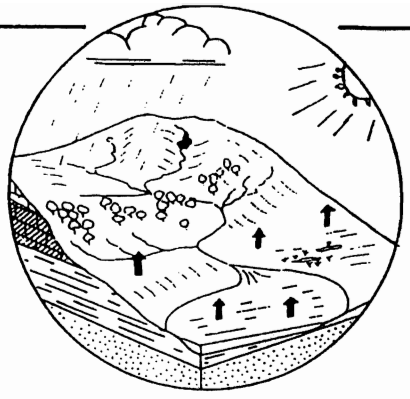
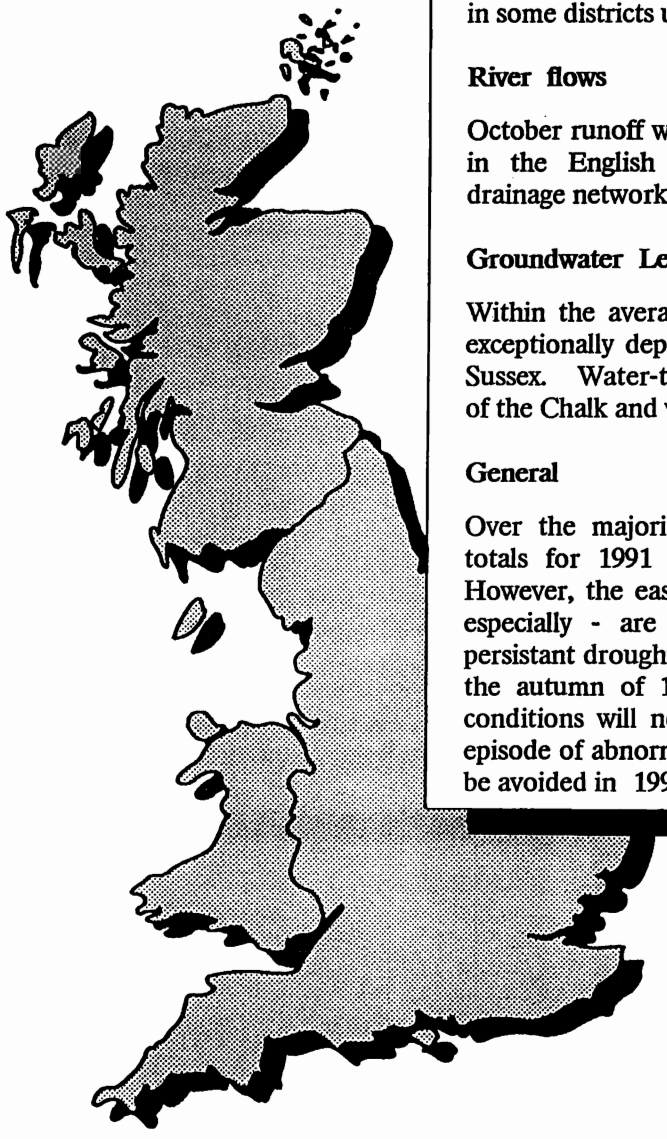
Hydrological Summary for Great Britain





OCTOBER 1991

Rainfall

Around 90% of average for GB but barely 50% in parts of the English lowlands. Long term rainfall deficiencies for many catchments in eastern England are remarkably large - in some districts unprecedented this century.

River flows

October runoff was below average in all regions, notably so in the English lowlands where the shrinkage of the drainage network since 1988 has been very substantial.

Groundwater Levels

Within the average range in parts of western Britain but exceptionally depressed east of a line from the Humber to Sussex. Water-tables are at unprecedented levels in much of the Chalk and very low in the Midland sandstones.

General

Over the majority of Great Britain, rainfall and runoff totals for 1991 thus far are within the normal range. However, the eastern lowlands of England - East Anglia especially - are afflicted by a severe and remarkably persistant drought. Reservoir stocks are healthier than in the autumn of 1990 but the current unsettled weather conditions will need to herald a wet winter if a further episode of abnormally depressed groundwater levels are to be avoided in 1992.

Institute of Hydrology

British Geological Survey

HYDROLOGICAL SUMMARY FOR GREAT BRITAIN - OCTOBER 1991

Data for this report have been provided principally by the regional divisions of the National Rivers Authority in England and Wales, the River Purification Boards in Scotland and by the Meteorological Office. Reservoir contents information for England and Wales has been supplied by either the Water Services Companies or the NRA. The most recent areal rainfall figures are derived from a restricted network of raingauges (particularly in Scotland) and a proportion of the river flow data is of a provisional nature.

A map (Figure 4) is provided to assist in the location of the principal monitoring sites.

Rainfall

October was generally dull and cool with anticyclonic conditions dominating in mid-month. There was, however, considerable frontal activity early and, especially, late in the month when a very unsettled spell culminated on the 31st which (for Great Britain) was the wettest day of the year thus far.

The provisional October rainfall total for Great Britain was only a little below average but regional variations were large. In broad terms, the October rainfall pattern was consistent with that which has characterised much of the last three years over England and Wales, resulting in a marked and enduring accentuation in the normal west-to-east rainfall gradient. Much of eastern England had below average rainfall in October and the lowest percentage totals - less than half the average - coincided fairly closely with the region where the drought has achieved its greatest intensity: a broad zone from Lincolnshire and the East Midlands to Kent.

Rainfall since early May has been very episodic in many areas but with only one decidedly wet month (June) accumulated rainfall totals over the last six months are below or well below average for all regions. The provisional May-October rainfall total for England and Wales is greater than the corresponding figures for 1989 and 1990 but still ranks in the driest dozen such sequences this century. More crucially in hydrological terms, the rainfall total for the three years ending in October 1991 is the lowest (for 36-month totals beginning in November) since the 1850s. Whilst this notable nationwide deficiency provides the backcloth to the current drought much of the stress on water resources (and aquatic habitats) is attributable to the concentration of the greatest deficiencies largely in those regions where average rainfall totals are lowest. For the Thames region the rainfall total since July 1988 is comparable with the minimum 39-month accumulation in a record from 1883 and, in the Anglian region, where the drought is currently most severe, some districts have recorded above average rainfall for only two or three months since February 1990 and only around six in the last 39 months. The associated long-term deficiencies - in excess of 25 per cent for the period from August 1988 in some areas - have no parallel this century.

Evaporation and Soil Moisture Deficits (SMDs)

Temperatures and sunshine hours were appreciably below average in most regions in October but the windy conditions helped keep potential evaporation (PE) losses close to the average. In marked contrast to the record losses registered in 1989 and 1990, PE losses for the first ten months of the year are well within the normal range. 1991 actual evaporation losses are generally also close to the 1961-88 average except in eastern England where they are among the lowest on record; towards the eastern seaboard persistently dry soils have inhibited evaporative losses for an extended period.

Soil moisture deficits currently present a very uneven picture. The relatively modest deficits in mid-summer have, in the lowlands, shown only a meagre decline and in some areas SMDs continued to increase through the early autumn; however, a general, and brisk, decline began over the final week of October. At month-end, soils were wet throughout most of western and northern Britain whilst deficits exceeded 100 mm adjacent to the Thames Estuary. In this area SMDs were more than 30 mm above average and, notwithstanding significant early November rainfall, substantial deficits still characterise much of eastern England and the Midlands. Early November deficits were the equivalent of about 6 weeks average precipitation in parts of Cambridgeshire and the lower Thames Valley. This serves to emphasise the need for sustained rainfall over the remainder of 1991 to create the necessary conditions for the required substantial aquifer recharge in early 1992.

Runoff

Except in rivers supported principally by groundwater, daily flow rates exhibited a considerable range in October. Around the 24th, notably low discharges for mid-autumn characterised most rivers. Thereafter, a strong recovery in runoff rates was evident in the west and north, especially following widespread rainfall on the 29th. At month-end some rivers reached flood alert levels in Wales and spate conditions were widespread in Scotland - the River Dee (at Park) recorded its highest flow for ten years on the 31st. In the English lowlands generally, only modest increases in flows occurred due to the moderating influence of the very dry soils.

Notwithstanding the widespread upturn in runoff rates over the final week, October runoff totals were below average in almost all index catchments (see Table 3). In western and most of northern Britain the runoff totals were, however, well within the normal range and typically much greater than in - for instance - the autumns of 1975 and 1978. Flows in some upland catchments were, however, very low. The Yorkshire Derwent recorded a new minimum October runoff total in an 18-year record and, more notably, the Dove (Derbyshire) registered an unprecedented October runoff total in a series from 1961.

Throughout much of the English lowlands monthly mean flows have remained notably stable since April and the absence, as yet, of any sustained seasonal upturn has resulted in exceptionally depressed flow rates for the third successive year. October runoff on the Trent and the Thames was the lowest since 1959 and 1947 respectively and the Little Ouse was one of an appreciable number of lowland rivers to establish new October minimum runoff totals this year. A more compelling testimony to the severity of the drought is the fact that the three lowest October runoff totals (in a record from 1968) on the Little Ouse have all been registered since 1988. Along with many rivers in a broad zone from Cleveland through much of the Midlands and East Anglia to Kent, the 95 per cent exceedance flow for the 1989-91 period is considerably lower than that for the preceding record.

The long-term decline in the baseflow contribution to streamflow continued. The Lud - a chalk stream - registered its 36th successive month with below average flows in October; over the three-year period, the Little Ouse recorded only two months, and the Thames five months, with above average flows. For many East Anglian rivers (and some others south-east of a line from the Tyne estuary to the Bristol Channel) the long term accumulated runoff totals are the lowest, or close to the lowest on record - commonly eclipsing the modest runoff which typified the 1971-74 period in the east. The current very extended period of runoff deficiency has been accompanied by a notable shrinkage in the drainage network.

As in most years, reservoir storages changed considerably through October. In the west, reservoir contents increased significantly over the month whereas in the lowlands stocks commonly declined at least until the final week. Healthy replenishment to both gravity-fed and pumped storage reservoirs was a feature of the fortnight beginning around the 29th October; this improvement is not fully

reflected in the figures presented in Table 4. By early November storages were generally substantially greater than at the same time in 1990; this is true even in the eastern lowlands of England where the contrast between surface water resources and groundwater levels (see below) is, in some areas, stark.

Groundwater

The expected upturn in well hydrographs anticipated after the heavy rainfall at the end of September did not materialise. Instead, groundwater levels continued to fall throughout October with minor upturns being recorded only in the West Country at the Ashton Farm and Bussels sites.

The effect of the droughts of 1989 and 1990 ensured that the summer recession of 1991 started at levels generally much below normal in eastern areas. The failure of any, other than very localised, recoveries to be generated by late-October left groundwater levels in the Chalk remaining very depressed east of a line from the Humber to Sussex. A substantial proportion of observation boreholes in this region are now recording unprecedented levels. A comparison of the autumn groundwater levels for 1990 and 1991 in eastern England provides a guide to the spatial extent of extreme groundwater drought conditions. Towards the extremities of the Chalk outcrop (as represented by the observation boreholes at Dalton Holme in the Yorkshire Wolds and Little Bucket in Kent) levels are a little above those registered last year. In between, levels in the Chalk are exceptionally depressed, the October levels are the lowest (for any month) on record at Washpit Farm (in a 40-year record), Fairfields (16 years) and Redlands (26 years).

Near to the eastern seaboard, and more extensively in East Anglia, water-tables have remained well below average levels for much of the last three years. One measure of the remarkable persistence and severity of the drought is provided by the series of annual minima for the Dalton Holme borehole which was commissioned in 1889. A further modest decline would produce a remarkable sequence of annual minimum levels, the three lowest on record being 1990, 1989 and 1988.

In the Triassic sandstones of the Midlands, levels are reportedly very depressed in the Nottingham area and at Weeford Flats the well has dried out. To the west at the Llanfair DC site, the level on the 14th of October, although above the minimum ever recorded, is substantially below the October minimum. By way of contrast, at the more southerly sites of Ampney Crucis (in the Jurassic limestones) and Compton House (in the Chalk), groundwater levels are only slightly below the seasonal norms and the West Woodyates (Chalk) trace is marginally above the monthly average *.

With SMDs still appreciable over large parts of the eastern Chalk outcrop the drought is now entering a critical phase. Below average rainfall over the forthcoming winter would result in the spring recession beginning from an extremely low level with the likelihood that, by the autumn of 1992, water-tables would have declined appreciably below any previously experienced in a broad zone from Humberside to the Thames Estuary. Generally, around 120-150 per cent of average winter rainfall (depending on its temporal distribution)will be required to return groundwater levels to close to the average spring peak. Although recoveries need to be generated from a very low base, groundwater level increases of the required magnitude are not especially rare - recent examples include 1974/75, 1976/77, 1978/79 and 1987/88.

* The August level reported in the August and September Hydrological Summaries was erroneous. The corrected value has been incorporated in the trace illustrated in Figure 3.

IH/BGS
12 November 1991

TABLE 1 1990/91 RAINFALL AS A PERCENTAGE OF THE 1941-70 AVERAGE

		Oct 1990	Nov	Dec	Jan 1991	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct 1991
England and	mm	103	67	101	92	65	75	69	14	92	69	30	62	75
Wales	%	124	69	112	107	100	127	119	21	151	95	33	75	90
NRA REGIONS														
North West	mm	175	73	151	98	94	110	67	16	96	65	65	68	123
	%	148	60	126	88	116	153	87	20	116	63	52	55	105
Northumbria	mm	107	61	127	83	113	85	41	23	73	55	37	42	76
	%	143	65	169	104	171	163	75	36	120	71	37	53	102
Severn-Trent	mm	93	52	87	77	43	59	67	11	74	77	21	55	55
	%	143	66	124	112	81	113	129	17	132	118	26	82	85
Yorkshire	mm	92	55	121	71	88	63	49	15	74	37	21	40	61
	%	133	62	164	92	138	119	88	24	128	53	23	56	88
Anglian	mm	51	53	47	44	39	29	45	13	77	38	18	62	28
	%	98	85	89	85	93	73	113	28	157	67	28	119	53
Thames	mm	58	34	68	80	38	45	63	14	96	79	19	52	37
	%	91	47	103	129	81	98	137	25	185	132	27	84	57
Southern	mm	105	63	65	98	39	59	56	17	125	87	15	50	48
	%	135	67	80	129	68	113	117	31	250	147	21	70	61
Wessex	mm	87	51	78	108	40	81	72	9	106	73	20	70	84
	%	106	53	87	129	68	140	133	13	196	118	24	89	102
South West	mm	128	106	124	153	82	127	100	10	127	91	32	84	116
	%	113	79	92	119	91	151	141	12	195	108	32	81	102
Welsh	mm	152	112	163	151	94	127	124	15	110	98	53	85	143
	%	118	78	112	111	98	146	144	16	134	103	45	68	111
Scotland	mm	213	102	191	151	83	127	123	43	121	92	67	129	147
	%	143	72	122	110	80	138	137	47	132	82	52	94	99
RIVER PURIFICATION BOARDS														
Highland	mm	225	147	241	180	71	141	131	67	124	108	84	181	175
	%	121	87	123	110	53	124	115	66	113	85	57	115	94
North-East	mm	136	95	97	60	77	81	62	48	128	57	33	57	110
	%	140	92	95	66	104	131	102	61	183	62	31	66	113
Tay	mm	186	63	149	154	90	117	110	22	136	91	41	108	140
	%	152	53	111	131	98	143	147	23	164	89	35	94	115
Forth	mm	194	56	143	133	86	103	90	19	108	96	39	99	102
	%	183	52	131	134	112	149	132	22	144	98	34	92	96
Tweed	mm	159	53	152	110	102	93	62	20	89	65	35	66	83
	%	181	51	169	118	148	160	102	21	131	73	31	71	94
Solway	mm	218	77	191	144	108	150	148	18	121	77	69	79	179
	%	151	53	126	103	116	165	168	17	134	70	53	52	124
Clyde	mm	301	94	226	187	90	156	184	35	129	110	86	157	188
	%	164	56	122	116	80	149	179	36	125	85	61	90	103

Note: The most recent monthly rainfall figures for England and Wales correspond to the MORECS areal assessments derived by the Meteorological Office; for the Scottish RPBs the October 1991 totals were estimated from the isohyetal map provided with the MORECS bulletin. The regional areal rainfall figures are regularly updated (normally one or two months in arrears) using figures derived from a far denser raingauge network.

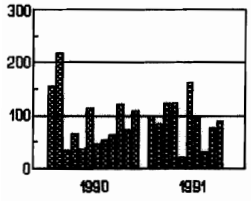
TABLE 2 RAINFALL RETURN PERIOD ESTIMATES

		May-Oct 91		Jan-Oct 91		Mar 90 - Oct 91		Nov 88 - Oct 91	
		Est Return Period, years		Est Return Period, years		Est Return Period, years		Est Return Period, years	
England and Wales	mm	343		644		1207		2393	
	% LTA	75	10-20	89	2-5	81	30-40	87	15-25
NRA REGIONS									
North West	mm	433		802		1668		3318	
	% LTA	68	20-30	82	5-10	83	15-25	91	5-10
Northumbria	mm	306		628		1246		2227	
	% LTA	67	20-35	88	2-5	86	10-15	84	35-55
Severn Trent	mm	293		539		1011		2024	
	% LTA	74	5-15	86	5-10	79	30-40	87	10-20
Yorkshire	mm	248		519		1066		2063	
	% LTA	59	60-90	77	10-20	78	40-60	83	40-60
Anglian	mm	236		393		738		1463	
	% LTA	73	10-20	79	10-20	73	>100	80	90-130
Thames	mm	297		523		870		1765	
	% LTA	82	2-5	93	2-5	75	45-65	84	20-35
Southern	mm	342		594		1036		2011	
	% LTA	89	2-5	96	2-5	81	10-20	84	20-35
Wessex	mm	362		663		1123		2270	
	% LTA	85	2-5	97	2-5	80	15-25	87	10-20
South West	mm	460		922		1664		3332	
	% LTA	83	2-5	100	<2	88	5-10	93	2-5
Welsh	mm	504		1000		1846		3725	
	% LTA	79	5-10	96	2-5	86	5-15	93	5
Scotland	mm	599		1083		2457		4747	
	% LTA	84	5-10	96	2-5	106	2-5	111	20-30
RIVER PURIFICATION BOARDS									
Highland	mm	739		1262		3097		6076	
	% LTA	89	2-5	93	2-5	111	5-15	118	>100
North-East	mm	433		713		1536		2662	
	% LTA	82	5-10	87	5-10	92	2-5	87	25-40
Tay	mm	538		1009		1997		3898	
	% LTA	85	2-5	101	2-5	98	2-5	104	2-5
Forth	mm	463		875		1829		3487	
	% LTA	79	5-10	97	2-5	99	2-5	104	2-5
Tweed	mm	358		725		1506		2751	
	% LTA	68	20-40	90	2-5	91	5-10	91	5-10
Solway	mm	543		1093		2203		4266	
	% LTA	76	5-15	97	2-5	95	2-5	100	<2
Clyde	mm	705		1322		2979		5742	
	% LTA	85	5-10	101	2-5	110	5-10	115	50-70

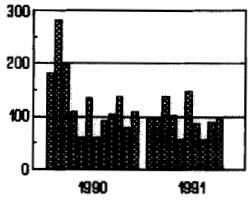
Return period assessments are based on tables provided by the Meteorological Office*. These assume a start in a specified month; return periods for a start in any month may be expected to be an order of magnitude less. "Wet" return periods underlined.
The tables reflect rainfall totals over the period 1911-70 only and the estimate assumes a sensibly stable climate.

* Tabony, R.C., 1977, The Variability of long duration rainfall over Great Britain, Scientific Paper No. 37, Meteorological Office (HMSO).

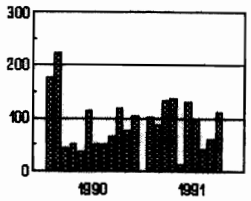
FIGURE 1. MONTHLY RAINFALL FOR 1990-1991 AS A PERCENTAGE OF THE 1941-1970 AVERAGE



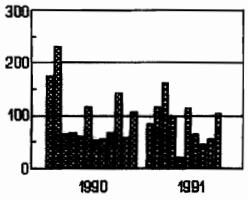
England and Wales



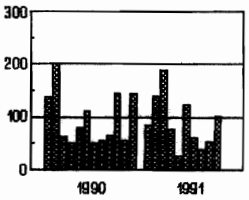
Scotland



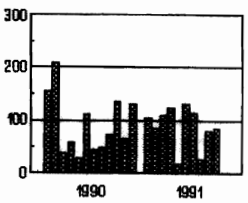
Welsh Region



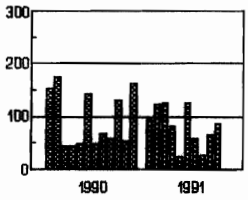
North West Region



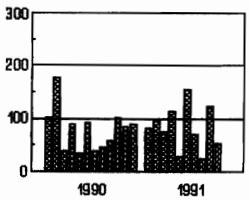
Northumbria Region



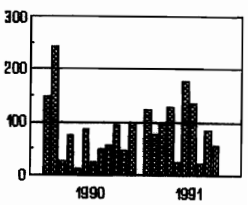
Severn-Trent Region



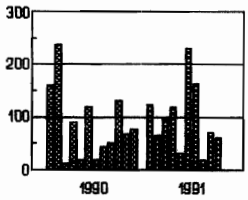
Yorkshire Region



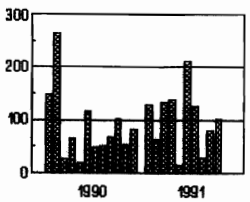
Anglian Region



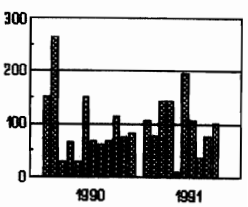
Thames Region



Southern Region



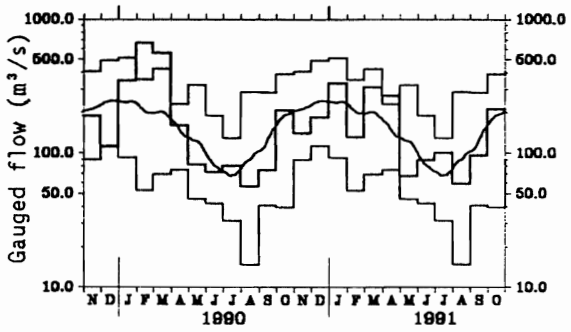
Wessex Region



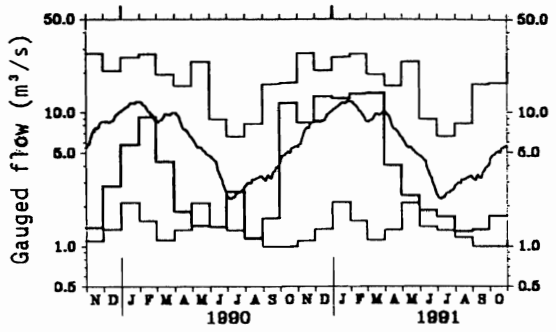
South West Region

FIGURE 2 MONTHLY RIVER FLOW HYDROGRAPHS

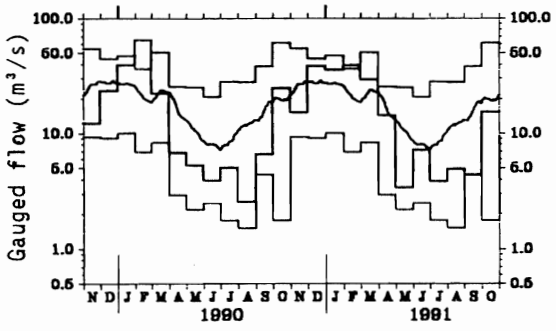
015006 Tay at Ballathie
Monthly mean flows for Nov 1989-Oct 1991
+ extremes and 30 day running mean for 1952-1988



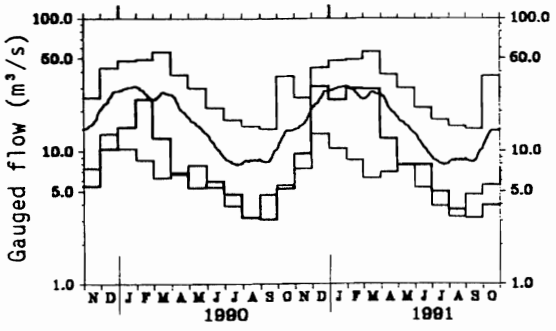
021023 Whiteadder Water at Hutton Castle
Monthly mean flows for Nov 1989-Oct 1991
+ extremes and 30 day running mean for 1969-1988



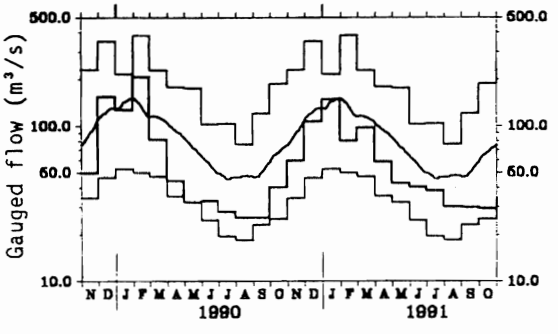
023004 South Tyne at Haydon Bridge
Monthly mean flows for Nov 1989-Oct 1991
+ extremes and 30 day running mean for 1962-1988



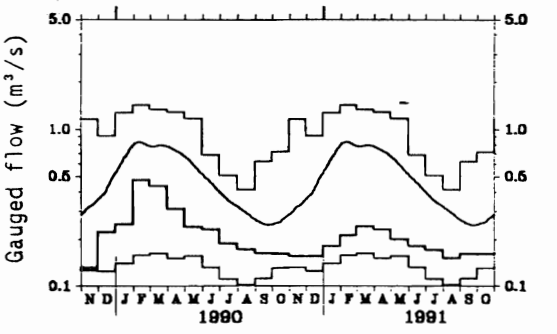
027041 Derwent at Buttercrambe
Monthly mean flows for Nov 1989-Oct 1991
+ extremes and 30 day running mean for 1973-1988



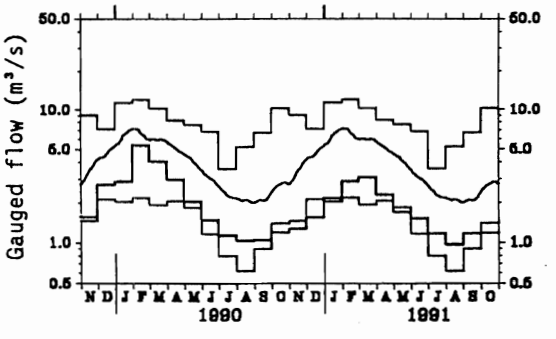
028009 Trent at Colwick
Monthly mean flows for Nov 1989-Oct 1991
+ extremes and 30 day running mean for 1958-1988



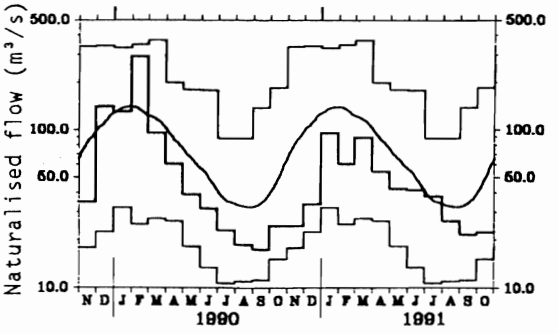
029003 Lud at Louth
Monthly mean flows for Nov 1989-Oct 1991
+ extremes and 30 day running mean for 1968-1988



033034 Little Ouse at Abbey Heath
Monthly mean flows for Nov 1989-Oct 1991
+ extremes and 30 day running mean for 1968-1988

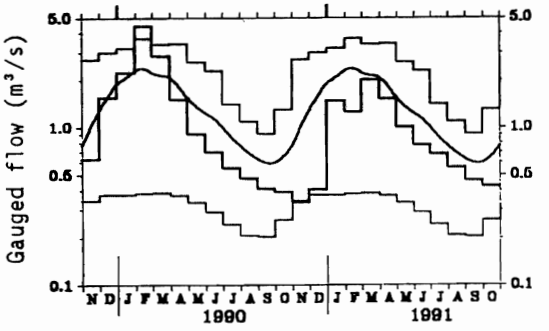


039001 Thames at Kingston
Monthly mean flows for Nov 1989-Oct 1991
+ extremes and 30 day running mean for 1883-1988



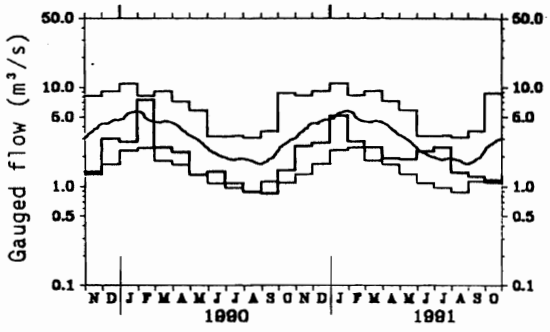
039020 Coln at Bibury

Monthly mean flows for Nov 1989-Oct 1991
+ extremes and 30 day running mean for 1963-1988



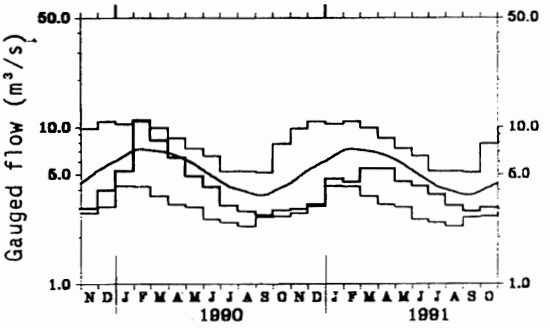
040011 Great Stour at Horton

Monthly mean flows for Nov 1989-Oct 1991
+ extremes and 30 day running mean for 1964-1988



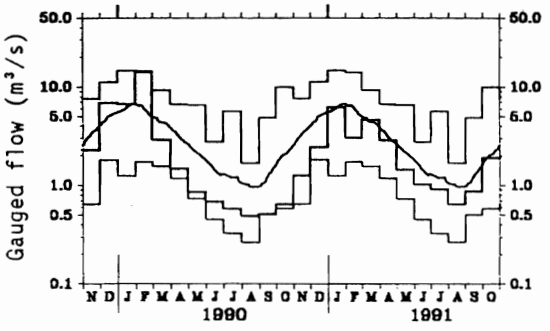
042010 Itchen at Highbridge+Allbrook

Monthly mean flows for Nov 1989-Oct 1991
+ extremes and 30 day running mean for 1958-1988



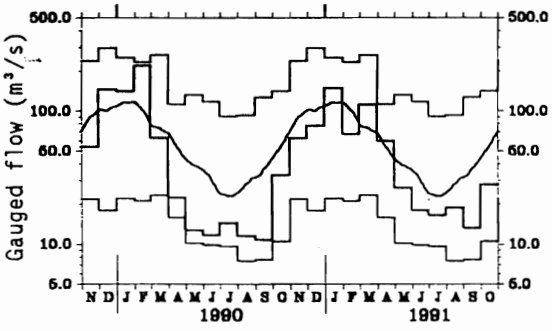
052005 Tone at Bishops Hull

Monthly mean flows for Nov 1989-Oct 1991
+ extremes and 30 day running mean for 1961-1988



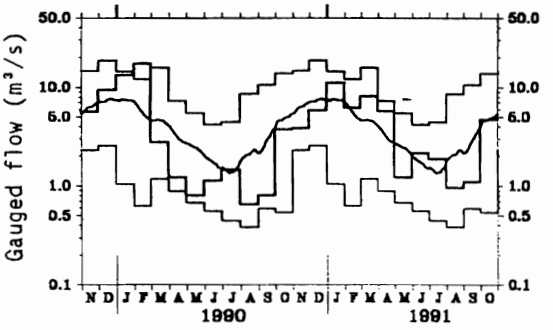
054001 Severn at Bewdley

Monthly mean flows for Nov 1989-Oct 1991
+ extremes and 30 day running mean for 1921-1988



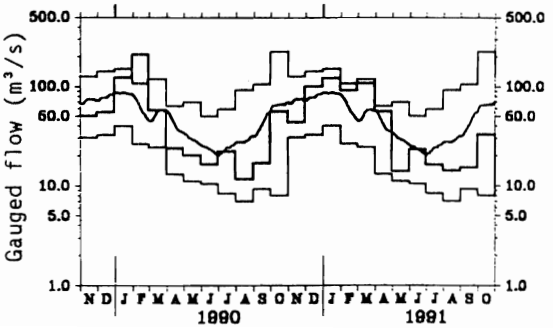
057004 Cynon at Abercynon

Monthly mean flows for Nov 1989-Oct 1991
+ extremes and 30 day running mean for 1957-1988



076007 Eden at Sheepmount

Monthly mean flows for Nov 1989-Oct 1991
+ extremes and 30 day running mean for 1967-1988



084013 Clyde at Daldowie

Monthly mean flows for Nov 1989-Oct 1991
+ extremes and 30 day running mean for 1963-1988

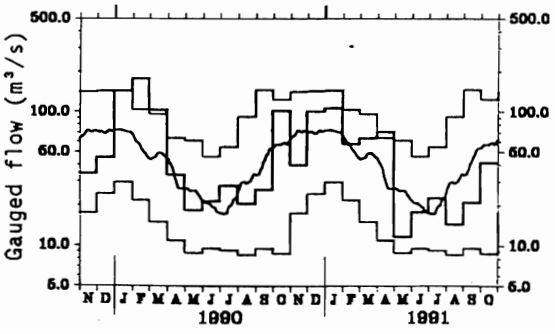


TABLE 3 RUNOFF AS MM. AND AS A PERCENTAGE OF THE PERIOD OF RECORD AVERAGE WITH SELECTED PERIODS RANKED IN THE RECORD

River/ Station name	Jun 1991	Jul 1991	Aug 1991	Sept 1991	Oct 1991		6/91 to 10/91		1/91 to 10/91		5/90 to 10/91		5/89 to 10/91	
	mm %LT	mm %LT	mm %LT	mm %LT	mm %LT	rank /yrs	mm %LT	rank /yrs	mm %LT	rank /yrs	mm %LT	rank /yrs	mm %LT	rank /yrs
Dee at Park	56 153	42 149	17 53	17 41	70 87	11 /19	201 92	11 /19	613 99	9 /19	950 88	6 /18	1576 84	1 /17
Tay at Ballathie	50 111	58 146	34 66	54 77	124 111	28 /40	321 101	22 /39	954 111	31 /39	1471 97	18 /38	2925 111	29 /37
Whiteadder Water at Hutton Castle	10 57	9 70	7 45	7 44	9 32	6 /23	41 46	3 /22	281 90	8 /22	499 97	9 /21	677 75	5 /20
South Tyne at Haydon Bridge	25 93	14 48	17 43	15 29	55 79	12 /30	126 58	3 /28	543 97	12 /28	902 89	7 /26	1579 88	4 /24
Wharfe at Flint Mill Weir	24 97	18 67	15 37	15 33	36 56	9 /37	108 54	3 /36	461 85	8 /36	761 79	4 /35	1348 80	1 /34
Derwent at Buttercrambe	13 77	8 56	6 42	5 37	7 34	2 /31	39 50	3 /30	208 80	7 /30	321 74	5 /29	491 64	2 /28
Trent at Colwick	14 74	14 88	11 66	10 60	10 43	2 /34	59 66	5 /33	208 74	2 /33	332 70	2 /32	636 76	2 /31
Lud at Louth	8 39	8 49	7 51	8 71	8 66	7 /24	39 56	2 /23	89 39	2 /23	159 45	1 /22	303 50	1 /21
Witham at Claypole Mill	7 72	5 71	4 57	5 81	5 59	15 /33	25 66	9 /33	103 68	8 /32	143 60	6 /32	299 70	6 /31
Little Ouse at Abbey Heath	6 55	4 48	4 52	4 54	4 40	1 /24	23 52	3 /24	67 48	2 /23	108 47	1 /23	219 55	1 /22
Colne at Lexden	5 93	4 96	3 74	3 71	3 36	10 /33	19 71	9 /32	56 52	4 /32	84 49	4 /31	192 63	2 /30
Thames at Kingston (natr.)	11 87	10 106	7 80	6 67	6 45	15 /109	40 75	34 /109	130 67	17 /109	186 59	8 /108	430 76	18 /107
Blackwater at Swallowfield	16 108	15 131	11 96	11 84	12 62	14 /40	65 93	17 /39	183 88	13 /39	279 79	10 /38	579 93	13 /37
Coln at Bibury	19 71	17 81	14 83	11 78	11 69	6 /29	71 76	7 /28	249 76	5 /28	352 68	3 /27	764 83	6 /26
Great Stour at Horton	17 110	19 135	11 82	9 65	9 44	3 /28	65 84	8 /26	171 74	5 /25	265 67	3 /24	464 67	1 /22
Itchen at Highbridge+Allbrook	30 86	27 89	23 82	21 80	23 76	6 /34	124 84	5 /33	302 78	5 /33	501 77	2 /32	918 82	1 /31
Stour at Throop Mill	15 97	14 128	9 88	8 69	13 61	10 /19	60 87	7 /19	258 87	5 /19	335 69	3 /18	777 88	5 /17
Piddle at Baggs Mill	23 99	21 118	15 97	16 106	23 113	21 /29	97 105	19 /28	290 87	8 /27	402 76	3 /26	803 86	7 /24
Exe at Thorverton	24 101	32 155	15 53	14 36	56 75	18 /36	141 76	14 /36	551 92	10 /35	859 82	8 /35	1606 85	7 /34
Tone at Bishops Hull	13 74	12 78	8 65	11 72	25 94	21 /31	70 81	10 /31	303 83	9 /30	401 68	2 /30	904 85	5 /29
Severn at Bewdley	11 63	10 71	12 70	8 37	17 51	20 /71	58 56	11 /71	306 91	26 /70	449 78	9 /70	883 86	12 /69
Wye at Cefn Brwyn	96 114	107 98	178 125	102 62	167 80	13 /39	650 92	17 /35	1469 97	15 /34	2663 93	11 /30	4658 94	8 /25
Cynon at Abercynon	53 131	47 138	24 48	27 40	120 99	18 /34	270 86	16 /32	1064 118	25 /32	1519 94	12 /30	2962 103	15 /28
Dee at New Inn	67 115	63 94	54 59	43 32	146 72	6 /23	373 67	3 /22	1047 79	4 /22	1993 82	2 /21	3669 86	3 /20
Eden at Sheepmount	26 103	19 70	16 52	17 39	38 51	5 /22	117 62	3 /21	559 108	13 /21	890 99	10 /19	1596 101	8 /17
Clyde at Daldowie	24 91	32 117	20 49	28 49	58 70	9 /29	162 70	7 /28	586 103	17 /28	1082 104	15 /27	1983 110	20 /26

Notes:
(i) Values based on gauged flow data unless flagged (natr.), when naturalised data have been used.
(ii) Values are ranked so that lowest runoff as rank 1.
(iii) %LT means percentage of long term average from the start of the record to 1991. For the long periods (at the right of this table), the end date for the long term is 1991.

TABLE 4 START-MONTH RESERVOIR STORAGES UP TO NOVEMBER 1991

Area	Reservoir (R)/ Group (G)		Capacity● (Ml)	1991 Jun	Jul	Aug	Sep	Oct	Nov	1990 Nov
							(%)▲			
North West	Northern Command Zone[1]	(G)	133375	72	68	55	43	33	41	59
	Vyrnwy	(R)	55146	88	86	83	85	71	82	48
Northumbria	Teesdale[2]	(G)	87936	64	61	52	39	31	41	68
	Kielder	(R)	199175*					85*	85*	70*
Severn-Trent	Clywedog	(R)	44922	98	99	94	91	74	75	67
	Derwent Valley[3]	(G)	39525	78	74	66	53	35	32	43
Yorkshire	Washburn[4]	(G)	22035	80	72	59	46	36	28	38
	Bradford supply[5]	(G)	41407	76	76	65	50	38	37	52
Anglian	Grafham	(R)	58707	96	96	95	88	81	76	59
	Rutland	(R)	130061	85	80	81	70	68	63	61
Thames	London[6]	(G)	206232	90	91	90	80	66	57	52
	Farmoor[7]	(G)	13843	100	100	100	89	82	89	53
Southern	Bewl	(R)	28170	65	73	75	73	62	59	40
	Ardingly	(R)	4627	100	100	100	81	84	83	55
Wessex	Clatworthy	(R)	5364*	84*	71*	59*	47*	40*	59	41
	Bristol WW[8]	(G)	36620	91	79	71	57	46	39	24
South West	Colliford	(R)	28540	91	89	90	86	81	79	70
	Roadford	(R)	34500	98	94	95	89	84	81	55[9]
	Wimbleball[10]	(R)	21320	81	75	73	63	52	57	33
	Stithians	(R)	5205	83	77	66	53	40	34	18
Welsh	Celyn + Brenig	(G)	131155	96	94	89	79	68	71	64
	Brianne	(R)	62140	88	93	93	92	84	89	80
	Big Five[11]	(G)	69762	87	94	92	92	69	73	41
	Elan Valley[12]	(G)	99106	91	91	87	85	77	90	71

● Live or usable capacity (unless indicated otherwise)

* Gross storage/percentage of gross storage

▲ Percentage of live or usable capacity in storage at or close to the beginning of the month according to data availability (unless indicated otherwise)

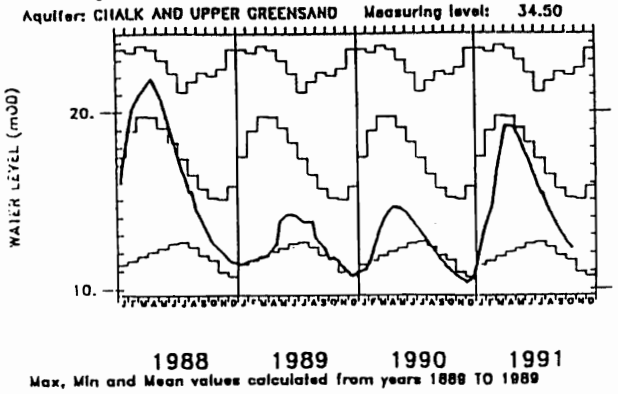
1. Includes Haweswater, Thirlmere, Stocks and Barnacre.
2. Cow Green, Selset, Grassholme, Balderhead, Blackton and Hury.
3. Howden, Derwent and Ladybower.
4. Swinsty, Fewston, Thruscross and Eccup.
5. The Nidd/Barden group (Scar House, Angram, Upper Barden, Lower Barden and Chelker) plus Grimwith.
6. Lower Thames (includes Queen Mother, Wraysbury, Queen Mary, King George VI and Queen Elizabeth II) and Lee Valley (includes King George and William Girling) groups - pumped storages.
7. Farmoor 1 and 2 - pumped storages.
8. Blagdon, Chew Valley and others.
9. The new Roadford reservoir was still filling after impounding.
10. Shared between South West (river regulation for abstraction) and Wessex (direct supply.
11. Usk, Talybont, Llandegfedd (pumped storage), Taf Fechan, Taf Fawr.
12. Claerwen, Caban Coch, Pen y Garreg and Craig Goch.

Note: Variations in storage depend on the balance between inputs (from catchment rainfall and any pumping) and outputs (to supply, compensation flow, HEP, amenity). There will be additional losses due to evaporation, especially in the summer months. Operational strategies for making the most efficient use of water stocks will further affect reservoir storages. Table 4 provides a link between the hydrological conditions described elsehwere in the report and the water resources situation.

FIGURE 3 GROUNDWATER HYDROGRAPHS

Site name: DALTON HOLME

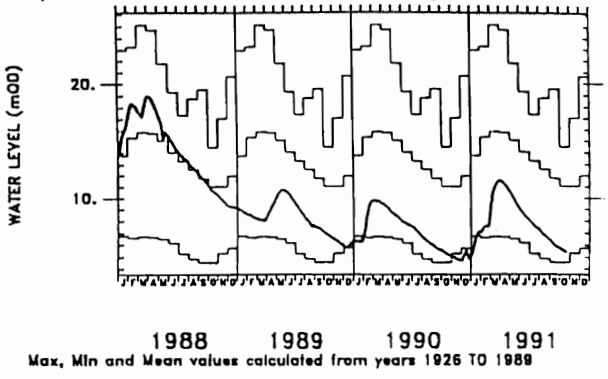
National grid reference: SE 9651 4530 Well number: SE94/5
Aquifer: CHALK AND UPPER GREENSAND Measuring level: 34.50



Max, Min and Mean values calculated from years 1988 TO 1989

Site name: LITTLE BROCKLESBY

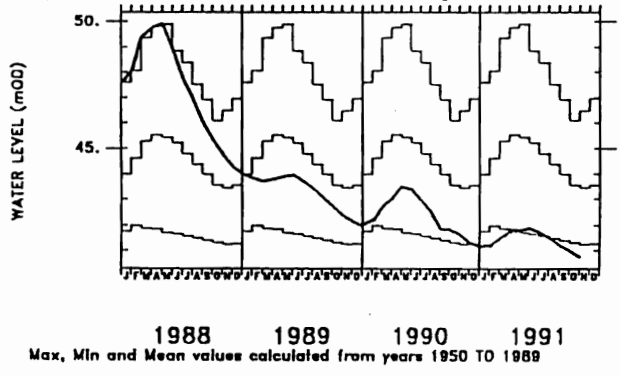
National grid reference: TA 1371 0888 Well number: TA10/40
Aquifer: CHALK AND UPPER GREENSAND Measuring level: 42.97



Max, Min and Mean values calculated from years 1926 TO 1989

Site name: WASHPIT FARM

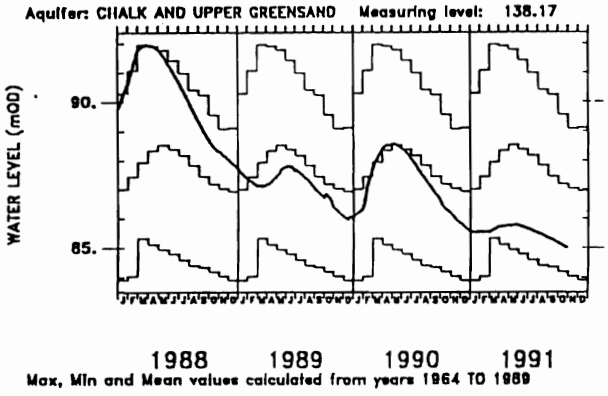
National grid reference: TF 8138 1960 Well number: TF81/2
Aquifer: CHALK AND UPPER GREENSAND Measuring level: 80.20



Max, Min and Mean values calculated from years 1950 TO 1989

Site name: THE HOLT

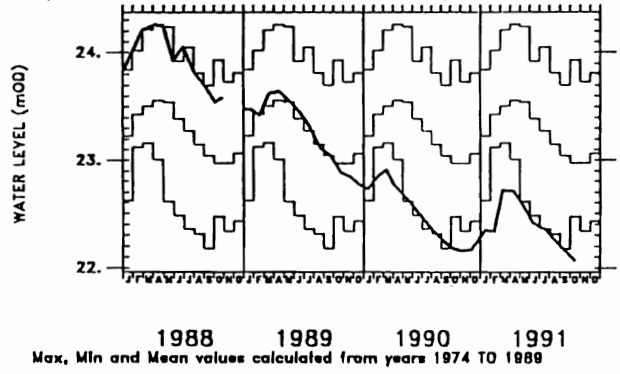
National grid reference: TL 1692 1965 Well number: TL11/9
Aquifer: CHALK AND UPPER GREENSAND Measuring level: 138.17



Max, Min and Mean values calculated from years 1964 TO 1989

Site name: FAIRFIELDS

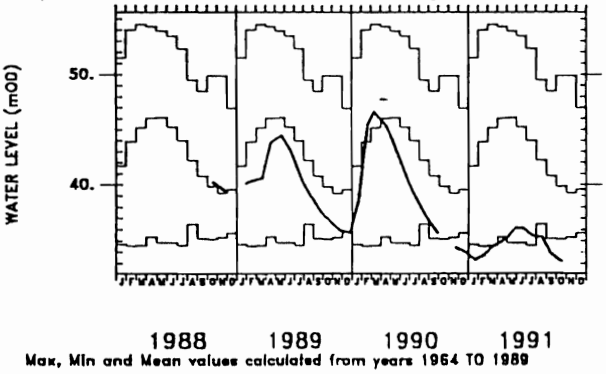
National grid reference: TM 2461 6109 Well number: TM26/46
Aquifer: CHALK AND UPPER GREENSAND Measuring level: 45.00



Max, Min and Mean values calculated from years 1974 TO 1989

Site name: REDLANDS HALL,ICKLETON

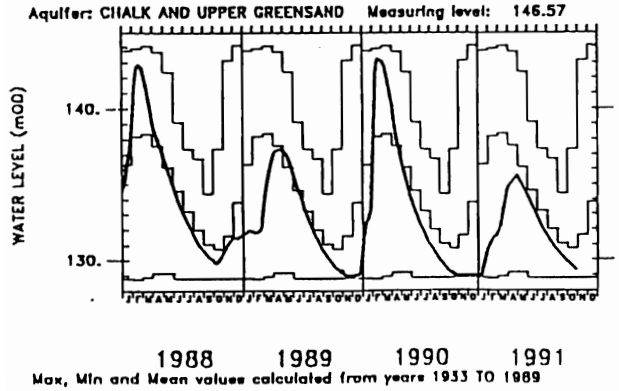
National grid reference: TL 4522 4182 Well number: TL44/12
Aquifer: CHALK AND UPPER GREENSAND Measuring level: 76.19



Max, Min and Mean values calculated from years 1964 TO 1989

Site name: ROCKLEY

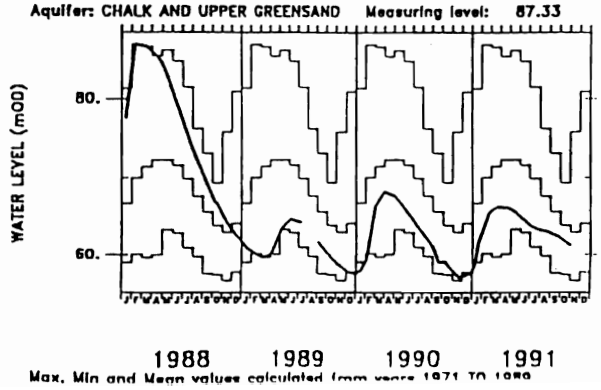
National grid reference: SU 1655 7174 Well number: SU17/57
Aquifer: CHALK AND UPPER GREENSAND Measuring level: 146.57



Max, Min and Mean values calculated from years 1933 TO 1989

Site name: LITTLE BUCKET FARM,WALTHAM

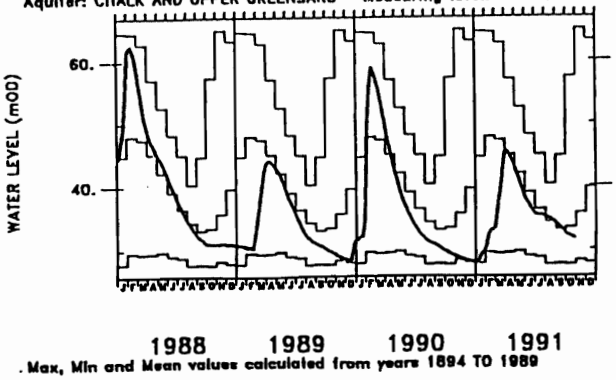
National grid reference: TR 1225 4690 Well number: TR14/9
Aquifer: CHALK AND UPPER GREENSAND Measuring level: 87.33



Max, Min and Mean values calculated from years 1971 TO 1989

Site name: COMPTON HOUSE

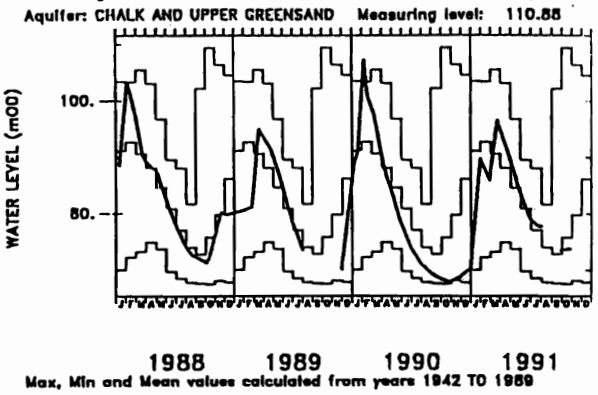
National grid reference: SU 7755 1490 Well number: SU71/23
Aquifer: CHALK AND UPPER GREENSAND Measuring level: 81.37



Max, Min and Mean values calculated from years 1894 TO 1989

Site name: WEST WOODYATES MANOR

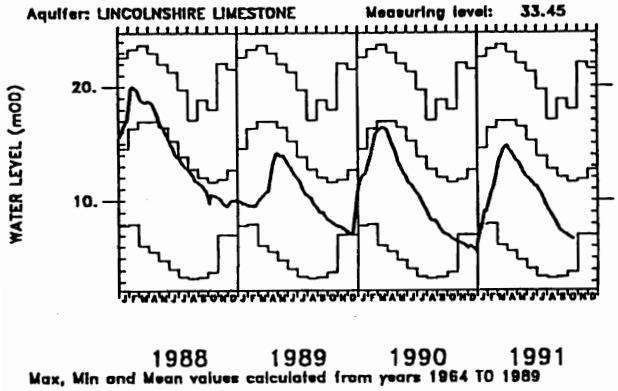
National grid reference: SU 0160 1960 Well number: SU01/58
Aquifer: CHALK AND UPPER GREENSAND Measuring level: 110.88



Max, Min and Mean values calculated from years 1942 TO 1989

Site name: NEW RED LION

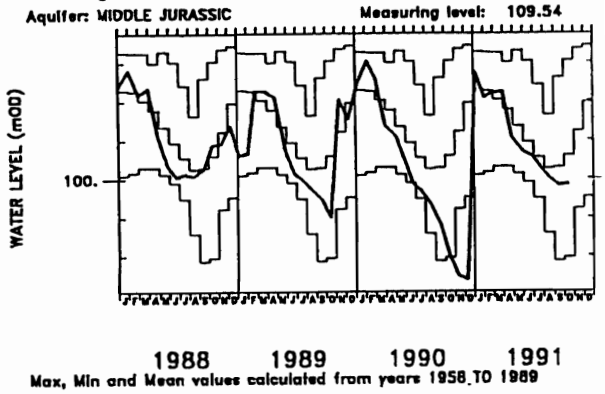
National grid reference: TF 0885 3034 Well number: TF03/37
Aquifer: LINCOLNSHIRE LIMESTONE Measuring level: 33.45



Max, Min and Mean values calculated from years 1964 TO 1989

Site name: AMPNEY CRUCIS

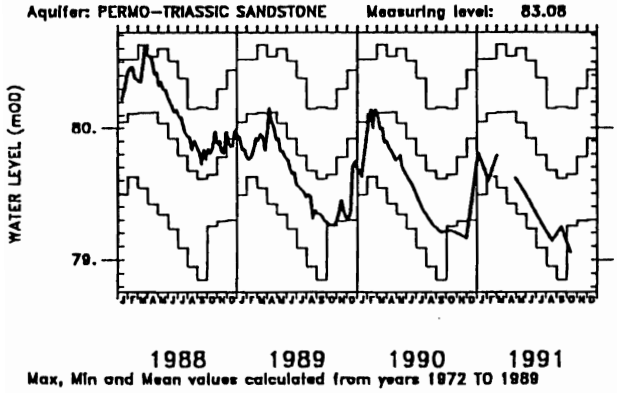
National grid reference: SP 0595 0190 Well number: SP00/62
Aquifer: MIDDLE JURASSIC Measuring level: 109.54



Max, Min and Mean values calculated from years 1958 TO 1989

Site name: LLANFAIR DC

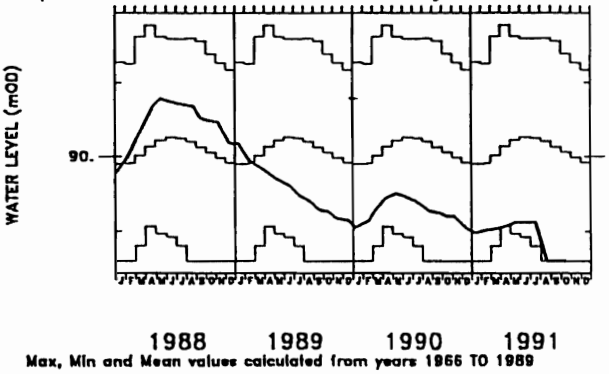
National grid reference: SJ 1374 5556 Well number: SJ15/15
Aquifer: PERMO-TRIASSIC SANDSTONE Measuring level: 83.08



Max, Min and Mean values calculated from years 1972 TO 1989

Site name: WEEFORD FLATS,WEEFORD

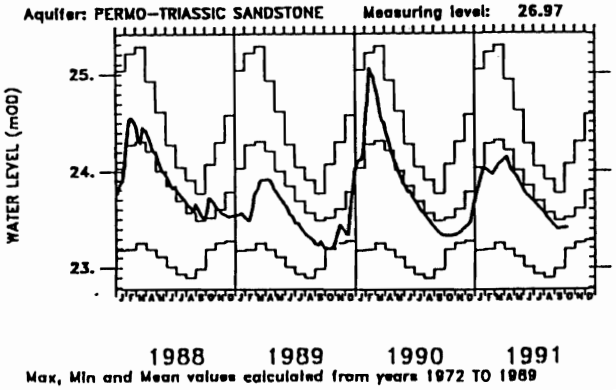
National grid reference: SK 1440 0464 Well number: SK10/9
Aquifer: PERMO-TRIASSIC SANDSTONE Measuring level: 96.21



Max, Min and Mean values calculated from years 1966 TO 1989

Site name: BUSSELS NO.7A

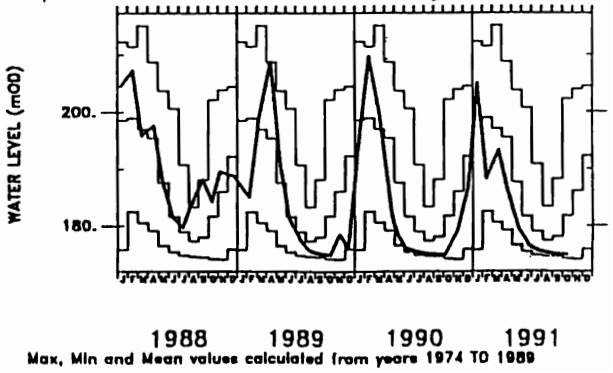
National grid reference: SX 9528 9872 Well number: SX99/37B
Aquifer: PERMO-TRIASSIC SANDSTONE Measuring level: 26.97



Max, Min and Mean values calculated from years 1972 TO 1989

Site name: ALSTONFIELD

National grid reference: SK 1292 5547 Well number: SK15/16
Aquifer: CARBONIFEROUS LIMESTONE Measuring level: 280.25



Max, Min and Mean values calculated from years 1974 TO 1989

TABLE 5 A COMPARISON OF OCTOBER GROUNDWATER LEVELS : 1991, 1976 AND 1973

Site	Aquifer	Records commence	Average October Level	October 1973		October 1976		October and November 1991		No of years October levels <1991	Lowest pre-1991 level (any month)
				Day	Level	Day	Level	Day	Level		
Dalton Holme	C & UGS	1889	15.12	27/10	16.30	23/10	12.17	21/10	12.23	4	10.34
Little Brocklesby	C & UGS	1926	11.04	17/10	9.51	29/10	4.82	21/10	5.42	2	4.56
Washpit Farm	C & UGS	1950	43.43	1/10	41.30	1/10	41.50	1/11	40.75	0	41.24
The Holt	C & UGS	1964	87.18	28/10	84.19	27/10	84.22	27/10	85.00	4	83.90
Fairfields	C & UGS	1974	22.97	-	-	29/10	22.56	15/10	22.07	0	22.15
Redlands Farm	C & UGS	1964	39.86	1/10	36.20	1/10	35.40	18/10	33.18	0	34.04
Rockley	C & UGS	1933	130.72	28/10	130.28	31/10	dry	27/10	129.34	8	dry (below 128.78)
Little Bucket Farm	C & UGS	1971	63.74	30/10	57.48	1/11	56.73	31/10	61.20	4	56.77
Compton House	C & UGS	1894	33.47	25/10	29.07	28/10	29.17	29/10	31.68	>10	27.64
West Dean	C & UGS	1940	1.58	26/10	1.27	22/10	1.70	25/10	1.44	>10	1.01
Lime Kiln Way	C & UGS	1969	124.95	30/10	124.63	15/10	124.14	09/10	124.38	2	124.09
Ashton Farm	C & UGS	1974	65.21	-	-	19/10	64.79	28/10	65.70	>10	63.10
West Woodyates	C & UGS	1942	75.81	28/10	70.52	14/10	69.86	28/10	73.74	>10	67.62
New Red Lion	LLst	1964	11.58	28/10	10.28	29/10	5.79	18/10	6.64	2	3.29
Ampney Crucis	Mid Jur	1958	100.59	28/10	99.67	10/10	97.95	14/10	99.84	8	97.38
Dunmurry (NI)	PTS	1985	28.24	-	-	-	-	19/10	27.50	1	27.47
Llanfair DC	PTS	1972	79.64	1/10	79.26	1/10	79.28	14/10	79.05	0	78.85
Morris Dancers	PTS	1969	32.55	24/10	32.18	19/10	31.83	15/10	32.03	2	30.87
Weeford Flats	PTS	1966	90.06	26/10	90.03	26/10	88.61	14/10	dry	1	(dry)
Bussels 7A	PTS	1972	23.51	31/10	23.41	05/10	23.36	09/10	23.41	9	22.90
Rusheyford NE	MgLst	1967	75.87	1/10	64.82	26/10	67.27	15/10	75.11	>10	64.77
Peggy Ellerton	MgLst	1968	34.18	26/10	32.34	25/10	32.48	07/10	33.03	6	31.10
Alstonfield	CLst	1974	181.72	-	-	21/10	185.26	15/10	175.00	6	174.22

Groundwater levels are in metres above Ordnance Datum

C & UGS	Chalk and Upper Greensand	Mid Jur	Middle Jurassic limestones
LLst	Lincolnshire Limestone	MgLst	Magnesian Limestone
PTS	Permo-Triassic sandstones	CLst	Carboniferous Limestone

FIGURE 4 LOCATION MAP OF GAUGING STATIONS AND GROUNDWATER INDEX WELLS