Fig. II-1-6 DURATION CURVE OF XE KATAM DOWNSTREAM AT INTAKE SITE

1991—1990(MEAN)

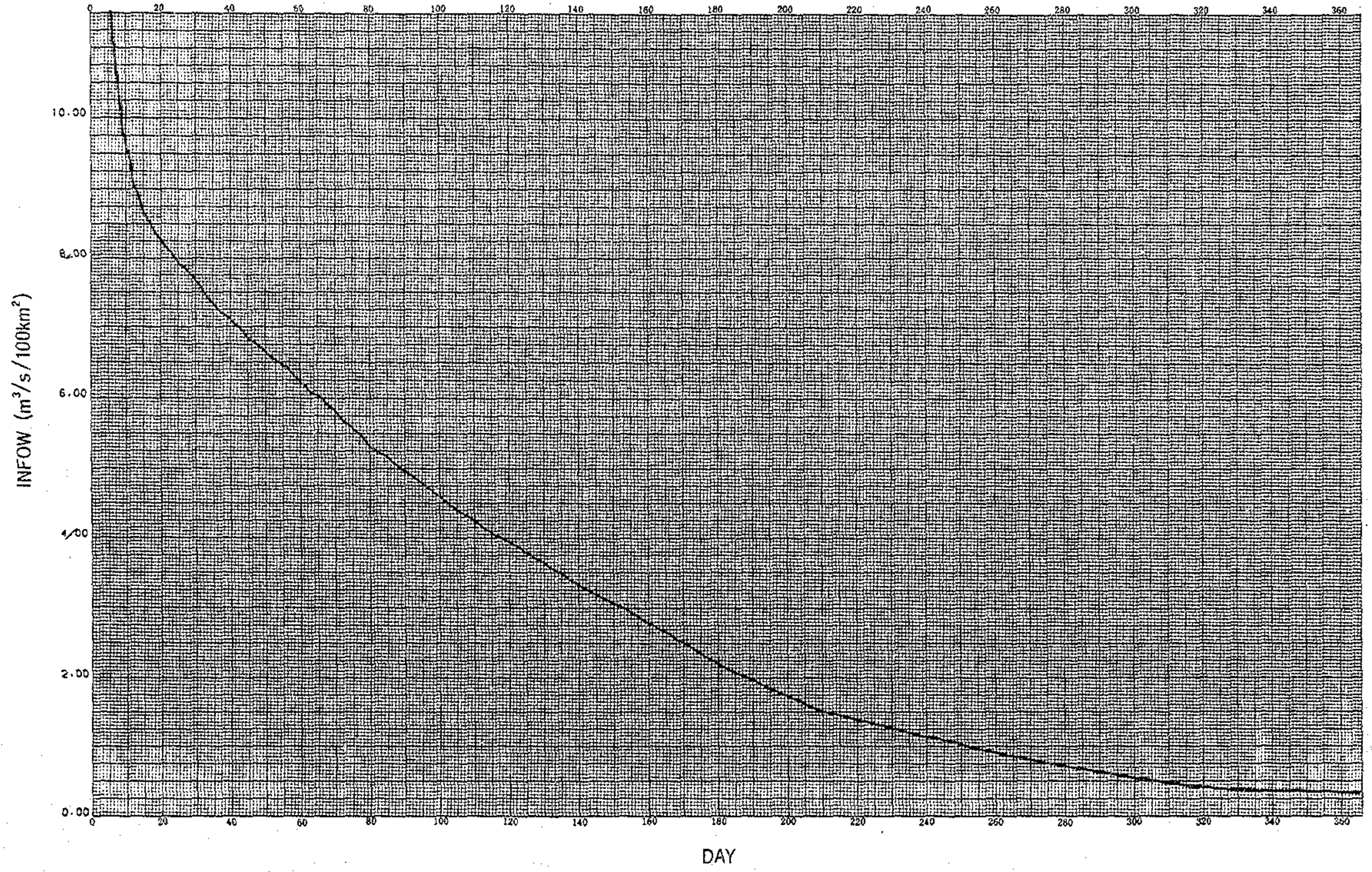


Table II-1-4 Calculated Discharge at Ban Latsasin

Xe Namnoy River (CA. 537 km^2)

(unit : m^3/s)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
81	3.22	1.31	1.33	2.46	17.91	44.70	43.39	56.50	31.51	26.50	12.29	7.57	20.86
82	4.97	2.54	1.01	1.01	1.78	8.95	39.71	40.73	43.85	21.33	19.55	14.80	16.78
83	6.66	4.29	1.96	1.41	20.51	32.18	26.25	29.99	29.68	35.99	15.14	7.43	17.71
84	5.07	2.83	2.08	1.68	3.81	15.20	22.52	63.58	65.66	39.77	27.30	12.66	21.94
85	7.97	5.57	4.22	16.30	20.18	35.06	47.33	47.58	43.93	23.04	14.25	9.03	22.97
86	6.58	4.12	2.07	2.48	16.59	18.19	32.67	51.12	44.75	29.06	15.78	8.40	19.43
87	5.90	3.44	1.69	1.38	1.33	4.44	28.59	38.91	31.22	24.73	12.55	6.54	13.49
88	4.46	2.29	1.21	2.33	12.36	23.34	17.39	32.56	19.76	22.35	11.60	5.87	13.04
89	3.81	1.76	0.97	1.37	4.29	13.64	20.24	35.00	29.78	15.69	7.97	5.16	11.70
90	3.19	1.31	4.51	3.68	3.84	11.92	16.07	21.33	34.20	29.30	12.31	6.05	12.36
AVE.	5.18	2.95	2.11	3.41	10.26	20.76	29.42	41.73	37.43	26.78	14.87	8.35	17.03
MAX.	7.97	5.57	4.51	16.30	20.51	44.70	47.33	63.58	65.66	39.77	27.30	14.80	22.97
MIN.	3.19	1.31	0.97	1.01	1.33	4.44	16.07	21.33	19.76	15.69	7.97	5.16	11.70

Table II-1-5 Calculated Discharge at Xe Katam Powerhouse Site

Xe Namnoy River (CA. 784 km^2)

(unit : m^3/s)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
81	5.51	2.65	2.90	3.95	26.12	64.12	61.61	80.93	45.00	38.46	18.33	11.91	30.32
82	7.52	3.72	2.17	2.34	3.37	13.46	57.21	57.95	62.62	30.74	28.78	21.54	24.43
83	10.60	6.57	3.06	2.81	29.83	46.58	37.49	43.18	42.65	51.54	21.80	11.90	25.79
84	7.81	4.24	3.39	2.75	5.44	21.96	31.90	91.25	93.05	56.46	39.29	18.94	31.52
85	12.15	8.17	6.13	23.35	28.27	50.13	66.96	67.53	62.14	32.81	20.62	13.56	32.78
86	9.62	5.76	3.20	4.19	24.13	25.94	47.00	73.15	63.54	41.59	22.94	13.24	28.03
87	8.90	5.00	2.98	2.78	2.78	7.13	41.41	56.07	44.49	35.66	18.55	10.74	19.84
88	7.16	3.76	2.64	4.28	18.35	33.68	25.36	47.03	28.57	32.63	17.13	9.70	19.30
89	6.14	3.11	2.39	3.12	7.07	20.15	29.84	50.45	42.82	23.03	12.60	8.70	17.55
90	5.33	2.62	7.64	6.19	6.43	17.92	23.45	31.24	49.34	42.09	18.18	10.21	18.47
AVE.	8.07	4.56	3.65	5.58	15.18	30.11	42.22	59.88	53.42	38.50	21.82	13.04	24.80
MAX.	12.15	8.17	7.64	23.35	29.83	64.12	66.96	91.25	93.05	56.46	39.29	21.54	32.78
MIN.	5.33	2.62	2.17	2.34	2.78	7.13	23.45	31.24	28.57	23.03	12.60	8.70	17.55

Table II-1-6 Calculated Discharge at Ban Nonghin

Xe Katam River (CA. 171 km^2)

(unit : m^3/s)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
81	1.19	0.69	0.80	1.02	5.82	14.03	13.36	17.46	9.55	8.11	3.74	2.41	6.56
82	1.57	0.86	0.65	0.68	0.91	3.10	12.58	12.62	13.53	6.51	6.09	4.53	5.33
83	2.18	1.40	0.77	0.79	6.67	10.26	8.19	9.37	9.20	11.08	4.57	2.44	5.60
84	1.65	0.97	0.91	0.78	1.31	4.89	7.01	19.87	20.12	12.04	8.27	3.86	6.84
85	2.48	1.72	1.33	5.13	6.19	10.92	14.52	14.56	13.31	6.89	4.27	2.78	7.04
86	2.02	1.28	0.88	1.12	5.46	5.79	10.32	15.93	13.72	8.87	4.81	2.73	6.11
87	1.90	1.15	0.85	0.81	0.80	1.75	9.20	12.31	9.68	7.69	3.94	2.26	4.39
88	1.56	0.93	0.77	1.12	4.18	7.46	5.58	10.25	6.17	7.03	3.64	2.05	4.25
89	1.35	0.81	0.71	0.86	1.72	4.54	6.60	11.03	9.28	4.92	2.65	1.84	3.88
90	1.19	0.71	1.84	1.52	1.55	4.03	5.19	6.84	10.73	9.07	3.83	2.12	4.07
AVE.	1.71	1.05	0.95	1.38	3.46	6.68	9.26	13.02	11.53	8.22	4.58	2.70	5.41
MAX.	2.48	1.72	1.84	5.13	6.67	14.03	14.52	19.87	20.12	12.04	8.27	4.53	7.04
MIN.	1.19	0.69	0.65	0.68	0.80	1.75	5.19	6.84	6.17	4.92	2.65	1.84	4.07

Table II-1-7 Calculated Discharge at Xe Katam Intake Site

Xe Katam River (CA. 290 km^2)

(unit : m^3/s)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
81	2.04	0.98	1.07	1.46	9.66	23.72	22.79	29.94	16.64	14.22	6.78	4.41	11.22
82	2.78	1.38	0.80	0.87	1.25	4.98	21.16	21.44	23.16	11.37	10.65	7.97	9.04
83	3.92	2.43	1.13	1.04	11.04	17.23	13.87	15.97	15.78	19.06	8.06	4.40	9.54
84	2.89	1.57	1.26	1.02	2.01	8.12	11.80	33.75	34.42	20.89	14.53	7.01	11.66
85	4.50	3.02	2.27	8.64	10.46	18.54	24.77	24.98	22.99	12.14	7.63	5.02	12.13
86	3.56	2.13	1.19	1.55	8.93	9.60	17.38	27.06	23.50	15.39	8.49	4.90	10.37
87	3.29	1.85	1.10	1.03	1.03	2.64	15.32	20.74	16.46	13.19	6.86	3.97	7.34
88	2.65	1.39	0.98	1.58	6.79	12.46	9.38	17.40	10.57	12.07	6.34	3.59	7.14
89	2.27	1.15	0.89	1.16	2.61	7.45	11.04	18.66	15.84	8.52	4.66	3.22	6.49
90	1.97	0.97	2.83	2.29	2.38	6.63	8.67	11.56	18.25	15.57	6.72	3.78	6.83
AVE.	2.99	1.69	1.35	2.06	5.62	11.14	15.62	22.15	19.76	14.24	8.07	4.83	9.18
MAX.	4.50	3.02	2.83	8.64	11.04	23.72	24.77	33.75	34.42	20.89	14.53	7.97	12.13
MIN.	1.97	0.97	0.80	0.87	1.03	2.64	8.67	11.56	10.57	8.52	4.66	3.22	6.49

2. Hydroelectric Power Potential of Xe Namnoy River Basin

Contents

List of Figures

List of Tables

2. Hydroelectric Power Potential of Xe Namnoy River Basin

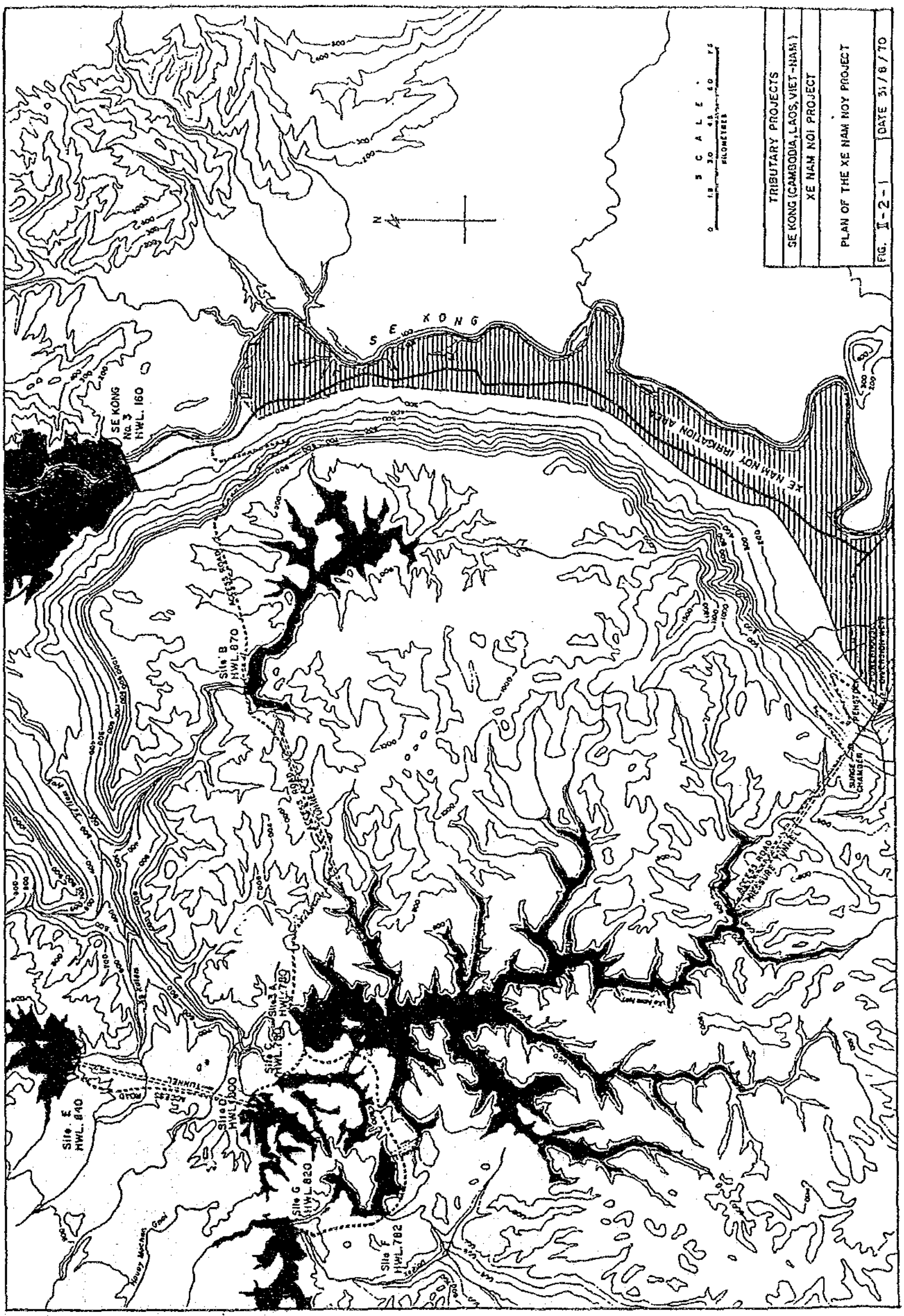
2.1 Review of Previous Study

Regarding water resources development projects in the Xe Namnoy River Basin, development potentials have been studied in the past by the Mekong Committee ("Inventory of Promising Tributary Projects in the Lower Mekong Basin, Volume II, Laos," Sept. 1970, Mekong Secretariat). The general project outlines are shown in Fig. II-2-1 and the project specifications in Table II-2-1. This examination was made by a desk study referring to the investigation carried out by the Japanese Mekong river Survey Mission from 1959 to 1961 (Comprehensive Report of Surveys of Major Tributaries in the Lower Mekong River Basin, September 1961) and investigations made subsequently, and further, using 1/50,000 topographical maps newly obtained, and except for Northern Laos and a part of Cambodia, field investigations were not especially carried out for this study.

This development project has bene formulated based on the fundamental development concept of catching and using the waters of the Xe Namnoy River Basin as much as possible, and consist of seven dams, tunnels of total length of 28,500 m, penstocks of total length of 2,080 m, and power stations of total installed capacity of 530 MW, and the annual energy production obtained is to be 2,793 GWh. (The river runoff used in the study was 4.8 $m^3/s/100\ km^2$ which is 50% more compared with the runoff of 3.2 $m^3/s/100\ km^2$ obtained in the present hydrological analysis (described in Chapter II, 1), so that if the runoff obtained this time were to be adopted, the annual energy production would be decreased to 1,860 GWh.).

As mentioned above, since the idea in this plan is to catch the waters of the basin as much as possible for development (without much regard for the economics and without any social or environmental considerations), the number of dams is large in comparison with the energy to be produced, while the scales of the individual dams are large, and moreover, the total tunnel length is also very long. In effect, the plan was formulated from only a technical standpoint with the purpose of developing the potential to the fullest degree, and it is understood that the Mekong Committee was well aware of this from the beginning when the plan was set up.

In this present study also, there was very little material available for use other than 1/50,000 topographical maps, while field reconnaissances were made of just a limited number of sites. The Study Team reviewed the projects with the aim to formulate a plan to obtain the maximum benefit with the minimum amount of investment. However, the extent of field surveys made this time by the Study Team was extremely limited, in addition to which not all relevant social and economic conditions including the ease or difficulty of approach to project sites had been taken into consideration, so that the conclusions below are quite tentative and only indicative.



TRIBUTARY PROJECTS
SE KONG (CAMBODIA, LAOS, VIET-NAM)
XE NAM NOI PROJECT
PLAN OF THE XE NAM NOY PROJECT
FIG. II-2-1
DATE 31/8/70
SCALE
KILOMETRES
SE KONG
SE KONG No. 3 HWL. 160
XE NAM NOY IRRIGATION AREA
Site B HWL. 870
ACCESS ROAD
TUNNEL
Site D HWL. 800
Site E HWL. 840
Site G HWL. 820
Site F HWL. 782
SURGE CHAMBER
PENSTOCK
PRESSURE TUNNEL

Table II-2-1 XE NAMNOY DEVELOPMENT PLAN BY MEKONG COMMITTEE

ITEM	UNIT	Site E	Site D	Site C	Site G	Site F	Site B	Site A	Total
Catchment Area	km^2	260.0	90.0	11.0	220.0	10.0	220.0	529.0	1,340.0
Reservoir									
HWL	m	840.0	800.0	780.0	820.0	782.0	870.0	780.0	
LWL	m	805.0	782.0	770.0	800.0	770.0	850.0	770.0	
Gross Storage	$10^6 m^3$	185.0	95.0	40.0	90.0	40.0	195.0	985.0	1,630.0
Effective Storage	$10^6 m^3$	155.0	55.0	25.0	85.0	30.0	130.0	350.0	830.0
Average Inflow	m^3/s	12.5	4.3	0.5	10.6	0.5	10.6	25.6	64.6
Regulation Ratio	%								
Dam									
Height	m	85.0	75.0	55.0	45.0	35.0	85.0	75.0	
Crest Length	m	1,100.0	350.0	350.0	1,300.0	175.0	400.0	1,000.0	
Power Plant									
Tunnel Length	m	7,000.0			1,300.0	1,200.0	10,000.0	9,000.0	28,500.0
Penstock Length	m							2,080.0	
Net Head	m							602.0	
Installed Capacity	MW							530.0	
Annual Energy	GWh							2,793.0	
Plnat Factor	%							60.2	

2.2 Hydroelectric Power Potential of Xe Namnoy River Basin

As previously mentioned, sites suitable for large-capacity reservoirs exist on the Xe Namnoy River mainstream and the midstream stretch of the Houay Katak-Tok River. By constructing a reservoir at a site just before the river becomes a swift stream to regulate the water and by making use of the high head obtained with the swift stream at the downstream side, it becomes possible for a large-scale or medium-scale dam-and-waterway type hydroelectric power project to be provided.

Other tributaries have catchment areas which are too small, or stream gradients which are uniformly steep, and do not possess suitable conditions for formulating large-scale dam-and-waterway type projects having reservoirs. Accordingly, hydropower plans on these tributaries will be small-scale run-of-river type projects with waterways.

As described above, the hydropower development projects in the Xe Namnoy River Basin would consist of large to medium-scale projects on the mainstream and the Houay Katak-Tok River, and small-scale projects on other tributaries. In general, in a hydroelectric power development project, when the population to be subjected to submersion is small, the economics will be more favorable the larger the size, while moreover, the influence of that project on the development potential of the whole basin will be great. Conversely, the economics of a power development project of small scale cannot escape being poorer than that of a project of large scale, while moreover, the influence of it on the development potential of the whole basin will be extremely small.

In studying the hydroelectric power potential of the whole basin, firstly, comparison studies were made of large and medium-scale development projects, the framework of the most appropriate entire basin development plan was decided, and the development potential of the basin as a whole was decided.

The study was made mainly using 1/50,000 topographical maps, while investigations in the field had to be made from the air by helicopter because of the poor accessibility.

The criteria given below were used in selection of projects.

- Select a dam site where a large reservoir can be provided with a dam as small as possible.
- Select a waterway route where maximum head can be obtained with the shortest route length.
- Avoid providing a structure at a place where there is a problem from a geological viewpoint such as the existence of a large fault.
- Avoid a plan under which extremely extensive submergence will occur.
- Since there is no large electric demand for the moment around the project site and it is not clear whether there will be a great increase in demand in the future, it is assumed that the energy will be exported to Thailand.

Since the energy value during peak demand is high in Thailand, planning was made for a peaking power generation project. Taking into consideration that a plant factor of 25 to 30% is normally adopted for a regulating pond type or reservoir type project for meeting peak demand in Thailand, the scale of installed capacity was set for the plant factor of the project to be approximately 30%.

The basic development concept for the Xe Namnoy River Basin is shown by Figs. II-2-2, II-2-3, II-2-4, and II-2-5, and the specifications of the plans are given in Tables II-2-2, II-2-3, II-2-4, and II-2-5. The area-capacity curves of the individual reservoirs are shown in Figs. II-2-6, II-2-7,II-2-8, and II-2-9.

2.2.1 Plan I (see Fig. II-2-2)

Plan 1 shown in Fig. II-2-2 is composed of three power generation projects.

(1) Plan 1, Project A

The Upper Xe Namnoy River Project (Project A) consists of a scheme aiming to increase the catchment area from 280 km^2 to 362 km^2 by constructing two fill dams of heights 95 m and 53 m at the upstream reaches of the Xe Namnoy River and connecting the two reservoirs by a tunnel of 2,800 m. The total effective storage capacity of the two reservoirs would be 277×10^6 m^3, and annual regulation will be amply possible. By conducting a maximum available discharge of 36 m^3/s to the Se Kong River near Attapu by a tunnel 5,700 m in length, an effective head of 650 m would be obtained, and with an installed capacity of 190 MW, annual energy production of 524.6 GWh is to be attained.

According to aerial surveys, it appears that construction of rockfill dams would be possible at both sites, but detailed investigations will be necessary in this regard.

(2) Plan 1, Project B

The Upper Houay Katak-Tok River Project (Project B) consists of constructing a fill dam of height 68 m at the upstream part of the Houay Katak-Tok River, conducting a maximum discharge of 19.4 m^3/s to the Se Kong River near Ban Kengxai by a tunnel 3,200 m in length to obtain an effective head of 749.5 m, and with an installed capacity of 118 MW, the annual energy production of 331.4 GWh can be obtained. With no accessibility to the dam site, surveys were attempted from the air, but the site was covered by vegetation and the condition of the foundation could not be observed. The eastern slope of the Bolaven Plateau where the penstock would be installed is in the form of a precipitous cliff. In consideration of work execution, it is necessary for an examination to be made as to whether the penstock is to be a above ground type or an underground type.

(3) Plan 1, Project C

The Lower Xe Namnoy River Project (Project C) consists of a fill dam of height 28 m on the Xe Namnoy River mainstream downstream of the confluence of the Xe Namnoy River and the Xe Katam River to provide a regulating pond having a daily storage capability and a tunnel 3,500 m in length which conducts a maximum discharge of 60 m^3/s, and produces annual energy of 139.3 GWh with an effective head of 73 m and an installed capacity of 36 MW.

Although the study made here is with a fill dam, there is also a possibility for a concrete dam.

2.2.2 Plan 2 (see Fig. II-2-3)

Plan 2 shown in Fig. II-2-3 is a compromise plan between Plan 1 and Plan 3 to be described later. Of the two dams of Project A (Plan 1) to be provided at the upstream part of the Xe Namnoy River, the one of height 53 m on the tributary would be omitted, as a result of which the catchment area would be decreased to 280 km^2, but the tunnel of 2,600 m length can be eliminated. The maximum discharge in Project A would be 28 m^3/s, effective head 650 m, installed capacity 148 MW, and annual energy production 404.3 GWh.

Project D consists of providing a regulating pond having a daily-to-weekly storage capability by construction of concrete dam 15 m in height on the midstream stretch of the Xe Namnoy River, conducting a maximum discharge of 26 m^3/s to the downstream part of the Xe Namnoy River by a tunnel 9,350 m in length, and with an effective head of 424.5 m and installed capacity of 90 MW, annually energy of 240.8 GWh can be given. It would be desirable for this regulating pond to be made as large as possible for a project in which primary energy can be obtained in large amount, but since the river gradient upstream of this site is very gentle, the upstream dam would be submerged if the dam height were to be increased.

2.2.3 Plan 3 (see Fig. II-2-4)

Plan 3 shown in Fig. II-2-4 consists of the three projects. Project D is provided at the midstream part of the Xe Namnoy River, Project C is provided at the downstream part of the Xe Namnoy River similarly to Plans 1 and 2, and Project B is provided on the Houay Katak-Tok River. Project D would be a scheme in which a fill dam 38 m in height would be constructed in the vicinity of Ban Latsasin immediately before the Xe Namnoy River changes into a swift stream. The maximum available discharge of 56 m^3/s would be conducted by a tunnel 9,350 m in length, and with an effective head of 440 m and installed capacity of 200 MW, annual energy of 529.1 GWh would be given. A large-scale reservoir cannot be provided at this site because of topographical constraints, and a regulating pond with weekly storage or monthly storage capacity would be provided. Project D, compared with Project A of Plan 1 would have a lower head, but because the catchment area would become larger, the energy production would be the same. At the D dam site, outcrops of basement rock have been confirmed at the river bed, and there will be no problem as the foundation for a fill dam. However, both banks form gentle slopes, and there is a possibility that weathering has progressed considerably.

The energy production from Project C to be provided at the downstream part of the Xe Namnoy River would be 181.9 GWh, and since there will be no reduction in water due to catchment area diversion upstream, it would be more than those obtained with Plan 1 and Plan 2.

2.2.4 Plan 4 (see Fig. II-2-5)

Plan 4 shown in Fig. II-2-5 is a variation of Plan 3, with Project D at the midstream stretch of the Xe Namnoy River developed divided into the two steps of D-1 and D-2.

The maximum discharge of Project D-1 would be 56 m^3/s, the effective head 291 m, the installed capacity 133 MW, and the energy production 350.4 GWh. The maximum discharge of Project D-2 would be 58 m^3/s, the effective head 150.0 m, the installed capacity 68 MW, and the energy production 179.8 GWh.

2.2.5 Comparisons of the abovementioned Four Plans

Of the four plans, the one with the largest installed capacity and energy production is Plan 2, the total installed capacity being 392 MW and the energy production 1,125 GWh.

On the other hand, the one with these being smallest is Plan 1 with installed capacity of 344 MW and energy production of 995 GWh, 12% less than in Plan 2.

Comparisons of the overall economics of the four plans are given in Tables II-2-2, II-2-3, II-2-4, and II-2-5.

The ones with favorable benefit-cost ratios are Plan 3 and Plan 4, those of Plan 1 and Plan 2 being inferior. That the ratio of Plan 2 is low is because that of Project D is extremely low, and if Project D is omitted, the ratio of Plan 2 would become roughly the same as that of Plan 1.

The one with the largest net benefit is Plan 2, with Plan 3 following, and Plan 1 has the smallest. Seen from construction costs per kWh and benefit-cost ratios, Plans 3 and 4 are superior to Plans 1 and 2.

In the cases of Plans 1 and 2, all of the waters at the upstream part of the Xe Namnoy River would be diverted directly to the Se Kong River, and water in the section until merging with the Xe Katam River would be greatly reduced. Even though there are hardly any hamlets of consequence in this section, this reduction in river water will inevitably have an effect on people living along the river, and further, on the flora and fauna. Considering just this point, it may be said that Plan 3 or Plan 4 is superior as a scheme. The economics of Plans 3 and 4 are almost the same, and with a difference in the economics of this degree, it cannot be said which is superior. At the next stage, studies should be made using hydrological, topographical, and geological data of greater accuracy to make final judgements on consideration of the topographical and geological conditions concerning dams, waterway routes, penstock routes, and powerhouses, and demand and fund procurement conditions.

However, it will be necessary to obtain the hydroelectric power potential of the entire Xe Namnoy River Basin, and here, Plan 3 which tentatively has a slightly more favorable benefit-cost ratio will be selected as the optimum plan.

The economics of Houay Katak-Tok is the best in the project, but it should be noted that the economics will differ greatly depending on the amount of inflow. In carrying out the study, examinations were made using the specific runoff of Ban Latsasin since there were no run-off data on the Houay Katak-Tok River, and at the next stage, studies using actual runoff measurements of the Houay Katak-Tok River will be necessary.

Fig. II-2-2 HYDROPOWER DEVELOPMENT IN XE NAMNOY BASIN
PLAN I

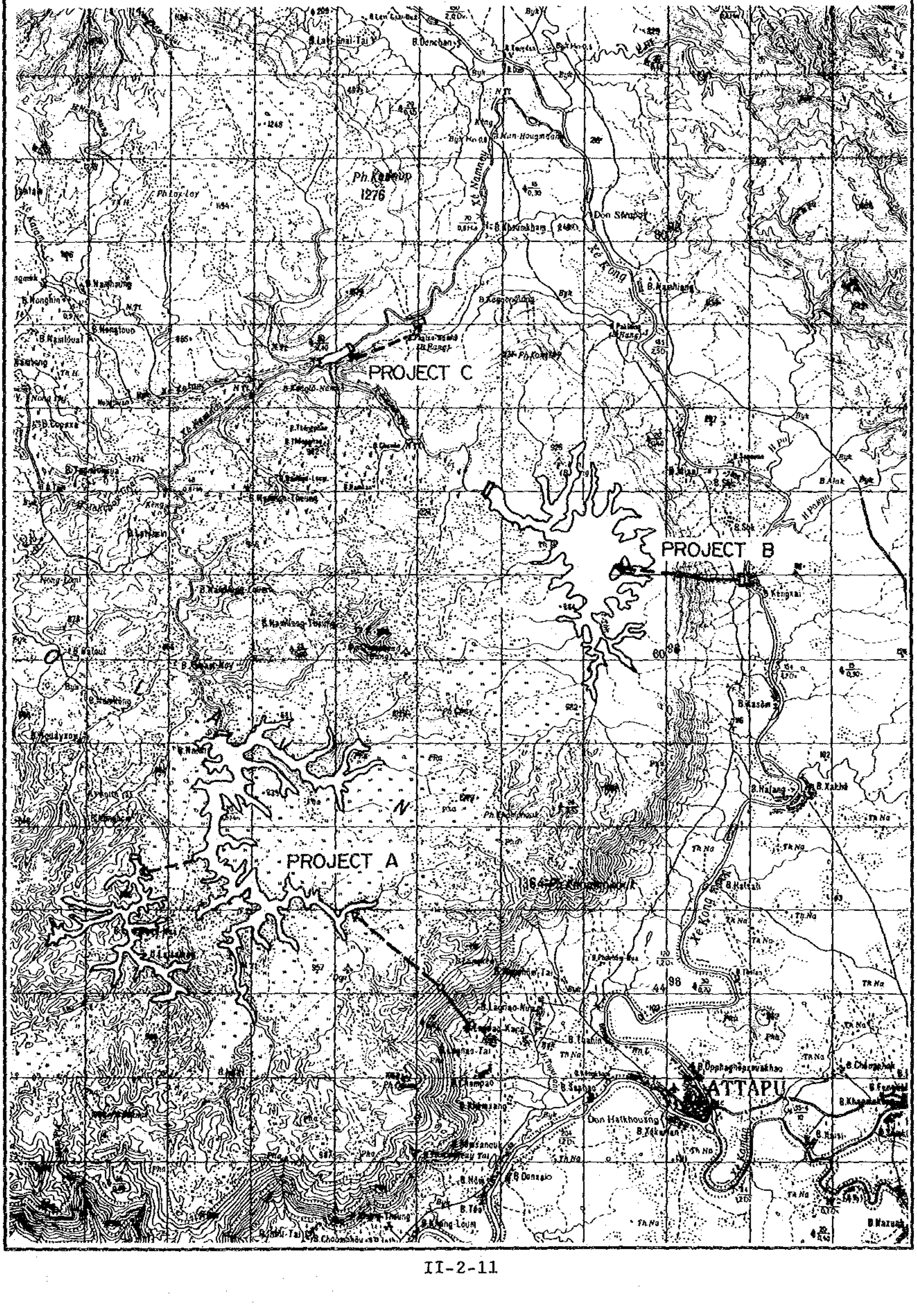


Fig. II-2-3 HYDROPOWER DEVELOPMENT IN XE NAMNOY BASIN
PLAN 2

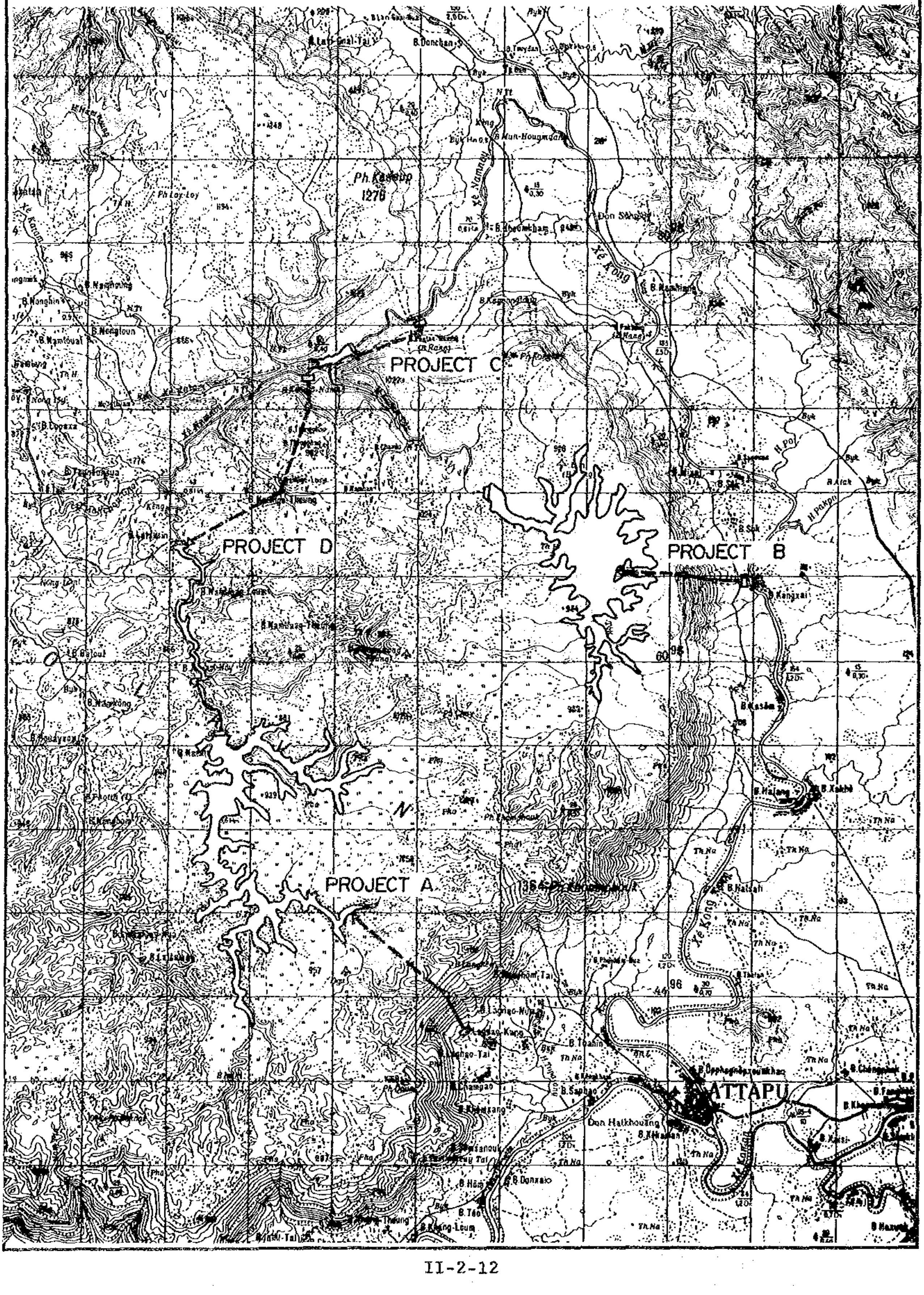


Fig. II-2-4 HYDROPOWER DEVELOPMENT IN XE NAMNOY BASIN PLAN 3

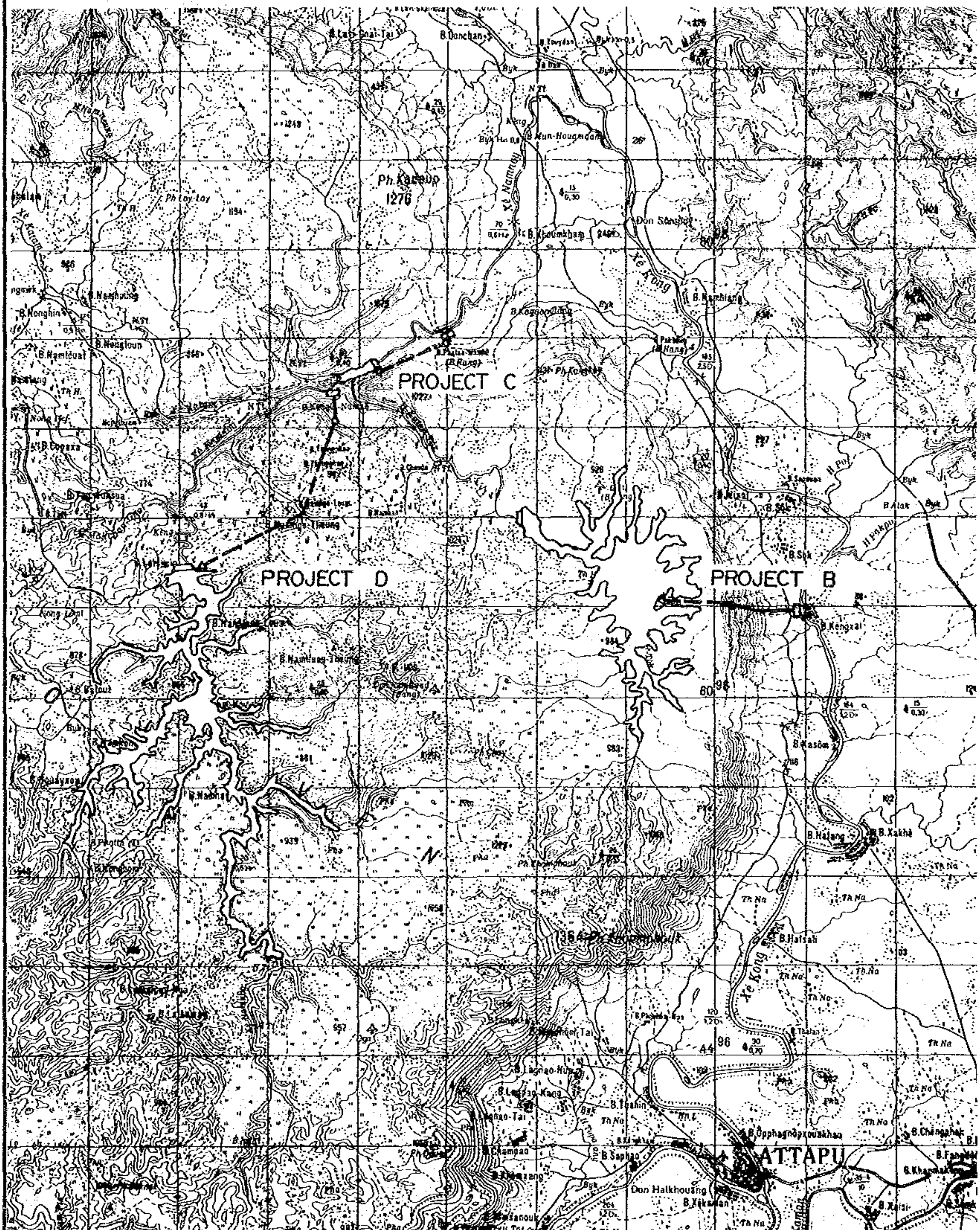


Fig. II-2-5 HYDROPOWER DEVELOPMENT IN XE NAMNOY BASIN PLAN 4

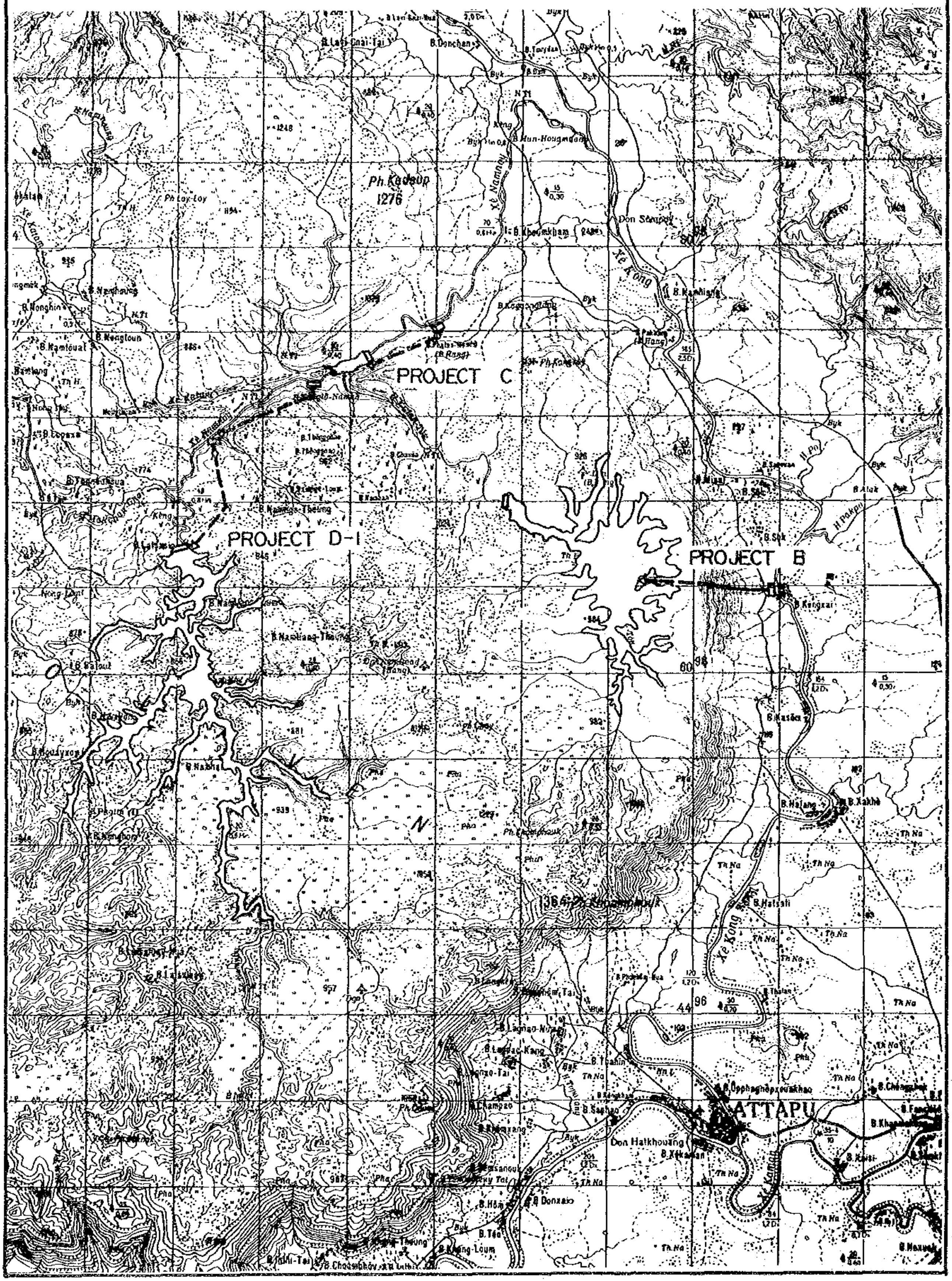


Table II-2-2 XE NAMNOY BASIN HYDROPOWER DEVELOPMENT PLAN 1

PLAN		A		B	C	
	UNIT	XE NAMNOY UPSTREAM		HOUAY KATAK-TOK	XE NAMNOY DOWNSTREAM	TOTAL
1.PROJECT FEATURE						
CATCHEMNT AREA	km^2	280.0	82.0	199.0	890.0	
DAM						
HEIGHT	m	95.0	53.0	68.0	28.0	
CREST LENGTH	m	500.0	300.0	300.0	200.0	
TUNNEL						
LENGTH	m	5,700.0	2,600.0	3,200.0	3,500.0	15,000.0
DIAMETER	m	4.0	2.2	3.2	4.8	
PENSTOCK						
LENGTH	m	2,340.0		2,960.0	220.0	5,520.0
DIAMETER	m	3.0		2.4	3.6	
MEAN INFLOW	m^3/s	11.5		6.3	28.2	
RESERVOIR						
HIGH WATER LEVEL	m	800.0		880.0	280.0	
LOW WATER LEVEL	m	790.0		870.0	278.0	
GROSS STORAGE CAPACITY	10^6 m^3	627.0		318.0	6.1	
EFFECTIVE STORAGE CAPACITY	10^6 m^3	277.0		168.0	1.2	
REGURATION RATIO	%	62.8		91.8		
POWER PLAN						
GROSS HEAD	m	676.0		776.0	79.0	1,531.0
NET HEAD	m	650.0		749.5	73.0	1,472.5
MAXIMUM DISCHARGE	m^3/s	36.0		19.4	60.0	115.4
INSTALLEC CAPACITY	MW	190.0		118.0	36.0	344.0
FIRM PEAK POWER	MW	185.4		115.5	7.6	308.6
ANNUAL ENERGY	10^6 kWh	524.6		331.4	139.3	995.3
FIRM ENREGY	10^6 kWh	406.1		252.8	16.7	675.6
SECONDARY ENERGY	10^6 kWh	118.5		78.6	122.6	319.7
PLANT FACTOR	%	31.5		32.1	44.2	33.0
2.PROJECT ECONOMY						
CONSTRUCTION COST	1,000US$	187,823.0		103,963.0	61,176.0	352,962.0
ANNUAL COST	1,000US$	18,943.7		10,485.6	6,170.2	35,599.5
ANNUAL BENEFIT	1,000US$	37,306.1		23,478.8	7,679.2	68,464.1
CONSTRUCTION COST / KWh	US$/KWh	0.36		0.31	0.44	0.35
CONSTRUCTIN COST / KW	US$/KW	988.54		881.04	1,699.33	1,026.05
B - C	1,000US$	18,362.4		12,993.2	1,509.0	32,864.6
B/C		1.97		2.24	1.24	1.92

Table II-2-3 XE NAMNOY HYDROPOWER DEVELOPMENT PLAN 2

PLAN	UNIT	A XE NAMNOY UPSTREAM	D XE NAMNOY MIDSTREAM	B HOUAY KATAK-TOK	C XE NAMNOY DOWNSTREAM	TOTAL
1.PROJECT FEATURE						
CATCHEMNT AREA	km^2	280.0	257.0	199.0	972.0	
DAM						
HEIGHT	m	95.0	15.0	68.0	28.0	
CREST LENGTH	m	500.0	90.0	300.0	200.0	
TUNNEL						
LENGTH	m	5,700.0	9,350.0	3,200.0	3,500.0	21,750.0
DIAMETER	m	3.6	3.6	3.2	4.8	
PENSTOCK						
LENGTH	m	2,340.0	1,370.0	2,960.0	220.0	6,890.0
DIAMETER	m	2.7	2.8	2.4	3.6	
MEAN INFLOW	m^3/s	8.9	8.2	6.3	30.8	54.2
RESERVOIR						
HIGH WATER LEVEL	m	800.0	730.0	880.0	280.0	
LOW WATER LEVEL	m	790.0		870.0	278.0	
GROSS STORAGE CAPACITY	10^6 m^3	552.0		318.0	6.1	
EFFECTIVE STORAGE CAPACITY	10^6 m^3	191.0		168.0	1.2	
REGURATION RATIO	%	66.3		91.8		
POWER PLAN						
GROSS HEAD	m	676.0	450.0	776.0	79.0	1,981.0
NET HEAD	m	650.0	424.5	749.5	73.0	1,897.0
MAXIMUM DISCHARGE	m^3/s	28.0	26.0	19.4	60.0	133.4
INSTALLEC CAPACITY	MW	148.0	90.0	118.0	36.0	392.0
FIRM PEAK POWER	MW	144.2	8.7	115.5	8.3	276.7
ANNUAL ENERGY	10^6 kWh	404.3	240.8	331.4	148.0	1,124.5
FIRM ENERGY	10^6 kWh	315.9	19.0	252.8	18.2	605.9
SECONDARY ENERGY	10^6 kWh	88.4	221.8	78.6	129.8	518.6
PLANT FACTOR	%	31.2	30.5	32.1	46.9	32.7
CONSTRUCTION COST	1,000US$	146,877.0	80,115.4	103,963.0	61,176.0	392,131.4
ANNUAL COST	1,000US$	14,813.9	8,080.4	10,485.6	6,170.2	39,550.0
ANNUAL BENEFIT	1,000US$	28,819.9	13,035.2	23,478.8	8,169.7	73,503.7
CONSTRUCTION COST / KWh	US$/KWh	0.36	0.33	0.31	0.41	0.35
CONSTRUCTIN COST / KW	US$/KW	992.41	890.17	881.04	1,699.33	1,000.34
B - C	1,000US$	14,006.04	4,954.85	12,993.21	1,999.54	33,953.65
B/C		1.95	1.61	2.24	1.32	1.86

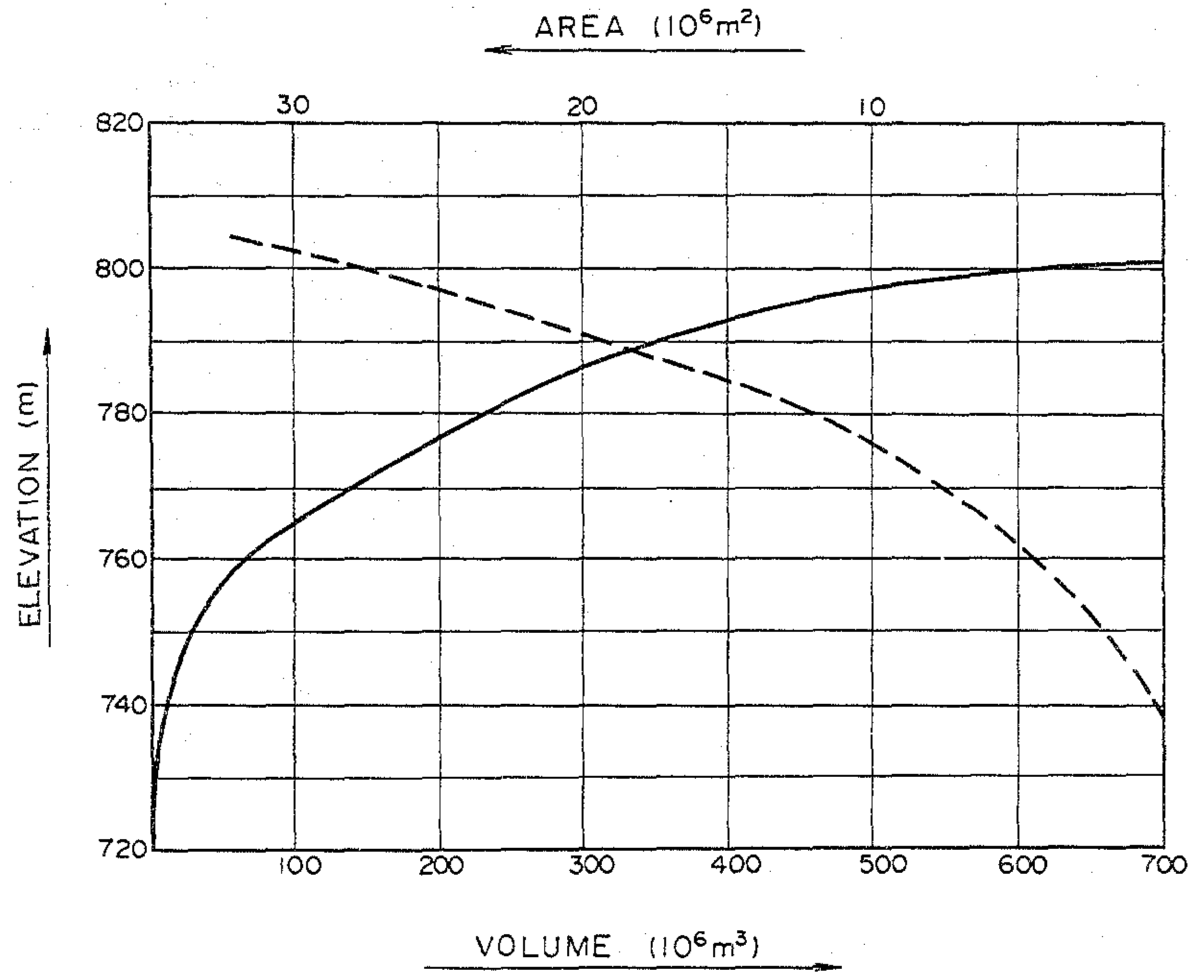
Table II-2-4 XENAMNOY HYDROPOWER DELOPMENT PLAN 3

PLAN	UNIT	D XE NAMNOY MIDSTREAM	B HOUAY KATAK-TOK	C XE NAMNOY DOWNSTREAM	TOTAL
1. PROJECT FEATURE					
CATCHEMNT AREA	km^2	537.0	199.0	1,252.0	
DAM					
HEIGHT	m	38.0	68.0	28.0	
CREST LENGTH	m	400.0	300.0	200.0	
TUNNEL					
LENGTH	m	9,350.0	3,200.0	3,500.0	16,050.0
DIAMETER	m	4.7	3.2	4.8	
PENSTOCK					
LENGTH	m	1,390.0	2,960.0	220.0	4,570.0
DIAMETER	m	3.5	2.4	3.6	
MEAN INFLOW	m^3/s	17.0	6.3	39.7	
RESERVOIR					
HIGH WATER LEVEL	m	750.0	880.0	280.0	
LOW WATER LEVEL	m	740.0	870.0	278.0	
GROSS STORAGE CAPACITY	10^6 m^3	170.0	318.0	6.1	
EFFECTIVE STORAGE CAPACITY	10^6 m^3	107.0	168.0	1.2	
REGURATION RATIO	%	19.9	91.8		
POWER PLAN					
GROSS HEAD	m	466.0	776.0	79.0	1,321.0
NET HEAD	m	440.0	749.5	73.0	1,262.5
MAXIMUM DISCHARGE	m^3/s	56.0	19.4	60.0	135.4
INSTALLED CAPACITY	MW	200.0	118.0	36.0	354.0
FIRM PEAK POWER	MW	73.7	115.5	28.9	218.1
ANNUAL ENERGY	10^6 kWh	529.1	331.4	181.9	1,042.4
FIRM ENERGY	10^6 kWh	161.3	252.8	63.3	477.4
SECONDARY ENERGY	10^6 kWh	367.8	78.6	118.6	565.0
PLANT FACTOR	%	30.2	32.1	57.7	33.6
2. PROJECT ECONOMY					
CONSTRUCTION COST	1,000US$	158,360.0	103,963.0	61,176.0	323,499.0
ANNUAL COST	1,000US$	15,972.1	10,485.6	6,170.2	32,627.8
ANNUAL BENEFIT	1,000US$	31,562.3	23,478.8	11,041.5	66,082.6
CONSTRUCTION COST / KWh	US$/KWh	0.30	0.31	0.34	0.31
CONSTRUCTIN COST / KW	US$/KW	791.80	881.04	1,699.33	913.84
B - C	1,000US$	15,590.2	12,993.2	4,871.3	33,454.8
B/C		1.98	2.24	1.79	2.03

Table II-2-5 XE NAMNOY HYDROPOWER DEVELOPMENT PLAN 4

PLAN	UNIT	D-1 XE NAMNOY MIDSTREAM UP PLAN	D-2 XE NAMNOY MIDSTREAM DOWN PLAN	B HOUAY KATAK-TOK	C XE NAMNOY DOWNSTREAM	TOTAL
1.PROJECT FEATURE						
CATCHEMNT AREA	km^2	537.0	537.0	199.0	1,252.0	
DAM						
HEIGHT	m	38.0		68.0	28.0	
CREST LENGTH	m	400.0		300.0	200.0	
TUNNEL						
LENGTH	m	5,440.0	5,150.0	3,200.0	3,500.0	17,290.0
DIAMETER	m	4.7	4.7	3.2	4.8	
PENSTOCK						
LENGTH	m	640.0	580.0	2,960.0	220.0	4,400.0
DIAMETER	m	3.5	3.5	2.4	3.6	
MEAN INFLOW	m^3/s	17.0	17.0	6.3	39.7	
RESERVOIR						
HIGH WATER LEVEL	m	750.0		880.0	280.0	
LOW WATER LEVEL	m	740.0		870.0	278.0	
GROSS STORAGE CAPACITY	10^6 m^3	170.0		318.0	6.1	
EFFECTIVE STORAGE CAPACITY	10^6 m^3	107.0		168.0	1.2	
REGURATION RATIO	%	19.9		84.4		
POWER PLAN						
GROSS HEAD	m	306.0	160.0	776.0	79.0	1,321.0
NET HEAD	m	291.0	150.0	749.5	73.0	1,263.5
MAXIMUM DISCHARGE	m^3/s	56.0	56.0	19.4	60.0	191.4
INSTALLED CAPACITY	MW	133.0	68.0	118.0	36.0	355.0
FIRM PEAK POWER	MW	49.0	24.9	115.5	28.9	218.3
ANNUAL ENERGY	10^6 kWh	350.4	179.8	331.4	181.9	1,043.5
FIRM ENERGY	10^6 kWh	107.2	54.5	252.8	63.3	477.8
SECONDARY ENERGY	10^6 kWh	243.2	125.3	78.6	118.6	565.7
PLANT FACTOR	%	30.1	30.2	32.1	57.7	33.6
2.PROJECT ECONOMY						
CONSTRUCTION COST	1,000US$	102,518.0	56,974.0	103,963.0	61,176.0	324,631.0
ANNUAL COST	1,000US$	10,339.9	5,746.4	10,485.6	6,170.2	32,742.0
ANNUAL BENEFIT	1,000US$	20,912.6	10,717.8	23,478.8	11,041.5	66,150.7
CONSTRUCTION COST / KWh	US$/KWh	0.29	0.32	0.31	0.34	0.31
CONSTRUCTIN COST / KW	US$/KW	770.81	837.85	881.04	1,699.33	914.45
B - C	1,000US$	10,572.7	4,971.5	12,993.2	4,871.3	33,408.7
B/C		2.02	1.87	2.24	1.79	2.02

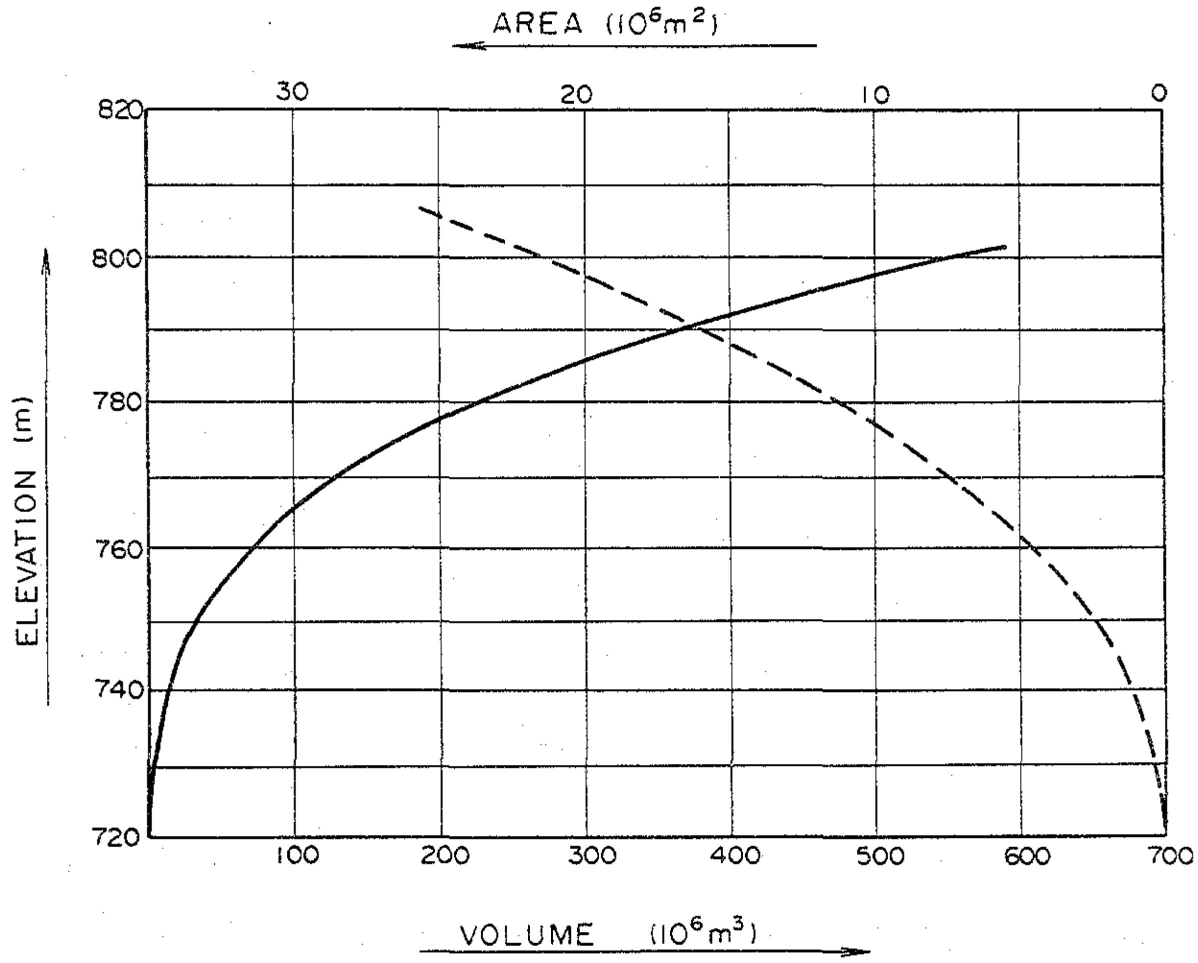
Fig. II-2-6 AREA – CAPACITY CURVE OF XE NAMNOY PROJECT
PROJECT A (PLAN I)



ELEVATION (m)	AREA ($10^6 m^2$)	VOLUME ($10^6 m^3$)
720	0.000	0.00
740	1.105	11.05
760	4.469	66.79
780	11.896	230.44
800	27.796	627.36

Fig. II-2-7 AREA - CAPACITY CURVE OF XE NAMNOY PROJECT

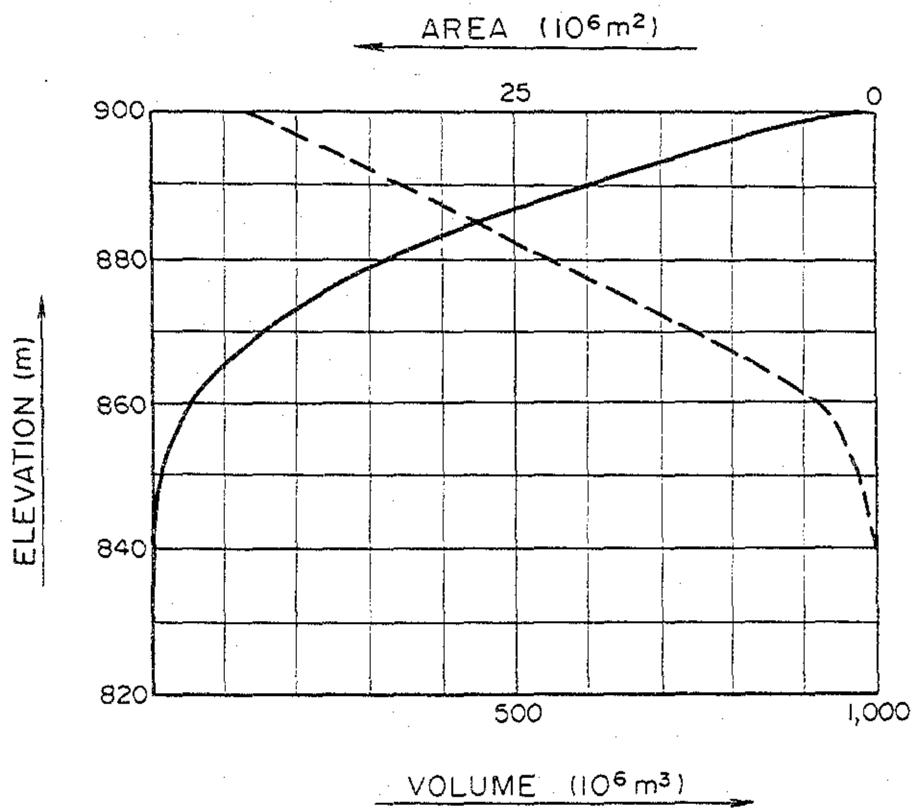
PROJECT A (PLAN 2)



ELEVATION (m)	AREA ($10^6 m^2$)	VOLUME ($10^6 m^3$)
720	0.000	0.00
740	1.105	11.05
760	4.469	66.79
780	11.218	223.66
800	21.637	552.21

Fig. II-2-8 AREA – CAPACITY CURVE OF XE NAMNOY PROJECT

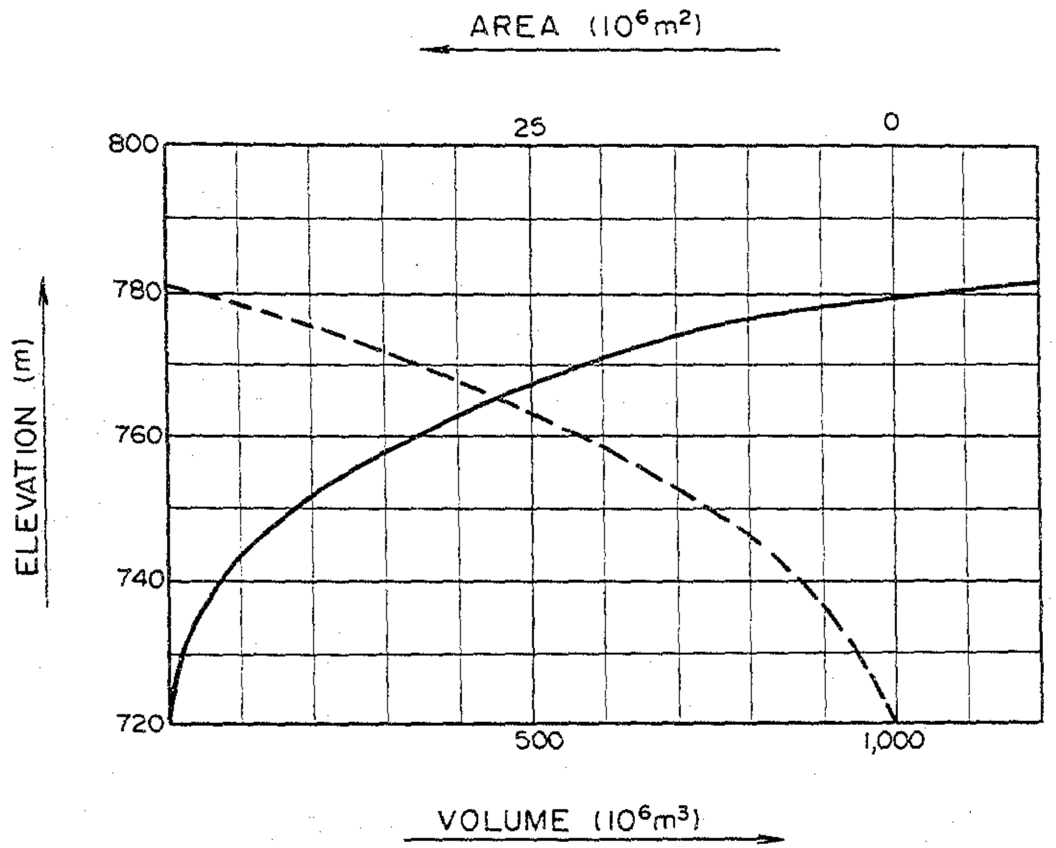
PROJECT B



ELEVATION (m)	AREA ($10^6 m^2$)	VOLUME ($10^6 m^3$)
820	0.000	0.00
840	0.293	2.93
860	4.242	50.10
880	22.572	318.24
900	43.326	977.22

Fig. II-2-9 AREA - CAPACITY CURVE OF XE NAMNOY PROJECT

PROJECT D



ELEVATION (m)	AREA ($10^6 m^2$)	VOLUME ($10^6 m^3$)
720	0.000	0.00
740	6.313	63.13
760	21.950	345.76
780	48.363	1,048.89

2.3 Small Scale Hydroelectric Power Development Projects in the Xe Namnoy Basin

Large- and medium-scale development projects of favorable economic conditions have been identified in the preceding studies. Next, a study is to be made of small-scale projects in a manner not to conflict with these projects, in order to identify the development potential of the entire Xe Namnoy River Basin. The following matters were taken into consideration in selecting the projects:

- Formulate plans which can be combined with the large-and medium-scale development projects identified in the preceding studies.
- Select routes with which high heads can be obtained with waterways as short as possible.
- Assume that electric power will be supplied to the surrounding area and determine installed capacity for plant factor of around 95%.

Five small-scale power projects, from E to I, thought to be feasible to be developed in the Xe Namnoy River Basin are shown in Fig. II-2-10.

2.3.1 Project E

Project E would be a scheme for construction of an intake dam immediately upstream of two waterfalls which locate at the most downstream part of the Xe Katam River, conduction of the water to the Xe Namnoy River side by a tunnel of 360 m and a penstock of 330 m, and generation of power with the effective head of 160.5 m.

2.3.2 Project F

Project F would be a scheme for providing an intake dam on the upstream part of the Xe Katam River in the vicinity of a point approximately 2 km north of Ban Nongtong, conducting water by a tunnel 2,150 m in length and a penstock of 390 m, and generating power with the effective head of 184 m.

2.3.3 Project G

Project G would be a scheme on a small stream which passes Ban Houaykong and merges with the Xe Namnoy River at the left-bank side immediately downstream of the confluence of the Houay Makchan Gnay River and the Xe Namnoy River. An intake dam would be provided approximately 1.2 km upstream of the junction with the Xe Namnoy River with water conducted by a tunnel of 1,500 m and a penstock of 250 m for power generation using the effective head of 147 m.

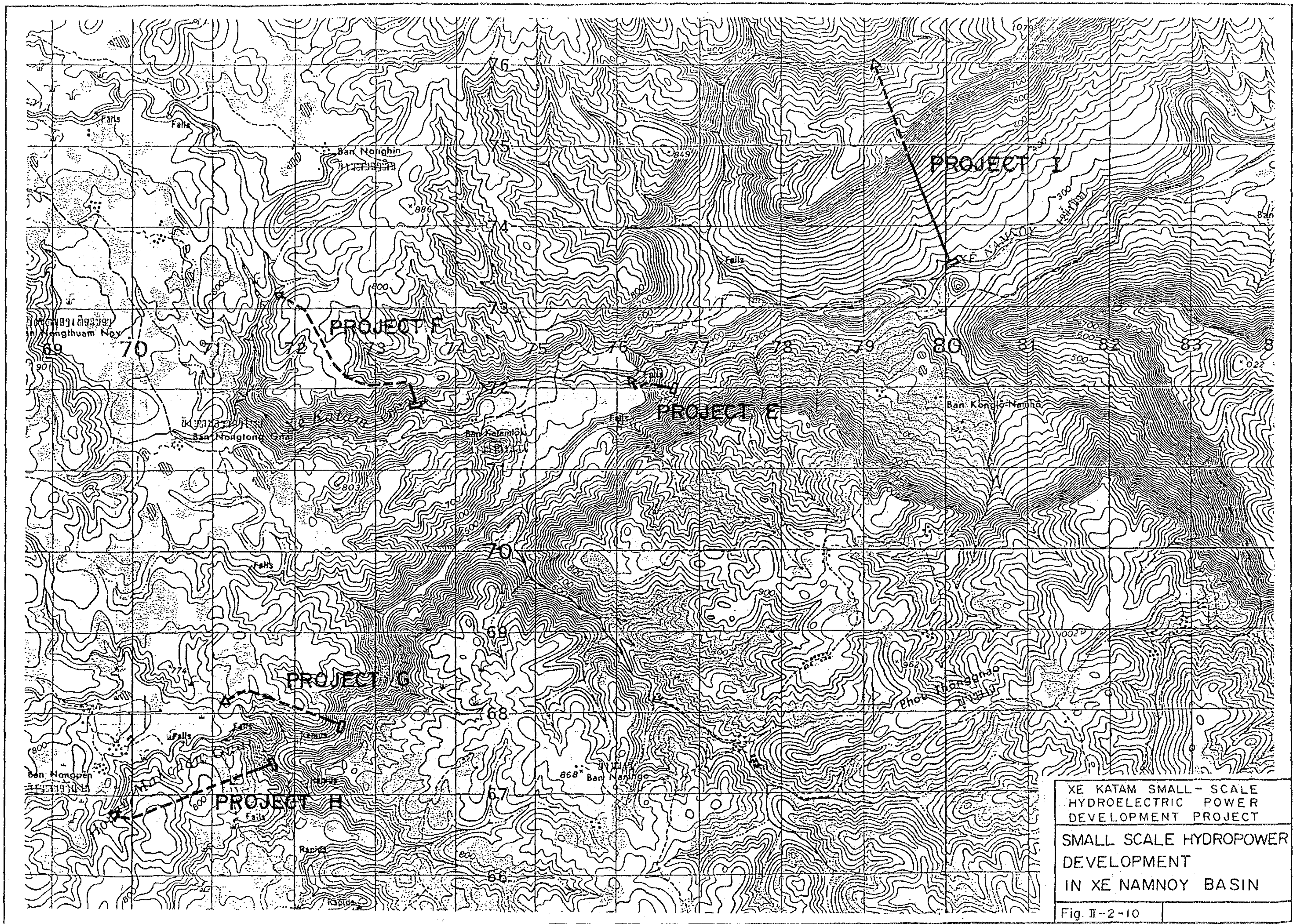
2.3.4 Project H

Project H would be a scheme on the Houay Makchan Gnay River which merges with the Xe Namnoy River at the left-bank side. An intake dam would be provided approximately 3 km upstream from the confluence and intaked water will be conducted by a tunnel of 2,050 m and penstock of 220 m to generate power using the effective head of 155 m.

2.3.5 Project I

Project I would be a scheme provided on a stream which merges with the Xe Namnoy River approximately 3.5 km downstream from the confluence of the Xe Katam River and the Xe Namnoy River, which has only a small catchment area but is on an extremely steep stream gradient. An intake dam would be provided in the vicinity of EL.740 m, with water conducted to the Xe Namnoy River by a tunnel of 1,150 m and a penstock of 1,520 m and power generated using the effective head of 415 m.

Since runoff data are not available except for the Xe Katam River and the Xe Namnoy River mainstream, discharge duration curves taking into consideration topography, vegetation, and rainfall distribution of the streams where these projects would be provided shown in the Figs. II-2-11 and II-2-12 were used.



XE KATAM SMALL-SCALE HYDROELECTRIC POWER DEVELOPMENT PROJECT

SMALL SCALE HYDROPOWER DEVELOPMENT IN XE NAMNOY BASIN

Fig. II-2-10

Fig. II-2-11 DURATION CURVE AT BAN NONGHIN
(FOR PROJECT G, H, I)

1981—1990(MEAN)

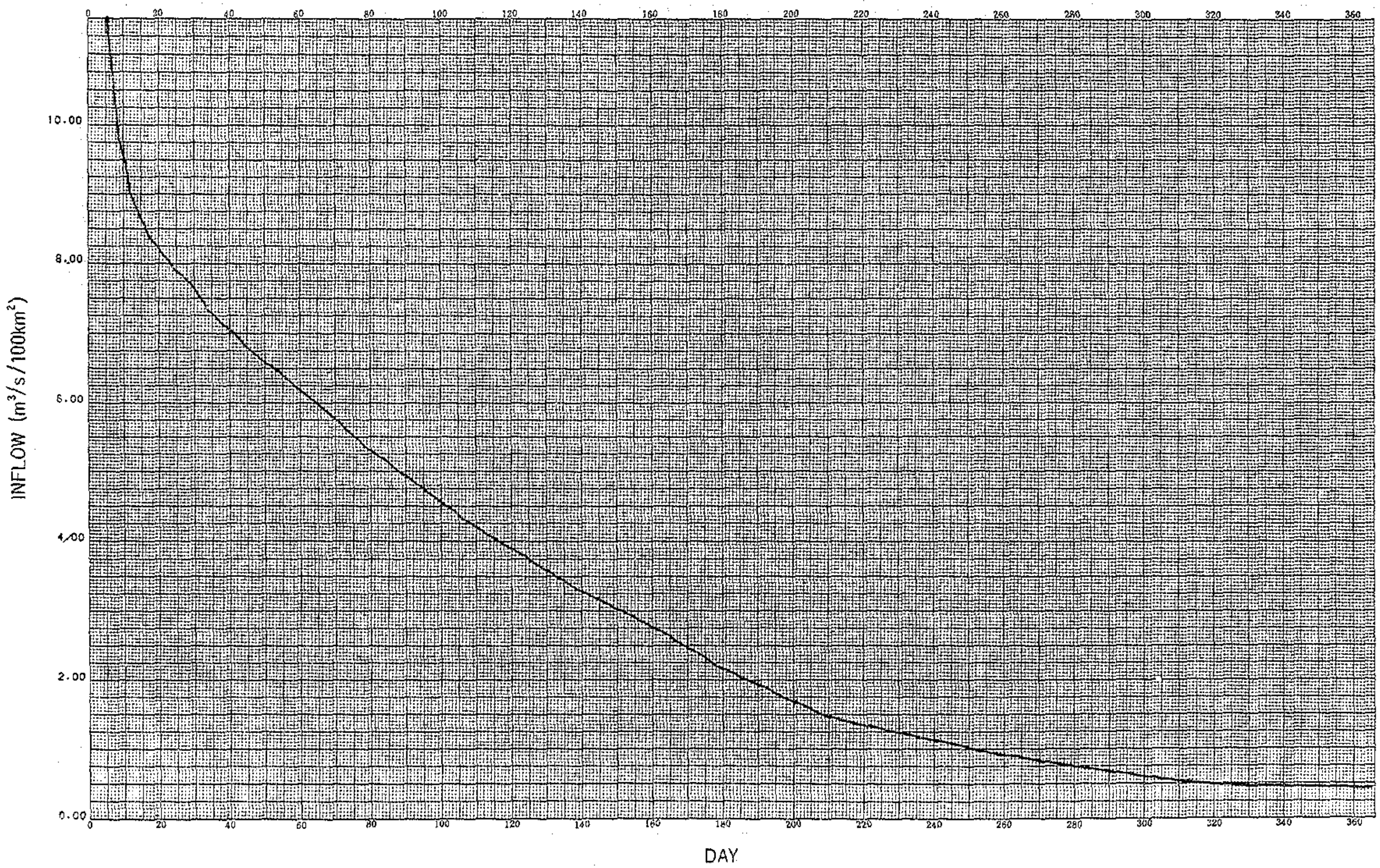
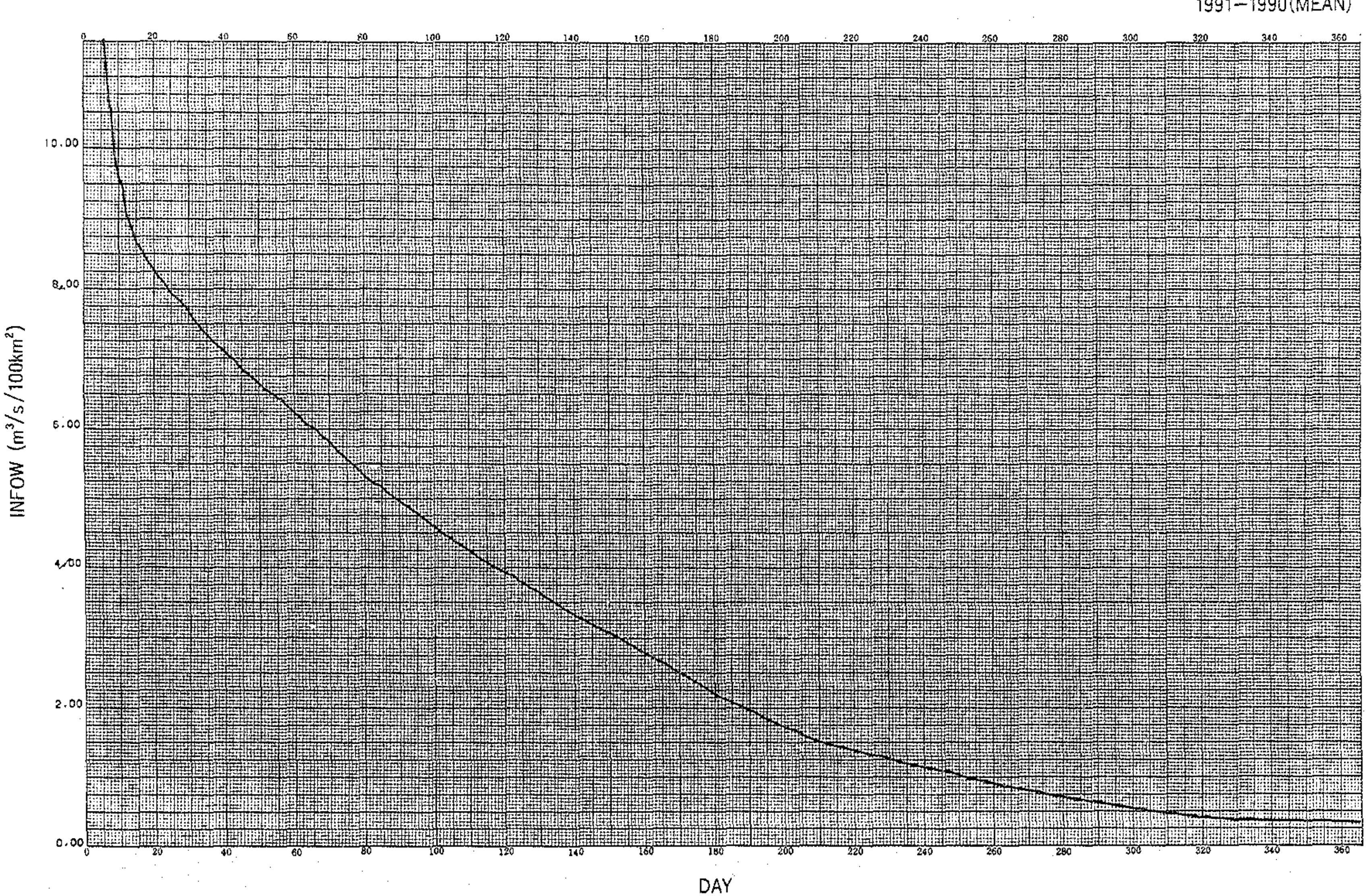


Fig. II-2-12 DURATION CURVE OF XE KATAM
(FOR PROJECT E, F, J)



2.4 Gross Hydroelectric Power Potential of Xe Namnoy River Basin including Small Hydro Development

The development schemes and development potential of the entire Xe Namnoy River Basin identified in the studies are shown in Fig. II-2-13 and Table II-2-6. The overall Xe Namnoy development scheme confirmed through the studies consists of three large scale projects and five small-scale projects, the total installed capacity being 360 MW and the annual energy production 1,096 GWh.

2.5 Effect to Downstream Area by the Xe Namnoy River Development

The Se Kong River with which the Xe Namnoy River merges in the end is a large river having a catchment area of 28,500 km^2, and it in turn merges with the Mekong River approximately 300 km downstream from the confluence with the Xe Namnoy River. The catchment area of the Xe Namnoy River is 1,500 km^2, the ratio of which in the catchment area of the Se Kong River, is only 5%, and even if the entire runoff of the Xe Namnoy River were to be regulated, the regulation effect on the Se Kong River downstream are very small.

The Xe Namnoy River downstream of the project forms a valley with both banks rising up vertically, and there are practically no farmlands or hamlets to benefit from flood control and irrigation effects as results of implementation of the project. However, fans are developed in the vicinity of the confluence between the Xe Namnoy River and the Se Kong River and in the vicinity of the downstream Attapu District, were cooperatively large villages and farmlands are spread out, and the overall development of the Xe Namnoy River would provide flood control and irrigation benefits for these areas.

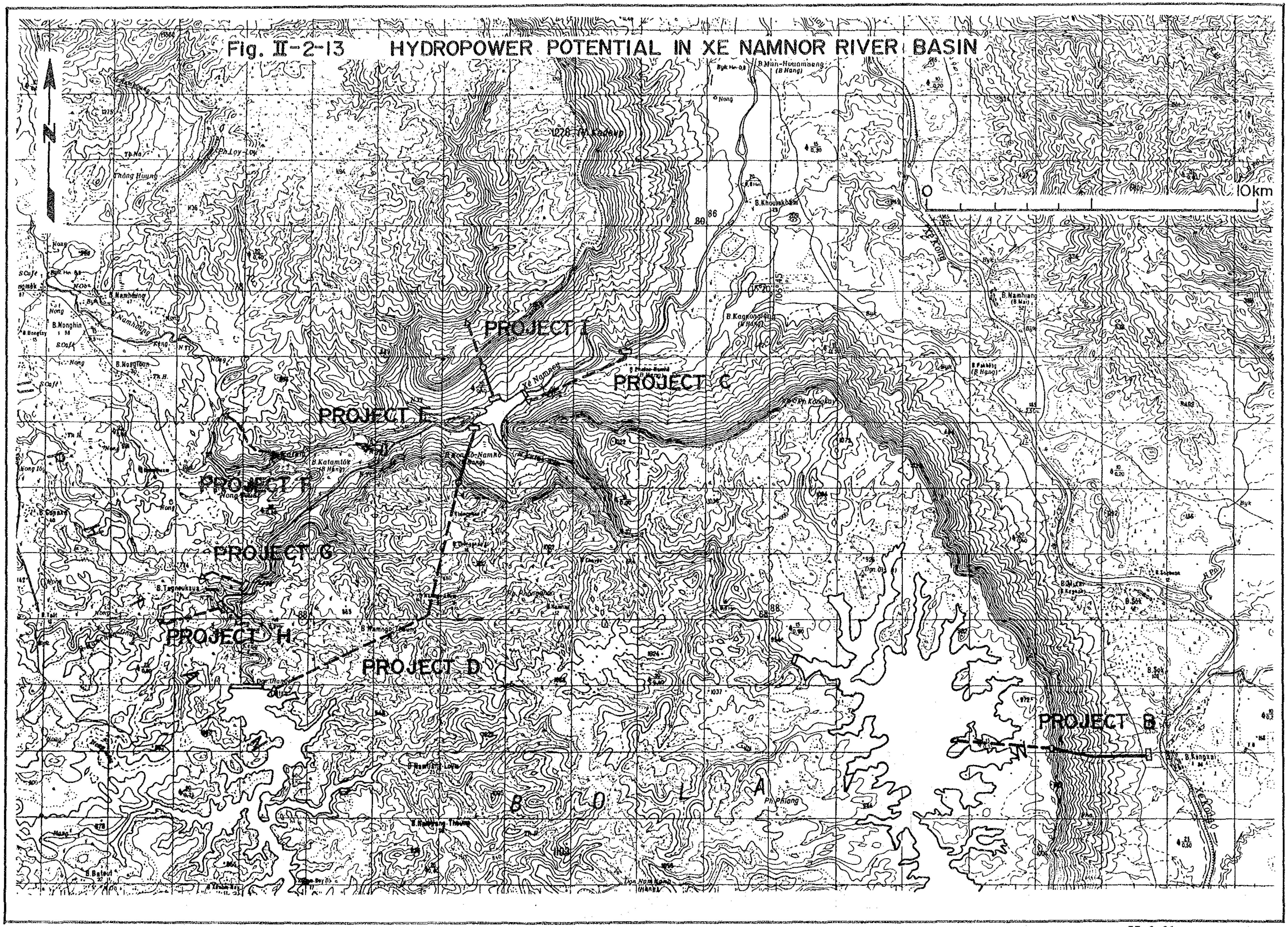


Fig. II-2-13 HYDROPOWER POTENTIAL IN XE NAMNOR RIVER BASIN
N
0
10km
PROJECT I
PROJECT C
PROJECT E
PROJECT F
PROJECT G
PROJECT H
PROJECT D
PROJECT B
B O L A V

Table II-2-6 HYDROPOWER POTENTIAL OF XE NAMNOY RIVER BASIN

Item	Project / Unit	B HOUAY KATAK-TOK	C XE NAMNOY DOWNSTREAM	D XE NAMNOY MIDSTREAM	E XE KATAM DOWNSTREAM	F XE KATAM UPSTREAM	G	H HOUAY MAKCHAN GNAI	I	Total
Stream Flow										
Catchment Area	km^2	199	1,252	537	290	260	79	91	62	
Average Annual Runoff	m^3/s	6.3	39.7	17.0	9.2	8.2	0.4	0.4	2.0	
Reservoir										
High Water Level	m	880.0	280.0	750.0	466.0	727.0	707.0	737.0	708.0	
Low Water Level	m	870.0	278.0	740.0	-	-	-	-	-	
Gross Storage Capacity	10^6 m^3	318.0	6.1	170.0	-	-	-	-	-	494.1
Effective Storage Capacity	10^6 m^3	168.0	1.2	107.0	-	-	-	-	-	276.2
Dam										
Type		Rockfill	Rockfill	Rockfill	C.G	C.G	C.G	C.G	C.G	
Height	m	68.0	28.0	38.0	4.5	5.0	5.0	5.0	4.5	
Crest Length	m	300.0	200.0	400.0	47.2	57.0	50.0	55.0	46.0	
Tunnel										
Length	m	3,200.0	3,500.0	9,350.0	361.5	2,146.7	1,500.0	2,050.0	1,150.0	
Diameter	m	3.2	4.8	4.7	2.3	2.3	2.3	2.3	2.3	
Power Generation										
Rated Head	m	749.5	73.0	440.0	160.5	184.0	147.0	155.0	415.0	
Maximum Discharge	m^3/s	19.4	60.0	56.0	1.6	1.4	0.5	0.5	0.4	
Installed Capacity	MW	118.0	36.0	200.0	2.0	2.0	0.5	0.7	1.2	360.4
Firm Peak Power	MW	115.5	28.9	73.7	1.3	1.5	0.4	0.5	0.9	222.7
Average Annual Energy	GWh	331.4	181.9	529.1	16.6	16.7	4.4	5.5	9.9	1,095.5
Firm Energy	GWh	252.8	63.3	161.3	11.0	11.3	3.4	4.2	7.6	514.9
Plant Factor	%	32.1	57.7	30.2	94.7	95.3	95.6	95.7	94.6	34.7

Note C.G : Concrete Gravity Dam

Chapter III Selection of Optimun Development Scheme

CHAPTER III SELECTION OF OPTIMUM DEVELOPMENT SCHEME

In Chapter III, the optimum scheme of small-scale hydroelectric power project for energy supply to Sekong and Attapeu, which is the main object of this study, is selected and the conditions required for preliminary design of the selected optimum plan are studied.

Firstly, in Section 1, the optimum plan of the Xe Katan Small-scale Hydroelectric Power Development Project is formulated based on the comparison study among alternative schemes.

Then, conditions of topography & geology and meteorology & hydrology are studied for the project site of the formulated optimum plan in Section 2 and Section 3 respectively.

In Section 3, future power demand in Sekong and Attapeu is forecasted and the capacity of the project to be developed is decided. Further, in Section 5, power transmission plan from the project site to demand area is formulated.

1. Selection of Optimum Development Scheme

Chapter III 1. Selection of Optimum Development Scheme

Contents

List of Figures

List of Tables

1. Selection of Optimum Development Scheme

The study results of the hydropower potential in the entire Xe Namnoy River Basin have been described in Chapter II. The optimum development scheme will be selected keeping in mind the overall image of the development projects obtained through these studies.

The objective of this study is the formulation of an hydroelectric power plan for supplying electric energy to the two townships of Attapu and Sekong. Diesel power plants are installed for lights, sawing, etc. In both towns the energy demand potential is expected to be very high. Although energy demand will increase steadily when energy is supplied to cover the demand, the demand will not so big that it requires large-scale hydropower development. From this point of view, Projects B, C, and D described in the preceding chapter which are large-scale hydroelectric power projects would be excluded from consideration.

On the other hand, installed capacities of Projects G, H, and I would be too small, and since the request from the consumer side for a supply capability of 2,000 kW in the first phase of the project cannot be met, these projects also would be excluded from consideration.

Therefore, what will be the object of comparison studies are the remaining Project E (Xe Katam Tunnel Plan, Fig. III-1-1) and Project F (Upper Xe Katam Plan, Fig. III-1-2).

Besides these, Project J (Lower Xe Katam Open Canal Plan, Fig. III-1-3) which is a variation of Project E, and although conflicting with the upstream Project D, Project K (Mainstream Xe Namnoy Plan, Fig. III-1-3) planned on the Xe Namnoy River will also be added.

Project J is a scheme selected in the Preliminary Study with an intake dam constructed approximately 1.8 km upstream of the large waterfall at the downstream part of the Xe Katam River, and the intaked water is conducted to the Xe Namnoy River side by an open channel 1,300 m in length and a penstock of 930 m to generate energy using the effective head of 190 m.

Project K has an intake dam immediately upstream of the waterfall on the Xe Namnoy River approximately 1.5 km upstream of the confluence of the Xe Katam River and the Xe Namnoy River, and conducts water by a tunnel of 1,080 m and a penstock of 210 m provided on the left-bank side of the Xe Namnoy River to generate energy using the effective head of 101 m.

The comparison study was made under the conditions below:

- Installed capacity is to be 2,000 kW in the first phase, and 4,000 kW in the second phase, a total of 6,000 kW.
- Regarding river runoffs, they are to be obtained through conversions based on catchment area ratios using the runoff durations obtained in hydrological analyses shown in Figs. II-2-11, II-2-12, and III-1-4.
- Regarding unit costs of construction materials, those known from survey in Lao P.D.R., such as the unit costs used in the Xe Set and Nam Thuen projects are to be used.
- Basically, 1/5,000 topographical maps are to be used.
- Comparisons of the projects are to be made with construction costs per kW or kWh as indices since the project would be a run-of-river type. In this case, the study is to be made assuming that all of the electric energy produced will be effective.

Although with the abovementioned very limited conditions, comparison studies were made of these schemes. The results are given in table III-1-1.

Whether seen from just the first phase or from the total including the second phase, the economic condition of Project E is the most favorable. Even in comparison with Project J, which is the next most economical, the economics of Project E is more favorable in excess of 10%. In the case of Project E, since it is a scheme for an intake dam to be provided immediately upstream of a waterfall with the head of the waterfall to be utilized, it will be possible to make the headrace tunnel short compared with the other projects described later.

Basaltic lava and autobrecciated lava are distributed at the intake dam site, the headrace tunnel route, and upper part of the penstock route of Project E, while terrace deposits are distributed at the powerhouse site. The basaltic lava mainly distributed at the intake dam site is fresh and hard, but the autobrecciated lava interbedded in the basaltic lava is porous, and its permeability is more than the basaltic lava one. Basaltic lava at headrace tunnel is weathered to 23 m in depth from the ground surface, so that it would be desirable for the headrace tunnel to be installed as deep as possible. Weathered basaltic lava is distributed at the surface layer of the upper parts of the penstock route, while talus deposits are distributed from the middle part to the lower part of penstock route. At the powerhouse site, terrace deposits are distributed to a thickness of about 5 m, overlying which there is distribution of sandstone.

Project J, when examined on the basis of the first phase, is economical next to Project E. However, the headrace of Project J will be an open channel of length 1,300 m provided on the right-bank side of the Xe Katam River, and of this length 400 m will pass over steep slopes inclined 45 deg or more or over vertical cliffs so that the volume of excavation will be as much as 32,000 m^3, while slope surfaces will required protective works. In order not to lose head, the head tank would be provided on flat land near an elevation of 500 m and the length of the penstock will become 930 m (which is the reason for worsening of the economic condition of this project).

Basaltic lava and autobrecciated lava are distributed at the intake dam site and the open channel route of Project J. Hard basaltic lava is distributed at the intake dam site, but at the base of the waterfall of head 1.5 m which is located immediately downstream to the dam, there is distribution of autobrecciated lava assumed to have high permeability so that leakage would be feared. Since weathered basaltic lava is mainly distributed on the steep slope of the open channel section, slope stability will become a problem. The penstock route and the powerhouse site are the same as in the beforementioned Project E, and the geological condition will be the same. The permeability of intake dam foundation is thought to be a problems more than that of project E.

Project F and Project K which required comparatively long tunnels are of poor economic condition.

Although the economic condition of Project K is better than that of Project F, when the relationship with the previously-mentioned future large-scale development at the upstream part of the Xe Namnoy River is considered, this project should be held in abeyance for the time being. The intake dam would be provided at a point approximately 400 m upstream of a large waterfall of a head of 70 m on the Xe Namnoy River. The left-bank side is a continuation of steep cliffs of inclinations 60 deg or more, and construction of an access road to the dam site will be extremely difficult. A settling basin would be provided at the left-bank side, but the space for this will be extremely limited.

Basaltic lava and autobrecciated lava are distributed as basement rocks of the intake dam site, headrace tunnel route, and penstock route of Project K. Sandstone is distributed at the powerhouse site. Basaltic lava is distributed at the left-bank slope of the intake dam site, but outcrops cannot be seen at the river bed and the right-bank side, and there is a possibility of river deposits and talus deposits being distributed thickly at these parts. Furthermore, the river width is approximately 60 m, and the widest of the four projects. The headrace tunnel may have adequate cover from the ground surface and it is estimated that fresh basaltic lava will be generally distributed.

Project F with the longest tunnel has the poorest economic condition. However, unlike Project K, this will not conflict with other schemes, and there is a possibility for it to be developed in the future. There are cascades of several stages (total: 50 m) at the upstream side of the intake dam site and it is conceivable for a dam to be provided at the upstream side of these falls. However, in this case, there is a stream joining in at the left-bank side and the headrace would be provided detouring this stream so that the lengths of the headrace and the penstock will become longer, and the economic condition would be impaired. Therefore, a project of good economics was selected this time even at the sacrifice of head. In the event a possibility arises for Project F to be developed in the future, an examination should be made of a plan to move the dam site to the upstream side in aiming for increased output.

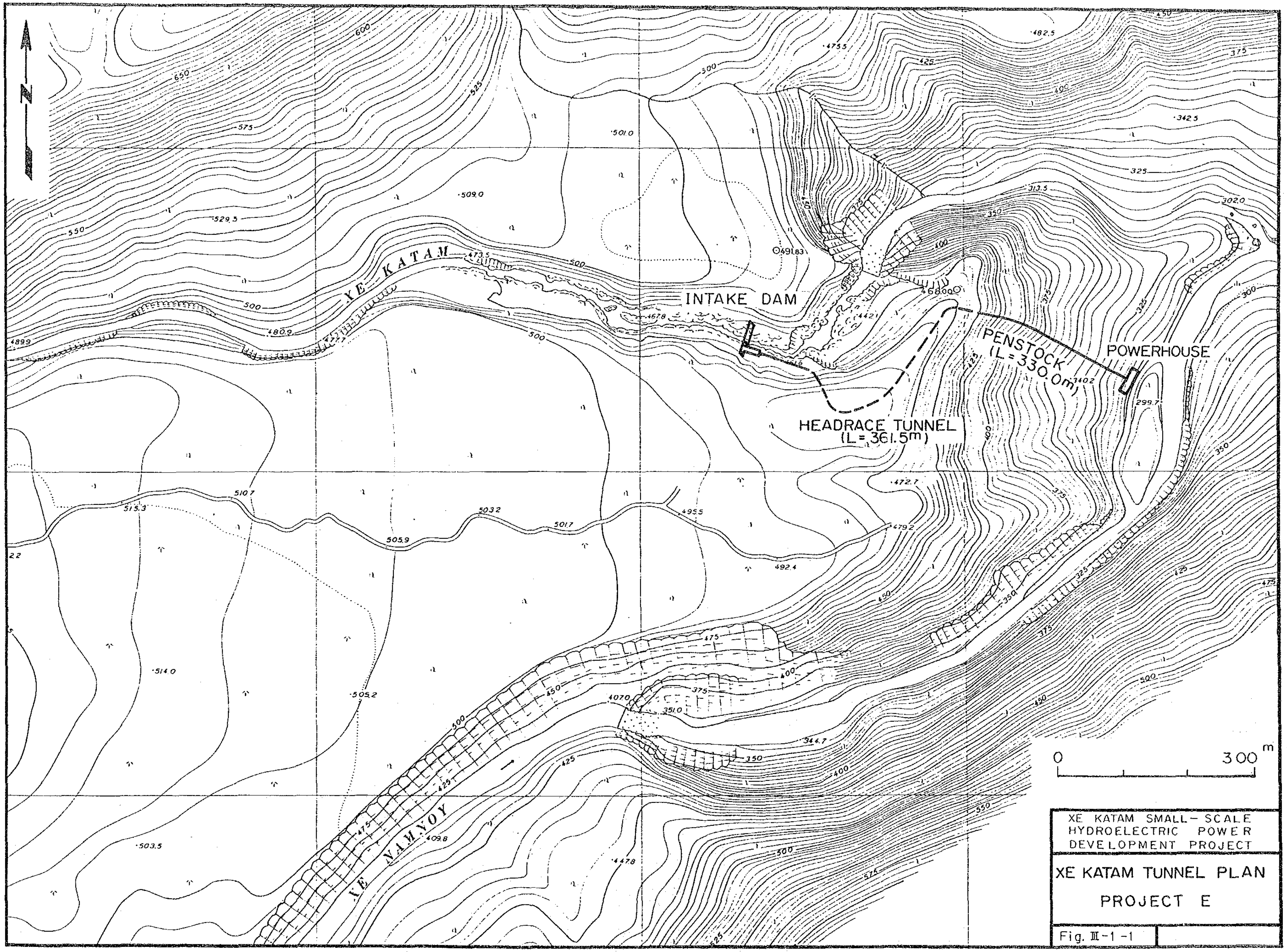
Sandstone is distributed at the headrace tunnel and penstock routes of the Project F, with basaltic lava distributed at the powerhouse site. The intake dame site locates to the geological boundary between basaltic lava and sandstone and there is concern that leakage will occur from the geological boundary. The headrace tunnel will have thick cover from the ground surface, sandstone is distributed at upper part of the penstock route, but talus deposits are thickly deposited from the middle part to the lower part of the penstock route. The powerhouse site consists of a slope of talus deposits having inclinations from 30 to 40 deg with basaltic lava as the basement rock, and it is thought excavation of this slope will be required for installation of the powerhouse.

A comparison of a project (Project E-U) of the case of moving the intake dam upstream approximately 230 m as a variation of Project E and Project E is given in Table III-1-2. According to this study result, even though head is obtained by moving the dam upstream, the increase in cost due to increase in waterway length would be more than the increase in energy production, and there would be no merit gained.

The conclusion is that Project E is the most favorable, and it was decided that this would be selected as the optimum plan, and hereafter, studies and designing of the feasibility level will be carried out on this project.

The 95% dependable discharge of the project site is 1.1 m^3/s, and in this case, output of 2,000 kW cannot be expected. Because of this, it is necessary for a study to be made concerning provision of a small pond for diurnal operation in consideration of inflow and demand in the dry season.

The feasibility design for the project selected will be carried out in Chapter IV. The final project specifications and generating capacity determined by this feasibility design are as shwon in Table III-1-3.



XE KATAM SMALL-SCALE HYDROELECTRIC POWER DEVELOPMENT PROJECT

XE KATAM TUNNEL PLAN

PROJECT E

Fig. III-1-1