Hydrological summary

for the United Kingdom

December 1999

General

Damaging gales, blizzards and widespread flooding produced a very boisterous end to 1999. Snowfall was significant in northern Britain and precipitation totals were well above average in all regions. Reservoir stocks increased briskly and, with the exception of 1998, stand at their highest January level since the national monitoring programme began in 1988. Saturated catchments increased the flood risk – many rivers remain vulnerable to further rainfall - but encouraged high rates of infiltration in most aquifer outcrop areas. The water resources outlook is very healthy.

Rainfall

Apart from an exceptionally cold spell in mid-month, the December weather was dominated by a sequence of vigorous frontal systems, carried mostly on a westerly airflow. Rainfall was well distributed through the month; there were few dry days and significant snowfall on northern hills (extending to southern England around the 21^{st}-23^{th}). The provisional UK December rainfall total ranks fifth wettest of the century; Scotland registered its second wettest December in a series from 1869 and, even more notably, Northern Ireland – where precipitation exceeded 250% of average in some parts of the west and north - reported its third wettest month of the twentieth century. Regional rainfall totals for December were mostly in the 140-190% range but a few eastern localities just failed to reach the average (e.g. in Lincolnshire). The wetness of the early winter helped ensure above average rainfall totals for 1999 in all regions. For the UK as a whole, 1999 is amongst the dozen wettest years of the century. But 1998 was wetter, and two-year rainfall totals are exceptionally high for many regions – north-western Britain and Northern Ireland especially. Despite a number of extended droughts during the last decade, the 1990-99 period just eclipsed 1980-89 as the UK's wettest decade of the century.

River flows

With catchments close to saturation during much of December, rivers throughout most of the country were vulnerable to significant rainfall. The rapid passage of most frontal systems usefully moderated storm rainfall totals but, on occasions, snowmelt was an exacerbating factor particularly in Scotland and Northern Ireland. Floodplain inundations were very common - many rivers in the west and north exceeding bankfull several times - and many areas were subject to substantial transport disruption. Peak flows commonly ranked amongst the highest December flows on record but, generally, return periods were below 10 years. Nonetheless, damaging flooding occurred early in the month, for example, in western Scotland (where Paisley and Kilmarnock were badly affected) and Northern Ireland (e.g. at Burndennet and Omagh), and later in the month when the South-West was severely affected. On the 18^{th}, the rivers Dart and Taw recorded their second and third highest flows in records of over 40 years. The river Mole registered it 3^{rd} highest monthly peak in a 30-year record on the 24^{th}. Numerous flood alerts were issued throughout the country and further rainfall triggered protracted inundation of the Somerset Levels towards month end. A few English lowland catchments reported below average December runoff totals but flows in most areas were exceptionally high, the Taw, Brue, Clyde and Camowen where amongst those rivers establishing new runoff maxima (for any month). Catchments where the 1999 annual runoff was unprecedented also showed a very wide distribution although modest annual runoff in parts of the English lowlands helped exaggerate the normal north-west/south-east runoff gradient across the UK – a recurring feature of the recent past.

Groundwater

The very wet December eliminated remaining soil moisture deficits apart from those in a zone from Cambridgeshire to the lower Trent basin. The sustained, but rarely intense, lowland rainfall provided excellent conditions for early winter aquifer recharge. Infiltration was around twice the monthly average over wide areas, causing an acceleration in the seasonal recovery of groundwater levels – the full benefit of which is not evident on all the hydrographs featured in the report (a consequence of the delay in water-table response and, in some cases, the early December level measurement). Levels in the Chalk are appreciably below average in parts of eastern England, but above the seasonal mean (notably so in Northern Ireland) and rising briskly throughout the majority of the outcrop. Levels are also above average in the Jurassic and Carboniferous Limestone index wells, and in the normal range in the Lincolnshire Limestone (where December recharge was relatively modest). In the Permo-Triassic sandstones notably healthy levels characterise most western outcrops, these contrast with average levels in much of the Midlands and depressed – but rising - levels in some of the slowest responding eastern units. The outlook for further significant groundwater recoveries in the late winter is good.

Institute of Hydrology

British Geological Survey

Rainfall . . . Rainfall . . . Rainfall.

Rainfall accumulations and return period estimates

Area	Rainfall	Dec 1999	Oct 99-Dec 99	RP	Jul 99-Dec 99	RP	Apr 99-Dec 99	RP	Jan 99-Dec 99	RP
England & Wales	**mm**	**144**	**286**		**524**		**728**		**959**	
	%	**153**	**106**	**2-5**	**108**	**2-5**	**108**	**2-5**	**107**	**2-5**
North West	mm	210	411		677		950		1291	
	%	169	110	2-5	99	2-5	105	2-5	107	2-5
Northumbrian	mm	128	255		455		689		928	
	%	158	105	2-5	98	2-5	108	2-5	109	2-5
Severn Trent	mm	112	244		467		671		902	
	%	145	115	2-5	118	5-10	118	5-10	120	10-15
Yorkshire	mm	110	230		415		642		876	
	%	133	97	2-5	95	2-5	104	2-5	107	2-5
Anglian	mm	67	164		357		517		670	
	%	121	100	<2	113	2-5	112	2-5	112	5-10
Thames	mm	99	196		418		600		760	
	%	142	99	2-5	115	2-5	115	2-5	110	2-5
Southern	mm	134	244		475		640		813	
	%	163	99	2-5	113	2-5	110	2-5	104	2-5
Wessex	mm	158	286		533		743		954	
	%	170	112	2-5	120	5-10	121	5-10	114	5-10
South West	mm	245	398		655		929		1220	
	%	176	105	2-5	105	2-5	111	2-5	104	2-5
Welsh	mm	239	483		838		1122		1519	
	%	156	112	2-5	116	2-5	116	5-10	116	5-10
Scotland	**mm**	**268**	**565**		**871**		**1201**		**1678**	
	%	**177**	**123**	**5-10**	**107**	**2-5**	**113**	**5-10**	**117**	**10-20**
Highland	mm	338	759		1099		1487		2148	
	%	172	127	5-10	110	2-5	116	5-10	122	30-40
North East	mm	162	365		579		821		1045	
	%	174	126	5-10	108	2-5	112	5-10	107	2-5
Tay	mm	239	475		768		1062		1470	
	%	188	126	5-10	116	5-10	121	10-15	120	10-20
Forth	mm	211	422		657		936		1246	
	%	192	125	5-10	107	2-5	114	5-10	112	5-10
Tweed	mm	161	315		522		782		1043	
	%	173	112	2-5	98	2-5	108	2-5	108	2-5
Solway	mm	269	508		841		1194		1631	
	%	182	113	2-5	105	2-5	114	5-10	115	5-10
Clyde	mm	352	701		1068		1419		1973	
	%	197	127	5-10	110	2-5	114	5-10	116	10-15
Northern Ireland	**mm**	**222**	**389**		**709**		**924**		**1192**	
	%	**213**	**121**	**2-5**	**123**	**5-10**	**118**	**5-10**	**113**	**5-10**

RP = Return period

 All monthly totals since July 1998 are provisional (see page 12). Recent monthly rainfall figures for the Scottish regions have been compiled using data provided by the Scottish Environment Protection Agency. The return period estimates are based on tables provided by the Meteorological Office (see Tabony, R.C., 1977, *The variability of long duration rainfall over Great Britain*, Scientific Paper No. 37) and relate to the specified span of months only (return periods may be up to an order of magnitude less if n-month periods beginning in any month are considered); RP estimates for Northern Ireland are based on the tables for north-west England. The tables reflect rainfall over the period 1911-70 and assume a stable climate. Artifacts in the England & Wales and Scotland rainfall series can exaggerate the relative wetness of the recent past. *See page 12.

Rainfall . . . Rainfall . . . Rainfall

Key

00% Percentage of 1961-90 average

Very wet

Substantially above average

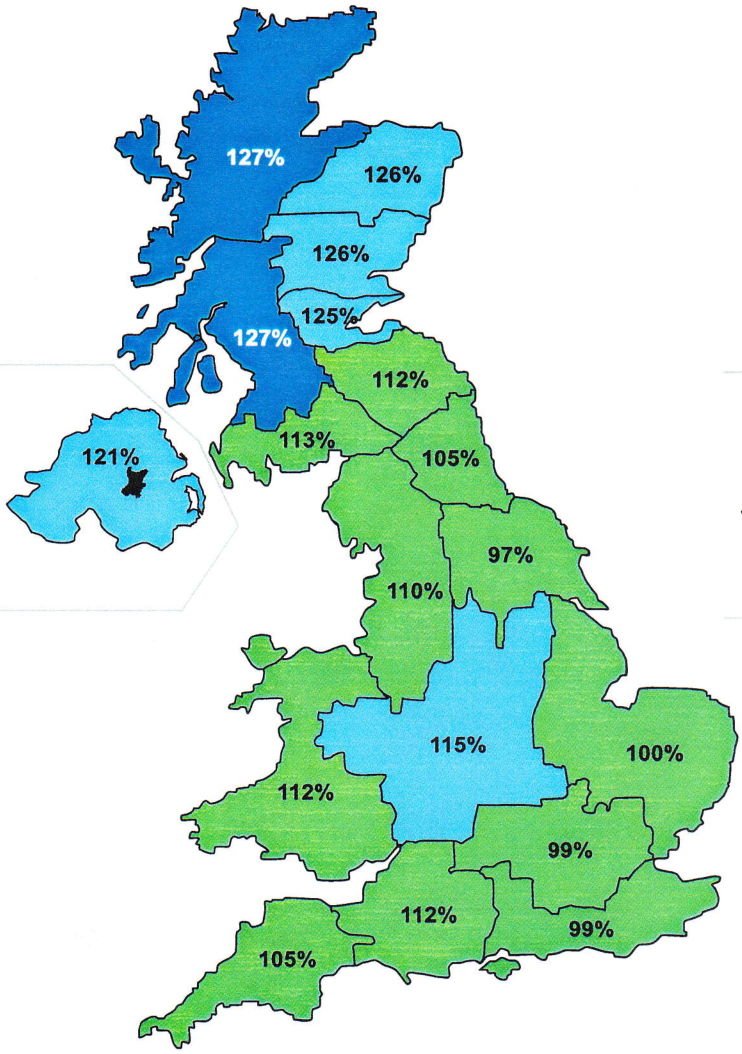
Above average

Normal range

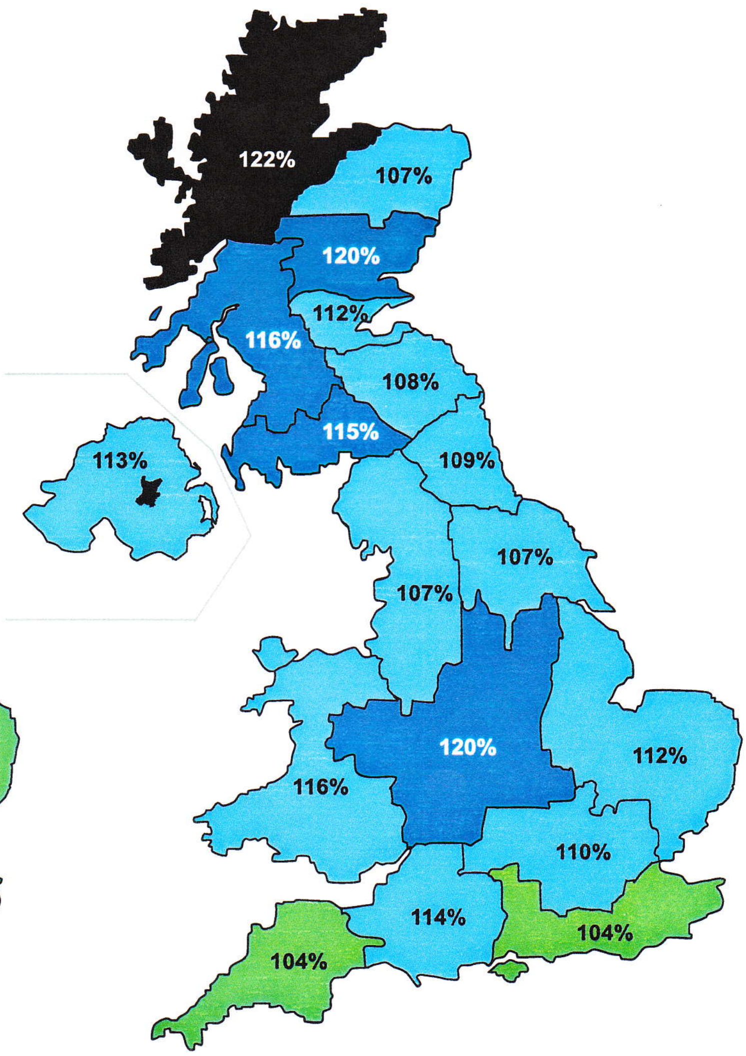
Below average

Substantially below average

Exceptionally low rainfall



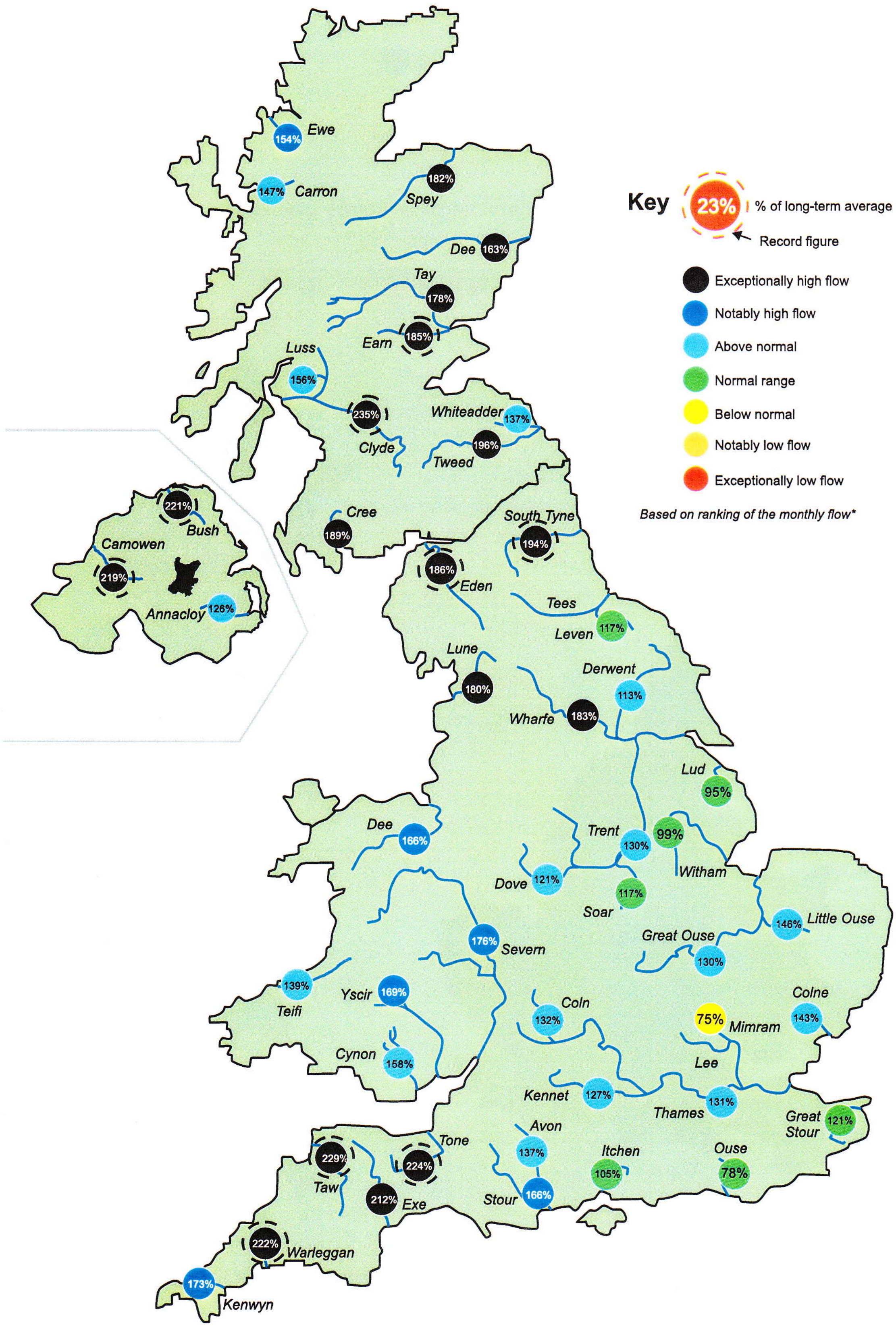
October 1999 - December 1999



January 1999 - December 1999

Rainfall accumulation maps

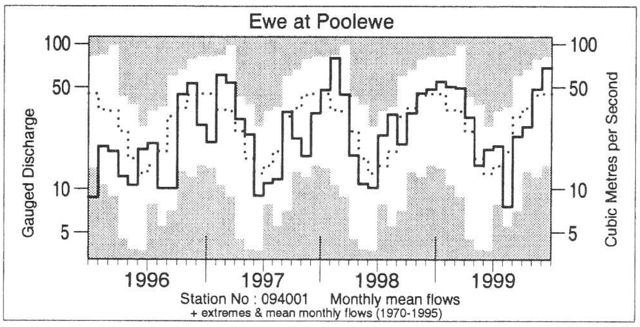
The fourth wettest November/December pairing since 1959 contributed to the high three-month rainfall totals in most regions of the UK. Placing 1999 rainfall totals in the context of the last century as a whole, the provisional rankings are: Scotland 5th; Northern Ireland 11th; England and Wales 40th.

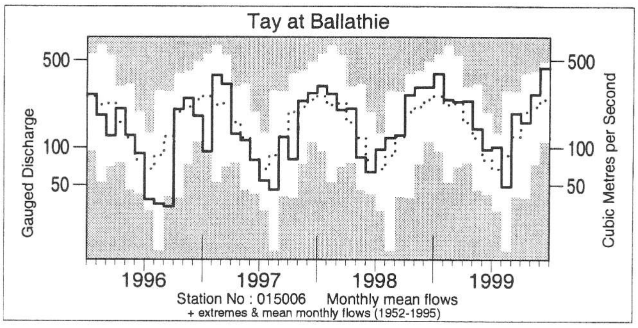


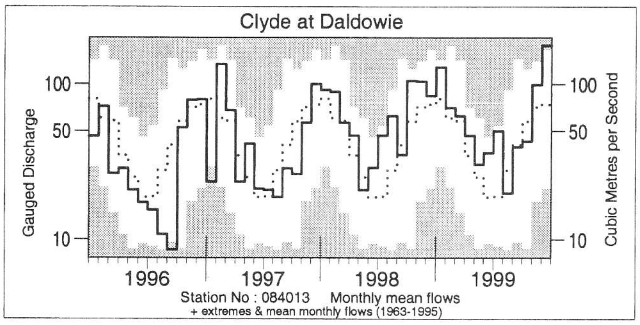
River flows - December 1999

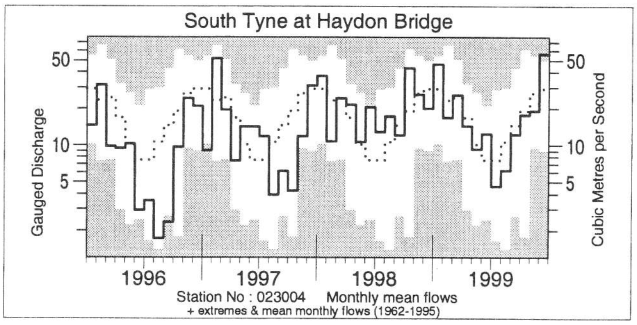
*Comparisons based on percentage flows alone can be misleading. A given percentage flow can represent extreme drought conditions in permeable catchments where flow patterns are relatively stable but be well within the normal range in impermeable catchments where the natural variation in flows is much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

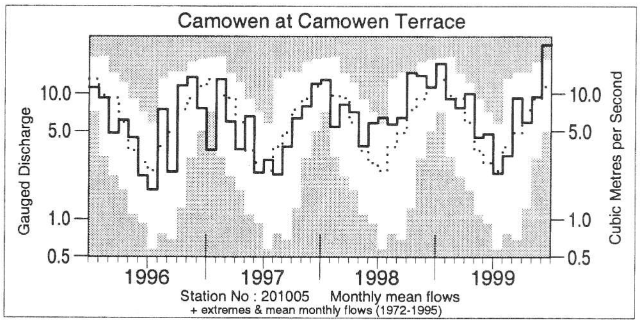
River flow . . . River flow . . .

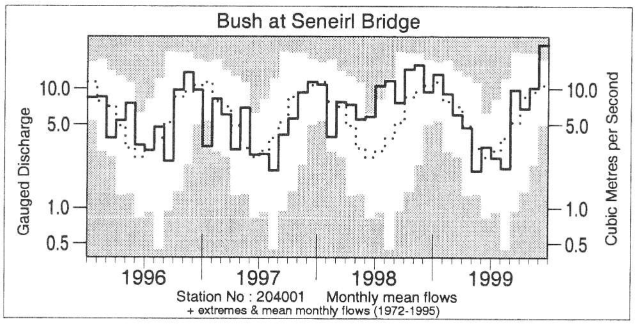


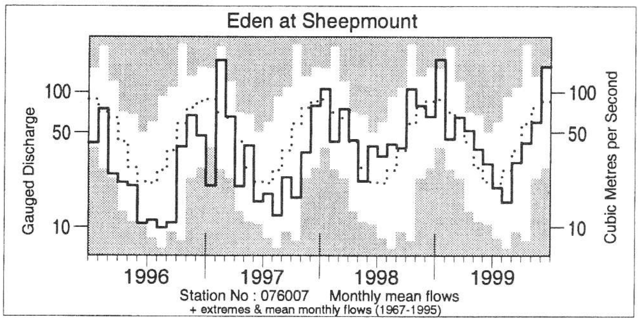


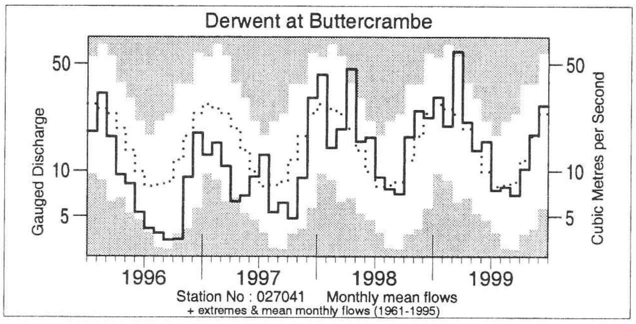


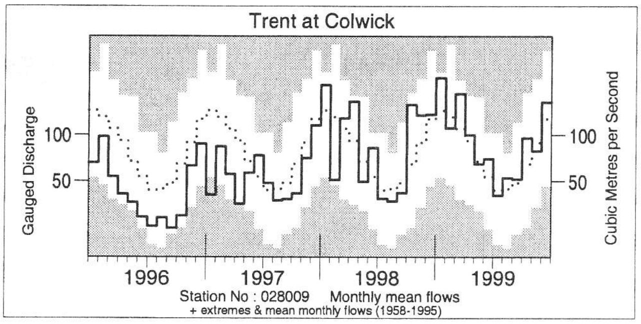


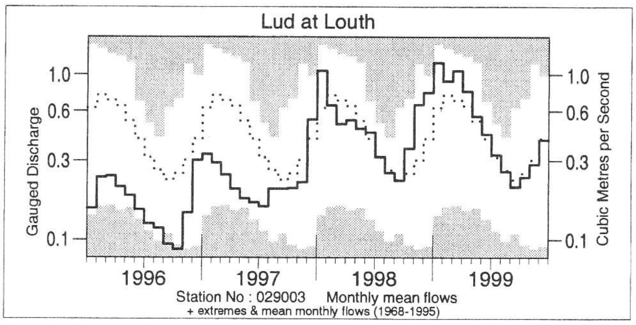








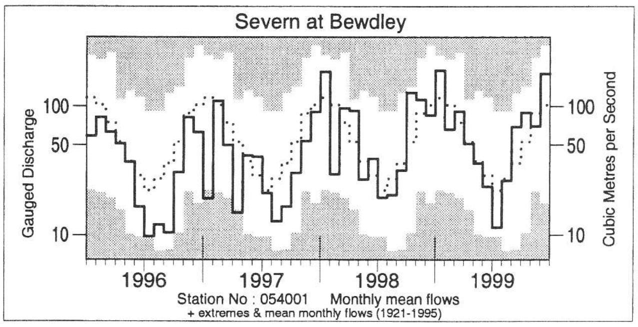


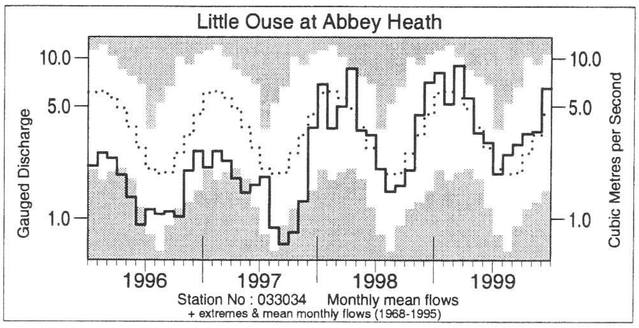


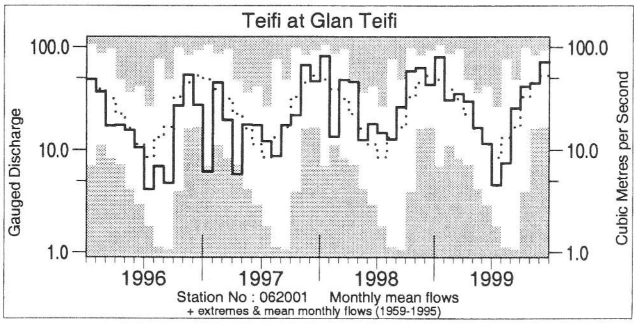
Monthly river flow hydrographs

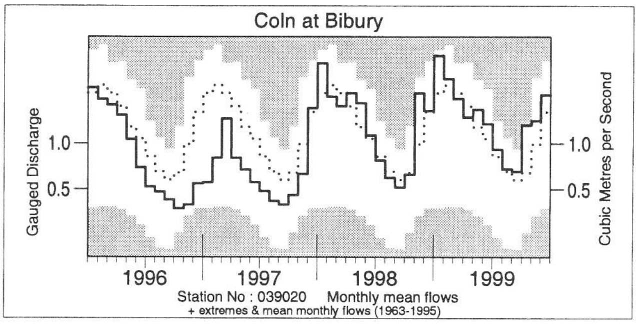
The river flow hydrographs show the monthly mean flow (bold trace), the long term average monthly flow (dotted trace) and the maximum and minimum flow prior to 1996 (shown by the shaded areas). Monthly flows falling outside the maximum/minimum range are indicated where the bold trace enters the shaded areas.

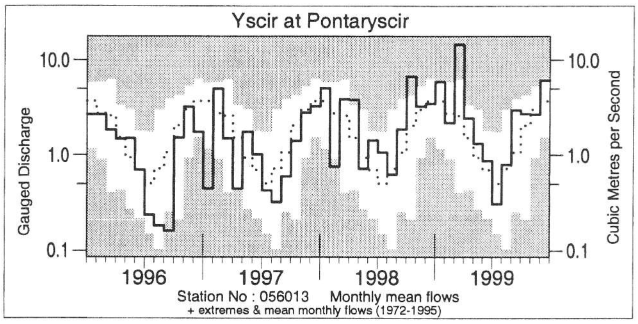
River flow . . . River flow . . .

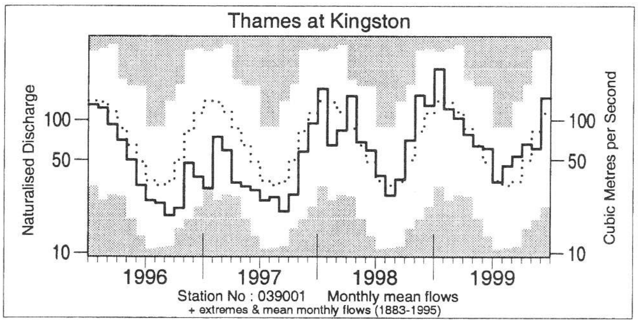


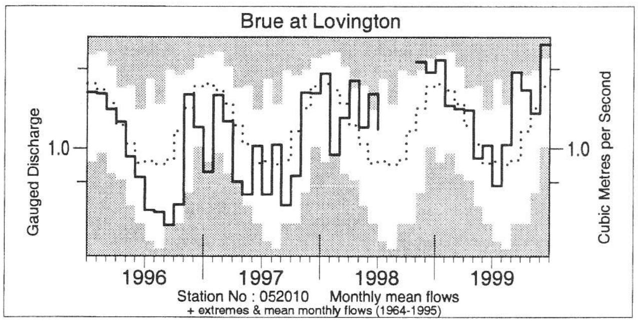


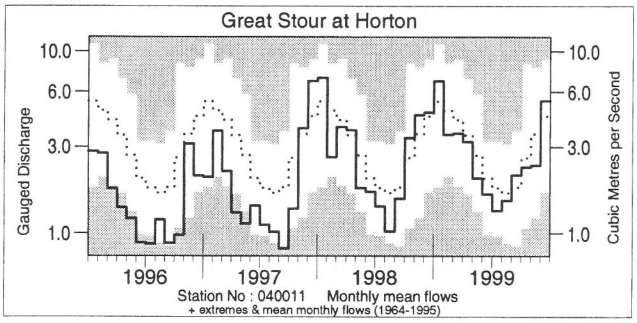


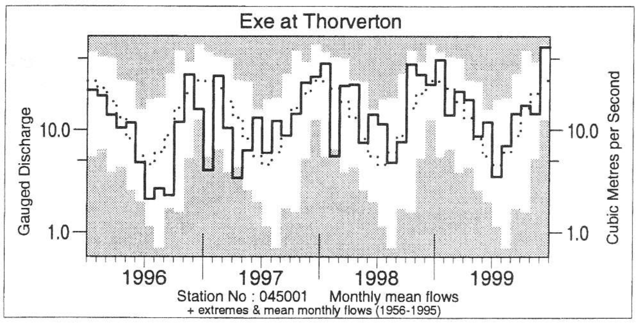


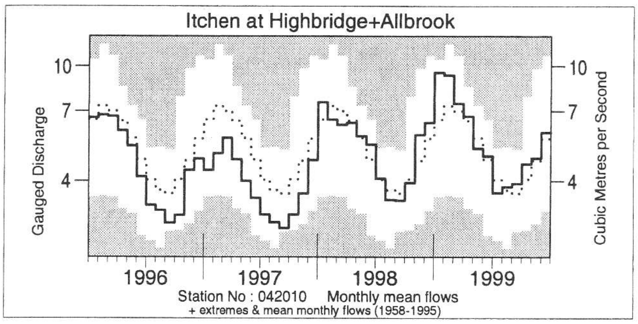












Notable runoff accumulations October 1999 - December 1999 (a); January 1999 - December 1999 (b)

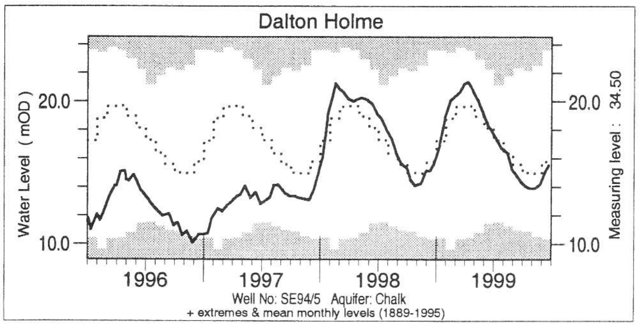
(a)

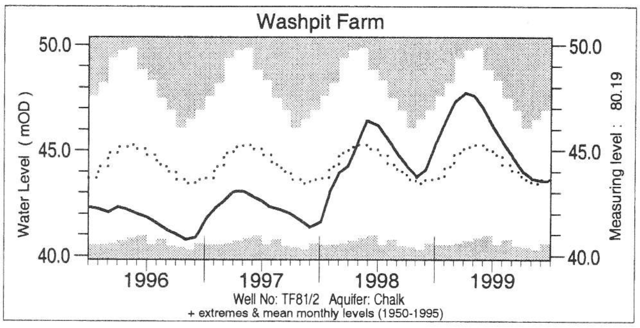
River	%lta	Rank
Taw	140	39/42
Brue	183	34/34
Clyde	153	37/37
Camowen	139	27/28

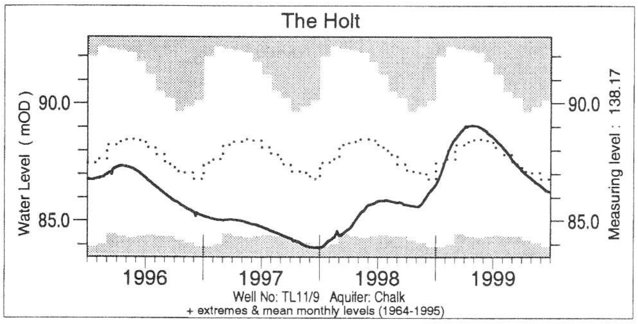
(b)

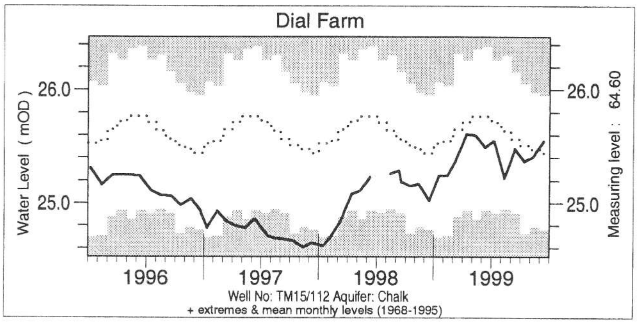
River	%lta	Rank	River	%lta	Rank
Tay	127	46/47	Brue	154	34/34
Trent	124	39/41	Eden	119	31/32
Medway	64	4/36	Clyde	139	36/36
Exe	129	40/43	Camowen	128	26/26

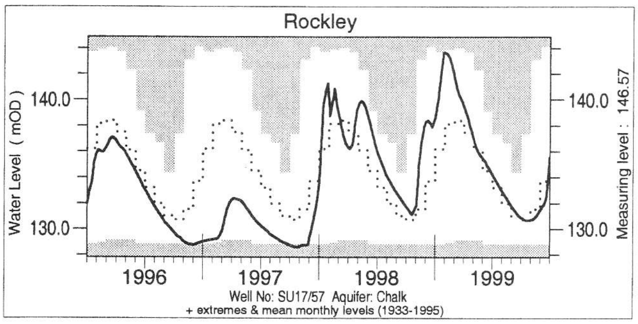
lta = long term average
Rank 1 = lowest on record

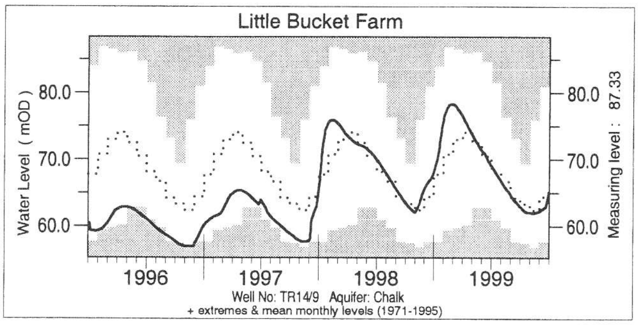


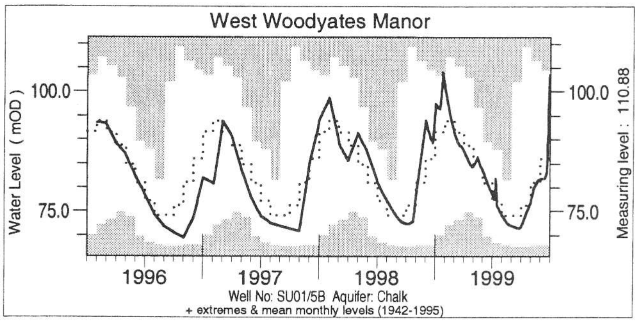


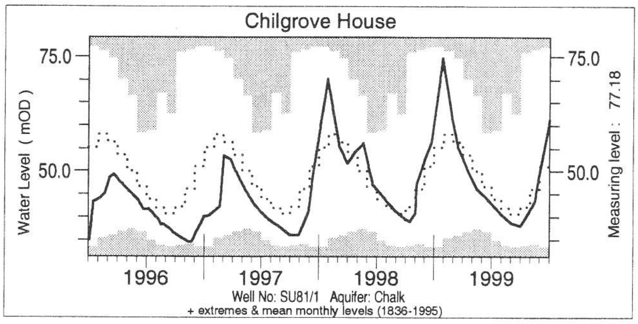


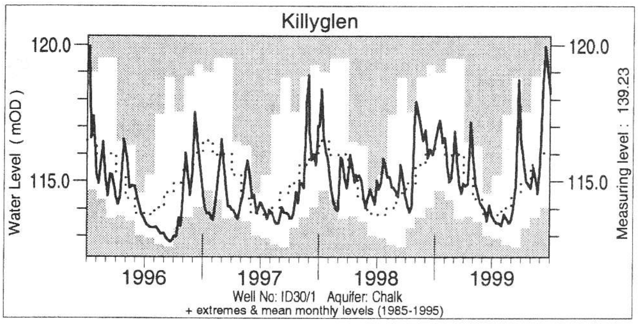


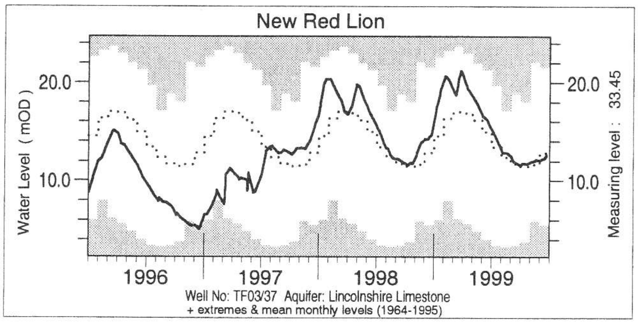








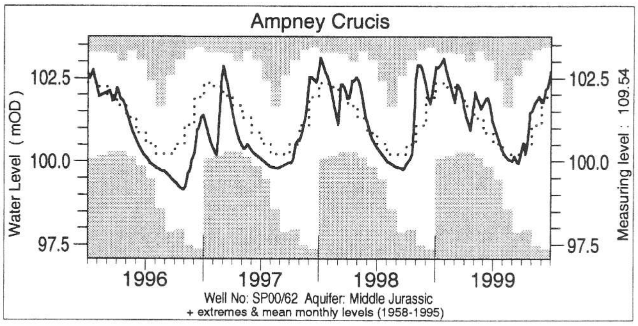


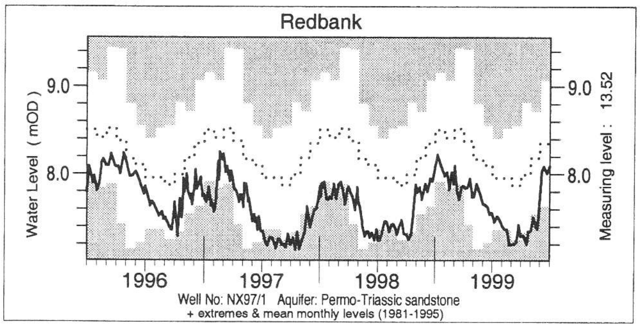


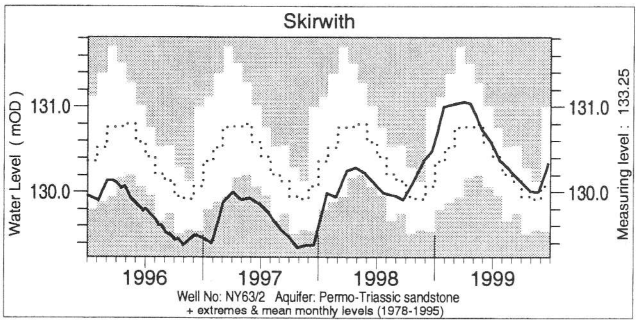
What is groundwater?

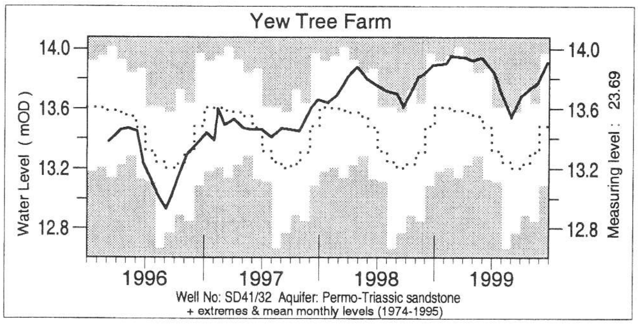
Groundwater is stored in the natural water bearing rock strata (or aquifers) which are found mostly in southern and eastern England (see page 11) where groundwater is the major water supply source. Groundwater levels normally rise and fall with the seasons, reaching a peak in the spring following replenishment 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 max., min. and mean levels 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.

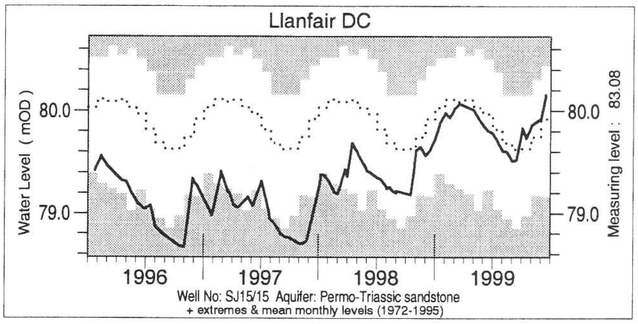
Groundwater . . . Groundwater

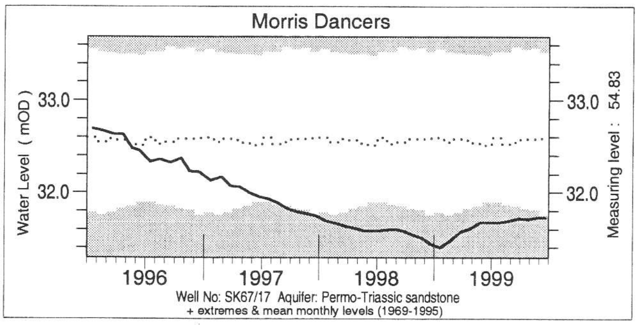


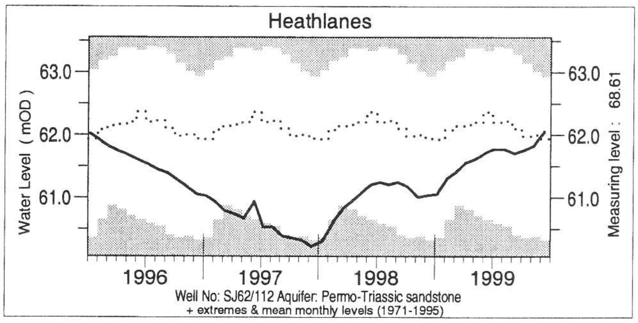


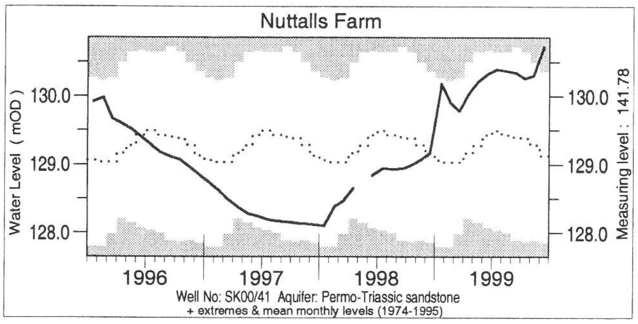


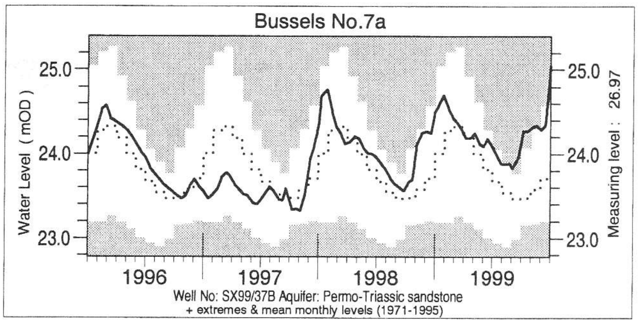


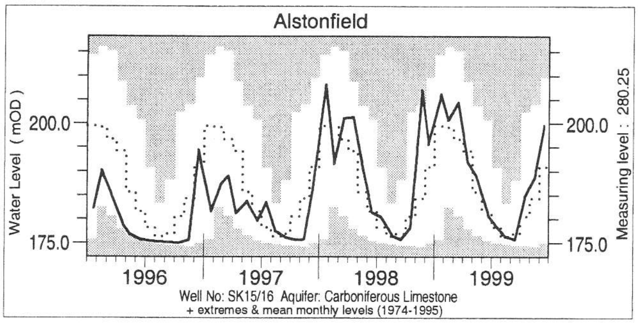












Groundwater levels December 1999/January 2000

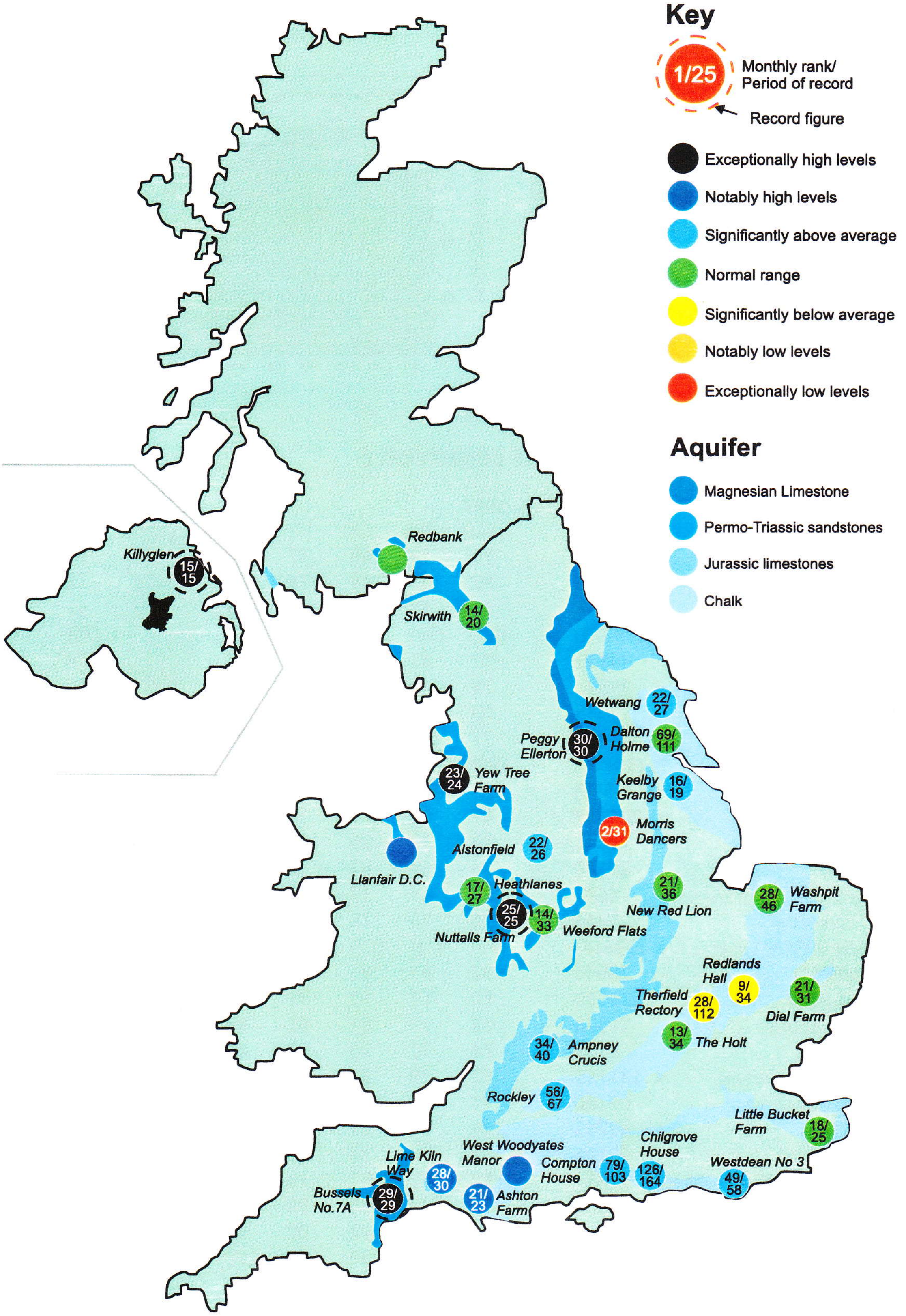
Borehole	Level	Date	Dec av.
Dalton Holme	15.56	23/12	15.54
Washpit Farm	43.57	20/12	43.20
The Holt	86.26	04/01	86.71
Dial Farm	25.55	13/12	25.39
Rockley	137.70	04/01	133.57
Little Bucket	65.09	29/12	63.66
West Woodyates	103.58	28/12	86.39

Borehole	Level	Date	Dec av.
Chilgrove	61.20	30/12	51.74
Killyglen	118.24	31/12	116.07
New Red Lion	12.63	21/12	12.41
Ampney Crucis	102.62	04/01	101.86
Redbank	8.09	30/12	8.24
Skirwith	130.33	22/12	130.12
Yew Tree Farm	13.91	24/12	13.47

Borehole	Level	Date	Dec av.
Llanfair DC	80.38	01/01	79.77
Morris Dancers	31.73	20/12	32.48
Heathlanes	62.06	11/12	61.80
Nuttalls Farm	130.72	13/12	129.22
Bussels No. 7A	25.04	30/12	23.74
Alstonfield	199.58	15/12	191.19

Levels in metres above Ordnance Datum

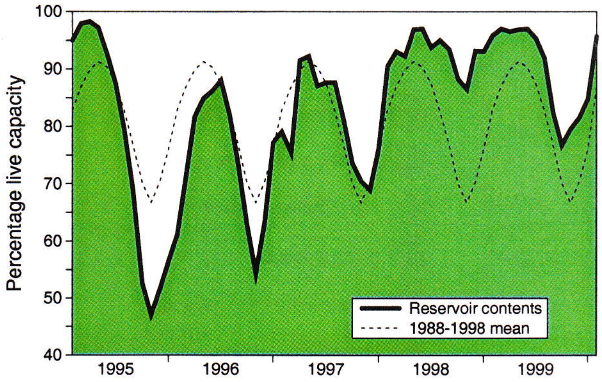
Groundwater . . . Groundwater



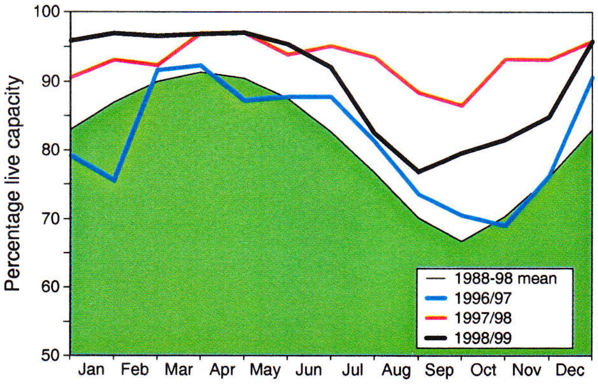
Groundwater levels - December 1999

The rankings are normally based on a comparison of current levels (usually a single reading in a month) with 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.

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

Area	Reservoir	Capacity (Ml)	1999 Aug	Sep	Oct	Nov	Dec	2000 Jan	Min. Jan	Year* of min
North West	N Command Zone	• 133375	71	56	60	57	67	93	51	1996
	Vyrnwy	55146	82	66	81	76	82	99	35	1996
Northumbrian	Teesdale	• 87936	69	61	66	68	69	99	41	1996
	Kielder	(199175)	(89)	(88)	(88)	(86)	(87)	(100)	(70)	1990
Severn Trent	Clywedog	44922	82	83	88	82	84	91	54	1996
	Derwent Valley	• 39525	79	69	64	85	84	100	10	1996
Yorkshire	Washburn	• 22035	83	74	74	72	71	99	23	1996
	Bradford supply	• 41407	77	67	76	77	78	99	22	1996
Anglian	Grafham	** (55490)	(88)	(89)	(89)	(92)	(96)	(95)	(57)	1998
	Rutland	**(116580)	(83)	(82)	(79)	(81)	(83)	(88)	(60)	1991
Thames	London	• 206399	89	85	79	79	90	94	60	1991
	Farmoor	• 13843	97	97	95	93	98	77	71	1991
Southern	Bewl	28170	74	66	61	58	54	74	38	1991
	Ardingly	4685	81	61	57	63	65	100	61	1990
Wessex	Clatworthy	5364	75	75	75	87	91	100	59	1989
	Bristol WW	• (38666)	(76)	(76)	(77)	(89)	(89)	(93)	(40)	1991
South West	Colliford	28540	92	84	81	81	82	96	46	1996
	Roadford	34500	90	87	91	91	90	99	20	1990
	Wimbleball	21320	88	79	81	83	88	100	46	1996
	Stithians	5205	86	77	70	63	60	94	37	1992
Welsh	Celyn and Brenig	• 131155	83	79	86	88	89	99	54	1996
	Brianne	62140	91	87	100	98	96	100	76	1996
	Big Five	• 69762	74	68	87	90	92	94	67	1996
	Elan Valley	• 99106	81	70	77	99	100	100	56	1996
East of Scotland	Edinburgh/Mid Lothian	• 97639	80	71	71	73	80	100	60	1999
	East Lothian	• 10206	94	93	86	90	98	99	48	1990
West of Scotland	Loch Katrine	• 111363	89	74	92	92	95	88	80	1996
	Daer	22412	87	73	80	93	100	100	83	1996
	Loch Thom	• 11840	90	75	82	73	84	100	93	1998
Northern	Silent Valley	• 20634	58	56	71	69	58			

Details of the individual reservoirs in each of the groupings listed above are available on request. The featured reservoirs may not be representative of the storage conditions across each region; this can be particularly important during droughts. The minimum storage figures relate to the 1988-1999 period only (except for West of Scotland where data commence in 1994). In some gravity-fed reservoirs (e.g. Clywedog) stocks are kept below capacity during the winter to provide scope for flood attenuation purposes.

Location map . . . Location map

National Hydrological Monitoring Programme

The National Hydrological Monitoring Programme was instigated in 1988 and is undertaken jointly by 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 of the Environment, Transport and the Regions, 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 regional divisions of the EA (England and Wales) and SEPA (Scotland), data for Northern Ireland are provided by the Rivers Agency and the Department of the Environment (NI). 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, the West of Scotland and East of Scotland Water Authorities, and the Northern Ireland Water Service.

The National River Flow Archive (maintained by IH) 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 (address 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. Since the discontinuation of The Met. Office's CARP system in July 1998, rainfall figures have been provided by differing methods. Initial rainfall estimates for Scotland and the Scottish regions were derived by IH in collaboration with SEPA. In England and Wales, between July 1998 and May 1999, provisional rainfall figures derive from MORECS*. Beginning with the June 1999 report, provisional rainfall figures for England and Wales, the EA regions and Northern Ireland (from January 1999) have been derived by the National Climate Information Centre (NCIC), formerly the UK Climate Studies Group, at The Met. Office. However, readers should note that the MORECS estimates have not been updated since July 1998. Negotiations are continuing with The Met. Office to provide more accurate areal figures and as a result, from October 1999, the rainfall estimates for the Scottish regions are derived by NCIC in a pilot collaboration with IH and SEPA. Until the negotiations are concluded the regional rainfall figures (and the return periods associated with them) should be regarded as a guide only.

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

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The cooperation of all data suppliers is gratefully acknowledged.

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