bewl		31000	82	72	65	2	32	1990	69	-4
	Ardingly		4685	79	63	54	-12	32	2003	48	6
Wessex	Clatworthy		5364	85	70	59	3	25	2003	36	23
	Bristol	•	(38666)	78	75	71	7	31	1990	58	13
South West	Colliford		28540	65	55	51	-18	38	2006	56	-5
	Roadford		34500	59	50	48	-22	26	1995	48	-1
	Wimbleball		21320	85	78	71	6	30	1995	47	24
	Stithians		4967	77	72	70	13	22	1990	41	29
Welsh	Celyn & Brenig	•	131155	91	89	89	7	39	1989	67	21
	Brianne		62140	89	97	100	12	48	1995	87	13
	Big Five	•	69762	75	82	85	15	19	1995	61	24
	Elan Valley	•	99106	85	83	91	16	33	1976	57	34
Scotland(E)	Edinburgh/Mid-Lothian	•	97223	81	84	87	9	43	1998	80	7
	East Lothian	•	9317	100	100	100	18	52	1989	74	27
Scotland(W)	Loch Katrine	•	110326	87	91	95	20	43	1995	68	28
	Daer		22494	81	99	97	19	32	1995	75	22
	Loch Thom		10798	98	100	100	16	56	1995	100	0
Northern Ireland	Total+	•	56800	87	92	92	17	29	1995	67	25
	Silent Valley	•	20634	87	94	90	19	27	1995	63	27

( ) 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.

Location map…Location map



NHMP

The National Hydrological Monitoring Programme (NHMP) was started in 1988 and is undertaken jointly by the Centre for Ecology & Hydrology (CEH) 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 CEH) and National Groundwater Level Archive (NGLA; maintained by BGS), including rainfall, river flows, borehole levels, and reservoir stocks.

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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
http://www.metoffice.gov.uk/climate/uk/about/methods

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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