CHAPTER IX SELECTION OF PRIORITY PROJECTS

9.1 SELECTION CRITERIA AND PROCEDURES

The priority of implementation for the four projects under study would be clarified in the contemplation of technical soundness, economic viability, and socio-economic impacts. Eleven (11) selection criteria are set forth as listed below.

Criteria - 1		Technical Soundness
	1.1	Stability of Dam Embankment
	1.2	Stability of Dam Foundation
	1.3	Present Irrigation Development
Criteria - 2		Economic Viability
	2.1	Project Economy
	2.2	Economic Impacts Caused by Secondary Benefits
	2.3	Associated Benefits
Criteria - 3		Socio-Economic Impacts
	3.1	Contribution to Regional Economy
	3.2	Administrative Consideration
	3.3	Employment Opportunity
	3.4	Impact on Farm Economy
	3.5	Other Socio-Economic Factors

In accordance with each sub-criterion above mentioned, each project would be assessed by four rankings such as highest, higher, ordinary and low.

9.2 ASSESSMENT

9.2.1 Technical Soundness

(1) Stability of Dam Embankment

As discussed in the section of "Preliminary Design of Dam", embankment materials obtainable around the proposed sites are unsuitable for the embankment higher than about 50 m even if the embankment will be made with a considerable gentle slopes. The Khlong Chaliang Lab and the Huai Yai dam is more stable than the others in the light of this criteria.

(2) Stability of Dam Foundation

According to the results of the geological investigation recently undertaken by the RID, the foundation of the Huai Khon Kaen site is geologically the most favourable for dam construction, followed by those of the Huai Saduang Yai and Khlong Chaliang Lab. As regards the foundation of the Huai Yai dam, the dam site is shifted to about 500 m upstream from the original site proposed by the RID, due mainly to geological and topographical condition at

the site. No geological data is available at the shifted site at present but the foundation thereof might be covered with rather thick alluvial deposit and not so stable as those of the other sites.

(3) Development Stage of Existing Irrigation System

The irrigation systems in the Huai Yai and Khlong Chaliang Lab areas have been relatively well developed by the Local Government and water users' association. Most of the systems have been better maintained by the water users' association. While, the existing irrigation system in the Huai Khon Kaen is ephemeral and much deteriorated owing to the poor maintenance. The Huai Saduang Yai would supplement irrigation water to the Pasak Left Bank and Sri Chan irrigation projects which have been relatively well-developed. In view of irrigation development in the future, the Saduang Yai area is the most convenient, followed by the Huai Yai and the Khlong Chaliang Lab.

On the basis of the assessment for each project above mentioned, the overall technical soundness of each project is concluded as tabulated below:

Sub-Criteria	Huai Saduang Yai	Huai Khon Kaen	Huai Yai	Khlong Chaliang Lab
1) Stability of Dam Embankment	Higher	Ordinary	Higher	Highest
2) Stability of Dam Foundation	Higher	Highest	Ordinary	Ordinary
3) Present Irrigation Development	Highest	Ordinary	Higher	Higher
Ranking at Overall Technical Soundness	1	3	4	2

9.2.2 Economic Viability

(1) Project Economy

The project economy of each project is assessed in terms of the economic internal rate of return as analized in Annex-VIII. As given below, the Huai Yai project indicates the highest IRR, followed by the Huai Saduang Yai, the Huai Khon Kaen project. The Khlong Chaliang Lab shows the lowest IRR among four projects.

Project	Economic IRR (%)
Huai Saduang Yai	16.1
Huai Khon Kaen	14.2
Huai Yai	21.0
Khlong Chaliang Lab	7.4

(2) Economic Impacts Caused by Secondary Benefits

Economic impacts caused by the secondary benefits are also evaluated as given in Annex-VIII. As shown below the Huai Yai project gains the highest economic IRR, followed by the Huai Saduang Yai project, the Huai Khon Kaen project and the Khlong Chaliang Lab project.

Project	Economic IRR (%)
Huai Saduang Yai	20.8
Huai Khon Kaen	17.9
Huai Yai	26.8
Khlong Chaliang Lab	10.1

(3) Associated Benefits

Each project receives associated benefits accruing from municipal water supply, hydro-power development, land enhancement by flood mitigation. The Huai Saduang Yai and the Huai Khon Kaen dam supply municipal water of about 900,000 m^3 per annum respectively and receive considerable amount of associated benefit in the future. Among four dams, the Huai Saduang Yai and the Huai Yai substantially function flood mitigation as studied in Annex-II, in terms of 50-year return period, both dams regulate about 10 m^3/sec respectively. The flood mitigation effect in the remaining two dams is negligible small. The proposed four dams have an available hydraulic head of about 25 m and possess almost same potential for hydro-power generation. Thus, in view of associated benefits, the Huai Saduang Yai would be highly evaluated, followed by the Huai Khon Kaen and the Huai Yai dam. The associated benefits accruing in the Khlong Chaliang Lab are negligible.

On the basis of the assessment mentioned above, the overall economic viability of each project would be concluded as tabulated below:

	Sub-Criteria	Huai Saduang Yai	Huai Khon Kaen	Huai Yai	Khlong Chaliang Lab
1)	Project Economy	Higher	Ordinary	Highest	Low
2)	Economic Impacts by Secondary Benefits	Higher	Ordinary	Highest	Low
3)	Associated Benefits	Highest	Higher	Ordinary	Low
	Ranking at Overall Economic Viability	2	3	1	4

9.2.3 Socio Economic Impacts

(1) Contribution to Regional Economy

More benefits and less project costs would substantially contribute to regional economy. Net present value is applicable as the index which identifies the project contributable to regional economy. As estimated in Annex-VIII and summarized below, the Huai Khon Kaen project is given the largest index and makes remarkable contribution to regional economy, followed by the Huai Yai project, Huai Saduang Yai project. The Khlong Chaliang Lab is given the smallest index and makes less contribution to regional economy.

Project	Net Present Value (Discount rate: 12%) (US$ million)
Huai Saduang Yai	2.7
Huai Khon Kaen	4.0
Huai Yai	3.7
Khlong Chaliang Lab	-0.8

(2) Administrative Consideration

The Huai Pa Daeng tank irrigation project was completed in 1976. Following the Huai Pa Daeng project, the Huai Yai project has been surveyed since 1976 by the RID. In view of the historical background, the Huai Yai project should be given the first priority of implementation.

Administratively, two projects i.e. the Huai Saduang Yai and the Huai Khon Kaen project come under the Lom Sak district: the Huai Yai and the Khlong Chaliang Lab project, under the Phetchabun district. To accelerate rural development in the backward areas, one project located at the Lom Sak district should be given the second priority of implementation, provided that the Huai Yai project located at the Phetchabun district would be given the first priority from other criteria. The Huai Saduang Yai project

at the Lom Sak district would supplement irrigation water for the Pasak Left Bank and the Sri Chan project, the irrigation system of which have already developed by the RID. Therefore, to reduce income disparities among the rural population, the Huai Khon Kaen project should be given the second priority.

(3) Employment Opportunity

There exist considerable amount of under-employed people especially during dry season in and around the project area. In construction and operation of the project, employment opportunity thereabout sharply increase in proportion to the scale of the project. This have great impacts on the regional economy. Therefore, among the four proposed projects, the Huai Khon Kaen project substantially gives the greatest impacts on the regional economy, followed by the Huai Saduang Yai.

(4) Impacts on Farm Economy

As given in Annex-V, the Huai Saduang Yai and Khlong Chaliang Lab project areas are relatively affluent from land holding size and family size, compared with the other two projects. In view of the reduction of income disparity, the Huai Khon Kaen and Huai Yai projects should be given higher priority of implementation.

(5) Other Socio-Economic Factors

Number of households dwelling in each reservoir site is as small as about ten or so. There is no serious problems on resettlement in each project. Ecological effects with the implementation of the project might be neglibibly small in each project area and its watershed, since the scale of each project is relatively small. Land acquisition for irrigation development is relatively ready in each project, because existing canal route would be possibly available. Based on these socio-economic factors, therefore, no substantial priority would be given over the proposed projects.

On the basis of the assessment above mentioned, the overall socio-economic impacts would be concluded as tabulated below.

	Sub-Criteria	Huai Saduang Yai	Huai Khon Kaen	Huai Yai	Khlong Chaliang Lab
1)	Contribution to Regional Economy	Ordinary	Largest	Larger	Small
2)	Administrative Consideration	Ordinary	Larger	Largest	Ordinary
3)	Employment Opportunity	Larger	Largest	Ordinary	Small
4)	Impacts on Farm Economy	Small	Largest	Larger	Ordinary
	Ranking at Overall Socio Economic Impacts	3	1	2	4

9.3 PRIORITY OF IMPLEMENTATION

The medium scale irrigation projects recently implemented in Thailand are basically aiming socio-economic impacts. Among these criteria, the criteria on socio-economic impacts should be highly regarded in the selection of priority project. Meanwhile, technical soundness of the project is evaluated in the criteria on economic viability to considerable extent. Therefore, the technical soundness would be less regarded in the selection of priority project.

Each priority would be indicated by a disc diagram to weight each criteria. The priority assessed by the criteria on socio-economic impacts would be given on the external ring of the disc diagram to give the heaviest weight to the said criteria (See Fig. 9.1). The priority assessed by the criteria on technical soundness would be shown on the inner small disc because this criteria is less regarded as previously mentioned. The priority assessed by the criteria on economic viability, therefore, would be given on the middle ring. The overall ranking assessed by each criteria would be indicated with the area of disc which is given by angle. As evidently illustrated in Fig. 9.1, the Huai Yai project sharing the largest area of the disc-diagram would be given the first priority of implementation, followed by the Huai Khon Kaen project. The Huai Saduang Yai and Khlong Chaliang Lab projects would be given the third and the last priority of implementation respectively.

TABLES

Table 3.1 Meteorological Data

Station PHETCHABUN
Index Station 48 379
Latitude 16°26' N.
Longitude 101°09' E.

Elevation of station above MSL. 117.93 meters
Height of varometer above MSL. 119.24 meters
Height of thermometer above ground 1.40 meters
Height of wind vane above ground 11.43 meters
Height of raingauge 1.25 meters

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Pressure (+1,000 or 900 mbs.) (1953 - 1975)													
Mean	13.50	11.46	09.78	08.09	06.44	05.55	05.91	05.75	07.09	10.28	12.83	13.76	09.19
Ext. Max.	28.84	24.57	23.31	19.05	15.87	13.07	18.90	14.80	15.87	19.07	22.84	24.92	28.84
Ext. Min.	03.70	01.54	99.79	97.85	97.78	95.94	94.37	96.53	94.10	93.89	03.37	02.99	93.89
Mean daily range	5.63	6.01	6.08	5.76	4.97	4.13	3.96	4.08	4.57	4.94	4.78	5.15	5.01
Temperature (°C) (1951 - 1975)													
Mean	24.7	27.3	28.2	30.9	29.8	28.7	28.0	27.5	27.4	27.4	26.1	24.5	27.6
Mean Max.	32.0	34.2	36.2	37.3	35.2	33.0	32.0	31.5	31.8	32.4	31.9	31.3	33.2
Mean Min.	14.7	17.9	21.0	23.2	24.0	23.8	23.4	23.4	23.3	22.0	18.8	15.5	21.0
Ext. Max.	38.9	39.1	40.6	43.0	42.4	40.0	36.5	36.7	36.3	36.5	36.4	36.0	43.0
Ext. Min.	2.0	9.5	11.0	13.5	20.7	21.4	20.6	21.0	18.3	15.4	7.5	5.1	2.0
Relative Humidity (%) (1951 - 1975)													
Mean	62.0	60.0	60.0	62.0	72.0	78.0	81.0	83.0	84.0	78.0	71.0	64.0	71.0
Mean Max.	91.0	88.7	87.5	87.0	91.7	94.2	95.3	96.2	96.7	95.3	92.8	92.3	92.4
Mean Min.	41.6	39.7	40.3	42.5	55.1	64.3	67.5	70.3	70.1	61.7	52.4	44.3	54.2
Ext. Min.	16.0	17.0	19.0	21.0	29.0	40.0	46.0	46.0	41.0	35.0	19.0	17.0	16.0
Dew Point (°C) (1951 - 1975)													
Mean	16.0	17.8	20.2	22.0	23.8	24.3	24.2	24.2	24.3	23.0	20.0	16.6	21.4
Evaporation (mm) (1957 - 1975)													
Mean-Piché	92.4	95.9	117.5	115.7	82.3	58.1	49.7	42.3	36.7	51.0	66.2	82.1	889.9
Cloudiness (0 - 8) (1951 - 1975)													
Mean	3.0	3.2	3.4	4.0	5.9	6.9	7.1	7.3	6.9	5.2	3.9	3.0	5.0
Wind (Knots) (1951 - 1975)													
Prevailing Wind	N	S	S	S	S	S	S	S	S	N	N	N	-
Mean Wind Speed	3.6	3.5	4.1	4.6	4.2	4.4	4.4	4.2	3.2	3.7	4.1	4.1	-
Max. Wind Speed	18N,NW	30SW	50N	46N	45S,W	22S	24S	22S	20S	25NE	20N	18N	-
Sunshine Duration (1976-1981)													
Mean	8.00	7.44	7.99	7.92	6.62	4.98	4.28	3.45	4.22	6.89	8.54	8.24	6.54
Number of Days with (1951 - 1975)													
Haze	17.4	21.6	23.1	13.8	1.2	0.7	0.1	0.3	0.6	3.6	7.0	11.5	100.9
Fog	10.6	8.6	5.2	2.9	0.8	0.6	0.8	1.2	2.3	6.6	8.1	8.7	56.4
Hail	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Thunderstorm	0.5	1.4	5.6	11.4	13.4	6.9	5.6	5.9	7.8	6.4	1.3	0.1	66.3
Squall	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 3.2 Stratigraphical Table

Age	Group	Formation	Symbol	Geological Aspect
Quaternary			Qa	Alluvial deposit
			Qt	Terrace gravel, talus, delluvial deposit
Tertiary		Chaliang Lab	Cl	Shale, yellowish gray Calcareous mudstone
Lower-Middle Jurassic	Khorat	Phra Wihan	Pw	Sandstone with shale
Lower Jurassic		Phu Kradung	Pk	Shale Sandstone
Upper Triassic		Nam Phong	np	Sandstone Conglomerate Shale
Permo Triassic		Huai Hin Lat	ht	Tuff Agglomerate
Middle Permian		Nam Duk	nd	Shale Sandstone Limestone
Lower-Middle Permian		Pha Nok Khao	pn	Limestone Chart Shale
Igneous Rocks			G	Granite diorite, gabbroic diorite

Table 3.3 Crop Production in Phetchabun Province

Year	Item	Crop			
		Paddy	Maize	Mungbean	Soybean
1971/72	Planted Area (1,000 rai)	648	468	107	23
	Production (1,000 ton)	264	161	21	5
1972/73	Planted Area (1,000 rai)	519	1,196	19	12
	Production (1,000 ton)	262	333	2	1
1973/74	Planted Area (1,000 rai)	608	800	147	64
	Production (1,000 ton)	267	400	17	11
1974/75	Planted Area (1,000 rai)	516	1,220	178	96
	Production (1,000 ton)	228	520	28	17
1975/76	Planted Area (1,000 rai)	1,111	1,669	180	29
	Production (1,000 ton)	513	686	18	5
1976/77	Planted Area (1,000 rai)	765	1,161	322	25
	Production (1,000 ton)	327	512	29	4
1977/78	Planted Area (1,000 rai)	835	1,428	529	188
	Production (1,000 ton)	272	458	41	18
1978/79	Planted Area (1,000 rai)	1,244	1,608	682	192
	Production (1,000 ton)	531	651	62	33
1979/80	Planted Area (1,000 rai)	804	1,658	641	77
	Production (1,000 ton)	265	628	60	10
Average	Planted Area (1,000 rai)	783	1,245	312	78
	Production (1,000 ton)	325	483	31	12

Source: Agricultural Statistics of Thailand

Table 5.1.(1) Monthly Runoff at Each Damsite

(Non-Excess Probability 20%)

Month	Rainfall (mm)	Runoff Coefficient (%)	Runoff (m^3) Huai Saduang Yai ($96\ km^2$)	Runoff (m^3) Huai Khon Kaen ($322\ km^2$)
Jan.	0.5	5.6	2,688	9,016
Feb.	2.0	6.0	11,520	38,640
Mar.	19.0	8.1	147,744	495,558
Apr.	37.0	10.1	358,752	1,203,314
May	135.0	22.1	2,864,160	9,606,870
Jun.	151.0	24.2	3,508,032	11,766,524
Jul.	119.0	21.0	2,399,040	8,046,780
Aug.	212.0	33.2	6,756,864	22,663,648
Sep.	168.0	28.9	4,660,992	15,633,744
Oct.	40.0	11.4	437,760	1,468,320
Nov.	1.0	5.8	5,568	18,676
Dec.	0.5	5.6	2,688	9,016
Total	885.0	-	21,155,808	70,960,106

Annual runoff (220 mm)

Annual runoff coefficient (24.9%)

Average unit runoff (7.0 $\ell/s/km^2$)

Table 5.1.(2) Monthly Runoff at Each Damsite

(Non-Excess Probability 20%)

Month	Rainfall (mm)	Runoff Coefficient (%)	Runoff (m^3)	
			Huai Yai (78 km^2)	Khlong Chaliang Lab (77 km^2)
Jan.	1	5.8	4,524	4,466
Feb.	6	6.5	30,420	30,030
Mar.	17	7.9	104,754	103,411
Apr.	37	10.1	291,486	287,749
May	123	20.7	1,985,958	1,960,497
Jun.	112	19.4	1,694,784	1,673,056
Jul.	166	27.2	3,521,856	3,476,704
Aug.	171	27.8	3,707,964	3,660,426
Sep.	237	38.2	7,061,652	6,971,118
Oct.	63	14.5	712,530	703,395
Nov.	5	6.3	24,570	24,255
Dec.	0	0.0	0	0
Total	938	-	19,140,498	18,895,107

Annual runoff (245 mm)

Annual runoff coefficient (26.1%)

Average unit runoff (7.8 $\ell/s/km^2$)

Table 5.2 Summary of Irrigation Water Requirement in Lom Sak Area and Phetchabun Area

(Unit: mm/month)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Lom Sak Area												
- LV					11.0	89.5	191.9	0	52.7	195.1	90.9	
(50%)					5.5	44.8	96.0	0	26.4	97.6	45.5	
- HYV						6.3	126.1	66.6	56.8	205.4	93.0	
(50%)						3.2	63.1	33.3	28.4	102.7	46.5	
- UC	139.6	189.2	191.5	80.2								
(35%)	48.9	66.2	67.0	28.1								
Total	48.9	66.2	67.0	28.1	5.5	48.0	159.1	33.3	54.8	200.3	92.0	0
Unit W.R. (ℓ/sec/ha)	0.18	0.27	0.25	0.10	0.02	0.19	0.59	0.12	0.21	0.75	0.35	0
Phetchabun Area												
- LV					8.6	112.9	121.9	12.7	31.3	188.6	100.6	
(50%)					4.3	56.5	61.0	6.4	15.7	94.3	50.3	
- HYV						8.0	101.2	88.0	35.4	198.9	102.7	
(50%)						4.0	50.6	44.0	17.7	99.5	51.4	
- UC	139.6	185.0	208.1	92.7								
(25%)	34.9	46.3	52.0	23.2								
Total	34.9	46.3	52.0	23.2	4.3	60.5	111.6	50.4	33.4	193.8	101.7	0
Unit W.R. (ℓ/sec/ha)	0.13	0.19	0.19	0.08	0.02	0.23	0.42	0.19	0.13	0.72	0.39	0

Note: LV - Local Varieties of Paddy
HYV - High Yield Varieties of Paddy
UC - Upland Crops

Table 5.3 Proposed Irrigation Plan

(1) Huai Saduang Yai Area

(1) Service Area: 37,460 rai (5,990 ha)

Sri Chan Irrigation Project - 6,000 rai (960 ha)
Pasak Left Bank Irrigation Project - 31,460 rai (5,030 ha)

(2) Recommendable Cropping Pattern: Crop Intensity 135%

Wet season

Paddy: Local Variety - 50%
High Yield Variety - 50%

Dry season

Upland crop (bean) - 35%

(3) Irrigation Water Requirement:

48,192,000 m^3/year (803 mm/year)

(4) Irrigation System:

Utilization of the existing irrigation systems in Sri Chan Irrigation Project and Pasak Left Bank Irrigation Project.

Table 5.3 Proposed Irrigation Plan

(2) Huai Khon Kaen Area

(1) Service Area: 27,500 rai (4,400 ha)

(2) Recommendable Cropping Pattern: Crop Intensity 135%

Wet season

Paddy: Local Variety - 50%

High Yield Variety - 50%

Dry season

Upland crop (bean) - 35%

(3) Irrigation Water Requirement:

35,340,000 m^3/year (803 mm/year)

(4) Irrigation Canal System:

Name of Canal	Canal Length			Command Area	Maximum Design Discharge
	New	Existing	Total		
	(km)	(km)	(km)	(ha)	(m^3/sec)
RMC	6.9	0.0	6.9	1,100	1.10
1L-RMC	0.4	7.2	7.6	770	0.77
1L-1L-RMC	0.0	7.1	7.1	360	0.36
LMC	35.1	0.0	35.1	3,300	3.30
1R-LMC	0.5	5.1	5.6	930	0.93
1L-1R-LMC	1.1	5.8	6.9	610	0.61
1L-1L-1R-LMC	2.3	3.3	5.6	310	0.31
2R-LMC	2.3	0.0	2.3	280	0.28
3R-LMC	2.0	1.0	3.0	130	0.13
4R-LMC	2.2	0.0	2.2	320	0.32
5R-LMC	2.0	0.0	2.0	180	0.18
Total	54.8	29.5	84.3	4,400	4.40

Table 5.3 Proposed Irrigation Plan

(3) Huai Yai Area

(1) Service Area: 9,380 rai (1,500 ha)

(2) Recommendable Cropping Pattern: Crop Intensity 125%

Wet season

Paddy: Local Variety - 50%

High Yield Variety - 50%

Dry season

Upland Crop (bean) - 25%

(3) Irrigation Water Requirement:

10,684,000 m^3/year (712 mm/year)

(4) Irrigation Canal System:

Name of Canal	Canal Length			Command Area	Maximum Design Discharge
	New	Existing	Total		
	(km)	(km)	(km)	(ha)	(m^3/sec)
MC	6.7	5.6	12.3	1,500	1.50
1R-MC	3.7	6.1	9.8	680	0.68
1R-1R-MC	2.5	1.1	3.6	200	0.20
2R-MC	0.6	2.3	2.9	260	0.26
Total	13.5	15.1	28.6	1,500	1.50

Table 5.3 Proposed Irrigation Plan

(4) Khlong Chaliang Lab Area

(1) Service Area: 1,440 rai (230 ha)

(2) Recommendable Cropping Pattern: Crop Intensity 125%

Wet season

Paddy: Local Variety - 50%

High Yield Variety - 50%

Dry season

Upland crop (bean) - 25%

(3) Irrigation Water Requirement:

1,638,000 m^3/year (712 mm/year)

(4) Irrigation Canal System:

Name of Canal	Canal Length			Command Area	Maximum Design Discharge
	New	Existing	Total		
	(km)	(km)	(km)	(ha)	(m^3/sec)
MC	0.8	1.5	2.3	230	0.23
1R-MC	0.4	0.7	1.1	30	0.03
2R-MC	0.0	1.7	1.7	130	0.13
Total	1.2	3.9	5.1	230	0.23

Table 5.4 Hydropower Potential

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1. Huai Saduang Yai Dam (Power house EL 164)												
Q (m^3/s)	0.637	1.213	1.655	0.625	0.096	0.096	0.096	1.655	1.655	0.642	0.154	0.154
H (m)	21.5	19.5	16.5	15.0	18.0	20.5	21.5	23.5	23.5	23.0	22.5	22.0
E·Q·H·g (Kw)	94	162	187	64	12	14	14	267	267	101	24	23
Monthly Kwh ($x10^3$ Kwh)	70	109	139	46	9	10	10	199	192	75	17	17
										Annual Kwh	893,000	Kwh
2. Huai Khon Kaen Dam (Power house EL 186.5)												
Q (m^3/s)	1.183	1.584	1.480	0.857	0.412	1.137	2.935	0.869	1.252	3.612	1.942	0.380
H (m)	19.5	14.5	12.0	7.5	16.0	20.5	25.0	21.5	25.0	25.0	17.0	12.0
E·Q·H·g (Kw)	158	152	122	0	45	160	503	128	215	620	227	32
Monthly Kwh ($x10^3$ Kwh)	118	102	91	0	33	115	374	95	155	461	163	24
										Annual Kwh	1,731,000	Kwh
3. Huai Yai Dam (Power house EL 185.5)												
Q (m^3/s)	0.274	0.365	0.369	0.212	0.102	0.428	0.703	0.360	0.271	1.163	0.667	0.078
H (m)	18.5	17.0	19.5	25.5	28.5	27.0	28.5	28.5	28.5	25.5	21.5	21.0
E·Q·H·g (Kw)	35	43	49	37	20	79	137	70	53	203	98	11
Monthly Kwh ($x10^3$ Kwh)	26	29	36	27	15	57	102	52	38	151	71	8
										Annual Kwh	612,000	Kwh
4. Khlong Chaliang Lab Dam (Power house EL 180.0)												
Q (m^3/s)	0.106	0.121	0.122	0.098	0.072	0.131	0.173	0.120	0.107	0.243	0.167	0.077
H (m)	13.5	13.0	10.5	16.5	16.5	16.5	16.5	16.5	16.5	16.0	13.0	12.0
E·Q·H·g (Kw)	10	11	9	11	8	15	20	13	12	27	15	6
Monthly Kwh ($x10^3$ Kwh)	7	7	7	8	6	11	15	10	9	19	11	4
										Annual Kwh	114,000	Kwh

Note: Generating efficiency E = 70%

Table 6.1 Main Features of Four Storage Dams

Description	Name of Dam			
	Huai Saduang Yai	Huai Khon Kaen	Huai Yai	Khlong Chaliang Lab
I. Reservoir				
(1) Drainage Area (km^2)	96	322	78	77
(2) Total Storage Capacity ($x10^3m^3$)	15,000	28,000	7,900	2,300
(3) Dead Storage Capacity ($x10^3m^3$)	960	3,220	780	770
(4) Useful Storage Capacity ($x10^3m^3$)	14,040	24,780	7,120	1,530
(5) High Water Level (m)	189.65	214.50	211.00	198.50
(6) Full Water Level (m)	187.50	211.50	209.00	196.50
(7) Dead Water Level (m)	174.50	186.50	196.00	190.00
(8) Reservoir Area at Full Water Level (km^2)	1.60	1.44	0.95	0.31
II. Dam				
(1) Dam Type	zone earth-fill dam	zone earth-fill dam	zone earth-fill dam	zone earth-fill dam
(2) Dam Crest Elevation (m)	191.00	216.00	212.50	200.00
(3) Freeboard (m)	1.35	1.50	1.50	1.50
(4) Dam Height (m)	30.5	52.0	32.5	25.3
(5) Dam Crest Length (m)	413.0	912.0	280.0	207.0
(6) Dam Crest Width (m)	8.0	10.0	8.0	7.0
(7) Embankment Slope				
Upstream	1:3.0	1:3.0	1:3.0	1:3.0
Downstream	1:2.5	1:2.5	1:2.5	1:2.5
(8) Embankment Volume ($x10^3m^3$)	667.7	2,728.6	327.7	151.2
III. Spillway				
III-1. Service Spillway				
(1) Design Discharge (m^3/s)	245.0	698.0	149.0	150.0
(2) Type	side channel	side channel	side channel	side channel
(3) Crest Length (m)	60.0	96.0	40.0	40.0
(4) Overflow Depth (m)	1.70	2.50	1.60	1.60
III-2. Emergency Spillway				
(1) Design Discharge (m^3/s)	354.0	940.0	218.0	193.0
(2) Type	side channel	overflow	overflow	side channel
(3) Crest Length (m)	30.0	34.0	25.0	40.0
(4) Overflow Depth (m)	0.45	0.50	0.40	0.40
IV. Intake Structure				
(1) Design Discharge (m^3/s)	2.0	6.0	1.8	0.6
(2) Type	Reinforced concrete tower	reinforced concrete tower	reinforced concrete tower	reinforced concrete tower

Table 6.2 Main Features of Irrigation Facilities

Description		Project Area		
		Huai Khon Kaen	Huai Yai	Khlong Chaliang Lab
1. Main Canals				
a) Type		Trapezoidal Section Concrete Lining	Trapezoidal Section Concrete Lining	Trapezoidal Section Concrete Lining
b) New canal length	(km)	42.0	6.7	0.8
c) Existing canal length	(km)	0.0	5.6	1.5
d) Excavation	(m^3)	149,500	24,500	3,200
e) Embankment	(m^3)	141,600	23,800	3,000
f) Lining concrete	(m^3)	14,300	3,100	310
2. Laterals				
a) Type		Trapezoidal Section Unlined	Trapezoidal Section Unlined	Trapezoidal Section Unlined
b) New canal length	(km)	12.8	6.8	0.4
c) Existing canal length	(km)	29.5	9.5	2.4
d) Excavation	(m^3)	36,500	14,900	2,100
e) Embankment	(m^3)	33,200	13,100	2,000
3. Canal Structures				
a) Regulator	(nos.)	8	3	1
b) Turnout	(nos.)	53	22	4
c) Siphon	(nos.)	3	1	0
d) Culvert	(nos.)	40	13	3
e) Drop	(nos.)	40	31	17
f) Cross drain	(nos.)	28	5	0

FIGURES

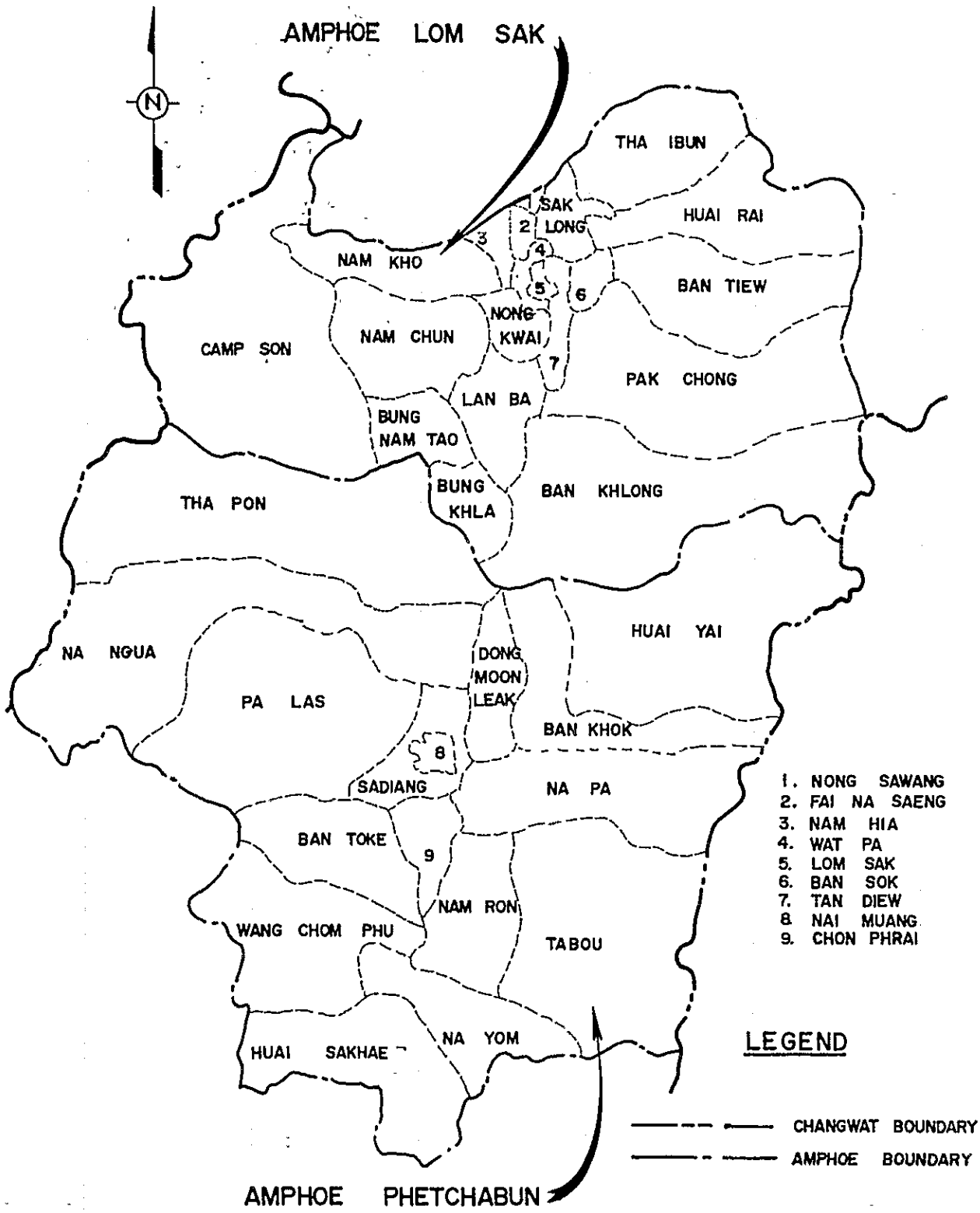


Fig. 2.1 ADMINISTRATIVE MAP

0 10 20 30 km

SCALE 1 : 5,000,000

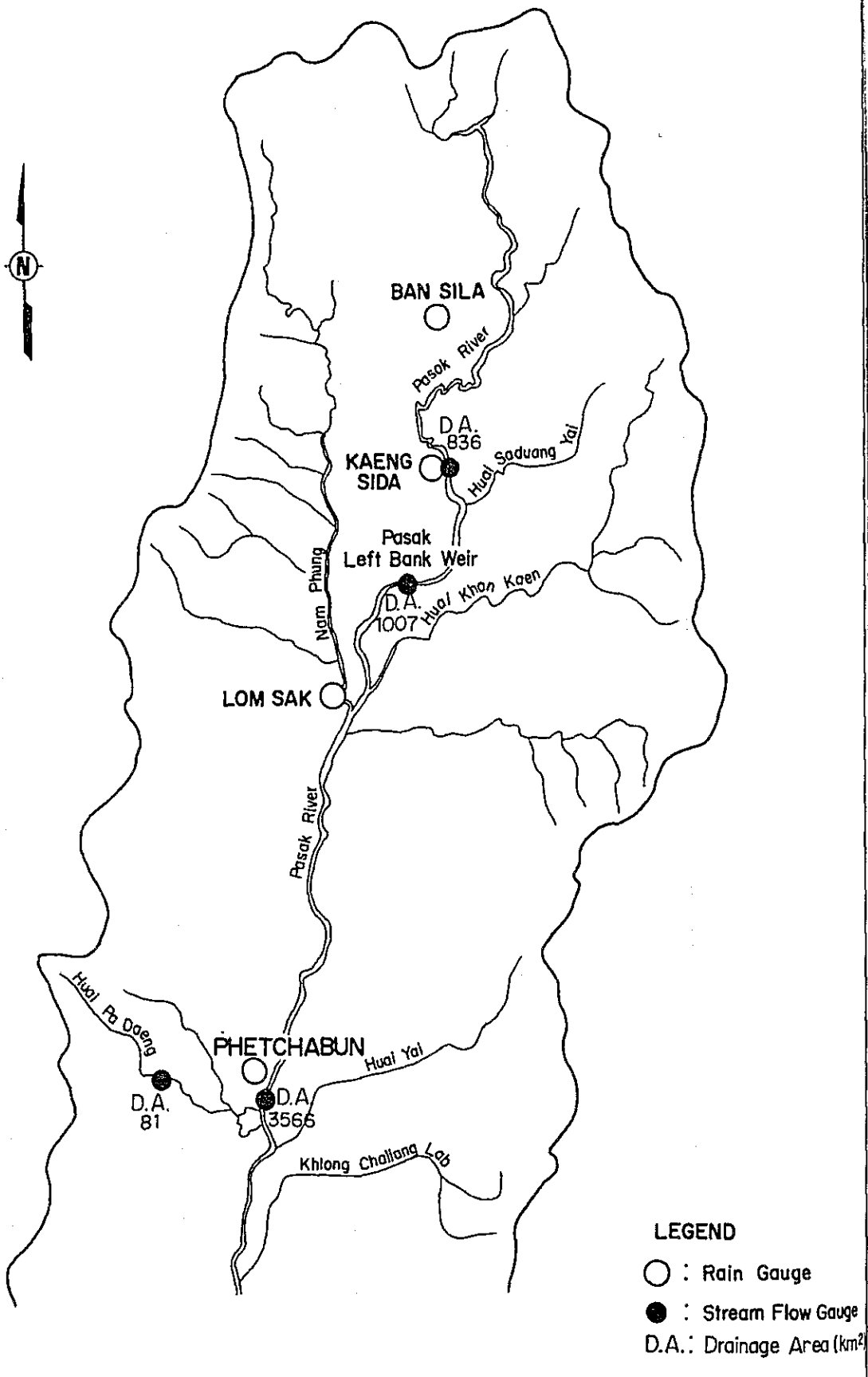


FIG. 3.1 LOCATION OF GAUGING STATION

(Upper Pasak Basin)

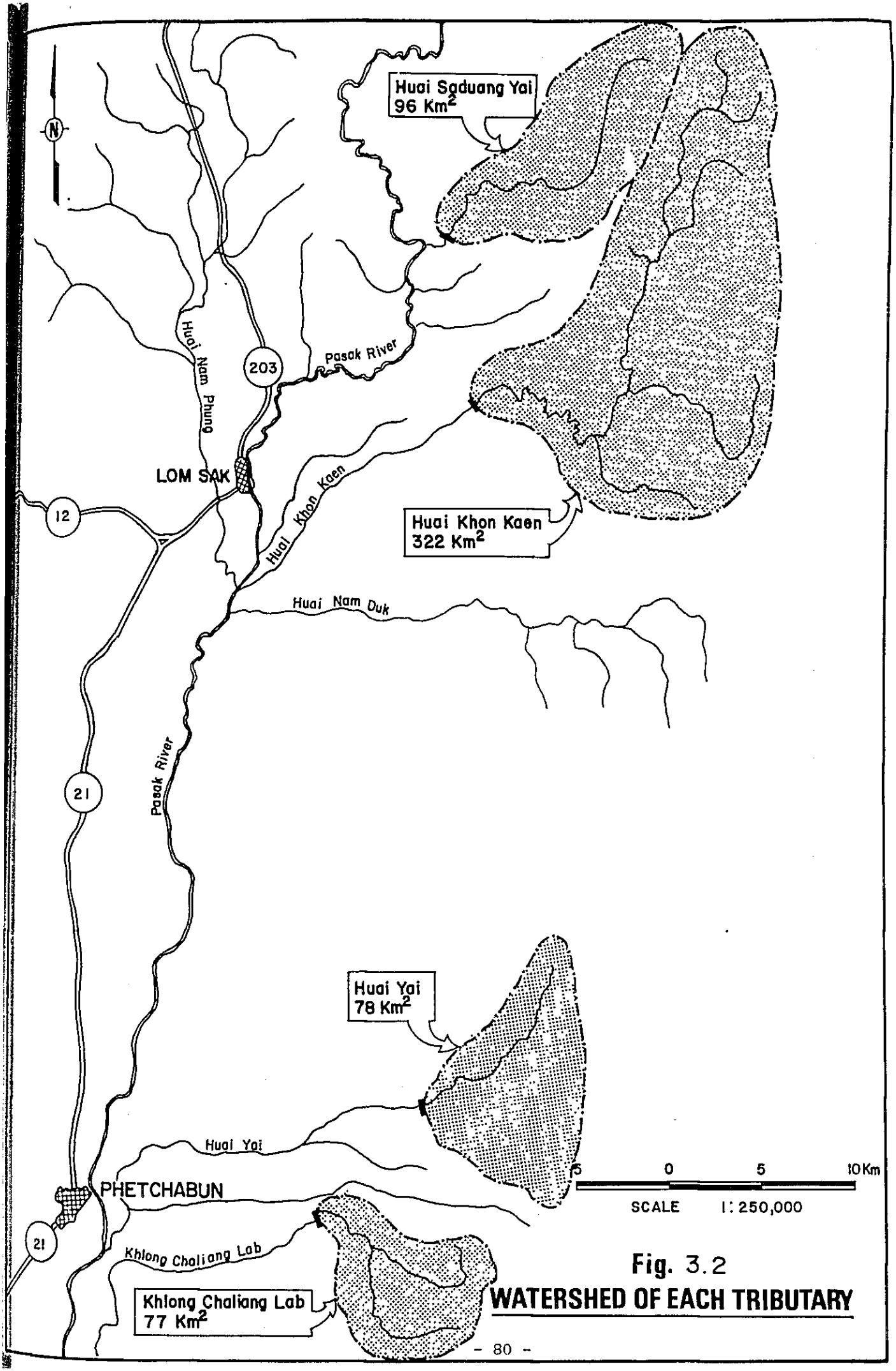


Fig. 3.2
WATERSHED OF EACH TRIBUTARY

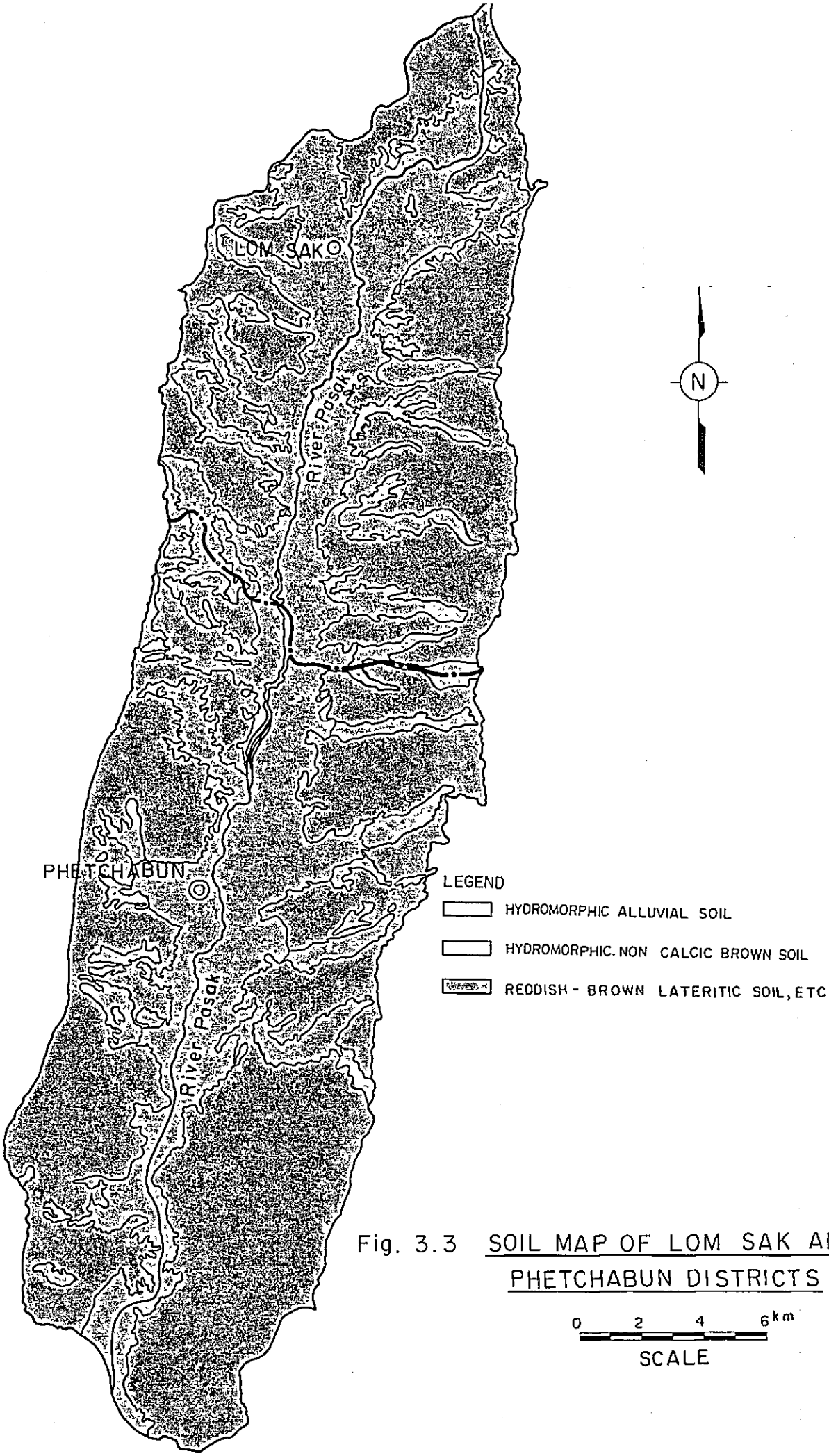
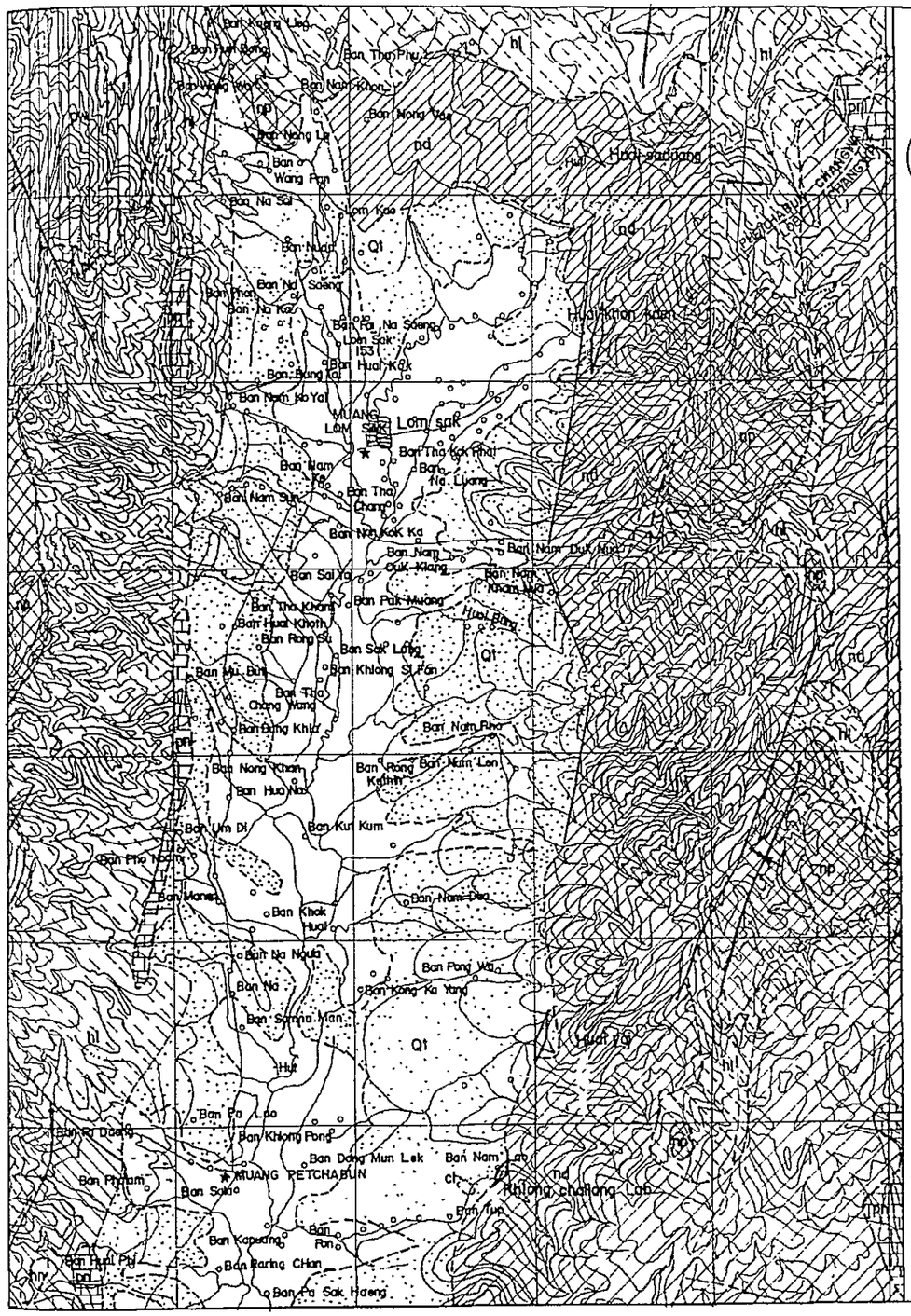


Fig. 3.3 SOIL MAP OF LOM SAK AND PHETCHABUN DISTRICTS



N

		FORMATION	GROUP	AGE
Qa	Alluvial deposit			QUATERNARY
Qt	Terrace gravel, talus, colluvial deposit			
	UNCONFORMITY			
cl	Shale : yellowish gsay, calcareous. mudstone : white, calcareous welbedded	CHALIANG LAB		TERTIARY
	UNCONFORMITY			
pw	Sand stone white pink orthogusrizitic cross bedded massive pebble layering on the upper bed, with some reddish brown and gray shale	PHAR WIHAN	KHORAT	LOWER MIDDLE JURASSIC
pk	Shale browr, reddish brown, purplish red, micaceous siltstone, sandstone brown ,grav, micaceous small scale cross bedded,with some lime-noduled conglomerate.	PHU KRADUNG	KHORAT	LOWER JURASSIC
np	Sandstone; reddish brown. brown, cross-bedded. conglomerate; pebples of quartz, quartzite chert red siltstone. up to 10 cm. in diameter shale siltstone brown, reddish brown.	NAM PHONG	KHORAT	UPPER TRIASSIC
hl	Tuff agglo merate rhyolite			PERMO TRIASSIC
	UNCONFORMITY			
nd	Shale; gray to black. sandstone, yellowish brown. fine-grained; limestone, lense and bedded. highly disturbant.	NAM DUK		MIDDLE PERMIAN
pn	Limestone, gray massive to thick bedded chert; black nodued or thin bedded. with thin bedded, gray shale	PHA NOK KHAO		LOWER - MIDDLE PERMIAN
	IGNEOUS ROCKS			
G	Granite, diorite gabbroic diorite			

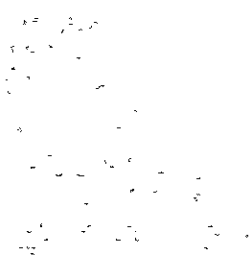
SYMBOLS

- Boundary
- Anticline, with plunging direction
- Syncline with plunging direction
- Fault

Fig. 3.4 GEOLOGICAL MAP

5 0 5 10 km

SCALE 1 : 250,000



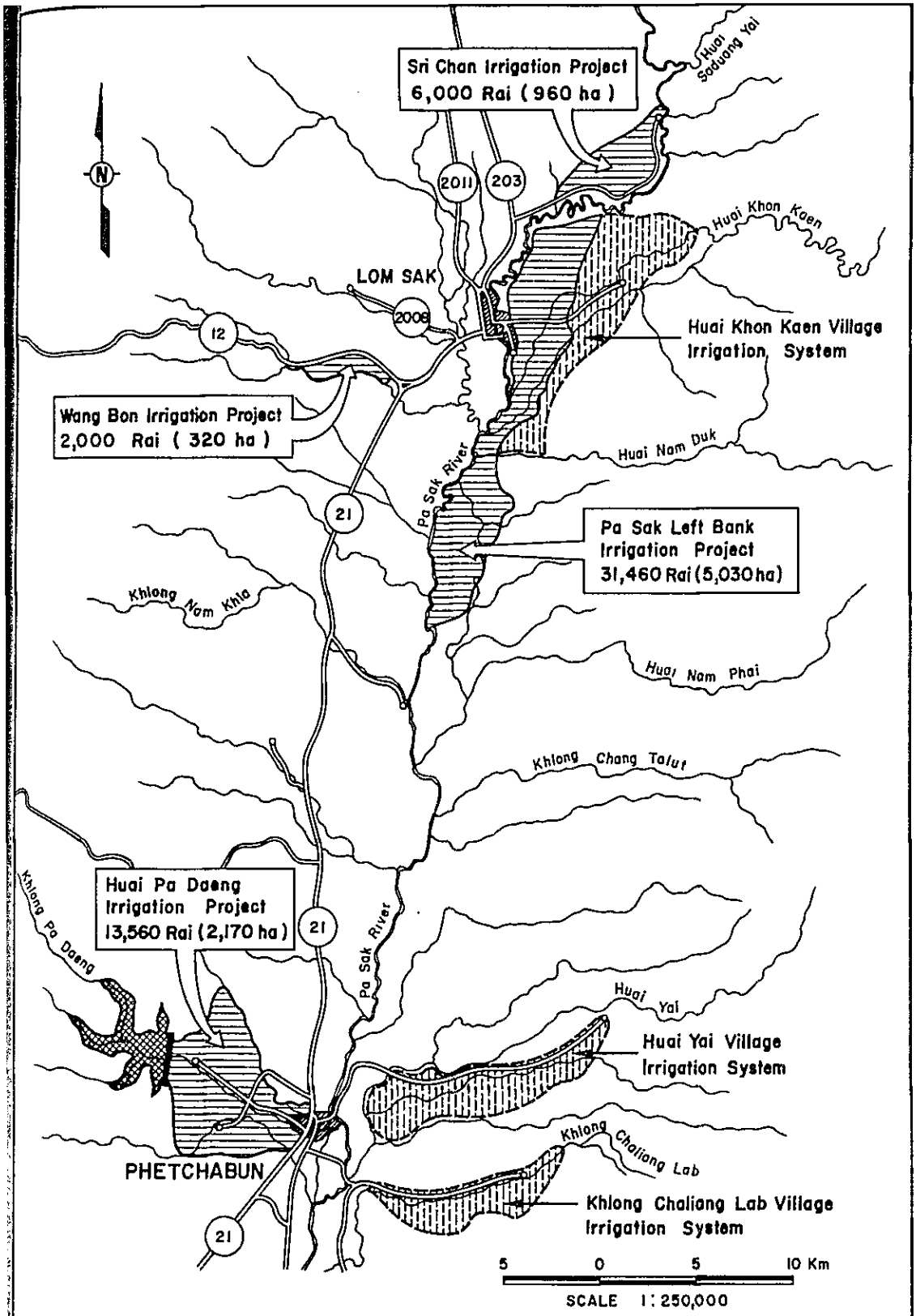


Fig. 3.5 LOCATION OF EXISTING IRRIGATION PROJECTS

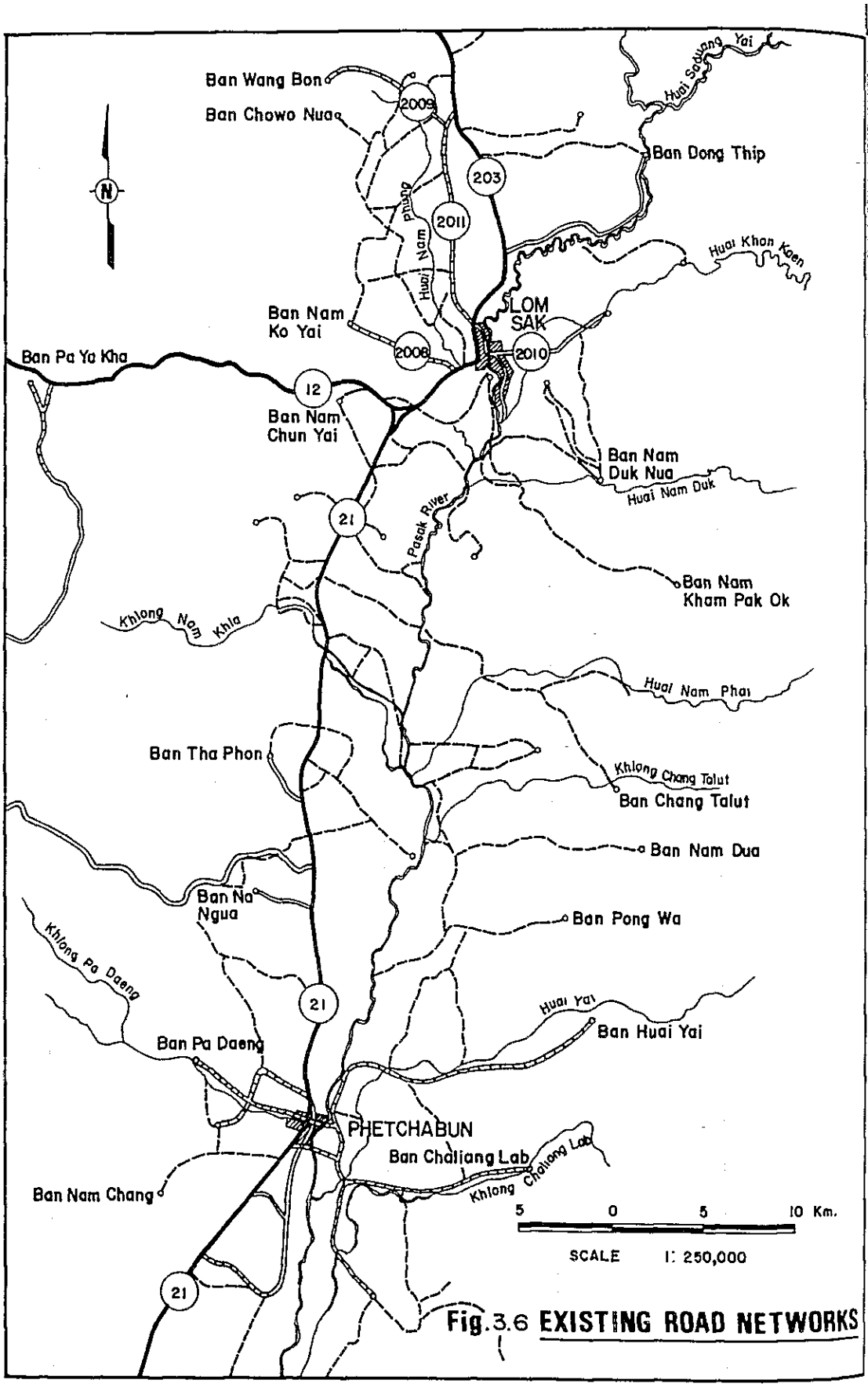


Fig. 3.6 EXISTING ROAD NETWORKS

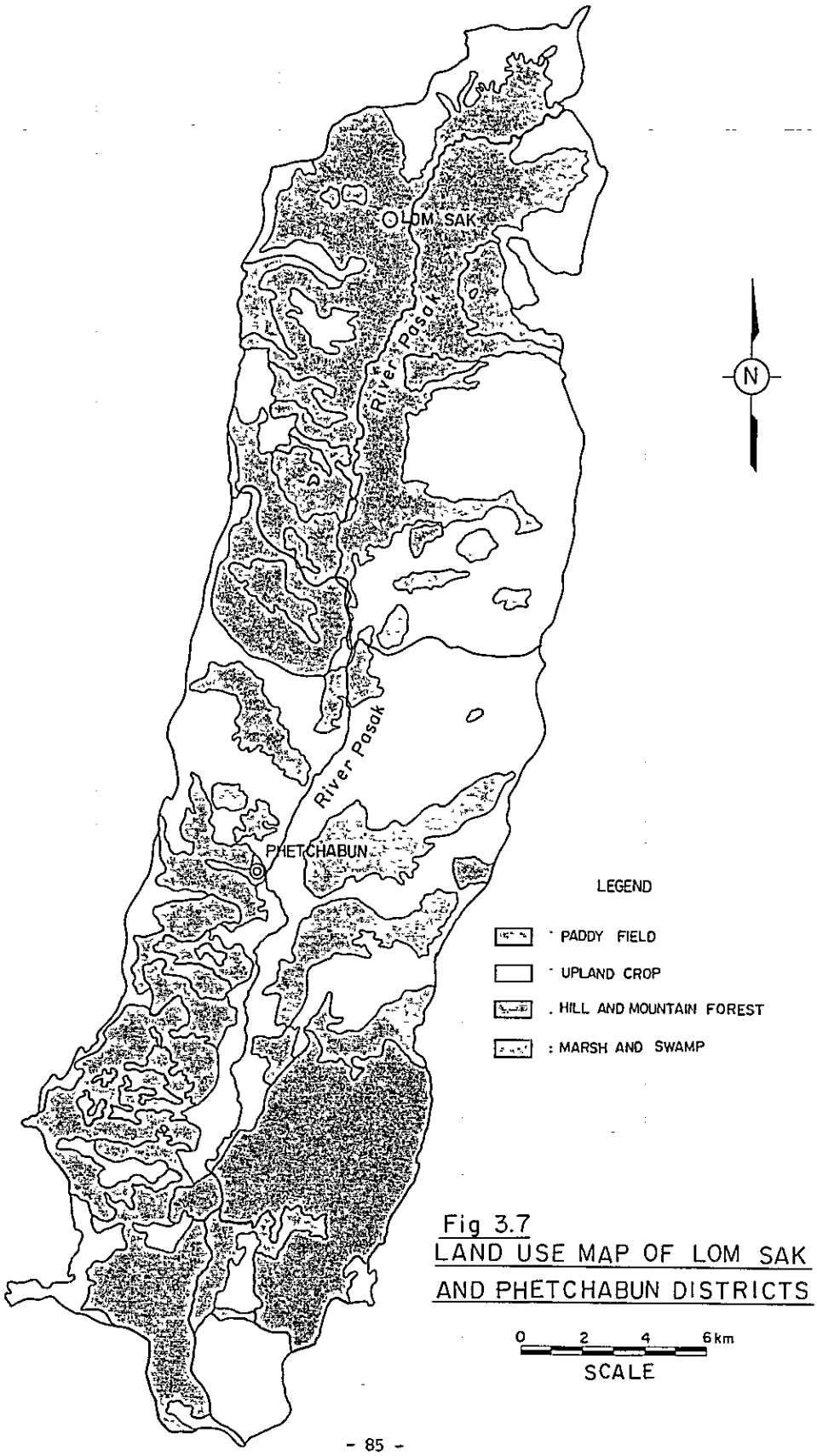
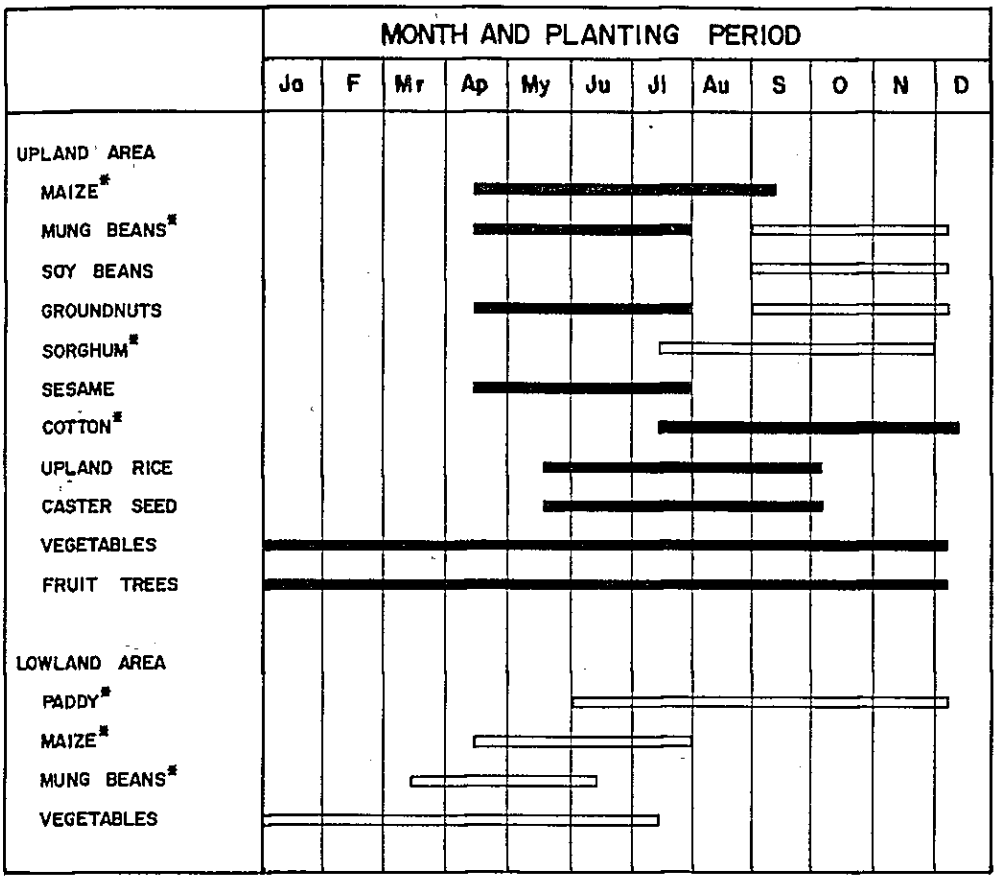


Fig 3.7
LAND USE MAP OF LOM SAK AND PHETCHABUN DISTRICTS

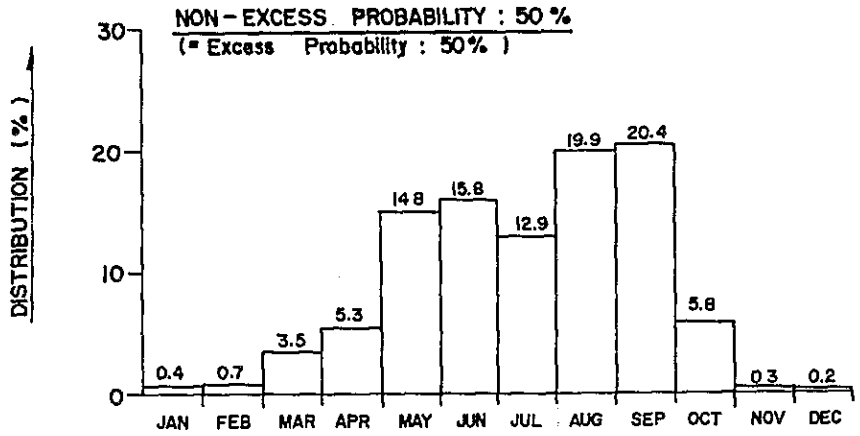


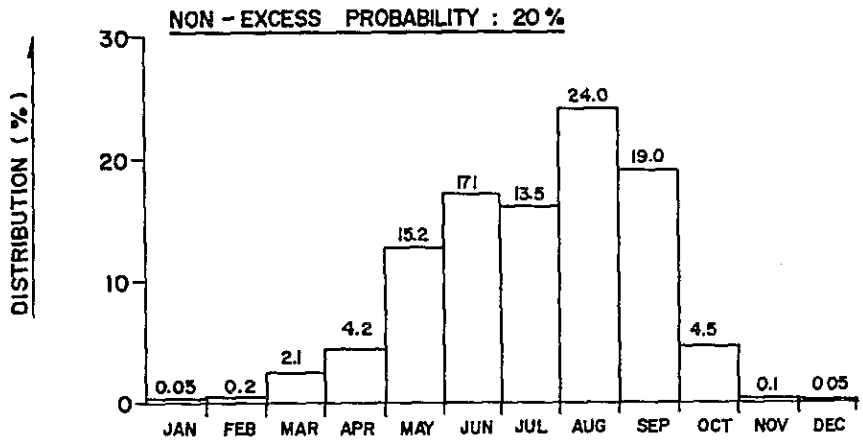
NOTE: FIRST CROP OR INTER CROP

SECOND CROP

* MAJOR CROPS IN THE PROJECT AREA.

Fig. 3.8 PRESENT CROPPING CALENDAR





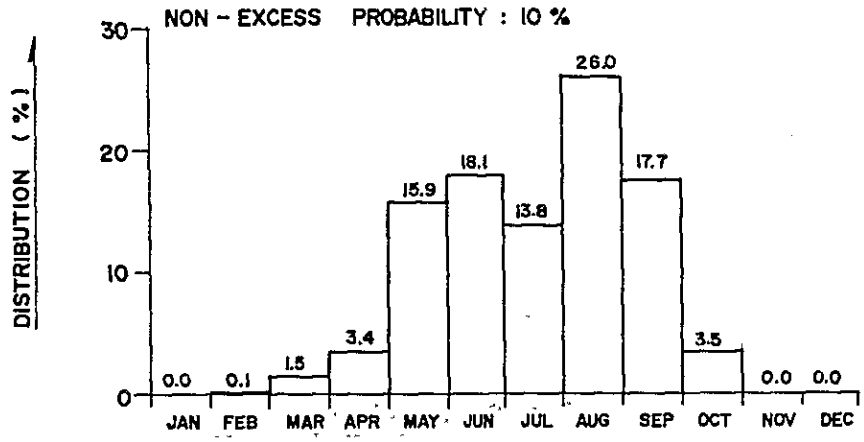


Fig.5.1.(1) MONTHLY RAINFALL DISTRIBUTION OF LOM SAK
(DROUGHTY YEAR)

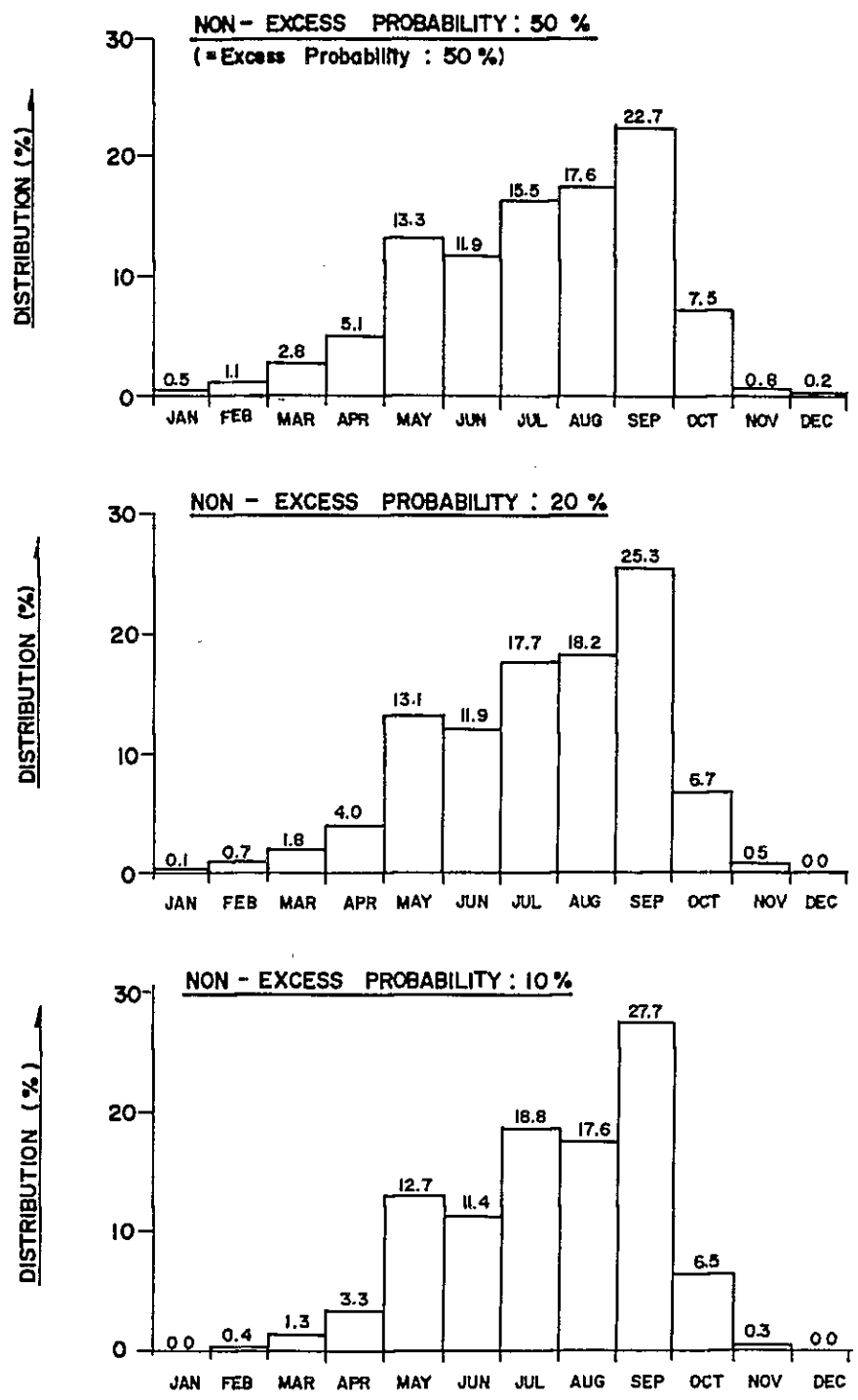


Fig. 5.1.(2) MONTHLY RAINFALL DISTRIBUTION OF PHETCHABUN
(DROUGHTY YEAR)

Type of Terrain

A – Steep mountainous area, no paddy field.
B – Rather steep area, open forest.
C – Rolling area, open forest, some paddy fields.
D – Gentle slope area, many paddy fields.
E – Flat area, many paddy fields.

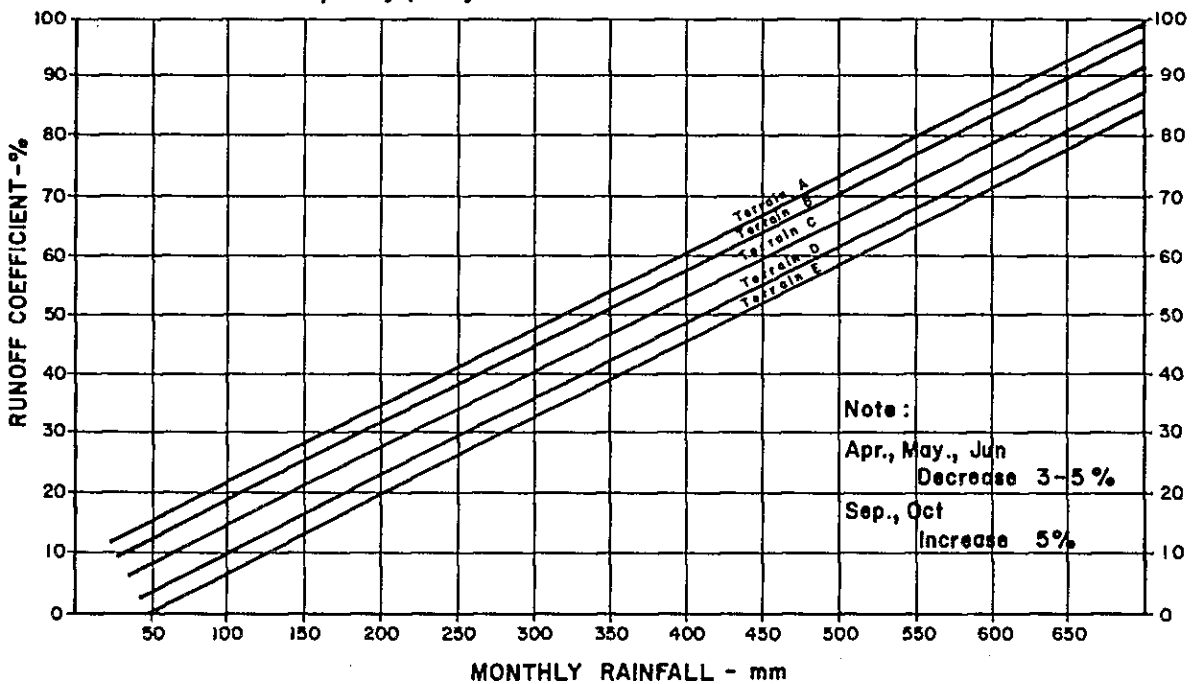


Fig. 5.2 ESTIMATE OF RUNOFF COEFFICIENT
(Developed by RID)

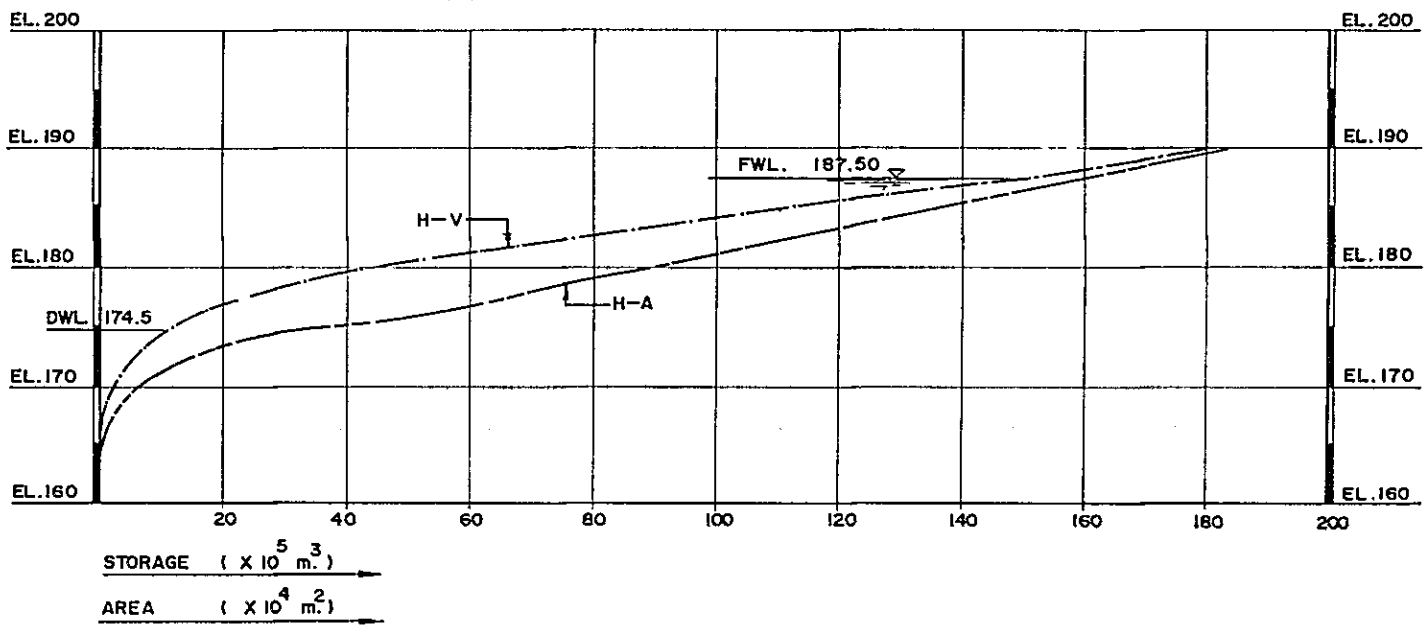


Fig. 5.3 (1) ELEVATION-STORAGE, ELEVATION-AREA CURVE OF HUAI SADUANG YAI RESERVOIR

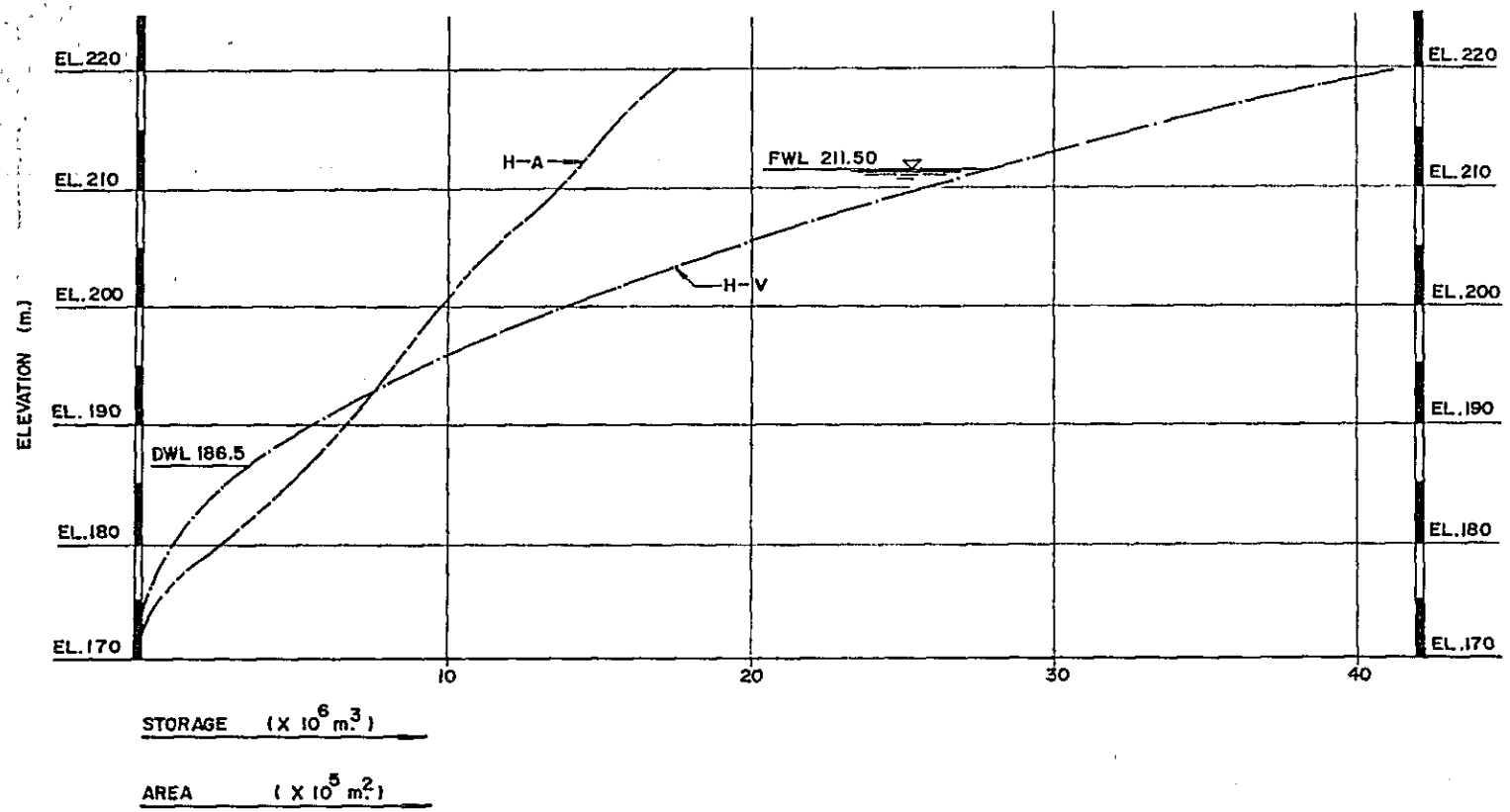


Fig. 5.3 (2) ELEVATION – STORAGE, ELEVATION – AREA CURVE OF HUAI KHON KAEN RESERVOIR

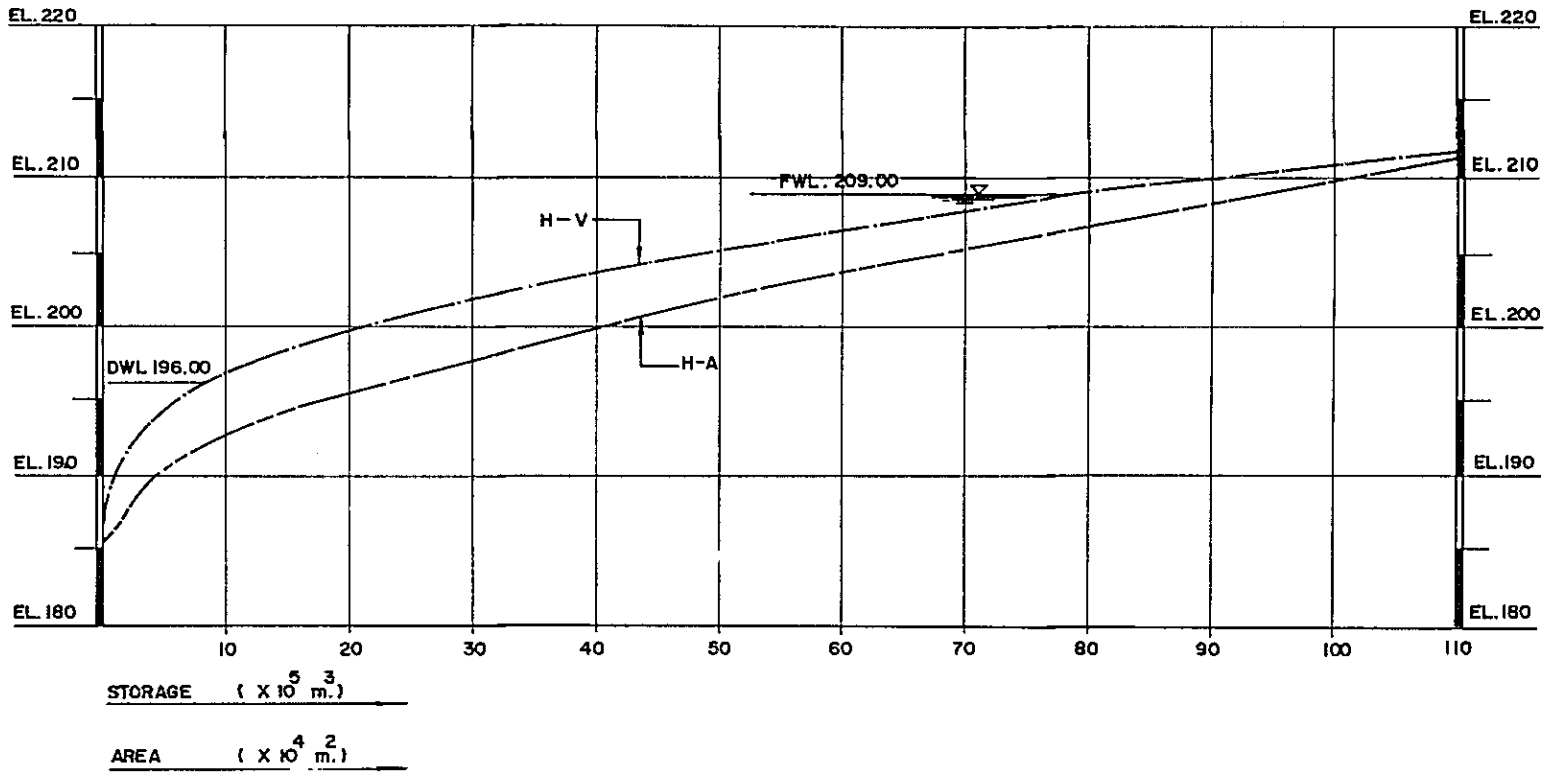


Fig. 5.3(3) ELEVATION – STORAGE, ELEVATION – AREA CURVE OF HUAI YAI RESERVOIR

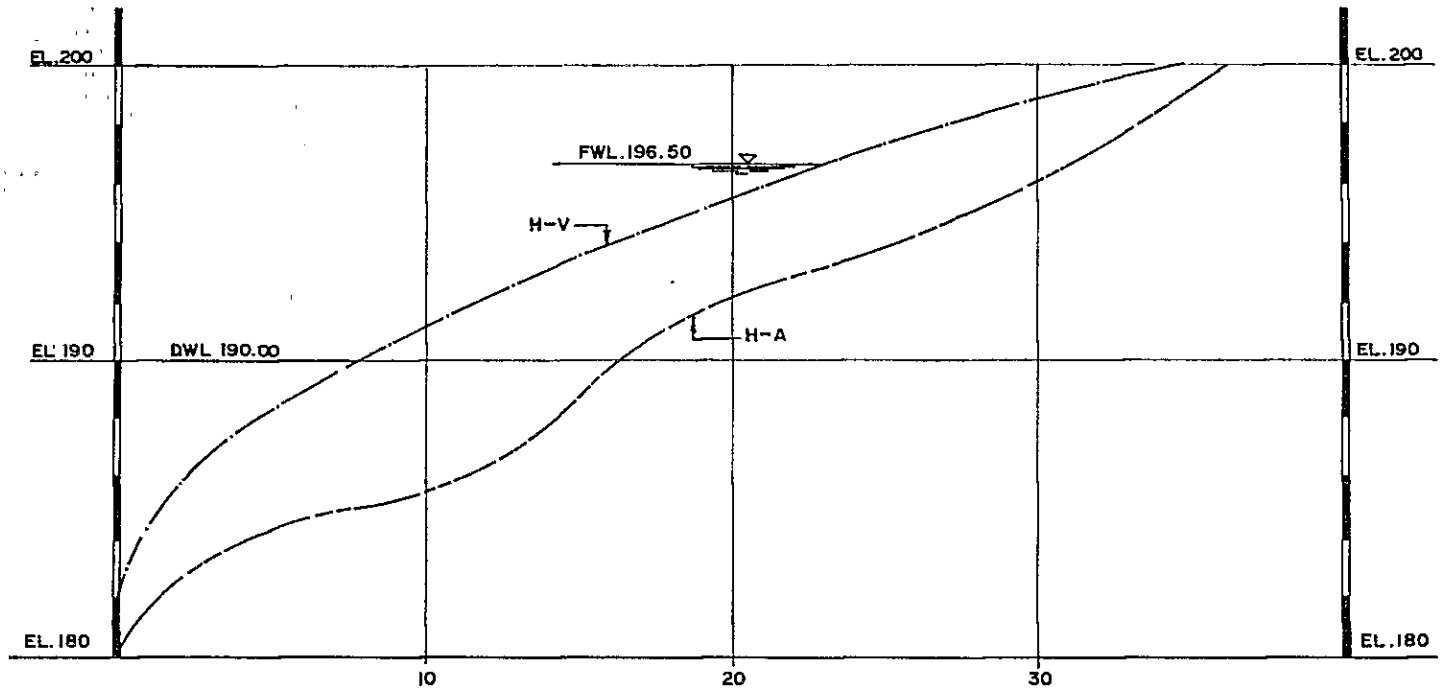


Fig. 5.3 (4) ELEVATION – STORAGE, ELEVATION – AREA CURVE OF KHLONG CHALIANG LAB RESERVOIR

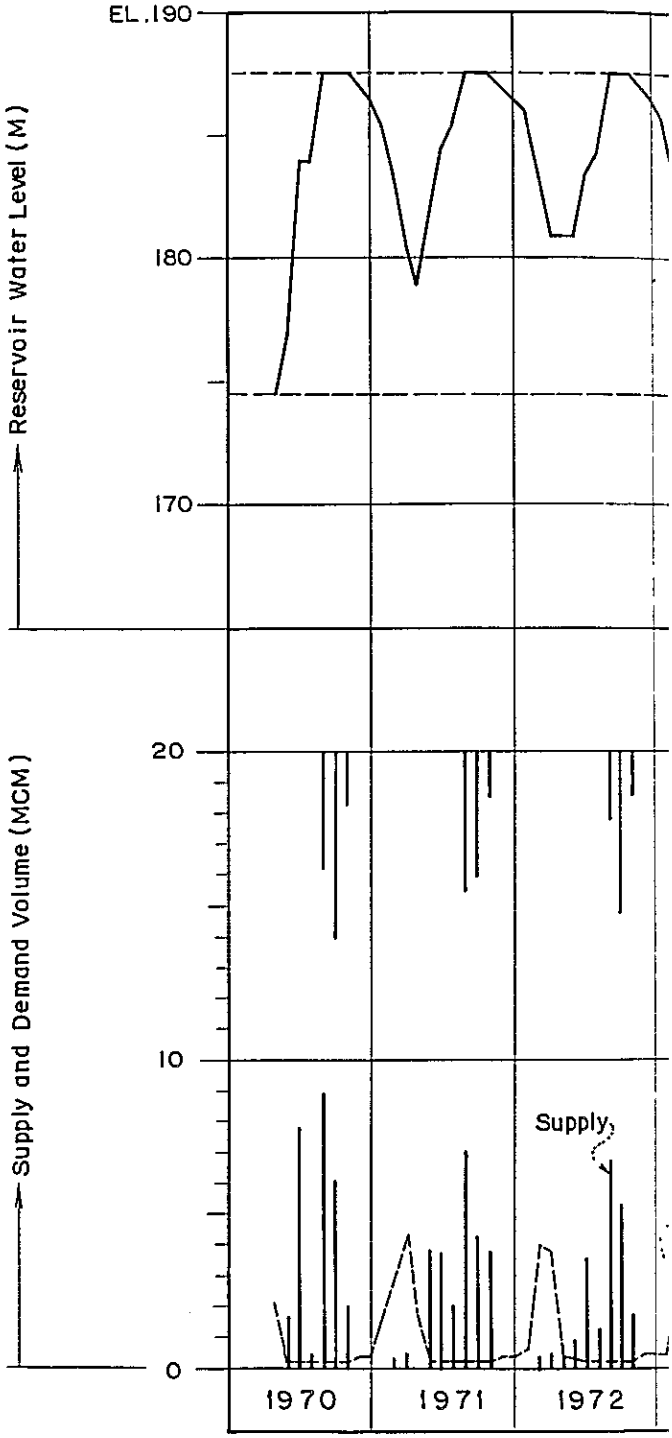

EL.190
180
170
Reservoir Water Level (M)
20
10
0
Supply and Demand Volume (MCM)
Supply
1970
1971
1972

Fig. 5

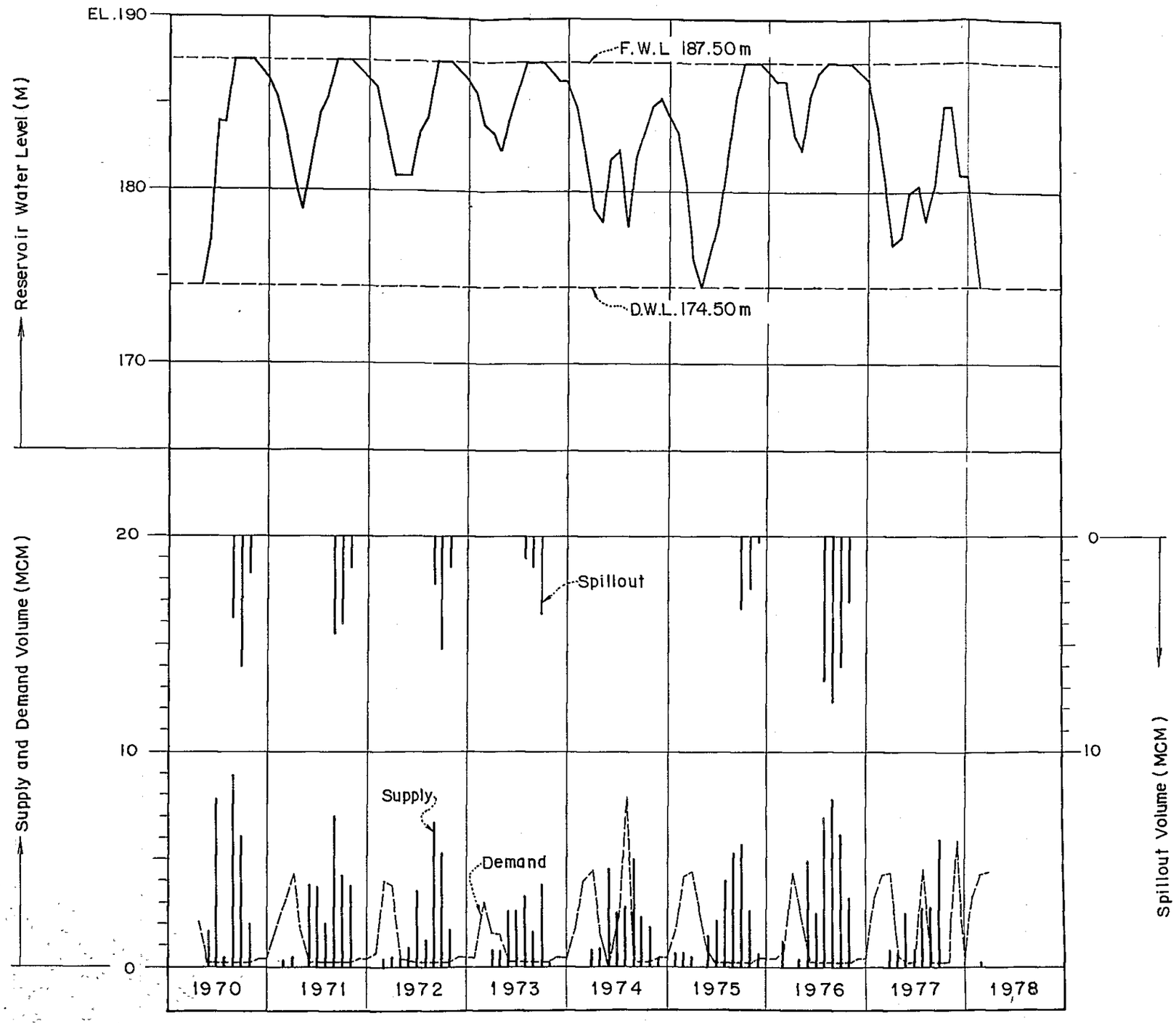


Fig. 5.4 OPERATION STUDY RESULT
(1) Huai Saduang Yai Reservoir

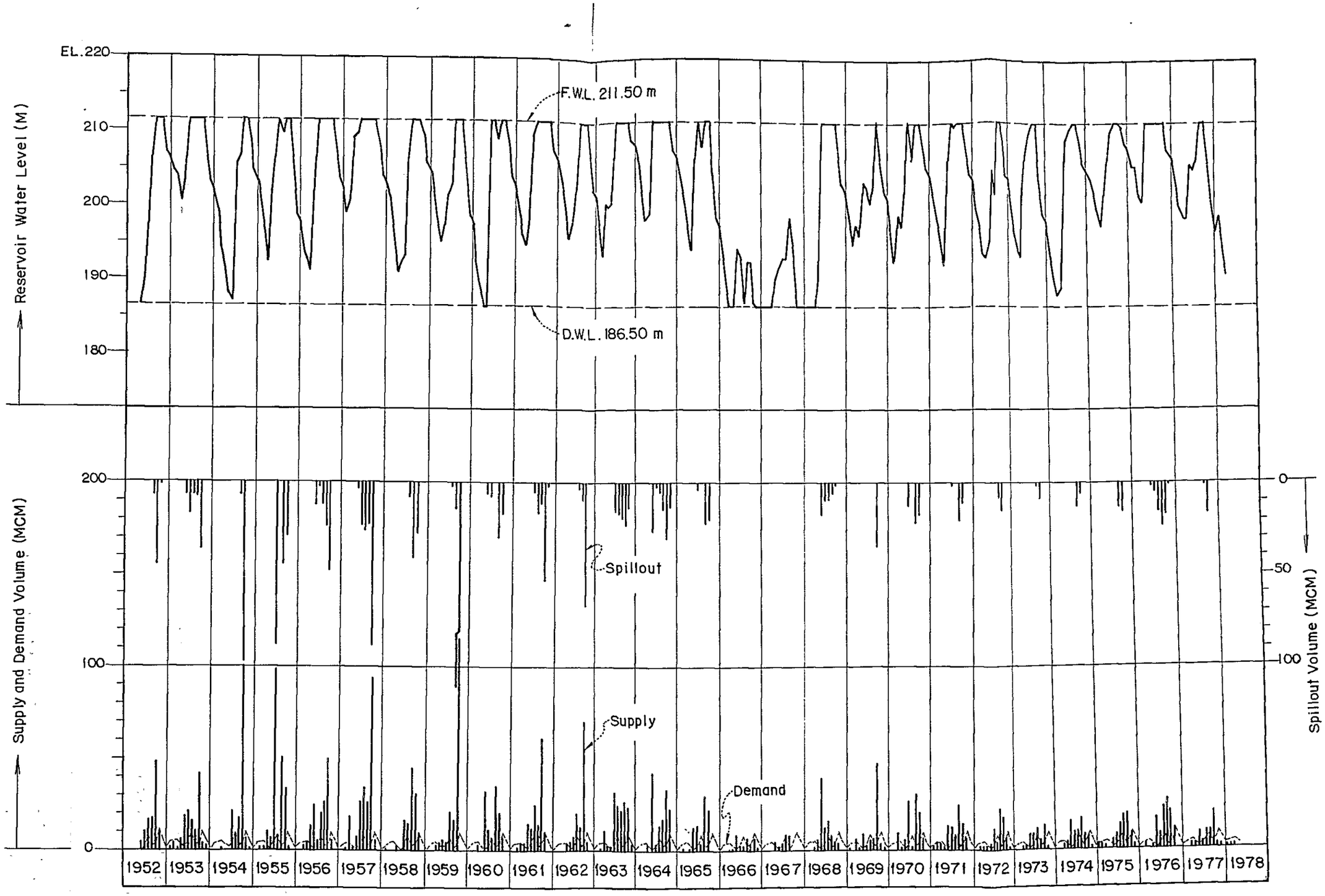


Fig. 5.4 OPERATION STUDY RESULT
(2) Huai Khon Kaen Reservoir

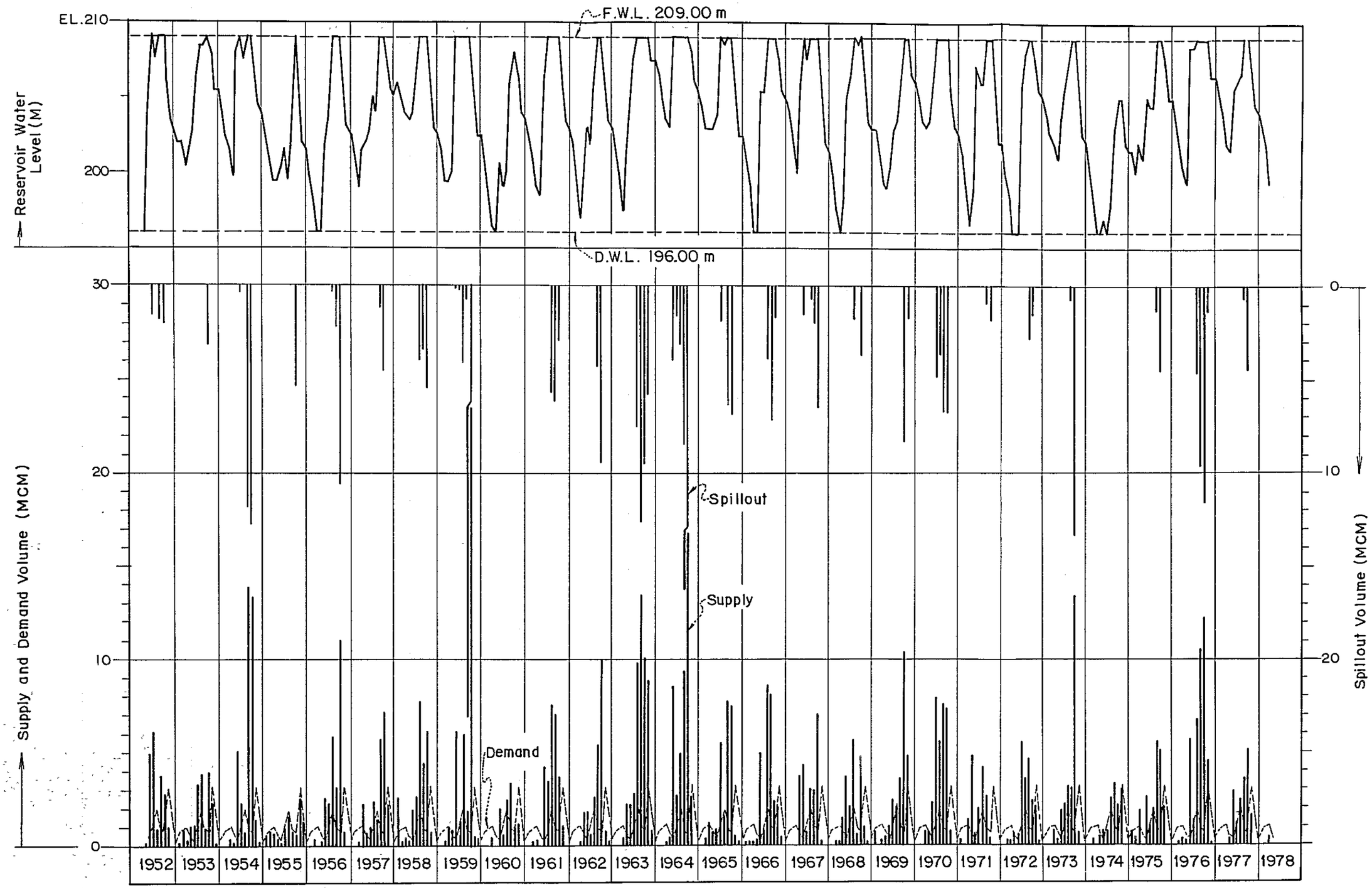


Fig. 5.4 OPERATION STUDY RESULT

(3) Huai Yai Reservoir

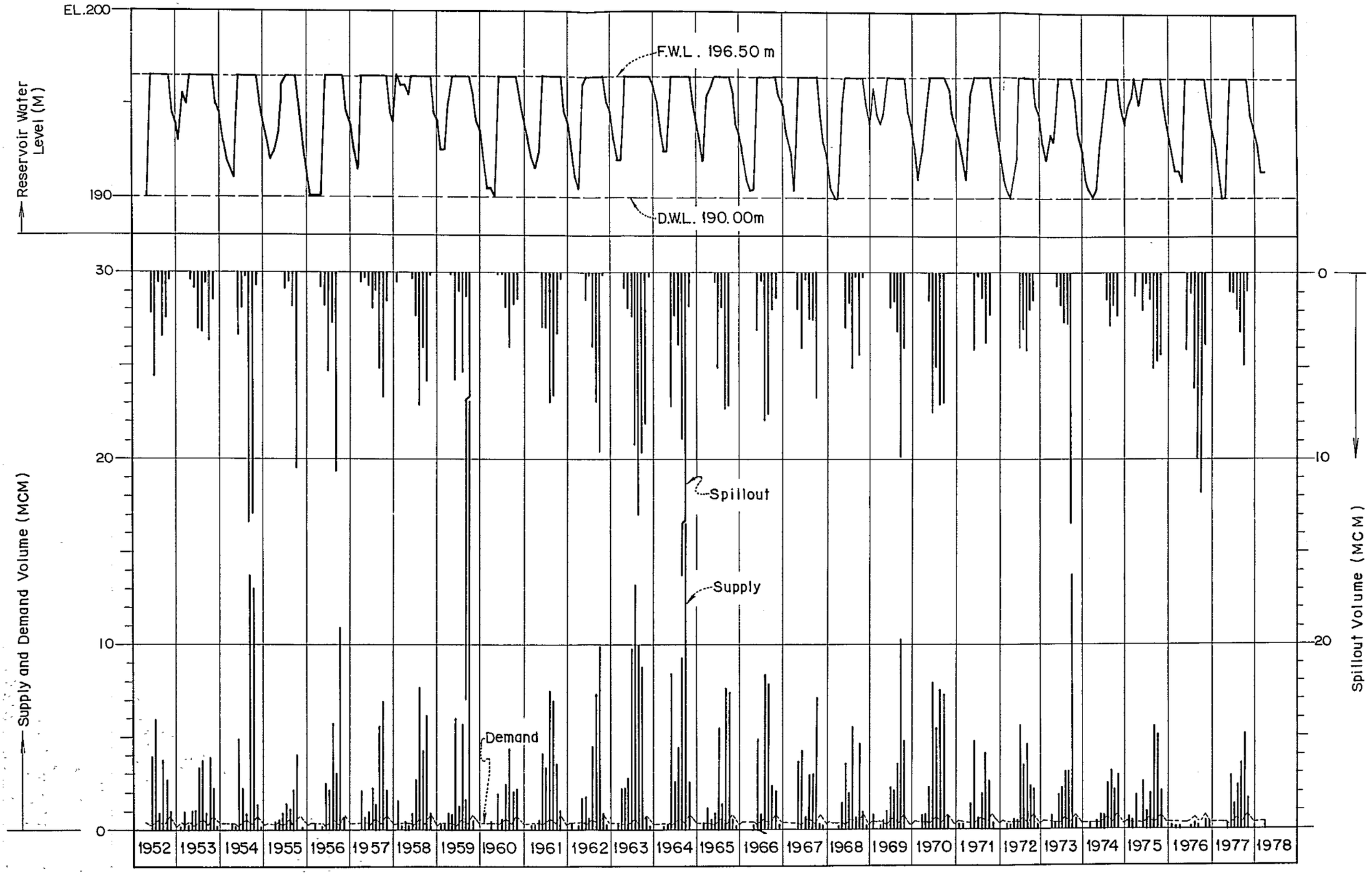
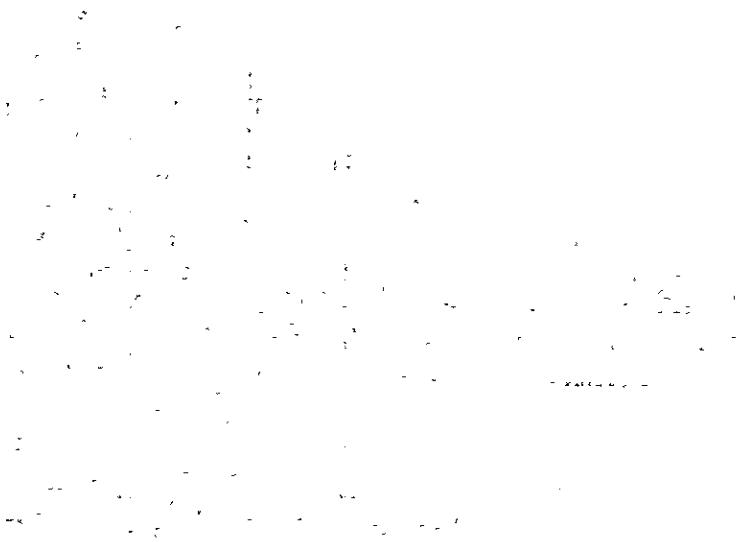


Fig. 5.4 OPERATION STUDY RESURT

(4) Khlong Chaliang Lab Reservoir



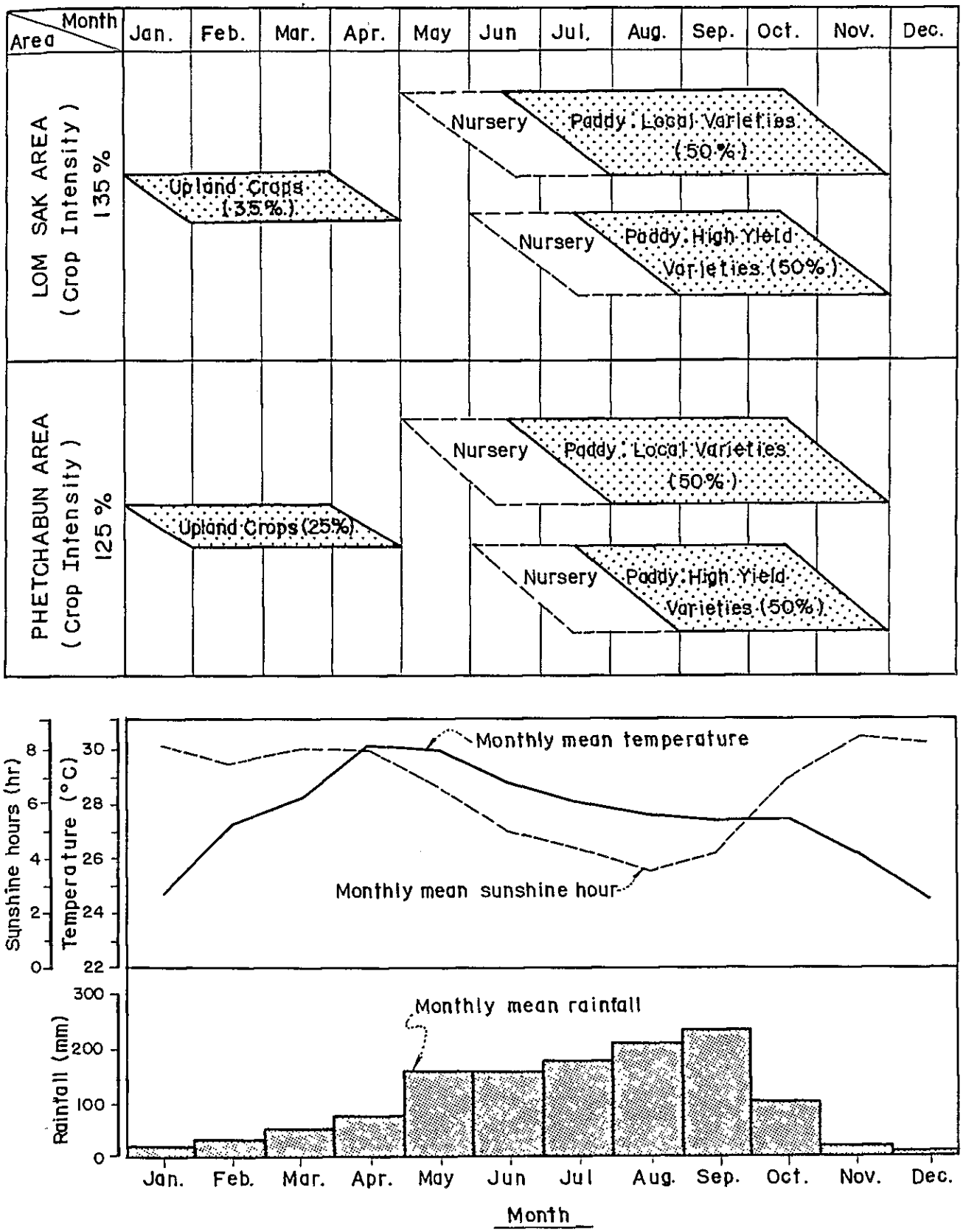


Fig. 5.5 RECOMMENDABLE CROPPING PATTERN

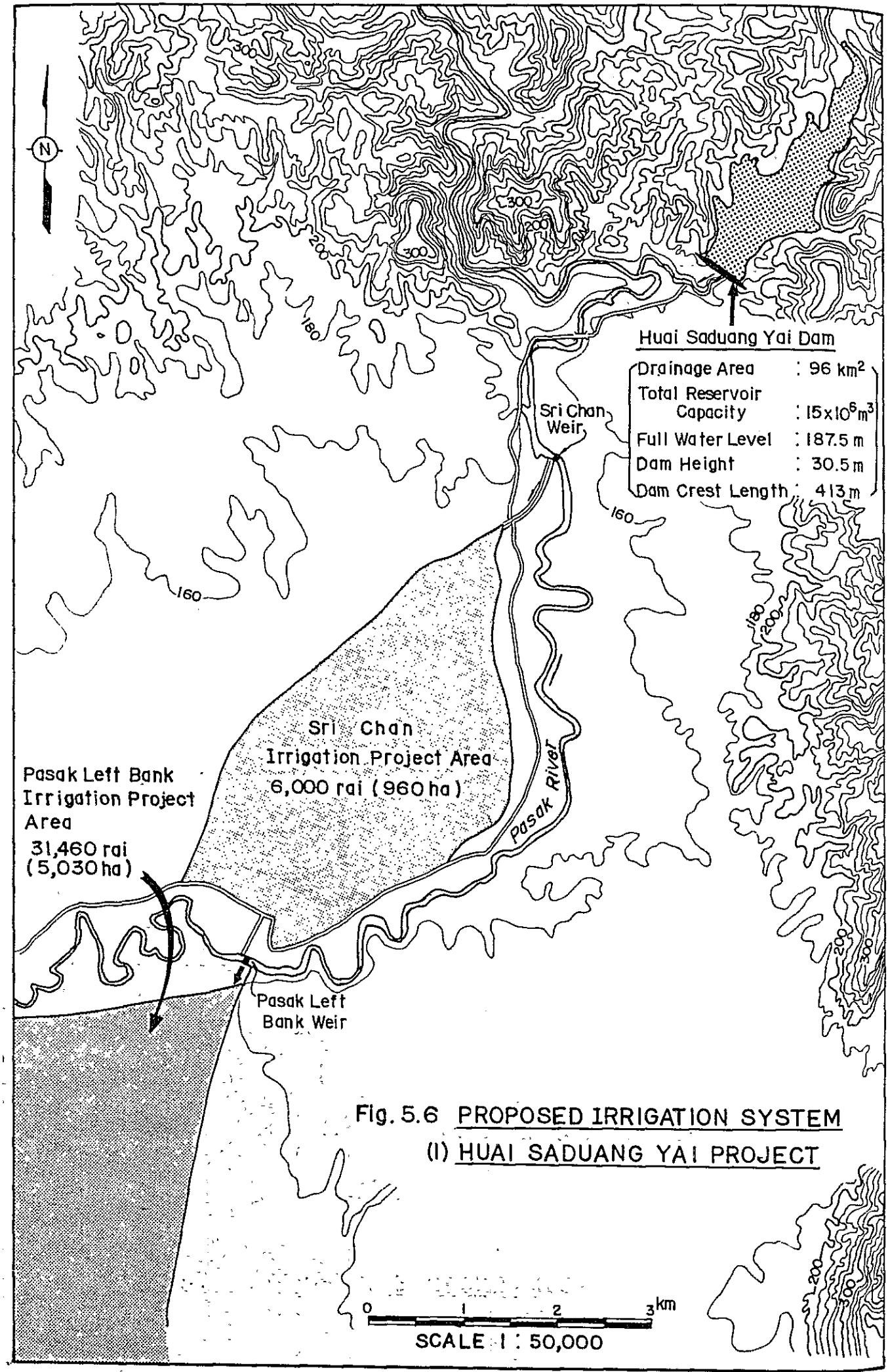
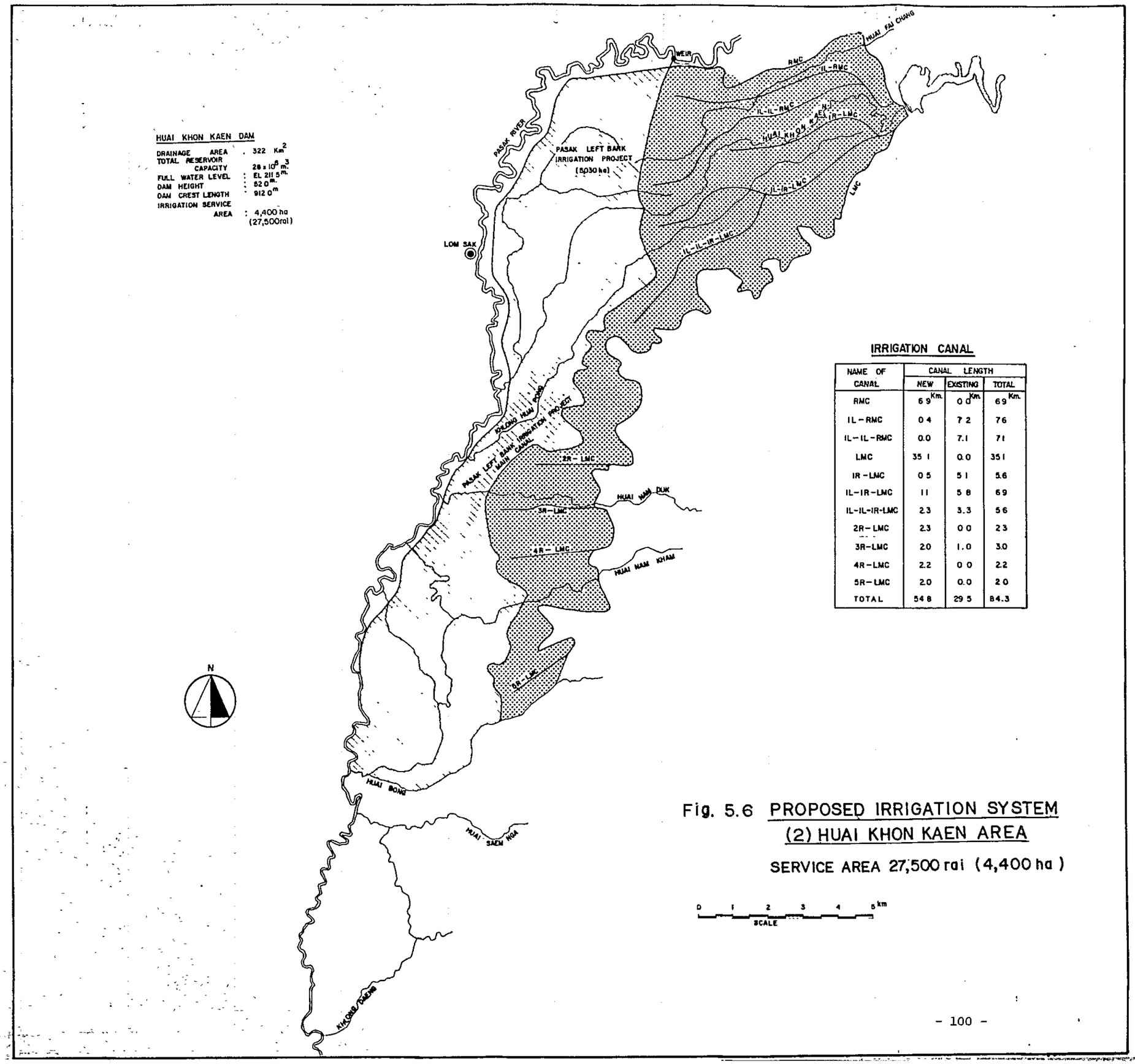


Fig. 5.6 PROPOSED IRRIGATION SYSTEM
(I) HUAI SADUANG YAI PROJECT



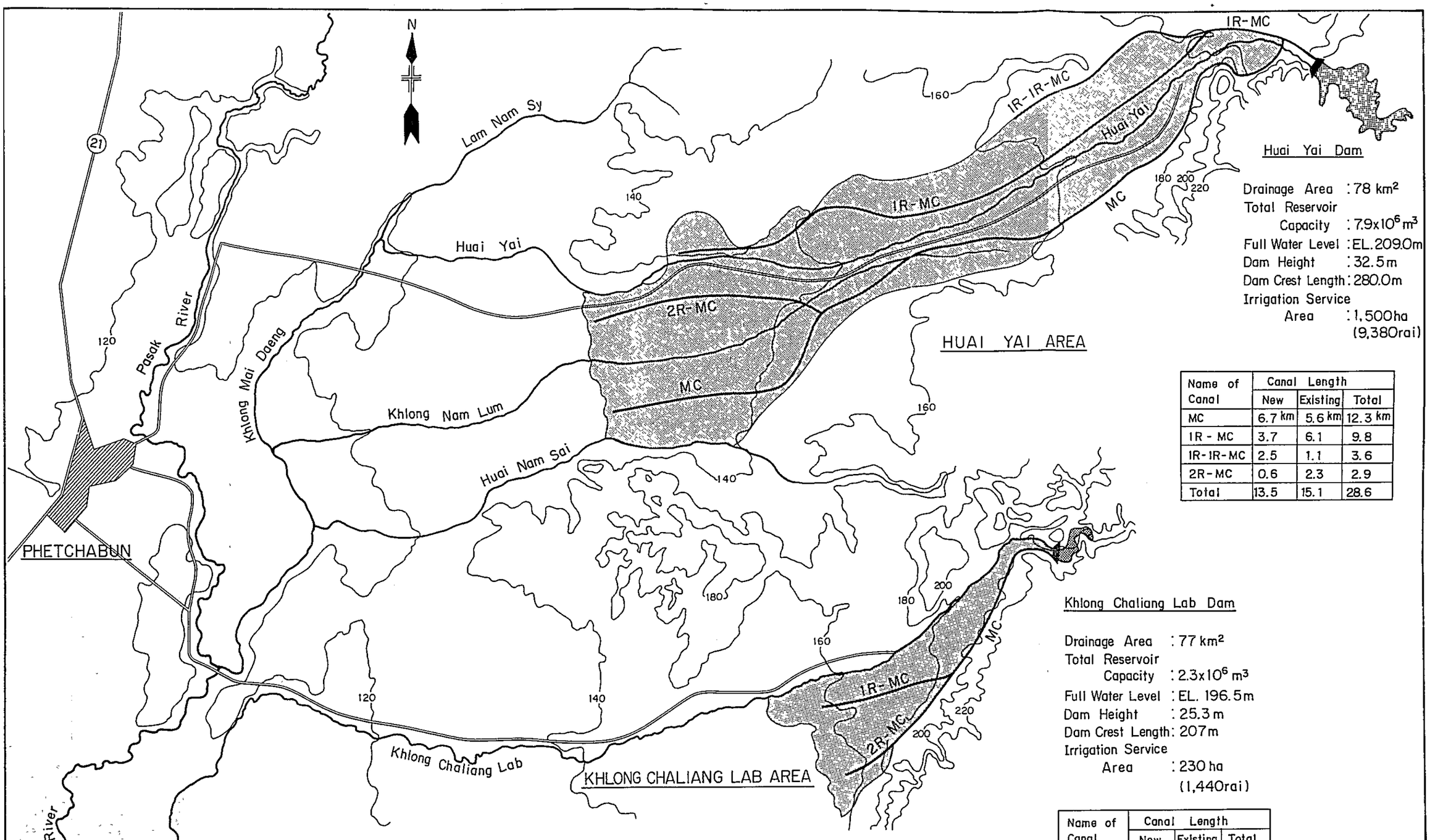
IRRIGATION CANAL

NAME OF CANAL	CANAL LENGTH		
	NEW	EXISTING	TOTAL
RMC	6.9 Km.	0.0 Km.	6.9 Km.
IL-RMC	0.4	7.2	7.6
IL-IL-RMC	0.0	7.1	7.1
LMC	35.1	0.0	35.1
1R-LMC	0.5	5.1	5.6
IL-1R-LMC	1.1	5.8	6.9
IL-IL-1R-LMC	2.3	3.3	5.6
2R-LMC	2.3	0.0	2.3
3R-LMC	2.0	1.0	3.0
4R-LMC	2.2	0.0	2.2
5R-LMC	2.0	0.0	2.0
TOTAL	54.8	29.5	84.3

Fig. 5.6 PROPOSED IRRIGATION SYSTEM
(2) HUAI KHON KAEN AREA

SERVICE AREA 27,500 rai (4,400 ha)

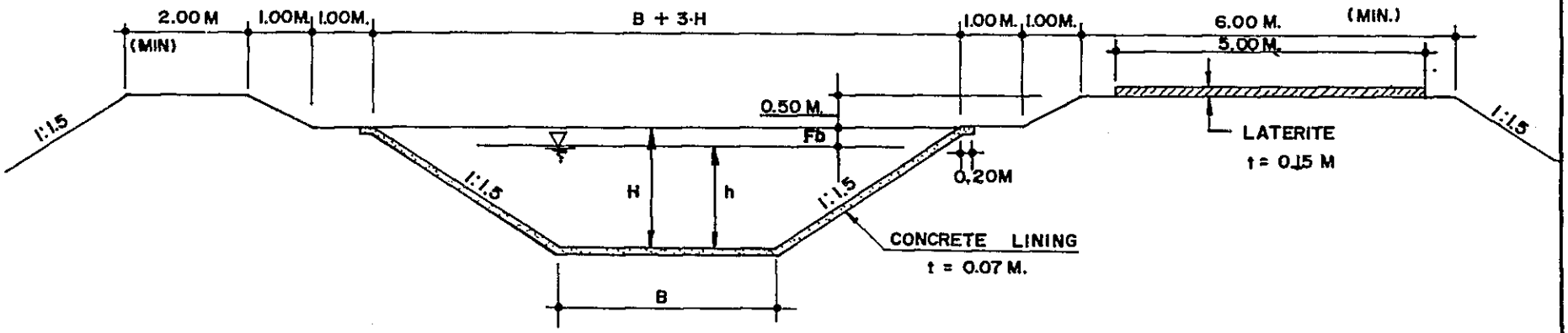
0 1 2 3 4 5 km
SCALE



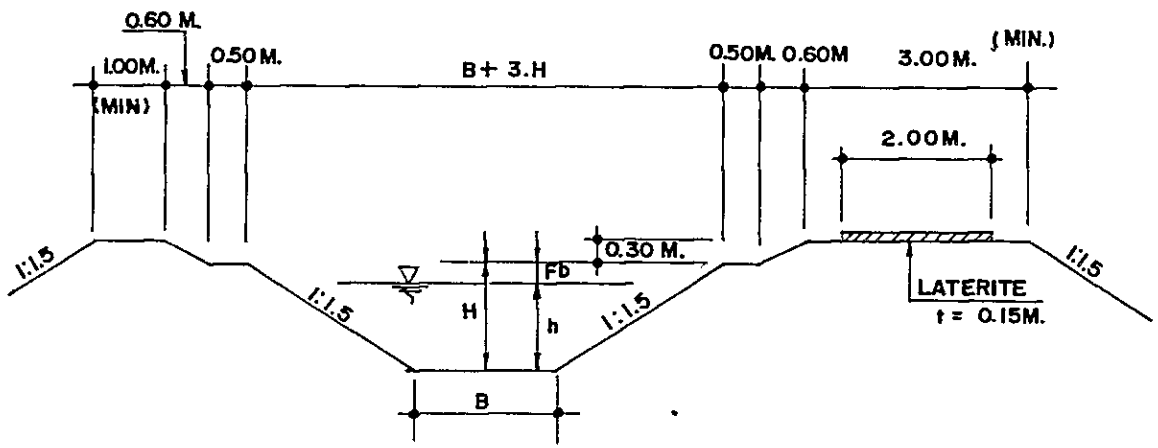
Name of Canal	Canal Length		
	New	Existing	Total
MC	6.7 km	5.6 km	12.3 km
IR - MC	3.7	6.1	9.8
IR-IR-MC	2.5	1.1	3.6
2R-MC	0.6	2.3	2.9
Total	13.5	15.1	28.6

Name of Canal	Canal Length		
	New	Existing	Total
MC	0.8 km	1.5 km	2.3 km
IR-MC	0.4	0.7	1.1
2R-MC	0.0	1.7	1.7
Total	1.2	3.9	5.1

Fig. 5.6 PROPOSED IRRIGATION SYSTEM
(3) HUAI YAI AREA AND KHLONG CHALIANGLAB AREA



MAIN CANAL



SCALE = 1 : 100

LATERAL CANAL

Fig. 6.1 TYPICAL CROSS SECTION OF IRRIGATION CANAL

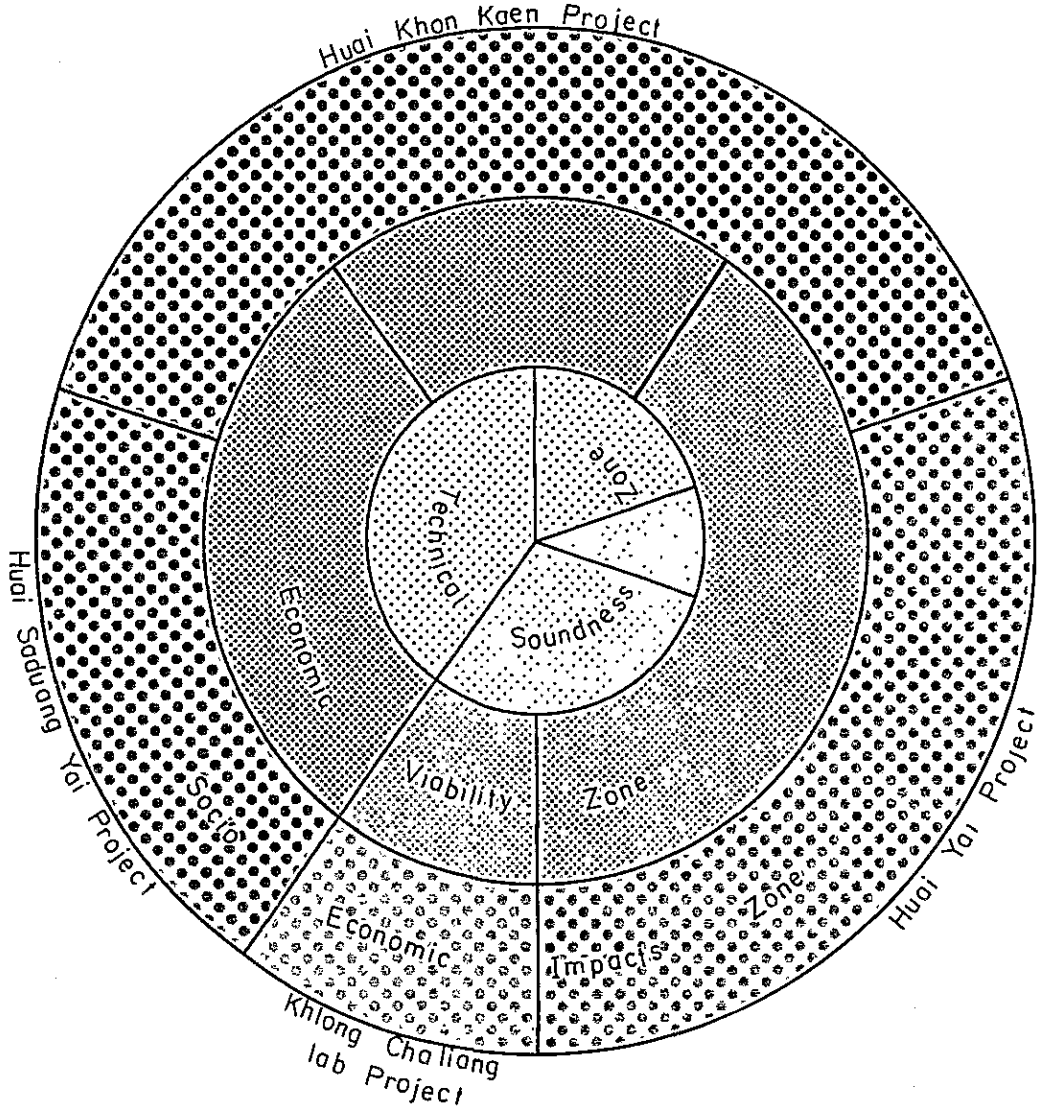
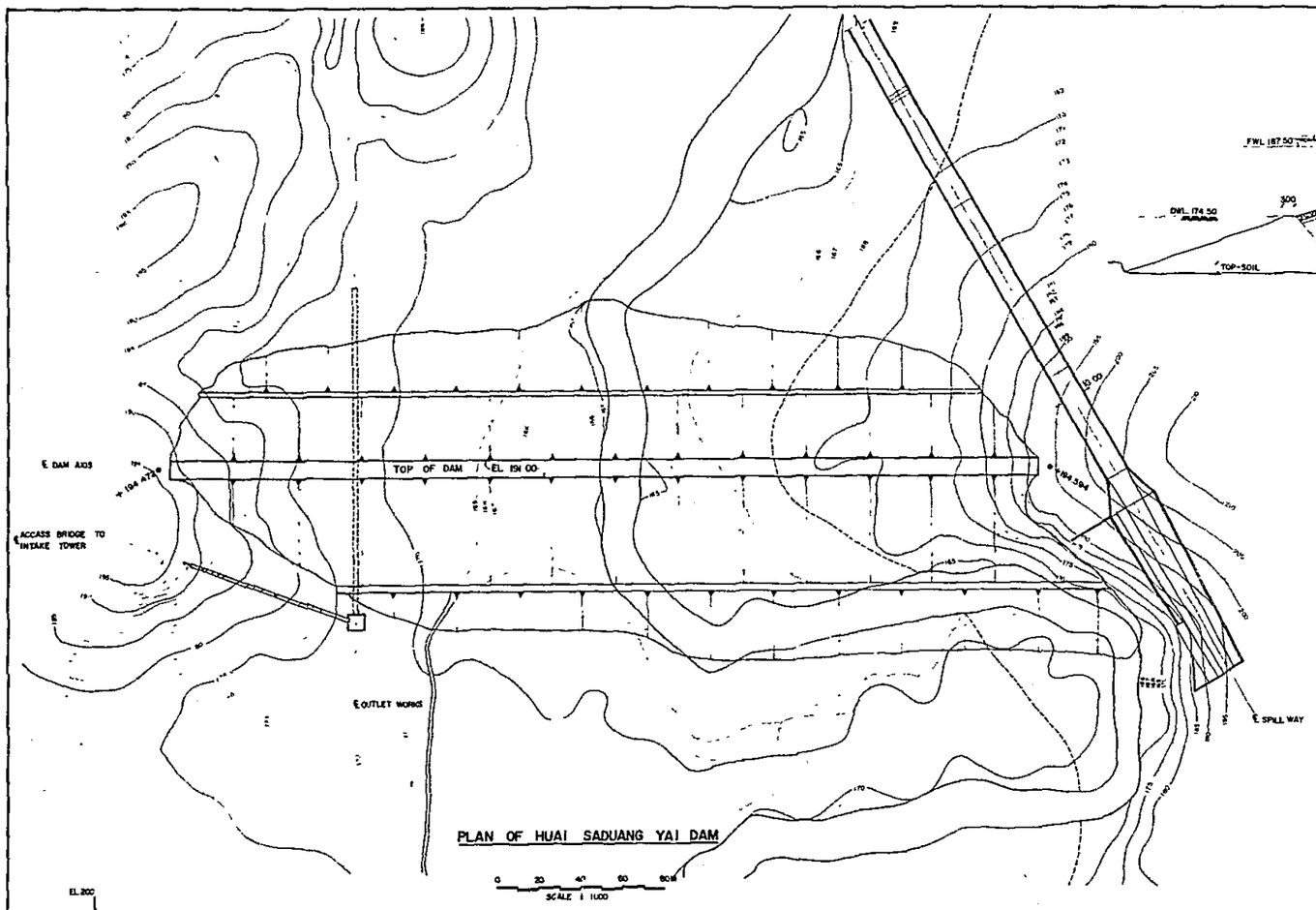


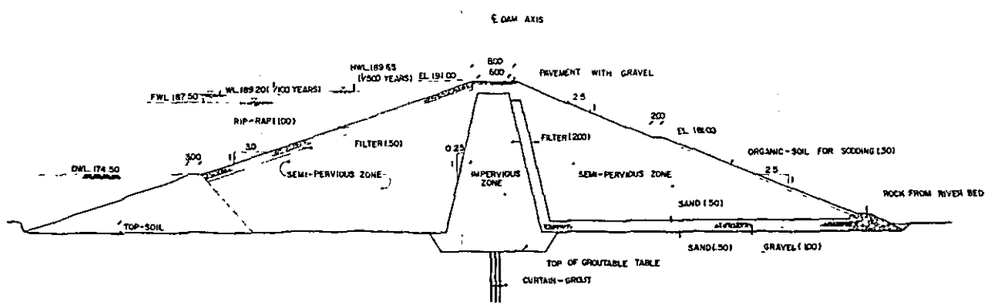
Fig. 9.1 DISK DIAGRAM FOR PROJECT PRIORITY

DRAWINGS

PLATE NO

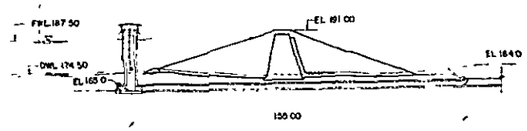


PLAN OF HUAI SADUANG YAI DAM

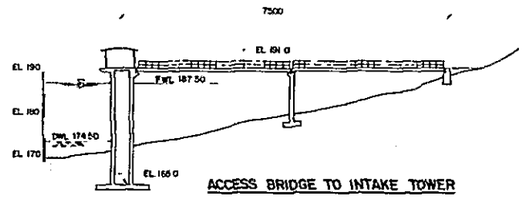


TYPICAL CROSS SECTION OF DAM

SCALE 1 400
0 10 20M

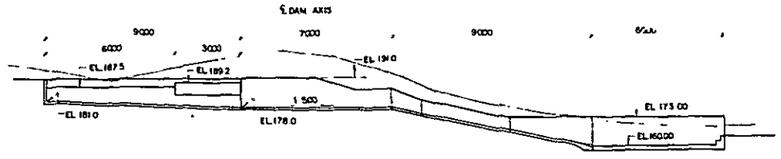


LONGITUDINAL SECTION OF OUTLET WORKS
SCALE 1, 1000



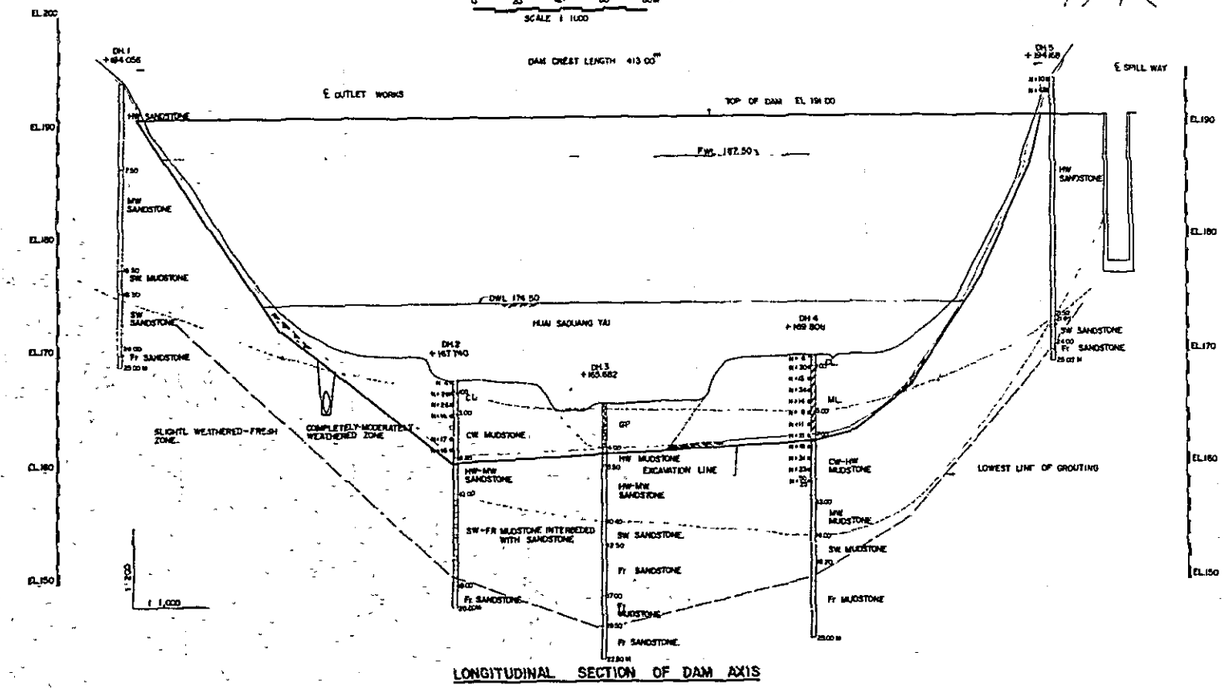
ACCESS BRIDGE TO INTAKE TOWER

SCALE 1 500
0 10 20 30M.



LONGITUDINAL SECTION OF SPILL WAY

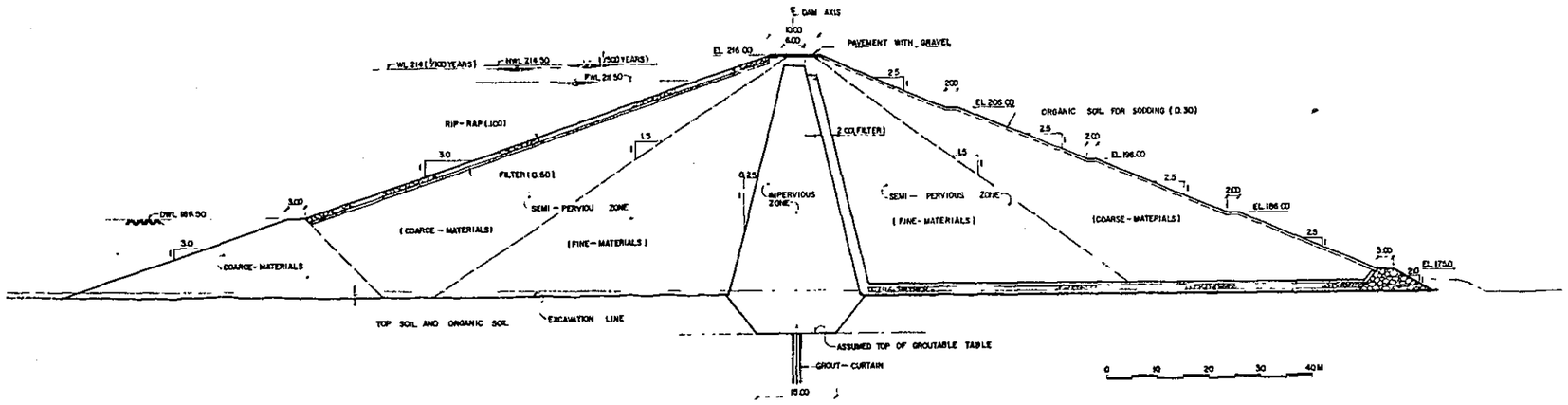
0 20 40 60 M
SCALE 1 1,000



LONGITUDINAL SECTION OF DAM AXIS

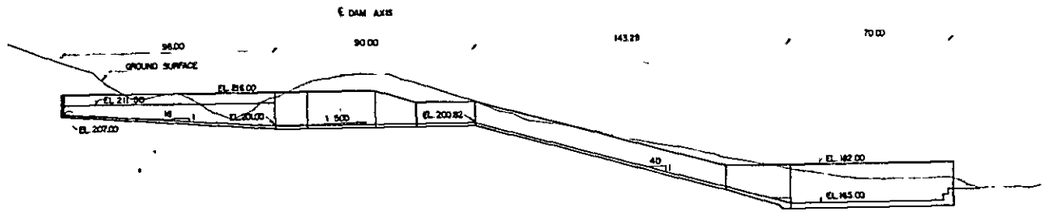
JAPAN INTERNATION COOPERATION AGENCY	
THE UPPER PASAK MEDIUM SCALE IRRIGATION PROJECT	
TITLE OF DRAWINGS GENERAL LAYOUT OF HUAI SADUANG YAI DAM (1/1)	
PREPARED BY	DWG NO 01
CHECKED BY	

PLATE NO



TYPICAL CROSS SECTION OF DAM

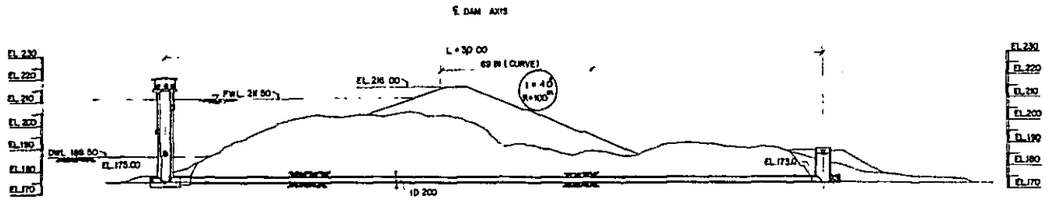
SCALE 1" 400



LONGITUDINAL SECTION OF SPILL WAY

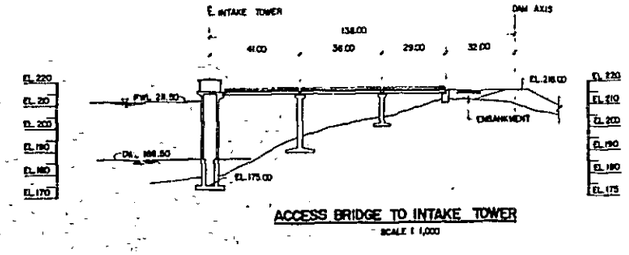
SCALE 1:1000

0 20 40 60 80



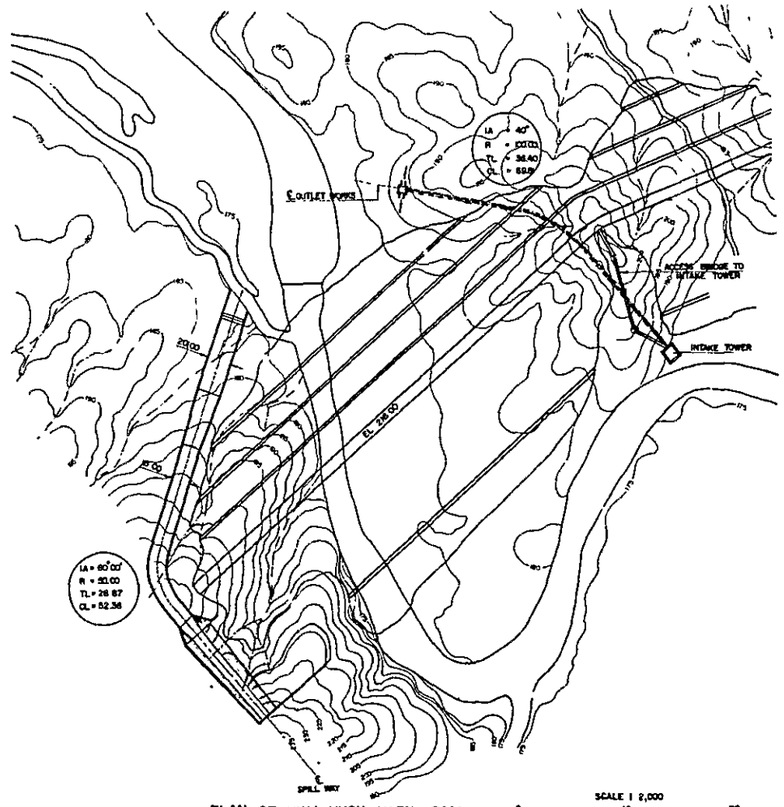
LONGITUDINAL SECTION OF OUTLET WORKS

SCALE 1:1000



ACCESS BRIDGE TO INTAKE TOWER

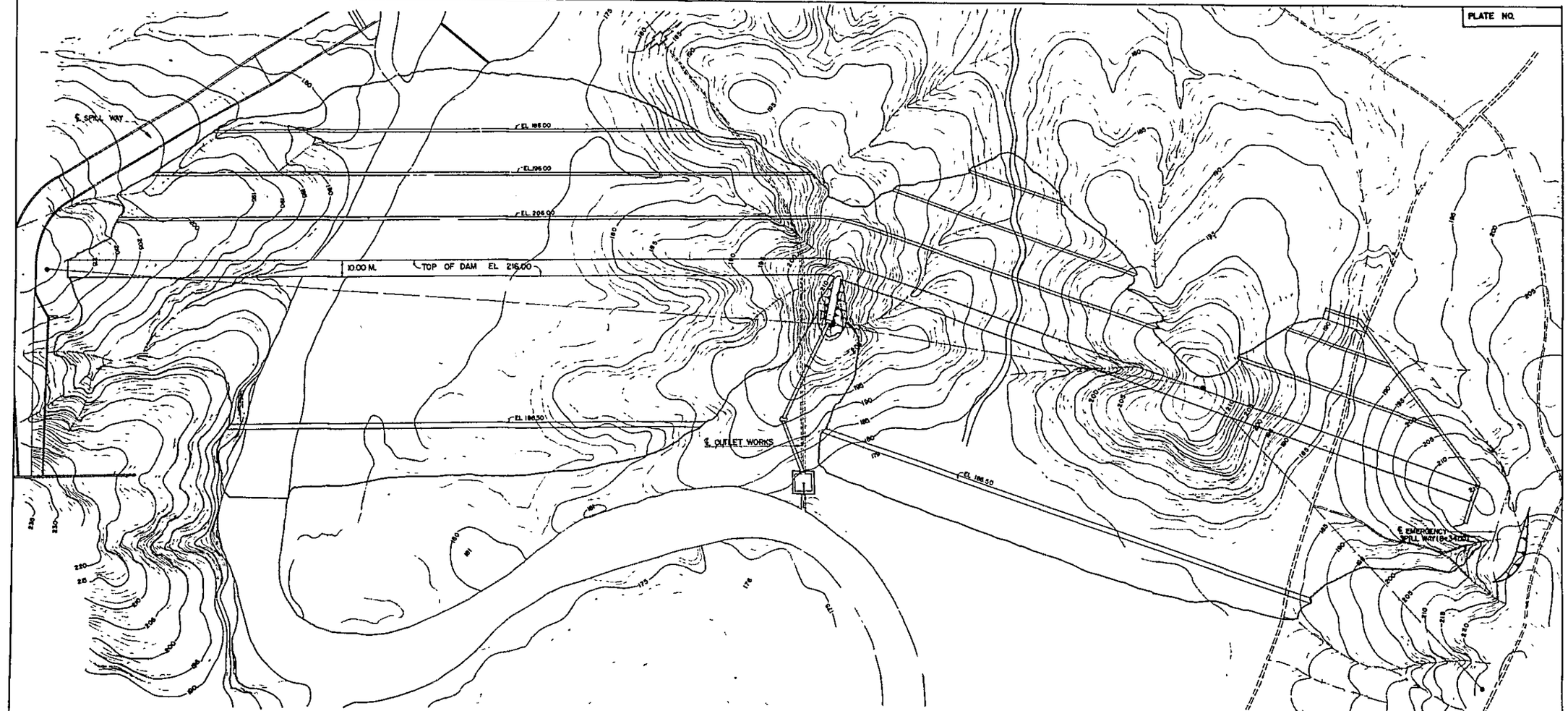
SCALE 1:1,000



PLAN OF HUAI KHON KAEN DAM

JAPAN INTERNATION COOPERATION AGENCY	
THE UPPER PASAK MEDIUM SCALE IRRIGATION PROJECT	
TITLE OF DRAWINGS · GENERAL LAYOUT OF HUAI KHON KAEN DAM (1/2)	
PREPARED BY :	DWG NO. 02
CHECKED BY :	

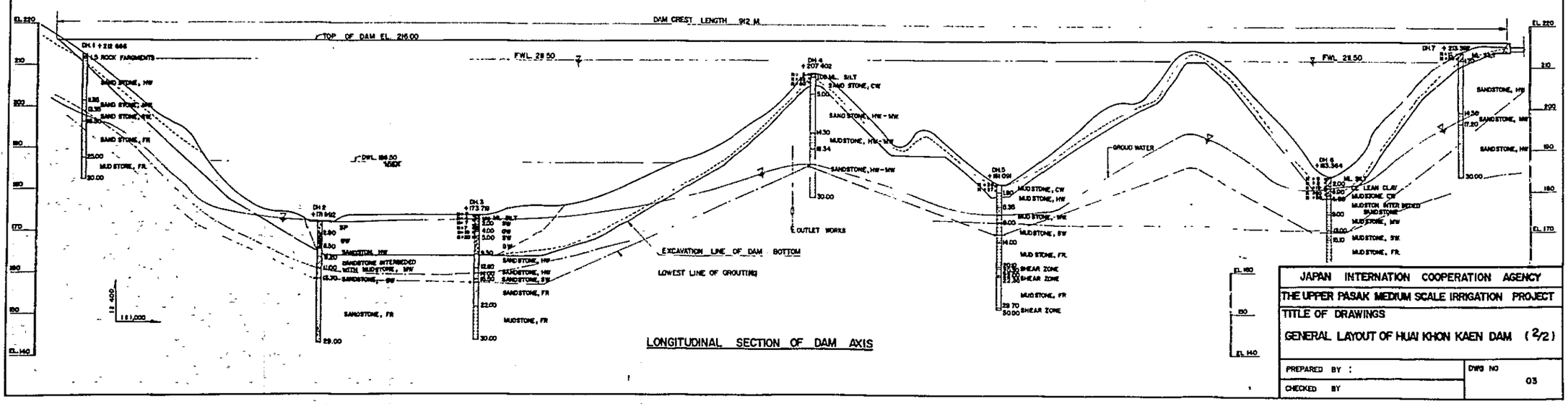
PLATE NO.



PLAN OF HUAI KHON KAEN DAM

SCALE 1 : 1,000

0 20 40 60 80 100 M.

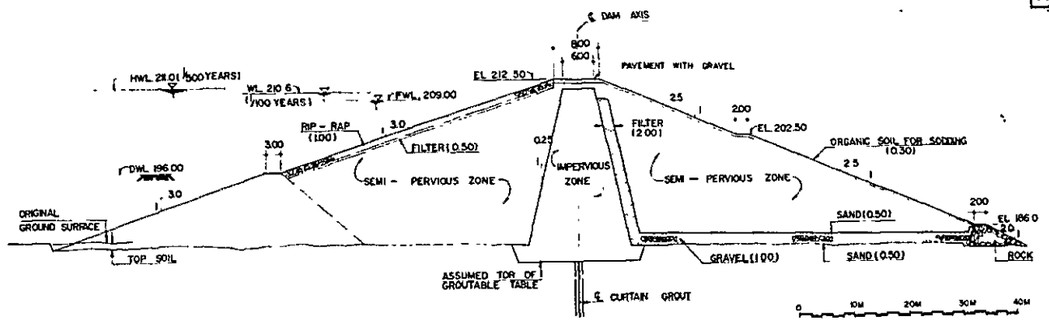


LONGITUDINAL SECTION OF DAM AXIS

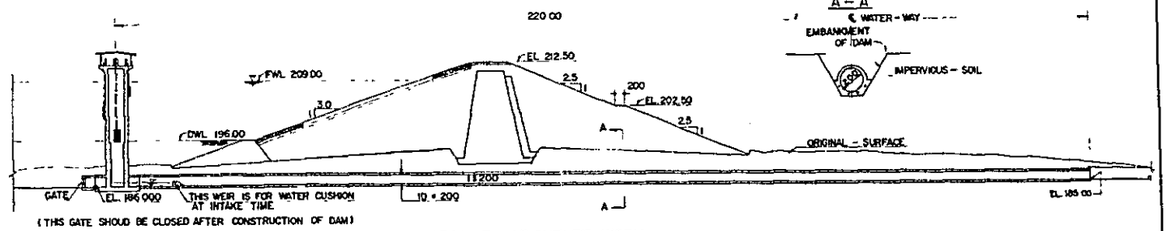
JAPAN INTERNATION COOPERATION AGENCY	
THE UPPER PASAK MEDIUM SCALE IRRIGATION PROJECT	
TITLE OF DRAWINGS: GENERAL LAYOUT OF HUAI KHON KAEN DAM (2/2)	
PREPARED BY :	DWG NO 03
CHECKED BY	

PLATE NO. —

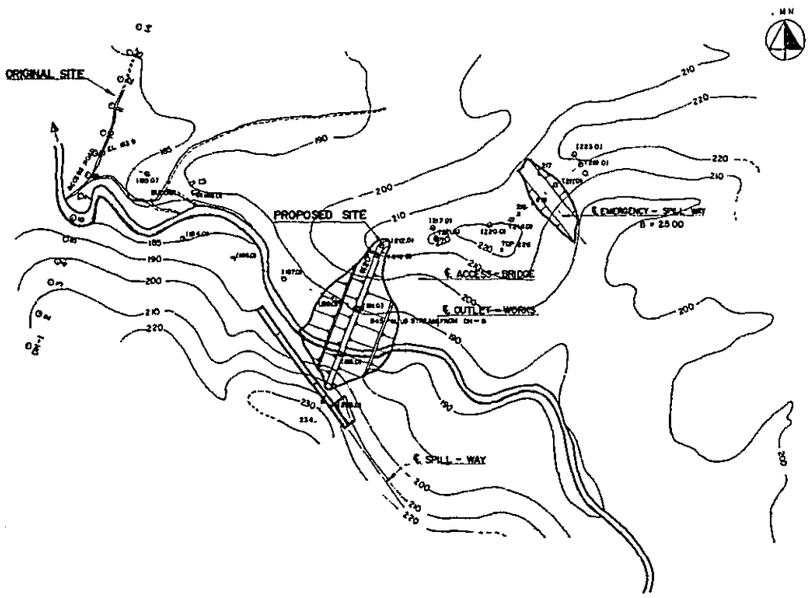
RESERVOIR AREA
SCALE 1 : 8,000
0 100 600 M



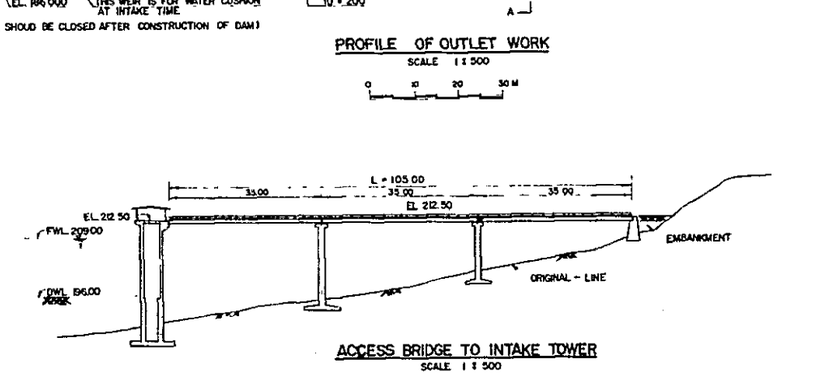
TYPICAL CROSS SECTION OF DAM
SCALE 1 : 400



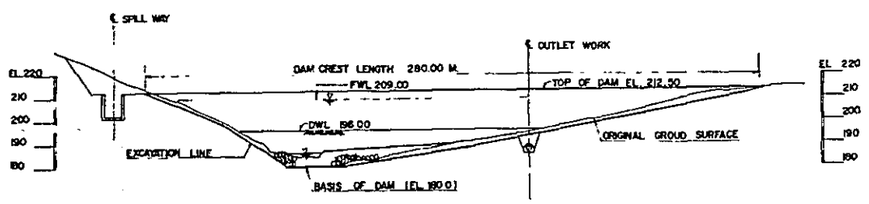
PROFILE OF OUTLET WORK
SCALE 1 : 500
0 10 20 30 M



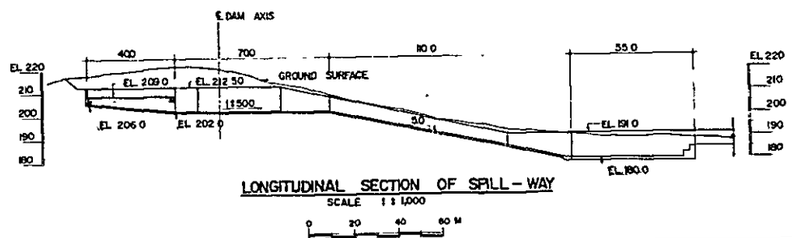
HUAI YAI LOCATION MAP OF PROPOSED DAM SITE
0 100M 200M 300M 400M



ACCESS BRIDGE TO INTAKE TOWER
SCALE 1 : 500



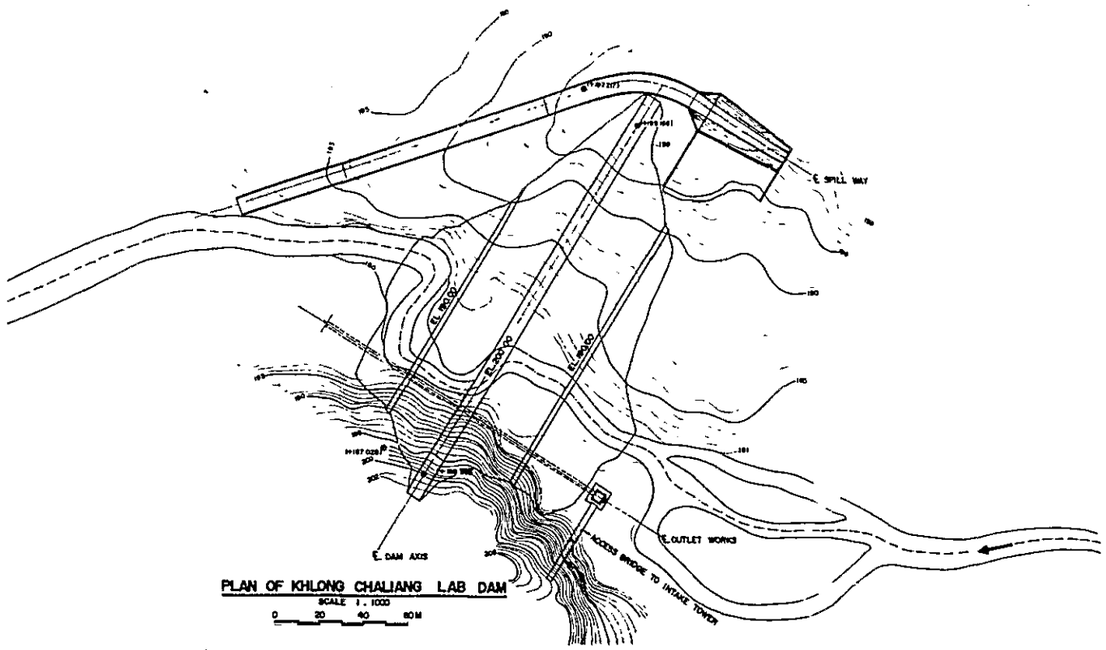
LONGITUDINAL SECTION OF DAM
SCALE 1 : 1000



LONGITUDINAL SECTION OF SPILL - WAY
SCALE 1 : 1,000
0 20 40 60 M

JAPAN INTERNATION COOPERATION AGENCY	
THE UPPER PASAK MEDIUM SCALE IRRIGATION PROJECT	
TITLE OF DRAWINGS GENERAL LAYOUT OF HUAI YAI DAM (1/1)	
PREPARED BY	DWG NO. 04
CHECKED BY	

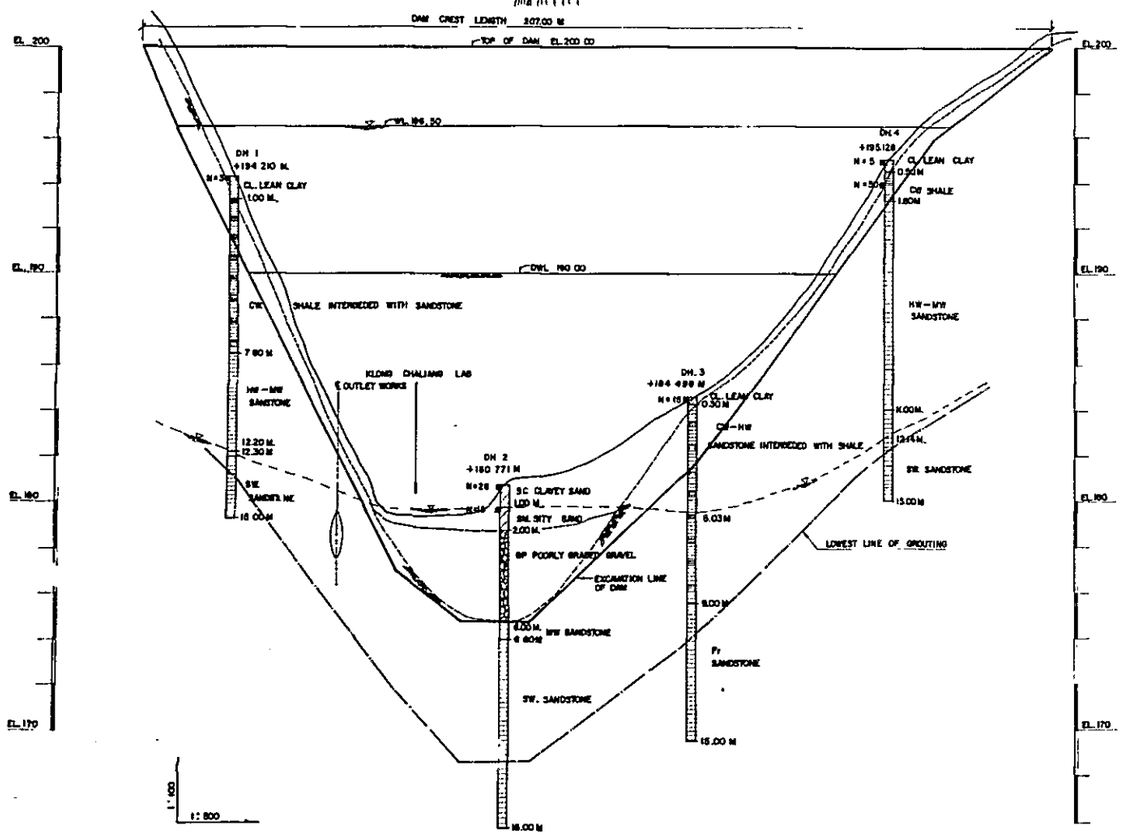
PLATE NO.



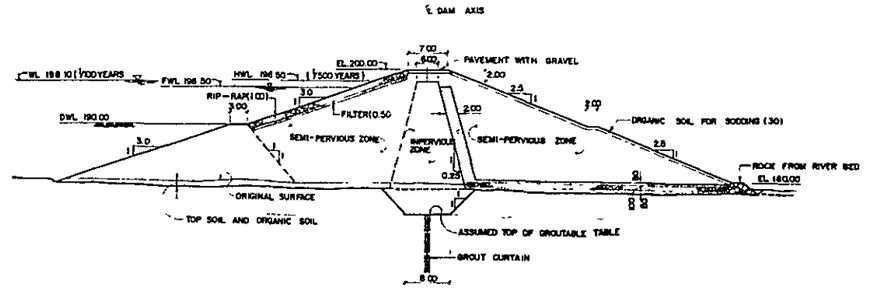
PLAN OF KHLONG CHALIANG LAB DAM

SCALE 1 : 1000

0 20 40 60M



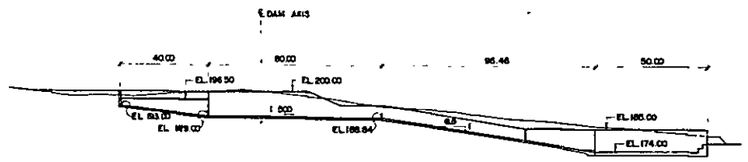
LONGITUDINAL SECTION OF DAM AXIS



TYPICAL CROSS SECTION OF DAM

SCALE 1 400

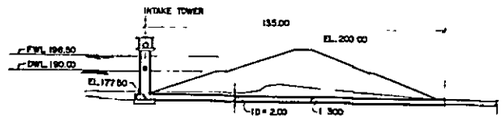
0 10 20 30 M



LONGITUDINAL SECTION OF SPILL WAY

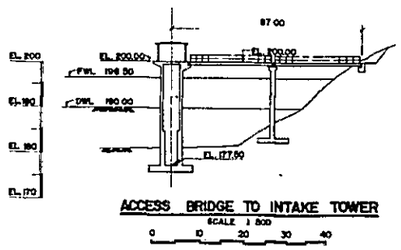
SCALE 1 1,000

0 20 40 80M



LONGITUDINAL SECTION OF OUTLET WORKS

SCALE 1 1,000



ACCESS BRIDGE TO INTAKE TOWER

SCALE 1 800

0 10 20 30 40

JAPAN INTERNATIONAL COOPERATION AGENCY
THE UPPER PASAK MEDIUM SCALE IRRIGATION PROJECT
TITLE OF DRAWINGS
GENERAL LAYOUT OF KHLONG CHALIANG LAB DAM (1/1)
PREPARED BY / CHECKED BY . — DWG NO 05

ATTACHMENTS

ATTACHMENT 1.

FUTURE PROSPECTS OF WATER RESOURCES IN THE PASAK RIVER BASIN

1. Endowed Water Resources in the Pasak River Basin

Annual mean rainfall in the Pasak river basin is averaged at about 1,170 mm based on the long-range records in the pluviometric stations installed in the basin. On the basis of the annual mean rainfall and the population in the basin, per capita endowed water resources in the basin are estimated at about 16,000 m^3 per annum which correspond to a little less than half of 34,000 m^3, the average amount estimated for the world population. The water resources are therefore extremely limited in this basin.

2. Basic Concept for Exploitation

Water demand will be bound to increase year by year making pace with regional development, increase of population, change of agricultural structures, etc. in the basin. The supply and demand of the irrigation water resources will surely be imbalanced in the future, in the light of the endowed water resources. The saving and effective use of water resources should be orientated in parallel with the rapid water resources development in the basin.

3. Exploitable Water Resources in the Basin

Major water source in the Pasak river basin is river flow. Groundwater is basically supplemental for the river flows. Forest areas which are feeding and conserving river flows occupy only about 35% of the whole Pasak river basin. Construction of storage dam is, therefore, the most effective for water resources development in the basin.

The Pasak river basin is extremely narrow and slender with an average width of 45 km and total length of 400 km. A number of small tributaries are confluent to the mainstream of the Pasak river from the east and the west. Hence, the development of the Pasak river mainly comprises creation of reservoirs in the watershed of the tributaries and the upper Pasak river.

The watershed of the upper Pasak river is fairly blessed with topographic condition for creation of reservoir. But the watersheds of the tributaries are narrow and steep, and unfavorable for dam construction. In these views, the upper limit of exploitable water resources in the basin should be conservatively assumed to be about 50% of the endowed water resources. The future, maximum exploitable water resources in the basin are, therefore, assessed to be 1,200 MCM.

4. Demand of Water Resources

4.1 Current Demand

a) Irrigation

Existing irrigation projects under operation and construction all over the basin are estimated at about 140,000 ha (870,000 rai) as brokendown below.

i)	Upper Pasak River Basin	6,900 ha (43,000 rai)
ii)	Middle Pasak River Basin	24,000 ha (150,000 rai)
iii)	Lower Pasak River Basin	108,800 ha (680,000 rai)
	Whole Basin	139,700 ha (873,000 rai)

From the present cropping pattern and intensity all over the basin, per hectar irrigation water consumption would be conservatively estimated at about 7,000 m^3/annum. Thus, present irrigation water consumption or demand would be evaluated to be about 980 MCM per annum.

b) Domestic, Municipal and Industrial Water

According to the Report on the Feasibility Study of the Upper Pasak Project prepared by the NEA, the development of the domestic, municipal and industrial water supply in the basin has been continuously undertaken by several agencies including Public Works Department, Public Health Department, Accelerated Rural Development Office, Mineral Resources Department, and Local Administrative Offices. The domestic, municipal and industrial water supply by the Public Works depending on the Pasak river and its tributaries is estimated at about 11 MCM per annum (30,000 m^3/day). Furthermore, the private sectors in the basin also have developed the industrial water of about 9 MCM per annum (23,000 m^3/day). The domestic, municipal and industrial water supply in the basin amounts to about 20 MCM per annum in total.

Thus, the present water consumption or demand in the basin total about 1,000 MCM per annum. As clarified above, the irrigation water shares a large portion of the present water demand in the basin.

4.2 Water Demand for the Project Under Investigation

a) Irrigation

The irrigation projects under investigation in the basin cover about 32,500 ha (or 203,000 rai), comprising 18 medium scale projects in the tributaries of 18,500 ha (115,500 rai) and Kaen Khoi Ban Mo pumping project of 14,000 ha (87,500 rai). Assuming about 8,000 m^3/ha/annum based on the cropping intensity of 135%, the water demand for these projects would be estimated at about 260 MCM per annum.

b) Domestic, Municipal and Industrial Water Supply

After fifty (50) years, the population of about 200,000 will further increase in the basin, in proportion to the present increase ratio of population. Assuming the per-capita consumption of 150 ℓ/day for domestic and municipal water, about 11 MCM water resources per annum will be additionally demanded. As regards industrial water supply, about 130 ℓ/day/capita are recommended in the guideline for future demand of industrial water in the Metropolitan Bangkok. About 9 MCM of industrial water are also estimated based on this guideline. Thus, the domestic, municipal and industrial water of 20 MCM would be further demanded in the basin in the implementation stage of these projects.

4.3 Irrigation Water Demand in the Potential Area

About 40,000 ha (250,000 rai) of paddy fields favourable for irrigated agriculture extend along the both banks of the Pasak river from the Phetchabun municipality downward. Provided that these paddy fields would be developed for irrigated agriculture, further 320 MCM of irrigation water resources would be required under 135% cropping intensity.

The water demand at present and in future mentioned above would be summarized as follows.

		Irrigation (MCM)	D.M.I. Water Supply (MCM)	Total (MCM)
i)	Present	980	20	1,000
ii)	Planning	260	20	280
iii)	Potential	320	-	320
	Total	1,560	40	1,600

5. Future Water Supply and Demand

The maximum exploitable water resources in the basin are assessed to be about 1,200 MCM which are deficit compared with the future demand of 1,600 MCM as listed above. Actually, however, about 20% to 30% of the exploitable amount might be reusable since the basin extends slenderly from north to south and the mainstream of the Pasak river stretches out to about 300 km. Therefore, the supply and demand in the river basin would be balanced even at the development stage of the potential areas by a little scale-down of the potential projects. Otherwise, supplemental water resources must be exploited by trans-basin projects.

Even at the development stage of the potential area, irrigated agriculture in the basin will be extended over only 70% of the existing paddy field. About 30% of the existing paddy field still remain under rainfed condition. In addition, upland of about 673,000 ha (4.2 million rai), corresponding to about 45% of total land resources would remain

low productive forever. The land productivity of these uplands, however, has to be increased in the future with a provision of irrigation water resources, since the population in the basin will sharply increase, resulting in food-crisis. To implement the agricultural development upto these stages, large scale trans-basin projects will be requisite in this basin.

6. Future Measures and Recommendation

Water resources are one of basic re-cycling resources composing of environment. To make effective use of the limited water resources, the saving and the rational use should be fully contemplated among rural population.

As previously clarified, the future demand of water resources in the basin will doubtlessly exceed the supply in the future. The following measures would be recommended in order to overcome the serious shortage of water resources in the basin.

6.1 Cropping Pattern and Intensity

The assessment of water resources in the basin mentioned above is made on the following assumption.

i) Irrigated agriculture would be practiced only in the existing paddy field,

ii) During wet season, paddy of high yielding variety would be grown with a cropping intensity of 100%, and

iii) During dry season after harvesting the wet season paddy, upland crops would be grown with a cropping intensity of 35%.

Making increase of the assumed cropping intensity of 135%, the irrigation water supply will be further deficient in the future. Thus, the cropping intensity should be severely restricted within 135% in this basin.

6.2 Exploitation of Deficient Water Resources

The available water resources in the basin will be surely deficient in the future in the contemplation of the effective land use of vast land resources. Thus, the large scale transbasin works will be essential in this basin in the full development stage.

6.3 Irrigation Water Saving

The irrigation water consumption shares about 98% of the total water consumption in the basin. Irrigation water saving signifies a passive water resources development. The saving would be basically attainable through up-grading of irrigation system and betterment of irrigation water management. In parallel with the water resources development, these works for irrigation water saving should be implemented all over the basin.

6.4 Exploitation of Groundwater

Groundwater resources should be reserved for the future exploitation for the time being. But the domestic, municipal and industrial water resources depending on the natural flow at present should be replaced by groundwater in the future when the shortage of river flow will be caused by the sharp increase of irrigation water demand. In view of water quality and quantity, groundwater is much favourable for the domestic, municipal, and industrial water.

ATTACHMENT 2.

SCOPE OF WORKS

FOR

PRE-FEASIBILITY STUDY AND FEASIBILITY STUDY

ON

THE UPPER PASAK MEDIUM SCALE IRRIGATION PROJECT

IN

THE KINGDOM OF THAILAND

The Japanese Scope of Works Mission (Japanese side), headed by Mr. AKIRA KAZAMA, Civil Engineer, Construction Department, Agricultural Improvement Bureau, Ministry of Agriculture, Forestry and Fisheries and the Thai Government (Thai side), headed by Mr. SUNTHORN RUANGLEK, Director General of the Royal Irrigation Department, Ministry of Agriculture and Cooperatives agreed the Scope of Works for Pre-Feasibility Study and Feasibility Study on the Upper Pasak Medium Scale Irrigation Project.

Signed in Bangkok

on 22nd April 1981

Mr. AKIRA KAZAMA
Leader of the Scope of Works
Mission for the Upper Pasak
Medium Scale Irrigation Project

Mr. SUNTHORN RUANGLEK
Director General
Royal Irrigation Department
Ministry of Agriculture and
Cooperatives

1. INTRODUCTION

In response to the request of the Government of Thailand (hereinafter referred to as "the Government"), the Government of Japan has decided to undertake the pre-feasibility study (A), and the feasibility study (B) on the Upper Pasak Medium Scale Irrigation Projects (hereinafter referred to as "the Project") as a part of the technical cooperation programme of the Government of Japan.

Accordingly, Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of the Government of Japan's technical cooperation programme will be the executing agency, and carry out the survey under the cooperation with the Royal Irrigation Department, Ministry of Agriculture and Cooperatives and other authorities concerned.

The Scope of Works for the Projects is prepared on the basis of the results obtained from the Preliminary Survey for the Project, describing the items to be studied, implementation schedule, and services and facilities to be provided by the Government for the smooth execution of the study.

This indicates the outline of essential features of the (A) and (B) which is to be carried out in close cooperation with the Government and its authorities concerned. The area for the irrigated agricultural development in the proposed project would be as follows.

Study (A)	1)	Huai Yai	About 1,900 ha
	2)	Huai Khon Kaen	" 4,700 ha
	3)	Khlong Chaliang Lab	" 1,200 ha
	4)	Huai Saduang Yai	" 440 ha

There is a possibility of changing the benefit area from the points of view of hydrological study and the effective use of the existing facilities.

Study (B) The area for (B) would be fixed after finishing (A)

2. OBJECTIVES OF THE STUDY

The objectives of the Study will be

1) to identify the order of priority (A)
2) to formulate an irrigated agricultural development project and identify the feasibility of the Project (B)
3) to determine the optimum water resources plan, and (B)
4) to undertake on-the-job training of the Government's officials in the course of the survey and study (A and B).

3. OUTLINE OF THE STUDY

The activities to be undertaken by the Study team will be divided into two stages.

(1) Field Works in Thailand (A and B)

(2) Home Office Works in Japan (A and B)

1) Field Works

The field works will cover the following items.

(1) to collect and review the relevant existing data and information including.

a. Meteorology and hydrology (A and B)
b. Topographic map (A and B)
c. Soil (B)
d. Geology and geohydrology (A and B)
e. Irrigation and drainage (A and B)
f. Agriculture (A and B)
g. Agro and regional economy and agricultural institution, etc. (A and B)
h. Flood control (A and B)
i. Others (A and B)

(2) to select and delineate the Project Area on the basis of review of data and information and reconnaissance survey (A and B)

(3) to carry out field surveys in the Project Area including the following items.

a. Meteological and hydrological survey (A and B)
b. Topographical Survey at proposed site (A)
c. Soil survey with test pits and laboratory analysis (B)
d. Geology and geohydrology survey (A and B)
e. Irrigation and drainage survey (A and B)
f. Land use survey (B)
g. Agro-economic survey (A and B)
h. Agricultural survey (A and B)
i. Regional economic and agro-institutional survey (A and B)
j. Construction material and cost survey (A and B)
k. Flood control survey (A and B)

(4) to determine the basic items for the project planning including (B)

a. Project boundary acreage
b. Outline of the land use and cropping pattern
c. Water requirement
d. Irrigation and drainage canal networks
e. Estimation of yield
f. Agro-institutional Plan
g. Dam planning and design in view of irrigation, flood control
h. Alternative study

2) Home Office Works

Based on the results of the field works, the home offices works will be carried out for the Study of the following items.

(1) to give a priority order to the proposed projects (A)

(2) to formulate an overall irrigated agricultural development plan including alternative plan for the Project Area (B)

(3) to prepare preliminary design of the major structures for the Project (B)

(4) to estimate the costs and benefits of the Project (A and B)

(5) to make economic evaluation for the Project (B)

(6) to prepare the implementation schedule of the Project (B)

(7) to make recommendations (A and B)

4. WORK SCHEDULE

The work schedule is shown in the attached sheet.

To carry out the Study, JICA will provide the required experts of the survey team in accordance with the work schedule attached herewith.

5. REPORTS

The following reports will be prepared and submitted to the Government.

(1) Plain of Operation (A and B)

Thirty (30) copies in English at the commencement of the field survey.

(2) Interim Report (A and B)

Thirty (30) copies in English at the end of the field survey.

(3) Draft Report (A and B)

Thirty (30) copies in English within one (1) months after the end of the home office work.

(4) Final Report (A and B)

Fifty (50) copies in English within two (2) months after receiving the comments of the Government on Draft Report.

6. UNDERTAKING OF THE GOVERNMENT

To facilitate smooth performance of the field works, the Government is requested.

(1) to provide the data and information necessary for the study (A and B)

(2) to arrange for the quick and smooth customs clearance of the survey equipment and materials required for the field works (A and B)

(3) to exempt from any taxes and duties imposed by the Government on the goods brought by the team members into Thailand for the purpose of the study (A and B)

(4) to make arrangement of exemption of taxes, duties and levies incurred during the survey by the team (A and B)

(5) to request the ministries and other governmental organizations concerned to cooperate with the team in smooth execution of the survey (A and B)

(6) to provide the necessary computer facilities free of charge, other equipments, etc. (A and B)

(7) to designate the counterpart personnel to cooperate with the team in conducting the Study effectively in the following field.

a. General Planning Engineer (A and B)
b. Irrigation and Drainage Engineer (A and B)
c. Foundation Engineer (B)
d. Dam Engineer (A and B)
e. Hydrologist (A and B)
f. Geologist (A)
g. Soil Experts (A)
h. Agronomist (B)
i. Agro-economist (A and B)
j. Agro-institutional Expert (B)
k. Survey Engineer (A and B)

The number of counterpart personnel and their respective assignment periods should be decided by consultation of the team with Thai Authorities concerned prior to conducting the survey.

(8) to provide the office space for the team (A and B)

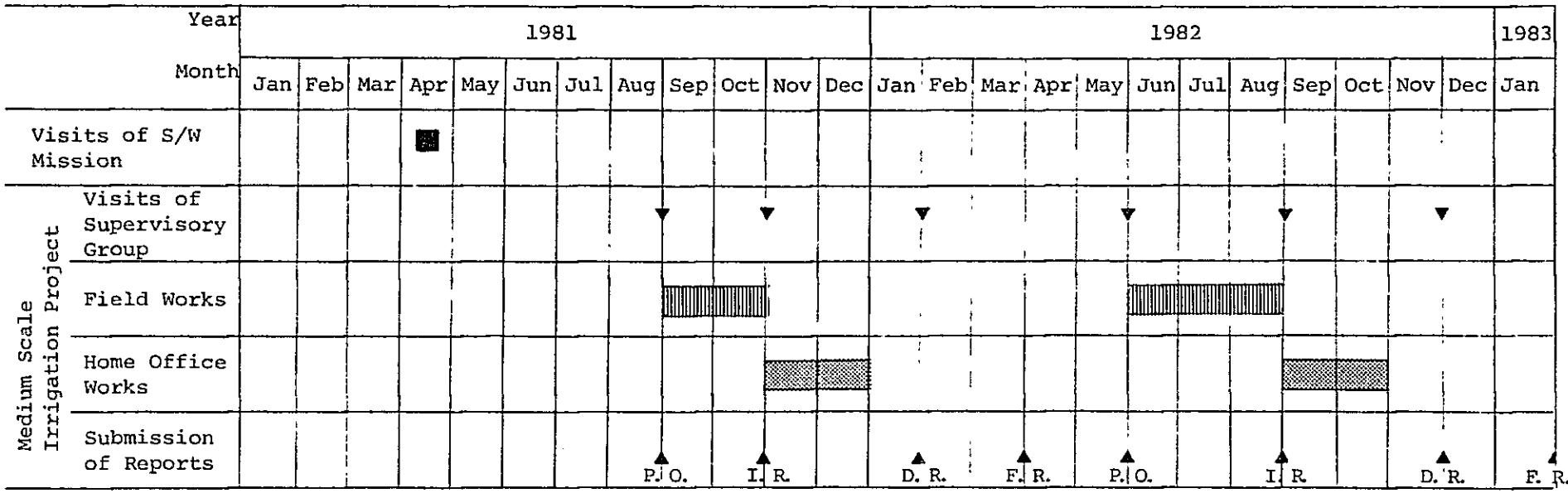
(9) to make the necessary arrangement to obtain the permission of the Authorities concerned for the team to conduct the survey in the objective area (A and B)

(10) to guarantee the security of the team members during the surveying period (A and B)

(11) to make arrangement for dispatching a few counterpart personnel to Japan in the course of the home office works (A and B)

(12) to extend close cooperation to the team in every respect for smooth execution of the Study (A and B)

WORK SCHEDULE FOR THE MEDIUM SCALE IRRIGATION PROJECTS



P.O. : Plan of Operation

I.R. : Interim Report

D.R. : Draft Report

F.R. : Final Report

ATTACHMENT 3.

MEMBER OF SUPERVISORY, STUDY TEAM AND COUNTERPART

(A) Supervisory Committee

1. Leader	Mr. Yuusuke Suematsu	(Agricultural Structure Improvement Bureau, Ministry of Agriculture, Forestry and Fishery)
2. Agriculture	Mr. Hideyuki Kawanishi	(")
3. Irrigation/Drainage	Mr. Akira Kazama	(")
4. Irrigation/Drainage	Mr. Yuuji Sakamoto	(Kinki Regional Administration Office, Ministry of Agriculture, Forestry and Fishery)
5. Agro-Economy	Mr. Hiromoto Aoki	(Tohoku Regional Administration Office, Ministry of Agriculture, Forestry and Fishery)

(B) Study Team and Counterpart

1. Team Leader Mr. Shinichi Yano	1. Overall co-ordination Mr. Charnchai Klinhom (Project Planning)
2. Deputy Team Leader Mr. Hiroshi Yamamoto	2. Overall co-ordination Mr. Supote Rujirakul (Project Planning)
3. Irrigation/Drainage Engineer Mr. Takeshi Kawaguchi	3. Survey Works Mr. Phyool Chantasiro (Topographic Survey)
4. Dam Engineer Mr. Akira Honda	4. Hydrologist Mr. Sanong Ruttasuk (Hydrology)
5. Hydrologist Mr. Toyotaka Niwa	5. Geologist Mr. Amphai Nuthitachareon (Soil & Geologic)
6. Geologist Mr. Takashi Ozeki	6. Soil Scientist Mr. Danai Triyadhen (Soil & Geologic)
7. Agro-Economist Mr. Tetsuo Watanabe	7. Agronomist Mr. Osot Charnvej (Operation & Maintenance)
8. Design/Survey Engineer Mr. Takashi Seki	8. Economist Miss Supha Sing-intara (Project Planning)

ATTACHMENT 4.

FURTHER INVESTIGATIONS REQUIRED FOR FEASIBILITY STUDY

1. SUPPLEMENTAL TOPOGRAPHIC SURVEY

All of dams are proposed as high as possible to exploit water resources to the maximum extent as far as topographic and geological conditions are allowable. Thus, the topographic maps available at present cannot fully cover the proposed reservoir areas and proposed dam sites. The dam site of the Huai Yai reservoir is shifted at about 500 m upstream from the original site surveyed by the RID. No details topographic map is available at the shifted site. The service area commanded by the Huai Khon Kaen reservoir extends to south along the Pasak Left Bank area. Some parts of the delineated area are not covered by the topographic map of 1/10,000 available at present.

In advance of the commencement of feasibility study, supplemental topographic survey should be made for the reservoir, dam, and irrigation planning. The site to be surveyed for each project is specified in Table A4.1 and demarcated in Fig. A4.1 to A4.5.

2. ADDITIONAL GEOLOGICAL SURVEY

According to the similar reasons mentioned above, additional geological surveys are essential for the dam planning of each project. Before the commencement of the feasibility study for these dams, the required geological surveys should be completed at latest. The surveys to be carried out are as specified in Table A4.1 and the location of drilling sites are presented in Fig. A4.1 to A4.4.

Table A4.1 Supplemental Surveys for Feasibility Study

Project	Item	Specification	Purpose
1. Huai Saduang Yai	Topographic Survey	(a) 1/4,000 scale to supplement the elevation upto 191.0 m above MSL.	Reservoir plan
		(b) 1/1,000 scale to supplement the elevation of both abutments.	Dam plan
		(c) Longitudinal section survey of axes of dam, spillway and outlet works.	Dam plan
	Geological Survey	Drilling holes	Foundation study
		(a) Left saddle No.1 - 15 m depth	
		(b) Axis of spillway No.2,3 - 20 m depth No.4-6 - 10 m depth	
		(c) Axis of outlet works No.7,8 - 10 m depth	
2. Huai Khon Kaen	Topographic Survey	(a) 1/1,000 scale to supplement the elevation of the left abutment.	Dam plan
		(b) Longitudinal section survey of axes of dam and spillway.	Dam plan
		(c) 1/10,000 scale covering about 3,000 ha of part of the proposed project area.	Irrigation plan
	Geological Survey	Drilling holes	Foundation study
		(a) Axis of spillway No.1-3 - 20 m depth No.4-6 - 10 m depth	
		(b) Axis of outlet works No.7,8 - 10 m depth	

(to be continued)

Project	Item	Specification	Purpose
3. Huai Yai	Topographic Survey	(a) 1/4,000 scale to supplement the elevation upto 213.0 m above MSL.	Reservoir plan
		(b) 1/1,000 scale covering the proposed dam site.	Dam plan
		(c) Longitudinal section survey of axes of dam, spillway and outlet works.	Dam plan
	Geological Survey	Drilling holes	Foundation plan
		(a) Dam axis No.1,4,5 - 30 m depth No.2,3,6 - 25 m depth	
		(b) Axis of spillway No.7,8 - 15 m depth No.9,10- 10 m depth	
		(c) Axis of outlet works No.11,12 - 10 m depth	
4. Khlong Chaliang Lab	Topographic Survey	(a) 1/1,000 scale to supplement the elevation of both abutments.	Dam plan
		(b) Longitudinal section survey of axes of dam, spillway and outlet works.	Dam plan
	Geological Survey	Drilling holes	Foundation plan
		(a) Axis of spillway No.1 - 15 m depth No.2-4 - 10 m depth	
		(b) Axis of outlet works No.5,6 - 10 m depth	

Boring Holes	Length
No.1	15 m
No.2	20 m
No.3	20 m
No.4	10 m
No.5	10 m
No.6	10 m
No.7	10 m
No.8	10 m

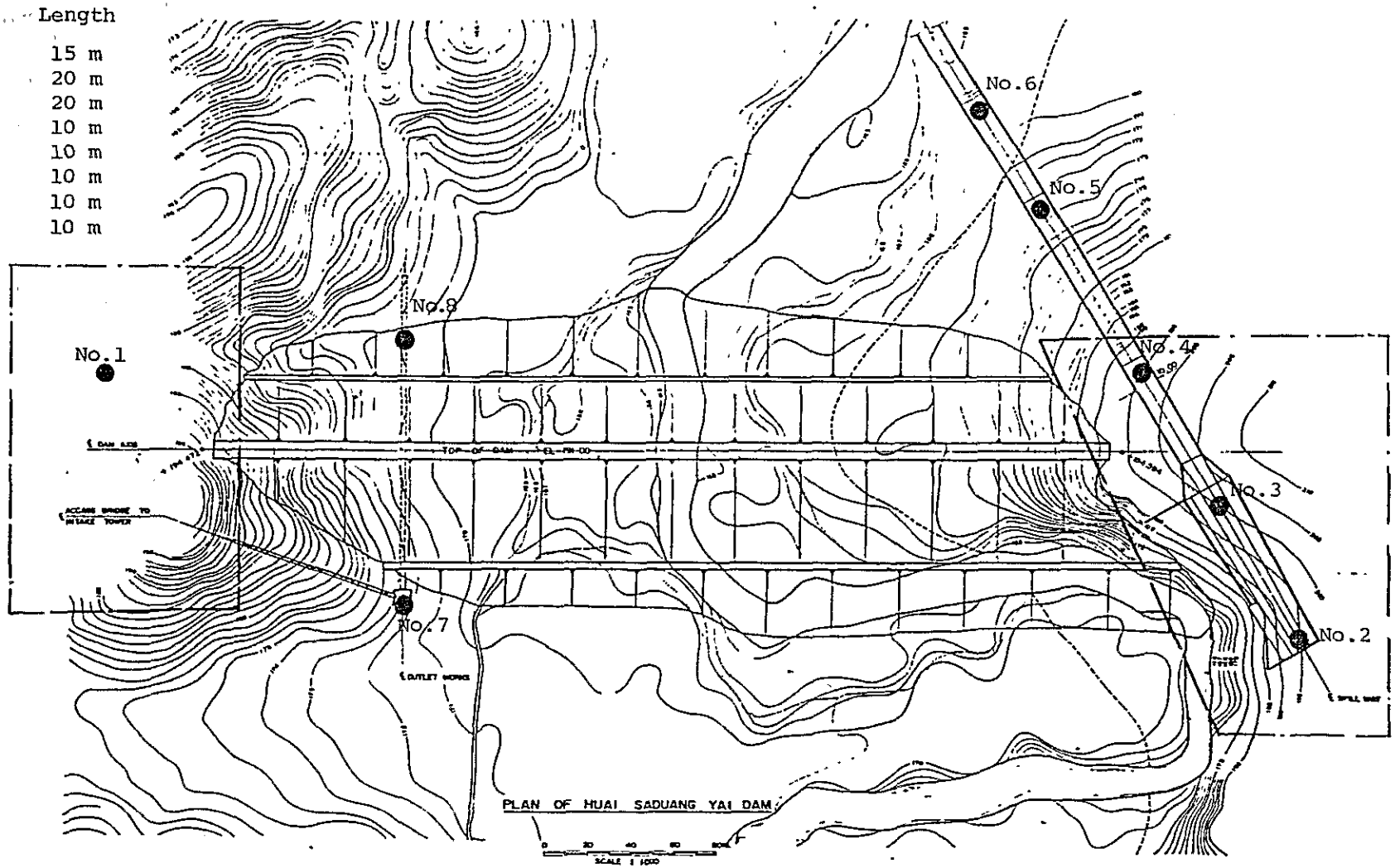
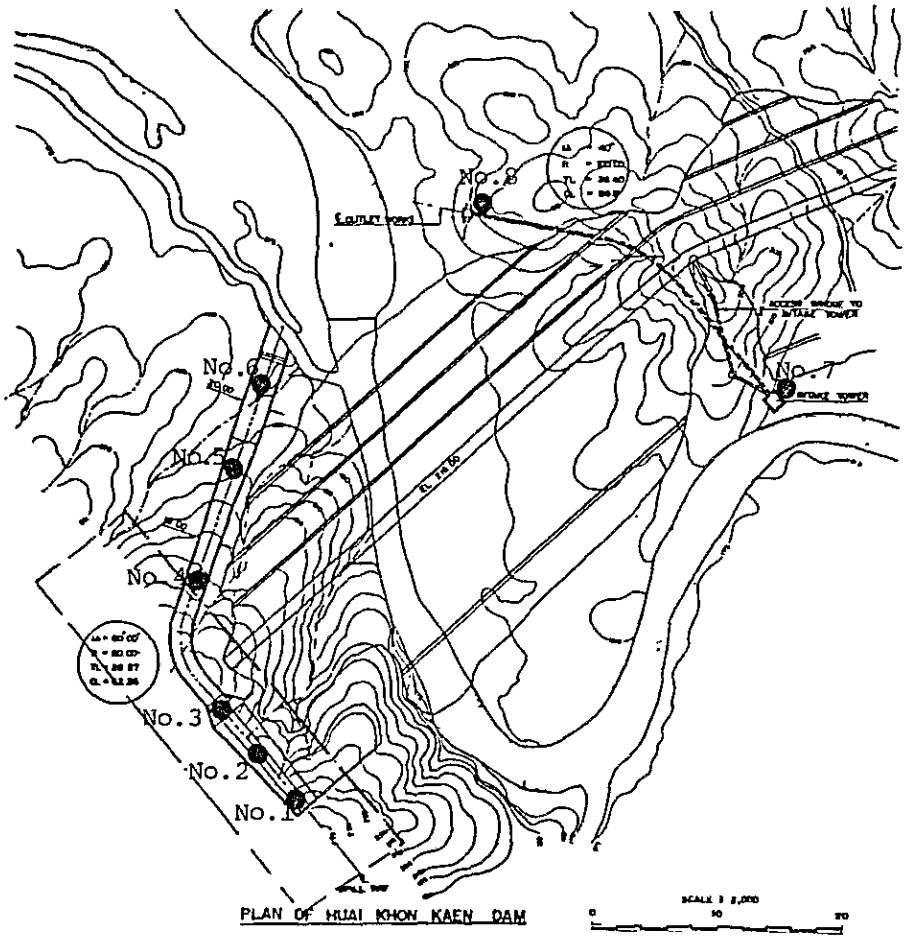
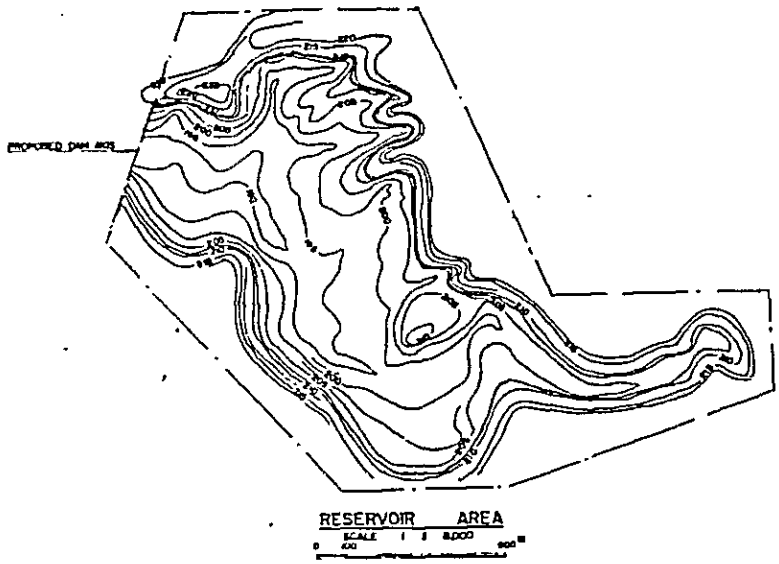


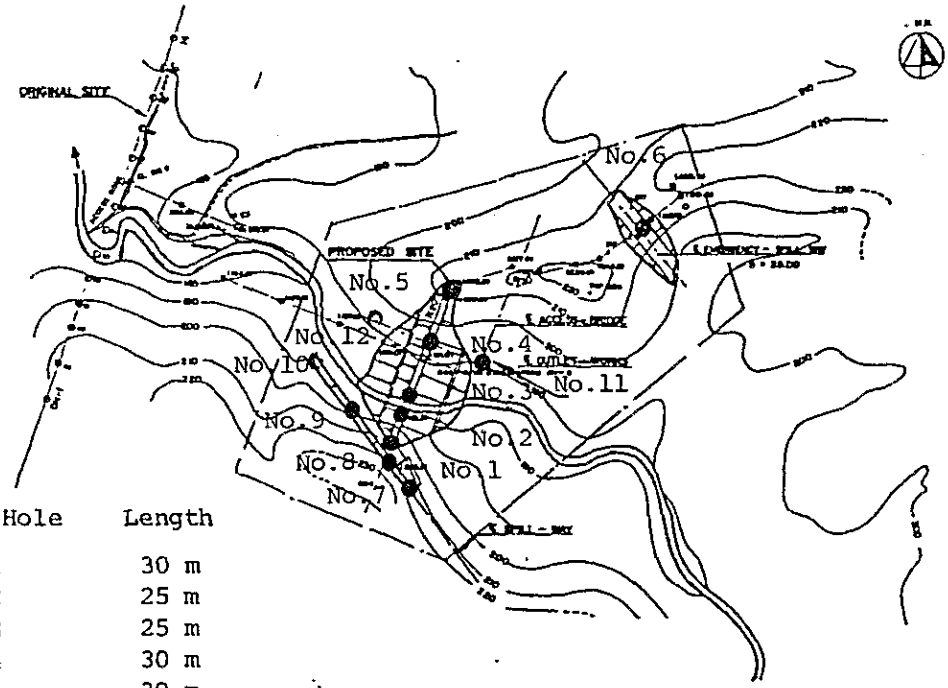
Fig. A4.1 SUPPLEMENTAL SURVEY AREA AND LOCATION OF DRILLING HOLE AT HUAI SADUANG YAI DAM SITE



Boring Hole	Length
No.1	20 m
No.2	20 m
No.3	20 m
No.4	10 m
No.5	10 m
No.6	10 m
No.7	10 m
No.8	10 m

Fig. A4.2 SUPPLEMENTAL SURVEY AREA AND LOCATION OF DRILLING HOLE AT HUAI KHON KAEN DAM SITE





Boring Hole	Length
No. 1	30 m
No. 2	25 m
No. 3	25 m
No. 4	30 m
No. 5	30 m
No. 6	25 m
No. 7	15 m
No. 8	15 m
No. 9	10 m
No.10	10 m
No.11	10 m
No.12	10 m

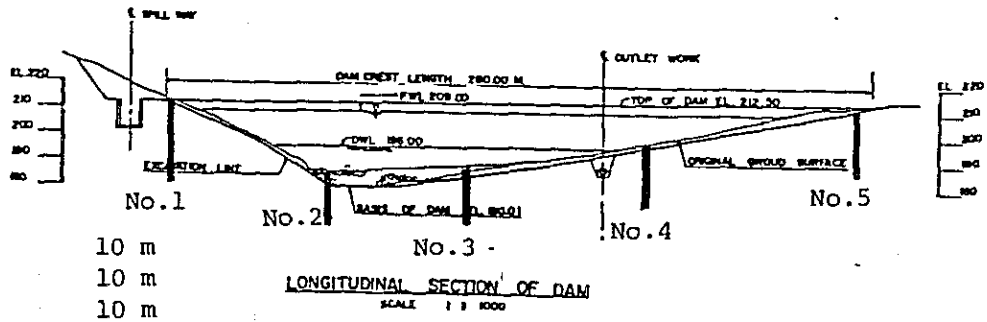
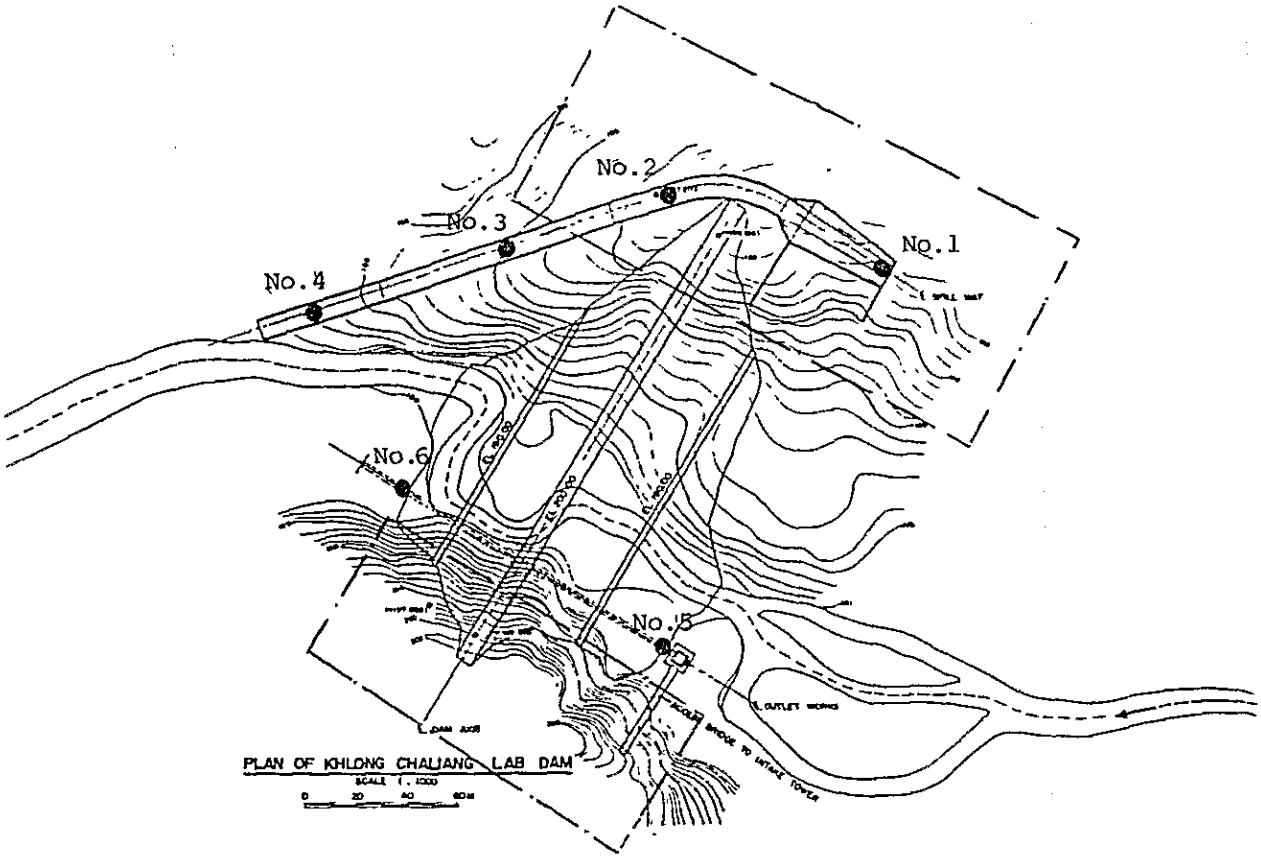


Fig. A4.3 SUPPLEMENTAL SURVEY AREA AND LOCATION OF DRILLING HOLE AT HUAI YAI DAM SITE



Boring Hole	Length
No.1	15 m
No.2	10 m
No.3	10 m
No.4	10 m
No.5	10 m
No.6	10 m

Fig. A4.4 SUPPLEMENTAL SURVEY AREA AND LOCATION OF DRILLING HOLE AT KHLONG CHALIANG LAB DAM SITE

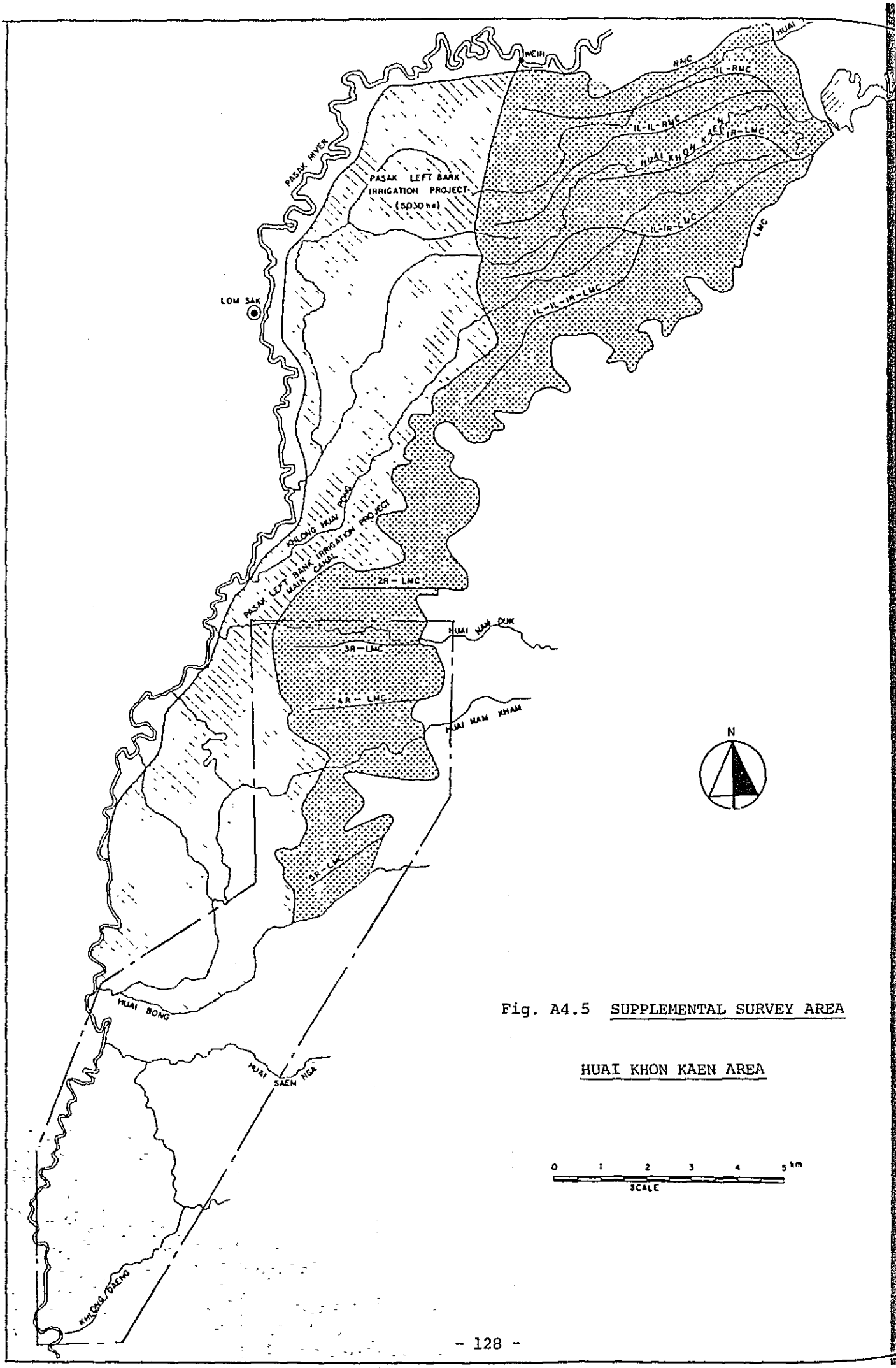


Fig. A4.5 SUPPLEMENTAL SURVEY AREA

HUAI KHON KAEN AREA

ATTACHMENT 5.

LIST OF REFERENCES

1. GOVERNMENT OF THAILAND, THE FOURTH NATIONAL ECONOMIC AND SOCIAL DEVELOPMENT PLAN (1977 - 1981)

   - National Economic and Social Development Board Office of the Prime Minister, Bangkok Thailand

2. AGRICULTURAL STATISTICS OF THAILAND 1979/80

   - Office of Agricultural Economics

3. SELECTED ECONOMIC INDICATORS RELATING TO AGRICULTURE

   - Ministry of Agricultural Economics, December 1979

4. AGRICULTURAL CENSUS, CHANGWAT PHETCHABUN, 1963 & 1978

   - National Statistical Office

5. STATISTICAL REPORTS OF CHANGWAT PHETCHABUN, 1980

   - National Statistical Office

6. CROPPING SYSTEMS RESEARCH IN THAILAND

   - Department of Agricultural Extension

7. RAINFALL AND EVAPORATION ANALYSES OF THAILAND

   - The Asian Institute of Technology, August 1980

8. FEASIBILITY STUDY REPORT OF UPPER PASAK PROJECT

   - Team Consulting Engineers Co., Ltd., January 1980

9. FEASIBILITY STUDY REPORT OF MEDIUM SCALE IRRIGATION PACKAGE PROJECT

   - Sir Alexander Gibb & Partners in Association with Team Consulting Engineers Co., Ltd., July 1981

10. CHAO PHRAYA-MEKLONG BASIN STUDY REPORT

    - Acres International Limited, Niagara Falls, Canada, January 1979

11. FEASIBILITY REPORT ON IRRIGATED AGRICULTURAL DEVELOPMENT PROJECT IN THE WEST BANK TRACT OF THE GREATER CHAO PHYA

    - Japan International Cooperation Agency, May 1977

12. FEASIBILITY REPORT ON THE MAE-KEW LOM IRRIGATED AGRICULTURE DEVELOPMENT PROJECT

    - Japan International Cooperation Agency, March 1980

13. FEASIBILITY STUDY REPORT FOR PHETCHABUN-CHAI BADAN HIGHWAY PROJECT

- Japan International Cooperation Agency, March 1979

14. FEASIBILITY STUDY REPORT FOR NONG BUA-BAN LAM CHI BON HIGHWAY PROJECT

- Japan International Cooperation Agency, February 1980

15. ROAD DEVELOPMENT STUDY REPORT IN THE NORTHERN REGION

- Japan International Cooperation Agency, June 1981

16. APPLIED HYDROLOGY

- Linsley, P.K., Kohler, M.A. and J.L.H. Paulhus

17. HANDBOOK OF APPLIED HYDROLOGY

- Van Te Chow

18. WATER-RESOURCES ENGINEERING

- Linsley·Franzini, International Student Edition

19. DESIGN OF SMALL DAMS

- United States Department of the Interior, Bureau of Reclamation

20. ECONOMICS OF WATER RESOURCES PLANNING

- McGraw-Hill Book Company

JICA