HYDROLOGICAL SUMMARY - OCTOBER 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 rainfall figures are devised from a restricted network of raingauges. Some revisions to earlier flow figures are featured in this report.

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

The very unsettled weather conditions which characterised the latter half of the month resulted in rainfall totals for October exceeding the 1941-70 mean in most regions; in some areas October registered the first above average monthly rainfall total since March. A continuing sequence of active low pressure systems brought further sustained rainfall in early November. In the west, the effect of the rainfall since mid-October has been to transform the short-term water resources outlook. By contrast, only a modest change in the drought's complexion occurred throughout lowland England. In a few eastern districts, some slight intensification was evident. Long-term rainfall deficits remain substantial in most regions and water resources prospects are still fragile, especially in southern England. The amount and temporal distribution of the autumn and coming winter's precipitation will largely determine the hydrological and water resources prospects for 1990.

Geological and soil moisture differences, at the regional and local scale, were as significant as total rainfall amounts in influencing catchment responses to the recent wet spell. The sustained rainfall produced brisk flow increases in the north and the west with a very healthy improvement in reservoir stocks but failed to satisfy the notably larger soil moisture deficits (SMDs) in lowland England. Here, the hydrological effectiveness of the October rainfall was greatly diminished. In some permeable catchments the modest amount of surface runoff hardly compensated for a further decline in baseflow; a few rivers recorded their lowest October runoff on record.

Some recharge to aquifers occurred late in the month and although the possible beginning of an upturn was observed at some sites, in the South West and western Cotswolds, a general upturn in groundwater levels is still awaited. Continuing, but relatively gentle, recessions typified most major aquifers and many monitoring boreholes recorded notably low levels for mid-autumn, especially the Chalk in eastern Yorkshire, which experienced new October minima. However the sharp decline in SMDs over the last four weeks implies that prospects for a significant upturn before the end of the year have improved considerably.

Review

The extended period of very dry weather, up to six months in some districts, which produced drought conditions throughout much of England and Wales and eastern Scotland, continued into October. However, the onset of a mild westerly airstream on the 5th heralded a sequence of weak autumn low pressure systems. Some rain was registered on the 5 - 7th but generally amounts were modest. From the 19th, however, the depressions became more vigorous and were accompanied by heavy frontal rainfall. As a consequence, rainfall over the last 12 days of October was close to the average, for the month in most regions; East Anglia was an exception. Provisional data suggest that October rainfall was significantly above average in north-west Scotland, south-east Wales and the southern Pennines, rainfall often exceeding 150% of average and , for the former two areas, exceeding twice the mean in a few locations. Overall, Great Britain exceeded the October average. The persistence of wet conditions into November resulted in rainfall totals for the three weeks up to the 8th being comparable to the total for the previous 3 months, in some regions. Drier than average conditions were experienced in the east; the Grampian Region, the Solway Firth and the Borders, east Yorkshire, the east Midlands and notably, East Anglia.

Notwithstanding the late-October rainfall, the six-month period beginning in May still ranks as the nineteenth driest in England and Wales in an series extending back to 1766;* this century only the notable droughts of 1919, 1921, 1947, 1959 and 1972 have been drier. Rainfall deficiencies over the twelve-month and nineteen-month timescales also remain considerable. At the regional scale, important spatial and temporal variations in drought severity may be recognised (Tables 1 and 2, Figure 1). Total rainfall over the May to October period has been in the range 60-75% of the average for all NRA regions; most of the regional shortfalls might be expected perhaps once every 10-15 years but more rarely in the Southern and Northumbrian regions. Both these latter areas and the Thames region have recorded less than three-quarters of normal rainfall over the last year and a particularly severe long term drought exists along parts of the south coast - Kent especially. In interpreting the figures presented in Table 2, it is important to appreciate that they refer to the quoted base periods only. For instance in the Thames basin an accumulated rainfall total of about 65% of average for the 6 months beginning in May might be expected approximately once every 10-20 years on average. In fact, five such droughts have occurred since 1883. However, if all six-month sequence are considered the number of occurrences increases to almost 70. Scotland was wetter over the longer durations, exceeding the long term average rainfalls. The May to October rainfall, however, was below average.

Decreases in sunshine hours and temperature through the autumn normally cause a steady decline in evaporation rates, allowing rainfall to greatly reduce the SMDs developed through the summer. This year, temperatures have remained high since August, sustaining evaporative losses and maintaining high SMDs which, in many cases, had shown no significant downturn by mid-October. At this time, calculated deficits were close to 125mm throughout the English lowlands and also greater than 100mm in some east coast districts of Scotland; by contrast, most of western Scotland had no deficits and a decline from the seasonally high deficits in western England and Wales had begun. Subsequently, decreases of 50mm in two weeks were relatively common, greatly extending the area of zero deficit in the west. Thus, apart from East Anglia, a rapid decrease in soil moisture characterised most regions. By month-end, however, existing deficits still exceeded the end-of-October average, distinctly so along the eastern seaboard.

* Other rankings of dryness may be seen (eg the Meteorological office). The differences may be ascribed to the use of differing, long term, precipitation series. The one used above appeared in Wigley, T.M.L., Lough, J.M. and Jones, P.D. 1984. Spatial Patterns of precipitation in England and Wales and a revised England and Wales precipitation series. J.Climatology 4. 1-12.

The variation in effective rainfall totals across Great Britain in October, accentuated by differing catchment characteristics, produced a geographically diverse runoff response to the recent wet spell. Heavy frontal rainfall in the west, often exceeding the infiltration capacity of the soils, produced very rapid increases in runoff. October runoff for rivers draining the Brecon Beacons, for instance, were an order of magnitude greater than those for September (Cynon and Yscir, Table 3) - flows exceeded the monthly average in the latter half of the month and, in the Rheidol and Teifi basins of west Wales, floodplain inundation was reported. At the other extreme, baseflow-dominated rivers in the South-East recorded only very modest increases in discharge, even by the end of the month. The River Kennet recorded its lowest October flow in a twenty-nine year record and the associated return period (Table 4) points to an exceptionally severe runoff drought. However, if the rarity of the annual 7-day minimum flow is examined, then the 1989 minimum flows on the Kennet would be expected perhaps once a decade. The differing frquencies reflect the fact that most recent droughts have terminated relatively early in the autumn, which may render the data series somewhat unrepresentative and tend to exaggerate the drought's intensity. Return periods of this order are fairly typical of rivers sustained largely from groundwater but flows on the Hampshire Itchen, when adjusted to allow for the impact of artificial augmentation, are remarkably low whatever basis for comparison is used. Away from the South-East, October discharge rates were generally well below average but not exceptionally so. Nonetheless a substantial proportion of catchments registered their lowest October runoff total since 1978 or earlier and accumulated runoff totals over the last 6 and 12 months testify to a significant drought event of considerable geographical extent, with the exception of western Scotland (Table 3)

Typically, reservoir gathering grounds in the west have experienced sufficient runoff to effect a transformation in some reservoir stocks, with refilling to capacity experienced in some reservoirs in mid-Wales and the South West. This is obviously dependent upon the relation between catchment area and capacity but even large reservoirs like the Elan Valley have recovered over 30% of capacity over a two week period. In the east, direct runoff has been insufficient to significantly augment surface storage, although replenishment to pumped storage reservoirs has continued.

Whilst groundwater levels through the late winter of 1988 and the early spring of 1989 were the lowest since the equivalent period of 1975-76 over wide areas, the subsequent infiltration, although limited in comparison with the winter recharge of a normal year, boosted groundwater resources at a time when a seasonal decline in levels is generally under way. Consequently, in early summer, water tables stood at about average levels in some regions (see, for example, the Compton and Rockley well hydrographs - Figure 3), although most observation boreholes showed levels somewhat below the average for June. However, only in parts of the Chalk aquifer in Sussex, Kent and Yorkshire were levels reported comparable with those registered in June 1976; increased abstraction rates (to supplement overground supplies), as well as the meteorological conditions, are an important factor in some of these localities.

Infiltration appears generally to have ceased by June 1989, and groundwater hydrographs have since followed a steady recession. By the end of October, levels were generally well below the seasonal mean, and the upturn that would have been expected by this time in a normal year had not taken place despite the heavy rainfall in the later half of the month. At the Bussells site in the Trias of south-west England, a single level at the end of the month shows an apparent rise of about 60mm, but later levels will be required to confirm that this is the beginning of the upturn. At the Compton House, Rockley and Washpit Farm sites, the upturn has not taken place and levels are still falling. At the Dalton Holme site in the Chalk of east Yorkshire, levels have fallen some 170mm beneath the minimum recorded October value and are approaching the minimum level recorded in any month in a 100 year record.

The amount of groundwater in storage in a aquifer in the early summer is dependent not only upon the volume of infiltration during the winter months (October to March) but also on the distribution during those months. If the rainfall is confined to the first half of this period, which means that infiltration will be largely confined to the same period, then the onset of the "summer" recession will be advanced to February, or even to January. The subsequent lack of infiltration will then mean that the storage will have been diminished by, say, the beginning of April (when the recession normally commences). However, the volume of water replenished to storage during a normal year is very much greater than that needed to raise water levels to average values, were it not for the continual outflow through natural discharge points; in particularly wet years, the recharge may so greatly exceed this outflow that groundwater levels build up to values greatly above the average. If the first half of the winter period is essentially dry, but average rainfall (and infiltration) occur through the latter half, then this may generally be sufficient to raise groundwater levels to average or near-average values; as a result, the volume of groundwater in storage at the beginning of April is relatively larger. These cosiderations need to tbe associated with the state of aquifer storage at the end of the summer. When SMDs are higher than normal and water levels below normal, average October to March rainfall needs to be optimally timed to ensure a return to average water level conditions in the Spring. A lack of rainfall through the last three months of 1989 will not, therefore, necessarily cause a lack of groundwater through the summer of 1990 but this observation needs qualifying by saying that SMDs were above average and water levels well below average at the end of October.

IH/BGS

15: November:1989

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

		Oct	Nov 1988	Dec	Jan	Feb	Mar 1989	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov88 -Oct	Shortfall Nov88-Oct mm
England and	mm	89	48	47	44	78	84	85	22	63	41	60	40	95	706	206
Wales	%	107	49	52	51	121	142	146	33	103	56	66	48	114	77	
Scotland	mm	170	99	149	172	239	188	71	58	84	60	181	89	173	1563	- 132
	%	114	70	96	126	230	204	79	64	91	54	140	65	116	109	
NRA REGIONS																
North West	mm	120	69	117	68	123	113	92	33	102	34	118	28	136	1032	185
	%	102	55	97	61	151	157	120	40	123	33	94	22	115	85	
Northumbrian	mm	101	74	53	32	70	55	49	25	65	19	87	21	85	635	244
	%	135	79	71	40	106	105	89	38	107	25	86	26	113	72	
Severn Trent	mm	62	38	33	35	65	69	87	23	53	37	40	37	83	600	173
	%	95	48	47	51	122	132	168	35	95	57	49	54	128	78	
Yorkshire	mm	90	55	47	24	64	63	79	24	84	38	47	19	83	627	206
	%	130	62	63	31	100	118	140	40	145	55	52	27	120	75	
Anglia	mm	52	35	22	31	34	48	74	14	62	44	37	29	43	473	137
	%	100	57	41	59	81	121	186	30	127	77	57	56	83	77	
Thames	mm	66	28	16	31	68	65	77	14	46	38	40	32	66	513	191
	%	103	38	24	50	129	141	167	25	88	63	57	51	103	73	
Southern	mm	84	32	19	29	62	75	81	11	50	32	28	29	80	528	266
	%	108	34	23	38	109	144	169	20	100	55	39	41	102	67	
Wessex	mm	101	33	22	44	89	87	74	25	33	47	45	52	103	654	215
	%	123	35	24	52	151	149	137	36	61	76	55	66	126	75	
South West	mm	144	55	59	65	135	115	92	18	38	36	63	99	141	916	208
	%	127	41	44	50	151	137	130	21	58	43	62	96	125	77	
Welsh	mm	125	69	73	80	140	151	89	23	65	49	78	57	164	1039	295
	%	97	48	50	59	146	174	103	25	79	52	66	46	127	78	

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

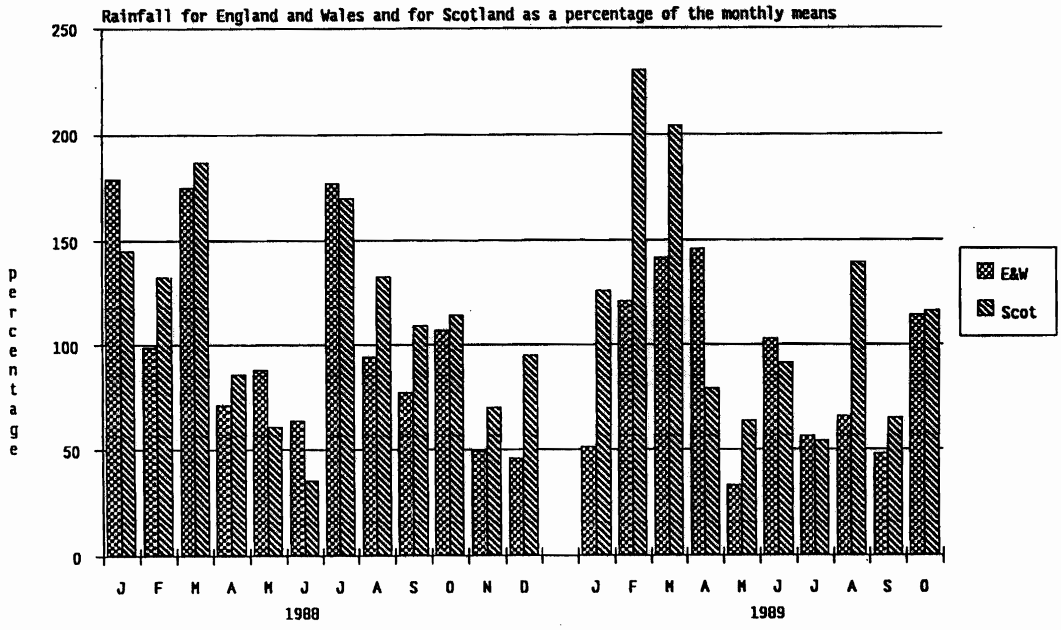
		MAY-OCT 1989	Est Return Period	NOV-OCT 1988-89	Est Return Period	APR-OCT 1988-89	Est Return Period
England and Wales	mm	320		706		1211	
	% LTA	70	10-20	77	20-30	85	10-20
Scotland	mm	645		1563		2409	
	% LTA	91	0-5	109	0-5	108	0-5
NRA REGIONS							
North West	mm	450		1032		1750	
	% LTA	71	10-20	85	5-10	91	<5
Northumbrian	mm	302		635	>50	1165	
	% LTA	66	20-50	72		84	10-20
Severn Trent	mm	273		600		1029	
	% LTA	68	10-20	78	10-20	84	10
Yorkshire	mm	295		627		1106	
	% LTA	70	10-20	75	20-50	84	10-15
Anglia	mm	229		473		818	
	% LTA	71	10-20	77	20	84	10
Thames	mm	236		513		894	
	% LTA	65	10-20	73	15-30	80	20
Southern	mm	230		528		889	
	% LTA	60	>50	67	>50	72	>50
Wessex	mm	305		654		1112	
	% LTA	71	10-20	75	20	82	10-20
South West	mm	395		916		1571	
	% LTA	72	10-15	77	10-20	87	5-10
Welsh	mm	437		1039		1783	
	% LTA	68	10-20	78	10-20	87	5-10

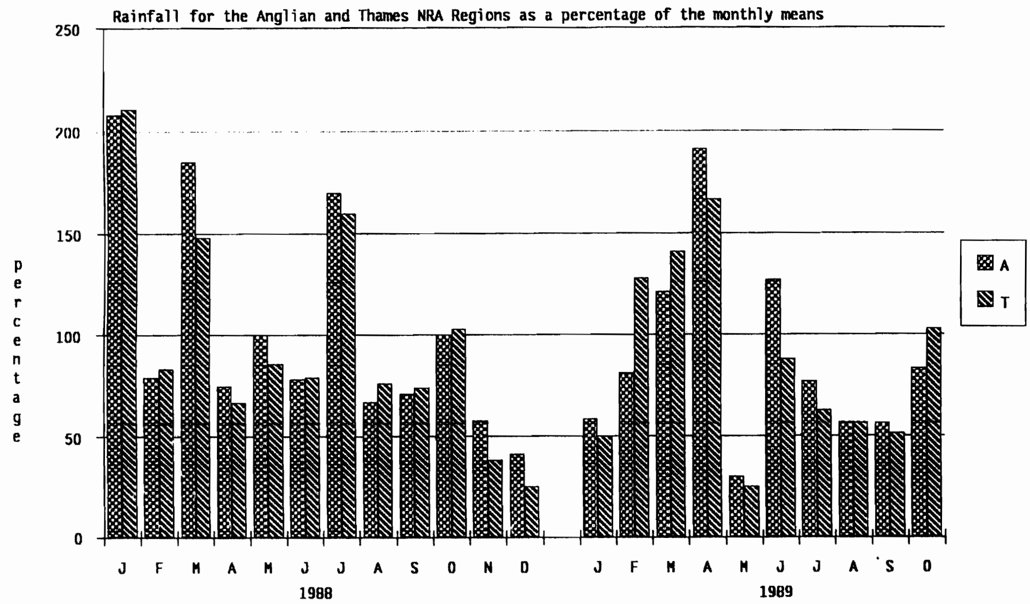
Return period assessments based on tables provided by the Meteorological Office.* These assume a start in a specified month; return periods for a start in any month may be expected to be an order of magnitude less.

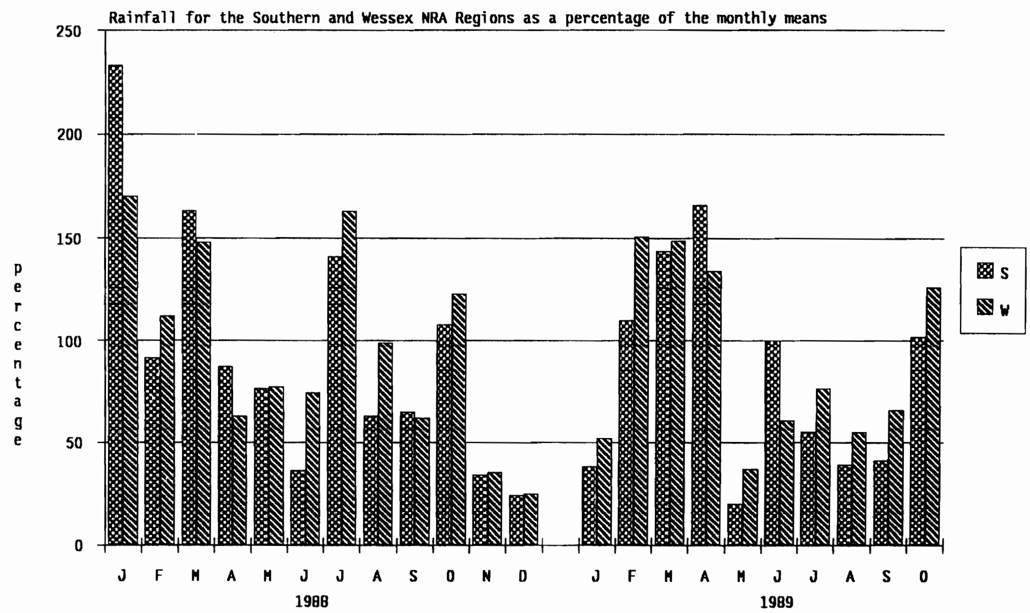
The tables reflect rainfall totals over the period 1911-70 only and the estimate assumes a sensibly stable climate.

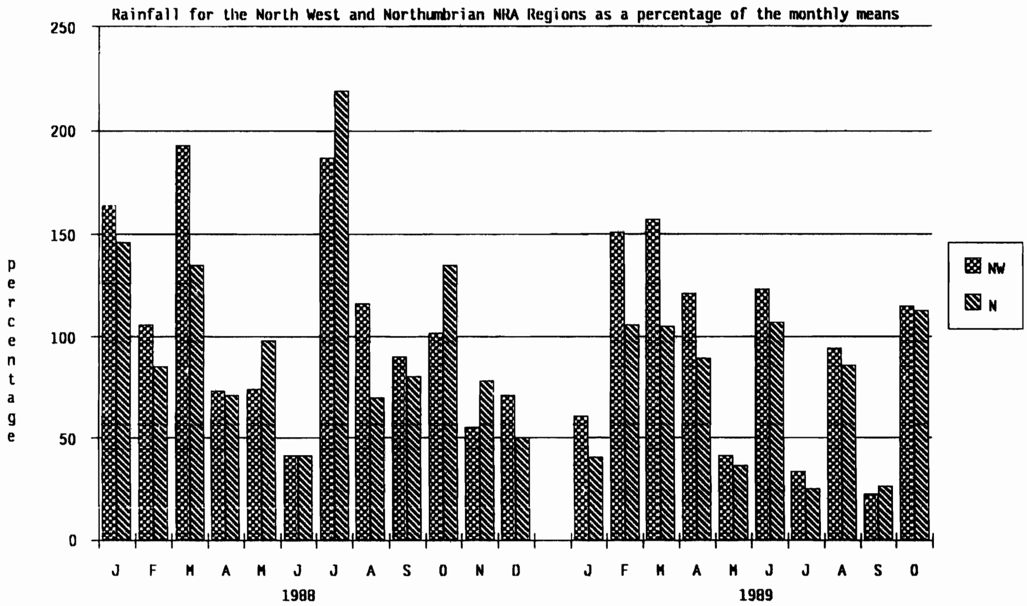
* Tabony, R C, 1977, The Variability of long-duration rainfall over Great Britain, Scientific Paper No 37, Meteorological Office (HMSO).

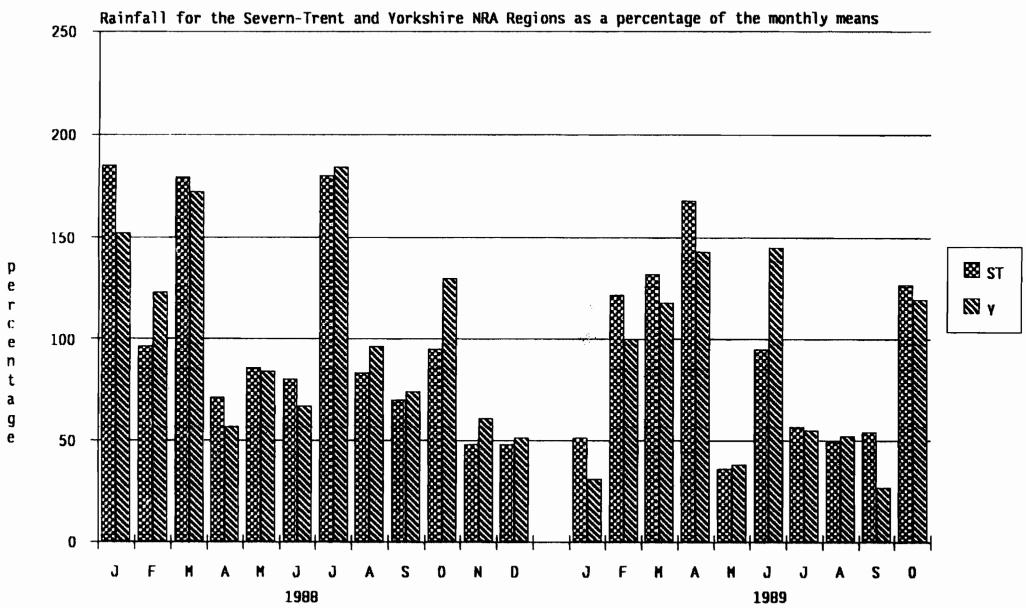
FIGURE 1.   MONTHLY RAINFALL - JANUARY 1988 TO OCTOBER 1989








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
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
1989

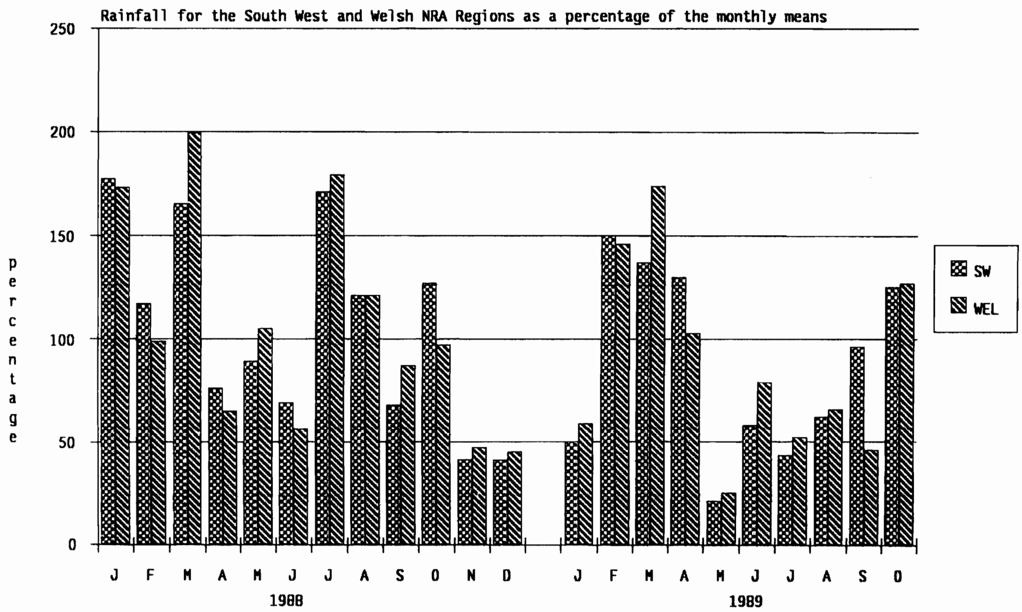
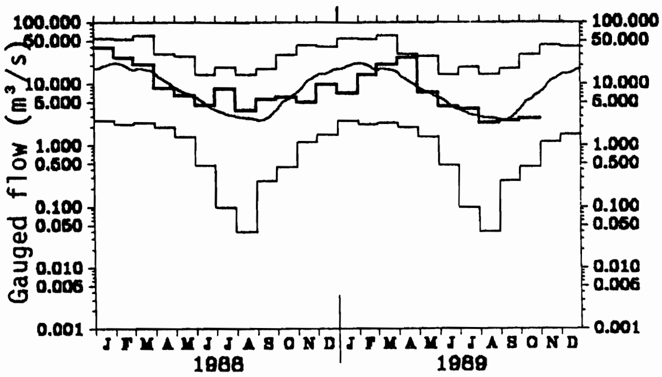

Rainfall for the South West and Welsh NRA Regions as a percentage of the monthly means
250
200
150
100
50
0
percentage
SW
WEL
J F M A M J J A S O N D
1988
J F M A M J J A S O
1989

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

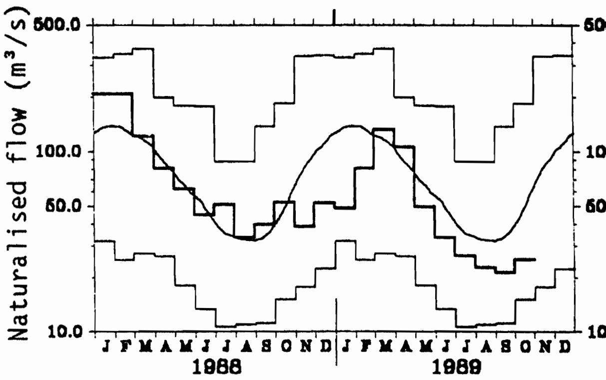
		J	F	M	A	M	J	J	A	S	O	Oct Rank	Min Oct. Year	11/88 to 10/89	rank / years	5/89 to 10/89	rank / year
Dee at	mm	62	55	116	52	48	23	11	17	29	34	4	26	570	2	162	1
Park	%	67	79	129	64	72	60	38	50	67	41	/17	1986	73	/17	57	/17
Tay at	mm	192	214	239	99	47	30	22	54	69	99	17	23	1273	31	321	10
Ballathie	%	138	201	203	120	66	66	55	104	97	89	/38	1972	115	/37	82	/37
Earn at	mm	223	219	267	86	34	16	13	43	69	95	16	24	1280	31	270	10
Kinkell Bridge	%	152	190	231	115	53	39	34	76	86	81	/42	1972	113	/39	69	/40
Tweed at	mm	104	94	140	55	25	16	11	27	29	32	4	8	644	7	140	3
Boleside	%	105	132	182	107	57	56	40	68	55	44	/29	1972	87	/28	54	/28
South Tyne at	mm	53	89	93	55	12	9	6	19	8	55	11	6	543	3	109	1
Haydon Bridge	%	54	133	111	100	32	32	20	45	15	79	/28	1972	72	/26	42	/26
Wharfe at	mm	42	64	95	71	15	13	10	14	10	39	9	11	513	2	101	2
Flint Mill Weir	%	43	87	126	131	38	51	37	33	21	60	/35	1972	71	/34	42	/34
Derwent at	mm	17	17	22	29	13	9	8	6	5	6	1	6	183	1	47	1
Buttercrambe	%	33	40	47	85	50	51	58	42	37	25	/17	1989	53	/16	44	/16
Trent at	mm	21	26	42	57	18	13	12	10	9	13	7	9	267	2	75	2
Colwick	%	41	60	103	177	70	67	74	59	52	54	/32	1959	74	/31	64	/31
Lud at	mm	15	12	16	17	15	12	10	9	8	9	7	6	153	4	63	4
Louth	%	47	33	42	50	52	56	59	64	69	72	/22	1977	56	/21	62	/21
Witham at	mm	8	8	12	31	14	8	6	4	4	5	12	2	113	5	41	10
Claypole Mill	%	30	30	45	148	87	80	84	56	63	57	/31	1964	60	/30	75	/31
Bedford Ouse at	mm	13	23	37	46	13	7	7	4	4	5	23	1	186	23	40	25
Bedford	%	36	69	117	231	98	85	117	77	80	49	/57	1959	85	/56	83	/57
Colne at	mm	13	14	23	20	6	4	5	3	5	3	3	2	114	7	26	8
Lexden	%	55	77	122	150	67	73	119	73	115	34	/31	1965	81	/30	72	/30
Mimram at	mm	9	8	10	14	11	9	9	7	6	6	4	4	109	10	48	6
Panshanger Park	%	77	68	74	110	88	82	92	77	73	71	/37	1973	87	/36	81	/37
Thames at	mm	13	20	36	28	13	9	7	6	6	7	16	4	169	23	48	23
Kingston (nat.)	%	35	61	115	124	74	71	74	68	67	52	/107	1934	69	/106	68	/107
Kennet at	mm	16	19	31	29	22	16	13	10	10	9	1	9	205	3	80	3
Theale	%	46	55	81	91	81	73	77	67	74	56	/29	1989	70	/28	73	/28
Coln at	mm	15	19	48	44	30	18	15	13	10	10	2	7	255	4	96	4
Bibury	%	29	35	89	101	89	66	70	76	69	61	/27	1976	65	/26	74	/26
Medway at	mm	7	17	27	41	7	6	4	3	4	4	3	3	135	2	28	2
Teston	%	14	46	85	185	47	60	62	41	40	21	/32	1972	49	/25	43	/28
Ouse at	mm	13	26	48	43	16	9	10	6	8	8	7	4	208	3	57	5
Gold Bridge	%	20	54	104	125	63	57	99	54	54	27	/30	1969	53	/28	54	/29
Itchen at	mm	26	26	39	40	36	23	22	21	19	21	2	20	326	2	142	3
Highbridge+Allbrook	%	53	53	74	85	84	66	71	73	71	68	/32	1959	70	/31	74	/31
Stour at	mm	19	28	57	39	15	11	8	6	6	8	2	7	231	2	54	1
Throop Mill	%	31	49	110	112	62	68	70	55	49	35	/17	1973	59	/16	57	/17
Taw at	mm	54	95	107	36	15	4	5	3	11	48	16	3	467	3	86	5
Umberleigh	%	46	114	158	79	49	24	32	15	44	75	/32	1978	68	/31	51	/31
Kenwyn at	mm	41	65	102	42	21	12	8	6	7	12	5	5	431	1	66	1
Truro	%	35	66	133	93	76	63	63	47	45	31	/22	1978	69	/21	53	/21
Tone at	mm	25	54	80	40	19	11	10	7	9	13	7	8	314	2	69	2
Bishops Hull	%	31	74	139	102	67	61	63	55	57	47	/29	1978	66	/28	59	/29
Severn at	mm	29	48	77	48	12	7	8	7	6	13	8	7	315	4	53	1
Bewdley	%	41	84	168	152	50	39	56	40	27	38	/69	1947	70	/68	41	/69
Yscir at	mm	92	130	182	72	18	10	11	8	11	90	8	9	729	2	148	3
Pontaryscir	%	62	128	165	120	40	32	49	25	22	97	/18	1972	74	/16	56	/18
Cynon at	mm	94	232	232	80	24	16	16	12	15	160	22	14	1003	6	243	7
Abercynon	%	50	182	199	105	39	38	46	23	21	132	/32	1978	82	/30	64	/30
Dee at	mm	133	215	333	129	23	34	23	34	36	226	15	29	1456	3	376	1
New Inn	%	55	136	189	125	32	57	33	35	25	113	/21	1972	80	/20	58	/20
Lune at	mm	94	167	196	82	20	14	12	44	13	121	14	12	999	7	224	3
Caton	%	64	186	203	110	39	34	23	61	14	99	/27	1972	88	/25	53	/27
Clyde at	mm	117	109	139	50	19	10	9	36	31	57	9	13	721	12	162	5
Blairston	%	115	153	196	111	52	38	36	91	54	70	/32	1972	95	/31	62	/31

FIGURE 2.   MONTHLY HYDROGRAPHS

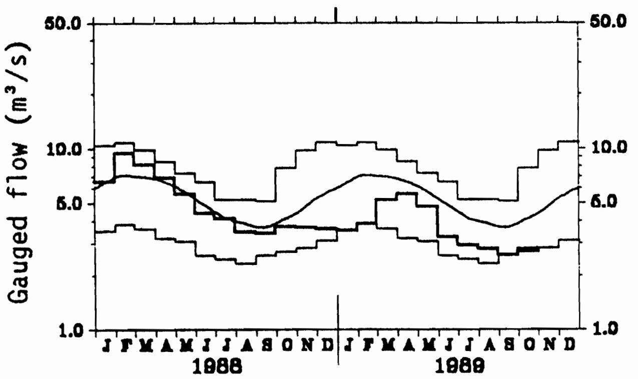
033002   Bedford Ouse at Bedford
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1933-1987



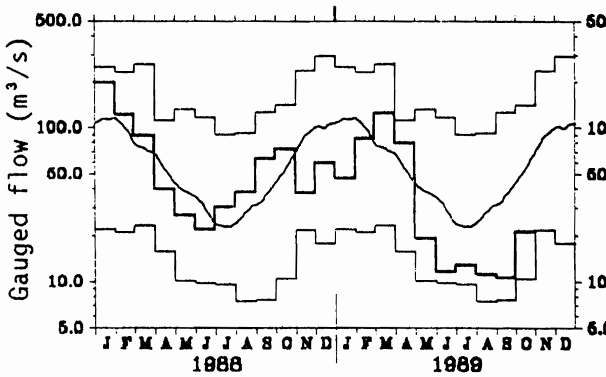
039001   Thames at Kingston
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1883-1987



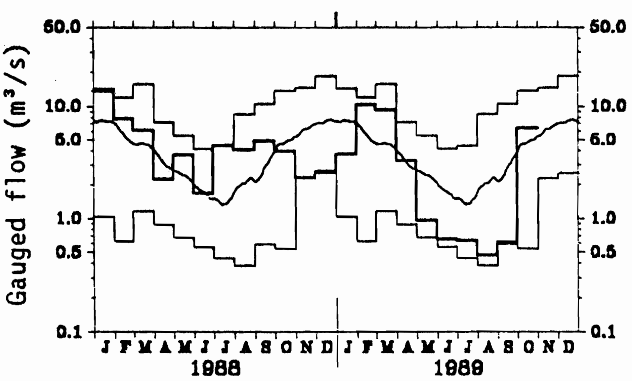
042010   Itchen at Highbridge+Allbrook
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1958-1987



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



084005   Clyde at Blairston
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1958-1987