Hydrological Summary
for the United Kingdom

November 2016

General

November was a cold, generally settled month and, with the exception of one stormy interlude, frequently under the influence of high pressure. The majority of substantial rainfall occurred within an unsettled three-day period mid-month, outside of which notable falls were relatively uncommon. Nevertheless, these totals were sufficient for most of England to register above average rainfall. For the rest of the UK, rainfall was notably below average under predominantly anticyclonic conditions, the culmination of a dry autumn for much of the country. Notably high river flows were registered during the stormy interlude mid-month, particularly in south-west England and the Scottish Borders, resulting in fluvial flooding and substantial disruption to transport networks. Despite this, average river flows for November were markedly below average across most of Northern Ireland and western Britain and generally within the normal range elsewhere. Groundwater levels generally continued their seasonal recession in early November although some boreholes responded rapidly to heavy rainfall mid-month. Although reservoir stocks for England & Wales were near average for November, some individual impoundments were substantially below average; stocks for Ardingly and Wimbleball were more than 20% below average, and Clatworthy similarly despite doubling its stocks during November. In Northern Ireland and parts of western Scotland, stocks fell relative to average and were around 15% below average. Whilst the water resources situation remains favourable overall, below average reservoir stocks in certain areas of the UK and the continued delay in aquifer recharge necessitate vigilance, particularly in light of seasonal outlooks which suggest drier weather is more likely than wetter weather for at least the early part of winter.

Rainfall

A series of high pressure systems generally limited rainfall through the first half of November; rainfall from weak fronts was showery with relatively few intense downpours. Cold northerly air led to snowfall in northern Britain (e.g. 7cm at Bingley, West Yorkshire on the 9th). On the 19th/20th, the first named storm of the season, 'Angus', tracked across the south of England, bringing destructive winds (causing power cuts for 2,200 properties), intense rainfall (e.g. 27mm in one hour at Exeter Airport) and surface water flooding. A more disruptive low pressure system followed shortly thereafter on the 21st/22nd, slowly traversing north-eastwards across England. Persistent heavy rainfall (e.g. 70mm at Chillingham Barns, Northumberland) onto ground saturated by rainfall from 'Angus' caused substantial disruption to road and rail travel (including the South West and East Coast main lines). Across the 19th-21st, Exeter recorded 109mm, 130% of average rainfall for November. The final week of November saw high pressure, cold temperatures in the northerly airflow and meagre rainfall. For November overall, north-eastern, central and southern England registered more than 130% of the long-term average rainfall. Conversely, less than 70% of average was registered in northern and western Scotland, and around half the average for the Scottish Highlands; it was the driest November for Scotland since 1993. Autumn rainfall accumulations were less than 90% of average across much of the UK, and were particularly notable in Scotland and parts of Northern Ireland and Wales where rainfall did not exceed around two thirds of the average. It was the driest autumn for the UK since 2007 and for western Scotland in more than twenty years.

River flows

Over the first week, low late October flows in some catchments continued into early November; daily minima were eclipsed for the Soar, Tone, Nith, Luss, Forth and Faughan. Between the 19th and 21st, river flows across England increased markedly in response to persistent heavy rainfall; flows on the Tone increased from new early November minima to register one of the highest flows in a 56-year record. Daily flows approached or exceeded previous November maxima for the Whiteadder Water, Exe, Brue and Otter; for these last three, flows ranked amongst the highest registered in any month (each in records of at least 50 years). In the south-west, properties in Braunton and Bradiford were flooded and the Mole overtopped forcing the evacuation of a caravan park. During the second storm, more than 40 Flood Warnings and 140 Flood Alerts were issued and fluvial flooding was reported in locations including Bristol, Greater Manchester and Rotherham. Over the final week of the month, high pressure led to protracted recessions on most rivers. By month-end, late November daily minima were being approached on the Forth, Soar, Cynon and Luss, and eclipsed on the Faughan, Lagan and Annacloy. For November overall, average river flows were notably low in south Wales and parts of western Scotland, registering around half of the average, and exceptionally low for the Earn. Although flows were mostly within the normal range across England and eastern Scotland, some were substantially below average. For the autumn overall, notably low flows characterised an extensive area of western Scotland (the Naver was exceptionally low), Northern Ireland and north Wales, with below normal flows throughout western parts of the UK. River flow deficiencies for much of western Britain have now extended over six months; the Annacloy registered a third of average flow over this timeframe.

Groundwater

Despite the relatively dry autumn, soil moisture deficits were generally near zero across much of the UK, but marginally above average in Anglian and Thames regions. In the Chalk, groundwater level recessions mainly continued and stabilised locally, although small overall increases occurred at Killyglen, West Woodyates Manor, Ashton Farm and Rockley. At Houndean Bottom and Tilshead, levels rose mid-month but then continued to recede. All Chalk index boreholes were within the normal range or below, apart from Aylesby which fell but remained slightly above average. New period of record minimum levels were recorded at Killyglen (despite the small increase) and notably low levels were registered at Chilgrove House; levels at several other sites also fell below normal. In the more rapidly responding Jurassic and Magnesian limestones, levels generally rose and stabilised where semi-confined (Aycliffe), but all remained in the normal range. In the Permo-Triassic sandstones, levels in all index boreholes were in the normal range or above; levels generally continued to recede, with small increases recorded at Bussells No.7a, Llanfair DC and Skirwith. Levels in the Carboniferous Limestone rose, and varied from below normal at Greenfield Garage to above normal at Pant y Lladron.

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

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Rainfall . . . Rainfall . . .

Met Office

Rainfall accumulations and return period estimates

Percentages are from the 1971-2000 average.

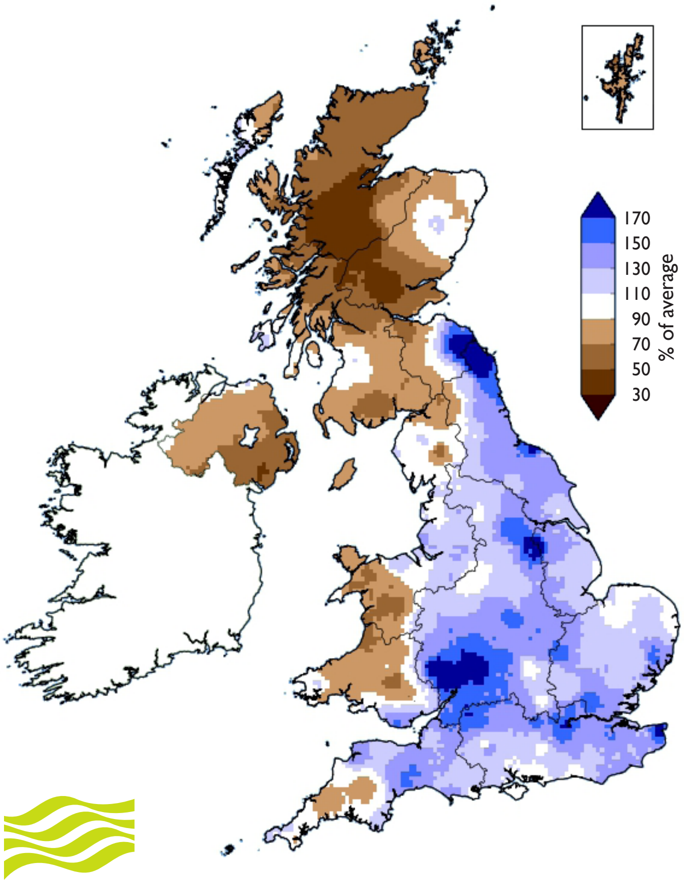
Area	Rainfall	Nov 2016	Sep16 – Nov16	RP	Jul16 – Nov16	RP	Mar16 – Nov16	RP	Dec15 – Nov16	RP
United	mm	**108**	256		425		760		1273	
Kingdom	%	**94**	79	5-10	90	2-5	100	2-5	118	15-25
England	mm	**104**	206		315		618		950	
	%	**127**	88	2-5	89	2-5	105	2-5	116	5-10
Scotland	mm	**113**	323		587		952		1705	
	%	**71**	72	5-10	93	2-5	96	2-5	119	15-25
Wales	mm	**133**	326		517		953		1686	
	%	**87**	78	2-5	87	2-5	101	2-5	123	10-20
Northern	mm	**81**	235		407		719		1223	
Ireland	%	**73**	74	5-10	84	5-10	91	2-5	110	5-10
England &	mm	**108**	223		343		664		1052	
Wales	%	**118**	86	2-5	89	2-5	104	2-5	118	5-10
North West	mm	**136**	285		531		891		1555	
	%	**109**	81	2-5	101	2-5	106	2-5	133	30-50
Northumbrian	mm	**117**	241		409		659		1120	
	%	**140**	105	2-5	115	2-5	109	2-5	135	50-80
Severn-Trent	mm	**93**	180		280		596		875	
	%	**132**	86	2-5	87	5-10	108	2-5	116	5-10
Yorkshire	mm	**105**	204		344		647		1014	
	%	**134**	91	2-5	100	2-5	111	2-5	125	10-15
Anglian	mm	**72**	161		232		515		671	
	%	**127**	96	2-5	88	2-5	113	2-5	111	2-5
Thames	mm	**94**	176		234		539		762	
	%	**142**	88	2-5	79	5-10	105	2-5	109	2-5
Southern	mm	**105**	177		234		522		806	
	%	**126**	73	2-5	69	10-20	94	2-5	104	2-5
Wessex	mm	**118**	230		304		621		935	
	%	**136**	92	2-5	84	5-10	103	2-5	108	2-5
South West	mm	**144**	293		401		714		1243	
	%	**108**	82	2-5	80	5-10	88	5-10	103	2-5
Welsh	mm	**133**	319		499		921		1619	
	%	**91**	79	2-5	87	2-5	101	2-5	123	10-20
Highland	mm	**116**	358		666		1074		1895	
	%	**57**	66	5-10	89	2-5	92	2-5	111	5-10
North East	mm	**90**	239		426		750		1247	
	%	**90**	83	2-5	100	2-5	108	2-5	132	25-40
Tay	mm	**80**	270		463		792		1624	
	%	**61**	71	5-10	86	5-10	92	2-5	128	30-50
Forth	mm	**75**	233		416		703		1356	
	%	**65**	69	5-10	85	5-10	89	2-5	120	10-20
Tweed	mm	**108**	238		439		700		1307	
	%	**115**	88	2-5	108	2-5	103	2-5	137	50-80
Solway	mm	**113**	305		556		917		1742	
	%	**76**	71	5-10	90	2-5	94	2-5	124	20-35
Clyde	mm	**146**	403		719		1136		2009	
	%	**78**	75	5-10	93	2-5	95	2-5	116	10-15

% = 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.

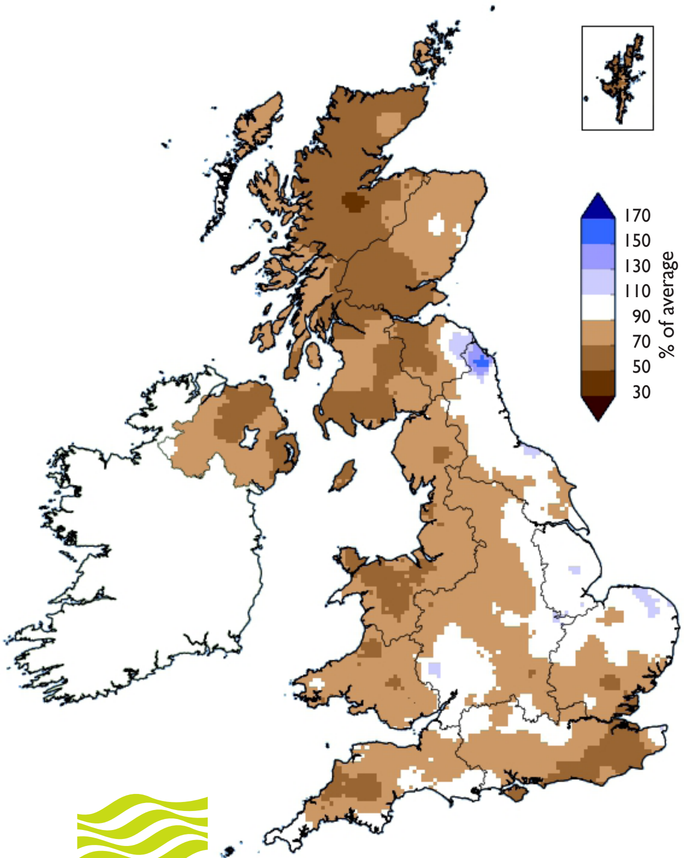
Rainfall . . . Rainfall . . .

November 2016 rainfall as % of 1971-2000 average



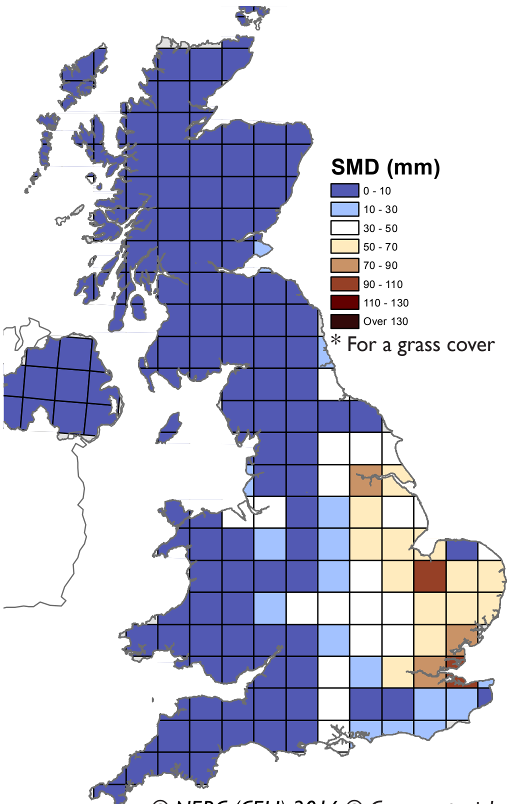
Met Office

September 2016 - November 2016 rainfall as % of 1971-2000 average



Met Office

MORECS Soil Moisture Deficits* November 2016



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Met Office

Met Office 3-month outlook Updated: November 2016

During December below-average precipitation is more likely than above-average. For December-January-February as a whole there is only a slight shift from the normal range of expected conditions, with below-average precipitation slightly more probable than above-average.

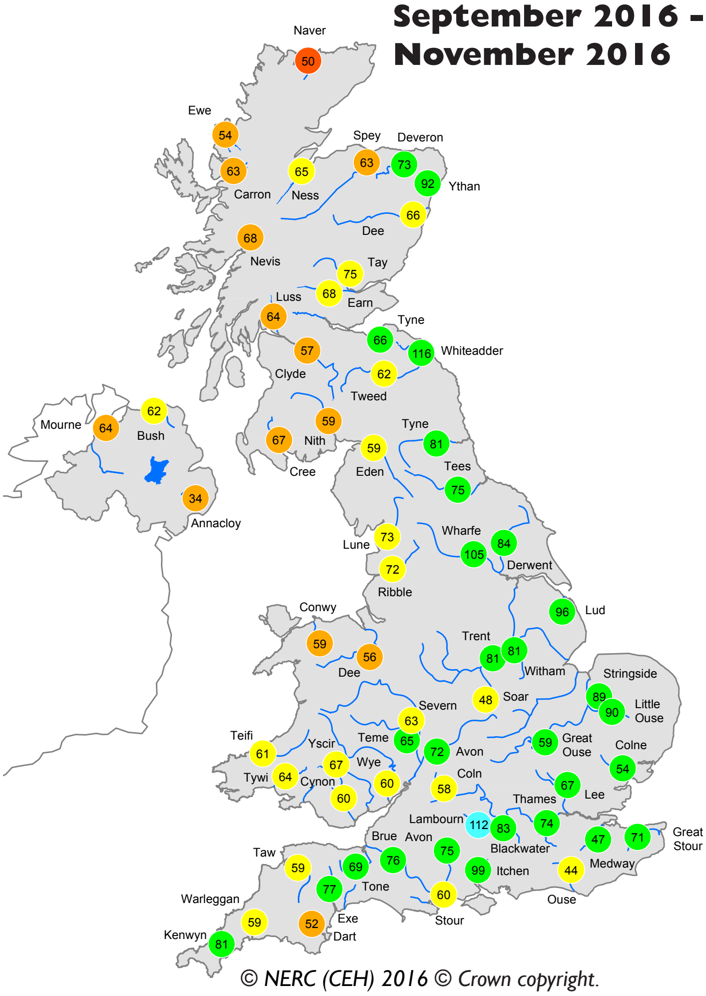
The probability that UK-average precipitation for December-January-February will fall into the driest of our five categories is between 20% and 25% and the probability that it will fall into the wettest of our five categories is around 15% (the 1981-2010 probability for each of these categories is 20%).

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.

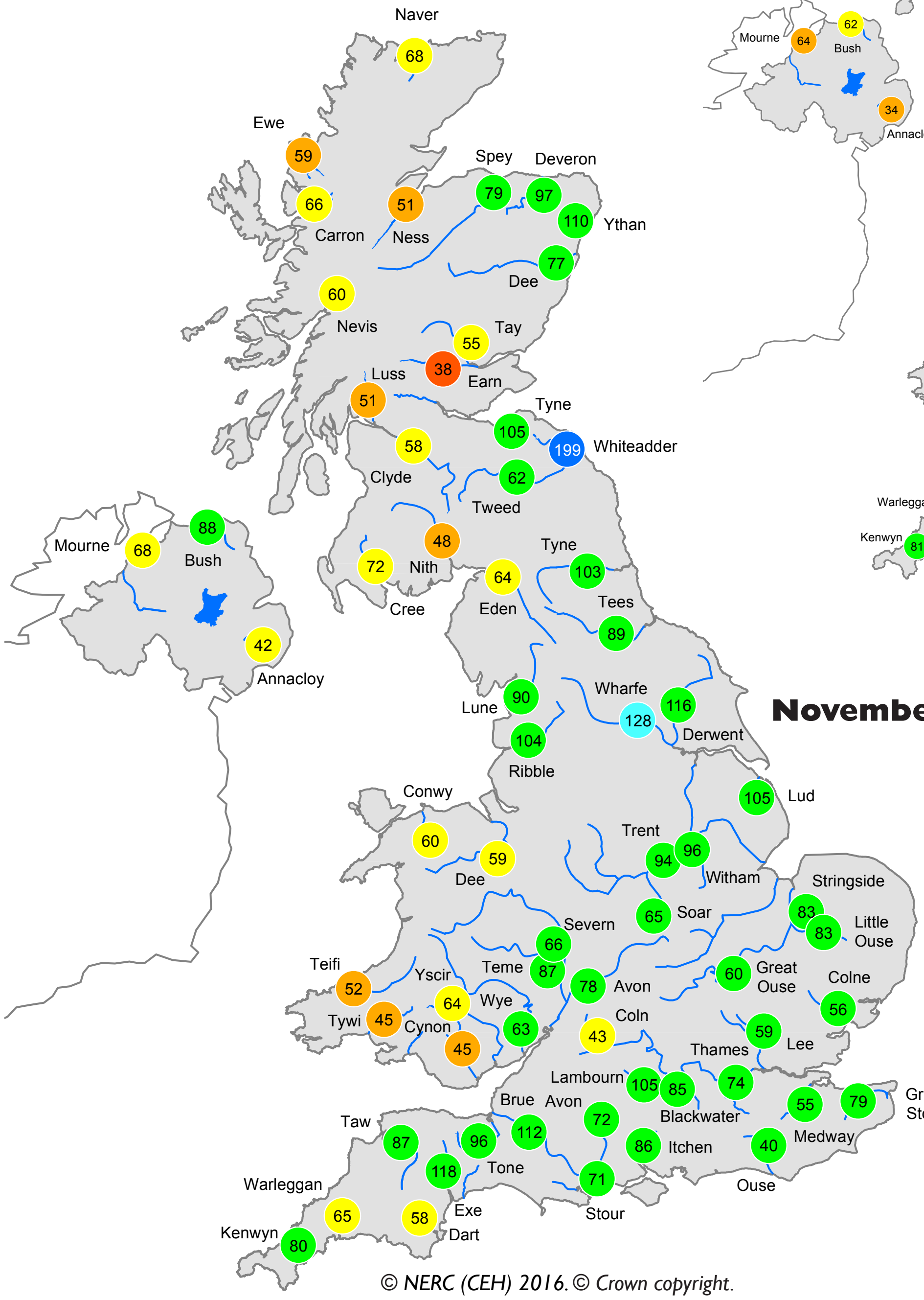
The latest shorter-range forecasts, covering the upcoming 30 days, can be accessed via:
http://www.metoffice.gov.uk/weather/uk/uk_forecast_weather.html
These forecasts are updated very frequently.

River flow . . . River flow . . .

September 2016 - November 2016



November 2016



Key

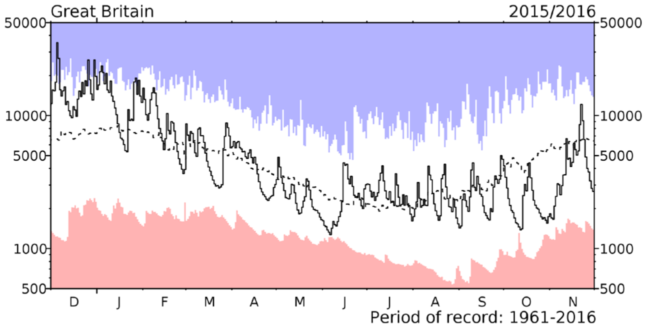
- 25 — % of long-term average (record figure when circled)
- Exceptionally high flow
- Notably high flow
- Above normal
- Normal range
- Below normal
- Notably low flow
- Exceptionally low flow

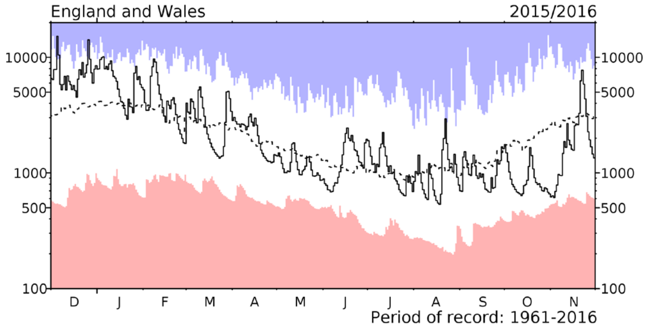
*Based on ranking of the monthly flow**

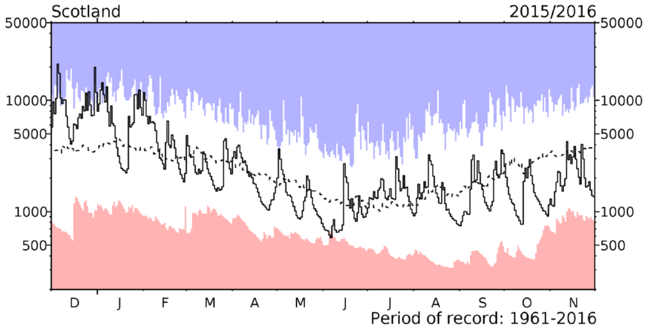
River flows

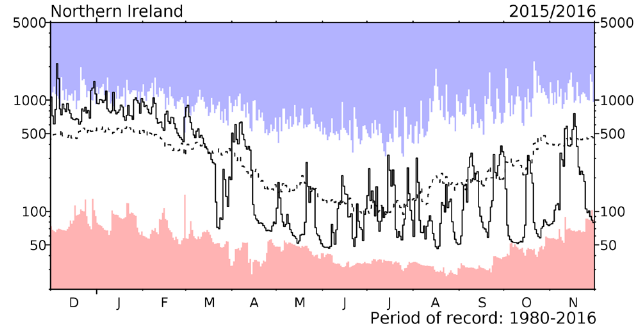
*Comparisons based on percentage flows alone can be misleading. A given percentage flow can represent extreme drought conditions in permeable catchments where flow patterns are relatively stable but be well within the normal range in impermeable catchments where the natural variation in flows is much 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.

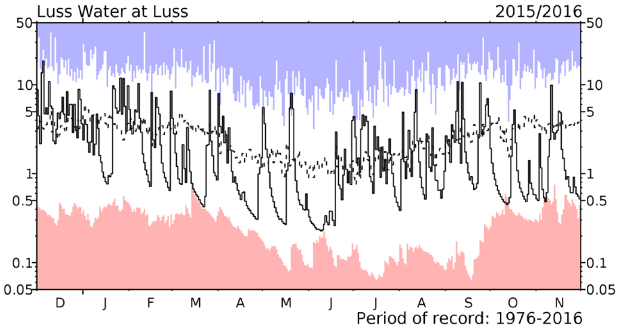
River flow . . . River flow . . .

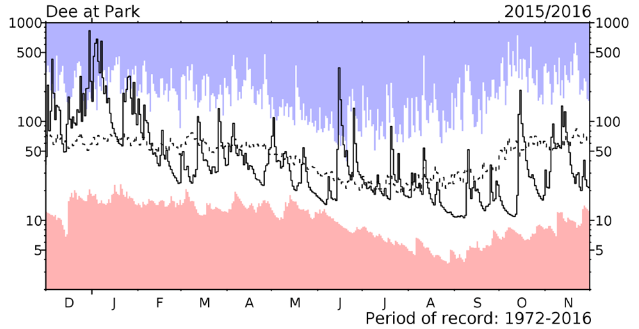


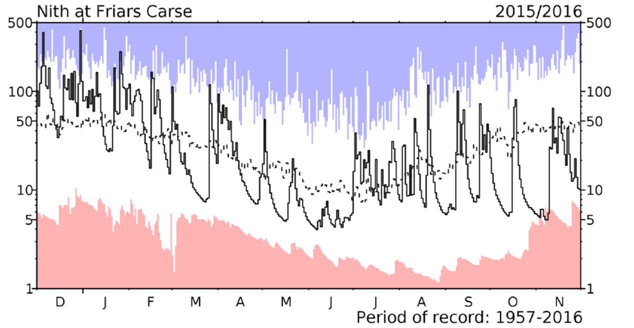


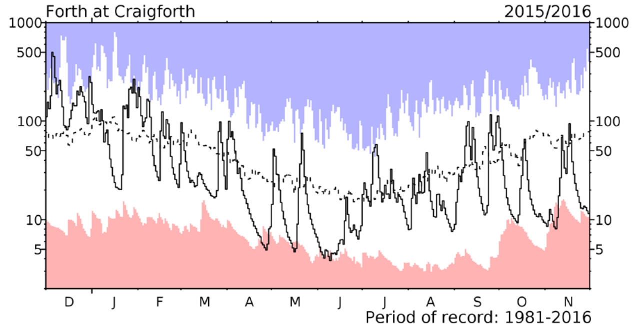


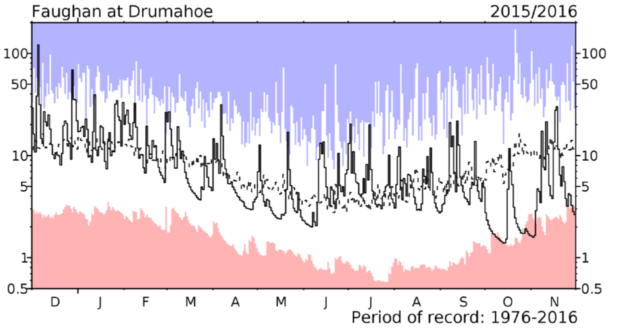


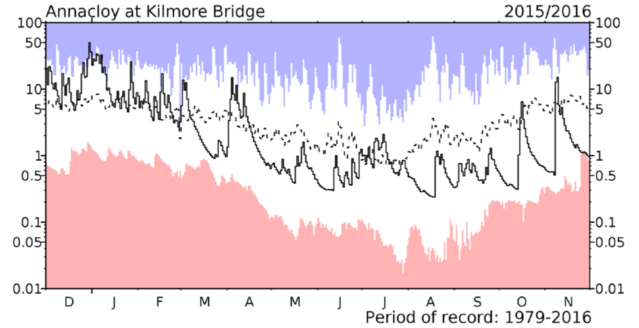








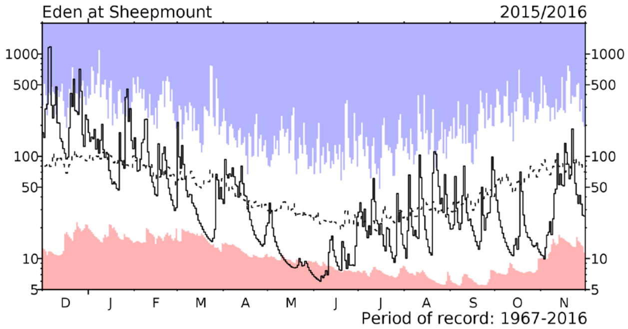


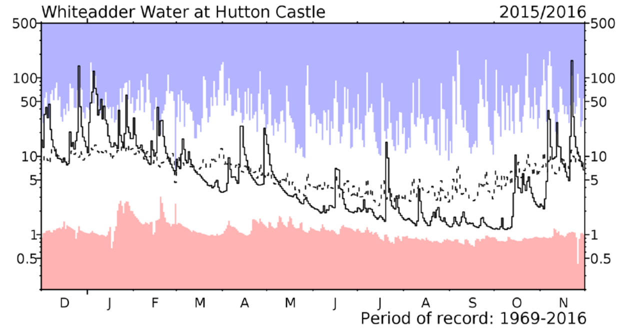


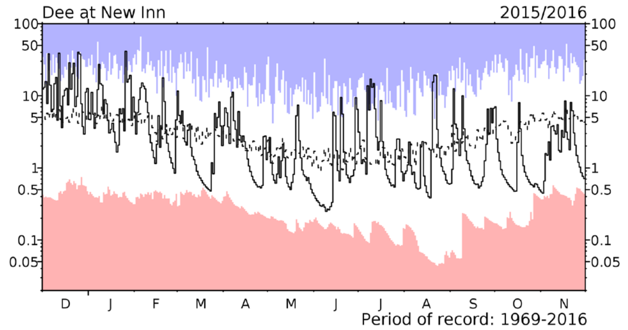
River flow hydrographs

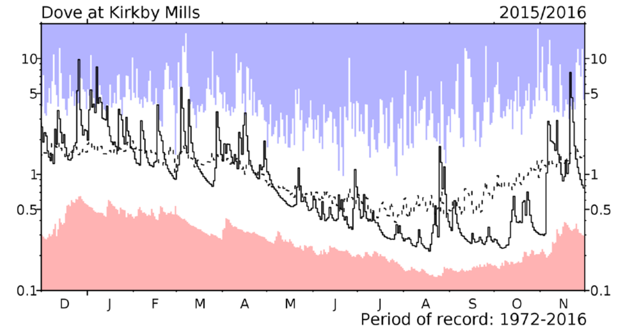
The river flow hydrographs show the daily mean flows together with the maximum and minimum daily flows prior to December 2015 (shown by the shaded areas). Daily flows falling outside the maximum/minimum range are indicated where the bold trace enters the shaded areas. Mean daily flows are shown as the dashed line.

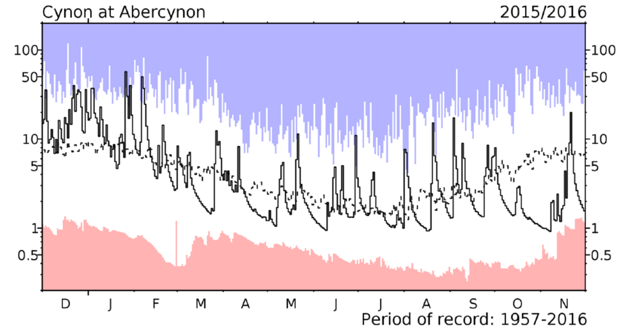
River flow . . . River flow . . .

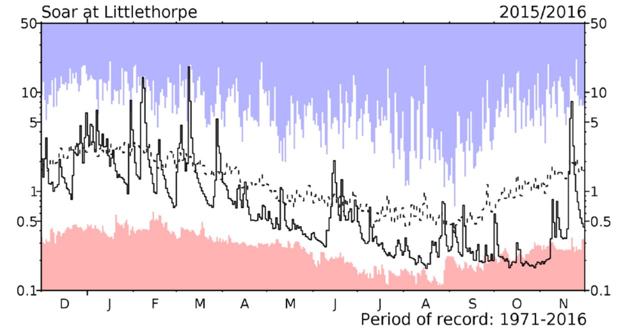


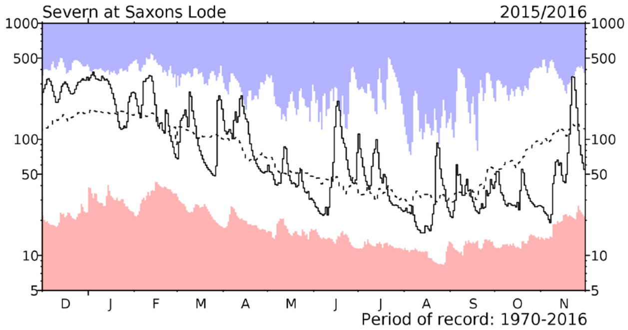


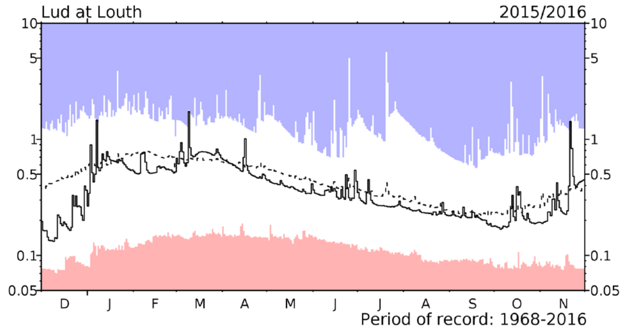


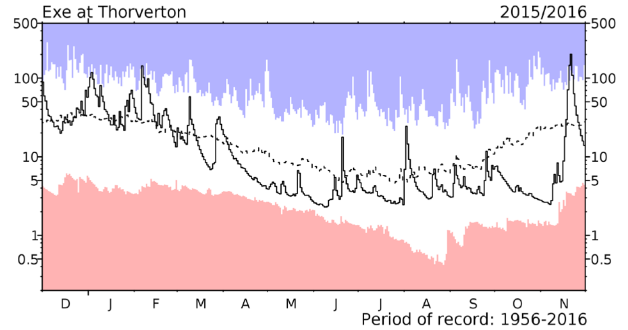


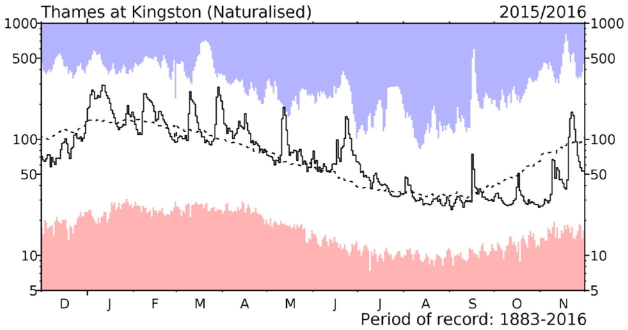


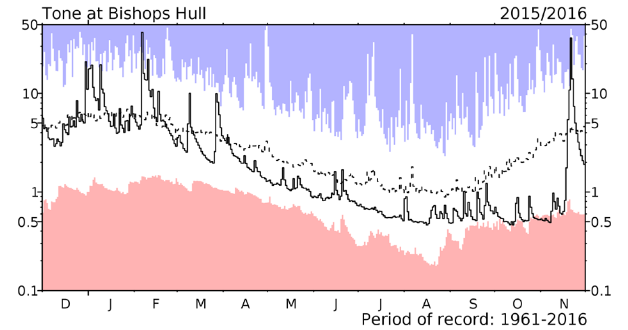


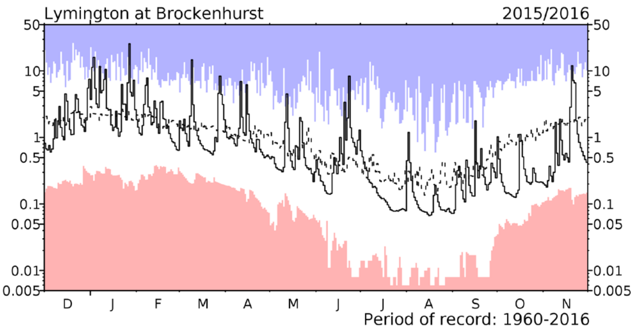




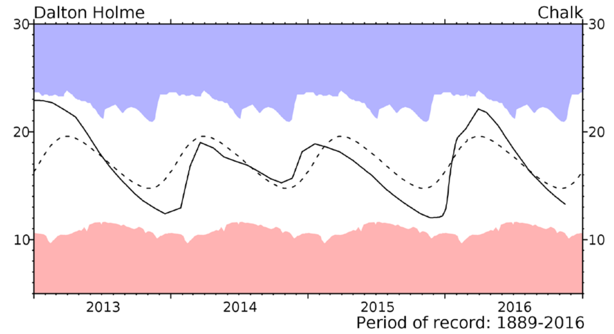


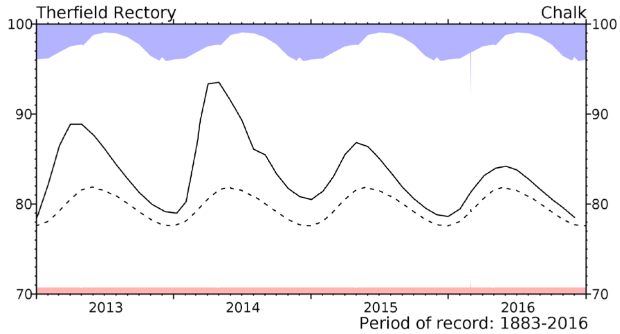


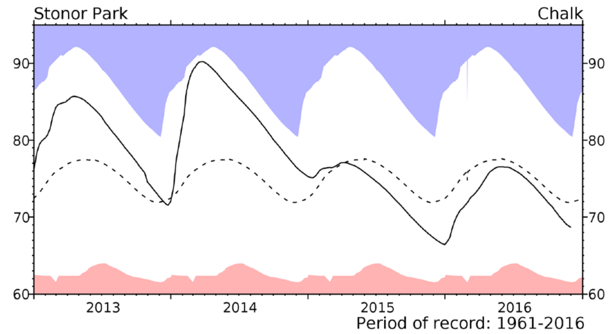


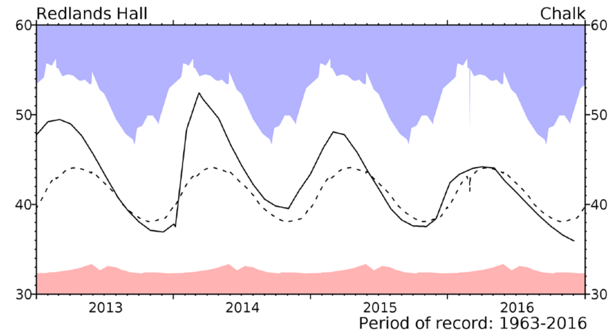


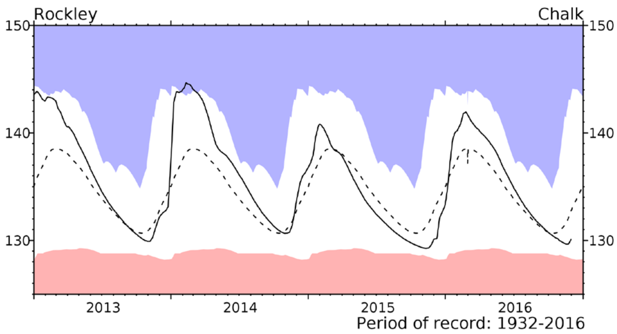
Groundwater . . . Groundwater

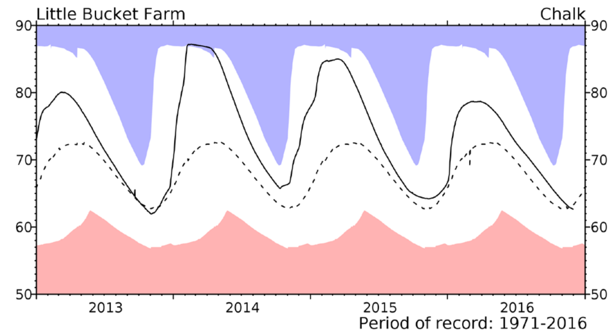


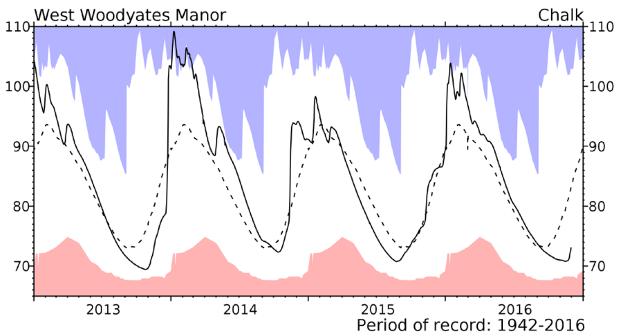


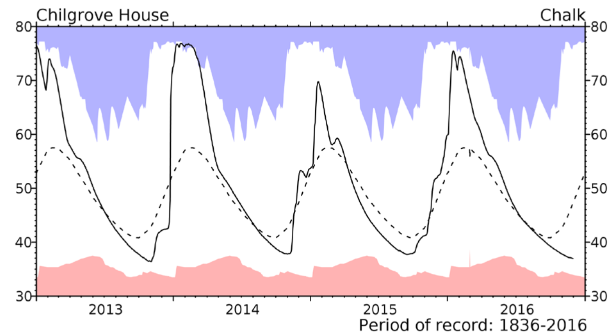


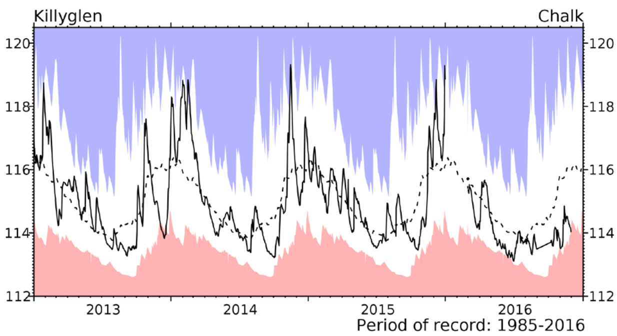


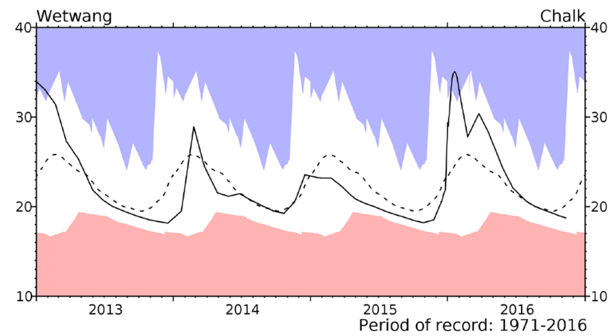






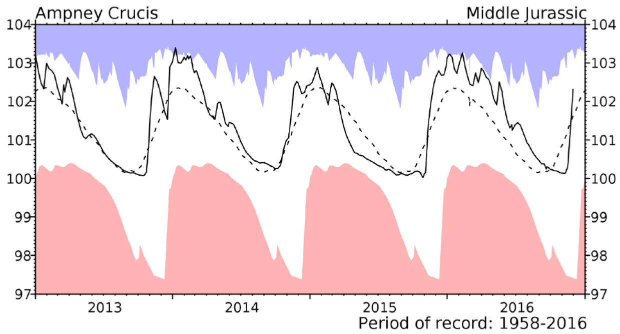


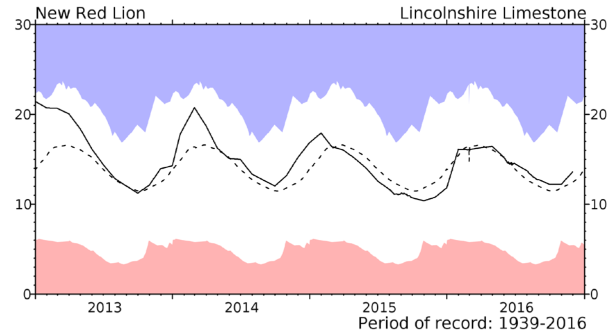


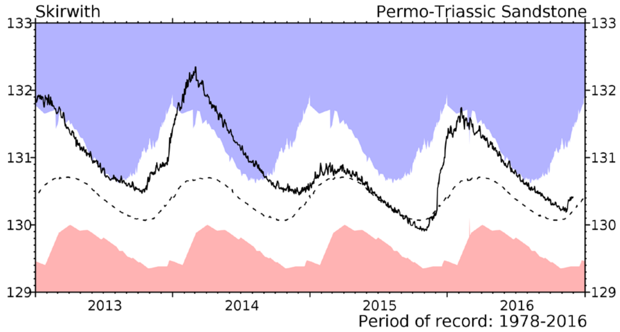


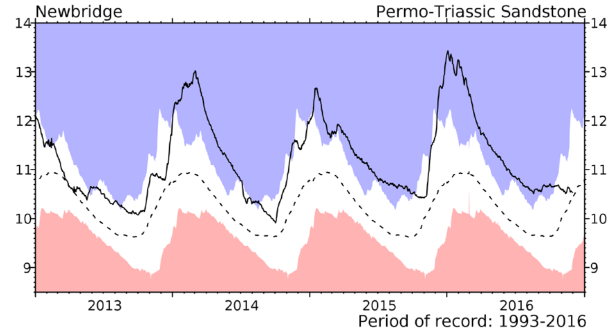
Groundwater levels normally rise and fall with the seasons, reaching a peak in the spring following replenishment through the winter (when evaporation losses are low and soil moist). They decline through the summer and early autumn. This seasonal variation is much reduced when the aquifer is confined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

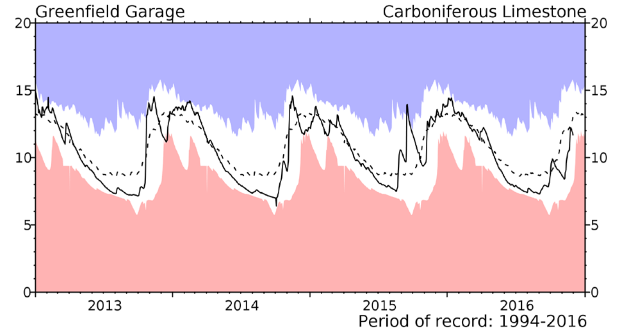
Groundwater... Groundwater

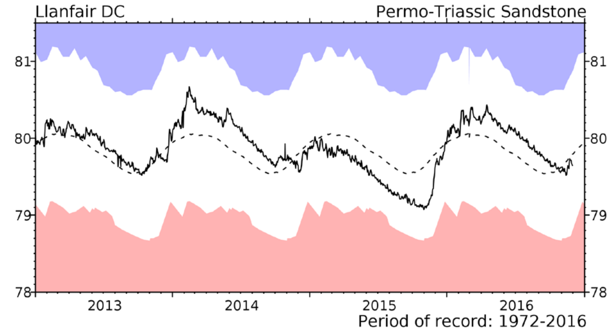


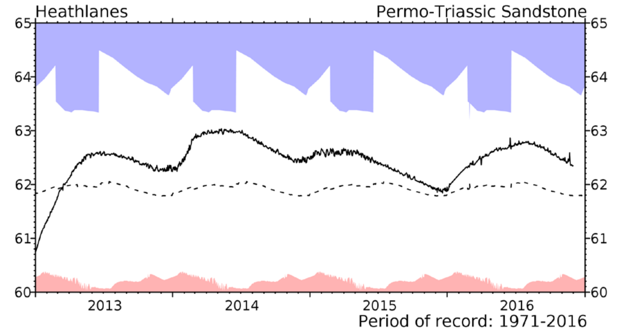


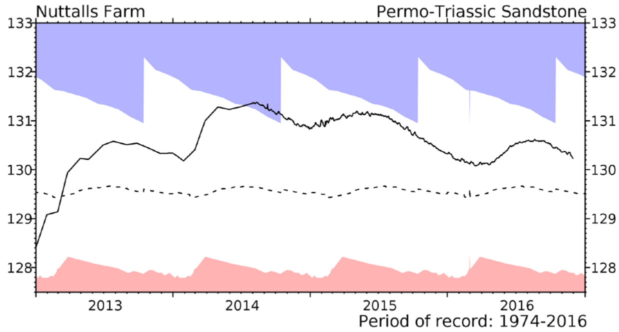


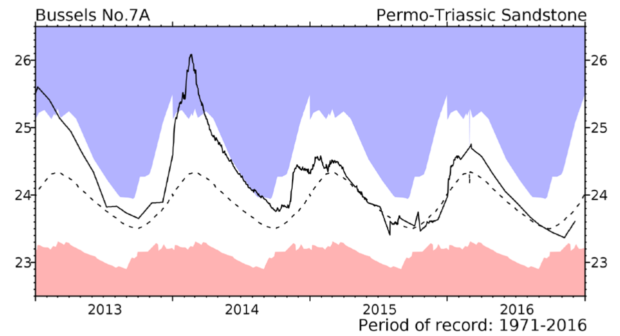


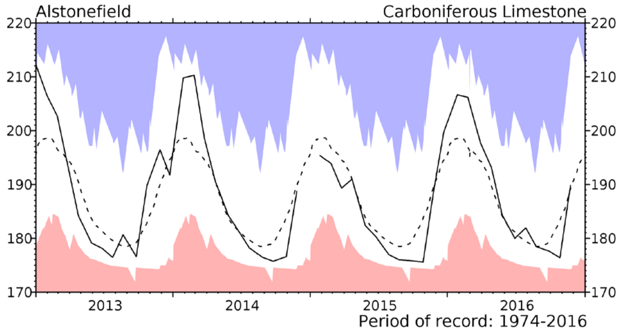










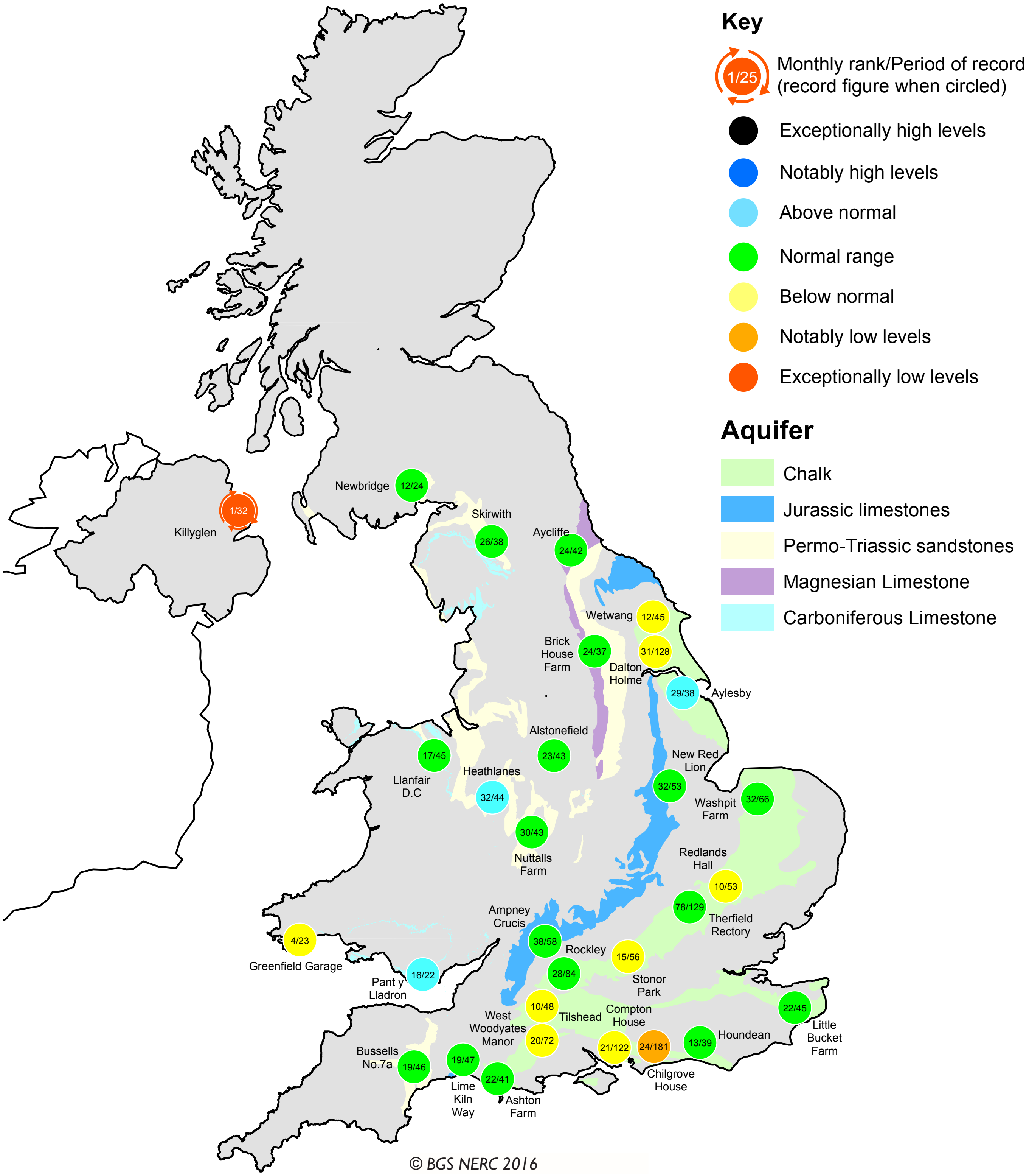


Groundwater levels November / December 2016

Borehole	Level	Date	Nov av.	Borehole	Level	Date	Nov av.	Borehole	Level	Date	Nov av.
Dalton Holme	13.26	16/11	14.78	Chilgrove House	36.94	30/11	46.37	Brick House Farm	12.99	07/12	12.40
Therfield Rectory	78.51	01/12	78.24	Killyglen (NI)	114.03	30/11	115.94	Llanfair DC	79.65	30/11	79.66
Stonor Park	68.69	30/11	72.06	Washpit Farm	43.19	30/11	43.31	Heathlanes	62.35	30/11	61.84
Tilshead	79.72	30/11	82.42	Ampney Crucis	102.31	30/11	101.25	Nuttalls Farm	130.23	30/11	129.63
Rockley	130.09	30/11	131.61	New Red Lion	13.59	30/11	12.31	Bussells No.7a	23.61	05/12	23.67
Houndean Bottom	4.26	30/11	8.28	Skirwith	130.41	30/11	130.15	Alstonefield	189.81	23/11	187.56
West Woodyates	73.02	30/11	80.69	Newbridge	10.54	30/11	10.33				

Levels in metres above Ordnance Datum

Groundwater...Groundwater

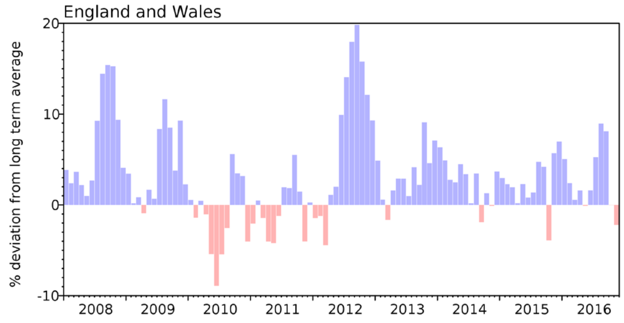


Groundwater levels - November 2016

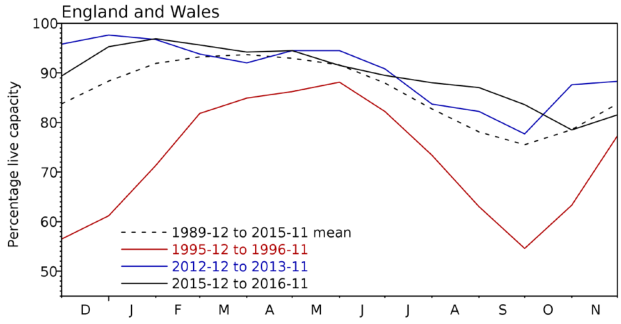
The calculation of ranking has been modified from that used in summaries published prior to October 2012. It is now based on a comparison between the most recent level and levels for the same date during previous years of record. Where appropriate, levels for earlier years may have been interpolated. 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 Sep	2016 Oct	2016 Nov	Nov Anom.	Min Nov	Year* of min	2015 Nov	Diff 16-15
North West	N Command Zone	•	124929	72	68	69	-9	44	1993	84	-14
	Vyrnwy		55146	99	79	82	-1	33	1995	96	-14
Northumbrian	Teesdale	•	87936	83	80	90	7	39	1995	94	-4
	Kielder		(199175)	92	88	82	-5	55	2007	98	-17
Severn-Trent	Clywedog		44922	89	83	89	8	43	1995	87	2
	Derwent Valley	•	39525	82	74	94	16	9	1995	81	13
Yorkshire	Washburn	•	22035	65	58	74	-2	16	1995	93	-18
	Bradford Supply	•	41407	70	66	81	-2	20	1995	87	-6
Anglian	Grafham		(55490)	90	88	86	3	47	1997	86	-1
	Rutland		(116580)	89	87	85	6	57	1995	79	6
Thames	London	•	202828	81	76	81	-2	52	1990	90	-9
	Farmoor	•	13822	98	90	87	-2	52	1990	89	-3
Southern	Bewl		28170	69	61	58	-6	34	1990	62	-5
	Ardingly		4685	62	47	48	-27	14	2011	68	-20
Wessex	Clatworthy		5364	40	29	58	-22	16	2003	98	-40
	Bristol	•	(38666)	64	55	66	-2	27	1990	75	-9
South West	Colliford		28540	69	65	66	-7	42	1995	83	-17
	Roadford		34500	68	65	67	-8	19	1995	85	-18
	Wimbleball		21320	50	43	51	-24	34	1995	74	-23
	Stithians		4967	60	62	75	9	29	2001	74	1
Welsh	Celyn & Brenig	•	131155	95	90	91	3	50	1995	98	-7
	Brianne		62140	100	98	91	-4	72	1995	100	-9
	Big Five	•	69762	81	72	80	-4	49	1990	79	1
	Elan Valley	•	99106	85	82	91	-3	47	1995	100	-9
Scotland(E)	Edinburgh/Mid-Lothian	•	96518	87	82	83	-3	45	2003	86	-3
	East Lothian	•	9374	92	98	100	11	38	2003	100	0
Scotland(W)	Loch Katrine	•	110326	95	89	88	-3	65	2007	98	-10
	Daer		22412	93	80	79	-18	73	2003	99	-20
	Loch Thom		10798	100	93	93	-2	72	2003	100	-7
Northern Ireland	Total+	•	56800	75	74	73	-13	59	2003	96	-23
	Silent Valley	•	20634	72	68	64	-18	43	2001	98	-34

( ) 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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12/2016

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