Part II

Feasibility Study — PRESENT CONDITIONS OF THE BOENG PHTEA AREA

C5 Natural Conditions

C5.1 Location

Boeng Phtea area (12-12N, 105-02E), located in Srok Ksach Kandal, is about 25km to the northeast of Phnom Penh, covering an area of about 6,000ha in the left bank of Mekong river. Access to the study area from Phnom Penh is easy: 22km by road along route 6A and cross the Mekong river by ferry boat at Prek Agnchagn village.

C5.2 Topography

Figure C5.1 shows the bird's-eye view of the Study Area. Figure C5.2 shows the contours lines of the study area. To evaluate the micro-topography of the study area lines were drawn parallel to the latitude and longitude, generating a grid-points system of 1km interval (Figure C5.3). The elevation of the grid points were interpolated with spot elevations surveyed for this study. Cross section charted along the lines parallel to the latitude are numbered "a-a" to " l-l", while those parallel to longitude " A-A" to "M-M" (Figure C5.4.)

From the east-west cross sections along the lines "a-a" to "l-l" it is observed that land to the west and east of Boeng Phtea, i.e., the stretch of natural levee along the left bank of Mekong river and area around the Phras Konlong road leading to the villages in Viheasour and the villages themselves are 8-10m in elevation. To the east of Boeng Phtea, the 6, 7 and 8m contour lines are close together, indicating that there is a steep slope fringing Boeng Phtea. Boeng Phtea is 'linked' to the Tbaung and Boeng Khcho lake to the northeast through the Phras Konlong bridge and the narrow stretch of land below 6m under the bridge. To the west of Boeng Phtea, the 6, 7 and 8m contour lines are wider and more irregular, indicating gentler slopes and considerable variations and irregularity in topography.

From the north-south cross sections along the lines "A-A" to "M-M", it is observed that the northern end (Svay Att Leu village) of the study area is higher in elevation, >9m. The land descends and gradates southward towards Boeng Phtea. The outlet of Boeng Phtea is long and narrow, expanding to a large area of land below 5m at around the fish trap near Peak Kdam reservoir.

On the whole, the study area is a concave topography, with Boeng Phtea -below 5m- being the center of the concavity. Many reservoirs, mostly located below the 7m contour line, are found in the periphery of Boeng Phtea.

C6 Meteorology

Like other regions in Cambodia, Boeng Phtea area is strongly influenced by the monsoon winds. Figure C6.1 is a summary of the basic meteorological data obtained from Pochentong Station (Phnom Penh), typical of the main climatic features of the Lower Mekong Basin in Cambodia. Since no observation station is found in the study area and there is no topographic barrier in between, the Pochentong Station is taken to represent the meteorological conditions of the study area. The rainy/wet season (May-November), under the influence of the Southwest Monsoon, is characterized by a relatively lower temperature, high rainfall intensity, lower evapotranspiration demand, high humidity and shorter sunlight hours. The dry season (December-April), under the influence of the Northeast Monsoon, is the exact opposite: hot ,dry, sunny and less humid.

Daily rainfall at Pochentong Station (1982-1995) is plotted in Figure C6.2. The contrast between the wet and dry season is distinct. Figure C6.3 shows the mean monthly wind data. Wind velocity is relatively high from May to August. By the end of wet season, wind velocity is as low as those of the dry season. Figure C6.4 shows the mean monthly maximum and minimum humidity. The difference of mean monthly maximum and minimum humidity ranges from 16% in October to 25% in May.

Figure C6.5 shows the monthly and annual rainfall records. Annual total ranges from 1,095mm (1992) to 1,552mm (1987), averaging at 1,279mm. Over 90% of rainfall occurs in the wet season. Average monthly rainfall during wet season ranges from 102mm in November to 282mm in September. In the dry season, with the exception of March and April which are the onset months of the Southwest Monsoon, average monthly rainfall in December through February is less than 5mm.

Figure C6.6 shows the average and total number of rainy days (defined as daily rainfall greater than or equal to 1mm) for Pochentong Station. Total monthly rainy day in wet season ranges from 6.6 days in November to 16.6 days in September. In dry season, the range is 0.2-4.4 days. Average annual rainy days is 94.6 days.

The table below gives the values of different return periods for rainy days and consecutive dry days for Jan-Dec and May-Dec.

Unit:(days)

Return period	Rainy day Jan-Dec (non-exceedance)	Consecutive dry days	
		Jan- Dec	May-Dec
2-year	93.5	92.2	43.4
10-year	86.1	133.0	59.6
30-year	83.7	155.7	67.6
50-year	82.9	165.8	71.1
100-year	82.0	179.2	75.5

Figure C6.7 shows the maximum value of 1-, 2- and 3-day consecutive rainfall at Pochentong Station (1982-1995). The average value of 1-, 2- and 3-day rainfall are 88.8, 107.0 and 122.0mm, respectively. Over 40% of the 1-, 2- and 3-day rainfall occurs in August and September. The occurrence in May is over 20%.

The table below shows the amount of rainfall of different return periods for 1-, 2- and 3-day consecutive rainfall.

Unit:(mm)

Return period	1-day	2-day	3-day
2-year	86.7	98.5	114.8
10-year	112.0	144.3	161.1
30-year	125.9	180.7	193.8
50-year	131.9	199.5	209.8
100-year	140.1	227.3	232.7

Figure C6.8 shows the effective rainfall for rice cultivation (defined as 80% of 5 to 80mm/day) in rainy season and the whole year. Only about 53% of the annual rainfall is effective in rice cultivation. Since most of the rainfall occurs in the wet season, the difference between wet season and that of the whole year is small, only about 4%. Rainfall intensity in wet season can be well over 80mm, resulting in only about 49% of rainfall being effective.

Potential evapo-transpiration, estimated by the Penman equation on meteorological data of Pochentong has shown very little variation over a period of 20 years (Master Plan Study on the Integrated Agricultural and Rural Development Project in the Suburbs of Phnom Penh, 1995). Figure C6.9 shows the evapo-transpiration derived by the conventional method - the modified Penman equation - for meteorological data averaged over 1985-1995.

C7 Hydrology

Chrouy Changvar, about 18km downstream of the study area, is the nearest gauging station and is taken as the reference station for hydrological and inundation analysis. Figure C7.1 shows the cross section of Mekong river at Chrouy Changvar measured by the Department of Hydrology on October 4, 1996. The width of Mekong was about 1,000m and the depth of flow was about 33.4m.

Figure C7.2 shows the periodic (annual) water level cycle of Mekong river at Chrouy Changvar: Water level begins to rise in May, peaks in September and declines in October. The rising rate is high from June through August and the falling rate is high from October through December.

Figure C7.3 shows the peak, mean and minimum values of water level. About 60% of the peak level occurred within a narrow band of 1m (±0.5m of the mean peak 8.89m). About 90% occurred within a band of 2m (±1.0m of the mean peak value). The mean range (peak - minimum level) is about 8.25m.

The table below shows the peak flood level of different return period for Chrouy Changvar. The year 1985 and 1966 are chosen as the typical year, based on the peak level, to represent monthly flood phenomena for 1/2 (average year) and 1/10 return period.

Peak flood level unit:(m)

1/2 return period	8.83 (1985 peak level 8.84)
1/10 return period	9.97 (1966 peak level 9.91)
1/25 return period	10.45
1/50 return period	10.78
1/100 return period	11.09

Figure C7.4 shows the mean monthly and maximum flood level for 1/2 ad 1/10 return period at Chrouy Changvar. The water level in the study area for the respective return periods is assumed to be 0.5m higher, tied in to the daily water level of Chrouy Changvar.

Figure C7.5 shows the period and length when the water level at Chrouy Changvar rose above 6, 7, 8 and 9m. The average period when water level stayed above 6, 7, 8 and 9m were 113, 85, 53 and 28 days, respectively. The general trend is that when water level at Chrouy Changvar rises above 8m sooner in the season, it tends to stay above it longer.

Figure C7.6 shows the gradient of water surface between Kompong Cham and Chrouy Changvar for 1994. In the wet season, when the water level in Mekong is high and discharge abound, the water surface gradient is about 1/57,000 or steeper. In the dry season when water level in Mekong is low and discharge small, the gradient is much less steep, about 1/165,000 or less. The average water surface gradient for wet season is assumed to be 1/50,000. Based on this assumption the difference in the elevation of water surface between Chrouy Changvar and the study area during the wet season is estimated to be 0.5m.

C8 Inundation Conditions

C8.1 Direction of flood flow

Figure C8.1 shows the general directions of water-flow into and out of the study area in the wet season: The major colmatage canals along Mekong river, Agn Cheng, Tamao and Kong Van, deliver flood water to the Boeng Phtea and the adjoining reservoirs, submerging the fields and flooding the forest when water level in Mekong river, when the colmatage canals reach the threshold level - assumed to be about 6m in this study. Flood water also flows into Boeng Phtea from Boeng Khcho (northeast to Boeng Phtea) through Phras Konlong bridge (partially dilapidated by flood in 1996), the smaller bridges and crossing structures cross-cutting the Phras Konlong road (repaired and renovated in 1996). Through the poorly designed and constructed Ta Gnel canal (a legacy of the Pol Pot regime), some water was channeled from Tonle Toch. At the end of the wet season, most of the flood water recedes southward. Late in the wet season water flows out through the long and narrow outlet of Boeng Phtea into Boeng Veal Samnap in Lovea De district, a large lake to the south which flows into Tonle Toch.

C8.2 Hypsometric curve

Figure C8.2 shows the hypsometric curve of Boeng Phtea area, assessed for each meter of 4-10m elevation to study the relationship between water level and the extent of inundation. The 6-5m and 9-8m elevation band claims 25.37 and 22.6% of total land area, followed by 7-6m band (12.49%), 8-7m band (12.46%), 5-4m band (7.55%) and 10-9 band (8.41%). Area higher than 10m and less than 4m are about 4.21% and 6.91%, respectively. About 52% of land is below 7m and 87% below 9m. The important flood water elevation is 8m, as evident from the existing land use and cropping calendar. Rainfed rice cultivation is practiced on fields above 8m. Inundation on fields above 8m is normally shallow (0-0.5m) and short (about 52days). Fields between 6-8m are cropped to sesame and other upland crops in

May-June before flooding and to recession rice in October when the flood recedes. No cultivation is possible on 6-8m land during July-September.

C8.3 Inundated area

Flooding has increased in the past 15 years, since there has been wide-spread deforestation, and the colmatage system which helped check and dissipate flood waters, has fallen into disrepair and disuse (Cambodia, An Environmental and Agricultural Overview and Sustainable Development Strategy, USAID, 1991). Figure C8.3 shows the inundation (hatched area) corresponding to water level 4, 5, 6, 7, 8 and 9m in the study area. Area inundated to 4m elevation (6.91% of land area) is the bottom line condition in the dry season, comprising of only Boeng Phtea and some remaining bogging scrubs. Area inundated to 9m elevation (87.38% of land area) is that of the peak in the wet season. The huge expanse of water is a far-reaching concern, crippling almost all activities and driving local populace and droves of animals to roadsides and embankment.

Flooding is a chronic but familiar yearly "force majeure". It is also a curse as well as blessing. Figure C8.4 shows the percentage of inundated area for 1/2 and 1/10 return period. In 1985 (1/2 R.P.) with the advancing flood, 42.58% was inundated in July, 64.41% in August, 87.89% in September, 76.31% in October, 45.32% in November and 15.48% in December, when the flood petered out. Inundation was confined mainly to the water body of Boeng Phtea in January through June. In 1966 (1/10 R.P.) inundation followed similar trend, except for September when the inundation covered a wider area, or 95.2% of total land area.

Figure C8.5 shows the monthly changes in inundation depth in 1985. In July flood level was 6.22m, resulting in 6.91% of land inundated to 3-4m deep, 7.55% to 2-3m, 25.37% to 1-2m and 2.75% to 0-1m. Following the periodic flood level, the 6-5m elevation band was inundated to different depths: 1-2m deep in July, 2-3m in August, 4-5m depth in September, 3-4m depth October and 1-2m depth in November. Figure C8.6 shows the monthly changes in inundated area in 1966.

Figure C8.7 and C8.8 show the monthly changes of average inundation extent for 1985 (1/2 R.P.) and 1966 (1/10 R.P.). In July only the area below 6m in the periphery of Boeng Phtea was inundated. As the flood advanced, the extent of inundation became wider, covering over 88% and 95% in September of the respective years. As the flood receded, land in the higher elevation re-surfaced sooner. By the end of December, water was found mainly in Boeng Phtea.

C9 Water Quality Survey

Water quality was surveyed for well, lake and river water in the study area to assess their suitability for drinking, irrigation and fish production. Well water was sampled from wells in the villages along Mekong (coded as gB, cD and aF, Figure C9.1) and Vihearsour village (jJ). Well coded gB, cD and aF are tube well equipped with hand pumps (installed by UNICEF). Well jJ is an open well. Water in the lake was sampled at three locations, the upper, middle and lower end of the Boeng Phtea (fG, hE and kE). River water was sampled from ferry boat at the middle of Mekong river (Ferry).

Most of the villagers along the Mekong river do not use the tube wells for drinking and cooking, despite for the anticipated hygienic improvement . For cooking and drinking purpose river water in the Mekong is preferred instead, for its taste and smell. Water in the tube wells was tested to contain 0.03-0.05% of NaCl.

The results of the simplified in-situ test is shown in Table C9.1. Laboratory test results of the samples brought back is shown in Table C9.2. The values of the parameters such as pH, COD, SS, Ec, and DO suggest that water in the river and lake poses no hazard for normal paddy growth. Derived parameters such as TDS (Total Dissolved Solids) and SAR (Sodium Adsorption Ratio) also show that water in the river and lake will not affect soil structure and irrigation of upland crops, considering the soil, climate and the extent of the periodic flood in the study area.

Test for C. Bacillus has shown that most of the water in the tube well and all open waters in the study area were infested with the bacteria. Water from these sources can be made safer for drinking by boiling.

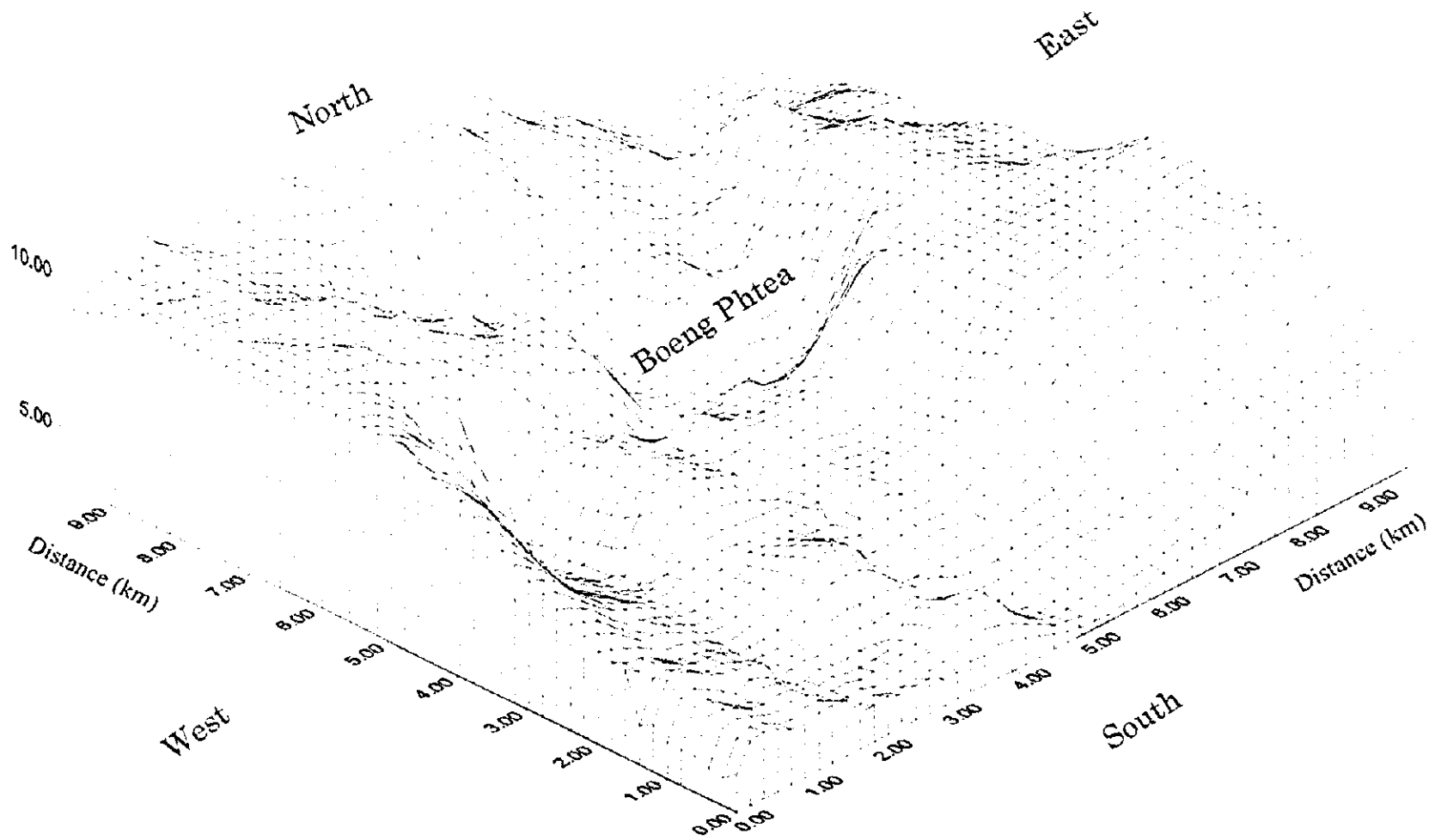


Figure C5.1 Bird's-eye view of the Study Area

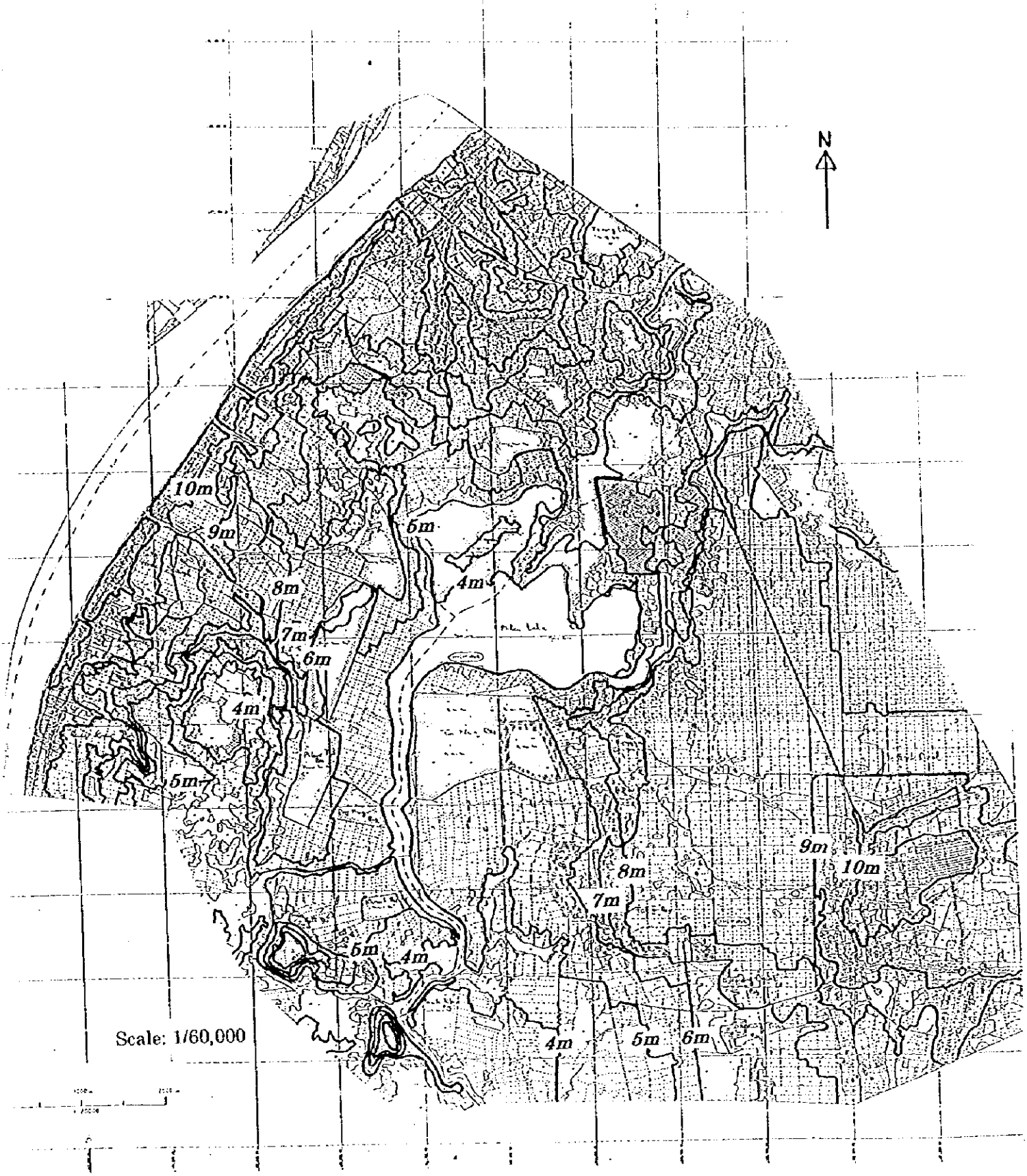


Figure C5.2 Topography of the Study Area.

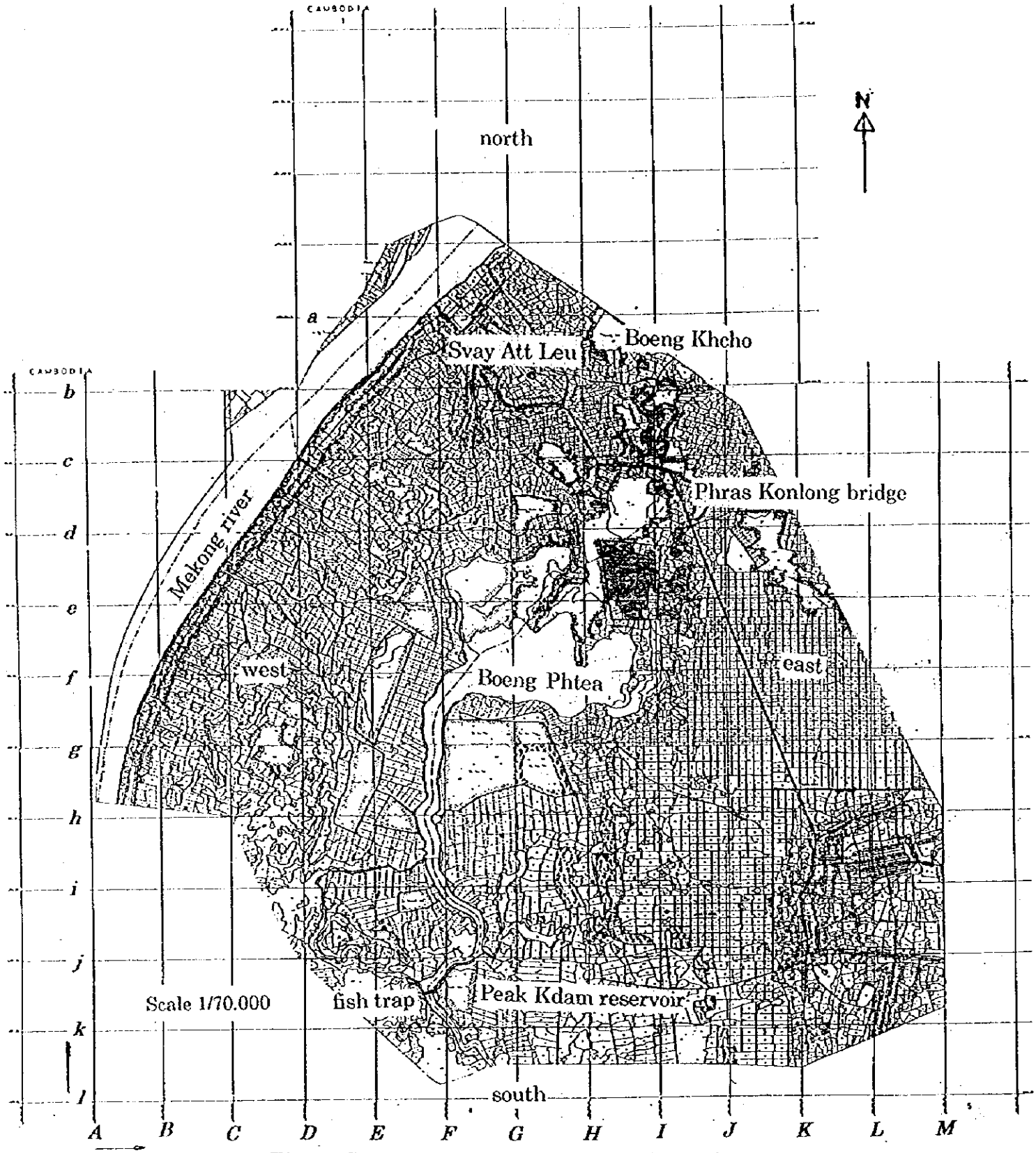


Figure C5.3 Grid-Point System of the Study Area.

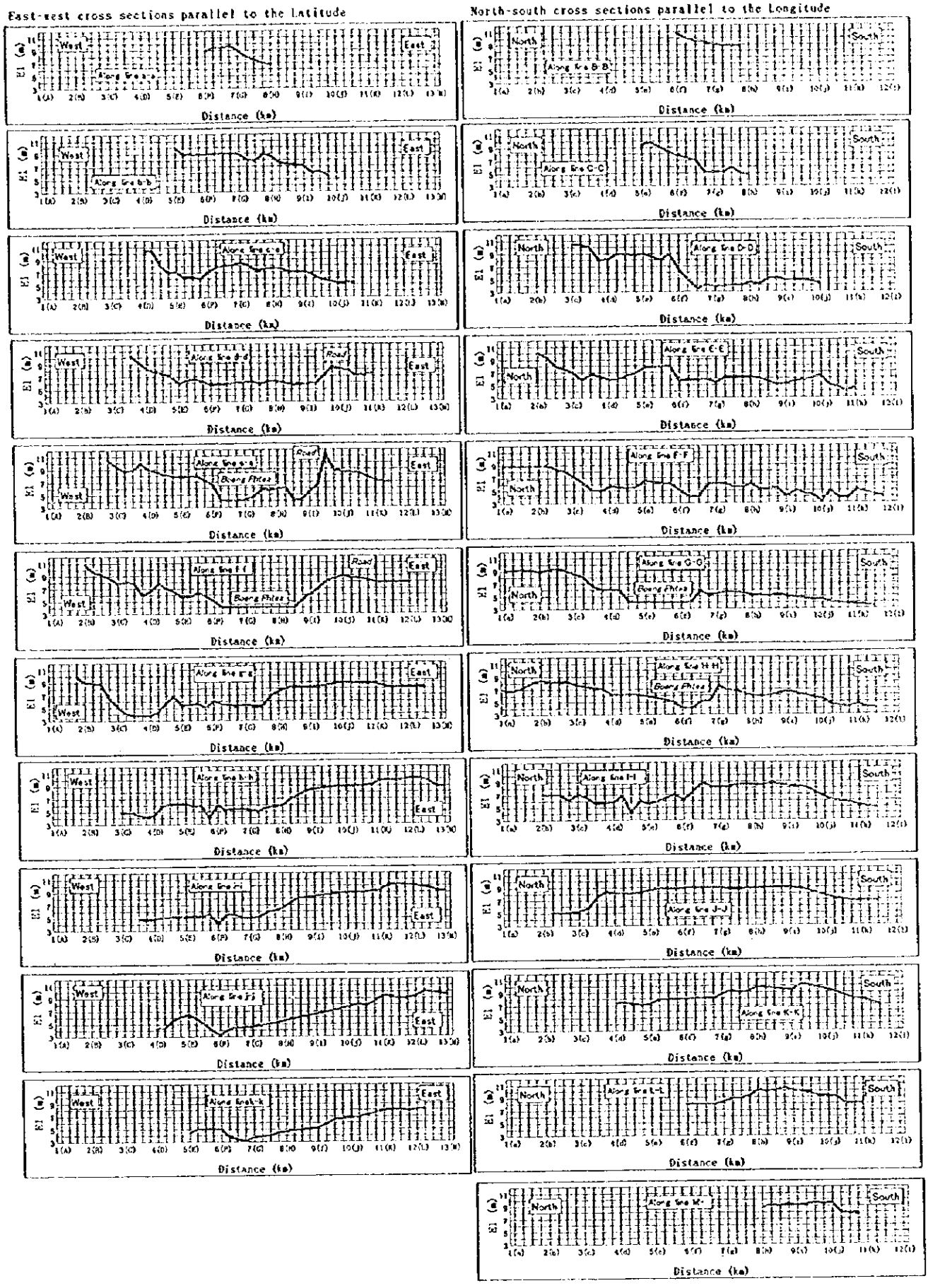
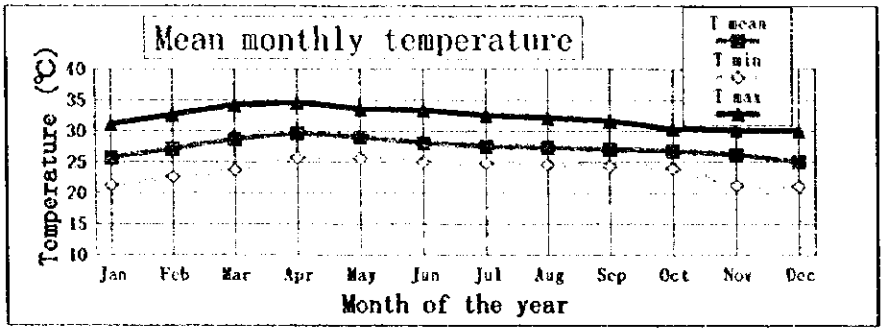


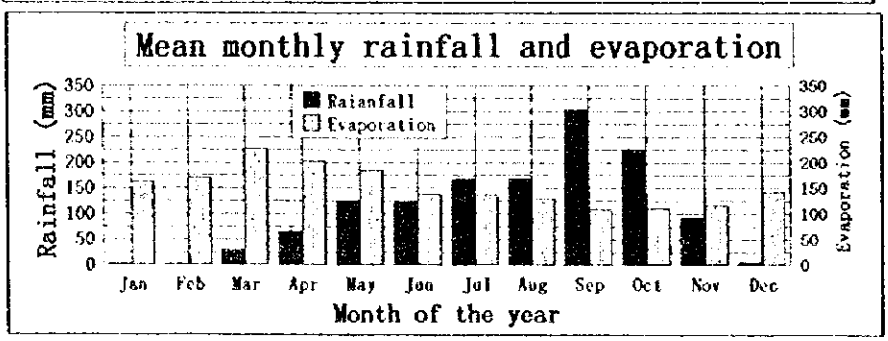
Figure C5.4 Cross sections Drafted along the Grid lines.

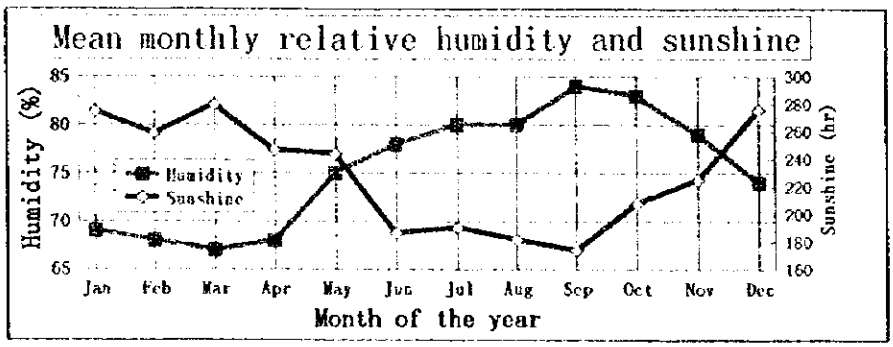
Basic meteorological data - Pochentong Station

Month	Jan I	Feb II	Mar III	Apr IV	May V	Jun VI	Jul VII	Aug VIII	Sep IX	Oct X	Nov XI	Dec XII	Total
Rainfall	3.6	2.8	29.5	66.3	121.6	122.5	167.7	168.3	303.4	225.5	92.5	6.5	1313.2
Temperature													
T mean	25.7	27.1	28.7	29.7	29	28.1	27.5	27.1	27	26.8	26.2	25	
T min	21.3	22.6	23.8	25.8	25.7	25	24.9	24.6	24.4	24	21.3	21.1	
T max	31.1	32.6	31.2	31.6	33.6	33.4	32.5	32.1	31.6	30.4	30.1	30	
Humidity													
U mean	69	68	67	68	75	78	80	80	81	83	79	74	
Evaporation	162	170.7	227.5	202.6	184.6	137.8	137.5	130.4	108.8	111.2	117.6	142.2	1832.6
(mm/day)	5.2	6.1	7.3	6.8	6.0	4.6	4.4	4.2	3.6	3.6	3.9	4.6	
Sunshine	271.9	258.8	279.7	246.9	241.1	186.5	190.3	181.5	173.9	207.9	225.1	276.1	2745.7
(hr/day)	8.9	9.2	9.0	8.2	7.9	6.2	6.1	5.9	5.8	6.7	7.5	8.9	

Meteorological data - Pochentong (1985～1995)
(No.991, 11° 33'N, 104° 51'E, 10m M.S.L.)







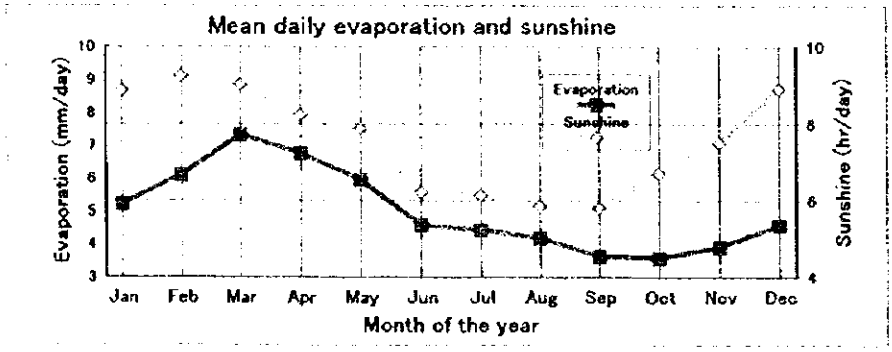


Figure C6.1 Basic Meteorological Data - Pochentong.

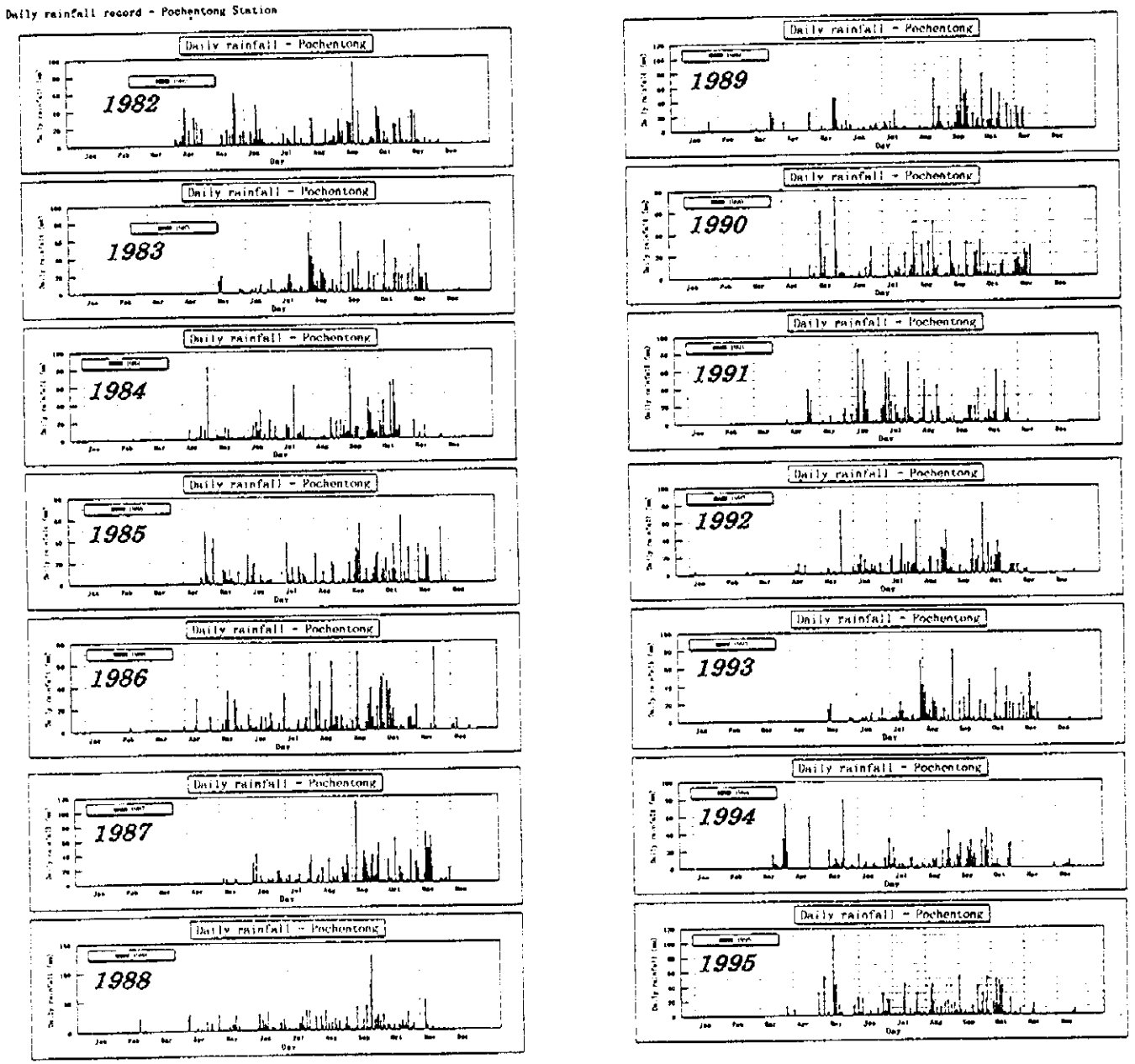


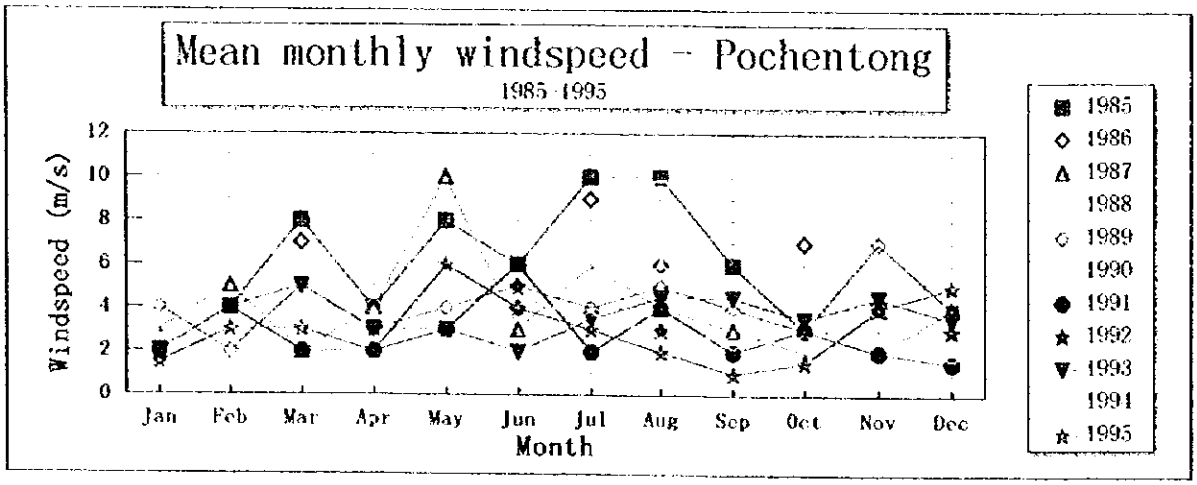
Figure C6.2 Daily Rainfall (1982-1995) - Pochentong.

Mean monthly windspeed - Pochentong

Lat:11-33 Long:105-50 Alt:10m

Unit:(m/s)

Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Mean	
												(m/s)	km/day
Jan	1.0	1.0	3.0	1.0	1.0	3.0	2.0	2.0	2.0	1.0	1.5	3.0	263.1
Feb	1.0	1.0	5.0	2.0	2.0	3.0	1.0	1.0	1.0	1.5	3.0	3.3	286.7
Mar	8.0	7.0	2.0	3.0	5.0	5.5	2.0	3.0	5.0	3.0	3.0	4.2	365.2
Apr	1.0	1.0	1.0	3.0	3.0	7.0	2.0	3.0	3.0	1.0	2.0	3.5	306.3
May	8.0	1.0	10.0	7.0	1.0	5.0	3.0	3.0	3.0	1.0	6.0	5.2	447.7
Jun	6.0	1.0	3.0	2.0	5.0	5.0	6.0	5.0	2.0	1.5	1.0	4.2	365.2
Jul	10.0	9.0	6.0	5.0	1.0	6.0	2.0	2.0	3.5	3.5	3.0	4.9	424.1
Aug	10.0	6.0	1.0	9.5	5.0	6.0	1.0	3.0	1.5	3.0	2.0	5.2	447.7
Sep	6.0	1.0	3.0	1.0	1.0	1.0	2.0		1.5	2.5	1.0	3.5	302.4
Oct	3.0	7.0	2.0	3.0	3.0	2.0	3.0	3.0	3.5	2.5	1.5	3.0	263.1
Nov	1.0	1.0	2.0	5.0	7.0	2.0	2.0	1.0	1.5	1.0	1.0	3.9	333.8
Dec	1.0	1.0	1.0	1.0	1.0	2.0	1.5	3.0	3.5	2.0	5.0	3.4	290.6



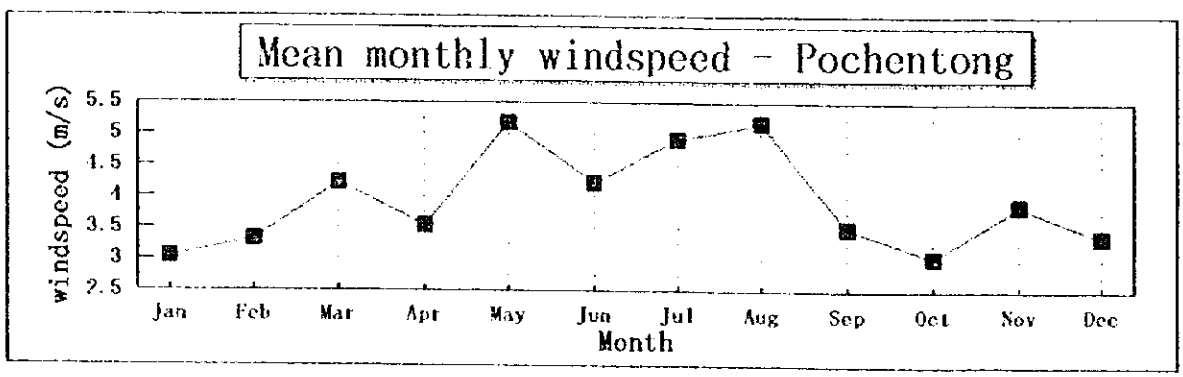


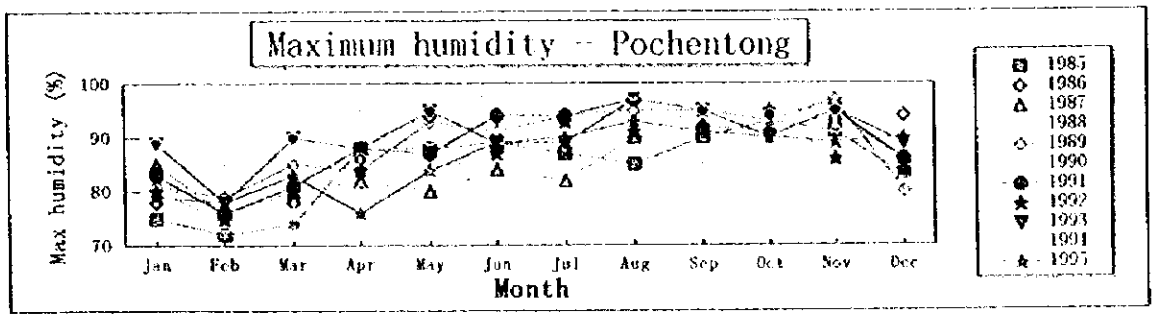
Figure C6.3 Mean Monthly Wind Speed- Pochentong.

Maximum and minimum humidity - Pochentong

Lat:11-33 Long:105 50 Alt:10m

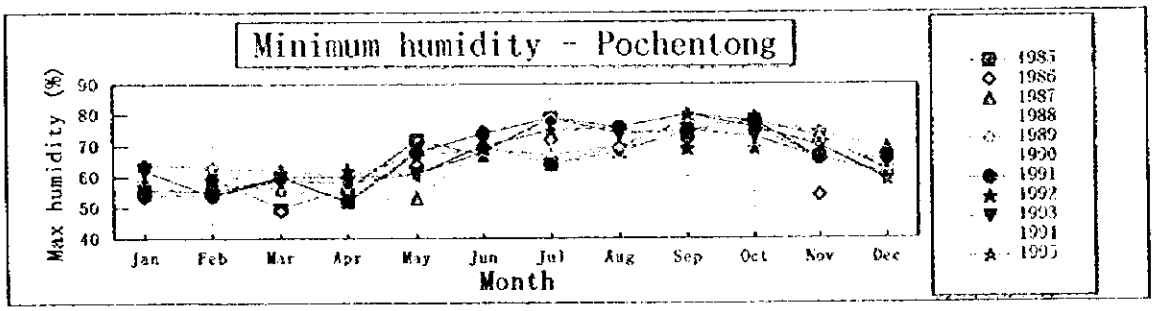
Maximum humidity Unit:(%)

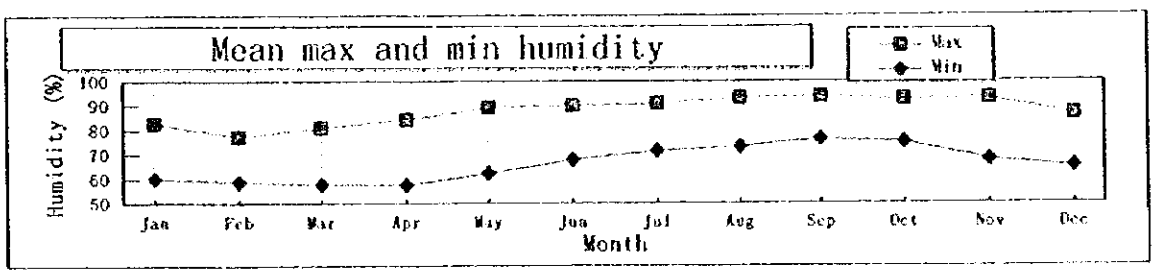
Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Mean
Jan	75	78	85	82	81	89	83	80	89	89	79	83
Feb	72	76	76	79	79	71	76	75	78	89	78	77
Mar	71	78	80	71	85	76	81	80	90	90	83	81
Apr	88	86	82	81	81	81	88	81	88	86	76	84
May	88	91	80	91	93	90	87	81	95	95	81	89
Jun	89	88	81	90	91	92	91	87	89	98	89	90
Jul	87	88	82	91	91	91	91	93	89	98	90	91
Aug	85	90	90	96	95	93	97	91	97	98	93	93
Sep	90	92	92	95	95	95	95	95	95	95	91	94
Oct	93	91	91	93	93	94	91	95	90	94	90	93
Nov	91	92	91	97	97	92	95	86	95	95	89	93
Dec	83	91	86	80	80	83	86	81	89	96	90	86



Minimum humidity Unit:(%)

Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Mean
Jan	57	57	55	61	61	60	51	64	62	68	56	60
Feb	59	59	58	60	63	59	51	59	51	67	55	59
Mar	50	49	56	51	62	60	60	61	59	64	60	58
Apr	56	56	52	66	60	51	52	62	58	58	60	58
May	72	61	53	58	67	61	68	61	61	58	61	62
Jun	67	70	70	66	69	62	71	67	68	65	70	68
Jul	61	72	61	75	67	69	79	61	79	78	75	71
Aug	68	76	70	78	70	71	76	76	74	68	76	73
Sep	75	72	74	78	78	79	80	69	75	80	80	76
Oct	78	78	79	76	76	71	78	69	73	68	76	75
Nov	73	51	71	66	66	72	66	67	66	73	70	68
Dec	62	65	69	66	61	61	66	67	66	71	59	65





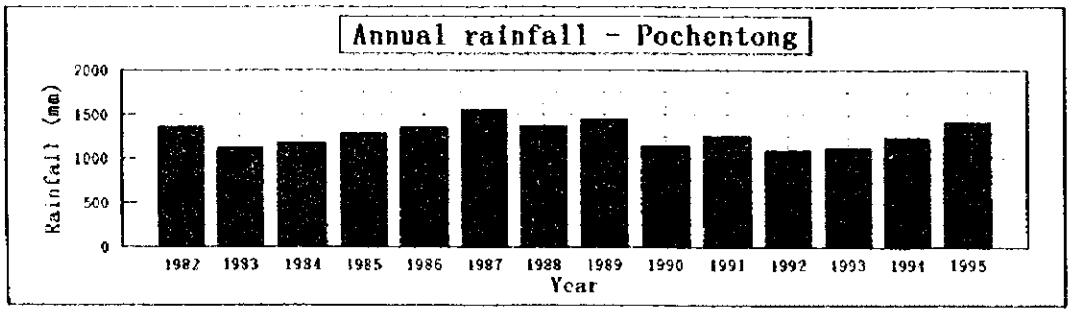
Source: Pochentong Meteorological Station.

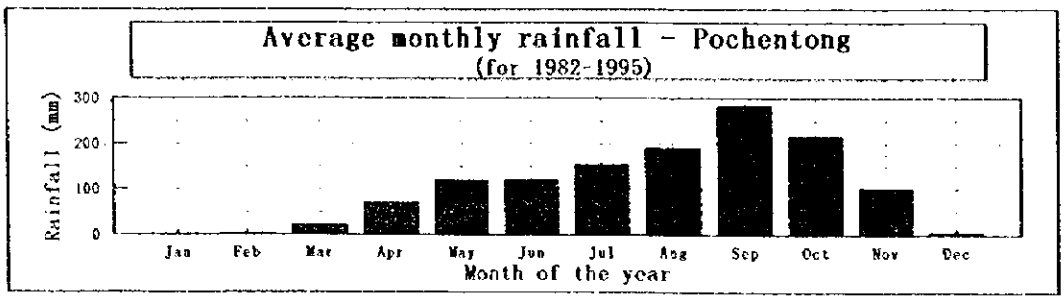
Figure C6.4 Mean Monthly Maximum and Minimum Humidity- Pochentong.

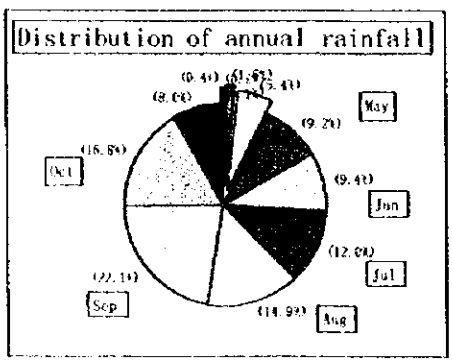
Monthly rainfall - Pochentong Meteorological Station

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Average
Jan	0.4	0.0	1.4	0.0	0.0	0.0	0.0	15.0	0.0	0.0	3.1	0.0	0.4	0.0	1.5
Feb	0.5	0.0	1.1	1.1	4.5	0.0	22.9	0.0	0.0	0.0	2.5	0.0	0.0	0.0	2.3
Mar	14.2	0.0	0.0	0.0	4.5	0.0	22.2	51.0	0.0	0.0	0.6	0.0	164.2	18.0	19.8
Apr	181.0	0.0	128.7	157.6	48.7	0.0	96.3	63.2	26.2	83.4	35.0	0.0	61.1	91.3	69.7
May	196.8	47.5	62.2	102.7	149.8	24.6	70.2	183.5	227.1	53.4	93.1	47.5	157.7	234.6	117.9
Jun	158.9	55.1	112.6	77.0	90.9	150.2	172.9	38.4	63.8	304.5	113.9	55.1	106.1	146.8	119.7
Jul	74.9	170.1	127.1	117.6	181.3	138.2	152.9	86.6	166.8	281.3	219.5	170.1	96.5	156.4	153.0
Aug	161.1	312.2	106.1	92.5	224.5	183.6	177.8	162.1	174.6	193.7	198.4	312.2	154.3	208.9	190.2
Sep	246.7	174.1	264.3	283.7	301.3	474.3	445.0	398.7	246.6	120.2	216.5	174.1	332.9	277.1	282.5
Oct	218.5	203.1	292.7	260.8	235.1	257.1	137.4	328.6	98.3	210.2	197.2	203.1	126.9	243.6	215.2
Nov	107.5	155.4	51.5	188.6	86.9	323.8	71.4	107.3	138.7	2.2	10.9	155.4	5.6	22.4	102.0
Dec	0.1	3.2	1.1	0.9	23.8	0.0	0.0	0.0	0.0	1.7	3.8	3.2	17.9	11.2	4.8
Annual	1360.6	1120.7	1178.8	1282.5	1351.3	1551.8	1369.0	1437.7	1142.1	1253.6	1094.8	1120.7	1223.6	1413.3	1278.6
Max	91.8	80.0	83.3	62.5	75.4	113.5	128.0	96.9	74.0	85.2	80.0	80.0	79.2	110.5	

Note: Max is maximum daily rainfall





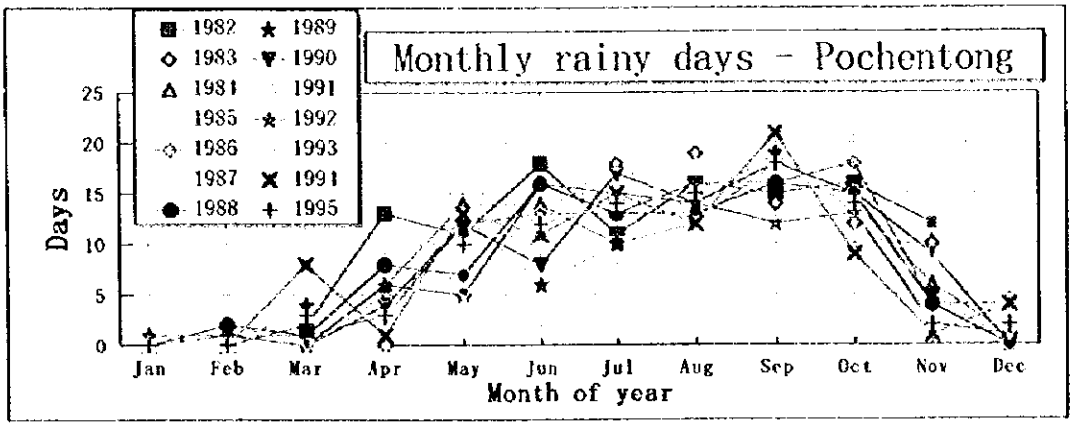


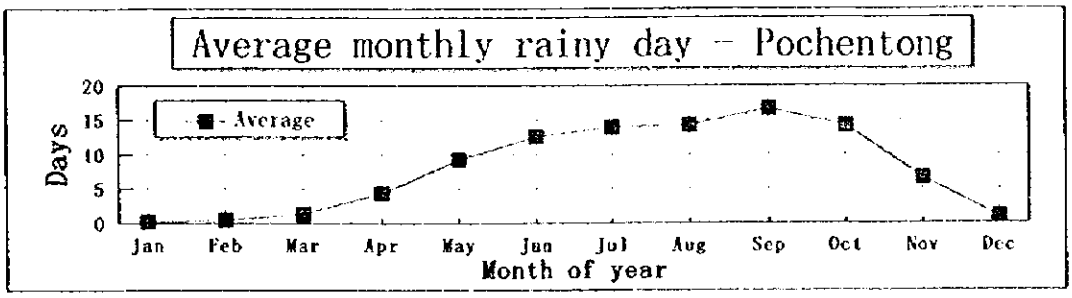
Note: Rainfall from May to October is about 81% of the annual total

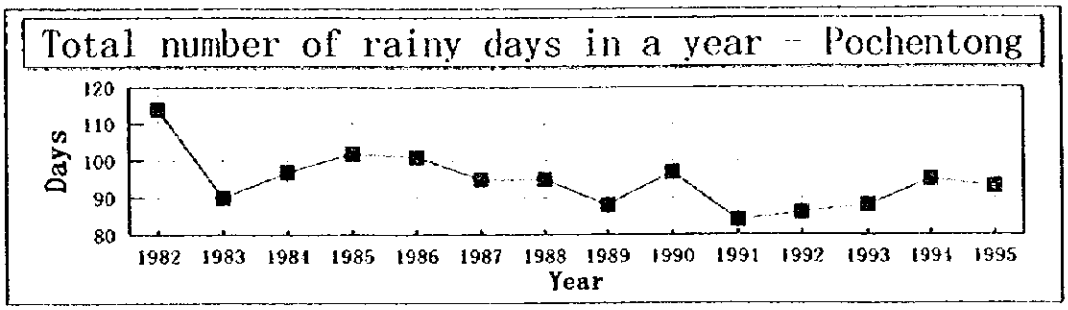
Figure C6.5 Monthly Rainfall (1982-1995) - Pochentong.

Average and total number of rainy days - Pochentong

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1982	0	0	2	13	11	18	11	16	15	16	12	0	114
1983	0	0	0	0	5	11	18	19	14	12	10	1	90
1984	1	1	0	6	14	14	10	12	18	14	6	1	97
1985	0	1	0	9	11	12	10	9	19	19	12	0	102
1986	0	1	1	3	12	13	13	16	16	18	4	4	101
1987	0	0	0	0	4	15	13	13	22	13	15	0	95
1988	0	2	1	8	7	16	13	13	16	15	4	0	95
1989	1	0	4	3	13	6	10	14	19	13	5	0	88
1990	0	0	0	4	12	8	17	14	18	15	9	0	97
1991	0	0	0	5	7	13	18	13	12	15	1	0	81
1992	1	1	0	6	5	16	15	14	12	13	2	1	86
1993	0	0	0	0	5	11	18	19	13	12	9	1	88
1994	0	0	8	1	13	11	15	12	21	9	1	4	95
1995	0	0	3	3	10	12	14	15	18	14	2	2	93
Average	0.2	0.4	1.4	4.4	9.2	12.6	13.9	14.2	16.6	14.1	6.6	1.0	91.6





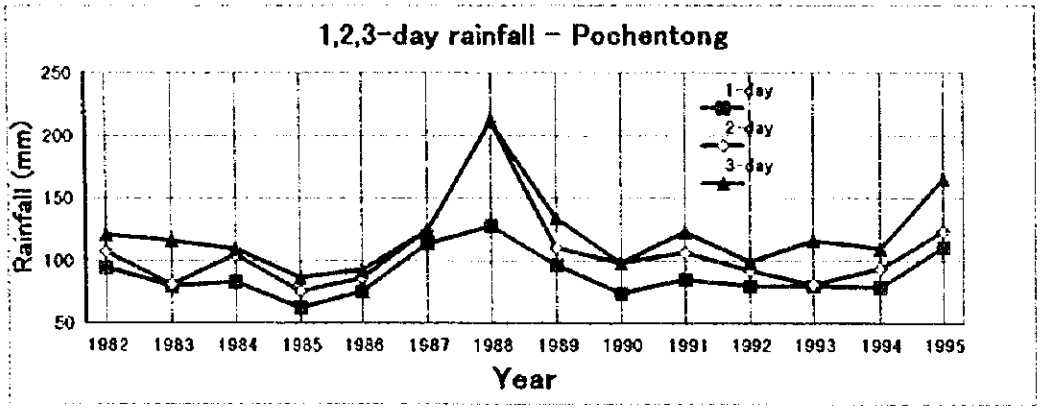


Note: Day with rainfall >= 1.0mm is taken to be a rainy day

Figure C6.6 Mean and Total Rainy Days - Pochentong.

Maximum 1, 2, 3-day rainfall and date of occurrence

Year	1-day		2-day		3-day	
	mm	date	mm	date	mm	date
1982	94.8	Sep.11	107.5	May.22-23	121.0	May.21-23
1983	80.0	Aug.29	81.2	Aug.29-30	116.0	Jul.30-Aug.1
1984	83.3	Apr.25	105.1	Oct.15-16	109.6	Oct.14-16
1985	62.5	Oct.19	75.9	Apr.29-30	86.9	Sep.8-10
1986	75.4	Nov.17	86.0	Sep.29-30	92.6	Sep.29-10.1
1987	113.5	Sep.5	124.1	Sep.4-5	124.1	Sep.4-6
1988	128.0	Sep.18	211.9	Sep.17-18	212.1	Sep.17-19
1989	96.9	Sep.13	110.1	Sep.12-13	134.1	Sep.11-13
1990	74.0	May.19	98.2	May.19-20	98.2	May.19-21
1991	85.2	Jun.6	106.6	Jun.6-7	123.2	Jun.5-7
1992	80.0	Sep.29	92.3	Sep.29-30	99.3	Sep.28-30
1993	80.0	Aug.29	81.2	Aug.29-30	116.0	Jul.30-8.1
1994	79.2	May.19	94.0	Mar.26-27	110.0	Mar.24-26
1995	110.5	May.8	123.3	May.8-9	165.3	May.8-10
Average	88.8		107.0		122.0	



Occurrence of 1,2,3-day rainfall in the respective month

Month	1-day		2-day		3-day	
	Count	(%)	Count	(%)	Count	(%)
Jan	0	0.0	0	0.0	0	0.0
Feb	0	0.0	0	0.0	0	0.0
Mar	0	0.0	1	7.1	1	7.1
Apr	1	7.1	1	7.1	0	0.0
May	3	21.4	3	21.4	3	21.4
Jun	1	7.1	1	7.1	1	7.1
Jul	0	0.0	0	0.0	2	14.3
Aug	2	14.3	2	14.3	0	0.0
Sep	5	35.7	5	35.7	6	42.9
Oct	1	7.1	1	7.1	1	7.1
Nov	1	7.1	0	0.0	0	0.0
Dec	0	0.0	0	0.0	0	0.0
Total	14	100	14	100	14	100

Note: Over 40% of 1,2,3-day rainfall occurred in August and September for the period 1982-1995. The occurence in May was more than 20%

Figure C6.7 Maximum 1-, 2-, and 3-day Rainfall - Pochentong.

Effective rainfall- Pochentong

Unit:mm

Year	Annual Total (a)	Effective rainfall			
		Yearly		Rainy season	
		(b)	(b)/(a)	(c)	(c)/(a)
82	1360.6	741.6	0.55	623.2	0.46
83	1120.7	606.8	0.54	606.8	0.54
84	1178.8	583.8	0.50	536.4	0.46
85	1282.5	707.8	0.55	634.4	0.49
86	1351.3	695.3	0.51	662.6	0.49
87	1551.8	774.0	0.50	774.0	0.50
88	1369.0	762.5	0.56	668.4	0.49
89	1437.7	733.1	0.51	638.5	0.44
90	1142.1	658.8	0.58	642.6	0.56
91	1253.6	612.4	0.49	565.9	0.45
92	1094.8	597.6	0.55	580.0	0.53
93	1120.7	606.8	0.54	606.8	0.54
94	1223.6	667.0	0.55	575.8	0.47
95	1413.3	738.6	0.52	685.0	0.48
Average	1278.6	677.6	0.53	628.6	0.49

Note: Effective rainfall =80% of 5 to 80mm/day (paddy cultivation)
Most of the effective rainfall
occurs in the rainy season (May - November)

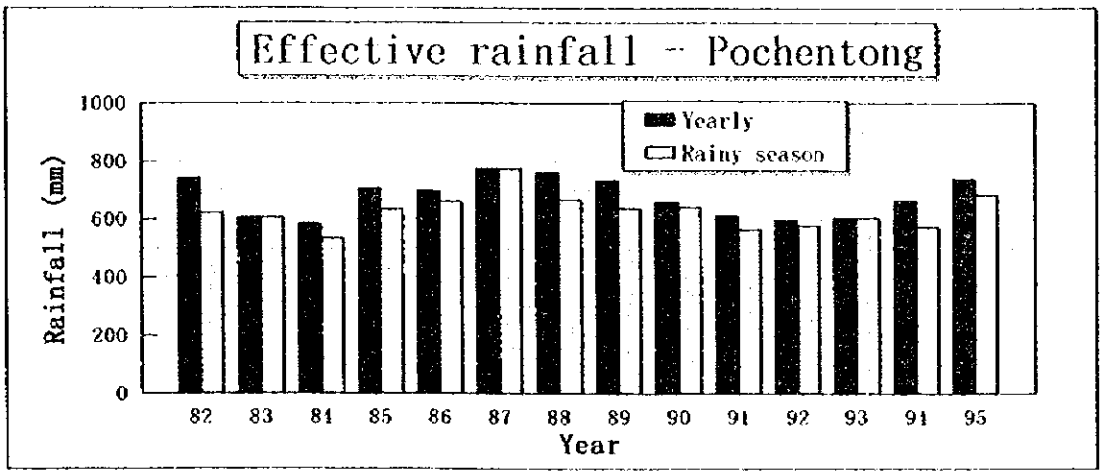


Figure C6.8 Effective Rainfall for Rice Cultivation - Pochentong.

********** COMPUTATION OF EVAPO-TRANSPIRATION **********

* Project title =		- Agricultural development -											
* Meteorological station =		- Cambodia Pochengton station -											
* Latitude (-:Southern hemisphere)		11.50											
* Altitude	(m)	10.00											
* Method of estimation		PENMAN ET=C*<W*RN+(1-W)*F(U)*(EA-ED)> mm/day											
* Height of wind measurement	(m)	12.00											
Correction factor of windspeed		.71											
* Ratio -- UDAY/UDAILY		1.30											
* Ratio -- UDAY/UNIGHT		1.50											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
* Maximum ralative himidity	(%)	80.0	76.0	79.0	83.0	88.0	88.0	90.0	91.0	93.0	92.0	92.0	85.0
Radiation at latitude	(mm/day)	12.9	14.0	15.2	15.7	15.6	15.4	15.4	15.6	15.2	14.5	13.4	12.6
Maximum possible sunshine	(hour)	11.5	11.7	12.0	12.4	12.7	12.8	12.7	12.5	12.1	11.8	11.5	11.4

Year -		Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean air temperature		(°C)	25.7	27.1	28.7	29.7	29.0	28.1	27.5	27.4	27.0	26.8	26.2	25.0
Actual daylight hours		(hr/day)	8.9	9.2	9.0	8.2	7.9	6.2	6.1	5.9	5.8	6.7	7.5	8.9
Mean relative humidity		(%)	69.0	68.0	67.0	68.0	75.0	78.0	80.0	80.0	84.0	83.0	79.0	74.0
Mean windspeed		(km/day)	263.1	286.7	365.2	306.3	447.7	365.2	424.1	447.7	302.4	263.1	333.8	290.6
Vapour pressure	EA	(mbar)	33.03	35.91	39.41	41.71	40.10	38.03	36.75	36.54	35.70	35.28	34.02	31.70
	ED	(mbar)	22.79	24.42	26.40	28.36	30.07	29.66	29.40	29.23	29.99	29.28	26.88	23.46
Wind fucntion	F(U)		.77	.82	.97	.86	1.13	.97	1.08	1.13	.85	.77	.91	.83
Weighting factor	W		.75	.76	.77	.78	.78	.77	.77	.76	.76	.76	.75	.74
Solar radiation	RS	(mm/day)	8.21	8.97	9.47	9.13	8.80	7.61	7.58	7.58	7.45	7.73	7.69	8.06
Net radiation	RN	(mm/day)	4.52	5.14	5.65	5.62	5.52	4.83	4.81	4.82	4.74	4.80	4.55	4.46
Daytime windspeed	UDAY	(m/sec)	2.81	3.06	3.90	3.27	4.78	3.90	4.53	4.78	3.23	2.81	3.57	3.10
Adjustment factor	C		1.00	1.01	1.01	1.03	1.01	.98	.97	.97	1.00	1.02	1.00	1.01
Evapo-transpiration	ET	(mm/day)	5.40	6.20	7.30	7.10	6.90	5.50	5.40	5.50	4.80	4.90	5.00	5.10

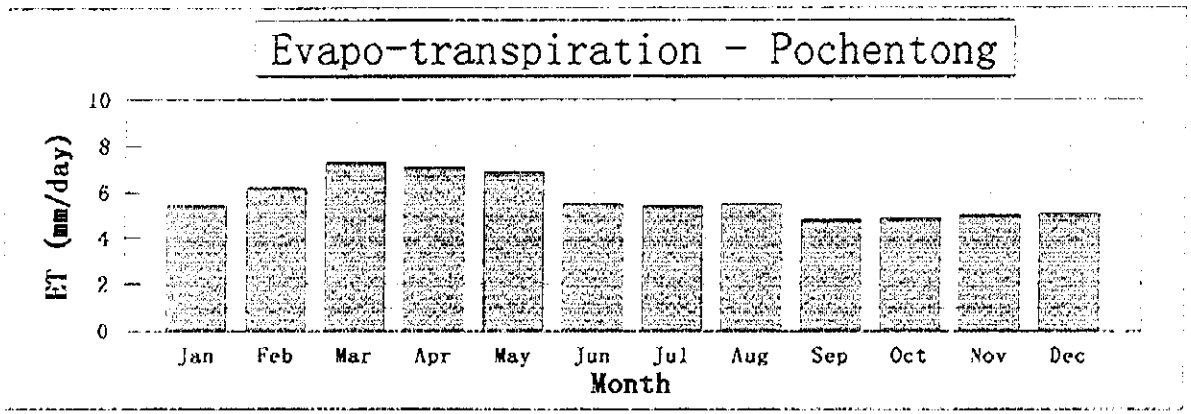


Figure C6.9 Mean Monthly Potential Evapo-transpiration - Pochentong.

Cross section of Chrouy Changvar Gauging Station (Mekong)
H019801

Unit: (m)

No.	Distance	Depth	No.	Distance	Depth
0	1	0.00	12	480	32.46
1	39	20.36	13	520	27.56
2	80	20.36	14	560	26.66
3	120	22.96	15	600	23.82
4	160	25.81	16	640	20.46
5	200	26.21	17	680	19.06
6	240	29.41	18	720	18.35
7	280	30.81	19	760	15.23
8	320	33.36	20	800	15.61
9	360	33.31	21	840	15.26
10	400	31.86	22	880	13.06
11	440	32.46	23	920	11.69
			24	980	0.00

Note: Measured on Oct 4, 1996 (17:30hr)
Distance was referred from left bank
Water level start: 10.98m
end: 10.95m

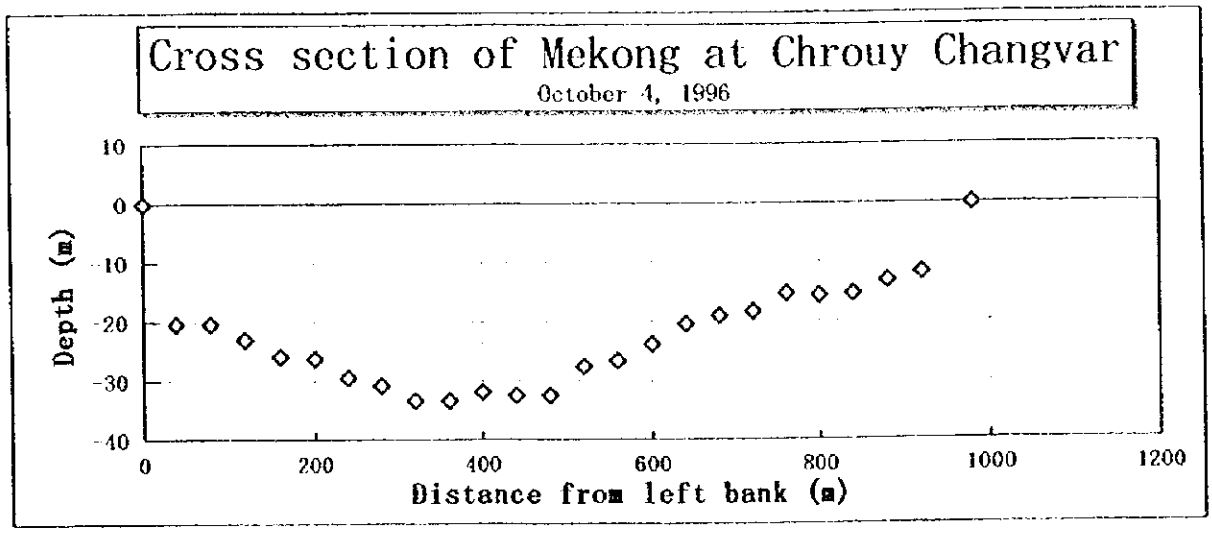


Figure C7.1 Cross Section of Mekong River - Chrouy Changvar.

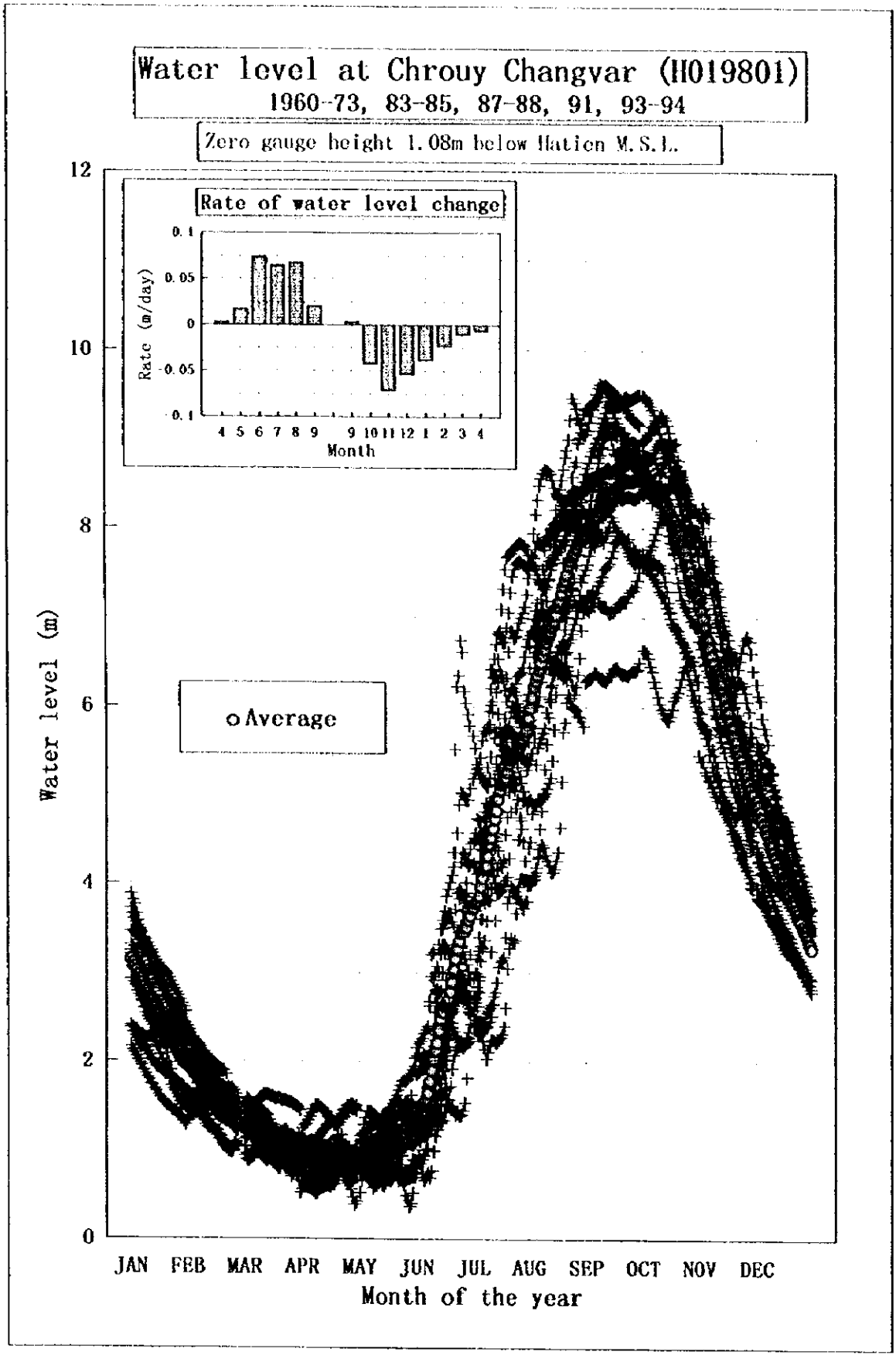


Figure C7.2 Periodic Flood Level of Mekong River - Chrouy Changvar.

Peak, mean and minimum water level
Chrouy Changvar (H019801, Mekong River)

Unit:(m)

No.	Year	Peak	Min	Mean
1	1960	8.87	0.14	3.63
2	1961	9.90	0.66	4.60
3	1962	9.14	0.69	4.34
4	1963	8.75	0.53	3.97
5	1964	9.11	0.71	4.05
6	1965	8.31	0.52	4.13
7	1966	9.94	0.67	4.34
8	1967	8.76	0.62	3.78
9	1968	8.71	0.59	3.48
10	1969	8.81	0.37	3.95
11	1970	9.16	0.64	4.23
12	1971	8.83	0.64	4.35
13	1972	9.20	0.60	4.18
14	1973	8.87	0.76	3.96
15	1983	8.65	0.57	3.69
16	1984	9.62	0.63	4.39
17	1985	8.84	0.74	4.29
18	1987	8.18	0.51	3.53
19	1988	6.61	1.16	3.31
20	1991	9.61	1.02	4.41
21	1993	7.90	0.61	3.54
22	1994	9.50	0.65	4.33
23	1995	9.12	0.66	4.08
	Mean	8.89	0.64	4.02

Note: About 60% of the peak flood level occurred within a narrow band of 1m, or ±0.5m of the mean peak flood level (8.89m).
About 90% occurred within a band of 2m, or ±1m of mean peak level.
The range of observed peak flood for 1960-1995 was 3.3m

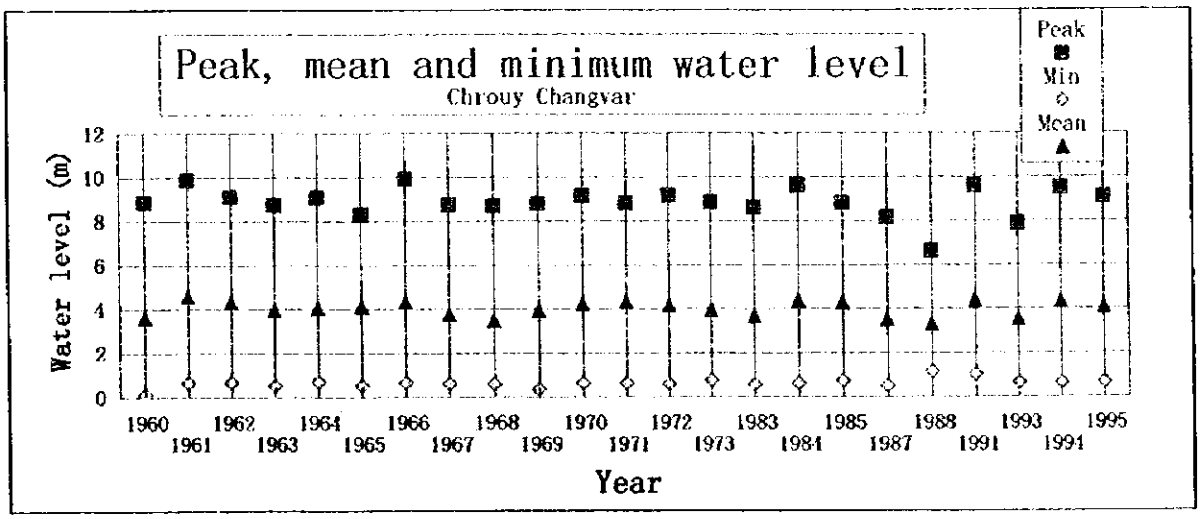


Figure C7.3 Peak, Mean and Minimum Flood Level - Chrouy Changvar.

Maximum and mean monthly water level - Chrouy Changvar for 1985 (1/2 R.P.) and 1966 (1/10 R.P.)

Unit:(m)

Return period	1/2 (1985)		1/10 (1966)	
	Mean	Maximum	Mean	Maximum
Jan	2.61	3.24	2.51	3.17
Feb	1.64	2.02	1.57	1.84
Mar	1.20	1.45	1.06	1.42
Apr	0.90	1.01	0.91	1.02
May	1.37	1.57	1.34	2.76
Jun	3.26	6.74	2.77	3.57
Jul	5.72	6.42	5.40	7.25
Aug	7.47	8.30	7.81	8.43
Sep	8.56	8.84	9.43	9.94
Oct	8.01	8.73	8.50	9.58
Nov	5.94	6.93	6.20	7.52
Dec	4.54	5.60	4.30	5.22

Note: 1985 and 1966 were chosen to represent 1/2 and 1/10 R.P. based on peak flood level only.

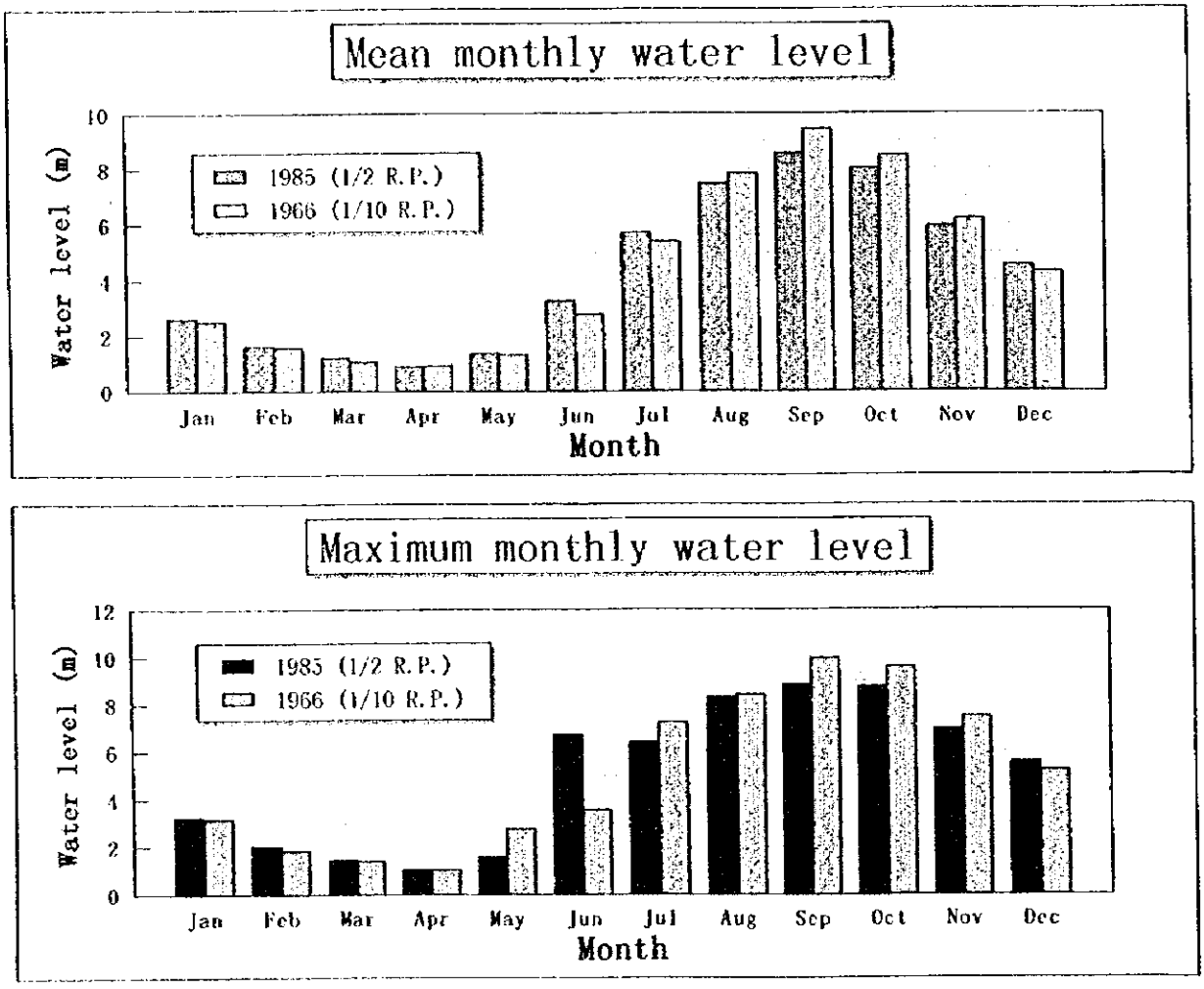


Figure C7.4 Flood Level of 1/2 and 1/10 Return Period - Chrouy Changvar.

Period when flood level was higher than 6, 7, 8, and 9m (Chrouy Changvar)

Year	Flood level >= 6m			Flood level >= 7m			Flood level >= 8m			Flood level >= 9m		
	From	To	Days	From	To	Days	From	To	Days	From	To	Days
1960	08.08	11.19	101	08.20	11.07	80	08.27	10.27	62	-	-	
1961	07.21	11.28	131	08.17	11.17	93	08.22	11.08	79	08.29	10.30	63
1962	07.16	11.18	126	08.01	11.08	100	09.08	10.29	52	09.25	10.12	18
1963	07.28	11.25	121	08.02	10.27	87	09.03	10.17	45	-	-	
1964	08.16	11.28	105	08.28	11.18	83	09.22	10.30	39	10.03	10.12	10
1965	06.25	11.09	138	08.27	10.18	53	09.12	10.03	22	-	-	
1966	07.21	11.18	118	07.27	11.05	102	08.15	10.22	69	09.07	10.08	32
1967	08.08	11.07	92	08.27	10.31	66	09.22	10.23	32	-	-	
1968	08.15	11.03	81	08.17	10.18	63	09.11	10.02	22	-	-	
1969	07.15	11.09	128	07.28	10.27	92	09.05	10.16	42	-	-	
1970	07.09	11.14	129	08.08	10.30	84	08.21	10.17	58	09.06	09.30	25
1971	07.11	11.16	129	07.17	11.05	112	08.22	10.17	57	-	-	
1972	07.31	11.15	108	08.07	11.01	90	08.16	10.20	66	09.10	09.15	6
1973	08.16	11.28	105	08.27	11.03	69	09.07	10.25	49	-	-	
1983	08.13	12.03	113	08.31	11.14	76	10.09	10.28	20	-	-	
1984	07.23	11.20	121	08.06	11.10	97	08.14	10.28	76	08.22	09.23	33
1985	08.03	11.13	103	08.10	10.31	83	08.18	10.14	58	-	-	
1987	08.21	10.30	71	08.23	10.16	55	08.28	09.23	27	-	-	
1991	07.24	11.21	121	08.06	11.13	100	08.23	11.03	73	08.29	10.16	49
1993	08.05	11.01	89	08.22	10.17	57	-	-		-	-	
1994	07.12	11.09	121	07.21	11.01	104	08.01	10.23	81	09.08	10.11	34
1995	08.01	11.19	111	08.11	11.10	92	09.01	10.26	56	09.11	09.22	12
1996	07.26	12.11	139	08.06	11.29	116	09.16	11.17	73	09.23	10.18	26
Average			113.2			85.0			52.6			28.0

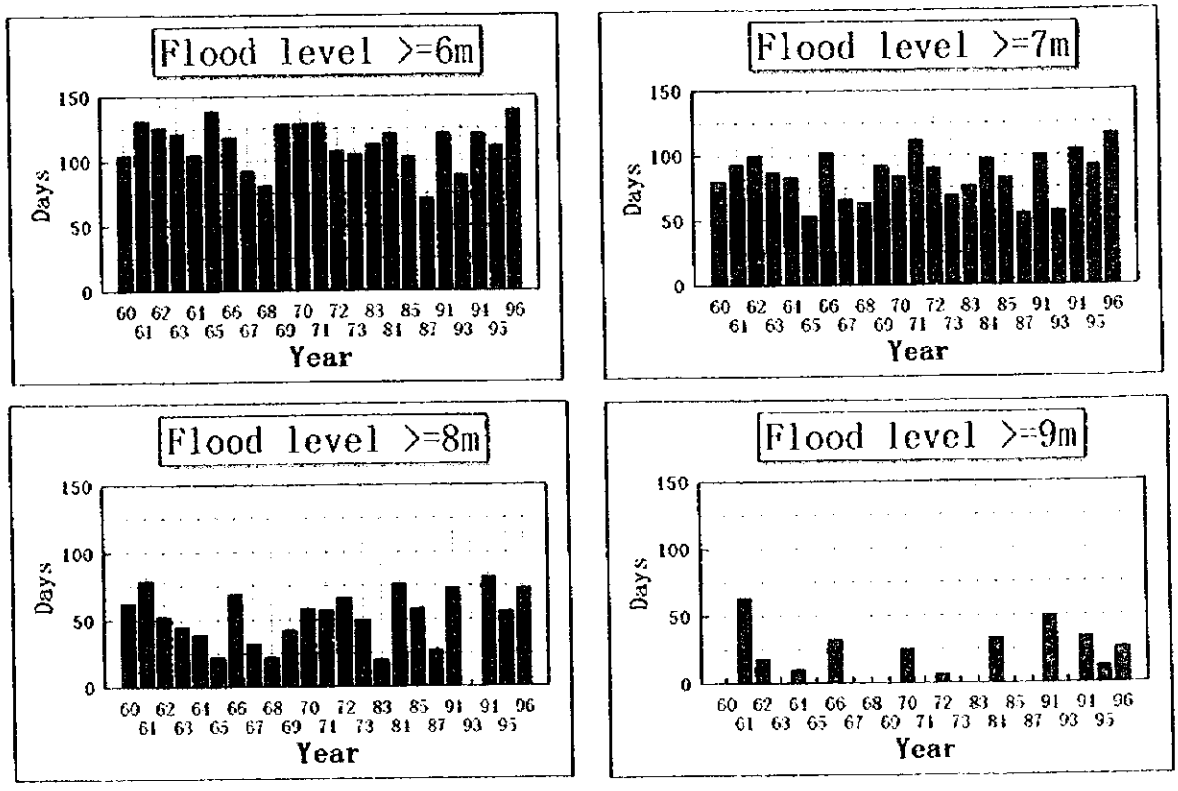


Figure C7.5 Period of Flood Level Above 6, 7, 8 and 9m - Chrouy Changvar.

Average monthly water level difference and gradient (1/I)
between Chrouy Changvar and Kompong Cham

Month	1/I*1000	Difference (m)
Jan	330	0.32
Feb	410	0.26
Mar	260	0.39
Apr	220	0.47
May	165	0.65
Jun	40	2.78
Jul	22	4.52
Aug	21	4.76
Sep	22	4.49
Oct	57	2.00
Nov	172	0.60
Dec	186	0.53

Note: calculated for daily water level difference of 1991
The smallest difference was 0.14m (February 20), largest 5.67m (Aug. 7)
Distance between the stations is about 100km

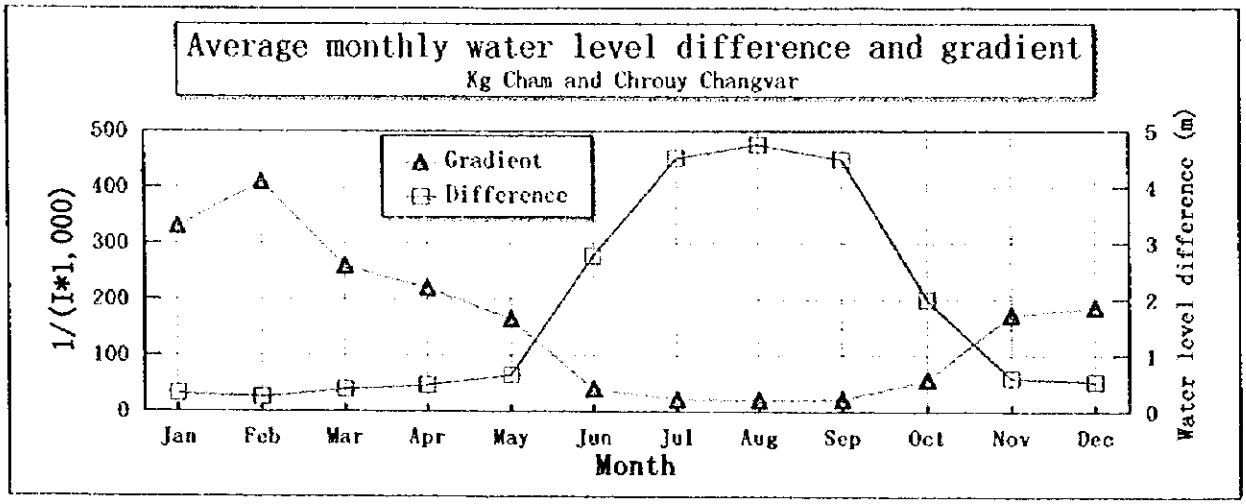


Figure C7.6 Mean Monthly Water Surface Gradient between Chrouy Changvar and Kompong Cham.

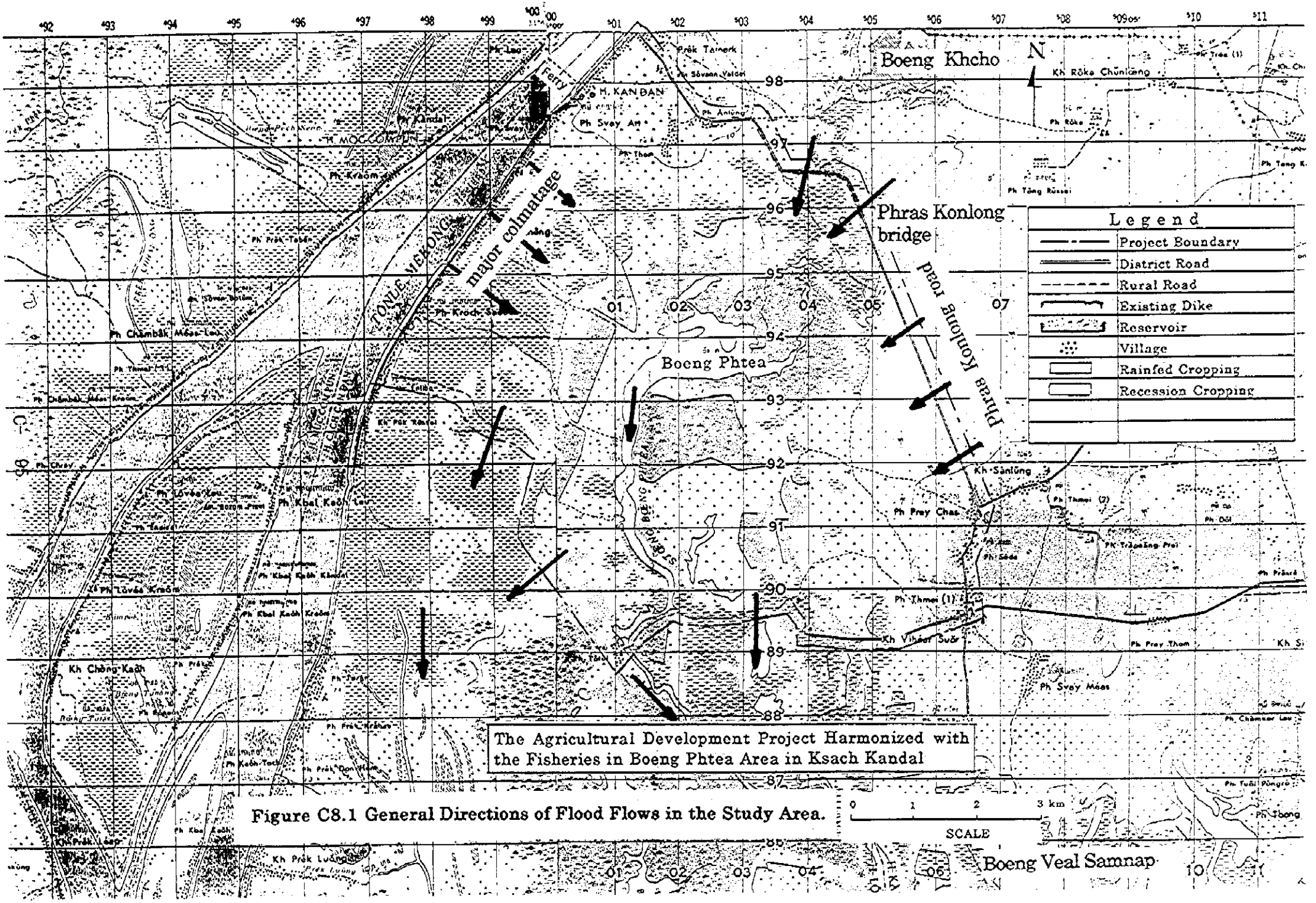


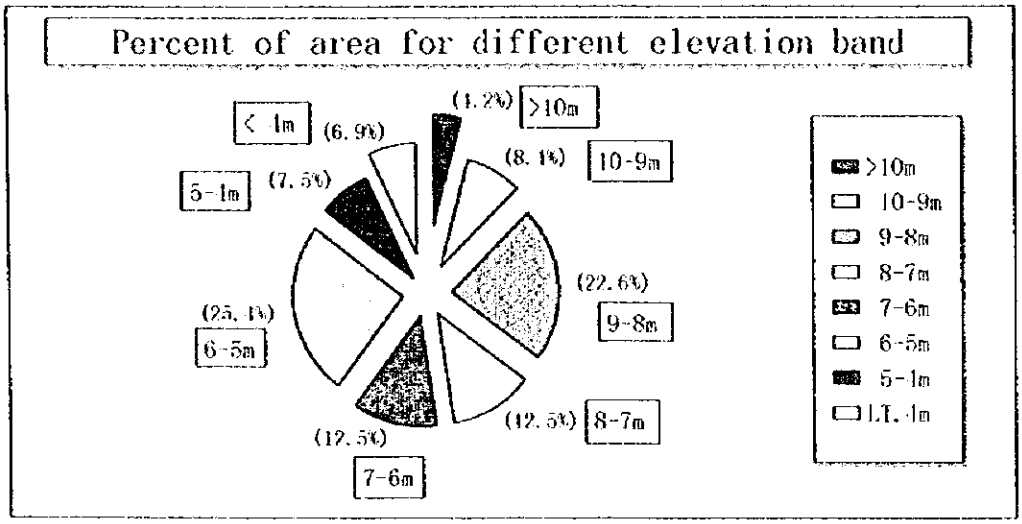
Figure C8.1 General Directions of Flood Flows in the Study Area.

Hypsometric curve - Boeng Phtea area

Total area = 6,130 ha

Elevation (m)	Area in each band (%)	(ha)	Elevation (m)	Cumulative area (%)	(ha)
>10	4.21	258.1	<1m	6.91	423.7
10-9	8.41	515.3	<5m	14.46	886.3
9-8	22.60	1385.4	<6m	39.83	2441.6
8-7	12.46	761.1	<7m	52.32	3207.1
7-6	12.49	765.6	<8m	61.78	3971.2
6-5	25.37	1555.3	<9m	87.38	5356.6
5-1	7.55	462.6	<10m	95.79	5871.9
< 1	6.91	423.7	>10m	100.00	6130.0
Total	100.00	6130.0			

Note: Area <1m is taken to be the water surface area of Boeng Phtea in May/June



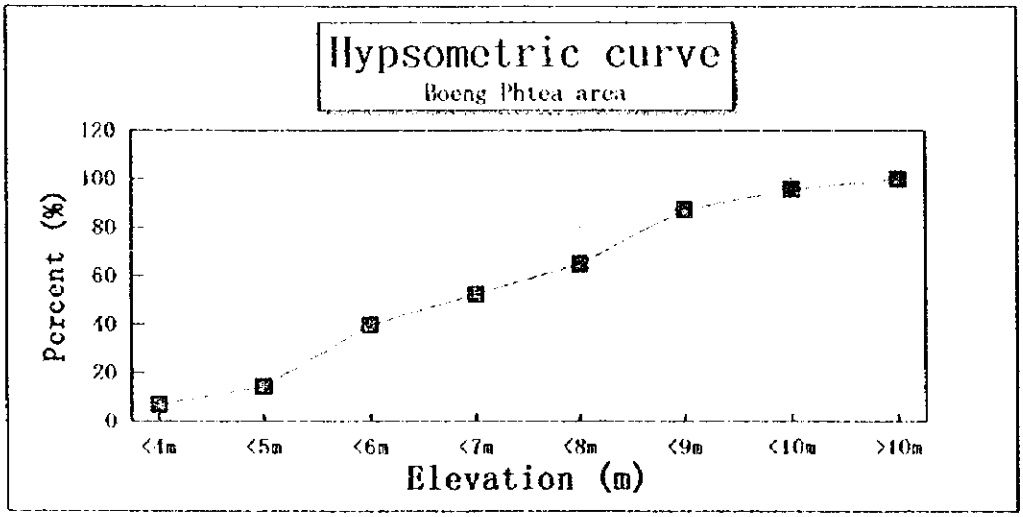
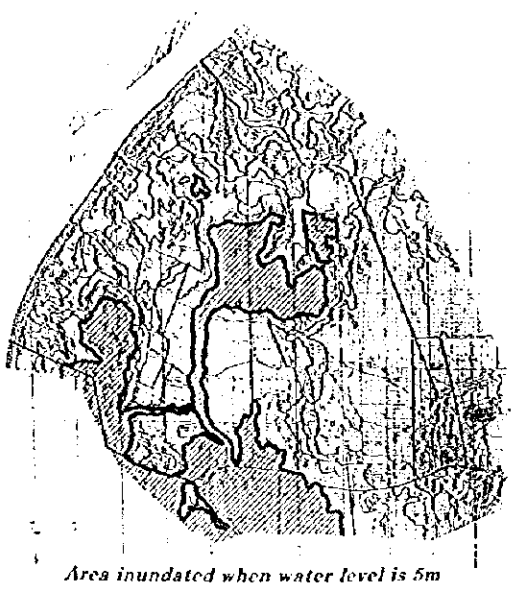
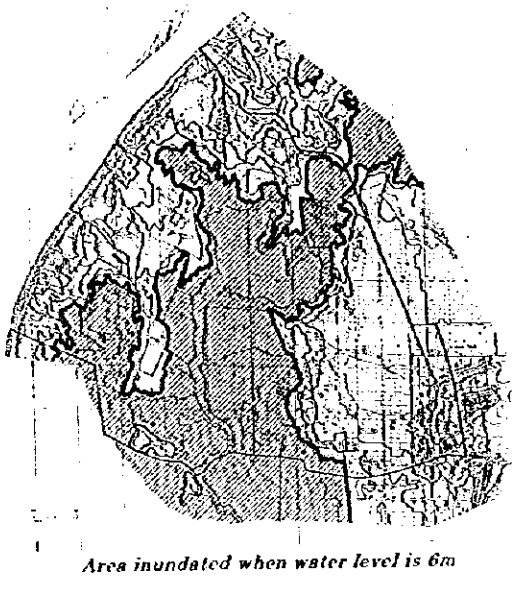


Figure C8.2 Hypsometric Curve of the Study Area.

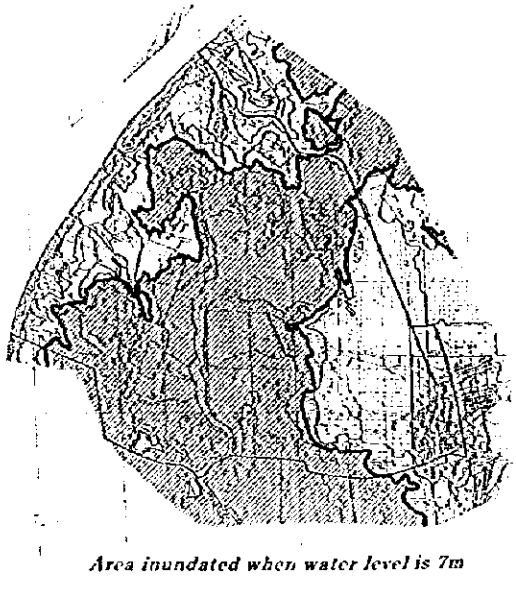
Area inundated when water level is 4m



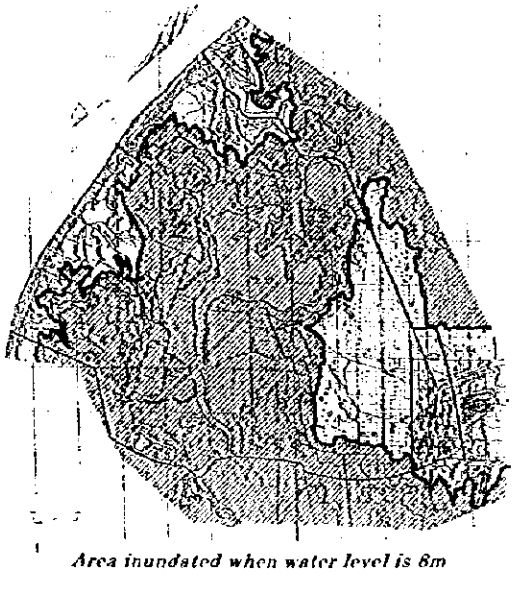
Area inundated when water level is 5m



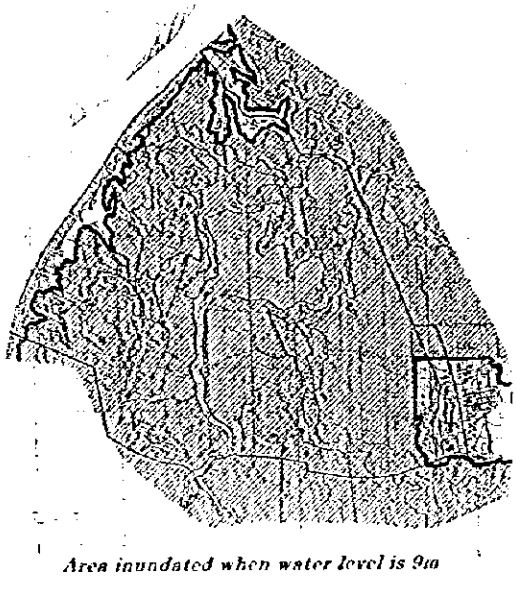
Area inundated when water level is 6m



Area inundated when water level is 7m



Area inundated when water level is 8m



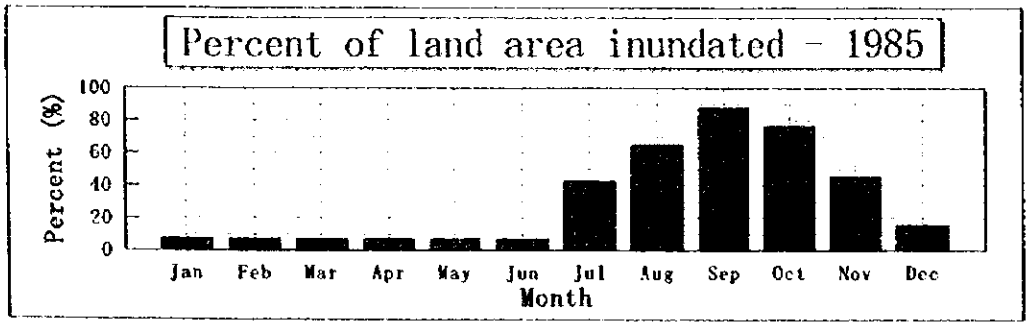
Area inundated when water level is 9m

Figure C8.3 Area Inundated When Water Level is 4, 5, 6, 7, 8 and 9m.

Water level and inundated area - 1985 & 1966

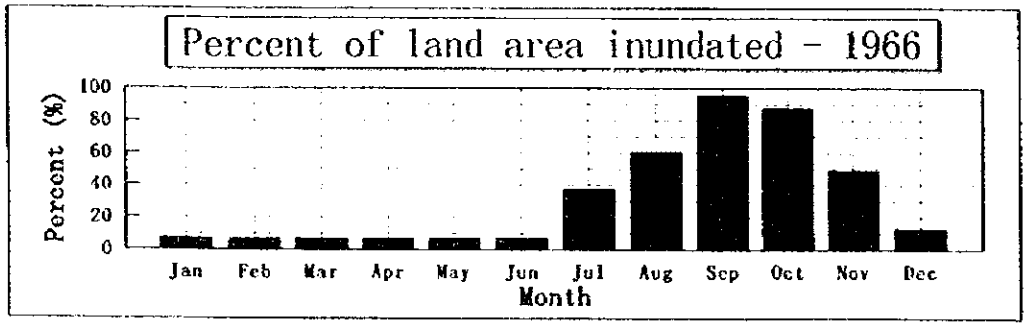
(a) 1985 (1/2 R.P.) Unit: (%)

Month	Water level (m)	Inundated area for each elevation band							Total
		<4m	4-5m	5-6m	6-7m	7-8m	8-9m	9-10m	
Jan	3.11	6.91	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Feb	2.14	6.91	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Mar	1.70	6.91	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Apr	1.40	6.91	0.00	0.00	0.00	0.00	0.00	0.00	6.91
May	1.87	6.91	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Jun	3.76	6.91	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Jul	6.22	6.91	7.55	25.37	2.75	0.00	0.00	0.00	42.58
Aug	7.97	6.91	7.55	25.37	12.49	12.09	0.00	0.00	64.41
Sep	9.06	6.91	7.55	25.37	12.49	12.46	22.60	0.51	87.89
Oct	8.51	6.91	7.55	25.37	12.49	12.46	11.53	0.00	76.31
Nov	6.44	6.91	7.55	25.37	5.49	0.00	0.00	0.00	45.32
Dec	5.01	6.91	7.55	1.02	0.00	0.00	0.00	0.00	15.48



(b) 1966 (1/10 R.P.) Unit: (%)

Month	Water level (m)	Inundated area for each elevation band							Total
		<4m	4-5m	5-6m	6-7m	7-8m	8-9m	9-10m	
Jan	3.01	6.91	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Feb	2.07	6.91	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Mar	1.56	6.91	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Apr	1.41	6.91	0.00	0.00	0.00	0.00	0.00	0.00	6.91
May	1.84	6.91	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Jun	3.27	6.91	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Jul	5.90	6.91	7.55	22.83	0.00	0.00	0.00	0.00	37.29
Aug	8.34	6.91	7.55	25.37	12.49	7.68	0.00	0.00	60.00
Sep	9.93	6.91	7.55	25.37	12.49	12.46	22.60	7.82	95.20
Oct	9.00	6.91	7.55	25.37	12.49	12.46	22.60	0.00	87.38
Nov	6.70	6.91	7.55	25.37	8.74	0.00	0.00	0.00	48.57
Dec	4.80	6.91	6.04	0.00	0.00	0.00	0.00	0.00	12.95



Note: Water level is assumed to be 0.5m higher than the flood level at Chrouy Changvar.
The water level in Boeng Phtea is assumed to be 1m in the dry season.

Figure C8.4 Water Level and Inundated Area for 1/2 and 1/10 Return Period.

Inundation depth - July to December - 1985 (1/2 R.P.)

Unit:(%)

Month	Water level (m)	Inundation depth (m)								Total
		0	0-1	1-2	2-3	3-4	4-5	5-6	>6	
Jan	3.11	6.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Feb	2.11	6.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Mar	1.70	6.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Apr	1.40	6.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.91
May	1.87	6.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Jun	3.76	6.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Jul	6.22	0.00	2.75	25.37	7.55	6.91	0.00	0.00	0.00	42.58
Aug	7.97	0.00	12.09	12.49	25.37	7.55	6.91	0.00	0.00	64.41
Sep	9.06	0.00	0.51	22.60	12.46	12.49	25.37	7.55	6.91	87.89
Oct	8.51	0.00	11.53	12.46	12.49	25.37	7.55	6.91	0.00	76.31
Nov	6.41	0.00	5.49	25.37	7.55	6.91	0.00	0.00	0.00	45.32
Dec	5.01	0.00	1.02	7.55	6.91	0.00	0.00	0.00	0.00	15.48

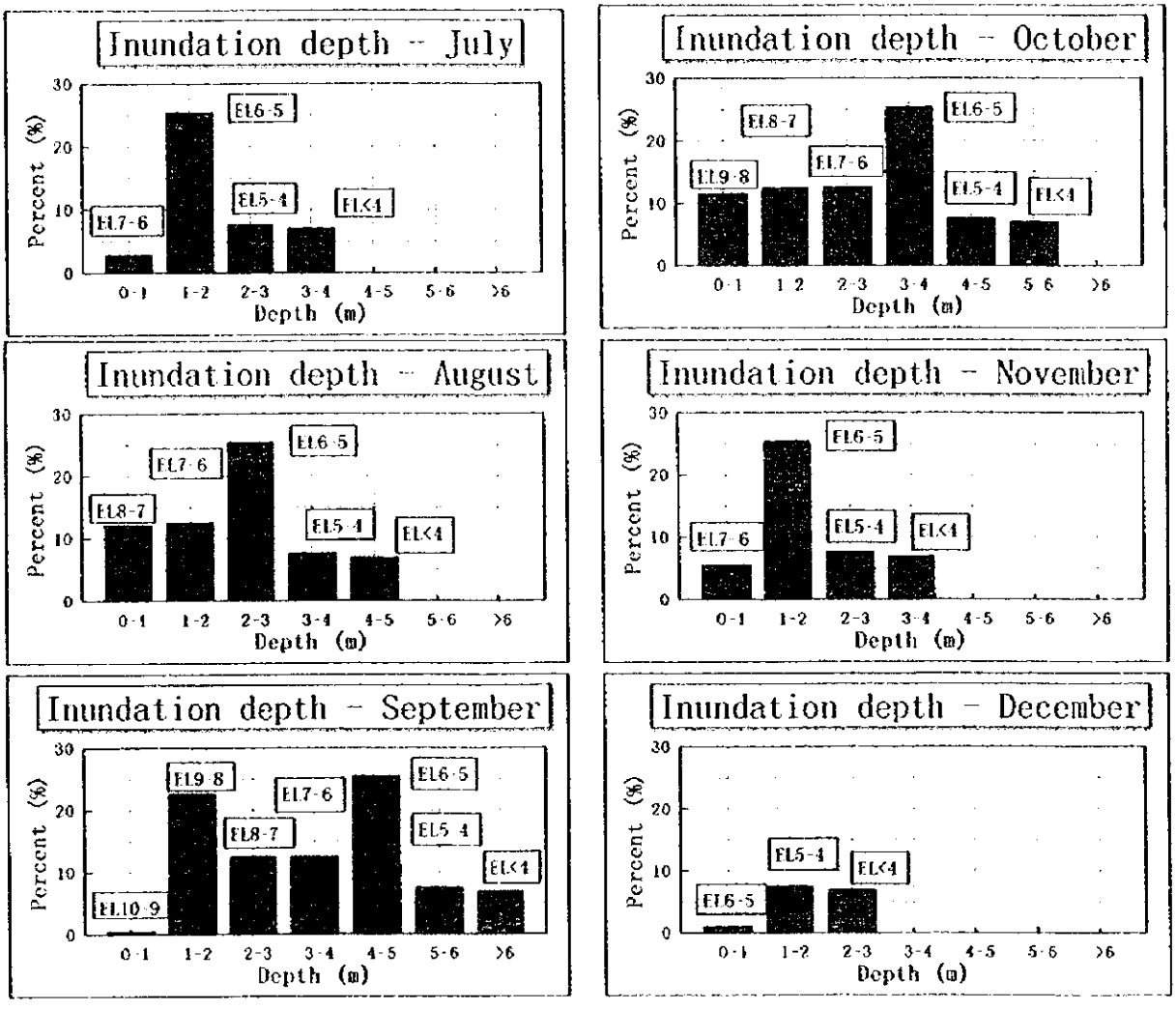


Figure C8.5 Mean Monthly Inundation Depth - 1/2 Return Period.

Inundation depth - July to December - 1966 (1/10 R.P.)

Unit:(%)

Month	Water level (m)	Inundation depth (m)								Total
		0	0-1	1-2	2-3	3-4	4-5	5-6	>6	
Jan	3.01	6.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Feb	2.07	6.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Mar	1.56	6.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Apr	1.41	6.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.91
May	1.81	6.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Jun	3.27	6.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Jul	5.90	0.00	22.83	7.55	6.91	0.00	0.00	0.00	0.00	37.29
Aug	8.31	0.00	7.68	12.49	25.37	7.55	6.91	0.00	0.00	60.00
Sep	9.93	0.00	7.82	22.60	12.46	12.49	25.37	7.55	6.91	95.20
Oct	9.00	0.00	22.60	12.46	12.49	25.37	7.55	6.91	0.00	87.38
Nov	6.70	0.00	8.74	25.37	7.55	6.91	0.00	0.00	0.00	48.57
Dec	1.80	0.00	6.04	6.91	0.00	0.00	0.00	0.00	0.00	12.95

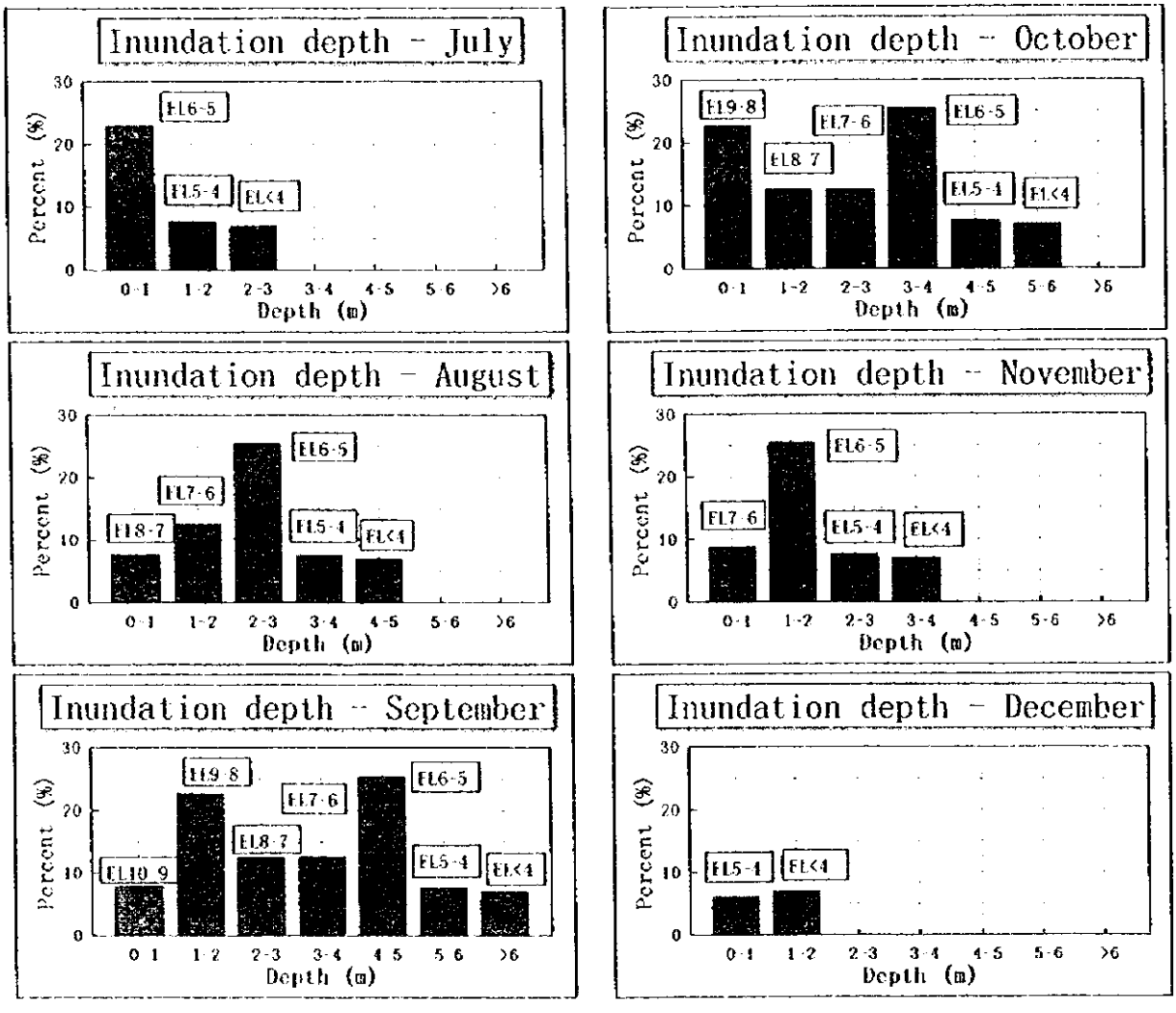


Figure C8.6 Mean Monthly Inundation Depth - 1/10 Return Period.

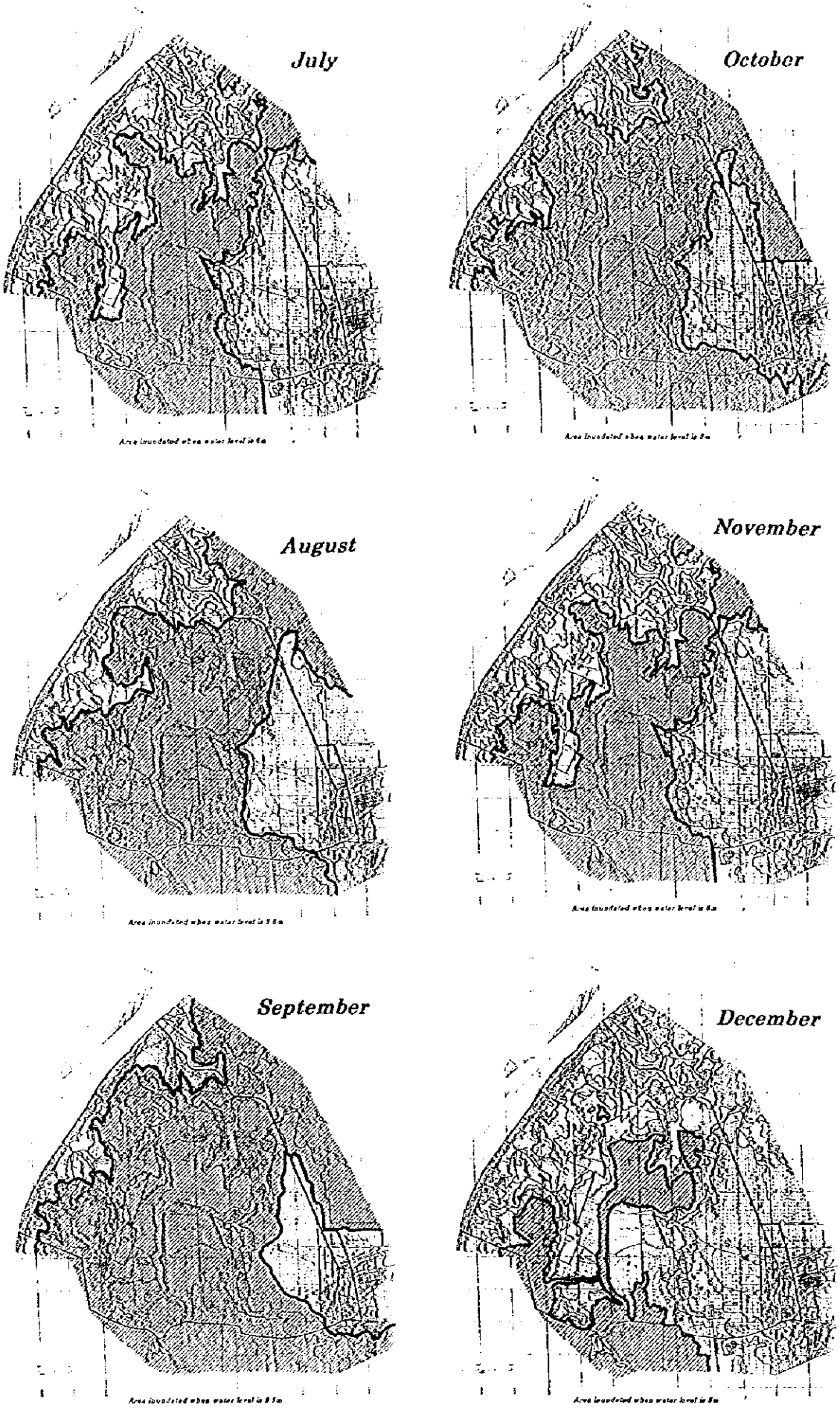


Figure C8.7 Mean Monthly Inundation Extent - 1/2 Return Period.

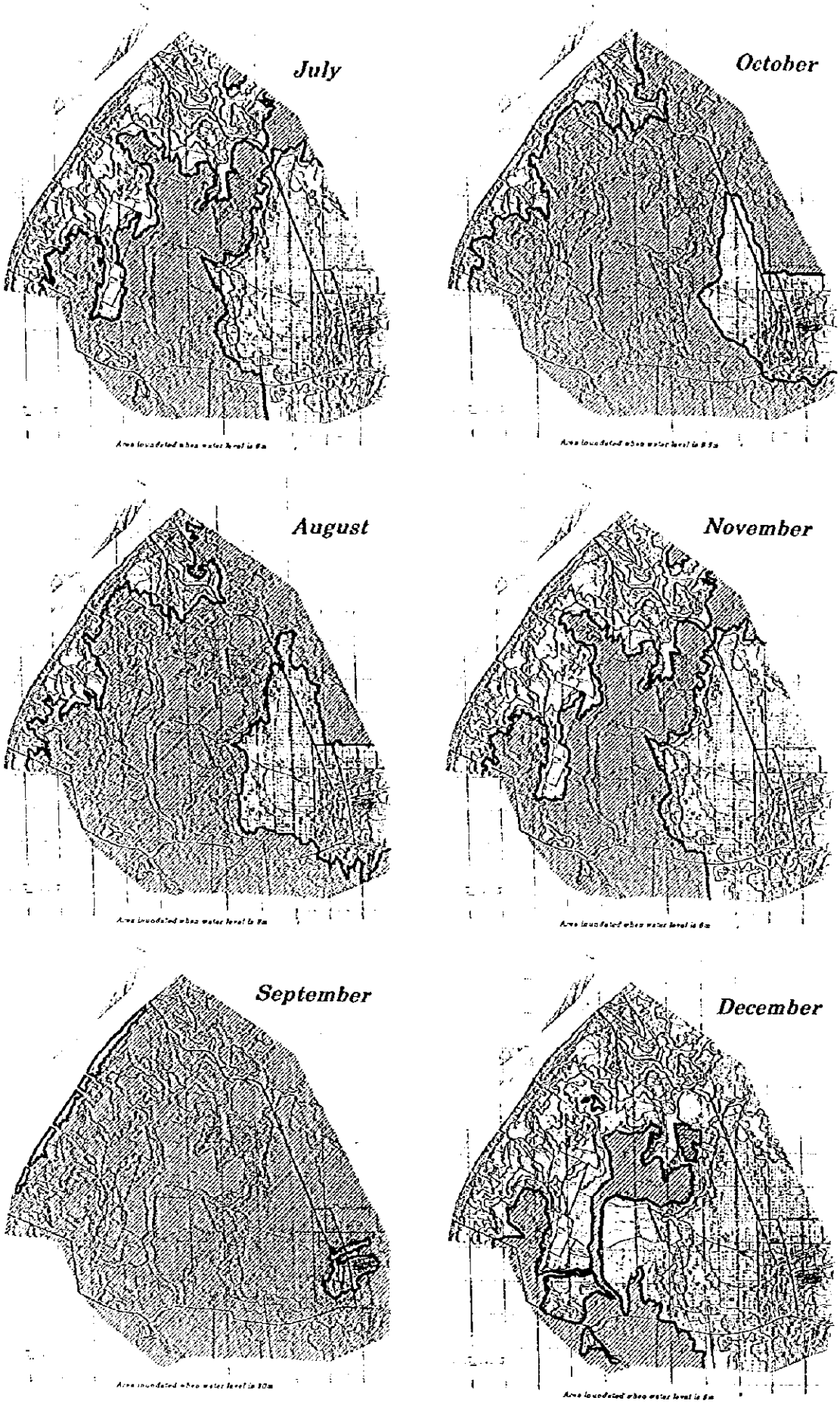


Figure C8.8 Mean Monthly Inundation Extent - 1/10 Return Period.