HYDROLOGICAL SUMMARY - NOVEMBER 1989

Data for this review 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.

The areal rainfall figures are derived from a restricted network of raingauges and a significant proportion of the river flow data is of a provisional nature. November river flow and groundwater level data have yet to be submitted for some areas - under such circumstances, assessments of the drought's severity are based principally on rainfall data.

For a fuller appreciation of the water resources impact of the drought, this hydrological review should be considered alongside assessments of the current reservoir storage and water demand situations in each region.

SUMMARY

Rainfall in the spring of 1989 divided the current drought - which extends well beyond twelve months in some areas - into two distinct phases. The second phase intensified through the hot dry summer but, in the west, some relief was afforded by sustained rainfall in October and early November. Subsequently, an exceptionally dry spell has left runoff and recharge rates very low - exceptionally so for early December in some areas - and the prospect of a second successive dry winter is a matter of considerable concern in relation to the water resources outlook for 1990, especially in those regions principally dependent on groundwater for water supply.

Throughout much of the United Kingdom November is, on average, the wettest month of the year. With very modest evaporation losses and soils generally at, or approaching field capacity the seasonal upturn in river flows and groundwater levels is normally well established by the end of autumn. In 1989, as in the English lowlands during 1988, there has been only a temporary rise in river discharge in western regions and very modest increases in runoff in many eastern and southern catchments. In these latter areas, groundwater levels are, commonly, still in gentle recession and many monitoring boreholes are close to, or below, their minimum recorded level for late November.

Away from western districts where the impact of the October/early November rainfall was considerable, a notable seven-month drought exists which is especially severe in some southern and eastern areas. Longer term rainfall deficits of a large magnitude - particularly for the periods commencing in April and November 1988 - may also be recognised. There is an evident regional dimension to the drought within these timeframes but for England and Wales as a whole the shortage of rain is also substantial.

River flow rates exhibited large spatial and temporal variations in November; catchment geology and soil moisture conditions were as influential as actual rainfall amounts in determining discharge responses to the rainfall early in the month and to the succeeding dry sequence. Broadly speaking, in the west, where soil moisture deficits had been satisfied in October, runoff rates were healthy at the beginning of the month but declined steeply thereafter. Conversely in some high baseflow rivers in southern and eastern catchments, no significant increase in river flow has occurred throughout the autumn. In many Chalk streams discharges are now extremely low and, for some, the accumulated runoff totals over periods of 6 to 12 months are unprecedented. Generally, daily mean flow rates entering the winter are more typical of summer flows and there is every expectation that runoff totals for the calendar year will be among the lowest on record over wide areas.

The limited recharge in western and northern regions during late October did not, in the event, foreshadow any general recovery in groundwater levels. Even where - as in the Cotswolds - brisk rises were reported in early November recessions had become re-established by December. Throughout the major aquifers groundwater levels are generally at their lowest level for more than a decade and in some areas, as in the Southern NRA region and parts of Yorkshire especially, water tables are standing at levels without modern precedent. In the short term there is little prospect of springs and bournes running and the late November increase in soil moisture deficits will serve to further delay any general improvement in groundwater resources.

Depressed ground water levels and meagre river flows throughout much of England and Wales imply a very fragile water resources outlook for 1990. However, there is still sufficient time before evaporation rates begin climbing in the spring for surface and groundwater storages to recover to adequate levels in almost all areas.

The longer term impact of the drought will be largely determined by precipitation amounts over the next three months.

REVIEW

Rainfall

The sequence of active low pressure systems which brought substantial rainfall to almost all parts of Britain in October persisted into the first ten or eleven days of November. Subsequently, high pressure extending from western Europe increasingly dominated weather patterns over the UK. The stable conditions were conducive to frost and fog but rainfall amounts were negligible during an extremely dry spell which, in some central and southern districts, extended up to thirty days; in a number of areas this is the longest sequence of rainless days since June/July 1976 and its occurrence in late autumn is very remarkable.

November rainfall totals approached the long term average only in a few western localities. Much of eastern Britain had less than half the normal rainfall, the lowest rainfall totals were recorded in the eastern lowlands of Scotland. Generally, the minimal rainfall over the last four weeks has more than counterbalanced the October rainfall and, overall, there has been an intensification of the drought. The autumn (Sept-Nov) has not been notably dry; considerably lower rainfall totals were recorded in 1985 and 1978 but since April, England and Wales rainfall has been less than 70 per cent of average. Only in 1921 and 1947 have lower rainfall totals for this seven-month period been registered over the last 200 years. As of mid-December it appears likely that 1989 will register the third lowest rainfall total this century, after 1921 and 1933. For the period November 1988 to November 1989 countrywide precipitation was only about three-quarters of the average. This represents a shortfall of about 240 mm. To make good this accumulated deficit over the January to April period would require rainfall of almost twice the average; no previous precipitation of this magnitude has occurred in the England and Wales rainfall record which extends back to 1767. In the Southern and Northumbrian NRA regions, where 13-month rainfall deficits are equivalent to well over twice the normal January to April rainfall, the likelihood of the deficits being fully made up by the early spring are vanishingly small.

As with all droughts, its impact has been far from uniform with the longest, and most severe, periods of rainfall deficiency being found in the east and south. Since April 1989, rainfall in all regions apart from western Scotland has been less than 75 per cent of average. Very long return periods are associated with the seven-month droughts in the Southern and Northumbrian NRA regions (see Table 2) and even greater intensities may be found as a result of spatial variations within these regions. Parts of Kent, for instance, have been remarkably dry and in the Tyne catchment the Whittledean raingauge, which has a 140-year record, has registered new minimum rainfall totals for a number of periods between seven and thirteen months ending in November 1989. Over the longer timescales the regional character of the drought is also prominent with the greatest intensities confined to the English lowlands and parts of the North-East. In the South and some eastern areas the extended period over which deficits have accumulated - stretching to 20 months in places - is of greater significance than the recent hot, dry summer with regard to groundwater levels and baseflows in rivers.

Soil Moisture Deficits

Soil moisture deficits (SMDs) declined steeply early in the month but began to build again in the latter half of November and into December. The net effect was a modest decrease on mid-October deficits but, with the exception of the west, SMDs are substantially above average for the time of year and higher than at the same time in 1988. These deficits will reduce the hydrological effectiveness of the early-1990 precipitation.

Runoff

Late-autumn runoff rates displayed considerable spatial and temporal variation. The lag in catchment response to rainfall, mainly due to variations in geology and soils, interacted with regional rainfall and soil moisture differences to produce a complex picture. Nonetheless, with the exception of South Wales and western Scotland, the November runoff totals were well below average - typically in the range of 40-60 per cent of the long term mean. Generally, western areas recorded a sharp increase in river flows through October. This increase was sustained into November resulting in healthy replenishments to many strategically important reservoir systems. However, the seasonal upturn in runoff rates proved to be temporary and from mid-November steep recessions characterised relatively impermeable catchments. The Tay, for instance, which overall recorded about 80 per cent of its mean November runoff had, by the end of the month, declined to its lowest daily mean flow during November since 1973. Reductions in flow from the second week of November by an order of magnitude were reported from the South-West. In Severn Trent, early December flows were exceedingly low in the Derwent and Severn catchments - less than 20 per cent of the December average. The contrast between flows early and late in November needs to be considered when assessing the significance of the return periods presented in Table 4. These were based on mean monthly flows.

In eastern Scotland, the North-East and throughout much of the English lowlands, a strong seasonal upturn in river flows is still awaited and over wide areas the early winter discharge rates are comparable to, or below, those recorded in 1975. There are obvious parallels with 1988 when discharges increased in October only for monthly runoff totals to remain relatively stable through much of the succeeding winter period. Concern for the aquatic environment and for the water resources outlook, especially in the south, focuses on the significantly lower base, relative to last year, from which any seasonal response now needs to be generated. A continuation of dry conditions into 1990 will certainly result in some of the record minimum runoff totals established in January and February 1989 being eclipsed. There will also be the expectation - in rivers supported primarily from baseflow - of extremely low discharge rates in the following summer. The hydrological drought is especially severe in the Southern NRA region where the Itchen (Hampshire) and the Medway (Kent) both registered November minima from 30-year records.

From a water resources viewpoint accumulated runoff totals are rather more significant than individual monthly values. The Itchen, a Chalk river, has remained below average for 19 successive months, an unprecedented sequence. Further, each monthly runoff total through the autumn, adjusted to take augmentation from ground water into account, has been less than the previous minimum on record; a distinction shared with the Yorkshire Derwent which also depends principally on groundwater. Table 3 confirms that accumulated runoff is notably low over the seven and thirteen-month periods beginning in May 1989 and November 1988. Over the last six months the runoff for the Itchen - adjusted to take account of the impact of groundwater augmentation - is lower than for *any* six-month period in its record. It is a measure of the severity of the 1989 drought that in parts of the South flows have, for a sustained period, fallen below those experienced in 1976.

Depending on the accounting period adopted, large variations in the severity of the hydrological drought may be recognised. Throughout much of Britain, runoff since April has been less than three-quarters of the average. On the 13-month timescale the exceptional drought in, for instance, the Medway catchment may be contrasted with a number of the Scottish catchments where - notwithstanding the limited summer and autumn runoff in 1989 - accumulated runoff totals remain among the highest on record.

Groundwater

Infiltration in the spring of 1989 - although insufficient to compensate for the lack of groundwater recharge through the winter of 1988/89 - boosted groundwater resources at a time when a seasonal decline in levels is normally underway. Consequently, in early summer, water tables stood at, or a little below average levels in most regions (see, for example, the Compton and Rockley hydrographs - Figure 3) with only the Chalk aquifer in Sussex, Kent and Yorkshire reporting levels comparable with those registered during the 1976 drought.

From June, groundwater levels continued to decline following the normal seasonal recession. However, the anticipated brisk recovery in groundwater resources through the late autumn failed to materialise and the dry spell over the last four weeks has effectively stopped any significant recharge to the major aquifers. A temporary upturn in groundwater levels followed the October rainfall in the South-West and in the Cotswolds; a similar but more modest response was noted in the Magnesium Limestone outcrop in Yorkshire and even in some shallow Chalk wells in the Southern NRA region. By late November however, recessions had been re-established and exceptionally low groundwater levels were recorded for early winter. At Dalton Holme in the Chalk of Yorkshire, where levels have been routinely monitored for over 100 years, the water table now stands well below the period of record minimum. The observation borehole at Rockley has dried up for the first time since November 1976; the levels in a nearby well of rather greater depth are still falling. In summary, the groundwater situation is significantly worse than that which attracted considerable attention at the end of 1988.

In eastern and southern England, soil moisture deficits over the Chalk outcrop, in particular, are high - ranging from 20 mm to more than 100 mm. It is probable that these would require from one to three weeks steady rainfall to be eliminated and for significant recharge to take place. Average rainfall through until the end of March would then be expected to raise groundwater levels to a point somewhat below the average for the spring. If no further recharge occurs this winter, groundwater levels are likely to fall beneath recorded minima over wide areas. There is but one continuous groundwater level record of more than 150 years duration - for the Chilgrove House well in the Chalk of the South Downs. Examination of the hydrograph indicates that the occurrence of zero, or near zero, winter recharge is approximately once in 40 years.

The consequences of a further substantial shortfall in precipitation during the first quarter of 1990 are potentially serious, especially with regard to the Chalk. As an aquifer, the Chalk is unique in that the greater part of groundwater flow takes place through fissures and these are concentrated in a zone which extends downwards from the surface to some 30 metres beneath mean groundwater level in the topographically higher districts; adjacent to the coasts, 80m would be more typical. At minimum recorded groundwater levels, the water table may stand within a few metres of the base of the fissured zone over extensive areas. A further depletion in groundwater storage may drastically reduce the rate at which groundwater can flow to wells and boreholes - in such circumstances, deepening of wells might produce only small or insignificant increases in yield.

The areas of Chalk outcrop currently most at risk are in eastern Yorkshire, parts of East Anglia and especially Kent and Sussex. In the other major aquifer of England, the Permo-Triassic sandstones, the effects of a relatively dry winter should be less severe since the groundwater storage is largely intergranular. In addition, SMDs are generally more modest than over the Chalk implying that winter rainfall is likely to be rather more hydrologically effective.

IH/BGS 12/12/89

TABLE 1 1998/89 RAINFALL IN MM AND AS A PERCENTAGE OF THE 1941-70 AVERAGE

		Nov 1988	Dec	Jan	Feb	Mar 1989	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Nov88 -Nov	Shortfall Nov88-Nov mm
England and	mm	48	47	44	78	84	85	22	63	41	60	40	95	62	768	241
Wales	%	49	52	51	121	142	146	33	103	56	66	48	114	64	76	
Scotland	mm	99	149	172	239	188	71	58	84	60	181	89	173	62	1625	-52
	%	70	96	126	230	204	79	64	91	54	140	65	116	44	103	
NRA REGIONS																
North West	mm	69	117	68	123	113	92	33	102	34	118	28	136	75	1108	231
	%	55	97	61	151	157	120	40	123	33	94	22	115	62	83	
Northumbrian	mm	74	53	32	70	55	49	25	65	19	87	21	85	36	671	303
	%	79	71	40	106	105	89	38	107	25	86	26	113	38	71	
Severn Trent	mm	38	33	35	65	69	87	23	53	37	40	37	83	51	651	201
	%	48	47	51	122	132	168	35	95	57	49	54	128	65	76	
Yorkshire	mm	55	47	24	64	63	79	24	84	38	47	19	83	46	673	249
	%	62	63	31	100	118	140	40	145	55	52	27	120	52	73	
Anglia	mm	35	22	31	34	48	74	14	62	44	37	29	43	37	510	162
	%	57	41	59	81	121	186	30	127	77	57	56	83	60	76	
Thames	mm	28	16	31	68	65	77	14	46	38	40	32	66	37	550	227
	%	38	24	50	129	141	167	25	88	63	57	51	103	51	71	
Southern	mm	32	19	29	62	75	81	11	50	32	28	29	80	44	572	316
	%	34	23	38	109	144	169	20	100	55	39	41	102	47	64	
Wessex	mm	33	22	44	89	87	74	25	33	47	45	52	103	60	714	252
	%	35	24	52	151	149	137	36	61	76	55	66	126	62	74	
South West	mm	55	59	65	135	115	92	18	38	36	63	99	141	97	1013	315
	%	41	44	50	151	137	130	21	58	43	62	96	125	72	76	
Welsh	mm	69	73	80	140	151	89	23	65	49	78	57	164	100	1139	338
	%	48	50	59	146	174	103	25	79	52	66	46	127	70	77	

Note: August to October rainfalls are based upon MORECS figures supplied by the Meterological Office.

* Return period assessments are based on tables provided by the Meteorological Office; the estimates assume a sensibly stable climate.

TABLE 2 RAINFALL RETURN PERIOD ESTIMATES

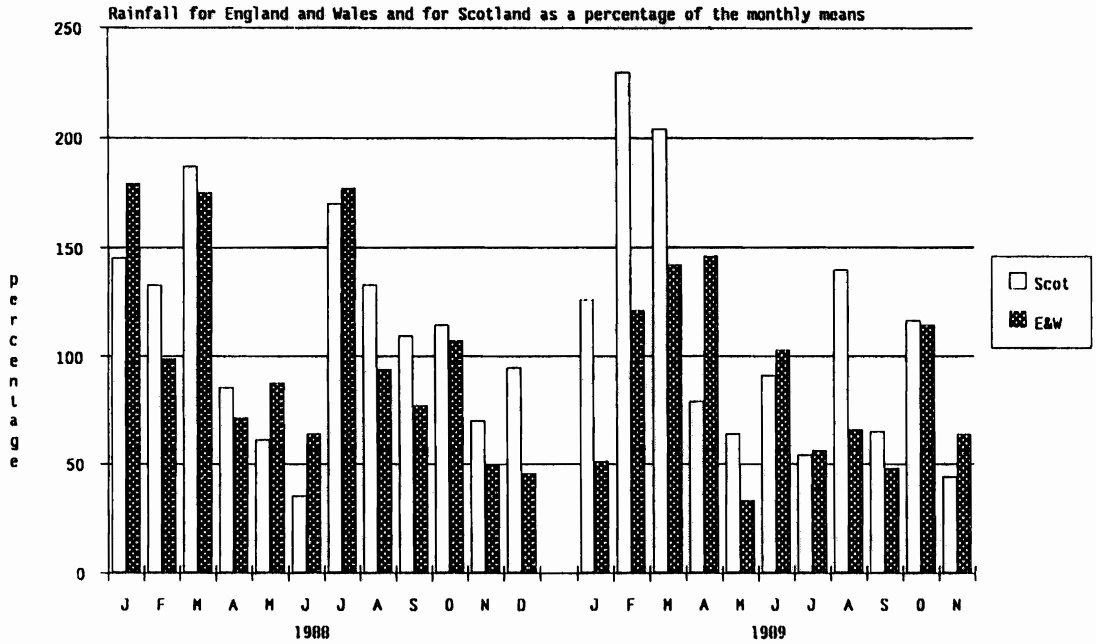
		MAY-NOV 1989	Est Return Period	NOV-NOV 1988-89	Est Return Period	APR-NOV 1988-89	Est Return Period
England and Wales	mm	382		768		1273	
	% LTA	69	30-40	76	30-40	84	15-20
Scotland	mm	707		1625		2471	
	% LTA	83	10	103		104	
NRA REGIONS							
North West	mm	526		1108		1826	
	% LTA	70	20-30	83	10	89	5
Northumbrian	mm	337		670		1200	
	% LTA	61	70-100	69	80-100	81	30
Severn Trent	mm	324		651		1081	
	% LTA	68	20-30	76	20-30	83	10-20
Yorkshire	mm	341		673		1152	
	% LTA	67	30-40	73	40-50	82	20
Anglia	mm	266		510		855	
	% LTA	69	20-30	76	20-30	83	15-20
Thames	mm	273		550		931	
	% LTA	62	30-50	71	40-50	78	30-40
Southern	mm	274		572		933	
	% LTA	57	70-100	64	>100	71	>100
Wessex	mm	365		714		1172	
	% LTA	70	10-20	74	20-30	81	15-20
South West	mm	492		1013		1668	
	% LTA	70	10-20	76	20-30	86	10
Welsh	mm	537		1139		1883	
	% LTA	68	30-40	77	20-30	85	10-15

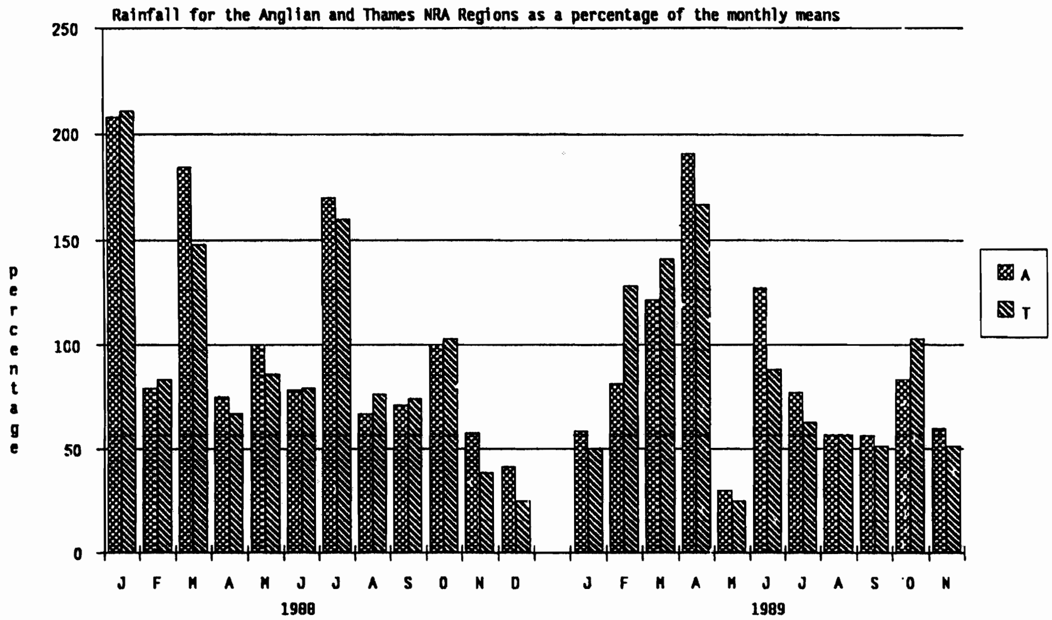
Return period assessments based on tables provided by the Meteorological Office.* These assume a start in a specified month; return periods for a start in any month may be expected to be an order of magnitude less.

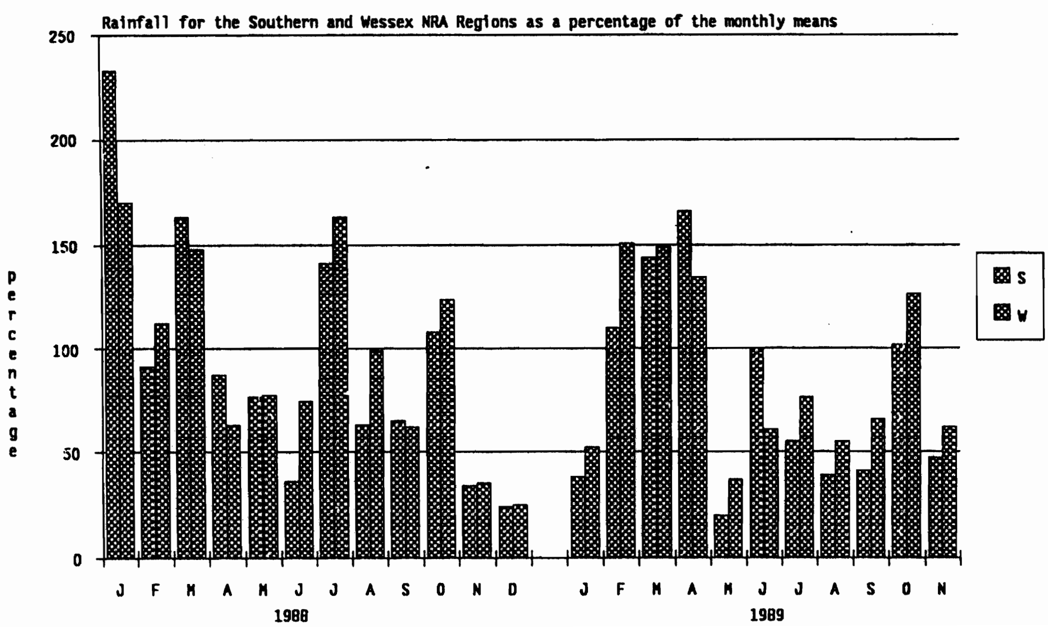
The tables reflect rainfall totals over the period 1911-70 only and the estimate assumes a sensibly stable climate.

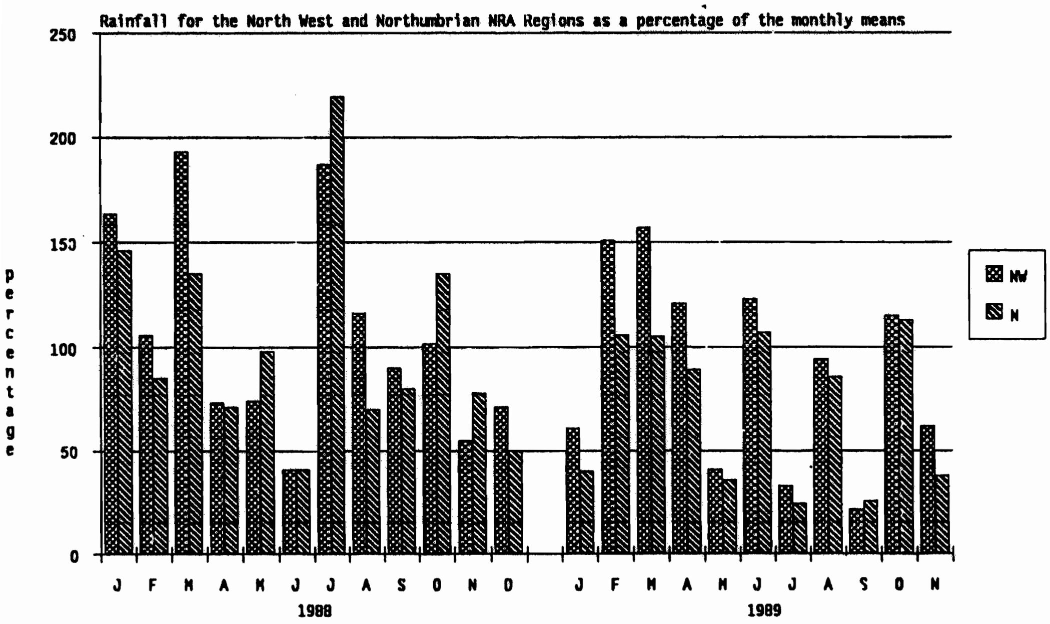
* Tabony, R C, 1977, The Variability of long-duration rainfall over Great Britain, Scientific Paper No 37, Meteorological Office (HMSO).

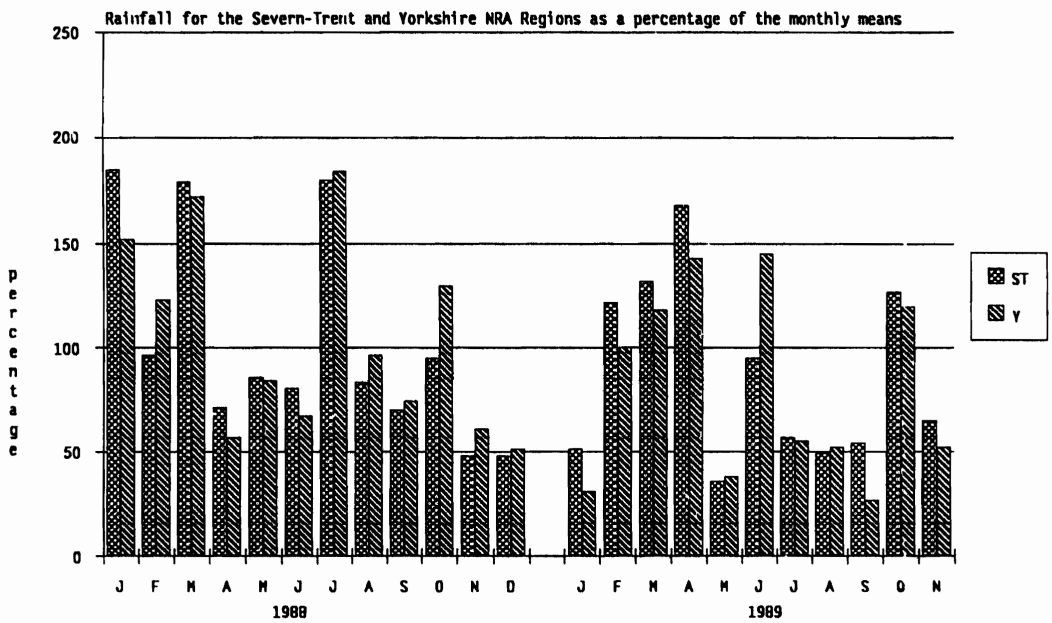
FIGURE 1. MONTHLY RAINFALL - JANUARY 1988 TO NOVEMBER 1989








Rainfall for the North West and Northumbrian NRA Regions as a percentage of the monthly means
250
200
150
100
50
0
percentage
NW
N
J F M A M J J A S O N D
1988
J F M A M J J A S O N
1989


Rainfall for the Severn-Trent and Yorkshire NRA Regions as a percentage of the monthly means
250
200
150
100
50
0
percentage
ST
Y
J F M A M J J A S O N D
1988
J F M A M J J A S O N
1989

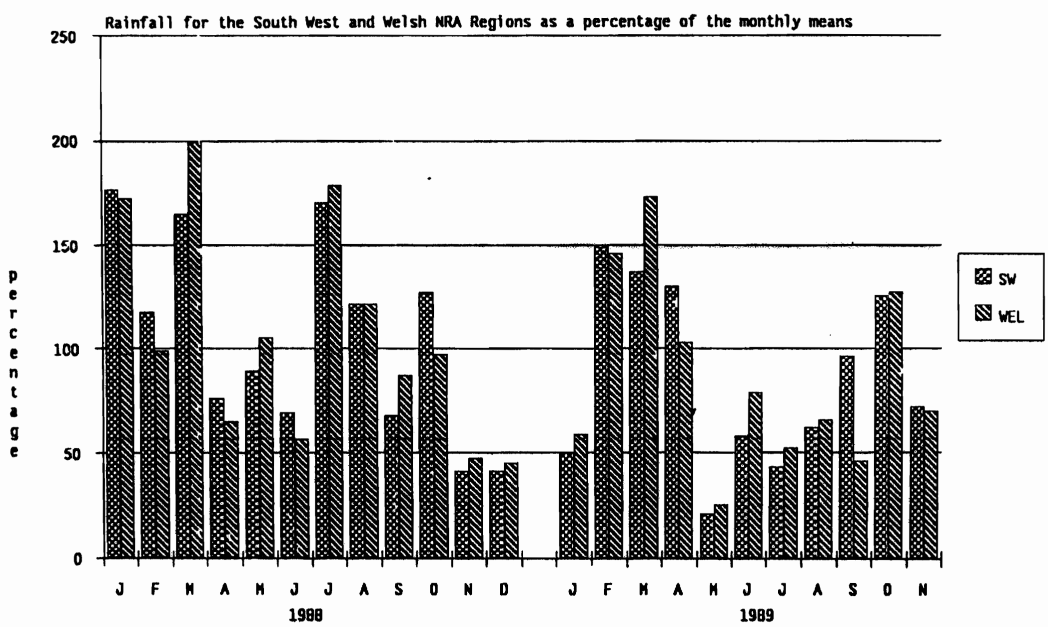
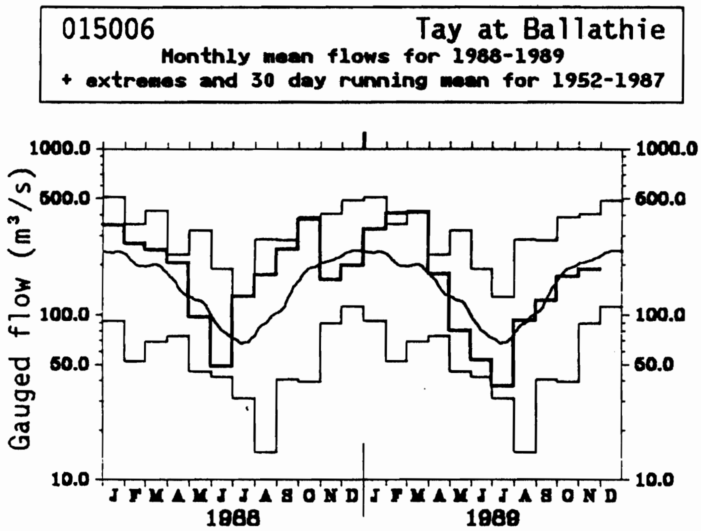
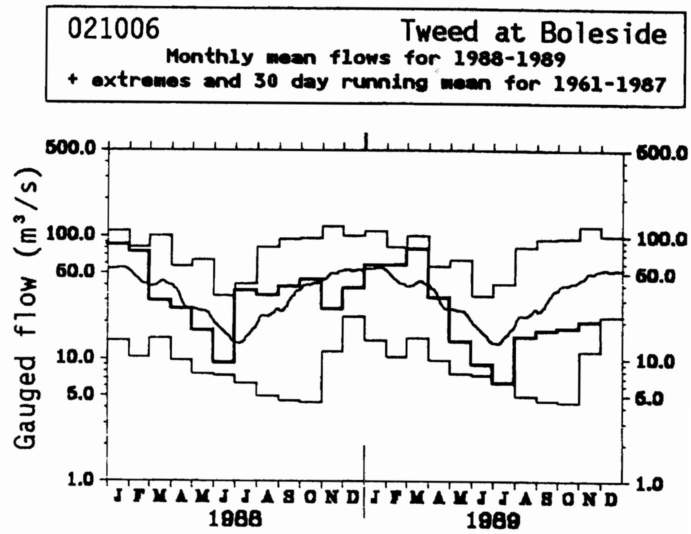
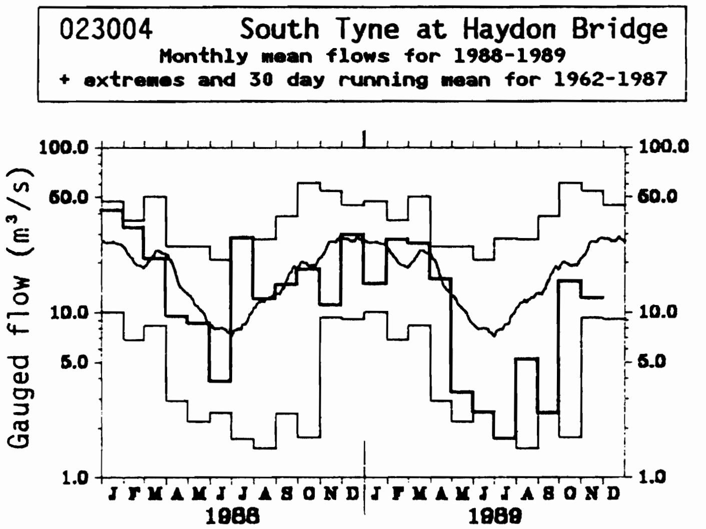
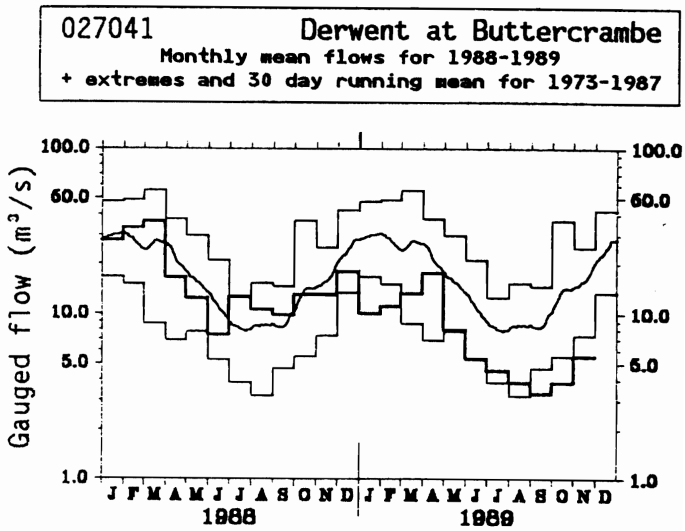

Rainfall for the South West and Welsh NRA Regions as a percentage of the monthly means
250
200
150
100
50
0
percentage
SW
WEL
J F M A M J J A S O N D
1988
J F M A M J J A S O N
1989

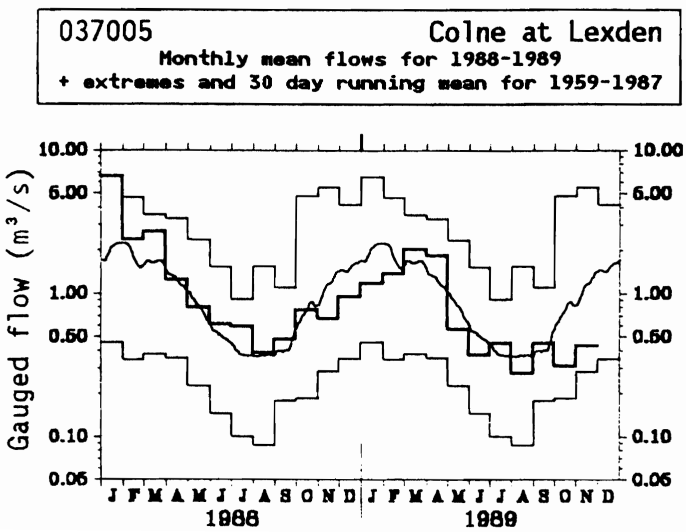
FIGURE 2.   MONTHLY HYDROGRAPHS

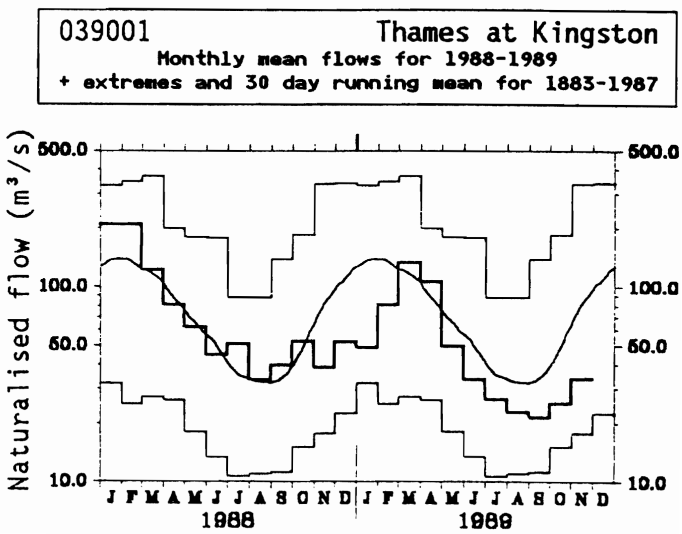




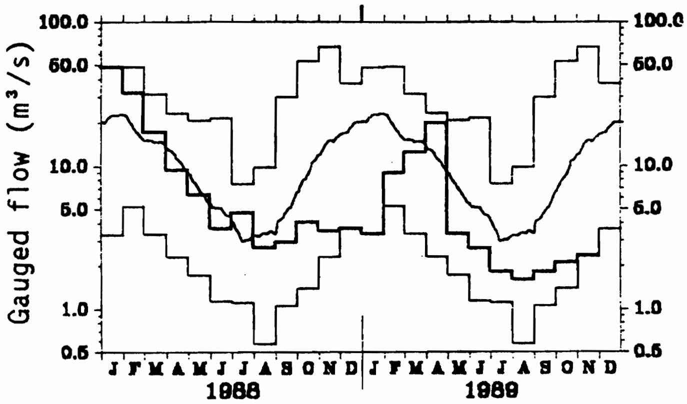




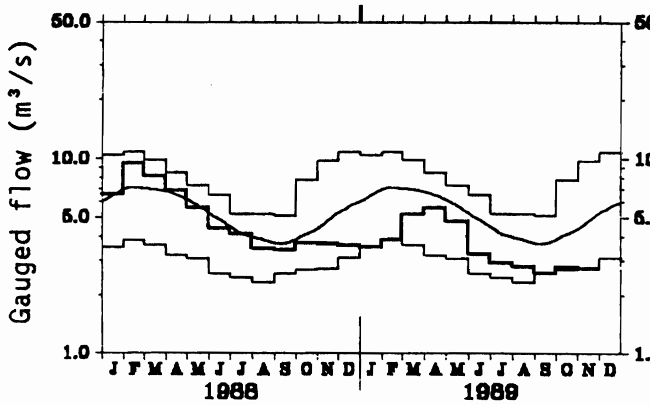




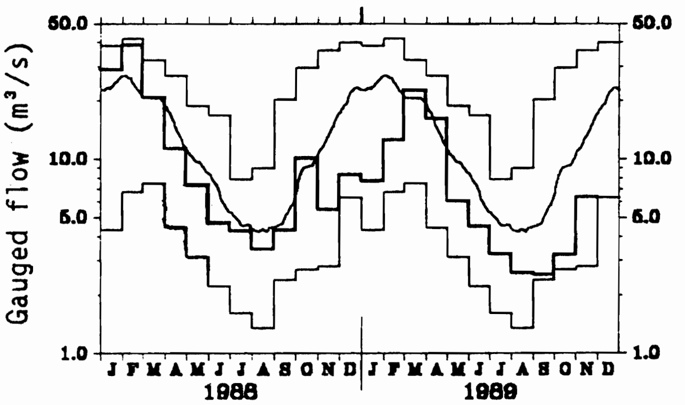
040003 Medway at Teston
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1956-1987



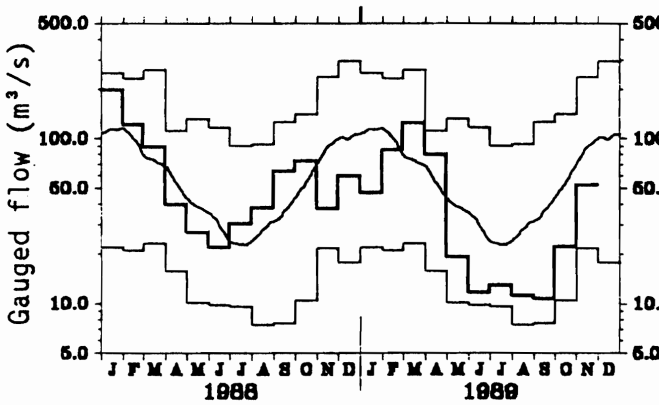
042010 Itchen at Highbridge+Allbrook
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1958-1987



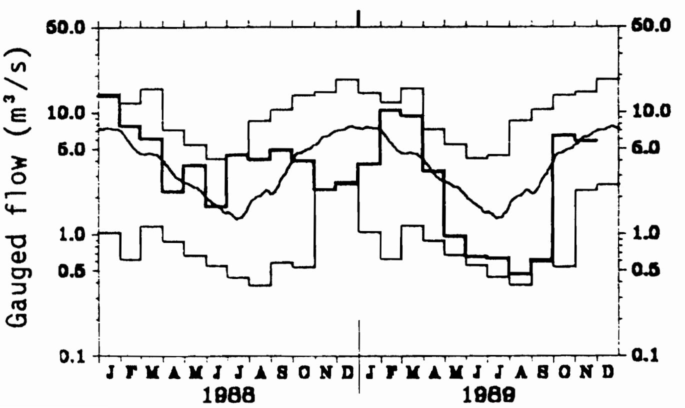
043007 Stour at Throop Mill
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1973-1987



054001 Severn at Bewdley
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1921-1987



057004 Cynon at Abercynon
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1957-1987



076007 Eden at Sheepmount
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1967-1987

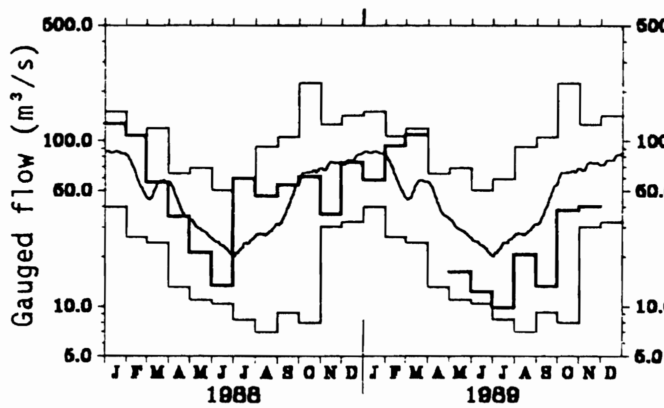


TABLE 3 RUNOFF AS MM AND AS A PERCENTAGE OF THE PERIOD OF RECORD AVERAGE WITH SELECTIVE PERIODS RANKED IN THE RECORD

River/ STATION NAME	Jan 1989	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Nov 1989	Min NOV	11/88 TO 11/89		5/89 TO 11/89	
	mm %LT	mm %LT	mm %LT	mm %LT	mm %LT	mm %LT	mm %LT	mm %LT	mm %LT	mm %LT	mm %LT	rank /yrs	mm year	mm %LT	rank /yrs	mm %LT	rank /yrs
Tay at	192	214	239	99	47	30	22	54	69	99	106	19	50	1379	28	426	9
Ballathie	138	201	203	120	66	66	55	104	97	89	88	/38	1972	112	/37	83	/37
Earn at	223	219	267	86	34	16	13	45	72	98	94	16	50	1382	29	372	8
Kinkell Bridge	152	190	231	115	53	39	34	79	90	83	71	/42	1956	110	/39	72	/40
Tweed at	104	94	140	55	25	16	11	27	29	32	35	5	20	679	5	175	2
Boleside	105	132	182	107	57	56	40	68	55	44	40	/29	1983	82	/28	51	/28
South Tyne at	53	89	93	55	12	9	6	19	8	55	42	5	32	584	3	150	1
Haydon Bridge	54	133	111	100	32	32	20	45	15	79	45	/28	1983	69	/26	43	/26
Wharfe at	42	64	95	71	15	13	10	14	10	39	29	3	23	543	2	130	1
Flint Mill Weir	43	87	126	131	38	51	37	33	21	60	36	/35	1958	68	/34	40	/34
Derwent at	17	17	22	29	13	9	8	6	5	6	9	1	9	193	1	57	1
Buttercrambe	33	40	47	85	50	51	58	42	37	25	35	/17	1989	52	/16	43	/16
Trent at	21	26	42	57	18	13	12	10	9	13	17	8	12	284	2	92	3
Colwick	41	60	103	177	70	67	74	59	52	54	55	/32	1975	73	/31	62	/31
Dove at	34	43	71	67	24	17	17	12	10	16	29	7	17	417	2	125	3
Marston on Dove	49	78	132	157	66	63	73	50	40	47	60	/29	1975	75	/27	58	/27
Lud at	15	12	16	17	15	12	10	9	8	9	8	6	6	163	3	72	4
Louth	47	33	42	50	52	56	59	64	69	72	53	/22	1975	57	/21	63	/21
Colne at	13	14	23	20	6	4	5	3	5	3	5	6	3	119	4	31	7
Lexden	55	77	122	150	67	73	119	73	115	34	39	/31	1978	78	/30	65	/30
Mimram at	9	8	10	14	11	9	9	7	6	6	6	4	3	114	6	53	5
Panshanger Park	77	68	74	110	88	82	92	77	73	71	68	/37	1973	84	/36	79	/37
Thames at	13	20	36	28	13	9	7	6	6	7	9	19	5	176	18	56	18
Kingston (Natr.)	35	61	115	124	74	71	74	68	67	52	41	/107	1921	66	/106	61	/107
Kennet at	16	19	31	29	22	16	13	10	10	9	11	3	10	217	3	91	3
Theale	46	55	81	91	81	73	77	67	74	56	55	/29	1978	69	/28	70	/28
Coln at	15	19	48	44	30	18	15	13	10	10	14	10	8	268	4	109	3
Bibury	29	35	89	101	89	66	70	76	69	61	56	/27	1973	64	/26	71	/26
Medway at	7	17	27	41	7	6	4	3	4	4	5	2	5	140	1	33	1
Teston	14	46	85	185	47	60	62	41	40	21	16	/31	1978	46	/25	34	/26
Ouse at	13	26	48	43	16	9	10	6	8	8	6	2	6	213	2	62	1
Gold Bridge	20	54	104	125	63	57	99	54	54	27	13	/29	1978	49	/27	41	/28
Itchen at	26	26	39	40	36	23	22	21	19	21	20	1	20	345	2	161	2
Highbridge+Allbrook	53	53	74	85	84	66	71	73	71	68	57	/32	1989	69	/31	71	/31
Stour at	19	28	57	39	15	11	8	6	6	8	15	8	7	247	2	70	2
Throop Mill	31	49	110	112	62	68	70	55	49	35	46	/17	1973	58	/16	55	/17
Piddle at	18	20	46	43	29	19	13	10	9	10	16	6	10	267	2	105	2
Baggs Mill	33	34	80	101	90	80	71	63	58	48	54	/27	1973	62	/25	68	/26
Tone at	25	54	80	40	19	11	10	7	9	13	29	13	8	343	1	98	4
Bishops Hull	31	74	139	102	67	61	63	55	57	47	68	/29	1978	66	/28	61	/29
Severn at	29	48	77	48	12	7	8	7	6	14	31	20	13	345	4	85	5
Bewdley	41	84	168	152	50	39	56	40	27	41	57	/69	1942	68	/68	47	/69
Cynon at	94	232	232	80	24	16	16	12	15	160	139	19	56	1143	7	382	6
Abercynon	50	182	199	105	39	38	46	23	21	132	90	/32	1988	82	/30	71	/30
Dee at	133	215	333	129	23	34	23	34	36	226	169	6	83	1625	3	544	1
New Inn	55	136	189	125	32	57	33	35	25	113	68	/21	1983	79	/20	61	/20
Lune at	94	167	196	82	20	14	12	44	13	121	81	5	65	1081	7	305	1
Caton	64	186	203	110	39	34	23	61	14	99	60	/27	1985	86	/25	55	/27
Eden at	68	98	127	53	19	14	11	24	15	44	45	5	34	645	5	172	2
Sheepmount	67	152	194	114	56	53	39	75	33	57	53	/20	1973	85	/18	56	/19

Notes:

(i) Values based on gauged flow data unless flagged (natr.), when naturalised data have been used.

(ii) Values are ranked so that the lowest runoff is rank 1.

(iii) %LT means percentage of the long term average from the start of the record to 1988. For the long periods (at the right of this table), the end date for the long term is 1989.

TABLE 4 RIVER FLOW RETURN PERIODS - NOVEMBER 1989

River	Station Name	First Year	Nov Flows	Return Period (in years)	Base Period Index
Tay	Ballathie	1952	187.50	2	0.65
South Tyne	Haydon Bridge	1962	12.20	10	0.35
Wharfe	Flint Mill	1955	8.60	25	0.39
Derwent	Buttercrambe (Yorks)	1973	5.50	>100	0.68
Trent	Colwick	1959	35.26	5	0.64
Derwent	St Mary's Bridge (Derby)	1953	7.85	10	0.62
Colne	Lexden (Essex)	1959	0.43	5	0.53
Mimram	Panshanger Park	1952	0.30	15	0.94
Thames	Kingston (nat)	1883	33.70	5-10	0.64
Thames	Kingston (nat)	1952	33.70	5-7	0.64
Kennet	Theale	1962	4.29	15-20	0.87
Mole	Kinnersley Manor	1972	0.85	5	0.37
Medway	Teston	1957	2.37	25	0.41
Ouse	Gold Bridge	1967	0.45	50	0.65
Itchen	Highbridge	1959	2.75	50-100	0.97
Avon	Amesbury	1965	1.36	5-10	0.91
Piddle	Baggs Mill	1963	1.10	5	0.89
Severn	Bewdley	1921	52.10	<5	0.53
Teme	Knightsbridge	1970	9.56	<5	0.57
Cynon	Abercynon	1957	5.68	2	0.42
Lune	Caton	1959	30.8	5	0.32
Eden	Sheepmount	1967	39.94	5-10	0.50

Note: Because of changes in the pattern of water utilisation in certain catchments and the effects of measures to counteract the impact of a drought on river flow rates, some return periods need to be treated with particular caution.

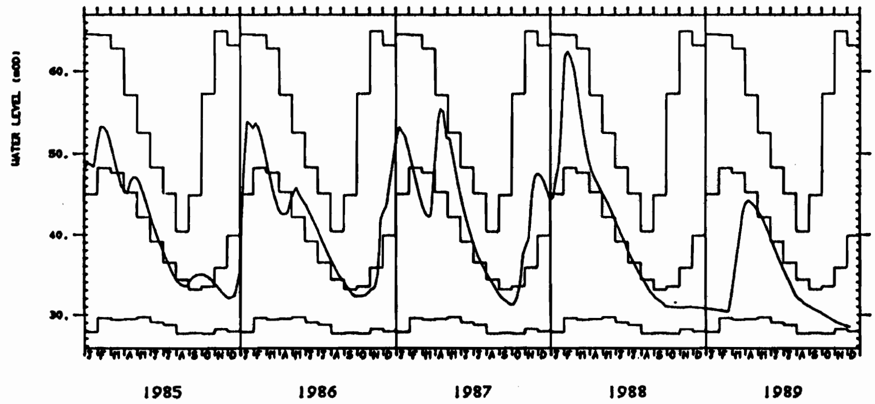
* The Itchen flow is adjusted to compensate for groundwater augmentation

FIGURE 3. GROUNDWATER WELL OBSERVATION HYDROGRAPHS

Site name: COMPTON HOUSE

National grid reference: SU 7755 1490 Well number: SU71/23

Aquifer: CHALK AND UPPER GREENSAND Measuring level: 81.37

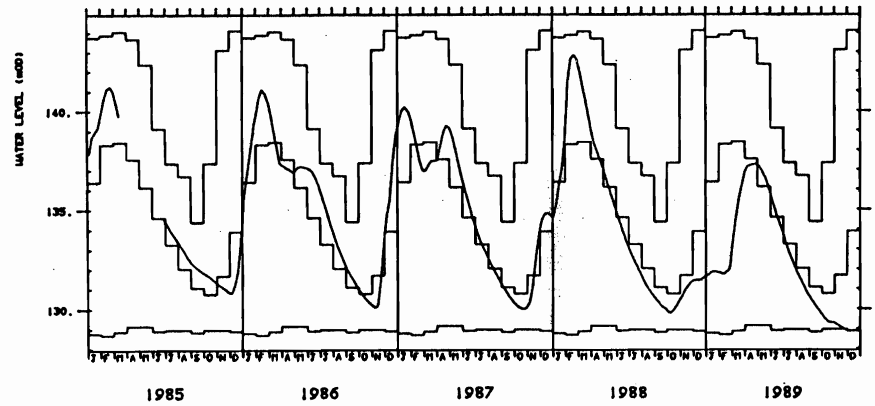


Max, Min and Mean values calculated from years 1894 TO 1988

Site name: ROCKLEY

National grid reference: SU 1655 7174 Well number: SU17/57

Aquifer: CHALK AND UPPER GREENSAND Measuring level: 146.39

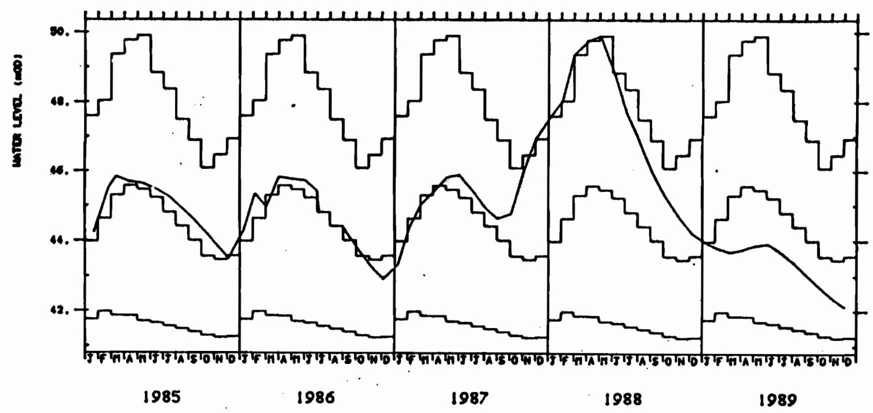


Max, Min and Mean values calculated from years 1933 TO 1988

Site name: WASHPIT FARM

National grid reference: TF 8138 1960 Well number: TF81/2

Aquifer: CHALK AND UPPER GREENSAND Measuring level: 80.20

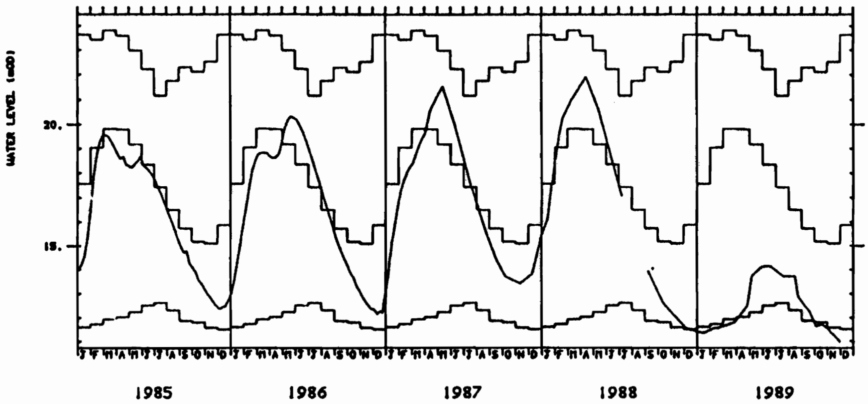


Max, Min and Mean values calculated from years 1950 TO 1988

Site name: DALTON HOLME

National grid reference: SE 9651 4530 Well number: SE94/5

Aquifer: CHALK AND UPPER GREENSAND Measuring level: 33.50



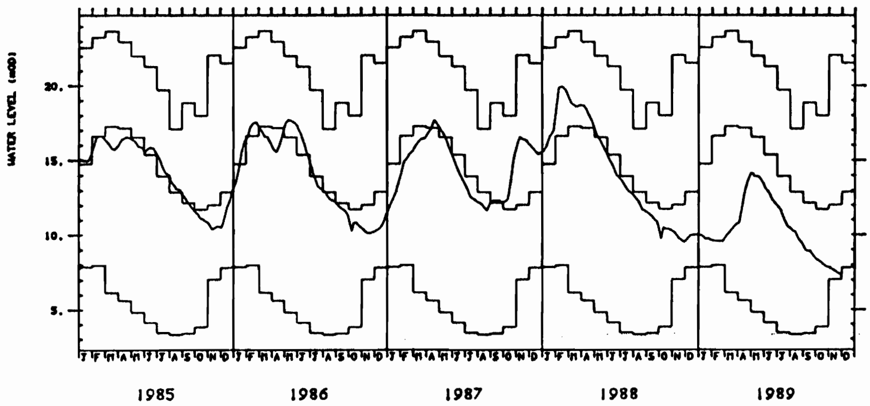
Max, Min and Mean values calculated from years 1889 TO 1988

A break in the data line indicates a recording interval of greater than 8 weeks

Site name: NEW RED LION

National grid reference: TF 0885 3034 Well number: TF03/37

Aquifer: LINCOLNSHIRE LIMESTONE Measuring level: 33.82

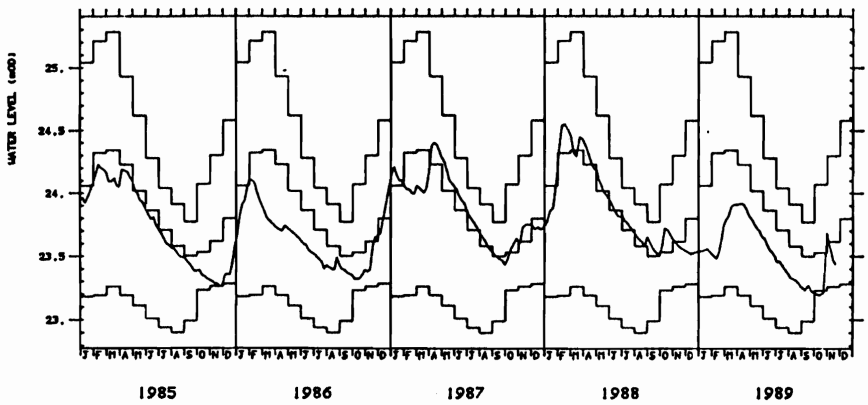


Max, Min and Mean values calculated from years 1964 TO 1988

Site name: BUSSELS NO.7A

National grid reference: SX 9528 9872 Well number: SX99/37B

Aquifer: PERMO-TRIASSIC SANDSTONE Measuring level: 26.07

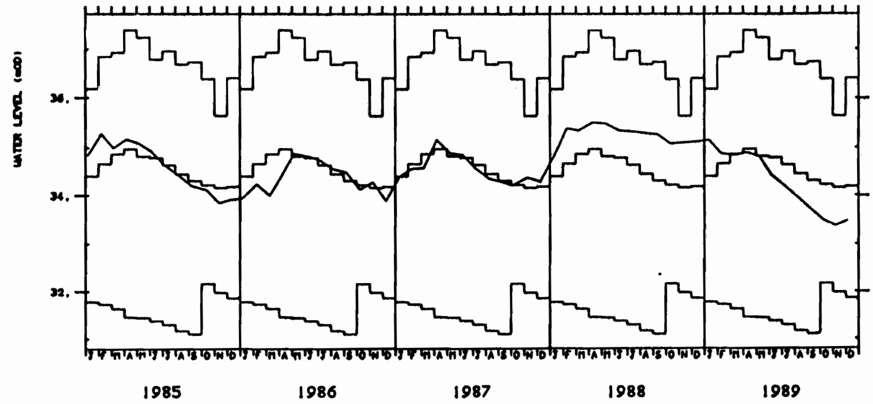


Max, Min and Mean values calculated from years 1972 TO 1988

Site name: PEGGY ELLERTON FARM,HAZLEWOOD

National grid reference: SE 4535 3964 | Well number: SE43/9

Aquifer: MAGNESIAN LIMESTONE | Measuring level: 51.40



Max, Min and Mean values calculated from years 1968 TO 1988