INSTITUTE of HYDROLOGY

TOGO/BENIN POWER STUDY

HYDROLOGY

Institute of Hydrology
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1. INTRODUCTION

This annexe describes the hydrological studies which have been carried out, as an extension of the Report A studies, to provide estimates of flow characteristics throughout the study area and in particular for the priority sites. Because the regional distribution of rainfall can be studied and mapped, relationships were derived between mean runoff at gauging stations and mean rainfall over the basin. The most useful relationship was between mean runoff and mean net rainfall after subtracting evaporation from the rainfall. This could be used to make a preliminary estimate of mean runoff at ungauged sites. As the priority dam sites are in most cases situated on rivers where there are gauging stations either upstream or downstream on the same river, the relationship has been used to transfer measured runoff figures at the gauging station to equivalent flows at the dam site.

In order to provide a long and comparable period of estimated river flow at priority sites, relations between monthly rainfall totals and monthly runoff amounts have been used in a time series analysis. Simulated streamflows have been derived for each of the priority sites - nos 10A, 12, 16, 20A, 24, 25A, 29 and 49 - for use in the reservoir operation model.

In order to provide flood estimates for sites in the study area, relationships have been derived between the average of the annual maximum daily inflow floods and catchment characteristics. In most cases it has been possible to estimate this value from nearby gauging stations. Dimensionless flood frequency curves have been derived from all the reliable flood records in the area to deduce the floods corresponding to a wide range of return periods.

2. DERIVATION OF NET RAINFALL

2.1 Gross rainfall

Because rainfall is the controlling factor in water balance studies, and because it is possible to present rainfall in the form of a map, records were obtained for all rainfall stations in Togo and Benin and efforts were made to make these records as complete as possible by filling small gaps in the record by comparison with nearby stations.

Records are available at over 120 stations in the two countries, though some of these records are of short duration. Early monthly records up to 1965 have been subjected to quality control and published in ORSTOM (1968); these records and additional records up to 1973 were also available on magnetic tape and were obtained in this form by courtesy of ORSTOM. Later records were obtained in manuscript form in Lomé and Cotonou and were added to the archive on magnetic tape at the Institute of Hydrology for subsequent analysis.

The whole monthly record for each station was tabulated and the annual rainfall totals checked; where there were gaps in the record which were likely to be a small proportion of the annual rainfall, they were filled where possible by comparison with adjacent gauges in order to complete the annual record. Certain records were rejected during this comparison; for example, the record at Savé before 1937 was rejected because the earlier annual totals were grossly out of comparison with adjacent stations; the average for the period 1928-36 was 2379 mm compared with 1144 mm for 1951-80. The monthly and annual averages were calculated for the whole of each record and also for the period 1951-80 which was selected as the standard period after establishing that records for most of the months over this period were available for the stations reviewed. Details of the locations of the rainfall stations in Togo and Benin and the periods of record of each station are presented in Table A2.1. The monthly and annual averages for the standard 1951-80 period are presented in Table A2.2.

The variations in annual rainfall are illustrated in Figure A2.1 where 7 year moving averages are shown for 9 typical stations covering the whole study area. It will be observed that the pattern of variations is not very similar at the different stations, except for a period of wet years at a number of stations in the 1950s. There is, however, similarity between the patterns at the three northern stations - Mango, Natitingou and Kandi - with a dry period about 1940 and a wet period around 1954. There is some similarity between Savé and Cotonou in southern Benin - with a wet period in 1960-65. However, it is not possible to generalise about patterns or trends in rainfall over the whole area.

The 1951-80 average annual rainfall values were used to compile an isohyetal map (Figure A2.2). This map presents a similar areal pattern to other maps which have been published, and reflects a distribution which is in accord with the topography and the vegetation of the area. There is high rainfall in the extreme southeast corner of Benin, near Porto-Novo, but a tongue of much lower rainfall leading inland to the northeast from Lomé. The most important features are the high rainfall along the mountain chain between Palimé and Atakpame and a broader belt of high rainfall in the high ground south of Lama-Kara. Although the location of these areas of high rainfall is not precisely defined by the rainfall stations alone, a reasonable representation of the rainfall pattern can be deduced from the rainfall records and the topographic maps. This pattern is supported by the distribution of vegetation, which is much thicker to the north of Palimé and also in the area of Sokodé and Bafilo. Apart from these relatively small areas, the rainfall over most of Togo and Benin varies slowly and is about 1200 mm over wide areas, decreasing to below

1000 mm in the extreme north.

The seasonal rainfall pattern is of equal importance to the annual total, and varies from north to south. The seasonal pattern is illustrated by mean monthly rainfall figures for selected stations in Figure A2.3, where the stations are shown according to geographical location. There is a single wet season in the northern part of the area, which lasts from April or May to October; at most stations average rainfall exceeds about 50 mm for 7 months. Further south, at Lama-Kara, the length of the wet season increases to 8 months in terms of rainfall averages, while at Atakpame a bimodal rainfall pattern is evident from the averages. Nearer the coast, this pattern of rainfall maxima in June and October is clearer from the averages, while August represents a relatively dry period. This bimodal pattern is even more clearly revealed by the records of individual years, which show that the relatively dry period occurs further north than the averages would imply.

Thus the arealvariation of rainfall is illustrated by the isohyetal map, the seasonal pattern by the monthly averages, and variations from year to year are shown up by the 7 year moving averages. The detailed rainfall records for the whole area are stored on magnetic tape for future analysis. They have been used in this investigation in comparison with evaporation to provide net rainfall amounts which can be related to runoff.

2.2 Climate and evaporation

In order to estimate evaporation over the area, climatological records were obtained covering the elements required to estimate potential evaporation or transpiration (E_T) by the Penman method. This uses records of temperature, tension de vapeur, radiation solaire et vitesse de vent. La radiation solaire est rarement mesureé directement mais est généralement estimée sur la base des enregistrements de l'insolation.

Il existe six stations climatologiques dans chaque pays où sont réalisées les observations approprieés. Le Tableau A2.3 présente un résumé de ces stations et de la période pendant laquelle les données ont été recueillies. On a calculé l'évaporation potentielle moyenne pour chaque année où les enregistrements ont été relevés et on a fait la moyenne pour obtenir l'évaporation potentielle mensuelle moyenne; les résultats figurent également au Tableau A2.3. L'evaporation change peu d'une année a l'autre; pour les 12 stations utilisées ici, le coefficient de variation est inferieur à 5% et dans beaucoup de cas inferieur à 3%.

The seasonal distribution reflects the rainfall pattern, with evaporation lower during the wet season when lower sunshine and higher humidity occur. The annual totals are relatively high on the coast at Lomé and Cotonou, decrease slightly inland at Savé and Atakpame, and are higher in the north at Mango and Kandi.

2.3 Net rainfall

The balance between average rainfall and potential evaporation in different parts of the area is illustrated in Figure A2.4. Average monthly rainfall is compared with potential evaporation for the 12 stations at which both are available. This illustrates the way in which the varying seasonal distribution of rainfall and in particular the increasing length of the rainfall season from north to south, affects the number of months in which average rainfall exceeds potential evaporation. The relatively short period of rainfall in the northern stations results in a market season of rainfall surplus lasting 3 or 4 months on the basis of average rainfall; towards the south, at Savé and Atakpame, the surplus is less marked and there is a tendency towards two peaks. On the coast, on the other hand, at Lomé and Cotonou, the surplus is centred on the June peak in rainfall.

Because it is the balance between rainfall and evaporation which is available for soil moisture recharge and runoff, it is essential to analyse rainfall and evaporation in combination. Net rainfall may be defined as the surplus of rainfall over potential evaporation. This depends not only on the quantity of rainfall but also on its seasonal distribution, which varies not only over the area but also in individual years. It is therefore necessary to analyse the records of individual stations in individual years before generalising about the pattern of net rainfall. The use of average monthly rainfall can only provide preliminary estimates.

Because records are available on a monthly basis, rainfall and evaporation were compared on this time interval; a shorter interval, for instance 10 days, would be justified in a detailed study, but for a regional study of this nature the month was considered to be an acceptable unit. The object of the analysis was to establish for each station for each year of record the excess of rainfall over potential transpiration or net rainfall, which is the surplus water available for soil moisture recharge and for runoff.

For each station, the potential transpiration at the nearest station for which estimates were available (Table A2.3) was subtracted from each rainfall total. The transpiration total used was the mean for the calendar month, as variations from year to year are less marked for the meteorological factors which control evaporation than for rainfall. When rainfall exceeded potential transpiration in a specific month, the difference was taken as net rainfall. When potential transpiration exceeded rainfall, the net rainfall was taken as zero. In this way the complete record of gross rainfall for all stations for all years was transformed to a record of net rainfall for subsequent analysis.

For the same period 1951-80, which was used in the gross rainfall analysis, the average net rainfall was calculated for each station on a monthly and annual basis (Table A2.4). These estimates, based on individual months and years, give more representative figures than would be provided by average rainfall. The average net rainfall is given in Figure A2.5 for 30 stations covering the area of study. This illustrates the single peak of net rainfall in the north and the bimodal distribution and the longer season of surplus in the south of the area. The mean annual net rainfall for each station for the period 1951-80 was used to draw a net rainfall isohyetal map (Figure A2.6) in the same way as the gross rainfall map (Figure A2.2) was drawn.

A map of net rainfall gives an indication of the potential runoff over a country (which may include groundwater recharge if this is significant). In an area where rainfall exceeds potential transpiration throughout the year, runoff will approximate to net rainfall. Where rainfall exceeds evaporation for all but a short season and the deficit during this drier season is small, then the soil moisture storage will maintain potential transpiration through this dry season and once again runoff should equal net rainfall.

Over Togo and Benin there is a pronounced dry season, and transpiration will not continue through this dry season at the potential rate. However, the annual water balance of the area may be simplified by considering the seasonal cycle as composed of a single period of water surplus during the wet season and a single period of deficit during the remainder of the year. During the wet season, monthly rainfall exceeds potential transpiration for several months, while during the rest of the year potential transpiration exceeds rainfall except in the occasional month.

Thus the net rainfall during the wet season is closely related to runoff plus soil moisture recharge. Because soil moisture depletion during the dry season will reach wilting point, the soil moisture recharge should be reasonably constant from year to year in the absence of land use change.

In order to estimate runoff from ungauged basins, it is necessary to compare net rainfall with runoff for those basins where records are available. For this purpose one may use comparisons between basins on the basis of mean annual net rainfall (Figure A2.6) and mean annual runoff. In order to extend runoff records comparisons for individual basins on the basis of net rainfall and runoff in individual years are useful. The comparisons serve to verify records of both rainfall and runoff and also to provide means of estimating runoff from ungauged basins or of extending annual runoff figures for sites where some years of record are available.

TABLEAU A2.1

CARACTERISTIQUES DES STATIONS PLUVIOMETRIQUES

TOGO

	Station	Lat	Long	Alt m	Periode
001	Lome Aero	6°10'	1°15'	20	1949-
004	Adeta	7°08'	0°44'	270	1937-
007	Afagna	6°30'	1°37'	70	1946-
010	Agadji	7°27'	0°54'	276	1937-
013	Agbelouve	6°40'	1°10'	122	1937-
016	Agou	6°51'	0°44'	235	1900-05,1948-79
019	Agoueve	6°14'	1°07'	35	1964-
022	Akaba	7°57'	1°03'	253	1954-
025	Aklakou	6°21'	1°43'	15	1937-
028	Akoumape	6°23'	1°26'	45	1954-
031	Aledo	9°15'	1°15'	799	1934-
034	Alokouegbe	6°26'	1°05'	55	1957-
037	Amou Oblo	7°23'	0°57'	264	1962-
040	Anecho	6°14'	1°36'	11	1900-
043	Anie Mono	7°45'	1°15'	160	1948-78
046	Assahoun	6°27'	0°54'	118	1937-
049	Atakpame	7°35'	1°07'	400	1900-
052	Atilakoutse	7°19'	0°42'	900	1946-68
055	Atitogon	6°25'	1°40'	42	1937-
056	Aveve	6°24'	1°45'		1968-72
058	Baguioa	6°10'	1°22'	5	1947-
061	Barkoissi	10°32'	0°18'	163	1948-79
064	Bassari	9°15'	0°47'	315	1902-13,1927-79
067	Blitta	8°20'	0°59'	350	1937-79
070	Borgou	10°46'	0°34'	150	1954-79
073	Chra	7°11'	1°10'	142	1954-
076	Dapango-Toaga	10°53'	0°15'	230	1957-77
079	Dapango Ville	10°51'	0°12'	300	1934-79
082	Elevagnon	7°58'	1°14'	175	1956-78
085	Fassao	8°42'	0°04'	57	1954-
088	Ganave	6°18'	1°38'	15	1956-
091	Glekove	6°43'	0°49'	121	1937-
094	Gobe	7°31'	0°48'	716	1956-
096	Gravillou	10°24'	0°30'	133	1957-64
097	Guerin Kouka	9°41'	0°37'	225	1937-
100	Kabou	9°27'	0°49'	310	1948
103	Klabe				1937-
106	Kande Agro	9°55'	1°03'	280	1966-72
109	Klouto	6°57'	0°34'	576	1891-
112	Koudjravi	7°08'	0°38'	730	1937-76
115	Kougnohou	7°39'	4°47'	590	1945-
118	Koussoumtou	8°50'	1°31'	356	1955-
121	Kouve	6°40'	1°25'	150	1953-
124	Kpedji	6°32'	1°01'	63	1953
127	Kpessi	8°04'	1°17'	190	1937-
130	Kpewa-Aledjo	9°17'	1°14'	729	1956-
133	Lama-Kara	9°33'	1°11'	290	1931-

TOGO (continued)

	Station	Lat	Long	Alt m	Periode
135	Lome ORSTOM	6°07'	1°13'	5	1961-70
136	Lome Ville	6°07'	1°13'	5	1901-13,1921-
139	Malfacassa	9°10'	0°58'	525	1953-
142	Mandouri	10°51'	0°49'	140	1954-77
145	Mango	10°22'	0°28'	146	1901-
148	Mission Tove	6°19'	1°07'	52	1937-
151	Niamtougou	9°46'	1°06'	461	1955-78
154	Nuatja	6°57'	1°11'	150	1905-
157	Ogou-Klinko	8°02'	1°33'	190	1954-
158	Okou	7°34'	0°51'	680	1937-44
160	Ountivou	7°22'	1°36'	170	1955-
163	Pagouda	9°45'	1°19'	430	1934-
166	Palime	6°53'	0°39'	205	1908-
169	Sanguera	6°13'	1°13'	45	1965-
172	Saoude	9°37'	1°14'	193	1957-
175	Sokode	8°59'	1°07'	400	1901-
178	Sotouboua	8°34'	0°59'	380	1948-78
181	Tabligbo	6°35'	1°30'	51	1937-
184	Takpamba	9°58'	34'	134	1956-
187	Tchamba	9°02'	1°25'	360	1937-
190	Tchekpo	6°32'	1°22'	81	1937-
193	Tchitchao	9°38'	1°09'	340	1956-
196	Tetetou	7°01'	1°29'	60	1954-
198	Togblekove	6°16'	1°13'	15	1941-46
199	Togoville	6°14'	1°29'	16	1954-75
202	Tokpli	6°40'	1°38'	28	1954'
205	Tomegbe	7°01'	0°36'	237	1954-
207	Tsevie Brigade	6°30'	1°12'	60	1961-64
208	Tsevie Ville	6°26'	1°13'	95	1908-
211	Xantho	6°56'	1°03'	134	1934-69
214	Yegue	8°11'	0°29'	591	1934-

TABLEAU A2.1

CARACTERISTIQUES DES STATIONS PLUVIOMETRIQUES

BENIN

	Station	Lat	Long	Alt m	Periode
001	Cotonou Aero	6°21'	2°23'	4	1952-
004	Abomey	7°11'	10°59'	260	1921-
007	Adjohon	6°42'	2°29'	60	1921-
010	Allada	6°39'	2°08'	92	1921-
013	Aplahoe	6°56'	1°40'	153	1921-
016	Athieme	6°34'	1°40'	11	1921-73
019	Banikoara	11°18'	2°26'	310	1954-
022	Bante	8°26'	1°53'	264	1942-
025	Bassila	9°01'	1°40'	384	1950'
028	Bembereke	10°12'	2°40'	491	1921
031	Beterou	9°12'	2°16'	252	1953-
034	Birni	9°59'	1°31'	430	1953-
037	Bohican	7°10'	2°03'	167	1940-
040	Bonou	6°56'	2°30'	10	1964-
043	Bopa	6°34'	1°58'	50	1921-
046	Boukombe	10°10'	1°06'	247	1923-
049	Cotonou ville	6°21'	2°26'	5	1910-
052	Dassa-Zoume	7°45'	2°10'	155	1941-
055	Djougou	9°42'	1°40'	439	1921-
058	Dogbo-Tota	6°45'	1°47'	70	1953-
061	Grand-Popo	6°17'	1°49'	5	1921-
063	Guene	11°44'	3°13'	215	1929-42
064	Ina	9°58'	2°44'	358	1947-
067	Kalale	10°18'	3°23'	410	1957-
070	Kandi	11°08'	1°56'	290	1921-
073	Kerou	10°50'	2°06'	314	1959-
076	Ketou	7°21'	2°36'	118	1950-
079	Kouande	10°20'	1°41'	442	1931-
082	Lonkly	7°09'	1°39'	110	1955-
085	Malanville	11°52'	3°24'	160	1942-
088	Natitingou	10°19'	1°23'	460	1921-
091	Niaouli	6°42'	2°07'	105	1941-
094	Nikki	9°56'	3°12'	402	1921-
097	Okpara	9°18'	2°44'	295	1956-
100	Ouesse	8°30'	2°23'	233	1964-
103	Ouidah	6°22'	2°06'	10	1921-
106	Parakou	9°21'	2°36'	392	1905-
109	Pobe	6°56'	2°40'	129	1921-
112	Porga	11°02'	0°58'	160	1964-
115	Porto-Novo	6°29'	2°37'	20	1896-
118	Sakete	6°43'	2°40'	69	1921-
121	Savalou	7°56'	1°59'	174	1921-
124	Save	8°02'	2°29'	198	1937-
127	Segbana	10°56'	3°42'	277	1954-
130	Seme	6°22'	2°38'	4	1943-
133	Tanquieta	10°37'	1°16'	225	1937-
136	Tchaourou	8°52'	2°36'	325	1937-76

BENIN (continued)

	Station	Lat	Long	Alt m	Periode
139	Tchetti	7°49'	1°40'	353	1964-
142	Toffo	6°50'	2°03'	60	1952-
145	Toui	8°41'	2°36'	316	1944-
148	Zagnando	7°15'	2°20'	102	1921-

TABLEAU A2.2

PRECIPITATION MOYENNE, 1951-80 (mm)

TOGO

	Station	J	F	M	A	M	J	J	A	S	O	N	D	Total
001	Lome Aero	14	30	67	97	147	255	84	28	48	98	21	8	898
004	Adeta	26	54	123	181	163	197	155	127	205	176	51	30	1487
007	Afagna	13	27	98	115	158	214	102	43	89	150	74	21	1104
010	Agadji	21	56	105	159	170	233	234	185	255	169	54	23	1663
013	Agbelouve	16	48	115	142	157	182	92	54	131	134	38	28	1136
016	Agou	32	57	131	142	149	237	174	121	164	145	66	40	1460
019	Agoueve	12	32	64	126	132	217	93	34	56	68	22	6	862
022	Akaba	6	17	76	106	125	172	165	147	184	91	19	15	1124
025	Aklakou	14	31	61	113	157	262	114	29	55	120	39	18	1011
028	Akoumape	12	21	79	115	130	205	81	33	73	102	43	16	910
031	Aledo	8	10	60	104	138	204	288	300	312	144	29	5	1600
034	Alokouegbe	23	46	100	142	166	232	99	63	112	108	48	23	1162
037	Amou Oblo	15	46	100	174	168	203	191	185	194	142	33	25	1475
040	Anecho	8	35	64	117	161	287	110	34	59	109	36	13	1032
043	Anie Mono	9	23	86	112	128	181	181	136	182	117	24	16	1195
046	Assahoun	18	53	126	128	157	218	78	43	122	154	57	32	1184
049	Atakpame	11	39	96	128	146	198	212	168	193	141	33	12	1377
052	Atilakoutse	30	49	144	172	164	265	220	201	264	201	74	30	1815
055	Atitogon	11	24	81	103	145	208	89	39	61	115	47	23	946
056	Aveve	8	42	77	69	147	227	91	32	55	88	60	4	898
058	Baguida	12	23	61	115	156	264	74	30	40	94	23	8	900
061	Barkoissi	1	3	22	61	108	124	191	230	231	71	9	5	1056
064	Bassari	5	10	54	88	129	200	211	193	303	189	34	12	1428
067	Blitta	10	25	77	114	133	168	208	208	238	129	18	9	1336
070	Borgou	0	2	18	64	98	164	181	264	233	62	7	1	1095
073	Chra	21	41	93	143	147	166	123	106	159	137	27	26	1187
076	Dapango-Toaga	0	5	15	46	114	136	190	276	212	55	6	1	1057
079	Dapango Ville	0	4	16	54	112	134	192	265	209	68	3	1	1058
082	Elevagnon	5	18	80	115	131	182	179	158	166	104	24	10	1173
085	Fassao	11	26	63	104	156	190	192	186	242	149	29	15	1365
088	Ganave	5	26	53	115	150	277	102	29	57	85	35	16	951
091	Glekove	33	54	116	130	143	172	104	64	143	143	44	24	1170
094	Gobe	16	36	132	122	138	196	186	199	245	138	40	21	1468
096	Gravillou	0	6	17	53	94	122	170	196	254	68	8	4	992
097	Guerinkouka	3	7	32	71	125	158	174	219	268	155	21	7	1240
100	Kabou	6	13	48	87	136	180	195	212	286	164	28	9	1364
103	Klabe	2	6	35	75	121	164	205	234	268	124	19	8	1261
106	Kande Agro	1	8	57	68	145	152	261	272	294	144	10	17	1427
109	Klouto	38	65	150	158	174	240	190	144	212	196	85	48	1699
112	Koudjravi	18	43	119	132	153	174	151	139	189	178	69	35	1401
115	Kougnohou	10	35	118	130	133	215	171	155	237	120	27	25	1376
118	Koussoumtou	8	14	50	96	132	145	230	221	217	116	12	5	1246
121	Kouve	12	50	100	133	138	151	91	58	124	130	39	18	1044
124	Kpedji	23	59	125	146	144	186	88	53	121	144	53	30	1173
127	Kpessi	6	20	82	103	111	165	170	142	169	104	27	14	1113
130	Kpewa-Aledjo	5	15	65	112	143	209	253	289	316	123	29	10	1570
133	Lama-Kara	3	10	45	89	130	175	236	247	266	122	16	6	1346

TOGO (continued)

	Station	J	F	M	A	M	J	J	A	S	O	N	D	Total
135	Lome (ORSTOM)	13	10	59	115	140	312	103	39	48	60	28	8	935
136	Lome Ville	12	28	63	106	142	245	78	26	39	88	25	8	859
139	Malfacassa	7	18	56	100	144	194	230	244	295	196	33	14	1531
142	Mandouri	2	3	16	49	98	149	152	246	221	52	5	1	994
145	Mango	0	4	22	59	124	139	196	244	241	85	10	4	1128
148	Mission Tove	16	37	91	122	137	190	100	38	107	131	65	21	1054
151	Niamtougou	3	10	46	98	157	198	217	253	301	158	33	7	1481
154	Nuatja	28	42	117	126	142	187	120	95	164	115	43	17	1195
157	Ogou-Klinko	19	21	74	119	128	170	196	166	172	108	27	6	1207
160	Ountivou	12	15	55	93	113	154	124	95	112	112	20	6	911
163	Pagouda	2	12	37	88	122	180	262	272	297	119	18	8	1417
166	Palime	27	60	122	154	164	226	159	106	205	160	68	38	1491
169	Sanguera	23	41	63	116	108	162	92	50	71	90	55	17	887
172	Saoude	3	12	48	98	132	188	236	293	264	134	29	9	1445
175	Sokode	8	20	63	102	148	202	245	250	274	131	21	13	1477
178	Sotouboua	9	22	70	113	139	173	211	179	217	117	25	11	1285
181	Tabligbo	14	38	106	136	150	175	80	47	111	147	57	20	1081
184	Takpamba	2	8	27	69	103	126	174	198	258	120	14	5	1104
187	Tchamba	9	22	70	113	139	173	211	179	217	117	25	11	1285
190	Tchekpo	14	40	97	130	155	198	108	68	131	140	54	19	1154
193	Tchitchao	1	11	56	91	151	179	216	240	280	140	26	4	1396
196	Tetetou	9	36	105	127	129	177	117	74	149	110	40	10	1085
199	Togoville	8	21	70	115	158	282	94	41	45	95	22	13	964
202	Tokpli	6	26	106	132	156	194	111	64	129	163	48	16	1150
205	Tomegbe	14	43	129	138	165	194	188	155	237	159	55	32	1509
207	Tsevie Brigade	5	9	92	127	204	262	188	66	113	111	54	31	1262
208	Tsevie Ville	15	35	104	122	139	207	92	44	107	135	45	22	1068
211	Xantho	31	39	123	148	152	176	118	88	149	118	49	26	1213
214	Yegue	4	36	97	119	141	188	172	158	251	127	32	21	1347

TABLEAU A2.2

PRECIPITATION MOYENNE, 1951-80 (mm)

BENIN

	Station	J	F	M	A	M	J	J	A	S	O	N	D	Total
001	Cotonou Aero	17	37	90	136	201	367	151	48	86	139	55	17	1345
004	Abomey	6	30	92	128	149	189	140	80	147	129	33	9	1134
007	Adjohon	11	24	83	129	176	239	123	57	98	138	48	16	1141
010	Allada	14	38	97	109	152	228	102	52	94	154	68	17	1125
013	Aplahoue	8	40	95	137	145	178	115	74	146	136	30	11	1114
016	Athieme	12	27	94	124	147	213	91	44	104	156	57	21	1089
019	Banikoara	0	2	5	32	102	139	186	300	194	48	4	2	1015
022	Bante	5	16	70	102	141	152	197	172	181	122	16	10	1183
025	Bassila	8	10	44	93	130	152	216	211	215	107	9	8	1204
028	Bembereke	3	3	20	68	129	158	233	251	252	85	3	3	1207
031	Beterou	7	14	39	85	126	168	182	208	196	110	14	8	1159
034	Birni	1	7	28	74	111	162	236	288	264	84	13	7	1274
037	Bohican	8	32	92	144	153	185	136	95	149	141	32	14	1181
040	Bonou	9	28	71	150	168	198	120	85	110	138	34	12	1122
043	Bopa	12	26	78	114	138	212	104	40	83	112	48	10	977
046	Boukombe	1	4	24	61	100	130	192	226	242	103	14	7	1104
049	Cotonou	21	38	93	135	210	370	161	50	86	143	52	16	1375
052	Dassa-Zoume	13	22	85	126	142	184	177	122	176	118	24	8	1197
055	Djougou	2	8	34	97	137	172	274	247	268	99	6	6	1350
058	Dogbo-Tota	8	30	110	119	153	181	107	67	123	134	47	13	1091
061	Grand-Popo	12	37	67	119	153	291	93	33	46	112	28	19	1008
064	Ina	6	6	25	81	139	161	220	246	257	106	12	3	1262
067	Kalale	2	7	20	66	135	155	196	262	245	72	10	2	1171
070	Kandi	0	2	10	37	106	160	205	293	228	46	1	0	1090
073	Kerou	2	3	19	38	109	151	256	278	194	50	4	4	1109
076	Ketou	16	29	71	133	162	175	132	87	137	146	22	11	1120
079	Kouande	2	5	25	82	121	170	235	252	284	88	12	3	1279
082	Lonkly	17	39	94	149	153	174	133	115	164	129	46	17	1229
085	Malanville	0	2	6	19	64	135	180	248	170	30	1	0	855
088	Natitingou	2	6	27	89	124	164	232	274	296	133	18	5	1369
091	Niaouli	14	41	110	124	167	238	95	57	112	184	60	13	1215
094	Nikki	4	4	20	75	146	165	196	223	228	82	8	3	1153
097	Okpara	3	9	41	100	127	172	185	201	225	108	8	8	1188
100	Ouesse	16	22	58	88	122	132	123	143	186	128	8	12	1038
103	Ouidah	12	26	82	119	181	323	133	49	82	126	40	13	1186
106	Parakou	4	13	42	91	126	180	189	191	223	104	8	9	1180
109	Pobe	17	39	105	150	188	196	113	68	129	165	35	9	1213
112	Porga	0	1	13	34	87	126	164	239	178	24	2	0	868
115	Porto-Novo	22	42	93	118	217	360	179	66	119	166	72	21	1475
118	Sakete	18	35	99	127	182	250	108	67	122	189	79	17	1292
121	Savalou	10	16	87	112	137	161	177	137	184	125	25	8	1179
124	Save	8	18	81	114	132	161	182	129	162	125	26	6	1144
127	Segbana	1	2	8	48	101	149	197	338	231	50	8	0	1132
130	Seme	25	38	83	144	227	427	186	64	123	168	58	19	1562
133	Tanquieta	0	4	20	54	105	142	183	238	259	95	10	6	1115
136	Tchaourou	7	14	63	95	129	160	191	185	200	146	14	10	1214

BENIN (continued)

	Station	J	F	M	A	M	J	J	A	S	O	N	D	Total
139	Tchetti	16	25	73	132	125	162	195	165	149	98	7	13	1161
142	Toffo	11	36	100	132	147	181	98	55	114	162	39	9	1084
145	Toui	8	18	67	107	133	156	174	148	186	149	22	7	1176
148	Zagnando	8	26	80	125	156	190	113	76	127	130	33	8	1071

TABLEAU A2.3

EVAPORATION POTENTIELLE (mm)

(E_T)

BENIN	J	F	M	A	M	J	J	A	S	O	N	D	Année
COTONOU (1971-80)	139	149	173	164	150	120	132	133	137	143	146	136	1722
BOHICON (1971-80)	141	149	163	151	144	118	113	110	116	132	139	137	1613
SAVE (1971-80)	146	149	167	153	147	120	110	102	106	123	135	136	1594
PARAKOU (1971-80)	176	175	197	181	160	129	117	109	115	131	151	162	1802
NATITINGOU (1971-80)	163	161	184	173	158	138	122	116	121	135	143	147	1761
KANDI (1971-80)	168	177	212	209	193	163	146	133	139	160	153	155	2008
TOGO													
LOME (1971-80)	137	140	162	151	140	110	117	123	127	140	139	129	1615
TABLIGBO (1976-80)	131	130	148	142	133	105	103	105	112	117	122	122	1470
ATAKPAME (1971-80)	150	144	157	144	136	111	102	101	100	123	135	141	1548
SOKODE (1971-80)	156	156	166	150	137	116	103	99	105	125	136	142	1591
LAMA KARA (1977-80)	196	194	203	154	158	132	114	112	115	132	151	177	1838
MANGO (1971-80)	187	184	204	188	172	140	122	114	117	140	150	165	1883

Note: Les valeurs sont arrondies de sorte que la somme des valeurs mensuelles ne correspond pas nécessairement et exactement au total annuel.

TABLEAU A2.4

PRECIPITATION NETTE MOYENNE, 1951-80 (mm)

TOGO

	Station	J	F	M	A	M	J	J	A	S	O	N	D	Total
001	Lome Aero	0	2	1	7	32	149	25	1	2	16	0	0	236
004	Adeta	0	0	11	49	42	91	71	56	107	61	0	0	489
007	Afagna	0	0	8	14	41	115	36	8	20	47	12	0	302
010	Agadji	0	4	6	38	49	124	140	106	156	58	5	0	685
013	Agbelouve	0	0	9	24	41	79	18	4	42	32	1	3	252
016	Agou	0	1	12	16	31	128	90	44	73	34	2	0	430
019	Agoueve	0	5	0	16	24	111	24	0	7	3	0	0	190
022	Akaba	0	0	1	8	14	64	75	64	86	11	1	0	323
025	Aklakou	0	0	1	10	38	158	47	4	5	25	0	0	288
028	Akoumape	0	0	8	5	23	99	16	1	8	10	0	0	170
031	Aledo	0	0	0	3	6	79	174	189	196	40	0	0	688
034	Alokouegbe	0	0	5	26	44	133	33	13	36	14	0	0	304
037	Amou Oblo	0	0	0	37	46	94	93	100	94	34	0	0	498
040	Anecho	0	1	1	11	37	179	46	9	4	10	0	0	298
043	Anie Mono	0	0	3	7	18	72	90	51	83	24	0	0	348
046	Assahoun	0	3	23	16	36	115	19	4	33	49	7	0	304
049	Atakpame	0	0	4	15	27	90	120	85	96	37	0	0	472
052	Atilakoutse	0	1	19	41	41	155	129	116	164	79	8	0	754
055	Atitogon	0	0	4	7	29	103	30	6	1	13	0	0	194
056	Aveve													
058	Baguida	0	0	3	7	39	159	19	3	1	15	0	0	245
061	Barkoissi	0	0	0	0	1	13	75	124	114	3	0	0	330
064	Bassari	0	0	0	3	6	74	104	87	188	68	0	0	530
067	Blitta	0	0	0	10	19	58	110	112	135	33	0	0	478
070	Borgou	0	0	0	3	2	46	66	159	116	0	0	0	391
073	Chra	0	0	4	24	29	59	44	38	63	33	0	0	295
076	Dapango-Toaga	0	0	0	0	2	17	76	171	96	2	0	0	363
079	Dapango Ville	0	0	0	0	1	22	74	160	93	3	0	0	352
082	Elevagnon	0	0	2	13	16	75	86	73	68	14	0	0	347
085	Fassao	0	0	2	2	36	77	93	94	137	42	1	0	485
088	Ganave	0	0	0	6	35	177	35	4	7	6	0	0	272
091	Glekove	3	2	12	13	30	73	34	11	42	41	0	0	259
094	Gobe	0	0	20	10	26	93	100	112	147	36	0	0	546
096	Gravillou	0	0	0	0	21	8	59	97	136	5	0	0	326
097	Guerin Kouka													
100	Kabou	0	0	0	1	10	54	90	107	171	43	0	0	477
103	Klabe	0	0	0	0	7	36	87	119	146	22	0	0	417
106	Kande Agro													
109	Klouto	0	0	18	32	53	129	99	65	113	78	7	0	594
112	Koudjravi	0	0	6	12	32	65	62	68	90	61	3	0	399
115	Kougnohou	0	2	14	18	20	104	79	72	137	30	0	0	476
118	Koussoumtou	0	0	0	4	21	39	128	124	114	21	0	0	451
121	Kouve	0	2	8	23	29	54	30	7	36	32	4	0	225
124	Kpedji	0	1	20	21	37	85	25	11	32	39	0	0	272
127	Kpessi	0	0	2	7	10	61	78	58	72	14	0	0	303
130	Kpewa-Aledjo	0	0	0	13	13	82	140	180	201	33	0	0	661
133	Lama-Kara	0	0	0	4	5	50	126	138	152	19	0	0	494

TOGO (continued)

	Station	J	F	M	A	M	J	J	A	S	O	N	D	Total
135	Lome (ORSTOM)	O	O	O	7	24	204	34	5	7	2	O	O	283
136	Lome Ville	O	1	O	4	23	141	18	3	1	10	O	O	201
139	Malfacassa	O	O	O	3	17	65	120	135	181	82	O	O	603
142	Mandouri	O	O	O	O	6	36	44	140	103	O	O	O	329
145	Mango	O	O	O	O	9	18	80	138	124	8	O	O	376
148	Mission Tove	O	O	4	7	23	84	30	4	23	23	2	O	201
151	Niamtougou	O	O	O	4	19	70	108	142	186	47	O	O	577
154	Nuatja	O	O	8	14	28	79	44	32	72	23	O	O	302
157	Ogou-Klinko	O	O	6	9	23	67	111	87	83	21	O	O	408
160	Ountivou	O	O	1	4	14	53	48	28	35	26	O	O	209
163	Pagouda	O	O	O	1	6	59	150	160	184	25	O	O	583
166	Palime	O	5	10	28	44	117	78	36	109	48	6	O	480
169	Sanguera	2	2	O	12	9	61	20	10	13	9	O	O	139
172	Saoude	O	O	O	2	7	64	124	182	149	27	O	O	554
175	Sokode	O	1	2	4	26	89	144	152	169	29	O	O	616
178	Sotouboua	O	O	5	2	26	62	109	86	113	20	O	O	424
181	Tabligbo	O	2	10	24	35	73	16	4	29	43	3	O	239
184	Takpamba	O	O	O	O	4	17	70	97	142	19	O	O	348
187	Tchamba	O	O	O	4	24	48	119	141	129	28	O	O	494
190	Tchekpo	O	2	6	17	37	96	40	21	54	40	4	O	318
193	Tchitchao	O	O	O	1	13	50	108	132	165	36	O	O	504
196	Tetetou	O	O	4	17	23	71	45	20	59	14	O	O	252
199	Togoville	O	O	O	12	34	174	30	12	1	11	O	O	274
202	Tokpli	O	O	8	22	43	93	46	16	44	58	O	O	330
205	Tomegbe	O	O	8	18	41	84	96	76	137	52	7	O	519
207	Tsevie Brigade	O	O	3	5	71	157	89	7	39	17	O	O	387
208	Tsevie Ville	O	O	11	16	27	103	30	5	24	37	O	O	252
211	Xantho	O	O	8	25	29	69	41	30	57	18	O	O	278
214	Yegue	O	O	3	5	21	72	76	70	146	21	O	O	413

TABLEAU A2.4

PRECIPITATION NETTE MOYENNE, 1951-80 (mm)

BENIN

	Station	J	F	M	A	M	J	J	A	S	O	N	D	Total
001	Cotonou Aero	0	0	5	10	56	247	69	11	10	26	1	0	436
004	Abomey	0	0	1	18	27	73	45	15	47	25	0	0	252
007	Adjohon	0	0	3	18	44	122	42	17	20	29	1	0	297
010	Allada	0	0	1	5	32	114	35	16	20	39	3	0	266
013	Aplahoue	0	0	8	18	33	65	36	19	51	32	0	0	261
016	Athieme	0	0	1	8	22	97	24	9	24	42	0	0	227
019	Banikoara	0	0	0	0	0	8	45	166	59	1	0	0	280
022	Bante	0	0	0	6	16	42	96	78	82	27	0	0	348
025	Bassila	0	0	0	1	20	44	116	116	111	18	0	0	427
028	Bembereke	0	0	0	0	7	19	91	120	119	4	0	0	360
031	Beterou	0	0	0	1	7	54	78	104	87	18	0	0	350
034	Birni	0	0	0	2	4	27	115	172	142	6	0	0	478
037	Bohican	0	0	2	20	28	69	45	26	45	34	0	0	269
040	Bonou	0	0	2	28	41	84	35	26	23	23	0	0	263
043	Bopa	0	0	0	9	21	98	39	4	17	13	0	0	203
046	Boukombe	0	0	0	0	5	19	76	110	121	8	0	0	339
049	Cotonou	0	1	6	15	67	250	73	13	6	28	3	0	463
052	Dassa-Zoume	0	0	1	14	15	70	80	38	78	19	0	0	316
055	Djougou	0	0	0	5	15	50	160	136	154	20	0	0	540
058	Dogbo-Tota	0	0	8	8	33	70	32	16	33	32	0	0	234
061	Grand-Popo	0	0	0	8	22	176	28	0	0	14	0	0	256
064	Ina	0	0	0	0	16	40	107	138	143	17	0	0	461
067	Kalale	0	0	0	5	7	19	59	130	107	1	0	0	329
070	Kandi	0	0	0	0	4	18	64	160	91	2	0	0	339
073	Kerou	0	0	0	0	0	14	110	145	66	4	0	0	339
076	Ketou	0	0	0	15	37	63	44	20	40	36	0	0	255
079	Kouande	0	0	0	3	6	40	114	138	163	7	0	0	471
082	Lonkly	0	0	6	27	33	62	50	42	59	30	0	0	309
085	Malanville	0	0	0	0	1	10	47	116	39	0	0	0	213
088	Natitingou	0	0	0	6	10	39	112	160	175	26	0	0	528
091	Niaouli	0	0	7	10	41	121	24	13	32	62	1	0	312
094	Nikki	0	0	0	5	17	42	85	116	113	7	0	0	386
097	Okpara	0	0	0	4	8	54	78	96	112	14	0	0	366
100	Ouesse	0	0	2	0	11	25	33	50	83	20	0	0	225
103	Ouidah	0	0	6	6	46	205	64	17	16	20	0	0	380
106	Parakou	0	0	0	2	10	60	80	83	110	12	0	0	355
109	Pobe	0	0	4	23	55	82	31	13	33	41	0	0	283
112	Porga	0	0	0	0	2	17	55	133	75	0	0	0	282
115	Porto-Novo	0	0	8	9	76	240	84	26	23	43	1	0	509
118	Sakete	0	0	9	15	46	135	31	21	28	68	3	0	356
121	Savalou	0	0	6	8	17	45	83	53	80	21	0	0	314
124	Save	0	0	1	8	16	49	85	49	62	22	0	0	292
127	Segbana	0	0	0	0	0	15	56	205	92	0	0	0	368
130	Seme	0	0	4	22	83	307	91	24	31	47	0	0	609
133	Tanquieta	0	0	0	0	1	18	67	122	138	10	0	0	356
136	Tchaourou	0	0	0	1	6	40	92	86	88	36	0	0	347

BENIN (continued)

	Station	J	F	M	A	M	J	J	A	S	O	N	D	Total
139	Tchetti	0	0	9	13	16	44	92	65	50	14	0	0	302
142	Toffo													
145	Toui	0	0	0	9	20	42	74	58	84	44	0	0	332
148	Zagnando													

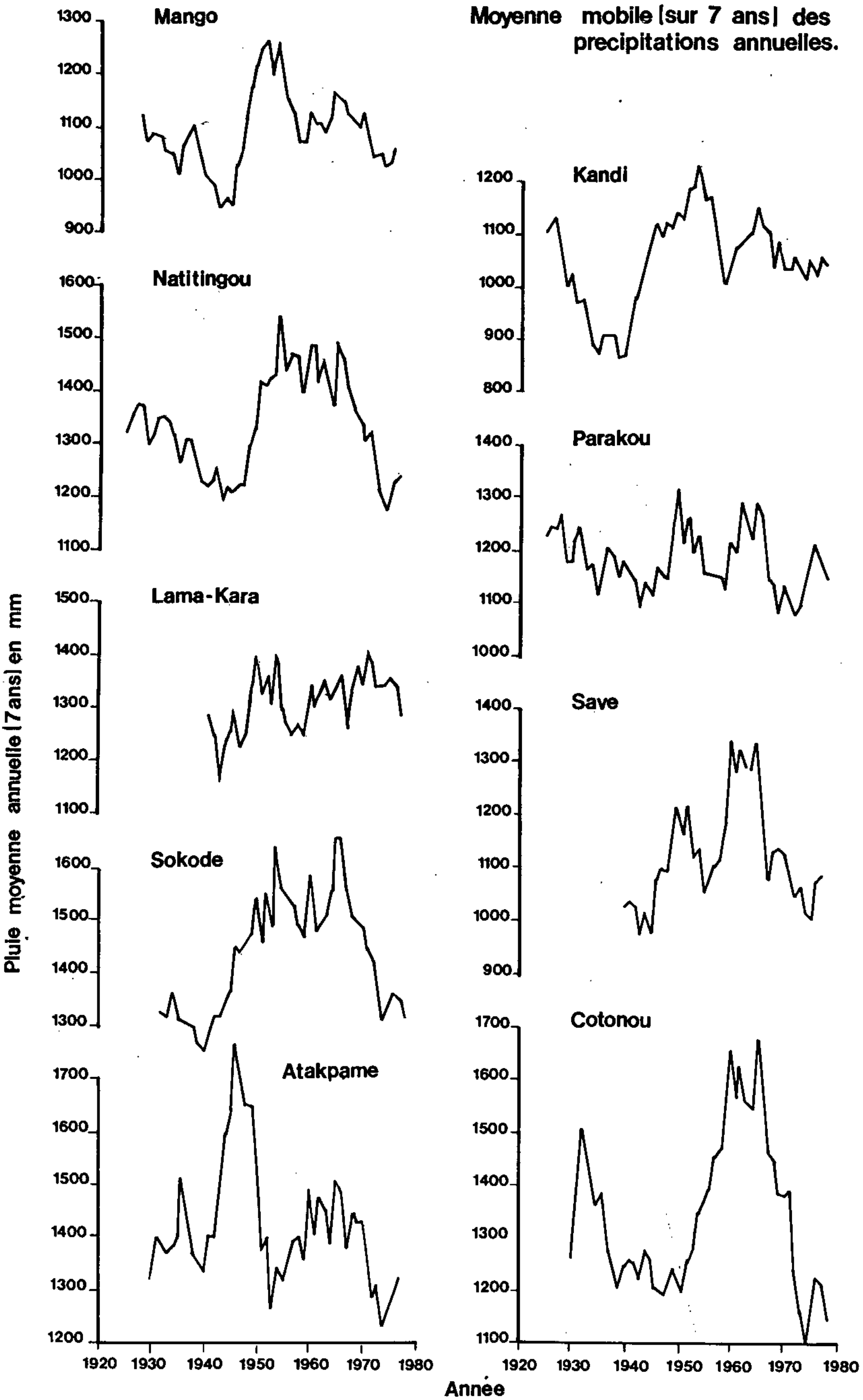

Moyenne mobile (sur 7 ans) des precipitations annuelles.
Mango
Natitingou
Lama-Kara
Sokode
Atakpame
Kandi
Parakou
Save
Cotonou
Pluie moyenne annuelle (7ans) en mm
Année
1920
1930
1940
1950
1960
1970
1980

Figure A2.1

Precipitations moyennes mensuelles et annuelles (1951-80)

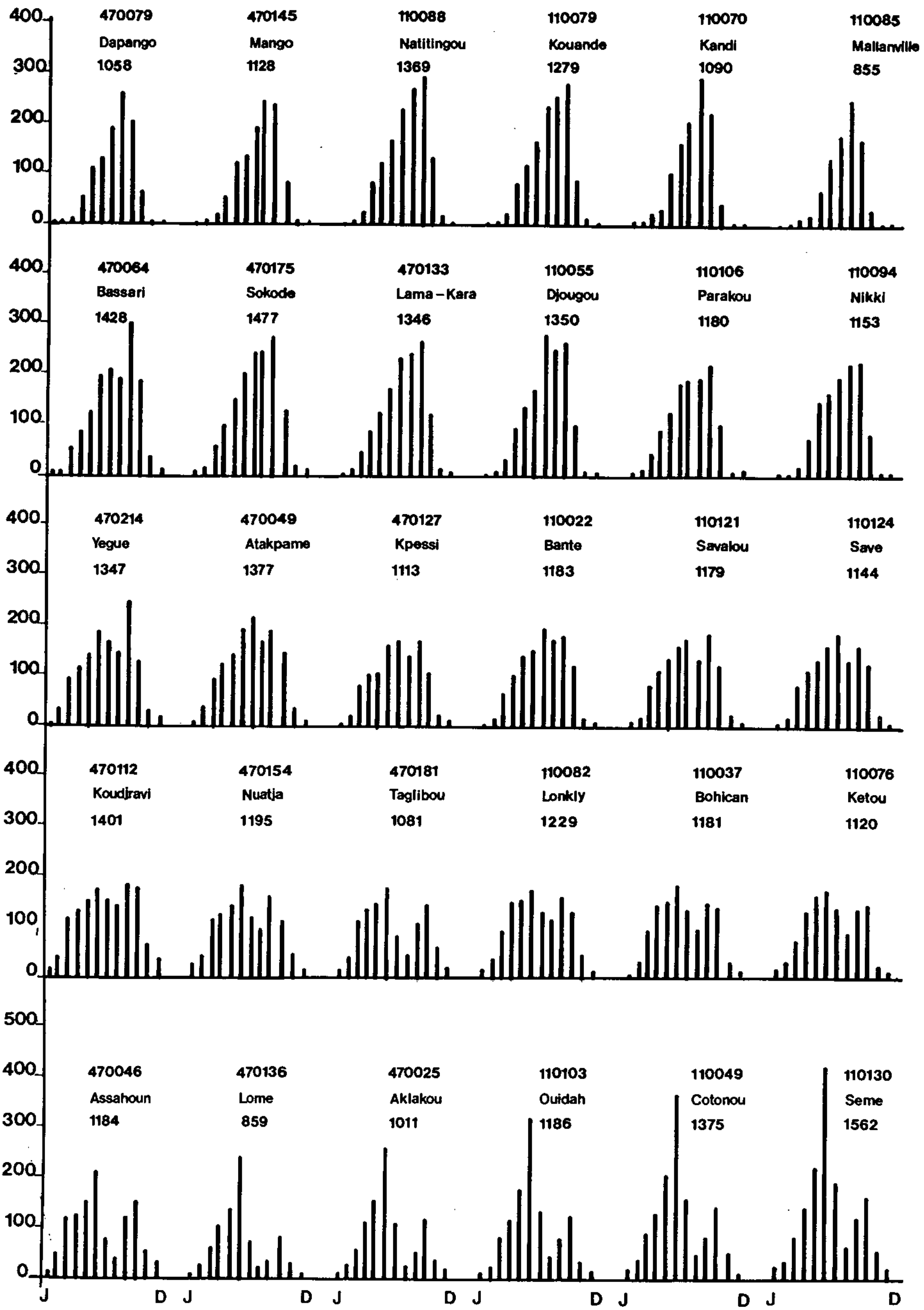


Figure A2.3

Precipitation moyenne mensuelle et evaporation potentielle [ET] [mm]

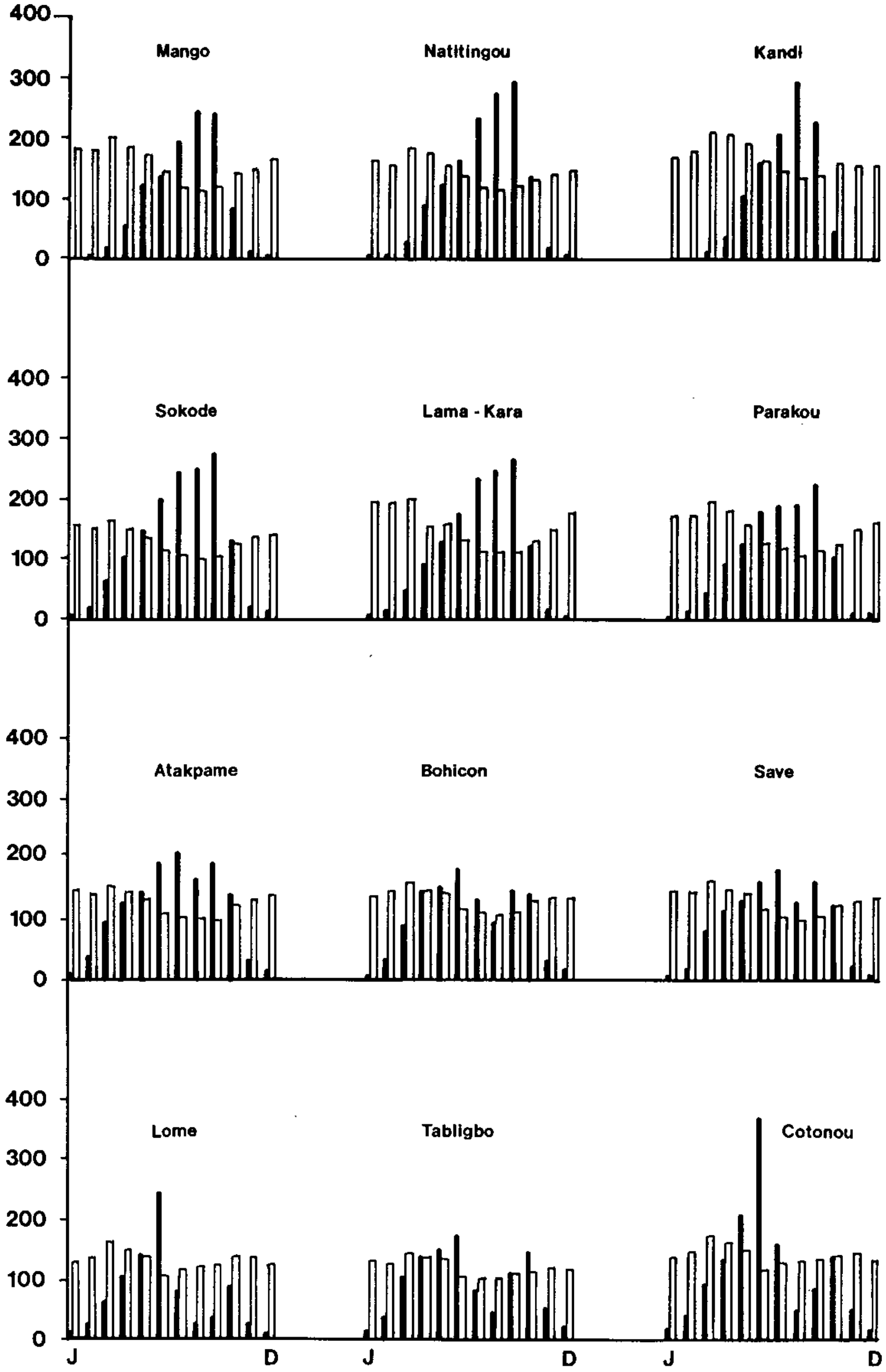
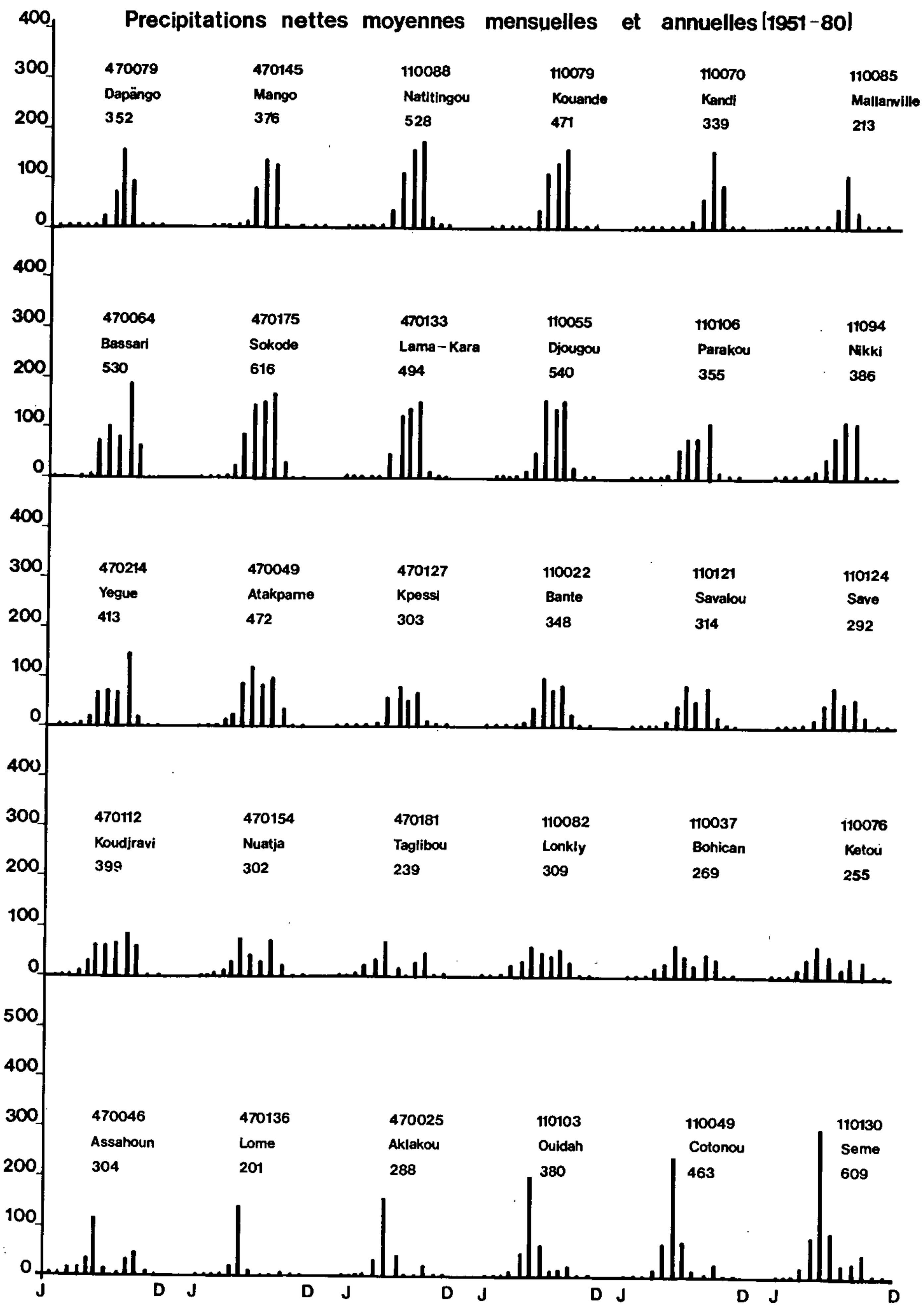


Figure A2.4



Precipitations nettes moyennes mensuelles et annuelles (1951-80)
470079 Dapängo 352
470145 Mango 376
110088 Natitingou 528
110079 Kouande 471
110070 Kandi 339
110085 Mallanville 213
470064 Bassari 530
470175 Sokode 616
470133 Lama-Kara 494
110055 Djougou 540
110106 Parakou 355
11094 Nikki 386
470214 Yegue 413
470049 Atakpame 472
470127 Kpessi 303
110022 Bante 348
110121 Savalou 314
110124 Save 292
470112 Koudjravi 399
470154 Nuatja 302
470181 Taglibou 239
110082 Lonkly 309
110037 Bohican 269
110076 Ketou 255
470046 Assahoun 304
470136 Lome 201
470025 Aklakou 288
110103 Ouidah 380
110049 Cotonou 463
110130 Seme 609
0
100
200
300
400
500
J
D

Figure A2.5

3. RIVER FLOWS

3.1 Introduction

Although the flow records were discussed at length in an earlier report, it is useful to recall much of the account of the flow records here for completeness and ease of reference.

Dans la premiere phase des études hydrologiques, les travaux étaient concentrés sur la collecte et la vérification des données disponibles.

A la suite de l'identification de l'étendue du réseau de jaugeage des débits dans chaque pays, on a recherché les sources de données publiées et non publiées. Au cours de la mission hydrologique au Togo et au Bénin, on a contacté les diverses agences gouvernementales et autres qui possédentdes données d'information. On a également réalisé des travaux de reconnaissance sur le terrain et visité les stations de jaugeage.

Un premier examen des données disponibles a fait ressortir qu'il existe de grandes divergences dans la qualité et la quantité de ces données, non seulement entre le Togo et le Bénin mais aussi entre les diverses régions a l'intérieur de chaque pays. On a réalisé des vérifications simples et examiné la consistance globale des annales: on en a retenu pour analyse supplémentaire une base définitive de données.

La présente analyse s'est attachée surtout à fournir une interprétation régionale de l'hydrologie, pouvant s'appliquer à des sites qui se trouvent dans des bassins versants non jaugés ou en des endroits éloignés de la station de jaugeage la plus proche. Par conséquent, les études ont été concentrées sur la dérivation des évaluations de la pluviosité annuelle moyenne brute et nette (c'est-à-dire, la pluviosité moins l'évaporation potentielle) et de les mettre en rapport avec les ruissellements observés. Ces rapports régionaux sont utilisés pour évaluer l'apport annuel moyen à un site donné, qu'il soit jaugé ou non.

3.2 Togo

Le réseau de stations de jaugeage du Togo est l'un les plus denses de l'Afrique occidentale. Quoique les annales d'une station partent de 1931, la majorité des observations ont été démarrées dans les années 1950. Le Tableau A2.5 présente un résumé des périodes pendant lesquelles on dispose de données aux principales stations; la Figure A2.7* montre l'emplacement des stations.

La Direction d'Hydrologie de la Direction de l'Hydraulique et de l'Energie du Ministère des Travaux Publics et ORSTOM se partagent à l'heure actuelle la gestion du réseau. Les observations hydrologiques sont centralisées et vérifiées par l'organisme responsable; elles sont ensuite envoyées au bureau d'ORSTOM à Paris pour être traitées par ordinateur et publiées. Grâce à cette méthode la majeure partie des données relatives aux ruissellements enregistés au Togo est aisément accessible sous forme de publication. Ces publications comprennent les Annuaires Hydrologiques du Togo (ORSTOM, 1973 et 1982) et les monographies ou études spécifiques de bassins versants individuels (ORSTOM, 1977).

La collecte et le traitement des données relatives au ruissellement sont continuels et bien organisés. Des jaugeages réguliers au moulinet sont réalisés et de nouvelles courbes d'étalonnage exécutées lorsque cela s'avère nécessaire. Toutefois, il convient de noter que l'apport journalier à une station donnée est normalement calculé sur la base d'une seule ou, au plus, de deux observations du niveau d'eau par jour. Dans les plus petits bassins versants où les debits augmentent

* If this map is not reproduced, it needs to be referred to as Figure 2.2 (Report A).

rapidement en réponse à la pluviosité, il est possible que les débits les plus élevés d'une crue ne soient pas enregistrés. D'un autre côté, il se peut que la pointe de la crue soit observée conduisant ainsi à une surestimation de l'apport journalier.

De même, pour un grand nombre de stations de jaugeage, il s'est avéré nécessaire d'éxtrapoler la courbe d'etalonnage pour obtenir les estimations des débits plus éléves. Pour réussir l'extrapolation des courbes d'étalonnage, il convient de posséder un bon jugement hydrologique et une connaissance des conditions locales: d'après nos observations, nous n'avons aucune raison de rejeter les courbes d'étalonnage et, donc, les données relatives au débit calculées par les hydrologues locaux. En fait, dans les derniers annuaires (ORSTOM, 1982), l'attention du lecteur est attirée lorsque la cadence des relevés est insuffisante ou que la courbe d'étalonnage est instable ou a subi une grande extrapolation.

3.3 Bénin

Les principales stations du réseau de jaugéage existant ont été établiés en collaboration avec ORSTOM au début des années 1950. Il a été créé, en même temps, un service hydrologique, chargé de l'exploitation et de l'entretien de routine de ces stations ainsi que de la collecte, du traitement et de la publication des données.

Les données relatives au ruissellement ont été publiées dans un certain nombre de rapports.

La Direction de l'Hydraulique du Ministère des Travaux Publics, des Constructions et de l'Habitat a, depuis 1970, àssumé seule la responsabilité du réseau hydrométrique, ORSTOM n'apportant que des contributions d'ordre mineur. Les hauteurs d'eau sont relevés et envoyés à Cotonou tous les mois. Toutefois, les stations individuelles ne font l'objet d'aucune visite d'inspection régulière et les jaugeages de routine par moulinet ne sont plus réalisés. En conséquences, bien que l'on possède les annales des niveaux fluviaux survenus à quelques stations ces dernières années, elles n'ont été ni vérifiées ni traitées d'aucune facon. Certaines observations des niveaux fluviaux ont été faites dans le cadre du Programme Onchocercose de l'OMS mais on n'a pas pu obtenir des informations concernant l'importance et la qualité de ces données.

Les données relatives au ruissellement survenu au Bénin et utilisées dans la présente étude ont été recueilliés auprès d'un certain nombre de sources; les Annuaires, Monographies et Rapports publiés par ORSTOM constituent la principale source de données et d'information. Le Tableau A2.6 présente un résumé des données disponible et des sources dont elles ont été dérivées. La Figure 2.2/A2.7 montre l'emplacement des principales stations de jaugeage.

La qualité des informations et données publiées concernant les années les plus récentes (après 1970) est clairement inférieure à celle des années antérieures en raison de l'absence d'une méthode de vérification des données et des courbes d'étalonnage continuelle. Plusieurs stations de jaugeage se trouvent dans des lits fluviaux naturels dont la stabilité et les caractéristiques de débit peuvent se trouver modifiées de manière importante en peu de temps. L'étude actuelle ne comporte pas d'études sur place détaillées permettant d'examiner si les courbes d'étalonnage sont restées stables ou non. Elle ne comprend pas non plus d'évaluation des observations et mesures qui ont été rassemblées à Cotonou mais qui n'ont été ni vérifiées ni traitées.

Toutefois, au cours d'autres études, des ingénieurs-conseils ont traité certaines des plus récentes données qui étaient utiles à leurs études particulières.

Dans les cas appropriés, ces données sont utilisées par la présente étude pour mettre en corrélation la lame d'eau et le ruissellement avec la pluviosité.

3.4 Ruissellement

On peut diviser la zone du Togo et du Bénin en cinq bassins versants principaux, à savoir, le Lac Togo, le Mono, l'Ouémé, l'Oti et les trois affluents de la rive droite du Niger - la Mékrou, l'Alibori et la Sota. La Figure 2.2/A2.7 indique l'emplacement de ces bassins et des plus importantes stations de jaugeage qui s'y trouvent.

La sélection des données relatives au débit utilisées dans la présente étude sur le ruissellement a été basée sur un certain nombre de critères; ceux-ci comprennent la période pour laquelle on dispose d'annales ininterrompues, la stabilité du profil en travers du cours d'eau et de la courbe d'étalonnage, et la question de savoir si cette courbe a été extrapolée bien au-delà du niveau jaugé le plus élevé. La dimension du bassin versant représente un autre facteur important car, comme on l'a fait remarquer plus haut, il est insuffisant de relever des observations une fois ou, au mieux, deux fois par jour, lorsque le bassin versant est petit et que la réponse des ruissellements a la pluviosité est rapide.

3.4.1 La Rivière Sio

La Sio s'écoule au sud d'Atakpamé et, avec la Chra, est l'une des quelques rivières qui sont affectées par deux périodes de débits élevés correspondant à la tendance de la pluviositè dans la partie sud du pays. La station de jaugeage à Kpedji possède une courbe d'étalonnage bien établie et ses annales sont jugées raisonnables; a Togblekopé toutefois, l'eau déborde sur les rives lorsque les débits sont supérieurs a 43 m^3/s et l'estimation des débits élevés sera donc vraisemblablement imprécise.

Un résumé des ruissellements annuels et mensuels moyens est porté au Tableau A2.7.

3.4.2 Le Fleuve Mono

Le Mono est le plus important cours d'eau du Togo. Quoiqu'il existe peu de données sûres pour les bassins versants des plus petits affluents, les biefs du cours moyen du fleuve principal ainsi que de l'Anié et de la Sirka sont bien connus et les données relatives au débit sont jugées fiables. Il existe des stations de jaugeage sur certains des affluents de la rive droite qui s'écoulement du plateau de Daie vers le sud d'Atakpamé; les bassins versants de ces rivières sont petits. Parmi ces stations, les données relevées à Chra sur la Chra semblent les plus sûres.

Un résumé des ruissellements annuels et mensuels moyens est porté au Tableau A2.8.

3.4.3 La Rivière Ouémé

L'Ouémé supérieure comprend trois bassins principaux: l'Okpara, l'Ouémé et la Zou, qui coulent du nord au sud et couvrent toute la partie centrale du Bénin. La plupart des plus petits affluents sont non-jaugés et les annales hydrologiques non vérifiées pour les années 1970 au Bénin doivent être considérées comme légèrement douteuses. Les données relevées jusqu'a l'année 1960 ont été traitées et publiées dans la Monographie de l'Ouémé Supérieure (1963).

Toutefois, une étude récente a traité les donnees enregistrées récemment sur l'Ouémé au Pont de Savé et au Pont de Bétérou jusqu'a l'année 1979 (ROMELECTRO, 1981).

Une autre étude sur la Zou (IFAGRARIA, 1976) a utilisé les données publiées antérieurement et ce rapport ne donne aucune donnée supplémentaire.

On ne dispose que de peu d'informations pour l'Okpara. A Nanon, à l'ouest de Parakou, il n'existe aucune donnée apres 1969. Les données utilisées ici ont été prises dans Thiébaux (1972b) et sont basées sur une analyse détaillée des courbes d'étalonnage et les enregistrements des hauteurs d'eau. ORSTOM (1960 et ultérieurement) a publié les données enregistrées à Kaboua, en aval, jusqu'a l'année 1973; mais il semble que, depuis 1964, il n'ait été effectué que deux vérifications des courbes d'étalonnage ce qui rend les plus récentes données incertaines.

Un résumé des ruissellements annuels et mensuels moyens est porté au Tableau A2.9.

3.4.4 Affluents du Niger

Le Niger a trois affluents importants, la Mékrou, l'Alibori et la Sota qui sont entièrement situés au Bénin. ORSTOM a publié les données enregistrées sur l'Alibori et la Sota jusqu'à l'année 1966 dans sa Monographie du Bassin du Niger (ORSTOM, 1970). Depuis lors, on ne possède des annales publiées que pour l'Alibori (ORSTOM, 1960 et ultérieurement). Toutefois, dans un ouvrage plus récent, Arnold (1978) a utilisé des données allant jusqu'a l'année 1966, ce qui nous renforce dans notre opinion que les annales les plus récentes sont douteuses.

Les seules données publiées pour la Mékrou se trouvent dans Thiébaux (1972a) où des enregistrements des apports mensuels continus ont été établis de 1958 à 1970. Depuis lors, il n'y a pas eu d'autres enregistrements.

Il convient de remarquer que, pour les stations dont les apports mensuels moyens sont portés au Tableau A2.10, ORSTOM a établi que l'année hydrologique commence en mai, tandis que pour les autres stations l'année hydrologique commence en mars.

3.4.5 La rivière Oti

L'Oti est un affluent de la Volta et prend sa source dans les montagnes Atakora, au Bénin, au nord de Natitingou, où il est connu sous le nom de Pendjari. Les trois principaux affluents sont la Koumongou (Kéran), la Kara et la Mo.

En 1977, ORSTOM a étudié ce bassin de facon détaillée dans sa Monographie du Bassin du Fleuve Volta (ORSTOM, 1977). Dans ce rapport, des fichiers opérationnels des débits mensuels allant jusqu'à et y compris l'année 1973 ont été établis. Les dernières Annales Hydrologiques du Togo (ORSTOM, 1982) comprennent des données ultérieures mais il y a de nombreuses lacunes qui en réduisent la valeur.

Les valeurs observées des ruissellements annuels et mensuels moyens aux meilleures stations sont portées au Tableau A2.11. Ces valeurs ont été calculées en s'appuyant sur les années pour lesquelles on possède des données complètes. Il n'exists aucune donnée sûre pour la Mô et les jaugeages de la Koumongou à Koumongou sont jugés incertains en raison d'une courbe d'étalonnage instable. Les bassins versants des affluents sont relativement petits; en ce qui les concerne, les dernières Annales (ORSTOM, 1982) font remarquer que la fréquence des observations est insuffisante et que les données devraient être ultilisées prudemment. La Daie à Dzogbegan où un limnigraphe a été installé fait exception à cette règle. Cette station est située dans un bassin versant expérimental et les chiffres relatifs aux ruissellements sont de bonne qualité. On ne possède encore aucun rapport sur ces travaux expérimentaux.

TABLEAU A2.5

RELEVES DU RUISSELLEMENT DISPONIBLES AU TOGO

Cours d'eau	Station	°E	°N	Superficie (km²)	Période	Années sans enregistrement	Source
OTI	Mango	0°28'	10°22'	35,650	1954-79	1974-'79	ORSTOM, 1977; ORSTOM, 1982
	Mandouri	0°51'	10°50'	29,100	1953-78	1974-'78	ORSTOM, 1977; ORSTOM, 1982
SANSARGOU	Borgou	0°34	10°45'	2,240	1960-78	1974-'77	ORSTOM, 1977; ORSTOM, 1982
KOIMEKPOUARBAGA	Nagbeni	0°24'	10°36'	208	1962-79	1965	ORSTOM, 1977; ORSTOM, 1982
PENDJARI	Porga	0°58'	11°03'	22,280	1952-73		ORSTOM, 1977
KERAN	Titira	1°07'	10°00'	3,695	1962-79	1974, '76, '79	ORSTOM, 1977; ORSTOM, 1982
	Naboulgou	0°49'	10°09'	5,470	1962-79	1977-'79	ORSTOM, 1977; ORSTOM, 1982
KARA	Lamakara	1°11'	9°32'	1,560	1954-79	1954	ORSTOM, 1977; ORSTOM, 1982
	Kpésside	0°57'	9°37'	2,790	1961-79	1975-'79	ORSTOM, 1977; ORSTOM, 1982
KPELOU	Kpésside	0°57'	9°38'	417	1962-70	1974-'75, '77-'79	ORSTOM, 1977; ORSTOM, 1983
LA DAYE	Dzogbégan	0°41'	7°15'	52	1963-73		ORSTOM, 1977
MONO	Tététou	1°32'	7°01'	20,100	1951-79	1951, '67, '77, '79	ORSTOM, 1973; ORSTOM, 1982
	Corrékopé	1°18'	7°48'	9,952	1954-79	1954, '79	ORSTOM, 1973; ORSTOM, 1982
	Dotaikopé	1°16'	7°49'	5,589	1960-79	1960, '62 '76, '79	ORSTOM, 1973; ORSTOM, 1982
OGOU	Sirka	1°22'	7°55'	4,035	1957-79	1974, '76	ORSTOM, 1973; ORSTOM, 1982
CHRA	Chra	1°10'	7°10'	360	1963-79	1963, '65, '72	ORSTOM, 1973; ORSTOM, 1982
ANIE	Anié-Gare	1°11'	7°45'	3,500	1954-65		
	Pont CFT	1°12'	7°44'	3,630	1964-79	1964, '76	ORSTOM, 1973; ORSTOM, 1982
SIO	Togblékopé	1°10'	6°15'	2,520	1962-79	1964, '65 '68-'70, '79	ORSTOM, 1973; ORSTOM, 1982
	Kpédji	1°00'	6°32'	1,812	1953-79	1963-'65 '79	ORSTOM, 1973; ORSTOM, 1982

TABLEAU A2.6

RELEVES DU RUISSELLEMENT DISPONIBLES AU BENIN

Cours d'eau	Station	°E	°N	Superficie (km^2)	Période	Années sans enregistrement	Source
SOTA	Koubéri	11°45'	3°20'	13410	1953-'66	1965, 1966	Arnold, 1978
ALIBORI	Route Kandi - Banikoara	2°04'	11°10'	8150	1952-'73	1971	Arnold, 1978 ORSTOM, 1960 et sequ
MEKROU	Kompongou	2°12'	11°24'	5700	1958-'70		Thiebaux, 1972a
OUEME	Pont de Bétérou	9°12'	2°16'	10326	1952-'79	1952	ORSTOM, 1963 ROMELECTRO, 1981
OUEME	Pont de Savé	2°25'	8°00'	23600	1951-'79	1951	ORSTOM, 1963 ORSTOM, 1960 et sequ ROMELECTRO, 1981
ZOU	Pont d'Atchérigbé	2°02'	7°32'	6955	1951-'73	1963, '68-'69	ORSTOM, 1963 ORSTOM, 1960 et sequ
OKPARA	Kaboua	2°43'	8°15'	9600	1951-'73	1958	ORSTOM, 1963 ORSTOM, 1960 et sequ
OKPARA	Nanon	9°17'	2°44'	2067	1951-'79	-	Thiebaux, 1972b

TABLEAU A2.7

LAME D'EAU OBSERVEE (mm)

BASSIN DE LA SIO

	M	A	M	J	J	A	S	O	N	D	J	F	Total
SIO à Togblékopé (1962-'78)	1	2	5	16	18	14	13	20	6	1	1	1	99
SIO à Kpédji (1954-'78)	1	3	5	21	21	18	23	28	8	2	1	1	132

TABLEAU A2.8

LAME D'EAU OBSERVEE (mm)

BASSIN DU MONO

	M	A	M	J	J	A	S	O	N	D	J	F	Total
MONO à Tététou (1952-'78)	0	1	1	7	23	37	54	32	6	1	0	0	162
MONO à Corrékopé (1955-'78)	0	0	0	3	21	47	68	33	5	1	0	0	179
MONO à Dotaikopé (1961-'78)	0	0	1	2	30	66	97	35	5	1	0	0	238
OGOU à Sirka (1957-'79)	0	0	0	3	13	55	53	26	4	0	0	0	135
CHRA à Chra (1964-'79)	0	1	3	14	25	18	28	26	4	0	0	0	119
ANIE à Anié Gare (1954-'65)	0	1	1	7	32	31	59	33	5	1	0	0	170
ANIE à Pont C.F.T. (1965 - '79)	0	1	1	5	31	54	81	28	4	1	0	0	205

Note: Les valeurs sont arrondies de sorte que la somme des valeurs mensuelles ne correspond pas nécessairement et exactement au total annuel.

: Les années qui au Tableau 2.2 sont indiquées comme ne comportant pas d'enregistrement ont été exclues.

TABLEAU A2.9

LAME D'EAU OBSERVEE (mm)
BASSIN DE L'OUEME

	M	A	M	J	J	A	S	O	N	D	J	F	Total
OUEME à Pont d'Atcherigbé (1952-73)	0	0	2	8	20	26	30	26	3	0	0	0	117
OUEME à Pont de Savé (1951-'79)	0	0	0	2	13	41	65	41	7	1	0	0	171
OUEME à Pont de Bétérou (1953-'79)	0	0	0	2	13	45	77	41	6	1	0	0	184
OKPARA à Kaboua (1951-'73)	0	0	0	1	7	21	43	43	10	1	0	0	128
OKPARA à Nanon (1952-'69)	0	0	0	1	7	33	76	57	7	1	0	0	182

TABLEAU A2.10

LAME D'EAU OBSERVEE (mm)
BASSIN DU NIGER

	M	J	J	A	S	O	N	D	J	F	M	A	Total
SOTA à Kouberi (1953-'66)	1	2	5	21	42	23	5	2	1	1	1	1	106
ALIBORI Route Kandi Banikaora (1952-'73)	1	2	9	40	71	24	2	0	0	0	0	0	149
MEKROU à Kompongou (1958-'70)	0	0	0	1	6	28	65	38	8	2	0	0	147

Note: Les valeurs sont arrondies de sorte que la somme des valeurs mensuelles ne correspond pas nécessairement et exactement au total annuel.

: Les années qui au Tableau 2.2 sont indiquées comme ne comportant pas d'enregistrement ont été exclues.

TABLEAU A2.11

LAME D'EAU OBSERVEE (mm)
BASSIN DE L'OTI

	M	A	M	J	J	A	S	O	N	D	J	F	Total
OTI à Mango (1953-'73)	0	0	0	2	6	22	51	34	4	1	0	0	122
OTI à Mandouri (1959-'73)	0	0	0	1	6	21	42	28	5	1	0	0	105
SANSARGOU à Borgou (1960-'78)	0	0	2	6	16	41	53	9	1	0	0	0	129
KOIMEPOURBAGA à Nagbeni (1962-'79)	0	0	1	2	14	43	61	22	5	2	0	0	150
PENDJARI à Porga (1952-'73)	0	0	0	1	4	19	40	31	5	1	0	0	101
KERAN à Titira (1962-'78)	0	1	3	7	40	97	127	50	12	3	1	0	343
KERAN à Naboulgou (1962-'76)	1	2	2	6	29	79	118	52	12	3	1	1	305
KARA à Lama Kara (1955-'79)	0	2	4	16	68	123	181	55	9	2	1	0	461
KARA à Kpesside (1961-'74)	0	2	6	17	57	119	141	59	11	2	1	0	415
KPELOU à Kpesside (1962-'76)	0	2	4	25	89	159	167	89	18	2	0	0	557

Note: Les valeurs sont arrondies de sorte que la somme des valeurs mensuelles ne correspond pas nécessairement et exactement au total annuel.

: Les années qui au Tableau 2.2 sont indiquées comme ne comportant pas d'enregistrement ont été exclues.

4. WATER BALANCE

General

A comparison of net rainfall with measured runoff at gauging stations serves to verify both sets of observations by the principles of water balance and provides useful estimates of runoff over a region. The comparison of annual net rainfall with annual runoff at individual gauging stations provides a simple relationship between the two which can be used to extend the annual runoff series and thus provide estimates of mean runoff over a standard period. The comparison of mean annual runoff with mean annual net rainfall at different gauged stations over a region then provides a method of estimating mean annual runoff at other sites.

For those gauging stations described in the previous section, where measured runoff records are available for periods ranging from 11 to 29 years, annual runoff totals in mm over the basin have been compared with annual net rainfall estimates as described in the following paragraphs. The regression equations derived from these comparisons have been used to estimate mean annual runoff at each gauging station corresponding to the standard period 1951-80. A relationship between mean annual runoff and mean annual net rainfall over the basin has then been derived for use in estimating runoff at ungauged sites.

For eight gauging stations (at locations close to the priority dam sites) extended streamflow sequences were derived from historical basin net rainfall series using time series analysis relating rainfall and runoff based on measured flows. The method developed for estimating runoff at ungauged sites was adapted to transfer the flow series derived for the gauging stations to each of the priority dam sites. These streamflow series were compared, where possible, with flows measured or derived by others.

4.1 Long term average net rainfall

4.1.1 Calculation of net rainfall

Estimates of rainfall over a basin in individual years may be obtained by a number of methods. The most common are the isohyetal, Thiessen polygon and percentile methods. The isohyetal method gives reasonable results if the station coverage is good but it does not lend itself to computer calculation. The Thiessen polygon method is satisfactory if the rainfall is fairly uniform over the basin, but was not used because it has the disadvantage that periods of missing records require the polygons to be recomputed. The chosen method is based on the percentile method, which can be applied to a changing network and takes advantage of the interpretation of rainfall distribution included in an isohyetal map.

For each station the net rainfall in each individual month or year is divided by the long term station annual average; this figure is in turn averaged for all the stations in or near the basin and then multiplied by the basin annual average derived from the isohyetal map. Thus the basin rainfall $\bar{P}_i$ for period i is calculated using records from n stations j as

$$\bar{P}_i = \left(\frac{1}{n} \sum_{j=1}^{n} P_{ij}/\bar{P}_j\right) \times \bar{P}$$

where P_{ij} is the rainfall in period i at station j, $\bar{P}_j$ is the long-term average at station j, and $\bar{P}$ is the long-term basin average. The precision of this estimate clearly depends on the number of stations available, which varies from basin to basin and also changes during the period of record.

This procedure was carried out for the basins of all 28 gauging stations, in terms of net monthly and annual rainfall, not only for the period 1951-80 but also for as far back as the availability of rainfall records permitted. In most cases this covered the 50 year period 1931-80, though the rainfall coverage was insufficient in some cases in the early years.

While the long-term monthly rainfall series was used to extend runoff records to provide long-term monthly runoff series by time series methods (section 4.3), the seasonal net rainfall totals were compared with records of the annual runoff at measured stations in order to provide a method of assessing the runoff at sites with no measured flows nearby.

4.1.2 Comparison of average annual runoff with average rainfall

In Figure A2.8 the mean annual runoff at all gauging stations, adjusted to the standard period 1951-80, is compared with the gross rainfall (Figure A2.8a) and the net rainfall (Figure A2.8b) for the same period, deduced from the isohyetal maps. It is interesting to compare the two graphs; the relationship between net rainfall and runoff is much closer than that between gross rainfall and runoff. It is evident that the actual evaporation varies with the length of the rainfall season and that the net rainfall takes better account of the way in which the rainfall pattern varies over the study area. In other words, the net rainfall represents fairly realistically the water available for runoff, but there is also the need to recharge the soil moisture at the beginning of the rain season before runoff will occur. Figure A2.8b suggests that a soil moisture recharge of 200 mm is a reasonable deduction; there is insufficient evidence to vary this over the country, while it is possible that the points which indicate a lower soil moisture recharge, which are derived from hilly basins near Lama-Kara and at Dzogbegan, have a rainfall which is underestimated.

Thus the map of annual net rainfall (Figure A2.6) can be used to estimate the mean annual runoff from an ungauged basin by subtracting 200 mm for the seasonal soil moisture recharge. Such an estimate can be improved in most cases by taking account of measured runoff. For an estimate for a site near a river gauge it is preferable to use the measured flows; estimates for a site above or below a river measurement station may take account of the difference in catchment area between the site and the station, and if the net rainfall for the incremental catchment area is very different from that for the catchment area of the gauging station, adjustment can be made by adding or subtracting the estimated runoff from the incremental area.

4.2 Annual rainfall/runoff relationship

For the gauging stations where measured flows were available, annual runoff totals were compared with seasonal net rainfall figures to study the variation of runoff from year to year. The runoff totals were expressed in mm over the basin, and in general were calculated from 1 March to 28 February. The net rainfall totals were based on a number of gauges within each basin, and the isopercentile method described above.

The relationships between annual net rainfall and runoff for these catchments are illustrated in Figure A2.9, and are summarised in Table A2.12. The closeness of the relationship varies from one basin to another, but this may well be due to the quality of the records of rainfall and runoff. In support of this, the correlation coefficient improves with the number of raingauges available to estimate the basin rainfall (see Figure A2.10).

It has been found in a study in a similar climate in India (Sutcliffe et al, 1981) that, where the rain season is well defined and short, the seasonal soil moisture recharge is constant from year to year because the catchment soil moisture is exhausted during the dry season. This is shown by the relationship between net rainfall P' and runoff R being of the form $R = P' - S$, where the soil moisture recharge S is a constant. A study of Table A2.12 shows that in the catchments round Lama-Kara where the rainfall surplus occurs in about 4 months and the net rainfall and runoff are relatively high, the relationship is of this form with $s(P') \approx s(R)$. (The standard deviations of net rainfall and runoff are equal). In other parts of the country the relationship is not of this form. The slope of the runoff-net rainfall relationship is less than 45^0, and $s(R) < s(P')$. It is not easy to deduce the reason for this, except to state that the evaporation and recharge are greater in wet years than in dry years.

The long-term mean runoff for each gauged site can be deduced from Table A2.12 by inserting the mean annual net rainfall in the regression equation, which gives a runoff adjusted to the period 1951-80. It is this runoff which is used in Figure A2.8 (see Table A2.12a).

If a simple method of deriving an annual runoff series is required at an ungauged site, the analysis summarised in Table A2.12 can provide it. The mean annual runoff can be estimated from the mean net rainfall of the basin from the equation $\bar{R} = \overline{PN} - 200$. An equation must then be deduced to express the variation of runoff in individual years corresponding to variations in annual net rainfall. In the Lama-Kara region this equation can take the form $R = PN - 200$ (which will pass through the mean $\bar{R}$, $\overline{PN}$, but in the rest of the country the equation for annual flows would more realistically take the form $R = 0.6(PN) - c$, where the constant c ensures that it goes through the point ($\bar{R}$, $\overline{PN}$)). This annual runoff may be divided between months according to the average distribution. Such estimations would be of a preliminary nature, and their precision is indicated by the scatter of points in Figures A2.9 and A2.10.

However, where adequate runoff records exist near the project site, a more precise extension of the runoff record may be obtained from time series analysis of the flow record. This is described in the following section.

4.3 Streamflow simulation

4.3.1 Choice of model

Streamflow sequences are required for each of the priority sites as inputs to a reservoir simulation model and were initially derived for eight gauging stations close to those sites. The eight stations and the period for which flow and rainfall data are available are listed in Table A2.13; the data themselves are listed in Appendix 1. Flow and rainfall data are expressed as mm depth over the catchment. Rainfall data for these stations have been calculated both as gross and net rainfall, the latter being defined as gross rainfall less evaporation.

The rainfall records, which cover a longer period than the flow records, may be used to extend the flow records, provided that a relationship between flow and rainfall can be determined. Because monthly flow is physically related to current rainfall and antecedent rainfall and flow, it is natural to base the modelling on these factors. This was done for the Togo/Benin data using linear regression models with flow as the dependent variable. Models were constructed only for the months June to December since for all of the stations flow in the months January to May is negligible. Regression models were fitted for the period for which both flow and rainfall data were available: this varied between 14 and 29 years at each station.

The choice of a best regression model was made principally using the data from Tetetou. Regression models were constructed using flow as the dependent variable and various combinations of flow and rainfall as explanatory variables. Rainfall measures used included gross and net rainfalls lagged by up to two months, cumulative totals of gross and net rainfall during the current year, and exponentially weighted sums of past rainfalls. The best fit was given by regression of monthly flow on the previous month's flow and on net rainfall in the current and previous months, and as this was a physically logical choice this set of independent variables was accepted.

4.3.2 Transformation of data

Both monthly flow and monthly rainfall have markedly skew distributions so the data were transformed in order to reduce the skewness before fitting a regression model. A logarithmic transformation was tried, but found to be too strong, yielding transformed flows with negative skewness. A square-root transformation was then considered and applied to both flow and rainfall values. When the transformed variables were used in the best regression model, several benefits were apparent: there was a small improvement in the fit of the regression model (as measured by the proportion of the variance of the dependent variable explained by the model), especially in months June and July; some nonlinearities apparent in the flow/rainfall relationship in June and July were greatly reduced; inequality in the variance of the residuals from the regression was removed; flow, rainfall and regression residuals all had a more nearly Normal distribution. Furthermore, modelling in terms of the transformed variables gives more realistic simulated flow sequences, particularly in years with little rainfall. Although a square-root transformation is rather artificial, the considerable advantages which it provides make it the preferred choice for simulation of streamflow. Thus the best model for monthly flows was decided to be

$$r_{y,m} = \beta_{0,m} + \beta_{1,m}\, r_{y,m-1} + \beta_{2,m}\, p_{y,m} + \beta_{3,m}\, p_{y,m-1} + e_{y,m} \qquad \ldots\ldots (1)$$

$$r_{y,m} = R^{\frac{1}{2}}_{y,m} \qquad p_{y,m} = PN^{\frac{1}{2}}_{y,m}$$

where $R_{y,m}$ is flow in year y, month m; $PN_{y,m}$ is net rainfall in year y, month m; $\beta_{j,m}$, j = 0, ..., 3, are regression coefficients; and $e_{y,m}$ is the residual in year y, month m, having variance σ^2_m.

4.3.3 Application of model

Although the full model-building procedure was not carried out for all stations, the statistical properties of the various flow and rainfall series were considered to be sufficiently similar for model (1) to be a good choice for all the stations. The model generally gave a good fit, accounting for 70-80% of the variance of the $r_{y,m}$ values in most months; for the southern stations (Tetetou and Pont de Savé) the fit was even better, with 80-90% of the variance of $r_{y,m}$ accounted for. Stations Kpessidé and Kompongou, with only 14 and 13 complete years of flow data respectively, gave a markedly worse fit than the other stations; simulations for these stations may therefore be unreliable.

The basic model (1) was modified for use in generating synthetic flow sequences for periods when only rainfall data are available. Flows were generated for the months June to December successively. When the June flow is generated, the May flow is not available, so the June flow is obtained by regression on rainfall only: April, May and June rainfalls are used as explanatory variables. Net rainfall in November and December is almost always zero, and so is omitted: November flows are generated from October flow and October rainfall; December flows are generated from November flow only. The explanatory variables used for each month are given in Table A2.14. The parameters of the regression models for each station are given in Appendix 2.

The aim of streamflow generation is to provide a realistic flow sequences for reservoir simulation, rather than to give best estimates of unobserved flows. Thus when generating synthetic flows from the model a random disturbance with variance σ_m^2 corresponding to the unexplained variance of $r_{y,m}$ was added to the value obtained from the regression. The same set of random numbers was used to generate the disturbances at each station, in order to aid direct comparison between the stations. A few negative flows which were generated were replaced by zero. Because each year's flow is generated independently of other years (there is no carry-over of the effects of the disturbance terms from December to the following June), each generated flow sequence may be expected to contain a mixture of years with high and low flows, and a single generated sequence should be sufficient to give a realistic pattern of variability of monthly flows. Flows for the months January to May are very small and erratic, and it is not worthwhile to model them explicitly. They were generated as proportions of the year's total flow, eg for January,

$$\text{generated January flow} = \text{average January flow} \times \frac{\text{generated June-December total flow}}{\text{average June-December total flow}}$$

the averages being calculated from the observed flow data.

Figure A2.11 summarises the generated flows for Tetetou (other stations give similar results). These flows were generated from the observed rainfalls in those years for which flow data were also available; the results of 48 such simulations are compared with the observed flows. The results demonstrate the ability of the generated flows to reproduce the average behaviour of the observed flows and to provide a realistic variation about the average.

The flow sequences finally generated consisted of observed flows when these were available and artificial flows generated from the simulation model otherwise. These flow sequences are listed in Appendix 3.

4.4 Runoff at ungauged sites

It was shown in Sections 4.1.2 and 4.2 that preliminary estimates of mean runoff can be made for ungauged sites in the study area. If there are no flow records at or near the site, mean annual runoff from a basin can be estimated from net rainfall minus the average loss to soil moisture recharge of 200 mm. Net rainfall in turn can be estimated from the net rainfall map.

However, such an estimate is not precise, and additional information is likely to be available at most sites in the form of river flows measured in the vicinity of the site of interest. In the case of most of the potential dam sites in the present study, there are flow measurements available on the same river.

The problem of assessing runoff at the dam site then reduces to one of making a reasonable estimate of the runoff from the intermediate catchment between the gauging station and the dam site. This intermediate runoff then has to be added to or subtracted from the runoff at the measured site.

In order to deduce the flow at the dam site from the flow at the gauging station, the difference in basin areas might be taken into account by using the ratio

$$Q_1/Q_2 = A_1/A_2$$

where Q_1 and Q_2 are the flows in $m^3 \times 10^6$ over a given time period at site 1 and site 2 (the dam site and gauge), and A_1 and A_2 are the corresponding basin areas. This approach, however, takes no account of any differences in rainfall and runoff between the gauged area and the incremental area. An approach which takes account of this should be based on the net rainfall map and may be expressed as

$$\frac{Q_1}{Q_2} = \frac{A_1(PN_1 - 200)}{A_2(PN_2 - 200)}$$

where PN_1 and PN_2 are the average basin net rainfall at sites 1 and 2 in mm, where Q_1 and Q_2 are expressed in $m^3 \times 10^6$.

If the flows, on the other hand, are expressed as R in terms of mm over the basin, the relationship becomes

$$\frac{R_1}{R_2} = \frac{(PN_1 - 200)}{(PN_2 - 200)} \text{ because } Q_1 = A_1R_1 \text{ and } Q_2 = A_2R_2$$

The mean net rainfall at all gauging stations has been estimated; if the incremental area (A_1-A_2) is relatively small, it is simpler to estimate the mean rainfall over A_1 from

$$PN_1A_1 = PN_2A_2 + PN_{1-2}(A_1-A_2)$$

where PN_{1-2} signifies the mean net rainfall in mm over the incremental area (A_1-A_2).

Using these relationships, the runoff for any period at the selected dam sites can be deduced from the corresponding runoff at the nearest gauging station using the figures given in Table A2.15. The penultimate column provides a ratio to express the runoff at the dam site as a ratio of the runoff at the gauging station where runoff is expressed as a volume; these ratios take account of the different catchment areas of the site and gauging station. The last column provides the ratios to transfer runoff figures from the gauging station to the dam site where the runoff is expressed in mm depth.

4.5 Comparison with other estimates

It is worth comparing the flow estimates which we have derived with earlier estimates which have been made by a different method. A useful example is Site 10, which has been previously studied by Sogreah.

Sogreah used measured flows at Nangbeto for 9 years, and extended these by correlation with Tetetou using an expression $Q_N = 0.7244\ Q_T + 374.58$ for annual discharges in $m^3 \times 10^6$; these annual flows have been converted to monthly flows using the record at Tetetou. The 27 years of flow record thus obtained have a mean of 2673 $m^3 \times 10^6$ per year.

We, on the other hand, have used the record at Tetetou covering 25 years, converting this to Site 10 using a ratio of area and net rainfall which is equivalent to $Q_N = 0.8270\ Q_T$. The mean flow for 25 years is 162 mm at Tetetou, which is converted to 2700 $m^3 \times 10^6$ at Site 10. This corresponds closely to the Sogreah estimate. When the Tetetou record is extended by time series analysis based on rainfall records, the 49 year runoff mean decreases to 152 mm, which corresponds to 2530 $m^3 \times 10^6$ per year.

Because we have preferred to use the more reliable Tetetou record throughout, there are differences in individual years between our estimates and those of Sogreah, but the two series are reasonably similar. For the comparable period of 26 years, the averages differ by only 2.5% and the correspondence of the two series is illustrated by their correlation coefficient of 0.982.

TABLE A2.12

Correlation entre ruissellement (R) annuel et pluie nette (PN)

Station No	Cours d'eau	Station	PN	R	R-PN	s(PN)	s(R)	r	n	a	b
1106	Oti	Mango	306	121	185	71	50	.88	21	.622	-69
1103	Oti	Mandouri	281	105	176	69	34	.86	15	.425	-14
6003	Sansargou	Borgou	328	135	193	81	38	.73	14	.342	+22
4203	Koimepouarbaga	Nagbeni	328	150	178	124	71	.47	17	.270	+61
2003	Pendjari	Porga	288	100	188	85	36	.79	22	.331	+5
4006	Keran	Titita	529	343	186	127	121	.89	15	.851	-107
4003	Keran	Naboulgou	475	304	171	97	92	.89	15	.849	-99
3910	Kara	Lamakara	574	479	95	169	217	.85	25	1.092	-147
3905	Kara	Kpesside	579	415	164	142	155	.92	14	1.004	-166
8103	Kpelou	Kpesside	552	557	-5	134	176	.89	13	1.165	-87
9061	La Daye	Dzogbegan	636	517	119	290	255	.80	11	.708	+66
0117	Mono	Tetetou	409	162	247	175	93	.94	25	.501	-43
0109	Mono	Correkope	433	179	254	163	102	.93	24	.580	-73
0111	Mono	Dotaikope	453	238	215	162	117	.87	16	.630	-48
2505	Ogou	Sirka	396	134	262	155	86	.87	20	.485	-58
1505	Chra	Chra	367	119	248	164	112	.79	14	.540	-79
1003	Anie	Anie-Gare	425	170	255	204	138	.95	12	.639	-102
1009	Anie	Pont-CFT	446	205	241	107	80	.64	14	.478	-8
2205	Sio	Togblekope	300	99	201	135	60	.95	12	.420	-27
2209	Sio	Kpedji	322	132	190	138	99	.93	22	.667	-83
3	Sota	Kouberi	411	106	305	109	49	.77	12	.350	-38
4	Alibori	Route K-B	385	149	236	100	69	.83	21	.573	-71
5	Mekrou	Komporgou	366	147	219	84	64	.76	13	.575	-63
8	Oueme	Pont de Beterou	442	184	258	157	106	.93	27	.629	-94
9	Oueme	Pont de Save	404	171	233	161	100	.94	29	.583	-65
12	Okpara	Kaboua	385	128	257	161	91	.92	22	.517	-71
13	Zou	Pont d'Atcherigbe	298	117	181	111	83	.90	19	.678	-85
28	Okpara	Nanon	421	182	239	149	100	.80	18	.541	-46

Note: r est le coefficient de correlation entre R et PN annuels; n est le nombre des années.
a et b sont les coefficients de la relation R = a(PN) + b.

PN et R sont les moyennes des observations des differentes périodes.

TABLE A2.12a

Valeurs moyennes pour la période 1951-80 de pluie (P), pluie nette (PN) et ruissellement (R)

Station No	Cours d'eau	Station	P	PN	R
1106	Oti	Mango	1000	300	118
1103	Oti	Mandouri	980	280	105
6003	Sansargou	Borgou	1030	350	143
4203	Koimepouarbaga	Nagbeni	1050	350	156
2003	Pendjari	Porga	970	270	94
4006	Keran	Titita	1350	520	336
4003	Keran	Naboulgou	1300	460	292
3910	Kara	Lamakara	1470	575	481
3905	Kara	Kpesside	1450	550	386
8103	Kpelou	Kpesside	1450	530	530
9061	La Daye	Dzogbegan	1600	620	505
0117	Mono	Tetetou	1250	410	162
0109	Mono	Correkope	1240	430	176
0111	Mono	Dotaikope	1250	450	236
2505	Ogou	Sirka	1180	390	131
1505	Chra	Chra	1250	350	110
1003	Anie	Anie-Gare	1320	430	173
1009	Anie	Pont-CFT	1320	430	198
2205	Sio	Togblekope	1200	320	107
2209	Sio	Kpedji	1220	350	150
3	Sota	Kouberi	1120	350	84
4	Alibori	Route K-B	1150	360	135
5	Mekrou	Komporgou	1125	360	144
8	Oueme	Pont de Beterou	1250	440	183
9	Oueme	Pont de Save	1200	400	168
12	Okpara	Kaboua	1180	350	110
13	Zou	Pont d'Atcherigbe	1170	320	132
28	Okpara	Nanon	1190	380	160

TABLE A2.13 Summary of available data

	Years of flow record	Years of rainfall record
Kompongou	1958-1970	1932-1980
Kouberi	1953-1966	1932-1980
Kpessidé	1961-1974	1941-1980
Lamakara	1955-1979	1932-1980
Pont de Betérou	1952-1979	1932-1980
Pont de Savé	1951-1979	1932-1980
Tetetou	1952-1978	1932-1980
Titira	1962-1979	1932-1980

TABLE A2.14 Explanatory variables used in regression models

Flow in month:	Regressed on: Flow in month	Regressed on: Rainfall in months
June	-	June, May, April
July	June	July, June
August	July	August, July
September	August	September, August
October	September	October, September
November	October	October
December	November	-

TABLE A2.15

Factors for calculating runoff at dam sites

Site No	Area km^2	Reference Site	Area km^2	Net rainfall	Increment km^2	Net rainfall	Runoff ratio expressed as: Volume	mm
10	15700	Tetetou	20100	410	-4400	366	0.8270	1.0587
12	19600	Tetetou	20100	410	- 500	275	0.9911	1.0164
16	20600	Tetetou	20100	410	500	250	1.0059	0.9815
20A	38000	Pont de Save	23600	400	14400	337	1.4169	0.8800
24	16300	Pont de Beterou	10326	440	5974	424	1.5400	0.9756
25A	22500	Pont de Save	23600	400	-1100	310	0.9744	1.0220
29	2730	Lama-Kara	1560	575			1.6333	0.9333
45A	7900	Kouberi	13410	350	-5510	310	0.6987	1.1860

Comparaison des moyennes annuelles [mm] de pluie brute [$\bar{P}$], pluie nette [$\overline{PN}$] et ruissellement [$\bar{R}$] observées aux stations

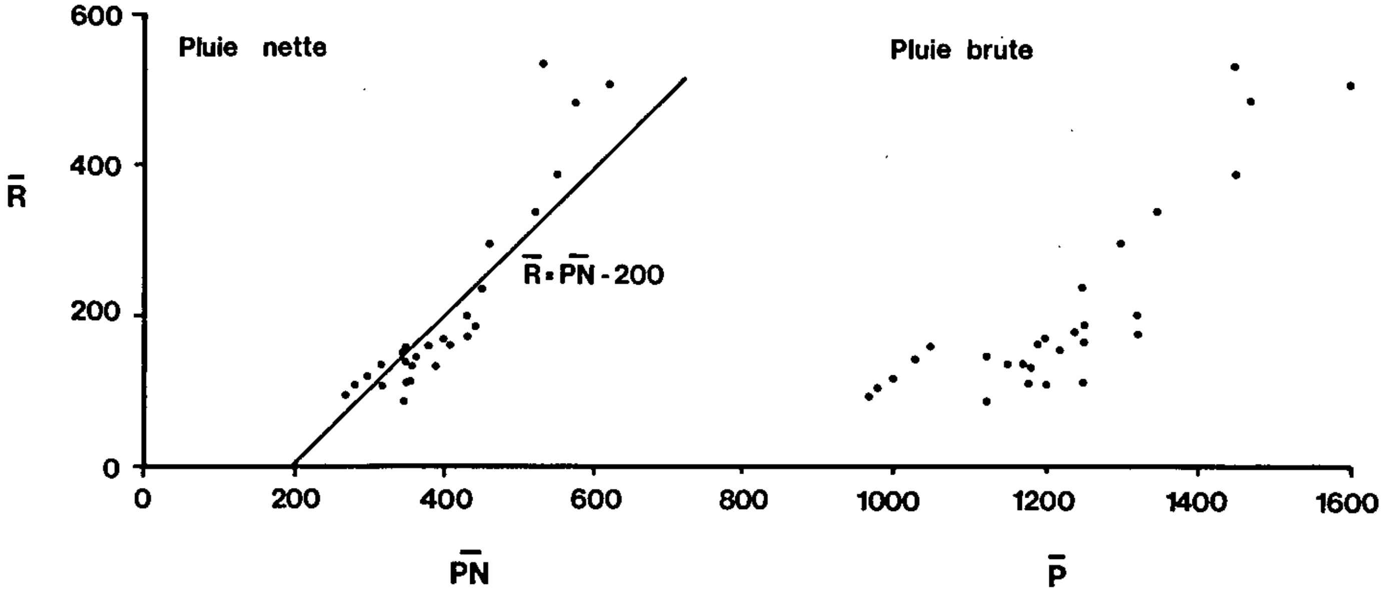


Figure A2.8

Ruissellement (R) et pluie nette (PN). (Valeurs annuelles mm)

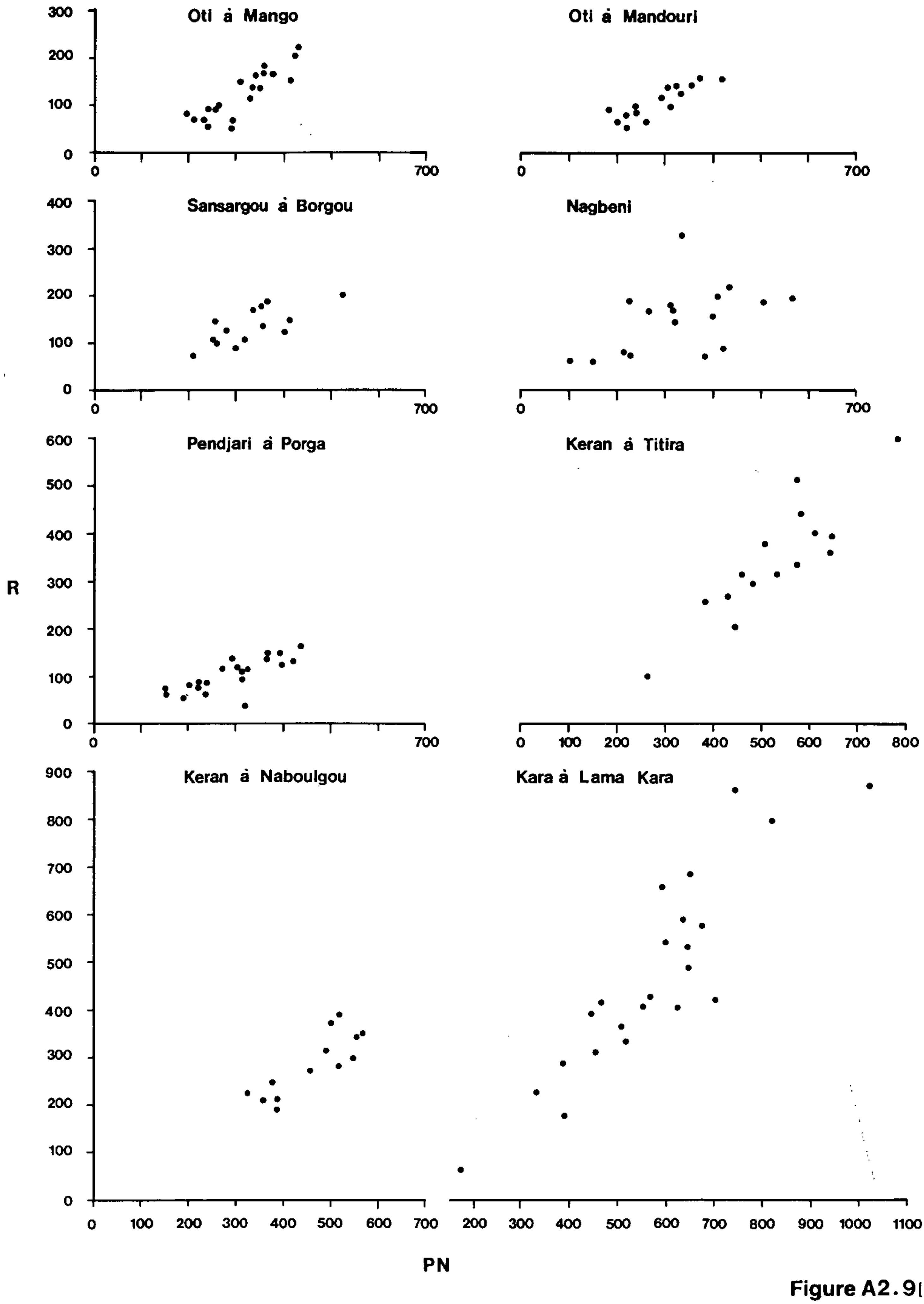


Figure A2.9(a)

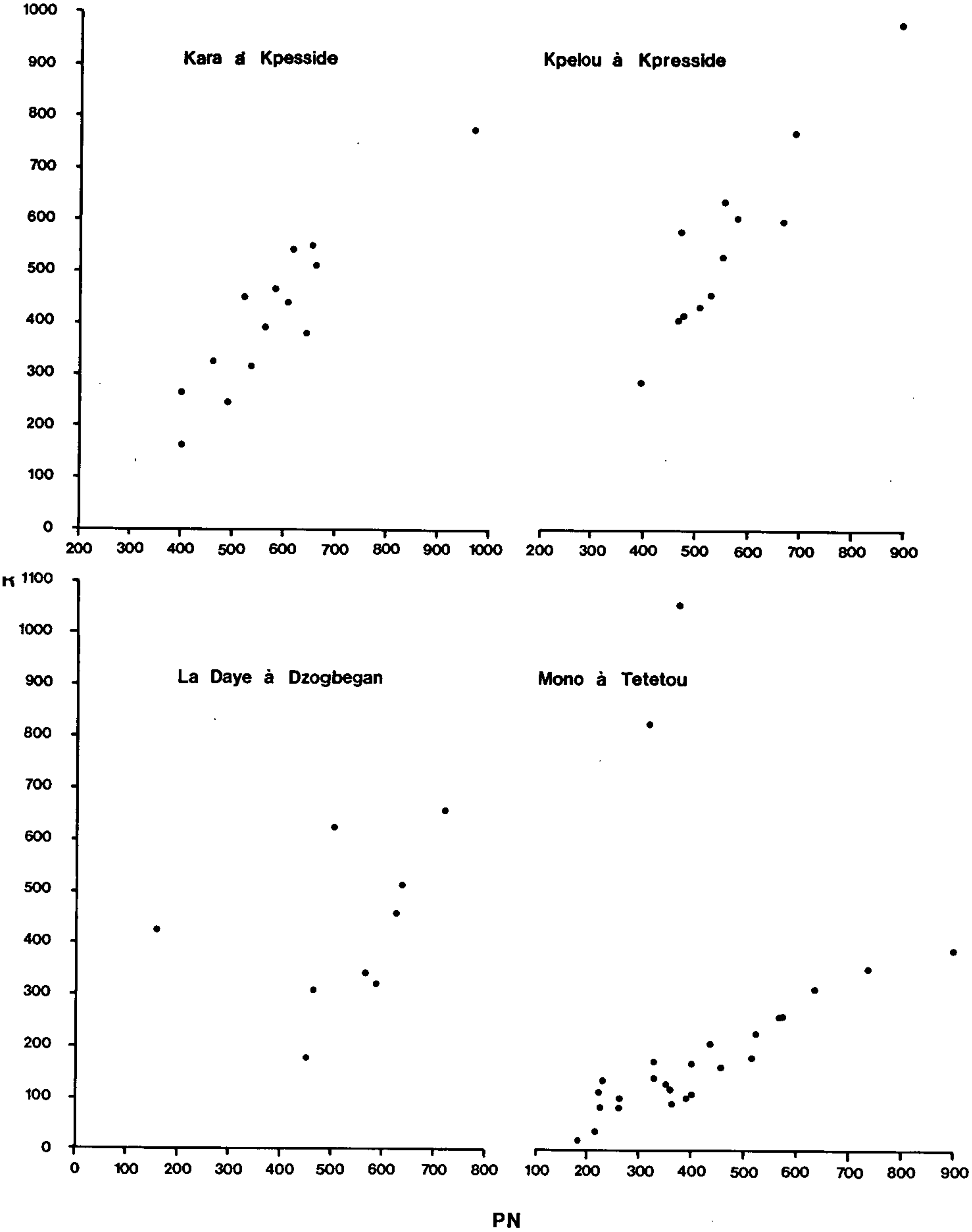

Kara à Kpesside
Kpelou à Kpresside
La Daye à Dzogbegan
Mono à Tetetou
R
PN
0
100
200
300
400
500
600
700
800
900
1000
1100

Figure A2·9 [b]

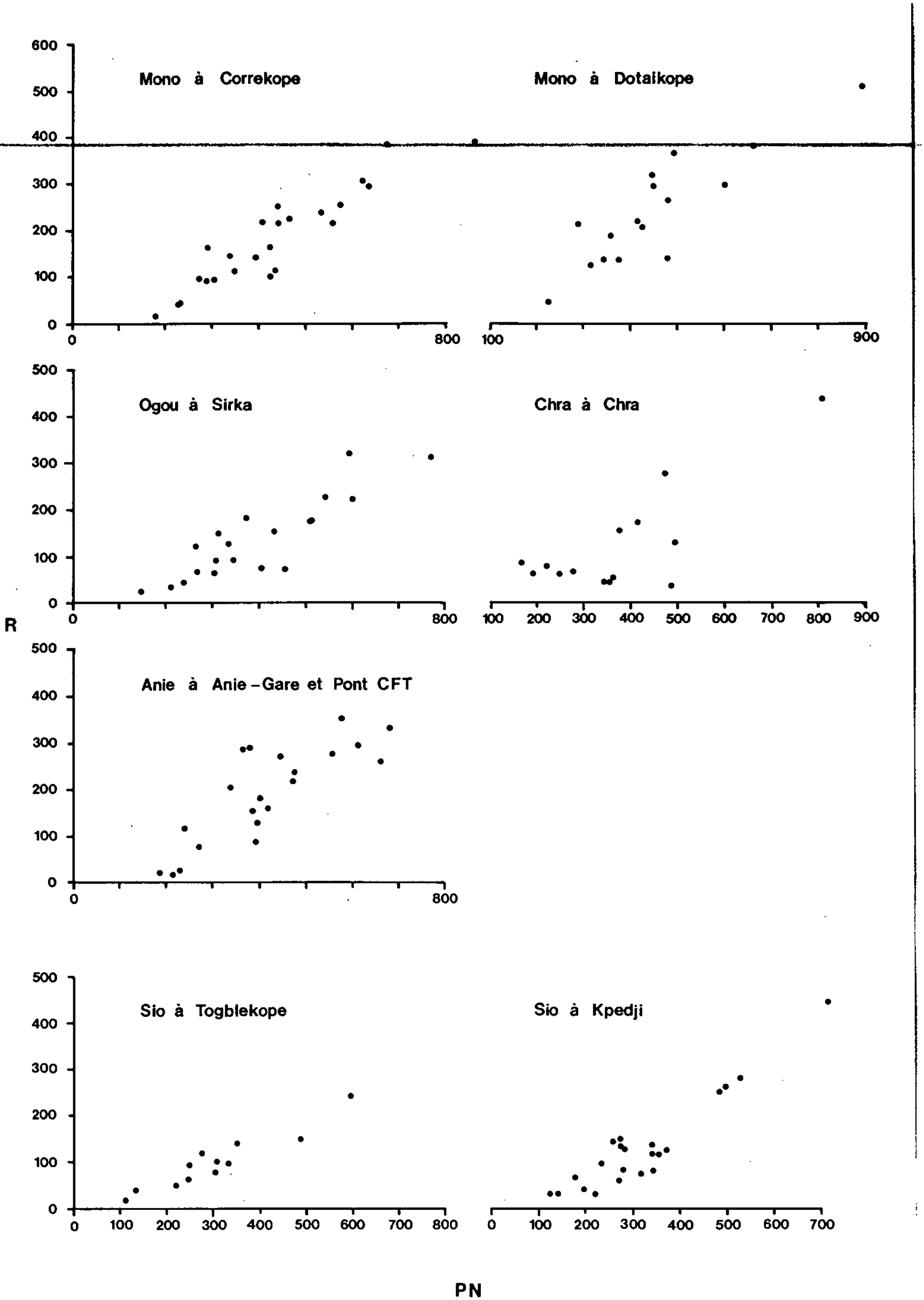
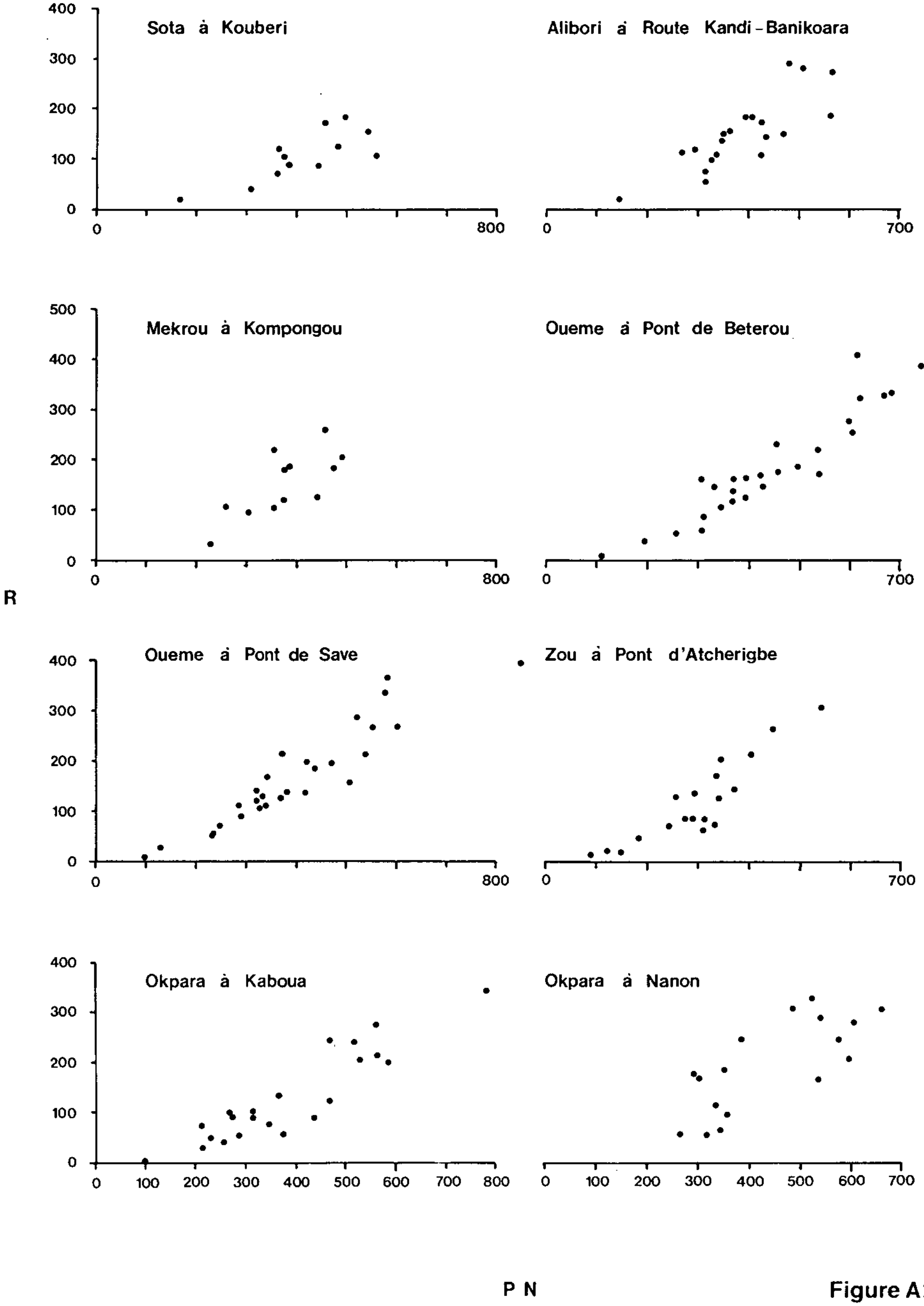

Mono à Correkope
Mono à Dotaikope
Ogou à Sirka
Chra à Chra
Anie à Anie-Gare et Pont CFT
Sio à Togblekope
Sio à Kpedji
R
PN

Figure A2.9 [c]



Sota à Kouberi
Alibori à Route Kandi - Banikoara
Mekrou à Kompongou
Oueme à Pont de Beterou
Oueme à Pont de Save
Zou à Pont d'Atcherigbe
Okpara à Kaboua
Okpara à Nanon
R
P N
0
100
200
300
400
500
700
800

Figure A2.9(d)

Comparison du coefficient de correlation [r] entre pluie nette et ruissellement au nombre de pluviometres

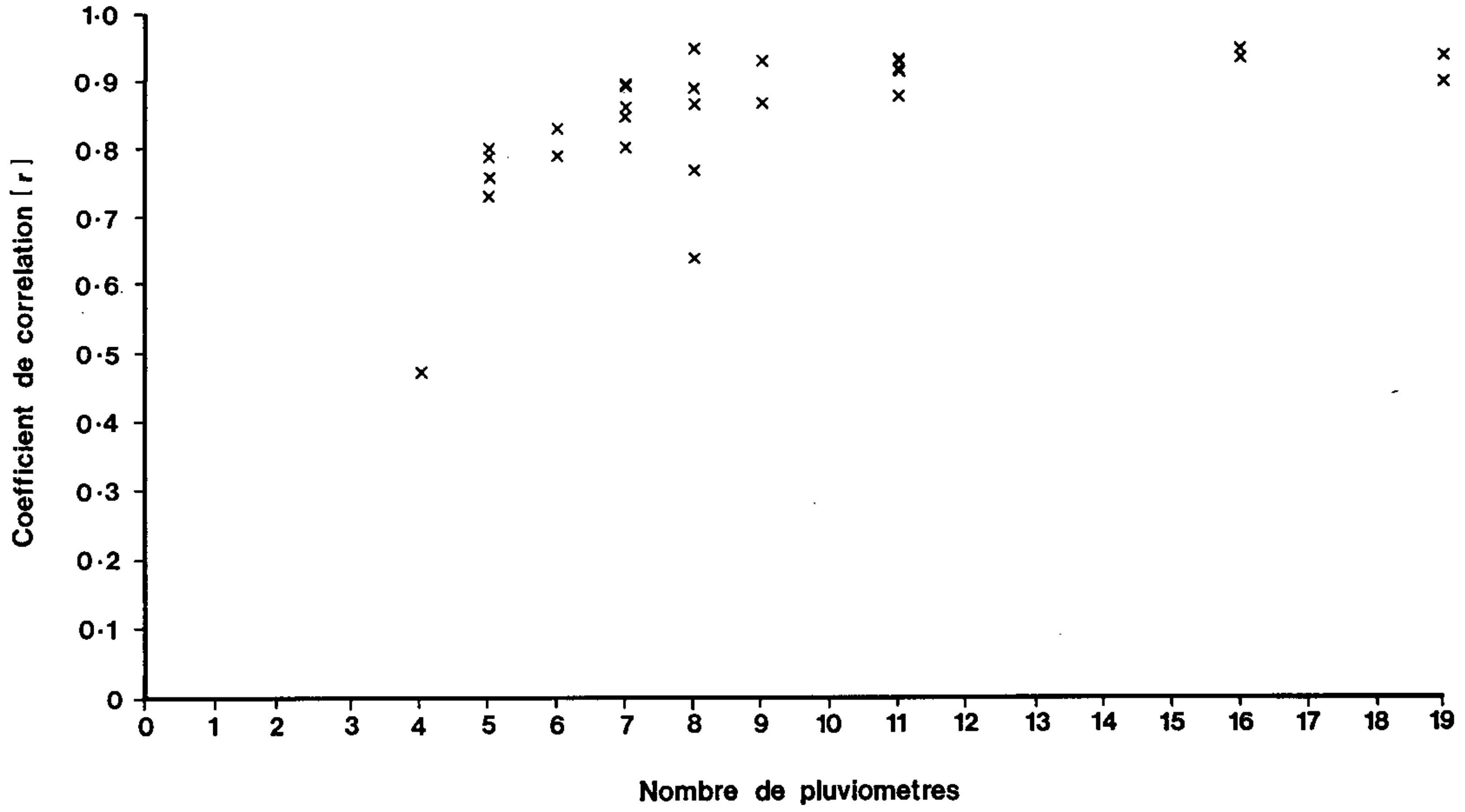
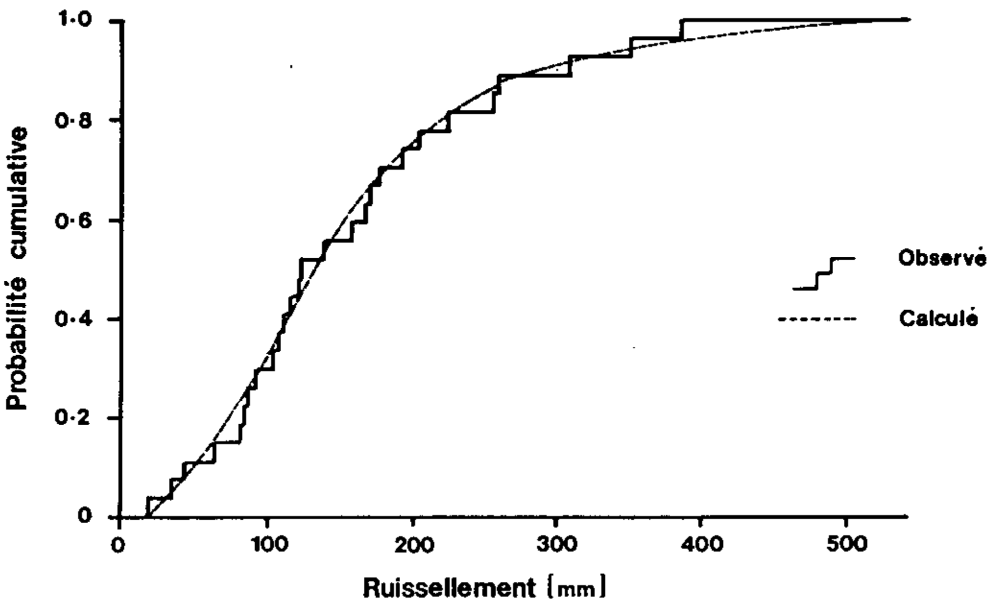


Figure A2.10

Comparaison de ruissellement observé et calculé à Tetetou

a. Distribution de ruissellement annuel à Tetetou [mm]



b. Ruissellement moyen mensuel à Tetetou [mm]

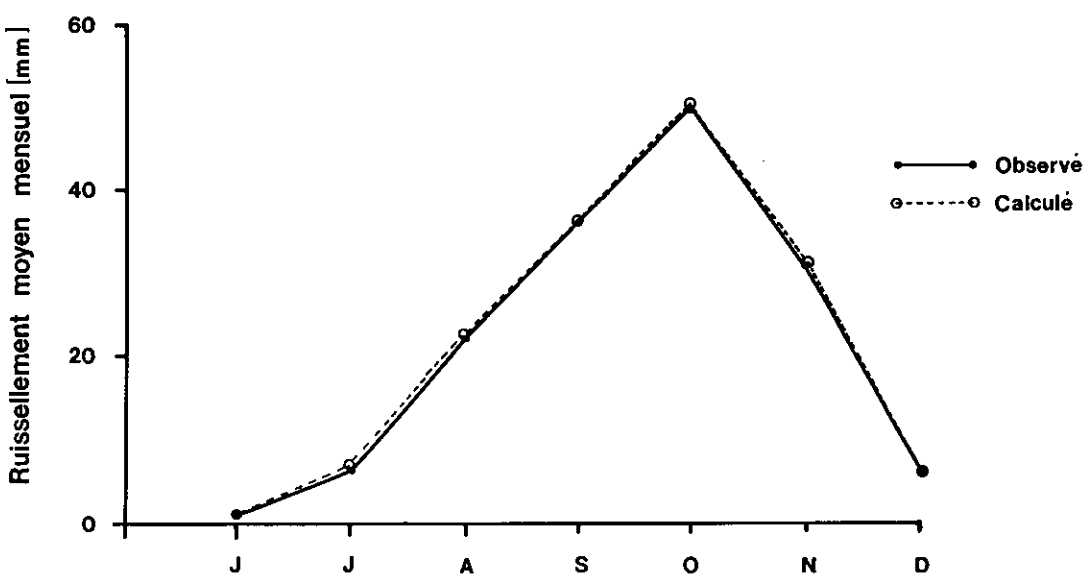


Figure A2.11

5. FLOOD ANALYSIS

5.1 Introduction

The object of the flood analysis is to provide a means of estimating floods at any site in the study area and to provide, for each of the potential dam sites, estimates of the peak inflow and flood volume for return periods ranging from 2 to 10,000 years upon which preliminary design of river diversion and spillway structures can be based.

Taking account of the large number of sites (44) inventoried in the earlier phases of this study a simple method of estimating design floods was required.

5.2 Flood estimation methods

A number of different methods of estimating floods are available; in increasing complexity they include empirical methods relating floods to catchment area and other characteristics; statistical analysis of recorded peak discharges; statistical analysis of rainfall and conversion to runoff using a suitable model.

Empirical methods are useful where data are scarce; they range from catalogues of maximum floods (UNESCO, 1976) to classification of these for different catchment areas and regions (Francou and Rodier, 1967) and empirical relationships between a flood index (eg the mean annual flood) and catchment characteristics like area and rainfall.

Statistical analysis of peak flows requires many years of streamflow record if floods of high return period are to be estimated without excessive extrapolation. The analysis can be based either on records from a single station or from a number of stations within a similar hydrological region. The annual maximum discharges from a single station are abstracted from the records, ranked and then plotted using an assumed theoretical distribution; for the regional analysis the sample size is increased by pooling the data together in dimensionless form.

Raingauges are more plentiful than river gauging stations and their periods of record are longer. Consequently the statistics of extreme rainfall can often be estimated more precisely than flood statistics. The conversion of point rainfall statistics to flood estimates involves a number of problems, including the areal extent of rainfall, runoff coefficients or catchment losses, and the timing of runoff. The unit hydrograph and losses model is commonly used but requires detailed investigation for each site.

The choice of method for this study has been influenced by the quality and availability of streamflow data. Morover, it was not considered that detailed flood analyses at individual sites were appropriate at this stage when only prefeasibility estimates are required. Consequently our analysis has been based on a combination of empirical and statistical methods. The statistical analysis of annual maxima has led to a relationship between mean annual flood and catchment characteristics, and also to a regional dimensionless flood frequency curve.

5.2 Available data

The availability of streamflow data in Togo and Benin has been discussed earlier (Section 3). However, data which are suitable for water resources analysis are not always appropriate for flood analysis. The reasons for this are that it is rare for gaugings to have been carried out at high flows; rating curves for flood discharges are therefore generally based on extrapolation. This means that at sites where the channel cross section is badly defined, ie the banks have a shallow slope and are badly overgrown, the extrapolation may be suspect.

The second problem is that in countries such as Togo and Benin, where rainfall is often very intense, the response of runoff to rainfall and the subsequent recession can be extremely rapid. Hence there is a serious danger, particularly on small catchments, that once (or even twice) daily observations of river level will lead to unrepresentative estimates of peak or mean daily discharges.

There are few river level recorders in Togo or Benin; moreover few of the charts collected have been processed. For this analysis we have therefore used annual maximum mean daily data. These data were abstracted from the relevant sources (see Section 3, Tables A2.5 and A2.6 for details), and are tabulated in Appendix 4. Some stations have been excluded either because their rating curves were considered unsatisfactory for the estimation of high flows or because the "cadence de relevées est insuffisante".

5.3 Estimation of the mean annual flood

5.3.1 Regression analysis

The basis for flood estimation is the mean annual flood ($\bar{Q}$), which in this case is defined as the arithmetic mean of the annual maximum daily mean flow. This can be estimated at stations where measurements exist, but can also most appropriately be estimated at ungauged sites by multiple regression of $\bar{Q}$ on variables such as catchment area and rainfall. The values of $\bar{Q}$ and other variables for the 19 stations available are given in Table A2.16. Experience has shown that logarithmic transformation of the data is appropriate, giving an equation of the general form:

$$\log \bar{Q} = a \log A + b \log P + c$$

where $\bar{Q}$ is the mean annual flood in m^3/s

A is the catchment area in km^2

P is the mean annual rainfall in mm

and a, b and c are constants.

The results of this regression analysis are given in Table A2.17, where the mean annual flood ($\bar{Q}$) is related to catchment characteristics like area (A), mean annual rainfall (P) and mean annual net rainfall (PN). Because the exponents of the rainfall terms in these two equations were very high, the variables were modified to (P - 800) and (PN - 200); the effect of these modifications were to reduce the exponents to nearly 1 in each case, but the explained variance decreased and standard error of estimate increased. Of the two rainfall terms, net rainfall was the more significant. From these results the most useful equation linking floods to area and rainfall is considered to be

$$\log \bar{Q} = 0.724 \log A + 2.612 \log PN - 6.967$$

or

$$\bar{Q} = 1.079 \times 10^{-7} A^{0.724} (PN)^{2.612}$$

The standard error of estimate is 0.141 in logarithmic form which is equivalent to + 0.384 or - 0.277 in multiplicative form. This is a reasonable result by comparison with similar analyses in other areas.

5.3.2 Comparison of observed and predicted values

The observed and predicted values of the mean annual flood are compared in Table A2.18. The residuals are expressed as ($\bar{Q}_{obs}/\bar{Q}_{pred}$). Inspection of this table or plotting the values on a map reveals that the equation provides underestimates in northern Togo, or specifically in all the gauged rivers north of Lama-Kara. There is a tendency towards overestimation in the flatter rivers of Benin, especially the Sota; it is possible that attenuation of the flood peak by flood plain storage is responsible for this overestimation. It is suggested that if this equation is used, estimates in northern Togo should be increased by 30%, being the average underestimate at gauged sites. Unfortunately, few observed flood records are available in the steeper rivers of southwest Togo, so that the equation cannot be tested there.

The last equation in the table is included for completeness but is not often likely to be useful. It expresses the mean annual flood ($\bar{Q}$) in terms of area (A) and mean annual runoff (R) in mm as

$$\log \bar{Q} = 0.758 \log A + 1.303 \log (R) - 3.226$$

or

$$\bar{Q} = 0.000594\ A^{0.758}\ (R)^{1.303}$$

This equation has a standard error of estimate of 0.080 in logarithmic form or +.202 to -.168 in factorial form. It will be seen that it provides smaller errors of estimate than the other equation, but requires estimates of mean annual runoff. It might be used at sites where an estimate of the mean annual runoff can be obtained from a short period of records by comparison with a long-term gauge, or where the record allows the total runoff to be estimated but is not considered reliable at high floods.

Although the regression equations provide a simple means of estimating the mean annual flood at an ungauged site, a more precise estimate will be provided from a measured flood record. Therefore it is preferable to estimate the mean annual flood from records at a gauging station if these are available on the same river at or near the dam site.

5.4 Flood frequency curve

5.4.1 Method of analysis

The method used is based on the statistical methods described in detail in the UK Flood Studies Report (NERC, 1975; Sutcliffe, 1978).

The method adopted is that of the regional flood frequency curve, rather than attempting to fit standard distributions to single series of observed floods and using the fitted equation to estimate rare floods. The method takes flood series from all suitable gauging stations within a homogeneous region, converts them into a dimensionless form and pools the records to increase the sample size. A curve is fitted to all the data points to provide a regional flood frequency curve which may be extrapolated graphically or algebraically to higher return periods than could be justified for single stations.

The regional flood frequency curve is a frequency distribution of $Q(T)/\bar{Q}$ where $Q(T)$ is the flood of T year return period and $\bar{Q}$ is the mean annual flood. Within a hydrologically homogeneous region, this curve which represents the mean of the different relationships for the different catchments within the region, provides a single curve which is valid for all stations. It is assumed that variations between curves at individual stations are due to the short period of records and that if sufficiently long records were available, the curves at individual stations would coalesce in the regional curve. The curves derived from different subregions are compared to test whether they are sufficiently similar to be combined into a single region.

5.4.2 Derivation of regional flood frequency curve

Series of annual maximum daily floods were available for the gauging stations listed in Table A2.16. Each record was converted into a dimensionless series $Q/\bar{Q}$ and the individual events ranked in ascending order. The plotting position y, corresponding to the flood of rank i in each series was estimated from the Gringorten formula given by

$$F_i = \frac{i - 0.44}{N + 0.12}$$

and $$y_i = -\ln(-\ln F_i)$$

where F_i is the plotting position expressed as a probability
i is the rank of the event
and N is the number of events in the series.

These dimensionless floods were then grouped into ranges of y (-1.5 to -1.0, -1.0 to -0.5 and so on) and the mean values of y and $Q/\bar{Q}$ were calculated for each range. These points were then used to define a regional curve. A return period scale was plotted along the horizontal y axis using the relationship $y = -\ln(-\ln{}^{1}/_{T})$ where T is the return period in years.

The series of annual maxima were intially divided into two groups, namely the Mono and Oueme rivers and their tributaries, and the tributaries of the Volta and Niger rivers. The growth curves for these two groups of stations are shown in Figure A2.12. The two curves were very similar, so the data were pooled into a single group. The resulting curve is also shown in Figure A2.12, including the 5 highest floods on record. The annual maxima used are given in Appendix 4, and the basic data for the regional curve are given in Table A2.19.

It is normal practice to fit a general extreme value distribution to these points, but in this case such a fitting would result in a growth curve which is curved downwards. Such a flood curve would be very unusual and it was considered to be more reasonable to assume a linear extension of the curve; this has been fitted to give an equation

$$Q/\bar{Q} = 1.06 + 0.215y$$

Similar investigations in other parts of West Africa (eg Guinea, Nigeria) have resulted in straight lines of moderate gradient, and it is possible that difficulties of defining the rating curve for high flows have been responsible for the relatively low values of the highest floods.

Since the records from all basins were used in this analysis, we have assumed that this regional growth curve is applicable to all sites within the study area. It is generally accepted that statistical estimates are reasonable up to return periods of about twice the period of record. The pooling of all records into a regional curve enables estimates to be made for floods of return periods up to about 1000 years at any site where the mean annual flood ($\bar{Q}$) is known. The mean annual flood can be estimated directly from records at or near the site or from the regression equation derived in Section 5.3.

5.5 Estimates of floods at priority sites

Although Section 5.3 provides a means of making preliminary flood estimates using a regression equation with catchment characteristics, there is some evidence that the residuals from the regression equation are regional. It is therefore recommended that the mean annual flood should be estimated from flood records at nearby stations where possible, and that a regional flood frequency curve should be used to deduce the flood of required return period from the estimated mean annual flood.

This technique has been followed to estimate floods at all the priority dam sites where records are available at nearby stations, and the results are summarised in Table A2.20. In each case the mean annual flood at nearby stations has been expressed in terms of m^3/s per 1000 km^2, and the most relevant station has been used to estimate the mean annual flood at the dam site.

As site 49 on the Pendjari is not near any gauged rivers, it is necessary to estimate the mean annual flood using the relationship with catchment characteristics. Inserting the area of 2680 km^2 and the net rainfall of 360 mm in the expression

$$\log \bar{Q} = 0.724 \log A + 2.612 \log PN - 6.967$$

gives

$$\log \bar{Q} = 0.724\ (3.42813) + 2.612\ (2.55630) - 6.967 = 2.192$$

or $\bar{Q} = 156\ m^3/s$

It is considered sensible to increase the flood by 30% (see Section 5.3.2) to allow for the underestimation of floods on the Pendjari and Oti downstream, and also to increase the estimate by 25% to allow for the ratio of peak to daily flow on a basin of this size (see Table A2.20). These adjustments give a flood estimate of 254 m^3/s.

For each of the eight sites the mean annual flood must be multiplied by a factor based on the regional curve to give floods of various return periods. For the 100 year flood a multiplier of 2.1 is appropriate, and estimates of this flood are given in Table A2.20. Although the length of records included in the regional curve do not permit a reliable estimate to be made of the multiplier for return periods exceeding 1000 years, a series of consistent design floods (Q_p) have been estimated by multiplying the mean annual flood by a factor of 4.0. The return period of this flood may be of the order of 10,000 years. It is recommended that at the feasibility study stage the flood estimate at the selected site or sites should be confirmed using a hydrometeorological approach to estimate storm amount and a unit hydrograph approach with direct flood measurements at the site to estimate the flood hydrograph shape.

5.6 Comparison with flood estimates by others

5.6.1 General

As a check on the reliability of this method of estimation the results have been compared with estimates made by other organisations for the same site. Because studies have been carried out and also reasonable flow records are available for the Tetetou/Nangbeto area, a variety of methods may be illustrated at these sites.

For site 12, the mean annual flood was estimated from the Tetetou record (788 m^3/s) and the 100 year flood and design flood were scaled up using factors of 2.1 and 4.0 which were based on a regional curve from the whole of Togo and Benin to give estimates of 1650 and 3200 m^3/s.

5.6.2 Empirical methods

Although it will be desirable to confirm the final design flood at the eventual selected sites, the study of the storm rainfall data, the percentage runoff in selected storms and floods, and the unit hydrograph which would be required to make an estimate by this method is not justified at this stage. It is, however, possible to compare the flood estimates with those which have been experienced over a wide area by using an empirical regional approach. An approach which has been developed in particular relation to African conditions is that of Francou and Rodier, in which African flood records have been assembled in the context of world flood extremes. The mean annual floods at design sites have been compared with area on the Francou-Rodier scale; 100 year floods and design floods are also shown. Francou and Rodier suggest that the majority of floods in their tables are of the order of 100 year return period, and that K values of 2-3 are appropriate for West African conditions. (K is defined by the equation $\frac{Q}{10^6} = (\frac{S}{10^8})^{1-K/10}$ where Q is maximum flood in m^3/s and S is catchment area in km^2). "Les grands fleuves tropicaux d'Afrique: Niger, Sénégal, Sanaga, sont relativement calmes: K varie de 2 à 3 lorsqu'il n'y a pas encore de grandes plaines d'inondation". Although the estimate on the Kara is much larger, this is compatible with the different topographic conditions. Apart from this site the relations between flood and area are in line with the Francou-Rodier results, with K values of 2.5 to 3.0 for the 100 year floods and about 3.5 for the design floods.

5.6.3 Statistical analyses

Another estimate of the 100 year flood could be made using simply the 28 year record at Tetetou. This is illustrated in Figure A2.13 where a frequency curve has been based on the observed records at the site. The 100 year flood is estimated as 1840 m^3/s by this method; the length of record does not permit a reasonable estimate of a rarer flood.

The LCHF atlas provides estimates of floods based on statistical analysis of records at a number of individual sites; the 100 year flood at Tetetou is estimated from records at 1480 m^3/s, while at N'gamboto it is estimated with less precision at 1470 m^3/s. These estimates are comparable to the present estimates.

The Sogreah/Electrowatt report, on the other hand, which is based on Tetetou records provides estimates of the 20 year flood of 1430 m^3/s. These are extended by statistical analysis, confirmed by the Gradex method, to give 100 year floods of 2150 m^3/s and 10,000 year floods of 4500 m^3/s. Similar results are obtained from the "Soil Conservation Service" method.

5.6.4 Conclusions

The above comparison shows that the different methods of estimating floods which have been previously used for sites in Togo and Benin lead to a significant scatter in the values obtained for the 100 year flood and an even wider variation in design flood. The method which has been used in this present study gives results which are within the range of previous estimates, as demonstrated particularly by Site 12 (Tetetou Amont), and is considered to provide a good basis for the present comparative studies of the priority sites. It is evident, however, that more detailed studies (and supplementary measurements) will be required during future feasibility studies of these sites and conservative values of the design flood, in particular, should therefore be used for the preliminary conception of the structures in this present prefeasibility study.

TABLE A2.16

Details of flood characteristics

River	Site	Mean annual flood (m^3/s)	Area km^2	Mean annual rainfall mm	Mean annual net rainfall mm
Sota	Kouberi	251	13410	1120	350
Alibori	Route Kondi-Banikoara	382	8150	1150	360
Okpara	Kaboua	254	9600	1180	350
Okpara	Nanon	101	2067	1190	380
Oueme	Pont de Beterou	492	10326	1250	440
Oueme	Pont de Save	968	23600	1200	400
Zou	Pont d'Atcherigbe	353	6950	1170	320
Porga	Pendjari	422	22280	970	270
Oti	Mandouri	570	29100	980	280
Oti	Mango	907	35650	1000	300
Keran	Titira	669	3695	1350	520
Keran	Naboulgou	589	5470	1300	460
Kara	Lama Kara	420	1560	1470	575
Kara	Kpesside	642	2790	1450	550
Anie	Pont CFT	390	3630	1320	430
Ogou	Sirka	181	4035	1180	390
Mono	Dotaikope	524	5589	1250	450
Mono	Correkope	515	9952	1240	430
Mono	Tetetou	788	20100	1250	410

TABLE A2.17

Regression of mean annual flood ($\bar{Q}$) on catchment characteristics

Variable No	Name	Coeff	seb	t	R	R^2	see	Const	Multiplier
1	A	0.290	0.132	4.8	0.470	0.221	0.222	1.510	32.36
2	A P	0.776 5.019	0.140 1.105	30.8 20.6	0.812	0.660	0.151	-15.849	1.416×10^{-16}
2	A (P-800)	0.680 1.225	0.161 0.380	17.9 10.4	0.726	0.527	0.178	-3.180	.000661
2	A PN	0.724 2.612	0.120 0.512	36.7 26.0	0.839	0.704	0.141	-6.967	1.079×10^{-7}
2	A (PN-200)	0.671 1.055	0.136 0.267	24.2 15.6	0.779	0.606	0.162	-2.367	.00430
2	A R	0.758 1.303	0.065 0.122	137 114	0.951	0.904	0.080	-3.226	.000594

Coeff. is the regression coeff b in an equation of the form: $\bar{Q}$ = multiplier. $A^{b_1} P^{b_2}$; seb is the standard error of estimate of b; t is the student's t statistic; R, R^2 are the coefficients of multiple, correlation and determination; see is the standard error of estimate of the relationship. The fractional standard error of estimate is the antilogarithm of see; Const is the intercept of the logarithmic equation; Multiplier is the antilogarithm of const. P is the mean annual rainfall; PN is the mean annual net rainfall; R is the mean annual runoff in mm; A is the catchment area in km^2.

TABLE A2.18

Comparison of observed and predicted mean annual flood ($\bar{Q}$)

	River	Site	Obs. $\bar{Q}$	Pred. $\bar{Q}$	$\bar{Q}_{OBS}/\bar{Q}_{PRED}$
1	Sota	Kouberi	251	466	0.54
2	Alibori	Route Kondi-Banikoara	382	349	1.09
3	Okpara	Kaboua	254	366	0.69
4	Okpara	Nanon	101	149	0.68
5	Oueme	Pont de Beterou	492	701	0.70
6	Oueme	Pont de Save	968	995	0.97
7	Zou	Pont d'Atcherigbe	353	229	1.54
8	Porga	Pendjari	422	342	1.23
9	Oti	Mandouri	570	456	1.25
10	Oti	Mango	907	632	1.44
11	Keran	Titira	669	515	1.30
12	Keran	Naboulgou	589	497	1.19
13	Kara	Lamakara	420	358	1.17
14	Kara	Kpesside	642	429	1.50
15	Anie	Pont GFT	390	310	1.26
16	Ogou	Sirka	181	259	0.70
17	Mono	Dotaikope	524	476	1.10
18	Mono	Correkope	515	643	0.80
19	Mono	Tetetou	788	944	0.83

TABLE A2.19

Regional flood frequency curve - daily flows. Averaged values of $Q/\bar{Q}$ and plotting position y.

y interval	No in interval	Mean y	Mean $Q/\bar{Q}$
North of Togo and Benin			
-1.5 to -1.0	13	-1.18	0.34
-1.0 to -0.5	24	-0.71	0.54
-0.5 to 0	33	-0.26	0.72
0 to 0.5	38	0.23	0.90
0.5 to 1.0	29	0.74	1.12
1.0 to 1.5	23	1.25	1.32
1.5 to 2.0	15	1.78	1.46
2.0 to 2.5	9	2.29	1.57
2.5 to 3.0	6	2.74	1.63
3.0 to 3.5	3	3.45	1.60
3.5 to 4.0	6	3.76	1.73
Five highest values of $Q/\bar{Q}$ and corresponding y values		3.77	1.79
		4.02	1.83
		4.35	1.88
		4.87	1.92
		5.87	1.93
South of Togo and Benin			
-1.5 to -1.0	14	-1.20	0.17
-1.0 to -0.5	29	-0.73	0.48
-0.5 to 0	40	-0.26	0.71
0 to 0.5	44	0.24	0.91
0.5 to 1.0	34	0.74	1.12
1.0 to 1.5	25	1.23	1.32
1.5 to 2.0	18	1.72	1.46
2.0 to 2.5	12	2.23	1.58
2.5 to 3.0	8	2.77	1.68
3.0 to 3.5	2	3.41	2.14
3.5 to 4.0	8	3.79	1.90
Five highest values of $Q/\bar{Q}$ and corresponding y values		3.93	2.06
		4.18	2.08
		4.51	2.11
		5.03	2.11
		6.03	2.44

TABLE A2.19 (continued)

y interval	No in interval	Mean y	Mean $Q/\bar{Q}$
Whole of Togo and Benin			
-1.5 to -1.0	27	-1.19	0.25
-1.0 to -0.5	53	-0.72	0.51
-0.5 to 0	73	-0.26	0.71
0 to 0.5	82	0.24	0.91
0.5 to 1.0	63	0.74	1.12
1.0 to 1.5	48	1.24	1.32
1.5 to 2.0	33	1.75	1.46
2.0 to 2.5	21	2.25	1.57
2.5 to 3.0	14	2.76	1.66
3.0 to 3.5	5	3.43	1.82
3.5 to 4.0	14	3.78	1.83
Five highest values of $Q/\bar{Q}$ and corresponding y values		4.55	2.06
		4.80	2.08
		5.13	2.11
		5.65	2.11
		6.65	2.44

TABLE A2.20

Flood estimates at potential dam sites

Site No	Catchment Area	Adjacent station Name	Adjacent station $\bar{Q}$ m^3/s	Adjacent station A km^2	Adjacent station $\bar{Q}/A$	Estimated floods at project sites $\bar{Q}/A$	$\bar{Q}$	Q_{100}	Q_P
10	15700	Tetetou	788	20100	39	52	816	1710	3300
		Correkope	515	9952	52				
12	19600	Tetetou	788	20100	39	39	788	1650	3200
16	20600	Tetetou	788	20100	39	39			
20) 20A)	38000	Pont de Save	968	23600	41	41	1560	3280	6200
24	16300	Beterou	492	10326	48	48	782	1640	3100
25A	22500	Pont de Save	968	23600	41	41	922	1940	3700
29	2730	Lama-Kara	420	1560	270	250	682 +25% =852	1790	3400
		Kpesside	642	2790	230				
45A	7900	Kouberi	251	13410	19	47	371 +15% =427	900	1700
		Alibori	382	8150	47				
49	2680	Formula linking flood with catchment characteristics					254	530	1000

Notes: $\bar{Q}$, the mean annual flood, is estimated from the most appropriate adjacent gauge in terms of $\bar{Q}/A$. $Q_{100}/\bar{Q}$ is taken as 2.1, and a project flood Q_P is estimated from $Q_P/\bar{Q} = 4.0$. To allow for the records being daily floods, a ratio of peak : daily flood has been added of 25% for areas 2000-5000 km^2, of 15% for areas 5000-10000 km^2. $\bar{Q}/A$ is expressed as $m^3/s/1000\ km^2$.

Debits journaliers maximum annuels Courbes regionales

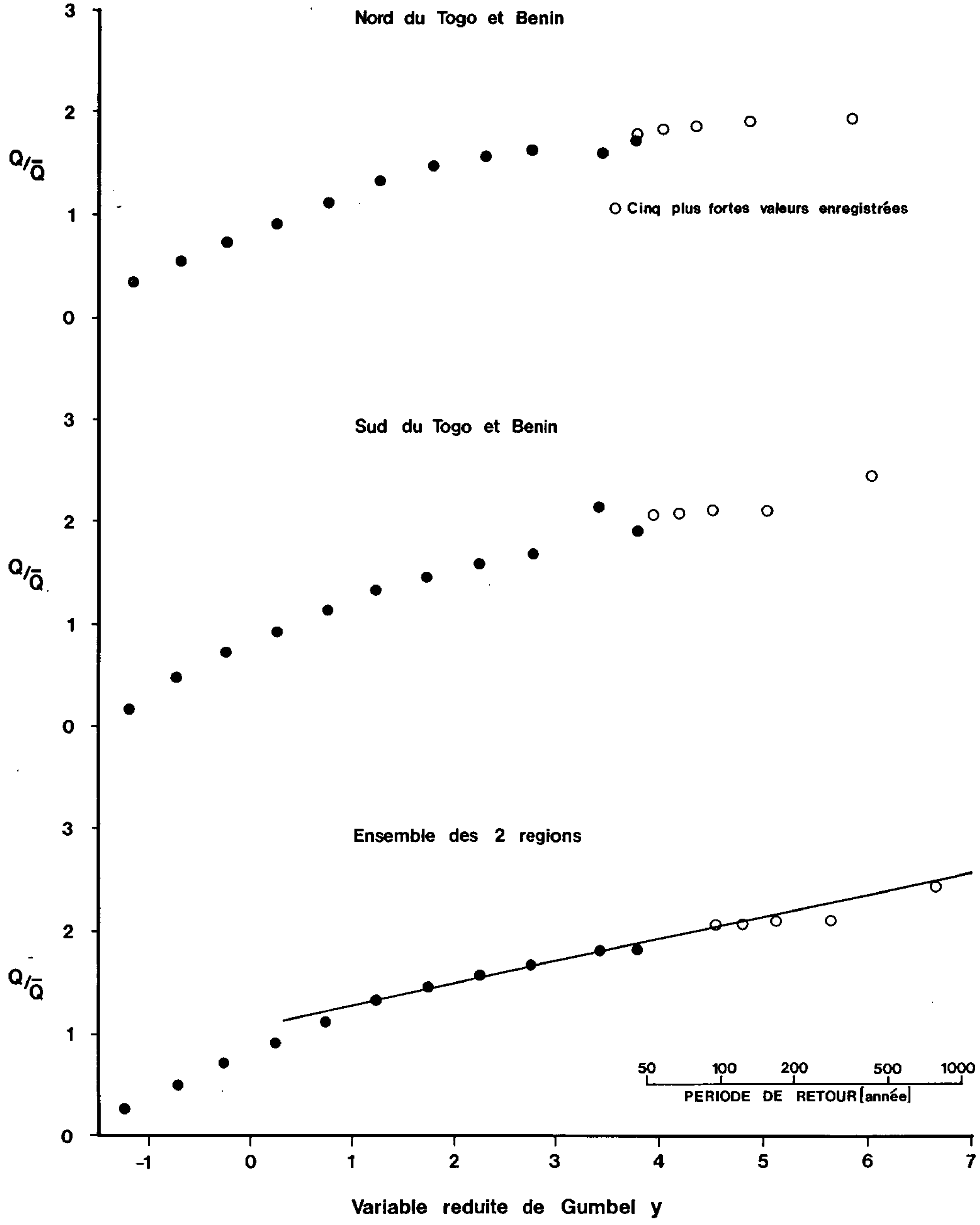


Figure A2.12

Debits journaliers maximum annuels - Mono à Tetetou

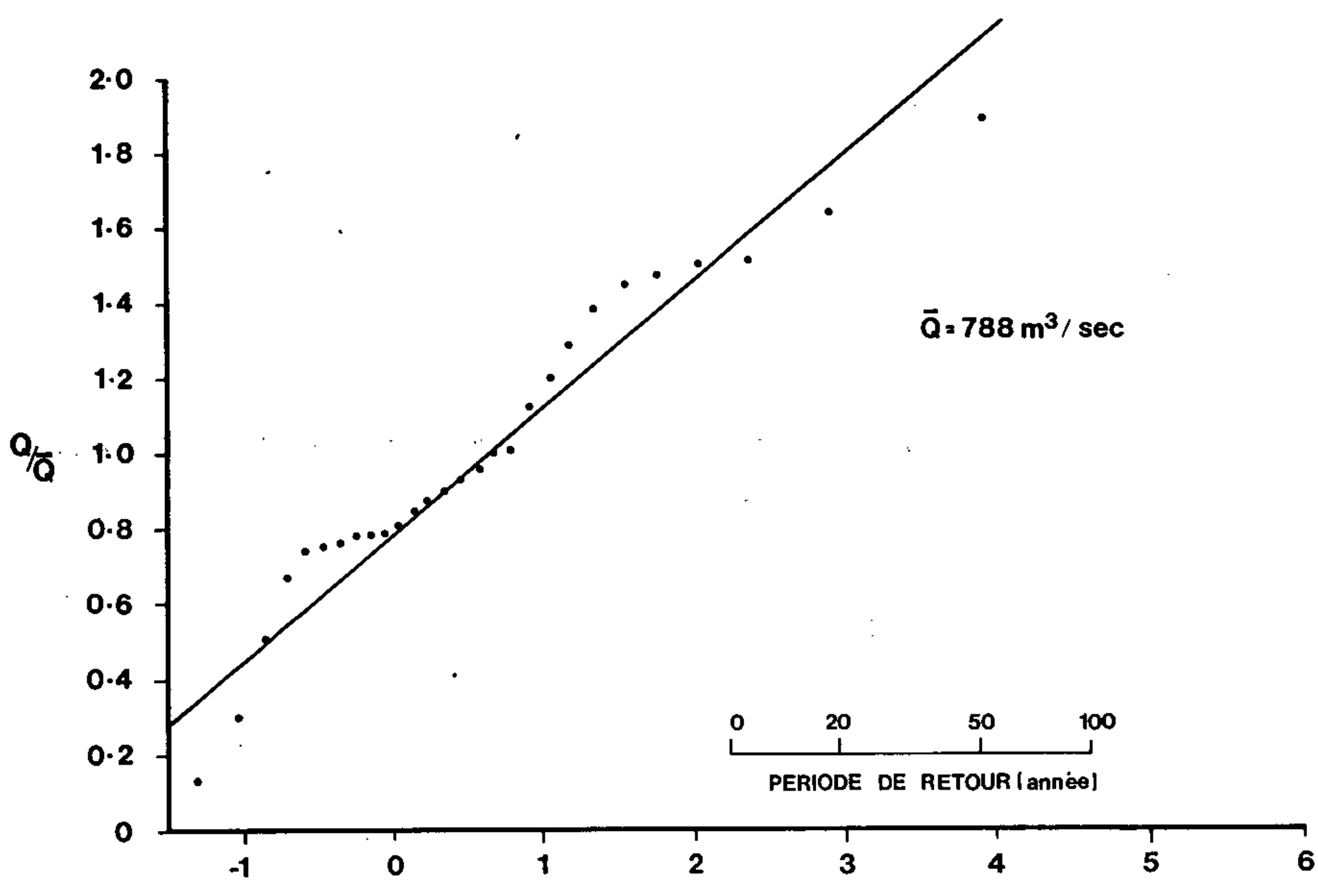


Figure A2.13

6. RECOMMENDATIONS FOR THE HYDROLOGICAL NETWORK

The availability of basic hydrological data was discussed in our previous report (SAGP, 1982), and the differences between the extent of the observation networks and the quality of the data collection and processing in each country was pointed out. Also mentioned in that report was the mission of a WMO Expert to Togo and Benin "dans le cadre du projet 'Planification et développement réseaux hydrométéorologiques et des services connexes en Afrique". Unfortunately the reports of his missions are still unavailable, so it seems appropriate to make only general comments and recommendations here, as it is assumed that the WMO reports will cover the topic in some detail.

6.1 Togo - streamflow

The network is already very extensive and is being operated and managed very competently by the Division Hydrologique de la Direction de l'Hydraulique in collaboration with ORSTOM. As mentioned earlier in this report, the main problems are concerned with the lack of flow measurements in the medium to high range of flows at some stations, and the uncertainties of river level read once or twice a day. At some sites the river bed is unstable, and the low flow ratings change after floods. However, the number of routine gaugings carried out at present seem sufficient to identify these changes when they occur, and the rating curves are modified as necessary.

The logistical problems of keeping a gauging team in the field, ready to do gaugings of high flows are considerable, particularly when access is made difficult by heavy rain. The present programme of routing gaugings should be encouraged and continued.

Our main recommendation is that more frequent observations should be made on the smaller tributaries, particularly those in the higher rainfall areas on the west of Togo and around Lama Kara. Although it would be possible to achieve this by increasing the number of observations made throughout the day the best solution would be to install limnigraphs. At the same time it would be necessary to ensure that adequate facilities are available for the "depouillement des limnigrammes". These charts would also help provide useful information on flood hydrographs that will be required in the next stage of the study when more detailed flood analysis is carried out.

6.2 Togo - rainfall

The country is reasonably well served by raingauges, except in the dry region to the northwest of Mango. However, the main problem appears not to be one of inadequate coverage, but rather one of poor processing and publishing of data. We therefore strongly recommend that steps are taken to improve the collection, quality control, archiving and retrieval of rainfall data at the Meteorological Department. It does not seem unrealistic to consider the use of computer technology to achieve this end.

6.3 Benin - streamflow

In contrast with Togo, the river flow records in Benin appear to be less satisfactory than the rainfall records. Once again the locations of the river gauges seem adequate; however, it is the routine operation, maintenance and inspection of the network that should be improved.

At present it appears that twice daily water level observations are being made at the majority of the stations. These readings have very little value if they are not subject to some basic quality control, and especially if individual rating curves have not been verified by regular current meter gaugings. In short, the individual stations within the network exist in a more or less operational state, but the infrastructure for processing the observations from these stations does not appear to be satisfactory. The whole of the network therefore needs a complete overhaul and rehabilitation, for without a thorough processing system the measurements that are being made are not reliable.

6.4 Benin - rainfall

The density of raingauges is reasonable in most areas except the area to the north of Parakou and Natitingou that includes the northward flowing tributaries of the Niger. The area is sparsely populated with few villages, so it is probably impracticable to consider setting up more raingauges of a conventional type. However, the installation of solid state recording gauges might be a solution.

In Benin, the rainfall data are processed by ASECNA, and in contrast with Togo, summaries of the monthly falls at individual stations are kept more or less up to date and are easily available for consultation or copying. This system would nevertheless benefit from some automation.

7. Recommendations for site studies

The general problem of improving the network for measuring rainfall and river flow, and the analysis of these measurements, has been covered in Section 6. In this section the further measurements and studies at selected sites are discussed, on the assumption that a limited number of sites are chosen for the next phase of investigation. The further investigations are first discussed without reference to specific sites, and then in terms of the present priority sites.

Where there are no gauging stations at or near the selected sites, it has been necessary to transfer flow measurements or estimates from the nearest gauging stations; this has been done in this study by comparing contributing areas and rainfall over the catchments of the gauging station and the selected site. These flow estimates could be improved if a subsidiary gauging station were set up at the selected site, so that a relationship between the two sets of flows could be obtained by comparing simultaneous measured river flows at the established gauging station and the selected site. A relationship based on measured flows at both sites would be preferable to one based on area and rainfall after a relatively short period of simultaneous measurements was available. It is probably premature to discuss whether the relationship should continue to be expressed as a simple ratio, or whether some more complex relationship could be justified.

At this stage, flood estimates at the selected sites have been obtained by estimating the mean annual flood and multiplying this by factors based on a regional dimensionless flood frequency curve. It will be necessary at the next stage to check these estimates by comparison with flood estimates based on storm-rainfall and subsequent runoff. Hydrometeorological estimates of catchment rainfall corresponding to appropriate return periods or to the maximum storm should be based on existing rainfall records and on both statistical and physical analysis. Statistical studies have already been carried out on a countrywide scale but these need to be supplemented by analysis of local data, including recent records. The maximisation of recorded storms with respect to atmospheric moisture provides a check on statistical extrapolation of rainfall records. Areal reduction factors should be estimated from regional data. The catchment response can be expressed in terms of catchment losses or of runoff coefficient, and this is best estimated from a study of local rainfall and runoff records. The timing of the catchment response can similarly be deduced from local rainfall and runoff records, from which a unit hydrograph can be abstracted. For this purpose, continuous flow records, preferably from a recorder, will be required and so will observations from recording raingauges. Although the unit hydrograph approach is generally required in spillway design flood estimation, it is possible that some of the catchments may prove to be too large for this approach to be entirely appropriate. However, the use of the method in the smaller catchments should indicate the reliability of the regional flood frequency curve approach.

The lack of measurements of sediment load have made it impossible to make realistic estimates of reservoir siltation. It is recommended that sampling should be carried out at the selected sites and adjacent gauging stations in order that a sediment load-discharge relationship may be built up to estimate total sediment loads.

Sites 10A, 12 and 16

The flows for these sites have been derived from Tetetou, where the measured flows have been extended by time series analysis using the long-term series of net rainfall. The flows at Tetetou were expressed in terms of mm over the basin, and these were transferred to the dam sites using ratios shown in Table A2.15 which were calculated on net rainfall over the Tetetou basin and the incremental area between Tetetou and the dam site. These ratios were in fact close to 1, varying from 0.98 to 1.06 for the three sites.

It is recommended that these ratios should be confirmed by simultaneous flow measurements. In order to minimise the effect of unavoidable measurement errors, it is probably preferable to calculate the ratios from annual runoff totals.

The flood estimates have also been derived from measured floods at Tetetou, except for Site 10A where the higher value of the mean annual flood (in m^3/s per km^2) derived from Correkope was used. These floods have been scaled up from the mean annual flood by factors of 2.1 and 4.0 to give estimates of the 100 year flood and a project flood. These flood estimates will require review for a selected site, but because of the size of the basin direct application of unit hydrograph methods would be difficult. It will be desirable to study the flood potential of the different tributaries and to combine these.

Sites 20A, 24 and 25A

The analysis for these sites has been somewhat similar. Measured flows at Pont de Save and Pont de Beterou have been extended by time series analysis using long-term net monthly rainfall. These flows have been transferred from Pont de Beterou to Site 24, and from Pont de Save to Sites 20A and 25A, in terms of mm over the basin and comparing average net rainfall over the corresponding basins. The ratios used should be confirmed using measured flows at the dam site in due course.

Mean annual flood estimates have been transferred in terms of m^3/s per km^2, and scaled up using countrywide flood frequency curves. Rainfall studies and unit hydrograph techniques should be used to confirm these estimates at the selected site.

Site 29

Although there are two gauging stations on the Kara, at Lama-Kara and Kpesside, the record at Lama-Kara was considered more reliable. The flow record was extended by time series methods, and the extended record was transferred to the site allowing for area and average net rainfall.

The flood estimate was based on records at both Lama-Kara and Kpesside, but was increased by 25% to allow for the difference between instantaneous and daily flows from a relatively small catchment. This estimate should be confirmed by rainfall and unit hydrograph analysis if this site is selected for further study.

Site 49

Because there was no gauging station on the same river as this site, the estimates had to be based on more indirect analysis, and the results must be less precise. The nearest similar gauging station is on the adjacent river, the Mekrou at Kompongou, and the measured flows at this site were extended by time series analysis to give a long-term flow series. As the mean net rainfall at Site 49 was precisely the same as at Kompongou, and the adjacent gauges used to estimate the long-term net rainfall series were identical at the two sites, the rainfall series were the same at both sites and therefore the generated flow series would be similar and could be transferred directly from one site to the other in terms of mm over the basin. In view of this, it was possible to use the measured and extended flow record from Kompongou as though it had occurred at Site 49. In view of this, it would be useful to measure flows at Site 49 and observe the actual ratio of flows on the two rivers.

The flood estimate was calculated from catchment characteristics using the formula derived from the analysis of flood records. It will be necessary to confirm this if this site is selected. Rainfall analysis could be supplemented by unit hydrograph analysis using a relatively short period of actual flow records at Site 49.

SYMBOLS

E_T	Potential transpiration
P	Precipitation or pluie
PN	Pluie nette
S	Soil moisture recharge
s(R)	Standard deviation
R	Ruissellement (mm)
A	Area
$\bar{Q}$	Mean annual flood

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STREAMFLOW - MONO AT TETETOU

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1951	-	-	0.1	0.3	0.7	1.4	7.2	11.8	30.0	-	-	1.7
1952	0.4	0.2	0.3	0.1	0.4	0.9	13.2	19.9	33.9	44.4	7.8	1.3
1953	0.4	0.2	0.9	0.2	1.1	13.0	38.2	41.5	34.5	24.2	4.7	0.7
1954	0.3	0.1	0.2	0.2	0.4	4.3	10.1	7.0	14.2	37.2	8.5	1.2
1955	0.2	0.1	0.5	2.2	2.4	11.2	40.5	68.1	82.6	41.7	9.1	1.6
1956	0.4	0.1	0.7	0.6	0.2	2.3	2.4	3.1	13.9	11.6	0.9	0.4
1957	0.1	0.0	0.1	0.3	3.3	21.1	49.4	64.3	89.9	61.8	15.9	4.2
1958	1.1	0.3	0.2	0.3	2.1	6.0	1.6	0.6	2.8	4.2	0.6	0.5
1959	0.1	0.0	0.1	0.5	1.3	0.6	15.5	8.5	44.1	32.4	4.3	1.1
1960	0.2	0.1	0.1	1.6	1.2	7.6	37.4	56.8	87.6	52.1	11.0	2.2
1961	0.7	0.2	0.1	0.2	0.4	2.0	11.6	7.9	10.1	10.0	0.7	0.0
1962	0.0	0.0	0.0	0.1	2.5	28.1	38.4	47.7	54.4	42.9	9.2	2.4
1963	0.3	0.2	0.6	0.5	0.9	6.0	66.8	89.4	109.5	91.8	18.7	2.1
1964	0.6	0.2	0.2	0.5	0.7	2.5	8.8	23.6	60.2	13.1	2.0	0.5
1965	0.2	0.1	0.1	0.5	0.4	11.6	64.5	60.4	52.6	14.4	1.5	0.3
1966	0.1	0.1	0.1	0.2	0.2	3.1	15.5	60.8	66.1	25.2	5.0	0.7
1967	0.2	0.1	0.2	0.7	1.0	5.2	18.3	54.4	72.2	34.6	4.9	1.5
1968	0.5	0.2	0.2	0.4	2.3	17.6	69.2	96.6	96.9	54.7	12.1	1.6
1969	0.4	0.2	0.2	0.7	0.6	1.5	16.5	40.9	60.6	33.7	13.8	1.5
1970	0.4	0.2	0.6	0.2	1.3	1.2	2.0	31.9	95.6	31.9	2.7	0.2
1971	0.1	0.6	0.2	0.5	0.4	0.6	6.7	38.0	30.6	9.9	0.9	0.4
1972	0.1	0.1	0.1	1.0	1.9	9.9	20.8	18.3	29.5	8.7	2.0	0.3
1973	0.2	0.1	0.1	0.3	0.3	0.8	4.2	29.8	40.3	25.7	3.0	0.5
1974	0.2	0.1	0.3	0.4	0.5	0.5	11.0	28.2	53.7	25.6	3.1	0.5
1975	0.2	0.1	0.1	0.7	0.5	1.4	13.3	40.8	44.6	34.6	2.9	1.0
1976	0.4	0.2	0.2	0.2	0.7	3.4	5.6	18.3	8.3	32.4	14.7	1.4
1977	0.5	0.2	0.0	0.0	0.2	0.4	1.3	6.5	35.3	19.2	1.4	0.3
1978	0.1	0.1	0.8	1.8	1.7	10.3	22.3	14.4	32.7	25.3	5.3	1.7
1979	0.8	0.3	-	1.3	3.5	7.3	-	-	62.7	-	4.6	1.4

STREAMFLOW - KERAN AT TITIRA

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1962	-	-	0.0	0.7	1.3	12.8	36.0	109.5	117.9	54.4	18.1	3.8
1963	1.8	0.3	0.4	1.3	1.3	1.5	56.0	185.6	186.6	118.9	31.1	9.3
1964	1.1	0.3	0.9	0.8	4.1	3.7	25.2	73.3	170.5	34.9	7.9	2.5
1965	1.4	0.5	0.3	0.4	4.6	8.0	19.9	69.2	75.8	19.8	3.4	1.1
1966	0.5	0.1	0.1	0.3	3.6	15.0	23.7	76.1	102.4	73.2	12.6	2.8
1967	1.1	0.3	0.2	0.5	3.6	4.1	45.4	164.5	104.5	62.8	9.6	4.9
1968	1.6	0.5	0.2	8.9	11.0	35.3	120.3	97.1	152.2	61.9	14.3	4.6
1969	2.1	0.8	0.3	1.3	1.4	1.8	33.3	90.6	183.8	79.7	37.7	8.0
1970	3.0	1.2	0.7	0.2	2.0	1.3	16.2	82.6	208.3	52.2	8.1	2.3
1971	[illegible]	0.6	0.3	1.3	1.2	1.7	66.5	154.4	124.2	32.8	5.3	2.0
1972	0.8	0.2	0.1	0.6	11.6	9.2	37.3	62.0	88.4	34.1	6.7	2.2
1973	[illegible]	0.3	0.1	0.1	1.3	2.0	10.6	82.6	115.7	46.3	6.0	1.2
1974	0.4	0.1	0.1	0.1	2.6	6.0	24.9	70.6	144.5	45.7	8.4	-
1975	0.8	0.3	0.1	2.5	2.1	1.3	39.2	88.4	129.8	40.4	6.3	1.9
1976	0.7	0.3	0.1	0.1	1.4	-	31.5	58.4	45.2	43.3	15.8	2.6
1977	0.9	0.3	0.1	0.4	0.9	2.2	12.7	19.1	51.1	10.9	1.1	0.2
1978	0.1	0.0	0.4	1.3	2.4	6.9	60.5	90.6	94.7	24.1	7.6	1.5
1979	0.6	0.1	0.1	0.1	2.3	8.3	63.5	78.3	154.3	52.3	-	1.7

STREAMFLOW - OUEME AT PONT DE BETEROU

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1952	-	-	-	-	-	0.2	10.1	57.6	62.8	78.3	10.3	1.4
1953	0.4	0.1	0.1	0.0	0.7	1.8	51.1	86.1	110.4	63.3	9.8	1.4
1954	0.3	0.0	0.0	0.0	0.3	3.3	5.6	42.8	60.5	41.0	6.0	1.7
1955	0.7	0.2	0.1	0.2	0.3	3.1	50.1	116.2	133.8	93.1	11.9	2.1
1956	0.5	0.1	0.2	0.1	0.1	1.6	2.4	15.8	49.5	32.7	3.1	0.8
1957	0.1	0.0	0.0	0.0	0.5	4.4	12.9	75.2	144.3	77.6	13.5	3.0
1958	0.6	0.1	0.0	0.0	0.2	0.1	0.6	0.5	2.7	4.3	0.5	0.0
1959	0.0	0.0	0.0	0.0	0.5	0.3	5.3	15.1	97.1	50.6	2.7	0.6
1960	0.0	0.0	0.0	0.1	0.1	0.3	24.7	68.7	139.1	90.0	8.2	0.9
1961	0.2	0.1	0.0	0.2	0.0	3.0	12.3	27.8	62.3	19.5	1.3	0.1
1962	0.0	0.0	0.0	0.0	0.1	4.0	11.9	69.5	103.9	52.9	9.8	1.5
1963	0.3	0.0	0.1	0.0	0.4	0.2	12.3	92.3	144.6	114.1	20.9	2.3
1964	0.5	0.1	0.0	0.0	0.1	0.8	7.7	38.1	90.4	21.0	2.8	0.5
1965	0.1	0.0	0.0	0.0	0.1	0.8	10.9	49.8	84.6	13.8	1.2	0.2
1966	0.0	0.0	0.0	0.0	0.5	2.3	6.4	24.3	34.9	45.4	5.8	0.5
1967	0.1	0.0	0.0	0.0	0.1	0.3	11.2	64.3	90.1	56.0	5.4	1.1
1968	0.3	0.0	0.0	0.4	1.1	8.7	50.8	61.5	100.4	46.9	6.2	0.8
1969	0.2	0.0	0.0	0.0	0.1	0.2	0.5	32.9	81.6	36.6	14.3	1.5
1970	0.3	0.0	0.0	0.0	0.0	0.3	1.7	27.2	75.1	37.6	2.4	0.4
1971	0.1	0.0	0.0	0.0	0.1	1.0	2.9	36.1	77.8	13.9	1.0	0.3
1972	0.0	0.0	0.0	0.0	0.3	1.4	3.8	8.0	16.4	5.9	0.8	0.2
1973	0.2	0.0	0.0	0.0	0.0	0.5	3.7	80.7	73.3	28.0	2.2	0.2
1974	0.0	0.0	0.0	0.0	0.0	0.1	8.6	37.4	92.6	33.7	2.4	0.2
1975	0.0	0.0	0.0	0.0	0.0	0.1	10.1	26.5	71.3	31.1	2.2	0.3
1976	0.1	0.0	0.0	0.0	0.9	4.8	5.1	12.0	8.0	17.4	10.3	0.8
1977	0.1	0.0	0.0	0.0	0.0	0.0	2.0	9.7	28.1	12.2	0.8	0.1
1978	0.0	0.0	0.0	0.0	0.4	1.1	18.0	32.2	22.7	6.8	3.2	0.3
1979	0.0	0.0	0.0	0.0	0.0	0.7	11.5	52.1	79.3	63.0	10.9	0.8

STREAMFLOW - OUEME AT PONT DE SAVE

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1951	-	-	0.0	0.0	0.0	0.0	3.6	38.8	68.2	53.5	27.2	2.5
1952	0.4	0.1	0.0	0.0	0.1	0.1	9.2	45.9	44.7	72.1	11.2	1.0
1953	0.2	0.0	0.0	0.0	0.0	15.8	45.7	74.5	80.2	57.9	10.0	1.0
1954	0.2	0.0	0.0	0.0	0.0	1.7	4.6	20.3	32.7	41.9	9.0	1.1
1955	0.1	0.0	0.0	0.0	0.0	8.7	59.5	102.1	99.8	61.3	11.0	1.6
1956	0.5	0.0	0.3	0.0	0.0	0.0	1.2	11.8	30.6	21.6	2.1	0.4
1957	0.0	0.0	0.0	0.0	0.5	10.4	19.6	68.3	141.2	71.5	17.2	4.1
1958	0.7	0.1	0.0	0.1	0.1	0.1	0.0	0.1	1.0	3.1	0.3	0.0
1959	0.0	0.0	0.0	0.2	0.4	0.2	7.5	12.3	84.0	47.6	3.7	0.3
1960	0.0	0.0	0.0	0.0	0.1	0.6	25.2	60.2	123.4	72.2	12.2	1.3
1961	0.2	0.0	0.0	0.3	0.0	0.1	16.6	22.7	40.7	22.2	1.8	0.1
1962	0.0	0.0	0.0	0.0	0.0	6.7	17.6	73.0	91.4	64.3	13.3	1.8
1963	0.1	0.0	0.0	0.0	0.0	0.7	26.3	111.7	133.9	100.4	19.5	2.1
1964	0.4	0.1	0.1	0.0	0.0	0.0	2.0	25.6	78.0	21.3	2.7	0.2
1965	0.0	0.0	0.0	0.0	0.0	0.8	19.0	60.2	67.7	17.4	1.5	0.1
1966	0.0	0.0	0.0	0.1	0.0	1.2	4.7	35.2	41.5	37.3	7.6	0.6
1967	0.0	0.0	0.0	0.2	0.0	0.4	8.5	59.4	88.3	48.9	5.6	1.2
1968	0.2	0.0	0.0	0.0	0.6	7.3	35.0	63.1	104.7	49.4	7.4	0.9
1969	0.1	0.0	0.0	0.0	0.0	0.0	1.3	18.2	68.6	33.6	13.7	1.2
1970	0.1	0.0	0.0	0.0	0.7	0.4	2.6	25.3	64.8	35.6	2.1	0.1
1971	0.0	0.0	0.0	0.0	0.0	0.5	1.6	27.7	63.2	15.4	1.0	0.1
1972	0.0	0.0	0.0	0.0	0.0	1.3	1.6	5.2	13.9	3.5	0.7	0.0
1973	0.0	0.0	0.0	0.0	0.0	0.1	2.3	47.9	52.5	32.2	3.3	0.1
1974	0.0	0.0	0.0	0.0	0.0	0.0	12.6	52.4	89.2	39.0	3.2	0.2
1975	0.0	0.0	0.0	0.0	0.0	0.0	15.5	29.6	50.3	40.2	2.9	0.2
1976	0.0	0.0	0.0	0.0	0.0	3.3	3.9	11.9	4.5	13.8	10.8	0.7
1977	0.1	0.0	0.0	0.0	0.0	0.0	0.0	8.3	26.1	16.1	1.1	0.0
1978	0.0	0.0	0.2	0.2	1.6	3.9	12.7	23.7	27.1	14.6	5.6	0.3
1979	0.0	0.0	0.0	0.0	0.0	0.3	11.1	59.4	79.8	52.9	7.6	0.5

STREAMFLOW - KARA AT KPESSIDE

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1961	-	-	0.6	1.9	10.8	15.1	39.6	37.7	29.6	24.4	2.1	0.5
1962	0.4	0.1	0.2	1.3	4.9	56.0	89.0	141.1	155.1	58.8	3.2	0.1
1963	0.0	0.1	0.4	3.3	2.4	6.4	107.5	262.1	186.7	162.2	38.9	3.7
1964	1.4	0.2	0.5	2.9	4.1	4.6	18.7	76.0	174.7	27.6	4.4	0.9
1965	0.6	0.3	0.1	0.7	6.5	19.1	59.9	69.8	87.6	15.0	1.8	0.3
1966	0.2	0.1	0.0	1.2	4.6	20.3	30.0	170.9	108.7	89.1	14.0	2.0
1967	0.5	0.2	0.6	3.8	1.2	4.5	65.9	107.5	183.0	86.0	8.5	4.8
1968	1.2	0.4	0.7	3.8	9.0	58.6	91.1	92.7	129.1	46.9	14.1	2.2
1969	0.7	0.3	0.2	3.3	7.4	3.3	56.4	157.4	201.6	81.6	29.7	2.2
1970	1.0	0.3	0.5	0.2	2.1	1.8	14.4	102.7	223.9	39.1	2.6	0.8
1971	0.4	0.4	0.7	1.0	5.8	7.8	90.5	136.3	114.3	18.0	2.5	0.7
1972	0.2	0.1	0.4	3.3	14.0	12.8	58.2	91.4	78.5	53.0	8.5	2.6
1973	1.2	0.1	0.0	0.3	7.5	13.6	17.3	90.0	75.0	34.5	6.8	0.6
1974	0.2	0.1	0.1	0.3	2.4	17.2	63.1	132.5	231.3	83.4	14.9	2.3
1975	0.7	0.3	-	-	7.8	7.9	60.8	-	132.9	49.3	3.9	1.2
1976	0.4	0.2	0.1	-	8.4	30.8	70.0	79.2	-	79.1	33.2	2.2
1977	0.7	0.2	0.0	1.3	-	-	-	56.1	81.4	-	1.5	0.4
1978	0.2	0.0	0.3	0.9	3.9	-	94.1	-	-	51.8	-	2.7
1979	0.1	0.0	-	0.3	5.4	12.9	63.3	152.6	135.6	-	-	-

STREAMFLOW - KARA AT LAMAKARA

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1954	-	-	-	-	-	-	42.1	28.3	73.1	44.5	4.8	0.7
1955	0.9	0.5	0.5	0.7	1.4	26.4	202.6	224.9	237.6	85.3	8.6	1.9
1956	0.7	0.5	2.6	0.7	1.2	5.5	19.6	81.4	259.2	32.4	2.8	1.7
1957	0.5	0.3	2.1	3.5	7.6	35.1	81.9	166.7	443.6	84.5	18.8	5.3
1958	1.4	0.6	0.3	5.0	1.5	9.8	6.5	3.6	20.4	12.0	1.7	0.5
1959	0.2	0.2	0.0	2.2	6.5	1.7	57.3	64.6	191.1	31.9	3.3	0.7
1960	0.2	0.0	0.2	0.8	1.2	20.3	82.1	113.5	221.0	82.4	15.3	2.2
1961	0.5	0.2	0.3	1.7	8.1	14.5	40.5	41.5	38.5	25.8	2.0	0.5
1962	0.2	0.2	0.2	0.3	6.5	83.9	64.2	119.5	140.7	48.1	15.8	2.6
1963	0.7	0.6	0.7	4.8	2.2	3.3	109.9	288.4	242.6	171.5	35.6	3.4
1964	1.4	0.2	0.7	5.0	4.3	5.0	23.9	114.2	212.7	29.2	4.0	0.9
1965	0.5	0.3	0.0	4.3	2.7	22.8	91.5	113.1	131.6	19.7	1.2	0.3
1966	0.2	0.2	0.0	1.5	1.7	18.6	25.2	187.1	172.8	94.3	26.1	1.2
1967	0.3	0.2	0.3	0.8	0.9	3.5	85.8	153.5	284.1	115.5	5.3	2.6
1968	0.7	0.2	0.2	2.5	4.6	33.6	86.5	73.1	169.5	45.5	5.8	1.2
1969	0.3	0.2	0.2	1.5	7.6	1.8	61.3	170.5	214.3	105.8	18.4	2.1
1970	0.9	0.3	0.3	0.2	1.5	1.7	14.8	119.8	224.3	36.2	2.3	0.7
1971	0.3	0.5	0.2	0.5	6.5	4.5	77.9	147.8	163.3	10.5	1.3	0.7
1972	0.3	0.2	0.2	1.2	10.6	13.3	42.8	71.4	122.5	35.7	4.3	2.9
1973	0.9	0.2	0.0	0.2	2.4	6.6	31.4	88.6	154.7	40.5	3.3	0.7
1974	0.3	0.2	0.2	0.2	1.9	9.3	121.0	204.3	252.6	80.9	9.0	1.5
1975	0.7	0.3	1.0	4.0	2.9	4.5	35.4	88.6	130.6	23.9	2.3	0.9
1976	0.5	0.3	0.2	0.7	6.9	23.1	87.6	55.5	34.9	46.0	23.3	2.1
1977	0.7	0.3	0.0	2.0	4.3	9.6	19.4	57.2	101.7	24.2	1.7	0.7
1978	0.3	0.2	0.5	1.2	3.8	24.4	156.2	160.9	114.1	33.0	10.3	0.2
1979	0.7	0.2	0.2	0.8	2.4	11.1	69.9	175.1	237.6	65.9	8.3	1.5

STREAMFLOW - SOTA AT KOUBERI

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1953	-1.0	-1.0	-1.0	-1.0	1.1	5.2	7.4	21.0	38.3	21.8	4.4	1.5
1954	1.1	1.0	1.0	0.8	1.2	2.7	2.1	18.0	52.8	20.4	3.8	1.5
1955	1.1	0.9	1.0	0.9	1.4	1.9	13.6	50.3	52.8	45.5	9.1	2.9
1956	2.0	1.7	1.7	1.2	1.2	1.6	3.1	12.6	25.9	18.2	3.1	1.4
1957	1.2	0.9	0.9	0.9	1.4	3.0	4.3	37.7	64.0	29.8	8.1	2.6
1958	1.6	1.3	1.3	1.3	1.2	1.7	1.6	2.3	3.6	4.2	1.2	0.9
1959	0.8	0.7	0.8	0.7	1.4	1.0	3.1	13.4	62.4	32.6	4.5	1.8
1960	1.4	1.1	1.2	1.1	1.3	3.2	7.5	11.6	43.1	37.3	7.0	2.5
1961	2.2	1.6	1.4	1.4	1.4	1.7	2.2	6.7	16.8	5.7	1.4	1.2
1962	1.1	0.8	0.9	0.8	1.2	2.3	10.8	43.9	71.1	28.0	6.4	2.2
1963	1.6	1.2	1.2	1.1	1.6	2.0	2.0	16.2	34.2	21.2	5.6	1.5
1964	1.1	0.8	0.9	0.9	1.0	2.3	3.1	16.3	42.9	13.4	2.5	1.4
1965	1.2	1.0	1.0	1.1	1.3	1.7	2.7	7.8	15.8	4.8	1.1	0.8
1956	-1.0	-1.0	-1.0	-1.0	-1.0	1.3	1.6	4.9	25.7	18.2	2.5	1.1

STREAMFLOW - MEKROU AT KOMPONGOU

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1958	0	0	0	0	0	1	3	5	18	5	0	0
1959	0	0	0	0	0	0	5	12	54	28	5	0
1960	0	0	0	0	0	0	2	9	57	45	7	1
1961	0	0	0	0	0	1	11	20	53	19	2	0
1962	0	0	0	0	0	0	10	46	86	49	11	3
1963	0	0	0	0	0	1	9	48	69	40	12	4
1964	1	0	0	0	0	0	6	27	65	22	4	1
1965	0	0	0	0	0	1	3	16	54	17	3	0
1966	0	0	0	0	0	1	4	10	28	42	9	2
1967	0	0	0	0	0	0	1	37	79	57	9	3
1968	1	0	0	0	0	2	25	60	78	45	8	1
1969	0	0	0	0	0	1	3	48	108	64	26	6
1970	2	1	0	0	0	0	2	24	90	56	7	2

NET RAINFALL - TETETOU

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1932	0.	0.	6.5	0.	27.8	3.8	20.0	36.2	44.8	0.	0.	0.
1933	0.	0.	8.6	1.2	90.6	72.7	94.3	88.0	97.9	0.4	0.	0.
1934	0.	0.	0.	0.	34.5	41.3	112.8	106.5	155.6	49.5	0.	0.
1935	0.	0.	0.	0.	13.1	48.1	106.4	94.6	57.5	0.	0.	0.
1936	0.	0.	4.4	10.1	3.5	87.9	93.5	26.5	172.7	2.8	0.	0.
1937	0.	0.	0.	0.	25.9	14.4	91.7	126.0	71.0	16.6	0.	0.
1938	0.	0.	0.	7.8	41.6	62.3	38.1	93.9	75.3	24.4	0.	0.
1939	0.	0.	14.1	0.	18.9	48.0	105.4	119.7	114.1	12.8	2.9	0.
1940	0.	0.	0.	25.3	19.0	26.7	128.6	134.8	72.7	28.9	0.	0.
1941	0.	0.	0.	0.	62.4	53.4	87.9	120.4	64.6	0.	0.	0.
1942	0.	0.	0.	1.4	56.8	14.2	32.6	70.0	71.6	11.2	0.	0.
1943	0.	0.	0.	0.	34.9	23.6	39.8	64.7	78.0	4.4	0.	0.
1944	0.	0.9	0.	26.5	0.	30.7	38.0	188.1	56.7	24.0	0.	0.
1945	0.	0.	0.	0.	6.6	35.7	191.5	48.0	141.8	39.4	0.	0.
1946	0.	0.	25.9	28.2	6.7	57.5	82.9	0.	121.4	68.7	0.	0.
1947	0.	1.9	6.4	9.2	18.5	57.4	171.2	185.2	200.2	42.8	0.	0.
1948	0.	0.	0.	19.5	19.8	77.8	81.8	161.3	75.0	2.2	0.	0.
1949	0.	0.	0.	0.	40.2	72.4	182.6	194.8	135.0	13.7	0.	0.
1950	0.	0.	0.	0.	19.4	43.4	58.3	28.7	55.1	4.0	0.	0.
1951	0.	0.	0.	0.	38.6	24.4	82.3	72.4	82.8	85.3	0.	0.
1952	0.	0.	0.	3.7	2.5	52.1	107.7	3.6	147.6	36.2	0.	0.
1953	0.	0.3	0.	0.	63.1	147.3	121.9	50.6	71.5	3.4	0.	0.
1954	0.	0.	0.3	8.0	0.	62.9	37.1	23.3	33.4	63.0	0.	0.
1955	0.	0.	9.2	9.4	11.9	130.6	133.9	105.4	152.3	24.0	0.	0.
1956	0.	0.	7.1	0.	15.9	67.6	12.1	43.4	71.6	0.	0.	0.
1957	0.	0.	5.3	12.5	67.7	122.5	89.2	138.4	145.8	54.3	0.	0.
1958	0.	0.	0.	2.3	44.7	46.0	0.	11.6	69.5	6.8	2.4	0.
1959	0.	0.	3.8	10.0	13.8	26.9	124.9	29.7	171.9	17.9	2.1	0.
1960	0.	0.	5.4	17.2	0.6	120.8	108.4	61.5	212.1	42.6	0.	0.
1961	0.	0.	0.	2.3	6.9	47.0	103.4	5.8	61.2	5.7	0.	0.
1962	0.	0.	0.9	24.7	47.5	162.8	83.2	96.8	71.5	38.0	0.2	0.
1963	0.	2.5	2.3	5.3	32.8	107.3	251.0	187.9	191.3	122.5	0.	0.
1964	0.	0.	0.	2.5	4.1	39.6	79.2	34.0	67.6	0.	0.	0.
1965	0.	0.	0.	22.6	24.2	123.2	134.6	70.7	61.7	0.9	0.	0.
1966	0.	0.	0.	8.4	12.8	108.6	86.7	192.7	91.9	15.4	0.	0.
1967	0.	0.	6.6	14.9	4.6	54.4	72.8	82.4	144.8	11.1	0.	0.
1968	0.	0.	0.	21.4	24.3	83.2	233.0	185.3	165.4	26.3	0.	0.
1969	0.	0.	0.	16.6	19.8	31.2	49.5	105.7	92.6	21.9	0.	0.
1970	0.	0.	4.6	1.8	51.0	9.2	33.2	127.9	168.1	7.4	0.	0.
1971	0.	0.	5.1	5.2	15.4	30.6	85.5	122.7	100.6	1.6	0.	0.
1972	0.	0.	1.7	17.5	34.8	33.2	78.8	51.4	23.3	24.2	0.	0.
1973	0.	0.	0.7	12.8	8.0	64.2	91.8	108.6	91.7	17.8	0.	0.
1974	0.	0.	0.4	0.0	9.4	31.9	145.6	68.7	89.7	16.3	0.	0.
1975	0.	0.	0.	18.9	14.4	24.2	120.6	44.2	101.3	7.6	0.	0.
1976	0.	0.	0.	2.2	22.5	75.8	19.9	58.5	23.4	64.1	0.	0.
1977	0.	0.	0.	0.0	11.2	22.9	37.5	73.9	99.7	9.1	0.	0.
1978	0.	0.	9.3	28.3	11.3	72.8	82.3	51.7	63.3	25.5	0.	0.2
1979	0.	0.	0.	4.0	44.9	102.6	187.1	89.6	108.0	4.2	0.	0.
1980	0.	0.	0.	0.6	18.2	40.0	96.5	203.5	50.9	57.4	0.	0.

NET RAINFALL - TITIRA

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1932	0.	0.	0.	0.	5.4	19.3	43.1	20.8	292.5	2.2	0.	0.
1933	0.	0.	0.	8.8	28.8	68.5	154.1	239.7	135.0	0.	0.	0.
1934	0.	0.	0.	0.	0.2	41.2	167.5	172.1	293.0	68.4	0.	0.
1935	0.	0.	0.	0.	0.	11.9	261.8	135.5	200.8	23.5	0.	0.
1936	0.	0.	0.	8.1	5.1	17.2	74.7	71.7	150.8	0.	0.	0.
1937	0.	0.	0.	0.	7.2	0.	108.3	145.4	122.3	0.3	0.	0.
1938	0.	0.	0.	0.	0.	37.4	28.0	107.1	143.7	0.	0.	0.
1939	0.	0.	0.	0.	25.7	17.9	101.8	143.6	152.1	38.3	0.	0.
1940	0.	0.	0.	0.	19.3	8.4	128.9	199.6	85.5	39.1	0.	0.
1941	0.	0.	0.	0.	43.6	20.6	152.5	176.1	93.5	0.	0.	0.
1942	0.	0.	0.	0.	0.	0.1	26.7	132.9	133.9	0.	0.	0.
1943	0.	0.	0.	0.	0.4	3.0	19.0	139.6	202.2	2.1	0.	0.
1944	0.	0.	0.	0.	0.	35.0	36.7	179.5	66.9	0.	0.	0.
1945	0.	0.	0.	0.	1.6	22.4	172.9	93.4	242.2	9.4	0.	0.
1946	0.	0.	0.	0.	0.	22.0	80.7	22.2	165.1	26.0	0.	0.
1947	0.	0.	0.	0.	0.	34.2	48.8	189.8	191.1	0.	0.	0.
1948	0.	0.	0.	3.8	0.	55.4	114.0	123.8	147.2	0.	0.	0.
1949	0.	0.	0.	0.	0.7	102.4	168.3	355.6	357.8	47.6	0.	0.
1950	0.	0.	0.	0.	30.2	48.4	76.0	69.0	143.0	0.	0.	0.
1951	0.	0.	0.	0.	0.	19.4	115.1	183.4	284.6	191.9	0.	0.
1952	0.	0.	0.	0.	0.	13.5	115.7	112.6	303.6	18.2	0.	0.
1953	0.	0.	0.	0.	45.6	126.9	233.1	94.6	227.8	0.	0.	0.
1954	0.	0.	0.	7.3	0.	107.2	8.5	53.8	141.5	26.0	0.	0.
1955	0.	0.	0.	0.	0.	83.9	228.9	192.2	187.6	24.0	0.	0.
1956	0.	0.	0.	0.	2.7	34.8	49.5	82.1	180.9	0.	0.	0.
1957	0.	0.	0.	3.7	77.7	60.2	68.6	252.4	266.1	55.3	0.	0.
1958	0.	0.	0.	0.	0.	19.8	22.4	24.5	203.7	0.	0.	0.
1959	0.	0.	0.	8.8	0.	12.9	139.5	201.9	169.5	0.	0.	0.
1960	0.	0.	0.	0.	8.2	72.9	109.6	112.3	256.9	41.7	0.	0.
1961	0.	0.	0.	0.	0.	105.8	91.0	37.2	95.2	0.	0.	0.
1962	0.	0.	0.	0.	15.6	127.7	140.5	203.5	153.0	24.4	0.	0.
1963	0.	0.	0.	0.	0.	34.3	176.7	269.2	206.4	119.9	0.	0.
1964	0.	0.	0.	0.	5.6	40.8	120.9	211.4	220.0	0.	0.	0.
1965	0.	0.	0.	0.	9.2	30.6	149.4	190.5	77.5	0.	0.	0.
1966	0.	0.	0.	0.	7.3	57.7	81.2	160.7	122.8	42.4	0.	0.
1967	0.	0.	0.	0.	2.9	42.0	151.8	208.8	189.0	28.2	0.	0.
1968	0.	0.	0.	34.5	0.	105.5	181.7	118.0	140.7	10.4	0.	0.
1969	0.	0.	0.	3.4	1.1	45.1	90.3	181.9	220.9	56.7	0.	0.
1970	0.	0.	0.	0.	16.0	0.0	165.1	124.0	218.1	0.	0.	0.
1971	0.	0.	0.	0.	0.	26.4	266.2	231.9	146.6	0.	0.	0.
1972	0.	0.	0.	0.	44.5	8.7	129.1	110.4	80.3	22.5	0.	0.
1973	0.	0.	0.	0.	0.	37.3	63.2	168.1	168.1	5.6	0.	0.
1974	0.	0.	0.	0.	4.3	44.4	149.5	213.2	189.1	0.	0.	0.
1975	0.	0.	0.	0.	3.1	0.	191.2	130.2	224.6	0.	0.	0.
1976	0.	0.	0.	0.	6.8	66.9	116.5	98.0	41.4	48.4	0.	0.
1977	0.	0.	0.	6.8	29.5	3.1	28.5	93.0	105.8	0.	0.	0.
1978	0.	0.	0.	13.5	3.6	16.0	201.9	168.3	86.4	10.4	0.	0.
1979	0.	0.	0.	0.	9.8	57.5	177.5	148.8	200.4	0.	0.	0.
1980	0.	0.	0.	0.	8.5	3.6	39.4	237.5	92.1	0.	0.	0.

NET RAINFALL - PONT DE BETEROU

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1932	0.	0.	0.	0.	0.	6.3	39.6	53.3	124.9	11.5	0.	0.
1933	0.	0.	0.	5.9	23.2	34.8	182.0	182.5	121.4	0.	0.	0.
1934	0.	0.	0.	0.	0.	13.4	118.2	152.6	312.8	14.7	0.	0.
1935	0.	0.	0.	0.	16.1	4.0	232.9	211.9	210.1	0.	0.	0.
1936	0.	0.	0.	0.	6.0	23.2	66.9	28.3	105.4	0.	0.	0.
1937	0.	0.	0.	0.	0.	1.0	149.2	138.4	187.0	0.	0.	0.
1938	0.	0.	0.	0.	0.	37.1	18.7	126.8	102.4	0.	0.	0.
1939	0.	0.	0.	0.	8.1	32.8	67.9	200.9	180.2	13.4	0.	0.
1940	0.	0.	0.	0.	25.0	52.0	83.3	179.9	114.8	12.2	0.	0.
1941	0.	0.	0.	0.	73.3	9.3	103.7	183.6	60.1	0.	0.	0.
1942	0.	0.	0.	0.	19.0	0.1	30.9	138.9	97.6	2.1	0.	0.
1943	0.	0.	0.	0.	42.7	23.4	17.7	164.2	135.7	0.	0.	0.
1944	0.	0.	0.	0.	0.	62.4	73.8	174.8	92.4	0.	0.	0.
1945	0.	0.	0.	0.	1.8	41.4	58.8	112.8	156.8	0.	0.	0.
1946	0.	0.	0.	0.	0.	22.6	55.1	50.1	107.5	47.2	0.	0.
1947	0.	0.	0.	0.	11.8	94.4	50.2	238.1	202.1	0.	0.	0.
1948	0.	0.	0.	0.9	0.	93.0	122.9	116.9	121.9	0.	0.	0.
1949	0.	0.	0.	0.	0.	45.6	118.9	240.0	188.0	4.3	0.	0.
1950	0.	0.	0.	0.	0.	9.6	98.9	107.3	79.0	0.4	0.	0.
1951	0.	0.	0.	0.	17.4	22.2	113.0	218.8	171.1	74.9	0.	0.
1952	0.	0.	0.	0.	1.5	26.4	125.5	32.4	194.6	14.3	0.	0.
1953	0.	0.	0.	0.	51.7	63.0	185.4	59.7	257.1	5.8	0.	0.
1954	0.	0.	0.	2.0	4.8	48.4	12.4	112.8	112.6	13.3	0.	0.
1955	0.	0.	0.	0.	1.8	63.6	219.0	146.0	167.1	15.1	0.	0.
1956	0.	0.	0.	0.	0.	40.2	83.9	69.4	153.2	0.	0.	0.
1957	0.	0.	0.	2.7	42.3	67.0	93.9	233.0	235.8	9.8	0.	0.
1958	0.	0.	0.	0.	0.	5.1	19.1	8.0	77.0	0.	0.	0.
1959	0.	0.	0.	0.	0.	31.4	110.6	162.6	234.8	0.	0.	0.
1960	0.	0.	0.	0.	7.2	92.3	164.1	162.1	223.3	24.1	0.	0.
1961	0.	0.	0.	0.	6.0	61.3	147.9	47.3	132.4	0.	0.	0.
1962	0.	0.	0.	0.	0.2	157.1	93.8	224.2	93.0	27.4	0.	0.
1963	0.	0.	0.	0.	15.3	8.4	189.4	259.9	187.6	81.1	0.	0.
1964	0.	0.	0.	0.	0.4	28.6	110.4	88.8	165.3	0.	0.	0.
1965	0.	0.	0.	0.	0.	44.1	87.9	167.8	69.7	0.	0.	0.
1966	0.	0.	0.	7.9	6.3	76.6	40.4	102.2	124.1	11.0	0.	0.
1967	0.	0.	0.	0.	4.0	36.9	81.7	169.2	146.8	17.0	0.	0.
1968	0.	0.	0.	19.1	0.	112.3	192.1	162.2	113.9	0.	0.	0.
1969	0.	0.	0.	0.	13.3	35.9	56.9	170.8	120.5	25.1	0.	0.
1970	0.	0.	0.	0.	6.3	2.3	92.4	110.7	120.4	0.	0.	0.
1971	0.	0.	0.	0.	28.0	0.	78.0	196.3	71.6	0.	0.	0.
1972	0.	0.	0.	0.	42.1	0.	69.2	37.9	41.9	3.0	0.	0.
1973	0.	0.	0.	0.	9.9	98.1	59.1	173.7	154.5	0.	0.	0.
1974	0.	0.	0.	0.	0.	60.3	162.4	80.5	154.2	0.	0.	0.
1975	0.	0.	0.	0.	2.7	10.2	210.2	59.9	146.6	0.	0.	0.
1976	0.	0.	0.	0.	33.3	69.1	33.5	84.2	19.9	66.4	0.	0.
1977	0.	0.	0.	0.	9.1	0.1	73.6	87.8	84.6	0.	0.	0.
1978	0.	0.	0.	25.5	0.	26.0	136.1	85.0	33.7	4.5	0.	0.
1979	0.	0.	0.	0.	7.3	43.4	148.8	162.7	175.5	0.	0.	0.
1980	0.	0.	0.	0.	4.8	18.1	46.5	155.1	70.4	2.7	0.	0.

NET RAINFALL - PONT DE SAVE

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1932	0.	0.	0.	0.	0.	7.9	29.2	39.3	92.2	14.9	0.	0.
1933	0.	16.2	0.	4.7	53.7	52.8	198.0	232.9	104.8	23.4	0.	0.
1934	0.	0.	0.	8.0	10.4	30.1	117.8	167.9	272.0	11.4	0.	0.
1935	0.	0.	0.	19.9	28.2	38.8	213.2	188.3	161.4	5.3	0.	0.
1936	0.	0.	0.	0.	4.7	39.5	68.1	21.9	85.3	0.	0.	0.
1937	0.	0.	0.	0.	2.1	6.3	167.9	94.6	144.8	6.6	0.	0.
1938	0.	0.	0.	0.	1.4	55.8	10.9	76.4	87.0	9.2	0.	0.
1939	0.	0.	0.	0.	19.9	55.2	76.1	139.0	108.7	7.6	0.	0.
1940	0.	0.	0.	0.	19.6	37.4	47.3	121.2	118.1	10.4	0.	0.
1941	0.	0.	0.	0.	63.6	26.5	95.3	123.3	59.3	0.	0.	0.
1942	0.	0.	0.	0.	23.4	1.8	20.7	93.0	98.5	12.8	0.	0.
1943	0.	0.	0.	0.	49.6	16.4	14.7	93.7	106.6	4.5	0.	0.
1944	0.	0.	0.	0.2	0.	48.7	48.7	149.6	115.1	0.	0.	0.
1945	0.	0.	0.	0.	0.9	49.2	65.2	74.6	137.0	24.5	0.	0.
1946	0.	0.	0.	0.	0.	37.0	28.0	25.5	63.1	54.4	0.	0.
1947	0.	0.	0.	1.2	13.2	75.9	48.0	230.9	165.3	4.2	0.	0.
1948	0.	0.	0.	11.5	0.	56.2	65.7	83.9	69.9	0.	0.	0.
1949	0.	0.	0.	0.	12.9	56.0	152.0	230.9	182.3	25.2	0.	0.
1950	0.	0.	0.	2.8	16.5	27.6	81.0	75.3	51.6	8.6	0.	0.
1951	0.	0.	0.	0.	14.7	22.5	107.9	160.4	102.3	71.2	0.	0.
1952	0.	0.	0.	2.4	3.4	24.6	182.6	18.7	164.5	52.2	0.	0.
1953	0.	0.	0.	0.5	55.4	80.5	181.9	35.5	150.2	23.5	0.	0.
1954	0.	0.	0.	2.9	3.5	43.9	16.0	67.4	98.6	64.2	0.	0.
1955	0.	0.	0.	0.	2.1	87.1	213.7	129.1	128.9	29.8	0.	0.
1956	0.	0.	0.	0.	0.5	25.8	46.7	51.3	123.2	0.	0.	0.
1957	0.	0.	0.	3.1	49.5	61.2	[illegible]	180.3	198.6	11.4	0.9	0.
1958	0.	0.	0.3	7.2	1.7	7.6	11.2	6.5	58.1	6.0	0.	0.
1959	0.	0.	4.0	2.3	17.2	28.6	107.6	113.1	235.6	6.1	0.	0.
1960	0.	0.	0.	6.6	4.1	104.8	133.1	141.6	188.0	27.5	0.	0.
1961	0.	0.	4.3	8.3	5.4	49.1	138.6	33.1	93.1	3.6	0.	0.
1962	0.	0.	0.	2.6	18.8	141.8	78.3	207.5	79.1	32.1	0.	0.
1963	0.	0.	0.	0.	15.0	40.8	260.6	257.9	196.8	92.5	0.	0.
1964	0.	0.	0.	0.	0.2	20.5	112.3	67.6	134.5	0.	0.	0.
1965	0.	0.	0.	0.	0.	60.1	102.5	128.9	51.5	0.4	0.	0.
1966	0.	0.	0.	8.5	8.8	95.3	31.7	127.4	82.7	21.7	0.	0.
1967	0.	0.	9.0	0.	10.6	47.0	60.1	141.1	100.5	9.3	0.	0.
1968	0.	0.	0.	11.3	1.7	94.5	170.6	171.7	140.7	16.0	0.	0.
1969	0.	0.	0.	5.4	9.1	37.1	37.4	110.6	101.1	18.1	0.	0.
1970	0.	0.	0.	0.	27.8	4.9	64.5	97.7	124.8	0.	0.	0.
1971	0.	0.	0.	0.	26.5	16.1	67.5	154.8	78.4	0.	0.	0.
1972	0.	0.	0.	0.	35.6	4.6	39.6	21.5	22.8	5.9	0.	0.
1973	0.	0.	0.	0.	8.8	66.5	48.1	146.9	129.4	19.3	0.	0.
1974	0.	0.	0.	0.	0.	36.4	193.4	66.1	129.9	0.	0.	0.
1975	0.	0.	0.	5.8	2.7	12.9	196.7	43.8	114.6	5.3	0.	0.
1976	0.	0.	0.	1.0	27.5	55.6	27.0	48.5	15.5	60.2	0.	0.
1977	0.	0.	0.	0.	6.1	7.1	61.3	75.0	84.0	0.7	0.	0.
1978	0.	0.	0.	36.1	13.5	25.8	91.0	58.8	58.5	11.7	0.	0.
1979	0.	0.	0.	5.4	24.7	37.1	160.8	156.8	157.4	2.3	0.	0.
1980	0.	0.	0.	0.	3.3	18.0	40.3	124.1	99.7	39.4	0.	0.

NET RAINFALL - KPESSIDE

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1941	0.	0.	0.	0.	67.9	64.6	137.8	246.9	68.5	0.	0.	0.
1942	0.	0.	0.	6.9	3.6	6.1	40.3	104.8	129.6	23.0	0.	0.
1943	0.	0.	0.	0.	2.9	7.5	31.5	100.2	169.5	36.7	0.	0.
1944	0.	0.	0.	0.	0.	73.4	65.1	244.3	78.2	5.6	0.	0.
1945	0.	0.	0.	0.	1.4	31.8	230.9	58.1	209.2	37.2	0.	0.
1946	0.	0.	0.	0.	0.	50.7	78.6	25.0	202.2	63.9	0.	0.
1947	0.	0.	0.	0.	0.	90.1	59.4	180.3	209.9	31.5	0.	0.
1948	0.	0.	0.	2.5	3.3	78.1	70.7	156.4	277.7	0.	0.	0.
1949	0.	0.	0.	0.	13.0	91.6	120.7	242.1	292.4	18.0	0.	0.
1950	0.	0.	0.	0.	6.5	36.7	24.3	21.7	96.6	12.7	0.	0.
1951	0.	0.	0.	0.	0.9	7.7	116.6	220.7	309.9	155.0	0.	0.
1952	0.	0.	0.	0.	6.7	20.4	175.5	32.6	298.5	78.0	0.	0.
1953	0.	0.	0.	0.	7.3	98.6	246.5	64.3	177.9	13.9	0.	0.
1954	0.	0.	0.	2.3	0.	121.5	1.7	54.7	118.9	46.0	0.	0.
1955	0.	0.	0.	0.	0.	107.2	202.8	212.2	222.3	17.8	0.	0.
1956	0.	0.	0.	0.	0.	30.7	61.8	88.0	230.5	0.	0.	0.
1957	0.	0.	0.	2.5	45.3	72.3	82.7	204.3	263.7	69.9	0.	0.
1958	0.	0.	0.	9.8	0.	49.1	16.4	3.7	131.1	2.1	0.	0.
1959	0.	0.	0.	1.4	0.	17.1	159.5	116.9	197.9	9.1	0.	0.
1960	0.	0.	0.	0.	11.2	110.0	137.5	99.7	192.9	59.0	0.	0.
1961	0.	0.	0.	0.	1.7	103.6	191.5	26.0	81.5	5.4	0.	0.
1962	0.	0.	0.	2.8	14.8	208.1	65.3	185.7	151.2	46.2	0.1	0.
1963	0.	0.	0.	0.9	7.3	33.4	229.0	278.7	257.3	160.1	0.	0.
1964	0.	0.	0.	0.	9.6	31.0	116.6	139.6	249.7	1.2	0.	0.
1965	0.	0.	0.	0.	9.6	47.1	122.9	147.4	73.7	1.8	0.	0.
1966	0.	0.	0.	5.8	4.5	93.5	77.8	260.9	126.1	49.6	0.	0.
1967	0.	0.	0.	0.	6.4	44.1	134.3	152.8	217.5	37.3	0.	0.
1968	0.	0.	0.	35.3	3.4	99.9	122.4	135.4	125.9	6.7	0.	0.
1969	0.	0.	0.	3.3	9.2	51.8	98.5	198.8	211.0	56.8	0.	0.
1970	0.	0.	0.	0.	11.0	14.4	133.8	160.3	253.0	0.	0.	0.
1971	0.	0.	0.	0.	11.6	25.8	207.8	223.7	189.7	0.	0.	0.
1972	0.	0.	0.	0.	44.8	16.2	119.0	130.0	108.6	52.1	0.	0.
1973	0.	0.	0.	0.	2.0	70.4	77.2	162.9	187.4	0.1	0.	0.
1974	0.	0.	0.	0.	0.	57.3	195.1	163.2	216.0	39.0	0.	0.
1975	0.	0.	0.	3.2	7.2	5.0	183.8	147.6	200.5	0.	0.	0.
1976	0.	0.	0.	0.	12.7	85.5	116.3	51.2	66.5	52.5	0.	0.
1977	0.	0.	0.	7.7	24.1	3.8	68.6	89.1	118.2	11.6	0.	0.
1978	0.	0.	0.	13.7	4.1	110.7	168.2	184.5	73.9	54.6	0.	0.
1979	0.	0.	0.	0.	7.3	56.1	195.5	195.9	197.2	12.0	0.	0.
1980	0.	0.	0.	0.	6.9	26.7	117.6	247.5	152.2	9.8	0.	0.

NET RAINFALL - LAMAKARA

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1932	0.	0.	0.	0.	2.8	19.3	55.5	83.4	211.9	3.5	0.	0.
1933	0.	0.	0.	12.8	41.9	56.3	136.5	156.1	134.2	0.	109.9	0.
1934	0.	0.	0.	0.	0.4	49.4	183.5	191.0	356.8	39.4	0.	0.
1935	0.	0.	0.	0.	0.	0.3	188.9	105.8	185.8	0.	0.	0.
1936	0.	0.	0.	23.7	0.	40.2	88.8	69.3	242.6	3.8	0.	0.
1937	0.	0.	0.	0.	30.0	3.7	165.7	239.1	145.2	0.4	0.	0.
1938	0.	0.	0.	0.	9.3	16.1	58.7	160.7	144.0	0.	0.	0.
1939	0.	0.	0.	0.	62.6	55.4	92.0	149.2	182.0	61.7	0.	0.
1940	0.	0.	0.	1.7	28.6	4.9	186.5	164.1	84.4	46.9	0.	0.
1941	0.	0.	0.	0.	76.4	51.3	151.9	278.4	73.3	0.	0.	0.
1942	0.	0.	0.	8.9	0.	7.9	51.7	87.7	129.1	18.1	0.	0.
1943	0.	0.	0.	0.	3.1	9.7	40.8	129.8	192.5	12.4	0.	0.
1944	0.	0.	0.	0.	0.	83.6	72.7	267.9	81.0	0.	0.	0.
1945	0.	0.	0.	0.	1.8	38.4	224.0	70.5	221.4	36.5	0.	0.
1946	0.	0.	0.	0.	0.	50.1	99.6	31.7	155.7	43.7	0.	0.
1947	0.	0.	0.	0.	0.	100.7	71.2	216.0	237.9	28.1	0.	0.
1948	0.	0.	0.	3.8	5.0	98.1	101.2	185.1	230.4	0.	0.	0.
1949	0.	0.	0.	0.	19.7	103.7	145.4	267.7	340.0	7.1	0.	0.
1950	0.	0.	0.	0.	9.7	35.9	36.4	31.3	107.9	9.3	0.	0.
1951	0.	0.	0.	0.	1.2	5.6	116.8	280.6	326.5	164.2	0.	0.
1952	0.	0.	0.	0.	9.0	27.5	190.8	8.3	263.7	49.0	0.	0.
1953	0.	0.	0.	0.	7.6	87.6	281.2	83.3	174.3	0.	0.	0.
1954	0.	0.	0.	2.9	0.	124.7	2.1	64.0	114.4	23.2	0.	0.
1955	0.	0.	0.	0.	0.	98.2	248.0	218.8	271.1	6.0	0.	0.
1956	0.	0.	0.	0.	0.	33.4	112.1	96.2	235.2	0.	0.	0.
1957	0.	0.	0.	3.6	30.6	70.7	82.2	256.0	277.2	40.6	0.	0.
1958	0.	0.	0.	18.3	0.	15.0	30.5	4.7	113.2	0.	0.	0.
1959	0.	0.	0.	0.	0.	16.7	166.1	122.1	213.7	0.	0.	0.
1960	0.	0.	0.	0.	15.5	113.9	149.2	98.4	191.5	41.4	0.	0.
1961	0.	0.	0.	0.	0.3	115.4	176.6	41.4	61.5	0.4	0.	0.
1962	0.	0.	0.	4.4	9.6	219.6	72.0	187.9	137.0	28.4	0.2	0.
1963	0.	0.	0.	1.4	1.8	22.4	251.0	328.1	277.8	166.0	0.	0.
1964	0.	0.	0.	0.	3.2	27.0	131.4	233.3	249.5	0.	0.	0.
1965	0.	0.	0.	0.	0.	62.3	135.4	171.6	79.2	0.9	0.	0.
1966	0.	0.	0.	9.2	7.1	95.8	99.8	297.8	135.0	17.0	0.	0.
1967	0.	0.	0.	0.	2.0	38.7	161.3	157.7	214.5	33.4	0.	0.
1968	0.	0.	0.	49.4	0.4	100.5	143.4	152.6	126.0	4.9	0.	0.
1969	0.	0.	0.	5.4	13.2	45.6	117.1	219.3	213.2	36.9	0.	0.
1970	0.	0.	0.	0.	9.3	22.8	136.9	153.6	244.4	0.	0.	0.
1971	0.	0.	0.	0.	20.3	32.6	229.7	266.6	174.3	0.	0.	0.
1972	0.	0.	0.	0.	50.9	10.7	136.0	123.2	105.8	42.4	0.	0.
1973	0.	0.	0.	0.	0.	77.6	79.3	176.3	195.4	0.1	0.	0.
1974	0.	0.	0.	0.	0.	47.6	241.9	182.6	168.8	30.6	0.	0.
1975	0.	0.	0.	0.	10.1	7.4	182.3	184.6	219.8	0.	0.	0.
1976	0.	0.	0.	0.	18.2	72.0	159.0	62.9	54.5	31.8	0.	0.
1977	0.	0.	0.	5.8	13.3	3.3	73.4	119.5	114.3	6.1	0.	0.
1978	0.	0.	0.	10.3	3.1	99.2	189.0	207.5	79.1	38.3	0.	0.
1979	0.	0.	0.	0.	8.6	52.7	220.6	212.0	183.2	10.7	0.	0.
1980	0.	0.	0.	0.	8.1	32.1	141.3	270.0	169.6	11.8	0.	0.

NET RAINFALL - KOUBERI

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1932	0.	0.	0.	0.	5.7	7.8	41.2	68.3	78.4	4.1	0.	0.
1933	0.	0.	0.	0.	4.7	35.8	130.9	158.7	82.9	0.	0.	0.
1934	0.	0.	0.	0.	9.3	28.4	45.6	183.9	89.3	0.	0.	0.
1935	0.	0.	0.	0.	0.	8.8	166.4	299.9	109.5	0.	0.	0.
1936	0.	0.	0.	0.	0.	0.	98.7	65.0	27.7	0.	0.	0.
1937	0.	0.	0.	0.	9.6	3.0	42.5	79.1	50.7	0.	0.	0.
1938	0.	0.	0.	0.	0.	19.9	47.8	107.1	87.6	0.	0.	0.
1939	0.	0.	0.	0.	6.2	32.5	34.4	161.6	123.8	1.3	0.	0.
1940	0.	0.	0.	0.	0.	14.3	43.6	256.8	45.1	10.8	0.	0.
1941	0.	0.	0.	0.	22.0	0.	60.9	131.9	44.4	0.	0.	0.
1942	0.	0.	0.	0.	0.	13.5	15.4	126.1	25.5	0.	0.	0.
1943	0.	0.	0.	0.	0.	12.4	13.8	125.4	59.7	0.	0.	0.
1944	0.	0.	0.	0.	0.	24.9	89.0	115.4	74.6	0.	0.	0.
1945	0.	0.	0.	0.	0.	25.5	46.0	246.4	72.6	0.2	0.	0.
1946	0.	0.	0.	0.	0.	0.9	17.7	112.0	175.7	19.5	0.	0.
1947	0.	0.	0.	0.	0.	51.8	38.4	198.5	147.0	0.	0.	0.
1948	0.	0.	0.	0.	0.	68.7	75.2	135.4	74.0	0.	0.	0.
1949	0.	0.	0.	0.	0.	7.3	67.9	231.6	25.4	0.	0.	0.
1950	0.	0.	0.	0.	0.	2.0	68.2	163.4	62.6	0.	0.	0.
1951	0.	0.	0.	0.	14.5	88.0	92.1	238.1	126.2	70.7	0.	0.
1952	0.	0.	0.	0.	0.	14.9	69.0	43.6	154.0	4.3	0.	0.
1953	0.	0	0.	0.	106.0	34.6	222.9	83.4	144.6	0.	0.	0.
1954	0.	0.	0.	0.	2.6	23.2	43.0	227.1	89.6	0.	0.	0.
1955	0.	0.	0.	0.	5.6	13.4	219.1	120.4	158.1	1.9	0.	0.
1956	0.	0.	0.	0.	0.	9.4	82.4	129.5	115.4	0.	0.	0.
1957	0.	0.	0.	0.	17.8	44.6	86.4	256.5	115.7	0.	0.	0.
1958	0.	0.	0.	0.	0.	20.2	2.1	55.4	69.1	0.	0.	.0.
1959	0.	0.	0.	0.	0.	7.1	52.3	241.5	155.2	0.	0.	0.
1960	0.	0.	0.	0.	0.	12.1	78.4	126.7	138.9	4.6	0.	0.
1961	0.	0.	0.	0.	0.	17.8	97.9	66.3	131.8	0.	0.	0.
1962	0.	0.	0.	0.	4.4	42.5	75.6	228.8	82.8	0.4	0.	0.
1963	0.	0.	0.	0.	3.6	30.3	57.5	217.7	76.9	4.0	0.	0.
1964	0.	0.	0.	0.	10.7	35.4	107.6	146.7	130.8	0.	0.	0.
1965	0.	0.	0.	0.	1.7	0.	44.6	155.2	79.3	.0.	0.	0.
1966	0.	0.	0.	0.	0.	41.1	0.5	162.3	126.2	0.	0.	0..
1967	0.	0.	0.	0.	0.2	2.9	48.9	151.3	157.5	0.	0.	0.
1968	0.	0.	0.	0.	0.	65.6	100.9	156.6	47.8	0.	0.	0.
1969	0.	0.	0.	0.	0.	24.3	72.3	204.5	75.5	1.4	0.	0.
1970	0.	0.	0.	0.	0.	0.	80.1	220.7	90.0	0.	0.	0.
1971	0.	0.	0.	0.	3.7	0.1	80.5	167.1	50.4	0.	0.	0.
1972	0.	0.	0.	0.	9.5	31.8	25.2	81.7	75.9	0.	0.	0.
1973	0.	0.	0.	0.	0.	56.0	25.1	147.9	47.8	0..	0.	0.
1974	0.	0.	0.	0.	0.	9.6	106.7	46.5	151.8	0.	0.	0.
1975	0.	0.	0.	0.	0.	7.6	158.8	87.6	49.4	0.	0.	0.
1976	0.	0.	0.	0.	4.0	37.5	0.	100.6	0.2	54.9	0.	0.
1977	0.	0.	0.	0.	3.5	35.0	17.8	69.6	98.5	0.	0.	0.
1978	0.	0.	0.	3.8	6.8	6.3	48.0	72.2	32.7	0.7	0.	0.
1979	0.	0.	0.	0.	0.3	10.4	53.1	121.1	84.2	0.	0.	0.
1980	0.	0.	0.	0.	1.2	29.2	18.7	166.7	34.5	3.8	0.	0.

NET RAINFALL - KOMPONGOU

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1932	0.0	0.0	0.0	0.0	4.5	9.4	13.6	16.5	153.6	0.0	0.0	0.0
1933	0.0	0.0	0.0	0.0	0.0	2.3	75.7	112.3	130.6	0.0	0.0	0.0
1934	0.0	0.0	0.0	0.0	0.0	22.2	94.2	111.7	192.3	33.5	0.0	0.0
1935	0.0	0.0	0.0	0.0	23.5	19.4	189.2	118.1	160.0	13.4	0.0	0.0
1936	0.0	0.0	0.0	0.0	16.2	11.4	47.7	35.4	140.8	0.0	0.0	0.0
1937	0.0	0.0	0.0	0.0	0.0	0.9	129.7	100.7	79.9	0.0	0.0	0.0
1938	0.0	0.0	0.0	0.0	0.0	12.5	18.4	87.7	54.8	0.0	0.0	0.0
1939	0.0	0.0	0.0	0.0	0.0	0.0	106.1	207.8	200.3	7.4	0.0	0.0
1940	0.0	0.0	0.0	0.0	23.2	26.8	70.4	133.4	56.1	6.9	0.0	0.0
1941	0.0	0.0	0.0	0.0	0.8	19.6	101.9	147.4	63.9	0.0	0.0	0.0
1942	0.0	0.0	0.0	0.0	0.0	0.0	0.0	91.2	60.9	0.0	0.0	0.0
1943	0.0	0.0	0.0	0.0	1.9	0.0	1.9	133.2	180.9	0.0	0.0	0.0
1944	0.0	0.0	0.0	0.0	0.0	31.9	60.9	144.5	56.7	4.3	0.0	0.0
1945	0.0	0.0	0.0	0.0	0.0	6.6	84.3	61.9	159.7	0.0	0.0	0.0
1946	0.0	0.0	0.0	0.0	0.0	0.0	1.2	10.0	152.3	47.0	0.0	0.0
1947	0.0	0.0	0.0	0.0	0.0	9.5	52.8	163.0	145.3	0.0	0.0	0.0
1948	0.0	0.0	0.0	0.0	0.0	46.7	72.6	128.0	133.0	0.0	0.0	0.0
1949	0.0	0.0	0.0	0.0	0.0	51.1	57.8	129.8	80.2	0.0	0.0	0.0
1950	0.0	0.0	0.0	0.0	0.0	6.5	26.5	82.0	86.8	0.0	0.0	0.0
1951	0.0	0.0	0.0	0.0	0.0	38.7	90.5	126.4	206.2	44.9	0.0	0.0
1952	0.0	0.0	0.0	0.0	1.9	16.1	36.3	114.6	246.1	0.0	0.0	0.0
1953	0.0	0.0	0.0	0.0	14.0	71.3	110.3	104.5	206.3	0.0	0.0	0.0
1954	0.0	0.0	0.0	4.5	0.0	38.8	30.3	82.6	87.1	35.1	0.0	0.0
1955	0.0	0.0	0.0	0.0	0.5	19.5	195.4	153.7	111.8	19.4	0.0	0.0
1956	0.0	0.0	0.0	0.0	3.0	21.1	70.9	137.9	105.1	0.0	0.0	0.0
1957	0.0	0.0	0.0	0.0	12.4	31.0	41.6	233.3	186.2	12.8	0.0	0.0
1958	0.0	0.0	0.0	0.0	0.0	0.0	18.4	59.2	149.6	0.0	0.0	0.0
1959	0.0	0.0	0.0	9.8	0.0	4.4	70.4	160.0	112.4	0.0	0.0	0.0
1960	0.0	0.0	0.0	0.0	0.0	10.1	104.6	100.6	157.7	0.0	0.0	0.0
1961	0.0	0.0	0.0	0.0	7.9	21.1	86.3	42.9	102.3	0.0	0.0	0.0
1962	0.0	0.0	0.0	0.0	6.1	46.3	80.8	273.5	81.0	2.3	0.0	0.0
1963	0.0	0.0	0.0	0.0	0.0	38.6	121.8	173.7	107.7	30.2	0.0	0.0
1964	0.0	0.0	0.0	0.0	0.0	14.0	106.0	222.2	98.3	0.0	0.0	0.0
1965	0.0	0.0	0.0	0.0	4.6	2.2	52.5	163.5	45.1	0.0	0.0	0.0
1966	0.0	0.0	0.0	9.4	0.0	20.6	43.2	115.3	96.9	20.0	0.0	0.0
1967	0.0	0.0	0.0	0.0	2.1	10.6	46.2	185.2	138.1	0.0	0.0	0.0
1968	0.0	0.0	0.0	12.3	0.0	40.9	133.9	111.5	33.2	3.7	0.0	0.0
1969	0.0	0.0	0.0	0.0	0.0	43.0	51.1	193.9	125.3	42.2	0.0	0.0
1970	0.0	0.0	0.0	0.0	0.0	2.7	74.9	133.1	167.4	0.0	0.0	0.0
1971	0.0	0.0	0.0	0.0	0.0	0.0	90.1	159.6	58.2	0.0	0.0	0.0
1972	0.0	0.0	0.0	0.0	0.0	1.2	25.0	153.2	109.3	0.5	0.0	0.0
1973	0.0	0.0	0.0	0.0	0.0	0.0	49.4	179.1	45.8	6.1	0.0	0.0
1974	0.0	0.0	0.0	0.0	3.8	21.1	72.7	122.9	143.4	0.0	0.0	0.0
1975	0.0	0.0	0.0	0.0	0.0	5.1	203.6	75.3	108.3	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0	10.7	38.5	8.8	104.1	22.2	35.0	0.0	0.0
1977	0.0	0.0	0.0	0.0	0.0	9.2	50.6	87.8	65.8	0.0	0.0	0.0
1978	0.0	0.0	0.0	5.8	0.0	8.2	121.5	100.8	68.2	0.0	0.0	0.0
1979	0.0	0.0	0.0	0.0	0.0	37.9	100.6	96.4	103.6	0.0	0.0	0.0
1980	0.0	0.0	0.0	0.0	0.0	9.8	60.5	169.6	37.1	0.0	0.0	0.0

PARAMETERS OF REGRESSION MODELS - KPESSIDE

	CONSTANT	FLOW-1	RAIN-0	RAIN-1	RAIN-2	SIGMA
JUNE	-0.359	-	0.436	0.227	0.413	1.054
JULY	-1.301	0.697	0.540	-0.021	-	1.604
AUGUST	-0.754	0.269	0.660	0.112	-	1.139
SEPTEMBER	-1.329	0.054	0.772	0.184	-	1.682
OCTOBER	1.052	0.024	0.506	0.297	-	0.934
NOVEMBER	-0.421	0.411	-	0.108	-	0.946
DECEMBER	0.480	0.232	-	-	-	0.369

PARAMETERS OF REGRESSION MODELS - LAMAKARA

	CONSTANT	FLOW-1	RAIN-0	RAIN-1	RAIN-2	SIGMA
JUNE	-0.411	-	0.451	0.224	0.250	1.093
JULY	-5.204	0.678	0.847	0.082	-	1.633
AUGUST	-1.812	0.254	0.674	0.177	-	1.223
SEPTEMBER	-2.269	0.426	0.774	0.068	-	1.796
OCTOBER	0.656	0.118	0.341	0.241	-	1.197
NOVEMBER	0.323	0.236	-	0.209	-	0.751
DECEMBER	0.602	0.207	-	-	-	0.344

PARAMETERS OF REGRESSION MODELS - PONT DE BETEROU

	CONSTANT	FLOW-1	RAIN-0	RAIN-1	RAIN-2	SIGMA
JUNE	-0,026	-	0.112	0.115	0.229	0.504
JULY	-1.463	0.921	0.399	0.098	-	0.902
AUGUST	-3.561	0.722	0.374	0.062	-	1.306
SEPTEMBER	-2.287	0.407	0.429	0.300	-	0.945
OCTOBER	-1.692	0.254	0.407	0.443	-	0.826
NOVEMBER	0.253	0.254	-	0.200	-	0.440
DECEMBER	0.039	0.354	-	-	-	0.189

PARAMETERS OF REGRESSION MODELS - PONT DE SAVE

	CONSTANT	FLOW-1	RAIN-0	RAIN-1	RAIN-2	SIGMA
JUNE	-1.467	-	0.249	0.266	0.072	0.769
JULY	-2,368	0.705	0,343	0.223	-	0.595
AUGUST	-0.508	0.646	0.330	0.139	-	0.972
SEPTEMBER	-1.781	0.449	0.424	0.245	-	0.938
OCTOBER	-1.107	0.403	0.338	0.277	-	0.673
NOVEMBER	-0.015	0.271	-	0.236	-	0.552
DECEMBER	-0.214	0.394	-	-	-	0.191

PARAMETERS OF REGRESSION MODELS - TETETOU

	CONSTANT	FLOW-1	RAIN-0	RAIN-1	RAIN-2	SIGMA
JUNE	-1.798	-	0.288	0.228	0.270	0.597
JULY	-1.963	0.843	0.378	0.114	-	0.688
AUGUST	-0.915	0.474	0.371	0.146	-	0.983
SEPTEMBER	-0.595	0.476	0.361	0.136	-	0.952
OCTOBER	0.297	0.254	0.420	0.157	-	0.633
NOVEMBER	-0.348	0.362	-	0.158	-	0.441
DECEMBER	0.197	0.345	-	-	-	0.231

PARAMETERS OF REGRESSION MODELS - TITIRA

	CONSTANT	FLOW-1	RAIN-0	RAIN-1	RAIN-2	SIGMA
JUNE	-0.053	-	0.286	0.247	0.349	0.778
JULY	-1.400	0.551	0.493	0.084	-	1.262
AUGUST	-3.272	0.310	0.673	0.195	-	1.152
SEPTEMBER	1.672	0.216	0.678	-0.069	-	1.172
OCTOBER	0.096	0.320	0.384	0.168	-	0.663
NOVEMBER	0.043	0.394	-	0.149	-	0.608
DECEMBER	0.172	0.464	-	-	-	0.261

PARAMETERS OF REGRESSION MODELS - KOMPONGOU

	CONSTANT	FLOW-1	RAIN-0	RAIN-1	RAIN-2	SIGMA
JUNE	0.570	-	-	-	-	0.560
JULY	-0.263	-	0.222	0.179	-	0.846
AUGUST	-1.913	0.618	0.351	0.097	-	1.287
SEPTEMBER	0.058	0.713	0.235	0.153	-	0.974
OCTOBER	-1.772	0.689	0.214	0.188	-	1.064
NOVEMBER	-0.759	0.508	-	0.207	-	0.349
DECEMBER	-0.508	0.609	-	-	-	0.432

PARAMETERS OF REGRESSION MODELS - KOMPONGOU

	CONSTANT	FLOW-1	RAIN-0	RAIN-1	RAIN-2	SIGMA
JUNE	1.241	-	0.012	0.091	-	0.199
JULY	-0.726	0.030	0.134	0.031	-	0.633
AUGUST	-2.886	1.163	0.281	0.135	-	0.670
SEPTEMBER	-5.258	0.528	0.434	0.367	-	0.583
OCTOBER	-1.771	0.511	0.674	0.265	-	0.593
NOVEMBER	0.232	0.385	-	0.117	-	0.226
DECEMBER	0.542	0.365	-	-	-	0.080

FLOW IN MONTHS JANUARY TO MAY AS PROPORTIONS OF JUNE-DECEMBER TOTAL FLOW

	KOMPONGOU	KOUBERI	KPESSIDE	LANAKARA	P.BETEROU	P.SAVE	TETETOU	TITIRA
JANUARY	0.0021	0.0136	0.0014	0.0012	0.0010	0.0007	0.0020	0.0041
FEBRUARY	0.0005	0.0107	0.0005	0.0006	0.0001	0.0001	0.0008	0.0014
MARCH	0.0000	0.0110	0.0008	0.0010	0.0001	0.0001	0.0017	0.0009
APRIL	0.0000	0.0101	0.0045	0.0040	0.0002	0.0002	0.0035	0.0042
MAY	0.0000	0.0129	0.0127	0.0088	0.0014	0.0009	0.0069	0.0107

SIMULATED FLOWS: TETETOU

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1932	0.1	0.0	0.1	0.1	0.2	0.0	1.5	6.8	17.5	7.0	0.1	0.0	33.5
1933	0.3	0.1	0.2	0.5	1.0	8.2	25.1	58.8	38.6	13.2	0.5	0.2	146.6
1934	0.4	0.1	0.3	0.6	1.3	1.7	15.1	40.1	59.6	53.0	14.5	1.8	158.4
1935	0.3	0.1	0.2	0.5	1.0	1.8	18.8	69.5	45.2	6.6	1.0	0.7	145.7
1936	0.2	0.1	0.2	0.4	0.7	2.7	15.4	24.2	43.1	18.6	0.5	0.4	106.5
1937	0.2	0.1	0.2	0.4	0.7	0.0	4.6	25.4	34.8	38.5	4.4	0.6	110.0
1938	0.3	0.1	0.2	0.5	0.9	8.7	20.0	31.0	44.7	27.8	4.2	0.5	138.9
1939	0.3	0.1	0.2	0.5	0.9	0.1	15.3	29.3	54.2	24.5	7.2	0.9	133.4
1940	0.4	0.2	0.3	0.7	1.3	3.0	17.7	51.3	74.6	34.3	8.1	1.7	193.6
1941	0.2	0.1	0.2	0.4	0.7	4.3	18.9	32.5	39.2	5.4	0.7	0.0	102.4
1942	0.1	0.0	0.1	0.2	0.4	1.2	1.0	11.9	25.5	17.4	2.2	0.2	60.4
1943	0.2	0.1	0.1	0.3	0.6	1.5	1.8	25.4	31.9	15.7	5.2	2.0	84.8
1944	0.2	0.1	0.1	0.3	0.6	0.2	3.7	27.6	35.1	13.7	1.7	0.2	83.4
1945	0.3	0.1	0.3	0.6	1.1	0.5	26.5	25.6	56.1	38.6	7.4	1.2	[illegible]
1946	0.2	0.1	0.2	0.4	0.9	10.0	20.0	1.8	26.3	46.1	9.3	0.8	116.0
1947	0.8	0.3	0.7	1.4	2.7	6.1	32.4	92.6	150.6	74.7	16.4	3.8	[illegible]
1948	0.4	0.1	0.3	0.6	1.3	6.4	23.8	77.0	61.0	14.4	1.2	0.4	[illegible]
1949	0.6	0.2	0.5	1.0	2.0	5.3	46.7	38.8	91.9	43.5	9.8	1.7	291.9
1950	0.1	0.0	0.1	0.2	0.4	4.3	13.0	11.9	16.2	10.6	1.4	0.3	59.5
1951	0.2	0.1	0.1	0.3	0.7	1.4	7.2	11.8	30.0	52.0	11.3	1.7	116.7
1952	0.4	0.2	0.3	0.1	0.4	0.9	13.2	19.9	33.9	44.4	7.8	1.3	121.8
1953	0.4	0.2	0.9	0.2	1.1	13.0	35.2	41.5	34.5	24.2	4.7	0.7	159.6
1954	0.3	0.1	0.2	0.2	0.4	4.3	10.1	7.0	14.2	37.2	8.5	1.2	83.7
1955	0.2	0.1	0.5	2.2	2.4	11.2	40.5	66.1	82.6	41.7	9.1	1.6	260.2
1956	0.4	0.1	0.7	0.6	0.2	2.3	2.4	3.1	13.9	11.6	0.9	0.4	36.6
1957	0.1	0.0	0.1	0.3	3.3	21.1	49.4	64.3	69.9	61.8	15.9	4.2	310.4
1958	1.1	0.3	0.2	0.3	2.1	6.0	1.6	0.6	2.8	4.2	0.6	0.5	20.3
1959	0.1	0.0	0.1	0.5	1.3	0.6	15.5	8.5	44.1	32.4	4.3	1.1	106.5
1960	0.2	0.1	0.1	1.5	1.2	7.6	37.4	56.8	87.6	52.1	11.0	2.2	257.9
1961	0.7	0.2	0.1	0.2	0.4	2.0	11.6	7.9	10.1	10.0	0.7	0.0	43.9
1962	0.0	0.0	0.0	0.1	2.5	28.1	38.4	47.7	54.4	42.9	9.2	2.4	225.7
1963	0.3	0.2	0.6	0.5	0.9	6.0	66.8	89.4	109.5	91.8	18.7	2.1	38[illegible].8
1964	0.6	0.2	0.2	0.5	0.7	2.5	8.8	23.6	60.2	13.1	2.0	0.5	112.9
1965	0.2	0.1	0.1	0.5	0.4	11.6	64.5	60.4	52.6	14.4	1.5	0.3	206.6
1966	0.1	0.1	0.1	0.2	0.2	3.1	15.5	60.8	66.1	25.2	5.0	0.7	177.1
1967	0.2	0.1	0.2	0.7	1.0	5.2	18.3	54.4	72.2	34.6	4.9	1.5	193.3
1968	0.5	0.2	0.2	0.4	2.3	17.6	69.2	96.6	96.9	54.7	12.1	1.6	352.3
1969	0.4	0.2	0.2	0.7	0.6	1.5	16.5	40.9	60.6	33.7	13.8	1.5	170.6
1970	0.4	0.2	0.6	0.2	1.3	1.2	2.0	31.9	95.6	31.9	2.7	0.2	168.2
1971	0.1	0.0	0.2	0.5	0.4	0.6	6.7	38.0	30.6	9.9	0.9	0.4	88.3
1972	0.1	0.1	0.1	1.0	1.9	9.9	20.8	18.3	29.5	8.7	2.0	0.3	92.7
1973	0.2	0.1	0.1	0.3	0.3	0.8	4.2	29.8	40.3	25.7	3.0	0.5	105.3
1974	0.2	0.1	0.3	0.4	0.5	0.5	11.0	28.2	53.7	25.6	3.1	0.5	124.1
1975	0.2	0.1	0.1	0.7	0.5	1.4	13.3	40.8	44.6	34.6	2.9	1.0	140.2
1976	0.4	0.2	0.2	0.2	0.7	3.4	5.6	18.3	8.3	32.4	14.7	1.4	85.8
1977	0.5	0.2	0.0	0.0	0.2	0.4	1.3	6.5	35.3	19.2	1.4	0.3	65.3
1978	0.1	0.1	0.8	1.8	1.7	10.3	22.3	14.4	32.7	25.3	5.3	1.7	116.5
1979	0.8	0.3	0.3	1.3	3.5	7.3	34.5	57.2	62.7	18.1	4.6	1.4	192.0
1980	0.3	0.1	0.3	0.6	1.2	3.1	18.1	52.7	51.4	35.0	6.1	0.9	169.7

SIMULATED FLOWS: TITIRA

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1932	1.3	0.4	0.3	1.3	3.3	2.0	28.7	7.8	194.0	68.0	9.6	2.1	318.9
1933	1.5	0.5	0.3	1.6	4.0	18.7	58.7	181.6	86.7	24.7	2.1	0.6	381.0
1934	2.0	0.7	0.4	2.1	5.3	3.1	42.5	102.6	190.8	114.1	36.6	7.8	508.0
1935	1.9	0.7	0.4	2.0	5.1	1.8	72.0	163.4	153.0	56.3	18.8	6.4	483.8
1936	0.7	0.3	0.2	0.8	1.9	3.9	15.0	37.0	99.2	24.0	0.8	0.7	184.6
1937	0.8	0.3	0.2	0.9	2.2	0.0	14.5	53.6	87.1	43.4	4.5	1.0	[illegible]
1938	0.8	0.3	0.2	0.8	2.1	4.1	17.1	34.2	111.8	28.3	3.0	0.6	[illegible]
1939	1.2	0.4	0.3	1.3	3.2	1.8	39.8	55.3	117.9	57.8	24.0	4.9	308.0
1940	1.3	0.4	0.3	1.3	3.4	2.1	24.4	102.4	112.2	51.8	17.0	5.0	321.7
1941	1.0	0.3	0.2	1.0	2.6	8.0	48.5	84.4	80.7	14.0	3.8	0.6	245.1
1942	0.6	0.2	0.1	0.6	1.6	0.0	0.0	30.1	93.5	24.9	3.0	0.5	155.3
1943	1.0	0.4	0.2	1.1	2.7	0.9	0.0	52.6	132.9	44.8	16.8	6.4	259.8
1944	0.5	0.2	0.1	0.5	1.3	0.5	11.6	50.9	50.9	5.5	0.1	0.0	122.1
1945	1.5	0.5	0.3	1.6	4.0	3.5	58.1	47.9	189.0	59.8	10.9	2.8	380.0
1946	1.0	0.3	0.2	1.0	2.5	5.1	13.6	2.0	137.4	63.1	11.7	1.8	239.7
1947	1.5	0.5	0.3	1.6	4.0	3.9	10.7	88.1	203.0	51.1	10.1	4.3	378.7
1948	1.1	0.4	0.3	1.2	3.0	4.9	38.6	96.1	109.7	24.9	3.1	1.1	284.6
1949	3.1	1.0	0.7	3.1	8.0	10.9	[illegible]	216.4	252.3	132.5	39.9	9.7	760.4
1950	0.9	0.3	0.2	0.9	2.4	20.8	40.0	29.7	97.1	26.9	4.5	1.1	224.9
1951	2.0	0.7	0.4	2.1	5.3	2.2	16.2	62.5	195.8	146.6	55.9	14.1	508.8
1952	1.3	0.4	0.3	1.3	3.3	0.3	17.9	40.5	162.2	70.1	12.9	2.9	313.1
1953	1.9	0.7	0.4	2.0	5.0	34.6	62.1	79.2	210.0	48.1	11.3	2.9	478.4
1954	0.9	0.3	0.2	0.9	2.3	17.9	7.7	8.1	102.1	69.5	10.5	2.1	222.5
1955	2.1	0.7	0.5	2.1	5.4	10.7	91.8	102.2	191.5	81.4	23.7	5.8	517.3
1956	1.3	0.4	0.3	1.3	3.4	10.5	51.1	54.1	154.0	38.8	5.7	2.3	323.2
1957	2.3	0.8	0.5	2.3	5.9	16.6	46.3	109.5	223.7	114.7	31.8	8.0	562.2
1958	0.8	0.3	0.2	0.9	2.2	3.5	3.7	0.0	140.5	45.2	9.5	2.5	209.2
1959	1.5	0.5	0.3	1.5	3.9	5.1	34.4	114.6	151.7	40.8	10.2	3.6	368.0
1960	1.9	0.7	0.4	2.0	5.1	3.3	73.7	91.1	180.9	97.8	18.8	4.8	485.5
1961	0.5	0.2	0.1	0.5	1.4	6.0	22.1	15.2	71.0	12.8	2.6	0.6	133.5
1962	1.4	0.5	0.0	0.7	1.3	12.8	56.0	[illegible]	117.9	54.4	18.1	3.8	356.4
1963	1.8	0.6	0.4	1.3	1.3	1.5	56.6	185.6	186.6	118.9	31.1	9.3	594.4
1964	3.1	0.9	0.9	0.8	4.1	3.7	25.2	78.3	170.5	34.9	7.9	2.5	332.8
1965	1.4	0.5	0.3	0.4	4.6	8.0	19.9	69.2	75.8	19.8	3.4	1.1	204.4
1966	0.5	0.1	0.1	0.3	3.6	15.0	23.7	76.1	102.4	73.2	12.6	2.8	310.4
1967	1.1	0.3	0.2	0.5	3.6	4.1	45.4	164.5	104.5	62.8	9.6	4.9	401.5
1968	1.6	0.5	0.2	8.9	11.0	35.3	120.3	97.1	152.2	61.9	14.3	4.6	507.9
1969	2.1	0.8	0.3	1.3	1.4	1.8	33.3	90.6	183.8	79.7	37.7	8.0	440.8
1970	3.0	1.2	0.7	0.2	2.0	1.3	16.2	82.6	208.3	52.2	8.1	2.3	378.1
1971	1.1	0.6	0.3	1.3	1.2	1.7	66.5	154.4	124.2	32.8	5.3	2.0	391.4
1972	0.8	0.2	0.1	0.6	11.6	9.2	37.3	62.0	88.4	34.1	6.7	2.2	253.2
1973	1.4	0.3	0.1	0.1	1.3	2.0	10.6	82.6	115.7	46.3	6.0	1.2	267.6
1974	0.4	0.1	0.1	0.1	2.6	6.0	24.9	70.6	144.5	45.7	8.4	1.4	304.8
1975	0.8	0.3	0.1	2.5	2.1	1.3	39.2	88.4	129.8	40.4	6.3	1.9	313.1
1976	0.7	0.3	0.1	0.1	1.4	27.1	31.5	58.4	45.2	43.3	15.8	2.6	226.5
1977	0.9	0.3	0.1	0.4	0.9	2.2	12.7	19.1	51.1	10.9	1.1	0.2	99.9
1978	0.1	0.0	0.4	1.3	2.4	6.9	60.5	90.6	94.7	24.1	7.6	1.5	290.1
1979	0.6	0.1	0.1	0.1	2.3	8.3	63.5	78.3	154.3	52.3	5.9	1.7	367.5
1980	0.7	0.2	0.1	0.7	1.8	3.4	13.9	65.4	63.1	16.6	2.3	0.7	169.0

SIMULATED FLOWS: PONT DE BETEROU

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1932	0.1	0.0	0.0	0.0	0.2	0.0	4.0	16.6	44.3	41.5	5.1	0.5	112.5
1933	0.2	0.0	0.0	0.0	0.3	2.3	23.0	110.9	82.8	27.3	1.4	0.2	248.6
1934	0.3	0.0	0.0	0.1	0.4	0.1	6.4	43.4	122.9	109.4	16.7	1.8	301.6
1935	0.4	0.0	0.0	0.1	0.6	0.9	28.1	154.3	160.1	47.9	5.8	1.3	399.5
1936	0.0	0.0	0.0	0.0	0.1	0.1	1.6	13.9	21.3	10.7	0.1	0.1	48.1
1937	0.2	0.0	0.0	0.0	0.3	0.0	6.4	31.3	79.5	67.7	3.6	0.4	169.4
1938	0.1	0.0	0.0	0.0	0.1	0.8	2.5	23.9	57.8	18.6	1.1	0.1	105.0
1939	0.2	0.0	0.0	0.0	0.3	0.1	7.8	33.8	102.6	57.7	12.9	1.3	216.8
1940	0.2	0.0	0.0	0.0	0.3	1.2	7.2	50.6	107.9	43.7	8.2	1.5	226.7
1941	0.1	0.0	0.0	0.0	0.2	1.6	11.0	40.3	55.3	5.6	1.4	0.1	115.5
1942	0.1	0.0	0.0	0.0	0.1	0.1	0.0	16.9	48.6	21.7	2.3	0.2	90.2
1943	0.2	0.0	0.0	0.0	0.2	2.2	0.0	42.4	77.0	29.7	6.3	1.6	159.7
1944	0.1	0.0	0.0	0.0	0.1	0.1	7.0	34.4	58.1	6.5	0.2	0.0	106.6
1945	0.1	0.0	0.0	0.0	0.2	1.0	6.7	21.4	75.9	26.8	1.9	0.3	136.4
1946	0.1	0.0	0.0	0.0	0.1	1.3	1.7	3.7	38.0	49.5	9.3	0.7	104.4
1947	0.3	0.0	0.0	0.1	0.5	2.9	6.6	75.3	187.3	65.5	6.5	1.5	346.5
1948	0.2	0.0	0.0	0.0	0.3	0.8	17.0	79.8	75.8	21.1	1.5	0.3	196.9
1949	0.3	0.0	0.0	0.1	0.4	0.8	19.4	81.3	132.7	73.7	11.3	1.5	321.6
1950	0.1	0.0	0.0	0.0	0.1	1.3	9.6	31.0	41.9	14.9	1.9	0.2	101.1
1951	0.3	0.0	0.0	0.1	0.4	1.2	6.2	35.7	107.5	87.4	22.7	3.3	264.6
1952	0.2	0.0	0.0	0.0	0.3	0.2	10.1	57.6	62.8	78.3	10.3	1.4	221.3
1953	0.4	0.1	0.1	0.0	0.7	1.8	51.1	66.1	110.4	83.3	9.8	1.4	325.2
1954	0.3	0.0	0.0	0.0	0.3	3.3	5.6	42.8	60.5	41.0	6.0	1.7	161.5
1955	0.7	0.2	0.1	0.2	0.3	3.1	50.1	116.2	133.8	93.1	11.9	2.1	411.8
1956	0.5	0.1	0.2	0.1	0.1	1.6	2.4	15.8	49.5	32.7	3.1	0.8	106.9
1957	0.1	0.0	0.0	0.0	0.5	4.4	12.9	75.2	144.3	77.6	13.5	3.0	331.5
1958	0.6	0.1	0.0	0.0	0.2	0.1	0.6	0.5	2.7	4.3	0.5	0.0	9.6
1959	0.0	0.0	0.0	0.0	0.5	0.3	5.3	15.1	97.1	50.6	2.7	0.6	172.2
1960	0.0	0.0	0.0	0.1	0.1	0.3	24.7	68.7	139.1	90.0	8.2	0.9	332.1
1961	0.2	0.1	0.0	0.2	0.0	3.0	12.3	27.8	62.3	19.5	1.3	0.1	126.8
1962	0.0	0.0	0.0	0.0	0.1	4.0	11.9	69.5	103.9	52.9	9.8	1.5	253.6
1963	0.3	0.0	0.1	0.0	0.4	0.2	12.3	92.3	144.6	114.1	20.9	2.3	387.5
1964	0.5	0.1	0.0	0.0	0.1	0.8	7.7	38.1	90.4	21.0	2.8	0.5	162.0
1965	0.1	0.0	0.0	0.0	0.1	0.8	10.9	49.8	84.6	13.8	1.2	0.2	161.5
1966	0.0	0.0	0.0	0.0	0.5	2.3	6.4	24.3	34.9	45.4	5.8	0.5	120.1
1967	0.1	0.0	0.0	0.0	0.1	0.3	11.2	64.3	90.1	56.0	5.4	1.1	228.6
1968	0.3	0.0	0.0	0.4	1.1	8.7	50.8	61.5	100.4	46.9	6.2	0.8	277.1
1969	0.2	0.0	0.0	0.0	0.1	0.2	0.5	32.9	81.6	36.6	14.3	1.5	167.9
1970	0.3	0.0	0.0	0.0	0.0	0.3	1.7	27.2	75.1	37.6	2.4	0.4	145.0
1971	0.1	0.0	0.0	0.0	0.1	1.0	2.9	36.1	77.8	13.9	1.0	0.3	133.2
1972	0.0	0.0	0.0	0.0	0.3	1.4	3.8	8.0	16.4	5.9	0.8	0.2	36.8
1973	0.2	0.0	0.0	0.0	0.0	0.5	3.7	80.7	73.3	28.0	2.2	0.2	188.8
1974	0.0	0.0	0.0	0.0	0.0	0.1	8.6	37.4	92.6	33.7	2.4	0.2	175.0
1975	0.0	0.0	0.0	0.0	0.0	0.1	10.1	28.5	71.3	31.1	2.2	0.3	143.6
1976	0.1	0.0	0.0	0.0	0.9	4.8	5.1	12.0	8.0	17.4	10.3	0.8	59.4
1977	0.1	0.0	0.0	0.0	0.0	0.0	2.0	9.7	28.1	12.2	0.8	0.1	53.0
1978	0.0	0.0	0.0	0.0	0.4	1.1	18.0	32.2	22.7	6.8	3.2	0.3	84.7
1979	0.0	0.0	0.0	0.0	0.0	0.7	11.5	52.1	79.3	63.0	10.9	0.8	218.3
1980	0.1	0.0	0.0	0.0	0.1	0.2	0.7	16.8	31.3	12.0	1.4	0.1	62.7

SIMULATED FLOWS: PONT DE SAVE

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1932	0.1	0.0	0.0	0.0	0.1	0.0	1.5	9.9	30.7	28.6	3.9	0.2	74.9
1933	0.2	0.0	0.0	0.1	0.3	4.4	30.2	128.3	94.4	52.1	6.7	0.6	317.4
1934	0.2	0.0	0.0	0.1	0.3	0.7	10.1	54.0	122.9	84.4	14.3	1.3	288.3
1935	0.3	0.0	0.0	0.1	0.3	5.0	36.2	143.8	135.9	52.1	8.9	1.5	384.1
1936	0.0	0.0	0.0	0.0	0.0	0.0	2.8	15.3	19.5	7.7	0.0	0.0	45.4
1937	0.1	0.0	0.0	0.0	0.1	0.0	7.0	31.3	60.0	59.0	4.5	0.3	[illegible]
1938	0.1	0.0	0.0	0.0	0.1	1.1	3.1	14.8	36.7	23.4	2.7	0.1	84.1
1939	0.1	0.0	0.0	0.0	0.1	0.3	11.7	32.8	66.2	31.0	9.0	0.6	[illegible]
1940	0.1	0.0	0.0	0.0	0.1	0.7	3.2	28.7	62.5	41.1	7.7	1.0	[illegible]
1941	0.1	0.0	0.0	0.0	0.1	3.6	13.1	35.7	44.1	8.0	1.3	0.0	106.0
1942	0.1	0.0	0.0	0.0	0.1	0.0	0.0	10.6	36.7	26.5	3.9	0.1	78.0
1943	0.1	0.0	0.0	0.0	0.1	2.1	0.3	24.5	45.8	26.6	8.8	1.7	[illegible]
1944	0.1	0.0	0.0	0.0	0.1	0.0	4.1	25.8	56.0	12.0	0.1	0.0	[illegible]
1945	0.1	0.0	0.0	0.0	0.1	0.6	9.3	19.3	61.2	41.0	7.1	0.7	139.4
1946	0.0	0.0	0.0	0.0	0.1	1.0	1.1	2.0	20.6	29.1	7.4	0.3	61.7
1947	0.2	0.0	0.0	0.1	0.5	4.5	10.5	71.1	165.9	72.4	9.4	1.7	[illegible]
1948	0.1	0.0	0.0	0.0	0.1	0.0	5.8	42.5	39.9	10.6	0.4	0.0	99.4
1949	0.3	0.0	0.0	0.1	0.3	2.6	28.5	92.5	134.4	91.2	19.6	2.4	371.9
1950	0.1	0.0	0.0	0.0	0.1	5.3	13.4	36.6	29.7	16.0	3.2	[illegible]	99.6
1951	0.1	0.0	0.0	0.0	0.0	0.0	[illegible]	30.6	68.2	55.5	27.2	[illegible]	194.6
1952	0.4	0.1	0.0	0.0	0.1	0.1	9.2	45.9	44.7	72.1	10.2	[illegible]	184.8
1953	0.2	0.0	0.0	0.5	0.0	15.8	45.7	74.5	80.2	57.9	10.0	[illegible]	285.3
1954	0.2	0.0	0.0	0.0	0.0	1.7	4.6	20.5	32.7	41.9	9.0	1.1	111.5
1955	0.1	0.0	0.0	0.0	0.0	0.7	59.5	102.1	99.8	81.3	11.0	1.6	354.1
1956	0.5	0.0	0.3	0.0	0.0	0.0	1.2	11.8	30.6	21.6	2.1	[illegible]	68.5
1957	0.0	0.0	0.0	0.0	0.5	10.4	19.6	68.3	141.2	71.5	17.2	[illegible]	332.6
1958	0.7	0.1	0.0	0.1	0.1	0.1	0.0	0.1	1.0	3.1	0.3	0.0	[illegible]
1959	0.0	0.0	0.0	0.2	0.4	0.2	7.5	12.5	84.0	47.6	3.7	[illegible]	156.2
1960	0.0	0.0	0.0	0.0	0.1	0.6	25.2	60.2	123.4	72.2	12.2	1.2	295.2
1961	0.2	0.0	0.0	0.3	0.0	0.1	16.6	22.7	40.7	22.2	1.8	0.1	104.7
1962	0.0	0.0	0.0	0.0	0.0	6.7	17.6	73.0	91.4	64.3	13.3	1.8	268.1
1963	0.1	0.0	0.0	0.0	0.0	0.7	26.3	111.7	133.9	100.4	19.5	2.1	394.7
1964	0.4	0.1	0.1	0.0	0.0	0.0	2.0	25.6	78.0	21.3	2.7	0.2	130.4
1965	0.0	0.0	0.0	0.0	0.0	0.8	19.0	60.2	67.7	17.4	1.5	0.1	166.7
1966	0.0	0.0	0.0	0.1	0.0	1.2	4.7	35.2	41.5	37.3	7.6	0.6	128.2
1967	0.0	0.0	0.0	0.2	0.0	0.4	8.5	59.4	88.3	48.9	5.6	1.2	212.5
1968	0.2	0.0	0.0	0.0	0.6	7.3	35.0	63.1	104.7	49.4	7.4	0.9	268.6
1969	0.1	0.0	0.0	0.0	0.0	0.0	1.3	18.2	68.6	33.6	13.7	1.2	136.7
1970	0.1	0.0	0.0	0.0	0.7	0.4	2.6	25.3	64.8	35.6	2.1	0.1	131.7
1971	0.0	0.0	0.0	0.0	0.0	0.5	1.6	27.7	63.2	15.4	1.0	0.1	109.5
1972	0.0	0.0	0.0	0.0	0.0	1.3	1.6	5.2	13.9	3.5	0.7	0.0	26.2
1973	0.0	0.0	0.0	0.0	0.0	0.1	2.3	47.9	52.5	32.2	3.3	0.1	138.4
1974	0.0	0.0	0.0	0.0	0.0	0.0	12.6	52.4	89.2	39.0	3.2	0.2	196.6
1975	0.0	0.0	0.0	0.0	0.0	0.0	15.5	29.6	50.3	40.2	2.9	0.2	138.7
1976	0.0	0.0	0.0	0.0	0.0	3.3	3.9	11.9	4.5	13.8	10.8	0.7	48.9
1977	0.1	0.0	0.0	0.0	0.0	0.0	0.0	8.3	26.1	16.1	1.1	0.0	51.7
1978	0.0	0.0	0.2	0.2	1.6	3.9	12.7	23.7	27.1	14.6	5.6	0.3	89.9
1979	0.0	0.0	0.0	0.0	0.0	0.3	11.1	59.4	79.8	52.9	7.6	0.5	211.6
1980	0.1	0.0	0.0	0.0	0.1	0.1	0.2	10.8	46.7	35.5	12.9	1.7	108.2

SIMULATED FLOWS: KPESSIDE

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1941	0.6	0.2	0.3	1.9	5.3	25.0	57.3	178.9	125.6	21.8	5.2	0.4	422.5
1942	0.4	0.1	0.2	1.3	3.6	3.1	39.8	71.7	106.8	55.7	6.3	0.7	289.7
1943	0.3	0.1	0.2	1.0	2.7	0.6	4.1	72.9	64.6	65.5	7.3	1.1	220.4
1944	0.4	0.1	0.2	1.2	3.5	10.2	26.4	141.0	63.1	27.3	8.2	0.8	282.5
1945	0.6	0.2	0.3	1.9	5.4	8.6	98.8	122.4	112.1	60.2	18.5	3.8	432.9
1946	0.3	0.1	0.2	1.0	2.9	3.2	16.4	29.0	95.2	79.8	6.1	2.0	236.3
1947	0.5	0.2	0.3	1.8	5.0	9.4	23.4	91.2	144.0	110.5	12.8	1.2	400.2
1948	0.6	0.2	0.4	2.1	5.8	25.1	67.2	110.1	216.8	37.4	2.2	0.2	468.1
1949	0.8	0.3	0.4	2.5	7.0	10.2	76.3	140.0	238.4	65.0	23.2	1.6	565.7
1950	0.2	0.1	0.1	0.7	2.0	5.3	6.1	13.5	88.0	32.0	7.7	1.8	157.4
1951	0.8	0.3	0.4	2.5	7.1	1.0	31.3	115.3	228.8	137.9	41.1	2.4	569.0
1952	0.5	0.2	0.3	1.7	4.8	3.3	33.2	35.8	170.2	115.7	20.6	1.4	387.6
1953	0.6	0.2	0.3	1.8	5.0	25.6	60.1	107.0	104.7	50.3	22.7	5.0	383.3
1954	0.2	0.1	0.1	0.6	1.8	14.8	9.1	18.0	58.9	35.2	3.1	0.3	142.2
1955	0.8	0.3	0.4	2.5	7.0	20.3	115.0	146.9	210.6	51.6	6.8	1.1	563.4
1956	0.5	0.2	0.2	1.4	3.9	11.4	15.4	36.0	207.2	34.5	1.5	0.0	312.2
1957	1.0	0.4	0.6	3.2	9.0	36.3	50.1	159.4	308.8	115.8	29.3	5.4	719.2
1958	0.2	0.1	0.1	0.5	1.4	10.5	13.4	12.3	48.2	21.7	1.6	0.8	110.7
1959	0.6	0.2	0.3	1.8	5.0	5.2	78.2	102.3	129.2	59.9	17.6	2.2	402.5
1960	0.6	0.2	0.4	2.0	5.9	44.8	97.8	86.3	120.4	85.0	18.2	1.7	463.4
1961	0.2	0.1	0.6	1.9	10.8	15.1	39.6	37.7	29.6	24.4	2.1	0.5	162.6
1962	0.4	0.1	0.2	1.3	4.9	56.0	89.0	141.1	155.1	58.9	3.2	0.1	510.1
1963	0.0	0.1	0.4	3.3	2.4	6.4	107.5	262.1	196.7	152.2	38.9	3.7	773.7
1964	1.4	0.2	0.5	2.9	4.1	4.6	18.7	76.0	174.7	27.6	4.4	0.9	316.0
1965	1.6	0.3	0.1	0.7	6.5	19.1	59.9	69.8	87.6	15.0	1.8	0.3	261.7
1966	0.2	0.1	0.0	1.2	4.6	20.3	30.0	170.9	108.7	89.1	14.0	2.0	441.1
1967	0.5	0.2	0.6	3.8	1.2	4.5	65.9	107.5	183.0	56.0	8.5	4.8	436.5
1968	1.2	0.4	0.7	3.8	9.0	58.6	91.1	92.7	129.1	46.9	14.1	2.2	449.8
1969	0.7	0.3	0.2	3.3	7.4	3.3	56.4	157.4	201.6	81.6	29.7	2.2	544.1
1970	1.0	0.3	0.5	0.2	2.1	1.8	14.4	102.7	223.9	39.1	2.6	0.8	389.4
1971	0.4	0.4	0.7	1.0	5.9	7.8	90.5	136.3	114.3	18.0	2.5	0.7	378.4
1972	0.2	0.1	0.4	3.3	14.0	12.8	58.2	91.4	78.5	53.0	8.5	2.6	323.0
1973	1.2	0.1	0.0	0.3	7.5	13.6	17.3	90.0	75.0	34.5	6.8	0.6	246.9
1974	0.2	0.1	0.1	0.3	2.4	17.2	63.1	132.5	231.3	83.4	14.9	2.3	547.8
1975	0.7	0.3	0.3	1.7	7.8	7.9	60.8	126.9	132.9	49.3	3.9	1.2	393.7
1976	0.4	0.2	0.1	1.5	8.4	30.8	70.0	79.2	28.8	79.1	33.2	2.2	333.9
1977	0.7	0.2	0.0	1.3	2.4	2.5	20.5	56.1	81.4	29.4	1.5	0.4	196.4
1978	0.2	0.0	0.3	0.9	3.9	51.8	94.1	120.4	55.0	51.8	9.8	2.7	390.9
1979	0.1	0.0	0.3	0.3	5.4	12.9	63.3	152.6	135.6	42.4	2.3	0.4	415.6
1980	0.5	0.2	0.3	1.7	4.8	3.3	24.6	188.7	102.9	41.1	13.2	1.3	382.6

SIMULATED FLOWS: LAMAKARA

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1932	0.4	0.2	0.3	1.3	2.8	2.1	30.4	50.7	174.3	51.6	3.7	0.7	318.4
1933	0.4	0.2	0.4	1.4	3.2	23.3	70.6	154.7	92.8	20.0	0.5	0.5	368.1
1934	0.8	0.4	0.7	2.7	5.9	7.3	76.1	147.5	299.2	117.7	24.1	1.9	684.4
1935	0.5	0.2	0.4	1.6	3.5	0.2	62.4	147.5	163.9	18.2	4.1	2.2	404.7
1936	0.3	0.2	0.3	1.1	2.4	7.2	20.8	55.4	151.9	37.5	0.8	1.2	279.1
1937	0.5	0.2	0.4	1.6	3.5	0.9	42.7	138.6	149.0	63.1	2.6	0.5	403.5
1938	0.3	0.2	0.3	1.1	2.5	6.5	25.2	84.6	147.0	21.8	0.9	0.2	290.7
1939	0.5	0.3	0.4	1.7	3.7	10.4	61.3	76.6	163.4	79.4	27.6	1.9	427.2
1940	0.5	0.3	0.4	1.7	3.7	2.4	51.9	125.8	160.7	58.3	15.7	2.6	423.8
1941	0.5	0.2	0.4	1.6	3.5	22.2	89.4	166.7	110.2	5.8	2.0	0.2	402.7
1942	0.2	0.1	0.2	0.7	1.5	1.5	0.4	34.4	86.2	42.5	5.9	0.6	174.2
1943	0.4	0.2	0.3	1.2	2.7	3.5	0.0	77.4	147.7	52.8	18.2	4.4	308.9
1944	0.3	0.2	0.3	1.0	2.3	6.0	31.5	126.6	90.5	2.0	0.0	0.1	260.6
1945	0.6	0.3	0.5	2.0	4.3	9.3	131.9	65.7	204.9	67.3	10.5	1.6	498.7
1946	0.3	0.2	0.3	1.1	2.4	17.2	28.8	13.3	129.7	73.0	9.7	0.5	276.4
1947	0.8	0.4	0.7	2.7	5.9	21.4	28.5	145.1	362.5	95.8	17.3	4.0	685.3
1948	0.6	0.3	0.5	1.9	4.3	18.2	59.3	163.0	214.3	26.5	1.5	0.9	491.4
1949	1.0	0.5	0.8	3.3	7.2	30.7	131.2	201.5	338.4	92.6	16.4	2.1	825.5
1950	0.2	0.1	0.1	0.5	1.2	22.8	16.4	12.2	46.4	30.0	5.4	0.9	136.2
1951	0.8	0.4	0.7	2.7	5.9	1.6	13.3	120.2	318.2	169.5	46.2	4.7	684.2
1952	0.3	0.2	0.3	1.1	2.4	4.0	62.7	13.1	97.7	78.7	11.7	1.3	273.3
1953	0.7	0.3	0.5	2.2	4.8	35.1	147.6	104.5	223.5	25.1	5.0	1.0	550.2
1954	0.3	0.1	0.2	0.9	2.0	31.3	42.1	28.3	73.1	44.5	4.8	0.7	228.3
1955	0.9	0.5	0.5	0.7	1.4	26.4	202.6	224.9	237.6	85.3	6.6	1.9	791.3
1956	0.7	0.5	2.6	0.7	1.2	5.5	19.6	81.4	259.2	32.4	2.8	1.7	408.3
1957	0.5	0.3	2.1	3.5	[illegible]	35.1	81.9	166.7	443.6	84.5	18.8	5.3	849.9
1958	1.4	0.6	0.3	5.0	1.5	9.8	6.5	3.6	20.4	12.0	1.7	0.5	63.3
1959	0.2	0.2	0.0	2.2	6.5	1.7	57.3	64.6	191.1	31.9	3.3	0.7	359.7
1960	0.2	0.0	0.2	0.8	1.2	20.3	82.1	113.5	221.0	82.4	15.3	2.2	539.2
1961	0.5	0.2	0.3	1.7	8.1	14.5	40.5	41.5	38.5	25.8	2.0	0.5	174.1
1962	0.2	0.2	0.2	0.3	6.5	83.9	64.2	119.5	140.7	48.1	15.8	2.6	482.2
1963	0.7	0.6	0.7	4.8	2.2	3.3	109.9	288.4	242.6	171.5	35.6	3.4	863.7
1964	1.4	0.2	0.7	5.0	4.3	5.0	23.9	114.2	212.7	29.2	4.0	0.9	401.5
1965	0.5	0.3	0.0	4.3	2.7	22.8	91.5	113.1	131.6	19.7	1.2	0.3	388.0
1966	0.2	0.2	0.0	1.5	1.7	18.6	25.2	187.1	172.8	94.3	26.1	1.2	528.9
1967	0.3	0.2	0.3	0.8	0.9	3.5	85.8	153.5	284.1	115.5	5.3	2.6	652.8
1968	0.7	0.2	0.2	2.5	4.6	33.6	86.5	73.1	169.5	45.5	5.8	1.2	423.4
1969	0.3	0.2	0.2	1.5	7.6	1.8	61.3	170.5	214.3	105.8	18.4	2.1	584.0
1970	0.9	0.3	0.3	0.2	1.5	1.7	14.8	119.8	224.3	36.2	2.3	0.7	403.0
1971	0.3	0.5	0.2	0.5	6.5	4.5	77.9	147.8	163.3	10.5	1.3	0.7	414.0
1972	0.3	0.2	0.2	1.2	10.6	13.3	42.8	71.4	122.5	35.7	4.3	2.9	305.4
1973	0.9	0.2	0.0	0.2	2.4	6.6	31.4	88.6	154.7	40.5	3.3	0.7	329.5
1974	0.3	0.2	0.2	0.2	1.9	9.3	121.0	204.3	252.6	80.9	9.0	1.5	681.4
1975	0.7	0.3	1.0	4.0	2.9	4.5	35.4	88.6	130.6	23.9	2.3	0.9	295.1
1976	0.5	0.3	0.2	0.7	6.9	23.1	87.6	55.5	34.9	46.0	23.3	2.1	281.1
1977	0.7	0.3	0.0	2.0	4.3	9.6	19.4	57.2	101.7	24.2	1.7	0.7	221.8
1978	0.3	0.2	0.5	1.2	3.8	24.4	156.2	160.9	114.1	33.0	10.3	0.2	505.1
1979	0.7	0.2	0.2	0.8	2.4	11.1	69.9	175.1	237.6	65.9	8.3	1.5	573.7
1980	0.7	0.3	0.6	2.3	5.0	5.6	43.3	177.2	303.8	36.4	3.2	1.6	580.0

SIMULATED FLOWS: KOUBERI

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1932	0.7	0.5	0.5	0.5	0.6	2.2	2.0	4.8	13.3	19.1	5.5	1.7	51.4
1933	1.8	1.4	1.4	1.3	1.7	2.0	13.5	42.3	48.1	19.4	3.2	1.3	137.5
1934	1.0	0.8	0.8	0.7	0.9	2.2	3.2	23.0	28.2	11.5	1.8	1.0	75.0
1935	2.3	1.8	1.9	1.7	2.2	1.5	6.8	45.7	78.1	31.6	6.8	2.1	182.7
1936	0.5	0.4	0.4	0.4	0.5	1.8	6.4	25.9	5.0	0.0	0.3	0.7	42.5
1937	0.2	0.2	0.2	0.2	0.2	1.9	2.2	7.1	4.5	0.6	0.0	0.5	17.8
1938	0.6	0.5	0.5	0.4	0.6	1.3	3.4	7.1	13.9	15.2	2.3	1.1	46.9
1939	1.4	1.1	1.1	1.0	1.3	2.6	5.7	17.4	42.9	26.4	4.8	1.6	107.4
1940	1.4	1.1	1.1	1.0	1.3	1.0	6.7	22.7	36.9	24.6	8.3	2.3	108.5
1941	0.6	0.5	0.5	0.4	0.5	2.4	2.8	11.7	19.1	4.0	1.3	1.0	44.8
1942	0.2	0.1	0.1	0.1	0.2	1.6	2.5	4.1	3.9	0.0	0.2	0.3	13.3
1943	0.2	0.2	0.2	0.2	0.2	1.5	0.8	3.0	9.0	2.8	0.6	0.6	19.3
1944	0.7	0.6	0.6	0.5	0.7	1.9	2.5	17.7	19.3	7.4	3.0	1.7	56.6
1945	1.0	0.8	0.8	0.8	1.0	1.1	5.2	21.2	39.5	7.5	1.2	0.8	81.0
1946	1.5	1.2	1.2	1.1	1.4	1.7	3.7	4.7	54.4	52.2	11.8	3.2	116.2
1947	1.3	1.0	1.1	1.0	1.2	2.5	1.8	7.0	52.6	26.3	4.1	1.3	101.2
1948	1.1	0.9	0.9	0.8	1.1	2.1	3.9	19.8	37.9	14.5	3.3	1.8	88.0
1949	1.0	0.8	0.8	0.8	1.0	1.3	4.9	35.9	28.0	3.3	0.7	0.8	79.3
1950	1.1	0.9	0.9	0.8	1.1	1.8	7.0	25.7	31.1	13.2	3.6	1.1	86.6
1951	3.4	2.7	2.8	2.6	3.3	4.1	6.4	29.0	61.8	117.1	29.1	6.2	268.4
1952	0.5	0.4	0.4	0.4	0.5	1.8	2.2	1.1	10.4	16.4	5.0	1.9	41.2
1953	1.4	1.1	1.1	1.0	1.1	5.2	7.4	21.0	38.3	21.8	4.4	1.5	105.2
1954	1.1	1.0	1.0	0.8	1.2	2.7	2.1	18.0	52.8	20.4	3.8	1.5	106.4
1955	1.1	0.9	1.0	0.9	1.4	1.9	13.6	50.3	52.8	45.5	9.1	2.9	181.4
1956	2.0	1.7	1.7	1.2	1.2	1.6	3.1	12.6	25.9	18.2	3.1	1.4	75.7
1957	1.2	0.9	0.9	0.9	1.4	3.0	4.3	37.7	64.0	25.8	8.1	2.5	154.8
1958	1.6	1.3	1.3	1.3	1.2	1.7	1.6	2.3	3.6	4.2	1.2	0.9	22.2
1959	0.8	0.7	0.8	0.7	1.4	1.0	5.1	13.4	62.4	32.6	4.5	1.8	125.2
1960	1.4	1.1	1.2	1.1	1.3	3.2	7.5	11.6	43.1	37.3	7.0	2.5	118.3
1961	2.2	1.6	1.4	1.4	1.4	1.7	2.2	6.7	16.8	5.7	1.4	1.2	43.7
1962	1.1	0.8	0.9	0.8	1.2	2.3	10.8	43.9	71.1	28.0	6.4	2.2	169.5
1963	1.6	1.2	1.2	1.1	1.6	2.0	2.0	16.2	34.2	21.2	5.6	1.5	89.4
1964	1.1	0.8	0.9	0.9	1.0	2.3	3.1	16.3	42.9	13.4	2.5	1.4	86.6
1965	1.2	1.0	1.0	1.1	1.3	1.7	2.7	7.8	15.8	4.8	1.1	0.8	40.3
1966	0.8	0.6	0.6	0.6	0.7	1.3	1.5	4.9	25.7	18.2	2.5	1.1	58.5
1967	0.9	0.7	0.7	0.6	0.8	1.4	2.6	8.2	30.5	16.4	2.7	1.2	66.7
1968	0.7	0.6	0.6	0.6	0.7	2.6	3.0	15.3	25.7	5.5	1.8	1.0	58.3
1969	1.3	1.0	1.1	1.0	1.2	2.0	3.3	18.1	37.7	29.2	4.6	1.6	102.1
1970	1.5	1.2	1.2	1.1	1.4	2.0	5.9	18.0	54.4	23.0	5.2	1.9	116.9
1971	1.5	1.2	1.2	1.1	1.4	3.0	11.5	41.7	39.7	10.5	2.1	1.3	116.2
1972	0.5	0.4	0.4	0.4	0.5	1.8	5.0	6.4	13.7	7.0	1.8	1.1	38.9
1973	0.3	0.3	0.3	0.3	0.3	2.2	2.1	2.1	11.5	4.8	1.5	1.0	26.6
1974	0.8	0.6	0.6	0.6	0.7	1.8	4.8	9.9	20.2	15.5	3.9	1.8	61.4
1975	1.2	0.9	0.9	0.9	1.1	1.5	14.4	41.4	19.5	6.9	1.1	0.8	90.7
1976	0.2	0.2	0.2	0.2	0.2	1.9	0.3	0.2	0.0	6.6	4.7	1.6	16.3
1977	0.8	0.6	0.6	0.6	0.8	1.5	11.3	11.7	19.2	12.3	1.7	0.9	62.2
1978	0.2	0.1	0.1	0.1	0.2	2.1	2.7	5.1	2.2	0.2	0.1	0.6	13.9
1979	0.9	0.7	0.7	0.7	0.9	1.8	4.7	15.4	27.7	11.2	3.2	1.9	69.8
1980	0.7	0.5	0.5	0.5	0.6	2.2	4.0	11.5	15.9	12.1	2.9	1.3	52.7

SIMULATED FLOWS: KOMPONGOU

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1932	0.1	0.0	0.0	0.0	0.0	0.3	0.5	0.8	32.5	30.2	5.4	0.2	70.0
1933	0.4	0.1	0.0	0.0	0.0	0.1	12.4	31.3	75.1	45.5	5.9	0.5	171.4
1934	0.4	0.1	0.0	0.0	0.0	0.1	7.0	43.7	62.7	55.2	15.2	3.2	187.7
1935	0.4	0.1	0.0	0.0	0.0	0.2	13.0	38.6	72.3	55.2	16.8	2.8	199.3
1936	0.2	0.1	0.0	0.0	0.0	0.8	6.1	31.1	49.2	17.9	2.9	1.2	109.5
1937	0.2	0.0	0.0	0.0	0.0	0.0	4.6	28.4	47.0	15.4	0.4	0.1	96.2
1938	0.1	0.0	0.0	0.0	0.0	0.0	1.8	4.3	17.8	23.4	1.8	0.0	49.3
1939	0.5	0.1	0.0	0.0	0.0	0.7	8.4	40.2	106.0	68.7	14.3	2.0	241.0
1940	0.2	0.1	0.0	0.0	0.0	0.0	13.1	20.2	46.6	17.9	6.1	0.4	104.6
1941	0.3	0.1	0.0	0.0	0.0	0.1	6.6	31.2	80.5	30.5	5.0	1.2	155.5
1942	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.1	10.8	0.4	0.0	0.0	11.6
1943	0.2	0.0	0.0	0.0	0.0	0.1	0.0	4.8	40.4	24.0	2.5	0.0	72.0
1944	0.3	0.1	0.0	0.0	0.0	0.7	2.9	39.4	59.3	28.4	9.4	4.5	144.9
1945	0.1	0.0	0.0	0.0	0.0	0.0	8.1	9.7	34.5	5.8	0.0	0.0	56.3
1946	0.1	0.0	0.0	0.0	0.0	0.6	0.5	0.0	16.2	15.2	6.3	1.0	[illegible]
1947	0.1	0.1	0.0	0.0	0.0	1.6	1.5	7.5	62.6	35.1	3.6	0.0	112.7
1948	[illegible]	0.1	0.0	0.0	0.0	0.7	6.6	37.7	113.3	64.0	12.2	5.3	240.4
1949	0.3	0.1	0.0	0.0	0.0	0.0	9.5	50.2	69.1	23.5	2.4	0.2	155.3
1950	0.2	0.0	0.0	0.0	0.0	0.6	5.3	12.6	33.4	22.8	4.3	0.6	79.9
1951	0.4	0.1	0.0	0.0	0.0	2.2	10.1	24.7	68.2	62.9	21.9	4.7	195.3
1952	0.2	0.0	0.0	0.0	0.0	0.6	1.2	3.6	47.8	25.3	4.5	0.9	84.1
1953	0.2	0.1	0.0	0.0	0.0	0.1	11.5	19.8	49.2	26.6	2.7	0.1	110.5
1954	0.2	0.0	0.0	0.0	0.0	1.5	1.5	6.9	45.9	26.0	12.2	2.4	97.0
1955	0.5	0.1	0.0	0.0	0.0	0.7	11.0	38.7	62.7	83.0	16.4	2.3	238.2
1956	0.3	0.1	0.0	0.0	0.0	1.1	9.3	11.9	65.5	38.9	7.4	1.2	135.6
1957	0.8	0.2	0.0	0.0	0.0	2.6	16.4	71.1	148.3	96.1	14.0	[illegible]	357.[illegible]
1958	0.0	0.0	0.0	0.0	0.0	1.0	3.0	5.0	18.0	5.0	0.0	0.0	32.0
1959	0.0	0.0	0.0	0.0	0.0	0.0	5.0	12.0	54.0	28.0	5.0	0.0	104.0
1960	0.0	0.0	0.0	0.0	0.0	0.0	2.0	9.0	57.0	45.0	7.0	1.0	121.0
1961	0.0	0.0	0.0	0.0	0.0	1.0	11.0	20.0	53.0	19.0	2.0	0.0	106.0
1962	0.0	0.0	0.0	0.0	0.0	0.0	10.0	46.0	86.0	49.0	11.0	3.0	205.0
1963	0.0	0.0	0.0	0.0	0.0	1.0	9.0	48.0	69.0	40.0	12.0	4.0	183.0
1964	1.0	0.0	0.0	0.0	0.0	0.0	6.0	27.0	65.0	22.0	4.0	1.0	126.0
1965	0.0	0.0	0.0	0.0	0.0	1.0	3.0	16.0	54.0	17.0	3.0	0.0	94.0
1966	0.0	0.0	0.0	0.0	0.0	1.0	4.0	10.0	28.0	42.0	9.0	2.0	96.0
1967	0.0	0.0	0.0	0.0	0.0	0.0	1.0	37.0	79.0	57.0	9.0	3.0	186.0
1968	1.0	0.0	0.0	0.0	0.0	2.0	25.0	60.0	78.0	45.0	8.0	1.0	220.0
1969	0.0	0.0	0.0	0.0	0.0	1.0	3.0	48.0	108.0	64.0	16.0	6.0	256.0
1970	2.0	1.0	0.0	0.0	0.0	0.0	2.0	24.0	90.0	56.0	7.0	2.0	184.0
1971	0.3	0.1	0.0	0.0	0.0	0.0	7.1	23.6	66.1	31.8	5.1	0.8	134.9
1972	0.1	0.0	0.0	0.0	0.0	1.1	0.6	0.5	31.7	24.2	4.5	0.6	63.2
1973	0.3	0.1	0.0	0.0	0.0	0.6	1.5	23.0	56.6	29.9	8.4	1.7	123.0
1974	0.5	0.1	0.0	0.0	0.0	0.2	17.1	53.1	88.6	55.9	7.4	1.3	224.2
1975	0.2	0.0	0.0	0.0	0.0	0.1	7.8	20.3	46.4	12.2	1.3	0.0	88.2
1976	0.2	0.1	0.0	0.0	0.0	0.0	15.9	17.8	42.4	31.4	8.3	0.8	117.0
1977	0.1	0.0	0.0	0.0	0.0	0.2	2.8	10.7	32.1	6.8	0.1	0.1	52.9
1978	0.3	0.1	0.0	0.0	0.0	0.4	9.7	32.1	68.7	30.2	6.0	3.6	151.1
1979	0.3	0.1	0.0	0.0	0.0	0.6	13.6	25.4	61.2	37.9	4.8	0.7	144.6
1980	0.2	0.0	0.0	0.0	0.0	0.4	6.7	30.7	43.1	13.7	1.3	0.1	96.4

TABLE

Annual maximum flows - Volta tributaries

River Site	Oti Mango	Oti Mandouri	Pendjari Porga	Kara Lama Kara	Kara Kpesside	Keran Naboulgou	Keran Titira
1951							
1952			610				
1953	1360		504				
1954	534		340	342			
1955	1540		571	501			
1956	616		373	711			
1957	1620		569	613			
1958	442		196	421			
1959	1220	754	464	377			
1960	1240	733	468	340			
1961	769	695	360	101			
1962	1750	834		282	540	849	490
1963	976	650	456	723	-	680	880
1964	1430	834	594	402	449	661	925
1965	406	328	234	360	300	441	294
1966	429	361	261	252	872	380	497
1967	651	488	370	443	533	616	1050
1968	717	430	342	325	503	582	645
1969	1510	813	590	478	1150	797	994
1970	1710	855	633	297	1150	692	862
1971	703	468	347	362	540	661	781
1972	537	390	311	513	458	392	348
1973	568	544	269	647	503	519	788
1974	1128	801		538	1106	671	733
1975	663	495		340	674	765	807
1976	251	173		257	277	427	327
1977	554	410		289	396	378	228
1978	375	347		704	470	559	596
1979	789			680	942	531	799
1980							

Sources ORSTOM, 1977 and 1982.

TABLE

Annual maximum flows - Niger tributaries

River Site	Sota Kouberi	Alibori Route Kandi-Banikaora
1951		
1952		228
1953	319	553
1954	351	384
1955	336	482
1956	274	287
1957	381	521
1958	45	145
1959	428	485
1960	333	424
1961	135	440
1962	481	685
1963	247	271
1964	312	298
1965	119	331
1966	271	363
1967	460	480
1968	268	390
1969	268	530
1970	350	440
1971	230	192
1972	168	355
1973	175	230
1974	195	550
1975	197	310
1976	37	216
1977	98	350
1978	54	

Sources ORSTOM (1970)
ORSTOM (Cotonou): Relevées d'hauteurs d'eau

TABLE

Annual maximum flows - Mono tributaries

River Site	Mono Tetetou	Mono Dotaikope	Mono Correkope	Ogou Sirka	Anie Pont CFT
1951	402				
1952	789				
1953	885				
1954	581		279		
1955	1010		569		
1956	240		128		
1957	1160		870	267	
1958	105		44	42	
1959	622		535	137	
1960	1140	665	662	261	
1961		68.8	128	53	
1962	641	435	497	225	
1963	1490	880	783	268	
1964	760	592	609	170	295
1965	794	533	603	218	217
1966	948	780	762	273	684
1967	1170	880	800	191	953
1968	1290	589	692	278	315
1969	734	850	764	225	452
1970	1090	799	834	377	439
1971	596	281	363	125	293
1972	587	354	389	75	320
1973	712	328	514	112	245
1974	682	387	551	255	223
1975	670	298	395	105	322
1976	530	260	303	45	230
1977	612	352	416	117	370
1978	624	370	408	76.4	277
1979	1189	604	723	276	601

Sources ORSTOM (1973)
ORSTOM (1982)

TABLE

Annual maximum flows - Oueme tributaries

River Site	Oueme Pont de Beterou	Oueme Pont de Save	Zou Pont d'Atcherigbe	Okpara Kaboua	Okpara Nanon
1951		795	388	196	
1952	477	1041	297	370	126
1953	723	1348	418	284	90
1954	373	634	340	271	103
1955	662	1578	543	405	109
1956	354	560	150	117	57
1957	738	2040	443	535	128
1958	43	56	90	7	6
1959	573	1479	213	371	132
1960	609	1430	430	330	90
1961	373	600	226	239	78
1962	599	1220	576	465	150
1963	784	1785	390	510	133
1964	530	1085	156	140	50
1965	446	900	340	228	69
1966	400	895	235	140	55
1967	518	1215	285	92	112
1968	570	1300	726	465	186
1969	392	1105	275	280	142
1970	456	1055	420	240	
1971	478	875	475	205	
1972	128	260	60	10	
1973	575	810	495	200	
1974	506	1200	480	220	
1975		800	375	245	
1976		290		200	
1977		395		91	
1978		350			

Sources ORSTOM, 1963 and 1967: ORSTOM relevées d'hauteurs d'eau
Thiebaux, 1972b

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