TABLE C-22 (1/5) MAXIMUM CONTINUOUS RAINFALL AT KAENG PHRA CHAO

Unit : mm

Water Year	1 Day		2 Days		3 Days		4 Days		5 Days	
	Rain	Date	Rain	Date	Rain	Date	Rain	Date	Rain	Date
1952										
53										
54										
55										
56										
57										
58										
59										
60										
61										
62										
63										
64										
65	58.8	23 Jul.	106.9	11 Jul.	136.1	18 Oct.	145.1	17 Oct.	173.0	27 May
66	125.9	31 Oct.	155.9	31 Oct.	180.2	30 Oct.	185.7	29 Oct.	185.7	29 Oct.
67	76.6	29 Jul.	124.1	29 Jul.	140.8	29 Jul.	148.1	29 Jul.	228.7	29 Jul.
68	63.4	27 Apr.	86.3	3 Aug.	116.3	2 Aug.	125.2	1 Aug.	146.9	2 Aug.
69	144.2	4 Nov.	212.6	3 Nov.	241.3	3 Nov.	244.8	3 Nov.	259.3	1 Nov.
70	310.6	29 Nov.	437.8	29 Nov.	449.6	28 Nov.	465.1	27 Nov.	512.1	28 Nov.
71	150.4	3 Jul.	232.6	2 Nov.	253.4	1 Nov.	305.1	31 Oct.	337.9	30 Oct.
72	127.2	7 Jul.	173.5	6 Jun.	198.7	5 Jun.	216.8	4 Jun.	240.7	5 Jun.
73	97.2	8 Jan.	141.2	8 Jul.	186.7	8 Jul.	217.2	7 Jul.	238.5	6 Jul.
74	195.5	8 Jul.	232.0	8 Jan.	244.6	8 Jan.	305.0	8 Jan.	315.0	7 Jan.
75	136.0	21 Nov.	163.0	21 Nov.	195.5	19 Oct.	205.0	19 Oct.	211.5	19 Oct.
76	186.7	27 May	338.5	26 May	362.2	26 May	382.2	25 May	395.6	25 May
77	73.8	20 Aug.	142.2	20 Aug.	209.2	19 Aug.	267.4	18 Aug.	332.4	17 Aug.
78	116.5	23 Oct.	141.9	23 Oct.	218.8	23 Oct.	218.8	23 Oct.	240.6	21 Oct.
79	224.0	20 Sep.	261.4	7 Jul.	394.1	5 Jul.	475.0	5 Jul.	512.1	4 Jul.
80	68.0	28 Aug.	114.0	18 May	148.6	18 May	175.2	18 May	199.3	17 May
81	132.0	5 May	185.9	4 May	185.9	4 May	185.9	4 May	190.3	12 Jun.
82	90.8	20 Jun.	121.5	20 Jun.	167.9	23 Aug.	173.3	23 Aug.	194.7	23 Aug.
83	41.2	17 May	68.9	6 Nov.	83.1	6 Nov.	83.1	6 Nov.	123.6	6 Nov.
84	87.9	29 Jun.	145.7	28 Jun.	166.3	27 Jun.	188.3	26 Jun.	235.7	25 Jun.
85	59.4	12 May	76.5	27 Apr.	106.7	27 Apr.	128.6	18 Jun.	136.9	18 Jun.
86	86.6	11 Aug.	145.9	10 Aug.	171.9	9 Aug.	203.3	7 Aug.	219.8	6 Aug.
87	62.3	22 Aug.	98.9	21 Aug.	108.6	21 Aug.	127.7	6 Nov.	146.5	6 Nov.
88										
89										
90										

TABLE C-22 (2/5) MAXIMUM CONTINUOUS RAINFALL AT X.46 A

Unit : mm

Water Year	1 Day		2 Days		3 Days		4 Days		5 Days	
	Rain	Date	Rain	Date	Rain	Date	Rain	Date	Rain	Date
1952										
53										
54										
55										
56										
57										
58										
59										
60										
61										
62										
63										
64										
65										
66										
67										
68										
69										
70										
71										
72										
73										
74										
75										
76										
77										
78	156.5	13 May	182.7	12 May	253.2	11 May	284.1	10 May	285.8	10 May
79	128.4	5 Jul.	242.7	5 Jul.	291.7	5 Jul.	345.0	5 Jul.	368.5	4 Jul.
80	60.6	19 May	98.0	19 May	129.0	18 May	149.2	17 May	163.5	17 May
81	82.3	19 Oct.	136.8	14 Jun.	167.1	14 Jun.	192.4	13 Jul.	205.9	12 Jun.
82	133.0	2 Nov.	159.0	2 Nov.	184.0	1 Nov.	184.8	30 Oct.	210.8	30 Oct.
83	66.2	15 Sep.	95.7	14 Sep.	110.2	13 Sep.	110.2	13 Sep.	119.6	6 Nov.
84	93.4	28 Jun.	175.5	28 Jun.	198.2	27 Jun.	259.7	26 Jun.	295.8	25 Jun.
85	69.5	19 Jun.	99.9	19 Jun.	122.1	19 Jun.	144.2	18 Jun.	162.3	18 Jun.
86	80.7	11 Aug.	142.7	10 Aug.	150.5	9 Aug.	172.9	8 Aug.	201.5	7 Aug.
87	112.5	14 Jun.	165.1	13 Jun.	172.1	13 Jun.	184.3	11 Jun.	195.4	13 Jun.
88	170.4	23 Nov.	193.5	22 Nov.	206.6	22 Nov.	216.9	21 Nov.	225.2	21 Nov.
89	271.2	4 Nov.	271.2	4 Nov.	271.2	4 Nov.	298.3	1 Nov.	325.6	4 Nov.
90	110.8	10 Nov.	143.3	9 Nov.	144.2	8 Nov.	152.5	28 Oct.	179.7	27 Oct.

TABLE C-22 (3/5) MAXIMUM CONTINUOUS RAINFALL AT A. THA SAE

Unit : mm

Water Year	1 Day		2 Days		3 Days		4 Days		5 Days	
	Rain	Date	Rain	Date	Rain	Date	Rain	Date	Rain	Date
1952										
53	51.0	20 Apr.	98.1	7 May	143.1	6 May	173.1	5 May	193.2	4 May
54										
55	120.0	21 Oct.	185.0	3 Nov.	231.0	3 Nov.	249.0	3 Nov.	281.7	18 Oct.
56	80.7	16 Nov.	107.1	27 Oct.	127.5	15 Oct.	158.2	14 Oct.	183.2	13 Oct.
57	81.4	3 Jul.	81.4	3 Jul.	122.4	29 Oct.	122.4	29 Oct.	122.4	29 Oct.
58	112.4	17 Nov.	168.7	16 Nov.	178.5	16 Nov.	178.5	16 Nov.	203.5	3 Oct.
59	108.3	24 Nov.	179.5	23 Nov.	208.4	23 Nov.	208.4	23 Nov.	208.4	23 Nov.
60	98.8	31 Jul.	122.4	2 Oct.	161.3	2 Oct.	205.9	2 Oct.	205.9	2 Oct.
61	94.2	30 Dec.	161.9	4 Nov.	232.8	3 Nov.	281.2	2 Nov.	322.5	2 Nov.
62	110.6	25 Oct.	159.6	25 Oct.	218.0	20 Oct.	232.9	9 Jul.	271.2	8 Jul.
63	88.2	23 Oct.	132.8	22 Oct.	136.9	21 Oct.	222.6	20 Oct.	222.6	20 Oct.
64	122.3	1 Nov.	214.4	1 Nov.	218.2	1 Nov.	227.0	1 Nov.	229.5	30 Oct.
65	102.5	17 Oct.	156.5	17 Oct.	251.9	17 Oct.	265.7	16 Oct.	278.3	15 Oct.
66	127.6	15 Nov.	163.8	15 Nov.	204.7	15 Nov.	231.2	15 Nov.	298.0	15 Nov.
67	85.5	1 Dec.	111.6	11 Feb.	117.7	10 Feb.	156.5	28 Nov.	168.8	28 Nov.
68	96.7	17 Mar.	154.0	17 Jan.	164.9	4 Feb.	169.7	3 Feb.	169.7	3 Feb.
69	102.0	4 Nov.	185.5	3 Nov.	220.7	3 Nov.	221.9	3 Nov.	225.5	1 Nov.
70	143.2	29 Nov.	226.2	29 Nov.	247.4	28 Nov.	271.2	27 Nov	273.1	26 Nov.
71	156.5	3 Nov.	274.9	2 Nov.	300.6	1 Nov.	359.3	31 Oct.	417.1	30 Oct.
72	105.7	28 Sep.	203.0	23 Nov.	230.8	22 Nov.	233.6	22 Nov.	253.4	22 Nov.
73	75.3	31 Oct.	88.3	17 Nov.	123.9	17 Nov.	147.6	31 Oct.	153.5	31 Oct.
74	278.2	8 Jan.	314.7	8 Jan.	345.8	7 Jan.	350.9	6 Jan.	368.3	7 Jan.
75	80.3	21 Nov.	84.0	21 Nov.	93.3	1 May	126.2	1 May	128.7	1 May
76	228.5	10 Feb.	239.0	10 Feb.	239.0	10 Feb.	239.0	10 Feb.	239.0	10 Feb.
77	118.2	4 Jan.	137.8	4 Jan.	137.8	4 Jan.	169.1	18 Aug.	202.5	17 Aug.
78	116.8	13 Nov.	166.0	13 Nov.	181.1	11 May	186.3	11 May	187.9	11 May
79	138.6	9 Aug.	225.0	8 Aug.	297.6	2 Aug.	337.3	2 Aug.	357.8	3 Jul.
80	154.3	24 Apr.	154.3	24 Apr.	245.5	24 Apr.	245.5	24 Apr.	245.5	24 Apr.
81	102.0	14 May	180.5	14 May	180.5	14 May	227.7	14 May	251.1	14 May
82	73.1	20 Jun.	118.4	20 May	128.7	20 May	134.9	30 Oct.	157.2	30 Oct.
83	120.0	2May.	210.0	2 May	210.0	2 May	210.0	2 May	210.0	2 May
84	51.0	28 Jun.	72.9	28 Jun.	80.2	28 Apr.	113.3	25 Jun.	135.2	25 Jun.
85	247.5	24 Apr.	247.5	24 Apr.	247.5	24 Apr.	251.2	24 Apr.	282.1	24 Apr.
86	70.5	1 Mar.	91.3	1 Mar.	94.4	1 Mar.	117.9	1 May	120.5	13 Jul.
87	115.8	9 Nov.	146.6	8 Nov.	168.1	7 Nov.	186.4	6 Nov.	195.7	5 Nov.
88	103.9	14 Nov.	147.0	6 Jun.	175.3	22 Nov.	180.5	21 Nov.	180.5	21 Nov.
89	209.4	4 Nov.	292.5	4 Nov.	398.3	4 Nov.	408.5	4 Nov.	413.2	4 Nov.
90	112.2	21 Nov.	141.3	1 Nov.	141.31	21 Nov.	141.3	21 Nov.	141.3	21 Nov.

TABLE C-22 (4/5) MAXIMUM CONTINUOUS RAINFALL AT A. MUANG

Unit : mm

Water Year	1 Day		2 Days		3 Days		4 Days		5 Days	
	Rain	Date	Rain	Date	Rain	Date	Rain	Date	Rain	Date
1952	152.4	25 Jan.	195.8	3 Dec.	231.6	23 Jan.	231.6	23 Jan.	256.7	23 Jan.
53	92.4	20 Feb.	99.6	19 Feb.	99.6	19 Feb.	119.2	16 Nov.	147.9	12 Nov.
54	94.5	3 Dec.	130.9	2 Dec.	154.7	3 Dec.	191.5	3 Dec.	227.9	2 Dec,
55	148.6	18 Nov.	192.6	17 Nov.	234.3	17 Nov.	253.7	16 Nov.	285.4	15 Nov.
56	238.8	16 Nov.	353.7	15 Nov.	423.8	15 Nov.	423.8	15 Nov.	423.8	15 Nov.
57	83.3	30 Oct.	99.6	30 Oct.	103.5	29 Oct.	121.0	30 Dec.	131.5	30 Oct.
58	55.6	4 Oct.	109.4	4 Oct.	133.7	3 Oct.	146.7	3 Oct.	160.3	3 Oct.
59	125.8	24 Oct.	188.6	24 Oct.	237.8	23 Oct.	287.9	22 Oct.	331.8	22 Oct.
60	95.5	27 Feb.	171.2	27 Feb.	172.4	27 Feb.	192.4	27 Feb.	238.8	27 Feb.
61	208.8	30 Dec.	317.9	4 Nov.	333.0	3 Nov.	351.4	4 Nov.	377.1	30 Dec.
62	116.3	22 Oct.	156.9	25 Oct.	196.8	20 Oct.	243.2	22 Oct.	284.0	22 Oct.
63	143.8	23 Oct.	178.3	22 Oct.	190.0	21 Oct.	220.6	20 Oct.	304.0	19 Oct.
64	148.7	2 Nov.	204.5	1 Nov.	213.8	1 Nov.	218.4	30 Oct.	262.9	29 Oct.
65	62.6	26 Nov.	101.9	10 Jul.	117.0	16 Oct.	137.5	16 Oct.	150.8	15 Oct.
66	120.9	31 Oct.	177.3	27 Sep.	219.9	26 Sep.	247.7	25 Sep.	264.3	15 Nov.
67	78.2	1 Dec.	100.4	26 Oct.	117.8	26 Oct.	138.1	28 Nov.	146.2	28 Nov.
68	84.0	17 Mar.	109.9	29 Nov.	131.4	5 Jan.	143.4	27 Apr.	152.3	27 Apr.
69	76.8	4 Nov.	126.6	3 Nov.	147.7	3 Nov.	163.6	1 Nov.	184.7	1 Nov.
70	264.1	29 Nov.	339.0	29 Nov.	374.1	28 Nov.	399.6	27 Nov.	399.7	26 Nov.
71	242.1	3 Nov.	303.8	2 Nov.	335.0	2 Nov.	393.9	31 Oct.	155.5	30 Oct.
72	93.1	23 Nov.	131.4	23 Nov.	160.4	22 Nov.	170.5	4 Dec.	190.7	20 Nov.
73	65.0	13 Nov.	128.0	26 Feb.	154.0	17 Nov.	163.9	12 Nov.	217.7	13 Nov.
74	423.4	8 Jan.	446.3	7 Jan.	488.7	6 Jan.	508.9	6 Jan.	519.6	5 Jan.
75	73.3	29 Jul.	133.2	2 Nov.	139.2	2 Nov.	168.8	31 Oct.	192.2	30 Oct.
76	138.3	10 Feb.	196.8	10 Feb.	243.4	9 Feb.	243.4	9 Feb.	262.2	11 Oct.
77	109.7	4 Jan.	179.3	4 Jan.	246.6	5 Nov.	265.1	4 Nov.	292.6	5 Nov.
78	123.1	23 Oct.	159.1	13 Nov.	174.0	23 Oct.	177.8	22 Nov.	179.1	23 Oct.
79	95.9	9 Aug.	148.8	8 Aug.	178.4	8 Aug.	189.3	7 Aug.	200.0	5 Aug.
80	153.5	19 Nov.	161.4	19 Nov.	218.2	9 Nov.	249.3	8 Nov.	278.4	8 Nov.
81	144.5	24 Oct.	153.9	24 Oct.	161.5	13 Nov.	176.8	12 Nov.	197.0	27 Mar.
82	88.4	2 Nov.	153.0	1 Nov.	188.6	1 Nov.	214.3	30 Oct.	249.9	30 Oct.
83	104.7	15 Nov.	139.4	15 Nov.	173.5	13 Nov.	208.2	13 Nov.	222.0	12 Nov.
84	83.9	26 Oct.	98.4	10 Aug.	153.4	26 Oct.	155.1	25 Oct.	158.9	24 Oct.
85	83.4	1 Dec.	162.7	1 Dec.	165.3	30 Nov.	175.2	29 Nov.	175.4	29 Nov.
86	96.1	10 Sep.	117.0	10 Sep.	125.1	10 Sep.	135.7	29 Oct.	159.9	29 Oct.
87	91.7	8 Nov.	131.7	6 Oct.	143.8	6 Nov.	175.4	6 Nov.	201.9	5 Nov.
88	219.8	23 Nov.	278.5	22 Nov.	294.3	22 Nov.	306.9	21 Nov.	307.8	20 Nov.
89	88.8	4 Nov.	117.7	3 Nov.	120.9	3 Nov.	169.4	1 Nov.	179.6	31 Oct.
90	136.8	10 Nov.	185.4	9 Nov.	190.4	8 Nov.	190.5	8 Nov.	205.3	28 OCt.

TABLE C-22 (5/5) MONTHLY CONTINUOUS RAINFALL AT SAWI

Unit : mm

Water Year	1 Day		2 Days		3 Days		4 Days		5 Days	
	Rain	Date	Rain	Date	Rain	Date	Rain	Date	Rain	Date
1952										
53										
54										
55										
56										
57										
58										
59										
60										
61										
62										
63										
64										
65										
66										
67	95.6	28 Nov.	117.1	27 Nov.	117.7	27 Nov.	122.2	26 Nov.	128.8	23 Oct.
68	103.3	14 Dec.	117.8	14 Dec.	118.2	14 Dec.	121.0	2 Aug.	130.8	1 Aug.
69	86.4	4 Nov.	118.1	4 Nov.	145.8	3 Nov.	167.0	3 Nov.	168.1	2 Nov.
70	205.6	29 Nov.	255.4	29 Nov.	280.7	28 Nov.	299.7	27 Nov.	304.2	26 Nov.
71	170.2	3 Nov.	151.1	2 Nov.	282.0	1 Nov.	328.8	31 Oct.	392.3	30 Oct.
72	87.4	29 Nov.	154.4	7 Jun.	186.5	29 Nov.	198.8	28 Nov.	223.8	29 Nov.
73	97.3	13 Nov.	176.3	24 Oct.	215.5	24 Oct.	218.7	23 Oct.	300.8	24 Oct.
74	316.8	8 Jan.	382.6	7 Jun.	435.5	6 Jan.	461.6	6 Jan.	474.7	5 Jan.
75	70.0	2 Nov.	123.8	20 Nov.	140.6	20 Nov.	157.3	18 Nov.	175.3	17 Nov.
76	112.3	1 Jan.	118.0	1 Jan.	133.2	10 Oct.	166.6	11 Oct.	237.6	11 Oct.
77	112.6	10 Jun.	164.3	11 Nov.	210.9	11 Nov.	226.4	10 Nov.	232.2	9 Nov.
78	136.2	23 Oct.	156.3	22 Oct.	171.3	22 Oct.	188.7	22 Oct.	199.1	22 Oct.
79	79.6	31 Mar.	143.0	8 Aug.	170.8	7 Aug.	175.0	7 Aug.	207.1	5 Aug.
80	122.3	11 Nov.	184.2	11 Nov.	236.5	11 Nov.	247.6	10 Nov.	253.8	9 Nov.
81	78.2	21 Nov.	131.2	21 Nov.	145.2	20 Nov.	168.9	21 Nov.	182.9	20 Nov.
82	102.1	10 Apr.	131.6	7 Dec.	132.5	9 May	132.5	9 May	136.0	10 Apr.
83	59.8	16 Nov.	100.5	13 Nov.	124.6	14 Nov.	184.4	13 Nov.	185.8	12 Nov.
84	70.1	29 Jun.	87.1	28 Jun.	115.6	27 Jun.	125.1	26 Jun.	148.9	25 Jun.
85	92.0	1 Dec.	139.3	1 Dec.	169.0	30 Nov.	180.2	29 Nov.	180.2	29 Nov.
86	65.9	11 Nov.	86.2	1 Nov.	105.5	5 Dec.	125.7	1 Nov.	125.9	31 Oct.
87	72.0	19 Feb.	98.1	7 Nov.	124.3	6 Nov.	135.1	5 Nov.	155.5	4 Nov.
88	138.6	23 Nov.	213.0	22 Nov.	232.4	21 Nov.	250.1	22 Nov.	269.5	21 Nov.
89	134.3	8 Nov.	142.2	8 Nov.	147.3	8 Nov.	201.5	5 May	209.3	4 May
90	171.8	18 Mar.	176.8	17 Mar.	176.8	17 Mar.	176.8	17 Mar.	181.3	28 Oct.

TABLE C - 23 (1/7) MONTHLY RUNOFF OF KHLONG RAP RO AT KAENG PHRA CHAO (D.A = 330 sq.km)

Unit : MCM

Water Year	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
1952													
53													
54													
55													
56													
57													
58													
59													
60													
61													
62													
63													
64	*	*	*	*	*	*	*	*	*	-	-	4.045	-
65	3.191	5.454	18.413	32.168	23.897	42.768	56.743	31.260	29.125	10.992	6.248	5.293	266.280
66	5.318	10.670	9.173	25.879	26.479	39.817	40.713	49.976	31.344	15.249	6.300	4.397	265.315
67	3.759	7.725	10.599	36.751	110.462	37.174	36.680	14.359	12.281	5.702	4.298	2.988	282.778
68	2.465	8.929	8.264	16.853	72.857	27.151	19.346	11.456	8.335	10.174	11.382	3.224	200.436
69	2.306	3.206	6.889	31.781	26.247	60.394	21.424	51.300	11.458	8.632	5.549	3.560	232.746
70	5.101	5.784	16.653	35.480	69.788	33.536	24.540	54.225	77.406	16.785	8.822	6.132	354.252
71	4.011	4.664	18.941	39.561	13.062	11.922	47.553	80.460	12.377	6.663	4.236	3.215	246.665
72	6.877	2.768	15.040	34.065	48.094	22.147	29.446	45.547	67.858	13.684	7.797	6.464	299.787
73	3.562	6.712	19.342	89.203	49.531	32.003	38.016	48.057	18.963	8.549	4.948	3.797	322.683
74	3.751	9.899	20.661	15.753	31.177	27.817	33.248	29.002	13.654	32.591	7.315	5.225	230.093
75	4.655	7.963	67.848	20.509	73.831	46.725	64.394	66.519	23.249	12.169	6.333	4.521	398.716
76	3.659	43.039	21.224	16.359	19.109	44.090	35.551	37.732	11.608	7.773	7.992	5.970	254.106
77	2.222	2.832	3.359	9.523	65.455	57.629	35.554	29.737	10.256	7.472	5.516	2912	232.467
78	3.952	22.404	25.726	14.469	73.903	66.535	74.667	18.084	9.010	5.323	2.900	1.942	318.915
79	2.227	9.702	10.060	78.853	107.672	28.750	32.518	10.400	5.771	3.730	2.344	1.636	293.663
80	1.774	8.402	24.316	29.596	42.676	32.059	23.129	15.822	11.810	4.605	4.052	1.877	200.118
81	1.421	3.388	31.882	15.502	61.558	35.626	25.110	49.673	17.868	7.121	4.208	3.719	257.076
82	5.373	3.110	6.096	20.974	55.551	41.443	19.253	25.521	10.475	4.952	2.185	1.357	196.290
83	0.536	2.090	8.799	10.002	20.005	11.844	30.198	35.885	7.161	3.871	2.745	1.607	134.743
84	1.593	2.675	20.869	17.809	48.603	52.410	47.978	14.679	8.388	5.076	3.475	3.203	226.758
85	3.100	7.407	32.815	11.727	30.520	26.599	31.770	27.308	10.085	5.512	2.621	1.795	191.259
86	2.063	19.139	20.824	62.894	82.916	43.260	49.896	27.714	13.332	6.571	3.413	3.171	335.193
87	2.389	3.828	15.400	6.399	14.801	20.284	15.436	41.762	12.001	*	*	*	-
88													
89													
90													
Mean (22)	3.347	8.998	18.991	30.260	52.427	37.350	37.170	35.214	19.173	9.236	5.213	3.546	260.925
mm	10.1	27.3	57.6	91.7	158.9	113.2	112.6	106.7	58.1	28.0	15.8	10.7	790.7
Runoff C.	0.079	0.111	0.216	0.320	0.474	0.439	0.423	0.519	0.651	0.492	0.313	0.202	0.353

TABLE C - 23 (2/7) MONTHLY RUNOFF OF KHLONG MALA AT HAT SOM PAEN (D.A = 188 sq.km)

Unit : MCM

Water Year	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
1952													
53													
54													
55													
56													
57													
58													
59													
60													
61													
62													
63													
64													
65													
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70													
71													
72													
73													
74													
75													
76													
77													
78													
79													
80													
81													
82	*	*	*	*	*	*	*	*	*	4.030	1.672	0.790	-
83	0.167	1.144	5.446	6.117	11.047	6.875	17.042	17.795	4.533	2.754	2.427	0.928	76.275
84	0.254	2.420	19.223	10.358	44.550	26.558	23.354	8.722	5.626	2.891	1.579	1.513	147.048
85	1.411	5.196	25.732	9.267	14.057	15.404	24.049	16.795	8.040	3.268	1.690	0.840	125.749
86	0.801	6.844	11.252	28.779	57.887	32.398	24.281	12.957	6.928	3.719	1.763	1.286	188.895
87	0.900	2.643	10.300	4.539	12.944	14.166	8.375	17.496	5.380	3.135	1.461	0.711	82.050
88	1.226	5.200	22.236	17.841	12.404	13.125	31.825	39.766	12.983	-	-		-
89													
90													
Mean (5)	0.707	3.649	14.391	11.812	28.097	19.080	19.420	14.753	6.101	3.153	1.784	1.056	124.003
mm	3.8	19.4	76.5	62.8	149.4	101.5	103.3	78.5	32.5	16.8	9.5	5.6	659.6

TABLE C - 23 (3/7) MONTHLY RUNOFF OF KHLONG RAP RO AT BAN HAT TAENG (X.46A)
(D.A = 617 sq.km)

Unit : MCM

Water Year	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
1952													
53													
54													
55													
56													
57													
58													
59													
60													
61													
62													
63													
64													
65													
66													
67													
68													
69													
70													
71													
72													
73													
74													
75													
76													
77													
78	7.263	94.109	51.521	36.323	161.267	132.549	158.154	45.797	24.348	15.898	8.422	4.873	740.524
79	6.566	19.068	19.427	171.772	248.918	63.128	61.720	26.689	13.612	8.990	6.147	5.305	651.342
80	1.020	15.464	44.488	70.080	93.059	84.502	50.413	36.357	26.891	6.908	5.975	5.305	440.462
81	-	-	-	-	-	-	-	-	-	-	-	-	-
82	8.965	6.076	9.099	38.504	109.341	76.465	38.657	55.690	20.849	11.939	6.332	3.450	385.367
83	0.904	3.804	18.101	20.496	34.663	21.340	59.009	68.292	13.427	7.664	5.403	2.611	255.714
84	3.371	7.805	57.527	39.934	105.330	91.237	82.275	28.868	19.265	10.841	6.467	5.333	458.253
85													
86													
87													
88													
89													
90													
Mean (6)	4.682	24.388	33.360	62.851	125.430	78.203	75.038	43.615	19.732	10.373	6.458	4.480	488.610
mm	7.6	39.5	54.0	101.9	203.3	126.7	121.6	70.7	32.0	16.8	10.5	7.3	791.9

TABLE C - 23 (4/7) MONTHLY RUNOFF OF KHLONG RAP RO AT BAN THA KHAM (X.46)
(D.A = 751 sq.km)

Unit : MCM

Water Year	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
1952													
53													
54													
55													
56													
57													
58													
59													
60													
61													
62													
63													
64													
65													
66													
67													
68													
69													
70													
71													
72													
73													
74													
75													
76													
77													
78	8.840	114.548	62.710	44.212	196.291	161.336	192.502	55.743	29.636	19.351	10.251	5.931	901.351
79	7.992	23.209	23.646	209.077	302.978	76.838	75.124	32.485	16.568	10.942	7.482	6.457	792.798
80	1.242	18.822	54.150	85.300	113.270	102.854	61.362	44.253	32.731	8.408	7.273	6.457	536.122
81	3.895	9.179	95.134	40.262	132.110	98.740	63.774	137.306	44.384	18.991	8.597	7.197	659.569
82	10.912	7.396	11.075	46.866	133.088	93.072	47.053	67.785	25.377	14.532	7.707	4.199	469.062
83	1.100	4.630	22.032	24.947	42.191	25.975	71.825	83.124	16.343	9.328	6.576	3.178	311.249
84	4.103	9.500	70.021	48.607	128.206	111.052	100.143	35.138	23.449	13.195	7.872	6.491	557.777
85	5.977	21.199	80.806	26.619	52.031	52.862	67.471	80.146	40.048	9.047	4.678	2.798	443.682
86	3.454	34.229	44.829	113.309	223.577	116.052	114.204	65.124	22.045	13.934	8.287	6.971	766.015
87	4.015	7.862	36.819	14.773	38.909	49.072	32.499	89.393	23.439	8.847	5.096	4.002	314.726
88	5.244	13.073	80.393	48.708	34.074	49.336	123.376	194.639	47.359	21.538	13.117	18.327	649.184
89	13.586	64.570	79.370	85.555	158.947	115.170	92.332	254.380	47.599	29.150	18.600	15.170	973.429
90	16.006	35.539	47.132	39.994	105.595	117.985	178.447	223.224	44.637	25.457	16.337	15.373	865.726
Mean (13)	6.644	27.904	54.470	63.710	127.790	90.026	93.855	104.826	31.816	15.594	9.375	7.889	633.899
mm	8.8	37.2	72.5	84.8	170.1	119.9	125.0	139.6	42.4	20.8	12.5	10.5	844.1
Mean	1979-80,	82, 84-	88, 90	(9)									
MCM	6.549	18.981	49.875	70.362	125.741	85.458	88.853	92.465	30.628	13.989	8.650	7.897	599.455
mm	8.7	25.3	66.4	93.7	167.58	113.8	118.3	123.1	40.8	18.6	11.5	10.5	798.2

TABLE C-23 (5/7) MONTHLY RUNOFF OF KHLONG THA SAE AT BAN THA SAE (X.64)
(D.A = 957 sq.km)

Unit : MCM

Water Year	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
1952													
53													
54													
55													
56													
57													
58													
59													
60													
61													
62													
63													
64													
65													
66													
67													
68													
69													
70													
71													
72													
73	6.307	13.807	29.985	177.574	68.602	64.973	95.213	198.634	46.138	18.317	9.050	6.718	735.318
74	12.925	29.860	41.234	25.661	45.641	42.098	77.587	118.800	42.012	112.774	21.103	11.444	581.139
75	8.880	21.165	102.432	36.122	107.482	81.648	146.621	268.963	49.5072	21.387	10.936	7.834	862.977
76	8.476	134.568	50.268	21.289	22.702	39.740	92.318	141.264	7.194	19.423	27.652	15.604	600.498
77	6.441	6.420	5.495	10.498	79.816	68.515	50.630	68.839	17.466	18.118	25.916	9.063	367.217
78	11.474	142.875	52.384	23.721	114.337	-	215.870	55.132	18.606	10.420	7.258	5.028	-
79	3.020	14.390	17.008	166.795	251.446	49.546	42.669	12.156	5.210	2.035	0.492	0.039	564.806
80	0.065	7.288	28.598	51.620	43.347	50.138	41.459	25.423	39.364	5.858	8.942	0.531	302.633
81	0.428	14.360	-	16.260	-	50.738	30.491	188.533	36.625	11.016	5.918	2.501	-
82	22.926	10.925	16.360	44.988	124.070	63.539	41.178	107.814	33.506	9.737	4.069	2.510	481.622
83	2.544	2.435	9.164	4.947	11.934	7.150	43.873	116.552	5.134	2.642	-	2.359	-
84	11.626	17.148	44.694	61.653	80.008	99.8217	118.778	37.851	31.836	20.532	15.293	14.026	553.272
85	5.667	16.289	48.400	19.354	26.400	34.471	113.839	90.859	34.074	12.243	6.899	5.202	413.697
86	4.583	27.888	24.571	91.953	154.083	53.111	119.523	114.870	21.232	12.168	7.138	10.490	641.610
87	3.891	6.649	21.613	7.122	11.158	24.732	16.260	150.364	38.297	9.180	6.069	4.001	299.336
88	4.662	14.615	30.491	22.874	13.452	53.362	85.209	219.069	43.424	17.035	12.484	21.111	537.788
89	-	-	-	-	-	-	-	-	-	-	-	-	-
90	5.944	9.314	10.956	7.517	12.385	23.501	79.519	176.288	19.332	8.916	4.942	12.346	370.960
Mean (14)	7.530	23.595	33.722	53.216	74.328	53.514	80.057	123.657	32.042	20.551	11.499	8.637	522.348
mm	7.9	24.6	35.2	55.6	77.7	55.9	83.7	129.2	33.5	21.5	12.0	9.0	545.8
Mean	1979-80	,82. 84-	88. 90	(9)									
MCM	6.932	13.834	26.966	52.653	79.594	50.247	73.159	103.855	29.586	10.856	7.370	7.806	462.858
mm	7.2	14.5	28.2	55.0	83.2	52.5	76.5	108.5	30.9	11.3	7.7	8.2	483.7

TABLE C - 23 (6/7) MONTHLY RUNOFF OF KHLONG THA SAE AT BAN TA NGO
(D.A = 223 sq.km)

Unit : MCM

Water Year	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
1952													
53													
54													
55													
56													
57													
58													
59													
60													
61													
62	*	*	*	*	*	*	*	*	*	4.933	3.097	2.682	*
63	2.672	2.423	8.848	8.215	13.026	23.010	33.006	44.627	9.459	3.693	3.255	3.574	155.808
64	2.414	7.957	5.093	9.683	30.982	32.778	19.628	49.675	4.876	4.354	3.148	2.807	173.395
65	2.737	4.996	14.218	20.193	9.466	15.883	47.701	16.632	25.528	6.559	5.102	7.089	176.104
66	5.555	8.607	9.082	11.906	14.453	33.445	23.254	57.605	22.505	5.868	3.960	4.234	200.474
67	3.204	5.167	5.585	26.420	54.422	17.845	29.274	7.849	18.639	2.310	3.871	2.736	177.322
68	2.826	9.728	9.437	13.783	43.791	22.377	16.572	7.830	9.076	*	*	*	*
69													
70													
71													
72													
73													
74													
75													
76													
77													
78													
79													
80													
81													
82													
83													
84													
85													
86													
87													
88													
89													
90													
Mean (10)	3.316	5.830	8.565	15.284	24.470	24.592	30.573	35.278	16.201	4.557	3.867	4.088	176.621
mm	9.4	16.6	24.3	43.4	69.5	69.9	86.9	100.2	46.0	13.0	11.0	11.6	501.8

TABLE C - 23 (7/7) MONTHLY RUNOFF OF KHLONG CHUMPHON AT BAN SIAP YUAN (X.53)
(D.A = 223 sq.km)

Unit : MCM

Water Year	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
1952													
53													
54													
55													
56													
57													
58													
59													
60													
61													
62													
63													
64													
65													
66													
67													
68													
69													
70													
71													
72													
73													
74													
75													
76													
77													
78	4.964	27.868	37.416	28.866	120.912	78.762	63.599	19.151	7.690	4.337	2.544	2.095	398.204
79	1.874	12.556	15.817	47.558	119.718	15.533	24.268	7.786	5.359	4.071	2.855	3.104	260.499
80	0.999	10.733	22.196	41.346	63.345	59.134	27.700	45.943	19.300	4.420	2.625	0.438	298.179
81	4.489	7.750	40.481	18.789	66.168	47.885	30.634	65.547	18.301	7.900	5.403	4.850	318.197
82	7.270	6.459	11.741	36.985	73.470	49.077	12.597	47.178	15.672	5.583	3.309	3.145	272.486
83	0	0.341	8.815	14.339	20.904	19.677	30.916	63.141	5.244	2.384	1.162	0.022	166.945
84	3.459	6.442	51.398	33.234	-	-	43.322	11.213	6.959	4.697	3.078	2.945	-
85	2.285	9.694	46.243	10.098	27.704	42.429	38.954	37.044	26.176	4.695	2.714	2.280	250.316
86	1.824	-	29.803	77.109	94.921	60.341	30.205	25.313	7.949	4.536	2.794	3.249	-
87	2.270	3.634	14.238	3,683	15.113	13.266	11.950	39.768	4.226	2.046	2.206	2.360	114.760
88	2.472	7.417	48.420	40.738	18.339	29.484	77.877	100.226	17.111	7.017	3.784	5.580	358.465
89	-	-	-	-	-	-	-	-	-	-	-	-	-
90	2.748	8.743	17.614	8.258	48.832	38.088	64.454	47.408	9.628	5,505	3.072	2.899	257.249
Mean (10)	2.937	9.520	26.298	25.066	57.450	39.334	38.295	47.319	12.871	4.796	2.967	2.677	269.530
mm	13.2	42.7	117.9	112.4	257.6	176.5	171.7	212.2	57.7	21.5	13.3	12.0	1,208.7

FIGURE C-1 MAJOR CLIMATIC FACTORS OBSERVED AT CHUMPHON (1961-1990)

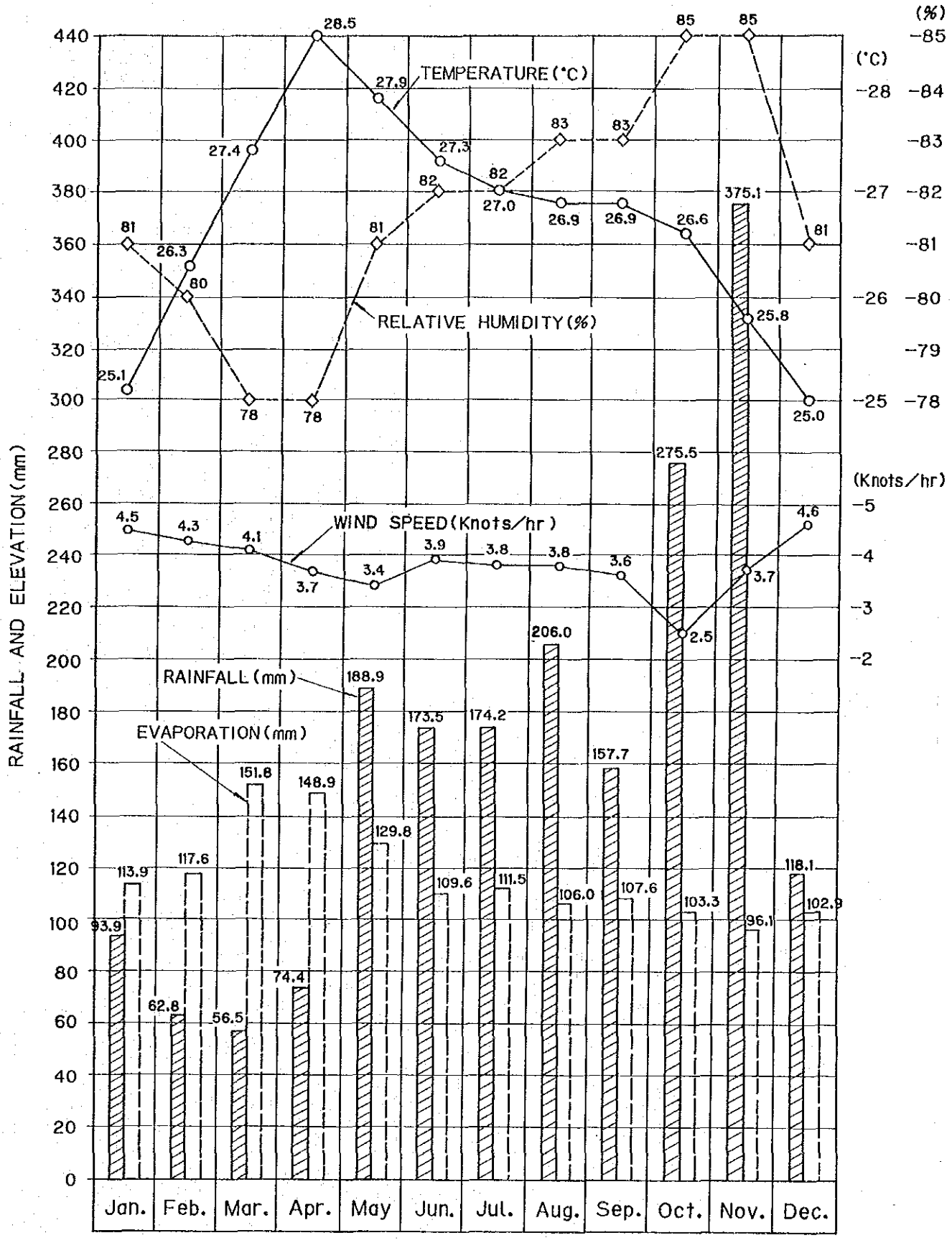


FIGURE C-2 ISOHYET MAP
(ANNUAL RAINFALL FOR 1925-1985)

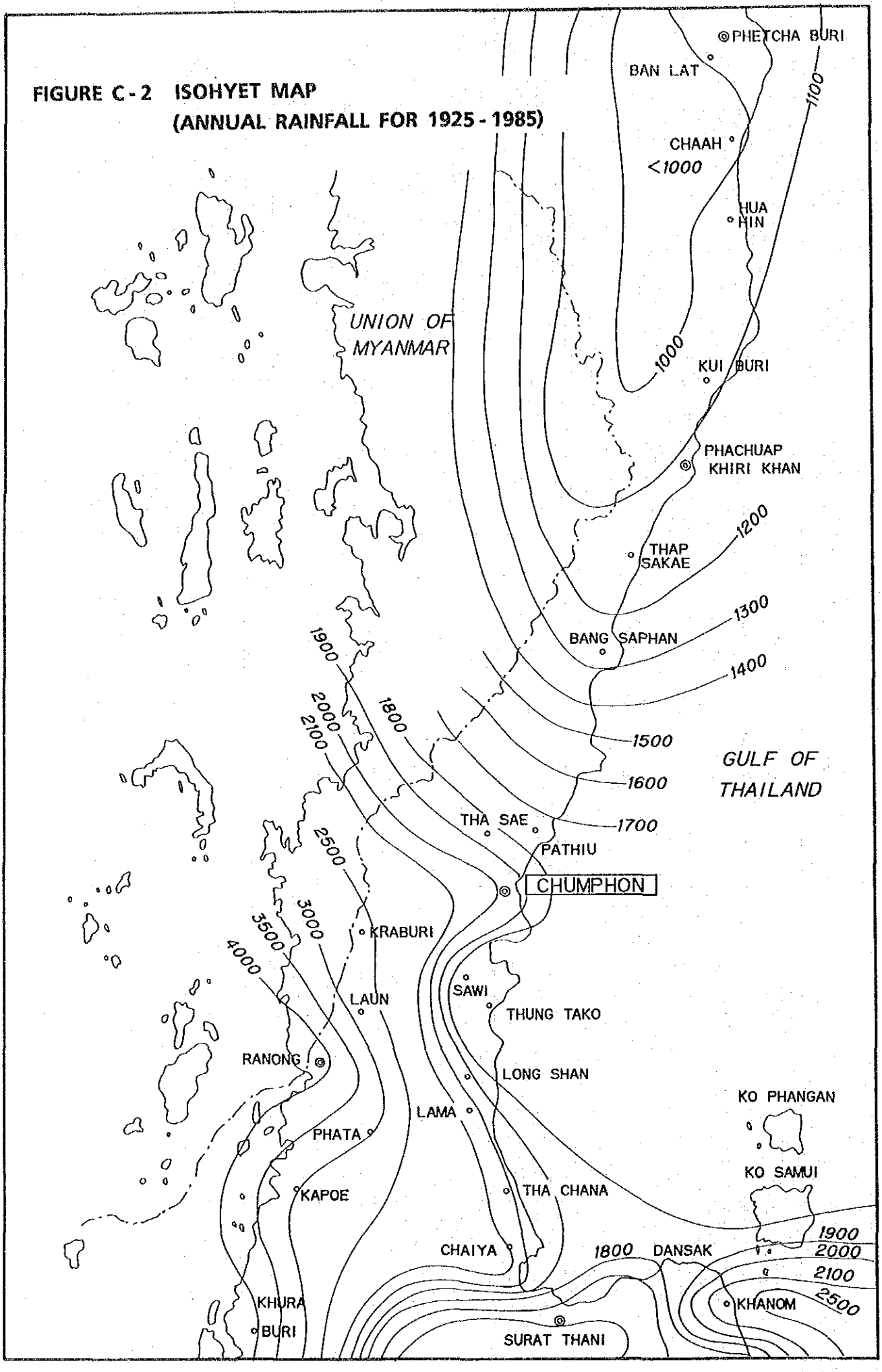


FIGURE C-3 DIRECTION OF MONSOONS & STORMS

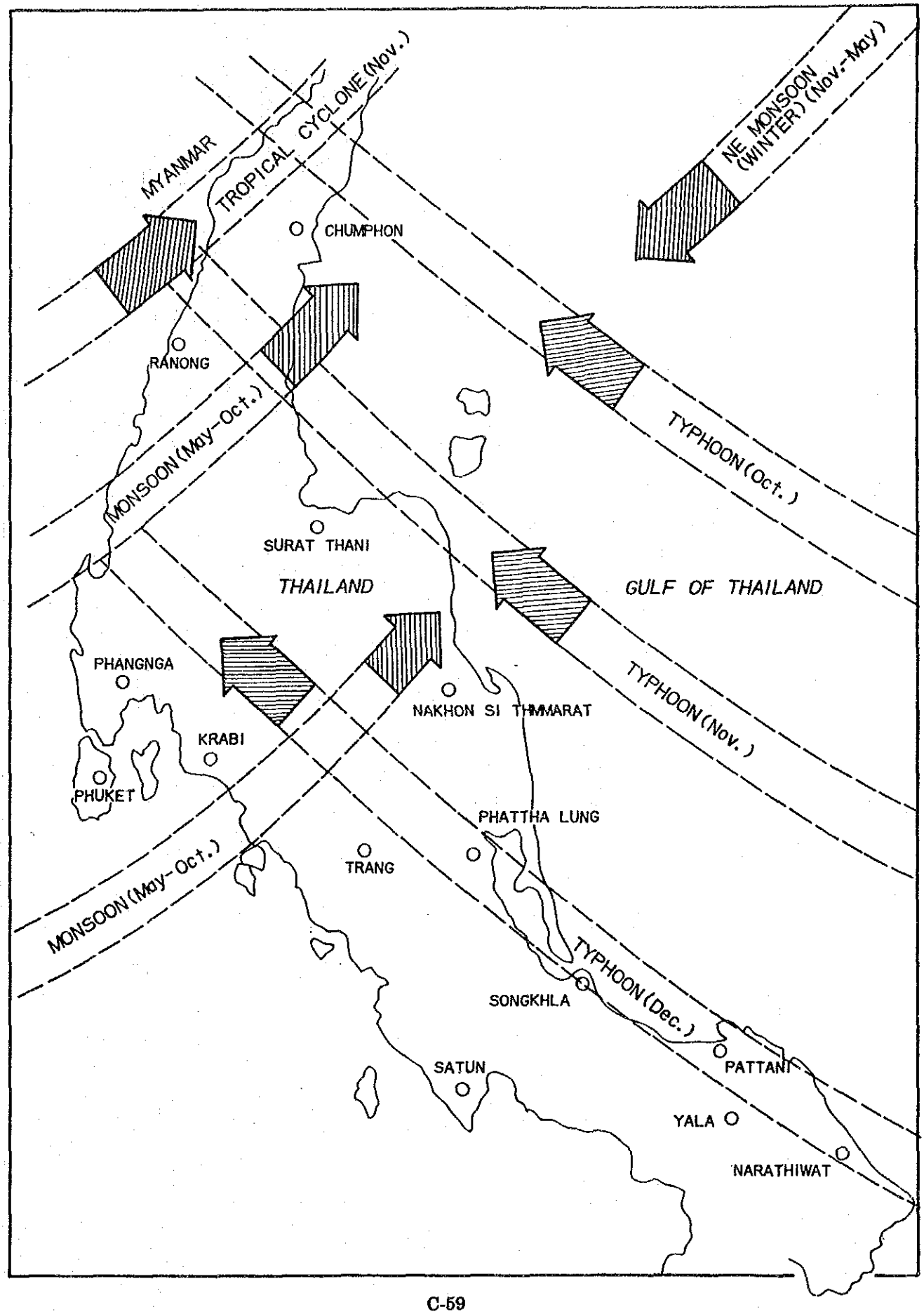


FIGURE C-4 LOCATION OF GAUGING STATIONS

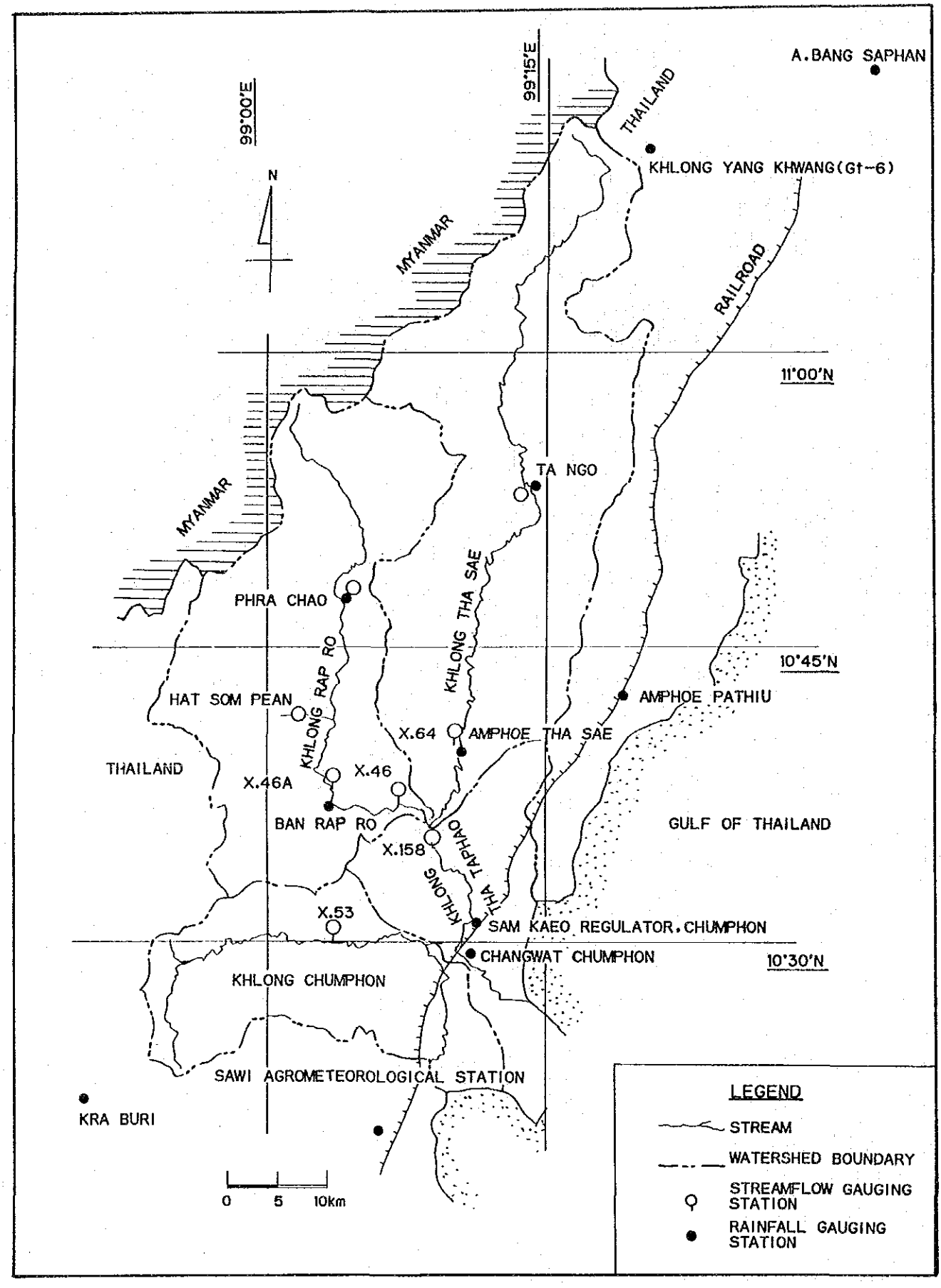


FIGURE C-5 BASIN MAP OF STUDY AREA

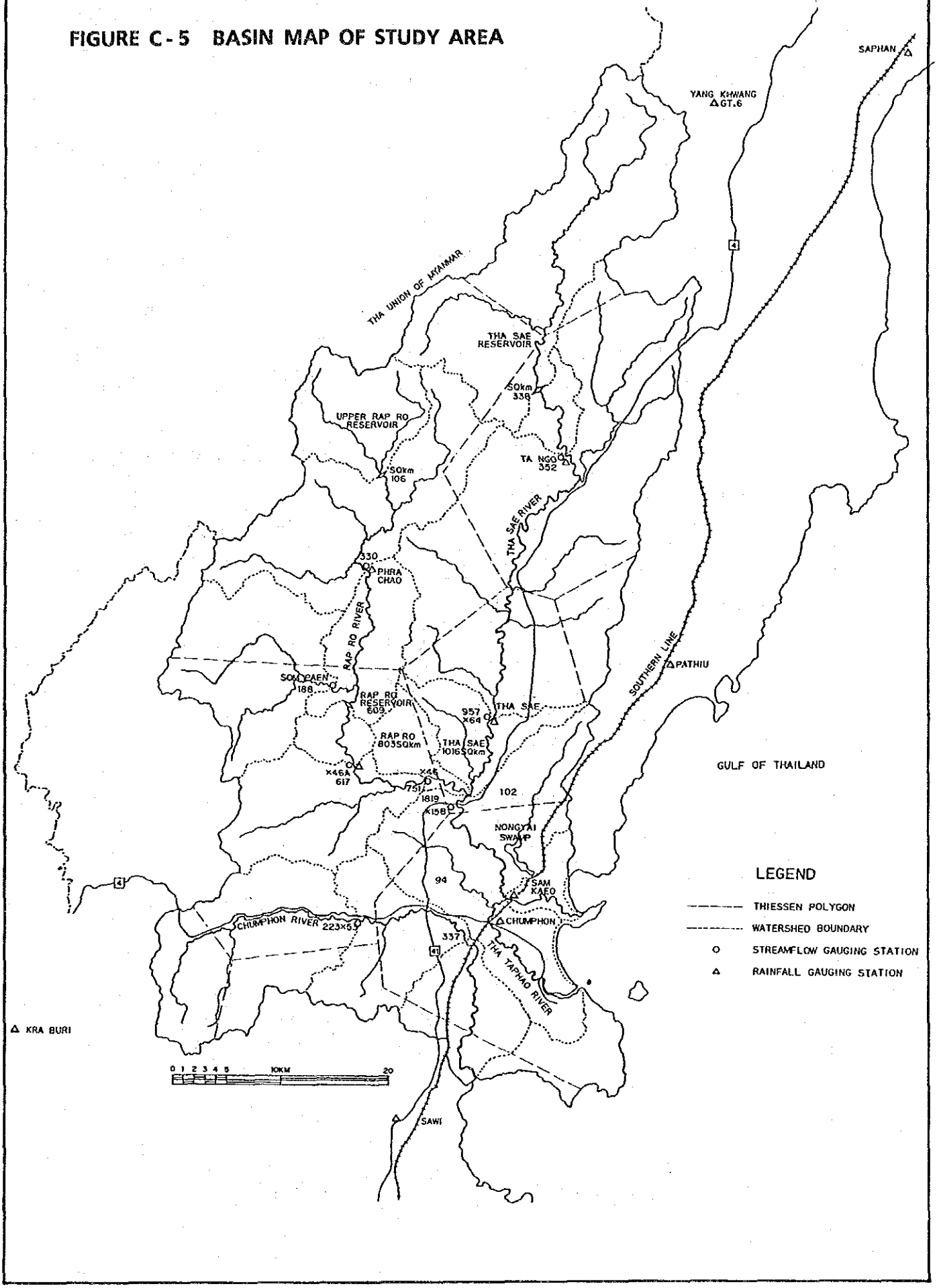


FIGURE C-6 MONTHLY AVERAGE RAINFALL (1965-1986)

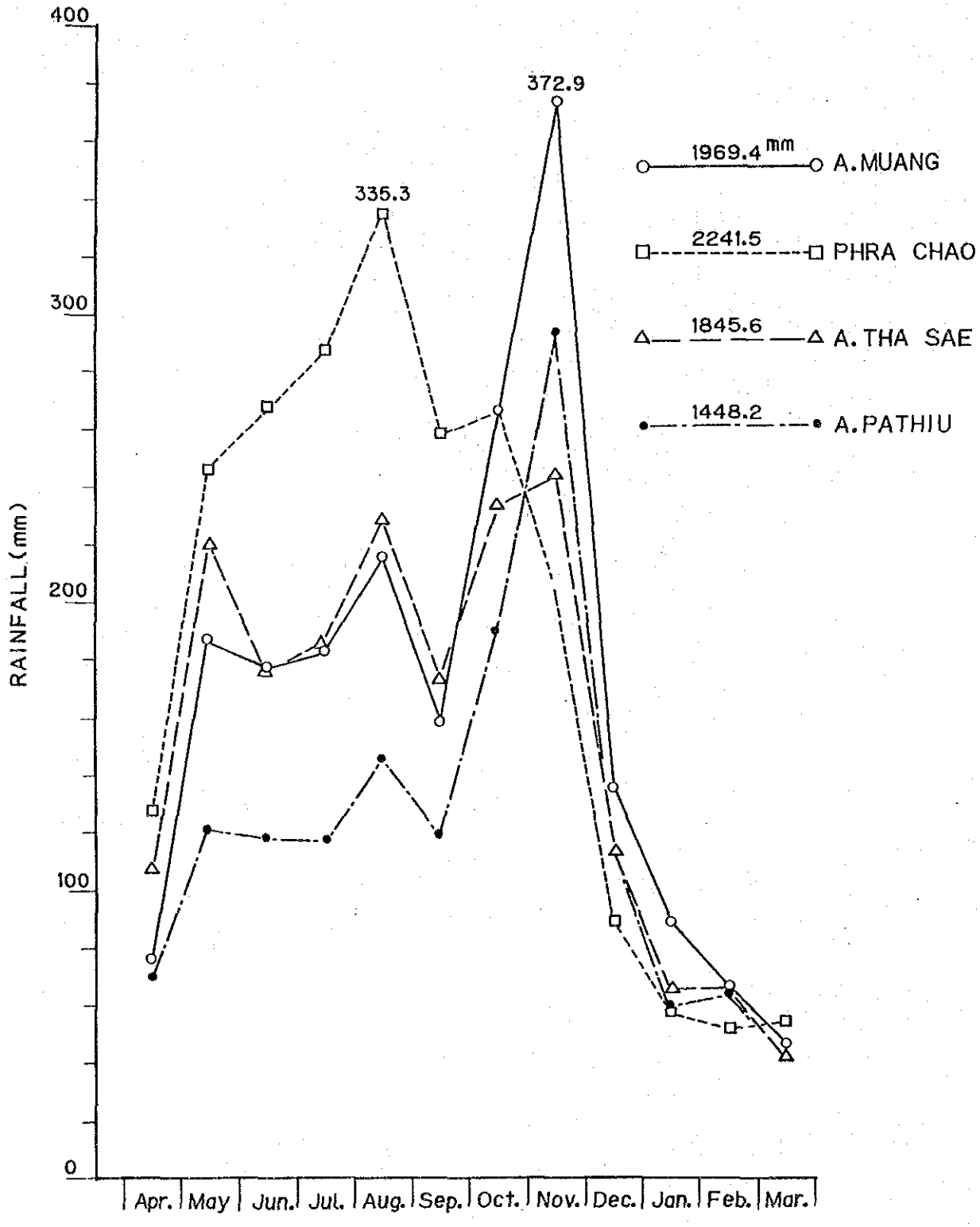


FIGURE C-7 ANNUAL RAINFALL

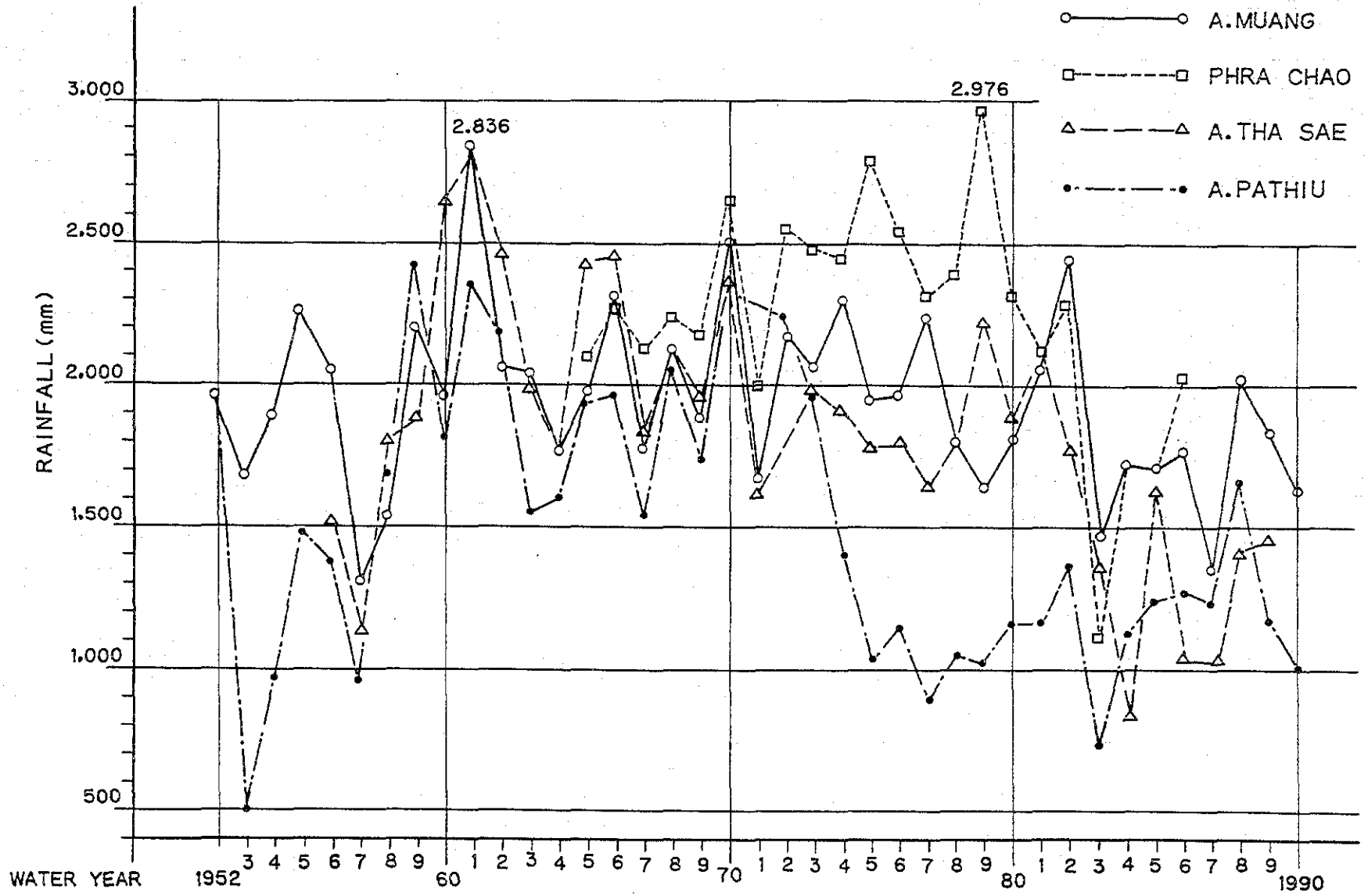
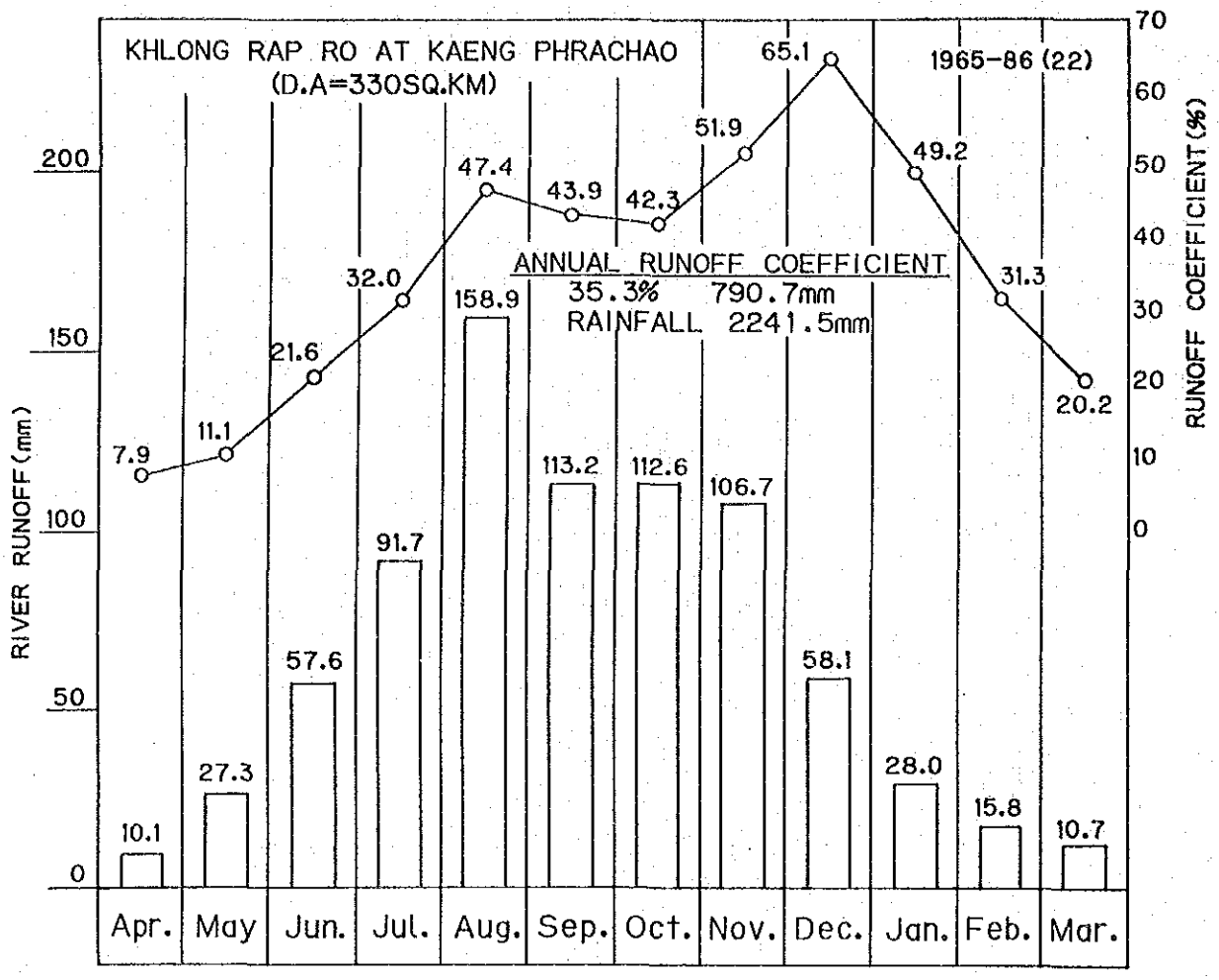


FIGURE C-8 MONTHLY RUNOFF



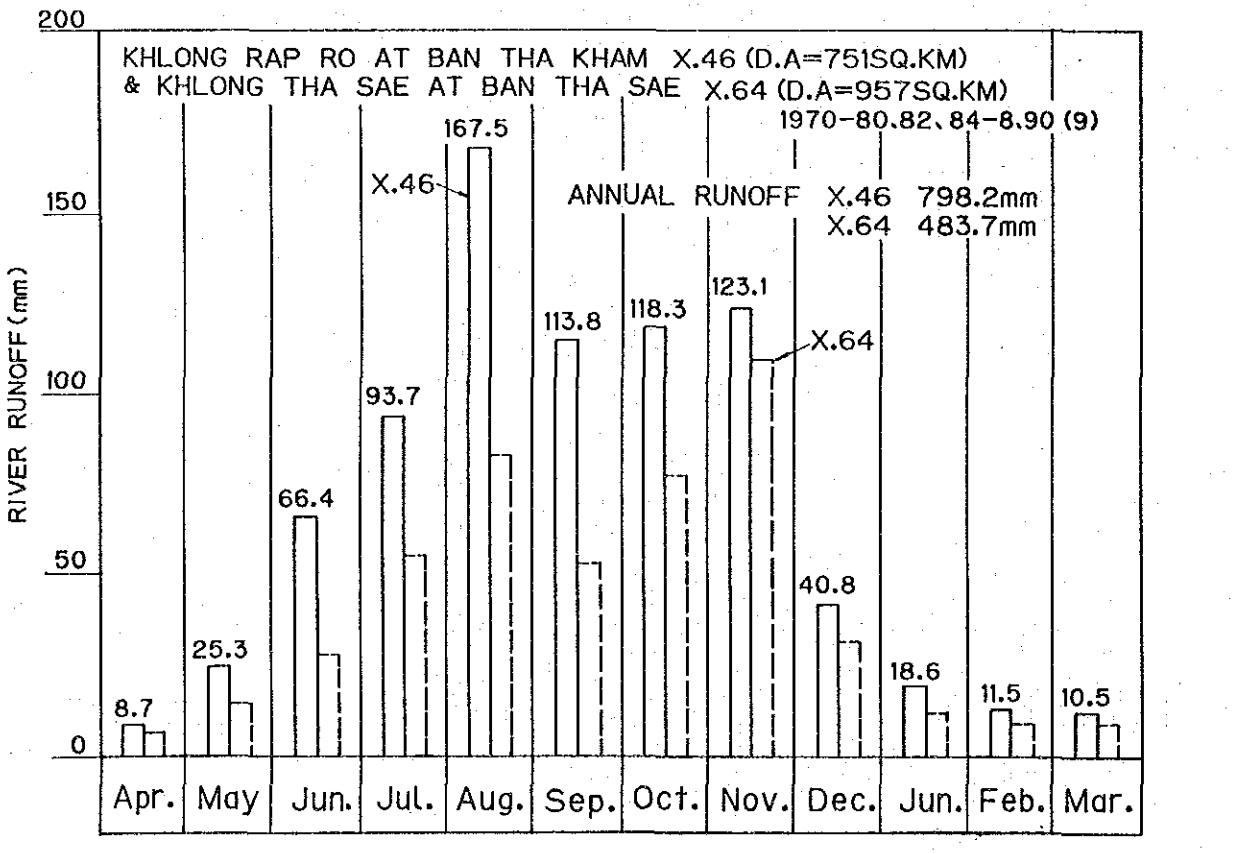
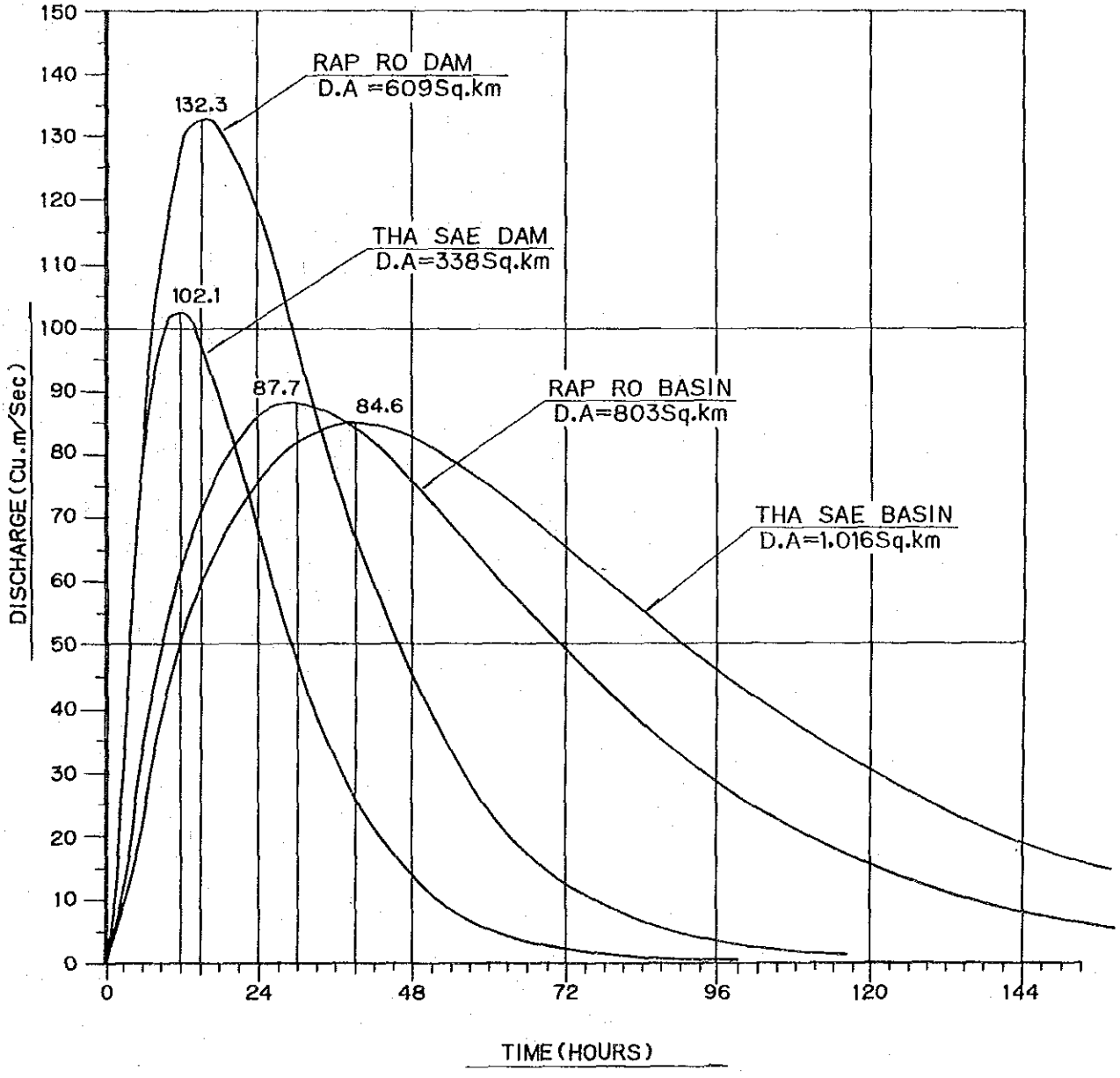


FIGURE C-9 ADOPTED 10 MM UNIT HYDROGRAPH



APPENDIX D. IRRIGATION AND WATER RESOURCES

CONTENTS

APPENDIX D. IRRIGATION AND WATER RESOURCES

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LIST OF FIGURES

APPENDIX D. IRRIGATION AND WATER RESOURCES

D - 1 PRESENT CONDITIONS

D - 1 - 1 Existing Water Resources

(1) Surface Water Resources

The Study Area is extended to 3 Amphoe in Chumphon province and 1 Amphoe in Prachuap Khiri Khan province, covering 4 basins, Tha Sae, Rap Ro, Tha Taphao and Chumphon, of which total area is 2,625 sq.km (1.64 million rais). The average annual rainfall and run-off in the area is about 1,900 mm and 650 mm respectively. The situation of water resources development in the southern region is the lowest among the whole Thailand, which may be caused by comparatively much rainfall enough for plantation in rainy season. In the Study Area, there is no large scale existing projects, but there exist one medium scale and 16 small scale projects of RID and 9 small size projects of Kor Sor Chor exclusive of river improvement projects as shown in Table D-1 and D-2. The existing irrigation facilities are consisted of weir, reservoir and pump station, but there are no irrigation canals except some ditches constructed by farmer themselves. The existing irrigation projects including 8 river improvement projects are assumed to irrigate approximately 15% (105,000 rais) of the total plantation area of about 740,000 rais, thus about 85% of the total area relys on the rainfed cultivation. The existing projects only utilize about 120 MCM water (assuming the water consumption of 7.0 MCM/1,000 ha), therefore more than 90% of the total run-off water (approximate 1,700 MCM) discharges to the sea.

(2) Ground Water

As for ground water resources, there are 2 main aquifers, Matasediment aquifer in the mountainous and rolling area, and Chao Phraya aquifer in the plain area centering Chumphon city. The quality of ground water is generally good but locally inferior due to high iron content, however the average yield of the former aquifer is 5 to 10 m^3/hr and the latter, 5 to 30 m^3/hr, which will not be expected as sufficient water resources. In the Study Area, there are about 300 wells under the Department of Mineral Resources

(DMR), and about 140 wells of ARD project for domestic use, but 80 to 90% of the area still depends on the rain water providing with earthen water bottles.

(3) Water Resources Area

The forest area plays an important role of water resources holding the water. However, according to the report of Land Use Plan in Chumphon province prepared by DLD 1989, a total of forest area in Chumphon province is only 24% of the total area, decreasing 45% of it during the period of 28 years from 1961 to 1989.

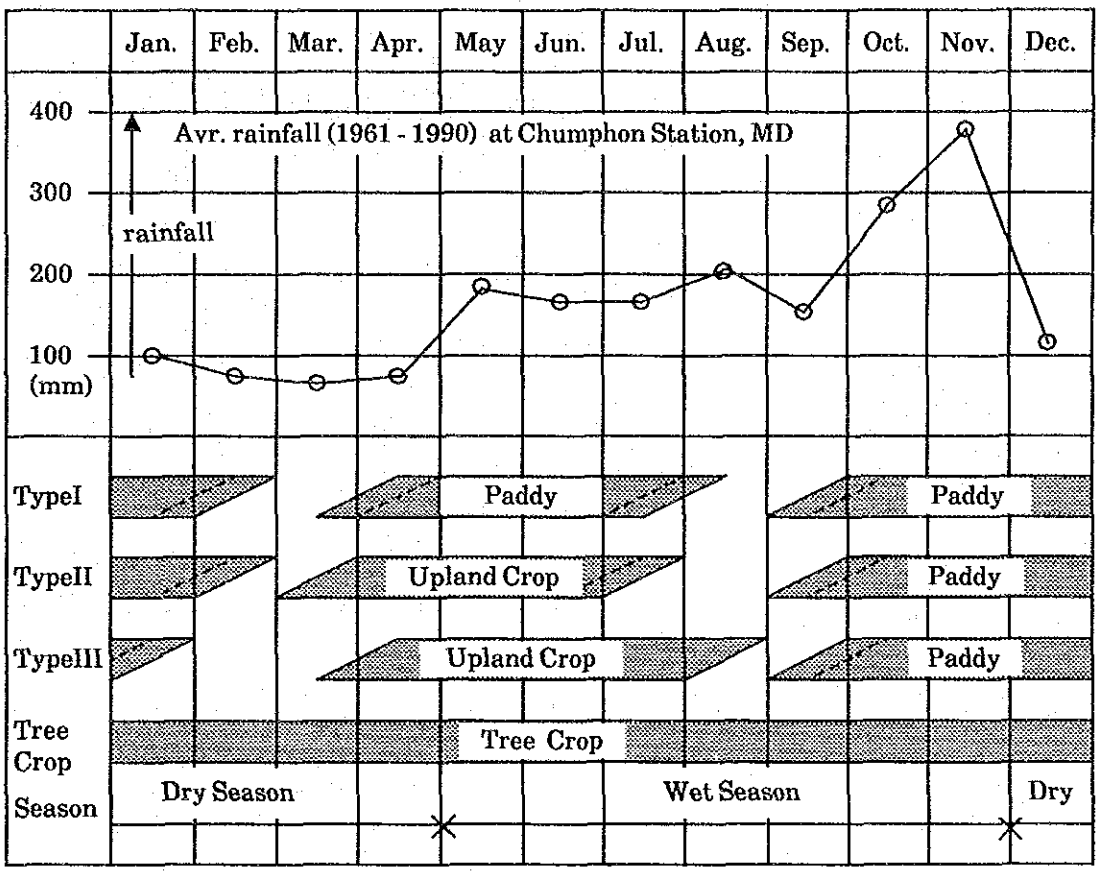
Year	1961	1976	1978	1982	1989
Forest share (%)	69.0	34.8	28.0	25.2	23.7

D - 1 - 2 Cropping Pattern

The irrigation is mainly conducted to such crops as paddy, vegetable, coffee and fruit tree by using portable pumps, but if irrigation made to oil palm and rubber tree, the yield of them will be increased.

The representative present cropping patterns within the east of southern region are summarized by RID O/M Division as follows;

PRESENT CROPPING PATTERN



D - 1 - 3 Development Plan

(1) MOAC's 7th Operation Plan (1992~1996)

From the results of the previous development in agricultural sector, MOAC prepared the 7th Operation Plan (1992~1996) relevant to land and water resources development in association with the Seventh Five Year National, Economic and Social Development Plan.

a) Objectives of the 7th National Development Plan

To create a balance between development quantitywise and qualitywise, and justice in the society coupled with it, including the income distribution, the maintenance of economic stability and the quality of life, and maintaining the environment and the natural resources.

b) Target for Developing Natural Resources

Forest;

* To have the reserved forest area, 25% of the total country
* To have the economic forest area, 15% of the total country

Land;

* To reform the agricultural land, 30 million rais during the 7th Plan.

Water resources;

* To provide small scale water sources in the agricultural area not less than 500 spots per year.

Mangrove Forest;

* To reforestrate the mangrove forest, 250,000 rais during the 7th Plan.

c) Measures for Water Resources

* To prepare a master plan for the whole system of the water sources throughout the rivers basin.
* To develop small scale water sources at the plantation level.
* To accelerate construction of small and medium scale irrigation facilities.
* To improve efficiency of water use by developing the water supply system, water allocation system and to collect the water bills for sake of maintaining the irrigation system.
* To manage in conserving the water origins and streams

(2) Medium Phase Work Plan

At the time of typhoon "Gay", the maximum flood discharge of Tha Taphao river was estimated at approximately 1,200 m^3/sec. The Sam Kaeo irrigation gate with the design capacity of 262 m^3/sec could discharge only 140 m^3/sec of flood water. The rest of the flood water flow run across the Chumphon city toward the sea, as the Tha Taphao river had limited flow capacity. At the same time, flood water from Chumphon river had raised and overflowed the banks. In consideration of the fact mentioned above, RID studied and prepared

the following Work Plan for water resources development and flood mitigation in the Chumphon province in Oct. 1991.

a) Emergency Work Plan (Nov. 1989-Oct. 1990)

To remedy the problem urgently, the following works were conducted.

- Installation of water pumps for substituting the damaged crops, in A.Muang, A Pathiu and A. Tha Sae	35	units
- Drilling of wells for drinking and consumption in A. Pathiu and A. Tha Sae, Chumphon, and A. Bang Sapan Noi, Prachuap Khiri Khan	1,699	wells
- Pond (124×171-4m) at Nikon Sahakorn A. Tha Sae	1	unit
- Public wells in A. Tha Sae and A. Pathiu	30	wells
- Improvement and adjustment of land condition for cultivation in A. Tha Sae	16,050	rais
- Specific control of the forest fire within A. Tha Sae	259.26	kms
- Specific operation and others		

b) Medium-term Work Plan (1991-1995)

- Dig Ban Hua Wang-Panang Tuk irrigation canal	8.3	kms
* Irrigation Canal	(8.3	kms)
* Irrigation gates at the head and end of the canal	(2	units)
- Improvement of Sam Kaeo regulator and existing Sam Kaeo irrigation canal	14.2	kms
* Short-cut canal	(0.624	kms)
* Irrigation gate	(1	unit)
* Kor Sor Lor bridge (ℓ=90.0m)	(1	unit)
* Improvement of dike of canal	(8.9	kms)
* Short-cut canal	(4.702	kms)

- Dredging of the Tha Taphao river 25 kms
- Dredging of the natural canals 36 kms
  * Chumphon river
  * Nong Sai river
  * Ma Young river
  * Nong Muang Kom river
  * Kanai river

c) Long-term Work Plan

- Construction of Rap Ro reservoir 1 unit
- Construction of Tha Sae reservoir 1 unit
- Installation of forecasting and natural disaster warning systems 1 unit

D - 1 - 4 Flood Damage of Irrigation Facilities

In case of heavy rainfall in the basins of Rap Ro and Tha Sae, river flow often overflows the banks of Tha Taphao river, thereby causing inundation in low-lying areas along the river where the municipality of Chumphon is located. The Sam Kaeo canal project is a first large scale project with dual purpose of flood control and irrigation in Chumphon province. The construction of the head regulator with the capacity of 262 m^3/sec and 4 canals with the total length of 11 km was started in 1951 to complete in 1954. With the completion of the Sam Kaeo canal project, the economic activity of the municipality of Chumphon was rapidly developed.

In recent years, floods of the Tha Taphao river have come into question; frequent floods may be due to decrease in flow capacities of rivers and canals, and deforestation in the river basins. Big floods are recorded in December, 1970, November, 1988 and November 1989. The maximum river stages of the Tha Taphao river at the Sam Kaeo regulator were 6.04 m MSL in 1970, 5.88 m MSL in 1988 and 5.95 m MSL in 1989.

The typhoon "Gay" on November 4, 1989 flooded the Tha Taphao river and Chumphon river, causing great damages to farm crops, public facilities and

property in Amphoe of Tha Sae, Pathiu, Muang Chumphon and Sawi. The flood damages of irrigation facilities in the Study Area are summarized as follows;

FLOOD DAMAGE TO IRRIGATION FACILITIES

Description	Quantities	Repair Cost	Remarks
1) Sam Kaeo irrigation canal		(1,000 Baht)	
- dike and wall	1,050 m	901	
- riprap and revetment	4,890 m^3	1,095	
2) Offices and others	11 units	212	
3) Small sized irrigation facilities			(weir, pump station)
- projects handed over to the province	4 units	148	
- projects not yet handed over	3 units	1,100	
4) Mobile agricultural service center facilities	1 units	114	
Total		3,570	

(Note) Data source : Report on the typhoon and floods in Chumphon province during 4 to 9 Nov. 1989 (RID Irrigation Office 11th)

D - 1 - 5 Problems and Needs

(1) Problems

From the results of field survey conducted in the Phase I stage, the following problems for development of water resources in the Study Area are identified.

a) Land

* The forest area, as water source area, shares only about 25% of the Study Area, and the other remained area has been mostly developed as the plantation area of tree crops, fruit tree, vegetable etc.

b) Rainfall

* 80 to 90% of annual rainfall concentrates in the period of seven months from May to November, and 35 to 40% of that is in the two months from October to November, typhoon season.

* On the other hand, the rural people in the basin suffer from the shortage of domestic and irrigation water in the dry season for five months from December to April.

c) Irrigation

* Most farm land relies on the rainfed cultivation, although there exist one medium scale of flood mitigation project with the storage function of water and 25 of small scale water resources structures such as pond and weir under RID and Kor Sor Chor project, and the pumping irrigation from the rivers are conducted in the dry season.

* The major crops to be irrigated are such crops as paddy, vegetable, upland crop and fruit tree, which are planted on scattered and combined conditions, so that the plan of irrigation system and operation will need careful study on topography.
  Furthermore, the low land nearby Chumphon city is major cultivation area, and the water from resources shall be conveyed to the area with comparatively long length of canal.

d) Others;

* There are about 400 wells under DMR and ARD for domestic water use in the Study Area, but 80 to 90% of the area still depends on rain water.

* By sedimentation, reduction of discharge and storage capacity of river is occurred yearly, especially in the lower basin, in spite of dredging and digging works by RID and other government agencies concerned.

(2) Needs for Irrigation Development

The Study Area receives relatively much rainfall when compared to other regions; however, in addition to irrigation in the dry season, supplementary irrigation in the rainy season is needed for successful growth of crops as given below:

CROP WATER BUDGET

(Unit: mm)

Crops	Wet Season(May-Nov)			Dry Season (Dec-Apr)			Total
	NWR (mm)	ER (mm)	SW (mm)	NWR (mm)	ER (mm)	SW (mm)	SW (mm)
- Paddy	1,049	855	194	909	281	628	822
- Upland crop	937	838	99	738	304	434	533
- Fruit tree	749	838	-	590	304	281	281

(Note) NWE : Net Water Requirement, ER : Effective Rainfall
SW : Shortage of Water

In order to increase and stabilize the agricultural products in the area, introduction of irrigation projects combined with flood alleviation projects shall be required.

D - 2 DEVELOPMENT PROPOSAL

D - 2 - 1 Available Water

(1) Basin Rainfall

There are 10 rainfall stations in and around the Study Area. Among them, the observatory at the Sam Kaeo regulator is located at very close to the meteological station of Chumphon, since then the data from the latter station is employed in the rainfall analysis as the representative one in the respective area. The average annual rainfall of each basin estimated by the Thiessen Method during the period of 1965 to 1986 is as follows:

AVERAGE BASIN RAINFALL

Station	Annual Rainfall (mm)	Basin (km^2)				
		Tha Sae	Rap Ro	Tha Taphao	K. Chumphon	Total
1) K. Phra Chao	2,242	141	487	-	-	628
2) X.46A	1,879	-	286	31	157	474
3) Tha Sae	1,845	188	12	66	-	266
4) Ta Ngo	1,556	385	18	-	-	403
5) Pathiu	1,448	60	-	-	-	60
6) GT. 6	1,731	242	-	-	-	242
7) A. Muang	1,971	-	-	260	115	375
8) Sawi	1,883	-	-	-	95	95
9) Kra Buri	2,536	-	-	-	82	82
Total		1,016	803	357	449	2,625
Average Rainfall (mm)		1,740	2,090	1,940	2,020	1,920

Note : Detail, refer to APPENDIX C "Meteorology and Hydrology"

(2) Run-off

The coefficient of long-term average annual run-off is presumed to be 0.35 from the run-off records of Kaeng Phra Chao (Rap Ro river) and X.64 (Tha Sae river). Applying the run-off coefficient of 0.35, the run-off of each basin is estimated as below:

ANNUAL RUN-OFF

Basin	Drainage Area (km^2)	Average Rainfall (mm)	Average Run-off (mm)	Annual Discharge (MCM)
Tha Sae	1,016	1,740	609	618.7
Rap Ro	803	2,090	732	587.8
Tha Taphao	357	1,940	679	242.4
K. Chumphon	449	2,020	707	317.4
Total	2,625	1,920	672	1,766.3

(3) Available Water

As mentioned in the former para. 1-1, Existing Water Resources, about 105,000 rais of plantation area are irrigated totally, and it is considered to consume about 120 MCM/year on the assumption of the water demand of 7.0 MCM/1,000 ha/year. This fact indicates that less than 10 percent of the total annual run-off is utilized for irrigation, and more than 90 percent of run-off is available for the future development.

D - 2 - 2 Irrigation Water Requirement

(1) Estimate of Water Requirement

The diversion water requirement is estimated by the following formula:

- Net water requirement = Crop consumptive use + Percolation + Water requirement for field preparation

- Field water requirement = Net water requirement - Effective rainfall + Field losses

- Diversion water requirement = Field water requirement + Conveyance and operation losses

(2) Crop Consumptive Use (Cu)

Since there were no effective measured data, the crop consumptive use was estimated by applying the modified Penman Method as follows:

$$Cu = ETo \times Kc$$

Where, Cu : Consumptive use (mm)
ETo : Evapotranspiration (mm)
Kc : Crop factor (Crop Coefficient)

The evapotranspiration in the Chumphon province was computed based on the climatological data for resent 30 years 1961 - 1990 from Meteological Department as shown in Table D - 3 "Evapotranspiration (ETo)".

While, Kc of major crops are decided basing on the report of "Crop Coefficient and Pan Coefficient" prepared by Water Requirement Research and Irrigated Agriculture Section, O/M Division, RID on Oct. 1990 as below:

CROP FACTOR (Kc)

Crops \ Week	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th
1) Paddy															
- H.Y.V (RD 23)	0.92	0.94	1.00	1.13	1.23	1.29	1.32	1.30	1.26	1.21	1.11	0.95	0.75		
2) Upland Crop															
- Maize	0.52	0.59	0.70	0.91	1.04	1.29	1.35	1.37	1.36	1.32	1.22	1.02	0.79	0.60	
- Groundnut	0.58	0.69	0.80	0.88	0.95	1.00	1.03	1.03	1.01	0.97	0.89	0.76	0.62	0.53	0.48
- Soybean	0.58	0.63	0.74	0.92	1.14	1.23	1.26	1.24	1.17	1.01	0.79	0.69	0.65	0.62	

The Kc values for vegetable and upland crop being planted in full season, and for tree crop are presumed as follows:

Crops	Average Kc
Vegetable	1.1
Upland Crop or Mixed Farm	1.0
Fruit Tree	0.8

(Note) Mixed Farm : Vegetable + Fruit Tree

(3) Other Requirement

Besides the consumptive use, the water requirements for percolation and land preparation for paddy, and preparatory works for upland crop shall be considered. Considering the soil characteristics in the subject area, the percolation value of 1.0 mm per day is adopted for the paddy field, and that for the upland area percolation is regarded as a water loss. Such additional water requirements as land preparation water for paddy and pre-irrigation water for upland are designed as below, referring to the data available from other similar natured projects in Thailand.

ADDITIONAL WATER

Crop	Requirement (mm)	Required Period (days)
Paddy	270	30
Upland Crop	40 ~ 50	10

(4) Effective Rainfall

As for the estimate of effective rainfall for crops, there are some data in Thailand which are applied generally as standard, as shown in Figure D-1. In this study, the method developed by the Mae Klong Project under JICA is adopted. That equation is as follows:

EFFECTIVE RAINFALL

Crop	Effective Rainfall (ER)	Upper Limit ER	
		One Month	10 Days
Paddy	0.75 × R	200 mm	70 mm
Sugarcane	0.75 × R	150 mm	50 mm
Other Upland	0.75 × R	120 mm	40 mm

(Note) R : Monthly rainfall or 10 days rainfall (mm)
The effective rainfall for tree crop is also adopted to the upland crop ER.

(5) Losses

A part of the irrigation water from the water sources will be lost in the field during conveyance and operation of water. The field losses varies with different irrigation methods and field conditions, and the conveyance and

operation losses are depended on the different structures and operation methods of conveyance system. Taking those water losses into consideration, the diversion water requirements which are required at the diversion site can be estimated as follows;

$$DWR = \frac{FWR}{Ec \times Eo} = \frac{NWR - ER}{Ef \times Ec \times Eo}$$

Where, DWR : Diversion water requirement
FWR : Field water requirement
NWR : Net water requirement
ER : Effective rainfall
Ef : Field efficiency
Ec : Conveyance efficiency
Eo : Operation efficiency

Judging from the previous studies and researches conducted in Thailand, the following efficiencies are generally applied.

	Paddy Land	Upland
Field efficiency (Ef)	0.70 - 0.80	0.55 - 0.60

	Lined Canal	Unlined Canal
Conveyance efficiency (Ec)	0.90 - 0.95	0.80 - 0.90
Operation efficiency (Eo)	0.90 - 0.95	0.90 - 0.95

From the view point of effective use of water, recently the lined canal and/or pipeline system become to be a dominant one. Therefore, in this study, the overall efficiencies namely irrigation efficiencies were employed as below;

	Ef	Ec	Eo	Overall (E)
Paddy	0.70	0.90	0.90	0.55
Upland and others	0.60	0.90	0.90	0.50

(6) Irrigation Water Requirement

Basing on the method mentioned, the irrigation water requirements for each type of cropping pattern proposed in the former para. are estimated as shown in Table D-4, and those results are summarized as below;

IRRIGATION REQUIREMENT

(per 1,000 ha)

	Type I		Type II		Type III		Type IV		Type V	
Month	mm	MCM	mm	MCM	mm	MCM	mm	MCM	mm	MCM
Jan.	132	1.32	132	1.32	132	1.32	130	1.30	76	0.76
Feb.	-	-	-	-	-	-	181	1.81	126	1.26
Mar.	-	-	537	5.37	-	-	256	2.56	188	1.88
Apr.	-	-	298	2.98	220	2.20	218	2.18	152	1.52
May	-	-	140	1.40	144	1.44	56	0.56	-	-
Jun.	-	-	-	-	-	-	31	0.31	-	-
Jul.	-	-	-	-	-	-	38	0.38	-	-
Aug.	-	-	-	-	-	-	33	0.33	-	-
Sep.	369	3.69	369	3.69	369	3.69	29	0.29	-	-
Oct.	-	-	-	-	-	-	14	0.14	-	-
Nov.	-	-	-	-	-	-	-	-	-	-
Dec.	186	1.86	186	1.86	186	1.86	81	0.81	29	0.29
Total	687	6.87	1,662	16.62	1,051	10.51	1,067	10.67	571	5.71

Note : TypeI : Wet season paddy only, Type II : Wet and Dry season paddy,
Type III : Wet season paddy + Upland crop,
Type IV : Mixed farm (vegetable + fruit tree), Type V : Fruit tree

D - 2 - 3 Domestic Water and Others

In addition to the irrigation water, such water requirements as domestic water for the beneficial area and Amphoe Pathiu, municipal water for Chumphon city etc. are considered in the water resources development plan.

(1) Domestic Water for the Beneficial Area

Presently the domestic water in the rural area mostly relies on the rain water. Thereby, it will be required to supply the domestic water and other necessary water for living, especially in the dry season as well as the irrigation

water. The water requirement for domestic use was employed with the following figures as prevailing ones in Thailand.

Item	Requirement per day	Supply Area
Domestic Water	100 ℓ/person	Beneficial Area
Livestock	50 ℓ/cattle	ditto
	20 ℓ/pig	

Based on the present conditions in the area, the water demand for it was estimated approximately as follows;

Item	Requirement	Number 1/	Water Demand
Domestic Water	100 ℓ/person	82 km^2	8,200 ℓ/day/km^2
Livestock			
Cattle	50 ℓ/cattle	13	750
Pig	20 ℓ/pig	30	600
Total			9,450 = 10.0 m^3/day/km^2

Note: 1/ : Analyzed from NRD-2C, 1990

(2) *Domestic Water for Amphoe Pathiu*

The coast area in Amphoe Pathiu where is outside of the Study Area, about 570 km^2 is suffered from water shortage due to the smallest amount of rainfall among the Chumphon province. So that, 5700 m^3/day of water for domestic use shall be supplied to the area when planning the Tha Sae reservoir.

(3) Municipal Water for Chumphon City

Presently, water supply to the Chumphon city is conducted by receiving the river run-off of Tha Taphao. However, the water shortage problem is predicted when considered the future development of the city.

Thereby, forecasting the city population after 20 years, 2010, the water supply plan is made as follows;

- Present population : 14,500 persons (1990) 1/

- Rate of increase : 2.0%/year (1991 ~ 1996) 2/
  2.0%/year (1997 ~ 2000) assumed
  1.5% year (2001 ~ 2010) assumed
- Increased population : 6,000 persons
- Water requirement : 200 ℓ/day/person
- Water demand : 1,200 m^3/day

1/ : Source, Chumphon Municipal Office

2/ : Source, Master Plan for Developing Agriculture and Cooperative, Provincial Level (2535 - 2539) "Chumphon Province", MOAC

(4) Other Water

In addition to the water demand mentioned above, the total 1.5 MCM/year of additional water is considered for inland fishery and harbor development.

Consequently, the water requirements for domestic water and others are summarized as below.

Item	Water Requirement
a) Domestic water for beneficial area	10.0 m^3/day/km^2
b) Domestic water for A. Pathiu	5,700 m^3/day
c) Municipal water for Chumphon city	1,200 m^3/day
d) Others for fishery pond & harbor	1.5 MCM/Year

D - 2 - 4 Sedimentation

Sedimentation in reservoir is depended upon such various conditions as topography, soil and geology, vegetation, rainfall etc. in the drainage area, so that the estimation of sediment volume is rather difficult in theological. In addition, there are none of records on sedimentation of reservoir due to no existing reservoirs of large and medium scale in the Study Area. The sediment volume, therefore is assumed based on the suspended sediment recorded by RID, Hydrology Division. The sedimentation is consisted of suspended sediment and bed load sediment which is assumed with 30 percent of suspended one.

	Description		Tha Sae River	Rap Ro River	Ma La River
a)	Drainage area	(km^2)	352	330	188
b)	Mean annual suspended sediment	(ton)	15,800	18,800	5,650
c)	Assumed total sediment	(ton)	20,540	24,440	7,345
d)	ditto	(m^3)	15,800	18,800	5,650
e)	Specific sediment	(m^3/km^2/year)	45	57	30

Note: Unit weight of sediment is assumed to be 1.3 ton/m^3.

The feasibility study of Rub Roh project conducted by NEA reported that the average annual sediments at the Kaeng Phra Chao and Ma La dam were 70 and 25 m^3/km^2 respectively. Considering the future development at the surrounding area of reservoir, the sediment will increase, therefore the design specific sediment shall be taken to 150 m^3/km^2/year for safety. The design period of sediment for reservoir is applied with 100 years equivalent to twice of economic life time of reservoir. Each design sediment for the potential reservoir is resulted as follows;

Reservoir	D. A	Specific Sediment	Design Period	Sediment Volume
	(km^2)	(m^3/km^2/year)	(years)	(MCM)
Tha Sae	338	150	100	5.1
Rap Ro	609	150	100	9.1
Upper Rap Ro	106	150	100	1.6

As reference, Kira's Formula which is a prevailing one in Japan for estimation of sediment volume is as follows;

$$qs = C \cdot \gamma s / 100\,F$$

where, qs : Average specific sediment volume (m^3/km^2/year)
C : Reservoir capacity (m^3)
γs : Annual mean sediment ratio (%)
$\gamma s = 0.00012\phi^{0.868}$
$\phi = Rf/(C/F)$
Rf : Average relief of watershed (m)
F : Watershed (km^2)

Applying the said formula, the specific sediment of Tha Sae reservoir and Rap Ro reservoir are resulted with 150 and 170 m^3/km^2/year respectively.

D - 2 - 5 River Maintenance Flow

From the view point of environment aspect, a certain water flow of river is required for habitation of fish and shale, animal and vegetable nearby river, stabilization of groundwater, navigation of fishery boat, and appearance of water front, namely maintaining the river function. The design discharge for river maintenance is generally applied with the droughty discharge, although depending on the characteristic of each river. Where, the discharge records at RID gauging stations indicate the followings;

River	Guaging Station	D. A	Average Min. Flow	Discharge per 100 km^2
		(sq.km)	(cu.m/sec)	(cu.m/sec)
Rap Ro	X. 46	751	1.71	0.23
Tha Sae	X. 64	957	1.42	0.15

From the above table, 0.5 cu.m/sec/100 sq.km of discharge is adopted as the river maintenance.

D - 3 BASIN DEVELOPMENT

D - 3 - 1 Potential Reservoir Sites

(1) Possible Reservoir Sites

The flood mitigation and water resources development are a key subject in development of the Study Area. One of the most effective means for the flood mitigation and water resources development is considered to be an introduction of reservoir construction. Based on the topographical maps scaled 1 to 50,000, the following 10 reservoir sites were preliminarily nominated as a possible site. (refer to Table D-8, (1/3), (2/3), (3/3))

River Basin	Number of Possible Re.	Assumed Project Scale	
		Large	Medium
Tha Sae	1 site	1	-
Rap Ro	6 sites	5	1
Chumphon	3 sites	-	3
Total	10 sites	6	4

(2) Selection of Potential Reservoir Sites

In order to select potential reservoir sites among 10 possible sites identified on the topographic maps, firstly, evaluation was made from the viewpoint of engineering based on the following criteria:

① Scale of catchment area and reservoir capacity:
The larger a reservoir has catchment area and storage capacity, the higher the efficiency of water resources development is attained.

② Irrigation area:
The larger a project has irrigable area, the larger the project has an impact on the local community.

③ Storage efficiency:
The higher the storage efficiency expressed in terms of Q (reservoir capacity) / (V (embankment volume) is, the better the project economy is.

④ Civil work engineering:
Geological conditions of damsites and availability of construction materials nearby the damsites.

The evaluation of 10 reservoir sites was made according to the scoring criteria presented in Table D-11 as given below:

ENGINEERING EVALUATION OF POSSIBLE SITES

Reservoir	Catchment Area and Reservoir Capacity	Irrigable Area	Storage Efficiency	Civil Works	Score	Rank
Tha Sae (RID)	5	5	1	3	14	4
Rap Ro (RID)	5	5	5	3	18	1
Kaeng Phra Chao*	5	5	5	3	18	1
Ma La *	3	5	5	3	16	3
Upper Rap Ro	3	3	5	3	14	4
Pha-ngan	3	3	3	3	12	6
Nam Ron	1	1	5	3	10	7
Kum	1	1	1	3	6	9
Upper Kum	1	1	1	3	6	9
Kaphon	1	1	3	3	8	8

Note: * shows the site proposed by NEA.

As a result of engineering evlauation, 10 sites are ranked from 1 to 9. Five large scale reservoirs with the gross storage capacities of more than 100 MCM are given high ranks mainly due to high storage efficiency and large irrigable area. From the civil engineering viewpoint, it has been concluded that the construction of 10 reservoirs are technically feasible.

As a second step, social evaluation is made to 10 sites with respect to their reservoir areas to be submerged as follows:

① Present land use in the proposed reservoir area: If there are farm lands and houses on a large scale, it may causes social problems as well as increasing costs.

② Land use regulation:
The reserved forest and development project plans by other government agencies shall be cosidered in the selectionof proposed reservoir.

The evaluation of 10 reservoir sites was made according to the scoring criteria presented in Table D-11 as given below:

SOCIAL EVLAUATION OF POSSIBLE SITES

Reservoir	Reservoir Area	Land Use Regulation	Score	Rank
Tha Sae (RID)	15	6	21	1
Rap Ro (RID)	5	6	11	5
Kaeng Phra Chao (NEA)	0	2	2	9
Ma La (NEA)	0	2	2	9
Upper Rap Ro	5	2	7	6
Pha-ngan	0	6	6	7
Nam Ron	10	2	12	4
Kum	0	6	6	7
Upper Kum	15	6	21	1
Kaphon	10	6	16	3

According to the field reconnaissance survey to the 10 reservoir sites, most of the proposed reservoir areas of 4 sites (Kaeng Phra Chao, Ma La, Pha-ngan and Kum) are used for farming, and relatively many peoples are living in the area. In the combined reservoir area of Kaeng Phra Chao and Ma La, large scale plantation of oil palm is being operated with the concession issued by the government.

The above-mentioned 4 reservoirs are excluded from the proposed reservoirs for water resources development of the Menam Chumphon basin, and the following 6 reservoirs have been proposed for the water resources development:

PROPOSED RESERVOIR

Reservoir	Basin	Catchment Area (sq.km)
Tha Sae	Tha Sae	338
Rap Ro	Rap Ro	503
Upper Rap Ro	- do -	106
Upper Kum	Khlong chumphon	16
Kaphon	- do -	15
Nam Ron	Rap Ro	21

D - 3 - 2 RESERVOIR OPERATION STUDY

In order to estimate the effective storage of reservoir for the purpose of irrigation and other water requirements, and its beneficial area, the reservoir operation study for the 3 large scale reservoirs is made on monthly basis. Based on the results of it, the effective storages of reservoir and the beneficial areas for the medium scale projects are assumed.

(1) Effective Storage

The effective storage space of reservoir for irrigation and other purposes is estimated by subtracting flood control space and sediment capacity from the gross storage capacity.

Reservoir	Gross Storage Capacity	Flood Control Space	Sediment Capacity	Effective Storage
	(MCM)	(MCM)	(MCM)	(MCM)
- Tha Sae	133.0	47.6 1/	5.1	80.3
- Rap Ro (W/O Upper)	192.0	120.1 1/	9.1	62.8
- Rap Ro (W/ Upper)	192.0	90.2 2/	9.1	92.7
- Upper Rap Ro	144.0	29.9 2/	1.6	112.5

(Note) W/O Upper; without Upper Rap Ro
W/Upper ; with Upper Rap Ro
1/; refer to Chapter IV-2-2 in Main Report
2/; Based on the results of flood control study described in Chapter IV-2-2, the flood control space of Upper Rap Ro reservoir is assumed to be 70% of the total flood water (427 MCM), equivalent with 29.9 MCM. Thus, the flood space of Rap Ro reservoir with Upper Rap Ro reservoir is estimated to be 90.2 MCM subtracting 29.9 MCM from the total control space, 120.1 MCM.

(2) Reservoir Operation

Basing on the water requirements for irrigation and other objectives as mentioned in the para. D-2-2 and D-2-3, the reservoir operation studies for each large potential reservoir are conducted under the following conditions.

① Inflow data

As inflow data to the reservoirs, 1/10 dry year's probable run-off (1985 year), at X64 station for Tha Sae reservoir and Kaeng Phra Chao station for Rap Ro and Upper Rap Ro reservoirs are employed (refer to Table C-18, in Appendix C).

② Water loss in the reservoir

Evaporation ; 70% of pan evaporation
Seepage ; 0.03% of total storage water per day

③ The operation study for Rap Ro reservoir is made by the two cases;

- Without Upper Rap Ro reservoir (D.A = 609 km^2)
- With Upper Rap Ro Reservoir (D.A = 503 km^2)

From the results of the operation study, the effective storage for each reservoir is estimated as follows;

EFFECTIVE STORAGE OF RESERVOIR (MCM)

Reservoir	Total Storage	Dead Water	Flood Water	Irrigation Water	D.A (km^2)
Tha Sae	133.0	5.1	47.6	80.3	338
Rap Ro (W/O Upper)	192.0	9.1	120.1	62.8	609
Rap Ro (W/ Upper)	192.0	9.1	90.2	92.7	503
Upper Rap Ro	63.9	1.6	29.9	32.4	106

ANNUAL WATER UTILIZATION (MCM)

Reservoir	Total Inflow	River Maintainance	Irrigation Water	Municipal & Other Water	Spill Water
Tha Sae	195.9	52.5	94.7	17.0	31.7
Rap Ro (W/O Upper)	349.4	94.7	77.5	18.0	159.2
Rap Ro (W/ Upper)	288.0	78.2	117.8	21.7	70.3
Upper Rap Ro	61.4	16.4	34.6	8.5	1.9

(Note) W/O Upper ; Case of without Upper Rap Ro reservoir
W/ Upper ; Case of with Upper Rap Ro reservoir
River M. Muni & O ; River Maintainance, Municipal Water and Others
D.A ; Drainage Area

The Upper Rap Ro has a maxim reservoir space of 144MCM in its topography, however, the actual total storage is found to be 63.9 MCM due to the limitation of its watershed.

D-3-3 Storage Scheme

As mentioned in the former, the ten of possible reservoir sites excluded with small scale project were found in the Study Area, basing on the topographical maps scaled 1 to 50,000. However, the four sites out of ten are judged to be no-possibility due to big environmental problems in those areas, remaining the six sites.

The potential sites are consisted of three large storage and three medium storage reservoirs. The large storage reservoirs will be a multipurpose project for flood control, irrigation, domestic and municipal water supply, and others. While, the medium storage reservoir aims to be the irrigation and domestic water supply for its beneficial area, without flood control purpose because of the small reservoir capacity.

The area also has a potential for construction of small scale reservoirs especially in the rolling area. In the rolling area excluding such un-usable area as watersheds of potential large and medium scale dams, concession area of oil palm, ALRO's area, area of wild-life sanctuary etc, about 45 sites of small scale reservoirs might be available assuming 10 km^2 of watershed for one storage

site but those locations are not identified because the projects will be implemented in response to the farmer's request.

Basing on and referring to the results of reservoir operation study for the large storage reservoirs, the storage scheme for potential reservoirs in the Study Area are resulted as follows;

POTENTIAL STORAGE SCHEME

Basin	Potential Storage Scheme			
	Project Scale	Nos	Catchment Area (km^2)	Storage (MCM)
Tha Sae	Large	1	338	80.3
	Small	23	228	34.7
Rap Ro	Large	1	503	92.7
	Medium	2	127	39.3
	Small	10	98	17.9
Tha Taphao	Small	4	40	6.8
K. Chumphon	Medium	2	31	12.1
	Small	8	86	15.2
Total		51	1,451	299.0

(Note) 1/: As for the Rap Ro basin, the table is shown with the two reservoirs construction, Upper Rap Ro and Rap Ro.

2/: Storage means the effective storage for the purpose of irrigation and other water requirements.

Table D-9 shows the tentative project feature for the potential reservoirs of large and medium scale.

D-3-4 Run-of-river Scheme

(1) River of Tha Taphao and Chumphon

River flows of two rivers of Tha Taphao and Chumphon are possible water resources for irrigation development of the downstream farm lands around the town of Chumphon where is located far downstream of the water source areas. The monthly average river runoff available for irrigation use is estimated at the crossing points with the railway.

AVAILABLE WATER AT INTAKE PLACE

Month	Tha Taphao River (D.A = 2,050 km²) (W/O. Re.)	(Ri. Main.)	Chumphon River (D.A = 346 km²) (W/O. Re.)	(Ri. Main.)
Jan.	28.99	26.56	7.45	4.48
Feb.	18.44 *		4.61	
Mar.	17.22 *		4.16 *	
Apr.	15.86 *		4.56 *	
May	61.17		14.77	
Jun.	91.55		40.81	
Jul.	131.61		38.90	
Aug.	241.75		89.14	
Sep.	170.66		61.02	
Oct.	216.44		59.43	
Nov.	226.72		73.42	
Dec.	66.77	26.56	19.97	4.48
Total	1,287.18	318.72	418.24	53.76

(Note) W/O. Re.: Available water without potential reservoirs
Ri. Main: River maintenance water
*: Water shortage by river maintenance
(Refer to Table D-10 (1/2), (2/2))

The above table indicates that the river runoff of two rivers are not effective for irrigation development of dry season cropping, thus leading to a conclusion that the water resources development of uncontrolled river runoff is technically not feasible.

(2) Stored Water in Nong Yai Swamp

The Nong Yai swamp which is proposed to a part of Ban Hua Wang Phanang Tuk canal will have a function as a water resources for irrigation purpose together with flood way by storing the excess water during the wet season in the swamp. The water will be stored by closing the gate to be installed at the reach of canal during dry season.

While the surrounding area of the swamp located at the north-east of Chumphon city, will be left from the developing area under the potential reservoirs, so that the area is sought for a new water resources.

Basing on the topographical maps scaled 1 to 10,000 surveyed by RID, the potentiality of swamp for pond is assumed as follows:

- Location : T. Bangluk and Nathung, A Muang Chumphon
- Watershed : 102 km^2
- Average Rainfall : 1,780 mm/year
- Average Run-off : 81.1 MCM/year
- Total Storage Capacity : 4.5 MCM
- F.W.L : 4.5 m (MSL)

D-3-5 Service Area

(1) Area for Storage Scheme

In the Study Area, the crops to be irrigated are mainly paddy, upland crop, vegetable and fruit tree as mentioned in the present conditions because of beneficial crops, and the production of oil palm and rubber tree will be increased if irrigated. As visualizing in the land use maps, those crops are scattered in the whole basin due to its topographical condition, so as to be difficult in selection of the target area for irrigation.

However, the paddy which is the basic crop for living is mainly planted along the main rivers and in the low land area, while the fruit tree and tree crop are in the rolling area, and vegetable and upland crops are planted mostly as an inter crop of tree crops and fruit tree, as a second crop in the paddy field and/or in some area, although those locations can't be identified due to small acreage.

a) Large Scale Reservoirs and Upper Rap Ro Reservoir

Since the abundant amount of water for irrigation is available from such potential reservoirs as Tha Sae, Rap Ro and Upper Rap Ro, the water shall be conveyed by gravity to the low land where the paddy fields are concentrated irrigating the other crops along the main rivers on the way.

From the results of reservoir operation study by monthly basis, the irrigable areas are preliminarily estimated as follows;

Reservoir	Description	Cropping Pattern Type I	Type II	Type III	Type IV	Type V	Total
	A (%)	17	8	9	64	2	100
	B (ha)	18,000	5,500	11,000	8,000	12,500	
Tha Sae	C (ha)	3,060	440	990	5,120	250	9,860
Rap Ro	B (ha)	18,000	4,500	9,000	6,000	8,500	
(W/O Upper)	C (ha)	3,060	360	810	3,840	170	8,240
Rap Ro	B (ha)	26,500	6,500	12,500	9,500	14,500	
(W/ Upper)	C (ha)	4,505	520	1,120	6,080	290	12,520
Upper Rap	B (ha)	5,200	2,200	3,400	3,200	5,000	
Ro	C (ha)	880	180	300	2,050	100	3,510

(Note)
A : Share of each type in the beneficial area
B : Maximum irrigable area by individual type
C : Irrigable area by each type, [A×B (%)]
Type I : Wet season paddy only
Type II : Wet season paddy + Dry season paddy
Type III : Wet season paddy + Upland crop
Type IV : Mixed farm (Vegetable + Fruit tree)
Type V : Fruit tree

b) Medium Scale Reservoirs

The potential medium scale reservoirs are located at the foot of mountains, undeveloped and/or less developed area. Judging from the economical point of view, the beneficial area will be the downstream, not so far from the reservoirs. The major crops in those beneficial area are fruit trees.

The irrigable area of each medium scale reservoir is presumed referring to the results of water operation study for the large scale reservoirs as below;

				Irrigation Area (ha)
Rap Ro Basin	:	Nam Ron reservoir	:	1,060
Chumphon Basin	:	Upper Kum reservoir	:	1,100
ditto	:	Kaphon reservoir	:	770
Total	:	3	:	2,930

c) Small Scale Reservoirs

The beneficial areas under the small scale reservoirs will be selected in the comparative high rolling areas being left from the water supply by the said large and medium scale reservoirs so as to be in fruit tree.

Basing on the results of water operation study for the large scale reservoirs, the beneficial areas under the small scale reservoirs are estimated by each basin as below;

Basin	Watershed (km^2)	Irrigable Area (ha)
Tha Sae	228	5,350
Rap Ro	98	2,760
Tha Taphao	40	1,050
Chumphon	86	2,340
Total	452	11,500

(2) Area for Nong Yai Project

There is some area where will not receive any water from the potential reservoirs, in the low land, north-east of Chumphon city. The area is one of the most beneficial area for supply of agriculture products to the city because of vicinity of city. The area can obtain the irrigation water from Nong Yai swamp as mentioned in the former para, and its beneficial area is estimated through the water operation study, resulting the irrigable area of 1,200 ha.

(3) Total Service Area

After completion of the all potential projects, the service area in the Study Area will be as follows;

POTENTIAL IRRIGABLE AREA

Basin	Project Scale	Name /Nos	Watershed (km^2)	Storage for Irrigation (MCM)	Irrigable Area (ha)	
Tha Sae	Large	Tha Sae Re.	338	80.3	9,860	
	Small	23 projects	228	34.7	5,350	
Rap Ro	Large	Rap Ro Re.	503	92.7	12,520	(W/Upper)
	Medium	Upper Rap Ro Re.	106	32.4	3,510	
		Nam Ron Re.	21	6.9	1,060	
	Small	10 projects	98	17.9	2,760	
Tha	Medium	Nong Yai Swamp	102	3.9	1,200	
Taphao	Small	4 projects	40	6.8	1,050	
	Medium	Upper Kum Re.	16	7.1	1,100	
Chumphon		Kaphon Re.	15	5.0	770	
	Small	8 projects	86	15.2	2,340	
Total			1,553	302.9	41,520	(259,500 rais)

(Note) W/ Upper ; with Upper Rap Ro reservoir Re. : reservoir

D - 4 NONG YAI IRRIGATION PROJECT

D - 4 - 1 Nong Yai Reservoir

(1) Development Plan

The Nong Yai swamp located at north-east of Chumphon city, far from about 4 km is presently utilized as an irrigation water resources to the surrounding farm lands.

During flood season, the water surface level of the swamp increases to more than 5.0 m MSL submarging about 700 ha (4,300 rai) for a while, but during dry season, that of the swamp decreases to 2.0 to 2.5 m MSL forming about 30 ha (200 rai) of swamp area, because no facilities to retain water are provided.

Therefore, the farming in the surrounding area of the swamp confronts with unstable situation.

In addition to the objective to use the swamp as a part of flood way, the Nong Yai swamp will be developed by enclosing it with dike and road as a water resources for the multi-purposes described below;

- Prevention of flood damages in the surrounding farm land of the swamp
- Development of water resources for irrigation
- Creation of fishery pond
- Development of transportation means for agriculture products
- Creation of resort area

(2) Reservoir Boundary and Water Level

The boundary of Nong Yai reservoir was planned basing on the following considerations.

- The boundary shall be inside of the public land, namely within 6.0 m contour where is the submarged area by flood.

- The present cultivation area shall be excluded within the reservoir area as much as possible.

While the decision of water level of reservoir was made by the following attentions.

- To avoid appearance of ill drainage area by raising groundwater table after completion of reservoir.
- To introduce gravity irrigation as wider as possible by retaining high water level.
- To retain the water depth at least 1.5 m for breading fishes.

Furthermore, taking into account of transportation means for agriculture products and maintenance works for reservoir, the width of dike was employed with 8.0 m, and at the portions without dike, the connecting roads were planned as enclosing the reservoir. Those road system can be connected with a railway station.

(3) Reservoir Feature

Basing on the topographical maps of swamp scaled 1 to 4,000 and the project area maps scaled 1 to 10,000 prepared by RID Survey Division, the reservoir plan was formulated as shown below;

GENERAL FEATURE OF NONG YAI RESERVOIR

1) Location : T. Bang Luk, Na Cha Ang and Na Thung
A. Muang Chumphon

2) River
- River Name : Lamu river, Khi Nak river, Krut river
- Watershed : 102 km^2
- Av. Rainfall : 1,780 mm/year (1981 - 1990)
- Av. Run-off : 795 mm/year (1981 - 1990)

3) Reservoir
- Reservoir Area : 5.43 km^2
- H. W. S : 6.2 m mean sea level (1/30 year flood)

- N. W. S : 4.5 m mean sea level
- L. W. S : 3.0 m mean sea level
- Total Storage : 4.5 MCM (N.W.S.)
- Effective Storage : 3.9 MCM
- Dead Storage : 0.6 MCM

4) Dike & Road
- Total Length : 13.9 km
- Crest Elevation : 7.5 m mean sea level
- Crest Width : 8.0 m

5) Irrigable Area : 1,200 ha (7,500 rai)

(4) Reservoir Operation Study

In order to estimate the irrigable area under the Nong Yai reservoir, the reservoir operation study was conducted with two cases for 10 years (1981 to 1990) by 10 days basis based on the following conditions.

- Case I : Irrigable area 1,130 ha
  Case II : Irrigable area 1,200 ha
- Rainfall data : Average rainfall data of Chumphon Meteorological station for 30 years (1961 - 1990)
- Run-off data : Run-off data for 10 years (1981 - 1990) at X 46A and X 46 RID gauging station
- Water requirement : Irrigation water and domestic water for the beneficial area
- Water losses in reservoir : Evaporation and seepage

The results of reservoir operation study are shown in Table D-12, Table D-13, Figure D-3 and Figure D-4. The reservoir operation study indicates that the Case I (1,130 ha of irrigable area) causes one time of water shortage during 10 years and the Case II (1,200 ha), two time.

D - 4 - 2 Irrigable Area

(1) Present Conditions

In the Study Area, most of farm land relies on the rainfed cultivation. But in this year, 1992, RID schedules to install a total of 33 units of irrigation pump with 6 to 8 inches diameters along the main rivers, Rap Ro, Tha Sae, Tha Taphao and their tributaries within Chumphon province for irrigation water, which will cover 2,160 ha (13,500 rai) of cultivation land, especially paddy field.

For this Nong Yai project, two units of pump out of 33 units will be provided in the north-west area, which can irrigate a total of 130 ha (800 rai) land.

Some part of the project area are irrigated by providing farmer's own portable pump when its necessary.

The area is divided into two areas, northern area and southern area from the view of irrigation aspect bordering the central hill crossed with west to east direction.

In the northern area, the agriculture is farmed by utilizing the Nong Yai swamp as a water resources, however, the water table of Nong Yai swamp rises 5.5 to 6.0 m mean sea level during every flood season, particularly November so that local varieties paddies such as Nang Phaya, Luang Pratue and Kao Surat which are strong in saturated condition are planted in the surrounding area of the swamp.

While, in the southern area, the Sam Kaeo canal plays a role of drainage canal and water resources for irrigation, however, the canal can't be used for irrigation water resources during the season when the water table of Tha Taphao river is low, January to July due to high content of salt.

The results of water quality test conducted in this study proved that fact showing the high value of 40 ms/cm electric conductivity.

In the northern bank of Sam Kaeo canal out of the southern area, the agriculture is practiced by utilizing another swamp which is formed in the low land during rainy season.

(2) Water Requirements

The proposed cropping patterns are classified into 4 types: type I (rainy season paddy), type II (rainy season paddy and dry season paddy), type III (mixed orchard) and type IV (vegetables). Based on the cropping patterns, irrigation water requirements are calculated. The crop consumptive use is estimated by the Modified Penman Method as Cu = KC × ETo. Crop factors (Kc) are derived from the report prepared by O & M Division, RID, and evapotranspiration (ETo) is calculated by Project Planning Division, RID.

In addition to the crop consumptive use, the following water is needed for irrigation of crops:

Paddy:
- Percolation : 1.0 mm/day
- Nursery bed : 400 mm
- Land preparation : 270 mm

Vegetables:
- Pre-irrigation : 40 ~ 50 mm

The net water requirements by cropping types are given below:

NET WATER REQUIREMENT

(Unit: mm)

Month	Type I (Paddy)	Type II (Paddy)	Type III (Orchard)	Type IV (Vegetables)
Jan.	142.8	142.8	108.3	148.9
Feb.	17.4	17.4	110.2	151.6
Mar.	-	337.6	136.5	187.7
Apr.	-	219.8	132.0	181.5
May	-	218.7	118.2	162.5
Jun.	-	146.7	108.6	149.3
Jul.	-	16.2	111.4	153.1
Aug.	-	-	109.3	150.3
Sept.	321.4	321.4	106.2	146.0
Oct.	167.4	167.4	101.5	139.6
Nov.	178.6	178.6	94.2	129.5
Dec.	191.1	191.11	103.3	142.0
Total	1,018.7	1,957.7	1,339.7	1,842.0

The diversion water requirements from the water resources is estimated taking effective rainfall and irrigation efficiency into account to the above net water requirement as presented in the former Chapter D-2-2.

(3) Irrigable Area

Considering the soil and topographical conditions, proposed cropping pattern, and flood-way plan, the proposal for land use of the project is made as shown below;

LAND USE PLAN

Description	Area (ha)	Share (%)
Crop land		
- Paddy	630	27.8
- Mixed orchard	1,221	54.0
- Coconut	144	6.4
- Rubber	5	0.2
- Vegetable	40	1.8
- Meadow	38	1.7
Sub-total	2,078	91.9
Natural Vegetation	68	3.0
Complex Land Use	4	0.2
Others	110	4.9
Total	2,260	100.0

Note: The land for Sam Kaeo and Hua Wang Phanang Tuk canals is included with the item of others.

Furthermore, the proposed land use is divided into seven blocks from the view point of topographical condition as below:

Block	Land Use Plan by Block (ha)				
	Paddy	Orchard	Vegetable	Others	Total
Block A	66	35	20	29	150
Block B	106	74	10	37	227
Block C	14	78	10	-	102
Block D	19	148	-	-	167
Block E	80	39	-	15	134
Block F	29	208	-	77	314
Block G	316	597	-	220	1,133
Sam Kaeo Canal	-	-	-	33	33
Total	630	1,179	40	411	2,260

Such crops as paddy, mixed orchard and vegetable will be irrigated as described in the former para., however the irrigation for paddy and vegetable whose productivity are easily affected by water shortage will be made with priority, since the storage water of Nong Yai reservoir will have limitation, so as to irrigate to mixed orchard as available as possible within the remaining water.

In addition, the net irrigable area is calculated subtracting areas of irrigation canals, roads, on-farm facilities, residences, etc. from the gross irrigable area, equivalent with about 7% of it. And 10% of the total paddy land is proposed to be double cropping area (wet season paddy and dry season paddy).

Basing on the considerations mentioned above, the reservoir operation study was conducted resulting the followings:

RESERVOIR OPERATION

Crops	Irrigable Area (ha)	
	Case I	Case II
Rainy Season Paddy	570	570
Double Cropping of Paddy	60	60
Mixed Orchard (Fruits)	460	530
Vegetable	40	40
Total	1,130	1,200
Water Shortage in 10 years	1	2

When 1,200 ha of farm lands are irrigated with the storage water of the Nong Yai reservoir (3.9 MCM), water shortage will occur in 2 years in the 10 year-period, whereas, in case of irrigation area of 1,130 ha, water shortage shall decrease to 1 year in the 10 year-period; the difference of irrigation area is only 70 ha. In drought years, water supplies will be saved for on irrigation as fruit trees are tolerable to water shortage. Accordingly, the irrigation plan has proposed to command 1,200 ha of farm lands, which are total farm lands in the project area except for coconut fields.

D - 4 - 3 Irrigation System

(1) Intake Capacity

The proposed irrigation area of 1,200 ha is divided into 7 blocks in consideration of topographic conditions, of which only one block (600 ha) is irrigated by gravity from Hua Wang Phanang Tuk canal; 6 blocks (600 ha) need pumping up of irrigation water from the Nong Yai reservoir and Hua Wang Phanang Tuk canal as given below:

IRRIGATION AREA

(Unit: ha)

Block	Type (Paddy)	Type II (Paddy)	Type III (Orchard)	Type IV (Vegetable)	Total	Remarks
A	60	6	17	20	103	Pumping
B	96	10	36	10	152	Pumping
C	13	1	38	10	62	Pumping
D	17	2	57	-	76	Pumping
E	72	8	19	-	99	Pumping
F	26	3	79	-	108	Pumping
G	286	30	284	-	600	Gravity
Total	570	60	530	40	1,200	

(Note) All of orchard area and 34 ha of paddy area (Type I 31 ha and Type II 3 ha) in the G Block are irrigated by pumping from the open channels after dividing water by gravity.

The design capacity of intake facility is depended on the irrigation and operation method but the effective rainfall in the field is not counted practically.

The water discharge for intake facility is estimated applying the following equation.

$$W.D = \Sigma [I \cdot A \times N \cdot W \cdot R / I \cdot E / O \cdot H]$$

where,

W.D	;	Water discharge by each time	
I · A	;	Irrigable area	
N · W · R	;	Net water requirement	
I · E	;	Irrigation efficiency	
		Paddy	0.55
		Orchard and vegetable	0.50

O · H ; Operation hour
Gravity 24 hour/day
Pumping 12 hour/day

The peak discharge out of estimated water discharges is employed as a design capacity of intake facility (refer to Table D-14 "Design Capacity of Irrigation Facility).

The summary of computation results is as follows;

Block	Irrigable Area (ha)	Peak Discharge (m^3/s)	Unit Discharge (ℓ/s/ha)
A	103	0.403	3.9
B	152	0.612	4.0
C	62	0.155	2.5
D	76	0.188	2.5
E	99	0.431	4.4
F	108	0.275	2.5
G	600	1.340	2.2
Total	1,200	3.404	

Peak water requirement occurs in September for rainy season paddy, whereas it occurs in March for dry season paddy, fruits and vegetables. With the proposed cropping patterns as above, peak water requirement occurs in the third 10 days of September.

(2) Irrigation System

After water intake, the irrigation water are conveyed through the open channels in the A, B, E and G blocks where are comparative flat areas, but in the C, D and F blocks the pipeline system is applied due to high land, down to a terminal irrigation area of 300 rai (48 ha).

The irrigation diagram by each block is shown in the attached drawings. Farm ditches will be provided to distribute water to each fields by farmer's groups. Water duty is 2.5 ℓ/s/ha for paddy (24 hours operation), 2.53 ℓ/s/ha for fruit trees (10 hours operation) and 3.48 ℓ/s/ha for vegetables (10 hours operation).

D - 4 - 4 Drainage System

(1) Drainage Modulus

a) Drainage of Project Area

The removal of excess irrigation water and rainfall from the soil surface is necessary to prevent damage to crops. Heavy rain falls mostly in consecutive 3 days. The following criteria are proposed for planning of drainage systems:

DRAINAGE MODULUS

Design Rainfall	:	Maximum 3 days rainfall of 254.7 mm
Return Period	:	5 years
Drainage Modulus	:	80% of the design rainfall for 3 days 17.9 mm/day, or 7.9 ℓ/s/ha (or 1.3 ℓ/s/rai)

In planning of drainage system, RID applies the reduction factor depending on the size of drainage area after consideration of the characteristic of rainfall prevailing in Thailand, however the drainage areas of one drainage system are mostly smaller than 2,000 rai (300 ha) with some undulated area, since then the reduction factor is not considered in this planning.

b) Drainage of Outside Project Area

Some of drainage canals have their watershed extended to outside of the project area. The designed discharge to such outside area was employed with 5 year frequency flood as below;

Design Rainfall	:	Maximum one day rainfall of 165.0 mm
Return Period	:	5 years
Drainage Modulus	:	80% of the design rainfall for one day 132.0 mm/day, or 15.3 ℓ/s/ha (or 2.4 ℓ/s/rai)

(2) Drainage System

Natural channels will be improved as main drainage canals. The project area is divided into 2 drainage systems; in the northern part, excess water is drained into Nong Yai reservoir and Hua Wang - Phanang Tuk canal; in the southern part, into Sam Kaeo canal.

The main drainage canals are planned as follows;

Block	Drainage Canal	Drainage Area (ha)	Canal Length (km)	Design Discharge (m^3/sec)
B	DB-1	512 (114)	1.9	7.0
E	ED-1	553 (140)	2.2	7.4
E	ED-2	319 (81)	1.2	4.3
G	GD-1	142 (142)	4.1	1.1
G	GD-2	553 (304)	6.4	6.2
G	GD-3	207 (207)	1.4	1.6
Total	6	2,286 (988)	17.2	

Note: Figure enclosed by ( ) means the drainage area inside of the project area.

D - 4 - 5 Preliminary Study on Sedimentation Problem

(1) General

The Nong Yai reservoir having with the major objectives of a part of flood-way and water resources for irrigation will be confronted with a sedimentation problem which will be caused by flood discharge from its watershed and Tha Taphao river through the two canals, Pak Phraek and Upper Hua Wang Phanang Tuk.

The preliminary study on the sedimentation problem of Nong Yai reservoir is made under the conditions of various assumptions as follows;

(2) Sediment from Natural Rivers

The sediment load in the Nong Yai reservoir from the three natural rivers, Lamu, Khi Nak and Krut river (a total watershed area of 102 km^2) is estimated to 15,300 m^3/year (150 m^3/km^2/year × 102 km^2) based on the study results described in the former para. D-2-4 "Sedimentation".

(3) Sediment from the Tha Taphao River

During the flood season, a part of flood water of Tha Taphao river together with suspended soils will be diverted into the Nong Yai reservoir through the two canals, Pak Phraek and Hua Wang Phanang Tuk canal, i.e., when the flood discharge of Tha Taphao river is 1,150 m^3/sec at the ×158 gauging station, a total of 540 m^3/sec discharge will flow into the reservoir.

In such case mentioned above, some of suspended soils will be deposited in the reservoir due to reduction of its flow velocity in the reservoir, but at this moment the theoretical analysis for those phenomena is rather difficult because of a lack of available data, so as to be preliminary conduction as below;

a) Size of Suspended Load

Depending on the velocity and/or energy of flood water, soil particles in the flow water are to be suspended, traveled or settled.

Flow condition for a certain particle will be judged by applying Mrs. Shinohara and Tsubaki formulas as described below equations and figure.

$$\phi_e = \frac{\Psi}{\Psi_o} \cdot \cdot \phi \qquad (1)$$

$$\phi = \frac{Uf^2}{(\sigma/\rho - 1)\, g \cdot d} \qquad (2)$$

$$\Psi = Um/Uf \qquad (3)$$

$$\Psi_o = 6.0 + 5.75 \log_{10} \frac{h}{d} \qquad (4)$$

where,

h	;	water depth
d	;	diameter of particle
Um	;	average water velocity
Uf	;	friction velocity $= \sqrt{g \cdot h \cdot I}$
I	:	slope of river bed

The flow condition of suspended soil (ϕ_e) of the Tha Taphao river at the just upstream diversion point of the Hua Wang Phanang Tuk canal, station No 31 + 28.00 was analyzed with the discharge of 880 m^3/sec. The results is shown in the below figure.

$$\phi_e = \frac{Um \times Uf}{(6.0 + 5.75 \log_{10} \frac{h}{d})(\sigma/\rho - 1)\, g \cdot d}$$

where,

h ; 7.596 m

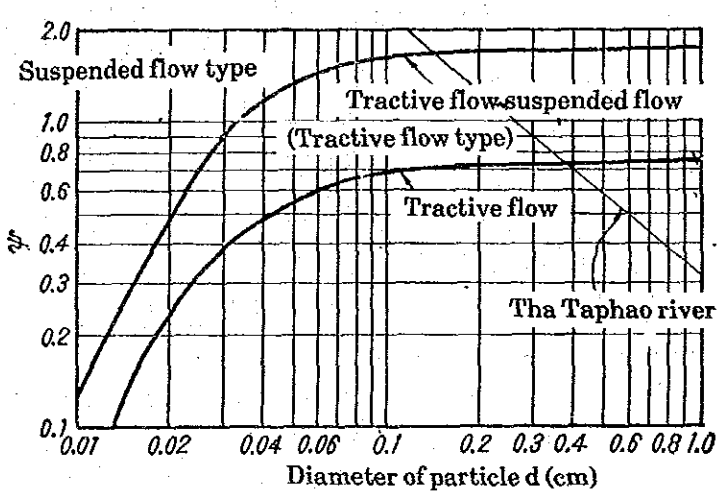
I ; 1/354.2

Uf : 0.458 m/sec

Um; 2.611 m/sec

σ ; 2.65

ρ ; 1.0



Border of flow type

The figure indicates that such small particles less than 2.0 mm in diameter as fine sand, silt and clay maybe flow into the reservoir from the Tha Taphao river being suspended in the flood water at the occurrence of flood with 880 m^3/sec discharge, namely the larger particles will travel and move to the downstream river as bed load.

b) Sediment Volume per 1,000 cu.m of Flood Water

The settlement phenomena of the suspended soils will occur in the reservoir because of reduction of flow velocity.

When Reynolds number is less than 1, the settling velocity of particle is estimated adopting Stokesian formula as below;

$$v = \frac{1}{18} \cdot (\rho'/\rho - 1) \cdot \frac{g}{\gamma} \cdot d^2 = \alpha \cdot Q/A = 2.16 \times 10^{-2} \text{ cm/sec} \qquad (6)$$

Where,

v	;	settling velocity of particle	(cm/sec)
ρ'	;	particle density (g/cm^3)	2.65
ρ	;	water density (g/cm^3)	1.00
g	;	acceleration of gravity	(cm/sec^2) 980
d	;	diameter of particle (cm)	
γ	;	coefficient of kinematic viscosity (g/cm.sec)	1.0×10^{-2}
α	;	coefficient affected by turbulent flow and eccentric flow	2.0
Q	;	inflow (cm^3/sec)	540 m^3/sec = 5.4×10^8 cm^3/sec
A	;	reservoir area (cm^2)	500 ha = 5×10^{10} cm^2

$$d = \sqrt{\frac{18 \cdot \gamma \cdot v}{(\rho'/\rho - 1) \cdot g}} = 1.55 \times 10^{-3} \text{ (cm)} = 0.0155 \text{ (mm)}$$

From the results of above computation, the particles with diameter of 2.0 to 0.01 mm are predicated to settle in the reservoir when the flood of 1,150 m^3/sec discharge occurs at ×158 gauging station.

Where, assuming the contexture of suspended load, the presumed settling rate of each soil in the reservoir is as below;

Soil	Assumed Share (%)	Assumed Settling Rate (%)
- Fine Sand (0.42 ~ 0.075 m/m)	10	100
- Silt (0.075 ~ 0.005 m/m)	40	70
- Clay (under 0.005 m/m)	40	-

Furthermore, on the assumption that the turbidity of the flood water is an average of 1,000 ppm, the sediment volume per 1,000 cu.m of flood water in the reservoir is estimated as below;

- Fine sand ; $1{,}000\ kg \times 0.1 \times 1.0 = 100$
- Silt ; $1{,}000\ kg \times 0.4 \times 0.7 = 280$
- Clay ; -

Total 380 kg/1,000 m^3

c) Inflow Water to the Reservoir

When about 20 percent of the Tha Taphao river flow-water in average is assumed to enter into the reservoir during the rainy season from August to November, the annual total inflow water to the reservoir is estimated as follows;

AVERAGE RUNOFF (MCM)[3/]

River/Reservoir	Watershed (km^2)	Aug.	Sep.	Oct.	Nov.	Total
- Rap Ro river	803	134.45[1/]	91.38	95.01	98.87	419.71
	(194)	(32.48)[2/]	(22.08)	(22.95)	(23.89)	(101.40)
- Tha Sae river	1,016	84.50	53.34	77.67	110.26	325.77
	(678)	(56.39)	(35.60)	(51.83)	(73.58)	(217.40)
	1,819	218.95	144.72	172.68	209.13	745.48
Sub-total	(872)	(88.87)	(57.68)	(74.78)	(97.47)	(318.80)
- Nong Yai reservoir		43.79	28.94	34.54	41.83	149.10
		(17.77)	(11.54)	(14.96)	(19.49)	(63.76)

1/ : without the multipurpose reservoirs
2/ : with the multipurpose reservoirs
3/ : Refer to Appendix, Table C-23, (4/7), (5/7)

d) Annual Sediment Volume in the Reservoir

From the results of above study, the assumed sediment volumes per year in the Nong Yai reservoir are as below;

In case of no multipurpose reservoirs;

$$V = 149.10\ MCM \times 0.38\ ton/1{,}000\ m^3/1.3\ t/m^3 \fallingdotseq 45{,}000\ m^3/year$$

In case of the multipurpose reservoirs;

$$V = 63.76\ MCM \times 0.38\ ton/1{,}000\ m^3/1.3\ t/m^3 \fallingdotseq 20{,}000\ m^3/year$$

(4) Dredging Plan

The Nong Yai reservoir provides the dead storage capacity of 600,000 cu.m for treat of sedimentation below the low water level of 3.0 m mean sea level.

Where, the sediment periods are calculated in the both cases without and with the proposed multipurpose reservoirs as follows;

In case of no-multipurpose reservoirs;

$$600{,}000\ m^3/(15{,}300 + 45{,}000) \fallingdotseq 10\ years$$

In case of the multipurpose reservoirs;

$$600{,}000\ m^3/(15{,}300 + 20{,}000) \fallingdotseq 17\ years$$

From the above results, the dredging works by dredger are recommended to be conducted periodically with about 10 years and 15 years in the case without and with the proposed multipurpose reservoirs respectively in order to treat the sedimentation problem in the Nong Yai reservoir. The dredged materials may fertilize the farm lands surrounding the reservoir.

TABLE D-1 LIST OF EXISTING WATER RESOURCES FACILITIES (RID)

Changwat	Amphoe	Project Name	Project Type	Beneficial Area (rai)	Re.
Chumphon (Medium)	Muang C.	Flood Relief.	Sam Kaeo Irr. canal, Gate	30,000	
Chumphon (Small)	Muang C.	Klo. Phru Kam Weir	Weir	1,000	
	ditto	Klo. Khun Krating Weir	ditto	1,500	
	ditto	Huai Mood Re.	Reservoir	2,000	
	ditto	Klo. Ma Young P.	Pump	2,500	
	Tha Sae	Pump Station	Pump	1,000	
	ditto	Klo. Krut Weir	Weir	1,300	
	Pathiew	Klo. Phala Weir	ditto	1,200	
	ditto	Klo. Bang Talai Weir	ditto	1,500	
	ditto	Klo. Sam Nak Weir	ditto	1,000	
	ditto	Klo. Kok Mha Weir	ditto	1,500	
	ditto	Klo. Pru Pling P.	Pump	500	
	ditto	Klo. Wat Nai Re.	Reservoir	1,200	
	ditto	Huai Loot Weir	Weir	300	
	ditto	Klo. Poke Rarng Weir	ditto	3,000	
	ditto	Klo. Toong Po Re.	Reservoir	1,500	
	ditto	Klo. Toong Sang Weir	Weir	3,000	
Total		17 projects		81,000	

TABLE D-2 LIST OF EXISTING WEIRS (KOR SOR CHOR PROJECT)

Changwat	Amphoe	Project Name	Project Type	Beneficial Area (rai)	Re.
Chumphon	Muang	Ma Yang Weir	Weir		
	ditto	Huai Ra Kum Weir	ditto		
	ditto.	Ban Khao Lan Weir	ditto		
	Tha Saè	Klo. Ta Ko Weir	ditto		
	ditto	Klo. Khuring Weir (No1)	ditto		
	ditto	Klo. Khuring Weir (No2).	ditto		
	ditto	Klo. Tak Weir	ditto		
	ditto	klo. Ka Po Weir	ditto		
	Pathiew	Klo. Wang Chang Weir	ditto		
Total		9 projects			

(Note) Data source; Summary Briefing Irrigation Projects in Chumphon Province (RID Chumphon Irrigation Office, Sep. 1992)

TABLE D-3 EVAPOTRANSPIRATION BY MODIFIED PENMAN METHOD

Station	CHUMPHON	Latitude	degree,LTD.....	10.0	Elevation of station above MSL.,(H). 3.0
			lipda,LTL.....	29.0	Height of wind vane above ground,(Z) 12.1
			LT=0.01745*(LTD+LTL/60)=...	0.183	P=1010-0.1115*H+(0.00175*H)^2=..... 1009.7

	Item	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
*	Mean Temperature,T	degree,C	25.1	26.3	27.4	28.5	27.9	27.3	27.0	26.9	26.9	26.6	25.8	25.0
*	Mean Relative Humidity, RH	%	81	80	78	78	81	82	82	83	83	85	85	81
*	Cloudiness (0-10)	-	5.2	4.9	4.8	5.8	7.7	8.3	8.3	8.6	8.2	7.6	7.1	5.8
*	Wind Speed, U(Z)	knot	4.5	4.3	4.1	3.7	3.4	3.9	3.8	3.8	3.6	2.5	3.7	4.6
	EA=6.108*exp(17.27*T/(T+237.3))	mbar	31.9	34.2	36.5	38.9	37.6	36.3	35.7	35.4	35.4	34.8	33.2	31.7
	ED=EA*RH/100	mbar	25.8	27.4	28.5	30.4	30.4	29.8	29.2	29.4	29.4	29.6	28.2	25.7
	U=(2/Z)^0.1874*U(Z)*1.85*24	km/day	142.6	136.3	129.9	117.2	107.7	123.6	120.4	120.4	114.1	79.2	117.2	145.8
	f(U)=0.27*(1+U/100)		0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.6	0.7
	DL=EA/(T+276)*(6790/(T+276)-5.028)		1.9	2.0	2.1	2.2	2.1	2.1	2.0	2.0	2.0	2.0	1.9	1.8
	W=DL/(DL+0.0006595*P)		0.74	0.75	0.76	0.77	0.76	0.76	0.75	0.75	0.75	0.75	0.74	0.73
	J=Int.(30.42*M-15.23)		15	45	76	106	136	167	197	228	258	288	319	349
	SD=0.4093*sin(0.0172*J-1.405)	radian	-0.4	-0.2	-0.0	0.2	0.3	0.4	0.4	0.2	0.0	-0.2	-0.3	-0.4
	SL=1-0.01673*cos(0.017214*J)	radian	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	XX=sin(SD)*sin(LT)		-0.1	-0.0	-0.0	0.0	0.1	0.1	0.1	0.0	0.0	-0.0	-0.1	-0.1
	YY=cos(SD)*cos(LT)		0.9	1.0	1.0	1.0	0.9	0.9	0.9	1.0	1.0	1.0	0.9	0.9
	NL=arcos(-XX/YY)	radian	1.5	1.5	1.6	1.6	1.6	1.7	1.6	1.6	1.6	1.5	1.5	1.5
	RA=15.54*(NL*XX+sin(NL)*YY)/SL^2	mm/day	13.1	14.1	15.2	15.7	15.6	15.3	15.4	15.5	15.3	14.5	13.4	12.7
	N/NN=1-0.05557*C-0.00122*C^2		0.7	0.7	0.7	0.6	0.5	0.5	0.5	0.4	0.5	0.5	0.5	0.6
	RNS=(0.19+0.375*N/NN)*RA	mm/day	5.8	6.4	6.9	6.7	5.9	5.5	5.5	5.5	5.6	5.5	5.3	5.5
**	RNL	mm/day	1.3	1.3	1.2	1.1	0.9	0.8	0.8	0.8	0.8	0.9	1.0	1.2
	(1-W)*f(U)*(EA-ED)	mm/day	1.0	1.1	1.2	1.2	1.0	1.0	0.9	0.9	0.9	0.6	0.8	1.1
	W*RN=W*(RNS-RNL)	mm/day	3.3	3.8	4.3	4.3	3.8	3.6	3.6	3.5	3.6	3.5	3.2	3.1
	ETr = W*RN+(1-W)*f(U)*(EA-AD)	mm/day	4.4	4.9	5.5	5.5	4.8	4.5	4.5	4.4	4.4	4.1	3.9	4.2
	ETr	mm/m	135.4	137.8	170.6	165.0	147.8	135.7	139.2	136.6	132.7	126.9	117.7	129.1

* Climatological data of Thailand 30-year period (1961-1990) of METEOROLOGICAL DEPARTMENT,MINISTRY OF COMMUNICATIONS,BANGKOK,THAILAND,November 26,1991

** RNL=8.7274/10^12*(7.7273-(ED)^0.5)*(1+9*N/NN)*(T+273)^4)

(This paper was prepared by PPD. Section 2. RID)

TABLE D-4 DIVERSION WATER REQUIREMENT (WET SEASON PADDY) (1/4)

Month	Sep			Oct			Nov			Dec			Jan			Feb		
10 days	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Cropping Pattern																		
Element - Growing day	10	20	30	40	50	61	71	81	91	101	111	122	132	137				
- Crop Factor(Kc)	0.92	0.94 0.92	1.00 0.94 0.92	1.11 1.00 0.94 0.92	1.21 1.11 1.00 0.94	1.29 1.21 1.11 1.00	1.32 1.29 1.21 1.11	1.30 1.32 1.29 1.21	1.27 1.30 1.32 1.29	1.21 1.27 1.30 1.32	1.15 1.21 1.27 1.30	1.07 1.15 1.21 1.27	0.84 1.07 1.15 1.21	0.75 0.84 1.07 1.15	0.75 0.84 1.07	0.75 0.84	0.75	
Average Kc	0.92	0.93	0.95	0.99	1.07	1.15	1.23	1.28	1.30	1.28	1.23	1.18	1.07	0.95	0.89	0.80	0.75	
- ETr (mm/day)	4.4			4.10			3.9			4.2			4.4			4.9		
- ETc (mm/day)	4.05	4.09	4.18	4.06	4.39	4.72	4.80	4.99	5.07	5.38	5.17	4.96	4.71	4.18	3.92	3.92	3.68	
- Percolation(mm/d)	1.00			1.00			1.00			1.00			1.00			1.00		
- ETc + P (mm/day)	5.05	5.09	5.18	5.06	5.39	5.72	5.80	5.99	6.07	6.38	6.17	5.96	5.71	5.18	4.92	4.92	4.68	
- Initial Leaching - Land Preparation	70 mm 200 mm																	
Equation - Initial Leaching - Land Preparation - Normal Irrigation	1/3 1/3 1/9	1/3 1/3 3/9	1/3 1/3 5/9	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	23/24	2/3	1/3	1/24	
Water Requirement - Initial Leaching - Land Preparation - Normal Irrigation	23.3 66.7 5.6	23.3 66.7 17.0	23.4 66.6 28.8	50.6	53.9	62.9	58.0	59.9	60.7	63.8	61.7	65.6	57.1	49.6	36.1	16.4	1.0	
- NWR (mm/month)	321.4			167.4			178.6			191.1			142.8			17.4		
- Rainfall	157.7			275.5			375.1			118.1			93.9			62.8/2		
- Effective Rainfall	118.3			200.0			200.0			88.6			70.4			23.6		
- FWR (mm/month)	203.1			0.0			0.0			102.5			72.4			0.0		
- Irrigation E	0.55			0.55			0.55			0.55			0.55			0.55		
- DWR (mm/month)	369.3			0.0			0.0			186.4			131.6			0.0		

(Note) 1) NWR ; Net Water Requirement , FWR ; Field Water Requirement , DWR ; Diversion Water Requirement
E ; Efficience

TABLE D-4 DIVERSION WATER REQUIREMENT (DRY SEASON PADDY) (2/4)

Month	Mar			Apr			May			Jun			Jul			Aug		
10 days	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Cropping Pattern																		
Element - Growing day	10	20	31	41	51	61	71	81	92	102	107							
- Crop Factor(Kc)	0.93	0.97 0.93	1.10 0.97 0.93	1.23 1.10 0.97 0.93	1.30 1.23 1.10 0.97	1.32 1.30 1.23 1.10	1.28 1.32 1.30 1.23	1.22 1.28 1.32 1.30	1.10 1.22 1.28 1.32	0.88 1.10 1.22 1.28	0.75 0.88 1.10 1.22	0.75 0.88 1.10	0.75 0.88	0.75				
Average Kc	0.93	0.95	1.00	1.06	1.15	1.24	1.28	1.28	1.23	1.12	0.99	0.91	0.82	0.75				
- ETr (mm/day)	5.5			5.5			4.8			4.5			4.5			4.4		
- ETc (mm/day)	5.12	5.23	5.50	5.83	6.33	6.82	6.14	6.14	5.90	5.04	4.46	4.10	3.69	3.38				
- Percolation(mm/d)	1.00			1.00			1.00			1.00			1.00			1.00		
- ETc + P (mm/day)	6.12	6.23	6.55	6.83	7.33	7.82	7.14	7.14	6.90	6.04	5.46	5.10	4.69	4.38				
- Initial Leaching - Land Preparation	70 mm 200 mm																	
Equation - Initial Leaching - Land Preparation - Normal Irrigation	1/3 1/3 1/9	1/3 1/3 3/9	1/3 1/3 5/9	1/1	1/1	1/1	1/1	1/1	1/1	1/1	23/24	2/3	1/3	1/24				
Water Requirement - Initial Leaching - Land Preparation - Normal Irrigation	23.3 66.7 6.8	23.3 66.7 20.8	23.4 66.6 40.0	68.3	73.3	78.2	71.4	71.4	75.9	60.4	52.3	34.0	15.3	0.9				
- NWR (mm/month)	337.6			219.8			218.7			146.7			16.2					
- Rainfall	56.5			74.4			188.9			173.5			174.2/2			206.0		
- Effective Rainfall	42.4			55.8			141.7			130.1			65.3			154.5		
- FWR (mm/month)	295.2			164.0			77.0			16.6			0.0			0.0		
- Irrigation E	0.55			0.55			0.55			0.55			0.55			0.55		
- DWR (mm/month)	536.7			298.2			140.0			30.2			0.0			0.0		

(Note) 1) NWR ; Net Water Requirement , FWR : Field Water Requirement , DWR ; Diversion Water Requirement
E ; Efficience

TABLE D-4 DIVERSION WATER REQUIREMENT (DRY SEASON UPLAND CROP) (3/4)

Month	Mar			Apr			May			Jun			Jul			Aug		
10 days	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Cropping Pattern																		
Element - Growing day	10	20	31	41	51	61	71	81	92	102	107							
- Crop Factor(Kc)	0.54	0.66	0.91	1.13	1.33	1.37	1.35	1.26	1.02	0.86	0.60							
		0.54	0.66	0.91	1.13	1.33	1.37	1.35	1.26	1.02	0.86	0.60						
			0.54	0.66	0.91	1.13	1.33	1.37	1.35	1.26	1.02	0.86	0.60					
				0.54	0.66	0.91	1.13	1.33	1.37	1.35	1.26	1.02	0.86	0.60				
Average Kc	0.54	0.60	0.70	0.81	1.01	1.19	1.30	1.33	1.25	1.12	0.94	0.83	0.73	0.60				
- ETr (mm/day)	5.5			5.5			4.8			4.5			4.5			4.4		
- ETc (mm/day)	2.92	3.30	3.85	4.46	5.56	6.55	6.24	6.38	6.00	5.04	4.23	3.74	3.29	2.70				
- Land Preparation																		
Equation - Land Preparation - Normal Irrigation	1/9	3/9	5/9	1/1	1/1	1/1	1/1	1/1	1/1	1/1	23/24	2/3	1/3	1/24				
Water Requirement - Land Preparation - Normal Irrigation	3.3	11.0	23.5	44.6	55.6	65.5	62.4	63.8	66.0	50.4	40.5	24.9	11.0	0.6				
- NWR (mm/month)	37.8			165.7			192.2			115.8			11.6					
- Rainfall	56.5			74.4			188.9			173.5			174.2/2			206.0		
- Effective Rainfall	42.4			55.8			120.0			120.0			60.0			120.0		
- FWR (mm/month)	0.0			109.9			72.2			0.0			0.0			0.0		
- Irrigation E	0.50			0.50			0.50			0.50			0.50			0.50		
- DWR (mm/month)	0.0			219.8			144.4			0.0			0.0			0.0		

(Note) 1) NWR ; Net Water Requirement , FWR ; Field Water Requirement , DWR ; Diversion Water Requirement
E ; Efficience

TABLE D-4 DIVERSION WATER REQUIREMENT (VEGETABLE, UPLAND CROP, FRUIT TREE) (4/4)

Description \ Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cropping Pattern												
- Vegetable												
- Upland Crop												
- Fruit Tree												
- Crop Factor (Kc)												
Vegetable	1.1	→										1.1
Upland crop	1.0	→										1.0
Fruit tree	0.8	→										0.8
- ETr (mm/month)	135.4	137.8	170.6	165.0	147.8	135.7	139.2	136.6	132.7	126.9	117.7	123.1
- ETc (mm/month)												
Vegetable	148.9	151.6	187.7	181.5	162.6	149.3	153.1	150.3	146.0	139.6	129.5	142.0
Upland crop	135.4	137.8	170.6	165.0	147.8	135.7	139.2	136.6	132.7	126.9	117.7	129.1
Fruit tree	108.3	110.2	136.5	132.0	118.2	108.6	111.4	109.3	106.2	101.5	94.2	103.3
- Rainfall(mm/month)	93.9	62.8	56.5	74.4	188.9	173.5	174.2	206.0	157.7	275.5	375.1	118.1
- Effective Rainfall	70.4	47.1	42.4	55.8	120.0	120.0	120.0	120.0	118.3	120.0	120.0	88.6
- FWR (mm/month)												
Vegetable	78.5	104.5	145.3	125.7	42.6	29.3	33.1	30.3	27.7	19.6	9.5	53.4
Upland crop	65.0	90.7	128.2	109.2	27.8	15.7	19.2	16.6	14.4	6.9	0.0	40.5
Fruit tree	37.9	63.1	94.1	76.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.7
- Irrugation E	0.5	→										0.5
- DWR (mm/month)												
Vegetable	157.0	209.0	290.6	251.4	85.2	58.6	66.2	60.6	55.4	39.2	19.0	106.8
Upland crop	130.0	181.4	256.4	218.4	55.6	31.4	38.4	33.2	28.8	13.8	0.0	81.0
Fruit tree	75.8	126.2	188.2	152.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.4

(Note) 1) FWR ; Feild Water Requirement , DWR ; Diversion Water Requirement
E ; Efficience

TABLE D-5 LIST OF SEDIMENT STATIONS , DRAINAGE AREA AND MEAN ANNUAL SEDIMENT

OF

PENINSULA-EAST COAST

Sedimentation Investigation Branch.
Hydrology Division.
Royal Irrigation Department.

Programmer. T. Amornchit

Date. 25 Oct 1990

NO.	RIVER	CODE	LOCATION		APPROX.		PERIOD	D.A.	MEAN ANNUAL SEDIMENT	*
			AMPHOE	CHANGWAT	LAT. ° N	LONG. ' E		Sq.Km.	TONS	
1.	Khlong Tha Sae	210101	Tha Sae	Chumphon	10-52.5	99-14.3	1964-1968	352	15,800	2
2.	Khlong Rap Po	210103	Tha Sae	Chumphon	10-47.3	99-04.1	1966-1981 1983-1984 1986	330	18,800	2
3.	Khlong Mala	210104	Tha Sae	Chumphon	10-41.2	99-03.4	1983-1987	188	5,650	2
4.	Khlong Sawi	210401	Sawi	Chumphon	10-12.6	99-04.8	1983-987	393	29,200	2
5.	Lang Suan River	210501	K.Phato	Chumphon	9-56.1	98-16.5	1963-1971 1973-1976	1,240	629,000	2
6.	Khlong Tha Thon	211101	Sichon	Nakhon Si Thammarat	8-52.1	99-45.6	1985-1986	45.6	6,420	2
7.	Khlong Klai	211202	Tha Sala	Nakhon Si Thammarat	8-44.0	99-43.2	1973	448	137,000	2
8.	Khlong Phai	211901	Khiri Ratthanikhom	Surat Thani	6-13.5	101-30.0	1965-1974 1976-1980 1982-1983 1985-1987	1,190	374,000	2
9.	Khlong Thepa	X.27	Thepa	Songkhla	6-42-50	100-57-48	1965-1966	1,577	36,200	1
10.	Khlong Takhian	X.103	Chaiya	Surat Thani	9-25-31	99-09-44	1981-1988	180	4,398	1
11.	Khlong Tha Krachai	X.104	Tha Chana	Surat Thani	9-34-47	99-08-14	1984	354	8,086	1
12.	Kolok	X.119	Sugai Kolok	Narathiwat	6-04-09	102-02-22	1981-1984 1986-1987	1,600	117,893	1
13.	Khlong Waeng	X.121	Waeng	Narathiwat	5-55-26	101-55-14	1987-1988	43	5,914	1

TABLE D-6 AVE. MONTHLY DISCHARGE OF THA SAE (X64, CA = 957km²)

(unit: m³/sec)

Year	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1973	1.40	2.00	2.40	6.57	14.00	13.00	12.00	24.00	10.00	4.75	3.00	2.00
1974	1.20	2.20	8.25	4.50	9.50	8.75	10.00	13.00	9.00	6.25	6.75	3.20
1975	2.28	1.90	9.56	8.24	12.00	17.00	24.00	28.00	11.00	6.00	3.23	1.90
1976	2.25	3.80	7.00	5.00	5.00	7.80	6.40	16.00	7.20	4.60	4.20	3.00
1977	1.95	1.80	1.50	1.50	3.60	12.00	10.00	9.00	4.60	3.20	3.00	2.70
1978	2.70	1.95	7.40	6.20	7.80	0	26.90	10.00	5.40	3.00	3.00	0.30
1979	0.15	0.45	1.50	9.00	13.25	8.00	7.00	2.55	1.20	0.45	0.00	0.00
1980	0.00	0.00	1.20	5.20	4.80	8.60	4.20	4.20	1.05	0.60	0.00	0.00
1981	0.00	0.00	0	2.85	0	5.20	6.20	11.00	6.20	2.70	1.35	0.00
1982	1.50	1.50	2.45	3.05	6.00	9.50	8.50	16.80	5.20	2.45	1.20	0.75
1983	0.95	0.66	0.62	0.64	0.63	0.60	0.61	10.00	0.60	0.66	0	0.60
1984	3.92	3.92	4.64	10.61	7.60	25.15	21.72	10.84	8.40	6.80	5.40	4.46
1985	0.78	1.98	4.00	3.70	2.95	6.80	13.00	12.50	6.00	3.70	2.35	1.59
1986	1.20	1.06	3.28	6.66	12.02	9.00	12.98	9.69	5.47	3.54	2.37	1.98
1987	1.28	1.20	2.30	1.54	1.44	4.85	3.95	8.40	4.85	2.45	1.68	1.12
1988	0.66	2.38	1.54	5.16	2.20	6.87	14.22	6.87	8.04	4.60	3.68	2.94
1989	0	0	0	0	0	0	0	0	0	0	0	0
1990	2.00	1.40	2.00	2.00	1.60	3.80	7.00	13.75	4.40	1.80	1.40	1.20
To.	24.22	28.20	59.64	82.42	104.39	146.92	188.68	206.60	98.61	57.55	42.61	27.74
Av.	1.42	1.66	3.73	4.84	6.52	9.18	11.10	12.15	5.80	3.39	2.66	1.63
100 km²	0.15	0.17	0.39	0.51	0.68	0.96	1.16	1.27	0.61	0.35	0.28	0.17

TABLE D-7 AVE. MONTHLY DISCHARGE OF RAPRO (X46, CA = 751km²)

(unit: m³/sec)

Year	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1985	0.72	2.00	3.35	6.15	4.70	10.44	10.68	11.16	4.84	2.00	1.52	0.56
1986	0.40	0.16	4.64	9.80	12.50	18.20	19.40	10.50	6.80	4.06	2.74	1.57
1987	0.97	1.33	2.72	2.90	2.38	10.00	6.39	8.80	4.92	2.50	1.60	0.97
1988	1.00	2.90	2.15	6.50	7.10	7.40	19.81	10.64	9.92	5.90	3.80	3.05
1989	3.16	3.16	9.00	5.94	17.62	28.89	20.57	19.64	13.46	9.00	6.30	4.42
1990	3.99	4.16	11.64	11.90	10.86	22.79	27.41	27.41	12.68	6.20	5.35	3.99
To.	10.24	13.71	33.50	43.19	55.16	97.72	104.26	88.15	52.62	29.66	21.31	14.56
Av.	1.71	2.29	5.58	7.20	9.19	16.29	17.38	58.32	8.77	4.94	3.55	2.42
100 km²	0.23	0.30	0.74	0.96	1.22	2.17	2.31	7.76	1.17	0.66	0.47	0.32

TABLE D-8 LIST OF POSSIBLE RESERVOIRS (1/3)

1) Reservoir Name	(1) Tha Sae Re. (RID)	(2) Rap Ro Re. (RID)	(3) Kaeng Phra Chao Re. (NEA)	(4) Ma La Re. (NEA)
2) Location				
Changwat	Chumphon	Chumphon	Chumphon	Chumphon
Amphoe	Tha Sae	Tha Sae	Tha Sae	Tha Sae
Tumbon	Hong Chalern/Rap Ro	Rap Ro	Rap Ro /Khu Ning	Rap Ro
3) Watershed				
a) River Name	Khlong Tha Sae	Khlong Rap Ro	Khlong Rap Ro	Khlong Ma La (tributary of Khlong Rap Ro)
b) Watershed Area(km^2)	338	609	333	183
c) Ave. Rainfall (mm/y)	1,550 (Tha Ngo)	2,240 (Phra Chao)	2,240 (Phra Chao)	2,240 (Phra Chao)
d) Ave. Runoff (mm/y)	550	780	780	780
4) Reservoir Area				
a) Limited Max. W.L (m)	100	65	135	120
b) Limited Max. Area (ha)	815 (5,094 rai)	1,899 (11,900rai)	4,284 (26,780rai)	5,203
c) Max. Potential Storage (MCM)	133	192	511	1,243
d) Vegetation	Mostly forest/some plantation (rubber, coffee, bean, etc)	Plantation area (oil palm, rubber, coffe, etc)	Plantation area (mostly oil palm by the big private companies/some rubber, coffee, etc)	Plantation area (coeffe, coconut, oil palm, rubber, etc)
e) Household (families)	about 20	not less than 200		500 to 1,000
5) Dam Site				
a) Geological Foundation	Palaeozoic pebbly slaty shale, siltstone, partly sand stone/shallow bed rock/near fault	Palaeozoic pebbly siltstone deep bed rock	Palaeozoic tuff, agglomerate, andesitic dike, quartz dike/shale at the down stream/shallow-bed rock/near fault	Palaeozoic pebby siltstone, partly sandstone/shallow bed rock/near fault
b) Construction Materials	Much of rock & transition but core material shall be investigated	Enough materials (rock, transition, core)	Much of rock & transition but core material shall be investigated	Enough materials (rock, transition, core)
6) Dam-body				
a) Dam Type	Fill type (clouser)	Fill type (clouser)	Fill type (clouser)	Fill type (clouser)
b) Assumed Crest Length (m)	Appx. 1,130	Appx. 260	Appx. 290 (mein dam)	Appx. 400
c) Assumed Dam Height (m)	Appx. 50	Appx. 40	Appx. 45	Appx. 70
7) Others	Large scale	Large scale	Large scale	Large scale

(Note) #1 ; Limited Max. W.L means that the highest water level which will be limited by the topographical and other technical conditions
#2 ; Reservoir capacity and dam dimension are assumed basing on the topo-maps scaled 1/50,000
#3; Project scale is assumed tentatively from the reservoir capacity

TABLE D-8 LIST OF POSSIBLE RESERVOIRS (2/3)

1) Reservoir Name	(5) Upper Rap Ro Re	(6) Pha-ngan Re	(7) Nam Ron Re	(8) Kum Re
2) Location				
Changwat	Chumphon	Chumphon	Chumphon	Chumphon
Amphoe	Tha Sae	Tha Sae	Tha Sae	Muang Chumphon
Tumbon	Hong Chalern/Rap Ro	Rap Ro	Rap Ro /Khu Ning	Banna
3) Watershed				
a) River Name	Khlong Rap Ro	Khlong Pha-ngan(tributary of Khlong Rap Ro)	Khlong Nam Ron(Khlong Pha-ngan/Khlong Rap Ro)	Khlong Kum (tributary of Khlong Chumphon)
b) Watershed Area(km^2)	106	73	21	46
c) Ave. Rainfall (mm/y)	2,240 (Phra Chao)	1,880 (X 46 A)	1,880 (X 46 A)	2,540 (Kra Buri)
d) Ave. Runoff (mm/y)	780	660	660	890
4) Reservoir Area				
a) Limited Max. W.L (m)	160	55	100	120
b) Limited Max. Area (ha)	951 (5,940rai)	1,010 (6,310rai)	240 (1,500rai)	385 (2,410rai)
c) Max. Potential Storage (MCM)	144	156	48	72
d) Vegetation	Forest and plantation area(oil palm, coffee, bean ,etc)	Plantation area (fruit tree, coffee, coconut, etc)	Forest and plantation area (fruit tree, coconut, etc)	Plantation area (fruit tree, coffee, coconut, etc)
e) Household (families)	200 to 300	not less than 1,000	50 to 100	not less than 200
5) Dam Site				
a) Geological Foundation	Palaeozoic pebbly siltstone, partly conglomerate/shallow bed rock/near fault	Palaeozoic siltstone deep bed rock at the left bank	Palaeozoic shale orthoquatzite /shallow bed rock	Palaeozoic sandstone, siltstone/deep bed rock/landslide at the left bank
b) Construction Materials	Much of rock & transition but core material shall be investigated	Enough impervious materials	Much of rock & transition but core material shall be investigated	Avairable for constraction materials
6) Dam-body				
a) Dam Type	Fill type (clouser)	Fill type (clouser)	Fill type (clouser)	Fill type (clouser)
b) Assumed Crest Length (m)	Appx. 420	Appx. 800	Appx. 490 (mein dam)	Appx. 700
c) Assumed Dam Height (m)	Appx. 30	Appx. 45	Appx. 50	Appx. 50
7) Others	Large scale	Large scale	Large scale	Large scale

(Note) #1 ; Limited Max. W.L means that the highest water level which will be limited by the topographical and other technical conditions
#2 ; Reservoir capacity and dam dimension are assumed basing on the topo-maps scaled 1/50,000
#3; Project scale is assumed tentatively from the reservoir capacity

TABLE D-8 LIST OF POSSIBLE RESERVOIRS (3/3)

1) Reservoir Name	(9) Upper Kum Re	(10)Kaphon Re		
2) Location				
Changwat	Chumphon	Chumphon		
Amphoe	Muang Chumphon	Muang Chumphon		
Tumbon	Banna	Wangnai		
3) Watershed				
a) River Name	Khlong Kum (tributary of Khlong Chumphon)	Khlong Kaphon(tributary of Khlong Chumphon)		
b) Watershed Area(km^2)	16	15		
c) Ave. Rainfall (mm/y)	2,540 (Kra Buri)	1,880 (X 46 A)		
d) Ave. Runoff (mm/y)	890	660		
4) Reservoir Area				
a) Limited Max. W.L (m)	140	70		
b) Limited Max. Area (ha)	120 (750rai)	155 (1,030rai)		
c) Max. Potential Storage (MCM)	36	25		
d) Vegetation	Mostly forest/some plantation(coffee, fruit tree, coconut, etc)	Plantation area (coffee, fruit tree, coconut, etc)		
e) Household (families)	about 20	50 to 100		
5) Dam Site				
a) Geological Foundation	Palaozoic sandstone/deep bed rock at the right bank/landslide at the left bank	Palaeozoic pebbly siltstone, partly sandstone/deep bed rock at the right bank/near fault		
b) Construction Materials	Available for construction materials	Available for constraction materials		
6) Dam-body				
a) Dam Type	Fill type (clouser)	Fill type (clouser)		
b) Assumed Crest Length (m)	650	500		
c) Assumed Dam Height (m)	70	40		
7) Others	Medium scale	Medium scale		

(Note) #1 ; Limited Max. W.L means that the highest water level which will be limited by the topographical and other technical conditions
#2 ; Reservoir capacity and dam dimension are assumed basing on the topo-maps scaled 1/50,000
#3; Project scale is assumed tentatively from the reservoir capacity

TABLE D-9 TENTATIVE PROJECT FEATURE FOR POTENTIAL RESERVOIRS

Description \ Reservoir	Tha Sae	Rap Ro	Upper Rap Ro	Upper Kum	Nam Ron	Kaphon
1) Location						
Changwat	Chumphon	Chumphon	Chumphon	Chumphon	Chumphon	Chumphon
Amphoe	Tha Sae	Tha Sae	Tha Sae	Muang	Tha Sae	Muang
Tumbon	Salui	Rap Ro	Rap Ro/Hong	Wangmai	Rap Ro	Wangumai
2) River						
a) River Name	Tha Sae	Rap Ro	Rap Ro	Kum (tributary of Khlong Chumphon)	Nam Ron (Pha -ngan/Rap Ro)	Kaphon (Chumphon)
b) Watershed (km^2)	338	503 [609]	106	16	21	15
c) Ave. Rainfall (mm/y)	1,550	2,240	2,240	2,540	1,880	1,880
d) Ave. Runoff (mm/y)	550	780	780	890	660	660
3) Reservoir Area						
a) Objective	F.I	F.I	F.I	I	I	I
b) Total Sto. Capa.(MCM)	133	192	63.9	7.3	7.2	5.2
c) Flood Capa. (MCM)	47.6	90.2 [120.1]	29.9	-	-	-
d) Irrigation Capa. (MCM)	80.3	92.7 [62.8]	32.4	7.1	6.9	5.0
e) Sediment Volume (MCM)	5.1	9.1	1.6	0.2	0.3	0.2
f) F.W. L (m)	100	65	150	106	71	48
g) Reservoir Area (ha)	815 (5,100 rai)	1,899 (11,900 rai)	630 (3,900 rai)	49 (310 rai)	65 (410 rai)	50 (310 rai)
4) Dam-body						
a) Dam Type	Fill type	Fill type	Fill type	Fill type	Fill type	Fill type
b) Crest Length (m)	1,130	260	300	430	240	250
c) Dam Height (m)	50	40	25	40	25	25
5) Distribution						
a) Irrigable Area (ha)	9,860 (61,600 rai)	12,520 [8,240] (78,300 rai)	3,510 (21,900 rai)	1,100 (6,800 rai)	1,060 (6,600 rai)	770 (4,500 rai)
6) Others	Large scale	Large scale	Mediumscale	Medium scale	Medium scale	Medium scale

(Note) a) ; Dam dimensions are assumed based on the millitary maps scaled 1 to 50,000
b) ; Sto. ; storage, Capa ; capacity
F ; flood, I ; irrigation
c) ; Figure in [ ] is in case of without Upper Rap Ro

TABLE D - 10 AVERAGE RUN-OFF AT INTAKE FACILITY (1/2)

(Without Potential Reservoirs)

(Unit : MCM)

Month	Run-off of Rap Ro Basin 1/ (D.A = 803 km²)	Run-off of Tha Sae Basin 2/ (D.A = 1,016 km²)	Total (D.A = 1,819 km²)	Run-off of Tha Taphao Basin 3/ (D.A = 2,050 km²)
Jan	15.03	10.69	25.72	28.99
Feb	9.02	7.34	16.36	18.44
Mar	7.79	7.49	15.28	17.22
Apr	6.70	7.37	14.07	15.86
May	28.19	26.04	54.23	61.17
Jun	51.87	29.36	81.23	91.55
Jul	68.28	48.50	116.78	131.61
Aug	133.19	81.32	214.51	241.75
Sep	92.97	58.46	151.43	170.66
Oct	103.43	88.62	192.05	216.44
Nov	94.39	106.78	201.17	226.72
Dec	61.26	27.99	59.25	66.77
Total	642.12	499.96	1,142.08	1,287.18

(Note) 1/ : average run-off at ×46 × (803/751),
2/ : average run-off at ×64 × (1,016/957),
3/ : average run-off accumulated × (2,050/1,819),

TABLE D - 10 AVERAGE RUN-OFF AT INTAKE FACILITY (2/2)

(Unit : MCM)

Month	Run-off of ×53 1/ (D.A = 223 km²)	(With Potential Reservoirs) Run-off of K. Chumphon 2/ (D.A = 229 km²)	(Without Potential Reservoirs) Run-off of K. Chumphon 3/ (D.A = 346 km²)
Jan	4.80	4.93	7.45
Feb	2.97	3.05	4.61
Mar	2.68	2.75	4.16
Apr	2.94	3.02	4.56
May	9.52	9.78	14.77
Jun	26.30	27.01	40.81
Jul	25.07	25.74	38.90
Aug	57.45	59.00	89.14
Sep	39.33	40.36	61.02
Oct	38.30	39.33	59.43
Nov	47.32	48.59	73.42
Dec	12.87	13.22	19.97
Total	269.55	276.78	418.24

(Note) 1/ : average run-off at ×53,
2/ : average run-off at ×53 × (229/223), 229 = total (346)-M.Dam(31) -S.Dam(86)
3/ : average run-off at ×53 × (346/223),

TABLE D-11 SCORING CRITERIA

Engineering Evaluation

Item	Score	Parameter
① Scale of catchment area and reservoir capacity	5	more than 200 sq.km / more than 100 MCM
	3	199 to 50 sq.km / 99 to 30 MCM
	1	less than 50 sq.km / less than 30 MCM
② Irrigation area	5	more than 10,000 ha
	3	3,000 to 10,000 ha
	1	less than 3,000 ha
③ Storage efficiency	5	$Q > 100$
Q (reservoir capacity)	3	$50 < Q < 100$
V (embankment volume)	1	$Q < 50$
④ Civil works	5	good foundation / construction materials available
	3	moderate
	1	poor foundation / poor construction materials

Social Evaluation

① Reservoir area	15	mostly forest / less than 50 houses
	10	coarse plantation / 51 to 200 houses
	5	dense plantation / 201 to 500 houses
	0	mostly plantation / more than 500 houses
② Land use regulation for development	10	land without regulation
	6	land with regulation
	2	land with strong regulation (i.e., wildlife sanctuary area)

TABLE D-12 NONG YAI RESERVOIR OPERATION (CASE: 1) (1/5)

WATER OPERATION STUDY OF NONG YAI SWAMP

WATERSHED : 102.0 (Km2) IRRI-AREA TYPE 1: 570.0 TYPE 4: 40.0
RE.CAPACITY: 3.9 (MCM) (ha) TYPE 2: 60.0 TYPE 5: 0.0
TYPE 3: 460.0 TOTAL : 1130.0

YEAR : 1981

MONTH	10 DAYS	RAIN	INFLOW	IRRI. WATER	DOMESTIC WATER	OTHER WATER	STORAGE WATER	SPILL WATER
		(mm)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)
Jan	1	0.0	0.43	1.03	0.00	0.01	3.29	0.00
	2	3.6	0.37	0.88	0.00	0.01	2.77	0.00
	3	12.6	0.34	0.58	0.00	0.01	2.51	0.00
Feb	1	80.0	0.35	0.01	0.00	0.01	2.84	0.00
	2	0.0	0.39	0.39	0.00	0.01	2.83	0.00
	3	0.0	0.25	0.38	0.00	0.01	2.68	0.00
Mar	1	0.0	0.30	0.57	0.00	0.01	2.40	0.00
	2	0.1	0.28	0.59	0.00	0.01	2.07	0.00
	3	0.0	0.30	0.61	0.00	0.01	1.75	0.00
Apr	1	15.4	0.10	0.40	0.00	0.01	1.44	0.00
	2	45.2	0.21	0.16	0.00	0.01	1.48	0.00
	3	4.7	0.22	0.50	0.00	0.01	1.18	0.00
May	1	113.1	0.37	0.01	0.00	0.01	1.53	0.00
	2	142.2	0.27	0.01	0.00	0.01	1.77	0.00
	3	46.1	0.61	0.11	0.00	0.01	2.26	0.00
Jun	1	48.0	0.77	0.04	0.00	0.01	2.98	0.00
	2	142.8	8.78	0.01	0.00	0.01	3.90	7.84
	3	27.2	3.37	0.18	0.00	0.01	3.90	3.17
Jul	1	45.8	1.32	0.04	0.00	0.01	3.90	1.27
	2	14.1	2.11	0.28	0.00	0.01	3.90	1.82
	3	35.9	2.04	0.11	0.00	0.01	3.90	1.91
Aug	1	69.2	2.59	0.01	0.00	0.01	3.90	2.57
	2	75.7	8.19	0.01	0.00	0.01	3.90	8.17
	3	28.2	7.16	0.16	0.00	0.01	3.90	6.98
Sep	1	0.3	2.08	1.45	0.00	0.01	3.90	0.61
	2	91.8	3.98	0.44	0.00	0.01	3.90	3.52
	3	69.8	7.35	0.77	0.00	0.01	3.90	6.57
Oct	1	18.7	2.31	0.63	0.00	0.01	3.90	1.67
	2	96.3	2.34	0.01	0.00	0.01	3.90	2.33
	3	183.8	4.01	0.01	0.00	0.01	3.90	3.99
Nov	1	58.4	2.66	0.17	0.00	0.01	3.90	2.48
	2	222.6	5.84	0.00	0.00	0.01	3.90	5.83
	3	169.8	10.14	0.00	0.00	0.01	3.90	10.13
Dec	1	3.7	2.85	1.03	0.00	0.01	3.90	1.81
	2	23.2	1.75	0.69	0.00	0.01	3.90	1.05
	3	0.3	1.43	1.10	0.00	0.01	3.90	0.32
TOTAL		1888.6	87.85	13.36	0.04	0.42		74.03

WATER OPERATION STUDY OF NONG YAI SWAMP

WATERSHED : 102.0 (Km2) IRRI-AREA TYPE 1: 570.0 TYPE 4: 40.0
RE.CAPACITY: 3.9 (MCM) (ha) TYPE 2: 60.0 TYPE 5: 0.0
TYPE 3: 460.0 TOTAL : 1130.0

YEAR : 1982

MONTH	10 DAYS	RAIN	INFLOW	IRRI. WATER	DOMESTIC WATER	OTHER WATER	STORAGE WATER	SPILL WATER
		(mm)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)
Jan	1	3.4	1.04	0.97	0.00	0.01	3.90	0.06
	2	3.2	0.83	0.89	0.00	0.01	3.82	0.00
	3	12.3	0.71	0.59	0.00	0.01	3.90	0.03
Feb	1	0.9	0.46	0.55	0.00	0.01	3.80	0.00
	2	15.2	0.45	0.26	0.00	0.01	3.90	0.07
	3	0.0	0.26	0.38	0.00	0.01	3.77	0.00
Mar	1	0.0	0.27	0.57	0.00	0.01	3.45	0.00
	2	0.0	0.17	0.59	0.00	0.01	3.01	0.00
	3	197.0	0.54	0.13	0.00	0.01	3.41	0.00
Apr	1	120.0	0.37	0.05	0.00	0.01	3.71	0.00
	2	58.5	0.74	0.09	0.00	0.01	3.90	0.46
	3	19.5	0.37	0.38	0.00	0.01	3.88	0.00
May	1	48.9	0.21	0.08	0.00	0.01	3.90	0.09
	2	110.5	0.27	0.01	0.00	0.01	3.90	0.25
	3	101.6	0.53	0.02	0.00	0.01	3.90	0.50
Jun	1	27.7	0.31	0.21	0.00	0.01	3.90	0.09
	2	85.8	0.33	0.01	0.00	0.01	3.90	0.31
	3	55.3	0.86	0.01	0.00	0.01	3.90	0.84
Jul	1	111.2	0.64	0.01	0.00	0.01	3.90	0.62
	2	170.9	4.07	0.01	0.00	0.01	3.90	4.05
	3	36.1	1.66	0.11	0.00	0.01	3.90	1.53
Aug	1	82.9	0.89	0.01	0.00	0.01	3.90	0.87
	2	31.9	4.63	0.14	0.00	0.01	3.90	4.48
	3	192.8	12.55	0.01	0.00	0.01	3.90	12.53
Sep	1	83.1	7.14	0.39	0.00	0.01	3.90	6.74
	2	44.1	3.48	0.88	0.00	0.01	3.90	2.58
	3	91.0	2.01	0.59	0.00	0.01	3.90	1.41
Oct	1	68.2	1.86	0.01	0.00	0.01	3.90	1.84
	2	73.1	2.22	0.01	0.00	0.01	3.90	2.20
	3	101.9	2.31	0.01	0.00	0.01	3.90	2.29
Nov	1	281.8	4.71	0.00	0.00	0.01	3.90	4.70
	2	100.3	2.67	0.00	0.00	0.01	3.90	2.65
	3	81.7	1.82	0.00	0.00	0.01	3.90	1.81
Dec	1	199.0	1.45	0.01	0.00	0.01	3.90	1.43
	2	0.0	1.08	1.06	0.00	0.01	3.90	0.01
	3	0.0	0.91	1.11	0.00	0.01	3.69	0.00
TOTAL		2609.8	64.81	10.12	0.04	0.42		54.43

TABLE D - 12 NONG YAI RESERVOIR OPERATION (CASE: 1) (2/5)

WATER OPERATION STUDY OF NONG YAI SWAMP

WATERSHED : 102.0 (Km2) IRRI-AREA TYPE 1: 570.0 TYPE 4: 40.0
RE.CAPACITY: 3.9 (MCM) (ha) TYPE 2: 60.0 TYPE 5: 0.0
TYPE 3: 460.0 TOTAL : 1130.0

YEAR : 1983

MONTH	10 DAYS	RAIN	INFLOW	IRRI. WATER	DOMESTIC WATER	OTHER WATER	STORAGE WATER	SPILL WATER
		(mm)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)
Jan	1	21.9	0.73	0.67	0.00	0.01	3.74	0.00
	2	6.5	0.64	0.84	0.00	0.01	3.53	0.00
	3	19.7	0.60	0.47	0.00	0.01	3.65	0.00
Feb	1	0.0	0.45	0.57	0.00	0.01	3.53	0.00
	2	9.4	0.36	0.31	0.00	0.01	3.57	0.00
	3	0.0	0.23	0.38	0.00	0.01	3.41	0.00
Mar	1	0.9	0.23	0.57	0.00	0.01	3.06	0.00
	2	0.0	0.18	0.59	0.00	0.01	2.63	0.00
	3	0.2	0.16	0.61	0.00	0.01	2.17	0.00
Apr	1	0.0	0.09	0.53	0.00	0.01	1.72	0.00
	2	0.0	0.04	0.53	0.00	0.01	1.21	0.00
	3	3.0	0.02	0.51	0.00	0.01	0.71	0.00
May	1	7.1	0.07	0.42	0.00	0.01	0.35	0.00
	2	0.0	0.29	0.48	0.00	0.01	0.14	0.00
	3	102.3	0.26	0.02	0.00	0.01	0.37	0.00
Jun	1	14.8	0.38	0.32	0.00	0.01	0.42	0.00
	2	12.3	0.52	0.33	0.00	0.01	0.60	0.00
	3	82.3	2.10	0.01	0.00	0.01	2.68	0.00
Jul	1	7.0	0.91	0.34	0.00	0.01	3.23	0.00
	2	63.9	1.49	0.01	0.00	0.01	3.90	0.80
	3	94.4	0.99	0.01	0.00	0.01	3.90	0.97
Aug	1	17.8	0.91	0.24	0.00	0.01	3.90	0.66
	2	36.9	3.40	0.10	0.00	0.01	3.90	3.29
	3	22.2	1.42	0.21	0.00	0.01	3.90	1.19
Sep	1	26.1	0.77	1.04	0.00	0.01	3.62	0.00
	2	61.4	0.99	0.71	0.00	0.01	3.89	0.00
	3	48.0	1.77	0.96	0.00	0.01	3.90	0.78
Oct	1	15.8	3.13	0.67	0.00	0.01	3.90	2.44
	2	61.9	2.32	0.09	0.00	0.01	3.90	2.22
	3	111.8	4.30	0.01	0.00	0.01	3.90	4.28
Nov	1	186.3	3.96	0.00	0.00	0.01	3.90	3.94
	2	224.0	5.83	0.00	0.00	0.01	3.90	5.82
	3	0.0	1.50	1.02	0.00	0.01	3.90	0.47
Dec	1	0.0	0.91	1.09	0.00	0.01	3.72	0.00
	2	14.8	0.70	0.82	0.00	0.01	3.58	0.00
	3	57.9	0.61	0.26	0.00	0.01	3.90	0.01
TOTAL		1330.6	43.26	15.72	0.04	0.42		26.88

WATER OPERATION STUDY OF NONG YAI SWAMP

WATERSHED : 102.0 (Km2) IRRI-AREA TYPE 1: 570.0 TYPE 4: 40.0
RE.CAPACITY: 3.9 (MCM) (ha) TYPE 2: 60.0 TYPE 5: 0.0
TYPE 3: 460.0 TOTAL : 1130.0

YEAR : 1984

MONTH	10 DAYS	RAIN	INFLOW	IRRI. WATER	DOMESTIC WATER	OTHER WATER	STORAGE WATER	SPILL WATER
		(mm)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)
Jan	1	6.1	0.52	0.93	0.00	0.01	3.48	0.00
	2	0.0	0.35	0.94	0.00	0.01	2.88	0.00
	3	15.9	0.39	0.53	0.00	0.01	2.73	0.00
Feb	1	100.4	0.33	0.01	0.00	0.01	3.04	0.00
	2	0.9	0.36	0.38	0.00	0.01	3.02	0.00
	3	1.9	0.20	0.36	0.00	0.01	2.84	0.00
Mar	1	0.0	0.19	0.57	0.00	0.01	2.44	0.00
	2	0.0	0.13	0.59	0.00	0.01	1.97	0.00
	3	25.7	0.11	0.40	0.00	0.01	1.67	0.00
Apr	1	0.0	0.19	0.53	0.00	0.01	1.32	0.00
	2	11.2	0.17	0.44	0.00	0.01	1.04	0.00
	3	38.7	0.20	0.22	0.00	0.01	1.00	0.00
May	1	53.6	0.28	0.05	0.00	0.01	1.22	0.00
	2	18.5	0.50	0.33	0.00	0.01	1.38	0.00
	3	7.5	0.51	0.43	0.00	0.01	1.45	0.00
Jun	1	76.1	0.56	0.01	0.00	0.01	1.99	0.00
	2	71.6	0.89	0.01	0.00	0.01	2.86	0.00
	3	149.7	8.06	0.01	0.00	0.01	3.90	7.00
Jul	1	58.4	3.20	0.01	0.00	0.01	3.90	3.17
	2	3.4	2.04	0.36	0.00	0.01	3.90	1.67
	3	18.5	1.37	0.24	0.00	0.01	3.90	1.11
Aug	1	100.4	1.65	0.01	0.00	0.01	3.90	1.63
	2	109.9	9.01	0.01	0.00	0.01	3.90	8.99
	3	99.7	6.75	0.01	0.00	0.01	3.90	6.73
Sep	1	45.0	5.47	0.74	0.00	0.01	3.90	4.72
	2	104.3	4.63	0.43	0.00	0.01	3.90	4.18
	3	32.1	4.98	1.21	0.00	0.01	3.90	3.76
Oct	1	47.7	5.59	0.18	0.00	0.01	3.90	5.40
	2	26.0	3.80	0.55	0.00	0.01	3.90	3.24
	3	167.0	4.21	0.01	0.00	0.01	3.90	4.20
Nov	1	45.9	2.02	0.28	0.00	0.01	3.90	1.73
	2	82.1	1.54	0.00	0.00	0.01	3.90	1.53
	3	70.9	1.21	0.09	0.00	0.01	3.90	1.11
Dec	1	4.6	0.95	1.01	0.00	0.01	3.82	0.00
	2	14.1	0.84	0.83	0.00	0.01	3.81	0.00
	3	73.5	1.40	0.13	0.00	0.01	3.90	1.17
TOTAL		1681.3	74.60	12.80	0.04	0.42		61.34

TABLE D-12 NONG YAI RESERVOIR OPERATION (CASE: 1) (3/5)

WATER OPERATION STUDY OF NONG YAI SWAMP

WATERSHED : 102.0 (Km2) IRRI-AREA TYPE 1: 570.0 TYPE 4: 40.0
RE.CAPACITY: 3.9 (MCM) (ha) TYPE 2: 60.0 TYPE 5: 0.0
TYPE 3: 460.0 TOTAL : 1130.0

YEAR : 1985

MONTH	10 DAYS	RAIN	INFLOW	IRRI. WATER	DOMESTIC WATER	OTHER WATER	STORAGE WATER	SPILL WATER
		(mm)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)
Jan	1	10.4	0.66	0.86	0.00	0.01	3.69	0.00
	2	0.8	0.55	0.93	0.00	0.01	3.29	0.00
	3	89.9	0.59	0.01	0.00	0.01	3.86	0.00
Feb	1	2.2	0.46	0.53	0.00	0.01	3.78	0.00
	2	0.0	0.37	0.39	0.00	0.01	3.74	0.00
	3	14.4	0.24	0.27	0.00	0.01	3.70	0.00
Mar	1	19.1	0.26	0.42	0.00	0.01	3.53	0.00
	2	63.0	0.34	0.14	0.00	0.01	3.72	0.00
	3	0.0	0.28	0.61	0.00	0.01	3.38	0.00
Apr	1	15.8	0.18	0.40	0.00	0.01	3.15	0.00
	2	17.5	0.14	0.39	0.00	0.01	2.89	0.00
	3	57.7	0.49	0.09	0.00	0.01	3.28	0.00
May	1	94.7	0.39	0.01	0.00	0.01	3.64	0.00
	2	155.3	1.59	0.01	0.00	0.01	3.90	1.31
	3	37.6	0.90	0.18	0.00	0.01	3.90	0.71
Jun	1	45.3	0.51	0.06	0.00	0.01	3.90	0.44
	2	130.1	3.43	0.01	0.00	0.01	3.90	3.41
	3	70.9	7.03	0.01	0.00	0.01	3.90	7.01
Jul	1	23.8	1.51	0.20	0.00	0.01	3.90	1.29
	2	51.2	0.99	0.01	0.00	0.01	3.90	0.97
	3	9.6	1.12	0.31	0.00	0.01	3.90	0.79
Aug	1	53.0	0.80	0.01	0.00	0.01	3.90	0.78
	2	80.6	3.05	0.01	0.00	0.01	3.90	3.03
	3	42.3	3.22	0.06	0.00	0.01	3.90	3.15
Sep	1	55.6	3.55	0.62	0.00	0.01	3.90	2.91
	2	32.3	1.98	1.07	0.00	0.01	3.90	0.90
	3	48.9	1.64	0.95	0.00	0.01	3.90	0.68
Oct	1	127.3	4.45	0.01	0.00	0.01	3.90	4.43
	2	56.5	3.01	0.14	0.00	0.01	3.90	2.86
	3	36.6	1.70	0.48	0.00	0.01	3.90	1.21
Nov	1	158.1	2.55	0.00	0.00	0.01	3.90	2.53
	2	76.3	6.65	0.03	0.00	0.01	3.90	6.60
	3	20.0	1.69	0.70	0.00	0.01	3.90	0.98
Dec	1	162.9	3.81	0.01	0.00	0.01	3.90	3.80
	2	26.5	0.93	0.63	0.00	0.01	3.90	0.28
	3	0.3	0.69	1.10	0.00	0.01	3.48	0.00
TOTAL		1886.5	61.75	11.65	0.04	0.42		50.06

WATER OPERATION STUDY OF NONG YAI SWAMP

WATERSHED : 102.0 (Km2) IRRI-AREA TYPE 1: 570.0 TYPE 4: 40.0
RE.CAPACITY: 3.9 (MCM) (ha) TYPE 2: 60.0 TYPE 5: 0.0
TYPE 3: 460.0 TOTAL : 1130.0

YEAR : 1986

MONTH	10 DAYS	RAIN	INFLOW	IRRI. WATER	DOMESTIC WATER	OTHER WATER	STORAGE WATER	SPILL WATER
		(mm)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)
Jan	1	4.9	0.51	0.95	0.00	0.01	3.03	0.00
	2	0.0	0.39	0.94	0.00	0.01	2.47	0.00
	3	4.0	0.33	0.72	0.00	0.01	2.06	0.00
Feb	1	2.6	0.27	0.52	0.00	0.01	1.80	0.00
	2	0.0	0.22	0.39	0.00	0.01	1.61	0.00
	3	0.0	0.15	0.38	0.00	0.01	1.37	0.00
Mar	1	11.4	0.16	0.48	0.00	0.01	1.03	0.00
	2	0.0	0.12	0.59	0.00	0.01	0.55	0.00
	3	0.0	0.10	0.61	0.00	0.01	0.03	0.00
Apr	1	2.0	0.06	0.51	0.00	0.01	0.00	0.00
	2	0.0	0.34	0.53	0.00	0.01	0.00	0.00
	3	1.2	0.07	0.53	0.00	0.01	0.00	0.00
May	1	104.6	0.58	0.01	0.00	0.01	0.56	0.00
	2	74.8	2.08	0.03	0.00	0.01	2.59	0.00
	3	68.4	1.99	0.04	0.00	0.01	3.90	0.63
Jun	1	21.3	0.73	0.26	0.00	0.01	3.90	0.45
	2	66.5	0.63	0.01	0.00	0.01	3.90	0.61
	3	78.0	4.73	0.01	0.00	0.01	3.90	4.71
Jul	1	62.3	1.63	0.01	0.00	0.01	3.90	1.61
	2	158.0	10.29	0.01	0.00	0.01	3.90	10.27
	3	22.7	3.47	0.21	0.00	0.01	3.90	3.24
Aug	1	137.1	7.31	0.01	0.00	0.01	3.90	7.28
	2	86.9	19.06	0.01	0.00	0.01	3.90	19.04
	3	9.6	4.00	0.30	0.00	0.01	3.90	3.68
Sep	1	128.2	4.06	0.30	0.00	0.01	3.90	3.75
	2	31.2	4.69	1.09	0.00	0.01	3.90	3.58
	3	70.7	7.01	0.76	0.00	0.01	3.90	6.24
Oct	1	110.1	8.42	0.01	0.00	0.01	3.90	8.40
	2	17.5	4.05	0.68	0.00	0.01	3.90	3.35
	3	136.8	3.04	0.01	0.00	0.01	3.90	3.02
Nov	1	144.3	5.34	0.00	0.00	0.01	3.90	5.32
	2	2.0	2.13	0.98	0.00	0.01	3.90	1.14
	3	42.5	1.38	0.34	0.00	0.01	3.90	1.02
Dec	1	93.6	1.14	0.01	0.00	0.01	3.90	1.12
	2	12.0	0.94	0.87	0.00	0.01	3.90	0.06
	3	34.6	0.92	0.55	0.00	0.01	3.90	0.36
TOTAL		1739.8	102.31	13.65	0.04	0.42		88.89

TABLE D - 12 NONG YAI RESERVOIR OPERATION (CASE: 1) (4/5)

WATER OPERATION STUDY OF NONG YAI SWAMP

WATERSHED : 102.0 (Km2) IRRI-AREA TYPE 1: 570.0 TYPE 4: 40.0
RE.CAPACITY: 3.9 (MCM) (ha) TYPE 2: 60.0 TYPE 5: 0.0
TYPE 3: 460.0 TOTAL : 1130.0

YEAR : 1987

MONTH	10 DAYS	RAIN	INFLOW	IRRI. WATER	DOMESTIC WATER	OTHER WATER	STORAGE WATER	SPILL WATER
		(mm)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)
Jan	1	13.8	0.72	0.80	0.00	0.01	3.80	0.00
	2	1.9	0.61	0.91	0.00	0.01	3.49	0.00
	3	2.1	0.56	0.75	0.00	0.01	3.29	0.00
Feb	1	0.5	0.45	0.56	0.00	0.01	3.16	0.00
	2	0.0	0.40	0.39	0.00	0.01	3.16	0.00
	3	0.0	0.28	0.38	0.00	0.01	3.05	0.00
Mar	1	37.6	0.44	0.26	0.00	0.01	3.21	0.00
	2	0.0	0.29	0.59	0.00	0.01	2.90	0.00
	3	0.0	0.22	0.61	0.00	0.01	2.50	0.00
Apr	1	0.0	0.17	0.53	0.00	0.01	2.12	0.00
	2	3.4	0.20	0.50	0.00	0.01	1.80	0.00
	3	0.1	0.18	0.54	0.00	0.01	1.43	0.00
May	1	107.0	0.43	0.01	0.00	0.01	1.84	0.00
	2	7.2	0.36	0.42	0.00	0.01	1.76	0.00
	3	100.6	0.27	0.02	0.00	0.01	2.01	0.00
Jun	1	20.1	0.46	0.27	0.00	0.01	2.19	0.00
	2	135.3	2.52	0.01	0.00	0.01	3.90	0.79
	3	30.7	2.01	0.15	0.00	0.01	3.90	1.84
Jul	1	4.8	0.97	0.36	0.00	0.01	3.90	0.60
	2	3.9	0.59	0.35	0.00	0.01	3.90	0.23
	3	32.3	0.44	0.14	0.00	0.01	3.90	0.29
Aug	1	7.9	0.42	0.32	0.00	0.01	3.90	0.09
	2	28.9	0.89	0.16	0.00	0.01	3.90	0.72
	3	98.1	3.98	0.01	0.00	0.01	3.90	3.95
Sep	1	15.4	2.61	1.21	0.00	0.01	3.90	1.38
	2	30.6	2.58	1.10	0.00	0.01	3.90	1.47
	3	37.1	1.48	1.13	0.00	0.01	3.90	0.33
Oct	1	152.8	1.07	0.01	0.00	0.01	3.90	1.05
	2	9.7	1.48	0.81	0.00	0.01	3.90	0.66
	3	110.3	1.87	0.01	0.00	0.01	3.90	1.85
Nov	1	245.1	4.72	0.00	0.00	0.01	3.90	4.70
	2	43.1	5.06	0.32	0.00	0.01	3.90	4.72
	3	52.7	2.37	0.25	0.00	0.01	3.90	2.11
Dec	1	0.4	1.64	1.08	0.00	0.01	3.90	0.55
	2	2.5	0.85	1.02	0.00	0.01	3.72	0.00
	3	2.3	0.69	1.07	0.00	0.01	3.33	0.00
TOTAL		1338.2	44.27	17.05	0.04	0.42		27.33

WATER OPERATION STUDY OF NONG YAI SWAMP

WATERSHED : 102.0 (Km2) IRRI-AREA TYPE 1: 570.0 TYPE 4: 40.0
RE.CAPACITY: 3.9 (MCM) (ha) TYPE 2: 60.0 TYPE 5: 0.0
TYPE 3: 460.0 TOTAL : 1130.0

YEAR : 1988

MONTH	10 DAYS	RAIN	INFLOW	IRRI. WATER	DOMESTIC WATER	OTHER WATER	STORAGE WATER	SPILL WATER
		(mm)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)
Jan	1	16.7	0.50	0.76	0.00	0.01	3.06	0.00
	2	1.8	0.37	0.91	0.00	0.01	2.50	0.00
	3	14.5	0.34	0.55	0.00	0.01	2.27	0.00
Feb	1	0.0	0.25	0.57	0.00	0.01	1.94	0.00
	2	13.4	0.24	0.28	0.00	0.01	1.89	0.00
	3	10.8	0.20	0.30	0.00	0.01	1.78	0.00
Mar	1	9.7	0.16	0.49	0.00	0.01	1.44	0.00
	2	0.0	0.18	0.59	0.00	0.01	1.02	0.00
	3	0.4	0.20	0.61	0.00	0.01	0.60	0.00
Apr	1	57.3	0.25	0.08	0.00	0.01	0.76	0.00
	2	67.1	0.24	0.08	0.00	0.01	0.91	0.00
	3	9.7	0.22	0.46	0.00	0.01	0.65	0.00
May	1	41.2	0.63	0.14	0.00	0.01	1.13	0.00
	2	55.8	0.60	0.04	0.00	0.01	1.67	0.00
	3	16.0	0.55	0.36	0.00	0.01	1.85	0.00
Jun	1	109.4	5.40	0.01	0.00	0.01	3.90	3.33
	2	98.3	3.87	0.01	0.00	0.01	3.90	3.85
	3	3.5	1.65	0.38	0.00	0.01	3.90	1.25
Jul	1	45.1	1.25	0.04	0.00	0.01	3.90	1.19
	2	50.6	3.22	0.01	0.00	0.01	3.90	3.20
	3	83.2	2.14	0.01	0.00	0.01	3.90	2.12
Aug	1	3.6	1.37	0.35	0.00	0.01	3.90	1.01
	2	32.5	1.13	0.13	0.00	0.01	3.90	0.99
	3	97.9	2.12	0.01	0.00	0.01	3.90	2.10
Sep	1	22.5	1.25	1.10	0.00	0.01	3.90	0.14
	2	66.0	1.48	0.67	0.00	0.01	3.90	0.80
	3	78.1	3.97	0.70	0.00	0.01	3.90	3.26
Oct	1	79.6	5.50	0.01	0.00	0.01	3.90	5.48
	2	77.1	7.13	0.01	0.00	0.01	3.90	7.11
	3	28.0	4.13	0.62	0.00	0.01	3.90	3.50
Nov	1	40.5	1.66	0.34	0.00	0.01	3.90	1.31
	2	187.3	7.14	0.00	0.00	0.01	3.90	7.13
	3	306.9	17.63	0.00	0.00	0.01	3.90	17.62
Dec	1	2.0	3.11	1.05	0.00	0.01	3.90	2.05
	2	0.9	1.85	1.05	0.00	0.01	3.90	0.79
	3	4.9	1.47	1.03	0.00	0.01	3.90	0.43
TOTAL		1732.3	83.39	13.71	0.04	0.42		68.65

TABLE D - 12 NONG YAI RESERVOIR OPERATION (CASE: 1) (5/5)

WATER OPERATION STUDY OF NONG YAI SWAMP

WATERSHED : 102.0 (Km2) IRRI-AREA TYPE 1: 570.0 TYPE 4: 40.0
RE.CAPACITY: 3.9 (MCM) (ha) TYPE 2: 60.0 TYPE 5: 0.0
TYPE 3: 460.0 TOTAL : 1130.0

YEAR : 1989

MONTH	10 DAYS	RAIN	INFLOW	IRRI. WATER	DOMESTIC WATER	OTHER WATER	STORAGE WATER	SPILL WATER
		(mm)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)
Jan	1	9.3	1.05	0.88	0.00	0.01	3.90	0.16
	2	28.7	0.87	0.48	0.00	0.01	3.90	0.38
	3	137.1	1.00	0.01	0.00	0.01	3.90	0.98
Feb	1	0.6	0.66	0.56	0.00	0.01	3.90	0.09
	2	19.3	0.71	0.23	0.00	0.01	3.90	0.46
	3	0.7	0.41	0.37	0.00	0.01	3.90	0.02
Mar	1	142.8	1.33	0.10	0.00	0.01	3.90	1.22
	2	0.6	0.69	0.58	0.00	0.01	3.90	0.09
	3	14.9	0.47	0.49	0.00	0.01	3.87	0.00
Apr	1	35.2	0.56	0.23	0.00	0.01	3.90	0.28
	2	59.1	0.85	0.08	0.00	0.01	3.90	0.75
	3	0.0	0.44	0.54	0.00	0.01	3.79	0.00
May	1	88.8	0.51	0.02	0.00	0.01	3.90	0.37
	2	83.6	0.96	0.02	0.00	0.01	3.90	0.93
	3	100.1	7.40	0.02	0.00	0.01	3.90	7.36
Jun	1	67.1	2.11	0.02	0.00	0.01	3.90	2.08
	2	18.3	1.90	0.28	0.00	0.01	3.90	1.61
	3	108.7	6.77	0.01	0.00	0.01	3.90	6.75
Jul	1	5.5	2.17	0.35	0.00	0.01	3.90	1.81
	2	135.7	1.64	0.01	0.00	0.01	3.90	1.61
	3	109.6	7.81	0.01	0.00	0.01	3.90	7.79
Aug	1	101.2	3.79	0.01	0.00	0.01	3.90	3.77
	2	52.5	8.48	0.01	0.00	0.01	3.90	8.46
	3	50.6	9.22	0.01	0.00	0.01	3.90	9.20
Sep	1	88.7	5.41	0.34	0.00	0.01	3.90	5.06
	2	32.5	4.50	1.07	0.00	0.01	3.90	3.42
	3	44.8	5.38	1.00	0.00	0.01	3.90	4.36
Oct	1	23.4	3.43	0.55	0.00	0.01	3.90	2.87
	2	27.2	5.40	0.53	0.00	0.01	3.90	4.86
	3	91.5	3.71	0.01	0.00	0.01	3.90	3.69
Nov	1	288.3	19.12	0.00	0.00	0.01	3.90	19.10
	2	125.8	11.49	0.00	0.00	0.01	3.90	11.47
	3	21.8	3.94	0.67	0.00	0.01	3.90	3.26
Dec	1	0.0	2.63	1.09	0.00	0.01	3.90	1.53
	2	18.1	2.02	0.77	0.00	0.01	3.90	1.23
	3	10.3	1.82	0.94	0.00	0.01	3.90	0.86
TOTAL		2142.4	130.63	12.27	0.04	0.42		117.90

WATER OPERATION STUDY OF NONG YAI SWAMP.

WATERSHED : 102.0 (Km2) IRRI-AREA TYPE 1: 570.0 TYPE 4: 40.0
RE.CAPACITY: 3.9 (MCM) (ha) TYPE 2: 60.0 TYPE 5: 0.0
TYPE 3: 460.0 TOTAL : 1130.0

YEAR : 1990

MONTH	10 DAYS	RAIN	INFLOW	IRRI. WATER	DOMESTIC WATER	OTHER WATER	STORAGE WATER	SPILL WATER
		(mm)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)
Jan	1	5.6	1.44	0.94	0.00	0.01	3.90	0.49
	2	11.1	1.28	0.76	0.00	0.01	3.90	0.51
	3	9.9	1.24	0.63	0.00	0.01	3.90	0.60
Feb	1	10.9	1.00	0.39	0.00	0.01	3.90	0.60
	2	0.2	0.91	0.39	0.00	0.01	3.90	0.51
	3	0.0	0.61	0.38	0.00	0.01	3.90	0.22
Mar	1	0.6	0.71	0.57	0.00	0.01	3.90	0.12
	2	1.9	0.66	0.57	0.00	0.01	3.90	0.08
	3	0.0	0.69	0.61	0.00	0.01	3.90	0.07
Apr	1	4.8	0.54	0.49	0.00	0.01	3.90	0.04
	2	2.4	0.87	0.51	0.00	0.01	3.90	0.35
	3	36.8	0.76	0.23	0.00	0.01	3.90	0.52
May	1	4.9	0.65	0.44	0.00	0.01	3.90	0.19
	2	75.7	1.59	0.03	0.00	0.01	3.90	1.55
	3	85.2	2.59	0.02	0.00	0.01	3.90	2.56
Jun	1	84.5	2.13	0.01	0.00	0.01	3.90	2.11
	2	32.4	2.47	0.16	0.00	0.01	3.90	2.29
	3	21.5	1.81	0.23	0.00	0.01	3.90	1.56
Jul	1	14.0	1.74	0.28	0.00	0.01	3.90	1.45
	2	9.7	1.76	0.31	0.00	0.01	3.90	1.44
	3	21.9	1.93	0.22	0.00	0.01	3.90	1.70
Aug	1	15.1	1.40	0.26	0.00	0.01	3.90	1.12
	2	56.9	3.69	0.01	0.00	0.01	3.90	3.67
	3	123.6	9.26	0.01	0.00	0.01	3.90	9.23
Sep	1	19.6	5.22	1.14	0.00	0.01	3.90	4.07
	2	30.7	4.81	1.10	0.00	0.01	3.90	3.70
	3	50.5	5.99	0.94	0.00	0.01	3.90	5.04
Oct	1	71.0	9.27	0.01	0.00	0.01	3.90	9.25
	2	32.1	6.09	0.45	0.00	0.01	3.90	5.63
	3	243.2	8.88	0.01	0.00	0.01	3.90	8.86
Nov	1	224.1	13.23	0.00	0.00	0.01	3.90	13.21
	2	31.9	10.37	0.50	0.00	0.01	3.90	9.86
	3	97.7	6.72	0.00	0.00	0.01	3.90	6.71
Dec	1	20.7	2.31	0.75	0.00	0.01	3.90	1.54
	2	1.8	1.99	1.03	0.00	0.01	3.90	0.94
	3	14.3	1.77	0.88	0.00	0.01	3.90	0.88
TOTAL		1467.2	118.35	15.25	0.04	0.42		102.64

TABLE D - 13 NONG YAI RESERVOIR OPERATION (CASE: 2) (1/5)

WATER OPERATION STUDY OF NONG YAI SWAMP

WATERSHED : 102.0 (Km2) IRRI-AREA TYPE 1: 570.0 TYPE 4: 40.0
RE.CAPACITY: 3.9 (MCM) (ha) TYPE 2: 60.0 TYPE 5: 0.0
TYPE 3: 530.0 TOTAL : 1200.0

YEAR : 1981

MONTH	10 DAYS	RAIN	INFLOW	IRRI. WATER	DOMESTIC WATER	OTHER WATER	STORAGE WATER	SPILL WATER
		(mm)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)
Jan	1	0.0	0.43	1.08	0.00	0.01	3.24	0.00
	2	3.6	0.37	0.93	0.00	0.01	2.67	0.00
	3	12.6	0.34	0.62	0.00	0.01	2.38	0.00
Feb	1	80.0	0.35	0.01	0.00	0.01	2.71	0.00
	2	0.0	0.39	0.44	0.00	0.01	2.64	0.00
	3	0.0	0.25	0.43	0.00	0.01	2.45	0.00
Mar	1	0.0	0.30	0.64	0.00	0.01	2.10	0.00
	2	0.1	0.28	0.65	0.00	0.01	1.71	0.00
	3	0.0	0.30	0.67	0.00	0.01	1.32	0.00
Apr	1	15.4	0.10	0.45	0.00	0.01	0.96	0.00
	2	45.2	0.21	0.17	0.00	0.01	0.99	0.00
	3	4.7	0.22	0.56	0.00	0.01	0.64	0.00
May	1	113.1	0.37	0.01	0.00	0.01	0.99	0.00
	2	142.2	0.27	0.01	0.00	0.01	1.23	0.00
	3	46.1	0.61	0.11	0.00	0.01	1.71	0.00
Jun	1	48.0	0.77	0.04	0.00	0.01	2.43	0.00
	2	142.8	8.78	0.01	0.00	0.01	3.90	7.29
	3	27.2	3.37	0.21	0.00	0.01	3.90	3.15
Jul	1	45.8	1.32	0.04	0.00	0.01	3.90	1.26
	2	14.1	2.11	0.31	0.00	0.01	3.90	1.78
	3	35.9	2.04	0.13	0.00	0.01	3.90	1.90
Aug	1	69.2	2.59	0.01	0.00	0.01	3.90	2.57
	2	75.7	8.19	0.01	0.00	0.01	3.90	8.17
	3	28.2	7.16	0.19	0.00	0.01	3.90	6.96
Sep	1	0.3	2.08	1.50	0.00	0.01	3.90	0.56
	2	91.8	3.98	0.44	0.00	0.01	3.90	3.52
	3	69.8	7.35	0.77	0.00	0.01	3.90	6.57
Oct	1	18.7	2.31	0.65	0.00	0.01	3.90	1.64
	2	96.3	2.34	0.01	0.00	0.01	3.90	2.33
	3	183.8	4.01	0.01	0.00	0.01	3.90	3.99
Nov	1	58.4	2.66	0.17	0.00	0.01	3.90	2.48
	2	222.6	5.84	0.00	0.00	0.01	3.90	5.83
	3	169.8	10.14	0.00	0.00	0.01	3.90	10.13
Dec	1	3.7	2.85	1.07	0.00	0.01	3.90	1.77
	2	23.2	1.75	0.71	0.00	0.01	3.90	1.02
	3	0.3	1.43	1.15	0.00	0.01	3.90	0.27
TOTAL		1888.6	87.85	14.20	0.04	0.42		73.19

WATER OPERATION STUDY OF NONG YAI SWAMP

WATERSHED : 102.0 (Km2) IRRI-AREA TYPE 1: 570.0 TYPE 4: 40.0
RE.CAPACITY: 3.9 (MCM) (ha) TYPE 2: 60.0 TYPE 5: 0.0
TYPE 3: 530.0 TOTAL : 1200.0

YEAR : 1982

MONTH	10 DAYS	RAIN	INFLOW	IRRI. WATER	DOMESTIC WATER	OTHER WATER	STORAGE WATER	SPILL WATER
		(mm)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)
Jan	1	3.4	1.04	1.02	0.00	0.01	3.90	0.01
	2	3.2	0.83	0.94	0.00	0.01	3.78	0.00
	3	12.3	0.71	0.63	0.00	0.01	3.85	0.00
Feb	1	0.9	0.46	0.60	0.00	0.01	3.70	0.00
	2	15.2	0.45	0.30	0.00	0.01	3.83	0.00
	3	0.0	0.26	0.43	0.00	0.01	3.64	0.00
Mar	1	0.0	0.27	0.64	0.00	0.01	3.26	0.00
	2	0.0	0.17	0.65	0.00	0.01	2.76	0.00
	3	197.0	0.54	0.14	0.00	0.01	3.15	0.00
Apr	1	120.0	0.37	0.06	0.00	0.01	3.45	0.00
	2	58.5	0.74	0.09	0.00	0.01	3.90	0.19
	3	19.5	0.37	0.42	0.00	0.01	3.84	0.00
May	1	48.9	0.21	0.08	0.00	0.01	3.90	0.05
	2	110.5	0.27	0.01	0.00	0.01	3.90	0.25
	3	101.6	0.53	0.02	0.00	0.01	3.90	0.49
Jun	1	27.7	0.31	0.23	0.00	0.01	3.90	0.07
	2	85.8	0.33	0.01	0.00	0.01	3.90	0.31
	3	55.3	0.86	0.01	0.00	0.01	3.90	0.84
Jul	1	111.2	0.64	0.01	0.00	0.01	3.90	0.62
	2	170.9	4.07	0.01	0.00	0.01	3.90	4.05
	3	36.1	1.66	0.13	0.00	0.01	3.90	1.52
Aug	1	82.9	0.89	0.01	0.00	0.01	3.90	0.87
	2	31.9	4.63	0.15	0.00	0.01	3.90	4.46
	3	192.8	12.55	0.01	0.00	0.01	3.90	12.53
Sep	1	83.1	7.14	0.39	0.00	0.01	3.90	6.74
	2	44.1	3.48	0.88	0.00	0.01	3.90	2.58
	3	91.0	2.01	0.59	0.00	0.01	3.90	1.41
Oct	1	68.2	1.86	0.01	0.00	0.01	3.90	1.84
	2	73.1	2.22	0.01	0.00	0.01	3.90	2.20
	3	101.9	2.31	0.01	0.00	0.01	3.90	2.29
Nov	1	281.8	4.71	0.00	0.00	0.01	3.90	4.70
	2	100.3	2.67	0.00	0.00	0.01	3.90	2.65
	3	81.7	1.82	0.00	0.00	0.01	3.90	1.81
Dec	1	199.0	1.45	0.01	0.00	0.01	3.90	1.43
	2	0.0	1.08	1.11	0.00	0.01	3.86	0.00
	3	0.0	0.91	1.16	0.00	0.01	3.61	0.00
TOTAL		2609.8	64.81	10.73	0.04	0.42		53.91