

ANNEX 3.2.1

HYDROLOGY

**THE STUDY ON WATER SUPPLY SYSTEM
FOR SIEM REAP REGION IN CAMBODIA**

**FINAL REPORT
Vol. III SUPPORTING REPORT**

ANNEX 3.2.1 HYDROLOGY

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ANNEX 3.2.1 HYDROLOGY

1. Introduction

The hydrological availability of the following three surface water sources for the water supply in the Study Area, Siem Reap Region were investigated:

- 1) Siem Reap River;
- 2) West Baray; and
- 3) Lake Tonle Sap.

2. Hydrological Condition of Siem Reap River

2.1 General Meteorology

The tropical climate, occurring over Cambodia is governed by two seasonal monsoons: the southwest monsoon (the rainy season) and the northeast monsoon (the dry season). Isohyetal map of annual rainfall in Cambodia is shown in Figure 2.1.1.

General meteorological condition in Siem Reap is shown in Table 2.1.1 and Figure 2.1.2. Annual rainfall varies between 1,100 mm-1,800 mm, with an average of 1,418 mm (average in 20 years from 1979 to 1998). About 88% of annual rainfall (1,248 mm) falls during the rainy season from May to October. The peak rainfall occurs in September with 265 mm. On the contrary, only 12% of annual rainfall (170 mm) are produced during the dry season from November to April. January and February are the driest months with 6.2 and 4.1 mm rainfall, respectively.

The climate in the Study Area is modified by the local topography, dominated by the Lake Tonle Sap and the Kulen Mountains. Breezes reinforced over the lake are forced upwards due to the presence of Kulen Mountains and, on cooling, induce showers in the rainy season.

The mean daily temperature varies only slightly between a high of 29.9 °C in April to a low of 24.5 °C in December. Average relative humidity ranges from 70% in March to 86% in September. The annual pan evaporation is 1,542 mm.

Table 2.1.1 Meteorological Condition in Siem Reap

Length of Record	8 years	8 years	20 years	20 years	20 years	20 years
Period of Record	1989 - 1996	1989 - 1996	-	-	-	1979 - 1998
Month	Temperature	Relative Humidity	Sunshine Hours	Wind	Evaporation	Rainfall
	()	(%)	(hrs/day)	(km/day)	(mm/m)	(mm)
Jan	24.6	73.3	9.4	104	120.9	6.2
Feb	26.1	70.5	9.1	78	120.4	4.1
Mar	28.6	69.8	9.0	86	155.0	34.7
Apr	29.9	71.1	8.6	78	153.0	53.5
May	29.1	77.3	7.7	86	148.8	151.0
Jun	28.4	80.4	7.0	60	129.0	205.8
Jul	27.7	82.9	6.4	86	130.2	166.7
Aug	27.6	83.8	6.0	78	124.0	218.4
Sep	27.3	85.9	6.0	78	117.0	265.4
Oct	26.6	85.0	7.3	60	117.8	208.5
Nov	25.8	80.9	8.5	86	111.0	57.8
Dec	24.5	74.9	9.2	104	114.7	13.2
Total	-	-	-	-	1541.8	1385.2
Ave.	27.2	78.0	7.9	82	128.5	115.4
Min.	24.5	69.8	6.0	60	111.0	4.1
Max.	29.9	85.9	9.4	104	155.0	265.4

Station Name: Siem Reap Airport

Location: 13°22 N, 103°51 E Altitude: 21 m

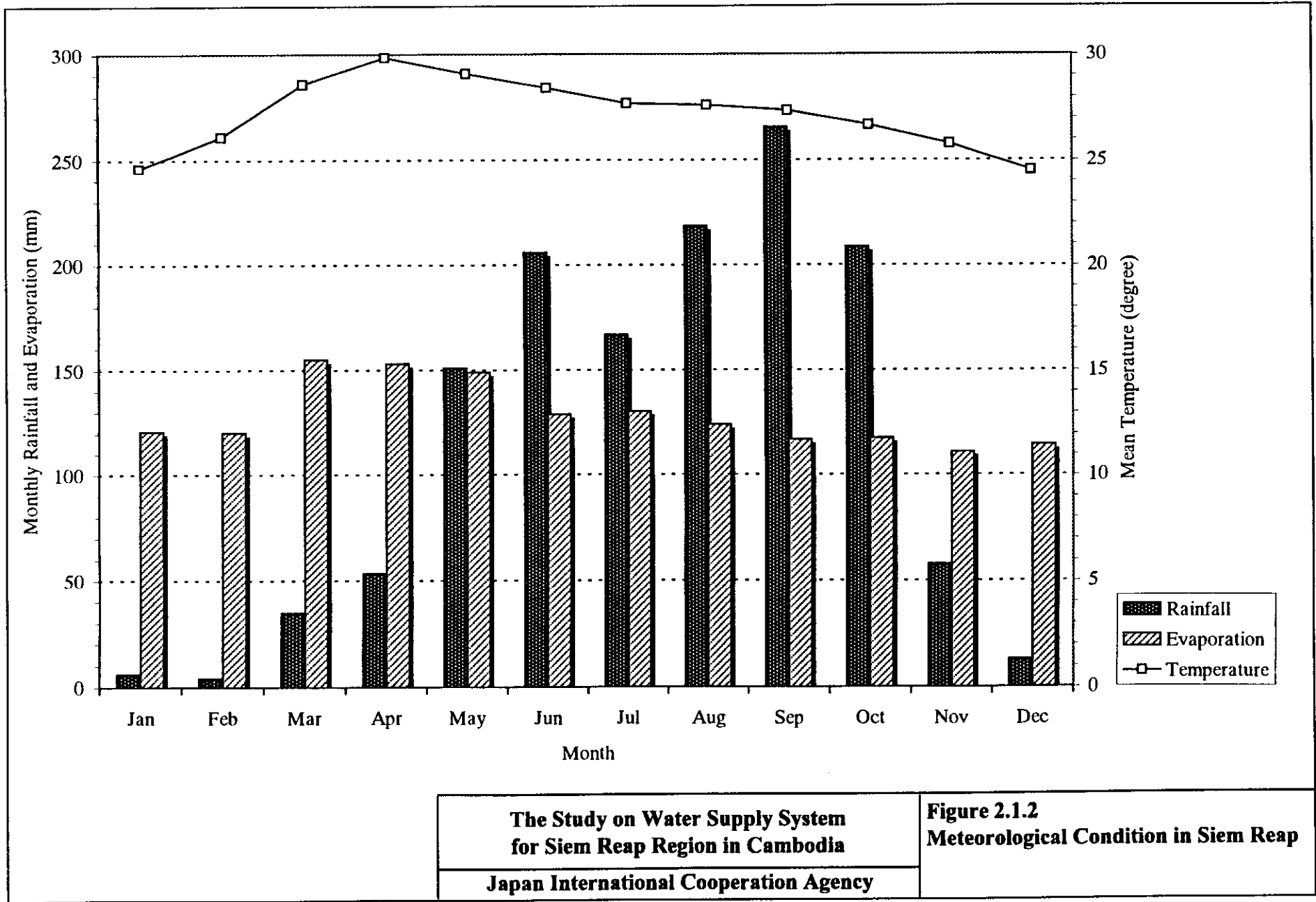
Source:

1) Temperature, Humidity, Rainfall

Hydrology Office in Siem Reap, MOA (Meteorological Observation Data at Airport)

2) Sunshine, Wind, Evaporation

Mekong Secretariat (June 1994) "Irrigation Rehabilitation Study in Cambodia - Final Report"



2.2 River Morphology

(1) River System

The Siem Reap River is the only permanent stream in Siem Reap region. The watershed of the river is a part of the Lake Tonle Sap basin with 67,600 km² as shown in Figure 2.2.1. The watershed of the river approximately amounts to 670 km² rising in the Kulen Mountains at EL. 420 m, flows through alluvial fans to the Siem Reap Town and finally pours into the Lake Tonle Sap near Phnom Krom. The watershed of the Siem Reap river and its surrounding is shown in Figure 2.2.2. The total length of the river is about 80 km with an average slope of 1/2,000 in lower reaches of the Angkor Heritage Area. The watershed consists mainly of forests and agricultural areas, which could have been a former lake bottom.

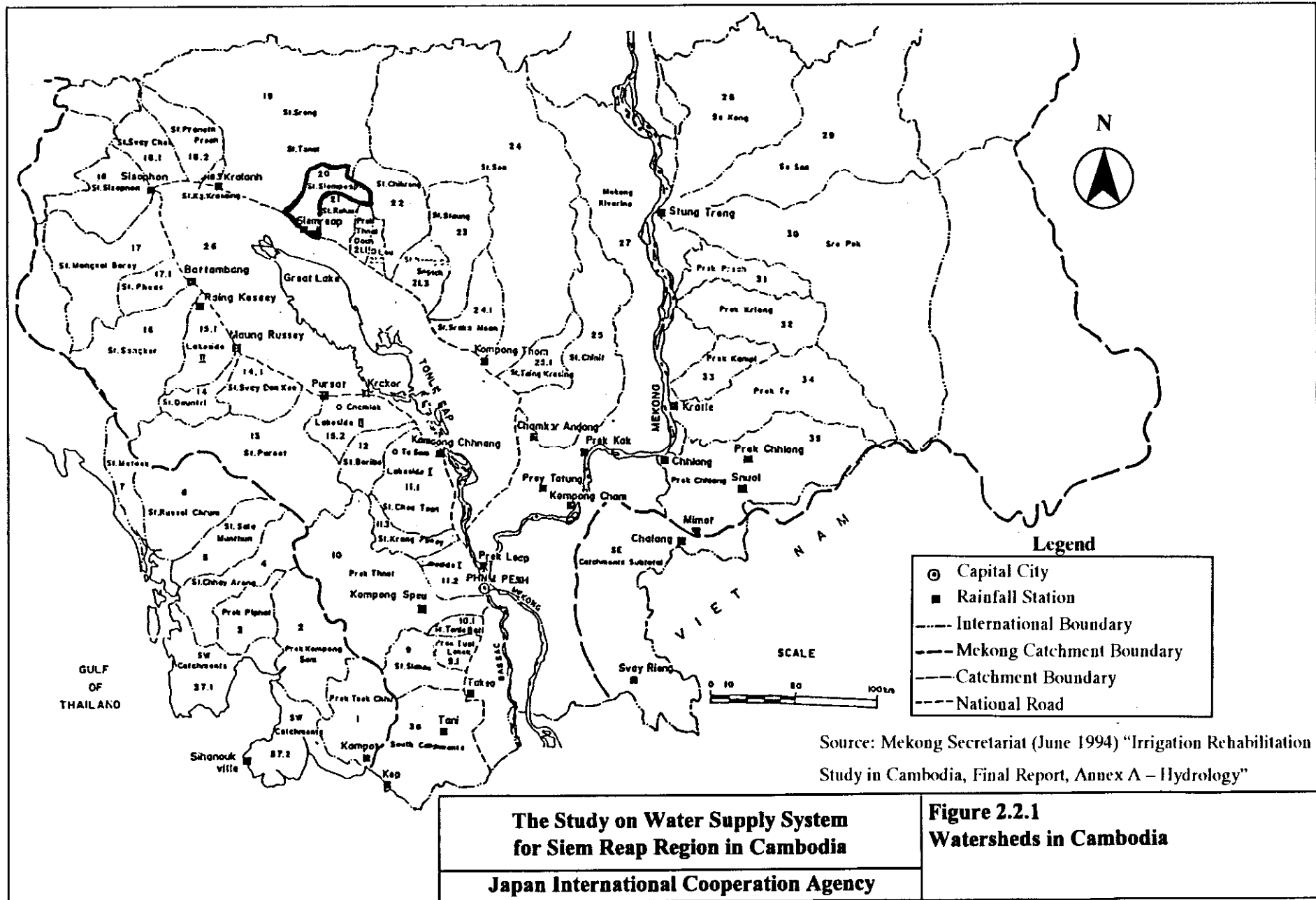
The river collects the runoff from the mountains and flows to the northwest until it reaches a gorge from where it changes direction to the southwest. It discharges through this gorge to the plains at El 50 m. The river continues to flow in a southwest direction towards the ancient diversion structure constructed in the 10th century.

The present river course diverted at the ancient diversion structure then arrives at the heritage area. The lower reaches adjacent to Phnom Bok, located about 8 km upstream of the French Weir does not follow its original course at present. During the construction of Angkor Wat and its associated communities, the river was diverted into its current course to provide water supply for both domestic and irrigation uses.

The French Weir constructed in 1937 is located crossing the mainstream in the northeastern part of the heritage area. An artificial canal (Canal A) constructed in 1939 diverts flow from just upstream of the weir and stores the flow in the West Baray (refer to Figure 2.2.3). The river then flows through Siem Reap Town southward and it eventually discharges into the Lake Tonle Sap at downstream of Phnom Krom.

(2) Watershed between Siem Reap and Roluos Rivers

The road to Banteay Srei running north and south in Pradak district consists of the watershed boundary between the Siem Reap and Roluos Rivers. The Roluos River has been completely dammed by the dyke (Ta Neav Dam) crossing east and west at the foot of Phnom Bok and a reservoir has been formed along the north of the dyke since 1965. The dyke was once destroyed in 1997 by the overflow of flood and rehabilitated in June 1998 by the aid of the European Community.

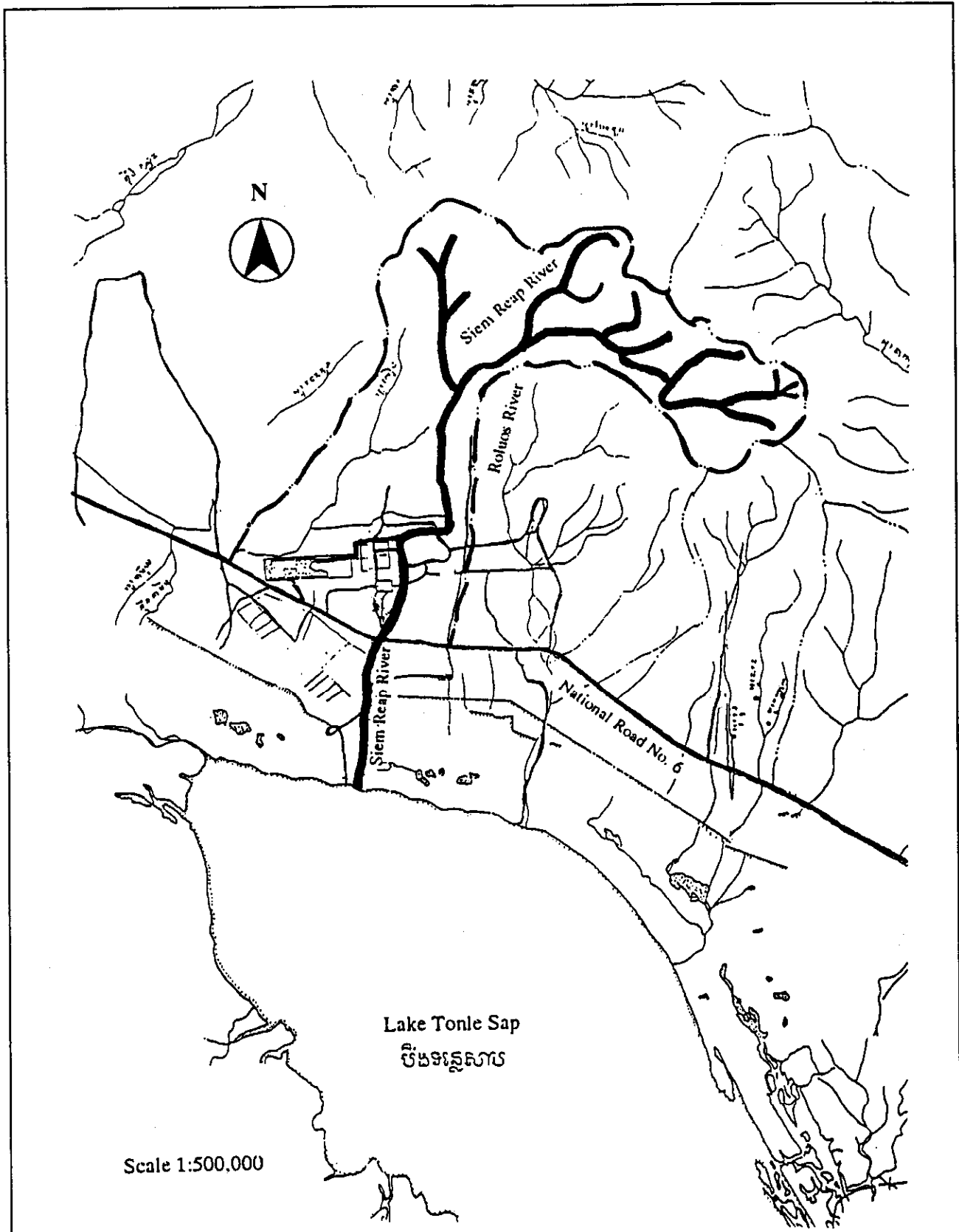


Source: Mekong Secretariat (June 1994) "Irrigation Rehabilitation Study in Cambodia, Final Report, Annex A – Hydrology"

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**Figure 2.2.1
Watersheds in Cambodia**

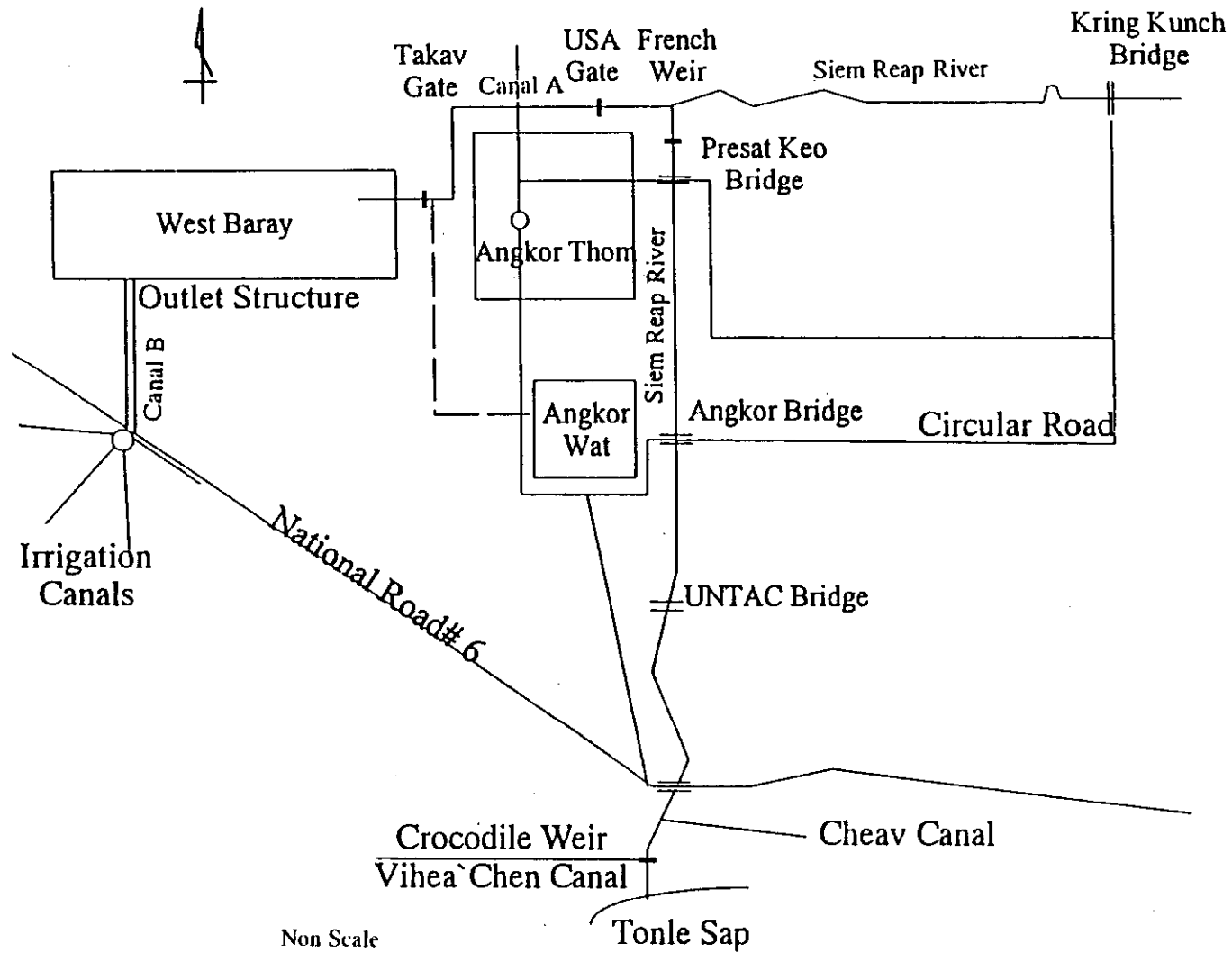


Source: Hydrology Office in Siem Reap, Ministry of Agriculture and Fishery

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**Figure 2.2.2
Watershed of Siem Reap River**

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Non Scale

<p>The Study on Water Supply System for Siem Reap Region in Cambodia</p>	<p>Figure 2.2.3 River System in Study Area</p>
<p>Japan International Cooperation Agency</p>	

Field reconnaissance confirmed that there is no surface water flow from the reservoir to the Siem Reap River. According to the interview survey to the chief of Pradak district, the reservoir water is utilized only for the irrigation water supply for the five communities in the district located in the eastern part of former East Baray. The remainder of supplied water almost returns to the Roluos River at lower reaches.

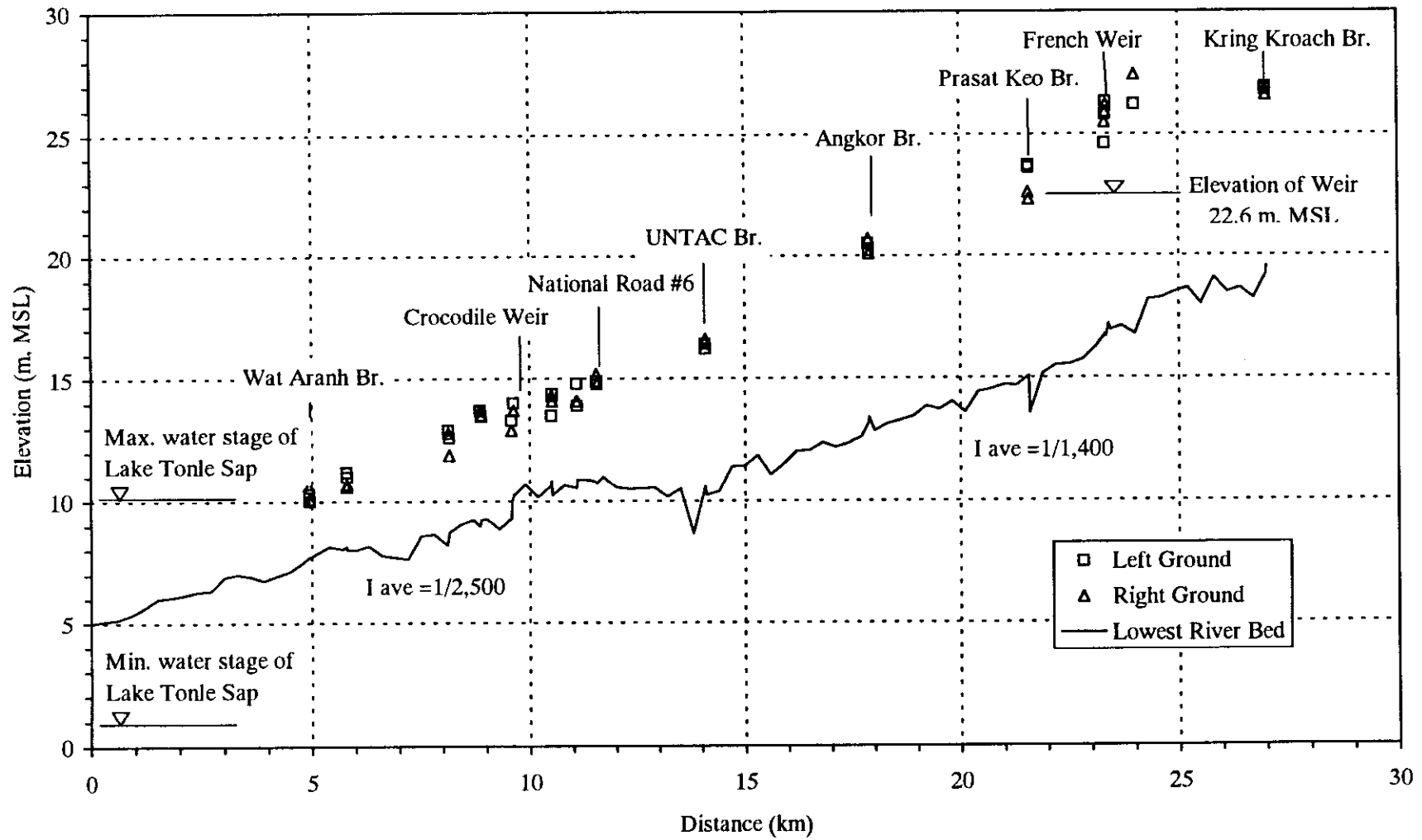
There is a drainage canal from the reservoir to the Siem Reap River, however, the canal is buried in many places according to the recent aerial photographs (FINNMAP 1:25,000, February 1993). So, the channel does not function completely. Places buried are probably the local transport between farmlands constructed by farmer without permission. However, it is impossible to confirm the actual condition by field reconnaissance, since almost all of the area along the canal is a military area.

(3) Longitudinal Profiles

The longitudinal profile of the Siem Reap River is shown in Figure 2.2.4. The river bed slope is gentler than that of the ground; the valley becomes gradually deeper as going upstream. The average river bed slopes and river width are as follows:

Stretches	Slope	River Width (m)
Kring Kroach Bridge - UNTAC Bridge	1/1,400	15
UNTAC Bridge - Estuary	1/2,500	20-40

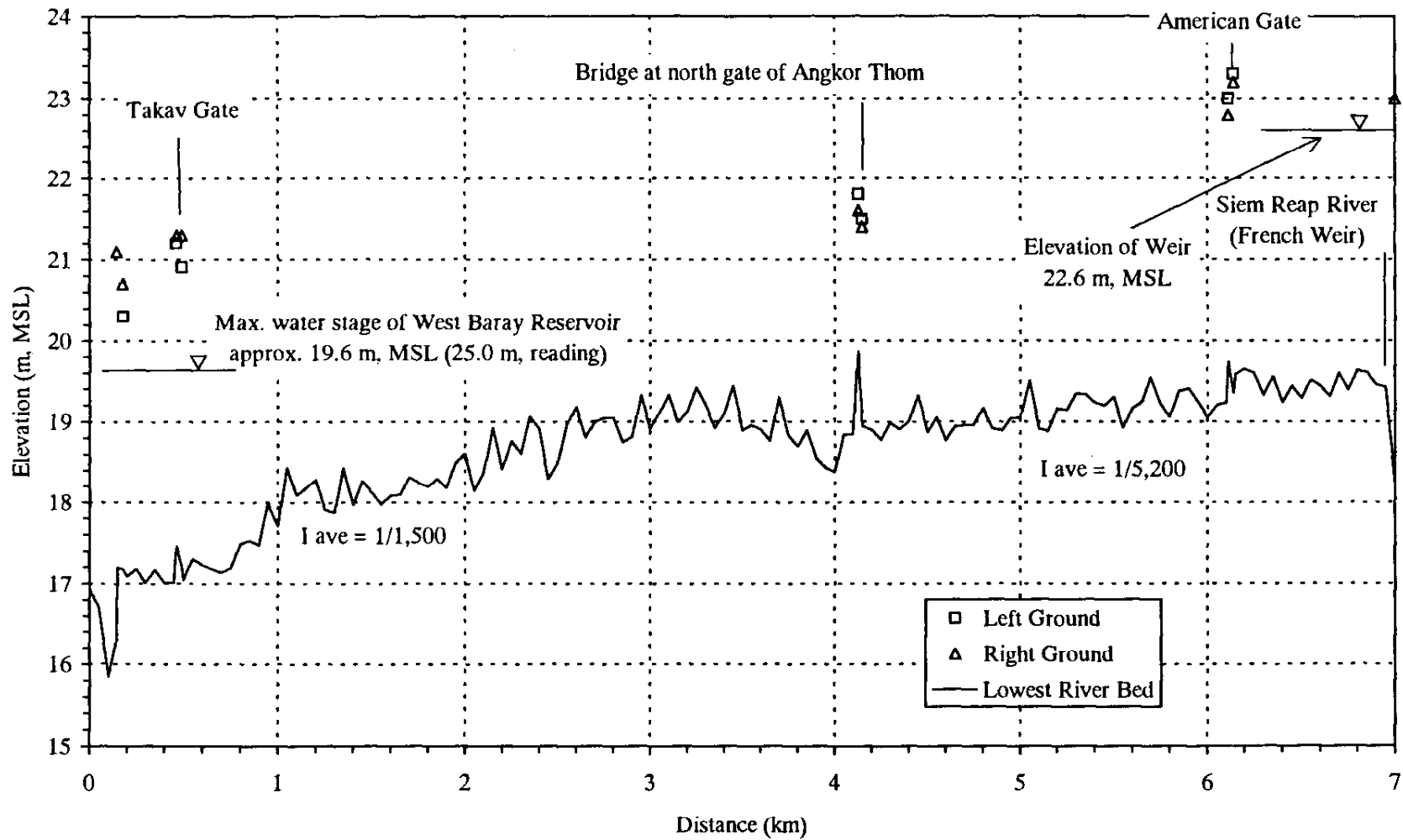
The profile of the Canal A (French Weir - West Baray) is also shown in Figure 2.2.5. The average width is 10 m. The slope is steeper in the lower reaches than that in the upper reaches: the channel is artificial.



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**Figure 2.2.4
Longitudinal Profile of Siem Reap River**



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**Figure 2.2.5
Longitudinal Profile of Canal A
<French Weir – West Baray Reservoir>**

2.3 Hydrometry

(1) Installation of Stream Gauges

At the beginning of the Study, no hydrological data on the Siem Reap River was available, neither in the Hydrology Office in Siem Reap nor the Ministry of Agriculture, Forest and Fisheries (MOA) in Phnom Penh. Thus, as already suggested by several previous related studies, the establishment of a hydrological observation network in the Study Area is urgently required. Therefore, the Study Team has installed several stream gauges along the Siem Reap River and has conducted intensive hydrometry not only along the river but also on irrigation canals since 1997. The water level of the West Baray has also been measured frequently by the Study Team to supplement the data by the Hydrology Office in Siem Reap, MOA (Hydrology Office).

The inventory of the hydrometry is shown in Table 2.3.1 and the location is shown in Figure 2.3.1.

The French Weir is the principal hydraulic control structure on the Siem Reap River. It is located just 60 m downstream of the bifurcation of Canal A (French Weir - West Baray). The main purpose of the weir is to control the flow into this canal. Several staff gauges were installed in February 1997; a staff gauge attached on the concrete abutment on the left bank is still in use.

At Prasat Keo, a staff gauge was first installed in March 1997 on the downstream frame of the water wheel located at the flow measurement section and a supplementary gauge was installed in January 1999. A float-type automatic water level gauging station was constructed in February 1998 near the staff gauge. The automatic gauge is equipped with a data logger and a solar cell, and records river level at hourly intervals. The relationship of the level reading between staff gauge and the automatic gauge is as follows:

$$H (\text{staff gauge}) + 0.26 \text{ m} = H (\text{automatic gauge})$$

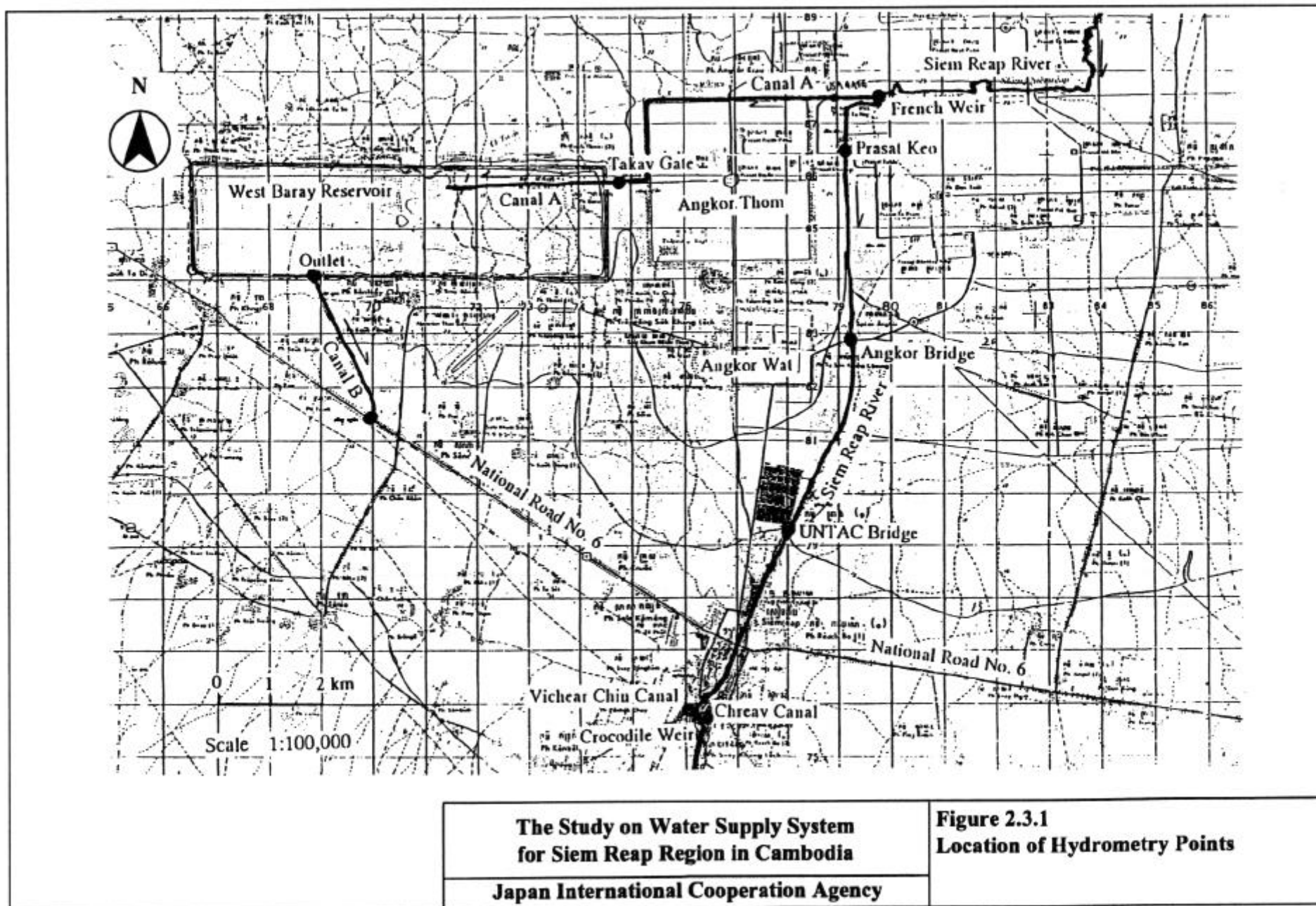
At the Angkor Bridge, a staff gauge was installed on the right bank of the downstream of the bridge in February 1997 and a supplementary gauge was installed in January 1999.

(2) Hydrometry

Several staff gauges had already been installed at the UNTAC Bridge by MOA at the beginning of the Study in December 1996, no reading had been conducted, though. The Study Team commenced gauge reading (twice a day at 7:00 and 19:00) in December 1996 obtaining the cooperation of a local observer.

Table 2.3.1 Inventory of Hydrometry by JICA Study Team

Location		No.	Water Stage				Flow Measurement		
			Staff Gauge	Period	Automatic Gauge	Period		Period	
Siem Reap River	French Weir	1	Yes	Feb. '97-	-	-	Yes	Feb. '97-	
	Prasat Keo	2	Yes	Mar. '97-	Yes	Feb. '98-	Yes	Mar. '97-	
	Angkor Bridge	3	Yes	Feb. '97-	-	-	Yes	Feb. '97-	
	UNTAC Bridge	4	Yes	Dec. '96-	-	-	-	-	
West Baray Reservoir	Outlet	5	Yes	Jan. '97-	-	-	-	-	
Irrigation Canals	West Baray Reservoir System	Canal A at Takav Gate	6	-	-	-	-	Yes	Jun. '97-
		Canal B (total of Canal-C2, C3 and C8)	7	-	-	-	-	Yes	Jan. '97-
	Crocodile Weir System	Vichear Chin Canal	8	-	-	-	-	Yes	Feb. '97-
		Chreav Canal	9	-	-	-	-	Yes	Feb. '97-



The summary of hydrometry on the Siem Reap River is shown in Table 2.3.2. The observed daily mean water level (average of 7:00 and 19:00) at the UNTAC Bridge is shown in Table 2.3.3.

It is also essential to investigate the actual conditions of the vested water use for irrigation to estimate the possible water yield from each surface water source. However, there is no regulations on water use and no record is available on the intake amount at present. Therefore, the Study Team has measured the flows of the principal irrigation canals of the West Baray and the Crocodile Weir irrigation systems periodically. The summary of the flow measurements on irrigation canals is shown in Table 2.3.4.

(3) Preparation of Rating Curves

The rating curves are prepared at Prasat Keo and the Angkor Bridge as shown in Figure 2.3.2 by using the hydrometry records of 1997 and 1998. We judge that the rating curves for both locations are reliable for a full range from low flow to high flow. The rating curves also indicate the appropriateness of the flow measurement sections and the high reliability of the measurements itself.

It is to be desired that the rating curves be further improved by supplementary measurements in future especially in mid flow range for both locations and very low flow range at Prasat Keo.

2.4 Estimate of Daily Flow of Siem Reap River in 1998

(1) Characteristics of Observed Water Level and Flow

The water levels and flows measured by the Study Team are plotted in Figure 2.4.1 and Figure 2.4.2 from January 1997 to January 1999, respectively. The flow patterns in 1997 and 1998 contrast sharply as can be seen from the water level hydrograph at the UNTAC Bridge.

The former shows, if anything, rainy year pattern with remarkably big floods from September to October, which caused severe inundation in Siem Reap Town. On the other hand, the latter shows typical drought year pattern without any particular water level rises. The annual rainfall in 1997 and 1998 is 1,524 mm and 1,326 mm, respectively, in Siem Reap (refer to Table 5.1.1); no large difference can be seen.

The peak discharge at the UNTAC Bridge in September 30, 1997 is roughly estimated around 150 m³/s according to the uniform flow calculation based on the observed peak water level and the river survey conducted by the Study Team.

Table 2.3.2 Summary of Hydrometry on Siem Reap River (1/3)

No.	Year	Month	Day	French Weir (SG#1)			Prasat Keo Bridge			Angkor Bridge		
				Time	Stage (m)	Flow (m ³ /s)	Time	Stage (m)	Flow (m ³ /s)	Time	Stage (m)	Flow (m ³ /s)
1	1997	2	5	9:55	0.82	1.34						
2	1997	2	6	14:35	0.61	1.54						
3	1997	2	11	15:45	0.60	1.61						
4	1997	2	13	14:50	0.87	1.49						
5	1997	2	13	16:03	0.87	1.50						
6	1997	2	17	15:47	0.89	1.63				14:42		1.81
7	1997	2	18	16:23	1.05	1.82				15:00		1.79
8	1997	2	22	11:10	0.80	1.55				9:15		1.58
9	1997	2	25	8:43	0.71	1.48				11:23		1.60
10	1997	2	25	9:43	0.70	1.44						
11	1997	2	26	9:30	0.70	1.43				15:00		1.51
12	1997	2	28	8:55	0.65	1.28						
13	1997	3	3	9:25	0.62	1.23	10:40		1.39	11:35		1.47
14	1997	3	5	10:40	0.58	1.14	15:40		1.31	15:00		1.41
15	1997	3	11	10:47	0.77	1.11	9:23		1.12	8:10		1.18
16	1997	3	11				10:08		1.17			
17	1997	3	13	10:55	0.75	1.03	10:05		1.09	9:20		1.14
18	1997	3	14	15:35	0.73	1.02				14:40		0.97
19	1997	3	17	11:15	0.62	0.97	10:15		0.96	9:05	0.24	1.03
20	1997	3	17	16:14	0.67	0.96						
21	1997	3	18	15:50	0.62	0.95						
22	1997	3	20	11:08	0.59	0.95				7:45	0.22	1.08
23	1997	3	22							11:47	0.21	1.02
24	1997	3	24	9:50	0.55	0.91				16:20	0.20	0.90
25	1997	3	25	8:20	0.51	0.69				16:10	0.20	0.86
26	1997	3	26	14:50	0.50	0.87				11:32	0.19	0.78
27	1997	3	27	13:45	0.50	0.84						
28	1997	3	28	15:30	0.50	0.87				14:30	0.16	0.91
29	1997	3	29	13:45	0.50	0.79				14:50	0.18	0.86
30	1997	3	31	14:35	0.51	0.82				15:55	0.19	0.89
31	1997	4	2	8:20	0.49	0.80	9:40		0.80	10:40	0.17	0.81
32	1997	4	5	9:30	1.08	0.83				14:25	0.18	0.93
33	1997	4	7	9:05	1.08	0.83				8:00	0.18	0.86
34	1997	4	8	15:45	1.10	0.84				14:40	0.17	0.88
35	1997	4	10				17:45		0.88			
36	1997	4	11	15:20	1.09	0.83				14:30	0.17	0.89
37	1997	4	17									
38	1997	4	18	9:00	1.04	0.79				8:00	0.15	0.88
39	1997	4	21	8:40	1.01	0.72				9:40	0.14	0.78
40	1997	4	23	15:30	1.30	1.07				9:40	0.25	1.22
41	1997	4	25	8:10	1.11	0.87				9:25	0.18	0.98
42	1997	4	28	8:45	1.11	0.88				10:35	0.18	0.96
43	1997	4	30	14:50	1.01	0.80				10:10	0.16	0.88
44	1997	5	2	15:00	1.14	0.76				16:10	0.17	0.93
45	1997	5	5	8:40	1.18	1.15						
46	1997	5	7	15:35	1.20	1.03	10:00		1.03	14:35	0.20	1.10
47	1997	5	9	8:15	1.12	0.92				9:20	0.18	0.85
48	1997	5	12	8:15	1.45	1.32				9:45	0.25	1.25
49	1997	5	14	15:05	1.50	1.18				16:35	0.23	1.08
50	1997	5	15							14:35	0.22	1.15
51	1997	5	16	7:30	1.15	1.15						
52	1997	5	19							10:15	0.38	1.88
53	1997	5	23	9:00	1.10	1.09				8:10	0.22	1.17
54	1997	5	26							15:50	0.40	1.77
55	1997	5	27				8:45		1.65	7:55	0.38	1.77
56	1997	6	21				11:00		1.48			
57	1997	7	11	15:50	1.88		15:35	0.25		15:10	0.60	
58	1997	7	15	8:40	4.68		9:05	0.64				
59	1997	7	16	15:00	4.48		15:15	0.64				
60	1997	7	18	9:10	4.32							

Table 2.3.2 Summary of Hydrometry on Siem Reap River (2/3)

No.	Year	Month	Day	French Weir (SG#1)			Prasat Keo Bridge			Angkor Bridge		
				Time	Stage (m)	Flow (m ³ /s)	Time	Stage (m)	Flow (m ³ /s)	Time	Stage (m)	Flow (m ³ /s)
61	1997	7	21	10:10	4.48		9:10	0.63				
62	1997	7	24	9:55	5.88		16:00	1.28				
63	1997	7	24	15:50	5.72							
64	1997	7	26	9:45	5.46		10:10	1.94				
65	1997	7	28	9:40	5.36		9:20	1.68				
66	1997	7	30	9:40	5.90		9:15	0.98				
67	1997	8	1	10:15	5.49							
68	1997	8	4	9:20	5.80							
69	1997	8	7	15:25	4.30		15:40	1.90				
70	1997	8	11	9:30	5.50		9:40	1.97				
71	1997	8	13	9:10	5.24		9:30	1.05				
72	1997	8	15	10:20	5.19		10:00	0.67				
73	1997	8	18	15:30	4.73		15:15	0.61				
74	1997	8	21	9:20	4.38		9:45	0.58				
75	1997	8	25	9:50	5.85		9:30	1.30				
76	1997	8	27	9:00	5.68		9:30	1.06				
77	1997	8	29	9:15	5.04		9:40	0.66				
78	1997	9	1	9:55	5.40		10:15	1.57				
79	1997	9	3	15:45	5.55		15:30	0.71				
80	1997	9	5	9:15	5.00		9:40	0.66		10:20	1.15	
81	1997	9	8	9:30	4.52		9:55	0.62		10:35	1.07	
82	1997	9	11	9:15	4.19		9:00	0.57		8:35	1.00	
83	1997	9	15	8:50	5.54		9:15	0.36		10:10	0.71	
84	1997	9	17	10:30	5.94		9:55	0.85		9:20	1.36	
85	1997	9	22	9:30	5.75		9:45	4.03		10:30	4.54	
86	1997	9	24	9:50	5.68		10:10	3.73		10:40	4.30	
87	1997	9	29	9:45	7.90		10:20	7.60				
88	1997	10	6	9:40	5.60		8:55	2.10		8:30	3.22	
89	1997	10	8	9:15	5.50		9:40	1.75		10:15	3.37	
90	1997	10	10							14:05	2.67	17.71
91	1997	10	11	8:50	5.29		9:00	1.14				
92	1997	10	13							9:00	3.70	32.73
93	1997	10	14				14:30	3.74	51.91			
94	1997	10	15							9:10	3.75	35.29
95	1997	10	16	8:55	5.60		9:10	3.20	36.00			
96	1997	10	17	9:00	5.48	23.38						
97	1997	10	20	9:10	5.30	19.82						
98	1997	10	21							9:00	3.22	25.80
99	1997	10	23				9:30	2.72	26.89			
100	1997	10	24	9:00	5.45	25.62				15:00	3.05	25.16
101	1998	1	13	15:05	2.25	2.30	10:15	0.21	2.16	8:20	0.47	2.38
102	1998	1	15	15:00	2.28	2.47	9:45	0.20	2.19	8:25	0.45	2.48
103	1998	1	17	14:55	2.26	3.39	10:00	0.18	2.03	8:40	0.45	2.30
104	1998	1	19				16:00	0.17	2.02	14:35	0.43	2.21
105	1998	1	20	9:00	2.16	2.22						
106	1998	1	21							15:40	0.40	2.16
107	1998	1	22	8:50	2.15	2.40	10:45	0.16	1.88			
108	1998	1	23				16:00	0.16	1.88	14:40	0.40	2.29
109	1998	1	24	15:00	2.23	1.92						
110	1998	1	26				9:30	0.15	1.76	8:15	0.39	2.13
111	1998	1	28	8:55	2.12	4.10	10:30	0.14	1.69	14:30	0.38	1.94
112	1998	1	29				15:00		0.71	16:15	0.17	1.03
113	1998	1	30	8:50	1.94	1.66						
114	1998	2	2				16:00	0.12	1.57	14:45	0.34	1.89
115	1998	2	4	8:45	1.75	1.47	16:00	0.13	1.46	14:40	0.34	1.65
116	1998	2	6	8:50	1.72	1.42	10:15	0.13	1.50	15:05	0.33	1.65
117	1998	2	9				10:05	0.10	1.37	9:00	0.31	1.43
118	1998	2	10	8:50	1.69	1.50						
119	1998	2	11	15:05	1.70	1.35	16:30	0.10	1.57			
120	1998	2	12							8:25	0.30	1.62

Table 2.3.2 Summary of Hydrometry on Siem Reap River (3/3)

No.	Year	Month	Day	French Weir (SG#1)			Prasat Keo Bridge			Angkor Bridge		
				Time	Stage (m)	Flow (m ³ /s)	Time	Stage (m)	Flow (m ³ /s)	Time	Stage (m)	Flow (m ³ /s)
121	1998	2	17	9:45	1.67	1.33						
122	1998	2	18				9:00	0.09	1.39			
123	1998	2	20							15:10	0.26	1.52
124	1998	2	23	8:15	1.63	1.20						
125	1998	2	26				14:00	0.05	1.10	15:40	0.23	1.18
126	1998	3	2	14:50	1.58	1.07						
127	1998	3	3				10:00	0.05	1.12	10:45	0.22	1.16
128	1998	3	11	7:30	1.68	1.58	8:55	0.29	2.58	10:40	0.48	2.25
129	1998	3	18	16:00	1.82	1.55	15:15		1.07	14:30	0.18	0.99
130	1998	3	25				8:55		0.94	9:45	0.14	0.69
131	1998	4	3				9:15		0.91	10:10	0.15	0.81
132	1998	4	10							7:40	0.11	0.81
133	1998	4	17							8:55	0.15	0.77
134	1998	4	24	14:30	0.43	1.85	15:50	0.02	1.32	16:40	0.16	0.88
135	1998	5	2	14:45	0.21	0.69	15:45		0.77	16:30	0.13	0.75
136	1998	5	9	9:40	0.23	0.74	10:50		0.79	11:30	0.15	0.79
137	1998	5	16	9:05	0.18	0.67	9:55		0.78	10:55	0.13	0.79
138	1998	5	23	9:30	0.94	0.54	10:20		0.56	11:10	0.03	0.56
139	1998	5	30	9:50	1.02	0.67	10:35		0.66	11:35	0.13	0.79
140	1998	6	6	9:35	1.11	0.77	10:30		0.95	11:00	0.14	0.81
141	1998	6	13	9:30	1.15	0.85	10:15		0.79	11:05	0.15	0.84
142	1998	6	20	9:45	1.19	0.75	10:30		0.74	11:15	0.11	0.74
143	1998	6	27	9:40	1.28	0.81	10:55		0.74	11:35	0.10	0.67
144	1998	7	4	9:20	1.39	1.16	10:15	0.05	1.41	11:00	0.29	1.46
145	1998	7	11	9:10	1.00	0.83	10:00		0.92	10:55	0.15	0.88
146	1998	7	18	9:20	0.97	0.49	10:05		0.86	10:55	0.14	0.86
147	1998	7	25	9:00	0.88	0.52	9:40		0.61	10:20	0.02	0.60
148	1998	8	1	9:15	0.96	0.78	10:00		1.10	10:45	0.21	1.11
149	1998	8	8	9:30	1.05	0.93	10:10		0.95	10:50	0.19	1.02
150	1998	8	15	8:50	3.98		9:30		0.87	10:10	0.15	0.88
151	1998	8	22	14:55	4.75		15:35		0.94	16:20	0.20	1.01
152	1998	8	29	9:00	3.65		9:45		1.01	16:25	0.19	1.00
153	1998	9	5	8:45	3.69		9:55		0.96	10:45	0.16	0.93
154	1998	9	12	9:15	3.92		10:05		0.77	10:55	0.15	0.84
155	1998	9	19	8:50	4.28		9:10	1.24		9:30	1.90	
156	1998	9	26	8:55	9.15		9:05	1.14		9:25	1.86	
157	1998	10	3	9:00	5.88		9:30	1.28		9:55	1.95	
158	1998	10	10	8:45	5.83		9:00	1.26		9:10	1.93	
159	1998	10	17	8:50	5.65		8:55	0.91		9:15	1.20	
160	1998	10	24	8:35	5.63		9:15	0.20	2.19	10:00	0.48	2.28
161	1998	10	31	9:25	5.59		8:25	0.15	1.62	10:10	0.39	1.84
162	1998	11	7	8:40	5.63		9:15	0.40	3.33	10:05	0.77	3.51
163	1998	11	14	10:15	5.59		9:55	0.38	3.03	9:15	0.75	3.29
164	1998	11	21	8:40	5.89					9:50	1.05	
165	1998	11	28	8:50	5.91					10:00	1.11	
166	1998	12	7				10:55	0.18		10:30	0.52	
167	1998	12	16				9:15	0.18		9:15	0.50	
168	1998	12	16				16:45	0.18		16:25	0.52	
169	1998	12	17				8:00	0.18		7:45	0.52	
170	1998	12	23	8:20	3.75		9:30	0.05	1.44	9:45	0.31	1.53
171	1998	12	30				8:30	0.05		8:15	0.30	
172	1998	12	30				17:30	0.04		17:15	0.31	
173	1999	1	6				14:40	0.02		15:25	0.26	
174	1999	1	14				15:45	0.00		16:05	0.24	
175	1999	1	20				15:45	-0.02		16:10	0.20	
176	1999	1	27				9:30	-0.03	0.91	10:40	0.20	
177	1999	1	29	16:10	3.37		16:25	-0.03		16:40	0.20	
178	1999	2	5	16:50	3.57		17:05	-0.06		17:25	0.17	

Table 2.3.3 Daily Mean Water Stage at UNTAC Bridge

Year: 1997 unit: m

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.95	0.83	0.89	0.51	0.84	1.56	0.93	1.31	1.65	3.80	1.63	1.30
2	0.88	0.81	0.87	0.47	0.82	1.81	0.85	2.15	1.97	3.50	1.62	1.29
3	0.90	0.73	0.81	0.53	0.83	1.55	1.11	2.80	1.46	2.90	1.53	1.23
4	1.01	0.65	0.83	0.58	0.93	1.12	0.83	3.30	1.13	2.65	1.47	1.15
5	0.91	0.89	0.80	0.58	0.98	0.98	0.85	3.17	1.00	2.65	1.53	1.17
6	0.73	0.90	0.78	0.57	0.93	0.85	0.80	2.50	1.00	2.54	1.66	1.16
7	0.93	0.90	0.79	0.57	0.90	0.45	0.69	1.96	0.99	2.38	1.56	1.16
8	1.05	0.91	0.83	0.43	0.89	0.30	0.79	1.72	1.13	2.13	1.59	1.14
9	1.08	0.98	0.73	0.48	0.93	0.53	0.79	1.70	1.13	2.03	1.61	1.05
10	0.88	0.93	0.65	0.44	0.88	0.85	0.73	1.95	0.99	2.00	1.47	1.13
11	0.80	0.90	0.50	0.44	0.87	0.65	0.84	1.97	0.98	2.09	1.48	1.08
12	0.88	0.85	0.25	0.41	0.87	0.57	0.83	1.58	0.98	2.18	1.46	1.00
13	1.00	0.83	0.25	0.40	0.87	0.45	0.93	1.23	0.90	2.60	1.45	0.98
14	1.03	0.88	0.21	0.41	0.85	0.30	1.05	0.95	0.89	3.03	1.52	1.00
15	0.90	0.93	0.28	0.39	0.91	0.26	0.98	0.95	0.91	2.68	1.51	1.03
16	0.83	1.00	0.48	0.34	0.86	0.35	1.00	0.85	1.37	2.55	1.41	1.08
17	0.78	0.90	0.60	0.33	0.87	0.55	0.97	0.87	1.60	2.28	1.39	0.95
18	0.83	1.03	0.68	0.43	0.91	0.66	0.98	0.84	1.63	2.11	1.37	0.98
19	0.73	0.98	0.68	0.50	1.03	0.60	1.04	1.02	1.73	2.03	1.41	0.95
20	0.77	0.90	0.65	0.51	0.99	0.53	1.07	1.11	1.63	1.99	1.39	1.03
21	0.80	0.83	0.74	0.52	0.90	0.51	0.99	1.11	2.47	2.27	1.47	1.08
22	0.84	0.70	0.74	0.53	0.86	0.98	0.90	1.23	3.00	2.60	1.48	1.13
23	0.98	0.85	0.77	0.61	0.88	0.85	0.98	1.44	3.00	2.38	1.49	1.03
24	0.99	0.83	0.74	0.83	0.89	0.80	1.42	1.43	2.97	2.21	1.43	0.97
25	0.97	0.83	0.68	0.87	0.88	0.89	1.77	1.72	2.73	2.05	1.29	0.90
26	0.97	0.85	0.61	0.85	1.03	1.00	1.87	1.49	3.30	1.97	1.25	0.93
27	0.97	0.88	0.58	0.83	1.04	0.64	1.84	1.33	4.85	1.90	1.48	1.00
28	0.94	0.89	0.53	0.83	0.72	0.65	1.72	1.28	4.90	1.65	1.56	0.97
29	0.85		0.48	0.86	0.65	0.82	1.69	1.20	4.60	1.63	1.30	0.93
30	0.85		0.41	0.84	0.70	0.89	1.40	1.21	3.90	1.69	1.16	0.99
31	0.87		0.46		1.22		1.71	1.27		1.63		1.03
Average	0.90	0.87	0.62	0.56	0.89	0.76	1.11	1.57	2.03	2.32	1.46	1.06
Min.	0.73	0.65	0.21	0.33	0.65	0.26	0.69	0.84	0.89	1.63	1.16	0.90
Max.	1.08	1.03	0.89	0.87	1.22	1.81	1.87	3.30	4.90	3.80	1.66	1.30

Year: 1998 unit: m

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.94	0.65	0.80	0.52	0.69	0.59	0.60	0.77	0.42	0.50	0.80	1.20
2	0.93	0.60	0.85	0.50	0.72	0.64	0.53	0.83	0.47	0.75	1.02	1.50
3	0.93	0.55	0.93	0.47	0.69	0.73	0.73	0.91	0.50	1.00	1.00	1.90
4	0.95	0.58	1.00	0.53	0.67	0.79	0.94	0.90	0.73	1.43	0.98	0.84
5	0.92	0.75	1.03	0.73	0.70	0.80	0.92	0.84	0.81	0.86	0.94	0.92
6	0.90	0.95	0.98	0.73	0.71	0.75	0.90	0.68	0.81	0.68	0.98	0.91
7	0.93	0.95	0.85	0.69	0.63	0.73	0.84	0.73	0.80	0.50	1.00	0.88
8	0.85	0.87	0.75	0.54	0.59	0.70	0.80	0.85	0.82	0.52	1.03	0.82
9	0.90	0.82	0.45	0.60	0.63	0.69	0.72	0.92	0.83	0.48	1.02	0.74
10	0.98	0.84	0.20	0.68	0.61	0.69	0.47	0.88	0.83	0.49	1.01	0.71
11	1.03	0.84	0.55	0.74	0.64	0.72	0.50	0.74	0.85	0.51	1.00	0.75
12	1.08	0.82	0.68	0.72	0.65	0.77	0.62	0.56	0.90	0.54	0.89	1.04
13	1.11	0.84	0.65	0.68	0.66	0.65	0.65	0.47	0.86	0.60	0.80	1.10
14	1.10	0.89	0.70	0.68	0.64	0.59	0.74	0.42	0.86	0.78	0.85	1.14
15	1.00	0.94	0.63	0.73	0.65	0.60	0.73	0.40	0.84	1.20	0.84	1.11
16	0.98	0.91	0.50	0.77	0.62	0.58	0.74	0.45	0.83	1.25	0.82	1.12
17	1.00	0.89	0.40	0.51	0.63	0.56	0.74	0.40	0.82	1.37	1.05	1.14
18	0.97	0.83	0.45	0.57	0.64	0.50	0.70	0.40	0.85	1.67	1.10	1.14
19	1.00	0.81	0.42	0.60	0.63	0.58	0.63	0.48	0.90	1.69	1.24	1.11
20	1.05	0.78	0.40	0.66	0.61	0.65	0.55	0.60	0.97	1.75	1.22	0.82
21	1.00	0.71	0.48	0.69	0.68	0.72	0.48	0.63	1.32	1.92	1.38	0.60
22	1.01	0.70	0.70	0.78	0.66	0.73	0.47	0.68	1.25	1.65	1.44	0.56
23	0.99	0.77	0.77	0.81	0.63	0.72	0.44	0.49	1.15	1.15	1.57	0.90
24	0.98	0.68	0.77	0.82	0.65	0.68	0.40	0.47	0.64	0.71	1.22	0.61
25	0.88	0.63	0.73	0.82	0.53	0.64	0.43	0.40	0.59	0.70	1.10	0.60
26	0.75	0.73	0.70	0.79	0.61	0.58	0.48	0.40	1.10	0.95	0.85	0.63
27	0.80	0.75	0.68	0.75	0.60	0.50	0.60	0.40	0.95	0.80	0.85	0.73
28	0.88	0.73	0.61	0.70	0.62	0.60	0.62	0.38	0.80	0.69	1.00	0.90
29	0.88		0.51	0.69	0.70	0.71	0.69	0.37	0.60	0.65	1.08	0.88
30	0.80		0.47	0.68	0.68	0.74	0.73	0.41	0.48	0.75	1.20	0.90
31	0.73		0.51		0.67		0.75	0.42		0.80		0.93
Average	0.94	0.78	0.65	0.67	0.65	0.66	0.65	0.59	0.82	0.95	1.04	0.94
Min.	0.73	0.55	0.20	0.47	0.53	0.50	0.40	0.37	0.42	0.48	0.80	0.56
Max.	1.11	0.95	1.03	0.82	0.72	0.80	0.94	0.92	1.32	1.92	1.57	1.90

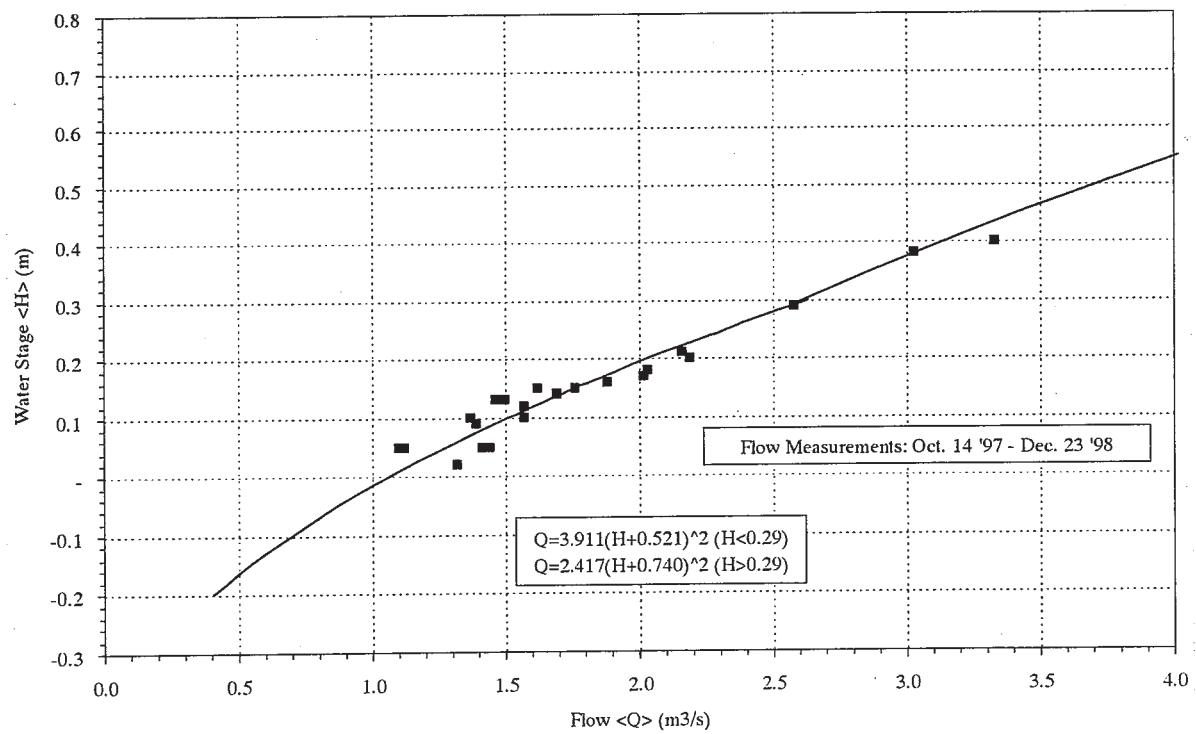
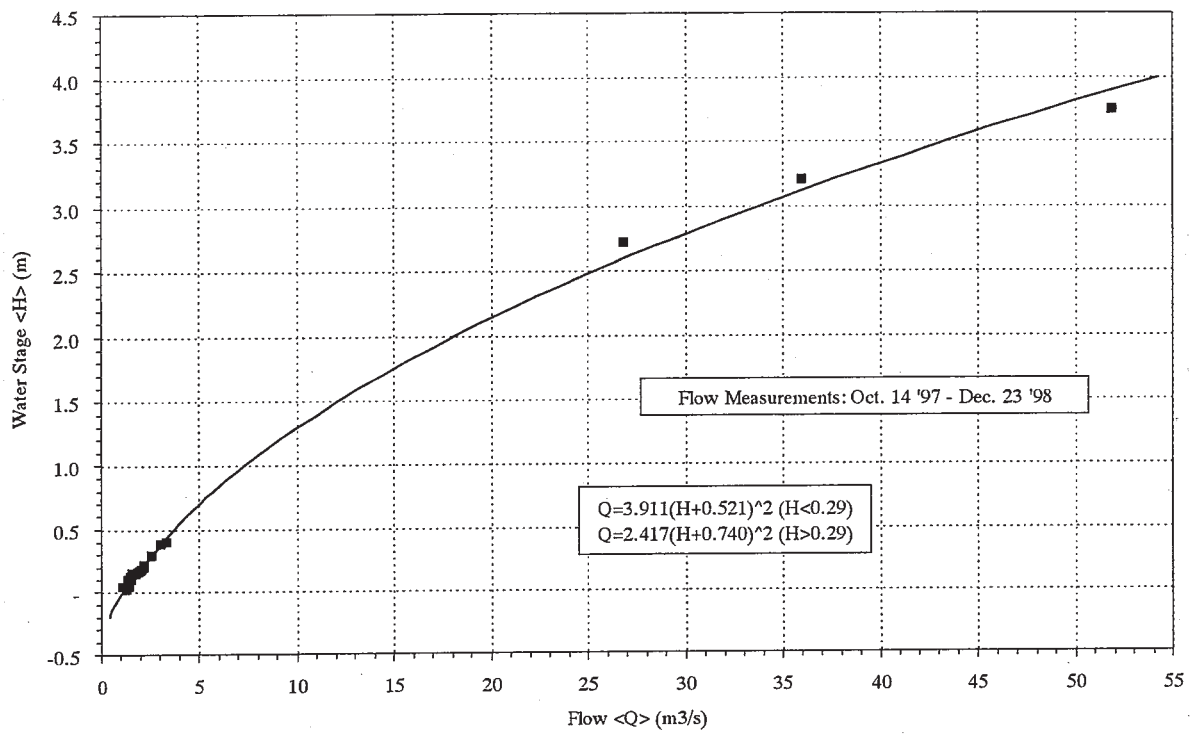
Source: JICA Study Team (average of reading at 7:00 AM and 7:00 PM)

Table 2.3.4 Summary of Hydrometry on Irrigation Canals (1/2)

No.	Year	Month	Day	West Baray Reservoir System								Crocodile Weir System							
				Canal A (at Takav Gate)			Canal B (Reservoir - N.R. 6)					Vichear Chin Canal			Chreav Canal				
				Time	Stage	Flow	Time	Reservoir Stage	Canal C2	Canal C3	Canal C8	Total	Time	Stage	Flow	Time	Stage	Flow	
				(m)	(m ³ /s)	(m)	(m)	(m ³ /s)	(m ³ /s)	(m ³ /s)	(m ³ /s)	(m)	(m)	(m ³ /s)	(m)	(m)	(m ³ /s)		
1	1997	1	3				9:45	23.74	1.39	0	0	1.39							
2	1997	2	7														16:05	0.04	0.03
3	1997	2	11				11:20	24.12	1.35	0	0	1.35	10:43	1.12	0.57				
4	1997	2	12										11:00	1.07	0.19				
5	1997	2	13													9:55	1.07	0.97	
6	1997	2	14				10:20	24.10	2.34	0	0	2.34	16:10	1.02	0.35	14:30	1.02	0.93	
7	1997	2	19										16:39	1.18	0.32	15:47	1.18	1.35	
8	1997	2	20				16:00	24.02	2.01	0	0	2.01							
9	1997	2	21				11:00	23.94	2.23	0	0	2.23							
10	1997	2	25										15:20	0.88	0.15	16:15	0.89	0.20	
11	1997	3	10				11:00	23.48	1.86	0	0	1.86							
12	1997	3	21				15:00	23.12	1.74	0	0	1.74							
13	1997	3	26				16:40	23.05	0.82	0	0	0.82	15:30	0.94	0.16	16:10	0.94	0.17	
14	1997	4	3													15:40	0.91	0.05	
15	1997	4	4													14:30	0.45	0.25	
16	1997	4	5				8:20	22.50	2.52	0	0	2.52							
17	1997	4	7				15:36	22.35	1.73	0.64	0	2.37							
18	1997	4	8													8:10	0.57	0.34	
19	1997	4	9													14:25	0.47	0.06	
20	1997	4	17				15:00	22.18	1.41	1.22	0	2.63							
21	1997	4	21				15:00	22.06	1.50	1.17	0	2.67							
22	1997	4	22													14:20	1.15	0.57	
23	1997	4	24				15:10	22.10	0	1.68	0	1.68							
24	1997	4	28				14:35	22.05	0	0.78	0	0.78	15:15	1.00	0.33				
25	1997	4	29													14:10	1.02	0.50	
26	1997	5	6													15:15	1.06	0.94	
27	1997	5	12				14:20	21.75	0.39	0	0	0.39							
28	1997	5	15				16:00	21.87	0.36	0	0	0.36							
29	1997	5	19				15:00	21.80	0.43	0	0	0.43							
30	1997	6	9	11:30	0.88	1.26													
31	1997	7	14				9:35	22.08	0	0	0	0	15:40	0.96	0.34				
32	1997	7	15													14:30	1.25	1.20	
33	1997	7	16				8:55	22.07	0	0	0	0							
34	1997	7	18	8:35	1.02											15:40	1.02	0.94	
35	1997	7	21	10:40	1.19		15:10	22.30	0.43	0	0	0.43							
36	1997	7	23										14:55	0.83		15:15	0.83		
37	1997	7	24	10:30	1.10														
38	1997	7	25				9:20	22.45	0	0	0	0							
39	1997	7	28	10:15	0.99		16:20	22.52	0	0	0	0							
40	1997	7	29										10:20	1.32		10:10	1.32		
41	1997	7	30				15:20	22.68	0	0	0	0							
42	1997	8	1				15:05	22.82	0	0	0	0							
43	1997	8	5				16:15	23.30	0	0	0	0							
44	1997	8	7	14:55	1.80														
45	1997	8	8				10:10	23.45	0	0	0	0	10:15	1.19		9:00	1.19		
46	1997	8	11	9:15	1.80		16:10	23.55	0	0	0	0							
47	1997	8	12													14:40	1.08		
48	1997	8	13				16:30	23.65	0	0	0	0							
49	1997	8	15				15:30	23.70	0	0	0	0							
50	1997	8	18	15:55	1.30		9:15	23.75	0	0	0	0							
51	1997	8	20				9:10	23.80	0	0	0	0				16:05	1.09		
52	1997	8	22				9:30	23.83	0	0	0	0							
53	1997	8	25	10:20	2.42														
54	1997	8	26				9:00	24.04	0	0	0	0	15:55	1.15		15:25	1.15		
55	1997	8	28				9:30	24.12	0	0	0	0							
56	1997	8	30										14:45	1.18		14:30	1.18		
57	1997	9	1				15:35	24.30	0	0	0	0							
58	1997	9	4				9:40	24.40	0	0	0	0							
59	1997	9	8	9:00	1.09								15:00	0.99		15:00	0.99		
60	1997	9	9				8:50	24.46	0	0	0	0							
61	1997	9	12				8:45	24.45	0	0	0	0							
62	1997	9	15	8:30	2.11														
63	1997	9	16				9:20	24.55	0	0	0	0	15:55	1.22		15:30	1.22		

Table 2.3.4 Summary of Hydrometry on Irrigation Canals (2/2)

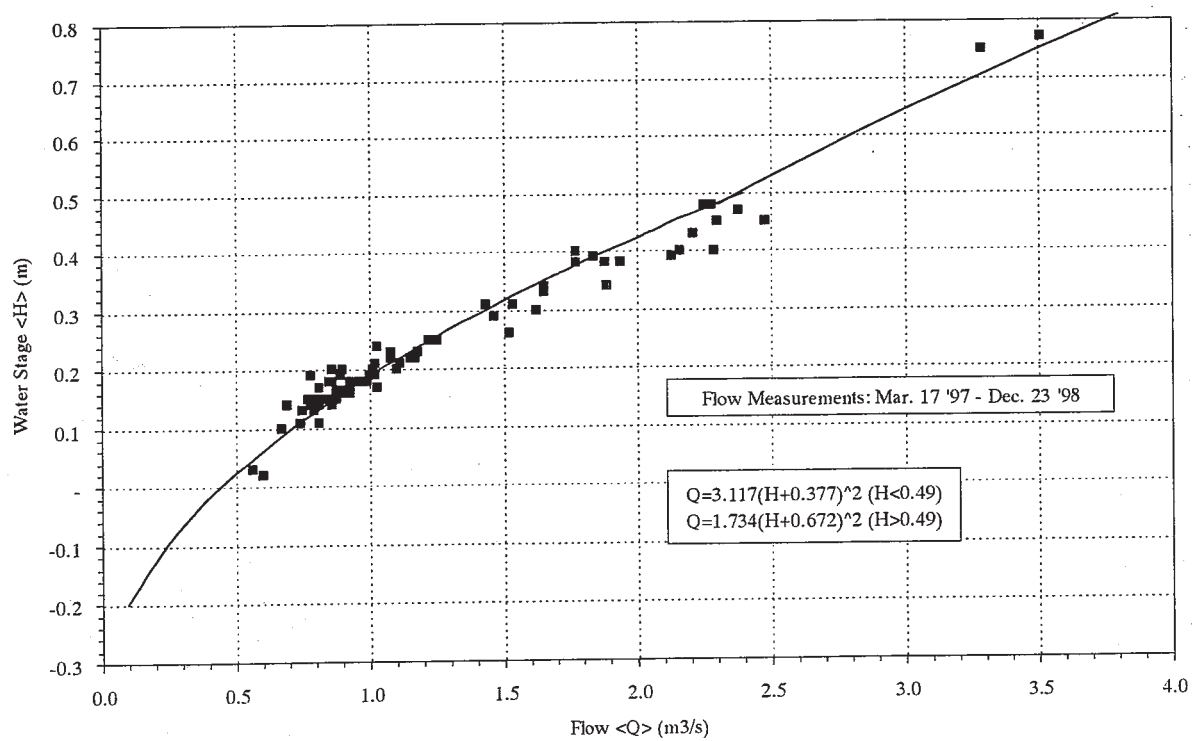
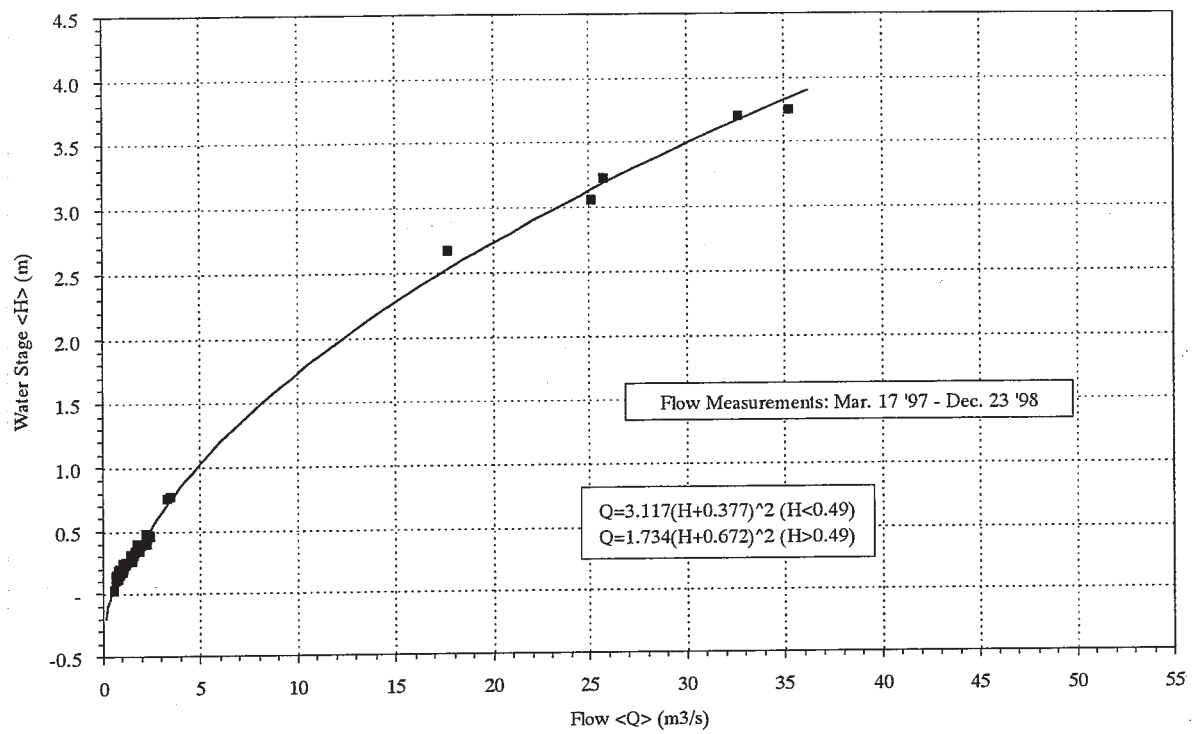
No.	Year	Month	Day	West Baray Reservoir System								Crocodile Weir System						
				Canal A (at Takav Gate)			Canal B (Reservoir - N.R. 6)					Vichear Chin Canal			Chreav Canal			
				Time	Stage (m)	Flow (m ³ /s)	Time	Reservoir Stage (m)	Canal C2 (m ³ /s)	Canal C3 (m ³ /s)	Canal C8 (m ³ /s)	Total (m ³ /s)	Time	Stage (m)	Flow (m ³ /s)	Time	Stage (m)	Flow (m ³ /s)
64	1997	9	19				9:30	24.69	0	0	0	0						
65	1997	9	22	10:00	2.32		9:10	24.88	0	0	0	0	8:15	2.00		8:00	2.00	
66	1997	9	23				16:00	24.86	0	0	0	0						
67	1997	9	25															
68	1997	9	29	8:30	4.47								15:50	2.52		16:00	2.52	
69	1997	10	3				9:20	25.10	0	0	0	0						
70	1997	10	6	10:00	2.17													
71	1997	10	7				9:00	25.01	0	0	0	0	15:30	1.85		15:15	1.85	
72	1997	10	9										15:30	1.57	1.10			
73	1997	10	10				8:15	24.95	4.81	0	3.90	8.71						
74	1997	10	13										14:55	1.80	1.41			
75	1997	10	14				9:10	24.90	0	0	0	0				10:40	1.99	3.92
76	1997	10	15										15:30	1.76	1.33	14:30	1.76	2.98
77	1997	10	20										15:55	1.51	0.99	14:40	1.51	2.07
78	1997	10	21				15:40	24.85	0	0	0	0						
79	1997	10	23										14:45	1.68	1.17	15:00	1.68	2.78
80	1998	1	10				8:10	23.75	0	0	0	0	15:50	1.10	0.34	16:20	1.10	0.92
81	1998	1	12				14:35	23.75	2.15	0	0	2.15						
82	1998	1	14				9:00	23.73	1.83	0	0	1.83	9:50	1.20	0.66	10:25	1.20	1.07
83	1998	1	16				15:08	23.67	2.04	0	0	2.04	9:20	1.10	0.51	8:20	1.10	0.99
84	1998	1	19				10:20	23.59	1.05	0	0	1.05	9:20	1.20	0.60	8:20	1.20	1.09
85	1998	1	21				9:40	23.57	2.01	0.48	0.32	2.81	10:45	1.18	0.63	14:35	1.18	1.67
86	1998	1	22				14:45	23.55	0	0.71	0.88	1.59						
87	1998	1	24				10:05	23.45	2.44	0	0	2.44	8:00	1.14	0.57	8:55	1.14	0.90
88	1998	1	26				14:45	23.35	1.69	0.43	0.64	2.76						
89	1998	1	28										15:50	1.00	0.37			
90	1998	1	29				10:05	23.32	1.77	0	0.57	2.34				8:00	1.00	0.75
91	1998	1	30				15:20	23.31	1.93	1.14	1.49	4.56						
92	1998	1	31													9:30	0.71	0.45
93	1998	2	3				8:55	23.18	1.95	0.71	1.63	4.29				14:55	0.60	0.23
94	1998	2	5				9:40	23.11	1.02	0	1.82	2.84				15:30	1.00	0.97
95	1998	2	7				9:30	23.05	2.09	0.45	0.55	3.09	15:45	1.14	0.32	14:45	1.14	0.88
96	1998	2	11				10:25	22.90	1.98	0.76	1.30	4.04						
97	1998	2	12										14:45	0.99	0.33			
98	1998	2	13				14:40	22.85	2.28	0.56	1.38	4.22						
99	1998	2	17				14:45	22.69	2.09	0.36	1.35	3.80						
100	1998	2	19													14:35	0.67	0.48
101	1998	2	21				10:15	22.56	2.11	0	0	2.11						
102	1998	2	27				9:40	22.27	1.68	0.40	1.21	3.29						
103	1998	3	4				9:45	22.16	2.13	0.54	1.75	4.42						
104	1998	3	25				14:35	21.10	2.52	0	1.36	3.88						
105	1998	4	3				11:20	20.90	0.93	0	0.72	1.65						
106	1998	4	10				10:25	20.68	0	0	0.80	0.80						
107	1998	5	2				8:55	20.07	1.07	0	0.40	1.47						
108	1998	12	17	12:25		0.35												
109	1998	12	23	10:45		0.96	14:55	23.95	0.38	0	0	0.38						
110	1999	1	8				9:45	23.82		0								
111	1999	1	12				16:00	23.77										
112	1999	1	17				11:45	23.72		0								
113	1999	1	22				11:15	23.65		0								
114	1999	1	27	8:40		0.21	15:30	23.60	1.44	0	0.65	2.09	16:10		0.42	11:05		0.59
115	1999	2	1				15:00	23.45										



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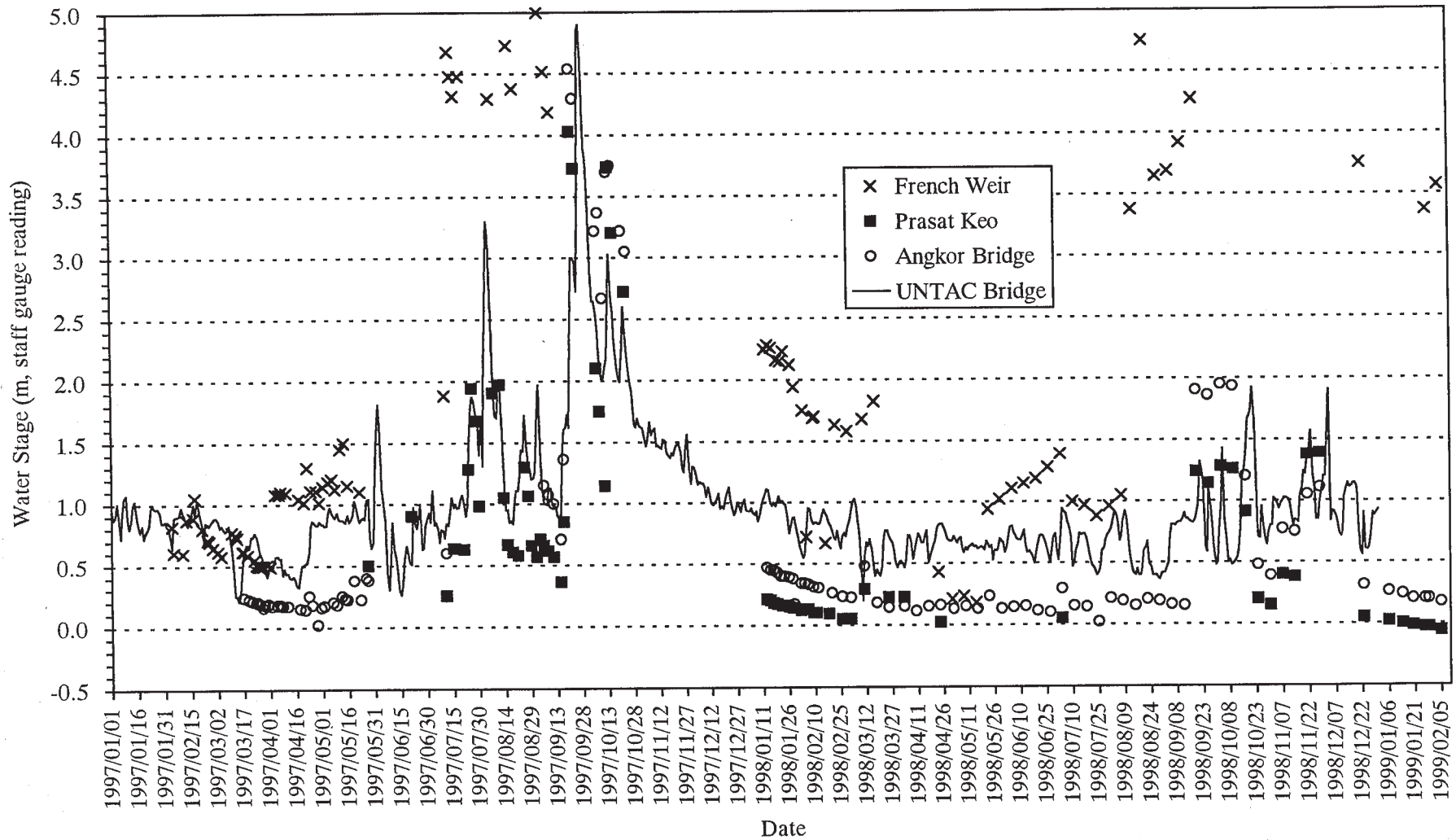
Figure 2.3.2
Rating Curves of Siem Reap River (1/2)
<Prasat Keo>



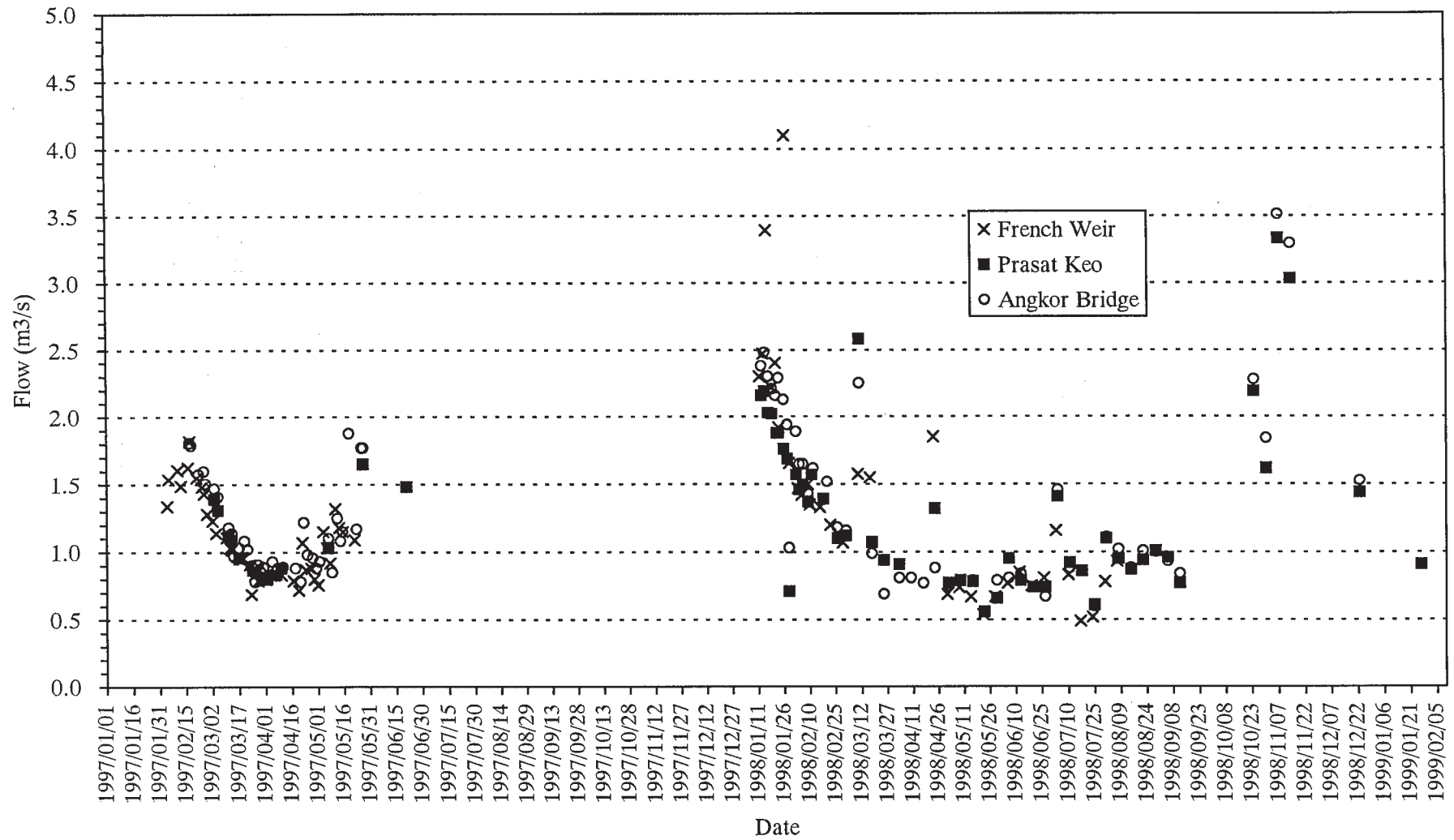
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Figure 2.3.2
Rating Curves of Siem Reap River (2/2)
<Angkor Bridge>



<p align="center">The Study on Water Supply System for Siem Reap Region in Cambodia</p>	<p align="center">Figure 2.4.1 Observed Water Stages on Siem Reap River <1997 - 1999></p>
<p align="center">Japan International Cooperation Agency</p>	



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Figure 2.4.2
Observed Flow on Siem Reap River
<1997 - 1999>

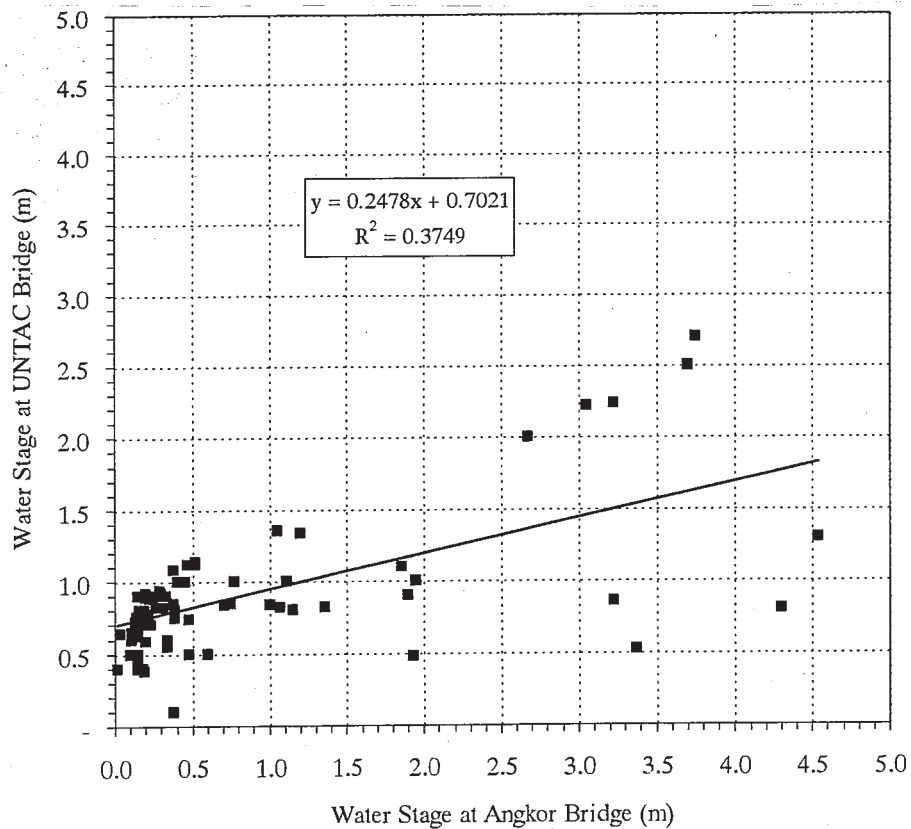
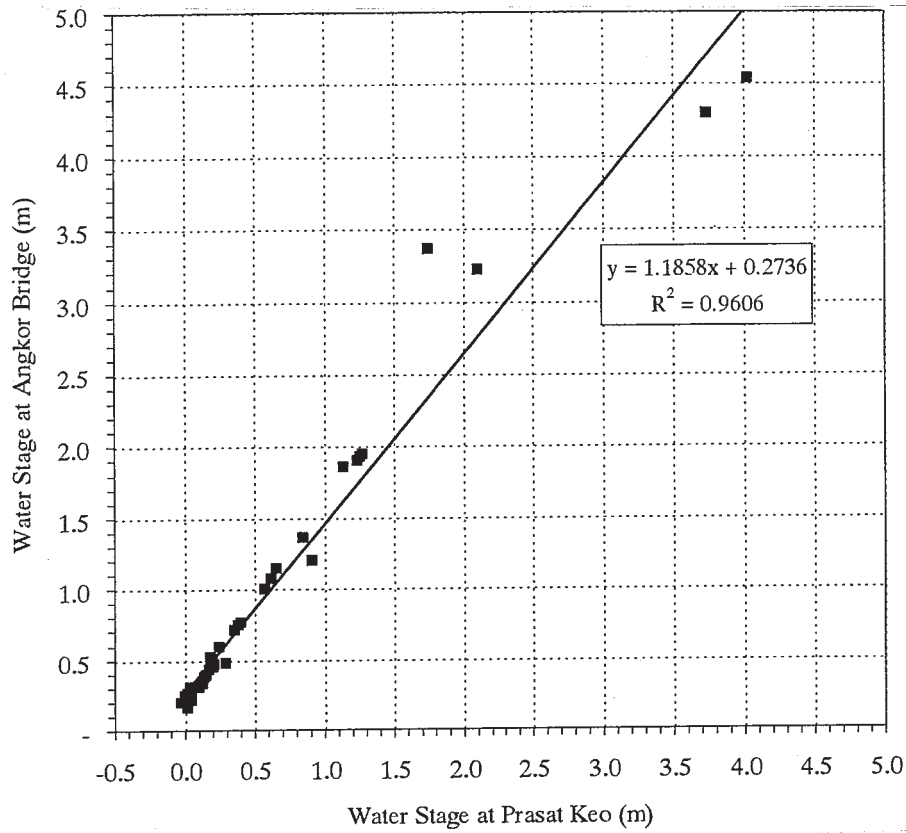
According to “Ville de Siem Reap - Angkor, Plan D’urbanisme de Reference et Projets Prioritaires” (APSARA, 1995) (French Study, 1995), the flood flow in September 1994 was calculated at 140 m³/s at the Crocodile Weir.

The flow gradually decreases from the end of the rainy season in November and reaches annual minimum value in the end of the dry season during April and May. The observed minimum flows at Prasat Keo in 1997 and 1998 are 0.80 m³/s and 0.56 m³/s, respectively. There is no flow in Canal A in the driest season at present because of the reasons described in next paragraph. Therefore, these values are purely annual minimum flows of the Siem Reap River. The total rainfall from November to April in 1997 and 1998 are 169.0 mm and 20.3 mm, respectively.

The sluice gate at the French Weir has currently been deteriorated as already reported in the French Study, 1995. Presently considerable amounts of water flow down the mainstream through the broken portion throughout the year. Accordingly, the water level at the weir falls gradually in the dry season as decrease of the flow from the upper reaches. Then, the level finally becomes lower than that of the bottom of the canal entrance; the canal dries up completely in the driest period. The bottom elevation of the canal corresponds roughly to the staff gauge reading of 1.0 m at the weir.

The relationship of the water level and flows between Prasat Keo and the Angkor Bridge show high correlation with the correlation coefficient above 0.95 as shown in Figure 2.4.3. The reason is that no tributary joins in the reaches of 3.7 km between both locations and the difference of both catchment is quite small (approximately 500 km² at Prasat Keo and 525 km² at Angkor Bridge).

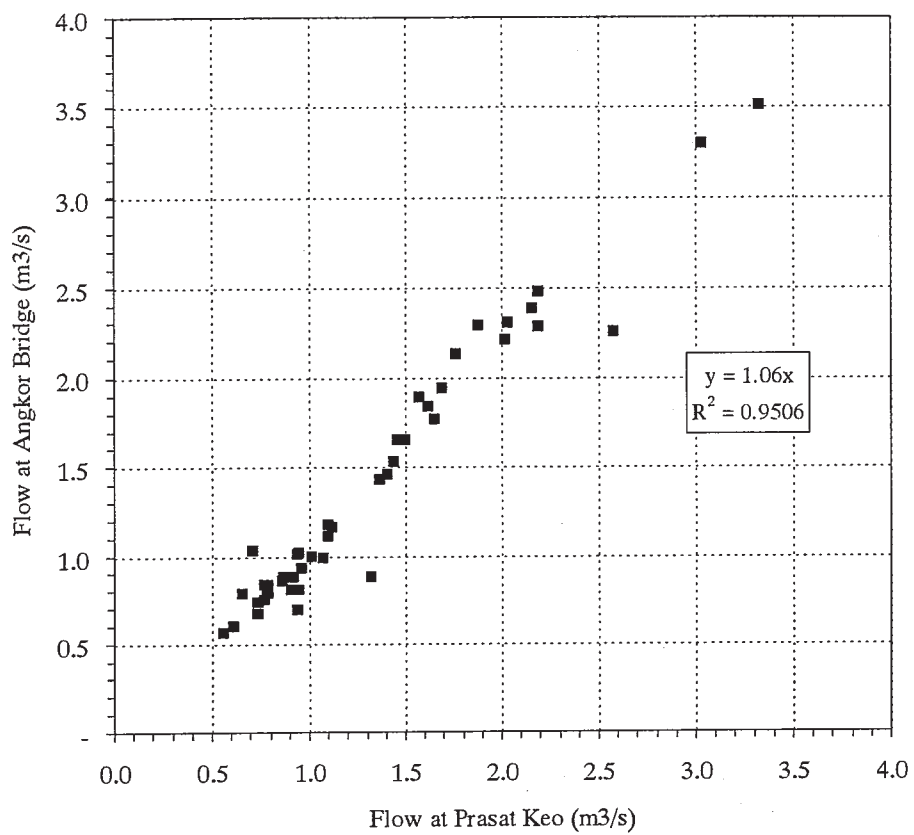
On the other hand, the correlation between the Angkor and UNTAC bridges is very low, even though no tributary joins in the reaches of 3.5 km between both locations and the difference of both catchment is negligibly small. The low correlation reflects the backwater effect at the UNTAC Bridge caused by the Crocodile Weir located 4.4 km downstream.



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Figure 2.4.3
Relationship of Observed Data
between 2 Stations (1/2)



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Figure 2.4.3
Relationship of Observed Data
between 2 Stations (2/2)

(2) Methodology

It is essential to estimate the daily flow regime of the Siem Reap River before the bifurcation at the French Weir at least one year to analyze the availability of raw water. It is ideal that flow measurement point be established in upper reaches of the French Weir. Therefore, an attempt was made at Kring Kroach Bridge on the circular road near East Mebon. However, it was not successful, since the flow velocity around the bridge was too slow to measure. Besides, it was practically difficult to stay in upper reaches of the French Weir for a long time because of the security problems as of 1997. In the end hydrometry in the upper reaches had to be abandoned.

Therefore, the estimate of the flow regime is conducted according to the following procedures:

- 1) Preparation of daily flow hydrograph in 1998 at Prasat Keo (1.7 km downstream of the French Weir) based on the hydrometry;
- 2) Estimate of daily inflow hydrograph to the West Baray in 1998 based on the rising curve of the reservoir water level, the reservoir Level-Volume curve and meteorological factor;
- 3) Estimate of daily flow hydrograph in upper reaches of the weir by summing up 1) Prasat Keo flow and 2) the inflow to the reservoir; and
- 4) Rough estimate of extended flow regime for 10 years based on 3) Estimated flow hydrograph in 1998 and the monthly rainfall pattern for 10 years.

The procedures from 1) to 3) are described in this section, and 4) is described in succeeding section 5.

There is an intake of a canal on the left bank of the river, which is located around 200 m upstream of the French Weir. It is unclear whether the canal functions at present or not; its origin is unknown, maybe, in Pol Pot regime. As the canal runs along the east side of Srah Srang, it is possible to confirm that the canal has completely no flow in the dry season. The French Study, 1995 reported that some of flood flow of the river is diverted to the canal because the intake has no gate. However, as there was no particular flood in 1998, canal flow was negligible despite some diversion.

The flow in 1997 is discarded from the object for of the following reasons:

- 1) There are difficulties in estimating the inflow to the West Baray in 1997, since the reservoir was operated by exceptionally to protect its deteriorated ring dyke, during the remarkably big floods in recent years (refer to succeeding section 3);

- 2) The hydrometry results seems insufficient to estimate the flow throughout the year; and
- 3) It is also difficult to use the water level at UNTAC Bridge for estimate the flow at the point located upstream because of the low correlation of water levels between both locations.

(3) Daily Flow Hydrograph at Prasat Keo

The estimate is concentrated on the flow in 1998. The 1998 drought flow pattern seems the most suitable for basis of low flow analysis. Prasat Keo is selected as an objective location for the preparation of daily flow hydrograph after the bifurcation of Canal A for the reasons as follows:

- 1) Prasat Keo is located just downstream of the French Weir (1.7 km);
- 2) No tributary joins between the weir and Prasat Keo and both catchment area can be regarded practically the same; and
- 3) Sufficient of hydrometry data with high reliability is available in 1998.

The daily flow hydrograph prepared is shown in Figure 2.4.4. The flow hydrograph from January to the middle of September is prepared by using the weekly interval flow measurement records and by interpolation between measurements.

The flow from September to December is prepared by the daily mean level (average of 24 hours) derived from the automatic gauge and the rating curve (refer to Figure 2.3.2). The hourly level from February to the middle of September is discarded because some mechanical error is found in the record throughout the period.

(4) Daily Inflow Hydrograph to West Baray

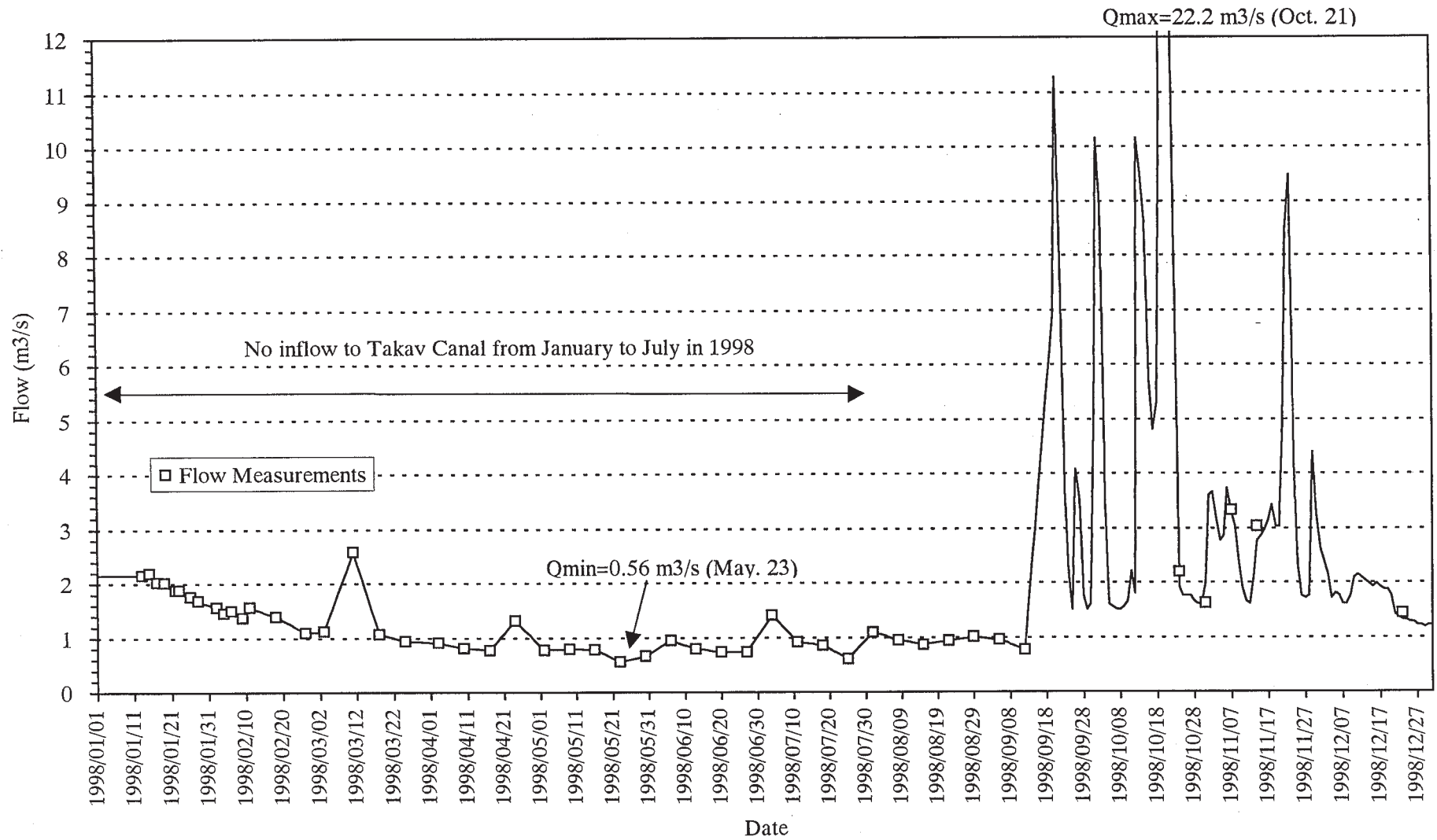
There was no inflow on Canal A from January to July in 1998 as the low water level at the French Weir indicates (refer to Figure 2.4.1). The level from January to the beginning of March was slightly higher (0.5~1 m) than that of the bottom of the canal entrance, however, no flow was practically observed according to field reconnaissance.

The inflow hydrograph to the reservoir is preliminary estimated indirectly according to the following procedures:

- 1) Estimate of daily increment of capacity by using the change of reservoir water level and the reservoir Water Level-Volume curve (refer to Figure 3.3.2);
- 2) Estimate of the daily increment of capacity based on storage by rainfall and loss by evaporation; and
- 3) Estimate of the inflow by 1) - 2).

The seepage amount is not taken into account here. The estimated inflow

hydrograph is shown in Table 2.4.1 and Figure 2.4.5. The flow capacity of the Canal A is estimated around 14 m³/s according to the uniform flow calculation based on the survey result; the peak inflow in 1998 is below the capacity. The storage in the reservoir in 1998 is summarized as follows:



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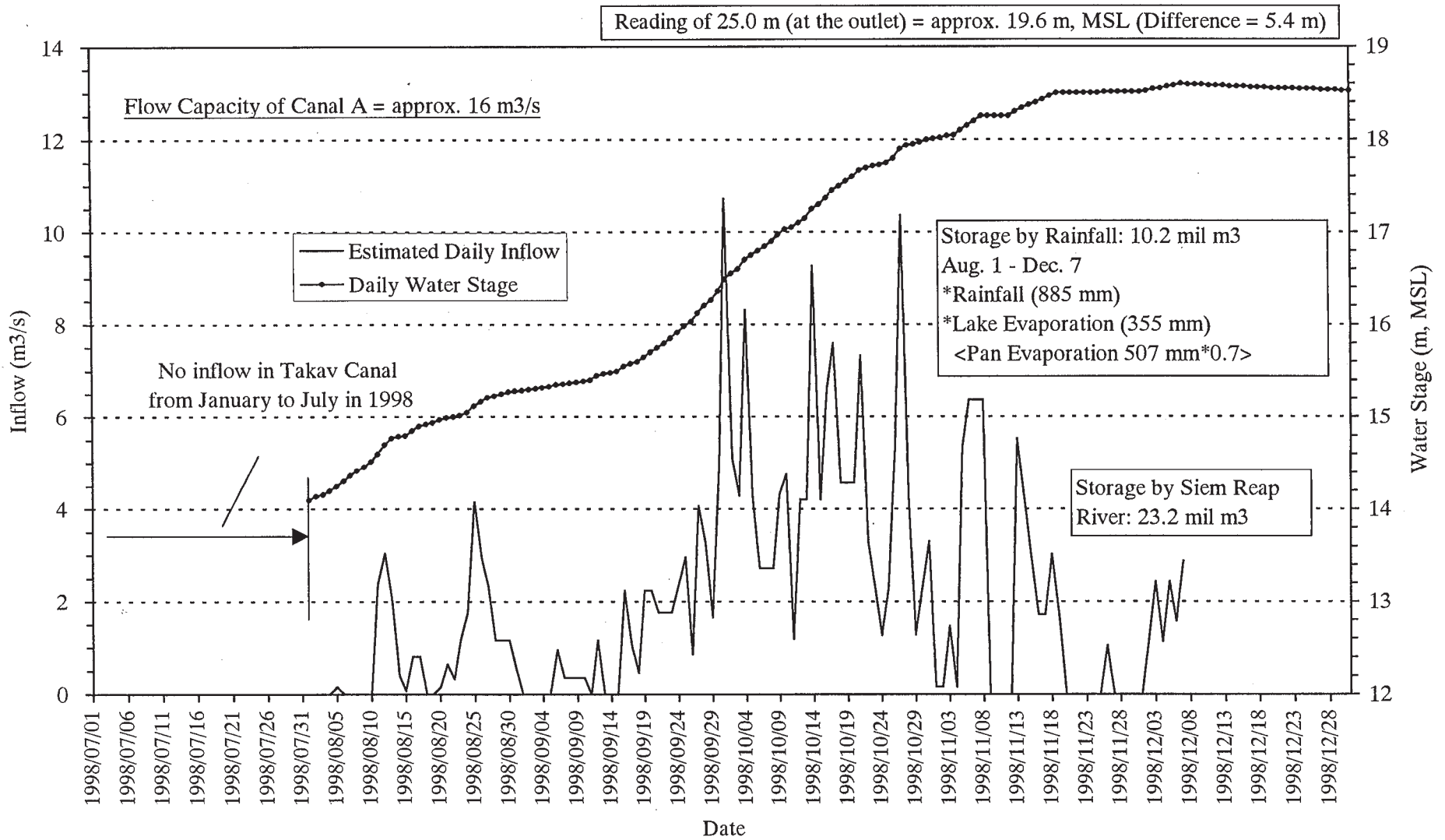
Figure 2.4.4
Daily Flow of Siem Reap River
at Prasat Keo in 1998

Table 2.4.1 Estimated Daily Inflow to West Baray Reservoir in 1998 (1/2)

West Baray Reservoir		5.4 (Difference of datum)			A=		0.7 A=		Inflow				
Date	Water Stage	Water Stage	Variation	Rainfall	5-day	15.56 km2	5-day Lake	10 km2	Volume	-(R-E)	Flow	Flow	
	(m, reading)	(m, MSL)	(m)	(mm)	(mm)	(m3)	(mm)	(m3)	(m3/d)	(m3/d)	(m3/s)	(m3/s)	
				<R>			<E>					23.21	
				885.4	885.4		354.8			10.2		25.7	
1998/08/01	19.50	14.10		5.8	54.8	852,688	14.0	140,000	712,688				
1998/08/02	19.54	14.14	0.04						126,540	-15,998	0.00	0.00	
1998/08/03	19.56	14.16	0.02						63,270	-79,268	0.00	0.00	
1998/08/04	19.60	14.20	0.04	47.2					126,540	-15,998	0.00	0.00	
1998/08/05	19.65	14.25	0.05	1.8					158,175	15,637	0.18	0.16	
1998/08/06	19.71	14.31	0.06	4.4	131.4	2,044,584	14.0	140,000	1,904,584	189,810	-191,107	0.00	0.00
1998/08/07	19.77	14.37	0.06	100.6					189,810	-191,107	0.00	0.00	
1998/08/08	19.82	14.42	0.05	2.8					158,175	-222,742	0.00	0.00	
1998/08/09	19.86	14.46	0.04	5.3					126,540	-254,377	0.00	0.00	
1998/08/10	19.92	14.52	0.06	18.3					189,810	-191,107	0.00	0.00	
1998/08/11	20.00	14.60	0.08	0.2	16.7	259,852	14.0	140,000	119,852	253,080	229,110	2.65	2.39
1998/08/12	20.10	14.70	0.10	7.2					316,350	292,380	3.38	3.05	
1998/08/13	20.17	14.77	0.07	9.3					221,445	197,475	2.29	2.06	
1998/08/14	20.19	14.79	0.02						63,270	39,300	0.45	0.41	
1998/08/15	20.20	14.80	0.01						31,635	7,665	0.09	0.08	
1998/08/16	20.25	14.85	0.05	1.2	34.8	541,488	14.0	140,000	401,488	158,175	77,877	0.90	0.81
1998/08/17	20.30	14.90	0.05	27.6					158,175	77,877	0.90	0.81	
1998/08/18	20.32	14.92	0.02	1.2					63,270	-17,028	0.00	0.00	
1998/08/19	20.34	14.94	0.02	0.5					63,270	-17,028	0.00	0.00	
1998/08/20	20.37	14.97	0.03	4.3					94,905	14,607	0.17	0.15	
1998/08/21	20.39	14.99	0.02	5.6	9.4	146,264	14.0	140,000	6,264	63,270	62,017	0.72	0.65
1998/08/22	20.40	15.00	0.01	3.8					31,635	30,382	0.35	0.32	
1998/08/23	20.42	15.02	0.02						114,050	112,797	1.31	1.18	
1998/08/24	20.45	15.05	0.03						171,075	169,822	1.97	1.77	
1998/08/25	20.52	15.12	0.07						399,175	397,922	4.61	4.15	
1998/08/26	20.57	15.17	0.05		11.9	185,164	16.8	168,000	17,164	285,125	282,264	3.27	2.95
1998/08/27	20.61	15.21	0.04	2.4					228,100	225,239	2.61	2.35	
1998/08/28	20.63	15.23	0.02	9.0					114,050	111,189	1.29	1.16	
1998/08/29	20.65	15.25	0.02	0.5					114,050	111,189	1.29	1.16	
1998/08/30	20.67	15.27	0.02						114,050	111,189	1.29	1.16	
1998/08/31	20.68	15.28	0.01	0.0					57,025	54,164	0.63	0.57	
1998/09/01	20.69	15.29	0.01	18.0	32.7	508,812	13.7	136,500	372,312	57,025	-17,437	0.00	0.00
1998/09/02	20.70	15.30	0.01	2.2					57,025	-17,437	0.00	0.00	
1998/09/03	20.71	15.31	0.01	0.1					57,025	-17,437	0.00	0.00	
1998/09/04	20.72	15.32	0.01	12.2					57,025	-17,437	0.00	0.00	
1998/09/05	20.73	15.33	0.01	0.2					57,025	-17,437	0.00	0.00	
1998/09/06	20.75	15.35	0.02		16.1	250,516	13.7	136,500	114,016	114,050	91,247	1.06	0.95
1998/09/07	20.76	15.36	0.01	13.3					57,025	34,222	0.40	0.36	
1998/09/08	20.77	15.37	0.01						57,025	34,222	0.40	0.36	
1998/09/09	20.78	15.38	0.01						57,025	34,222	0.40	0.36	
1998/09/10	20.79	15.39	0.01	2.8					57,025	34,222	0.40	0.36	
1998/09/11	20.80	15.40	0.01	14.6	64.8	1,008,288	13.7	136,500	871,788	57,025	-117,333	0.00	0.00
1998/09/12	20.85	15.45	0.05						285,125	110,767	1.28	1.16	
1998/09/13	20.87	15.47	0.02	18.2					114,050	-60,308	0.00	0.00	
1998/09/14	20.88	15.48	0.01	3.6					57,025	-117,333	0.00	0.00	
1998/09/15	20.90	15.50	0.02	28.4					114,050	-60,308	0.00	0.00	
1998/09/16	20.95	15.55	0.05	2.2	31.4	488,584	13.7	136,500	352,084	285,125	214,708	2.49	2.24
1998/09/17	20.98	15.58	0.03	2.0					171,075	100,658	1.17	1.05	
1998/09/18	21.00	15.60	0.02	14.6					114,050	43,633	0.51	0.46	
1998/09/19	21.05	15.65	0.05	12.4					285,125	214,708	2.49	2.24	
1998/09/20	21.10	15.70	0.05	0.2					285,125	214,708	2.49	2.24	
1998/09/21	21.15	15.75	0.05	9.6	45.8	712,648	13.7	136,500	576,148	285,125	169,895	1.97	1.77
1998/09/22	21.20	15.80	0.05	0.2					285,125	169,895	1.97	1.77	
1998/09/23	21.25	15.85	0.05	4.6					285,125	169,895	1.97	1.77	
1998/09/24	21.31	15.91	0.06	20.4					342,150	226,920	2.63	2.37	
1998/09/25	21.38	15.98	0.07	11.0					399,175	283,945	3.29	2.96	
1998/09/26	21.43	16.03	0.05	44.6	106.0	1,649,360	13.7	136,500	1,512,860	384,775	82,203	0.95	0.86
1998/09/27	21.52	16.12	0.09	31.2					692,595	390,023	4.51	4.07	
1998/09/28	21.60	16.20	0.08	5.4					615,640	313,068	3.62	3.27	
1998/09/29	21.66	16.26	0.06	15.0					461,730	159,158	1.84	1.66	
1998/09/30	21.76	16.36	0.10	9.8					769,550	466,978	5.40	4.87	
1998/10/01	21.89	16.49	0.13		0.0	-	13.3	133,000	-133,000	1,000,415	1,027,015	11.89	10.72
1998/10/02	21.95	16.55	0.06						461,730	488,330	5.65	5.10	
1998/10/03	22.00	16.60	0.05						384,775	411,375	4.76	4.29	
1998/10/04	22.10	16.70	0.10						769,550	796,150	9.21	8.31	
1998/10/05	22.15	16.75	0.05						384,775	411,375	4.76	4.29	
1998/10/06	22.20	16.80	0.05	2.8	48.4	753,104	13.3	133,000	620,104	384,775	260,754	3.02	2.72
1998/10/07	22.25	16.85	0.05	19.0					384,775	260,754	3.02	2.72	
1998/10/08	22.30	16.90	0.05	24.7					384,775	260,754	3.02	2.72	
1998/10/09	22.37	16.97	0.07	1.8					538,685	414,664	4.80	4.33	
1998/10/10	22.43	17.03	0.06	0.1					580,230	456,209	5.28	4.76	
1998/10/11	22.45	17.05	0.02	7.2	34.2	532,152	13.3	133,000	399,152	193,410	113,580	1.31	1.19
1998/10/12	22.50	17.10	0.05	6.5					483,525	403,695	4.67	4.21	
1998/10/13	22.55	17.15	0.05	0.1					483,525	403,695	4.67	4.21	
1998/10/14	22.65	17.25	0.10	7.6					967,050	887,220	10.27	9.26	
1998/10/15	22.70	17.30	0.05	12.8					483,525	403,695	4.67	4.21	
1998/10/16	22.77	17.37	0.07		23.1	359,436	13.3	133,000	226,436	676,935	631,648	7.31	6.59
1998/10/17	22.85	17.45	0.08	14.0					773,640	728,353	8.43	7.60	

Table 2.4.1 Estimated Daily Inflow to West Baray Reservoir in 1998 (2/2)

West Baray Reservoir		5.4 (Difference of datum)			A=		0.7 A=			Inflow			
Date	Water Stage	Water Stage	Variation	Rainfall	5-day	15.56 km2	5-day Lake	10 km2		Volume	-(R-E)	Flow	Flow
	(m, reading)	(m, MSL)	(m)	(mm)	(mm)	(m3)	(mm)	(m3)	R-E	(m3/d)	(m3/d)	(m3/s)	(m3/s)
				<R>	<R>		<E>		(m3)			25.7	23.2
				885.4	885.4		354.8		10.2				
1998/10/18	22.90	17.50	0.05	0.1						483,525	438,238	5.07	4.57
1998/10/19	22.95	17.55	0.05	9.0						483,525	438,238	5.07	4.57
1998/10/20	23.00	17.60	0.05							483,525	438,238	5.07	4.57
1998/10/21	23.07	17.67	0.07	0.3	0.4	6,224	13.3	133,000	-126,776	676,935	702,290	8.13	7.33
1998/10/22	23.10	17.70	0.03							290,115	315,470	3.65	3.29
1998/10/23	23.12	17.72	0.02							193,410	218,765	2.53	2.28
1998/10/24	23.13	17.73	0.01	0.1						96,705	122,060	1.41	1.27
1998/10/25	23.15	17.75	0.02							193,410	218,765	2.53	2.28
1998/10/26	23.20	17.80	0.05		0.3	4,668	16.0	159,600	-154,932	483,525	509,347	5.90	5.32
1998/10/27	23.30	17.90	0.10							967,050	992,872	11.49	10.36
1998/10/28	23.34	17.94	0.04	0.3						386,820	412,642	4.78	4.31
1998/10/29	23.35	17.95	0.01	0.0						96,705	122,527	1.42	1.28
1998/10/30	23.37	17.97	0.02	0.0						193,410	219,232	2.54	2.29
1998/10/31	23.40	18.00	0.03							290,115	315,937	3.66	3.30
1998/11/01	23.41	18.01	0.01	3.0	43.4	675,304	13.0	129,500	545,804	124,335	15,174	0.18	0.16
1998/11/02	23.42	18.02	0.01	40.4						124,335	15,174	0.18	0.16
1998/11/03	23.44	18.04	0.02							248,670	139,509	1.61	1.46
1998/11/04	23.45	18.05	0.01							124,335	15,174	0.18	0.16
1998/11/05	23.50	18.10	0.05							621,675	512,514	5.93	5.35
1998/11/06	23.55	18.15	0.05		12.0	186,720	13.0	129,500	57,220	621,675	610,231	7.06	6.37
1998/11/07	23.60	18.20	0.05							621,675	610,231	7.06	6.37
1998/11/08	23.65	18.25	0.05							621,675	610,231	7.06	6.37
1998/11/09	23.65	18.25	0.00	12.0						-	-11,444	0.00	0.00
1998/11/10	23.65	18.25	0.00							-	-11,444	0.00	0.00
1998/11/11	23.65	18.25	0.00		37.9	589,724	13.0	129,500	460,224	-	-11,444	0.00	0.00
1998/11/12	23.65	18.25	0.00							-	-11,444	0.00	0.00
1998/11/13	23.70	18.30	0.05							621,675	529,630	6.13	5.53
1998/11/14	23.74	18.34	0.04	0.7						497,340	405,295	4.69	4.23
1998/11/15	23.77	18.37	0.03	37.2						373,005	280,960	3.25	2.93
1998/11/16	23.80	18.40	0.03	0.3	75.3	1,171,668	13.0	129,500	1,042,168	373,005	164,571	1.90	1.72
1998/11/17	23.83	18.43	0.03							373,005	164,571	1.90	1.72
1998/11/18	23.87	18.47	0.04							497,340	288,906	3.34	3.02
1998/11/19	23.90	18.50	0.03							373,005	164,571	1.90	1.72
1998/11/20	23.90	18.50	0.00	75.0						-	-208,434	0.00	0.00
1998/11/21	23.90	18.50	0.00	11.9	24.9	387,444	13.0	129,500	257,944	-	-51,589	0.00	0.00
1998/11/22	23.90	18.50	0.00	12.6						-	-51,589	0.00	0.00
1998/11/23	23.90	18.50	0.00	0.4						-	-51,589	0.00	0.00
1998/11/24	23.90	18.50	0.00							-	-51,589	0.00	0.00
1998/11/25	23.90	18.50	0.00							-	-51,589	0.00	0.00
1998/11/26	23.91	18.51	0.01	15.8	16.2	252,072	13.0	129,500	122,572	124,335	99,821	1.16	1.04
1998/11/27	23.91	18.51	0.00	0.3						-	-24,514	0.00	0.00
1998/11/28	23.91	18.51	0.00							-	-24,514	0.00	0.00
1998/11/29	23.91	18.51	0.00	0.1						-	-24,514	0.00	0.00
1998/11/30	23.91	18.51	0.00	0.0						-	-24,514	0.00	0.00
1998/12/01	23.91	18.51	0.00	0.0	13.5	210,060	13.0	129,500	80,560	-	-16,112	0.00	0.00
1998/12/02	23.92	18.52	0.01	13.4						124,335	108,223	1.25	1.13
1998/12/03	23.94	18.54	0.02							248,670	232,558	2.69	2.43
1998/12/04	23.95	18.55	0.01	0.1						124,335	108,223	1.25	1.13
1998/12/05	23.97	18.57	0.02							248,670	232,558	2.69	2.43
1998/12/06	23.98	18.58	0.01		0.0	-	13.0	129,500	-129,500	124,335	150,235	1.74	1.57
1998/12/07	24.00	18.60	0.02							248,670	274,570	3.18	2.87
1998/12/08	23.99	18.59	-0.01										
1998/12/09	23.99	18.59	0.00										
1998/12/10	23.99	18.59	0.00										



<p>The Study on Water Supply System for Siem Reap Region in Cambodia</p>	<p>Figure 2.4.5 Estimated Daily Inflow to West Baray Reservoir in 1998</p>
<p>Japan International Cooperation Agency</p>	

Estimated Storage in West Baray in 1998 (Aug. 1 - Dec. 7)

Location	Total Capacity (10 ⁶ m ³)	Ratio (%)
Inflow from Siem Reap River (1)	23.2	70
Storage by Rainfall (2)	10.2	30
Total (1)+(2)	33.2	100

According to the level rising curve (refer to Figure 3.4.1), the level starts to rise from 19.5 m (approx. 14.1 m, MSL) on 1st of August, and reaches the highest at 24.0 m (approx. 18.6 m, MSL) on Dec. 7. The datum level of the reservoir is discussed in succeeding section 3. The gate at the outlet was closed during this period; there was no irrigation water supply. Water supply is generally commenced by the Hydrology Office from the end of November.

Storage by rainfall is estimated by using the total reservoir area of 15.56 km² and the daily rainfall record in 1998 at Siem Reap Airport located close to the reservoir.

Loss by evaporation is estimated by using the assumed water surface area of 10 km² and the monthly evaporation from the water surface derived from the pan evaporation at Siem Reap Airport (refer to Table 2.1.1). No evaporation data is available in 1998. The area of water surface gradually changes according to the water level, however, the area for this calculation is fixed at 10 km², present maximum area of water surface. According to “Water Resources Engineering (K. Linsley and Joseph B. Franzini)”, the relationship between pan evaporation and evaporation from the lake is 0.7 on average and the variation is 0.67 - 0.81. Therefore, the estimate is conducted roughly based on the following formulae:

$$E_r = 0.7 * E_p$$

where, E_r : Lake Evaporation

E_p : Pan Evaporation

(5) Daily Flow Hydrograph at French Weir

The daily flow hydrograph at the French Weir in 1998 is shown in Table 2.4.2 and Figure 2.4.6 by summing up 1) daily flow hydrograph at Prasat Keo and 2) daily inflow hydrograph to the West Baray. This hydrograph will be the basis of various kinds of flow regime analysis. The annual average flow is 2.62 m³/s. The daily minimum and maximum flows are 0.56 m³/s and 26.8 m³/s, respectively. The 5-day flow hydrograph at the weir is shown in Figure 2.4.7.

Table 2.4.2 Estimated Daily Flow of Siem Reap River in 1998 (1/6)

Date	Prasat Keo (1)		Estimated Inflow to West Baray Reservoir (2)		French Weir (Prasat Keo + Inflow to WBR) (1) + (2)	
	Daily (m ³ /s)	5-day (m ³ /s)	Daily (m ³ /s)	5-day (m ³ /s)	Daily (m ³ /s)	5-day (m ³ /s)
Volume (10⁶ m³)	59.7	60.0	23.2	23.0	82.9	83.0
1998/01/01	2.16	2.16	0.00	0.00	2.16	2.16
1998/01/02	2.16		0.00		2.16	
1998/01/03	2.16		0.00		2.16	
1998/01/04	2.16		0.00		2.16	
1998/01/05	2.16		0.00		2.16	
1998/01/06	2.16	2.16	0.00	0.00	2.16	2.16
1998/01/07	2.16		0.00		2.16	
1998/01/08	2.16		0.00		2.16	
1998/01/09	2.16		0.00		2.16	
1998/01/10	2.16		0.00		2.16	
1998/01/11	2.16	2.17	0.00	0.00	2.16	2.17
1998/01/12	2.16		0.00		2.16	
1998/01/13	2.16		0.00		2.16	
1998/01/14	2.18		0.00		2.18	
1998/01/15	2.19		0.00		2.19	
1998/01/16	2.11	2.03	0.00	0.00	2.11	2.03
1998/01/17	2.03		0.00		2.03	
1998/01/18	2.03		0.00		2.03	
1998/01/19	2.02		0.00		2.02	
1998/01/20	1.97		0.00		1.97	
1998/01/21	1.93	1.87	0.00	0.00	1.93	1.87
1998/01/22	1.88		0.00		1.88	
1998/01/23	1.88		0.00		1.88	
1998/01/24	1.84		0.00		1.84	
1998/01/25	1.80		0.00		1.80	
1998/01/26	1.76	1.68	0.00	0.00	1.76	1.68
1998/01/27	1.73		0.00		1.73	
1998/01/28	1.67		0.00		1.67	
1998/01/29	1.65		0.00		1.65	
1998/01/30	1.63		0.00		1.63	
1998/01/31	1.61		0.00		1.61	
1998/02/01	1.59	1.52	0.00	0.00	1.59	1.52
1998/02/02	1.57		0.00		1.57	
1998/02/03	1.51		0.00		1.51	
1998/02/04	1.46		0.00		1.46	
1998/02/05	1.48		0.00		1.48	
1998/02/06	1.50	1.44	0.00	0.00	1.50	1.44
1998/02/07	1.46		0.00		1.46	
1998/02/08	1.42		0.00		1.42	
1998/02/09	1.37		0.00		1.37	
1998/02/10	1.47		0.00		1.47	
1998/02/11	1.57	1.51	0.00	0.00	1.57	1.51
1998/02/12	1.54		0.00		1.54	
1998/02/13	1.51		0.00		1.51	
1998/02/14	1.49		0.00		1.49	
1998/02/15	1.46		0.00		1.46	
1998/02/16	1.44	1.38	0.00	0.00	1.44	1.38
1998/02/17	1.42		0.00		1.42	
1998/02/18	1.39		0.00		1.39	
1998/02/19	1.35		0.00		1.35	
1998/02/20	1.32		0.00		1.32	
1998/02/21	1.28	1.21	0.00	0.00	1.28	1.21
1998/02/22	1.25		0.00		1.25	
1998/02/23	1.21		0.00		1.21	
1998/02/24	1.17		0.00		1.17	
1998/02/25	1.14		0.00		1.14	
1998/02/26	1.10	1.10	0.00	0.00	1.10	1.10
1998/02/27	1.10		0.00		1.10	
1998/02/28	1.11		0.00		1.11	
1998/03/01	1.11	1.23	0.00	0.00	1.11	1.23
1998/03/02	1.12		0.00		1.12	
1998/03/03	1.12		0.00		1.12	
1998/03/04	1.30		0.00		1.30	
1998/03/05	1.49		0.00		1.49	

Table 2.4.2 Estimated Daily Flow of Siem Reap River in 1998 (2/6)

Date	Prasat Keo (1)		Estimated Inflow to West Baray Reservoir (2)		French Weir (Prasat Keo + Inflow to WBR) (1) + (2)	
	Daily (m ³ /s)	5-day (m ³ /s)	Daily (m ³ /s)	5-day (m ³ /s)	Daily (m ³ /s)	5-day (m ³ /s)
Volume (10⁶ m³)	59.7	60.0	23.2	23.0	82.9	83.0
1998/03/06	1.67	2.03	0.00	0.00	1.67	2.03
1998/03/07	1.85		0.00		1.85	
1998/03/08	2.03		0.00		2.03	
1998/03/09	2.22		0.00		2.22	
1998/03/10	2.40		0.00		2.40	
1998/03/11	2.58	2.15	0.00	0.00	2.58	2.15
1998/03/12	2.36		0.00		2.36	
1998/03/13	2.15		0.00		2.15	
1998/03/14	1.93		0.00		1.93	
1998/03/15	1.72		0.00		1.72	
1998/03/16	1.50	1.19	0.00	0.00	1.50	1.19
1998/03/17	1.29		0.00		1.29	
1998/03/18	1.07		0.00		1.07	
1998/03/19	1.05		0.00		1.05	
1998/03/20	1.03		0.00		1.03	
1998/03/21	1.01	0.98	0.00	0.00	1.01	0.98
1998/03/22	1.00		0.00		1.00	
1998/03/23	0.98		0.00		0.98	
1998/03/24	0.96		0.00		0.96	
1998/03/25	0.94		0.00		0.94	
1998/03/26	0.94	0.93	0.00	0.00	0.94	0.93
1998/03/27	0.93		0.00		0.93	
1998/03/28	0.93		0.00		0.93	
1998/03/29	0.93		0.00		0.93	
1998/03/30	0.92		0.00		0.92	
1998/03/31	0.92		0.00		0.92	
1998/04/01	0.91	0.90	0.00	0.00	0.91	0.90
1998/04/02	0.91		0.00		0.91	
1998/04/03	0.91		0.00		0.91	
1998/04/04	0.90		0.00		0.90	
1998/04/05	0.88		0.00		0.88	
1998/04/06	0.87	0.84	0.00	0.00	0.87	0.84
1998/04/07	0.85		0.00		0.85	
1998/04/08	0.84		0.00		0.84	
1998/04/09	0.82		0.00		0.82	
1998/04/10	0.81		0.00		0.81	
1998/04/11	0.80	0.79	0.00	0.00	0.80	0.79
1998/04/12	0.80		0.00		0.80	
1998/04/13	0.79		0.00		0.79	
1998/04/14	0.79		0.00		0.79	
1998/04/15	0.78		0.00		0.78	
1998/04/16	0.78	0.87	0.00	0.00	0.78	0.87
1998/04/17	0.77		0.00		0.77	
1998/04/18	0.85		0.00		0.85	
1998/04/19	0.93		0.00		0.93	
1998/04/20	1.01		0.00		1.01	
1998/04/21	1.08	1.21	0.00	0.00	1.08	1.21
1998/04/22	1.16		0.00		1.16	
1998/04/23	1.24		0.00		1.24	
1998/04/24	1.32		0.00		1.32	
1998/04/25	1.25		0.00		1.25	
1998/04/26	1.18	1.05	0.00	0.00	1.18	1.05
1998/04/27	1.11		0.00		1.11	
1998/04/28	1.05		0.00		1.05	
1998/04/29	0.98		0.00		0.98	
1998/04/30	0.91		0.00		0.91	
1998/05/01	0.84	0.79	0.00	0.00	0.84	0.79
1998/05/02	0.77		0.00		0.77	
1998/05/03	0.77		0.00		0.77	
1998/05/04	0.78		0.00		0.78	
1998/05/05	0.78		0.00		0.78	
1998/05/06	0.78	0.79	0.00	0.00	0.78	0.79
1998/05/07	0.78		0.00		0.78	
1998/05/08	0.79		0.00		0.79	
1998/05/09	0.79		0.00		0.79	
1998/05/10	0.79		0.00		0.79	

Table 2.4.2 Estimated Daily Flow of Siem Reap River in 1998 (3/6)

Date	Prasat Keo (1)		Estimated Inflow to West Baray Reservoir (2)		French Weir (Prasat Keo + Inflow to WBR) (1) + (2)	
	Daily (m ³ /s)	5-day (m ³ /s)	Daily (m ³ /s)	5-day (m ³ /s)	Daily (m ³ /s)	5-day (m ³ /s)
Volume (10 ⁶ m ³)	59.7	60.0	23.2	23.0	82.9	83.0
1998/05/11	0.79	0.78	0.00	0.00	0.79	0.78
1998/05/12	0.79		0.00		0.79	
1998/05/13	0.78		0.00		0.78	
1998/05/14	0.78		0.00		0.78	
1998/05/15	0.78		0.00		0.78	
1998/05/16	0.78	0.72	0.00	0.00	0.78	0.72
1998/05/17	0.75		0.00		0.75	
1998/05/18	0.72		0.00		0.72	
1998/05/19	0.69		0.00		0.69	
1998/05/20	0.65		0.00		0.65	
1998/05/21	0.62	0.59	0.00	0.00	0.62	0.59
1998/05/22	0.59		0.00		0.59	
1998/05/23	0.56		0.00		0.56	
1998/05/24	0.57		0.00		0.57	
1998/05/25	0.59		0.00		0.59	
1998/05/26	0.60	0.64	0.00	0.00	0.60	0.64
1998/05/27	0.62		0.00		0.62	
1998/05/28	0.63		0.00		0.63	
1998/05/29	0.65		0.00		0.65	
1998/05/30	0.66		0.00		0.66	
1998/05/31	0.70		0.00		0.70	
1998/06/01	0.74	0.83	0.00	0.00	0.74	0.83
1998/06/02	0.78		0.00		0.78	
1998/06/03	0.83		0.00		0.83	
1998/06/04	0.87		0.00		0.87	
1998/06/05	0.91		0.00		0.91	
1998/06/06	0.95	0.90	0.00	0.00	0.95	0.90
1998/06/07	0.93		0.00		0.93	
1998/06/08	0.90		0.00		0.90	
1998/06/09	0.88		0.00		0.88	
1998/06/10	0.86		0.00		0.86	
1998/06/11	0.84	0.80	0.00	0.00	0.84	0.80
1998/06/12	0.81		0.00		0.81	
1998/06/13	0.79		0.00		0.79	
1998/06/14	0.78		0.00		0.78	
1998/06/15	0.78		0.00		0.78	
1998/06/16	0.77	0.75	0.00	0.00	0.77	0.75
1998/06/17	0.76		0.00		0.76	
1998/06/18	0.75		0.00		0.75	
1998/06/19	0.75		0.00		0.75	
1998/06/20	0.74		0.00		0.74	
1998/06/21	0.74	0.74	0.00	0.00	0.74	0.74
1998/06/22	0.74		0.00		0.74	
1998/06/23	0.74		0.00		0.74	
1998/06/24	0.74		0.00		0.74	
1998/06/25	0.74		0.00		0.74	
1998/06/26	0.74	0.86	0.00	0.00	0.74	0.86
1998/06/27	0.74		0.00		0.74	
1998/06/28	0.84		0.00		0.84	
1998/06/29	0.93		0.00		0.93	
1998/06/30	1.03		0.00		1.03	
1998/07/01	1.12	1.28	0.00	0.00	1.12	1.28
1998/07/02	1.22		0.00		1.22	
1998/07/03	1.31		0.00		1.31	
1998/07/04	1.41		0.00		1.41	
1998/07/05	1.34		0.00		1.34	
1998/07/06	1.27	1.13	0.00	0.00	1.27	1.13
1998/07/07	1.20		0.00		1.20	
1998/07/08	1.13		0.00		1.13	
1998/07/09	1.06		0.00		1.06	
1998/07/10	0.99		0.00		0.99	
1998/07/11	0.92	0.90	0.00	0.00	0.92	0.90
1998/07/12	0.91		0.00		0.91	
1998/07/13	0.90		0.00		0.90	
1998/07/14	0.89		0.00		0.89	
1998/07/15	0.89		0.00		0.89	

Table 2.4.2 Estimated Daily Flow of Siem Reap River in 1998 (4/6)

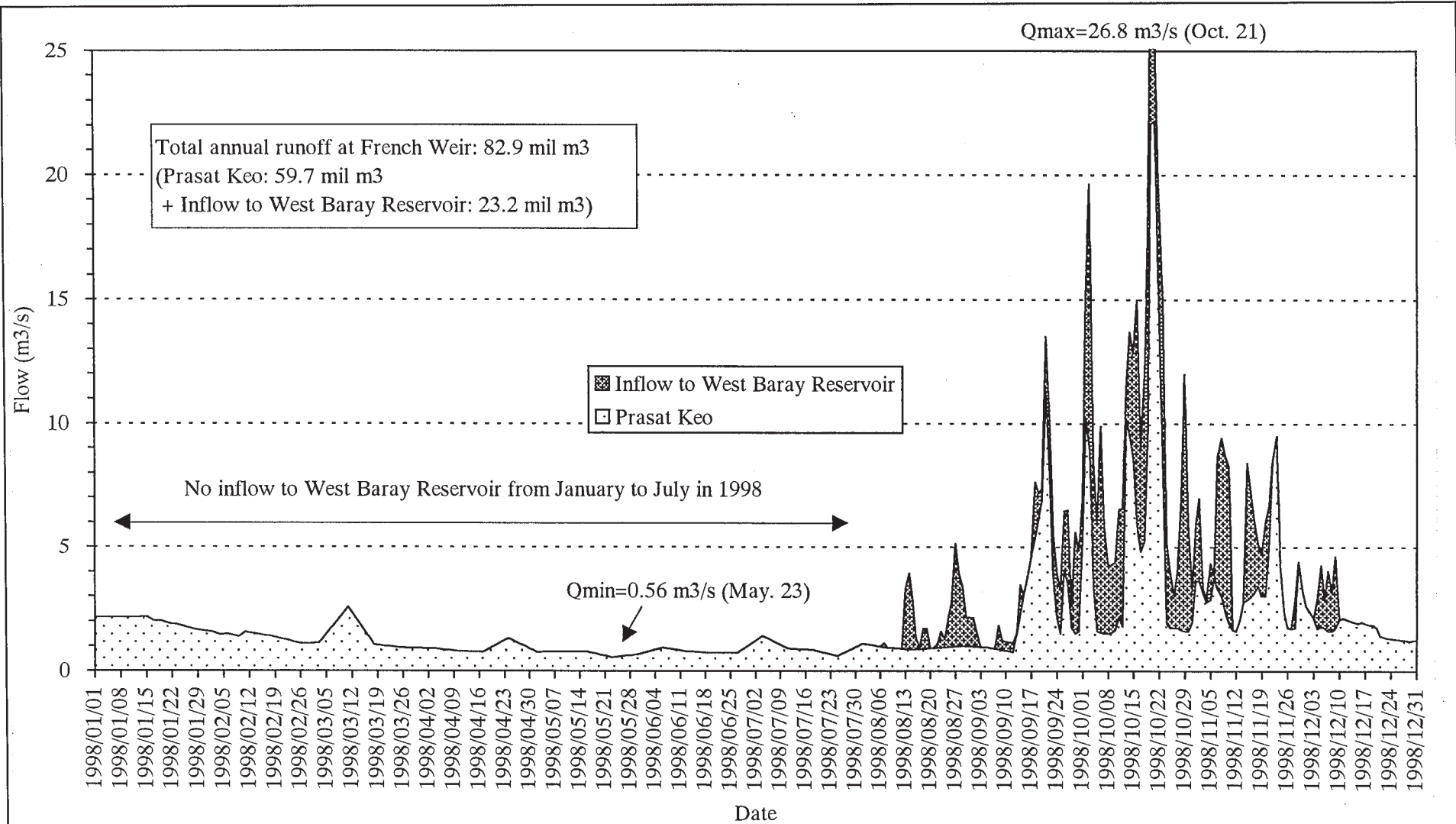
Date	Prasat Keo (1)		Estimated Inflow to West Baray Reservoir (2)		French Weir (Prasat Keo + Inflow to WBR) (1) + (2)	
	Daily (m ³ /s)	5-day (m ³ /s)	Daily (m ³ /s)	5-day (m ³ /s)	Daily (m ³ /s)	5-day (m ³ /s)
Volume (10⁶ m³)	59.7	60.0	23.2	23.0	82.9	83.0
1998/07/16	0.88	0.84	0.00	0.00	0.88	0.84
1998/07/17	0.87		0.00		0.87	
1998/07/18	0.86		0.00		0.86	
1998/07/19	0.82		0.00		0.82	
1998/07/20	0.79		0.00		0.79	
1998/07/21	0.75	0.68	0.00	0.00	0.75	0.68
1998/07/22	0.72		0.00		0.72	
1998/07/23	0.68		0.00		0.68	
1998/07/24	0.65		0.00		0.65	
1998/07/25	0.61		0.00		0.61	
1998/07/26	0.68	0.86	0.00	0.00	0.68	0.86
1998/07/27	0.75		0.00		0.75	
1998/07/28	0.82		0.00		0.82	
1998/07/29	0.89		0.00		0.89	
1998/07/30	0.96		0.00		0.96	
1998/07/31	1.03		0.00		1.03	
1998/08/01	1.10	1.06	0.00	0.00	1.10	1.06
1998/08/02	1.08		0.00		1.08	
1998/08/03	1.06		0.00		1.06	
1998/08/04	1.04		0.00		1.04	
1998/08/05	1.01		0.00		1.01	
1998/08/06	0.99	0.96	0.00	0.03	0.99	0.99
1998/08/07	0.97		0.16		1.13	
1998/08/08	0.95		0.00		0.95	
1998/08/09	0.94		0.00		0.94	
1998/08/10	0.93		0.00		0.93	
1998/08/11	0.92	0.89	0.00	1.50	0.92	2.39
1998/08/12	0.90		0.00		0.90	
1998/08/13	0.89		2.39		3.28	
1998/08/14	0.88		3.05		3.93	
1998/08/15	0.87		2.06		2.93	
1998/08/16	0.88	0.90	0.41	0.42	1.29	1.32
1998/08/17	0.89		0.08		0.97	
1998/08/18	0.90		0.81		1.71	
1998/08/19	0.91		0.81		1.72	
1998/08/20	0.92		0.00		0.92	
1998/08/21	0.93	0.95	0.00	0.46	0.93	1.41
1998/08/22	0.94		0.15		1.09	
1998/08/23	0.95		0.65		1.60	
1998/08/24	0.96		0.32		1.28	
1998/08/25	0.97		1.18		2.15	
1998/08/26	0.98	1.00	1.77	2.26	2.75	3.26
1998/08/27	0.99		4.15		5.14	
1998/08/28	1.00		2.95		3.95	
1998/08/29	1.01		2.35		3.36	
1998/08/30	1.00		1.16		2.16	
1998/08/31	1.00		1.16		2.16	
1998/09/01	0.99	0.97	1.16	0.35	2.15	1.32
1998/09/02	0.98		0.57		1.55	
1998/09/03	0.97		0.00		0.97	
1998/09/04	0.97		0.00		0.97	
1998/09/05	0.96		0.00		0.96	
1998/09/06	0.93	0.88	0.00	0.33	0.93	1.21
1998/09/07	0.91		0.00		0.91	
1998/09/08	0.88		0.95		1.83	
1998/09/09	0.85		0.36		1.21	
1998/09/10	0.82		0.36		1.18	
1998/09/11	0.80	1.70	0.36	0.38	1.16	2.08
1998/09/12	0.77		0.36		1.13	
1998/09/13	1.54		0.00		1.54	
1998/09/14	2.30		1.16		3.46	
1998/09/15	3.07		0.00		3.07	
1998/09/16	3.84	5.37	0.00	0.75	3.84	6.12
1998/09/17	4.60		0.00		4.60	
1998/09/18	5.37		2.24		7.61	
1998/09/19	6.13		1.05		7.18	
1998/09/20	6.90		0.46		7.36	

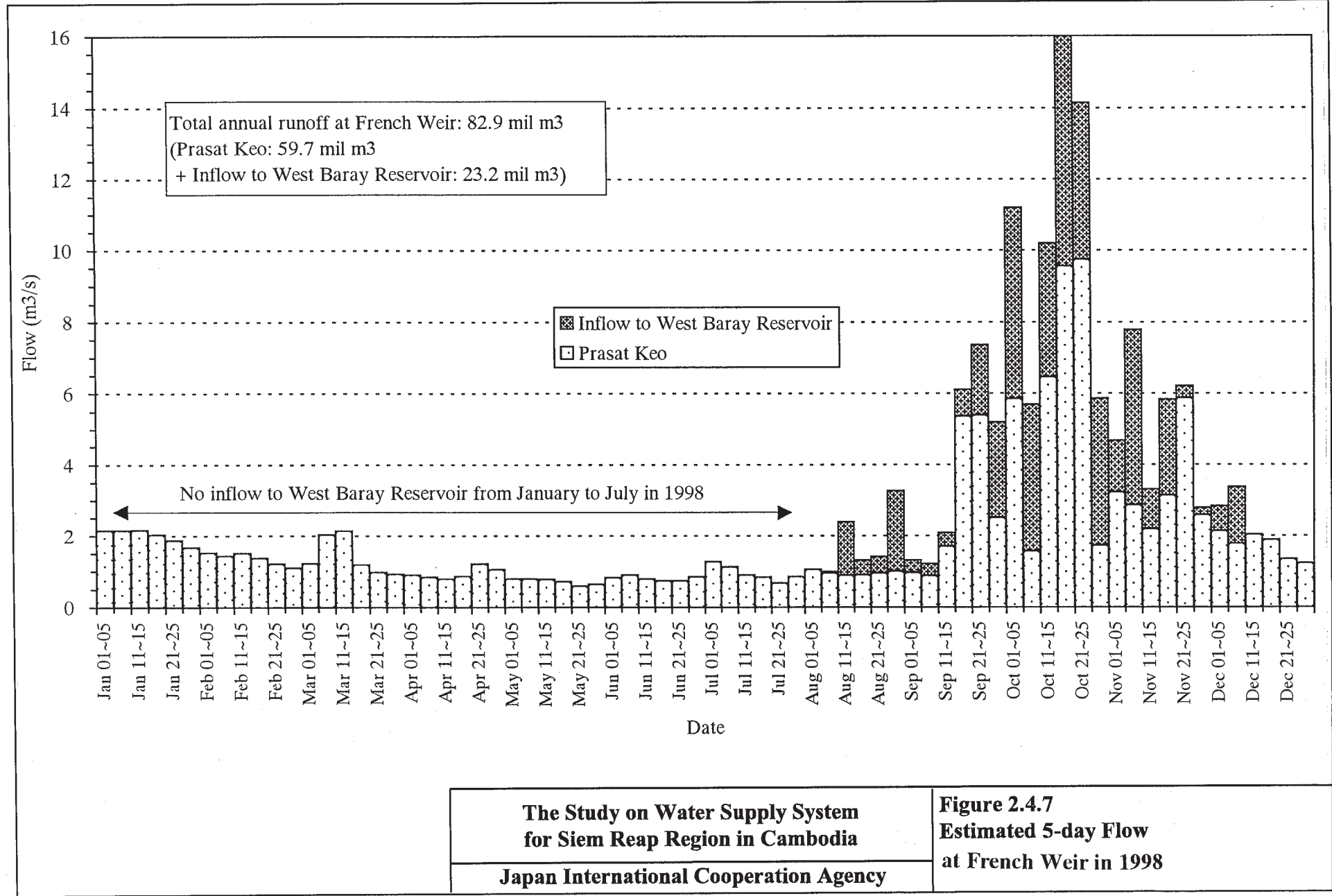
Table 2.4.2 Estimated Daily Flow of Siem Reap River in 1998 (5/6)

Date	Prasat Keo (1)		Estimated Inflow to West Baray Reservoir (2)		French Weir (Prasat Keo + Inflow to WBR) (1) + (2)	
	Daily (m ³ /s)	5-day (m ³ /s)	Daily (m ³ /s)	5-day (m ³ /s)	Daily (m ³ /s)	5-day (m ³ /s)
Volume (10⁶ m³)	59.7	60.0	23.2	23.0	82.9	83.0
1998/09/21	11.28	5.40	2.24	1.96	13.52	7.36
1998/09/22	8.36		2.24		10.60	
1998/09/23	3.72		1.77		5.49	
1998/09/24	2.15		1.77		3.92	
1998/09/25	1.51		1.77		3.28	
1998/09/26	4.08	2.50	2.37	2.71	6.45	5.21
1998/09/27	3.54		2.96		6.50	
1998/09/28	1.76		0.86		2.62	
1998/09/29	1.51		4.07		5.58	
1998/09/30	1.61		3.27		4.88	
1998/10/01	5.22	5.86	1.66	5.33	6.88	11.19
1998/10/02	10.16		4.87		15.03	
1998/10/03	8.91		10.72		19.63	
1998/10/04	3.42		5.10		8.52	
1998/10/05	1.61		4.29		5.90	
1998/10/06	1.56	1.56	8.31	4.15	9.87	5.71
1998/10/07	1.51		4.29		5.80	
1998/10/08	1.51		2.72		4.23	
1998/10/09	1.56		2.72		4.28	
1998/10/10	1.66		2.72		4.38	
1998/10/11	2.21	6.46	4.33	3.74	6.54	10.20
1998/10/12	1.81		4.76		6.57	
1998/10/13	10.16		1.19		11.35	
1998/10/14	9.48		4.21		13.69	
1998/10/15	8.63		4.21		12.84	
1998/10/16	5.73	9.55	9.26	6.45	14.99	16.00
1998/10/17	4.81		4.21		9.02	
1998/10/18	5.29		6.59		11.88	
1998/10/19	9.86		7.60		17.46	
1998/10/20	22.04		4.57		26.61	
1998/10/21	22.19	9.74	4.57	4.41	26.76	14.15
1998/10/22	14.99		4.57		19.56	
1998/10/23	7.83		7.33		15.16	
1998/10/24	1.92		3.29		5.21	
1998/10/25	1.76		2.28		4.04	
1998/10/26	1.76	1.73	1.27	4.14	3.03	5.87
1998/10/27	1.76		2.28		4.04	
1998/10/28	1.66		5.32		6.98	
1998/10/29	1.61		10.36		11.97	
1998/10/30	1.61		4.31		5.92	
1998/10/31	1.98		1.28		3.26	
1998/11/01	3.60	3.21	2.29	1.47	5.89	4.68
1998/11/02	3.66		3.30		6.96	
1998/11/03	3.14		0.16		3.30	
1998/11/04	2.77		0.16		2.93	
1998/11/05	2.87		1.46		4.33	
1998/11/06	3.72	2.87	0.16	4.92	3.88	7.79
1998/11/07	3.31		5.35		8.66	
1998/11/08	3.03		6.37		9.40	
1998/11/09	2.39		6.37		8.76	
1998/11/10	1.92		6.37		8.29	
1998/11/11	1.66	2.20	0.00	1.11	1.66	3.31
1998/11/12	1.61		0.00		1.61	
1998/11/13	2.09		0.00		2.09	
1998/11/14	2.77		0.00		2.77	
1998/11/15	2.87		5.53		8.40	
1998/11/16	2.98	3.12	4.23	2.72	7.21	5.84
1998/11/17	3.14		2.93		6.07	
1998/11/18	3.42		1.72		5.14	
1998/11/19	3.03		1.72		4.75	
1998/11/20	3.03		3.02		6.05	
1998/11/21	4.94	5.88	1.72	0.34	6.66	6.22
1998/11/22	8.45		0.00		8.45	
1998/11/23	9.48		0.00		9.48	
1998/11/24	4.21		0.00		4.21	
1998/11/25	2.32		0.00		2.32	

Table 2.4.2 Estimated Daily Flow of Siem Reap River in 1998 (6/6)

Date	Prasat Keo (1)		Estimated Inflow to West Baray Reservoir (2)		French Weir (Prasat Keo + Inflow to WBR) (1) + (2)	
	Daily (m ³ /s)	5-day (m ³ /s)	Daily (m ³ /s)	5-day (m ³ /s)	Daily (m ³ /s)	5-day (m ³ /s)
Volume (10⁶ m³)	59.7	60.0	23.2	23.0	82.9	83.0
1998/11/26	1.76	2.58	0.00	0.21	1.76	2.79
1998/11/27	1.71		0.00			
1998/11/28	1.76		1.04			
1998/11/29	4.40		0.00			
1998/11/30	3.25		0.00			
1998/12/01	2.61	2.13	0.00	0.71	2.61	2.84
1998/12/02	2.39		0.00			
1998/12/03	2.15		0.00			
1998/12/04	1.71		1.13			
1998/12/05	1.81		2.43			
1998/12/06	1.76	1.77	1.13	1.60	2.89	3.37
1998/12/07	1.61		2.43			
1998/12/08	1.61		1.57			
1998/12/09	1.76		2.87			
1998/12/10	2.09		0.00			
1998/12/11	2.15	2.03	0.00	0.00	2.15	2.03
1998/12/12	2.09		0.00			
1998/12/13	2.03		0.00			
1998/12/14	1.98		0.00			
1998/12/15	1.92		0.00			
1998/12/16	1.98	1.88	0.00	0.00	1.98	1.88
1998/12/17	1.92		0.00			
1998/12/18	1.87		0.00			
1998/12/19	1.87		0.00			
1998/12/20	1.76		0.00			
1998/12/21	1.41	1.34	0.00	0.00	1.41	1.34
1998/12/22	1.37		0.00			
1998/12/23	1.32		0.00			
1998/12/24	1.32		0.00			
1998/12/25	1.28		0.00			
1998/12/26	1.28	1.23	0.00	0.00	1.28	1.23
1998/12/27	1.23		0.00			
1998/12/28	1.23		0.00			
1998/12/29	1.19		0.00			
1998/12/30	1.23		0.00			
1998/12/31	1.23		0.00			





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Figure 2.4.7
Estimated 5-day Flow
at French Weir in 1998

The estimated annual runoff capacity are summarized as follows:

Estimated Annual Runoff Volume of Siem Reap River in 1998

Location	Annual Runoff Capacity (10 ⁶ m ³)	Ratio (%)
Prasat Keo (1)	59.7	72
Inflow to the reservoir (2)	23.2	28
French Weir (1)+(2)	82.9	100

(6) Runoff Ratio

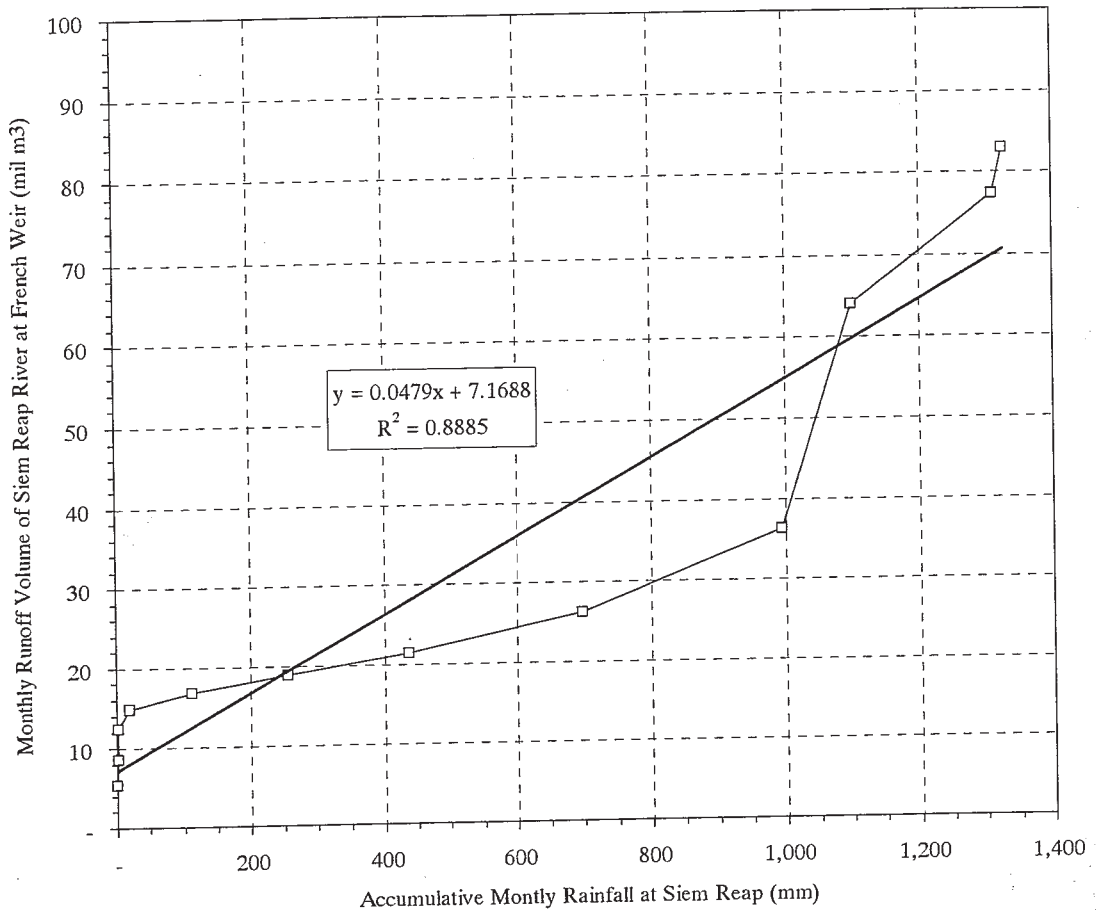
The double mass curve of the monthly runoff in 1998 is shown in Figure 2.4.8. The annual runoff ratio is estimated at 0.13 as shown in the figure. The runoff ratio of the adjacent Roluos River has been estimated at 0.11 by “Water Management in the Angkor Area” (Angkor Foundation - Hungary, 1993) (Hungarian Study, 1993). Therefore, the ratio in the Siem Reap River can be judged reasonable. The ratio of both rivers are summarized as follows:

	Siem Reap River (year 1998)	Roluos River (year 1962-1963)
Catchment area (km)	500 (at French Weir)	281 (at Kompong Thkeu)
Annual runoff height (mm)	166	160
Annual rainfall in Siem Reap (mm)	1,326	1,434
Runoff ratio	0.13	0.11

It is said that the rainfalls in the Kulen Mountains are more than 1.2 times as heavy as at Siem Reap. However, no data is available at the mountains, therefore, the ratio has to be roughly estimated only by the rainfall at Siem Reap.

(7) Flow Duration

Flow duration of the Siem Reap River in 1998 is analyzed as shown in Figure 2.4.9. The drought flow (355-day flow) at the French Weir and the Angkor Bridge are 0.65 m³/s and 0.81 m³/s, respectively.



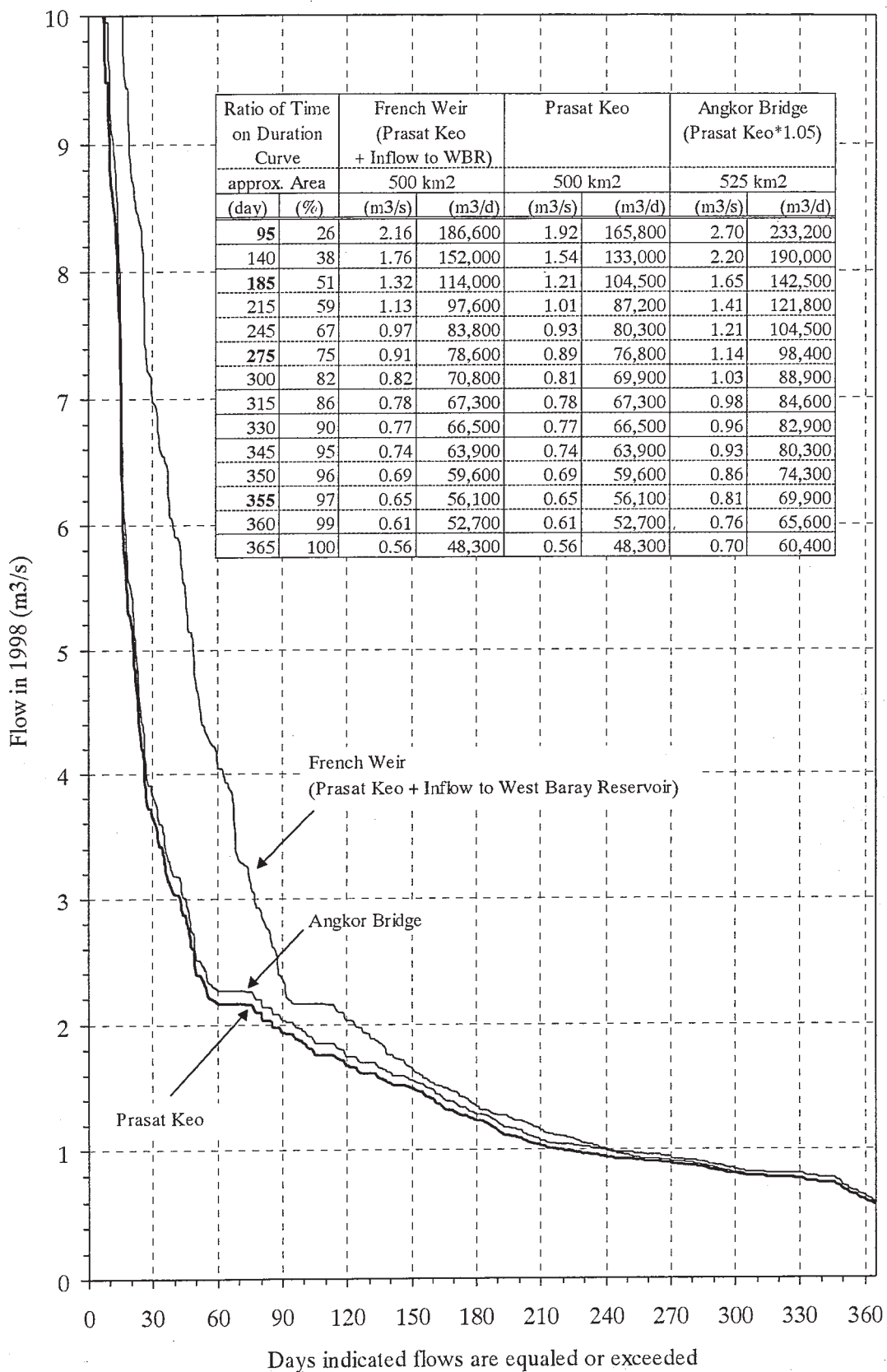
French Weir <Prasat Keo + Inflow to West Baray Reservoir>

Month	Monthly Mean Flow (m ³ /s)	Runoff Volume			Rainfall (Siem Reap)	
		Monthly (10 ⁶ m ³)	Accumulative (10 ⁶ m ³)	(mm)	Monthly	Accumulative
					(mm)	(mm)
Jan	2.00	5.36	5.36	10.7	0.0	0.0
Feb	1.38	3.34	8.70	17.4	1.3	1.3
Mar	1.40	3.75	12.45	24.9	0.0	1.3
Apr	0.94	2.44	14.89	29.8	18.2	19.5
May	0.72	1.93	16.82	33.6	92.3	111.8
Jun	0.81	2.10	18.92	37.8	145.2	257.0
Jul	0.95	2.54	21.46	42.9	180.8	437.8
Aug	1.79	4.79	26.25	52.5	259.3	697.1
Sep	3.88	10.06	36.31	72.6	296.8	993.9
Oct	10.37	27.78	64.09	128.2	106.4	1,100.3
Nov	5.11	13.25	77.34	154.7	209.7	1,310.0
Dec	2.09	5.60	82.94	165.9	16.1	1,326.1
Average	2.62	6.91			110.5	
A= 500 km ² (approx.)						
Runoff Coefficient = 0.13						

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Figure 2.4.8
Double Mass Curve of Siem Reap River in 1998
<at French Weir>



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Figure 2.4.9
Flow Duration of Siem Reap River in 1998

2.5 Irrigation System

(1) Irrigation Area

Two major irrigation systems, namely the West Baray System and the Crocodile Weir System occupy the majority of the irrigated area in the Study Area. The area of two systems is shown in Table 2.5.1. The supplied water is currently considered used at low efficiency due to the deterioration of the irrigation canal network, poorly organized irrigation control and the lack of true demand. The reconstruction work on the irrigation project is still under way.

In the rainy season, large irrigation areas are inundated by the expansion of the Lake Tonle Sap and the inundation is beneficial to agriculture by leaving fertile silt deposits over the land. Accordingly, the most fertile area is spreading near the lakeshore and the least fertile area is located just along the National Road No. 6.

The water intake amount for irrigation is unknown, since no regulation exists on water use right for the Siem Reap River and the West Baray. Therefore, the flows on the irrigation canals have been measured by the Study Team since 1997 as shown in Figure 2.5.1.

(2) West Baray Irrigation System

1) General

The West Baray irrigation system, principal system in the Study Area, is supplied water from the reservoir. In the rainy season, the reservoir water is fed by the inflow from the Siem Reap River and by direct rainfall. In the dry season, the water is supplied for irrigation from the reservoir outlet structure to Canal B and then distributed to several canals at the distribution structure located beside the National Road No. 6. The flow capacity of Canal B is 9 m³/s.

The average irrigated area is approximately 6,300 ha (refer to Table 2.5.1). The latest irrigation canal network map is not available so far, therefore the network as of 1960's is shown in Figure 2.5.2 instead. Major irrigated area is currently spreading south of Canal-C5, Dam 78 and no irrigated rice is fed along Canal-C3. Canal-C1 along the national road is not in use at present.

Table 2.5.1 Major Irrigation Area in Siem Reap Region

Irrigation System from West Baray Reservoir

unit: ha

Year	Floating Rice A	Rainfed Rice B	Receding Rice C	Irrigated Rice D	Total	Irrigated Area A+C+D
1986	942	776	1,240	492	3,450	2,674
1987	no data	no data	no data	no data	-	-
1988	1,288	2,262	2,850	2,638	9,038	6,776
1989	no data	331	12,980	no data	13,311	12,980
1990	no data	2,192	476	2,263	4,931	2,739
1991	no data	800	320	6,286	7,406	6,606
1992	no data	549	2,414	1,462	4,425	3,876
1993	no data	400	750	2,950	4,100	3,700
1994	no data	1,677	2,071	5,163	8,911	7,234
1995	no data	1,124	3,622	3,054	7,800	6,676
1996	no data	782	3,908	3,200	7,890	7,108
1997	215	745	2,440	(90)	-	-
1998	917	2,526	6,314	2,290	12,047	9,521
Average					7,574	6,354

Irrigation System from Crocodile Weir

unit: ha

Year	Floating Rice A	Rainfed Rice B	Receding Rice C	Irrigated Rice D	Total	Irrigated Area A+C+D
1986	106	111	805	50	1,072	961
1987	no data	no data	no data	no data	-	-
1988	65	724	1,644	1,640	4,073	3,349
1989	no data	664	2,849	no data	3,513	2,849
1990	no data	890	181	2,600	3,671	2,781
1991	no data	504	85	5,626	6,214	5,711
1992	no data	160	1,766	985	2,911	2,751
1993	no data	236	440	1,515	2,191	1,955
1994	no data	500	196	1,018	1,714	1,214
1995	no data	no data	602	1,177	1,779	1,779
1996	no data	172	760	485	1,417	1,245
1997	14	52	227	174	467	415
1998	no data	808	1,250	2,650	4,708	3,900
Average					2,811	2,409

Note:

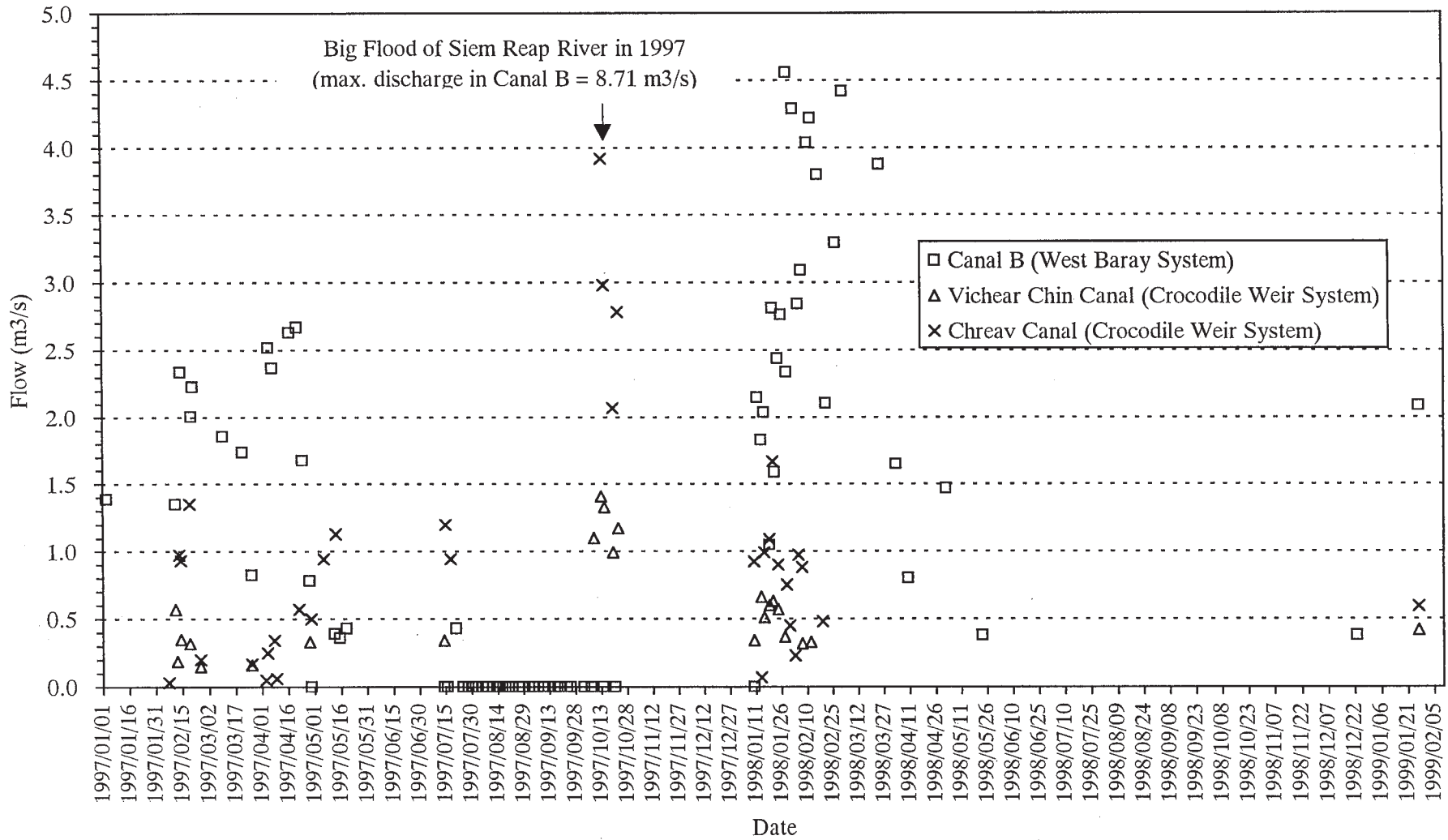
Floating rice area = Northern area along Dam 78

Rainfed rice area = Area between national road 6 and Canal-5

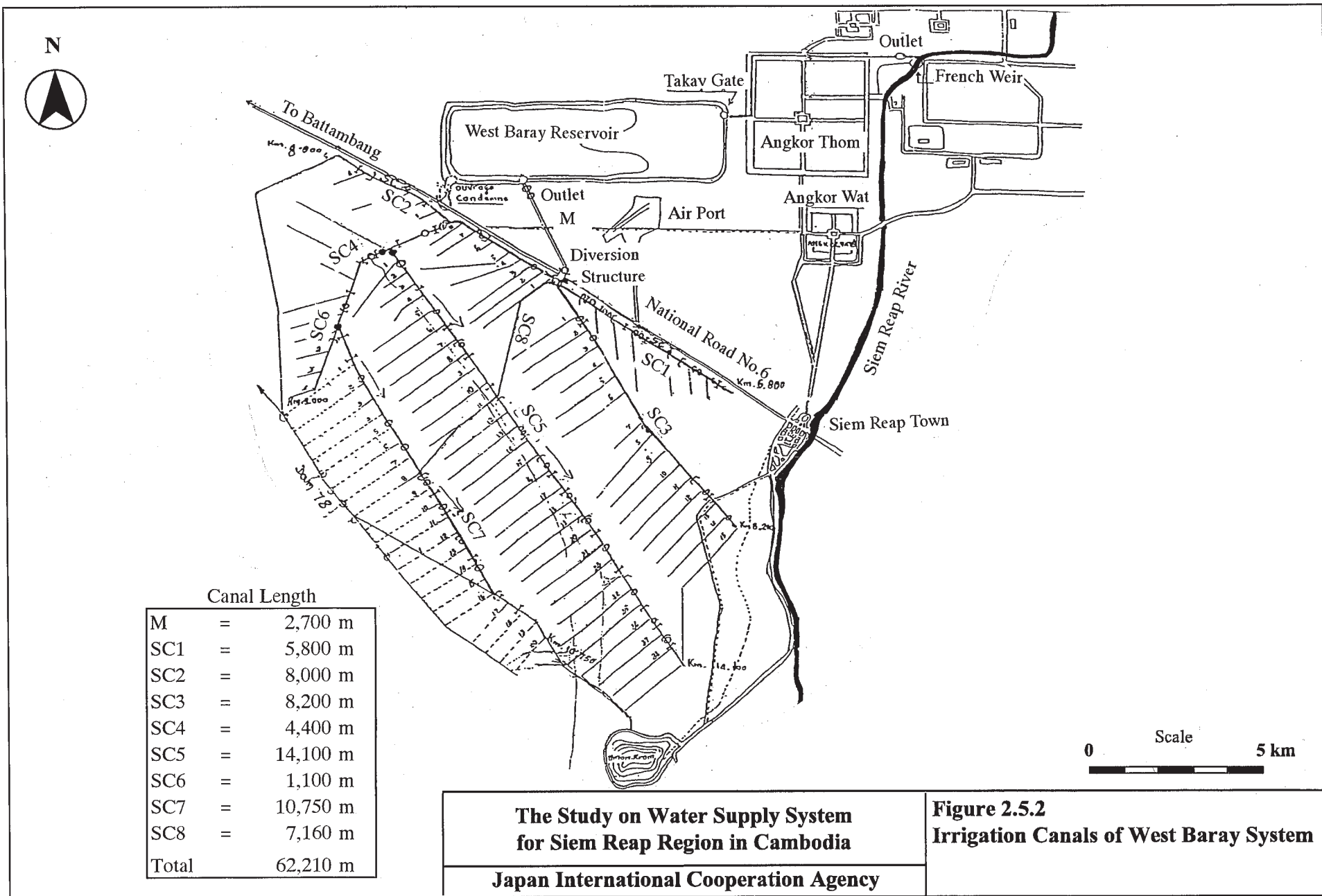
Receding rice area = Area between Canal-5 (shoreline of Lake Tonle Sap in rainy season) and Dam

Irrigated rice area = Southern area extending from Dam 78

Source: "Annual Cultivated Area Reports" by Hydrology Office in Siem Reap, MOA



<p>The Study on Water Supply System for Siem Reap Region in Cambodia</p>	<p>Figure 2.5.1 Observed Flows on Irrigation Canals <1997 - 1999></p>
<p>Japan International Cooperation Agency</p>	



**The Study on Water Supply System
for Siem Reap Region in Cambodia**

Japan International Cooperation Agency

**Figure 2.5.2
Irrigation Canals of West Baray System**

No relationship between discharge, gate opening ratio and reservoir water level has been established. According to the periodical flow measurements by the Study Team, the intake amount is approximately 2 m³/s in average except for the urgent discharge after the remarkable flood in 1997 (refer to Figure 2.5.1). According to the water balance review conducted in succeeding section 3, the average discharge from the reservoir is also estimated around 2 m³/s.

2) History

According to previous studies, the reconstruction of ancient irrigation system was implemented as follows:

History of West Baray Irrigation System

Year	Construction Items
1937	Construction of the French Weir
1939	Feeding canal from the French Weir to the West Baray Reservoir
1940	Construction of outlet structure of the reservoir
1943 - 1945	Structures on the irrigation canals
1953 - 1959	Reconstruction of the French Weir and Road on the crest of the ring dike
1983	Supplement of a turbine and a generator at the French Weir sluice

At the French Weir, the elevation of the overflow weir is approximately 22.6 m. The overflow weir automatically falls down when the weir receive 10 ton pressure in the flooding and automatically rise again as the water level decrease.

3) Operation of Irrigation System

The Hydrology Office operates the reservoir, the French Weir and relating structures (refer to table below), no operation manual is available, though. Actual condition is that the French Weir, the American and Takav Gates are currently deteriorated and it can not be operated properly. However, according to the interview survey at the Hydrology Office, the procedures of gate operation are described below:

The sluice gate at the French Weir is closed generally in June in the rainy season to store the water of the Siem Reap River to the reservoir via the Canal A. The American and Takav Gates are opened at that time.

The gates are closed and then the sluice of the weir is opened to stop the inflow from the river after the reservoir level reaches to the standard level at

25 m (approx. 19.6 m, MSL) around October to December.

The water supply from the reservoir is started generally from the end of November according to the request by the representative of farmers. The water supply period is divided into two terms: 1) the end of November - the end of January (Canal-C2 and C8) and 2) middle of February - April or May (Canal-C2, C3 and C8). The supply is once stopped to harvest rice in the beginning of February.

The gate operation pattern in typical year will be summarized as follows:

Typical Operation of West Baray Irrigation System

No.	Weir and Gate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	French Weir Sluice Gate on Siem Reap River	○	○	○	○	○	-	-	-	-	-	-	○
2	USA Gate on Canal A	○	○	○	○	○	○	○	○	○	○	○	○
3	Takav Gate on Canal A	○	○	○	○	○	○	○	○	○	○	○	○
4	Outlet of West Baray	○	(~15) ○ (15~)	○	○	○	-	-	-	-	-	-	○
5	Irrigation Canals (Canal-C2, C3 and C8)	○	(~15) ○ (15~)	○	○	○	-	-	-	-	-	-	○

Legend: ○: Open -: Close

The main function of the American and Takav Gates is to stop and/or regulate the flood flow from the Siem Reap River in the rainy season. The water supply to the moat of Angkor Wat from the Canal A is carried out by closing the Takav Gate only at the time of the Water Festival.

(3) Crocodile Weir Irrigation System

The Crocodile Weir irrigation system is supplied water from the Siem Reap River. The water is supplied through two irrigation canals, namely the Vichear Chin Canal on the right bank and the Chreav Canal on the left bank, by damming up the river water level by the Crocodile Weir. These two canals equipped with no intake gate.

The Crocodile Weir, former Pol Pot Weir constructed in 1986 controls both the flows to two irrigation canals and the river water level in the upstream reaches. The weir consists of five openings. The three in the middle have wooden gates; the raising and lowering of which are controlled by ratchet-and-gear mechanisms. The outer two openings have stop logs, which are placed and removed by hand. There is leakage through opening when it is closed.

The average irrigated area is approximately 2,400 ha (refer to Table 2.5.1). According to the periodical flow measurement conducted by the Study Team on the canals, the intake amount is approximately 1 m³/s on average (refer to Figure 2.5.1). It is naturally impossible for the Siem Reap River to secure 1 m³/s in the driest season judging from the flow duration in 1998 (refer to Figure 2.4.9).