Table A.18 Annual Maximum Water Levels of the Mekong

(unit : el.m)

Year	Vientiane		Nongkai		Phon Phisai		Mahiao	
	Level	Date	Level	Date	Level	Date	Level	Date
1965	166.62	8-20	163.68	8-12				
1966	170.74	9-04	168.25	9-10				
1967	167.21	8-24	163.95	8-14				
1968	168.20	8-18	164.80	8-18				
1969	169.92	8-20	166.46	8-20				
1970	169.89	8-15	166.56	8-16				
1971	170.55	8-22	167.14	8-22				
1972	167.90	8-27	164.59	8-27	160.52	8-27	162.77	Est.
1973	169.72	8-29	166.14	9-08	162.77	9-08	164.04	9-08
1974	168.36	9-03	165.02	9-04	161.79	9-03	163.44	9-03
1975	168.80	9-05	165.38	9-05	162.02	9-05	163.88	Est.
1976	168.80	8-17	165.79	8-17	161.91	8-15	164.06	Est.
1977	167.94	8-02	164.40	8-02	160.48	8-02	162.65	Est.
1978	170.12	8-16	166.86	8-16	163.17	8-16	165.21	Est.
1979	168.19	9-16	165.02	9-15	160.95	9-15	163.20	Est.
1980	169.94	9-06	166.57	9-08	162.62	9-09	164.81	Est.
1981	168.76	8-08	165.68	8-08	161.94	8-08	163.14	8-08
1982	168.78	8-26	165.49	8-26	161.79	8-26	163.84	Est.
1983	168.01	8-08	164.75	8-08	160.83	9-19	163.00	Est.
1984	168.32	7-18	165.11	7-18	160.68	9-08	163.13	Est.
1985	169.54	9-02	166.27	9-02	162.08	9-03	164.40	Est.
1986	167.88	8-12	164.73	8-01	160.43	8-12	162.81	Est.
1987	165.61	9-28	163.44	9-28	159.61	8-26	161.73	Est.

Note : Est. indicates that the water level was estimated by interporation.

Table A.19 Results of Discharge Measurement at Hong Xeng Automatic Gauge Site

Station : Hong Xeng
Period : June - September 1989

No.	Date	Hours Start	Hours End	Gauge height (m)	Water level (el.m)	Flow width (m)	Max. Depth (m)	Flow area (m2)	Dis-charge (m3/s)	Average velocity (m/s)	Remarks
1	1-Jun	15:15	15:30	0.77	164.72	10.75	1.45	10.16	3.75	0.37	
2	3-Jun	8:55	9:05	0.61	164.56	10.30	1.24	8.52	2.04	0.24	
3	5-Jun	9:15	9:03	0.79	164.74	9.80	1.50	10.52	3.56	0.34	
4	8-Jun	8:55	9:15	0.48	164.43	9.80	1.10	6.94	1.54	0.22	
5	12-Jun	10:00	10:15	0.42	164.37	9.70	1.05	6.38	1.38	0.22	
6	15-Jun	9:32	9:49	-	-	11.15	1.43	10.94	5.22	0.48	W.L. unstable
7	19-Jun	8:55	9:07	0.39	164.34	9.50	1.05	5.82	1.24	0.21	
8	22-Jun	9:20	9:30	0.24	164.19	8.65	0.89	4.43	0.61	0.14	
9	26-Jun	9:17	9:30	0.04	163.99	6.50	0.62	2.48	0.12	0.05	
10	29-Jun	9:25	9:40	1.08	165.03	12.80	1.80	14.55	7.72	0.53	
11	3-Jul	9:45	10:02	-	-	8.50	0.79	3.98	0.56	0.14	W.L. unstable
12	6-Jul	9:08	9:19	-	-	10.00	1.25	7.84	3.98	0.51	W.L. unstable
13	10-Jul	8:55	9:08	0.70	164.65	10.50	1.32	9.15	3.37	0.37	
14	13-Jul	9:00	9:15	-	-	9.40	1.13	5.62	0.22	0.04	W.L. unstable
15	17-Jul	9:10	9:20	0.04	163.99	8.10	0.77	3.81	0.12	0.03	
16	7-Aug	9:20	10:03	1.01	164.96	13.00	2.50	16.90	6.81	0.40	
17	10-Aug	8:45	9:05	1.20	165.15	13.20	2.59	17.08	7.78	0.46	
18	14-Aug	9:10	9:37	1.34	165.29	13.50	2.70	19.90	9.11	0.46	
19	17-Aug	8:45	8:57	1.20	165.15	13.00	2.70	18.55	7.51	0.40	
20	28-Aug	9:05	9:20	1.27	165.22	13.30	2.71	20.06	8.32	0.41	
21	31-Aug	9:18	9:30	1.23	165.18	13.00	2.60	18.57	8.54	0.46	
22	4-Sep	8:47	9:08	1.00	164.95	11.30	2.50	15.69	4.86	0.31	
23	7-Sep	8:47	9:10	1.40	165.35	13.80	2.73	21.13	10.84	0.51	
24	9-Sep	8:57	9:25	1.57	165.52	14.80	2.95	23.39	12.50	0.53	
25	11-Sep	9:20	9:40	1.55	165.50	14.80	2.95	24.54	12.88	0.52	
26	12-Sep	9:30	10:10	1.73	165.68	14.90	3.20	27.79	16.98	0.61	
27	14-Sep	9:40	10:05	1.64	165.59	14.90	3.00	26.19	13.12	0.50	
28	21-Sep	9:20	9:40	1.24	165.19	14.00	2.69	19.36	7.28	0.38	
29	18-Sep	9:20	9:32	1.26	165.21	14.00	2.68	19.82	8.56	0.43	
30	25-Sep	9:40	10:07	1.68	165.63	14.90	3.20	26.73	14.53	0.54	
31	29-Sep	8:40	9:00	1.55	165.50	14.90	2.91	23.63	11.30	0.48	
Maximum				1.73	165.68	14.90	3.20	27.79	16.98	0.61	
Average				1.02	164.97	11.83	2.00	14.53	6.33	0.36	

Table A.20 Results of Discharge Measurement at Hong Ke Automatic Gauge Site

Station : Hong Ke
Period : June - September 1989

No.	Date	Hours Start	Hours End	Gauge height (m)	Water level (el.m)	Flow width (m)	Max. Depth (m)	Flow area (m2)	Dis-charge (m3/s)	Average velocity (m/s)	Remarks
1	3-Jun	9:31	9:44	0.29	165.01	4.75	0.50	1.61	0.32	0.20	
2	5-Jun	10:25	10:32	0.55	165.27	5.20	0.65	2.27	0.21	0.09	Backwater effect
3	8-Jun	9:20	9:30	0.52	165.24	5.10	0.72	2.39	0.14	0.06	Backwater effect
4	12-Jun	10:25	10:32	0.50	165.22	5.10	0.76	2.65	0.19	0.07	Backwater effect
5	15-Jun	10:03	10:17	0.47	165.19	5.00	0.70	2.73	0.95	0.35	
6	19-Jun	9:17	9:30	0.50	165.22	5.15	0.72	2.40	0.11	0.05	Backwater effect
7	22-Jun	9:50	10:10	0.56	165.28	5.10	0.77	2.33	0.09	0.04	Backwater effect
8	26-Jun	10:00	10:20	0.58	165.30	5.20	0.80	2.61	0.12	0.05	Backwater effect
9	29-Jun	10:00	10:15	0.27	164.99	4.70	0.50	1.62	0.20	0.12	
10	3-Jul	10:30	11:00	0.52	165.24	5.35	0.83	2.81	0.14	0.05	Backwater effect
11	6-Jul	9:30	9:40	0.62	165.34	5.40	0.85	2.72	0.15	0.06	Backwater effect
12	10-Jul	9:40	10:00	0.55	165.27	5.20	0.79	2.94	0.47	0.16	
13	13-Jul	9:20	9:30	0.41	165.13	5.05	0.65	2.25	0.21	0.09	
14	17-Jul	9:30	9:50	0.40	165.12	5.10	0.67	2.43	0.18	0.07	
15	24-Jul	10:30	10:40	0.60	165.32	5.30	0.84	2.86	0.12	0.04	Backwater effect
16	27-Jul	9:10	9:30	0.25	164.97	4.60	0.46	1.40	0.09	0.06	
17	31-Jul	10:00	-	0.54	165.26	5.20	0.78	-	-	-	No flow
18	3-Aug	10:43	10:48	0.60	165.32	5.40	0.82	3.04	0.17	0.06	Backwater effect
19	7-Aug	10:25	11:35	0.63	165.35	5.30	1.20	4.05	1.00	0.25	
20	10-Aug	9:17	9:28	0.83	165.55	5.80	1.44	5.45	1.77	0.32	
21	14-Aug	9:43	10:00	0.70	165.42	5.40	1.38	4.36	1.42	0.33	
22	18-Aug	9:10	9:18	0.46	165.18	5.10	1.05	3.10	0.17	0.05	Backwater effect
23	28-Aug	9:35	9:48	0.68	165.40	5.40	1.25	4.54	1.06	0.23	
24	31-Aug	9:45	9:55	0.56	165.28	5.20	1.04	3.77	0.28	0.07	Backwater effect
25	4-Sep	9:25	9:37	0.50	165.22	5.10	1.08	3.38	0.21	0.06	Backwater effect
26	7-Sep	9:25	9:37	0.51	165.23	5.10	0.94	3.31	0.20	0.06	Backwater effect
27	9-Sep	9:40	9:47	0.60	165.32	5.20	1.15	3.88	0.73	0.19	
28	11-Sep	10:07	10:15	0.56	165.28	5.20	1.08	3.59	0.17	0.05	Backwater effect
29	12-Sep	10:25	10:35	1.07	165.79	6.50	1.43	7.07	3.90	0.55	
30	14-Sep	10:22	10:30	0.83	165.55	6.20	1.40	5.09	1.44	0.28	
31	21-Sep	9:47	9:57	0.61	165.33	5.80	1.18	3.89	0.26	0.07	Backwater effect
32	25-Sep	10:25	10:35	1.04	165.76	6.50	1.42	7.00	2.78	0.40	
33	29-Sep	11:00	9:20	0.79	165.51	6.00	1.33	4.91	0.40	0.08	Backwater effect
Maximum				1.07	165.8	6.50	1.44	7.07	3.90	0.55	
Average				0.58	165.30	5.32	0.94	3.39	0.61	0.14	

Table A.21 Discharges Converted from the Water Levels at Automatic Gauges

Day	June			July			August			September			October		
	Daily rain-fall (mm)	Discharge Hong Ke (m3/s)	Discharge Hong Xeng (m3/s)	Daily rain-fall (mm)	Discharge Hong Ke (m3/s)	Discharge Hong Xeng (m3/s)	Daily rain-fall (mm)	Discharge Hong Ke (m3/s)	Discharge Hong Xeng (m3/s)	Daily rain-fall (mm)	Discharge Hong Ke (m3/s)	Discharge Hong Xeng (m3/s)	Daily rain-fall (mm)	Discharge Hong Ke (m3/s)	Discharge Hong Xeng (m3/s)
1	24.0	0.58	2.25	0.0	0.76	0.50	0.0	0.70	0.47	0.0	-	6.31	1.0	1.22	7.95
2	0.5	0.77	2.54	13.5	0.77	0.50	0.0	0.52	0.47	27.0	-	6.10	2.0	1.13	7.47
3	5.0	0.71	1.44	8.0	0.95	2.36	48.5	1.06	1.78	0.0	-	6.13	0.0	1.04	6.48
4	0.0	0.47	0.87	0.0	1.03	2.87	73.0	0.83	4.49	0.0	-	4.23	0.5	0.96	5.99
5	5.5	0.46	2.55	0.0	0.98	1.30	22.0	2.86	8.53	0.0	-	3.56	2.5	0.87	6.08
6	0.5	0.25	1.63	34.0	1.14	2.12	0.0	2.23	7.60	28.5	-	3.00	39.0	1.82	7.85
7	0.5	0.28	1.64	0.0	1.12	3.14	0.0	0.92	6.98	9.5	-	7.93	0.0	1.19	7.39
8	0.5	0.63	1.63	20.5	1.15	3.15	34.0	0.48	6.17	34.5	0.77	10.10	0.0	0.95	7.20
9	0.0	0.70	0.89	0.0	1.00	3.12	31.0	1.11	6.58	2.0	0.88	11.49	0.0	0.84	7.53
10	1.0	0.71	0.50	0.0	0.77	3.52	1.5	1.63	7.77	0.0	0.79	11.53	0.0	0.74	7.09
11	8.0	0.05	1.05	11.0	0.72	2.34	51.0	2.66	9.96	0.0	0.75	11.03	2.0	0.68	7.61
12	4.0	0.05	1.34	3.0	0.68	3.27	0.5	1.82	9.47	84.0	2.45	12.64	0.0	0.62	6.24
13	23.0	0.45	1.18	1.0	0.72	2.05	30.0	1.06	10.38	9.5	2.48	12.59	3.0	0.55	6.06
14	18.0	0.30	1.21	0.0	0.84	1.37	7.5	1.19	10.03	0.0	1.75	12.44	0.0	0.55	6.63
15	10.0	0.33	2.17	0.0	0.45	1.39	0.5	0.85	9.10	1.0	1.34	11.33	2.5	0.56	8.07
16	0.0	0.60	1.96	-	0.39	0.50	0.0	0.64	8.54	0.0	1.18	10.32	4.0	0.47	8.58
17	0.0	0.56	1.75	-	0.27	0.50	0.0	0.50	7.98	0.0	1.06	8.94	0.0	0.40	8.16
18	0.0	0.62	1.43	-	0.34	0.60	0.0	0.42	6.84	8.0	0.97	7.71	0.0	0.38	8.21
19	0.0	0.42	1.21	-	0.59	1.02	11.5	0.37	5.56	4.5	1.01	7.19	0.0	0.33	7.99
20	0.0	0.51	0.79	-	0.58	1.10	0.0	0.34	4.14	3.0	1.02	7.94	0.0	0.28	7.73
21	0.0	0.64	0.71	-	0.63	0.50	4.5	0.32	2.94	5.5	0.94	7.52	0.0	0.24	7.25
22	0.0	0.71	0.55	0.0	0.69	0.50	7.5	0.32	4.41	9.0	1.03	7.32	0.0	0.21	5.49
23	3.0	0.66	0.53	33.0	0.64	0.50	20.5	0.30	3.35	32.5	1.08	7.28	0.0	0.17	3.77
24	0.5	0.69	0.50	8.5	0.94	0.50	20.5	0.4	4.34	52.0	2.19	9.41	0.0	0.14	5.57
25	0.0	0.73	0.58	0.5	0.73	0.47	4.0	0.5	6.17	15.5	2.76	12.46	0.0	0.11	3.88
26	7.5	0.88	0.50	0.0	0.22	0.47	58.0	-	6.33	0.0	2.20	12.15	0.0	0.09	3.57
27	29.0	0.92	0.50	10.5	0.10	0.47	4.5	-	8.02	0.0	1.75	11.56	0.0	0.07	3.80
28	2.5	1.18	0.50	0.0	0.16	0.47	1.0	-	7.75	0.0	1.58	10.94	0.0	0.07	2.55
29	0.0	0.49	1.73	0.0	0.49	0.56	0.0	-	7.63	0.0	1.47	10.04	0.0	0.06	3.13
30	0.0	0.86	0.69	0.5	0.61	1.43	3.0	-	7.38	0.0	1.35	9.03	0.0	0.06	1.12
31				1.0	0.74	1.02	1.0	-	7.04				0.0	0.06	1.85
Total	143.0	-	-	145.0	-	-	435.5	-	-	326.0	-	-	56.5	-	-
Ave.	-	0.57	1.23	-	0.68	1.42	-	0.96	6.37	-	1.43	9.01	-	0.56	6.21

Table A.22 Design Rainfall Calculation

Hours	Recorded rainfall	2-year Multi-plier	2-year Design rainfall (mm)	5-year Multi-plier	5-year Design rainfall (mm)	10-year Multi-plier	10-year Design rainfall (mm)	20-year Multi-plier	20-year Design rainfall (mm)	50-year Multi-plier	50-year Design rainfall (mm)
1	80.5	0.464	37.4	0.703	56.6	0.862	69.4	1.013	81.6	1.210	97.4
2	45.5	0.464	21.1	0.703	32.0	0.862	39.2	1.013	46.1	1.210	55.1
3	6.0	3.500	21.0	3.346	20.1	3.230	19.4	3.131	18.8	2.992	18.0
4	5.5	3.500	19.3	3.346	18.4	3.230	17.8	3.131	17.2	2.992	16.5
5	1.5	3.500	5.3	3.346	5.0	3.230	4.8	3.131	4.7	2.992	4.5
Total	139.0		104.0		132.1		150.6		168.4		191.4

Table A.23 Catchment Area of Main Canals at Control Points

(Unit : square km)

Point	Catchment area		Present			Year 2020			
No.	No.	Sub-area (Name)	Hilly	Paddy	Urban	Hilly	Paddy	Urban	Total
(1)	1	N + Outside Study area	24.10	25.20	2.90	24.10	22.70	5.40	52.20
-	2	Outside Study area	4.45	2.20	0.00	4.45	2.20	0.00	6.65
-	3	M	0.00	5.43	2.36	0.00	5.43	2.36	7.79
(2)	1+2+3	(Hong Xeng at Dongdeng)	28.55	32.83	5.26	28.55	30.33	7.76	66.64
(3)	3	L	0.00	0.25	1.89	0.00	0.25	1.89	2.14
(4)	1+2+3+4	(H. Xeng at confluence)	28.55	33.08	7.15	28.55	30.58	9.65	68.78
-	5	I + J + Part of K	2.40	3.70	4.20	2.40	1.70	6.20	10.30
(5)	1+2+3+4+5	(H. Xeng at Gauge)	30.95	36.78	11.35	30.95	32.28	15.85	79.08
-	6	H+G	0.00	0.00	1.88	0.00	0.00	1.88	1.88
-	7	C	0.00	0.00	1.96	0.00	0.00	1.96	1.96
(7)	6+7	(H. Ke at Nong Chang Outlet)	0.00	0.00	3.84	0.00	0.00	3.84	3.84
-	8	D+E+F	0.00	1.11	4.03	0.00	0.34	4.80	5.14
(8)	6+7+8	(Hong Ke at Gauge)	0.00	1.11	7.87	0.00	0.34	8.64	8.98
(9)	9	Part of A	2.68	2.35	0.58	0.00	3.26	2.35	5.61
(10)	10	B + Part of A	0.00	2.65	3.75	0.00	2.26	4.14	6.40
-	11	Outside Study area	12.50	32.30	0.00	12.50	32.30	0.00	44.90
(11)	6+7+8+9+10+11	(That Luang Drainage canal at Houa Khoua)	15.18	38.41	12.20	12.50	38.16	15.13	65.89
-	12	Outside Study area	4.80	5.20	0.60	4.80	5.20	0.60	10.60
(12)	6+7+8+9+10+11+12	(Hong Xeng at Nong Nieng)	50.93	80.39	24.15	48.25	75.64	31.58	155.57

Note : For the demarcation of catchment areas, refer to Fig. A1.20.

Table A.24 Recorded High-intensity Rainfall in 1989

Rank	Date	Hours	Max Hourly Rain [1]		Observed Inundation
			Observed (mm)	Effective [2] (mm)	
1.	Sep. 12	4 - 5	62.0	39.5	Extensive inundation
2.	Aug. 4	21 - 22	36.0	19.6	Extensive inundation (reported)
3.	Oct. 6	1 - 2	35.0	14.0	Local inundation
4.	Sep. 24	23 - 24	34.5	13.8	Local inundation
5.	Aug. 11	1 - 2	30.5	12.2	Unknown [3]
5.	July 23	16 - 17	30.5	12.2	Unknown [3]
7.	Aug. 9	19 - 20	29.5	11.8	Unknown [3]
8.	Aug. 4	20 - 21	28.5	11.4	See August 4, 21 - 22.
9.	Aug. 8	18 - 19	23.5	9.4	Unknown
9.	Sep. 2	5 - 6	23.5	9.4	Small-scale inundation
11.	Aug. 3	8 - 9	21.5	8.6	Unknown
12.	Aug. 13	17 - 18	20.5	8.2	Unknown

Notes [1] The hourly rainfalls are taken on the fixed intervals between 0 - 60 minutes of the hour.

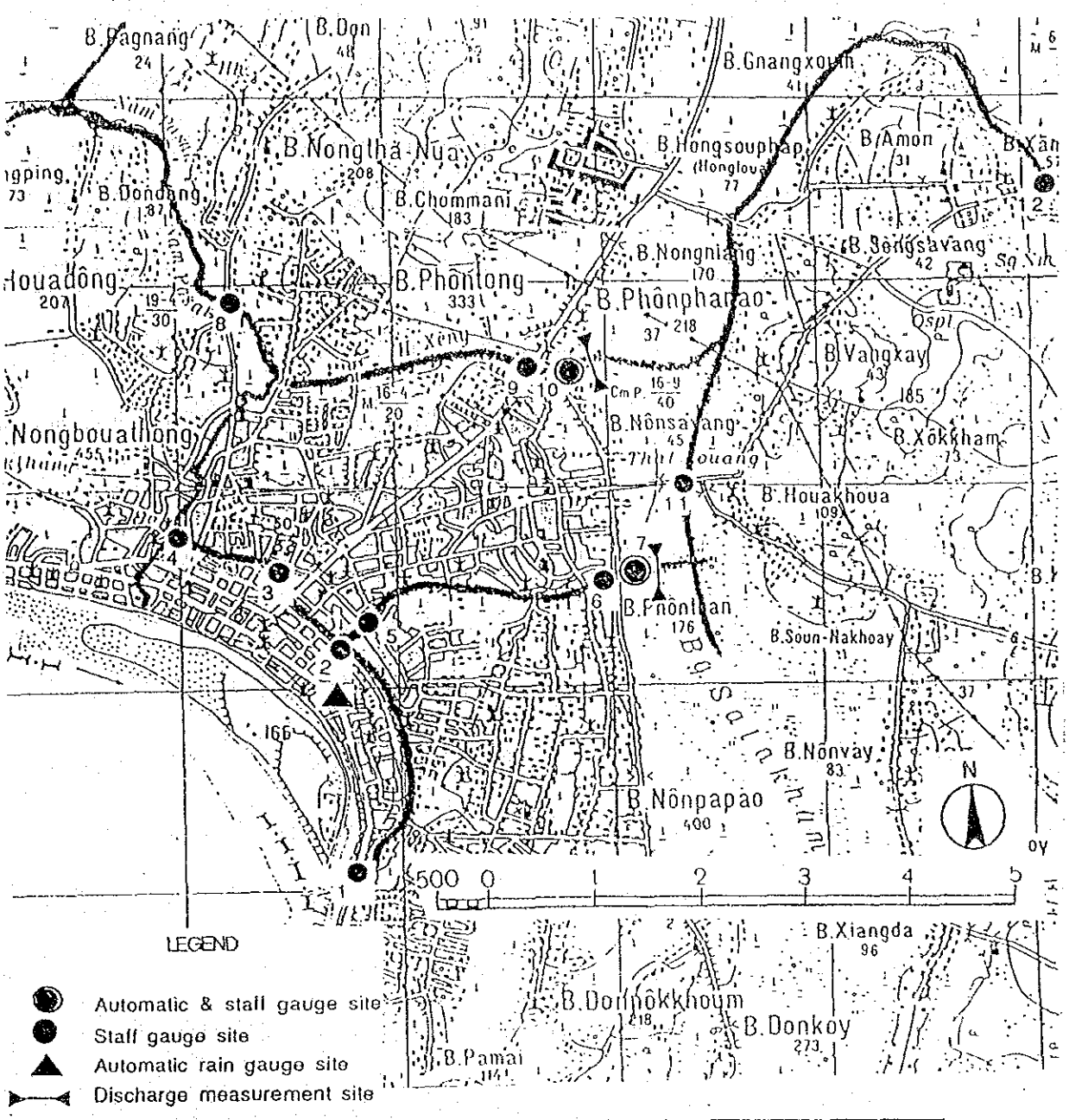
[2] Estimated for urban area (R_{sa} = 50, F_1 = 0.4)

[3] Because the Study team was outside of Vientiane at the time of occurrence.

Table A.25 Observed Discharges of Main Canal

No.	River/ Canal	Catchment area (km2)	On 24/5-25/5/1989 Dis-charge (m3/sec)	On 24/5-25/5/1989 Specific discharge (m3/sec /100km2)	On 31/5-2/6/1989 Dis-charge (m3/sec)	On 31/5-2/6/1989 Specific discharge (m3/sec /100km2)
2	Drain. canal from Subarea A	10.26	0.025	0.2	0.067	0.7
3	Hong Ke at That Luang	8.31	0.053	0.6	0.447	5.4
4	Khoua Khao	1.35	0.009	0.7	0.076	5.6
5	Hong Ke at middle reach	4.59	0.046	1.0	0.330	7.2
7	Khoua Khao	0.07	0.000	0.4	0.001	1.7
9	Hong Thong	0.38	0.017	4.5	0.017	4.5
11	Mahiao at Nong Nieng	155.57	0.295	0.2	2.534	1.6
12	Hong Xeng at Gauge	79.08	0.042	0.1	1.892	2.4
13	Nam Pasak-R	2.10	0.017	0.8	0.031	1.5
14	H. Thong at N. Pasak-R	0.11	0.008	7.1	0.019	16.5
15	N. Pasak-R at H. Thong	0.54	0.057	10.6	0.074	13.7
16	Drain. to N. Douang	0.19	0.015	7.5	0.018	9.3
17	Drain from N. Douang	0.96	0.021	2.1	0.170	17.7
19	N Pasak-L at Dongdeng	66.64	0.079	0.1	1.452	2.2

FIGURES



Item No.	River/canal	Location	Type	Zero Point (El.m)
Rainfall gauge				
N.A.		Vientiane Municipality	A	N.A.
Water Level Gauges				
1	Khou Khao	Inside the gate to the Mekong	S	165.865
2	Khou Khao	At the junction with Hong Ke	S	166.863
3	Hong Thong	At the Gas Station	S	167.465
4	Nam Pasak	At the junction with Hong Thong	S	166.622
5	Hong Ke	Downstream of Nong Chang Marsh	S	166.591
6	Hong Ke	Hong Ke upstream of the Gate to That Luang	S	165.484
7	Hong Ke	Downstream of the Gate to That Luang	S/A	164.724
8	Upstream Nam Pasak	At the Bridge of the road to Nong Tha Nhai	S	165.452
9	Hong Xeng	At the Bridge of Route 13	S	165.087
10	Hong Xeng	Downstream of the gate near the bridge of Route 13	S/A	163.950
11	That Luang irrigation canal	At the bridge of the road from That Luang market	S	163.967
12	Houei Mahiao	At the bridge near Ban Xaikhe	S	162.928

Note S; staff A; automatic

Fig. A.1 Location and Basic Data of Hydrological Instruments Installed

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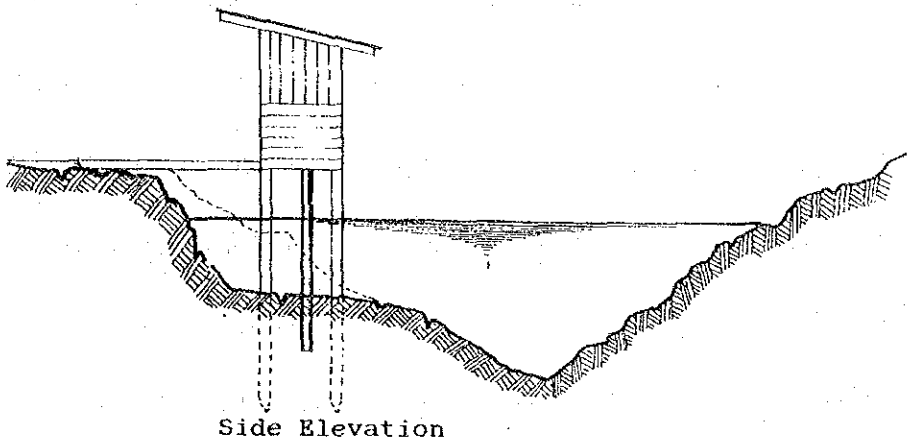
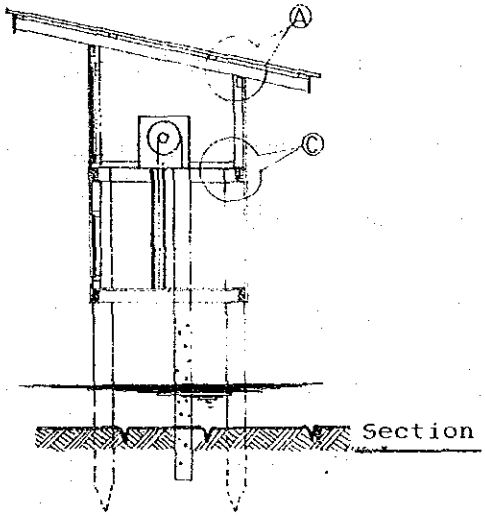
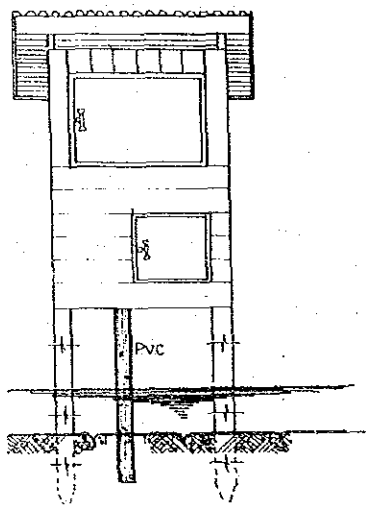


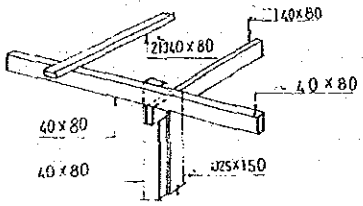
Side Elevation

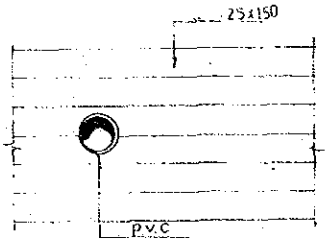


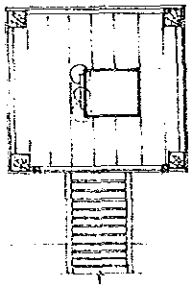
Section



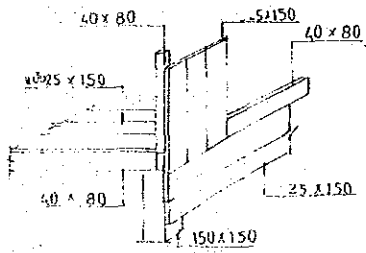
Front Elevation



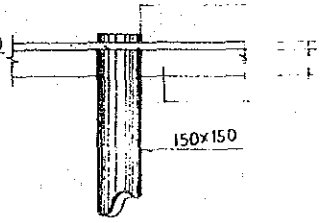




Plan



Detail of Joint



Detail of Pipe Joint

Fig. A.2 Sketch of Automatic Water Level Gauge House

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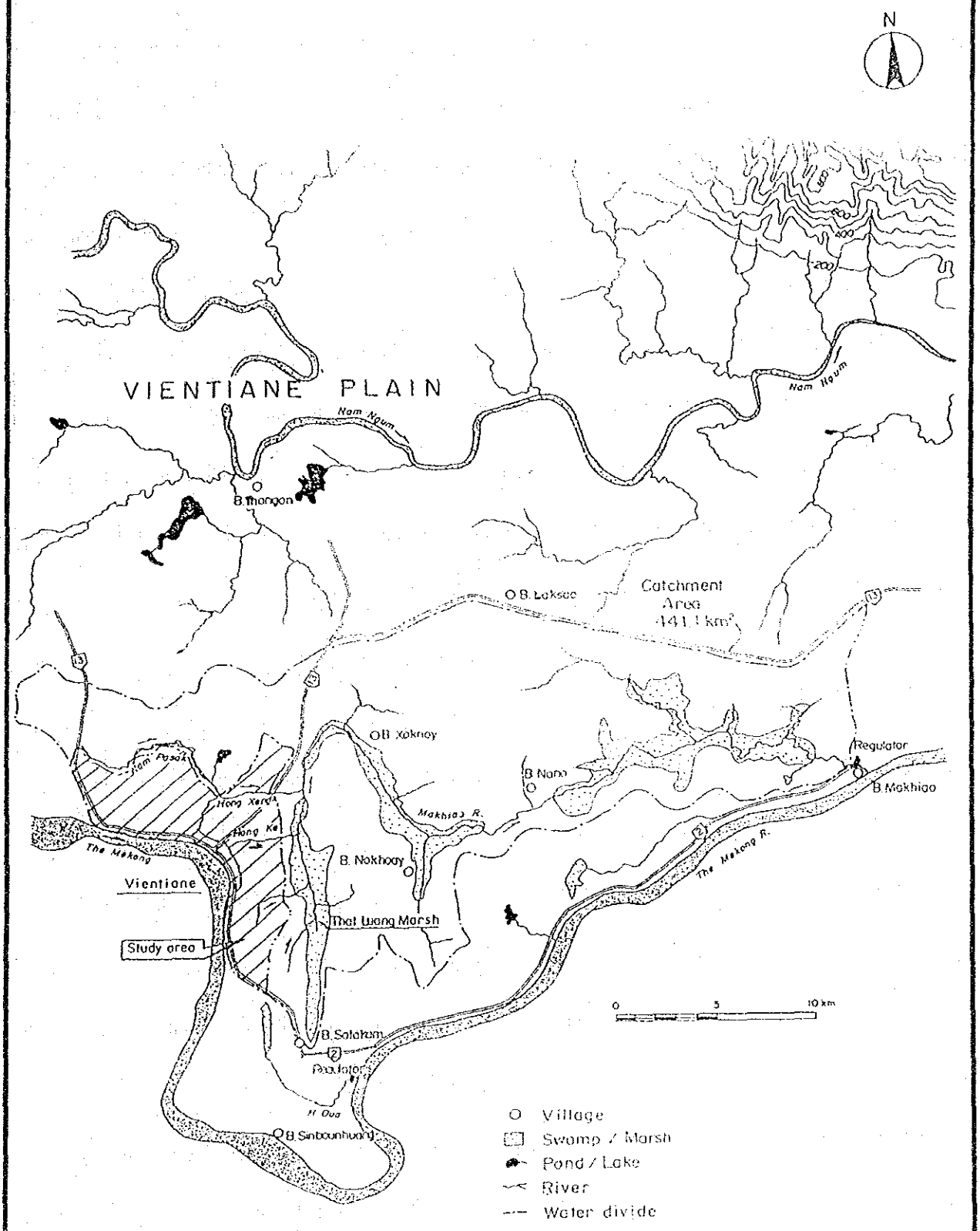

Fig. A.3 Study Area and Vientiane Plain

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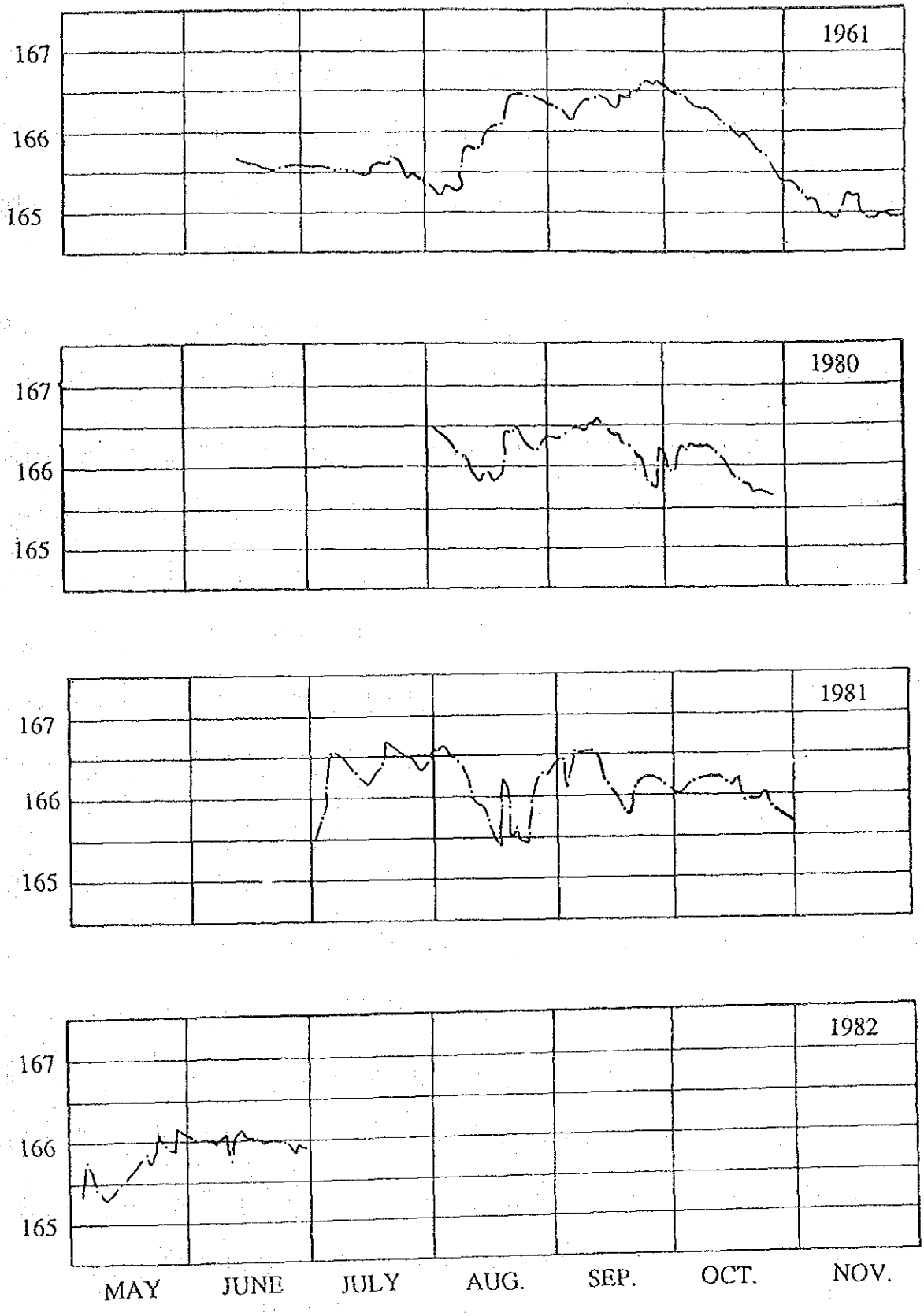

Fig. A.4 Water Levels of the Hong Xeng at Ban Phone Khen

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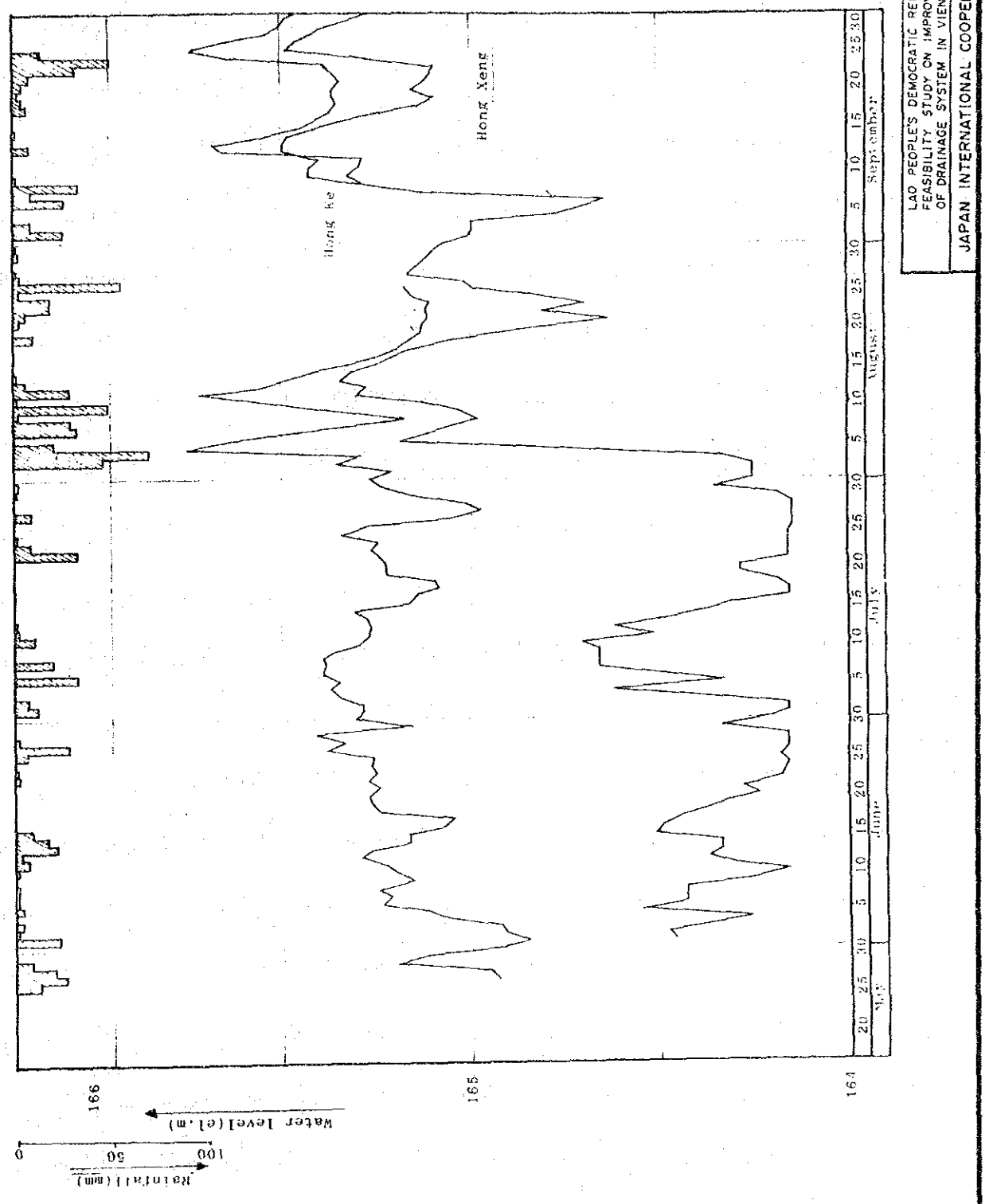

Fig. A.5 Water Levels of the Hong Xeng and Hong Ke Recorded by Automatic Gauges

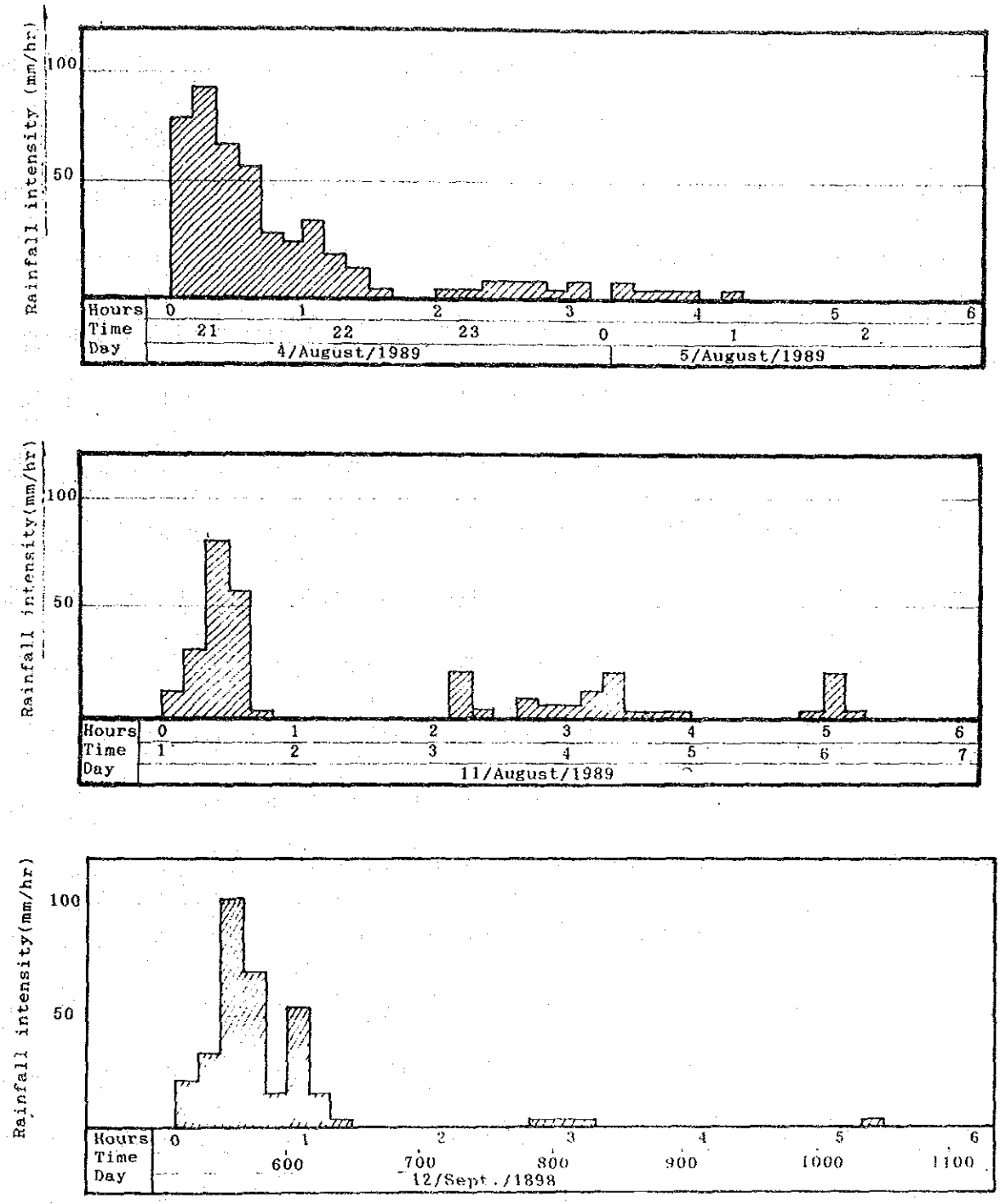

Fig. A.6 (1) Storm Rainfalls Recorded by Automatic Gauge

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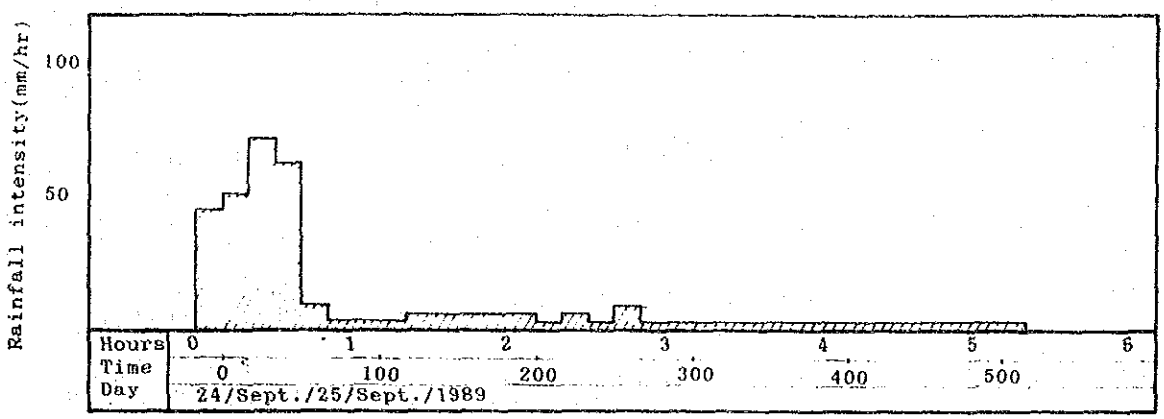

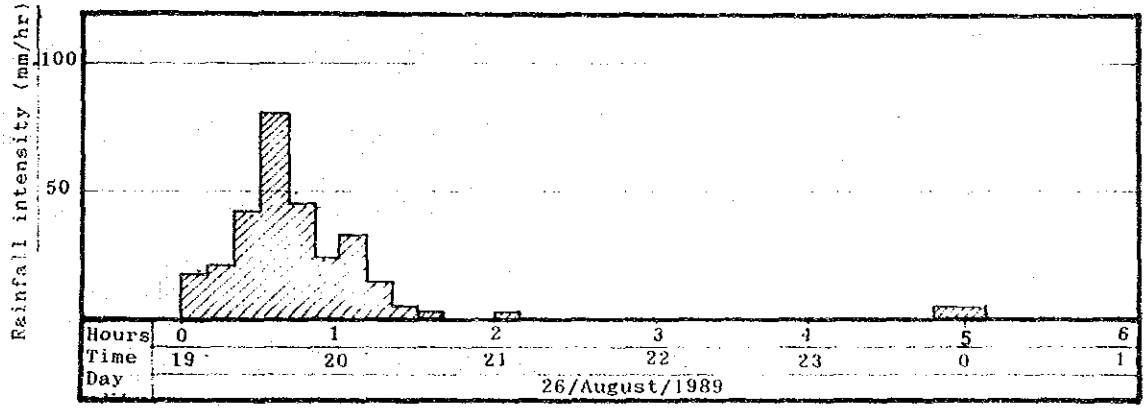

Fig. A.6 (2) Storm Rainfalls Recorded by Automatic Gauge

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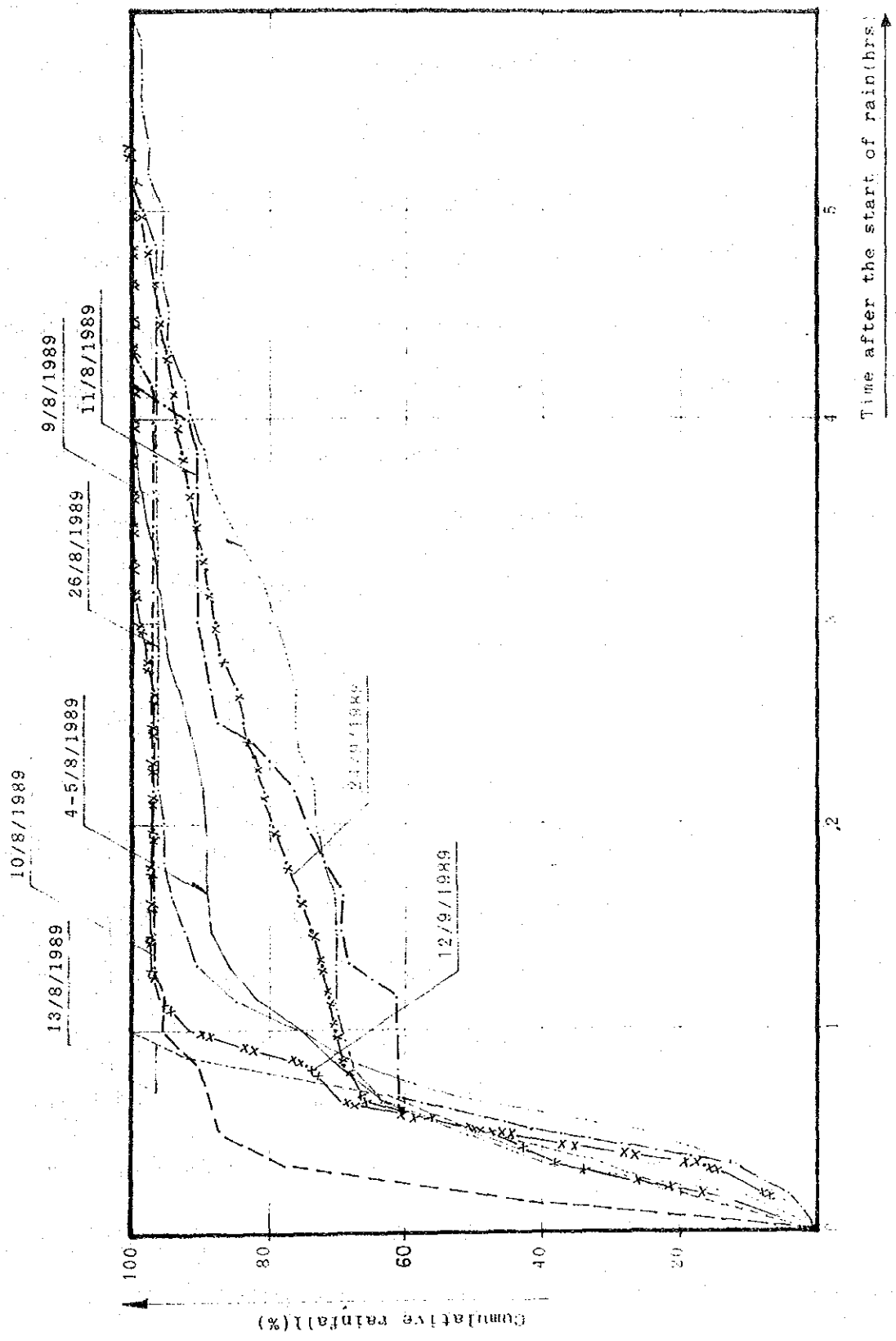

Fig. A.7 Mass Curves of Storm Rainfalls Recorded by Automatic Gauge

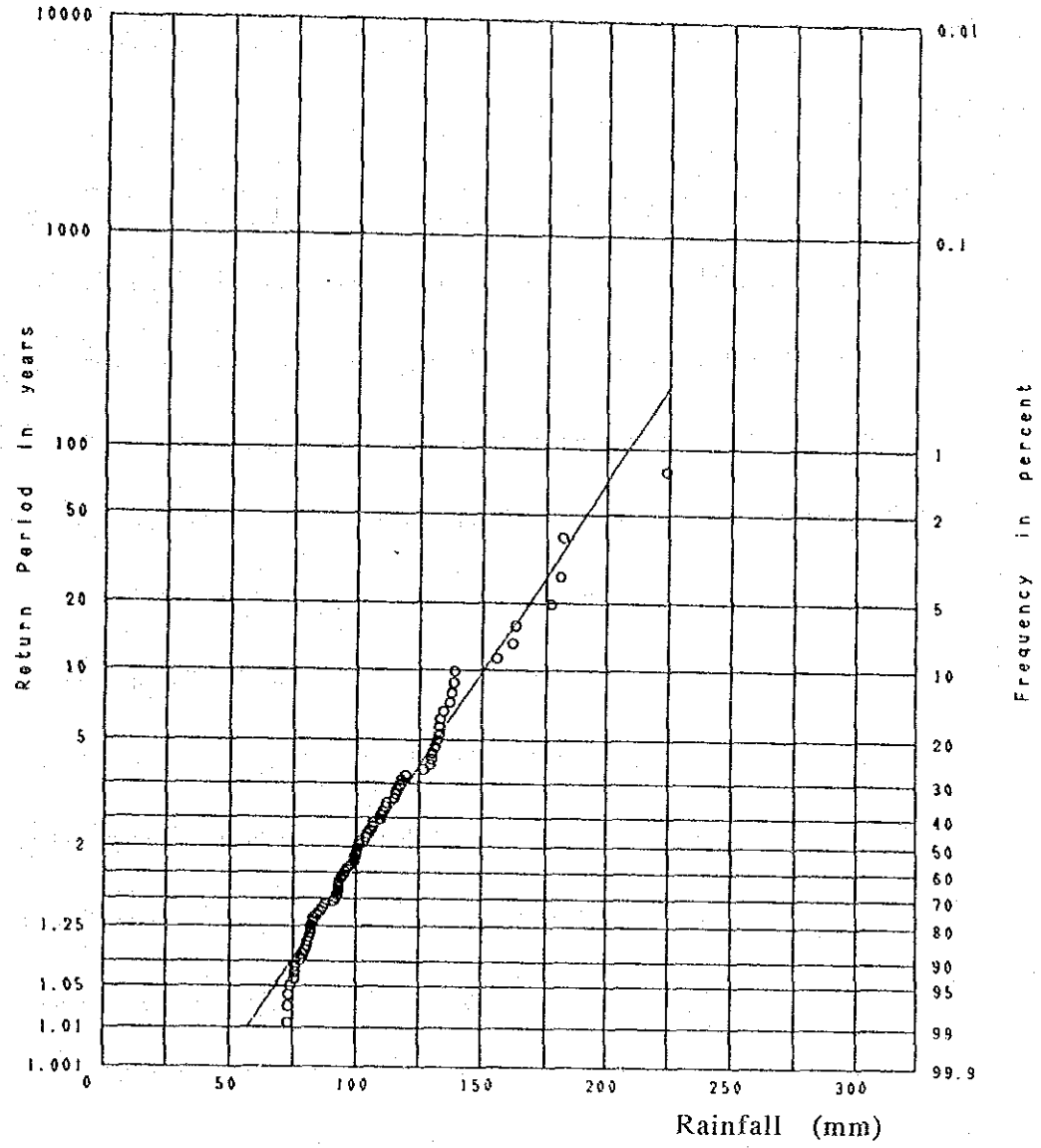

Fig. A.8 Frequency Curve of One-Day Storm Rainfall

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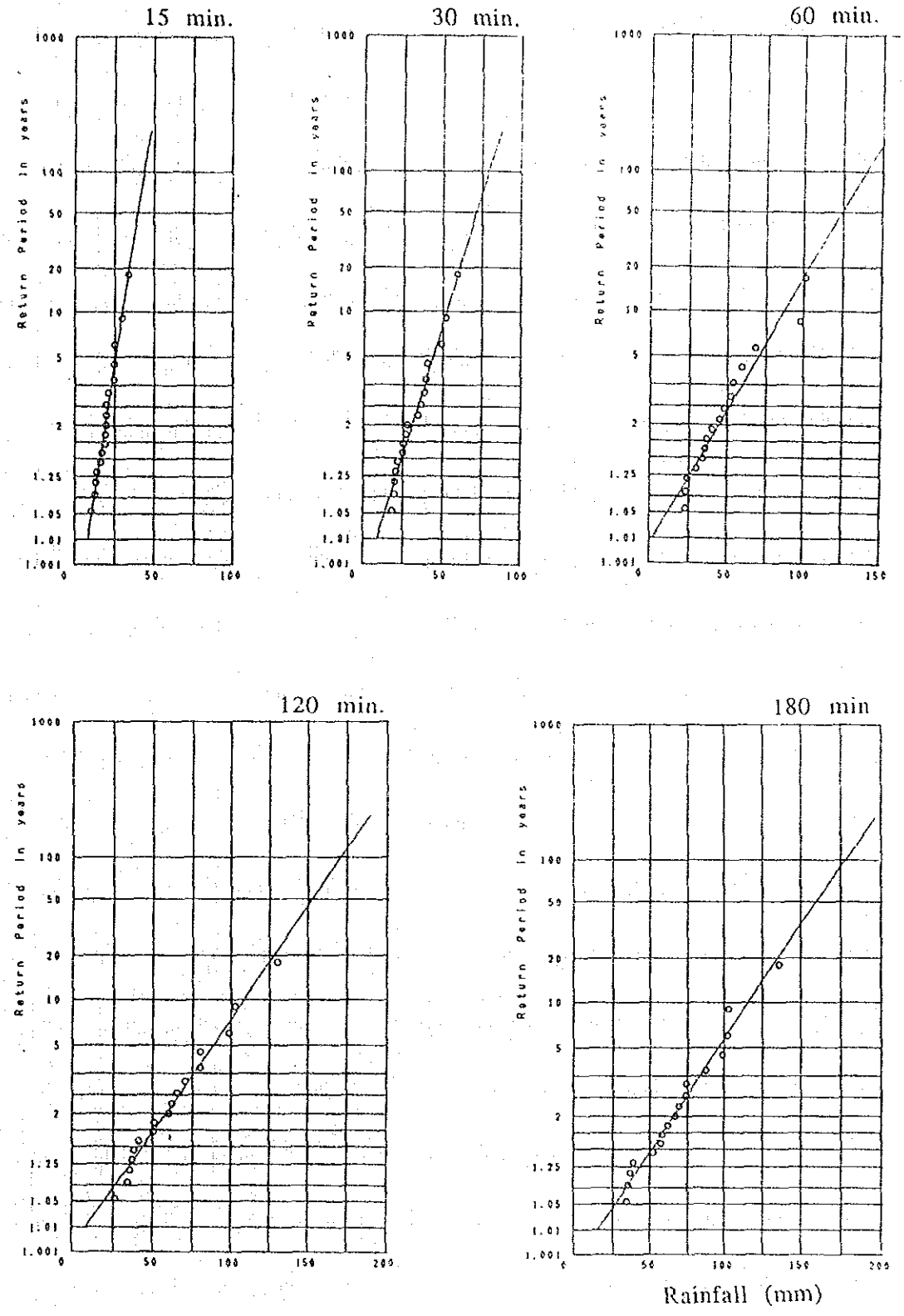

Fig. A.9 Frequency Curves of Storm Rainfall for Short Durations

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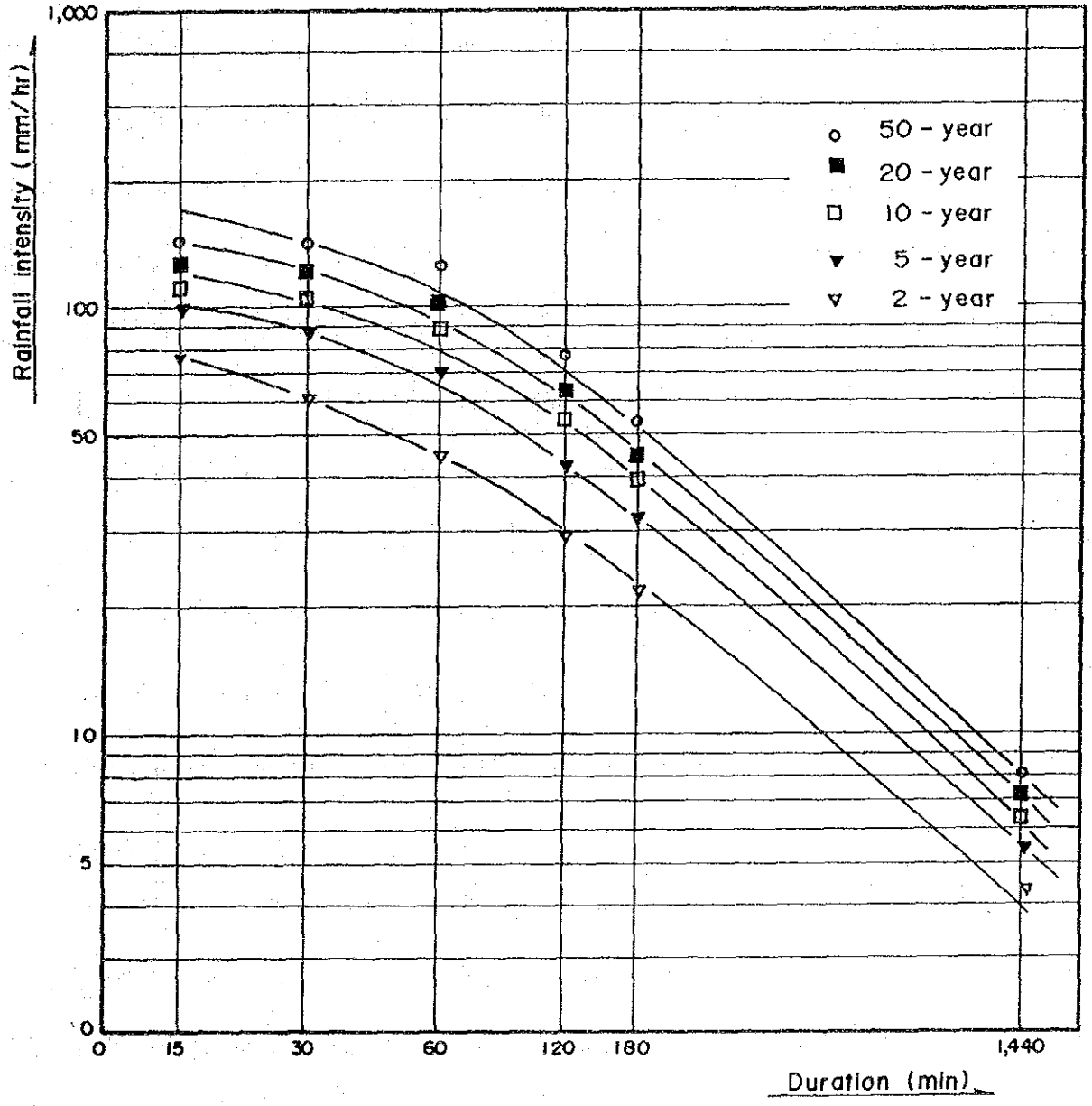

Fig. A.10 Talbot's Curves for Each Return Period

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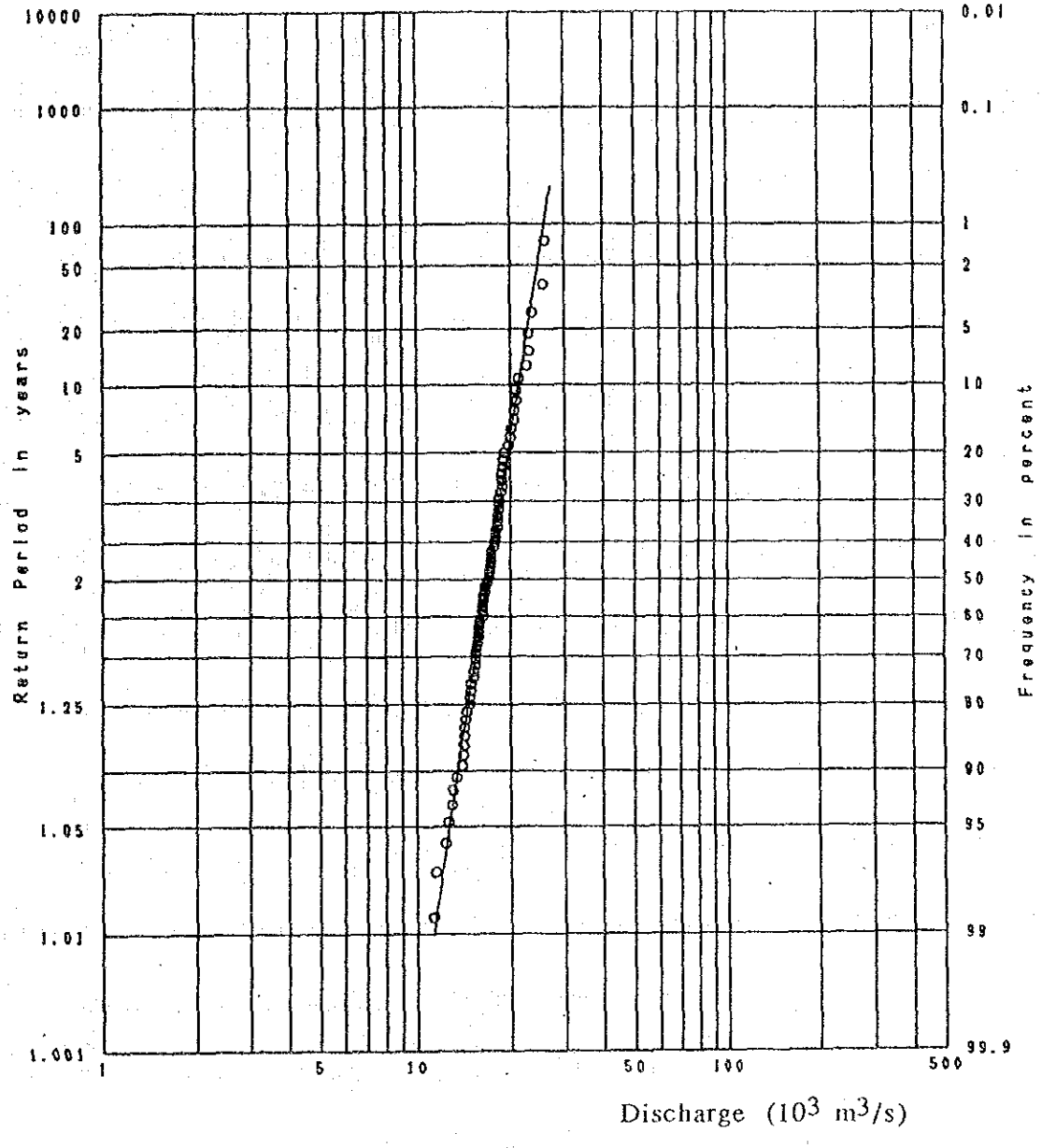

Fig. 3.5.3 Frequency Curve for Annual Max Discharge of the Mekong at Vientiane

Fig. A.11 Frequency Curve for Annual Max Discharge of the Mekong the Mekong at Vientiane

LAO PEOPLE'S DEMOCRATIC REPUBLIC
FEASIBILITY STUDY ON IMPROVEMENT
OF DRAINAGE SYSTEM IN VIENTIANE
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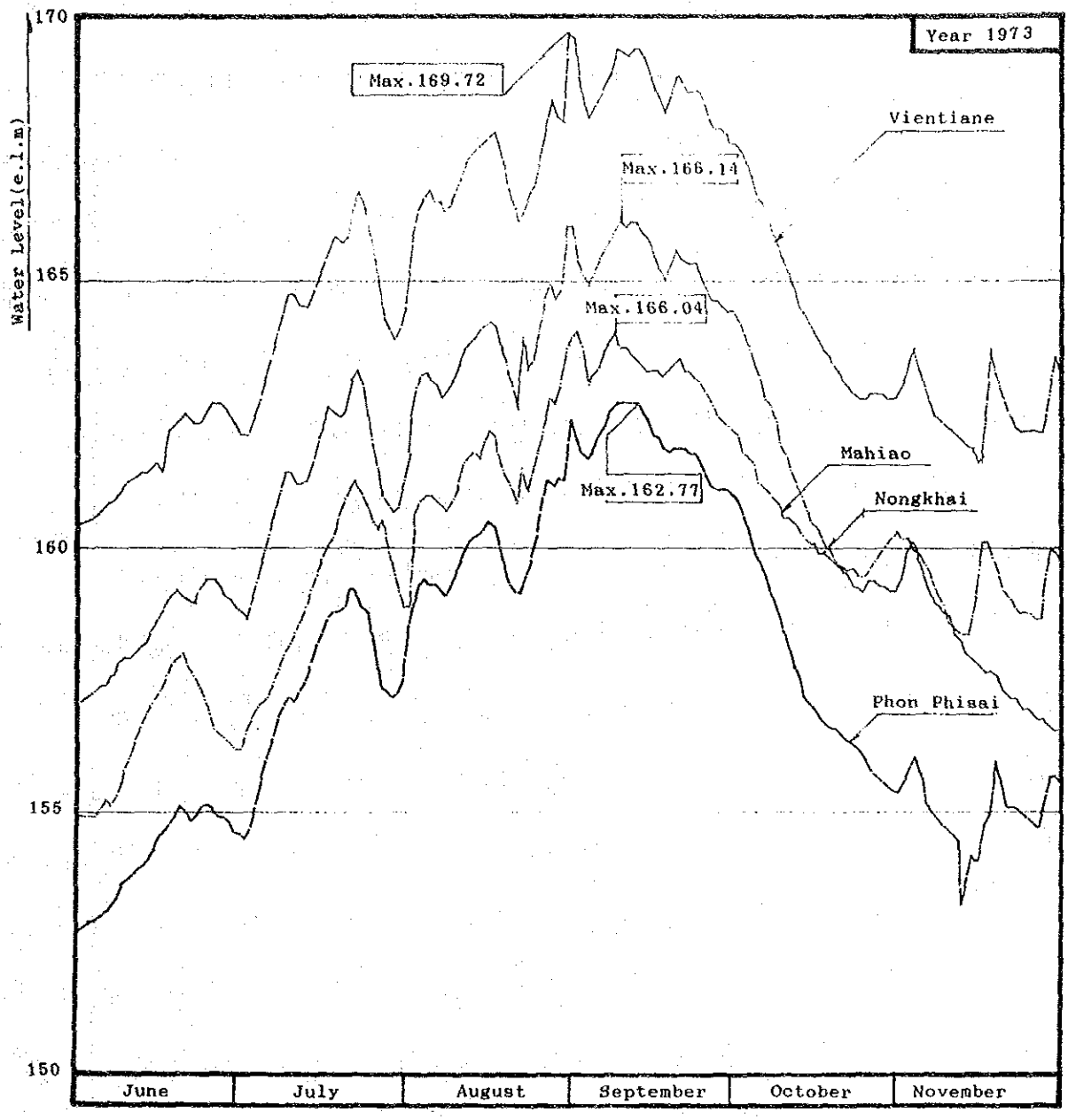

Fig. A.12 Water Levels of the Mekong at Vientiane, Nongkhai, Phonphisai and of Houei Mahiao at Regulator (1973)

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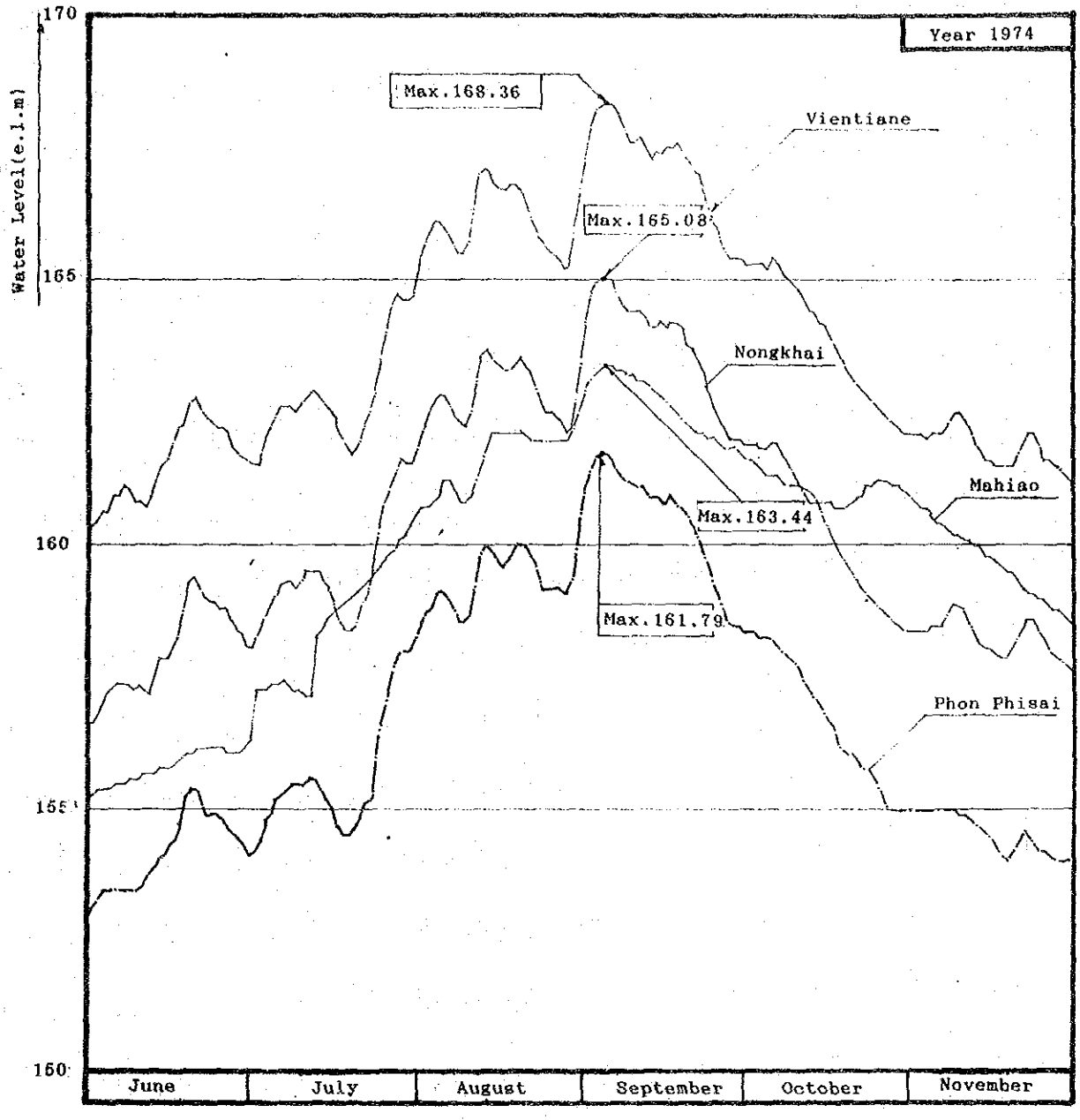

Fig. A.13 Water Levels of the Mekong at Vientiane, Nongkhai, Phonphisai and of Houei Mahiao at Regulator (1974)

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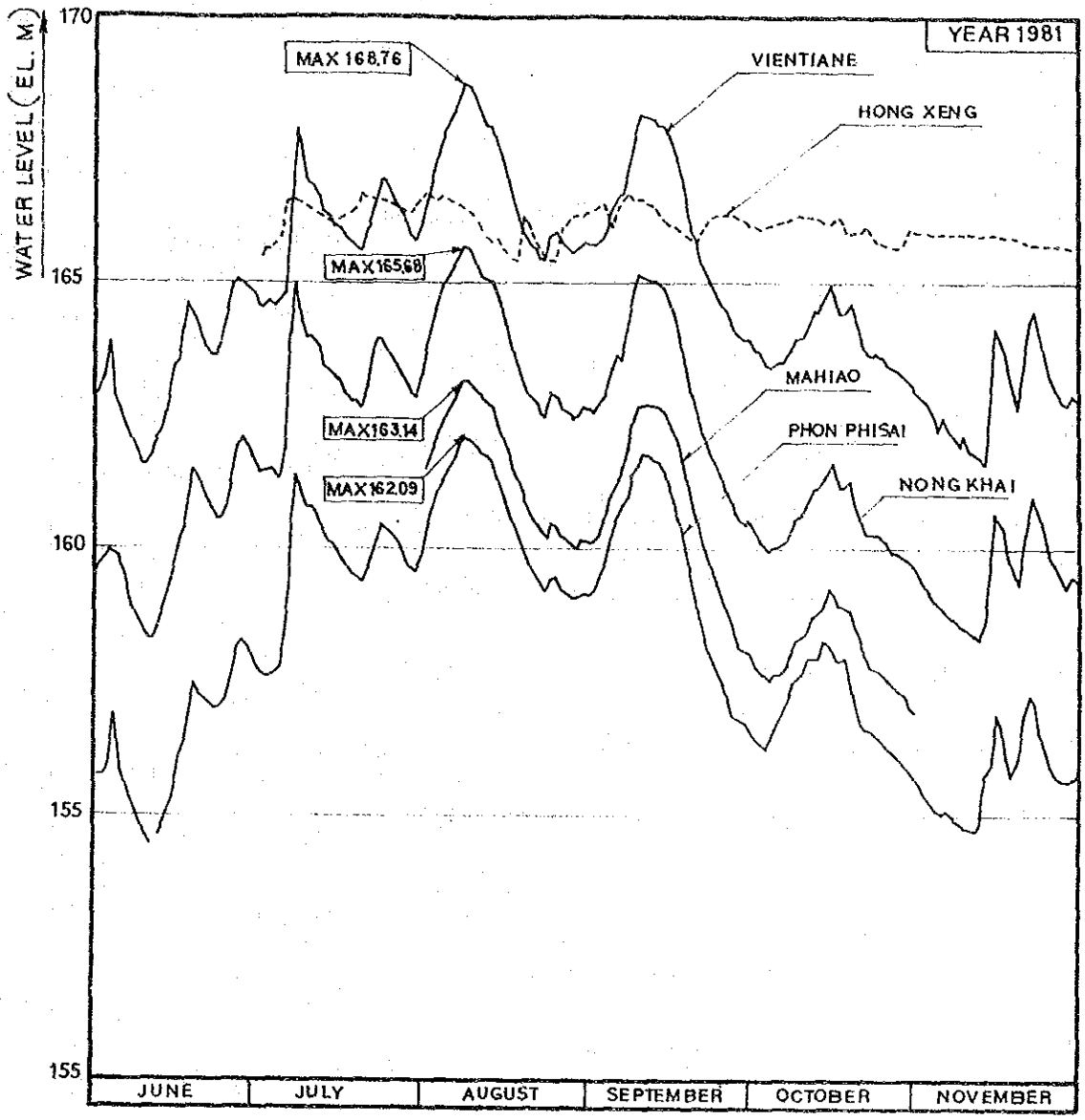

Fig. A.14 Water Levels of the Mekong at Vientiane, Nongkhai, Phonphisai and of Houei Mahiao at Regulator (1981)

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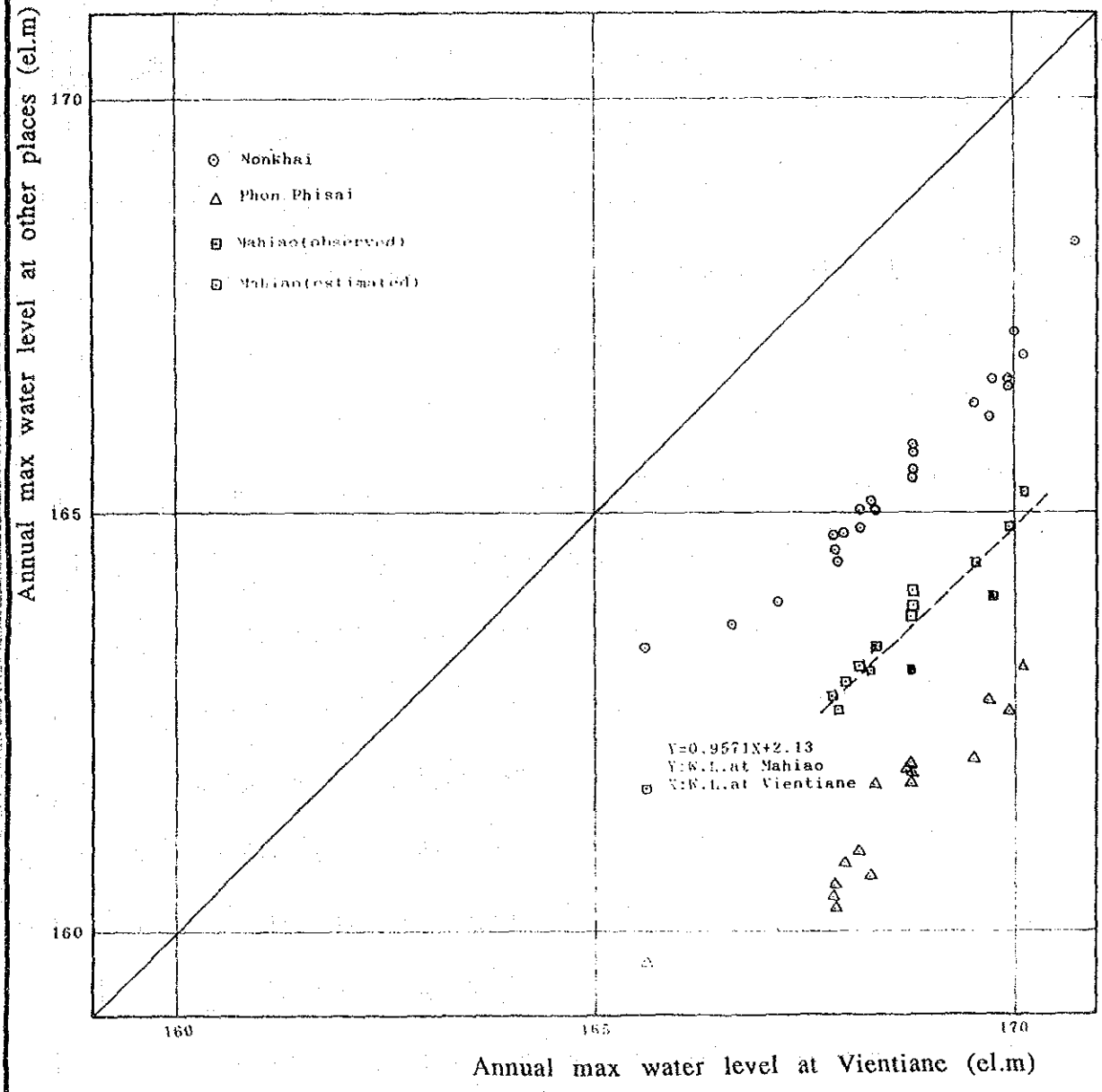

Fig. A.15 Annual Maximum Water Levels of the Mekong at Vientiane, Nongkhai,Phonphisai and Mahiao

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...F DRAINAGE SYSTEM IN VIENTIANE
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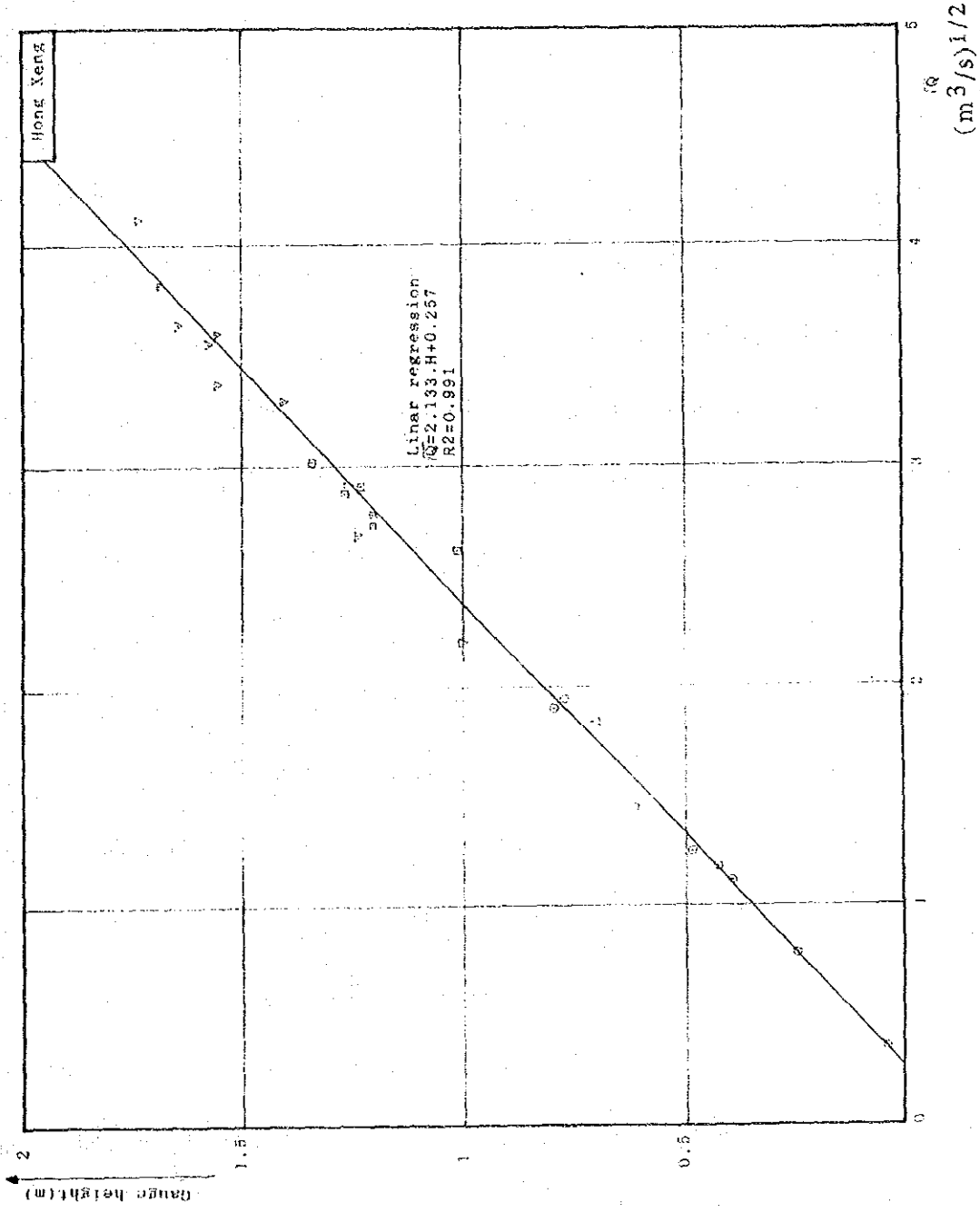

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Fig. A.16 Correlation between Square Root of Q and Gauge Height at Hong Xeng Site

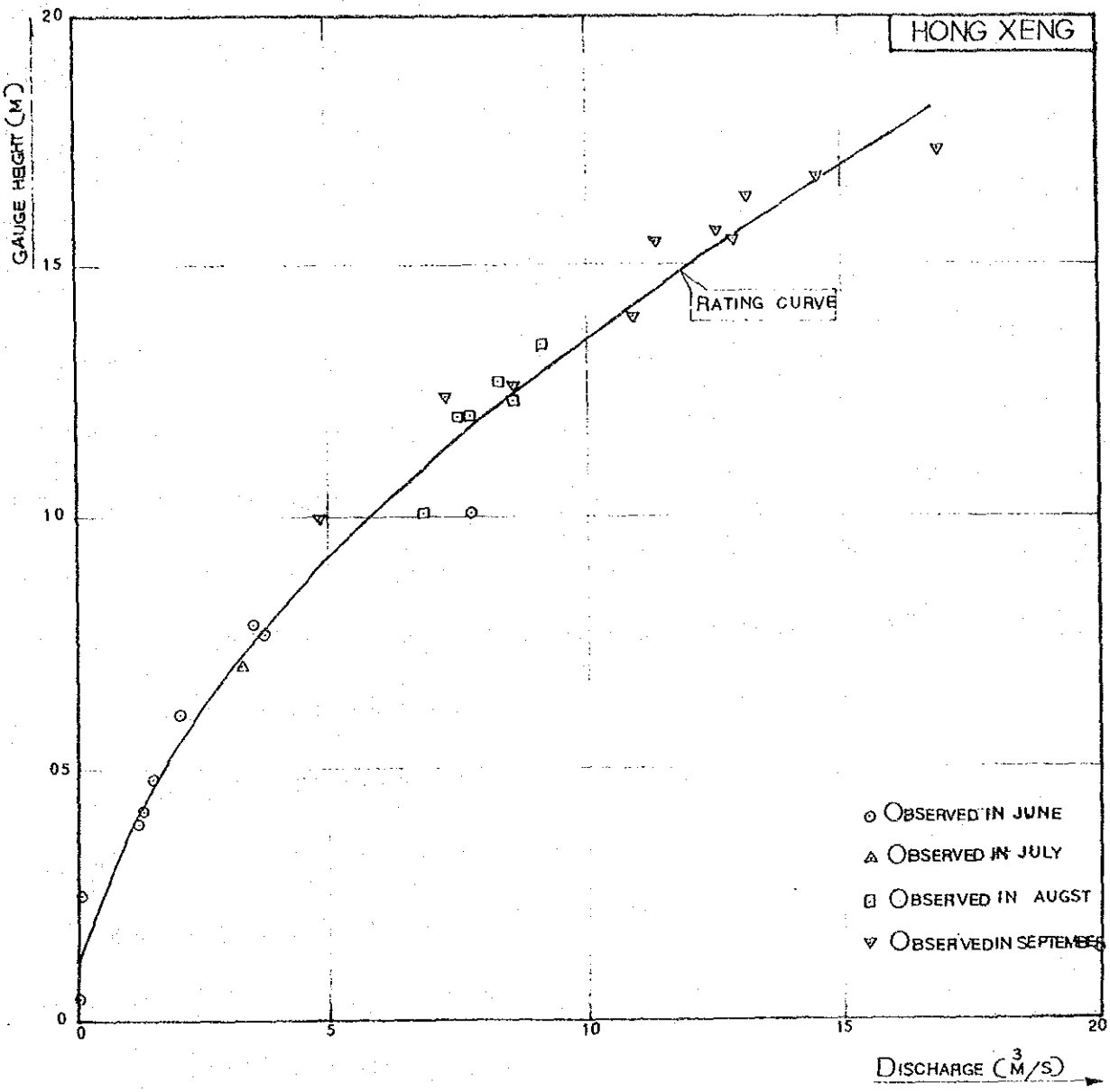

Fig. A.17 Rating Curve at Hong Xeng Site

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FEASIBILITY STUDY ON IMPROVEMENT
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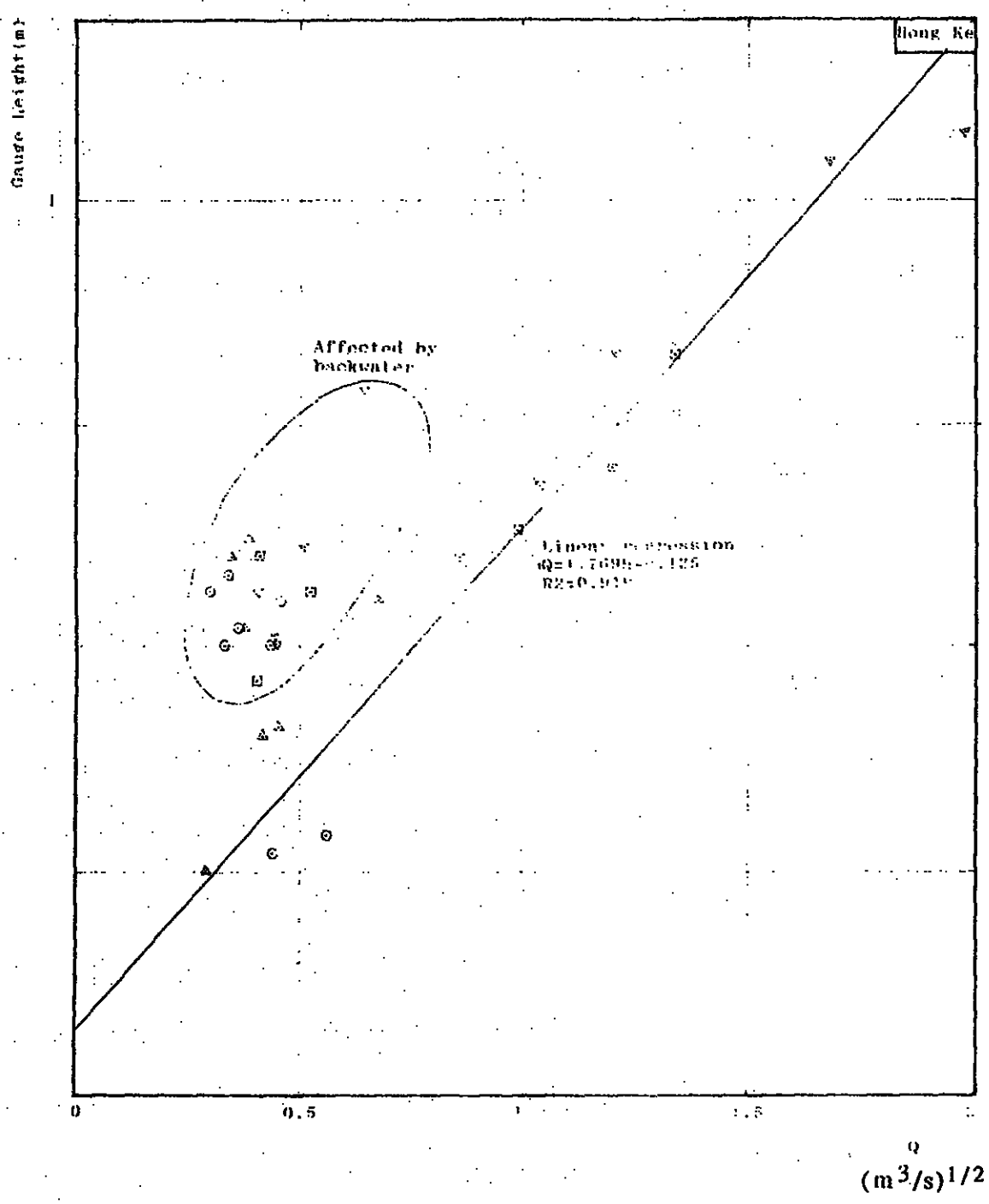

Fig. A.18 Correlation between Square Root of Q and Gauge Height at Hong Ke Site

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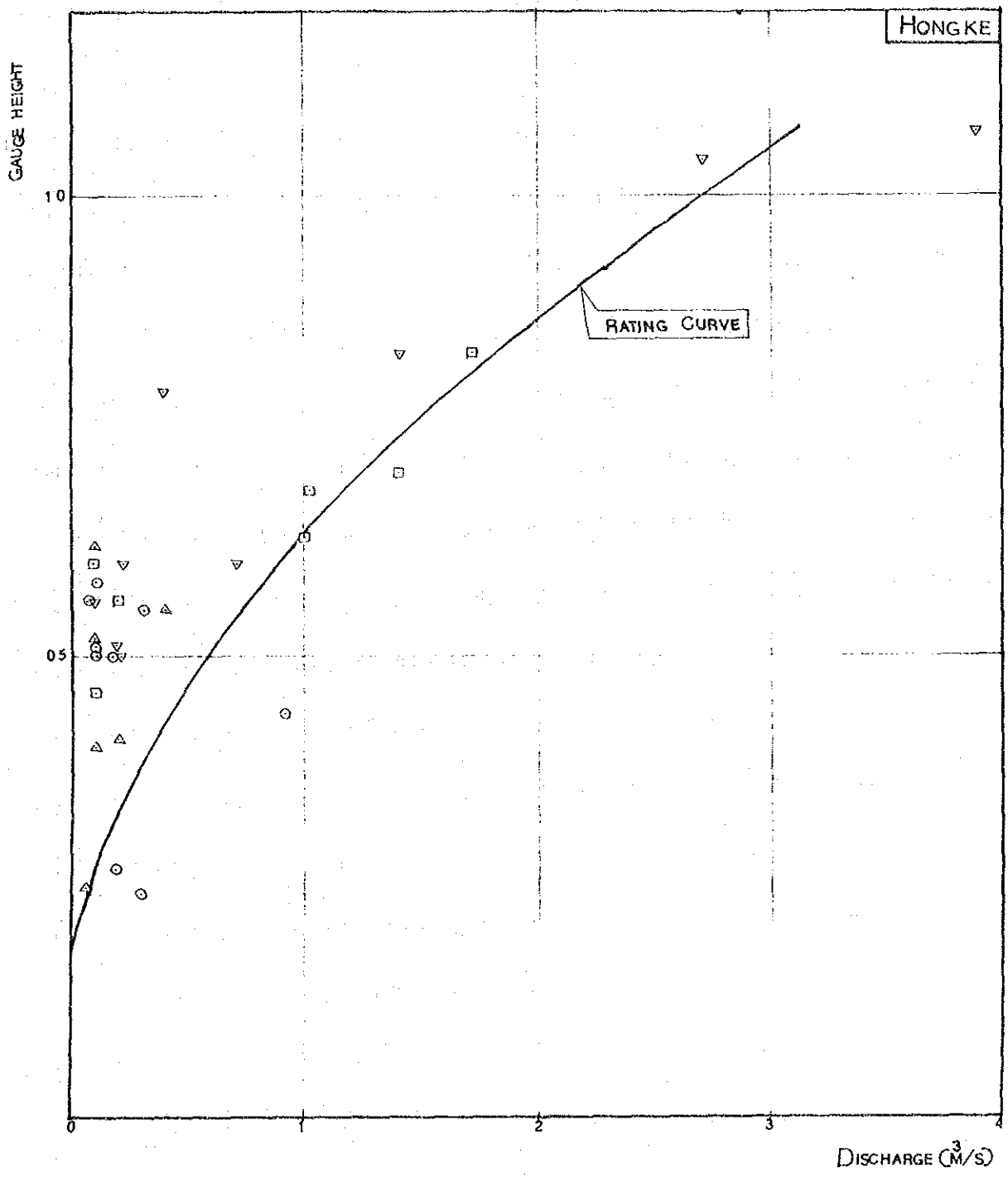

Fig. A.19 Rating Curve at Hong Ke Site

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OF DRAINAGE SYSTEM IN VIENTIANE
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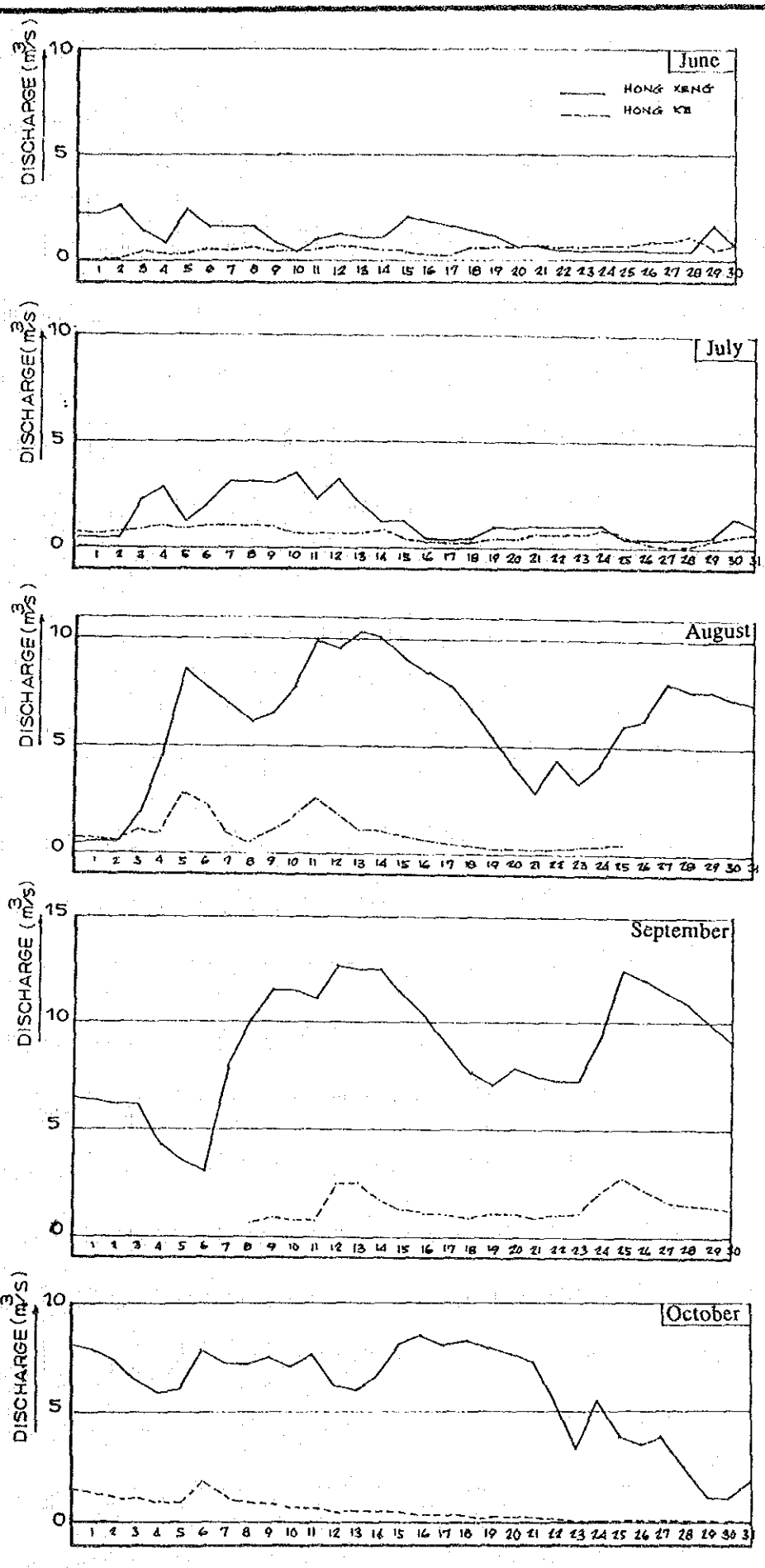

Fig. A.20 Daily Discharge of the Hong Xeng and Hong Ke at Automatic Gauges

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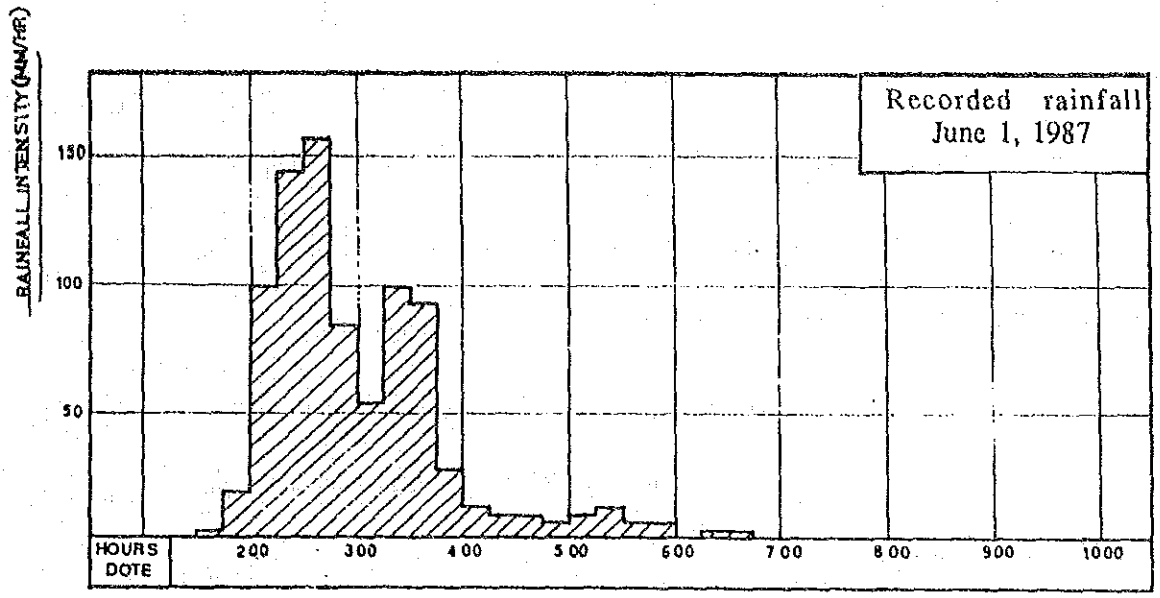

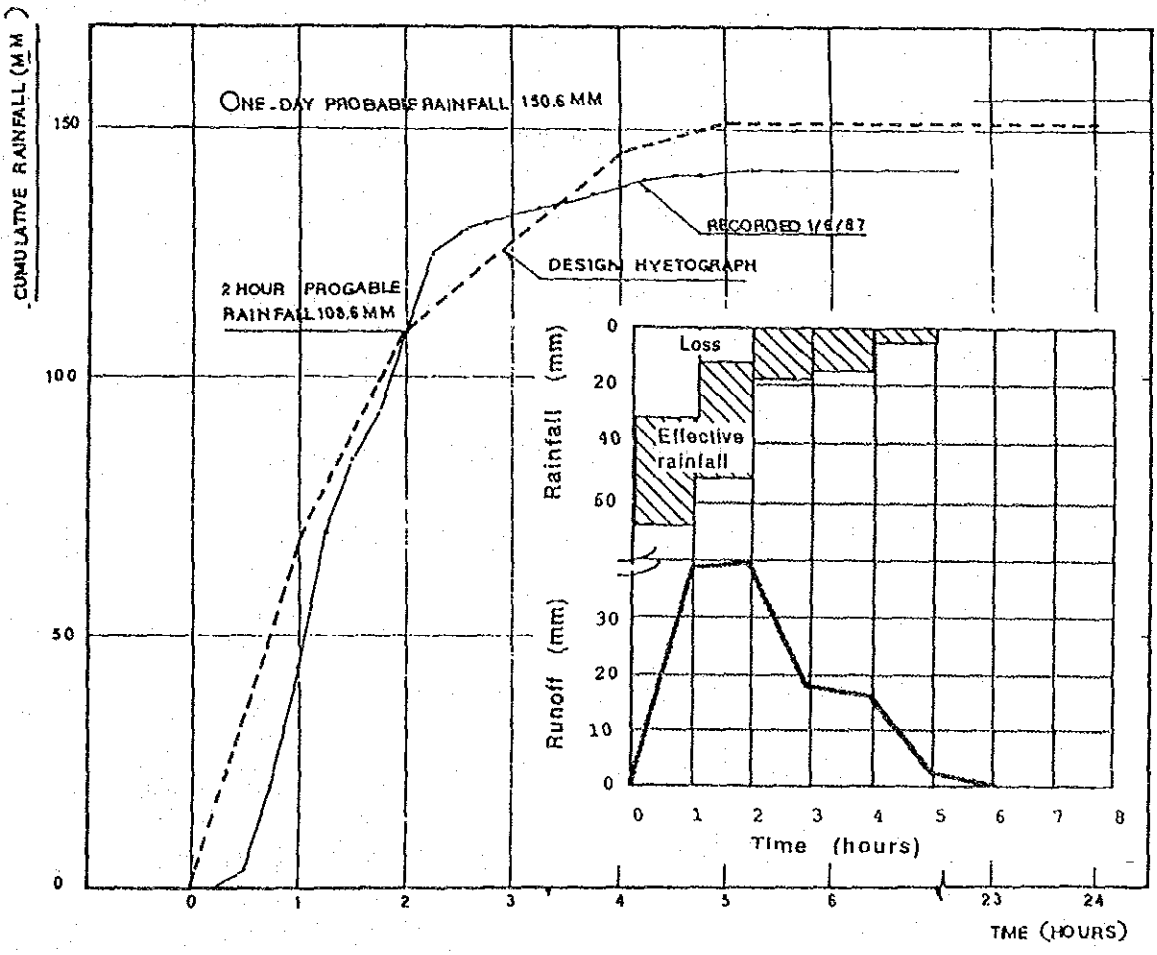

Fig. A.21 Design Storm and Hydrograph

LAO PEOPLE'S DEMOCRATIC REPUBLIC
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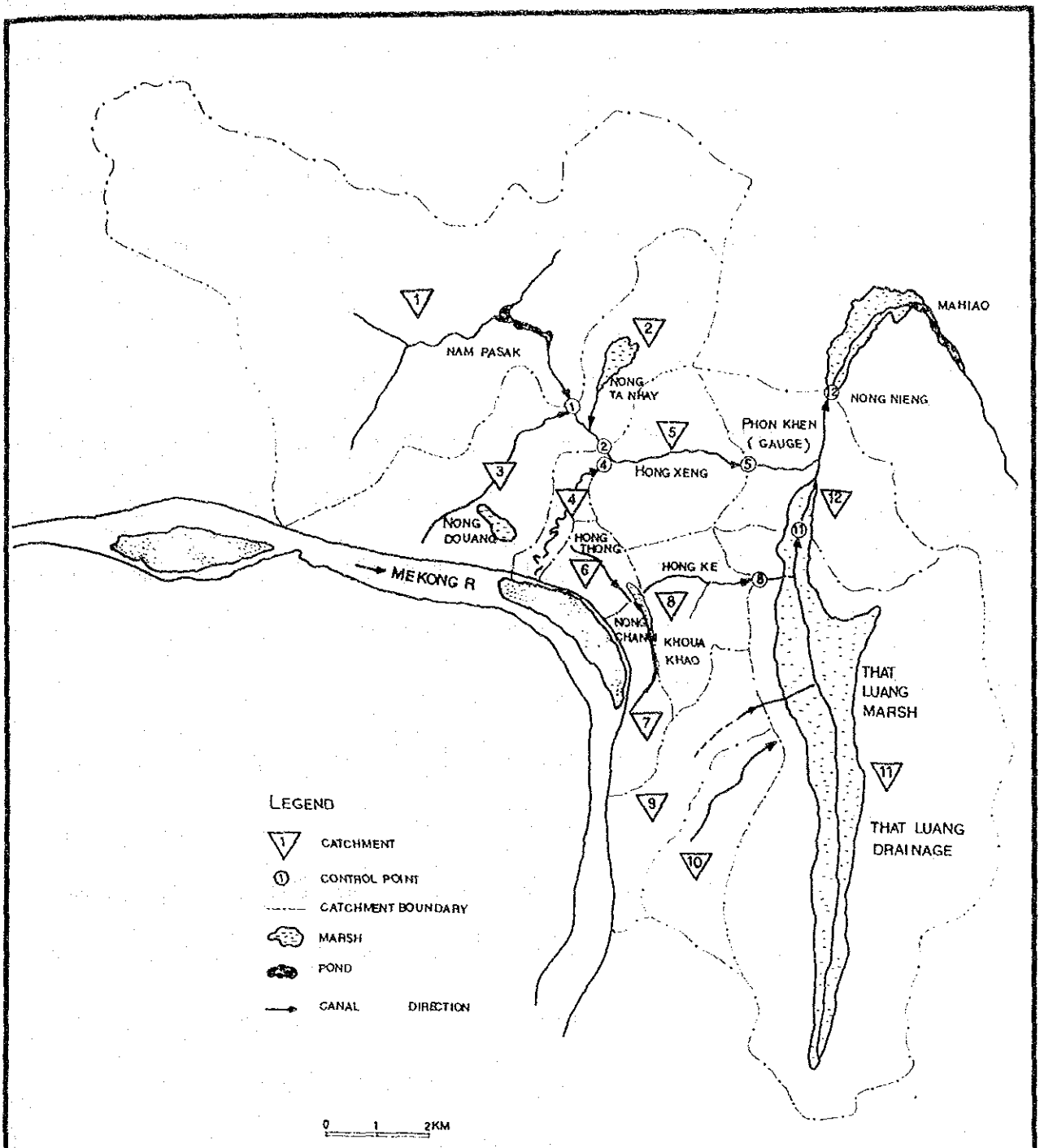

Fig. A.22 Demarcation of Catchment Areas

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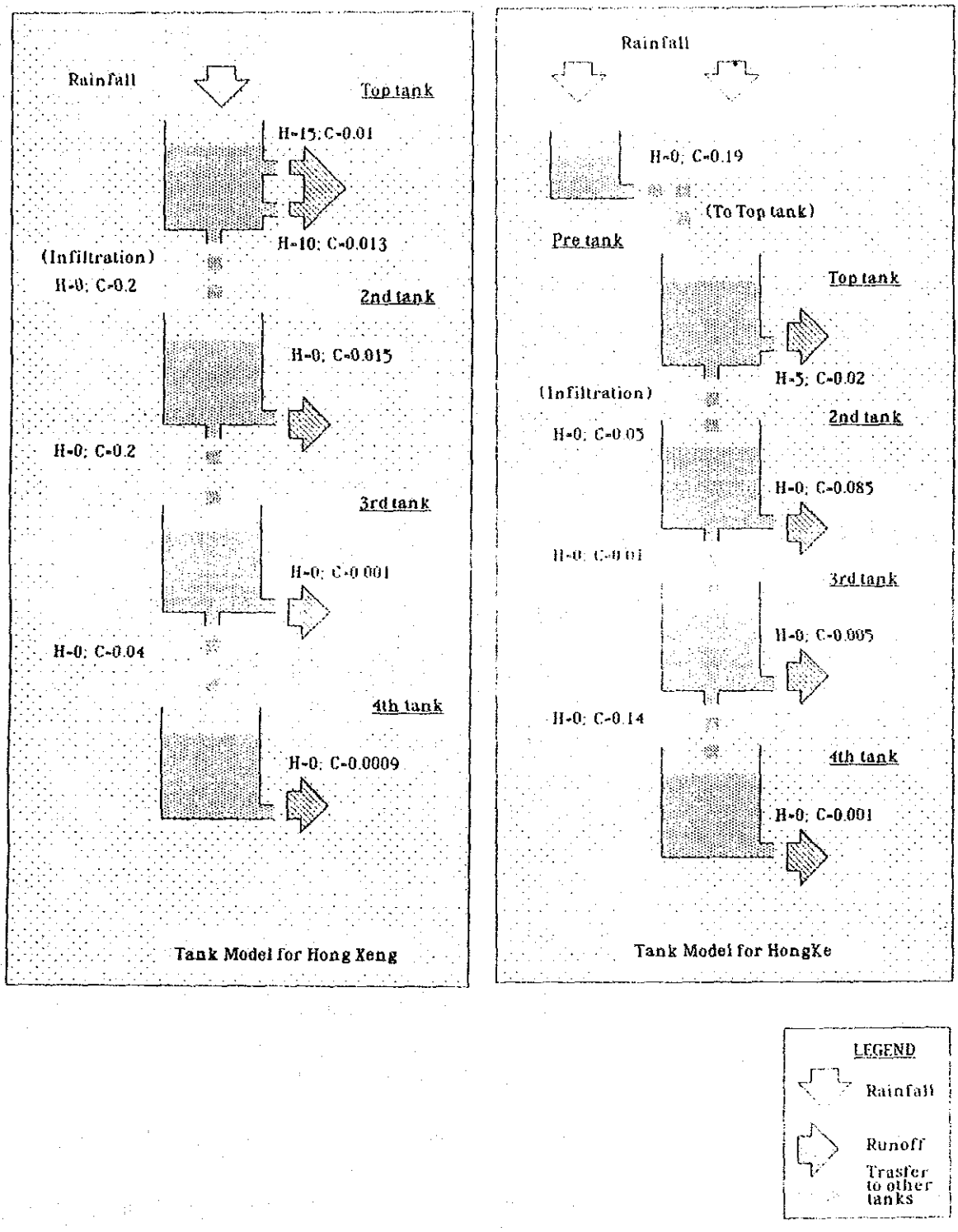

Fig. A.23 Schematic Illustration of Tank Model

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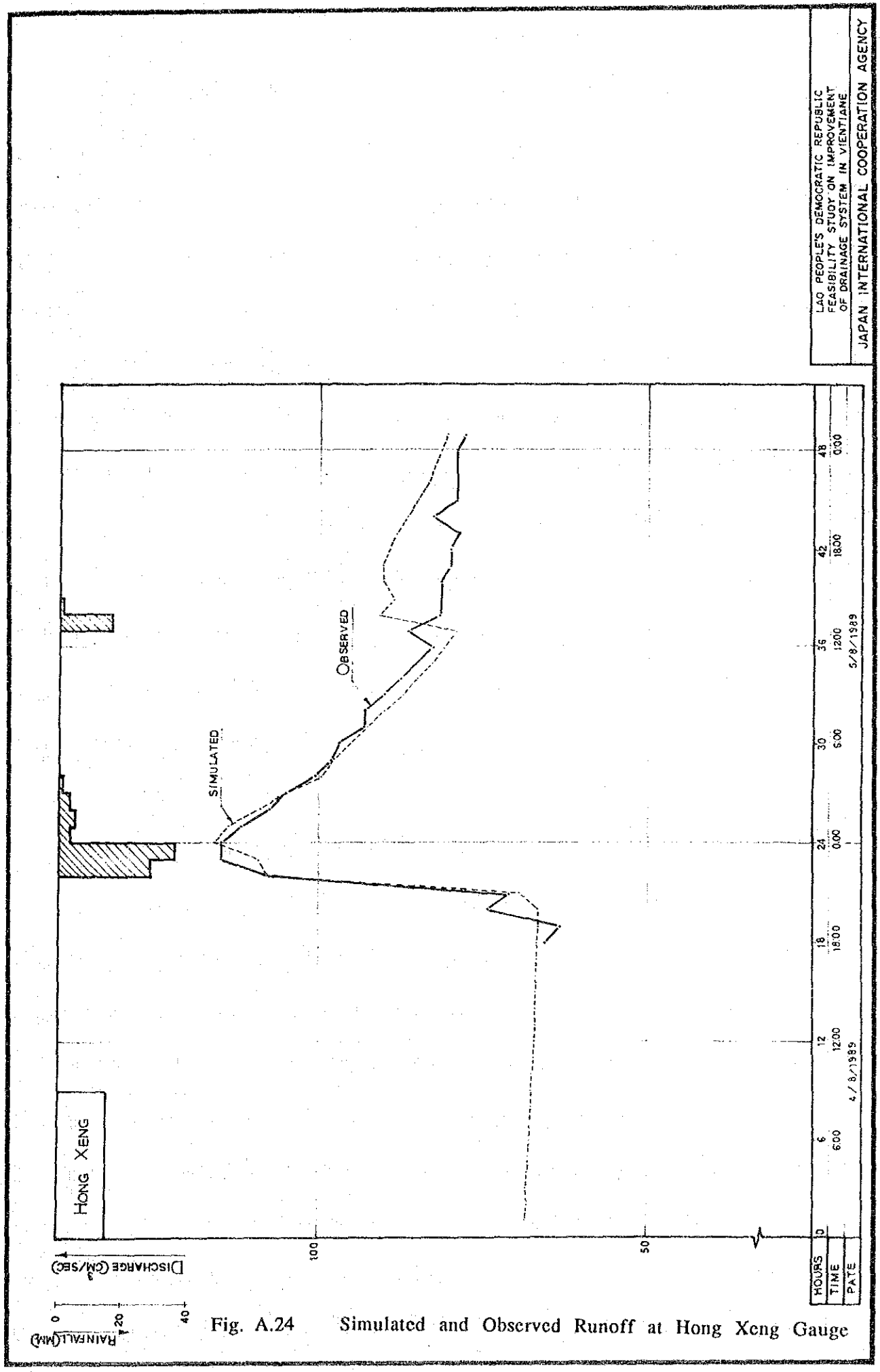

Fig. A.24 Simulated and Observed Runoff at Hong Xeng Gauge

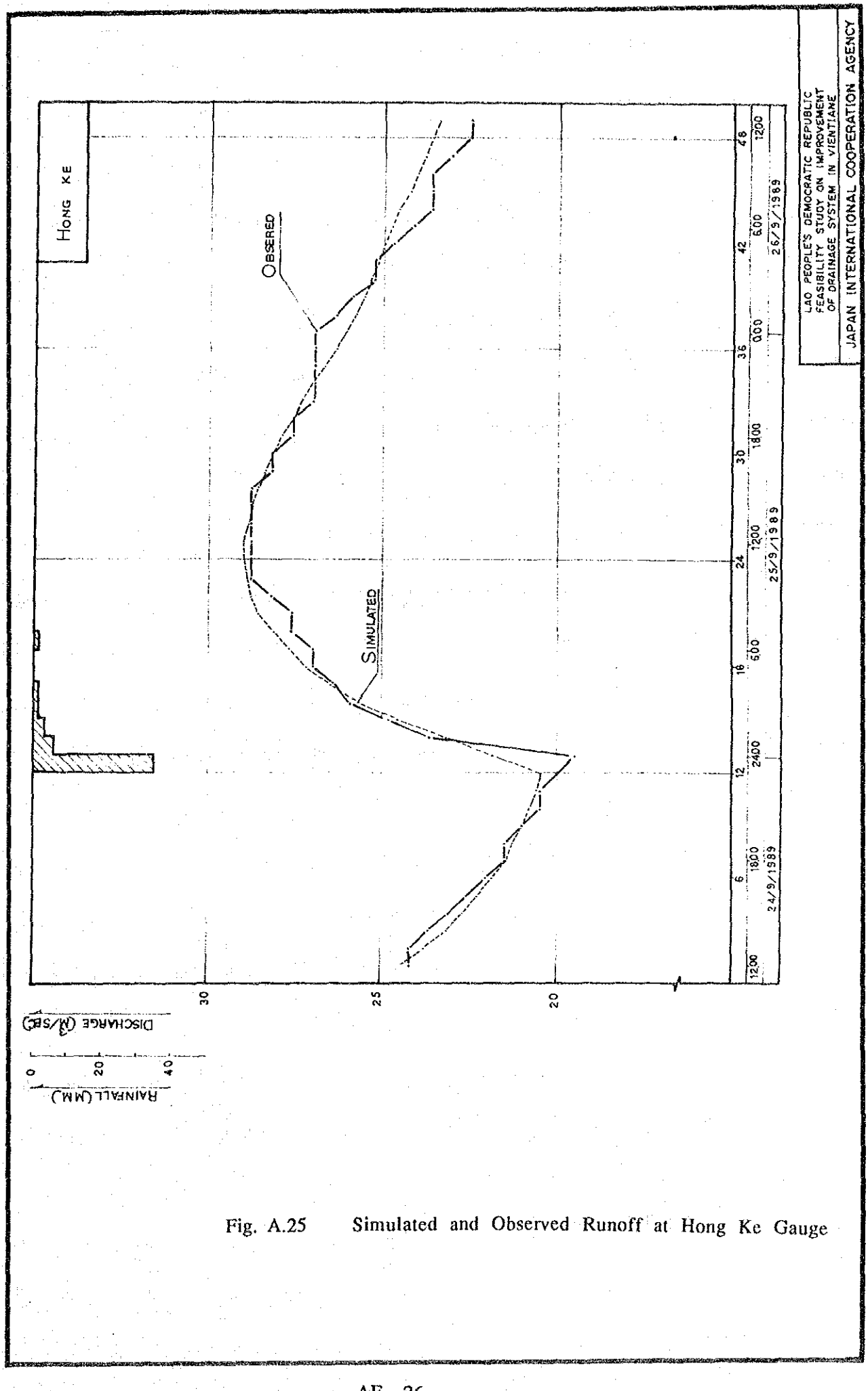

Fig. A.25 Simulated and Observed Runoff at Hong Ke Gauge

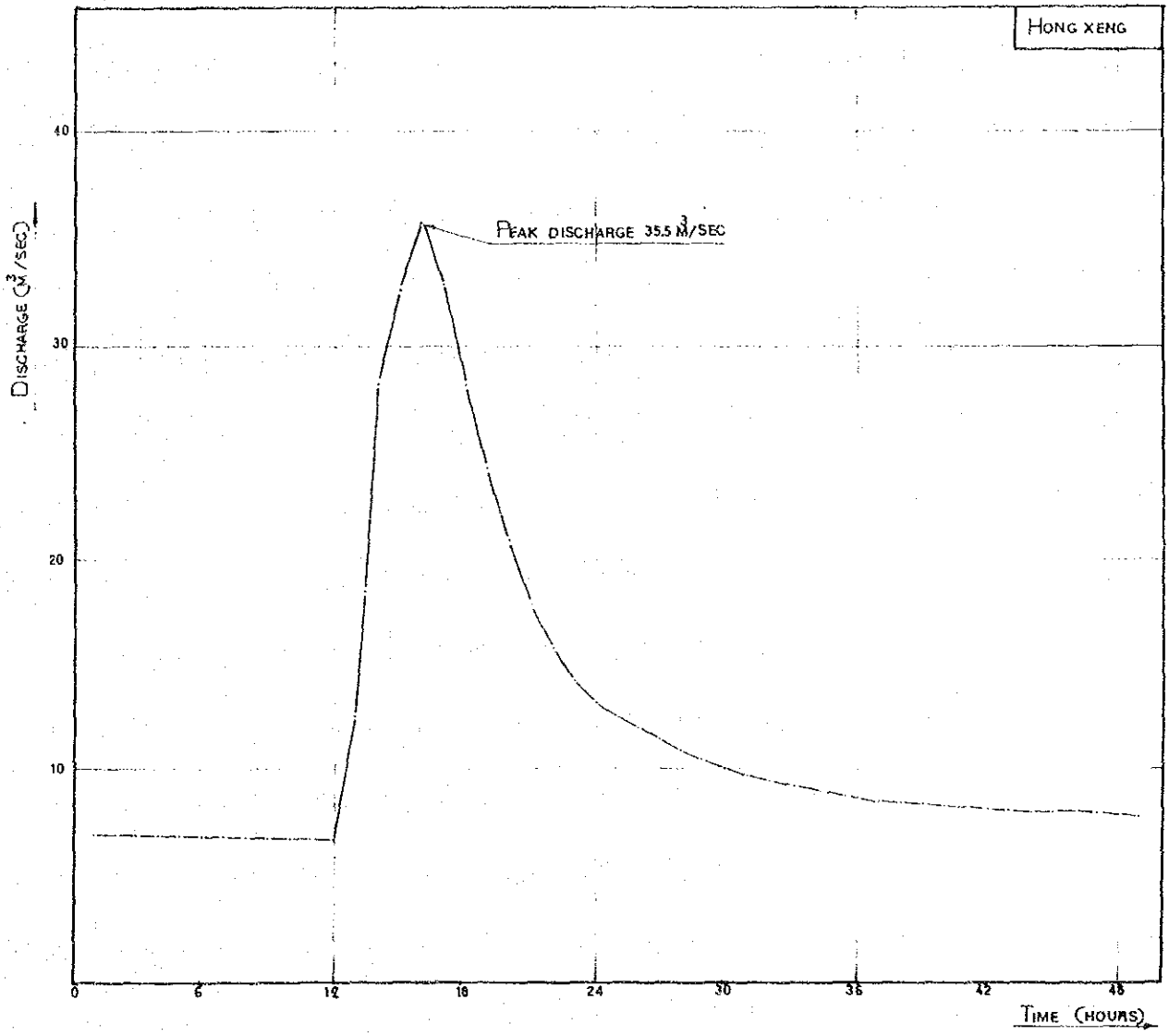

Fig. A.26 Simulated Flood Runoff Hydrograph at Hong Xeng Gauge (10-year Return Period)

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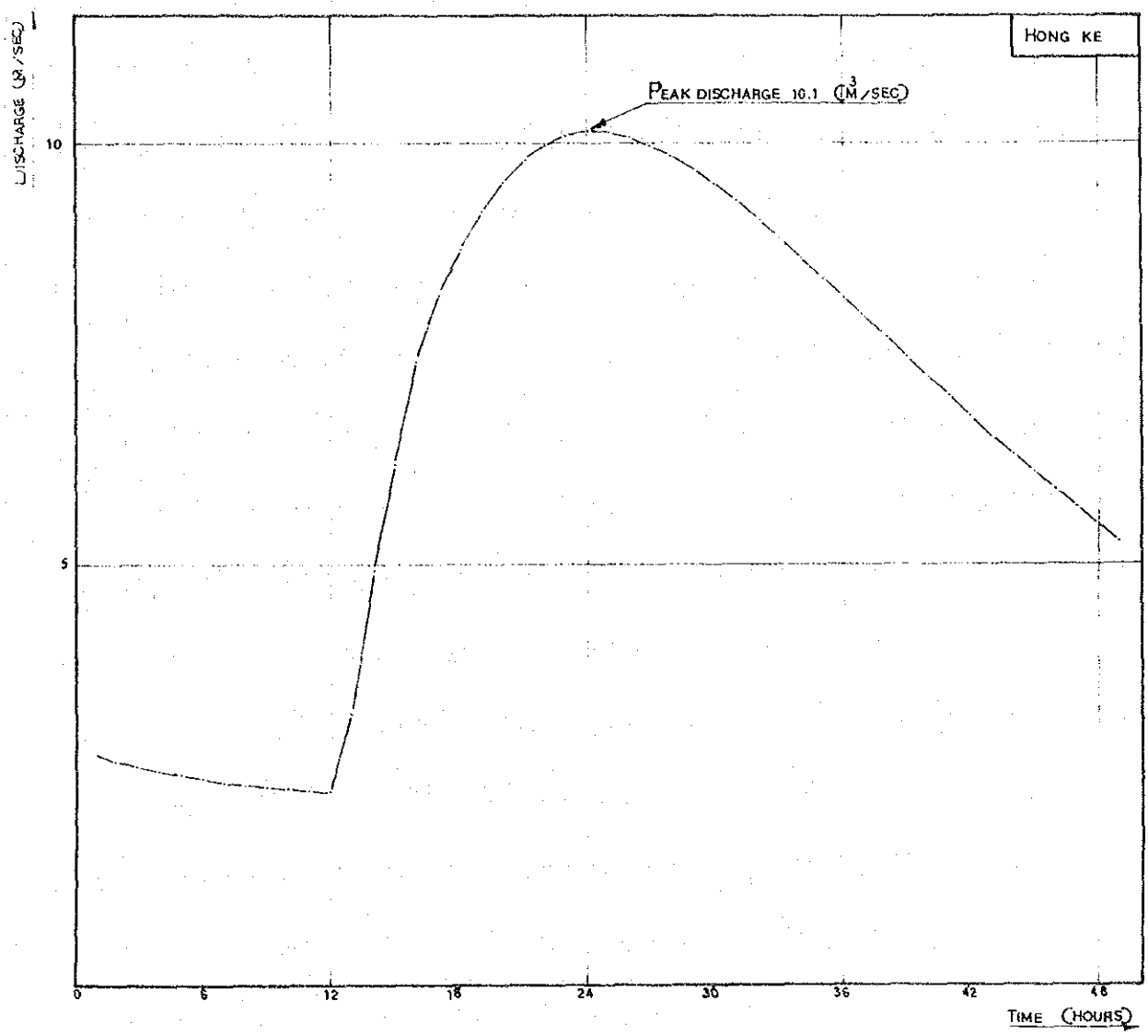

Fig. A.27 Simulated Flood Runoff Hydrograph at Hong Ke Gauge (10-year Return Period)

LAO PEOPLE'S DEMOCRATIC REPUBLIC
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OF DRAINAGE SYSTEM IN VIENTIANE
JAPAN INTERNATIONAL COOPERATION AGENCY

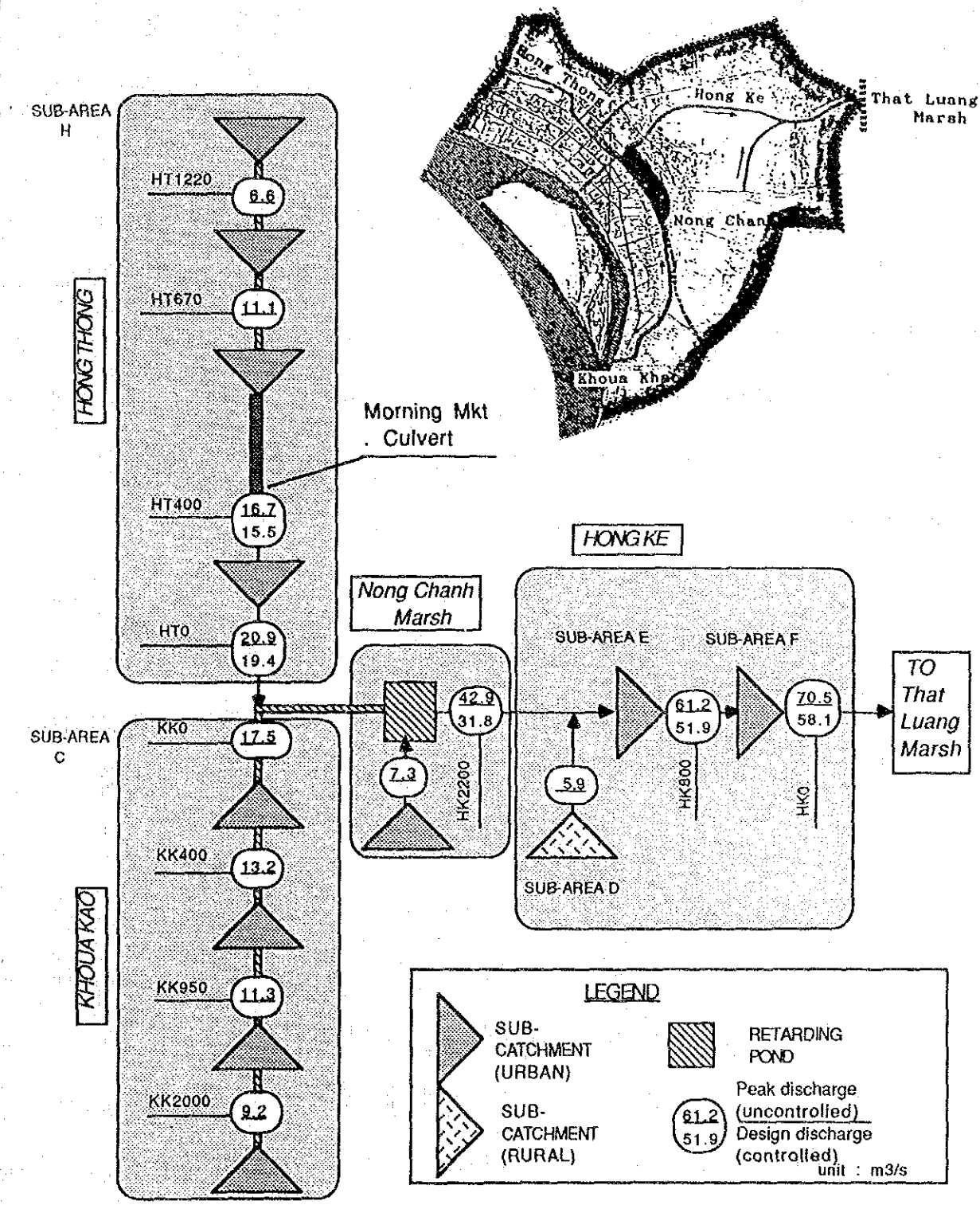

Fig. A.28 Design Discharges of the Hong Ke System

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FEASIBILITY STUDY ON IMPROVEMENT OF DRAINAGE SYSTEM IN VIENTIANE
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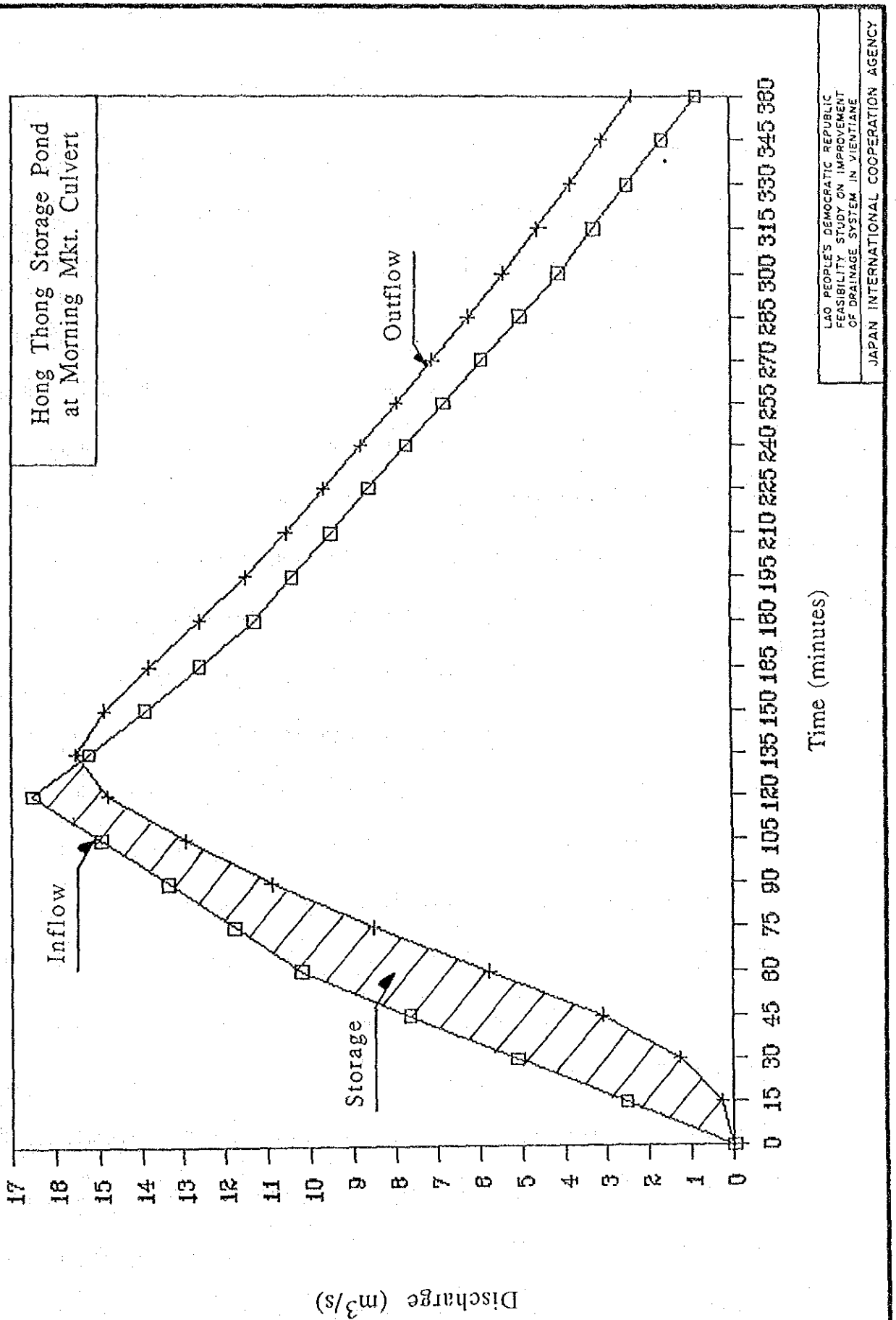


Fig. A.29 Inflow and Outflow Hydrographs at Hong Thong Storage Pond

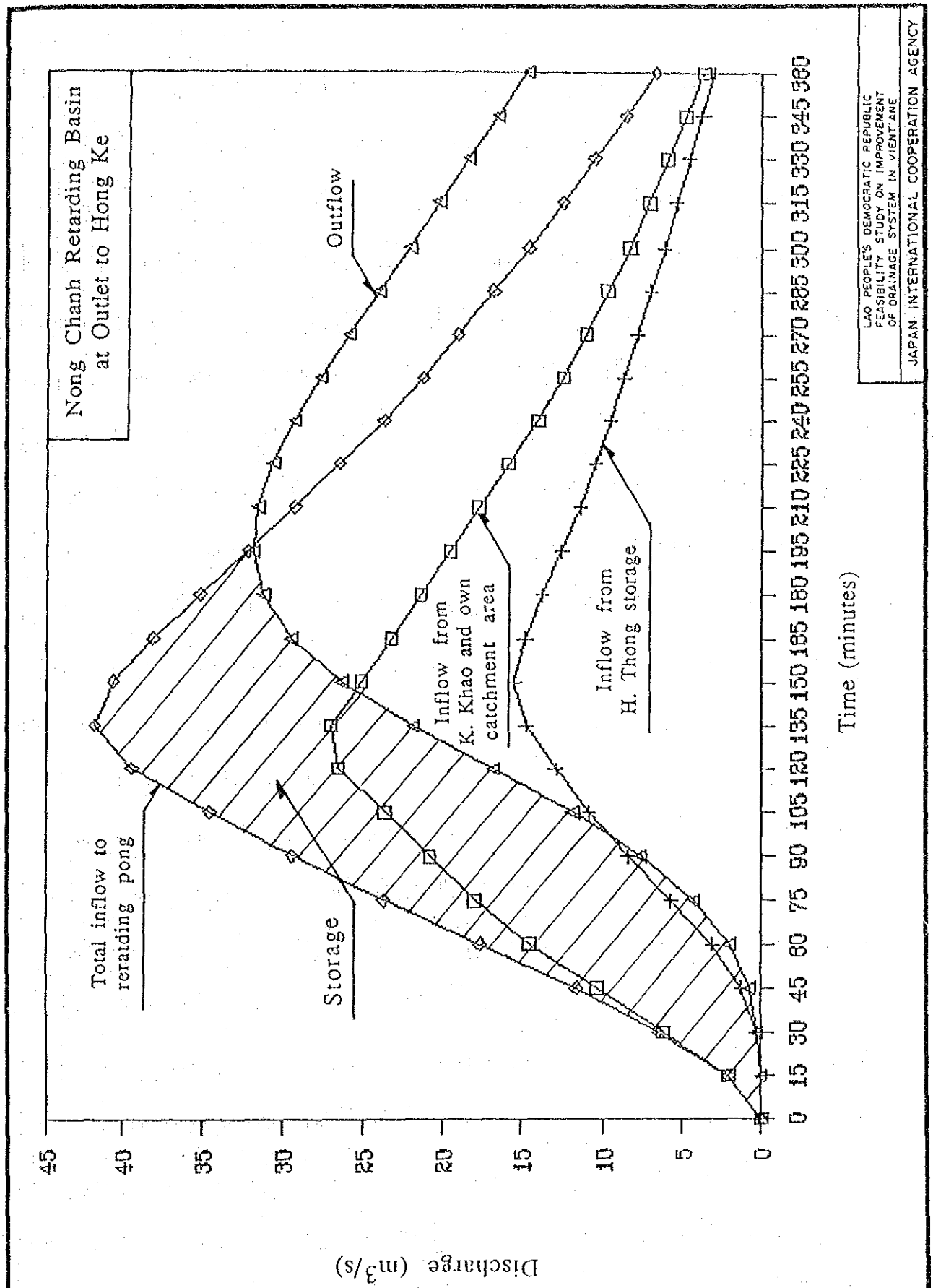


Fig. A.30 Inflow and Outflow Hydrographs at Nong Chanh Retarding Basin

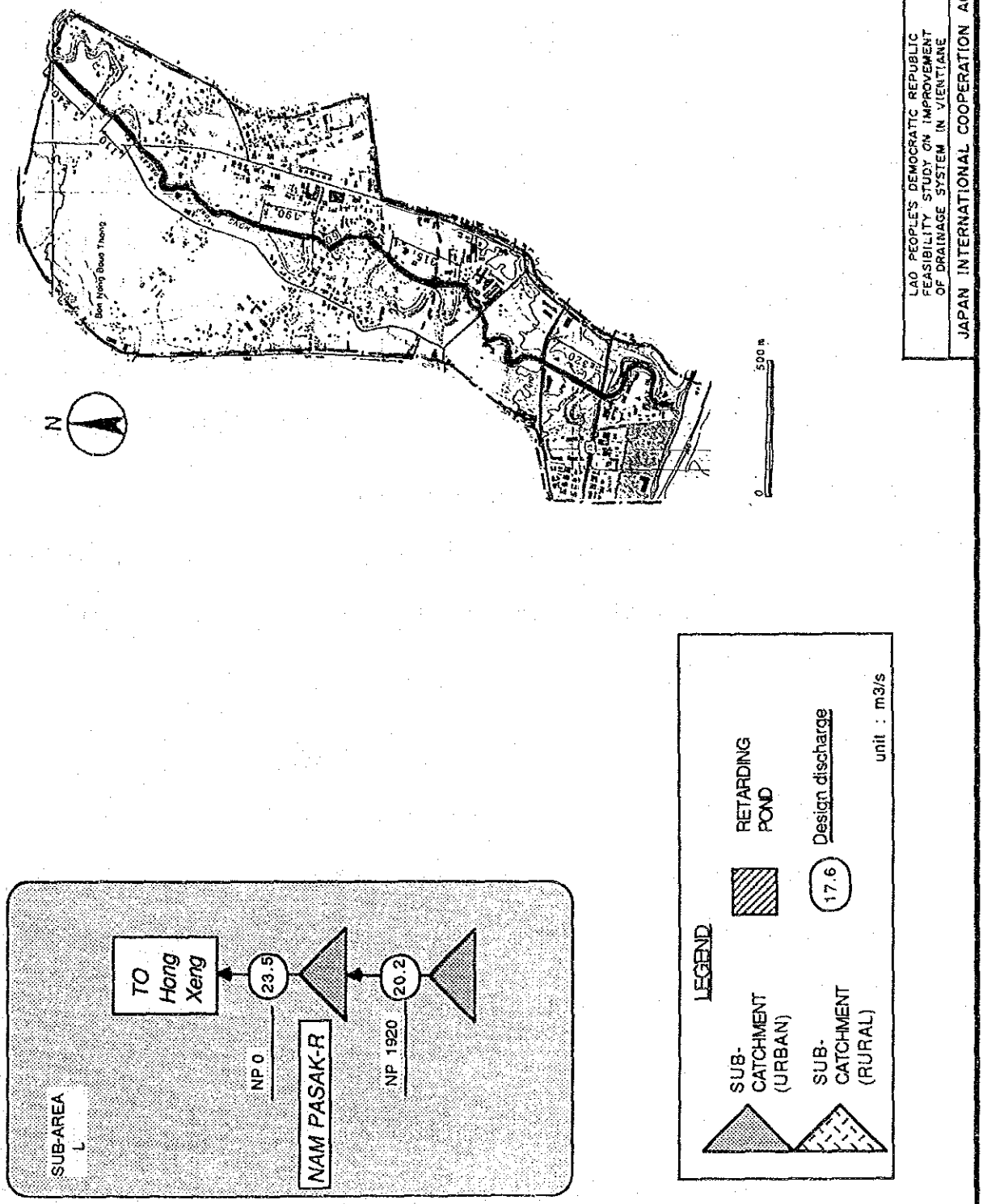
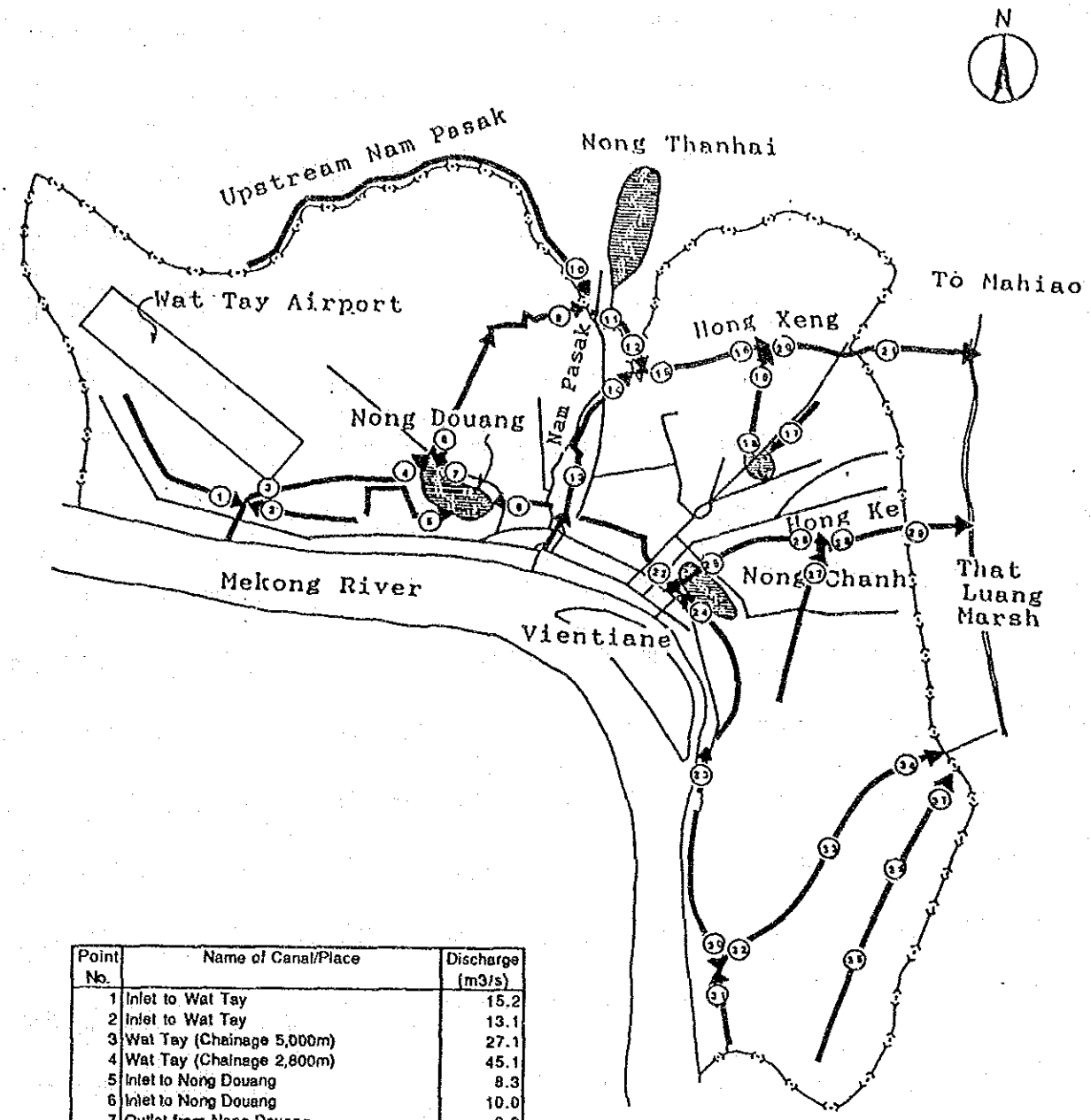


Fig. A.31 Design Discharges of the System for Sub-area L

Fig. A.32 Design Discharges of the System for Sub-area I



Point No.	Name of Canal/Place	Discharge (m3/s)
1	Inlet to Wat Tay	15.2
2	Inlet to Wat Tay	13.1
3	Wat Tay (Chainage 5,000m)	27.1
4	Wat Tay (Chainage 2,800m)	45.1
5	Inlet to Nong Douang	8.3
6	Inlet to Nong Douang	10.0
7	Outlet from Nong Douang	8.2
8	Wat Tay (Chainage 2,800m)	45.7
9	Wat Tay (Chainage 0 m)	55.8
10	Upstream Nam Pasak	30.0
11	Upstream Nam Pasak	84.2
12	Upstream Nam Pasak	119.0
13	Nam Pasak (Chainage 2,800 m)	6.8
14	Nam Pasak (Confluence with Honbg Xeng)	23.3
15	Hong Xeng (Chainage 3,344 m)	131.5
16	Hong Xeng (Confluence with H. Kai Keo)	139.7
17	Inlet to Nong Bon	17.6
18	Outlet from Nong Bon	16.8
19	Hong Kai Keo (Confluence with H. Xeng)	23.5
20	Hong Xeng (Chainage 1,600 m)	154.8
21	Hong Xeng at sluice gate	159.1
22	Hong Thong (Inlet to Nong Chanh)	20.9
23	Khoua Khao at Upstream	9.2
24	Khoua Khao (Inlet to Nong Chanh)	17.5

Point No.	Name of Canal/Place	Discharge (m3/s)
25	Outlet from Nong Chanh	42.9
26	Hong Ke (Chainage 800 m)	60.8
27	Dong Pai Na (Confluence with Hong Ke)	5.9
28	H. Ke (Chainage 800 m after confluence)	61.2
29	Hong Ke (Outlet to That Luang)	70.5
30	Thadeua Road (Souane Mone Area)	14.5
31	Thadeua Road (Souane Mone Area)	7.2
32	Inlet to Drainage Canal	19.3
33	Irrigation Drainage (Chainage 2,700m)	28.6
34	Outlet to That Luang Marsh	38.2
35	Irrigation Drainage(Chainage 1,370m)	21.2
36	Irrigation Drainage(Chainage 2,730m)	31.5
37	Outlet to That Luang Marsh	36.3

Fig. A.33 Design Discharges for Basic Plan

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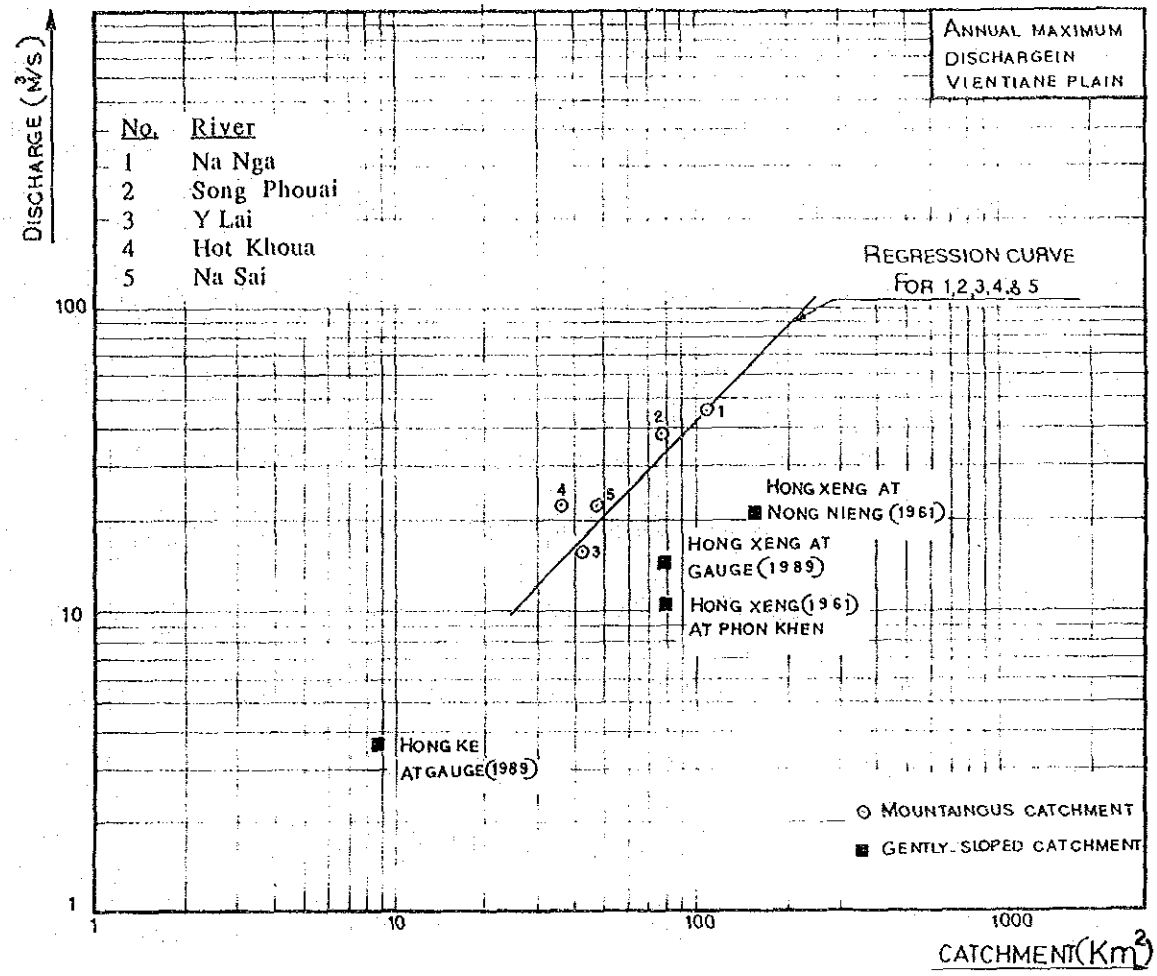

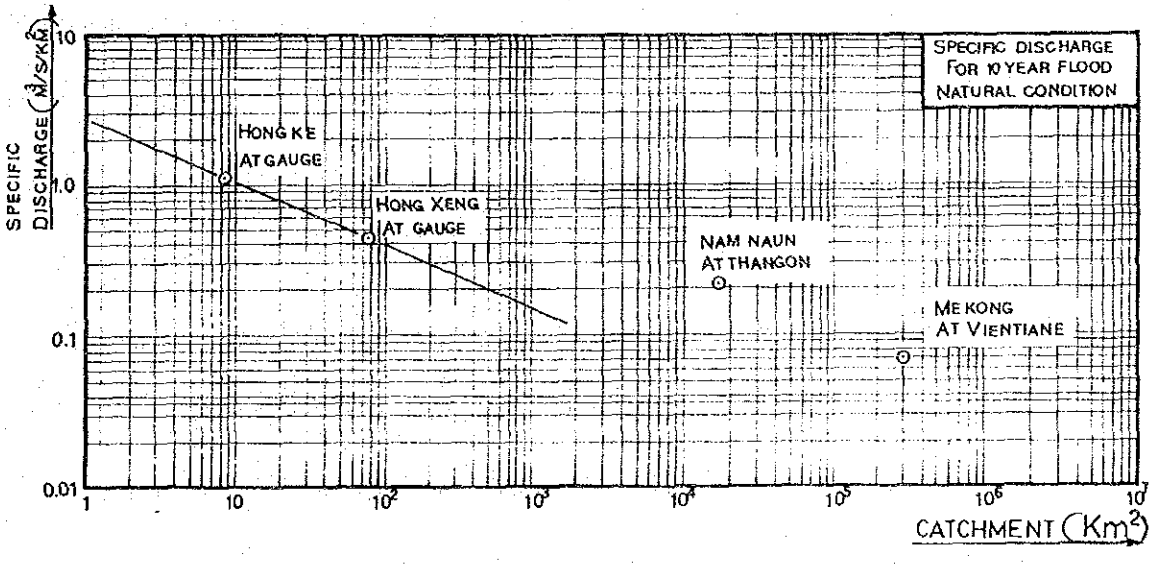

Fig. A.34 Cross Drainage Comparison of Flood Discharges

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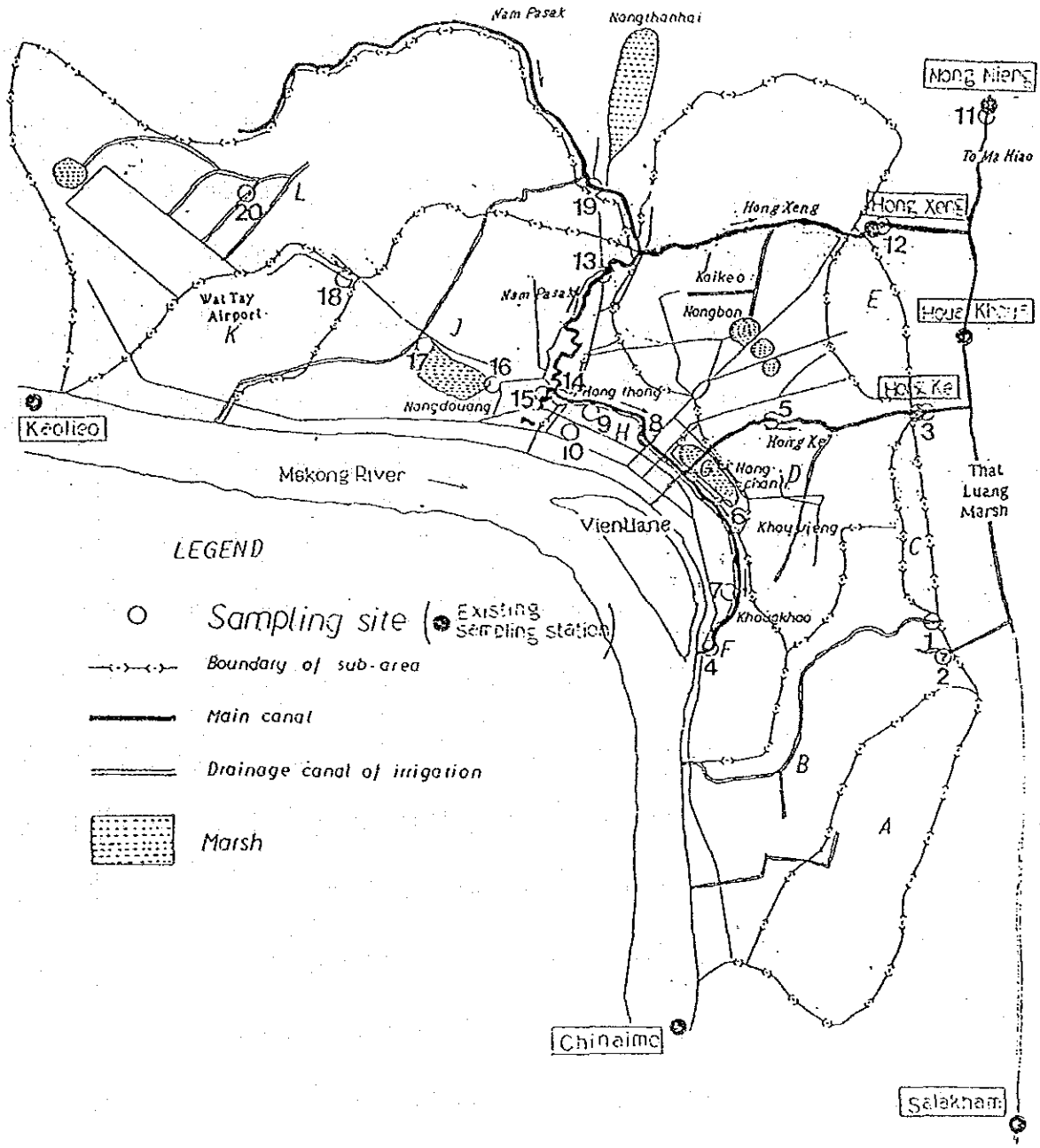

Fig. A.35 Sites for Discharge Measurement in Dry Season..

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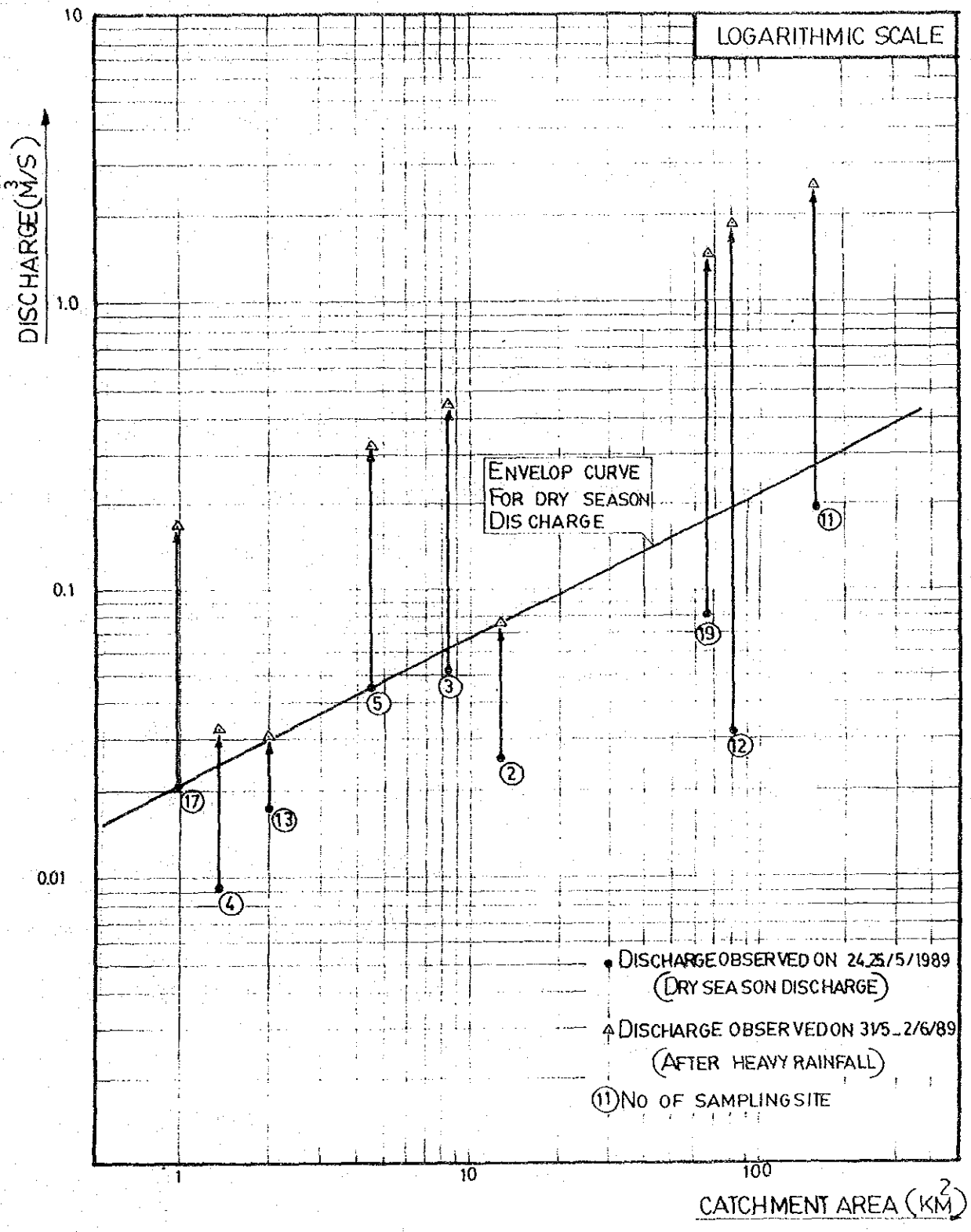

Fig. A.36 Low Flow Discharges in the Study Area

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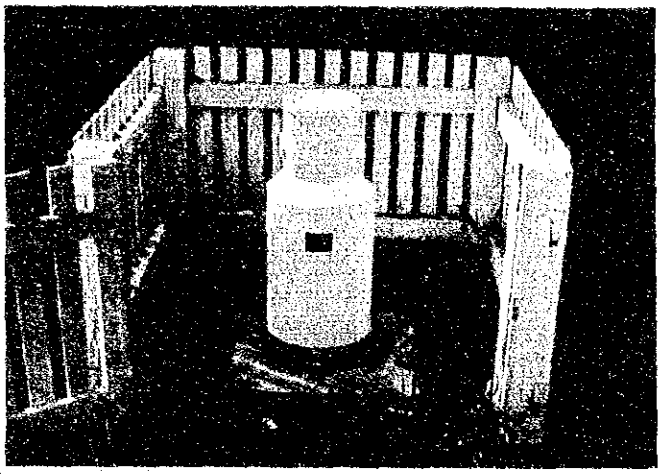
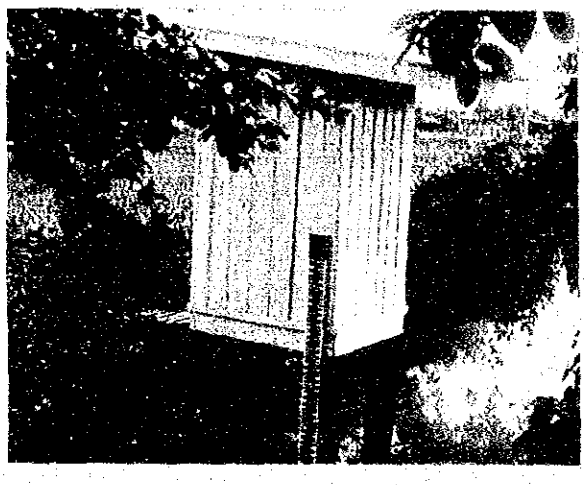
PLATE



Automatic Rain Gauge at MOV



Automatic Water Level Gauge at Hong Ke

Automatic Water Level Gauge at Hong Xeng

Discharge Measurement

Staff Gauge at Dong Deng

Plate A.1 Hydrological Observation

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APPENDIX B

ENVIRONMENTAL STUDY

APPENDIX B ENVIRONMENTAL STUDY

TABLE OF CONTENTS

B.1 Environmental Development Concept by Rivers

The zoning and the development concept of each stretch of a river are contemplated in the light of the necessary actions and development principles. Annex B.1 through B.8 are brief description of the present condition and issues for development for each main canal. The following are the summary of the points discussed in the Annex:

(1) Hong Ke

The Hong Ke starts at Nong Chanh Marsh and drains to That Luang Marsh. The existing river channel is 10 - 16 m wide with overgrown water grass on the banks. The river basin are occupied by quiet residential zones along the left side of its river course, and by paddy fields on the right. Given the high potential as residential use in the basin area, the river channel of the Hong Ke should be improved with necessary bank protection.

(2) Khoua Khao

The Khoua Khao collects water from the southeastern part of the areas within the dyke road around the central city of Vientiane, and drains to Nong Chanh Marsh. The river channel is 20 - 30 m wide for most of the stretch, with overgrown water grass. The existing dyke road runs along the Khoua Khao, with easy access to the water space. In the development of the Khoua Khao, the importance of water space in the urban environment should be given special consideration.

(3) Hong Thong

The Khoua Khao collects water from the northwestern part of the areas within the dyke road around the central city of Vientiane, and drains to Nong Chanh Marsh. The river channel is 10-16 m wide for most of the stretch. Water quality is bad due chiefly to the small volume of the flow. There are important facilities such as markets, a sport ground, government offices, schools and foreign embassies. This river should be improved as urban scenery area with an amenity water front.

(4) Nam Pasak (Right Branch)

The Nam Pasak (Right Branch) drains the western part of the central city area to the Hong Xeng. Since the river course used to be reverse (i.e. from the Hong Xeng to the Mekong), the course of the river is meandering with ox-bows near the Mekong river. Houses are built close to (or in some places within) the river area, and the water quality is bad. With realignment of the existing river course, the Nam Pasak area would have additional areas usable for residential use. This river basin thus should be considered as an area for urban re-development.

(5) Nam Pasak (Left Branch)

The Nam Pasak (Left Branch) drains the western part of the Study area to the Hong Xeng. The river basin area is dominantly natural, and is planned to remain so in the future. This area is proposed to be preserved as a rural green area, utilizing the existing good natural environment.

(6) Hong Xeng

The Hong Xeng start at the confluence of the two branches of the Nam Pasak, and drains to the Mahiao river. Water quality is good compared with the other main channels in the Study area. Along the river course are paddy fields watered by the Hong Xeng. Local residents often come for fishing in this river. The proposed development concept for the Hong Xeng is to preserve the river for agricultural and fishing uses.

(7) Wat Tai, Soune Mone and Nong Hay

These are predominantly rural areas with irrigated and rain-fed paddy fields. A large part of these agricultural land is planned to remain in the future, the development concept for these areas are set as rural green area.

(8) Nong Chanh Marsh

Nong Chanh Marsh has an surface area of about 13 ha, with an average of 1 m depth. In some part of the marsh, the cultivation of water vegetables is done by local residents. A rehabilitation program is being implemented by the Government in relation to the Bus Terminal Project. With an easy access from the marsh are the Morning Market, government buildings, temples and public schools. The water space secured in the marsh will have unique value in the central area for amenity and recreational uses. A multi-purpose use, including the regulation of flood flows, is thus recommended.

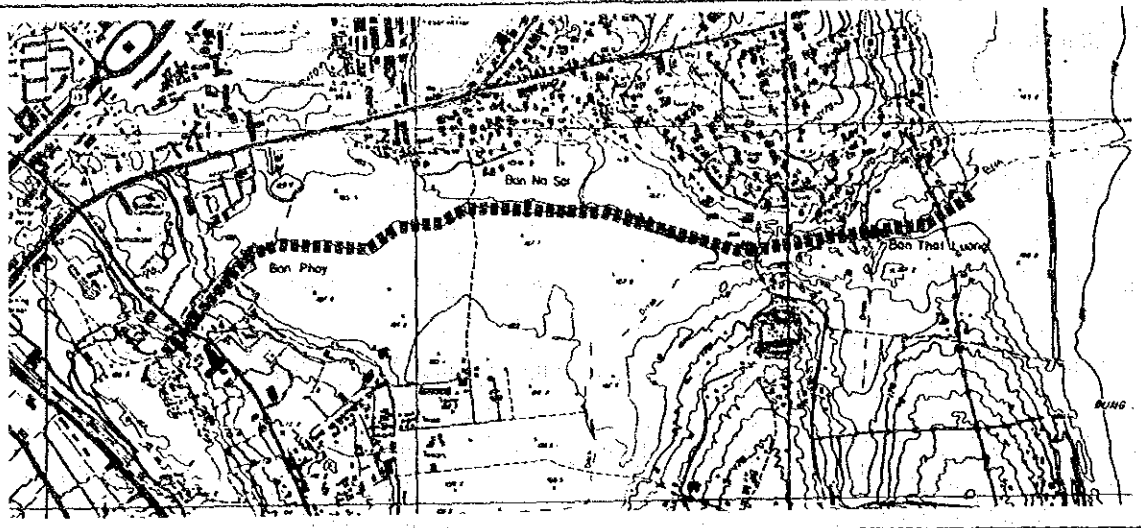
(9) Nong Douang

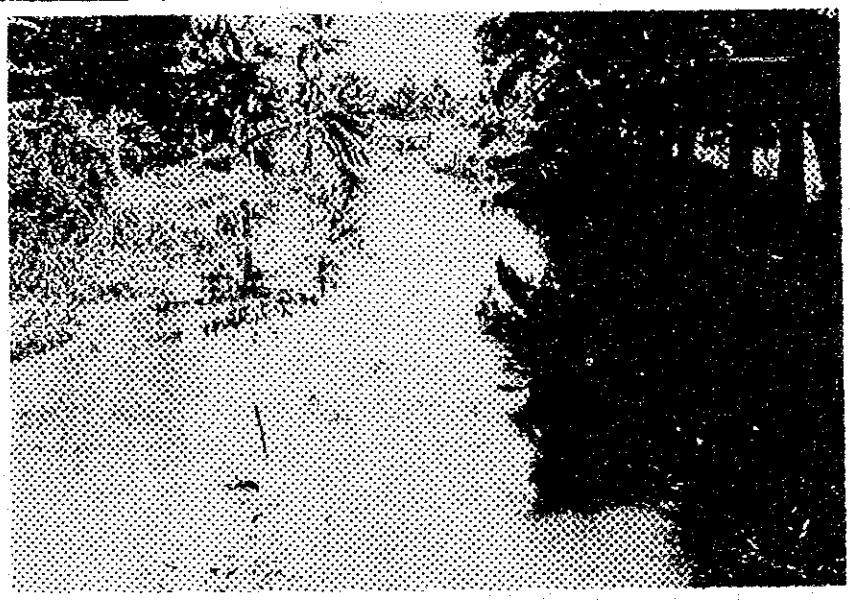
Nong Douang marsh is located west of the central city area. The water surface is about 82 ha at its maximum, with an average of 1 meter depth. The Nong Douang Marsh collects urban sewerage and rain water from relatively small areas around the marsh. The areas around the marsh is undergoing urbanization in recent years. The marsh is proposed for improvement as a multi-purpose retardation storage.

(10) Nong Bon

The Nong Bon is located east of the central city area. The natural water surface is about 5 ha and the depth of the water is about 1 m. The water quality is relatively good, and local residents use Nong Bon for swimming and fishing. With an easy access for local residents and generally urbanized vicinity, creation of amenity water-front area at Nong Bon is proposed as its development concept.

Karte (or chart) of Waterfront environmental survey No. 1 Name of River (Hong Ke)

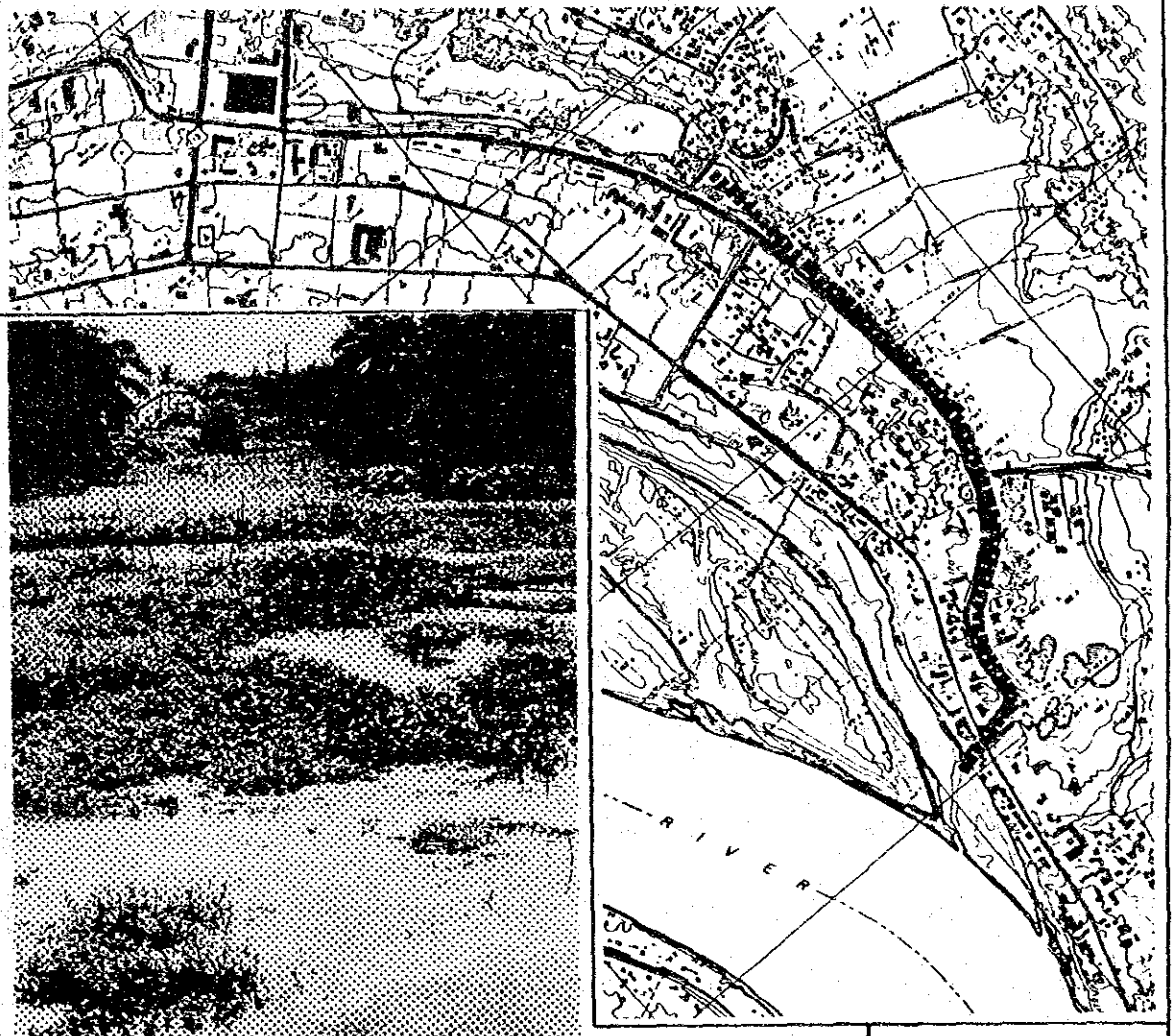




The river is grown in the natural environment and its waterfront is overgrown with water grass and weed.

Present aspect		Problems, etc.
Waterfront Area	River basin area	
·The riverhead is consisting of rain water and city drainage water in the river valley area. ·Although the water quality is deteriorated with the flow of city drainage water, its deterioration is diluted to some extent by the volume of river water. ·The river is generally 10 to 16 meter wide without bank and its waterfront area is overgrown with water grass and weed. ·The river water is used for fishing besides irrigation for agricultural water.	·Housing area and agricultural land. ·The housing area is quiet and better environment. ·There is no public facility to be seen in its vicinity.	·It is desired that the water quality is preserved and improved. ·The improvement of river channel including preparation of bank protection should be expedited inasmuch as it is forecast that the housing program will be developed in the upstream area.

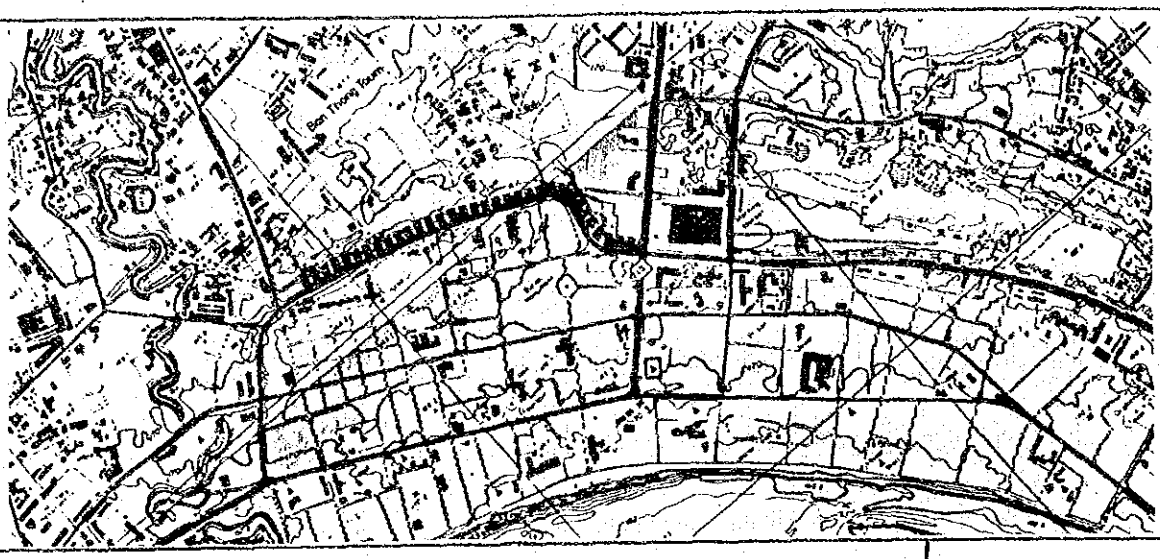
Karte (or Chart) of Waterfront Environmental Survey No.2 Name of River (Khoua Khao)

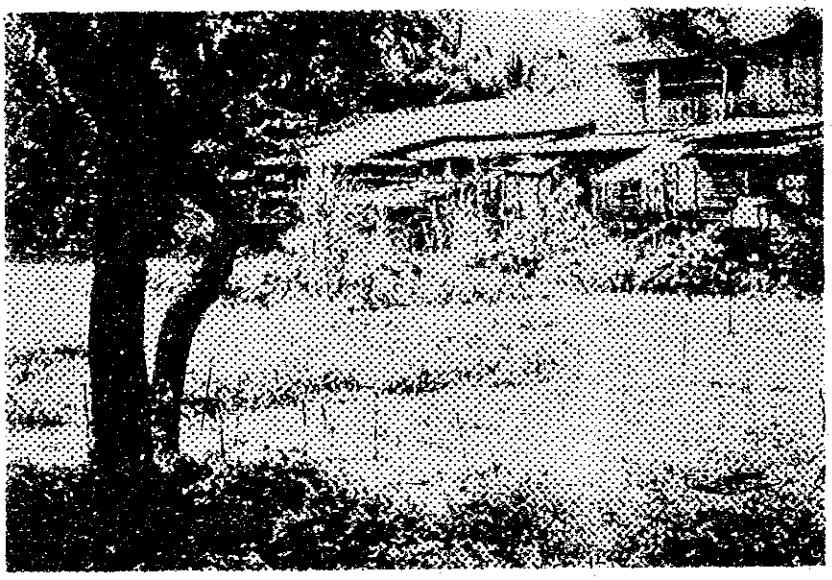


The waterfront is staying still and stickly covered with water grass.

Present Aspect		Problems, etc.
Waterfront Area	River Valley Area	
·The riverhead is consisting of rain water and city drainage water. ·The water quality is deteriorated with the flow of city drainage water ·In general the river is 20 to 30m wide without bank and it is overgrown with weed. ·No special waterfront use plan is to be seen, but fishing is performed around its confluence into the River Mekong.	·It is conspicuous that the houses are built at random or sprawling around the Nong Chanh marsh area. While there are better housing areas located in the left hand bank of the middle and down streams where are overgrown with greens and agricultural land is extended as its hinterland. On the other hand there is the old highway constructed on the right bank and it has beautiful road side trees. ·The houses are one to two story and they are built apart at a reasonable distance and space each other. ·There is no high-class facility to be seen in its vicinity. ·It is easy to access to the waterfront and the development potenciality is higher in the area.	·As the river front area is not yet improved, its environment is worse due to weed, accumulated sludge, deterioration of water, etc. ·Outworn wooden bridges are conspicuously to be seen. ·There are some inferior places for drainage over the right hand bank area

Karte (or chart) of Waterfront environmental survey No. 3 Name of River (Hong Thong)

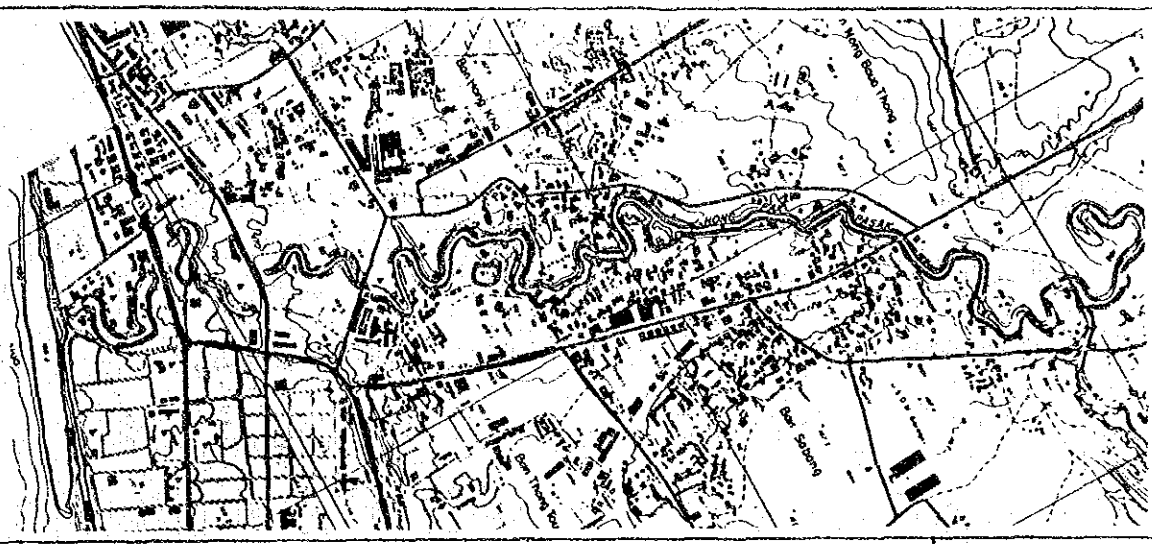


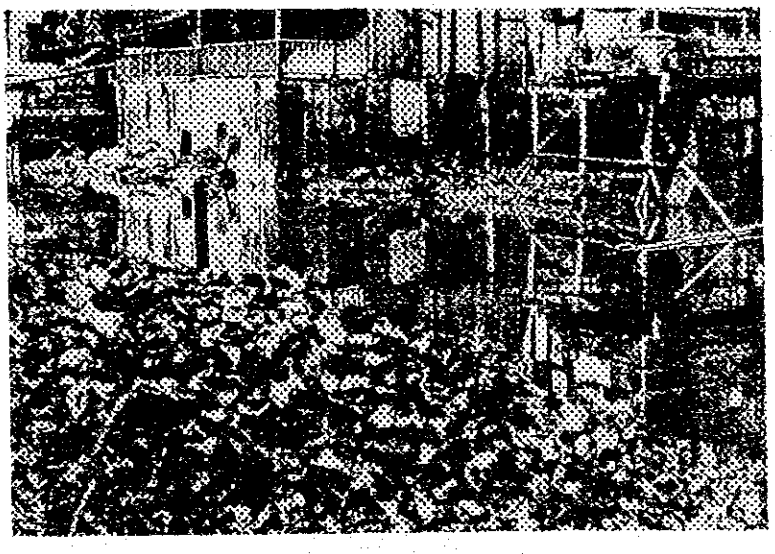


The waterfront is overgrown with water grass and there are housing quarters in some of the river bank areas.

Present aspect		Problems, etc.
Waterfront Area	River valley area	
·The riverhead is consisting of rain water and city drainage water. ·The water quality is deteriorated with the flow of city drainage water and also due to lack of water volume. ·In general the river is 10 to 16 meter wide without bank and its waterfront is overgrown with weed. ·There is cultivated area of acquatic vegetables to be seen in some waterfront area.	·The river is encompassing the outskirt of the center of the city and a trunk road is running in parallel with the right bank of the river; its left hand bank is housing area. ·There are markets, sports-recreation facilities, etc. in its vicinity. ·It is easier to access to the waterfront area. ·The development potenciality is higher in the left hand bank area.	·The waterfront area is deteriorated with weed, accumulated sludge, lack of water volume, etc. ·The water quality is being deteriorated. ·There are some inferior places for drainage beyond the road of the right hand bank.

Karte (or Chart) of Waterfront Environmental Survey No.4 (Name of River (Nam Pasak)



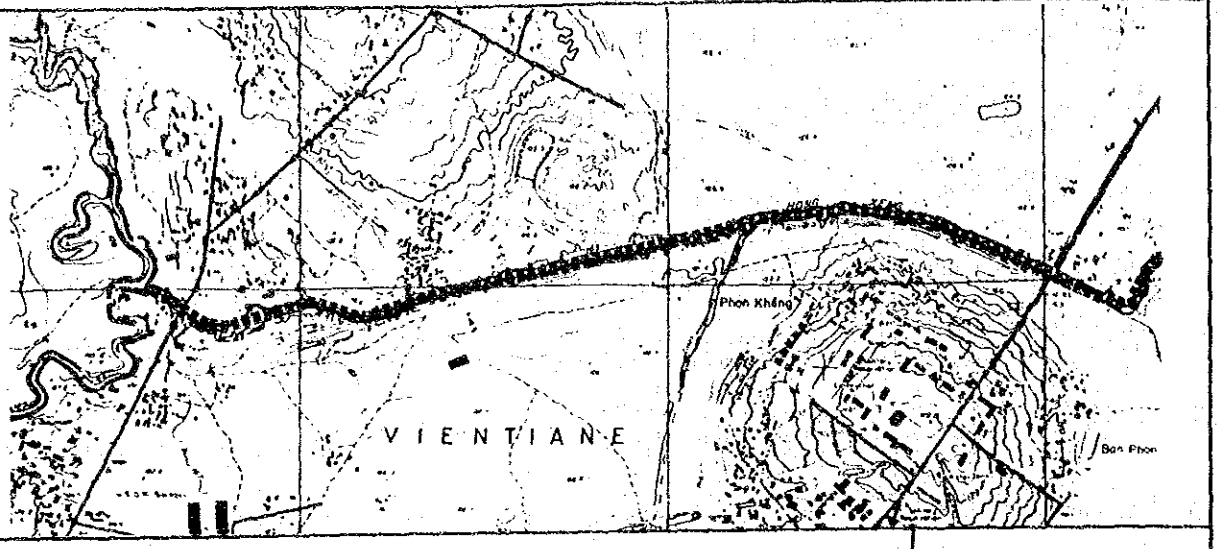


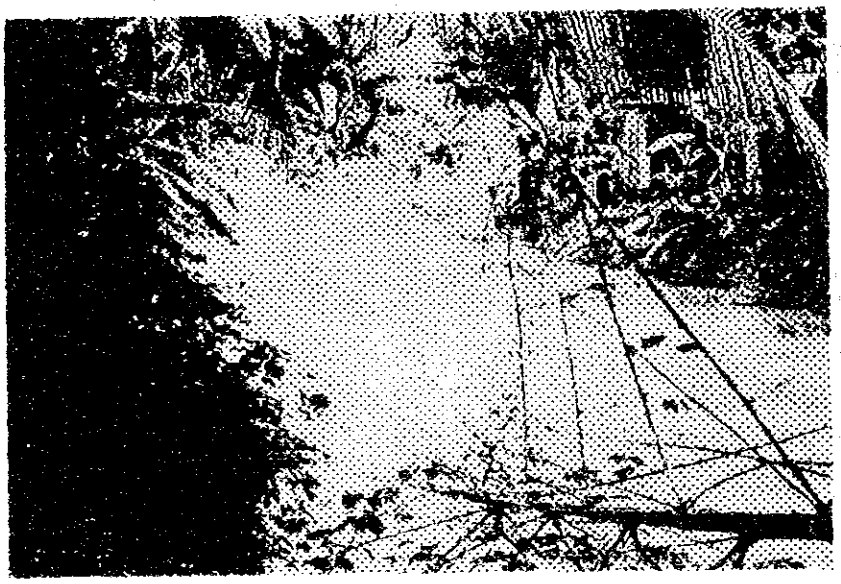
(Old down stream area)

- The houses are built closely with their backward sides confronting to the river in the old down stream area.
- The children are playing busily in the waterfront of the up-stream area.

Present Aspect		Problems, etc.
Waterfront Area	River Valley Area	
·The waterhead is consisting of rain water and city drainage water. The agricultural use water is taken from the River Mekong in the dry season. ·The water quality of the river is deteriorated with the much flow of the city drainage water inasmuch as it is passing through the center of the city. ·In general, the river is 15 to 30m wide without bank; the houses are standing very closely to the river bank; the stream is winding its way leaving residue ponds in some places. ·The cultivation of acquatic vegetable is performed in the some parts of the residue ponds.	·The waterfront area is forming a comparatively dense residential area. ·The houses are one to two story wooden-makes standing with their backward to the river. ·There are many temples in its vicinity. ·There are many inferior places for drainage. ·It is easier to access to the waterfront area.	·The waterfront area is presenting a deteriorated water environment due to the flow of the city drainage water. ·As some of the houses are built stretching to the waterfront area they will become the obstructing factor when the river improvement works are performed.

Karte (or Chart) of Waterfront Environmental Survey No.5 Name of River (Hong Xeng)

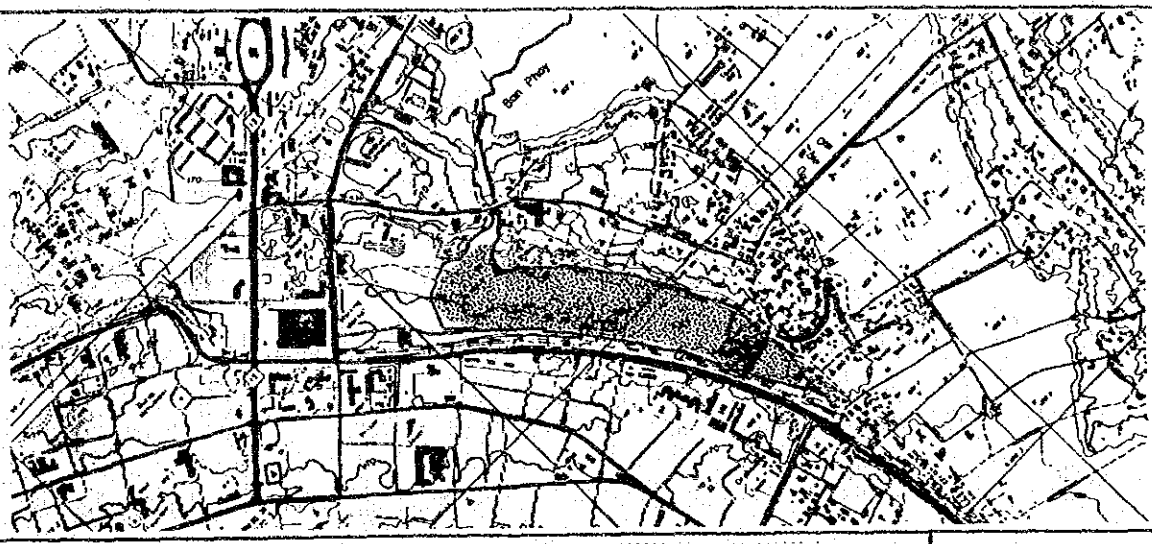




·The river is running down through the wood of miscellaneous trees.

Present Aspect		Problems, etc.
Waterfront Area	River Valley Area	
·The waterhead is mainly consisting of the surface flow of water from the upstream of Nam Pasak and rain water in the river valley areas. ·The water quality is comparatively better even though the drainage water from Nam Psak is flowing into the river in some places. ·In general the river is 15 to 20m wide without bank and the waterfront is overgrown with weed. ·The cultivation of acquatic vegetable and fishing are performed in some of the waterfront areas.	·There is the pastoral area where the paddy is mainly grown.	·Securing of agricultural use water and maintenance of water quality. ·Securing of the cultivated area of acquatic vegetable and preparation of river channel improvement. ·Securing of the habitat of fish and fishing areas.

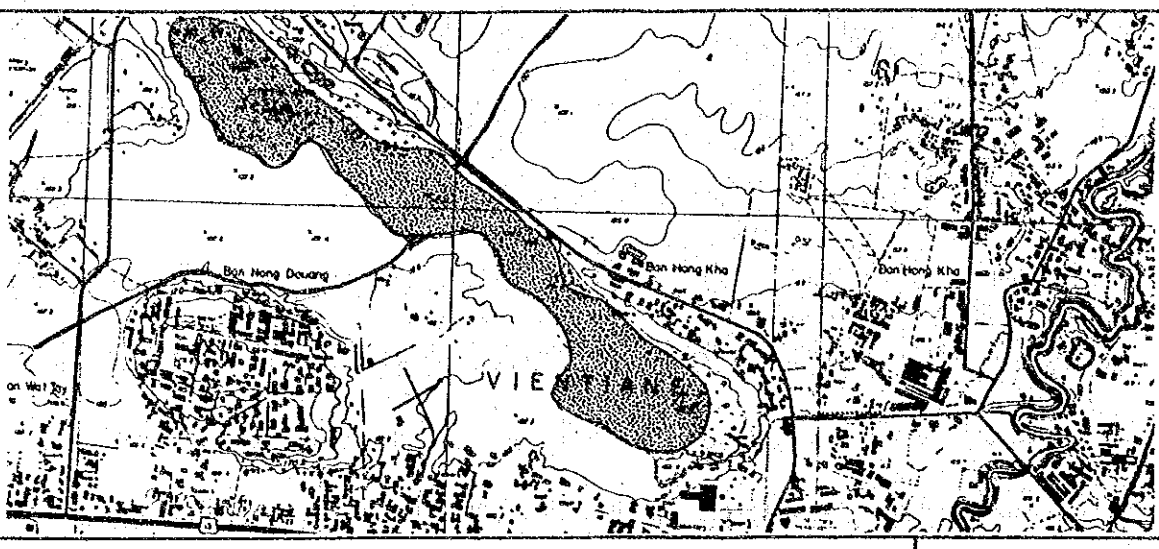
Karte (or Chart) of Waterfront Environmental Survey No.6 Name of River (Nong Chanh)

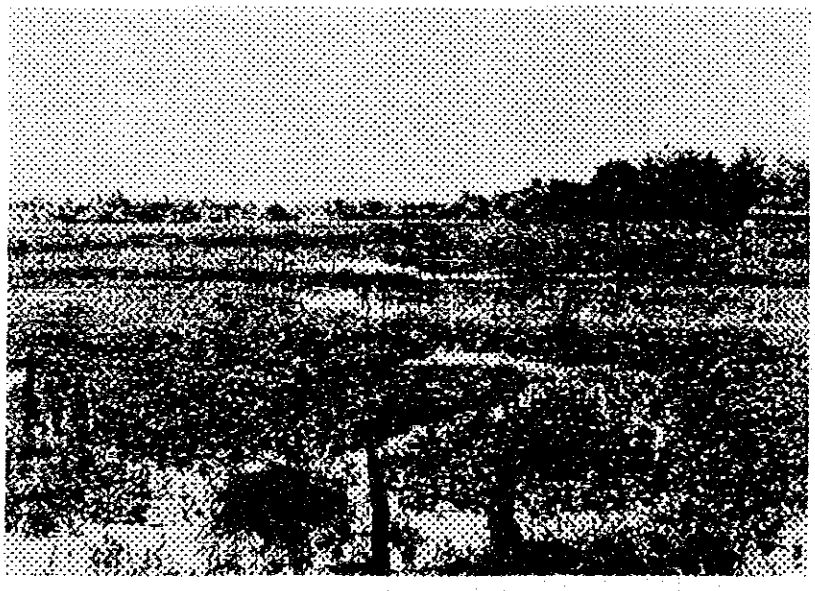


·The waterfront area becomes one of the important open spaces in the city and the cultivation of acquatic vegetable is going on in some places.

Present Aspect		Problems, etc.
Waterfront Area	River Valley Area	
·The waterhead is consisting of the running water from the River Khoua Khao and the River Hong Thong. ·The water quality is deteriorated inasmuch as a considerable volume of city drainage water is flowing into the rivers. ·The space of the marsh is about 13ha and its water depth is about one meter as average. ·The waterfront area is overgrown with water grass and weed, but the cultivation of acquatic vegetable is actively going on in some parts of the marsh. ·The waterfront area is providing a sizable open space in the center of the city.	·The waterfront area is composed of the living quarter with the wooden houses built at random and the green belt district. ·There are governmental and public buildings, markets, temples, schools, etc. in its vicinity. ·Some rehabilitation development plans are being promoted relevant to bus terminal markets, etc. ·It is easier to access to the waterfront area where is confronting deep water. ·There are some inferior places for drainage.	·The waterfront area is deteriorated with the flow of city drainage water. ·There are squatters' houses built in the river valley area. ·The use of the waterfront area is not yet developed as the important open space in the city. ·The housing program is developed. ·The area lacks landscape.

Karte (or Chart) of Waterfront Environmental Survey No.7 Name of River (Nong Douang)





·In the surrounding area the housing program is developed and so it is worried about that the water quality is badly affected with the flow of city drainage water.

Present Aspect		Problems, etc.
Waterfront Area	River Valley Area	
·The river-head is consisting of rain water and city drainage water in the river valley area. ·The water quality is comparatively better than that of Nam Pasak. ·The space of the marsh is about 82ha and its water depth is about one meter as average. ·The waterfront area is overgrown with water grass and weed presenting the aspect of a typical natural marsh. ·The caltivation of acquatic vegetable is performed in some places.	·The outskirt of the city is the paddy growing area. ·Wattai airport is located in its vicinity.	·Preservation of water quality.