Hydrological Summary

for the United Kingdom

November 2009

General

November was a singular month in hydrological terms; it was notably warm but with very boisterous weather conditions and exceptionally high rainfall across most of the country. The UK registered its wettest November on record (in a series from 1914) and, more remarkably, a new 24-hr maximum rainfall for the UK was established in the Lake District. Severe flooding affected Cumbria and parts of Scotland and floodplain inundations were both common and widespread. The sustained high runoff rates generated an exceptionally high (>10%) monthly increase in overall reservoir stocks for England & Wales, leaving them at their 4th highest early-December level in a series from 1988. Below average early-winter stocks in index reservoirs are restricted to a few reservoirs in the English Lowlands (e.g. Rutland and Bewl). November runoff totals exceeded previous maxima in many catchments and, with soil moisture deficits rapidly eliminated, the belated seasonal onset of aquifer recharge gathered considerable momentum through the month; some dramatic increases in groundwater levels were reported. Entering the winter, the water resources outlook is notably healthy in almost all regions but, with catchments generally saturated, many river basins are very vulnerable to further significant rainfall.

Rainfall

In contrast to much of 2009, November saw a relentless sequence of low pressure systems crossing the British Isles. The persistently cyclonic conditions resulted in rainfall on all but 2 or 3 days in most regions and in mid-month a near-stationary weather system allowed an exceptionally warm and moist subtropical airflow to track SSW-NNE across parts of the UK. This, together with substantial orographic enhancement, produced many storm totals of >50mm and culminated in extreme rainfall totals across high ground in the Lake District. A new UK 24-hr record was established at Seathwaite Farm, Borrowdale with 316.4mm up to 00:00 on the 20th (provisional return period 2000 years); the site also recorded remarkable totals of 402mm over 37 hrs and 495mm over 4 raindays (provisionally 4000 & 3000 years). Apart from the far north-west of Scotland, November rainfall totals exceeded the average, commonly by wide margins and many individual raingauge totals were outstanding. Existing monthly rainfall maxima were widely eclipsed e.g. Inveruglas (Strathclyde) notched 561.4mm and Glencaple (Dumfries & Galloway) exceeded, by 80mm, its previous maximum for any month in a 45-yr series. The exceptional late autumn rainfall considerably moderated medium and long term rainfall deficiencies: regional rainfall totals for the last 12 months are in the normal range across England & Wales, and considerably above average for Northern Ireland and Scotland.

River flows

Many responsive rivers remained in spate for much of November with an associated high flood risk across a substantial proportion of the country. Early in the month a rotating low pressure system caused gales and widespread flooding across Banff and Aberdeenshire (e.g. in Huntly and Stonehaven). The peak flow on the Deveron (at Muiresk) exceeded its previous maximum (registered in September) in a 50-yr record. By the third week, brisk (but seasonally-late) runoff recoveries were well established across the English Lowlands in both responsive and groundwater-fed streams; there were a few exceptions e.g. in East Anglia. Over the latter half of November flood warnings were very widespread. With catchments saturated and most responsive rivers in high spate, the extreme rainfall over the 17-20th triggered a devastating flood episode in Cumbria (and extending into south west Scotland). Many rivers in the Lake District (including the Derwent, Cocker and St Johns Beck) exceeded their previous maximum flow by a wide margin as did outflows from Windermere (in a 70-year series). Very exceptional flows were also reported in a broad band from north Wales to well into Scotland; the Nith eclipsed its previous November maximum in a 53-year series. Flooding was also severe in Northern Ireland (Lough Earn spilled causing extensive agricultural flooding). Floodplain inundations were both extensive and sustained with very severe impacts on communities (Cockermouth and Workington particularly). Collapsed bridges and landslips contributed to severe transport disruption (services on the West Coast Main Line were briefly suspended). The November outflows for the UK were the highest on record (in a series from 1961) and index rivers eclipsing previous November runoff maxima show a very wide distribution. Runoff accumulations, relatively depressed throughout much of 2009 in southern Britain, are now – for the year thus far – generally within, or above, average.

Groundwater

After meagre recharge since the early spring of 2009 in lowland aquifers, the sustained November rainfall eliminated residual soil moisture deficits in most areas and abundant infiltration characterised the latter half of the month, continuing into December. The recording schedules for the index boreholes (and the time taken for recharge to traverse the unsaturated zone) means that the groundwater level response is not captured in some of the featured hydrographs. Nonetheless, exceptionally steep groundwater level recoveries were recorded in parts of the southern Chalk (see, for example, the West Woodyates and Chilgrove hydrographs). This pattern is replicated in most of the index limestone wells which reported late in the month – see the hydrograph for Ampney Crucis in the Jurassic Limestone of the Cotswolds. In south west Scotland, the exceptional November rainfall resulted in the highest recorded level at the Newbridge borehole in a 16-yr series. The full effect of the late-autumn infiltration will not be evident until later in the year but the outstanding late-autumn recharge has transformed the general groundwater resources outlook; strong groundwater level recoveries are now well established across most major aquifer outcrop areas.

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Rainfall . . . Rainfall . . .

Rainfall accumulations and return period estimates

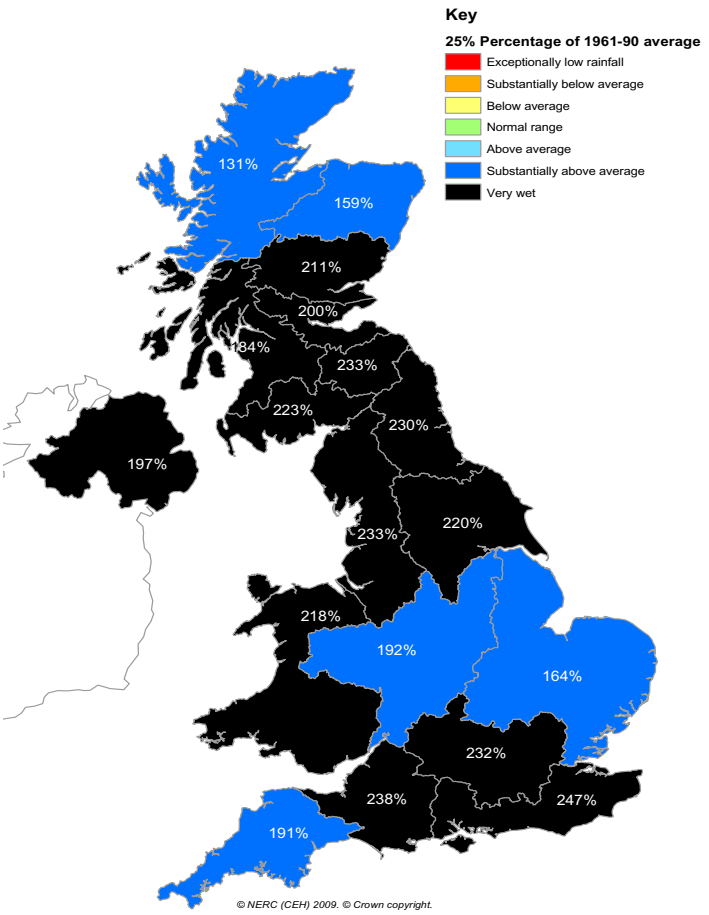
Area	Rainfall	Nov 2009	Sep 09 - Nov 09		Jun 09 - Nov 09		Mar 09 - Nov 09		Dec 08 - Nov 09	
England & Wales	**mm**	**196**	**306**		**574**		**723**		**930**	
	%	**214**	**119**	**2-5**	**125**	**5-10**	**110**	**2-5**	**103**	**2-5**
North West	mm	**292**	450		857		1082		1346	
	%	**233**	121	5-10	132	10-20	121	15-25	111	5-10
Northumbrian	mm	**199**	317		643		774		965	
	%	**230**	134	5-10	143	30-40	121	5-15	111	2-5
Severn Trent	mm	**138**	218		473		605		762	
	%	**192**	108	2-5	122	2-5	107	2-5	99	2-5
Yorkshire	mm	**180**	288		548		681		862	
	%	**220**	127	5-10	129	5-10	111	2-5	103	2-5
Anglian	mm	**95**	158		326		413		546	
	%	**164**	99	2-5	103	2-5	90	2-5	90	2-5
Thames	mm	**152**	223		405		511		685	
	%	**232**	118	2-5	115	2-5	99	2-5	98	2-5
Southern	mm	**211**	309		447		564		772	
	%	**247**	131	2-5	113	2-5	100	2-5	98	2-5
Wessex	mm	**202**	311		547		672		898	
	%	**238**	130	2-5	131	5-10	111	2-5	105	2-5
South West	mm	**244**	397		731		952		1283	
	%	**191**	117	2-5	129	5-10	118	5-10	108	2-5
Welsh	mm	**315**	486		881		1109		1395	
	%	**218**	121	2-5	132	5-15	117	5-10	104	2-5
Scotland	**mm**	**262**	**554**		**976**		**1328**		**1714**	
	%	**167**	**120**	**5-15**	**129**	**60-90**	**126**	**>100**	**117**	**20-30**
Highland	mm	**259**	636		1060		1510		1982	
	%	**131**	114	5-10	119	10-20	122	50-80	114	10-20
North East	mm	**165**	432		755		963		1222	
	%	**159**	145	20-30	141	>100	127	60-90	119	20-30
Tay	mm	**269**	529		925		1227		1558	
	%	**211**	138	10-20	144	50-80	135	>100	121	15-25
Forth	mm	**232**	425		793		1034		1288	
	%	**200**	122	5-10	133	20-30	124	20-35	112	5-10
Tweed	mm	**224**	370		751		917		1159	
	%	**233**	129	5-10	145	40-60	125	10-20	116	5-15
Solway	mm	**325**	534		1075		1405		1793	
	%	**223**	119	5-10	144	80-120	136	>100	125	50-80
Clyde	mm	**341**	654		1183		1626		2068	
	%	**184**	116	5-10	129	30-50	130	>100	118	15-25
Northern Ireland	**mm**	**211**	**357**		**705**		**981**		**1234**	
	%	**197**	**111**	**2-5**	**126**	**10-20**	**124**	**25-40**	**112**	**5-10**

% = percentage of 1961-90 average *RP = Return period*

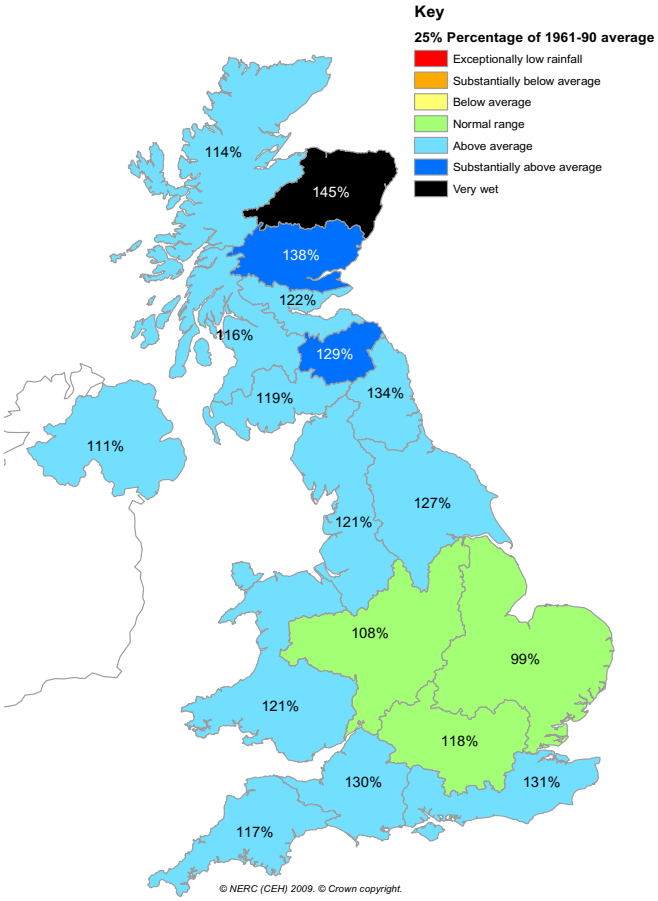
Important note: Figures in the above table may be quoted provided their source is acknowledged (see page 12). Where appropriate, specific mention must be made of the uncertainties associated with the return period estimates. The RP estimates are based on data provided by the Met Office and derived following the method described in: Tabony, R. C. 1977, *The variability of long duration rainfall over Great Britain*. Met Office Scientific Paper no. 37. The estimates reflect climatic variability since 1913 and assume a stable climate. 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.
All monthly rainfall totals since May 2009 are provisional.

Rainfall . . . Rainfall . . .

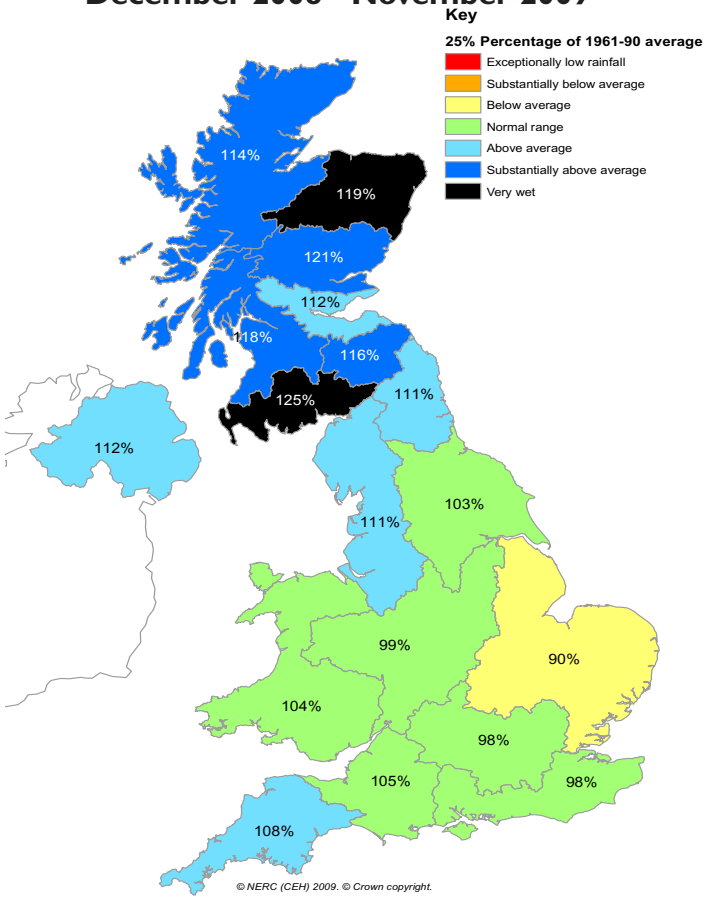
November 2009



September - November 2009



December 2008 - November 2009



Met Office Winter 2009/10 forecast

Forecast for Winter 2009/10:
Issued 27 November 2009

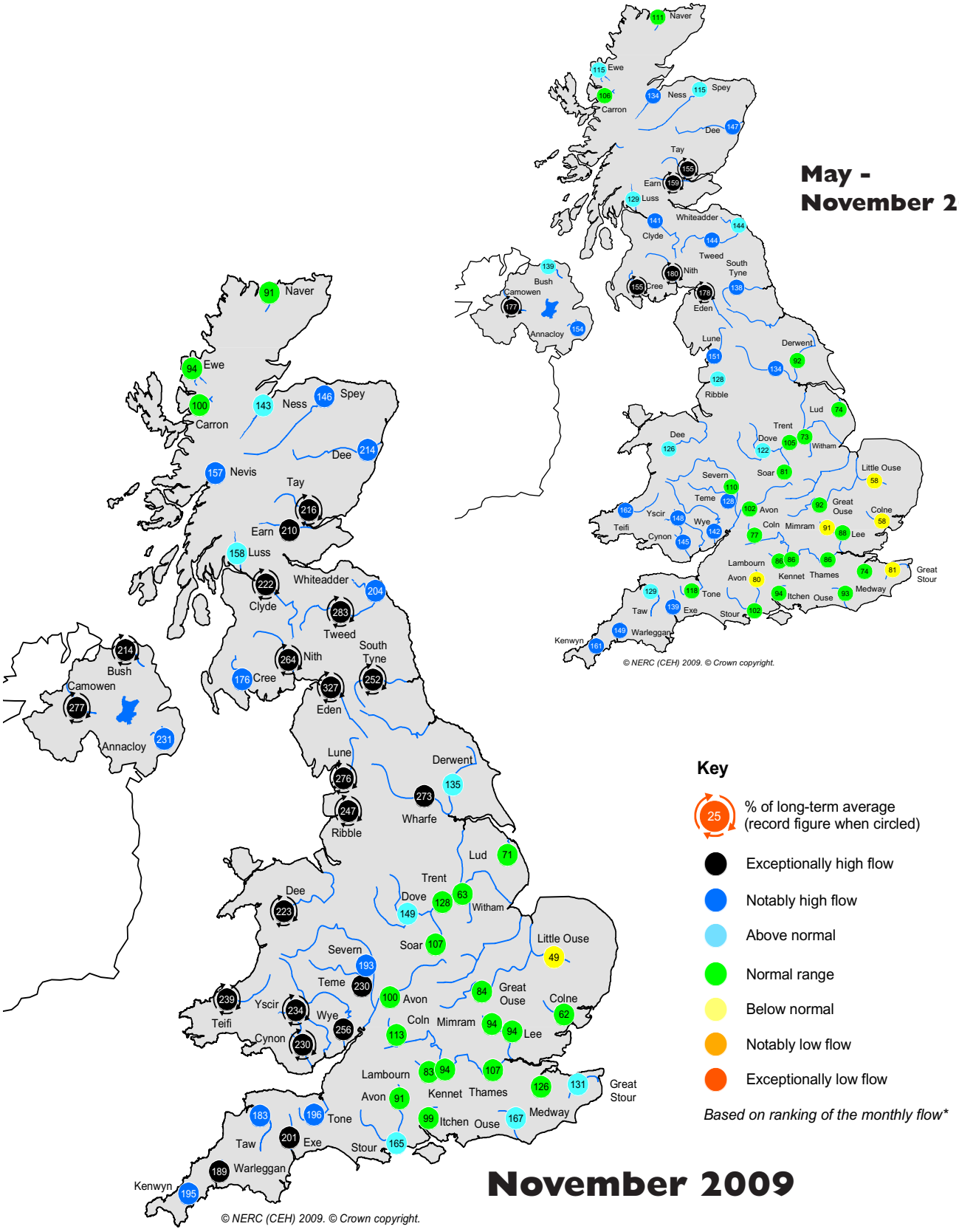
Temperature
For northern Europe, including the UK, there is a 20% chance of a colder winter, a 30% chance of an average winter and a 50% chance of a milder winter.

Rainfall
For northern Europe, including the UK, signals for precipitation are weak, with near equal chances for each of the three categories. There is a 30% chance of a drier winter, a 35% chance of an average winter and a 35% chance of a wetter winter.

Updates and reviews of the forecast
An update to the winter forecast will be issued in December A monthly appraisal of the winter will start in early February 2010.

For further details please visit:
http://www.metoffice.gov.uk/weather/seasonal/2009/winter/

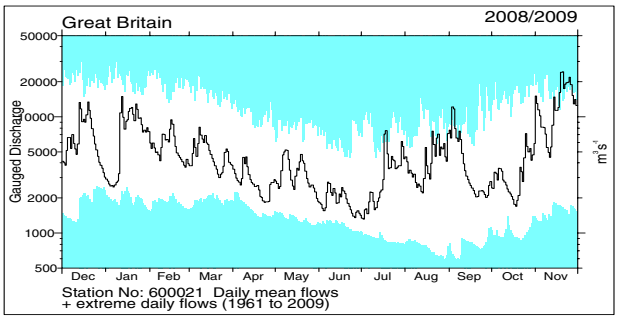
River flow . . . River flow . . .

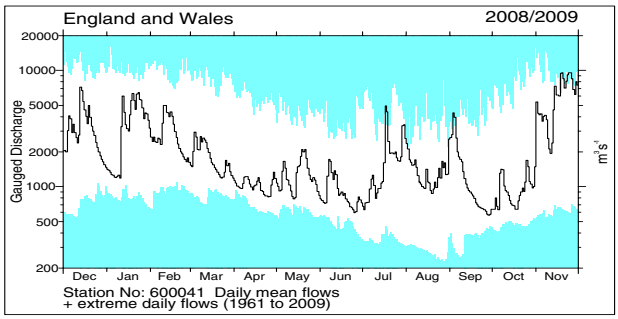


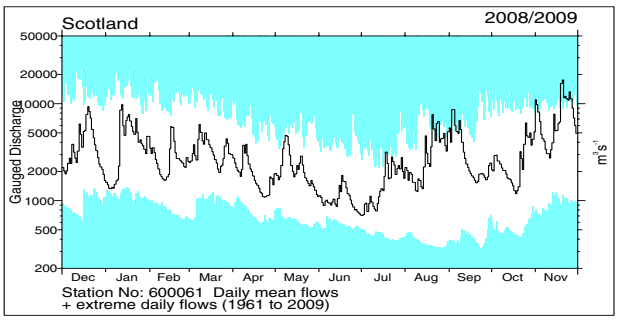
River flows

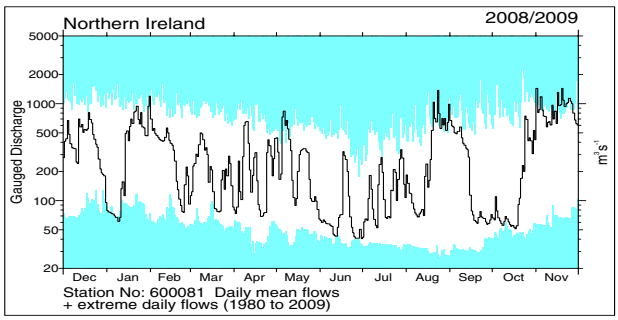
*Comparisons based on percentage flows alone can be misleading. A given percentage flow can represent extreme drought conditions in permeable catchments where flow patterns are relatively stable but be well within the normal range in impermeable catchments where the natural variation in flows is much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

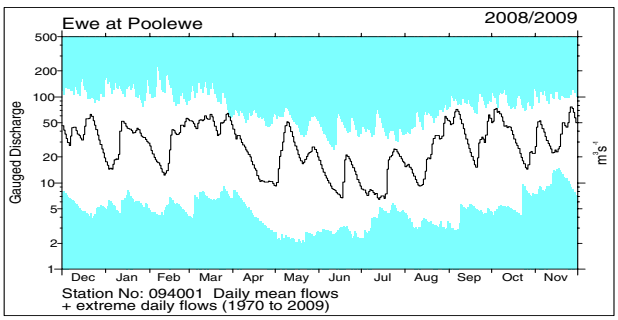
River flow . . . River flow . . .

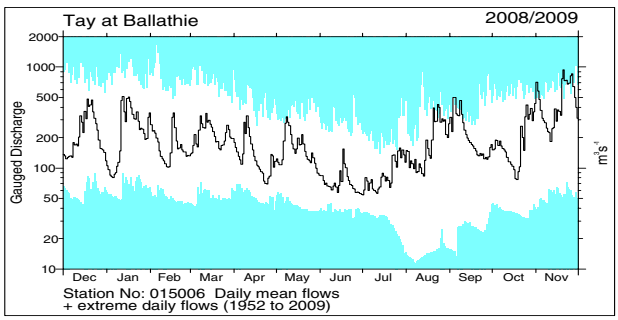


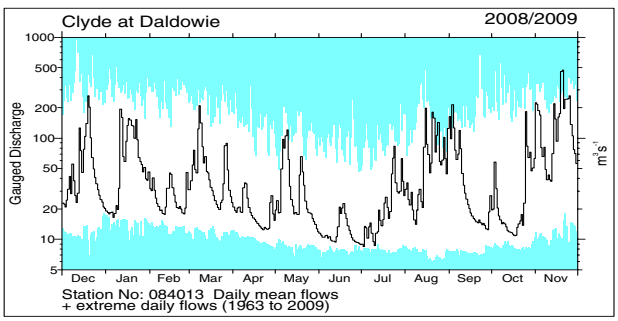


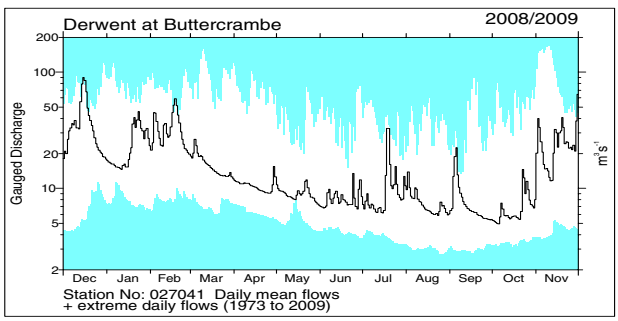


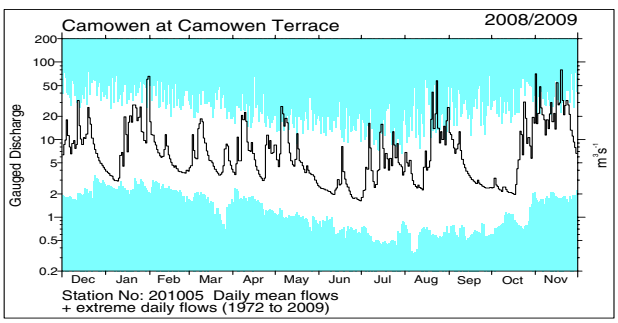


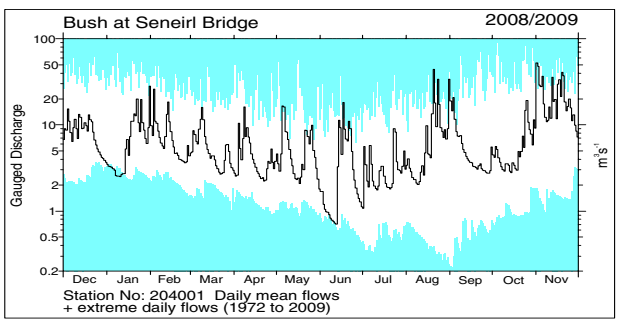








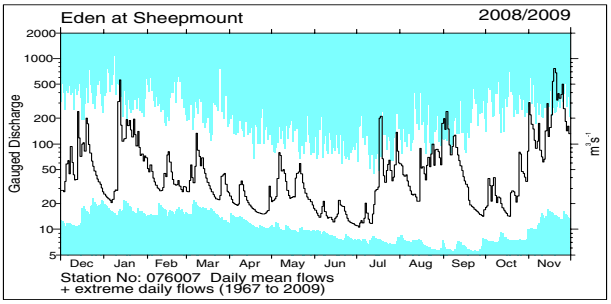


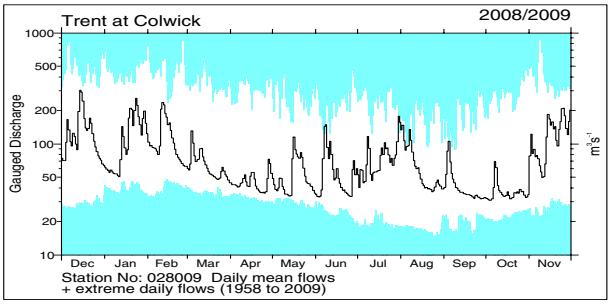


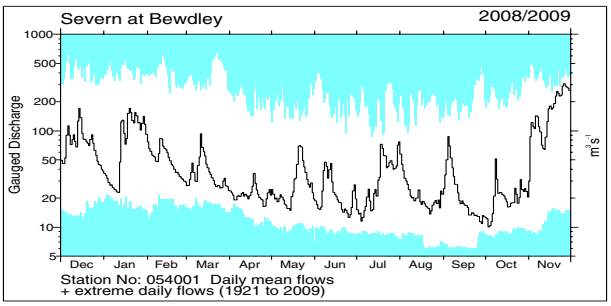
River flow hydrographs

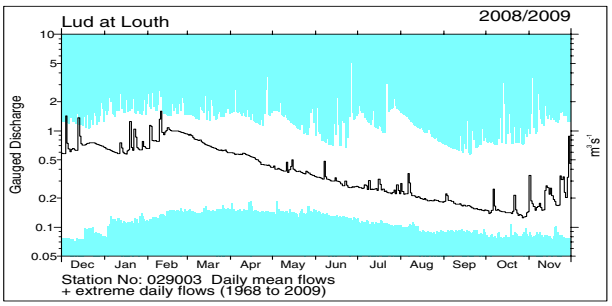
The river flow hydrographs show the daily mean flows together with the maximum and minimum daily flows prior to December 2008 (shown by the shaded areas). Daily flows falling outside the maximum/minimum range are indicated where the bold trace enters the shaded areas.

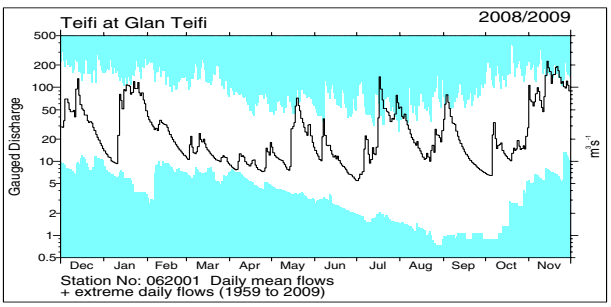
River flow . . . River flow . . .

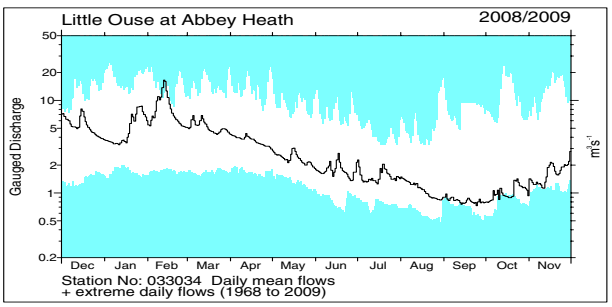


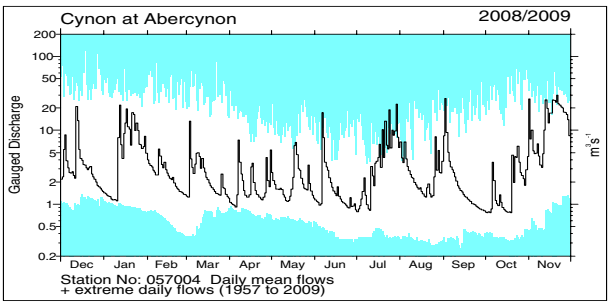


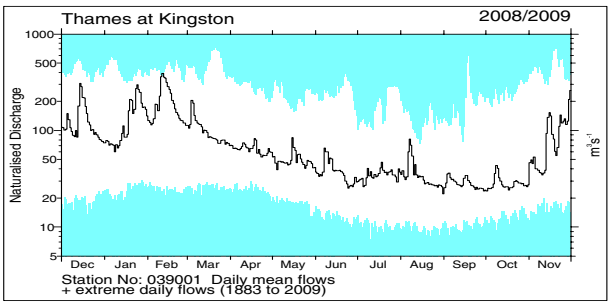


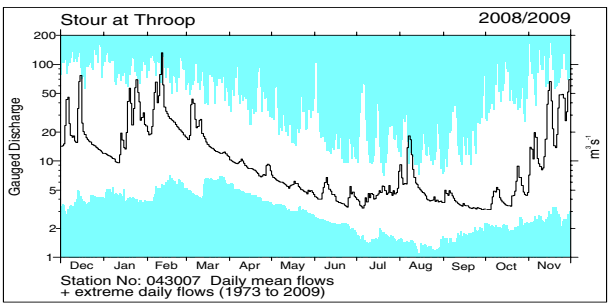


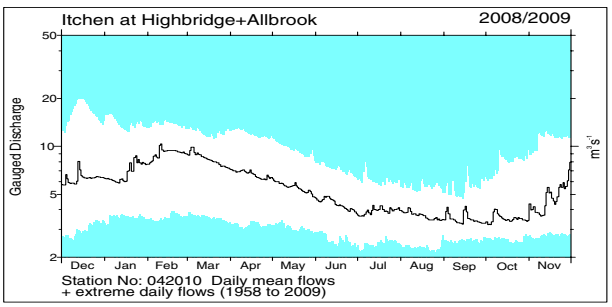












Notable runoff accumulations (a) July - November 2009, (b) May - November 2009

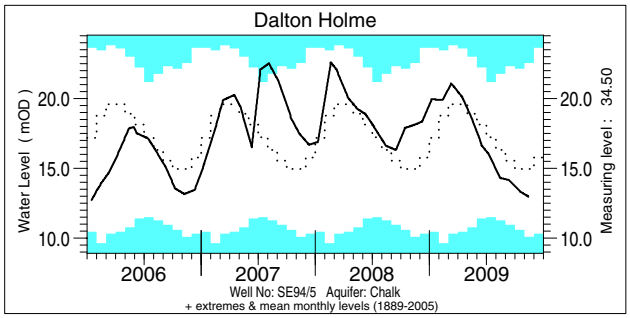
	River	%lta	Rank
a)	Ness	139	37/37
	Spey (Boat o'Garten)	141	57/58
	Tay	167	57/57
	Tweed (Norham)	169	48/50
	Tyne (Bywell)	168	48/51
	Little Ouse	54	4/39
	Tawe	166	50/51

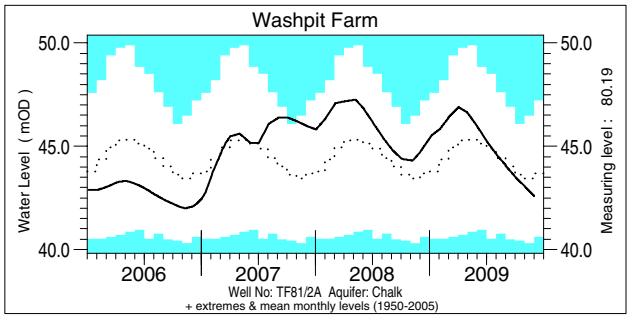
	River	%lta	Rank
a)	Teifi	171	48/50
	Lune	159	47/49
	Eden	197	42/42
	Cree	161	46/46
	Mourne	173	28/28

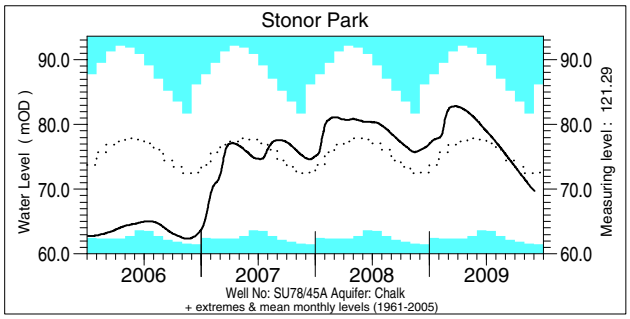
	River	%lta	Rank
b)	Dee (Woodend)	136	76/80
	Earn	159	62/62
	Forth	160	28/28
	Nith	180	52/52
	Clyde (Blairston)	157	50/50
	Camowen	177	38/38
	Annacloy	154	28/30

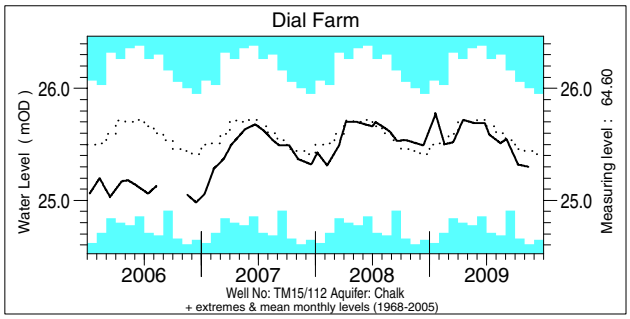
lta = long term average
Rank 1 = lowest on record

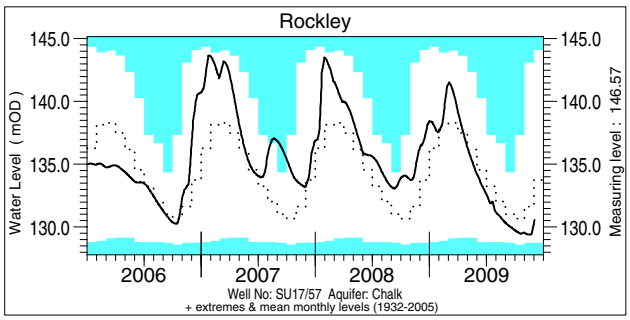
Groundwater . . . Groundwater

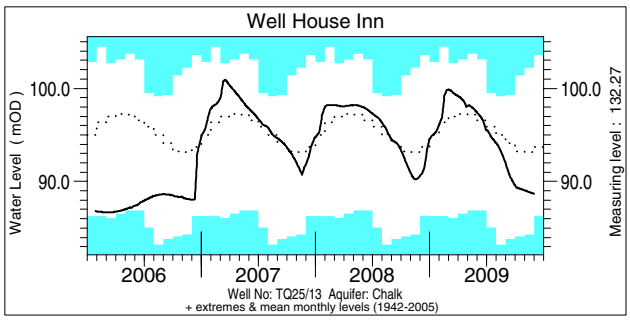


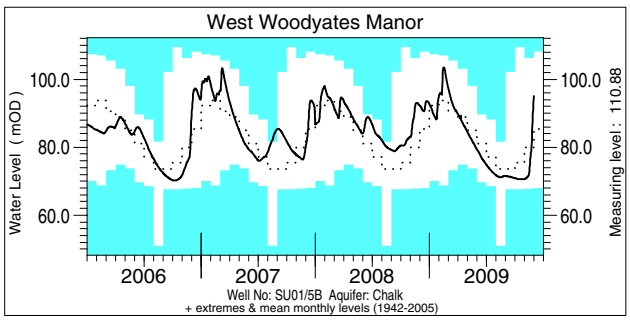


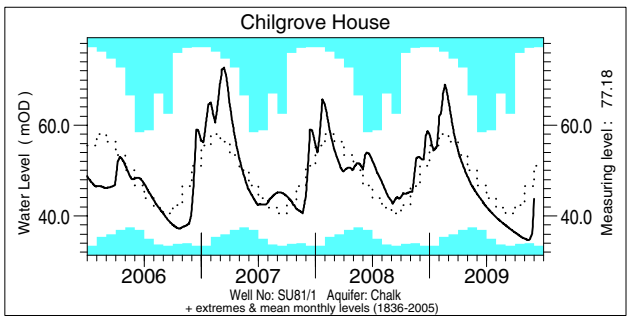


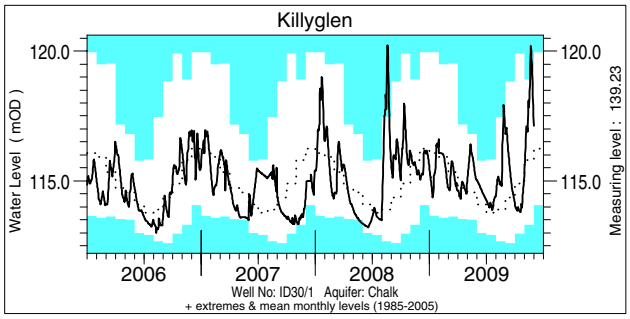


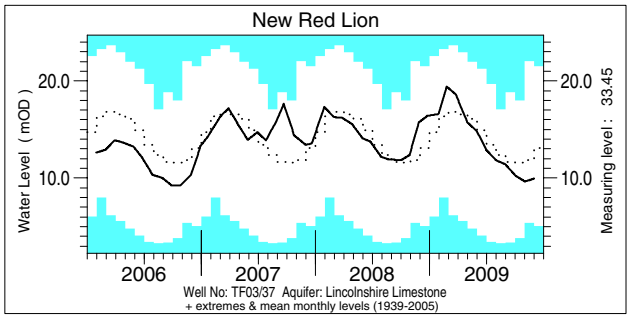






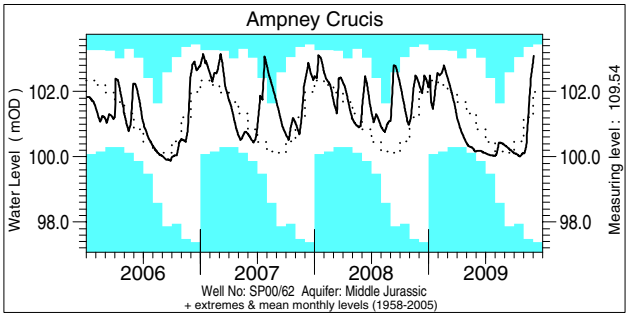


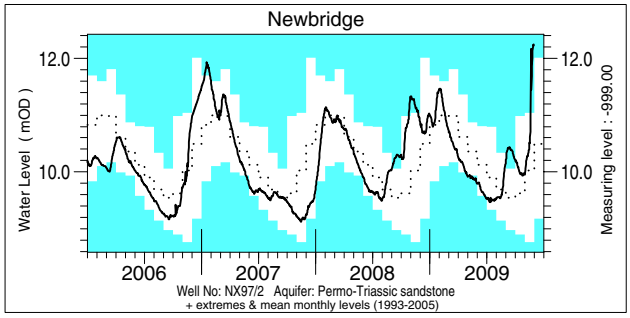


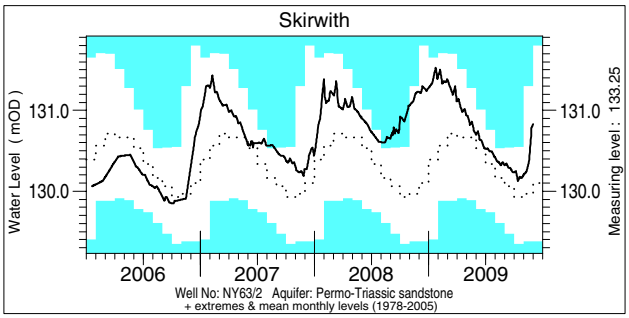


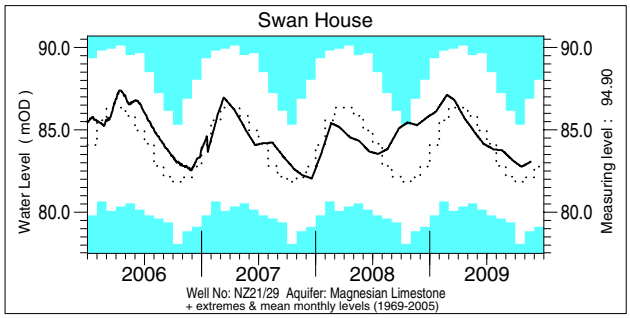
Groundwater levels normally rise and fall with the seasons, reaching a peak in the spring following replenishment through the winter (when evaporation losses are low and soil moist). They decline through the summer and early autumn. This seasonal variation is much reduced when the aquifer is confined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

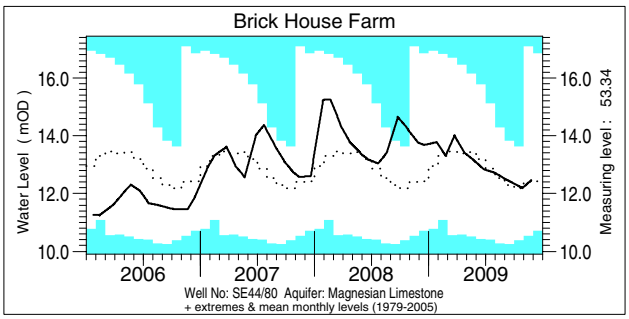
Groundwater . . . Groundwater

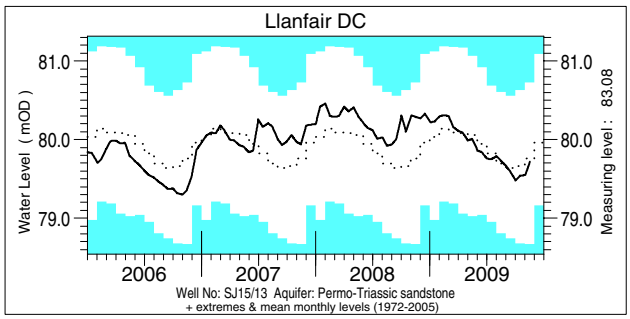


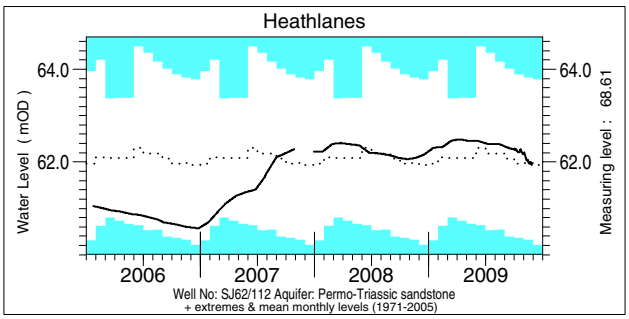


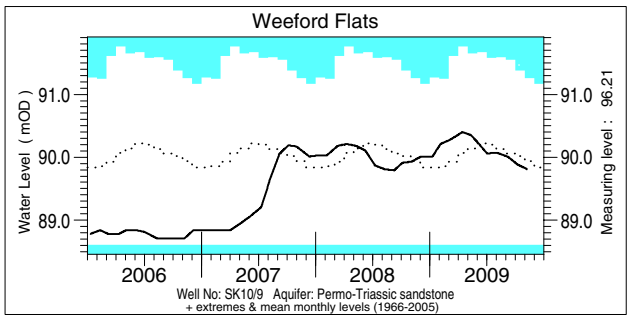


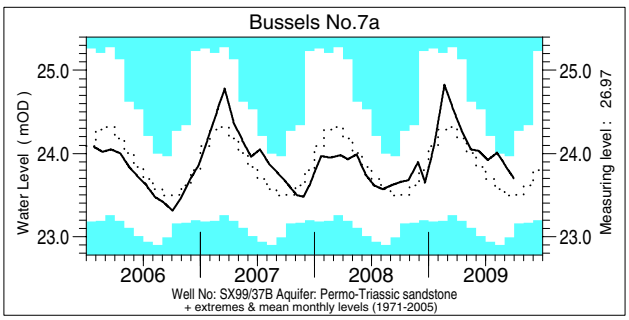


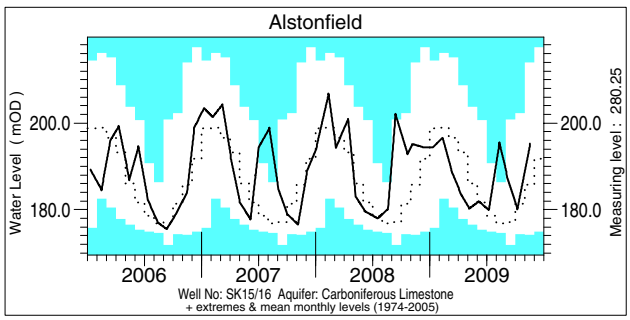












Groundwater levels November / December 2009

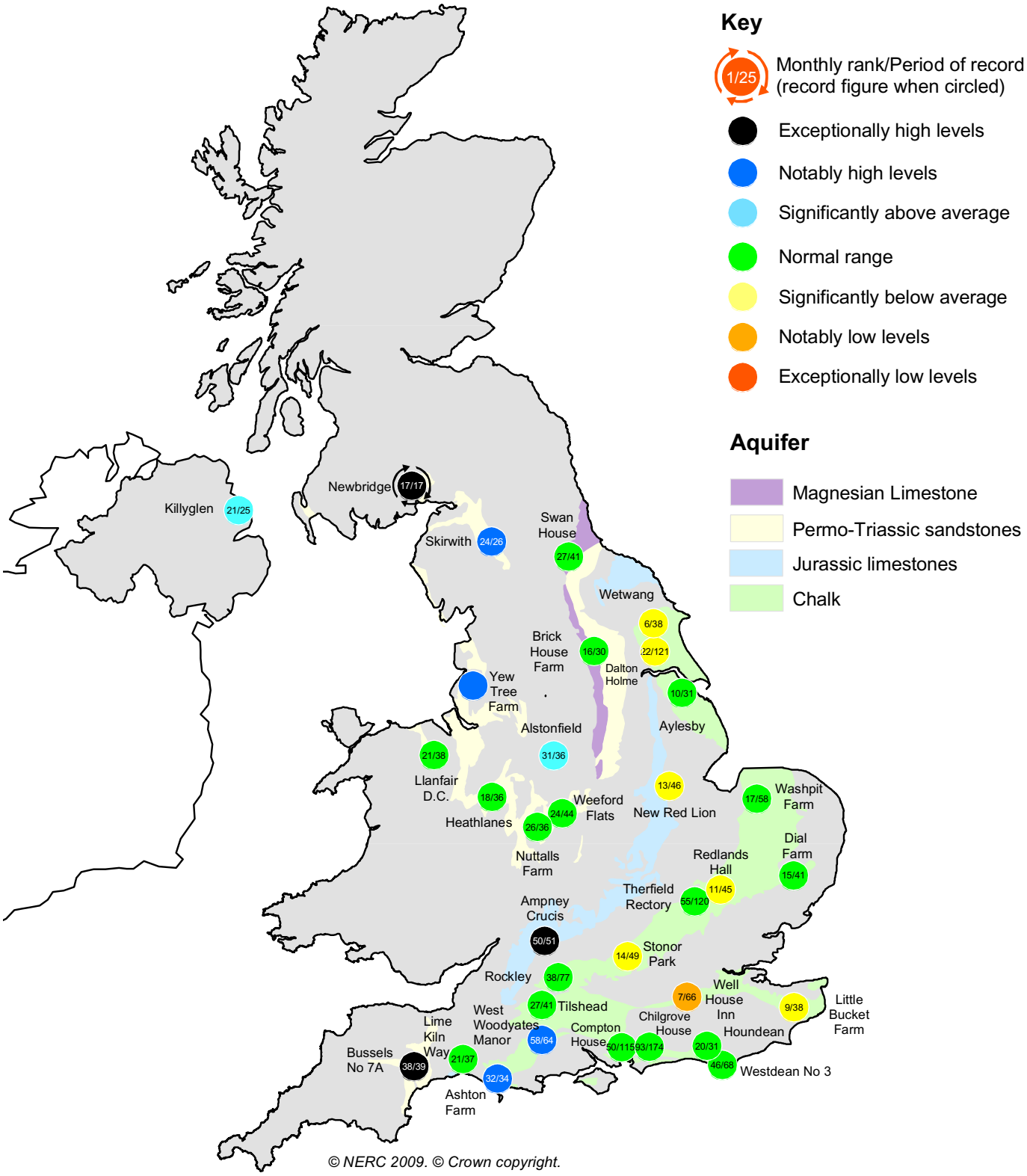
Borehole	Level	Date	Nov. av.
Dalton Holme	12.97	13/11	14.83
Washpit Farm	42.57	01/12	43.34
Stonor Park	69.73	02/12	72.32
Dial Farm	25.30	11/11	25.43
Rockley	130.57	02/12	131.68
Well House Inn	88.69	30/11	93.00
West Woodyates	94.98	30/11	80.86

Borehole	Level	Date	Nov. av.
Chilgrove House	43.83	30/11	46.52
Killyglen (NI)	117.12	30/11	115.83
New Red Lion	9.95	30/11	12.31
Ampney Crucis	103.10	02/12	101.22
Newbridge	12.23	29/11	10.10
Skirwith	130.83	30/11	130.05
Swan House	83.06	19/11	82.46

Borehole	Level	Date	Nov. av.
Brick House Farm	12.47	25/11	12.33
Llanfair DC	79.72	15/11	79.70
Heathlanes	61.94	26/11	61.89
Weeford Flats	89.81	06/11	89.70
Bussels No.7a	24.21	25/11	23.63
Alstonfield	195.29	16/11	186.73

Levels in metres above Ordnance Datum

Groundwater . . .Groundwater



Groundwater levels - November 2009

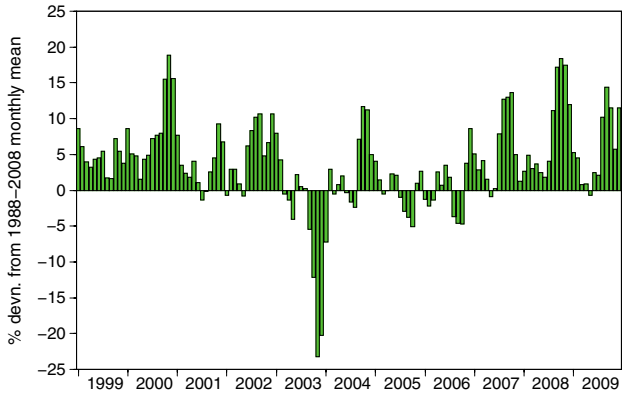
The rankings are based on a comparison between the average level in the featured month (but often only single readings are available) and the average level in each corresponding month on record. They need to be interpreted with caution especially when groundwater levels are changing rapidly or when comparing wells with very different periods of record. Rankings may be omitted where they are considered misleading.

Notes: i. The outcrop areas are coloured according to British Geological Survey conventions.

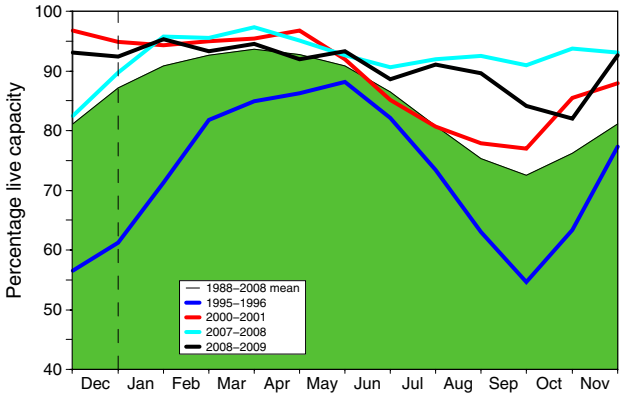
ii. Yew Tree Farm levels are now received quarterly.

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



These plots are based on the England and Wales figures listed below.

Percentage live capacity of selected reservoirs at start of month

Area	Reservoir		Capacity (Ml)	2009 Oct	Nov	Dec	Dec Anom.	Min Dec	Year* of min	2008 Dec	Diff 09-08
North West	N Command Zone	•	124929	87	90	**99**	23	44	1993	95	4
	Vyrnwy		55146	75	72	**99**	18	33	1995	93	6
Northumbrian	Teesdale	•	87936	81	92	**98**	19	39	1995	91	7
	Kielder		(199175)	(87)	(88)	**(97)**	13	55	2007	88	9
Severn Trent	Clywedog		44922	87	79	**98**	19	43	1995	79	19
	Derwent Valley	•	39525	76	67	**100**	22	9	1995	95	5
Yorkshire	Washburn	•	22035	78	77	**93**	21	16	1995	94	-1
	Bradford supply	•	41407	76	74	**100**	20	20	1995	97	3
Anglian	Grafham		(55490)	(84)	(81)	**(84)**	2	47	1997	93	-9
	Rutland		(116580)	(73)	(69)	**(70)**	-9	57	1995	88	-18
Thames	London	•	196628	84	80	**94**	13	52	1990	95	-1
	Farmoor	•	13822	84	85	**81**	-9	52	1990	93	-12
Southern	Bewl		28170	51	45	**54**	-10	34	1990	75	-21
	Ardingly		4685	64	55	**72**	-3	23	2003	93	-21
Wessex	Clatworthy		5364	83	72	**100**	23	16	2003	100	0
	Bristol WW	•	(38666)	(65)	(57)	**(80)**	13	27	1990	94	-14
South West	Colliford		28540	94	95	**100**	29	42	1995	100	0
	Roadford		34500	89	86	**98**	25	19	1995	97	1
	Wimbleball		21320	87	81	**100**	26	34	1995	100	0
	Stithians		4967	78	75	**91**	27	29	2001	88	3
Welsh	Celyn and Brenig	•	131155	88	85	**95**	8	50	1995	96	-1
	Brianne		62140	96	95	**100**	5	72	1995	98	2
	Big Five	•	69762	91	89	**91**	10	49	1990	96	-5
	Elan Valley	•	99106	96	93	**100**	7	47	1995	100	0
Scotland(E)	Edinburgh/Mid Lothian	•	97639	88	92	**100**	16	45	2003	97	3
	East Lothian	•	10206	100	97	**99**	12	38	2003	99	0
Scotland(W)	Loch Katrine	•	111363	94	93	**100**	10	65	2007	95	5
	Daer		22412	97	93	**98**	2	73	2003	99	-1
	Loch Thom	•	11840	95	95	**96**	3	72	2003	96	0
Northern Ireland	Total+	•	56920	91	96	**99**	16	59	2003	90	9
	Silent Valley	•	20634	92	95	**99**	23	43	2001	89	10

() figures in parentheses relate to gross storage • denotes reservoir groups +excludes Lough Neagh *last occurrence

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 1988-2008 period except for West of Scotland and Northern Ireland where data commence in the mid-1990's. In some gravity-fed reservoirs (e.g. Clywedog) stocks are kept below capacity during the winter to provide scope for flood attenuation purposes.
The London total has been revised to 196628 Ml as of November 2009.

Location map . . . Location map

National Hydrological Monitoring Programme

The National Hydrological Monitoring Programme (NHMP) was instigated in 1988 and is undertaken jointly by the Centre for Ecology and Hydrology Wallingford (formerly the Institute of Hydrology - IH) and the British Geological Survey (BGS). Financial support for the production of the monthly Hydrological Summaries is provided by the Department for Environment, Food and Rural Affairs (Defra), the Environment Agency (EA), the Scottish Environment Protection Agency (SEPA), the Rivers Agency (RA) in Northern Ireland, and the Office of Water Services (OFWAT).

Data Sources

River flow and groundwater level data are provided by the Environment Agency, the Environment Agency Wales, the Scottish Environment Protection Agency and, for Northern Ireland, the Rivers Agency and the Northern Ireland Environment Agency. In all cases the data are subject to revision following validation (flood and drought data in particular may be subject to significant revision). Reservoir level information is provided by the Water Service Companies, the EA, Scottish Water and Northern Ireland Water.

The National River Flow Archive (maintained by CEH Wallingford) and the National Groundwater Level Archive (maintained by BGS) provide the historical perspective within which to examine contemporary hydrological conditions.

Rainfall

Most rainfall data are provided by the Met Office (see opposite). To allow better spatial differentiation the rainfall data for Britain are presented for the regional divisions of the precursor organisations of the EA and SEPA. Following the discontinuation of the Met Office's CARP system in July 1998, the areal rainfall figures have been derived using several procedures, including initial estimates based on MORECS*. Recent figures have been produced by the Met Office, National Climate Information Centre (NCIC), using a technique similar to CARP. A significant number of additional monthly raingauge totals are provided by the EA and SEPA to help derive the contemporary regional rainfalls. Revised monthly national and regional rainfall totals for the post-1960 period (together with revised 1961-90 averages) were made available by the Met Office in 2004; these have been adopted by the NHMP. As with all regional figures based on limited raingauge networks the monthly tables and accumulations (and the return periods associated with them) should be regarded as a guide only.

The monthly rainfall figures are provided by the Met Office (National Climate Information Centre) and are Crown Copyright and may not be passed on to, or published by, any unauthorised person or organisation.

*MORECS is the generic name for the Met Office services involving the routine calculation of evaporation and soil moisture throughout Great Britain.

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The National Hydrological Monitoring Programme depends on the active cooperation of many data suppliers. This cooperation is gratefully acknowledged; the November Summary, in particular, stands as a testament to the assistance provided by many hydrometric personnel working in exceptionally challenging circumstances.

Subscription

Subscription to the Hydrological Summaries costs £48 per year. Orders should be addressed to:

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Selected text and maps are available on the WWW at
http://www.nerc-wallingford.ac.uk/ih/nrfa/index.htm
Navigate via Water Watch

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12/09