Hydrological Summary

for the United Kingdom

December 2016

General

December was a remarkably dry month for most of the UK, with mild temperatures bookended by two cold and frosty periods. The majority of the UK received below average rainfall, with much of England and Wales receiving less than half of the long-term average. It was particularly dry in southern England, further extending the rainfall deficiencies which have developed here since early summer. December river flows were below normal across much of the UK, and exceptionally low in most catchments in southern England. Groundwater level recessions continued in many index boreholes and were generally in the normal range or below, with notably low levels in parts of southern England. Reservoir stocks fell relative to average in many impoundments and were substantially below average in some regions, particularly in southern England where stocks have declined steeply since the summer. Stocks at Ardingly were 40% below average, the third lowest December stocks (after 2011 and 2003) in a series from 1987. A continuation of the below average rainfall received since the early summer and a further delay in aquifer recharge could have a significant impact on the water resources outlook in 2017. Particular vigilance is required in those parts of the UK with seasonally depressed groundwater levels and below average reservoir stocks, where any recovery will start from a below-normal baseline.

Rainfall

December began settled with high pressure bringing cold and dry weather. A southerly airflow was established from the 6th to the 20th bringing milder weather, but many areas still received little appreciable rainfall. Nevertheless, two-day totals included 63mm at Capel Curig (Snowdonia) on the 8th/9th and 59mm at Achnagart (Highlands) on the 20th/21st. The second named storm of the season, 'Barbara', tracked across Scotland on the 23rd/24th bringing heavy rain (39mm was recorded at Eskdalemuir, Scottish Borders) and strong winds that caused power cuts to thousands of properties. 'Conor' brought further strong winds and disruption to Scotland on the 25th/26th; 68mm of rainfall was recorded at Kinlochewe (Highlands). Settled conditions returned for the last week of the month, until the final day in Scotland when a further 110mm of rainfall was recorded at Kinlochewe. At the national scale, the UK received 68% of the December long-term average rainfall. While parts of north-west Scotland received moderately above average rainfall, the majority of England & Wales received less than half the average. It was particularly dry across southern England; Southern, Thames and Wessex regions all registered less than 30% of the December average and it was the third driest December for Southern region (in a series from 1910). Rainfall deficiencies are also evident across much of the UK for the last three to six months, with some regions receiving less than 60% of long-term average rainfall. For the October-December timeframe, it was the second driest in Wales and third driest in Northern Ireland (both in records from 1910). Rainfall for 2016 as a whole was near average, despite the exceptionally wet start to the year in northern Britain.

River flows

Following the settled end to November and dry December, recessions dominated river flows across much of the country. New daily flow minima were recorded for the first fortnight on the Faughan and Lagan and for the last fortnight on the Soar and Warleggan. In some catchments in southern England (e.g. the Great Stour) flows remained low throughout December. Moderate flow increases were seen across England and Wales mid-month and around Christmas, although in many catchments flows only approached the average for the time of year. Flood Alerts and Warnings were issued across Scotland during the passage of 'Barbara' and 'Conor'. Rainfall associated with these storms resulted in rapid flow responses in some catchments (e.g. the Clyde and Naver), but there were no reports of substantial flooding. For December overall, average river flows were below normal across much of the UK, with exceptionally low flows recorded in parts of the Midlands, south Wales and across most of southern England. Many of these catchments registered new December minima; the Medway recorded less than 20% of its December average flow (in a series from 1956). Correspondingly, December outflows remained mostly below average and approached daily minima in Scotland and Northern Ireland mid-month. It was the second lowest average December outflow from England & Wales (in a series from 1961) and third lowest from Northern Ireland (in a series from 1980). Runoff deficiencies were notable in the October-December timeframe in western Britain; new record minima were established for some catchments in Northern Ireland and western Britain. In some catchments (e.g. the Lagan, Medway and Soar) deficiencies can also be traced back to the start of summer.

Groundwater

As a result of the dry autumn and start of winter, soil moisture deficits were generally above average across much of southern and eastern England and levels in many index boreholes continued to fall during December due to the lack of recharge. In the Chalk, groundwater levels mainly continued to recede, but rose in parts of Yorkshire and Lincolnshire, as well as most of Wiltshire, Hampshire and Dorset. Levels in the Chalk were in the normal range or below, with the exception of Aylesby which remained above normal. Levels were notably low in many index boreholes in southern England, exceptionally low at Westdean No. 3 and new period of record minimum levels were recorded at Killyglen (for the second consecutive month). In the more responsive aquifers, levels in the Jurassic and Magnesian limestones were generally in the normal range, but fell to below average at Ampney Crucis. In the Permo-Triassic sandstones, levels generally rose slightly or were stable but remained in the normal range, except at Llanfair DC where levels were below normal. In contrast, levels fell slightly at Bussells No. 7a and were notably low. Levels in the Carboniferous Limestone fell to notably low in December, substantially so at Pant y Lladron where levels were above normal at the end of November.

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 1971-2000 average.

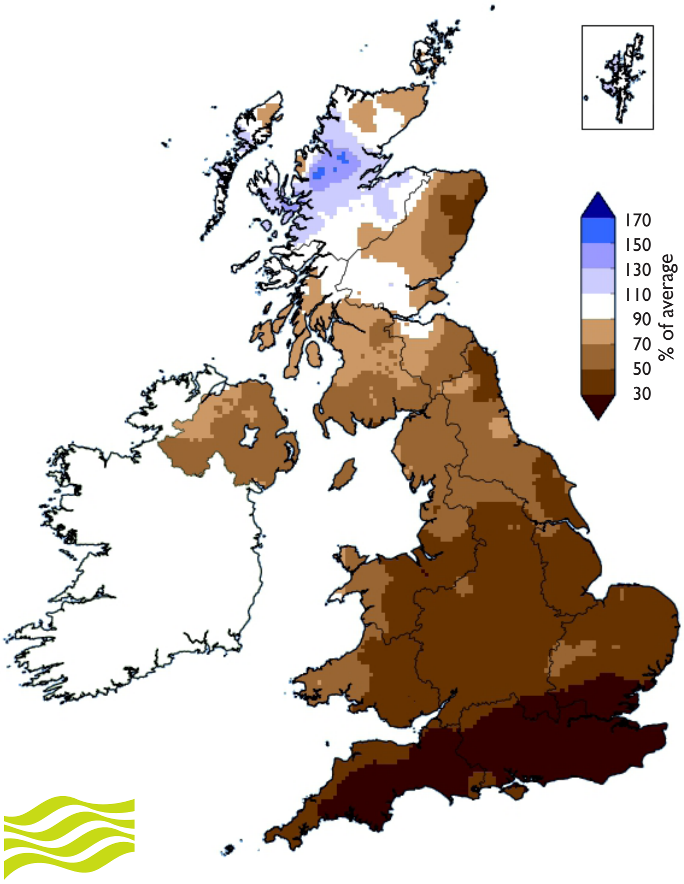
Area	Rainfall	Dec 2016	Nov16 – Dec16	RP	Oct16 – Dec16	RP	Jul16 – Dec16	RP	Jan16 – Dec16	RP
United	mm	**82**	190		239		508		1136	
Kingdom	%	**68**	81	2-5	69	20-30	86	5-10	105	2-5
England	mm	**36**	140		179		352		853	
	%	**41**	82	2-5	71	10-15	80	10-15	104	2-5
Scotland	mm	**158**	271		337		745		1535	
	%	**98**	85	2-5	71	10-15	94	2-5	107	2-5
Wales	mm	**88**	221		268		605		1439	
	%	**53**	70	5-10	58	30-50	80	8-12	105	2-5
Northern	mm	**78**	159		209		485		1081	
Ireland	%	**66**	70	10-15	61	40-60	81	10-15	97	2-5
England &	mm	**43**	151		191		387		934	
Wales	%	**44**	79	2-5	68	10-20	80	10-15	104	2-5
North West	mm	**77**	214		254		608		1298	
	%	**59**	83	2-5	67	10-20	92	2-5	110	2-5
Northumbrian	mm	**52**	169		229		462		947	
	%	**61**	100	2-5	93	2-5	104	2-5	114	2-5
Severn-Trent	mm	**34**	128		156		315		798	
	%	**43**	85	2-5	70	10-15	78	10-15	105	2-5
Yorkshire	mm	**46**	151		198		390		891	
	%	**52**	90	2-5	81	2-5	90	2-5	110	2-5
Anglian	mm	**23**	94		134		255		639	
	%	**40**	83	2-5	79	2-5	79	5-10	106	2-5
Thames	mm	**21**	114		141		254		710	
	%	**28**	82	2-5	67	8-12	69	15-25	101	2-5
Southern	mm	**19**	123		156		253		740	
	%	**21**	72	2-5	60	10-20	59	50-80	95	2-5
Wessex	mm	**28**	146		188		332		867	
	%	**27**	77	2-5	68	8-12	71	15-25	100	2-5
South West	mm	**45**	189		240		446		1119	
	%	**30**	67	5-10	59	20-35	68	20-35	93	2-5
Welsh	mm	**83**	216		262		583		1386	
	%	**53**	71	5-10	59	30-50	80	8-12	105	2-5
Highland	mm	**233**	349		415		900		1763	
	%	**118**	87	2-5	71	5-10	95	2-5	103	2-5
North East	mm	**77**	167		253		503		1131	
	%	**84**	87	2-5	87	2-5	97	2-5	119	5-10
Tay	mm	**128**	208		287		591		1386	
	%	**91**	77	2-5	71	10-15	87	5-10	109	2-5
Forth	mm	**112**	187		245		528		1173	
	%	**91**	78	2-5	69	10-15	86	5-10	104	2-5
Tweed	mm	**75**	184		242		514		1101	
	%	**72**	93	2-5	83	2-5	100	2-5	115	5-10
Solway	mm	**108**	222		271		665		1476	
	%	**67**	72	2-5	58	30-50	85	2-5	105	2-5
Clyde	mm	**173**	319		379		892		1809	
	%	**88**	83	2-5	66	10-20	92	2-5	104	2-5

% = percentage of 1971-2000 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 from February 2016 (inclusive) are provisional.

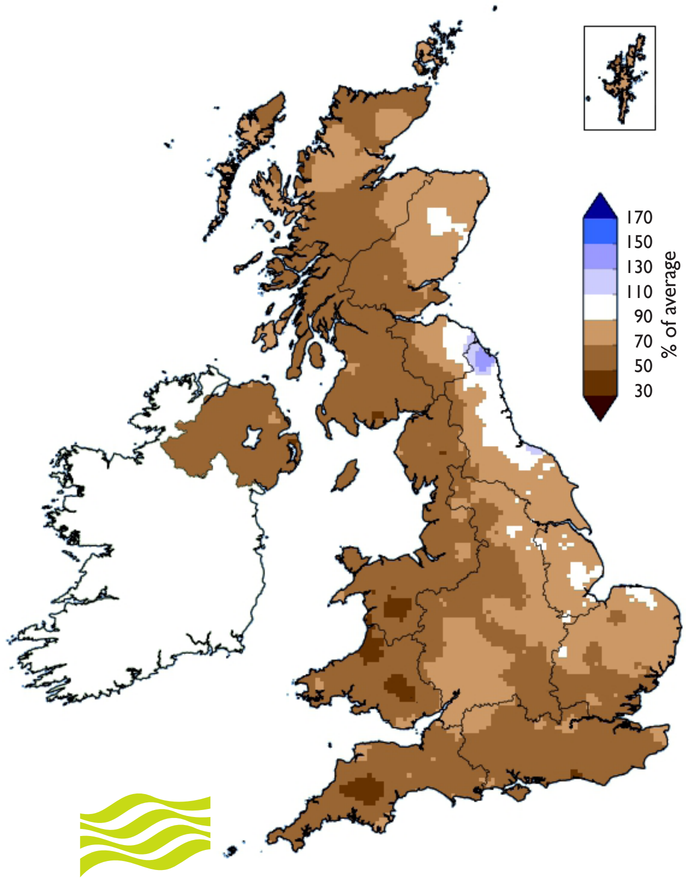
Rainfall . . . Rainfall . . .

December 2016 rainfall as % of 1971-2000 average



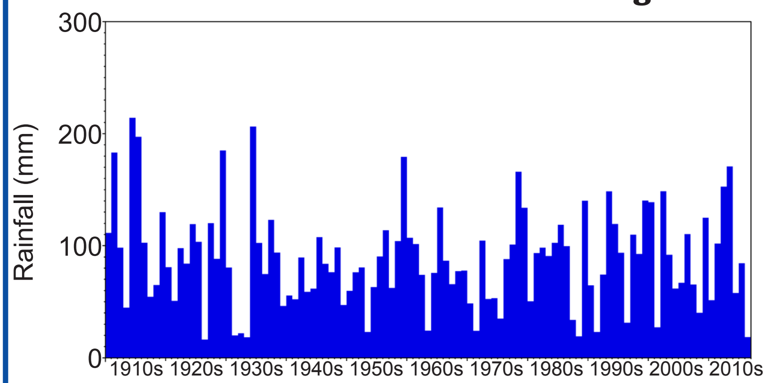
Met Office

October 2016 - December 2016 rainfall as % of 1971-2000 average

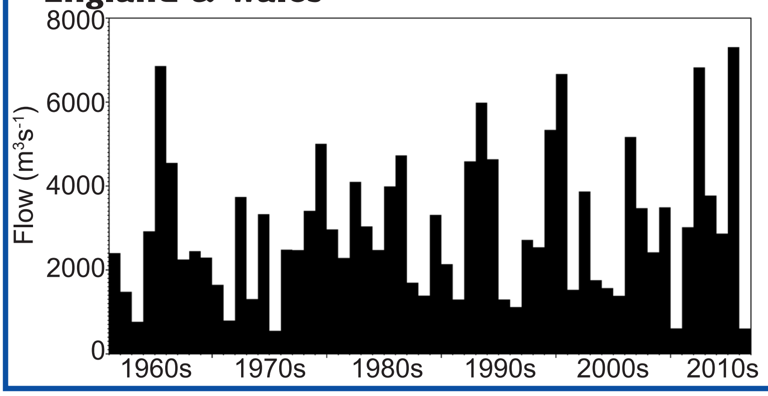


Met Office

December rainfall for Southern region



December average outflows for England & Wales



Met Office

Met Office 3-month outlook Updated: December 2016

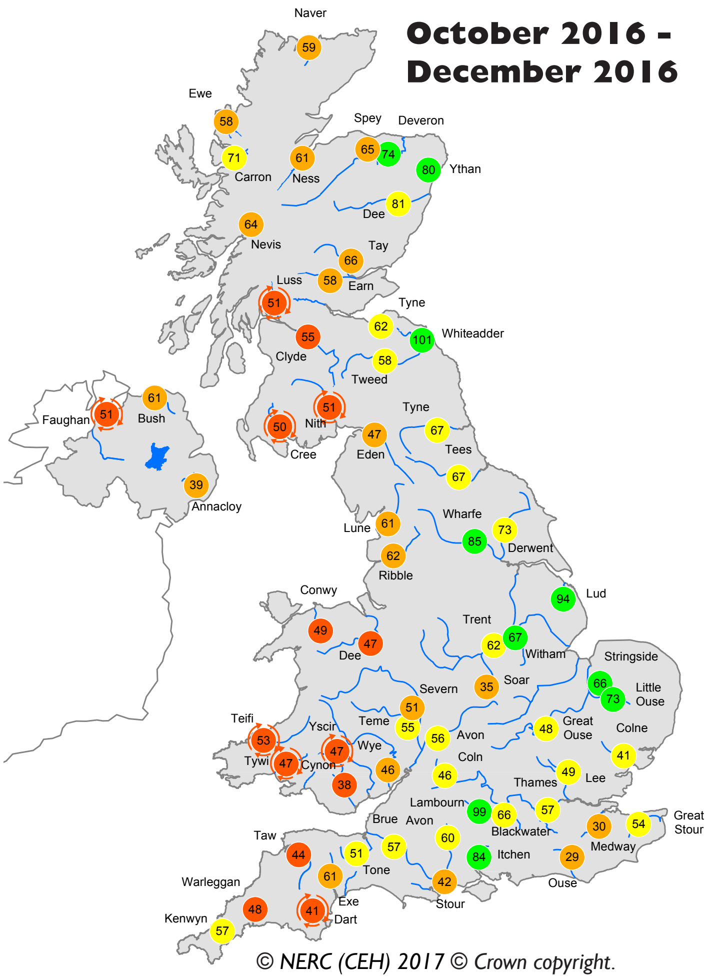
During January-February-March as a whole there is only a slight shift from the normal range of expected conditions, with above-average and below-average precipitation considered nearly equally probable.

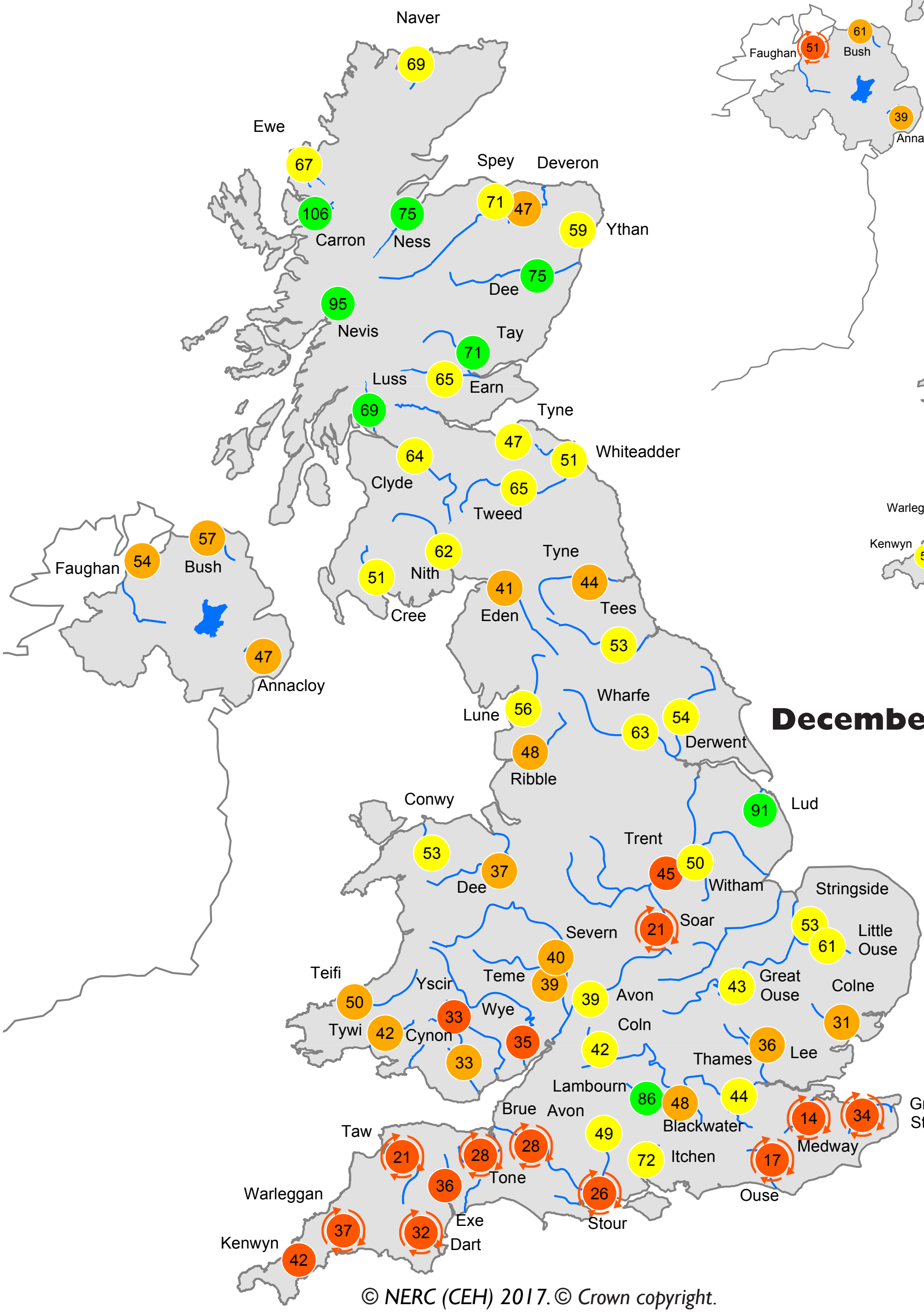
The probability that UK-average precipitation for January-February-March will fall into the driest of our five categories is between 15 and 20% and the probability that it will fall into the wettest of our five categories is between 15 and 20% (the 1981-2010 probability for each of these categories is 20%).

The complete version of the 3-month outlook may be found at:
http://www.metoffice.gov.uk/publicsector/contingency-planners
This outlook is updated towards the end of each calendar month.

The latest shorter-range forecasts, covering the upcoming 30 days, can be accessed via:
http://www.metoffice.gov.uk/weather/uk/uk_forecast_weather.html
These forecasts are updated very frequently.

River flow . . . River flow . . .





December 2016

Key

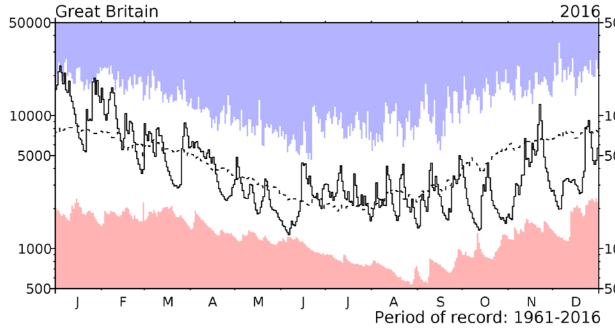
- 25 — % of long-term average (record figure when circled)
- Exceptionally high flow
- Notably high flow
- Above normal
- Normal range
- Below normal
- Notably low flow
- Exceptionally low flow

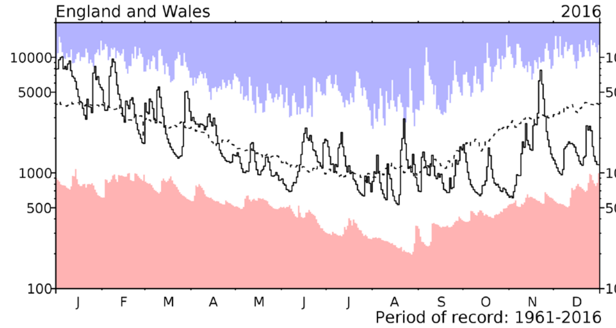
*Based on ranking of the monthly flow**

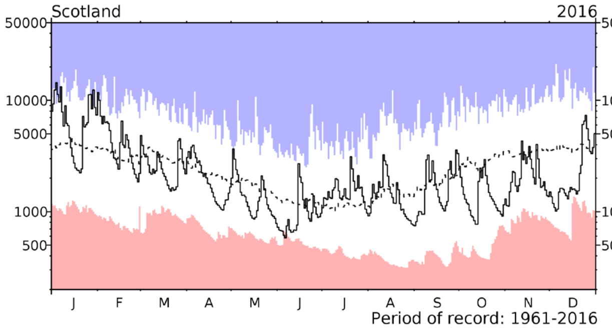
River flows

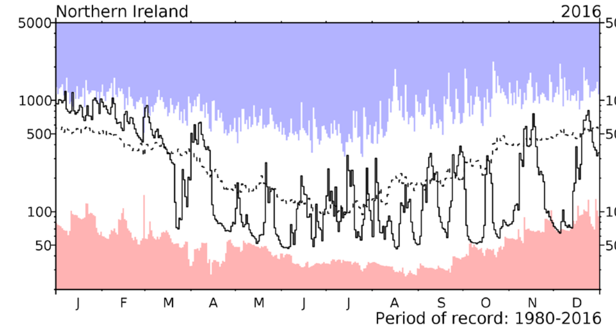
*Comparisons based on percentage flows alone can be misleading. A given percentage flow can represent extreme drought conditions in permeable catchments where flow patterns are relatively stable but be well within the normal range in impermeable catchments where the natural variation in flows is much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

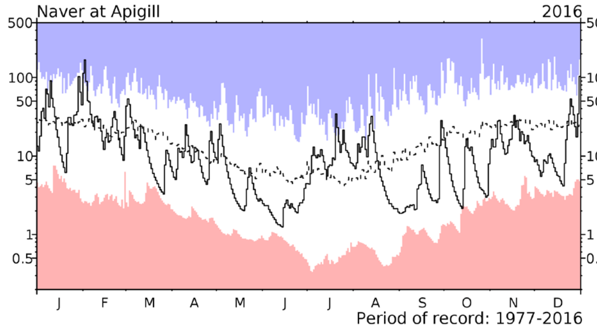
River flow . . . River flow . . .

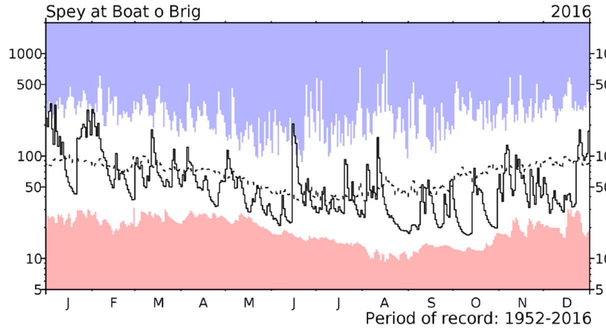


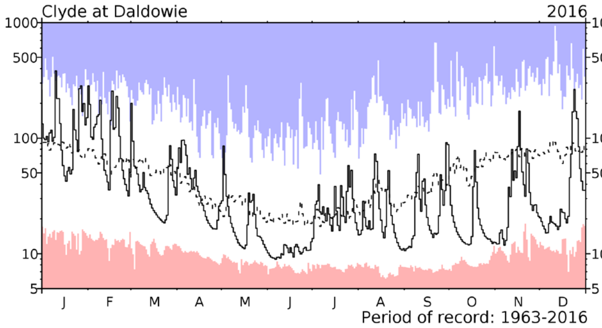


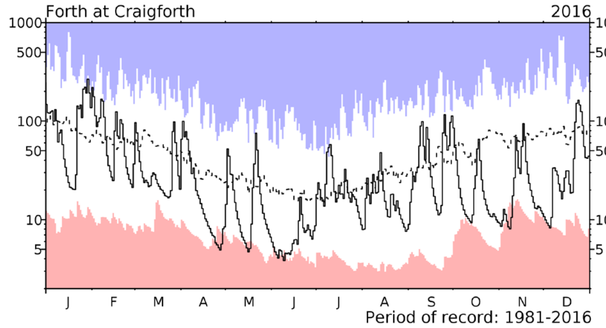


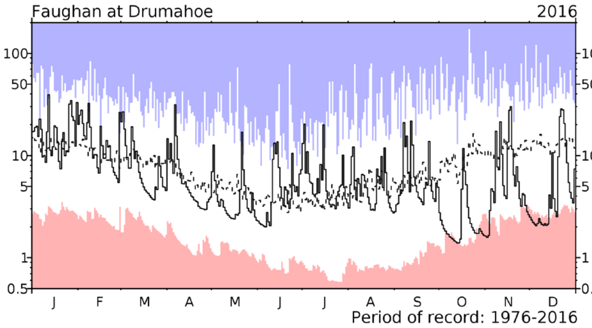


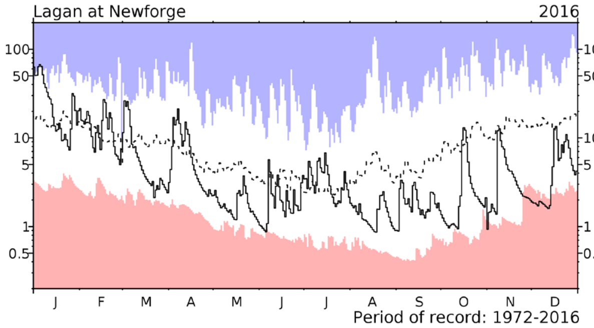








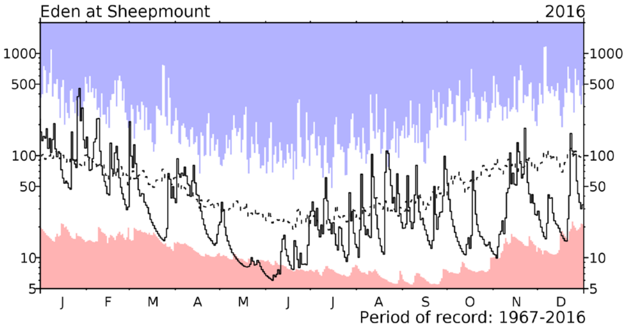


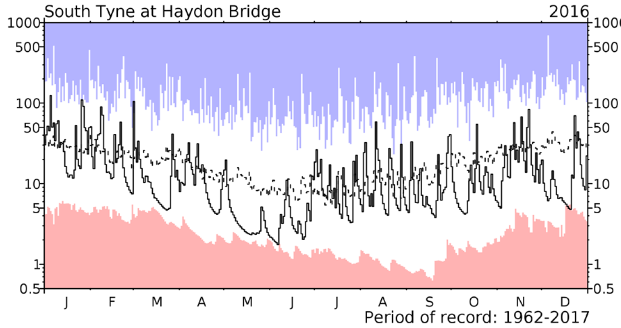


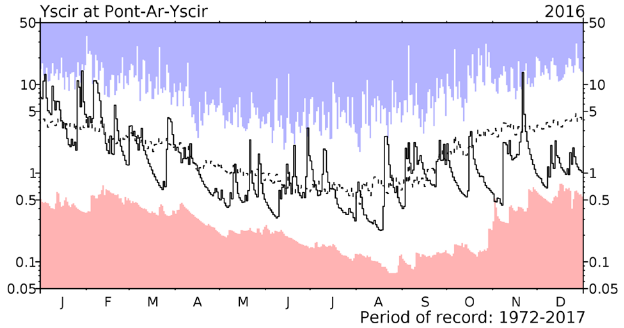
River flow hydrographs

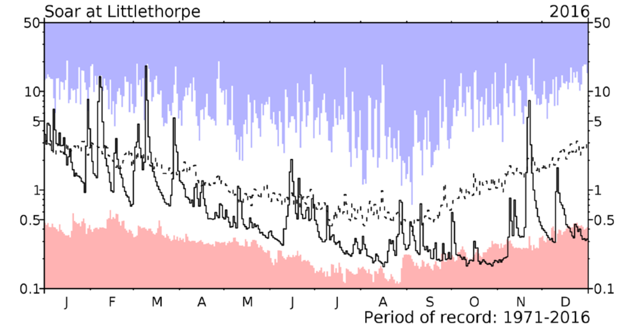
The river flow hydrographs show the daily mean flows together with the maximum and minimum daily flows prior to January 2016 (shown by the shaded areas). Daily flows falling outside the maximum/minimum range are indicated where the bold trace enters the shaded areas. Mean daily flows are shown as the dashed line.

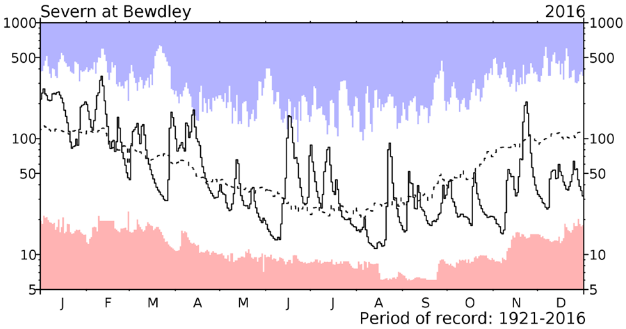
River flow . . . River flow . . .

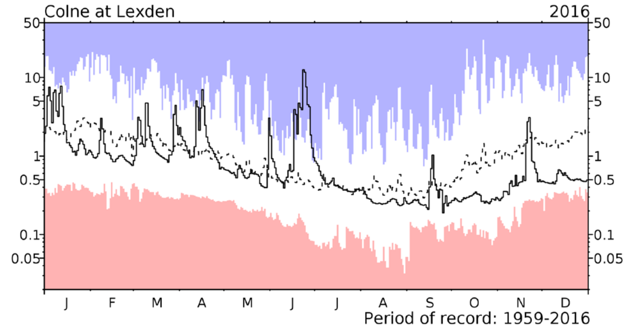


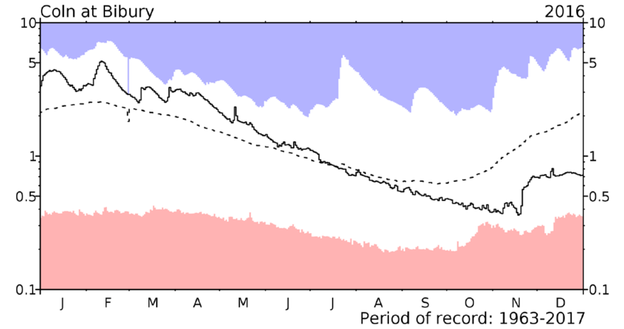


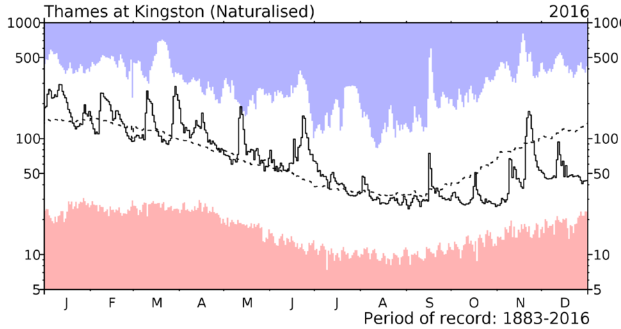


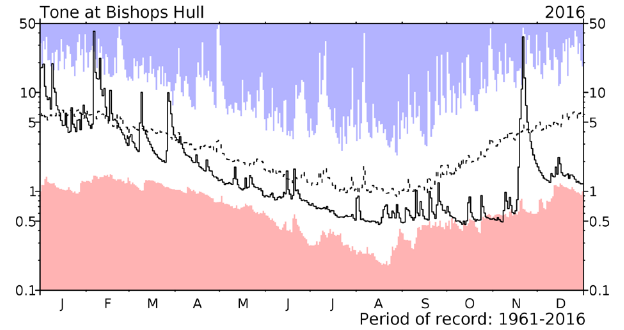


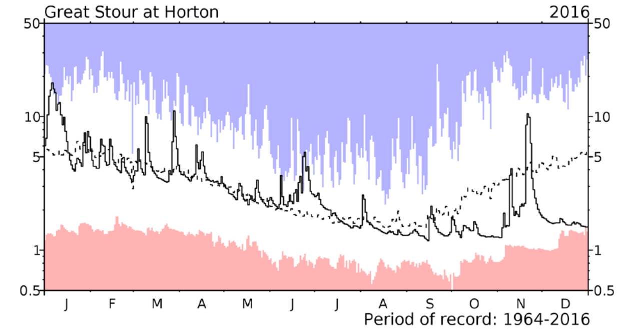


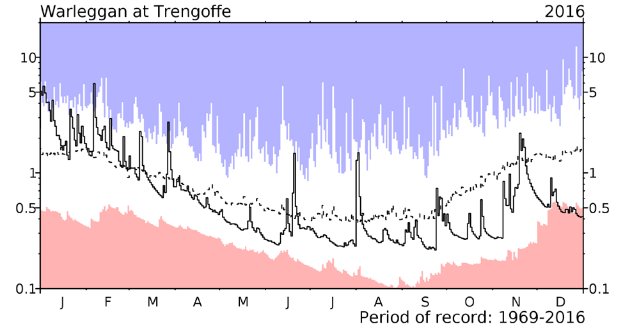


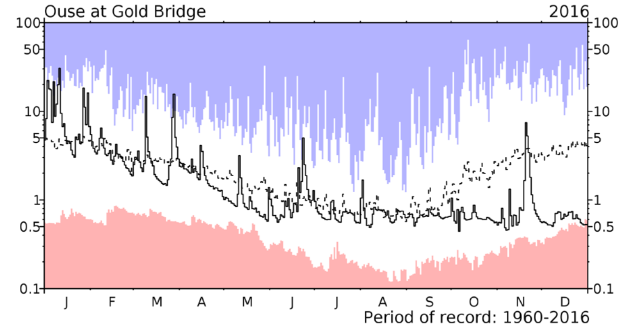




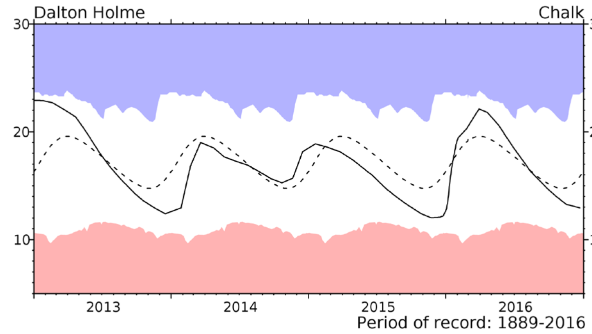


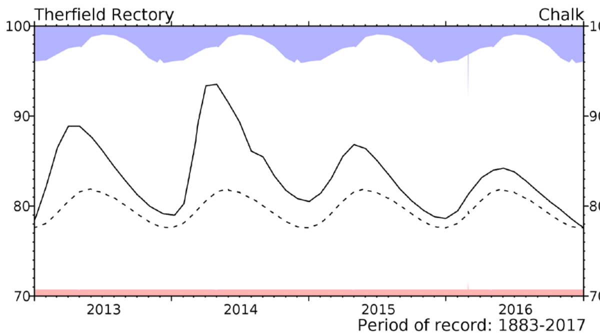


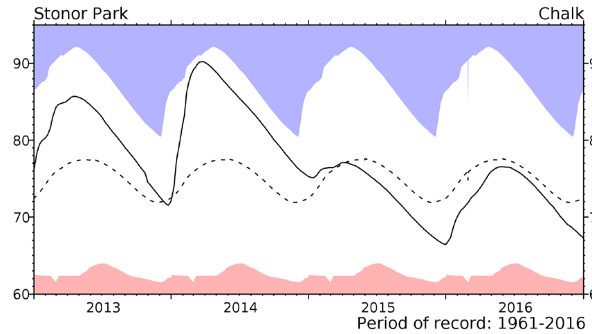


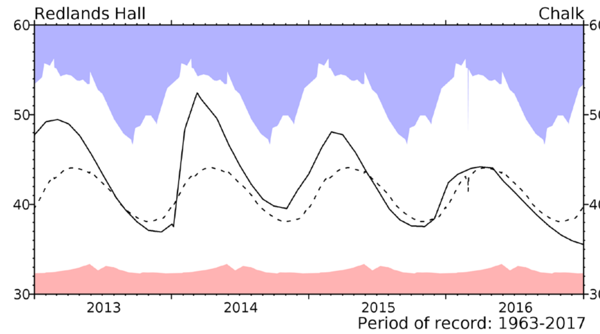


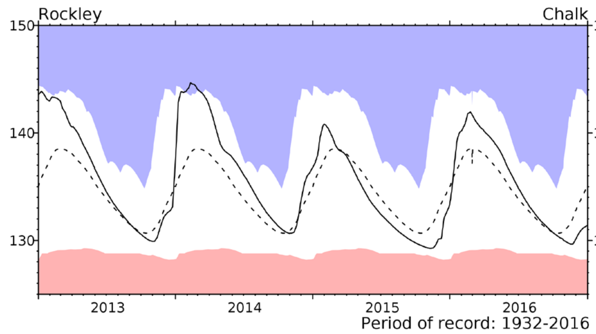
Groundwater . . . Groundwater

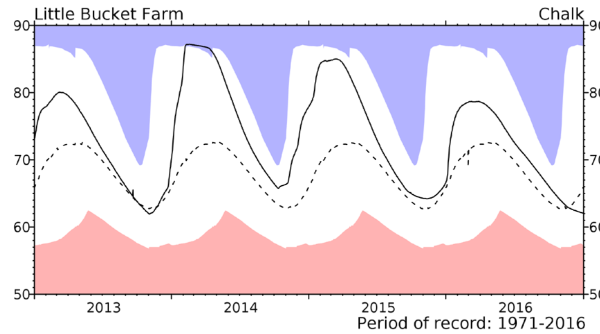


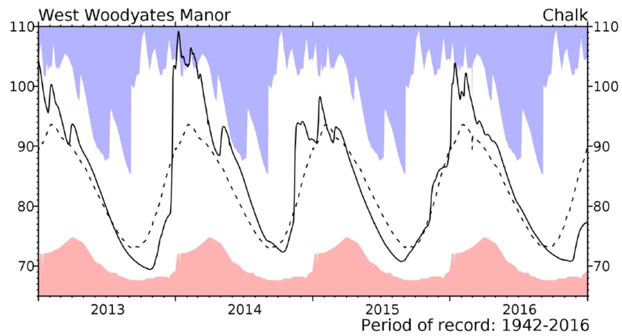


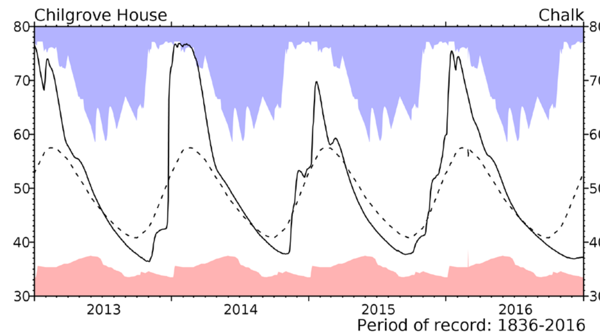


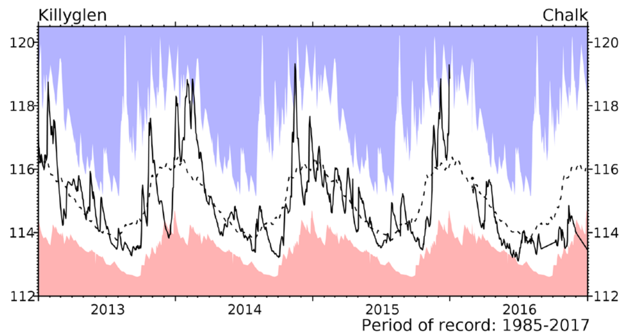


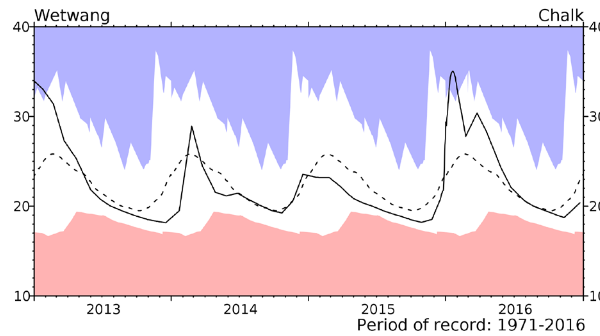






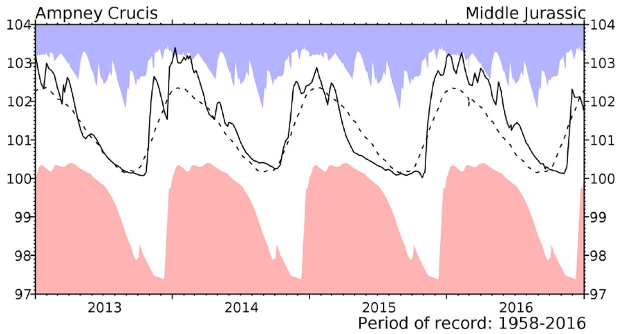


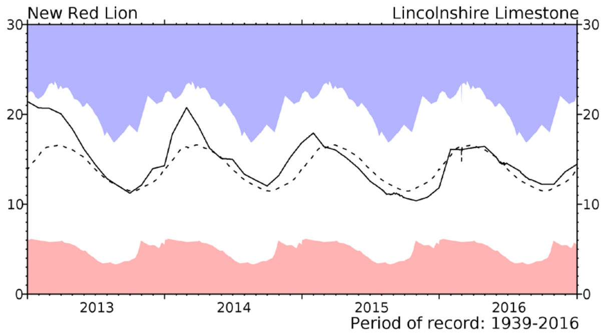


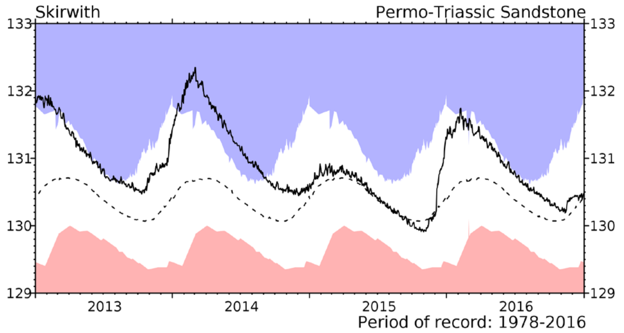


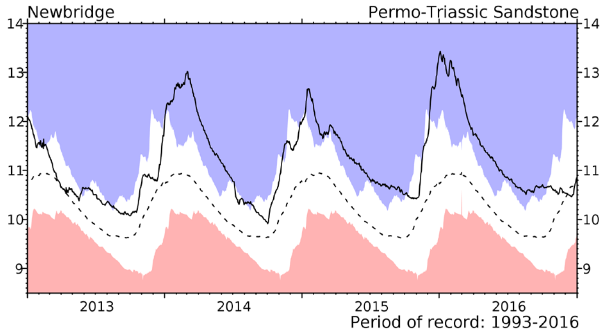
Groundwater levels normally rise and fall with the seasons, reaching a peak in the spring following replenishment through the winter (when evaporation losses are low and soil moist). They decline through the summer and early autumn. This seasonal variation is much reduced when the aquifer is confined 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. The latest recorded levels are listed overleaf.

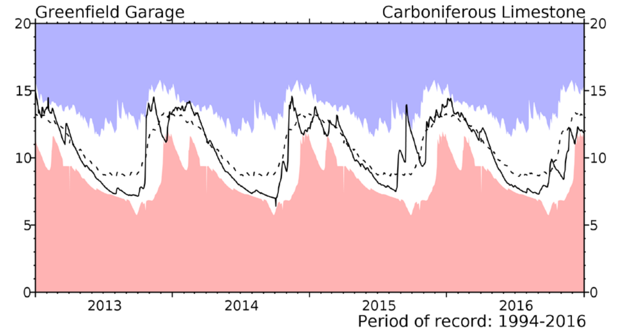
Groundwater... Groundwater

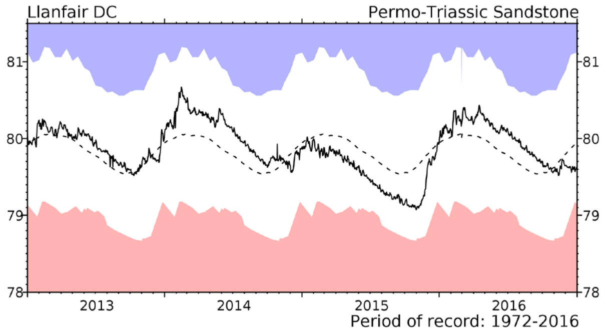


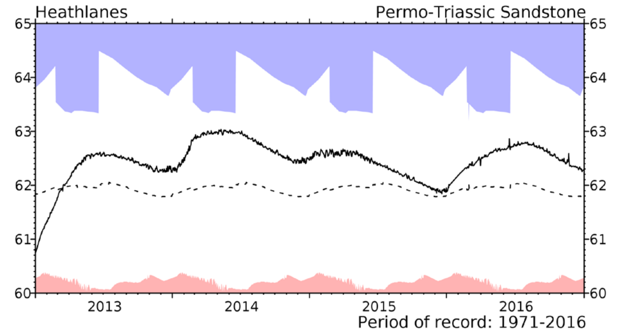


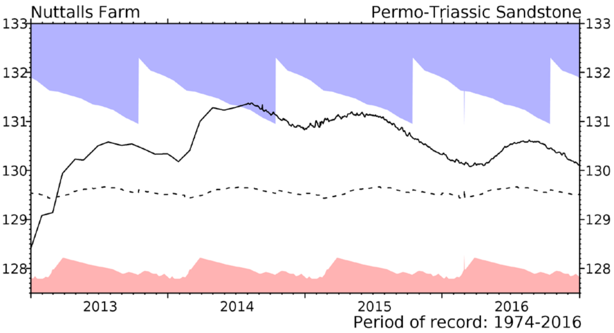


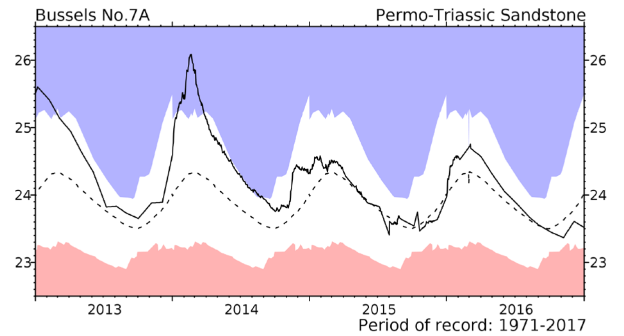


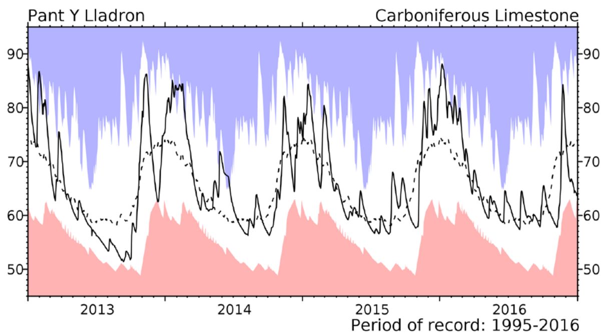










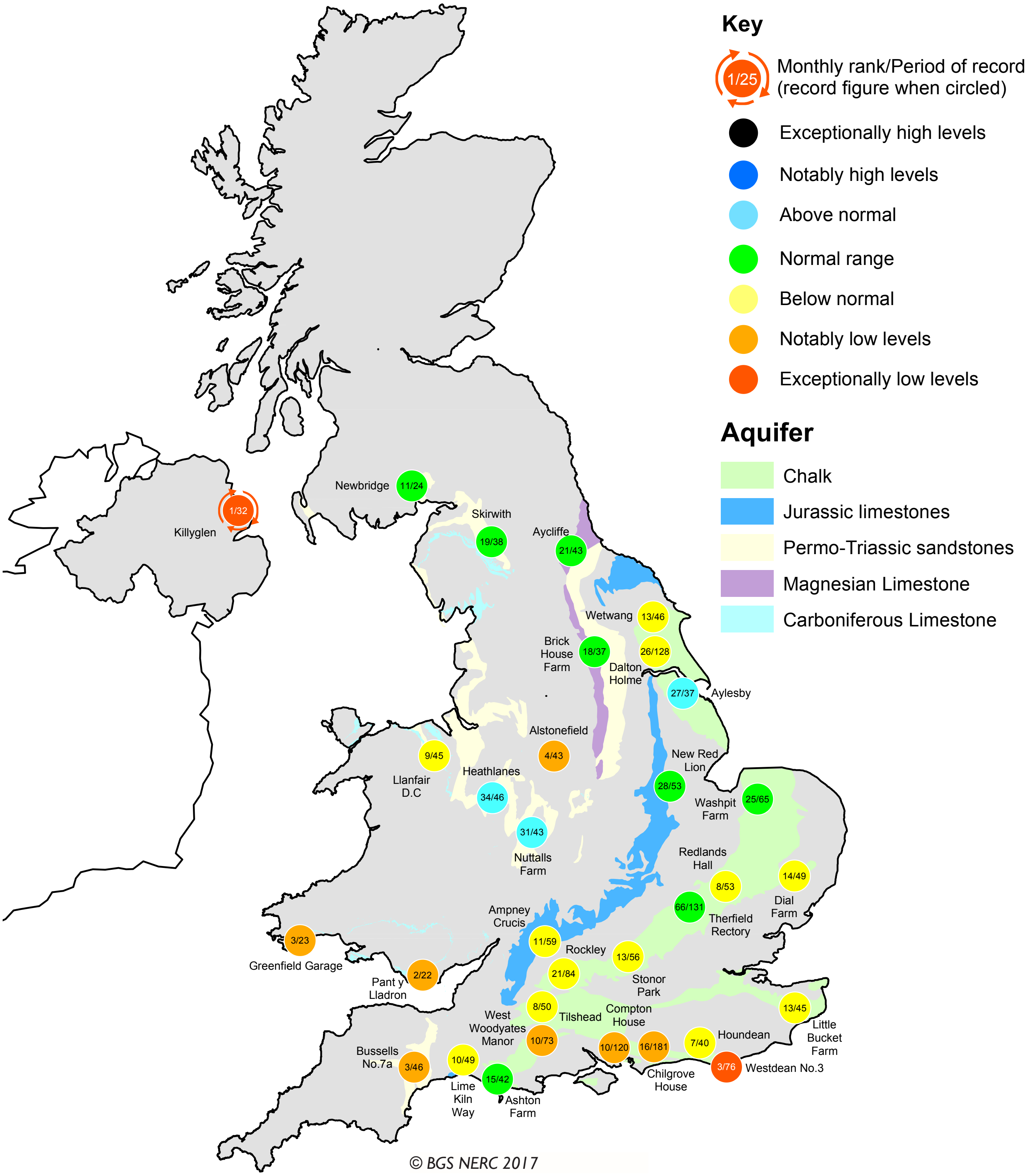


Groundwater levels December 2016 / January 2017

Borehole	Level	Date	Dec av.	Borehole	Level	Date	Dec av.	Borehole	Level	Date	Dec av.
Dalton Holme	12.94	22/12	15.57	Chilgrove House	37.21	31/12	51.92	Brick House Farm	12.85	04/01	12.66
Therfield Rectory	77.51	03/01	77.75	Killyglen (NI)	113.41	03/01	116.07	Llanfair DC	79.63	31/12	79.86
Stonor Park	67.32	31/12	72.11	Wetwang	20.37	23/12	21.83	Heathlanes	62.29	31/12	61.84
Tilshead	80.24	31/12	86.47	Ampney Crucis	101.77	31/12	102.01	Nuttalls Farm	130.11	31/12	129.61
Rockley	131.38	31/12	133.89	New Red Lion	14.41	31/12	13.15	Bussells No.7a	23.50	05/01	23.86
Redlands Hall	35.48	04/01	38.67	Skirwith	130.50	31/12	130.40	Alstonefield	183.61	28/12	193.44
West Woodyates	77.35	31/12	87.06	Newbridge	10.85	31/12	10.79				

Levels in metres above Ordnance Datum

Groundwater...Groundwater



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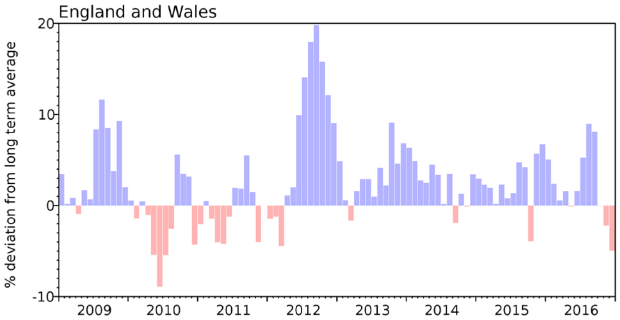
Groundwater levels - December 2016

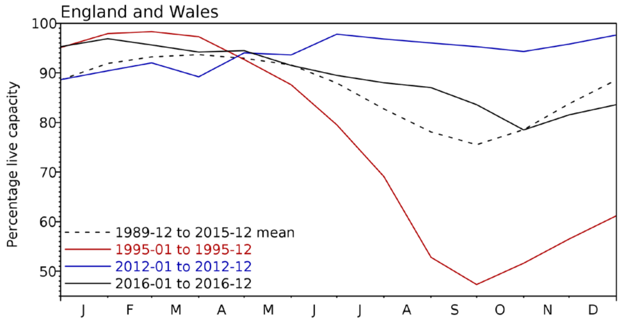
The calculation of ranking has been modified from that used in summaries published prior to October 2012. It is now based on a comparison between the most recent level and levels for the same date during previous years of record. Where appropriate, levels for earlier years may have been interpolated. 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)	2016 Oct	2016 Nov	2016 Dec	Dec Anom.	Min Dec	Year* of min	2015 Dec	Diff 16-15
North West	N Command Zone	•	124929	68	69	70	-17	51	1995	100	-30
	Vyrnwy		55146	79	82	85	-7	35	1995	100	-15
Northumbrian	Teesdale	•	87936	80	90	92	3	41	1995	100	-8
	Kielder		(199175)	88	82	88	-4	70	1989	97	-10
Severn-Trent	Clywedog		44922	83	89	87	2	54	1995	97	-11
	Derwent Valley	•	39525	74	94	100	10	10	1995	100	-1
Yorkshire	Washburn	•	22035	58	74	79	-7	23	1995	96	-17
	Bradford Supply	•	41407	66	81	80	-11	22	1995	100	-20
Anglian	Grafham		(55490)	88	86	78	-6	57	1997	86	-8
	Rutland		(116580)	87	85	81	-1	60	1990	87	-6
Thames	London	•	202828	76	81	86	-1	60	1990	96	-10
	Farmoor	•	13822	90	87	95	5	71	1990	78	17
Southern	Bewl		28170	61	58	56	-16	34	2005	70	-13
	Ardingly		4685	47	48	46	-40	30	2011	91	-45
Wessex	Clatworthy		5364	29	58	65	-27	54	2003	100	-35
	Bristol	•	(38666)	55	66	68	-11	40	1990	92	-24
South West	Colliford		28540	65	66	67	-12	46	1995	92	-25
	Roadford		34500	65	67	64	-14	20	1989	96	-32
	Wimbleball		21320	43	51	50	-34	46	1995	92	-42
	Stithians		4967	62	75	81	3	33	2001	98	-17
Welsh	Celyn & Brenig	•	131155	90	91	94	0	54	1995	100	-6
	Brianne		62140	98	91	97	0	76	1995	100	-3
	Big Five	•	69762	72	80	85	-5	67	1995	82	3
	Elan Valley	•	99106	82	91	91	-6	56	1995	100	-9
Scotland(E)	Edinburgh/Mid-Lothian	•	96518	82	83	86	-5	60	1998	100	-14
	East Lothian	•	9374	98	100	100	4	48	1989	100	0
Scotland(W)	Loch Katrine	•	110326	89	88	93	3	75	2007	99	-6
	Daer		22412	80	79	91	-7	83	1995	100	-9
	Loch Thom		10798	93	93	96	-1	80	2007	100	-4
Northern Ireland	Total+	•	56800	74	73	76	-12	61	2001	99	-23
	Silent Valley	•	20634	68	64	65	-20	39	2001	100	-35

( ) 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.

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Location map…Location map

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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.

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 Rivers Agency 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 1971-2000 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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