9.5 Reservoir Sedimentation

The estimated amount of reservoir sedimentation is reported in Section 6.3.4 and tabulated below.

Because no more data were gathered in the course of Pre-feasibility Study Stage, the amount presented in Hydropower Potential Study Stage is applied to the Study.

Projects	Catchment Area [km^2]	Specific Annual Yield [$ton/km^2/y$]	Sediment Volume after100 years [10^6m^3]
Se Kong No.4	5,400	419	226
Xe Kaman No.1	3,800	420	160
Xe Namnoy Mid	531	426	23
Xe Namnoy Down	721	425	31

The above catchment area of the Xe Namnoy Midstream Project was changed from 537 km^2 by recheck of the catchment area.

The above catchment area of the Xe Namnoy Downstream project excludes the catchment area of the Midstream Project because the Downstream Project will be developed as a cascade project with the Midstream Project in terms of economic point.

Table 9.2 - 1 Discharge Measurement Record of Se Kong River at Sekong Town

No.	Date	Water Level [m]	Area [m2]	Velocity [m/s]	Discharge [m3/s]
1	93/11/06	2.35	567	0.30	167
2	93/11/11	1.23	489	0.23	111
3	93/11/11	1.22	484	2.08	100
4	93/11/19	1.15	502	1.43	68
5	93/11/26	2.88	566	3.67	197
6	93/12/01	2.82	535	3.61	180
7	94/01/10	1.54	569	1.19	60
8	94/01/15	1.48	518	0.92	46
9	94/01/20	1.42	588	1.04	58
10	94/01/29	1.36	545	0.88	50
11	94/02/05	1.42	483	0.93	49
12	94/02/11	1.30	412	0.80	41
13	94/02/18	1.31	380	0.62	29
14	94/02/24	1.20	404	0.65	31
15	94/03/12	1.20	419	0.79	39
16	94/03/17	1.15	363	0.56	26
17	94/03/24	1.09	436	0.67	33
18	94/03/30	1.26	383	0.57	28
19	94/04/05	1.23	445	0.76	39
20	94/04/10	1.17	364	0.52	24
21	94/04/21	1.50	491	1.00	53
22	94/04/26	1.42	447	1.00	50
23	94/05/08	1.13	465	0.76	38
24	94/05/15	1.52	471	0.94	49
25	94/05/20	2.32	508	1.17	64
26	94/05/29	1.99	463	1.09	58
27	94/06/01	2.02	472	1.08	55
28	94/06/09	1.99	457	1.07	55
29	94/06/18	3.14	632	0.95	619
30	94/06/29	2.22	473	1.15	61
	Max	3.14			619
	Min	1.09			24

Table 9.2 - 2 Discharge Measurement Record of Xe Kaman River at B. Hatsaykhao

No.	Date	Water Level at B. Hatsaykhao [m]	Converted Water Level at B. Fangden [m]	Area [m2]	Velocity [m/s]	Discharge Measured at B. Hatsaykao [m3/s]
1	93/10/01	1.42	1.72	220	0.83	183
2	93/11/12	0.32	0.62	189	0.43	82
3	93/11/16	0.30	0.60	186	0.39	72
4	93/11/26	0.40	0.70	198	0.43	84
5	93/12/07	0.61	0.91	223	0.60	134
6	93/12/12	0.51	0.81	211	0.55	116
7	93/12/17	0.47	0.77	237	0.64	151
8	93/12/20	0.45	0.75	204	0.50	102
9	94/01/04	0.26	0.56	182	0.38	69
10	94/01/15	0.21	0.51	177	0.33	59
11	94/01/24	0.17	0.47	175	0.32	55
12	94/01/28	0.14	0.44	169	0.30	51
13	94/02/12	0.13	0.43	160	0.28	45
14	94/02/16	0.12	0.42	159	0.27	43
15	94/02/18	0.11	0.41	158	0.27	42
16	94/02/24	0.09	0.39	157	0.25	40
17	94/03/03	0.08	0.38	155	0.24	38
18	94/03/08	0.07	0.37	154	0.23	36
19	94/03/11	0.1	0.40	157	0.26	40
20	94/03/28	0.06	0.36	154	0.22	34
21	94/04/07	0.2	0.50	165	0.33	54
22	94/04/24	0.22	0.52	166	0.35	58
23	94/04/25	0.19	0.49	164	0.31	52
24	94/04/28	0.15	0.45	159	0.32	51
25	94/05/14	0.28	0.58	172	0.39	67
26	94/05/18	0.22	0.52	166	0.36	60
27	94/05/21	0.38	0.68	182	0.46	84
28	94/05/29	0.43	0.73	186	0.52	97
	Max	1.42	1.72			183
	Min	0.06	0.36			34

Table 9.2 - 3 Discharge Measurement Record of Xe Namnoy River at B. Latsasin

No.	Date	Water Level [m]	Area [m2]	Velocity [m/s]	Discharge [m3/s]	Index No.
1	91/05/17	1.02	17.44	0.21	3.7	1
2	91/05/23	0.96	16.03	0.22	3.6	1
3	91/05/27	0.93	18.14	0.26	4.8	1
4	91/05/30	0.97	19.40	0.30	5.8	1
5	91/06/05	1.06	19.24	0.47	9.1	1
6	91/06/07	1.03	21.68	0.40	8.6	1
7	92/02/02	0.77	14.42	0.18	2.6	1
8	92/02/05	0.76	14.22	0.17	2.4	1
9	92/02/08	0.74	14.05	0.20	2.8	1
10	92/02/11	0.74	14.02	0.17	2.4	1
11	92/02/14	0.74	14.05	0.18	2.5	1
12	92/02/17	0.74	12.78	0.20	2.5	1
13	92/02/23	0.69	12.36	0.16	2.0	1
14	92/02/26	0.67	12.21	0.15	1.8	1
15	92/03/01	0.65	12.41	0.15	1.8	1
16	92/03/04	0.65	12.46	0.14	1.7	1
17	92/03/15	0.62	10.34	0.09	1.9	1
18	92/03/19	0.60	8.95	0.10	0.9	1
19	92/03/23	0.58	8.48	0.08	0.7	1
20	92/03/23	0.56	8.52	0.08	0.7	1
21	92/03/26	0.53	5.11	0.09	0.5	1
22	92/04/03	0.52	4.94	0.09	0.4	1
23	92/04/11	0.52	4.88	0.09	0.5	1
24	92/04/23	0.50	4.71	0.08	0.4	1
25	92/04/27	0.47	4.29	0.08	0.3	1
26	92/04/29	0.48	4.43	0.08	0.4	1
27	93/10/14	1.69	77.10	0.13	9.8	
28	93/10/18	1.87	95.90	0.60	57.5	
29	93/10/22	1.74	90.20	0.36	32.5	
30	93/10/27	1.68	85.10	0.22	19.1	
31	93/11/07	1.42	72.60	0.13	9.2	
32	93/11/15	1.29	74.13	0.23	17.4	
33	93/11/22	1.21	61.25	0.24	14.6	
34	93/11/29	1.24	76.18	0.25	18.7	
35	93/12/03	1.25	67.00	0.22	14.6	
36	93/12/11	1.14	69.75	0.19	13.4	
37	93/12/20	0.99	62.50	0.20	12.6	
38	93/12/29	0.95	56.25	0.21	11.5	
39	94/01/05	0.92	49.38	0.22	10.7	
40	94/01/15	0.85	48.45	0.20	9.7	
41	94/01/21	0.81	48.50	0.27	13.0	
42	94/01/26	0.76	40.20	0.11	4.5	
43	94/01/28	0.75	36.06	0.22	7.9	
44	94/02/04	0.78	3.57	0.41	1.5	1
45	94/02/08	0.74	2.97	0.34	1.0	1
46	94/02/16	0.73	3.10	0.24	0.7	1
47	94/02/25	0.78	3.65	0.28	1.0	1
48	94/03/01	0.76	2.41	0.37	0.9	1
49	94/03/20	0.80	3.35	0.35	1.2	1
50	94/03/30	1.14	3.87	0.40	1.5	1
51	94/04/02	1.17	3.94	0.39	1.5	1
52	94/04/10	1.21	4.04	0.53	2.1	1
53	94/04/23	1.25	4.14	0.54	2.2	1
54	94/04/30	1.12	3.85	0.38	1.5	1
55	94/05/05	1.06	1.69	0.54	0.9	1
56	94/05/10	1.28	2.34	0.53	1.2	1
57	94/05/18	1.38	2.79	0.97	2.7	1
58	94/05/25	1.78	4.19	1.09	4.6	1
59	94/06/05	2.14	76.00	0.82	62.3	
60	94/06/14	2.24	112.90	0.98	110.8	
61	94/06/21	2.82	136.00	1.46	198.9	
62	94/06/30	2.37	114.75	1.01	115.7	
63	94/07/03	2.22	108.38	0.68	73.3	
64	94/07/07	2.33	105.50	0.95	100.1	
65	94/07/12	4.36	267.00	2.16	577.1	
	Max	4.36			577.1	
	Min	0.47			0.3	

Index No. = 1 : The data used in determination of the rating curve

Table 9.2 - 4 Discharge Measurement Record of Xe Katam River at B. Nonghin (1/3)

No.	Date	Water Level [m]	Area [m2]	Velocity [m/s]	Discharge [m3/s]
1	91/05/03	0.34	7.030	0.185	1.30
2	91/05/08	0.34	6.830	0.212	1.45
3	91/05/13	0.33	6.575	0.183	1.21
4	91/05/16	0.45	9.315	0.255	2.38
5	91/05/18	0.49	10.460	0.271	2.84
6	91/05/22	0.49	9.985	0.265	2.65
7	91/05/27	0.43	7.450	0.240	1.79
8	91/05/30	0.42	8.100	0.222	1.81
9	91/06/05	0.41	7.588	0.197	1.50
10	91/06/13	0.55	11.490	0.333	3.83
11	91/06/18	0.48	11.135	0.222	2.47
12	91/06/26	0.68	11.950	0.440	6.13
13	91/07/04	0.77	16.225	0.622	10.09
14	91/07/07	0.69	14.023	0.630	6.30
15	91/07/17	0.81	16.822	0.584	9.83
16	91/07/24	1.14	28.050	1.178	33.03
17	91/07/31	0.96	22.350	0.865	19.32
18	91/08/07	0.94	21.575	0.843	18.19
19	91/08/16	1.05	21.755	0.985	23.68
20	91/08/17	1.24	31.450	1.275	40.08
21	91/08/20	1.28	32.700	1.465	47.89
22	91/08/27	1.15	27.875	1.189	33.16
23	91/08/29	1.16	27.850	1.270	35.36
24	91/09/03	0.96	20.150	0.934	18.82
25	91/09/15	0.93	19.850	0.869	17.26
26	91/09/18	0.84	17.666	0.796	14.07
27	91/09/25	0.94	21.194	0.923	19.56
28	91/10/04	1.13	27.413	1.294	35.49
29	91/10/09	1.02	22.655	1.032	23.37
30	91/10/16	0.90	18.280	0.893	16.34
31	91/10/23	0.76	15.635	0.629	9.85
32	91/10/30	0.67	14.027	0.455	6.39
33	91/11/06	0.60	12.102	0.421	5.10
34	91/11/27	0.50	9.899	0.304	3.01
35	91/12/04	0.46	9.366	0.270	2.54
36	91/12/11	0.44	9.946	0.270	2.69
37	91/12/18	0.43	8.302	0.220	1.83
38	91/12/25	0.40	8.172	0.226	1.85
	Max	1.28			47.894
	Min	0.33			1.208

Table 9.2 - 4 Discharge Measurement Record of Xe Katam River at B. Nonghin (2/3)

No.	Date	Water Level [m]	Area [m2]	Velocity [m/s]	Discharge [m3/s]
39	92/01/02	0.38	8.603	0.206	1.78
40	92/01/08	0.38	8.848	0.227	2.01
41	92/01/15	0.36	8.495	0.192	1.63
42	92/01/21	0.36	8.573	0.203	1.74
43	92/01/29	0.34	7.894	0.192	1.51
44	92/02/03	0.33	7.495	0.187	1.40
45	92/02/08	0.33	7.523	0.190	1.43
46	92/02/12	0.32	7.419	0.177	1.13
47	92/02/15	0.32	7.369	0.171	1.27
48	92/02/19	0.31	7.361	0.154	1.13
49	92/02/22	0.30	7.277	0.145	1.05
50	92/02/26	0.30	7.302	0.148	1.09
51	92/02/29	0.30	7.410	0.141	1.05
52	92/03/04	0.30	7.540	0.148	1.12
53	92/03/07	0.28	7.044	0.116	0.82
54	92/03/11	0.28	7.054	0.113	0.80
55	92/03/14	0.28	7.128	0.117	0.83
56	92/03/18	0.33	7.770	0.190	1.47
57	92/03/21	0.31	7.520	0.156	1.18
58	92/03/25	0.33	7.950	0.160	1.28
59	92/04/01	0.32	7.770	0.149	1.16
60	92/04/08	0.30	7.460	0.141	1.05
61	92/04/11	0.29	7.288	0.119	0.87
62	92/04/18	0.46	9.482	0.253	2.40
63	92/04/22	0.39	8.621	0.223	1.92
64	92/04/25	0.38	8.607	0.207	1.78
65	92/04/29	0.34	7.776	0.192	1.49
66	92/05/02	0.40	8.420	0.214	1.80
67	92/05/05	0.42	8.710	0.218	1.90
68	92/05/08	0.48	9.704	0.254	2.46
69	92/05/11	0.45	9.624	0.260	2.50
70	92/05/14	0.48	9.812	0.292	2.87
71	92/05/17	0.50	10.221	0.306	3.13
72	92/05/20	0.61	12.240	0.418	5.12
73	92/05/23	0.50	10.520	0.317	3.33
74	92/05/26	0.82	16.508	0.678	11.19
75	92/05/29	0.70	14.288	0.518	7.40
76	92/06/01	0.62	12.335	0.408	5.03
77	92/06/04	0.76	15.384	0.583	8.97
78	92/06/07	0.71	14.224	0.548	7.79
79	92/06/10	0.73	15.040	0.551	8.29
80	92/06/13	0.94	20.082	0.852	17.11
81	92/06/16	0.92	19.086	0.818	15.61
82	92/06/19	0.95	19.512	0.868	16.94
83	92/06/22	1.04	22.038	1.018	22.43
84	92/06/25	1.00	21.683	0.923	20.01
85	92/06/28	1.48	39.562	2.184	86.40
86	92/07/01	1.04	22.642	0.986	22.32
87	92/07/04	0.86	17.218	0.738	12.71
88	92/07/07	0.79	16.014	0.648	10.38
89	92/07/10	0.78	16.009	0.622	9.96
90	92/09/01	1.18	33.55	0.352	11.82
91	92/09/04	1.07	24.31	0.454	11.049
92	92/09/08	0.93	21.821	0.82	17.889
93	92/09/08	0.93	21.821	0.820	17.89
94	92/09/15	0.83	17.900	0.699	12.52
95	92/09/18	0.80	15.817	0.707	11.19
96	92/09/21	0.86	18.99	0.155	2.952
97	92/09/24	1.12	25.25	0.25	6.337
98	92/09/27	0.96	21.925	0.208	4.577
99	92/09/30	0.86	21.595	0.191	41.143
100	92/10/05	0.79	15.974	0.746	11.93
101	92/10/08	0.74	14.699	0.626	9.21
102	92/10/12	0.68	13.145	0.548	7.21
103	92/10/15	0.65	12.468	0.509	6.35
104	92/10/18	0.63	11.875	0.478	5.68
105	92/10/22	0.59	11.172	0.447	5.00
106	92/10/25	0.60	11.550	0.443	5.12
107	92/10/28	0.58	10.991	0.421	4.63
108	92/10/31	0.61	12.024	0.452	5.44
109	92/11/02	0.58	11.001	0.423	4.66
110	92/11/05	0.55	10.682	0.426	4.56
111	92/11/08	0.53	9.762	0.361	3.53
112	92/11/11	0.52	9.750	0.360	3.52
113	92/11/14	0.50	9.440	0.369	3.49
114	92/11/17	0.49	9.300	0.337	3.14
115	92/11/20	0.48	8.796	0.322	2.84
116	92/11/23	0.47	8.332	0.326	2.72
117	92/11/26	0.46	7.823	0.308	2.41
118	92/11/30	0.44	7.362	0.275	2.03
119	92/12/02	0.42	7.402	0.255	1.89
120	92/12/05	0.42	7.402	0.263	1.95
121	92/12/08	0.42	7.412	0.262	1.95
122	92/12/12	0.40	6.885	0.237	1.64
123	92/12/15	0.39	6.520	0.236	1.54
124	92/12/18	0.39	6.520	0.239	1.56
125	92/12/21	0.38	6.389	0.244	1.56
126	92/12/24	0.38	6.389	0.253	1.62
127	92/12/28	0.38	6.439	0.251	1.62
128	92/12/31	0.41	7.101	0.260	1.85
	Max	1.48			86.40
	Min	0.28			0.80

Table 9.2 - 4 Discharge Measurement Record of Xe Katam River at B. Nonghin (3/3)

No.	Date	Water Level [m]	Area [m2]	Velocity [m/s]	Discharge [m3/s]
129	93/01/01	0.38	6.789	0.228	1.55
130	93/01/04	0.37	6.744	0.258	1.74
131	93/01/07	0.37	6.715	0.644	4.33
132	93/01/10	0.36	6.542	0.213	1.40
133	93/01/14	0.35	6.444	0.198	1.28
134	93/01/17	0.34	6.303	0.197	1.25
135	93/01/20	0.34	6.272	0.186	1.17
136	93/01/24	0.33	6.030	0.191	1.15
137	93/01/27	0.32	6.160	0.192	1.19
138	93/01/31	0.32	6.100	0.177	1.08
139	93/02/03	0.32	6.500	0.205	1.34
140	93/02/06	0.31	6.480	0.184	1.20
141	93/02/09	0.31	6.420	0.169	1.09
142	93/02/13	0.30	6.305	0.186	1.17
143	93/02/17	0.30	6.295	0.170	1.08
144	93/02/21	0.35	6.835	0.224	1.53
145	93/02/25	0.28	5.710	0.165	0.95
146	93/02/28	0.28	5.720	0.172	0.99
147	93/03/02	0.28	5.720	0.168	0.97
148	93/03/05	0.28	5.630	0.165	0.93
149	93/03/10	0.26	5.530	0.162	0.90
150	93/03/16	0.26	6.880	0.173	1.20
151	93/03/21	0.26	6.735	0.216	1.46
	Max	0.38			4.33
	Min	0.26			0.90

Tale 9.2-5 Monthly Discharge of Se Kong No.4

Drainage Area : 5,400 km2

[m3/s]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Standard Deviation	Max	Min	Annual Runoff Vol [x10^6m3]	Annual Runoff [mm]
1984								389	613	166	91	59	264	234.1	613	59	3,470	643
1985	40	28	25	23	92	111	133	344	789	116	106	80	157	216.7	789	23	4,956	918
1986	56	42	37	33	118	164	764	665	312	163	126	120	217	246.0	764	33	6,897	1,277
1987	72	53	43	38	95	146	642	612	316	153	194	116	207	211.2	642	38	6,570	1,217
1988	80	57	39	38	110	123	134	224	121	329	134	95	124	82.2	329	38	3,928	727
1989	66	48	42	43	127	223	367	444	461	279	147	81	194	158.3	461	42	6,147	1,138
1990	55	47	47	47	98	149	248	303	669	427	250	187	211	188.3	669	47	6,662	1,234
1991	89	53	52	50	63	115	159	548	430	391	149	116	185	171.5	548	50	5,854	1,084
1992	69	45	53	44	47	133	223	527	358	510	252	87	196	180.5	527	44	6,212	1,150
1993	50	49	50	63	54	67	135	473	248	199	142	202	144	125.4	473	49	4,579	848
1994	58	46	41	44	56	116	370						105	120.0	370	41	1,936	358
Average	64	47	43	42	86	135	318	453	432	273	159	114	181				5,201	963
St.Dev.	15	8	8	11	29	41	224	140	206	135	56	46		178				
Max	89	57	53	63	127	223	764	665	789	510	252	202			789		6,897	1,277
Min	40	28	25	23	47	67	133	224	121	116	91	59				23	1,936	358

Note ; Monthly Discharges based on regression analysis :

Aug. 1984 - July 1986	from	B.Nanay in Xe Done River basin
Jan. 1987 - May 1988		B.Nanay in Xe Done River basin
Aug. 1986 - Dec. 1986		Savannakhili in Xe Done River basin
June 1988 - May 1989		Attapu in Se Kong River basin
Dec. 1989		Attapu in Se Kong River basin
Oct. & Nov. 1990		Attapu in Se Kong River basin
July 1994		Attapu in Se Kong River basin

Table 9.2 - 6 Monthly Discharge [m3/s] of Xe Kaman No.1

Drainage Area : 3,800 km2

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Standard Deviation	Max	Min	Annual Runoff Vol [x10^6m3]	Annual Runoff [mm]
1984								330.5	316.7	293.0	320.8	164.6	285	68.8	330	165	3,763	990
1985	90.6	58.9	38.8	41.2	44.5	124.9	114.6	213.9	226.5	196.9	137.5	109.7	116	67.1	226	39	3,683	969
1986	62.8	36.3	18.4	16.0	130.4	61.3	97.2	294.9	283.2	322.1	170.2	245.3	145	114.6	322	16	4,600	1,211
1987	86.3	52.7	32.0	14.0	13.4	42.0	74.0	150.9	194.9	96.9	172.8	82.3	84	60.5	195	13	2,661	700
1988	37.6	24.1	15.2	12.4	39.2	75.3	85.8	175.1	72.9	279.4	78.7	48.5	79	77.0	279	12	2,504	659
1989	25.9	11.7	7.1	8.0	78.6	137.9	224.4	325.4	280.5	128.0	54.2	37.9	110	111.5	325	7	3,490	918
1990	20.7	14.0	12.8	13.7	19.4	70.6	89.3	229.0	447.5	376.7	168.0	64.8	127	149.9	447	13	4,024	1,059
1991	36.1	27.6	23.7	20.9	19.8	82.3	185.2	620.2	463.7	344.6	85.5	81.5	166	201.5	620	20	5,269	1,387
1992	52.5	47.0	51.4	40.6	57.4	115.0	210.8	402.2	314.2	300.0	145.1	57.9	150	126.8	402	41	4,744	1,249
1993	50.9	45.8	42.0	37.3	30.4	60.4	376.9	847.9	563.9	97.9	67.4	72.8	191	265.0	848	30	6,069	1,597
1994	48.7	40.7	34.4	39.7	53.7	83.6	320.6						89	103.5	321	34	1,643	432
Average	51	36	28	24	49	85	178	359	316	244	140	97	135				3,859	1,016
St.Dev.	23	16	14	14	35	31	106	219	143	105	78	63		143				
Max	91	59	51	41	130	138	377	848	564	377	321	245			848		6,069	1,597
Min	21	12	7	8	13	42	74	151	73	97	54	38				7	1,643	432

Note ; Monthly Discharges based on regression analysis :

Aug. 1984 - May 1988	from Kontum in Dak Bla River basin
June 1988 - Oct. 1991	Attapu in Se Kong River basin
Apr. 1992	Attapu in Se Kong River basin
Apr. 1993	Attapu in Se Kong River basin
June & July 1994	Attapu in Se Kong River basin

Table 9.2-7 Monthly Discharge [m3/s] of Xe Namnoy Midstream Project

Drainage Area 531 km2

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Standard Deviation	Max	Min	Annual Runoff Vo [x10^6m3]	Annual Runoff [mm]
1984								45.1	43.3	40.2	43.8	16.1	38	12	45	16	497	936
1985	7.2	3.9	3.0	4.5	14.8	61.6	51.1	55.6	53.6	33.2	16.5	8.9	26	23	62	3	828	1,559
1986	4.8	2.7	1.3	3.3	15.6	19.5	23.8	66.5	60.4	41.0	30.1	11.3	23	22	67	1	740	1,394
1987	3.5	2.4	1.7	1.4	12.5	20.2	94.3	89.9	45.6	21.2	16.5	6.2	26	33	94	1	837	1,576
1988	4.0	2.6	1.5	1.4	14.8	29.8	22.6	45.4	17.2	28.3	14.8	4.7	16	14	45	1	495	932
1989	4.2	1.7	0.4	3.1	20.4	42.9	55.3	78.5	91.4	41.4	14.1	7.3	30	32	91	0	953	1,794
1990	3.4	0.0	1.6	1.7	9.4	11.8	26.7	37.5	54.4	75.4	38.4	24.1	24	24	75	0	753	1,418
1991	3.8	2.6	1.5	0.6	5.1	29.9	76.8	108.8	88.3	48.9	14.7	6.6	32	39	109	1	1,026	1,931
1992	3.9	2.1	1.2	0.6	1.9	15.9	41.5	72.9	55.1	32.3	11.2	5.7	20	24	73	1	646	1,217
1993	3.3	1.7	1.6	1.6	4.5	12.0	33.3	79.2	57.0	28.2	13.4	7.7	20	25	79	2	645	1,214
1994	3.4	1.0	1.1	1.7	8.6	12.6	43.8						10	15	44	1	192	362
Average	4	2	1	2	11	26	47	68	57	39	21	10	24				692	1,303
St.Dev.	1	1	1	1	6	16	24	22	21	15	12	6		26				
Max	7	4	3	4	20	62	94	109	91	75	44	24			109		1,026	1,931
Min	3	0	0	1	2	12	23	38	17	21	11	5				0	192	362

Note ; Monthly Discharges based on regression analysis :

Aug. 1984 - Dec. 19 from B.Fangden in Xe Katam River basin
May 1994 - Jul. 1994 B.Fangden in Xe Katam River basin
Jan. 1985 - Jan. 1991 Xe Set P/S in Xe Set River basin

Table 9.2-8 Monthly Discharge [m3/s] of Xe Katam River at B.Nonghin

Drainage Area 171 km2

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Standard Deviation	Max	Min	Annual Runoff Vol [x10^6m3]	Annual Runoff [mm]
1984								14.8	14.3	13.4	14.4	3.4	12.1	4.9	14.8	3.4	159	930
1985	3.3	2.2	1.9	2.4	5.8	21.2	17.8	19.2	18.6	11.9	6.4	3.9	9.5	7.7	21.2	1.9	302	1,766
1986	2.5	1.8	1.4	2.0	6.1	7.4	8.8	22.9	20.8	14.4	10.9	4.6	8.6	7.4	22.9	1.4	273	1,597
1987	2.1	1.7	1.5	1.4	5.0	7.6	32.0	30.6	16.0	7.9	6.4	3.0	9.6	10.9	32.0	1.4	305	1,784
1988	2.2	1.8	1.4	1.4	5.8	10.8	8.4	15.9	6.6	10.3	5.8	2.5	6.1	4.6	15.9	1.4	192	1,125
1989	2.3	1.5	1.1	2.0	7.6	15.1	19.2	26.8	31.0	14.6	5.6	3.3	10.8	10.4	31.0	1.1	343	2,007
1990	2.0	0.9	1.4	1.5	4.0	4.8	9.7	13.3	18.9	25.8	13.6	8.9	8.7	7.9	25.8	0.9	277	1,621
1991	1.2	1.1	1.1	1.1	2.1	3.1	18.2	28.0	24.6	19.4	3.8	2.1	8.8	10.5	28.0	1.1	280	1,638
1992	1.5	1.1	1.2	1.7	4.0	20.1	18.6	37.7	25.6	6.9	3.1	1.8	10.3	12.2	37.7	1.1	326	1,905
1993	1.4	1.1	1.2	1.3	3.6	6.5	19.7	14.6	20.0	9.9	5.7	2.1	7.2	7.2	20.0	1.1	230	1,343
1994	1.4	1.2	1.3	2.8	3.9	5.4	14.4						4.3	4.7	14.4	1.2	80	469
Average	2.0	1.4	1.3	1.7	4.8	10.2	16.7	22.4	19.6	13.4	7.6	3.6	8.8				277	1,619
St.Dev.	0.6	0.4	0.3	0.5	1.6	6.5	7.0	8.2	6.7	5.7	4.0	2.1		8.6				
Max	3.3	2.2	1.9	2.8	7.6	21.2	32.0	37.7	31.0	25.8	14.4	8.9			37.7		343	2,007
Min	1.2	0.9	1.1	1.1	2.1	3.1	8.4	13.3	6.6	6.9	3.1	1.8				0.9	80	469

Note ; Monthly Discharges based on regression analysis :

Aug. 1984 - Dec. 19	from	B.Latsasin in Xe Namnoy River basin
Oct. 1993 - Dec. 1993		B.Latsasin in Xe Namnoy River basin
Jun & July 1994		B.Latsasin in Xe Namnoy River basin
Jan. 1985 - Dec. 1990		Xe Set P/S in Xe Set River basin

Table 9.2- 9 Monthly Discharge [m3/s] between Xe Namnoy Mid and Downstream Projects

Drainage Area 721 km2

[m3/s]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Standard Deviation	Max	Min	Annual Runoff Vol. [x10^6m3]	Annual Runoff [mm]
1984								61.7	59.4	55.3	60.1	18.8	51.0	18.2	61.7	18.8	673	934
1985	11.4	6.9	5.6	7.7	21.9	86.0	71.6	77.7	75.0	47.0	24.2	13.8	37.4	31.8	86.0	5.6	1,184	1,642
1986	8.2	5.2	3.3	6.1	22.9	28.3	34.2	92.8	84.4	57.7	42.9	17.0	33.6	30.6	92.8	3.3	1,064	1,476
1987	6.4	4.8	3.9	3.5	18.7	29.2	130.9	124.8	64.1	30.7	24.2	10.1	37.6	45.5	130.9	3.5	1,197	1,660
1988	7.0	5.1	3.6	3.5	21.8	42.5	32.5	63.8	25.1	40.4	21.8	8.0	22.9	19.1	63.8	3.5	728	1,010
1989	7.3	3.8	2.1	5.8	29.5	60.4	77.4	109.2	126.8	58.3	20.9	11.6	42.8	43.3	126.8	2.1	1,355	1,880
1990	6.2	1.6	3.7	3.9	14.4	17.8	38.2	53.0	76.1	104.9	54.2	34.6	34.1	32.9	104.9	1.6	1,081	1,500
1991	5.2	3.9	3.0	2.3	7.7	29.5	93.2	135.8	113.3	72.5	18.4	8.8	41.1	48.9	135.8	2.3	1,307	1,813
1992	5.7	3.6	3.0	3.3	8.3	47.0	65.3	123.2	88.1	38.0	14.2	7.7	33.9	39.8	123.2	3.0	1,077	1,494
1993	5.0	3.3	3.3	3.5	9.9	20.7	60.4	89.0	80.2	39.7	20.5	9.8	28.8	31.2	89.0	3.3	913	1,266
1994	5.1	2.8	3.0	6.1	13.6	19.4	60.0						15.7	20.5	60.0	2.8	292	405
Average	6.8	4.1	3.5	4.6	16.9	38.1	66.4	93.1	79.3	54.4	30.1	14.0	34.5				1,087	1,508
St.Dev.	1.9	1.5	0.9	1.7	7.2	21.6	30.0	29.2	28.1	21.6	16.1	8.1		35.1				
Max	11.4	6.9	5.6	7.7	29.5	86.0	130.9	135.8	126.8	104.9	60.1	34.6			135.8		1,355	1,880
Min	5.0	1.6	2.1	2.3	7.7	17.8	32.5	53.0	25.1	30.7	14.2	7.7				1.6	292	405

Note ; The above table was made of Table 9.2-7(Xe Namnoy Discharge) and Table 9.2-8(Xe Katam Discharge) in propotion to the catchment area.

Table 9.2-10 Monthly Discharge [m3/s] of Xe Pian Diversion Scheme

Drainage Area 223 km2

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Standard Deviation	Max	Min	Annual Runoff Vo [x10^6m3]	Annual Runoff [mm]
1984								19.3	18.7	17.5	18.9	4.4	15.8	6.4	19.3	4.4	208	932
1985	4.3	2.9	2.5	3.1	7.6	27.7	23.2	25.1	24.3	15.5	8.3	5.0	12.5	10.0	27.7	2.5	394	1,769
1986	3.3	2.3	1.8	2.6	7.9	9.6	11.5	29.9	27.2	18.9	14.2	6.1	11.3	9.6	29.9	1.8	357	1,600
1987	2.7	2.2	1.9	1.8	6.6	9.9	41.8	39.9	20.9	10.3	8.3	3.9	12.5	14.3	41.8	1.8	399	1,787
1988	2.9	2.3	1.8	1.8	7.6	14.1	10.9	20.7	8.6	13.4	7.6	3.2	7.9	6.0	20.7	1.8	251	1,127
1989	3.0	1.9	1.4	2.5	10.0	19.7	25.0	35.0	40.6	19.0	7.3	4.4	14.2	13.6	40.6	1.4	448	2,011
1990	2.7	1.2	1.9	1.9	5.2	6.3	12.7	17.4	24.6	33.7	17.8	11.6	11.4	10.3	33.7	1.2	362	1,624
1991	1.6	1.4	1.4	1.4	2.7	4.1	23.8	36.6	32.1	25.3	5.0	2.7	11.5	13.7	36.6	1.4	366	1,641
1992	2.0	1.5	1.5	2.2	5.2	26.3	24.3	49.3	33.4	9.1	4.0	2.4	13.4	16.0	49.3	1.5	426	1,909
1993	1.8	1.5	1.5	1.7	4.8	8.4	25.7	19.0	26.1	13.0	7.4	2.7	9.5	9.4	26.1	1.5	300	1,346
1994	1.8	1.5	1.7	3.6	5.1	7.1	18.9						5.7	6.2	18.9	1.5	105	470
Average	2.6	1.9	1.7	2.3	6.3	13.3	21.8	29.2	25.6	17.6	9.9	4.6	11.5				362	1,622
St.Dev.	0.8	0.5	0.3	0.7	2.1	8.4	9.2	10.7	8.8	7.4	5.2	2.7		11.2				
Max	4.3	2.9	2.5	3.6	10.0	27.7	41.8	49.3	40.6	33.7	18.9	11.6			49.3		448	2,011
Min	1.6	1.2	1.4	1.4	2.7	4.1	10.9	17.4	8.6	9.1	4.0	2.4				1.2	105	470

Note ; The above monthly discharges were estimated from those of Xe Katam River(Table 9.2-8) in proportion to the catchment area.

Table 9.4 - 1 Design Monthly Evaporation

Monthly Evaporation [%]

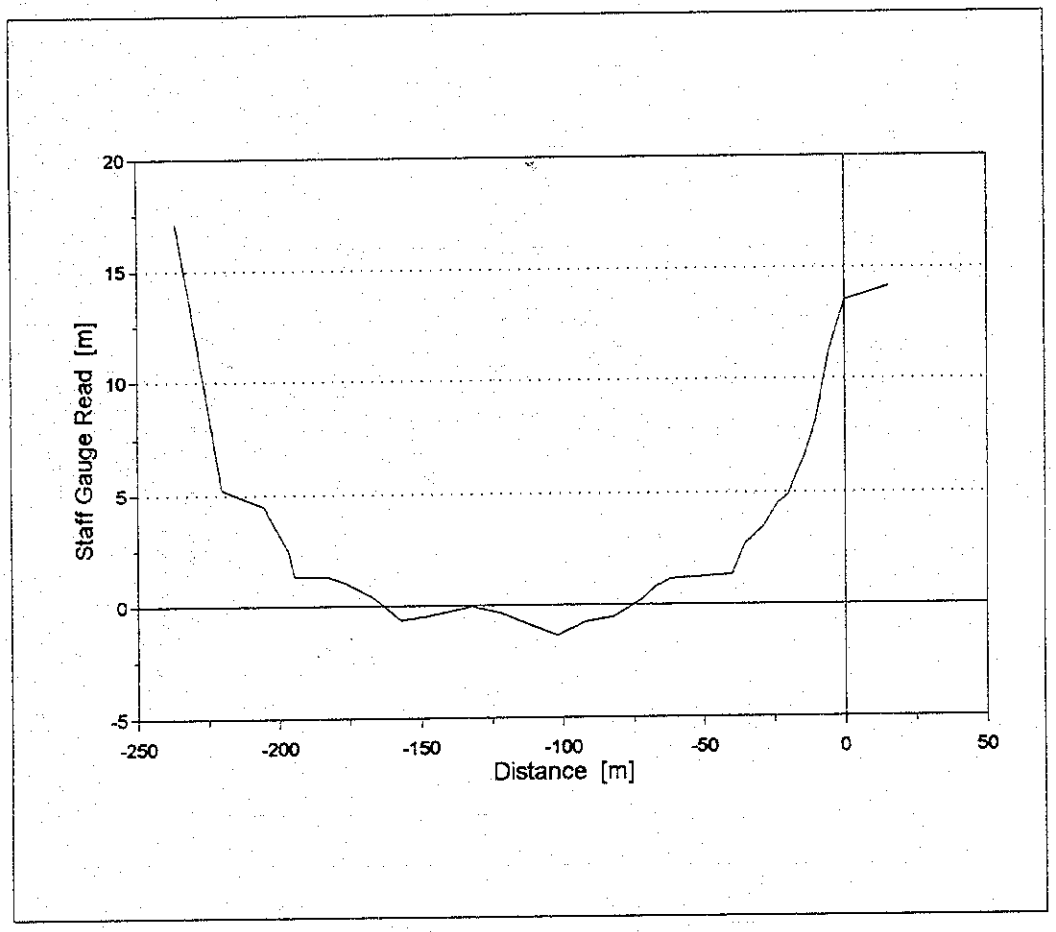
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual [%]
Pakse [%]	11.0	11.7	14.6	12.1	8.2	5.0	4.9	4.2	4.9	6.6	7.9	10.1	101.0
Attapu	9.5	12.5	12.9	8.1	9.1	4.4	5.5	5.0	4.6	7.0	10.9	11.9	101.2
Nikhon 34 [%]	10.7	12.8	10.7	8.2	7.3	6.6	6.5	5.9	5.4	7.3	9.3	10.0	100.7

Monthly Evaporation [mm]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual [mm]
Se Kong No.4	109	116	144	120	82	49	48	41	48	65	78	100	1,000
Xe Kaman No.1	103	136	140	88	98	48	59	54	50	76	118	130	1,100
Xe Namnoy	95	114	95	73	66	59	58	53	48	66	83	89	900

Note : Annual evaporation is quoted from "Interim Report, Nov,1993"

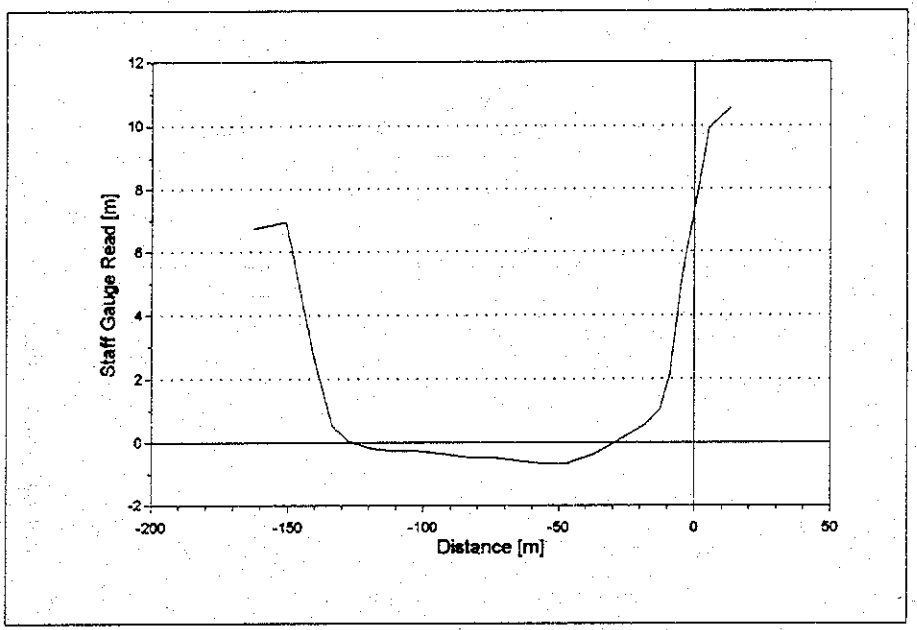
Fig.9.2-1 River Cross Section of Se Kong River at Sekong Town Gauging Station



Surveyed on January 29, 1994

Distance [m]	Staff Gauge Read [m]
-236.34	17.13
-220.02	5.26
-205.34	4.49
-196.56	2.52
-194.35	1.36
-182.99	1.36
-176.99	1.09
-166.99	0.41
-156.99	-0.64
-146.99	-0.44
-131.99	-0.04
-121.99	-0.34
-111.99	-0.84
-101.99	-1.34
-91.99	-0.74
-81.99	-0.54
-71.99	0.26
-66.99	0.81
-61.9	1.16
-39.99	1.36
-35.45	2.72
-28.54	3.52
-23.84	4.52
-20	4.92
-14.639	6.52
-10.26	8.12
-5.7	11.12
0	13.52
15.54	14.12

Fig.9.2 - 2 River Cross Section of Xe Kaman River at B.Fangden Gauging Station



Distance [m]	Staff Gauge Read [m]
-162.52	6.743
-150.78	6.943
-147.69	5.743
-140.76	2.843
-133.41	0.543
-127.4	0.043
-119.75	-0.157
-111.4	-0.257
-102.24	-0.257
-92.42	-0.357
-83.27	-0.457
-74.09	-0.457
-65.65	-0.557
-56.58	-0.657
-46.93	-0.657
-36.61	-0.357
-18.53	0.543
-12.54	1.043
-8.87	2.143
-4.78	5.043
5.57	9.943
13	10.543

Surveyed on January 30, 1994

Fig.9.2-3 Water Level Relation of Xe Kaman River

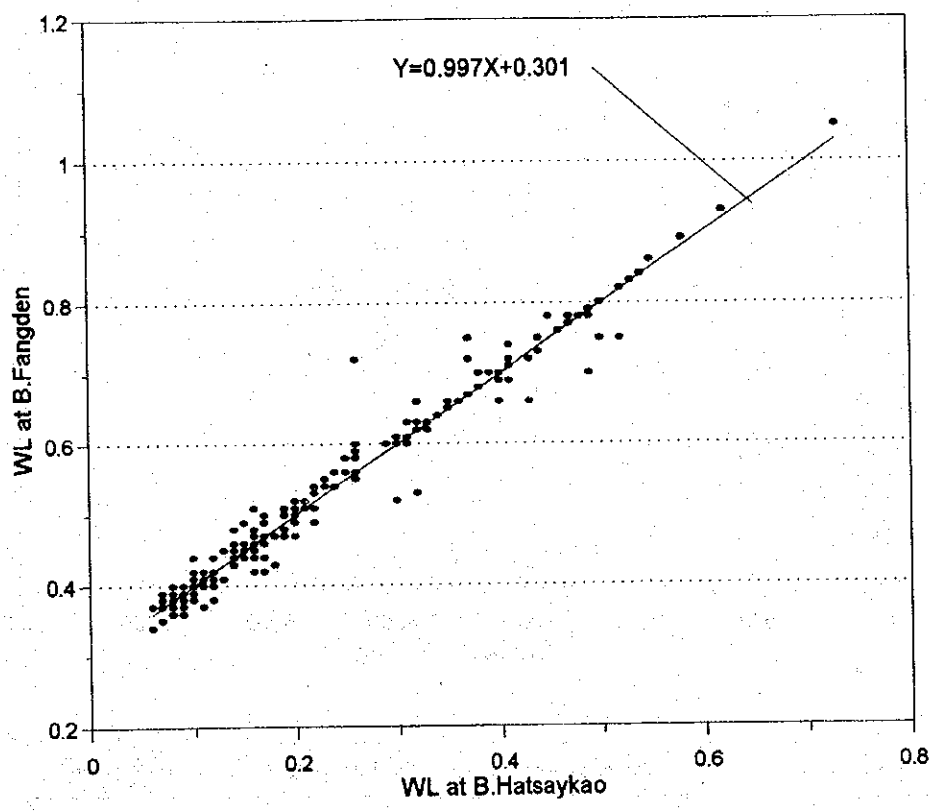


Fig.9.2-4 Estimated Rating Curve
of Se Kong River at Sekong Town

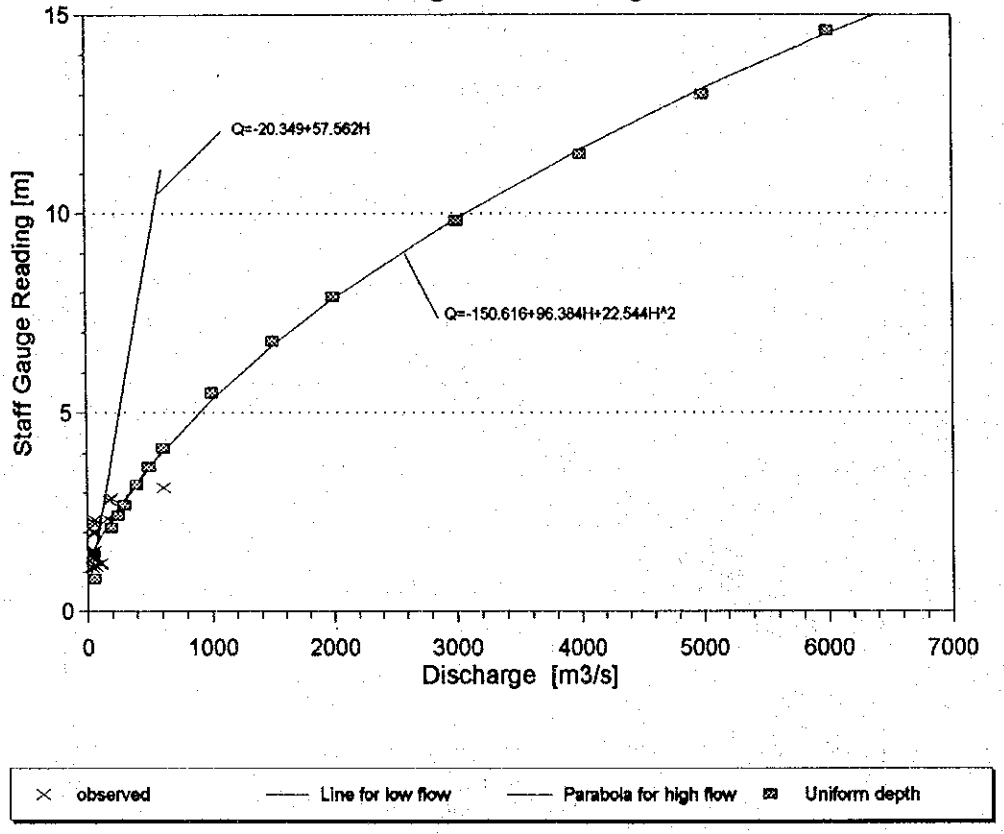


Fig.9.2 - 5 Estimated Rating Curve of Xe Kaman at B.Fangdeng

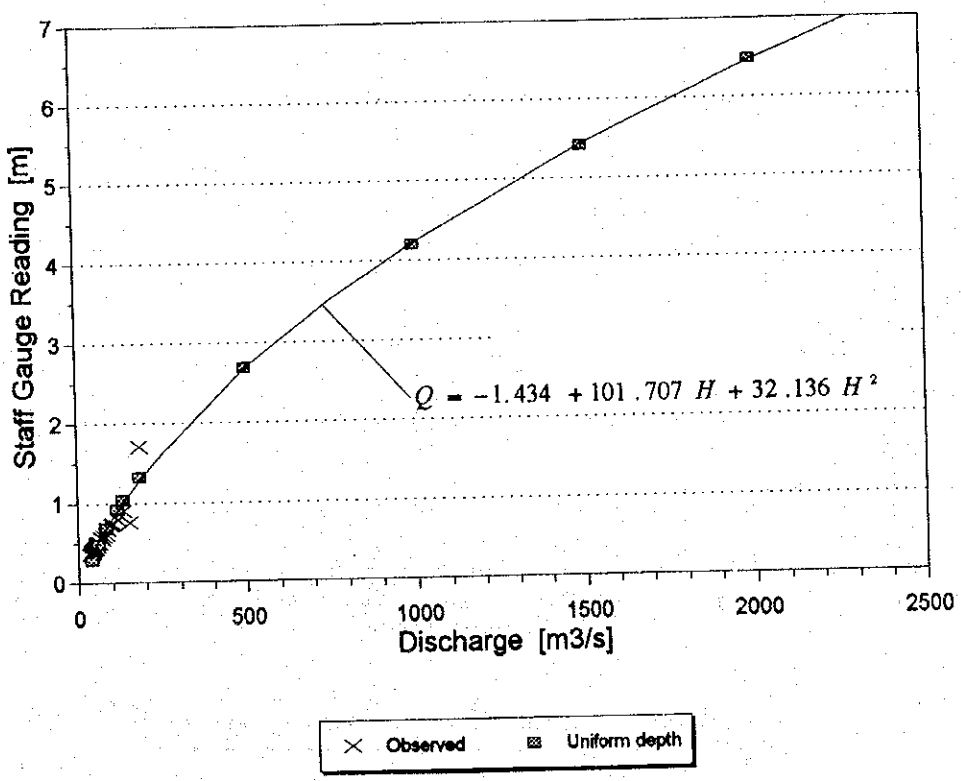


Fig.9.2-6 Observed Stage Discharge of Xe Namnoy River at B.Latsasin

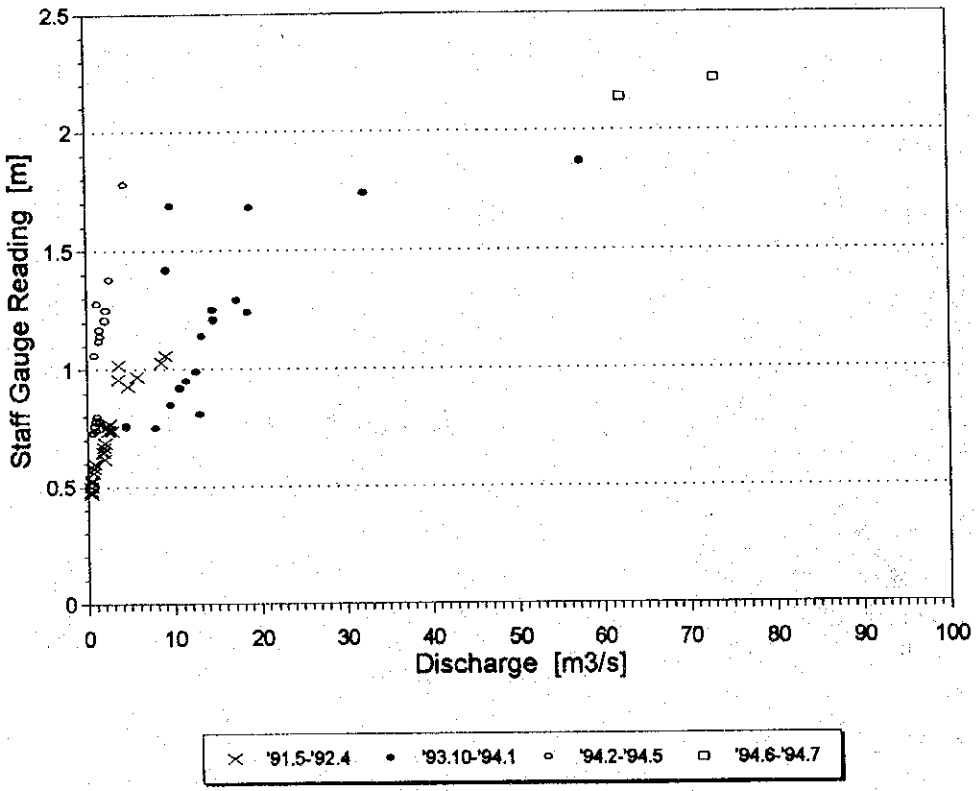


Fig.9.2-7 Estimated Rating Curve of Xe Namnoy River at B.Latsasin

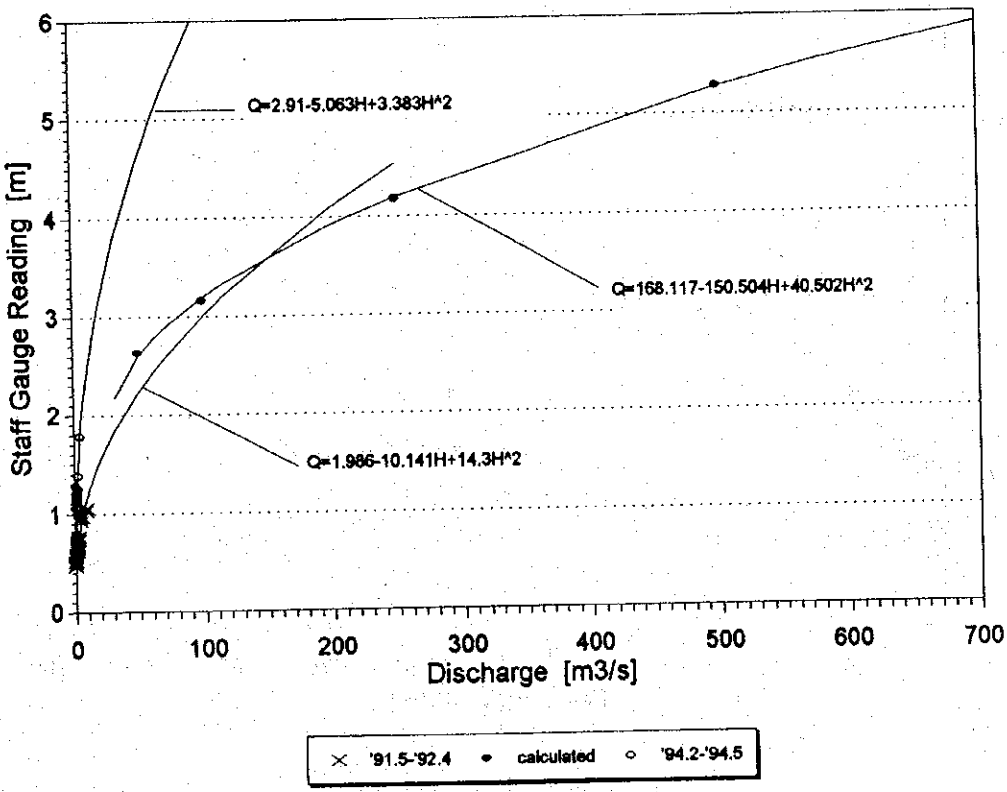


Fig.9.2-8 Rating Curve

of Xe Katam River at B.Nonghin G.S.

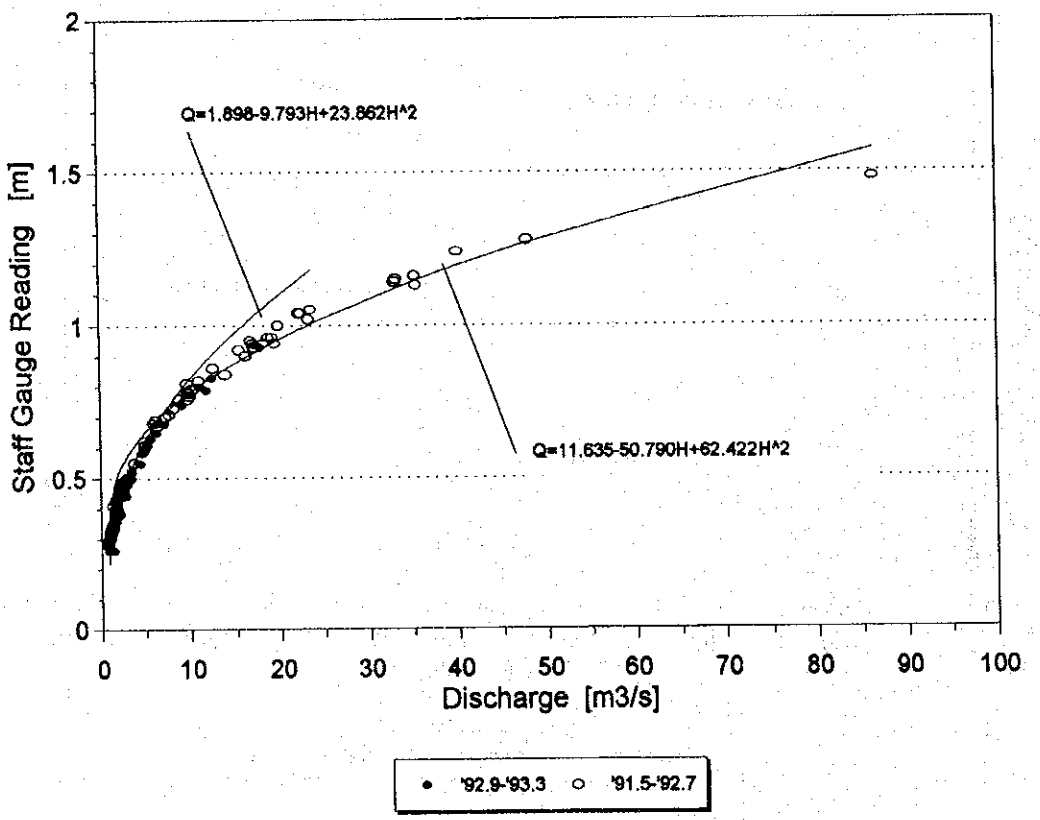


Fig. 9.2-9 Monthly Discharge of Se Kong No.4

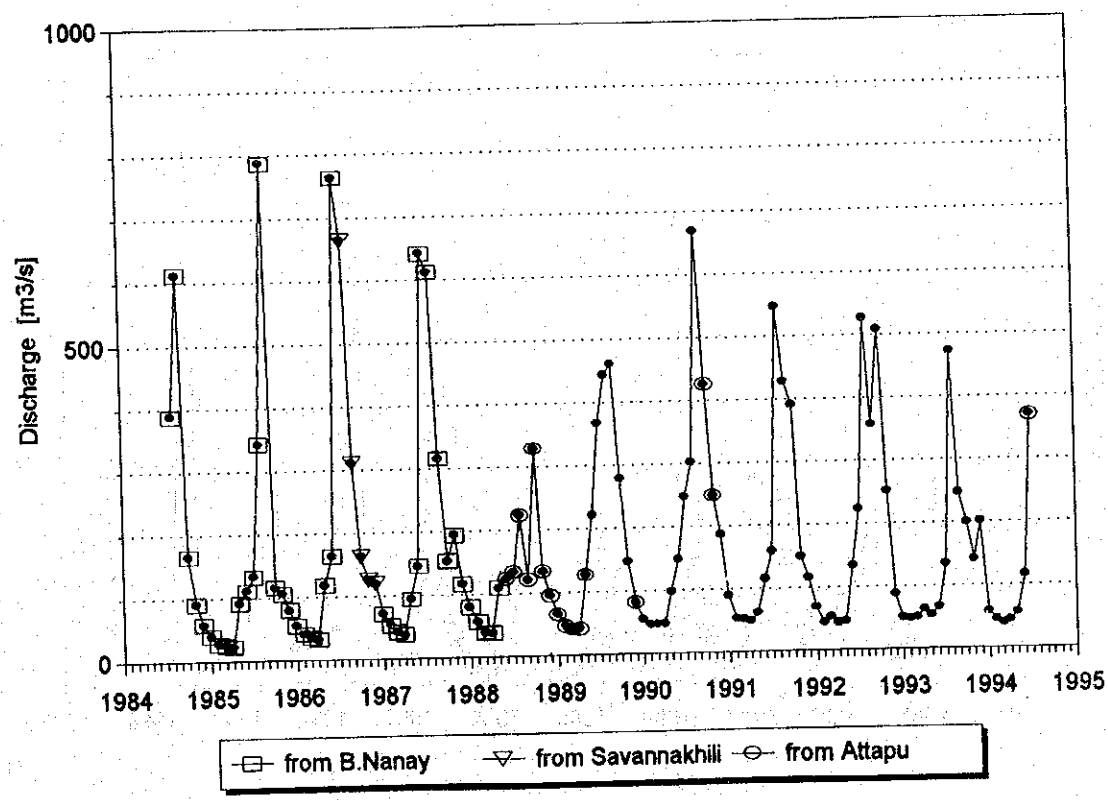


Fig. 9.2-10 Monthly Discharge of Xe Kaman No.1

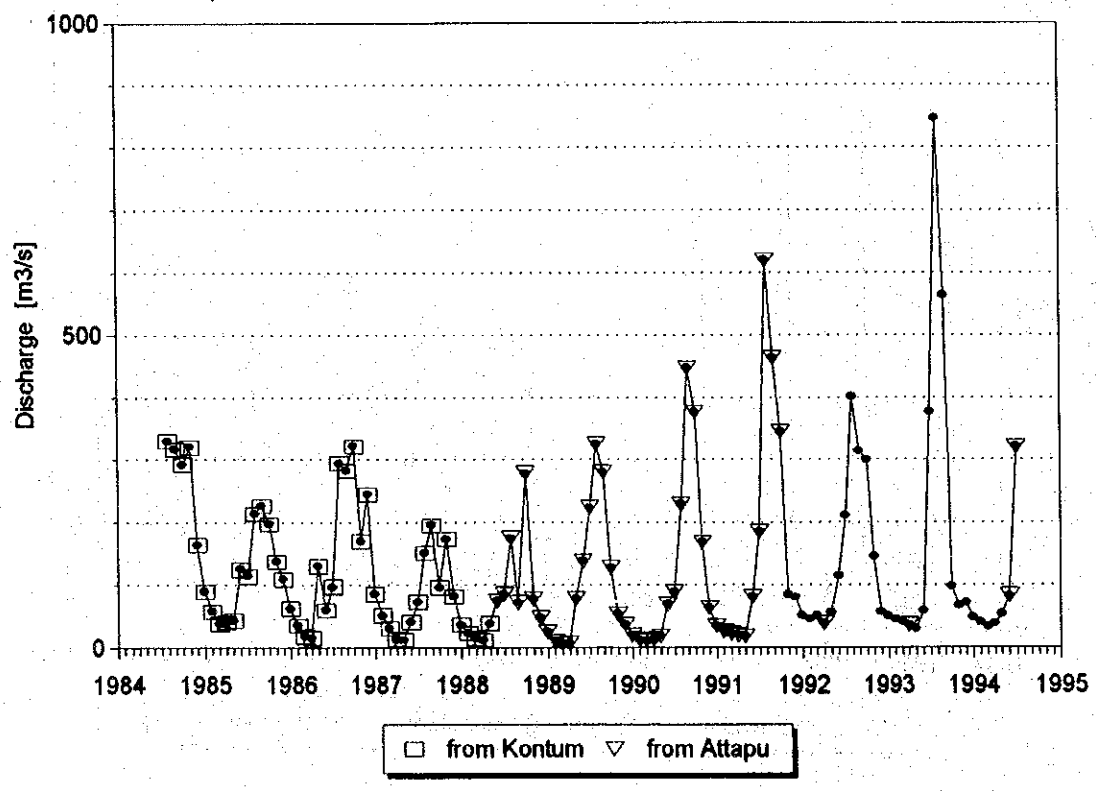


Fig. 9.2-11 Monthly Discharge of Xe Namnoy Midstream Project

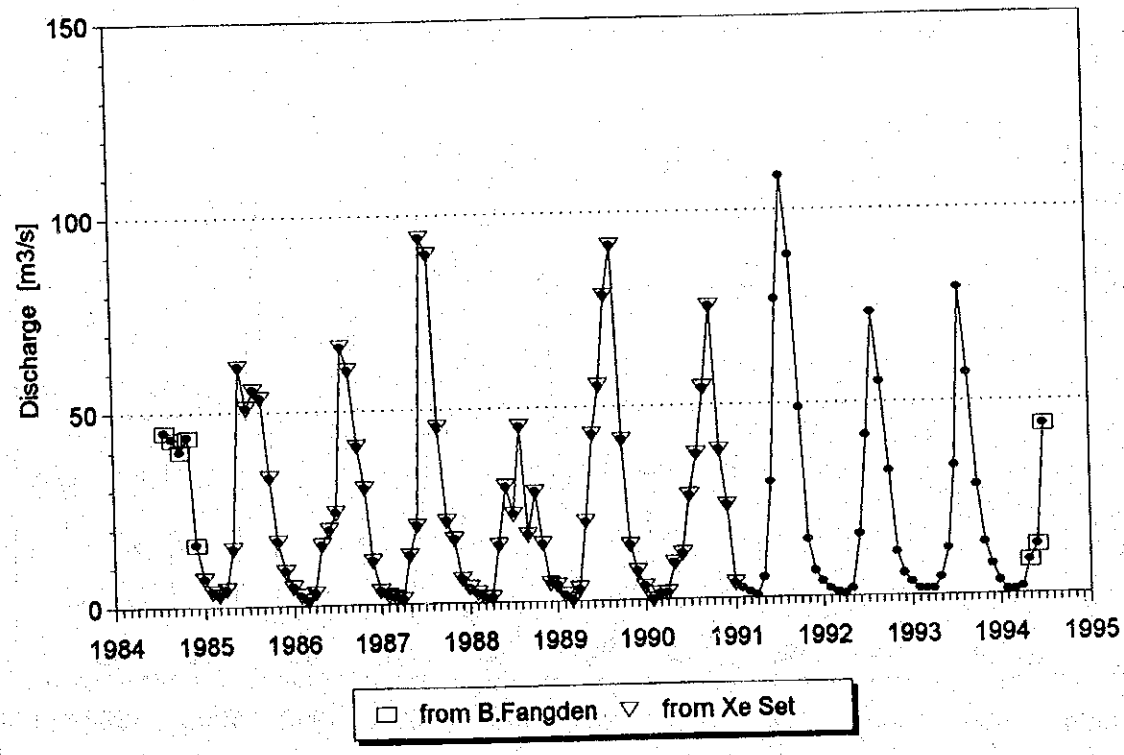


Fig. 9.2-12 Monthly Discharge of Xe Katam River at B.Nonghin

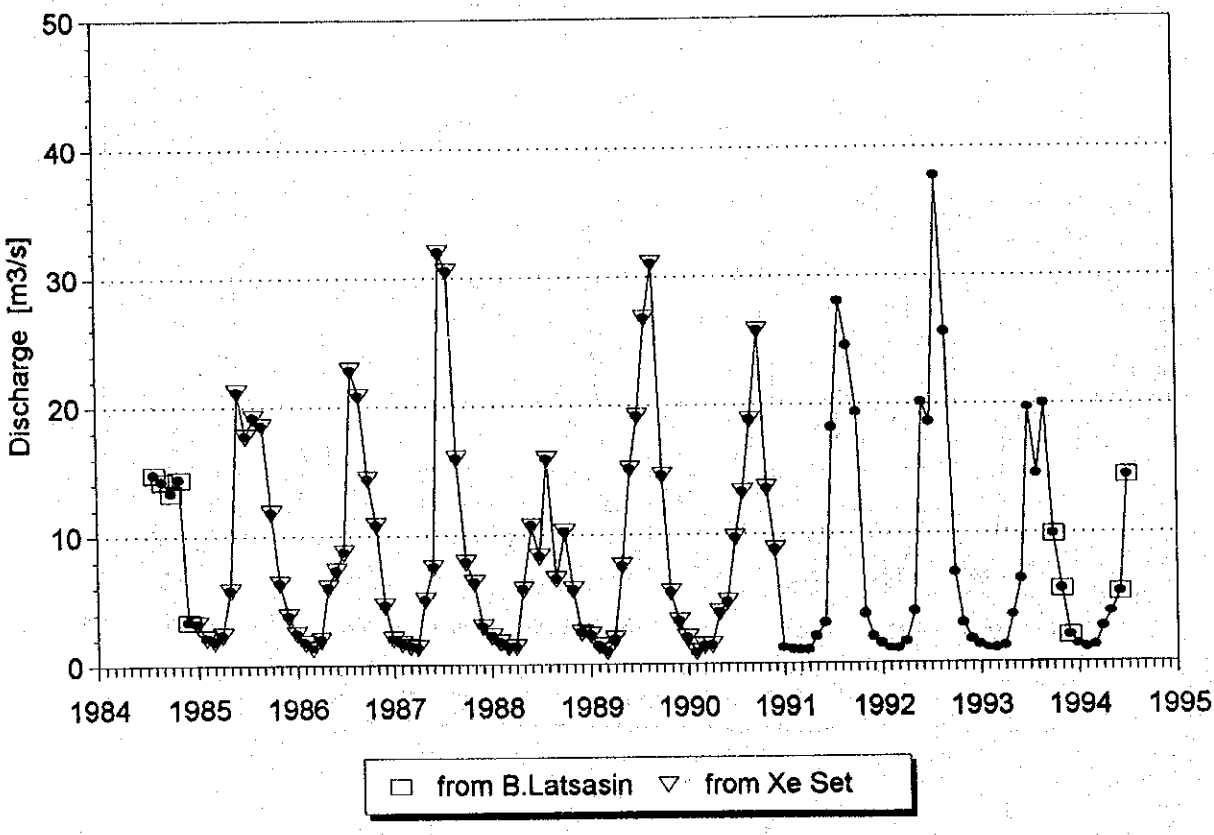


Fig. 9.2-13 Monthly Discharge bet. Xe Namnoy Mid & Down Projects

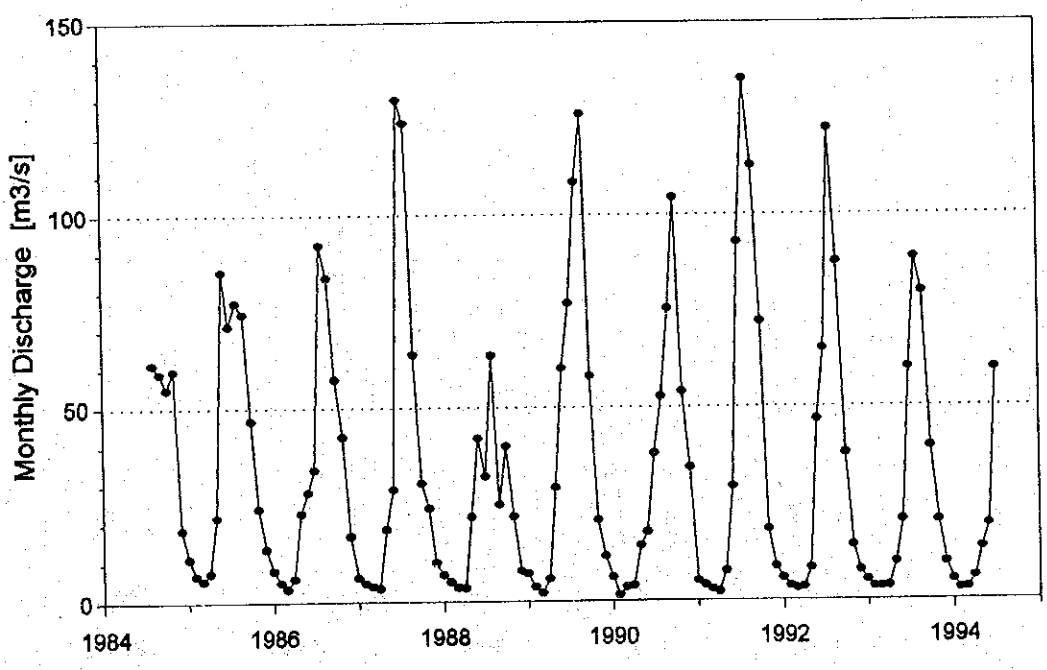


Fig.9.2-14 Monthly Discharge
of Xe Pian Diversion Scheme

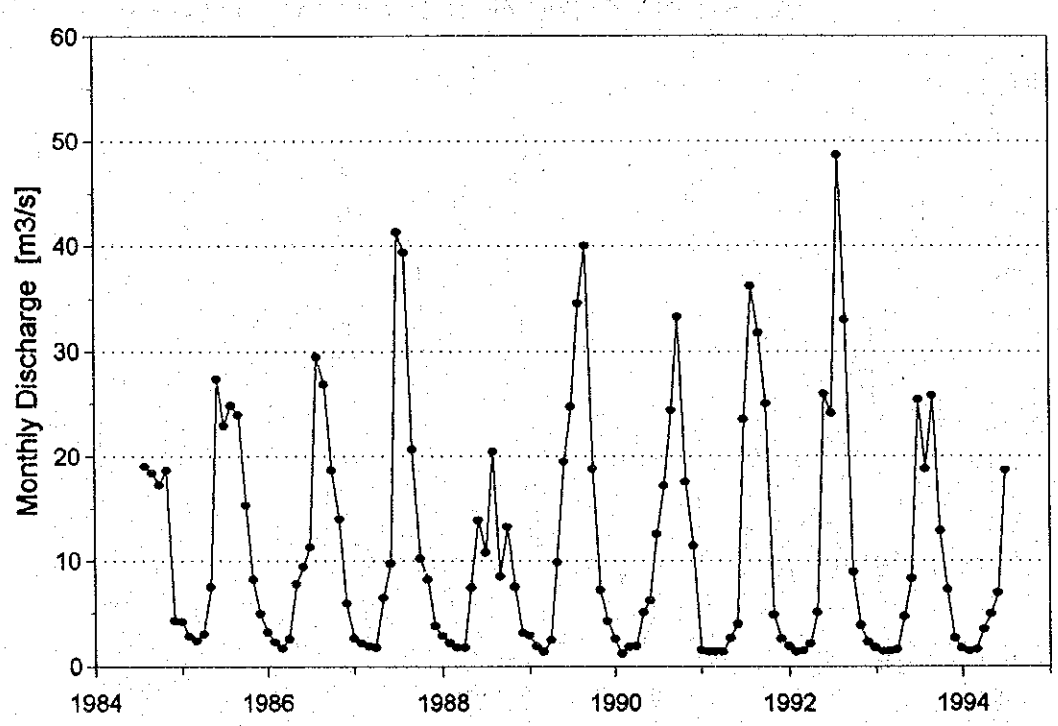


Fig.9.3-1 Peak & Mean Discharge Relation

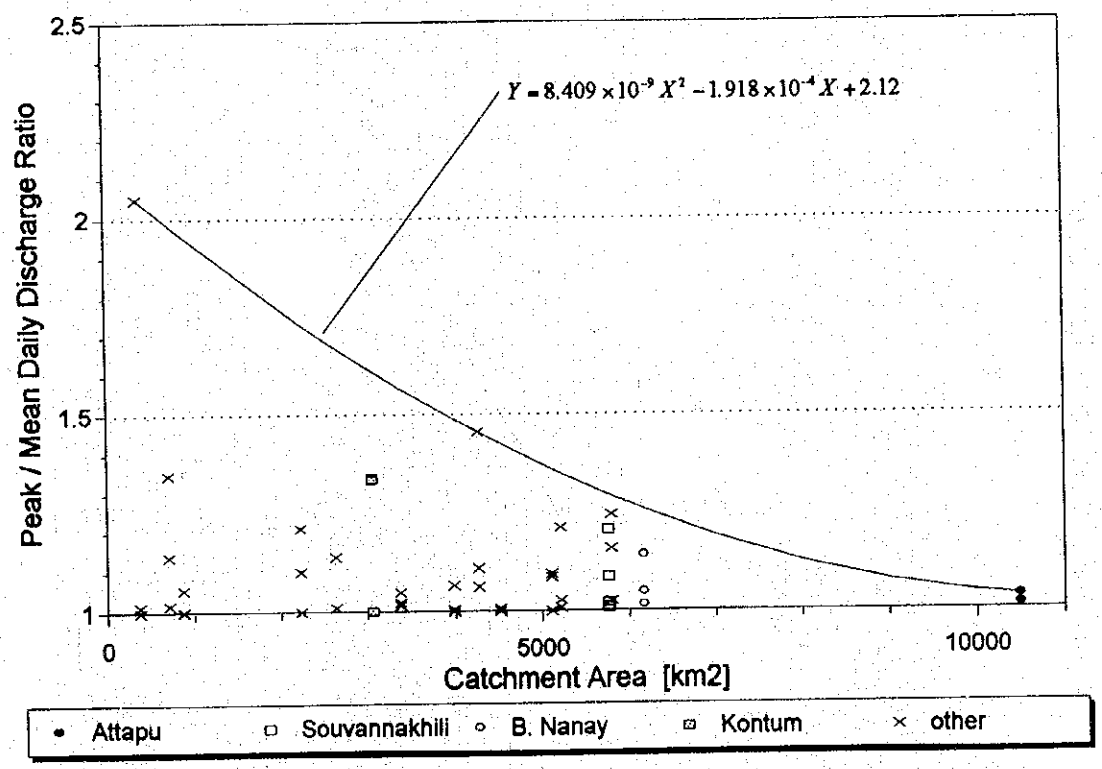


Fig. 9.3 - 2 Probable Flood of Se Kong No.4

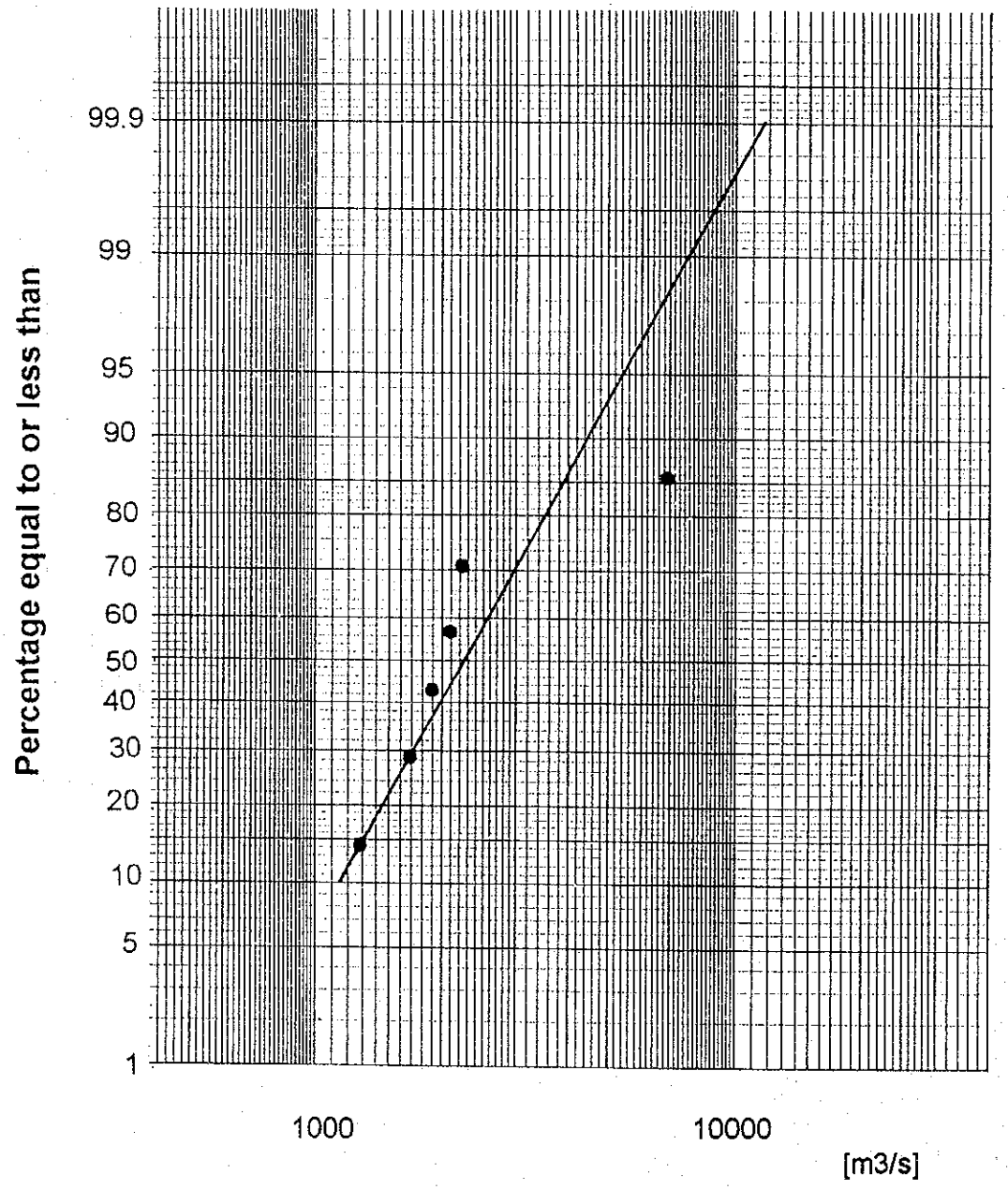


Fig. 9.3 - 3 Probable Flood of Xe Kaman No.1

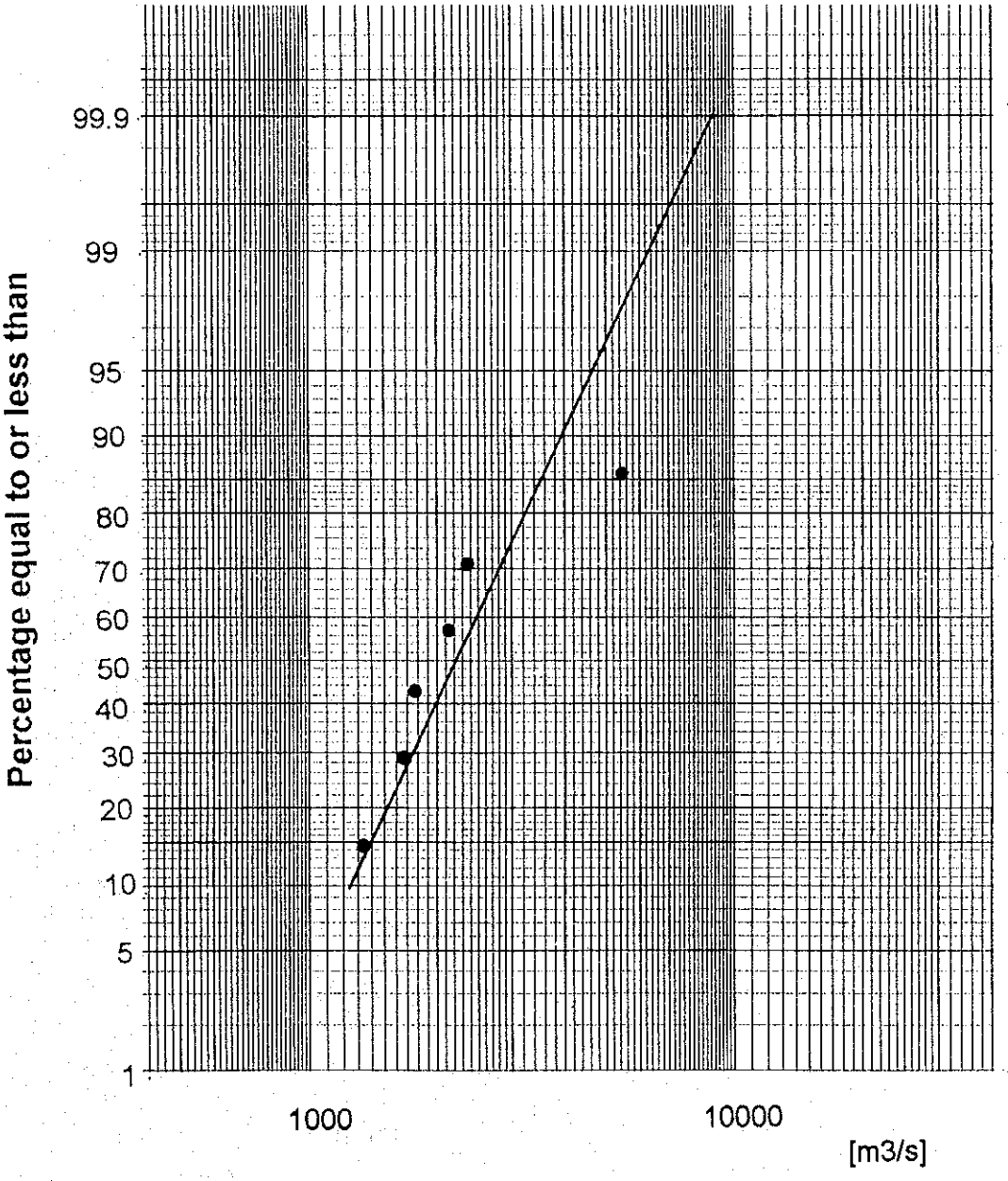


Fig. 9.3 - 4 Probable Flood of Xe Namnoy Midstream Project

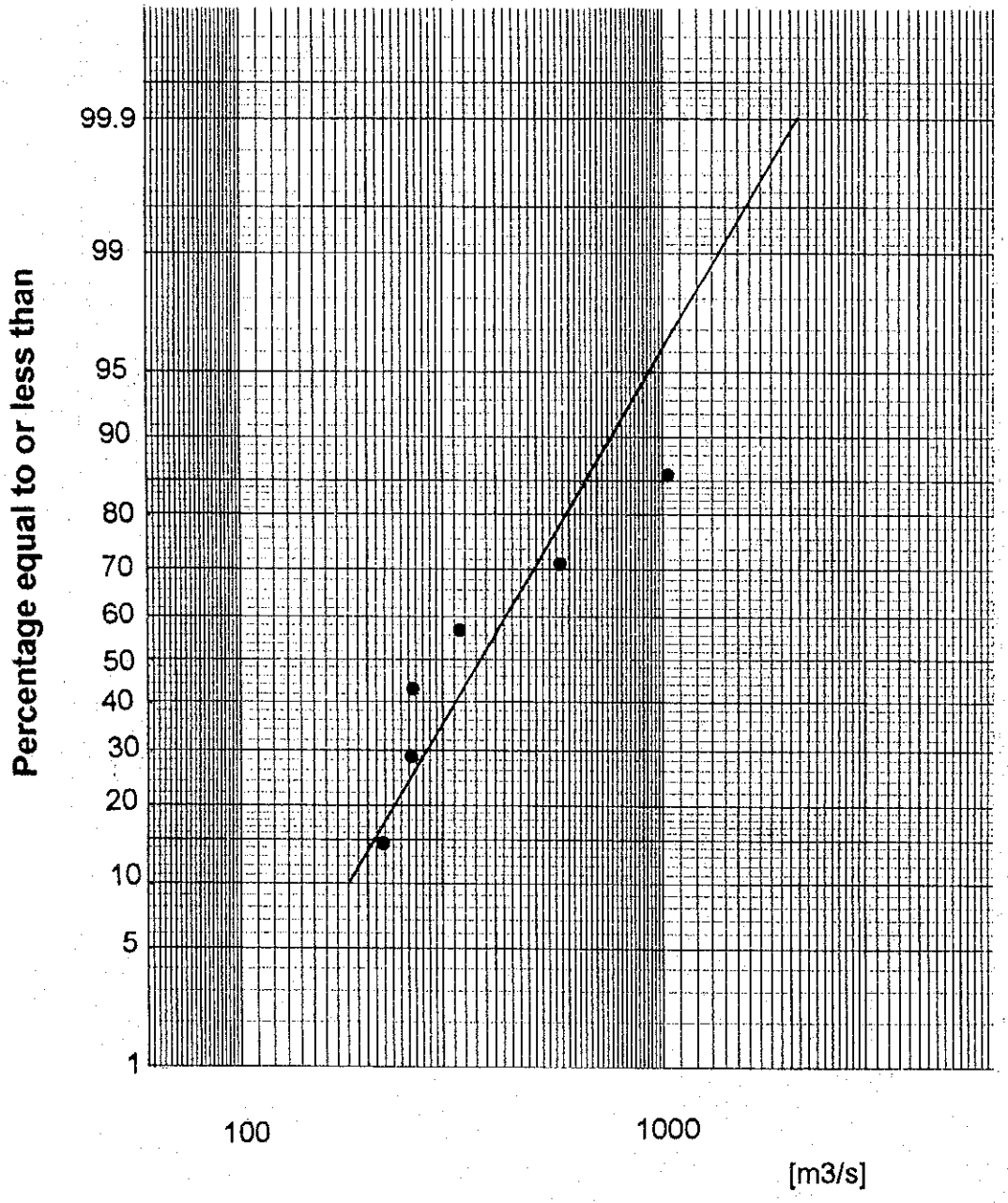
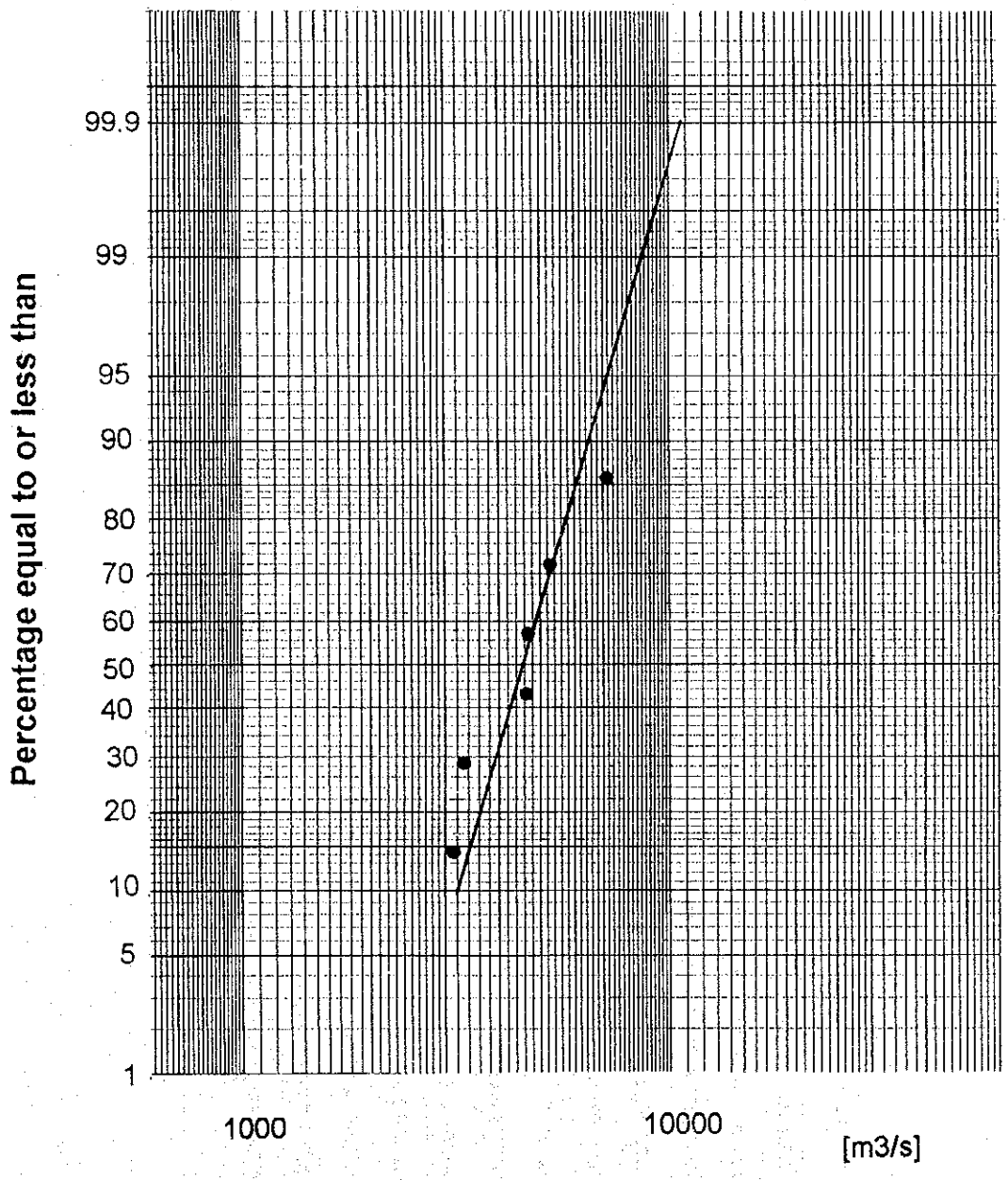


Fig. 9.3 - 5 Probable Flood of Se Kong River at Attapu



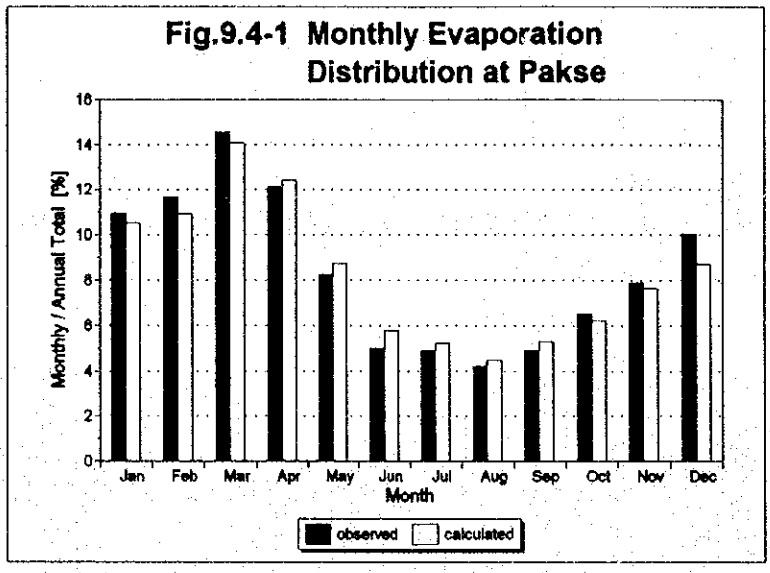


Fig.9.4-1 Monthly Evaporation Distribution at Pakse
Monthly / Annual Total [%]
0
2
4
6
8
10
12
14
16
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
observed
calculated

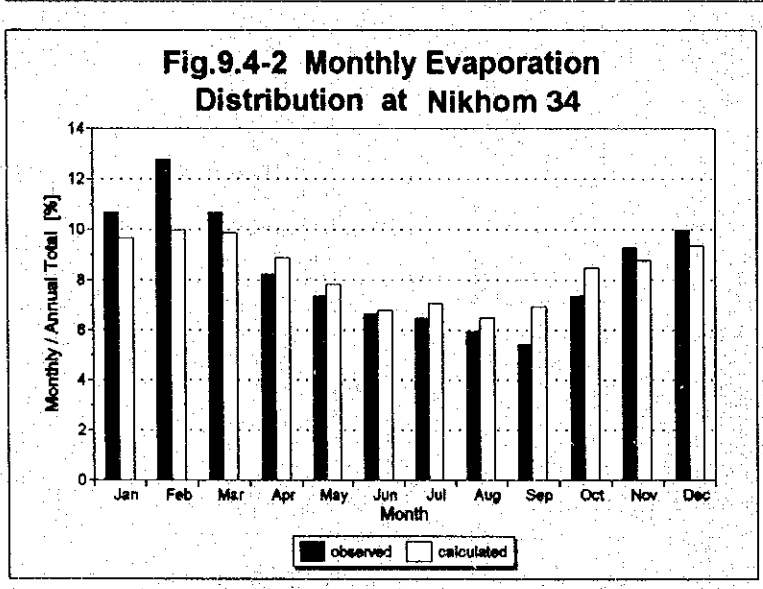


Fig.9.4-2 Monthly Evaporation Distribution at Nikhom 34
Monthly / Annual Total [%]
0
2
4
6
8
10
12
14
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
observed
calculated

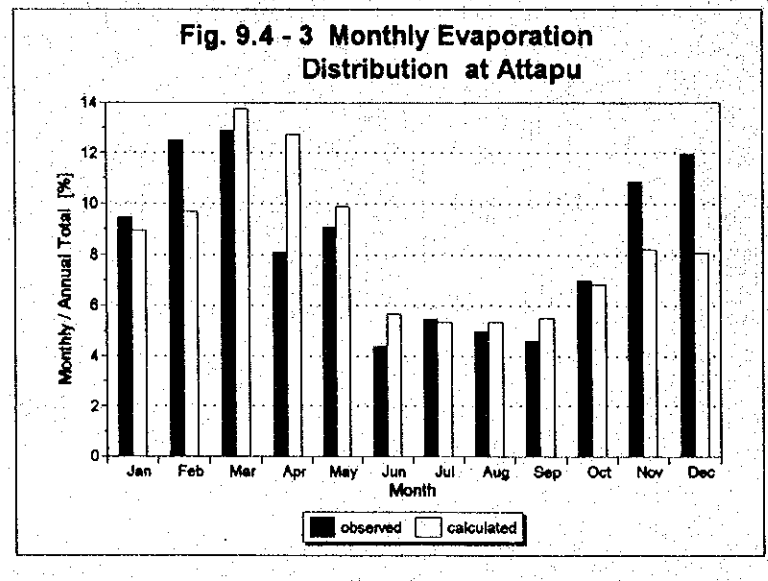


Fig. 9.4 - 3 Monthly Evaporation Distribution at Attapu
Monthly / Annual Total [%]
0
2
4
6
8
10
12
14
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
observed
calculated

Fig.9.4-4 Monthly Evaporation from 1993 to 1994 at Sekong Town

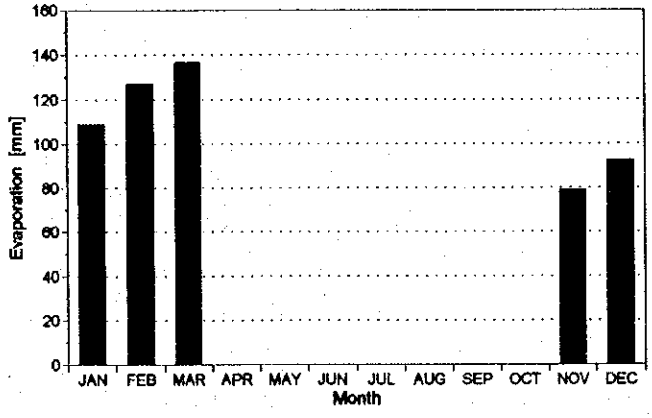


Fig. 9.4 - 5 Monthly Evaporation from 1993 to 1994 at Attapu

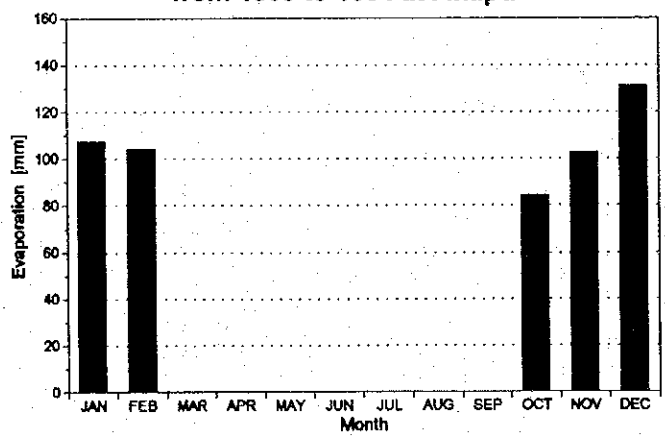
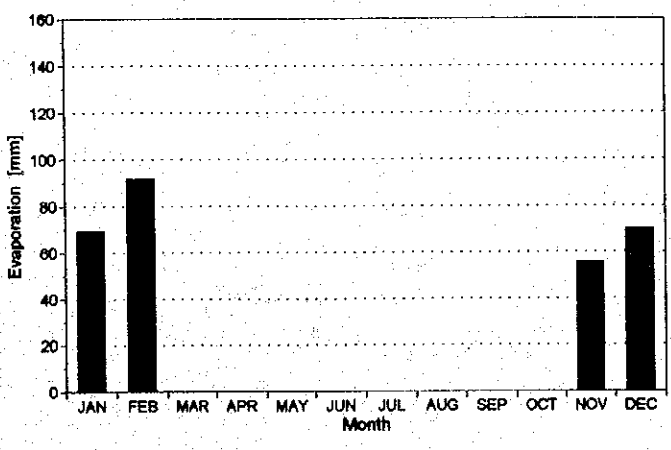


Fig. 9.4 - 6 Monthly Evaporation from 1993 to 1994 at B.Latsasin



10. Geology of Each Project

10. Geology of Each Project

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List of Drawings

Drawings	Description
DWG. 10.2-1	Se Kong No. 4 Project, Geology, Plan of Dam Site and it's Vicinity
DWG. 10.2-2	Se Kong No. 4 Project, Geology, Profile of Dam Site
DWG. 10.3-1	Xe Kaman No. 1 Project, Geology, Plan of Dam Site and it's Vicinity
DWG. 10.3-2	Xe Kaman No. 1 Project, Geology, Profile of Dam Site
DWG. 10.4-1	Xe Namnoy Midstream Project, Geology, Plan of Dam Site and it's Vicinity
DWG. 10.4-2	Xe Namnoy Midstream Project, Geology, Profile of Dam Site and it's Vicinity

10. Geology of Each Project

10.1 Outline of Geologic Data

Investigations carried out in Pre-Feasibility Stage in Se Kong No. 4, Xe Kaman No. 1 and Xe Namnoy Midstream Project Area are shown briefly in **Table 10.1-1**. These investigations are in the vicinity of dam sites.

The field geological survey was executed with topographic maps of scale 1:10,000, some of them are enlarged from 1:50,000 topographic maps published by National Geographic Department of Lap PDR. Aerial photographes are interpreted prior to this survey. Seismic prospecting and core boring are already described in Chapter 8.

Drilled cores are classified by the standard shown in **Table 10.1-2**. This standard consists of three fundamental factors such as weathering, hardness and crack spacing and each factor has 5 grades. The rock mass evaluation was tried by standards shown in **Table 10.1-3** and **10.1-4**, which are tentative and would be modified in later study stages.

Based on these data, geological plan of scale 1:10,000 and profile of scale 1:2,000 are provided in the vicinity of dam sites.

Other area or sites have no geological information except for those obtained in master plan stage by literature study interpretation of landsat images and aerial photographes and helicopter survey.

Table 10.1-1 Outline of Geological Investigation in Pre Feasibility Stage

Project	Geological Survey	Seismic Prospecting	Core Drilling
Se Kong No. 4	Dam site and its vicinity	Dam site 1 line, 1000 m	Dam site 3 holes, 260 m
Xe Kaman No. 1	Dam site and its vicinity	Dam site 2 lines, 1000m	Dam site 3 holes, 260m
Xe Namnoy Midstream	Dam site and its vicinity	Downstream of Dam site 1 line, 1000 m	Downstream of Dam site 6 holes, 380m

Table 10.1-2 Standard of Classification for Drilled Core

Weathering		Hardness		Crack spacing	
1	Very fresh. No weathering of mineral component.	1	Very hard. Broken into knifeedged pieces by strong hammer blow.	1	Over 30 cm
2	Fresh. Some minerals are weathered slightly. Usually no brown crack.	2	Hard. Broken into pieces by strong hammer blow.	2	10 - 30 cm
3	Fairly fresh. Some minerals are weathered. Cracks are stained and with weathered material.	3	Brittle. Broken into pieces by medium hammer blow.	3	3 - 10 cm
4	Weathered. Fresh portions still remain partially.	4	Very brittle. Easy broken into pieces by medium hammer blow.	4	1 - 3 cm
5	Strongly weathered. Most minerals are weathered and altered to second minerals.	5	Soft. Able to dig with hammer.	5	Under 1 cm

This standard has been used by EPDC.

Table 10.1-3 Standard of Rock Mass Evaluation

Class	Rock Mass Condition
a.	Fresh, sound, cracky in part
b.	Weathered, brittle, cracky
c.	Strongly weathered, soft or very cracky

Table 10.1-4 Relatiion of Rock Mass Evaluation and Classification for Drilled Core

		Grade of Weathering and Hardness				
		1	2	3	4	5
Grade of Crack Spacing	1	a	a	b	c	c
	2	a	a	b	c	c
	3	a	a	b	c	c
	4	b	b	b	c	c
	5	c	c	c	c	c

10.2 Se Kong No. 4 Project

(1) General Topography and Geology

Project area is in the upper course of Se Kong river. The altitude of mountains in the upstreammost area of the reservoir reached 1,500m, and the valleys are V shaped, those in remaining area are from 600 to 900 and valleys become wider with gentle slopes, and those in area downstream of the project area are about 400 m. Landslide topography, large scale slope failure and karst topography are subtle in the project area.

According to the geologic map (scale 1/1 million, Tien P.C. 1988) the project area is underlain by sedimentary rocks and volcanic rocks of Paleozoic and Mesozoic Age. In the neighboring area downstream of the project area is underlaine by younger strata composed of Jurassic to Cretaceous sandstone and shale which fold structure are readily traced by topography. But it is more difficult to interpret the geological structures by topography in the project area.

The bedrock of the project area is mainly composed of Ordovician sandstone and shist, Devonian red sandstone shale and conglomerate, Carboniferous shale chert and limestone, Permo-Carboniferous limestone, and Triassic conglomerate sandstone and rhyorite. Among them, limestone which sometimes affect the watertightness of the reservoir and dam site is judged to be limited and not continuous by the topographic information. The topographies indicating the limestone body in the project area was narrow discontinuous ridges. Coal seams are reported from Carboniferous strata.

(2) Dam Site

NNW-SSE trending mountain of some 500 m in elevation was cut by the Se Kong river at Se Kong No. 4 dam site. At dam site, river bed is elevation 140 m and around 100 m wide. The valley is about 900 m wide of high water level (El. 290 m). The slope on the right bank is 30° in average and steeper than that of right bank (20°).

According to the information obtained by aerophoto interpretation and geological survey along Se Kong river by boat, the dam site is located at the core of anticline formed by Post-Triassic strata. The dam axis is almost parallel to the anticline axis. But further detailed geologic structures are not obtained by aerophoto-interpretation. The filed geological survey, seismic prospecting and core boring provided the following information.

The geology in the vicinity of the dam site is shown in **DWG. 10.1-1** and **10.1-2**. Dam site is underlain by sandstone, shale and tuff. Sandstone and shale are distributed on the river bed and upstream of the dam site. Sandstone is gray in color, medium grained, thick bedded and with intercalation of carbonaceous shale. Shale is reddish grey in color, and distributed in the upstream of a gully on the right bank upstream of the dam site. Basalts are found on the river bed and in drillhole SK-1. Sandstone and shale dip downstream at 35 - 36° at the dam site and dip upstream in the upstream of the dam site. Though, existing geologic map (1:1 million, 1988) show the dam site with Triassic Manggiang. Formation, these sandstone and shale might belong to older formation.

Tuff layer accompanied by tuff breccia are andesitic and distributed on both banks of dam site and river bed downstream of the dam axis. They dip to the right bank. These tuff layers are supposed to unconformably overlie the sandstone and shale, which evidence have not obtained yet. Limestone block and fragments are rich in some layers and contain Permian Fusulina. Large limestone block are outcropped on the ridge at El. some 350 m on the right bank of the dam axis and at the river bank on the right bank about 1 km downstream of the dam axis. These blocks are up to 20 m thick and 200 m long, but not continuous. Tuff layers are overlain by conglomerate which is characterizey by dense white gravels, and maybe the lowermost layer of Jurassic series. These tuff layers are supposed to be of Manggian Formation because they contain Permian limestone blocks and are overlain by Jurrassic strata.

In the vicinity of the dam site, few lineament are interpreted and no fault sheared zone is confirmed by field geological survey.

Surface deposits such as talus deposits and recent river deposits are thin. The talus deposits in drillhole are less than 2 m in thickness, and correlating velocity layer of less than 700 m/sec provided by seismic prospecting does not exceed 4 m in thickness. Exceptionally, lower slope on the right bank of the dam axis would be covered by 10 - 20 m thick talus deposits judging from the existence of many blocks up to 5 m across and thick velocity layer of 1,500 m/sec.

The recent river deposits are inferred to be 10 m deep in maximum from abundant outcrops of tuff on the river bed downstream of the dam axis.

Weathering on the both banks are confirmed to be less than 5 m below rock surface in drillholes, 1.5 km/sec layer is some 10 m thick in general. The rock mass (tuff) below that depth has velocities more than 4 km/sec on the left bank and lower slope on the right bank,

Drillhole SK-1 penetrating these depth confirmed the rock mass to be fresh hard and intact in general. Most permeability test section in this drillhole are of less than 1 Lu, except from 50 to 70 m depth, where is characterized by fractuation of water level in drillhole during drilling, some dissolved calcite veins and the lugeon value up to 13.4 Lu. On the upper slope on the right bank 1.5 km/sec layer is underlain by 3.5 km/sec layer which is confirmed to be relatively loosened rock mass by the drillhole SK-3 providing the permeability from 5 - 10 Lu at the corresponding depth. Further below, from 70 ~ 90 m depth, the same drillhole has also permeability from 5 - 10 Lu.

Sandstone on the river bed has velocities of 4.5 to 5 km/sec, and revealed to be fresh, but cracky and somewhat permeable. (about half of luggeon test sections show some 10 Lu.)

The distribution of the limestone at the dam site is neither continuous nor wide.

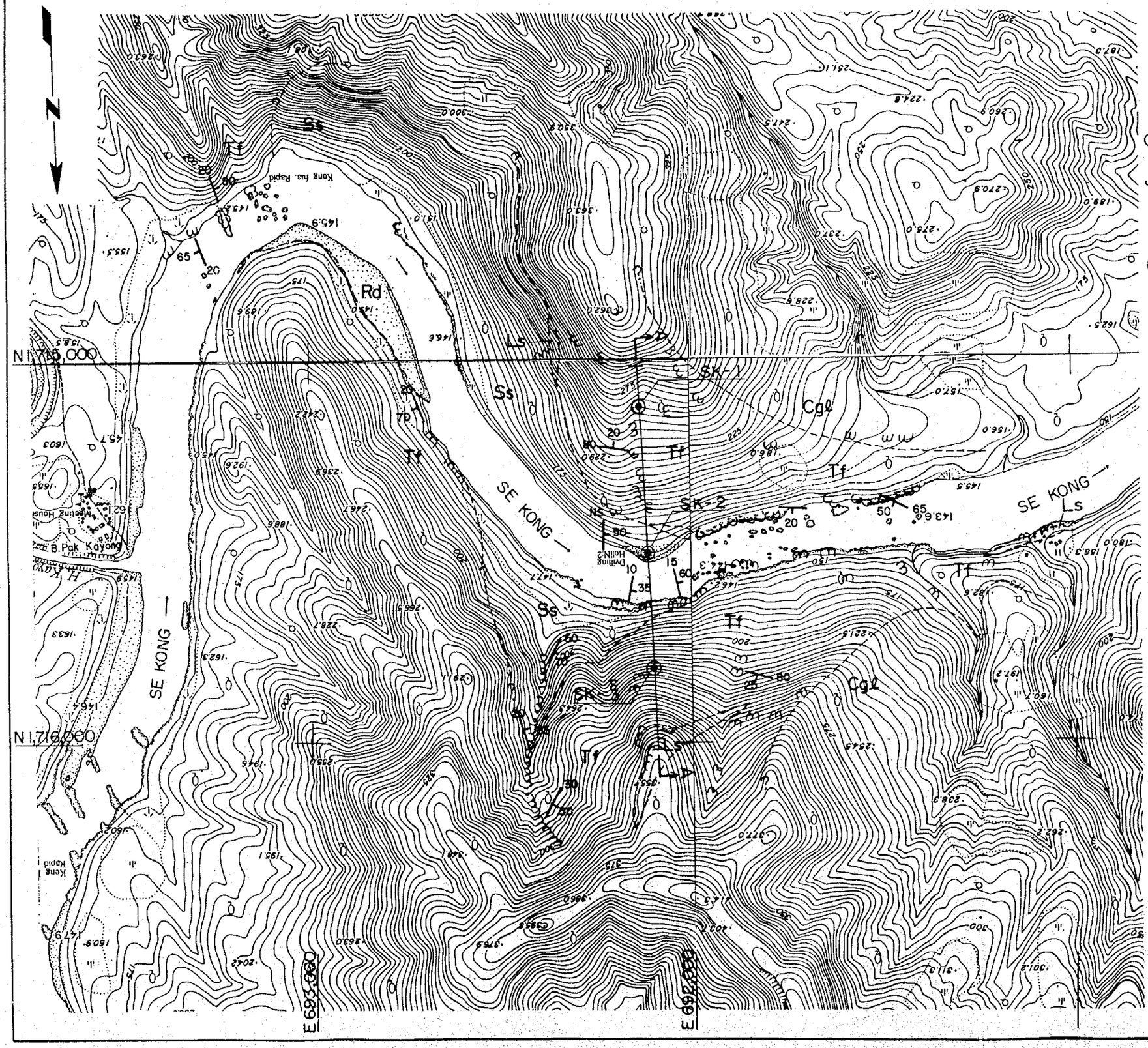
This dam site will not provide any serious geotechnical problems, because of shallow surface deposits and weathering, and generally low permeability.

(3) Reservoir Area

Upstream reservoir area is characterized by narrow valley and steep slopes rising up to El. 1,500 m. While, in remaining reservoir area, surrounding mountains are 400 to 600 m above sea level, valleys are widened and with gentle slopes. There is no distinct landslide topography, large scale slope failure and extensive karst topography.

According to the existing geological map (1:1 million, 1988), the reservoir area is underlain by the strata from Paleozoic to Triassic, mainly composed to shale and sandstone. Limestone distribution is judged from topography to be so limited and discontinuous that it will not cause any problem on reservoir watertightness, but farther investigations are still necessary. Coal seams distributed in the vicinity of B. Chakeui are reported to be the most favorable in Lao P.D.R., but their occurrence and altitude are not confirmed in this study.

It seems like that the reservoir area has few problems on stability of surrounding slopes and watertightness.



LEGEND

Quaternary	Rd	River deposits
Jurrasic	Cgℓ	Conglomerale
Triassic (Paleozoic?)	Tf	Tuff, tuff breccia shale
	Ls	Lime stone
	Ss	Sandstone

- Geologic boundary
- 70/30 Strike and dip of strata
- ω Rock outcrop
- ⊙ Drillhole
- Seismic prospecting line
- A A Profile

0 500m

MASTER PLAN STUDY ON HYDROELECTRIC POWER DEVELOPMENT IN THE SE KONG BASIN

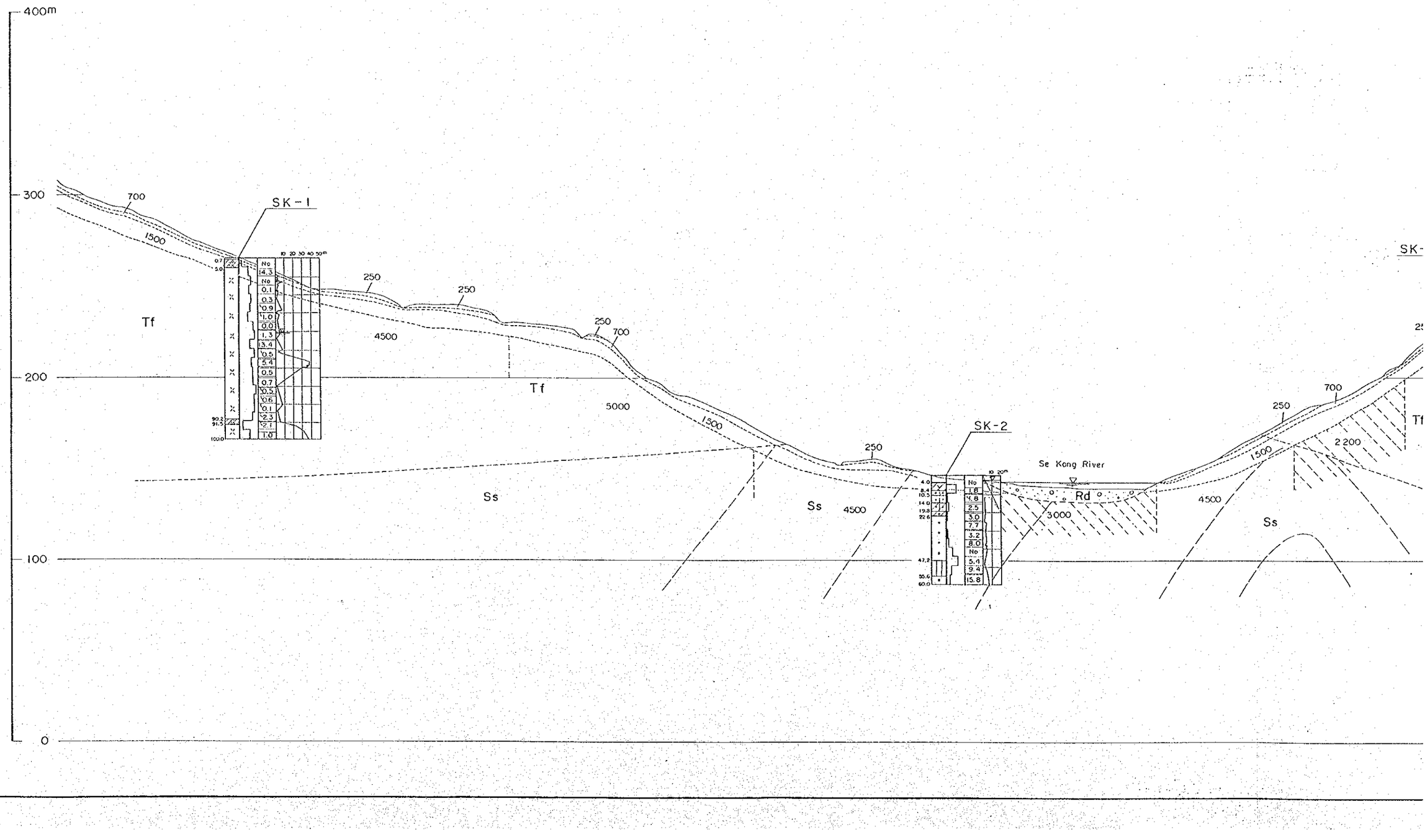
SE KONG NO.4 PROJECT

GEOLOGY

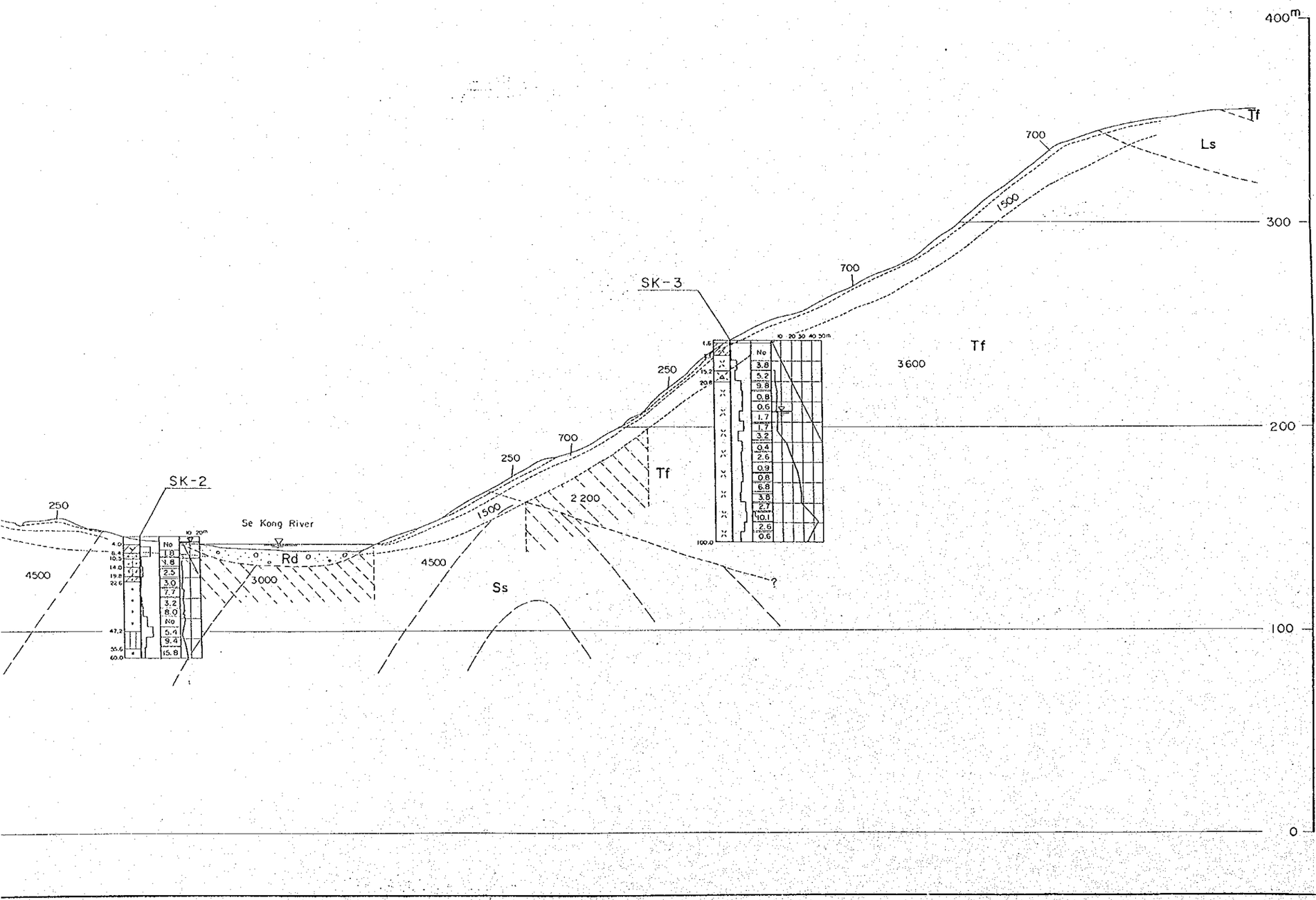
PLAN OF DAM SITE AND IT'S VICINITY

DWG. 10.2 - 1 | 1995

PROFILE A – A



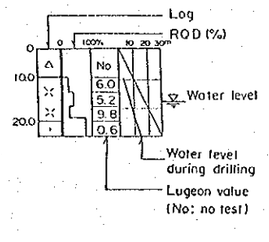
PROFILE A – A



LEGEND

- Rd — River deposits
- Tf — Tuff and tuff breccia
- Ls — Limestone
- Ss — Sandstone
- Geologic boundary
- Inferred bedding plane
- 1500 / 3000 — Velocity layer and velocity (m/sec)
- Low velocity zone

Log of Drillhole



Evaluation of drilled core

- c. class : Strongly weathered, cracky or soft
- b. class : Weathered or sheared, brittle and cracky
- a. class : Fresh, hard , cracky in part

0 — 100m

MASTER PLAN STUDY ON HYDROELECTRIC POWER DEVELOPMENT IN THE SE KONG BASIN

SE KONG NO.4 PROJECT

GEOLOGY

PROFILE OF DAM SITE

DWG. 10.2 – 2 | 1995

10.3 Xe Kaman No. 1 Project

(1) General Topography and Geology

The project area is located in the middle course of Xe Kaman river. The altitude of the mountains are 1,000 to 1,400 m on the left bank and some 1,000 m on the right bank. Xe Kaman river in the project area is El. 130 to 260 m and connects small basins separated by narrow gorges. Areas of gentle slope as high as some 1,000 m are remained in the vicinity of upstream to midstream project area. But close to the dam site mountains are eroded to have narrow ridges and steep slopes instead of gentle slopes.

Landslide topography and large-scale slope failure and remarkable karst topography are not observed in aerial photographs.

The project area underlain mainly by Padeozoic and Mesozoic rocks as shown in existing geologic map (1:1 million, 1988). They are Cambrian-Ordovician shist and sandstone, Devonian red sandstone, chert and shale, Carboniferous shale, chert and sandstone and Triassic Manggian Formation composed of conglomerate, siltstone and sandstone in descending order. Carboniferous strata are intruded by plutonic rocks. Basalt covers the plateau of elevation about 1,000 m on the right bank and seems to overline Mesozoic and Paleozoic strata.

(2) Dam site

The dam site is located on the second downstreamost gorge of Xe Kaman river. River bed is at elevation of about 130 m and 80 m wide. Valley is about 500 m wide at high water level (El. 260 m). The slopes below an elevation of some 240 m have an average gradient of 40° on the left bank and 50° on the right bank. The slopes above that elevation are 30° on the left bank and 40° on the right bank. Tributary valley on the right bank downstream of the dam site is deep and with steep slopes, and makes the mountain body on the right bank slender. A gentle slope at 25 to 30° is distributed locally just upstream of the dam site.

The dam site is underlain by sandstone and intercalating conglomerate and shale. Sandstone is reddish grey in color, medium to coarse grained, thick bedded. (each bed is usually 50 cm to 1 m thick) and some times get coarser to conglomerate. Shale are distributed locally outside of dam site, and less than 10 m in thickness, those found 400 m downstream from dam axis are reddish in color and found 600 m upstream are black.

Strata composed of sandstone, conglomerate and shale are wound in the vicinity of the dam site, but generally inclined downstream at 70° to 80°at the dam site.

Talus deposits are limited on the upper slope of the dam site, where they are 12.9 m thick in Drillhole XK-1. Their velocity of 1.7 km/sec, however indicate them to be strongly weathered rock.

Recent river deposits are inferred to be some 5 m thick by the cuterops on the river bed both downstream and upstream of the dam site.

Strongly weathered rock mass on the upper slope on the left bank are found above 19.3 m depth in Drillhole XK-1. Because this depth is in 3 km/sec layer, upper part of 3 km/sec layer corresponds to weathered rock. Below this depth XK-1 got fresh and hard core, low permeability (most test sections are less than 2 Lu) and small fractuation of water level in drillhole during drilling. Velocity layer of 3 km is supposed to represent the rock mass above 12.9 m depth, and rockmass below that depth has a velocity of 5 km/sec as obtained on the lower slope.

On the middle slope on the right bank Drillhole XK-3 met weathered zone down to 10 m depth, which corresponds to 1.4 km/sec layer. The depth of 1.4 km/sec layer is down to 10 to 20 m. This hole obtained fresh and hard cores but permeable bed rock (more than 10 Lu) down to 35 m depth, final water level at 40.2 m, continuous decrease in water level during drilling above 50 m depth. These data suggest the bed rock above 40 m depth to be loosened. This suggestion are supported by 3.5 km/sec velocity layer.

On the lower slope, bed rock is free of weathering but loosened. The velocity obtained by seismic prospecting is 3.2 km/sec.

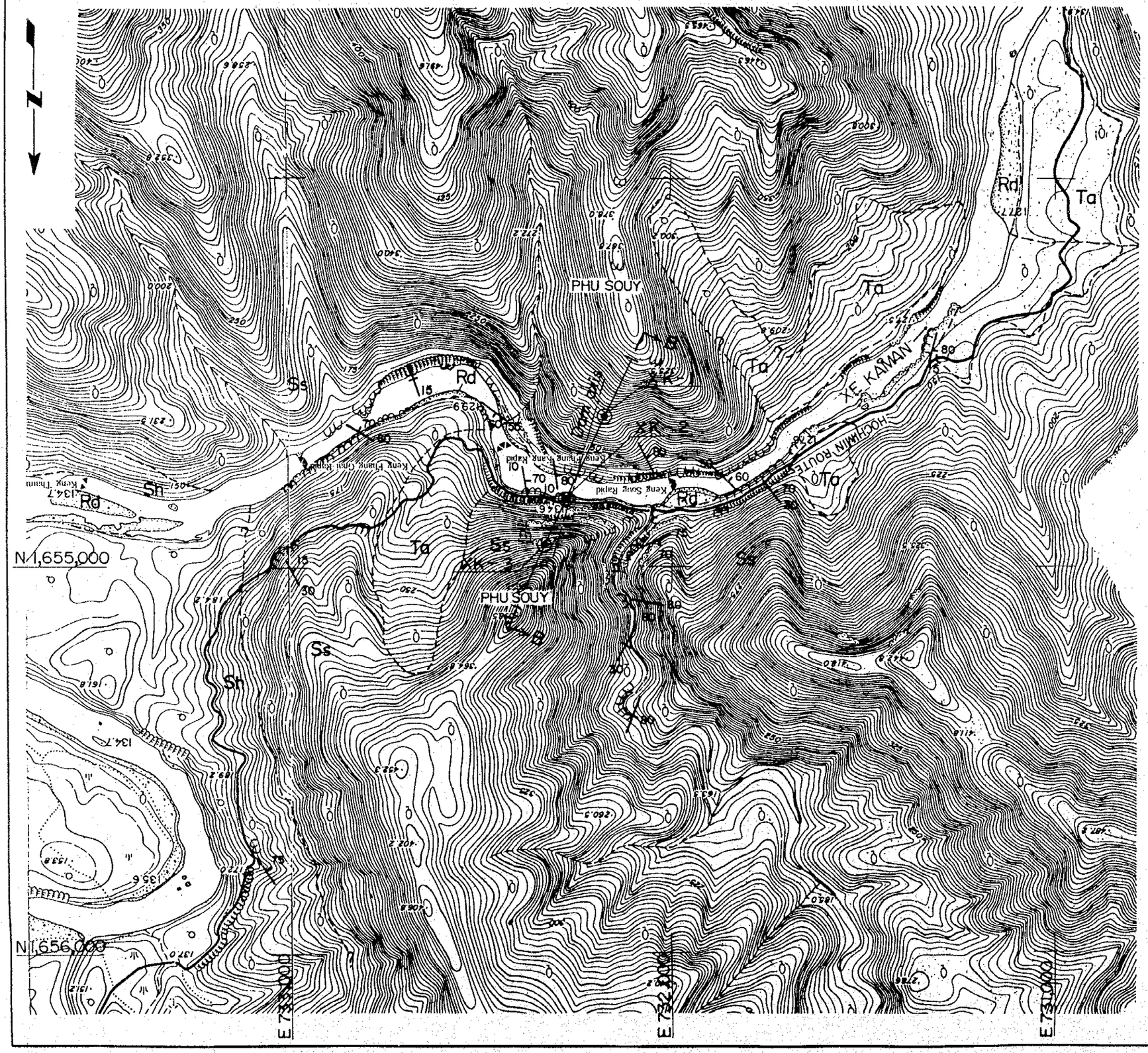
On the river bed, fresh and hard rock are exposed and also confirmed in Drillhole XK-3. But permeability of that hole is rather high (4 out of 9 sections are 5 to 15 Lu).

On the gentle slope on the right bank upstream of the dam site, any outcrop of bed rock is not confirmed. At the foot of this slope, at the river bank, black clay with rock fragment is found. This slope is supposed to be covered by thick talus deposits or coluvium and require consideration on slope stability in case of empond of the reservoir.

(3) Reservoir Area

The reservoir area is surrounded by the mountain having elevations from 1,000 to 1,400 m. Valleys are generally narrow and V shaped in the upstream reservoir area, some basins separated by short gorges appear in the downstream reservoir area. The ridges trend NW-SE and make gorges. The slopes surrounding the reservoir are usually high and some of them rise up to 1,000 m, but any distinct landslide topography or large slope failure is not observed. Close to the backwater of the reservoir, high white cliffs are continued along the Xe Kaman river and seems to be composed by limestone, but typical karst topographies are not found. This area should be further investigated in order to make clear the hydro geological role. Basalt on the right bank seems to cover Mesozoic and Paleozoic strata and be above high water level. Remaining strata are mainly composed of shale and sandstone and supposed to be watertight.

A NW-SE fault is shown in existing geological map (1:1 million, 1988) about 5 km upstream of the dam site. This fault is recognized in aerial photograph as a sharp strait lineament and one of the largest in the reservoir area, but don't bring any serious problems on slope stability, watertightness and seismotectonics.



LEGENT

Quaternary
- Rd — River deposits
- Ta — Talus deposits

Triassic
- Ss — Sandstone and conglomerate
- Sh — Shale

- Geologic boundary
- 40/70 — Strike and dip of strata
- ω — Rock outcrop
- Drillhole
- Seismic prospcting line
- B — B — Profile

0 — 500m

MASTER PLAN STUDY ON HYDROELECTRIC POWER DEVELOPMENT IN THE SE KONG BASIN

XE KAMAN NO.1 PROJECT

GEOLOGY

PLAN OF DAM SITE AND IT'S VICINITY

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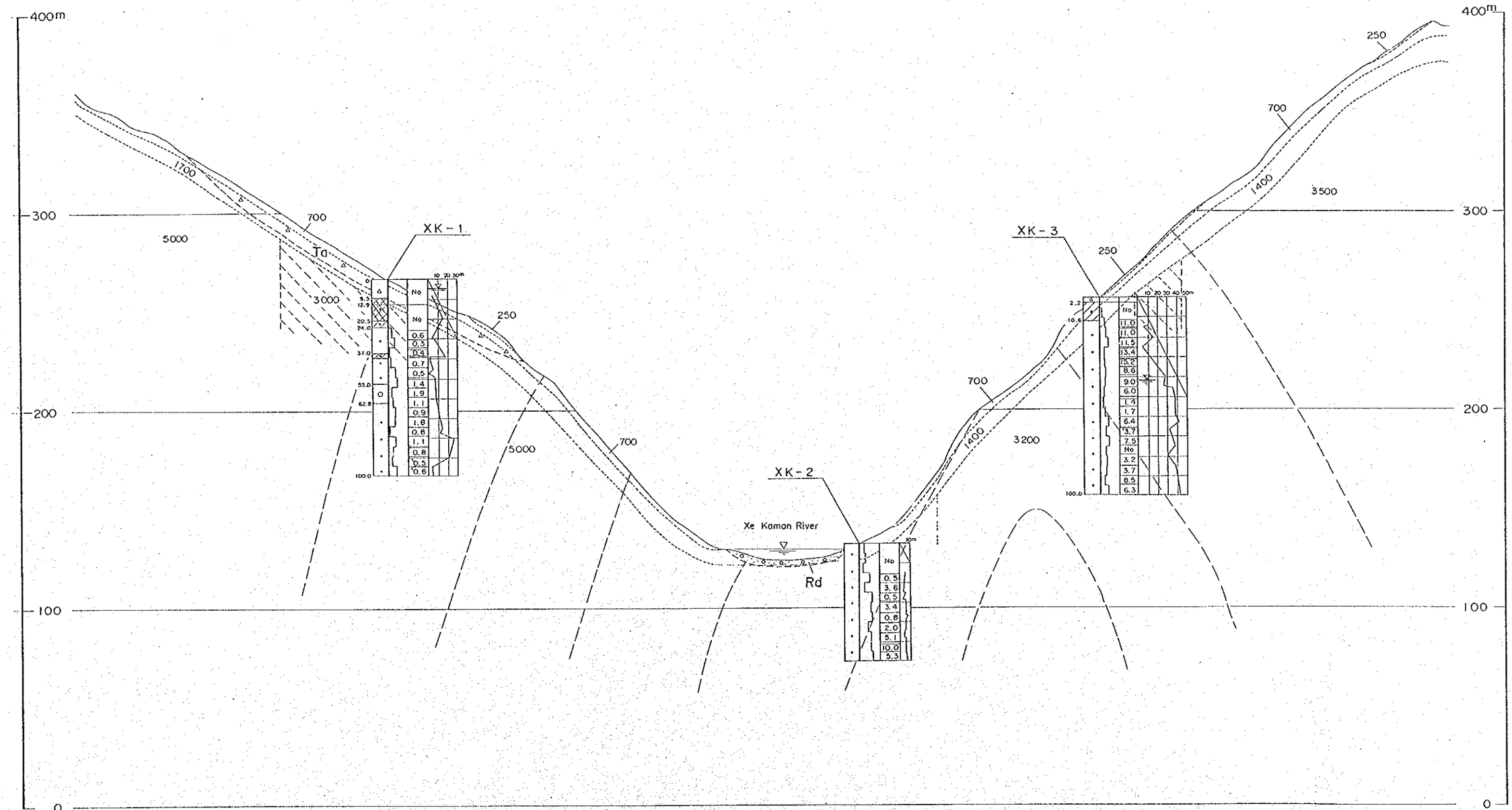
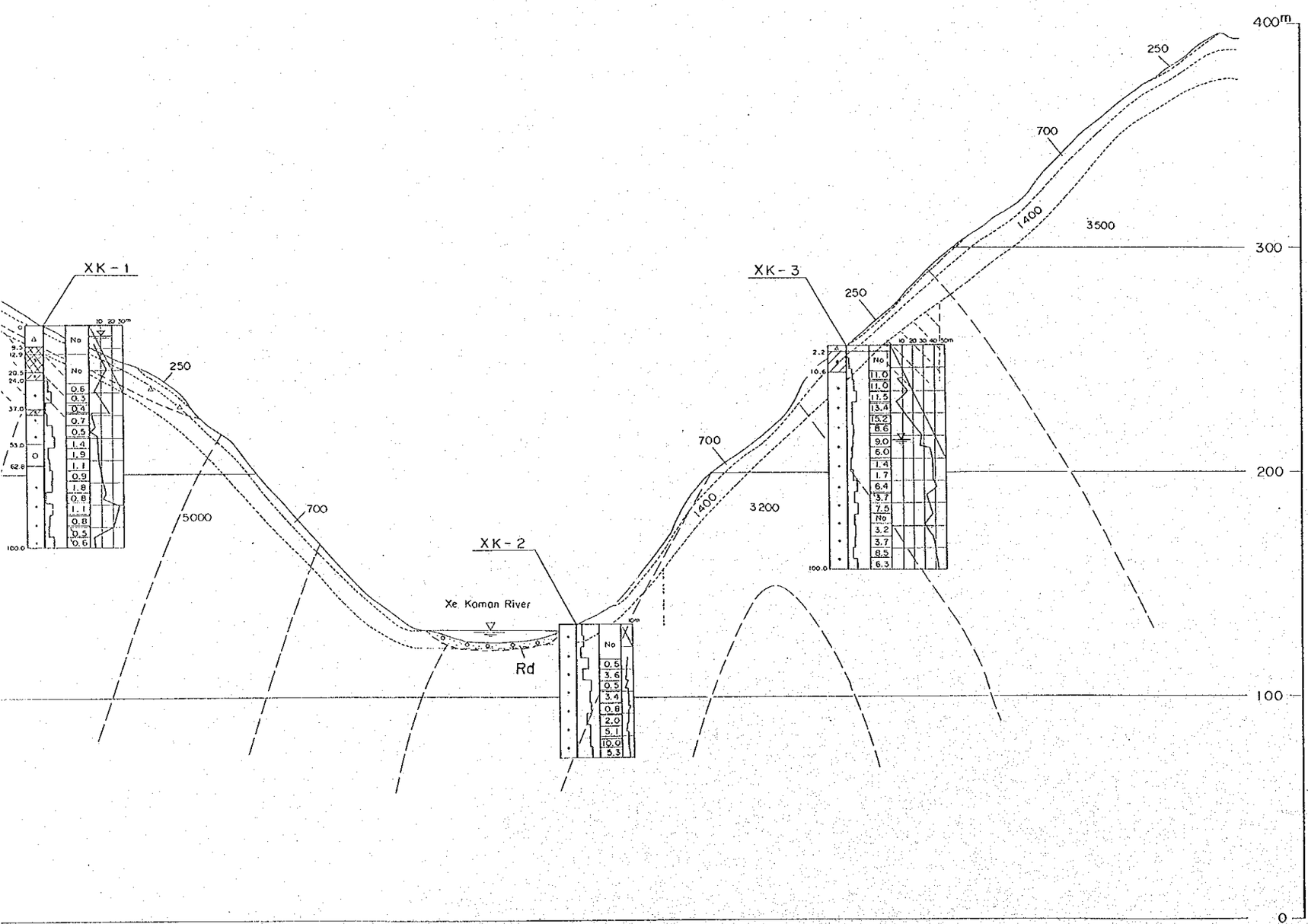
PROFILE B – B



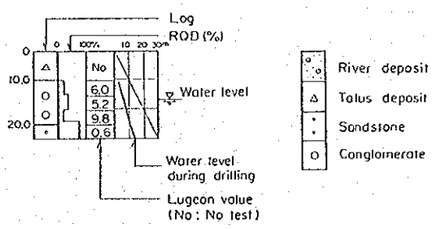
PROFILE B – B



LEGEND

- Rd — River deposits
- Ta — Talus deposits
- Ss — Sandstone and conglomerate
- Geologic boundary
- Inferred bedding plane
- 1400 / 5000 — Velocity layer and velocity (m/sec)
- Low velocity zone

Log of Drillhole



Evaluation of drilled core

- c. class : Strongly weathered, cracky or soft
- b. class : Weathered or sheared, brittle and cracky
- a. class : Fresh, hard, cracky in part

0 — 100m

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PROFILE OF DAM SITE

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