The Mae Ping river goes down southward joining many tributaries and meandering along the valley section to the Bhumibol reservoir. The catchment area of the Mae Ping river at P-1 station (Changwat Chiang Mai) is 6,356 sq.km. A maximum flood discharge was recorded to be 729 cu.m/sec at P-1 station (see Table A 7-1, Appendix A) in August 25, 1973.

While, the Mae Kuang river is the most important river in this Project and has the catchment area of 1,665 sq.km at P-5 station (Changwat Lamphun). A maximum flood discharge at the said station was 376 cu.m/sec.

b) Flood Features

Floods in the Project Area are caused by the Mae Ping river and the Mae Kuang river. The flood season lasts from July to December, but the floods concentrate in August and September. The biggest flood in the recent years occurred in 1973 and it corresponds to 1/50 years probability.

The flood in 1973 overflowed from the northern edge of the Chiang Mai valley and inundated over the northern part of the valley. The flood flowed down very slowly along the lower portion toward the low-lying lands. The sheets of flood seriously damaged the whole neighborhood of the Mae Ping-Mae Kuang junction.

As mentioned already, the catchment area of the Mae Ping river at P-1 station is 6,356 sq.km while that of the Mae Kuang river at P-5 station is 1,665 sq.km. The ratio of both catchment areas is about four to one. The most of floods in the valley are brought about by the Mae Ping river, but an influence of the Mae Kuang river is also noteworthy. This is due to the fact that the flood damages are caused from a combined effect of both rivers. In this sense, when flood control measures would be conceived even only for the Mae Kuang river, a remarkable flood control effect could be expected to medium or small scale flood.

c) Flood Damages

It is difficult to estimate an exact flood damage. As is shown in Table 3-10, the flood damages during 1952 to 1973 on both crops and structures are quoted from ECI report. As is evident in Table 3-10, about 90 percent of the flood damages is crop damages.

Meantime, the data on the crop-damaged area during 1972 to 1980 are available in the Muang Lamphun. An annual flood damage after 1973 was estimated basing on the flood damage data in 1973 which were commonly available regarding the above-mentioned data sources.

The figures in ECI report are presented in constant price basis in 1977 and referred to the entire Mae Ping river basin. Therefore, all figures are converted to 1981 constant price basis. Also, an annual flood damage amount during 1952 to 1980 in the Mae Kuang river basin was obtained through Table 4-7 taking into account the area ratio of the both basins for those below an elevation of 300 m. The column (5) in Table 3-10 indicates the results.

3.6 Present Agriculture

3.6.1 Agricultural Production

a) Crops and Cropping Pattern

Rice is predominant crop cultivated in the four Districts of San Sai, Doi Saket, San Kamphaeng and Muang Lamphun in the Project Area, being followed by groundnut, soybean and garlic. The orchard crops include banana, mango, longan, etc.

Seasonal cropping pattern prevailing in the Project Area may be described as follows: during the wet season, rice is extensively cultivated plus tobacco, groundnut and sugarcane as supplements, and during the dry season, groundnut, tobacco, garlic and soybean plus some paddy are grown in the Existing Irrigated Area. The dry season crop cultivation in the Existing Irrigated Area, which is

Table 3-10 Flood Damage Estimation

(Unit: ฿'000)

	(1) Muang Lamphun (Rai)	(2) Ping River Basin	(3) Flood Damage in Ping Basin			(4) 1981 Price	(5) Mae Kuan Basin
			Crop	Structure	Total		
1952			33,450	7,868	45,318	45,161	20,595
1953			-	-	-	-	-
1954			-	-	-	-	-
1955			-	-	-	-	-
1956			-	-	-	-	-
1957			2,255	89	2,344	2,562	1,168
1958			-	-	-	-	-
1959			-	-	-	-	-
1960			6,837	301	7,138	7,802	3,558
1961			2,704	114	2,818	3,080	1,404
1962			3,432	28	3,460	3,782	1,725
1963			3,854	384	4,238	4,632	2,112
1964			-	-	-	-	-
1965			-	-	-	-	-
1966			27,757	831	28,588	31,247	14,249
1967			7,953	991	8,944	9,776	4,458
1968			11,776	1,184	12,960	14,165	6,459
1969			23,042	979	24,021	26,255	11,972
1970			38,186	1,520	39,706	43,399	19,790
1971			39,153	2,212	41,365	45,212	20,617
1972	1,538		17,106	1,588	18,694	20,433	9,317
1973	9,321	230,597	230,597	40,740	271,337	296,571	135,236
1974	-	-	-	-	-	-	-
1975	9,851	243,709	271,174	35,601	306,775	335,304	152,900
1976	556	13,755	14,525	1,907	16,432	17,960	8,190
1977	1,450	35,872	35,872	4,709	40,581	44,355	20,226
1978	258	6,383	6,134	805	6,939	7,584	3,458
1979	-	-	-	-	-	-	-
1980	1,443	35,699	32,665	4,288	36,953	40,390	18,418
Total			808,472	106,139	914,611	999,670	455,850

Remarks: 1) Flood Damage during 1952 to 1973 is quoted from ECI Report.

2) Column (5) is 1981 constant price.

almost entirely sown with paddy during the wet season, is as shown in the following table. Groundnut and tobacco are generally grown in the eastern highland, while soybean is widely sown in the lowland. That is because of the natural predetermination on each crop: groundnut and tobacco prefer the well drained land but soybean prospers in the fine textured soils. (See Figure F1-1 ~ F1-3, Appendix F-1)

Dry Season Cultivation in the Existing Irrigated Area

(Unit: ha)

Crops	1978	1979	1980	Average
Groundnut	1,072	1,615	975	1,220
Tobacco	492	588	512	531
Soybean	930	756	380	689
Onion and garlic	124	217	318	220
Paddy	52	113	5	57
Total	2,670	3,289	2,190	2,717

Data Source: Operation and Maintenance Office for Mae Kuang Project

b) Cultivation Method and Input Material Supply

The advanced methods have been increasingly adopted by the local farmers for crop cultivation in these years, and such a tendency can be witnessed along three directions as briefed below: (See Table F2-1, Appendix F-2)

(1) Mechanization

Although ploughing is mainly done by use of buffalo, number of farmers who are switching to mechanical ploughing have increased gradually. According to 1978 Census, a quarter of the farm households in Chiang Mai Province and one-third of those in Lamphun Province employ tractor for ploughing (more exactly 24% and 34%, respectively). The use of sprayer is much more diffused as seen from the statistics which shows 39 percent of the farm households in Chiang Mai Province and 28 percent of those in Lamphun Provicne are using sprayers for plant protection.

As the prices of farming machinery are still rather high for the common farmers to procure for their individual use, percentage of farm households owning farm machinery is not high, 4-wheel tractor: 5.6%; 2-wheel tractor: 11.3%; sprayer: 19 - 20%. The local prices of farm machinery are given below:

4-wheel tractor (Johndeer)	59 Ps	฿ 289,000
2-wheel tractor (Kubota)	7 Ps	฿ 32,800 - 36,600
Water Pump (Diesel)	4-5 Ps	฿ 13,900
Sprayer (1 litre)		฿ 300 - 350
Sprayer (engine)	2-8 Ps	฿ 4,700

(2) Fertilizers

One-half of Chiang Mai farmers and two-thirds of Lamphun farmers are using both chemical fertilizers and organic manures. Crop-wise dosage of chemical fertilizers being applied by them is as follows:

Crops	Quantity of Chemical Fertilizers
Paddy	15.7 kg/rai
Upland crops	32.1 kg/rai
Vegetable crops	34.7 kg/rai

Source: 1978 Census for Chiang Mai and Lamphun

The amount of chemical fertilizers used for paddy cultivation has already reached the dosage level recommended by the Extension Office, and the farmers are also applying a considerable amount of chemical fertilizers to the upland crops although there is a preferential difference observed according to the kind of crops, among which tobacco is being given ample dosage under the intensive guidance.

(3) Agro-Chemicals

Use of agro-chemical has likewise become popular; 69 percent of the farmers in Chiang Mai Province and 36 percent of those in Lamphun Province are using agro-chemicals.

c) Crop Production

(1) Crop Yields

The standard yields of the main crops being raised in this area are as follows, according to the data available at the Chaing Mai Extension Office and Monopoly Office:

Paddy (wet season)	580 kg/rai or 3.63 ton/ha
Paddy (dry season)	516 kg/rai or 3.22 ton/ha
Soybean	200 kg/rai or 1.25 ton/ha
Groundnut	236 kg/rai or 1.48 ton/ha
Sweet corn	150 kg/rai or 0.94 ton/ha
Tobacco	60-200 kg/rai or 0.38 - 1.25 ton/ha
Garlic	1,800 kg/rai or 11.26 ton/ha
Cabbage	1,000 kg/rai or 6.25 ton/ha

(2) Total Production

The total agricultural production in the neighbouring districts is shown in the following table. Paddy occupies the largest share and upland crops comprise soybean, groundnut, tobacco, etc. Among paddy glutinous paddy is primarily reserved for the farmers' own consumption, while non-glutinous is for sale.

Total Production of Crops

	In Chaing Mai and Lamphun Prov.
Paddy	
Non-glutinous	207,445 tons
Glutinous	371,527 tons
Soybean	38,025 tons
Groundnut	35,697 tons
Tobacco	223,851 tons
Garlic	223,315 tons

d) Livestock Breeding

Income generated from livestock breeding is rather insignificant. The number of animals by kind, number of breeding farmers and number of animals per household are given in the following table. These figures represent those obtainable in Chiang Mai Province and

Lamphun Province, but it is assumed that the Project Area has a comparatively larger number of buffalo than other areas, due to the dense percentage of paddy field area.

Number of Animals, Number of Household Raising and Number of Animals per Household

Kind of Animals	Number of Heads	Number of Households	Number of Animals per Household
Cattle	149,280	39,675	3.76
Buffalo	134,547	41,531	3.23
Swine	252,943	87,025	2.91
Chicken	2,117,120	115,519	18.33
Duck	226,841	12,717	17.84

Source: 1978 Census

Cattle and buffalo are being raised in a natural way, that means their owners do not worry about the fodder to feed them. Cattles and buffaloes freely look after paddy straws and grasses in the post-harvest paddy field, fallow lands and roadsides. Such natural feeds are plentifully available during the wet season but are liable to be short in the dry season when the paddy straws collected during the wet season are fed to the animals although there is also a short supply of these straws around the end of the dry season and the animals may sometimes suffer from temporal famine.

3.6.2 Marketing of Farm Products and Input Supply

a) Farm Products' Price

The movement of the farm-gate prices of the selected products during the last few years in the country is shown in the following table.

	Rice Baht/ton	Soybean Baht/kg	Groundnut Baht/kg	Onion Baht/kg	Garlic Baht/kg	Tobacco Baht/kg
1974/75	2,232	3.99	3.58	6.83	10.12	21.74
1975/76	1,978	4.16	3.75	9.23	9.75	23.50
1976/77	1,870	4.70	4.29	9.41	10.81	24.14
1977/78	2,368	5.61	4.63	8.65	11.32	29.56
1978/79	2,314	5.39	5.02	11.65	13.33	29.15

Source 1978/79 Agricultural Statistics

b) Marketing and Processing of Farm Products

(1) Marketing of Farm Products

The produced paddy in this area is mostly retained for home consumption. Sales of paddy is quite limited The farm households having surplus paddy for selling are estimated at a little more than half of the whole households and the sales is considered to be rather small. It is estimated that 88 percent of surplus paddy are now selling to the local merchants especially in a same Amphoe where farmers are carrying out farming. No sales of paddy directly to rice miller can be found out (Refer to following figure and see Appendix F-3 for other farm Products).

Almost 100 percent (more than 95%) of other farm products which are mostly cash crops such as soybean, groundnut, garlic, and others produced in the dry season are purchased by local merchants.

The dry season crops are often harvested at the start of the wet season. For example, soybean which has larger share of cash crops in this area is planted after harvest of the wet season paddy and then harvested mostly at the start of the wet season has suffered from serious disadvantage in marketing due to harmful mold and insect damage.

The market mechanism of paddy selected as an example, is presented in the following figure for clarification. The figure shows number of farming households and merchants in percentage by channel. It was

not clear how much quantity of the products went through these channels, because of shortage in such marketing information.

Flows of Paddy Sales

From Farmers

Farmers →	→ Part Time Merchants and Merchants in Village	23.0%
	→ Merchants within Amphoe	38.4%
	→ Merchants in City	19.2%
	→ Merchants in other Amphoe	7.8%
	→ Government Agency Cooperative, Landlord and so on	11.6%
	→ Local Millers	0.01%

Remark: Above 88 percent of paddy sales from farmers is purchased by the merchants and more than 60 percent is bought by merchants within the Amphoe.

From Farm Merchants

Merchants →	→ Merchants within Amphoe	5.6%
	→ Millers in City	83.3%
	→ Local Millers	11.1%

Most of farm products are hauled by buyers' transportation facilities from the farm gates, and transportation of most of fresh and commercially valuable products are usually made by trucks for quick shipment to meet market requirements.

(2) Processing of Farm Products

Small rice milling units (500 kg capacity per day) owned by farmers are found in every smaller village, and village rice mill (1 - 2 ton capacity per day) is found in larger village.

The rice milling practices (farm level) are that the farmers 30 kg of paddy at one time to the rice mill and bring back milled rice, and sometimes rice bran too. Milling is usually free of charge for farmers, because all by-products including separated rice bran belongs to the mill owners. Exchange rates of milled rice against paddy are quite different in ranging from 50 percent to 70 percent.

Apart from such small village rice mills, there are other farm products processing plants as shown in the following table.

Farm Products Processing Plants in Changwat Chiang Mai and Amphoe, Muang Lamphun

District	Tobacco curing plant	Tobacco Drying and Processing Factory	Rice Mill	Vegetable Oil Extraction Plant	Peanut Sheller
Muang, Chiang Mai	1	1	10	2	7
Chom Thong	6	1	54	-	-
Doi Saket	4	1	40	-	-
Mae Taeng	5	-	-	-	-
Mae Rim	5	-	14	-	-
San Kamphaeng	7	-	3	-	1
San Sai	13	-	1	-	-
San Pa Tong	5	-	61	-	-
Saraphee	2	3	2	-	-
Han Pong	5	1	38	-	-
Sub-total	53	7	223	2	8
Muang Lamphun	7	1	5	-	1
Total	60	8	228	2	9

Two rice mills (24 tons per day capacity and 20 tons per day capacity each) are now under operation of cooperatives and five paddy storing warehouses (totaling 2,300 tons of storing capacity) are also operated by cooperatives.

Breakdown of Cooperatives' facilities in the Project Are is as follows:

Cooperatives' Facilities in the Project Area

Rice mill		Paddy warehouse	
Location	per day capacity	Location	Storing capacity
Doi Saket	24 tons	Doi Saket	50 tons x 2 totaling 1,000tons
		San Sai	500 tons
Muang Lamphun	20 tons	Muang Lamphun	500 tons and 300 tons totaling 800 tons
Total	48 tons		2,300 tons

c) Supply of Input Materials

Seeds: Most of the seeds are self-supplied by the cultivators themselves from the left-over of the previous season harvests, but the seeds of the improved varieties are distributed by the Extension Office in exchange for the same amount of rice grains. The seeds distributed by the Extension Office are disintected by use of the chemical, "Seresan". As regards soybean, groundnut, sweet corn, etc., half of their seeds are self-supplied and the remaining half is procured from the merchant. The seedling of tobacco is delivered to the tobacco growers by the Monopoly Office.

Fertilizers and Agro-chemicals: As above mentioned, the use of fertilizers and agro-chemicals are more and more popularized.

Local sales prices of chemical fertilizers and agro-chemicals are as follows:

Chemical Fertilizers:

16-20-0	฿ 255.00 - 260.00/50 kg
13-13-21	฿ 280.00 - 290.00/50 kg
15-15-15	฿ 280.00 - 285.00/50 kg
12-12 - 17+2	฿ 310.00 - 330.00/50 kg
Ammonium Sulfate	
21%	฿ 175.00 - 185.00/50 kg
Urea	฿ 300.00 - 320.00/50 kg

Agro-chemicals:

Furadan	฿ 25/kg
Sevin 85	฿ 131.58/kg
Malathion 571	฿ 78/kg
Dimethoate	฿ 58 = 104/liter
Methomyl D	฿ 647/kg
Manzate D	฿ 80/kg
Dithan M_{22}	฿ 85/kg

Farm Machinery: The farm mechanization has been steady in its diffusion since these few years, but, as mentioned already, the relative expensiveness of farm machinery has prevented individual ownership. Ordinary farmers are benefited from the rental basis mechanized farming services.

3.6.3 Farm Management

a) Population, Number of Agricultural Households, and Agricultural Labour

According to the data derived from the Chiang Mai University, the national population growth rate was greater than three percent per year, prior to the 3rd National Development Plan (1972 - 1976). But the population in Chiang Mai and Lamphun Provinces have expanded at a rate much slower than the national average, as a result of rapidly declining birth rates. The growth rate has also varied greatly between different Amphoes and there have been marked year to year fluctuations in the growth rate within Amphoes because of an unsystematic migratory movement as indicated in the following table:

Annual Population Growth Rate of Amphoes

(Unig. %)

Amphoe	1960-70	1970-72	1972-74	1970-74
San Sai	2.31	4.04	0.24	2.15
Doi Saket	2.06	1.75	1.09	1.44
San Kamphaeng	2.32	2.66	0.74	1.72
Muang Lamphun	-	0.25	4.66	2.20

The total number of agricultural households has decreased in three amphoes as shown in the following table:

Changes in Agricultural Households

Amphoe	Total Number of Agricultural Households		As Percentage of Total Households	
	1963	1970	1963	1970
San Sai	7,137	6,234	71.37	46.86
Doi Saket	7,009	6,696	76.84	62.09
San Kamphaeng	8,434	7,690	73.46	58.09
Muang Lamphun	-	14,279	-	60.75

As for the Project Area, in the absence of reliable data and information, the estimates have been made with the captioned items from the 1978 Census of the relevant Amphoes and the results of the sampling survey conducted in the Project Area, as follows:

Farmland under management of each farmhousehold:	9 rai (1.4ha)
Total number of farm households:	14,285
Agricultural Population:	approx. 130,000
Agricultural labour force:	43,000

b) Scale of Farm Management and Holdings

The land holding size per farm family declined between 1963 to 1977, but the cropped area increased, as shown below:

Long Term Changes in Average Holding Size and Cropped Area

Amphoe	Holding Size (rai/family)		Cropped Area (rai/family)	
	1963	1977	1963	1977
San Sai	8.84	5.12	7.40	12.44
Doi Saket	8.47	5.40	7.00	8.22
San Kamphaeng	10.18	9.83	9.40	15.49
Muang Lamphun	9.66	8.47	8.70	10.74

The results of sampling survey tell that in the Project Area an average size of cropped area per family is 12 rai (1.9 ha), while an average holding per family is 10 rai (1.6 ha). These figures show higher value than the Amphoe averages mentioned in the above. 63 percent of the total farmland belongs to the owner-farmers and the remaining area is being cultivated under tenants. The tenant rate is 50:50 share, the wet season paddy, the rent for dry season cropping with the exception of paddy is usually on a cash basis.

c) Categories of Farm Management

The farmers residing in the Project Area are largely comprised in the subsistence farmers who are depending on paddy cultivation once a year only during the wet season. They are cultivating groundnut, tobacco, etc., on supplementary basis. The size of farm management of the farmers in the Project Area as estimated from the Amphoe statistics range from 2 rai to 50 rai (0.3 ha - 8 ha) but the representative farmers or the so-called "medium-scaled farmers" which occupy 46 percent of the total are managing 6-15 rai (1-2.4 ha) on an average.

3.6.4 Farm Economy

There are various types of farm management in the Project Area. Of these types the most typical one is mainly seen in the Existing Irrigated Area. The following shows one of the farm budgets.

Table 3-11 Typical Farm Budget

(Unit: Baht/1.4ha)

Item	Amount (Baht)	Percentage (%)
Income		
Non-agriculture - - - - - - - - (1)	2,045	17.7
Agriculture - - - - - - - - - - (2)	9,488	82.3
Crop	(8,694)	
Livestock	(794)	
Total	11,533	100
Expense		
Non-agriculture - - - - - - - - (3)	5,531	49.2
Agriculture - - - - - - - - - - (4)	5,721	50.8
Crop	(3,229)	
Livestock	(2,492)	
Total	11,252	100
Net Income from Agriculture ---- (2)-(4)	3,767	
Net Income per Family ------ (1)+(2)-(4)	5,812	
Amount of Deposit per Family---(1)+(2)-((3)+(4))	281	

As seen in the above table, income of the typical farm household amounts to 11,533 Baht in total per annum, of which 9,488 Baht are derived from the agriculture and 2,045 Baht from the non-agriculture. On the other hand, expense of the same household amounts to 11,252 Baht of which 5,721 Baht are derived from the agriculture, and 5,531 Baht from the non-agriculture. The net income per family is worked out at 5,812 Baht.

With regard to the non-agricultural income and expense mentioned above, the detail is shown in Table 3-12.

Table 3-12 Typical Farm Budget

-from non-agriculture-

(Unit: Baht/1.4 ha)

Income			Expense		
Item	Amount	Percentage (%)	Item	Amount	Percentage (%)
Trade	918	44.9	Foods	3,812	68.9
Wages	1,127	55.1	Clothings	468	8.5
			Medicine	269	4.9
			Education	229	4.1
			Donation	230	4.1
			Others	524	9.5
Average per Family			Average per Family		
	2,045	100		5,532	100

With regard to the agricultural income and expense mentioned above, the detail is shown in Table 3-13.

Table 3-13 Typical Farm Budget

-from agriculture-

(Unit: Baht/1.4 ha)

Income			Expense		
Item	Amount	Percentage (%)	Item	Amount	Percentage (%)
Crop			Crop		
Rice	2,745	28.9	Fertilizer and chemicals	1,146	20.0
Tobacco	4,316	45.5	Labor charges	1,318	23.1
Groundnut	1,058	11.1	Seeds	230	4.0
Garlic	157	1.7	Interest of loan	429	7.5
Others	418	4.4	Others	106	1.9
Total	8,694	91.6	Total	3,229	56.5
Livestock			Livestock		
Buffalo	432	4.6			
Swine	339	3.6			
Fowls	23	0.2			
Total	794	8.4	Total	2,491	43.5
Average per Family			Average per Family		
	9,488	100		5,720	100
Average per person					
	1,956				

3.6.5 Agriculture Supporting Institutions

a) Agricultural Research Works

(1) Agricultural Research Works under Each Department

Agricultural Research works have been developed so far on departmental basis, according to the widely divided patterns of responsibilities for different sectors within the Ministry of Agriculture and Cooperatives.

Thus, the Department of Agricultural Technique deals with agricultural crops, the Department of Livestock with fodders and pastures, RID with the application of irrigation water to crops and so on, based upon administrative departmental basis.

From farmers' point of view, each of governmental research experimental station handles only one part of the wide range of activities which have to be integrated somehow when it comes down to farm level and this led to separated approach through departmental basis, before a linkage with extension works could be established.

(2) Regional Agricultural Development Center

Four Regional Agricultural Development Centers (Khon Kaen, in North Eastern Region, Chainat in Central Region, Songkla in Southern Region and Chiang Mai in Northern Region) have been established directly belonging to Under-Secretary Office, MOAC for the purpose of promoting agricultural development working together as a team particularly to study various problems as they face the farmers in the regions, not only from the technical point but also at the same time from economical aspects such as year-round cropping.

(3) Operation of Research Works

Most of main research staff belonging to the Department of Agricultural Technique are posted at Agricultural Research Station, Ban Khaen. It has been and also now playing a vitally important role

in the field of agricultural research works associated with the staff of neighbouring Kasetsat University for long time.

All kinds of research works on agricultural crops are conducted there. The staff carries on research works, designs of various kinds of crops and at the same time control experimental stations belonging to the Department, the staff of which are also assigned by the Department.

The results and data obtained at the local experimental stations are reported and/or collected to the Agricultural Research Station. The same operational system as well as agricultural crops is applied, for example, to Research Division of the Livestock Department.

b) Agricultural Extension Service

(1) Agricultural Extension Service before establishment of Kaset Tambol[1/] system

The disadvantages described about research works conducted by different Department and other Ministries are applied also to extension services. Coordination among various departmental agencies had hardly existed in the past[2/]. An integrated extension services have become rendered by the MOAC through creation of Central Extension Service, which came into operation in 1968, although this still left other Ministries with their individual extension claim.

But even with step, in point of fact, the shortage in number of extension staff is such that extension personnel can only be posted at Changwat and Amphoe level so that one extension officer had to look after some 8,000 farmers at the initial stage.

1/ Kaset Tambol: Agricultural Extension Officer at Tambol level

2/ Phaibul Changrien: Evaluation of Agricultural Development in Thailand, 1972 p. 41

William Stiffin: The Thai Bureaucracy, Institutional Change and Development, 1966, p. 248

(2) Newly-introduced Kaset Tambol system in Extension Service

Outline of Kaset Tambol System

The expanded extension program inaugurated in the year 1977 in the country to give much more intensified and efficient services to farmers through establishment of Kaset Tambol system. According to this newly-introduced system, at least one Kaset Tambol is to be posted within the boundary of Tambol which covers about 1,000 farming families and more Kaset Tambols are assigned to larger Tambol depending upon the number of farming families.

Kaset Tambol is the nearest agricultural extension officer who has direct contact with farmers. About ten percent farming families are selected among whole families under supervision of the Kaset Tambol. These selected farmers are called "Contact Farmers (C.O.F.)."

The extension works of Kaset Tambol are focussed upon training and visiting C.O.F. (T-V system) to transfer new agricultural techniques such as improved varieties, proper planting varieties, proper planting spacing, new agricultural method that all for necessary inputs and timely fertilization, etc. Kaset Tambol has positive duty to visit C.O.F. once every two weeks to conduct his assigned job. Other farmers than C.O.F. in the Tambol who have interest in C.O.F. farming activities are quite free to join and follow C.O.F. farming.

Coverage of Kaset Tambol System

Kaset Tambol system covers new 56 Changwats throughout the nation in 1981, and this program was scheduled to be completely finalized in the year of 1980 in covering 72 changwats, the whole Kingdom. In the case when this system is completely well organized and efficiently operated, Thailand could be said to be one of the countries which have most developed agricultural extension system in the south-east Asia.

Demonstration Farm

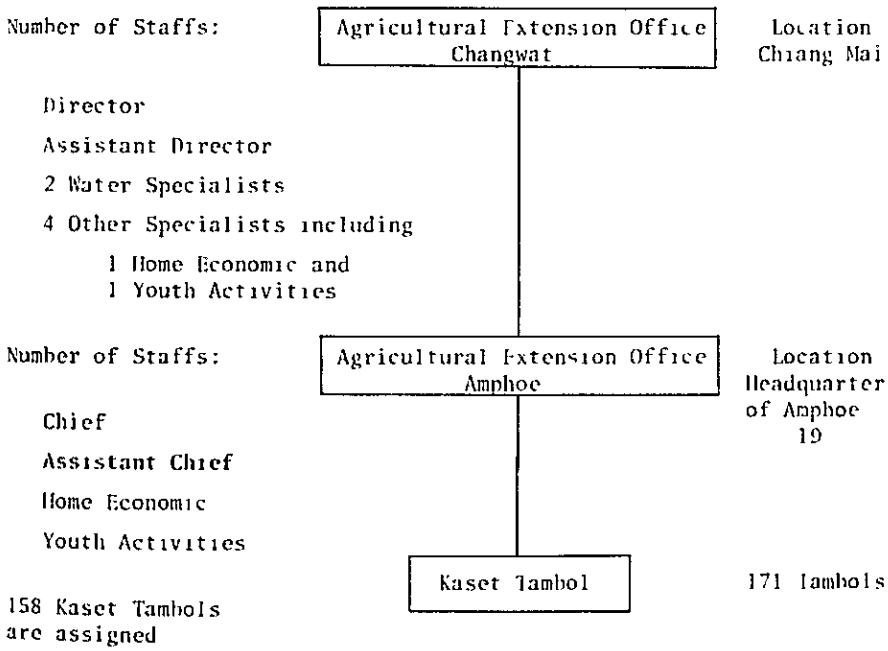
Every Tambol has several demonstration plots, and the size of which is 2 - 10 rai depending upon local agricultural condition. Demonstration plots are operated by farmers themselves with advices of kaset Tambol. All necessary agricultrual inputs to operate demonstration plots are provided by government at free of charge.

Current Agricultural Extension System in Changwat Chiang Mai is shown in the following figure (see Appendix F-5).

Extension Service through Mass Media

Every morning, special agricultural information are broadcasted at 8:30 a.m. about ten minutes. This service is well accepted and appreciated by local farmers. Almost all local broadcasting stations have their own programs in good coordination with the local agricultural authorities concerned.

Current Agricultural Extension System in Chiang Mai (1979)



Number of Assigned Kaset Tambol in Selected Amphoes

Name of Amphoe	Number of Tambol	Number of Assigned Kaset Tambol
San Sai	12	11
Doi Saket	13	11
Sam Kamphaeng	15	15
Saraphi	12	10
San Pa Tong	12	14

c) Farmers' Organization

Farmers' Organizations in Thailand having a different historical and social background by regions - especially traditional water supply to the paddy field, vary in the functions from each other, even under the same name at local level. Sometimes, it is found that organizations with different names are identified as the organization with the same function.

The irrigation systems in the vicinity of the Project Area have been developed and maintained by farmers for long time since their settlement in relatively narrow valley in the Upper North and then Mae Fack Project (Chiang Mai) was completed in 1937 as the first irrigation project under the Government, and furthermore, Mae Wang Project (Lamphaeng) and Mae Ping Kao Project (Lamphun) were started one after the other in the same year. The farmers' organization for using irrigation water, therefore, are different in their formation because of different backgrounds of their own. According to these facts, the office of the Mae Kuang Project recognized well that the Farmers' Organization for irrigation water supply in the area under existing office of operation and maintenance covering the so-called "existing Area of Mae Kuang Project", which is a major part of the said office, is different in Farmers' Organizations from the other irrigation systems even in the same Chiang Mai Valley. Accordingly, it would be impossible to identify and describe these different functions under the same name in the form of unity, and at the same time these Farmers' Organizations in the Upper North, call at not be applied to those in the other areas.

Meanwhile, the followings discusses the Farmers' Organizations which are currently prevalent all through the country.

(1) Formal and Informal Farmers' Organization

Formal organization are those which are created and operated according to the definite rules to pursue one or more "specific goals". There are traditional irrigation associations and the more recently-established Cooperatives and Farmers' Groups in Chiang Mai Valley, all of which will be termed "economic groupings", since they provide tangible economic benefits to members. There are also "social groupings", for example, the temple committee, the school committee, the young peoples' groups and funeral groups, all of which are created for the social functions and social welfare.

Economic groupings are usually organized in neglecting the administrative boundary of villages to secure a large economic scale as background. On the other hand, social groupings are usually organized within a boundary since their function is to strengthen the village unity and economic scale are proved to be neglected.

(2) Cooperative and Registered Farmers' Group

The important Farmers' organizations are Cooperatives (Sahakorn) and the registered farmers' groups (klun Kasetakorn), functions of which are very similar to each other, that is, they provide loans, fertilizers, insecticides and other necessary farming equipment for members. The difference is that the Farmers' Group is under the supervision of the Department of Agriculture, being smaller is size, while the Cooperative is under the supervision of the Department of Cooperatives with larger memberships and capital. Usually, every Amphoe has one cooperative at least, according to general policy of central government.

(3) Agricultural Cooperatives[1/]

The most important Farmers' Organization is Agricultural Cooperatives. There are six types of cooperatives in Thailand, namely: agricultural, fisheries, land settlement, consumers' thrift and cred.' and services cooperatives. As of December 31, 1978, all these six types of Cooperatives in the country were numbered by 1,464, of which 815 were Agricultural Cooperatives with the total membership of 1,462,949 families[2/], including 650,256 Agricultural Cooperatives member families

The activities of Agricultural Cooperatives include agricultural credit service, supplying farm inputs, processing and marketing of farm products, and occupation promotion for benefits of their members and others local people as well.

The organization of this type of Cooperatives has evolved from the amalgamation of the village credit cooperatives, land improvement cooperatives or farm products marketing cooperatives, into larger size unit covering the operation area of one entire Amphoe, capable to do multi-purpose functions to fulfill the needs of members.

Major activities of Agricultural Cooperatives are as follows:

Credit business

Every Agricultural Cooperative functions as the local banks for their members. The services provided by Cooperatives are both depositing and lending. The interest rate for the members' deposits, either saving or fixed depositing is the same as that of the commercial banks. The Bank for Agriculture and Agricultural Cooperatives is main supplier of credit for Agricultural Cooperatives at the rate of interest nine percent per annum to give loans to their members. The Agricultural Cooperatives provides only production loan i.e.,

---

1/ See Appendix F-5.

2/ Agricultural Statistics of Thailand 1978/79

short-term loans within 3 years, with flat rate of interest of 12 percent per annum. A limit in credit for each member is set by not exceeding 40,000 Baht.

Purchasing Business

The Agricultural Cooperatives provide facilities to store consumers' goods and agricultural materials such as fertilizers, insecticides, pesticides, and necessary agricultural tools and machines.

As regard to production supply, the Cooperatives Promotion Department received in 1979 the assistance from Japan in the form of grant aids as follows;

- Agricultural machinery/equipment valued at 950 million yen or 90 million Baht on the principle that these machineries and equipment will be sold to Agricultural Cooperatives and the member farmers in the Thai-Japan Project areas of five changwats, namely Saraburi, Lopburi, Phetchaboon, Sukhothai, Phisanloke and in the areas of Maeklong and Chaopraya Irrigation Projects in Changwats of Ayuthya, Nakhon Pathon, Ratchaburi and Kamchanaburi.
- 15,830 ton of fertilizer valued at 470 million yen or 57 million Baht is to be distributed to Agricultural Cooperatives, according to the Japanese assistance program.

Marketing business

The main business line of Agricultural Cooperatives is to collect paddy. As the storage is a necessary facility for collecting paddy from the members, the government has provided loans to Agricultural Cooperatives to set up storages for collecting paddy and other products from members. At present, the Agricultural Cooperatives have 615 storage with capacity of 291,300 tons in total.

The government has allocated 230 million Baht fund to the Cooperative for purchasing paddy from their members. But to enable

Cooperatives to collect paddy within the said capacity, this amount of fund is far behind the estimated necessary fund.

Processing of farm products

The government has promoted to increase the processing function of Agricultural Cooperatives by providing long-term loans for construcioin of rice mills for the Agricultural Cooperatives. At present, the Agricultural Cooperatives possess 42 rice mills with capacity of 1,762 ton per day. Processing plants for other products such as bamboo shoot, tea leaves as well as dairy processing plants were set up by Agricultural Cooperatives in order to process their members produces.

The rate of member families participating in the Cooperatives against whole farming households in the Kingdom was estimated at 12 percent, and about 20 percent was estimated in Changwat Chiang Mai and about 18 percent in Changwat Lamphun.

(4) Unregistered Farmers' Group

There is another Farmers' group unregistered (Klum Chao Na) which is completely different from the registered Farmers' group (although translated into the same as Farmers' group in English, it is essentially to be classified into different type of group as shown in term of Thai language). This group consists of only 10 - 30 members, two thirds of which is in principle, landowners. The function of this group is quite limited. Individual member is to be provided from institutional credit upon collateral security basis

(5) Informal Groupings of Farmers

Informal groupings of farmers are referred to the groups that have no fixed hierachial administrative pattern. One important informal grouping found in the rural area, especially in the Upper North Thailand is Cooperative "Labor Exchange Group". However, they have some unwritten "rules" that govern their behavior and function.

(6) Farmers' Organization for use of irrigation water

Irrigation canals had been constructed and maintained by farmers in the traditional and simple way since long time before, in the Upper Northern Area. Such irrigation systems still existing in the Project Area are called People's Irrigation System and under the jurisdiction of the Ministry of Interior.

(7) Farmers' Organization for use of irrigation water within the boundary of Operation and Maintenance Office (O & M Office), existing Mae Kuang Project (located at Doi Saket)

The coverage of the area of existing O & M office is about 9,600 ha (60,000 rai) irrigated by three main canals. According to historical background, Pha Teak main canal was constructed by RID and remaining two main canal were developed by RID after the construction of canal had been made by farmers. The laterals and the tertiary canals were made by farmers. Water supply from the main canals and maintenance of the main canals has been under the control of O & M office: however, duties of both O & M office and farmers' organizations are unexpectedly complicated, reflecting the above-mentioned background

Summarized activities of O & M office and Farmers' Organizations are described such as that i) operation and maintenance of main canals is conducted by O & M office and ii) at the same time, other canals such as laterals and tertiaries are kept by farmers themselves. There are farmers' organizations for the purpose of maintenance of canals as follows;

Farmers' Organizations

- SWAN

The area covered by irrigation water supply provided from each lateral is called as "SWAN", and a representative of the organization is called as "NUANA SWAN".

- CHAEK

Several CHAEKs are organized by 15 - 20 farming households along every tertiary canal inside SWAN. The number of CHAEKs inside SWAN is different in depending upon water supply to SWAN from main canal. Representative of CHAEK is called "HUMAN CHAEK" or "HUANA MUANG PAI."

The laterals and tertiaries maintained by the aforesaid farmers' organization in the Project Area.

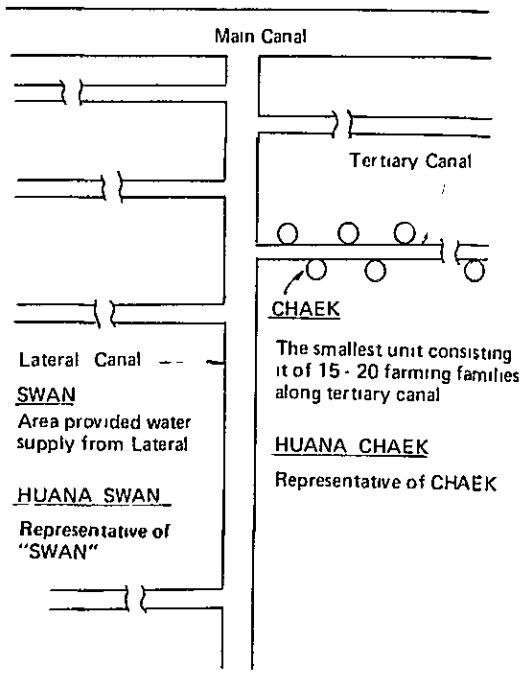
Responsibility and Authority of HUANA CHAEK for Maintenance of Canals

The representatives of both SWAN and CHAEK are farmers selected among themselves and they serve voluntarily the organization at free of remuneration. HUANA CHAEK has, however, strong power and at the same time has responsibility to collect appropriate labor forces from his CHAEK to clean the canals once a year, and every canal is operated and maintained by these labor forces according to traditional way in the area.

Furthermore, HUANA CHAEK has strong authority to impose some fines by 2 - 3 tang of paddy depending upon the case, where if some families can not provide labor force for such works and/or provide inadequate labor force in quality. The rate of fine is up to 50 tang in maximum.

Following figure indicates farmers' organization to use irrigation water supply from main canal in the area covered by the Operation and Maintenance Office in the Existing Irrigated Area.

FIGURE 3-8 FARMERS' ORGANIZATION FOR WATER USE



Planning and Performance of Water Supply to Laterals

A Special Committee, the Chairman of which is Nai Amphoe, is to be held once a year at the office of Nai Amphoe at the time just before the start of the dry season farming, participated by officials of O & M office, Kaset Amphoe, Sahakorn Amphoe, Kaset Tambols, all representatives of farmers' organizations in the areas along all kinds of canals, other interested farmers and others who are benefited from irrigation system with water supply, and the total of the participants will become 200 - 300 persons. Irrigation plan from the main canal to individual laterals during the dry season is decided in this meeting[1/].

1/ O & M office reports water supply capacity for the coming dry season first of all the objects in the meeting and comments and discussions will follow freely.

According to the water supply plan made by the Committee, a cropping pattern in the coming dry season will be selected by farmers, and then the start and period of water supply is regulated by "Zone Man"[1/] who belongs to O & M office only at the request of HUANA CHAEKs from the Main Canals to Laterals.

One Zone Man is usually assigned per 10,000 rais irrigated area A coverage of O & M office is now about 7,600 ha or 60,000 rais, with six Zone Man posted. The density of posted Zone Man in the area is said to be on average.

Special Remark

The said Farmers' Organization and function thereof are described within the boundary of existing O & M office, but cannot be applied to other irrigation systems with different background of establishment and development as they are.

d) Institutional Financing System to Farmers

1) Farmers' Debts before Establishment of Bank for Agriculture and Agricultural Cooperative (BAAC)

Estimated outstanding debts amounted to nine billion Baht before establishment of BAAC in 1966. A great deal of this debt must arise from the very high interest rate charges of commercial lenders which are generally said to range from 25 - 75 percent annum, or still higher according to risk. (see Table F6-1, Appendix F6)

2) Establishment of BAAC as Institutional Financing Organization to Farmers

Unless some form of organization can get them out of the said

---

1/ The Zone Man has no authority to settle water supply in volume from the main canal to laterals, but only can regulate water already decided by O & M office through gate operation at the request of HUANA CHAEK. The Zone Man keeps good contact with CHAEK and understands well its requirements.

situation, development in production to use improved agricultural inputs is to be very serious. The government has come to place an emphasis on institutional loan for farmers. The BAAC has been set up with view to be main instrument for loan to farmers in the future.

3) Development of Institutional Loan to Farmers after Establishment of the BAAC

BAAC has been developed nationwide for these years in starting with 15 branches at Changwat level and 43 Amphoes level office in November 1966, and now (1980) provided 61 Changwats level Branches and 498 Amphoes level offices covering 613 Amphoes out of about 700 Amphoes and Sub-Amphoes throughout the Kingdom. The staff of branches and Offices is totaled 3,504 in number.

The number of client farmers registered has marked by 960 thousand families and the membership of Agricultural Cooperatives serviced by BAAC implies 774 thousand families as of the end of March, 1981. The total clients are 1,734 thousand families. Besides the above 255 thousand farming families are also the clients belonging to Registered Farmers' Group and have received credit service from BAAC.

The total number of farming families in Thailand in 1980 was estimated by the Agricultural Economic Offices to be approximately 4.5 million. Thus the BAAC, combined with the commercial Bank were able to provide credit services to 51 percent of total farming households. This percentage can be divided into a-proximately 43 percent for the BAAC and eight percent for the Commercial Bank. However, BAAC's and Commercial Bank's combined total agricultural credit provisions are estimated to represent 66 percent of the total demand.

The interest rates on loan to individual client farmers vary with types of loans from seven to 14 percent; however, the rate of 12 percent per annum had been applied for main-crop production, which was reduced to 10 percent from April 1, 1981.

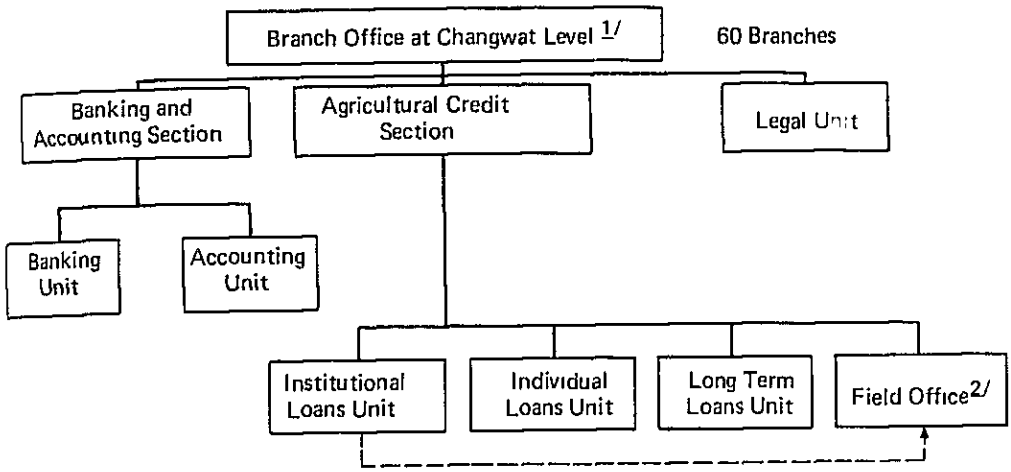
Table 3-14 and Figure 3-9 explain how Institutional Finance has contributed for farmers to develop their production activities.

Table 3-14 Statistical Highlights of Financing Operations of BAAC

Item	1967	1970	1973	1976	1978	1980
Capital Fund (mil. Baht)	304	771	1,213	1,284	1,773	2,037
Total Assets (mil. Baht)	474	1,317	2,174	7,471	12,814	18,501
Number of Changwat Office	15	45	58	58	58	61
Number of Field Office at Amphoe Level	43	205	284	331	409	498
Number of Amphoe Serve by Branches	95	317	450	504	528	613
Number of Farmers registered at Branches	45,278	228,611	330,628	604,787	780,514	960,465
Loan Extended to Individual Farmers (mil. Baht)	121	653	974	3,849	5,679	7,317
Loan Extended to Agricultural Cooperatives (mil. Baht)	125	108	249	815	1,641	3,614
Loan Extended to Farmers' Groups (mil. Baht)	-	-	-	533	183	90

Source: 1967, 1978, BAAC Annual report
1980, BAAC Preliminary Annual report

FIGURE 3-9 ORGANIZATION CHART OF BAAC BRANCH OFFICE



1/ About 40 percent of personnel belonging to Branch are working in Office of Branch and Other remaining 60 percent are posted at offices in Amphoes.

2/ Field Office at Amphoe level has one chief and two to three persons handling loan business who have knowledge on farming operation give advisory services to the client farmers to secure repayment of loans.

3.7 Present Status of Dam and Canal Constructions

3.7.1 General Programme

The Mae Kuang Dam Project has been implemented by RID since April, 1976, when the construction of camping facilities was commenced.

RID's general programme of the Project is as follows:

Name of Project.	Mae Kuang Project	
Construction Period:	12 years, 1976(2519) - 1978(2530)	
Project Cost	US$93,000,000	(฿ 1,860,000,000)
Surveying	417,075	(8,341,500)
General works	4,290,350	(85,807,000)
Dam and appurtenant structures	41,764,000	(835,280,000)
Water distribution system (100,000 rai)	30,000,000	(600,000,000)
Improvement of old facilities (60,000rai)	6,000,000	(120,000,000)
Administration	2,750,000	(55,000,000)
Contingency	5,278,540	(105,570,800)
Land acquisition	2,500,000	(50,000,000)

Up to the end of this fiscal year (September 1981), the total progress of the works will not be more than ten percent of the total in terms of the project cost. Still, this is almost on the RID original schedule and another 90 percent of the works were programmed to be done during the rest six years while in only three years, from the eight to the tenth, about 80 percent of the works shall be done.

However, this schedule will be revised since the Government of Thailand requested the Government of Japan in July 1980 to review the current technical problems on dam construction and to formulate the overall agricultural development plan.

Yearly progress ratio of the works from the commencement of the construction to the end of the fiscal year, September 1982 (2525) is as follows:

Year	Main Works	Progress Ratio to total Project Cost
1976 (2519)	Camp	0.10%
1977 (2520)	Camp, Survey, Resettlement	0.70 %
1978 (2521)	above 3 works, Geological Survey of Left Saddle	2.21 %
1979 (2522)	above 5 works, Road, Bridge	5.19 %
1980 (2523)	Survey, Resettlement, Left Saddle	7.46 %
1981 (2524)	above 5 works	9.44 %
1982 (2525)	above 3 works, Canal	12.09 % 1/

Note: 1/ Progress schedule for 1981 (2524) and 1982 (2525) are estimated on June 1981 by Mae Kuang Project Office. Former ratio of above 12.09 percent was 15.44 percent on the original schedule.

The Organization of the Project, headed by the Project Engineer, is as shown in the Figure 3-10. However, because of the stagnation of the Project in Progress, a part of officials and laborers figures are transferred to the following two Medium Scale Irrigation Projects

Pong Cho Project

Location:	Amphoe Chom Tong, Changwat Chiang Mai
Project Period:	1979 - 1981
Project cost:	US$1,985,000 (฿ 39,700,000)
Service area:	1,600 ha (10,000 rai)
Water resource:	Pong Cho Dam
Dam height:	18 m
Dam length.	400 m
Dam volume:	370,000 cu.m
Total storage·	2.6 MCM
Catchment area	8 sq.km

Mae Takrai Project

Location:	Amphoe San Kamphaeng, Changwat Chiang Mai
Project Period:	1981 - 1982
Project cost:	US$575,000 (฿ 11,500,000)
Service area:	224 ha (1,400 rai)
Water resource:	Mae Takrai Dam
Dam height:	24 m
Dam length:	150 m
Dam volume:	180,000 cu.m
Total storage:	0.8 MCM
Catchment area:	19.4 sq.km

These projects were in the prime of the works on July 1981 when JICA engineers visited the two sites.

3.7.2 Construction Programme of Dam and Canal

As mentioned above, the Mae Kuang Project has been started with the priority of the left saddle dam, according to the RID original schedule, but the construction has stagnated in progress since the beginning of 1981.

Principal points of difference between the plan by RID and the proposed plan by the Survey Team are as follows;

The proposed plan provides the specific features as;

- five-meter reduction of retention water level, high (flood) water level and dam top level.
- about 12 m lower of foundation level on an average at each damsite.
- accordingly, about seven meters addition of dam height.
- more foundation treatments to be considered.
- zoned earth fill to be considered as the dam type.
- river outlet works to be considered at the main dam, etc.

These details are shown in Table 3-15.

Table 3-15 Comparison Between RID Original and Proposed Plan on Mae Kuang Dam and Canals

Item	RID Original	Proposed Plan
1 General Items		
Location of the Dam	On the Mae Kuang, upstream of Ban Wang Than, Amphoe Doi Saket, Changwat Chiang Mai	Ditto
Catchment Area	565 sq.km	569 sq.km
Reservoir Area	9,400 rai (15 04 sq km)	13.40 sq km (8,375 rai)
(Retention Level) Elevation of Dam-top (1)	EL 400.00 m	EL 395 00 m
High (Flood) Water Level	EL 397.80 m	EL 392.80 m
Retention (full) Water Level	EL 395.00 m	EL 390.00 m
Low (Dead) Water Level	EL 345.00 m	EL 350 00 m
Elevation of River Bed	EL 337 0 m+	EL 337 0 m+
Storage Capacity at H W.L	404 MCM	363 MCM
R W.L.	397 MCM	325 MCM
L W L	5.6 MCM	14 MCM
Effective Storage Capacity	393.4 MCM	311 MCM
Forecasted Sediment	(27 4 MCM) in 500 yrs)	14 MCM in 100 yrs
2 Left Saddle Dam		
Type of the Dam	Earth Fill Dam	Zoned Earth Fill Dam
Foundation Level (2)	EL 353 m (Stripped base)	EL 343 (Trenched base)
Dam Height ((1) - (2))	47 m	52 m
Length of the Dam-top	670 m approx.	650 m
Width of Excavated Valley	350 m approx.	330 m approx.
Width of the Dam-top	10 m	10 m
Upstream Slope of the Dam	1.2.5 - 1 3 0	1:3.0
Downstream Slope of the Dam	1·2 5	1 2.5
Dam Volume	2,152,900 cu.m	2,258,000 cu m
Consolidation Grouting	None	8 rows x 15-17 m
Curtain Grouting	1 row x 36m max. (26.8 MB)	5 rows x 37m max.
Blanket Grouting	2 row x 6m	None
Name of the Outlet	Left Saddle Canal Outlet	Ditto
Maximum Discharge	25 or 33 cu.m/sec	9 14 cu m/sec
Size of the Outlet	ø3.0m x 300m (total 310m)	
Elevation of the Outlet base	EL 350.00 m	Ditto
Type & Size of the Gates	Not clear	1 5m x 1 5m HPG 2 sets
Type of Hydro-Stilling	Not clear	Stilling Basin Type II
Tail Water Level	Not clear	EL 350±
Construction Period	2521 (1978) - 2526(1983)	2521(1978) - 2527(1984)
Form of Execution	Force Account	Ditto
3 Main Dam		
Type of the Dam	Earth Fill Dam	Zoned Fill Dam
Foundation Level (2)	EL 333 m (Stripped base)	EL 318 m (Trenched based)

Item	RID Original	Proposed Plan
Dam Height ((1) - (2))	67 m	77 m
Length of the Dam-top	640 m approx.	645 m
Width of Excavated Valley	400 m approx.	380 m
Width of the Dam-top	10 m	10 m
Upstream Slope of the Dam	1:3.0	1:2.7
Downstream Slope of the Dam	1:2.5	1:2.2
Dam Volume	6,070,560 cu.m	5,576,000 cu.m
Consolidation Grouting	None	None
Curtain Grouting	1 row (13.6 MB)	3 rows x 50m max.
Blanket Grouting	None	4 rows x 15-22m
Name of the Outlet		River Outlet
Maximum Discharge		6.29 cu.m/sec
Size of the Outlet		ø2.2m x 300m
Elevation of the outlet base	None	EL 338.00 m
Type & Size of the Gate		1.5m x 1.5m HPG 2 sets
Type of Hydro-Stilling		Stilling Basin Type II
Tail Water Level		EL 338 m±
Construction Period	2527(1984) - 2528(1985)	2526(1983) - 2531(1988)
Form of Execution	Force Account	Ditto
4 Right Saddle Dam		
Type of the Dam	Earth Fill Dam	Zoned Earth Fill Dam
Foundation Level (2)	EL 363 m (Stripped base)	EL 354 m (Trenched base
Dam Height ((1) - (2))	37 m	41 m
Length of the Dam-top	680 m approx	655 m
Width of Excavated Valley	360 m approx	360 m approx
Width of the Dam-top	10 m	8 m
Upstream Slope of the Dam	1:3.0	1:3.0
Downstream Slope of the Dam	1:2.5	1:2.5
Dam Volume	1,690,000 cu.m	1,439,000 cu.m
Consolidation Grouting	None	None
Curtain Grouting	1 row (19.8 MB)	5 rows x 32m max
Blanket Grouting	None	4 rows x 15-17 m
Name of the Outlet	Right Saddle Canal Outlet	Ditto
Maximum Discharge	5.50 cu.m/sec	1.30 cu.m/sec
Size of the Outlet	ø1.8m x 260m (total 320m)	ø1.0m x 245m
Elevation of the Outlet base	EL 350.30 m	EL 350.00 m
Type & Size of the Gates	1.5m x 1.5m HPG 2 sets	1.0m x 1.0m HPG 2 sets
Type of Hydro-Stilling	Stilling Basin Type II	Ditto
Tail Water Level	EL 350±	Ditto
Construction Period	2526(1983) - 2527(1985)	2527(1984) - 2531(1988)
Form of Execution	Force Account	Ditto
5. Spillway		
Type of Spillway	Gateless Chute Type	Gateless Chute Type with Jet Flow Flip

Item	RID Original	Proposed Plan
Design Flood Inflow	2,300 cu.m/sec (500 yrs)	1,968 cu.m/sec (P.M.F.)
Design Flood Overflow	1,730 cu.m/sec	1,452 cu.m/sec
Length of Weir	200 m	150 m
Elevation of Sill-top	EL 395.00 m	EL 390.00 m
High Water Level	EL 397.80 m	EL 392.80 m
Design Head of Overflow	2.80 m	2.80 m
Width of the Chute	Not Clear	150m - 40m
Length of the Chute	Not Clear	350 m approx.
Length of the Tail Race	Not Clear	300 m approx.
Type of Hydro-Stilling	Not Clear	Jet Flip into Stilling Basin Type
Construction Period	1984 (2527)	2527(1984) - 2530(1987)
Form of Execution	Force Account	Ditto
Main Canal		
Canal Type	Trapezoidal Cross Section Concrete Lining	Trapezoidal Cross Section Concrete Lining
Length	Left Main Canal about 72 km Right Main Canal. about 15 km	Left Main Canal: about 72 km Right Main Canal. about 15 km
Longitudinal Slope of Canal	Left Main Canal 1. 8,000 Right Main Canal. 1 10,000	Left Main Canal 1: 8,000 Right Main Canal: 1:10,000
Service Area	Left Main Canal 20,000 ha Right Main Canal 2,880 ha Existing Canal: 13,000 ha Total 35,880 ha (224,250 rai)	Left Main Canal. 10,800 ha Right Main Canal 2,200 Existing Canal 7,000 ha Total 20,000 ha (125,000 rai)
Water requirement	0.001 cu.m/sec/ha = 0 00016 cu m/sec/rai or Relation of Canal Capacity to Irrigated Area on Kew Lom Project	Left Main Canal· 0.001 cu m/sec/ha = 0 00016 cu.m/sec/rai Right Main Canal 0 0007 cu m/sec/ha = 0 000112 cu m/sec/rai
Design Discharge	Left Main Canal. 20.000 cu m/sec Light Main Canal. 5.601 cu.m/sec Existing Canal: 13.000 cu.m/sec	Left Main Canal 10.800 cu.m/sec Right Main Canal 1.540 cu m/sec Existing Canal 7.000 cu.m/sec

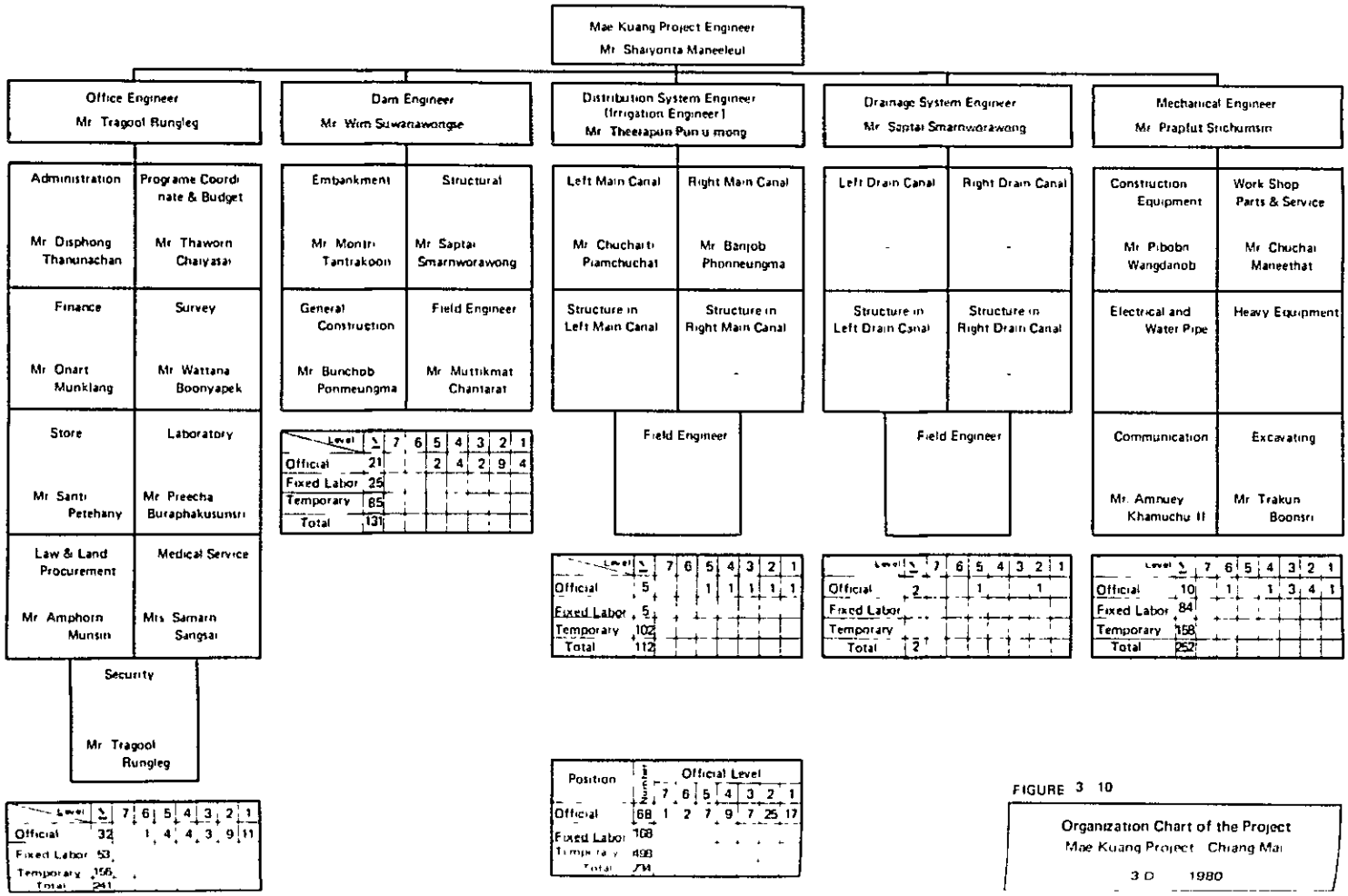


FIGURE 3 10

Organization Chart of the Project
Mae Kuang Project Chiang Mai
3 D 1980

3.8 Related Activities to the Project

3.8.1 Outline of the related Project

a) Resettlement Project[1/]

By the construction of the Mae Kuang dam, about 1,500 ha (9,400 rai) of forest and farm land will be submerged, and their descriptions are as follows:

- Farm lands and residence lot:	about	246 ha (1,540 rai)
- Forests and Others:	about	1,254 ha (7,860 rai)

Families	* having both house and land:	188 families
	* having only the land:	47 families
	* having only house:	34 families
	Total:	269 families
Population (in nine villages)		
	* Male:	492 persons
	* Female:	471 persons
	Total:	963 persons
Others	* Temples:	2
	* Irrigation systems:	2

In order to consolidate the new land for those farmers, the RID commenced the construction on the basis of the articles resolved by the Office of the Prime Minister on October 19, 1977. The new land for resettlement is one of the national reservation forest (Sansai Forest) of about 560 ha (3,500 rai), of which permission for resettlement was granted by the Department of Forestry.

1/ Land Consolidation Project for Emigration Farmers Living in the Submerged Mae Kuang Reservoir, Amphoe Doi Saket, Changwat Chiang Mai.

This land consolidation project has the following features,

1) Purpose

- to emigrate about 270 families in the Mae Kuang Reservoir area and to live in the new land in 1982.
- to set the land with necessary public services such as: schools, temples, roads, drinking water, irrigation water.
- to set the appropriate system of profession/occupation for the people.

2) Operation

- Land Provision for each family

Residence lot:	0.16 ha (1.0 rai)
Farm land:	0.96 ha (6.0 rai)
Forest:	0.16 ha (1.0 rai)
Total:	1.28 ha (8.0 rai)

- Road: about 50 km
- Water resources

Huai Hug Dam:

Capacity:	0.6 MCM
Dam height:	15 m
Crest length:	200 m

Huai Kiang Dam:

Capacity:	0.4 MCM
Dam height:	17 m
Crest length:	185 m

- Provision of schools and temples

3) Improvement of living standard and encouragement of professional and occupations practices.

The Royal Irrigation Department will:

i) ask for the cooperation from the governmental agencies concerned in assisting and advising people about professional/occupational opportunities,

ii) arrange a plan to improve and encourage the peoples' practice of profession.

iii) suggest and encourage the method of cooperative, and persuade people, who is going to get the land, to establish a cooperative in agriculture.

4) Right on the land

People who are entitled to the land shall have only the right to live and earn their livelihood throughout their life but they cannot transfer the right to others except through inheritance within the immediate family member.

5) Effect

It is hoped that this provision of land by the Project shall help each family to earn about 1,200 Baht per rai.

b) Mae Faek Irrigation Project

The Mae Faek Irrigation Project, which is the oldest of the neighboring four projects, Mae Taeng, Mae Faek, Mae Ping Khao and Mae Kuang, was constructed in the periods of 1928 to 1936 (BE. 2471-2479) to provide supplementary wet season irrigation to a gross area of 12,320 ha (77,000 rai), of which 11,200 ha (70,000 rai) is irrigable land.

The project consists of a diversion weir located on the Mae Ping river immediately upstream of the Mae Taeng - Mae Ping confluence, a head regulator with sluice, 12.35 cu.m/sec capacity, 36 km long main canals and 17 km laterals. The lower reach of the Mae Faek canal is connected with the Mae Kuang canal as spillway.

All of these facilities, at present, are forced to be rehabilitated for efficient year-round irrigation, this is, increasing main canal capacity and installation of water control strcutures.

c) Upper Ping River Basin Water Resources and Development Programme

Engineering Consultants, Inc. in association with Dr. Rachot Kanjanavanit & Associates (ECI) were commissioned to undertake the following studies by the Government of the Kingdom of Thailand, as represented by the Water Resources Subcommittee of the National Economic and Social Development Board, the Electricity Generating Authority of Thailand and the Royal Irrigation Department in August 1978.

- identify all major potential water resource projects on the Mae Taeng, Mae Ping, Mae Ngat and Mae Kuand rivers at pre-feasibility level
- assess their social and economic impacts
- assess alternative development option on these four tributaries, recommend how they may be integrated with existing developments and outline the principal inter-relationships between the separate projects from the point of view of power, streamflow regulation, flood control, navigation, irrigatoin and socio-economic condition
- identify all major potential water resource projects on the other tributaries in the basin at desk study level
- determine the magnitude and principal effects of total water resource development on energy production at Bhumiphol Dam
- identify and preliminary assess the principal environmental effects of development of the basin's water resource
- develop a preliminary ranking of planning studies and project implementation

- assess the technical effectiveness of the Peoples' Irrigation Scheme and make recommendations on its future execution

- identify and assess the principle effects of deforestation in the basin on river regimes above Bhumiphol Dam

- assess the effect of river-bed accretion in the Chiang Mai-Lumphun area and make recommendations on any required river training projects and/or further studies.

The ECI prepared a report under the title of "Potential Water Resources and Development Programs for Upper Ping River Basin, August 1978". A comprehensive study was made in the report covering various aspects involved in the basin development as follows;

- Water resources
- Geology
- Agriculture and irrigation
- Evaluation of private irrigation systems
- Municipal and industrial water supply
- Flood control
- River training
- Power
- Navigation
- Environmental considerations
- Basin planning
- Cost estimates
- Economic evaluations

The ECI report presents useful information in respective fields of the study.

d) Mae Ngat Project

Mae Ngat is one of the main tributaries of the Upper Ping River, located in Amphoe Phrao, Changwat Chiang Mai. The Mae Ngat Project is proposed to be constructed as a storage dam. In planning the Mae

Ngat Project, RID has taken into account not only the irrigation development but also forest land conservation, fisheries, tour business and flood control.

The Mae Ngat Project consists of dam, spillway, river outlets, emergency spillway, canal outlets on the left and right banks including the distribution and drainage systems. Power and transmission systems will be constructed and the right bank distribution system will also be constructed to connect with the Mae Taeng Project. Project data are outlined below.

1) Hydrometeorological Features

Catchment area above damsite:	1,281 sq.km
Average annual rainfall:	1,350 mm
Mean discharge:	13.19 cu.m/sec
Average yield:	406 MCM
Peak volume measured:	503 cu.m/sec (August 24, 1973)
Peak design discharge:	1,570 cu.m/sec

2) Dam and Reservoir

Type of dam:	Zoned-earthfill
Crest elevation:	+404.00m
Dam height:	59 m
Crest length:	1,950 m
Crest width:	9 m
Base width:	339 m
Total volume of dam:	6,607,000 cu.m
Earth:	6,000,000 cu.m
Rock:	607,000 cu.m
Maximum water level	+ 400.00 m
Retention level:	+ 396.00 m
Dead storage level:	+ 360.50 MCM
Res. capacity at maximum water level	325 MCM
Res. capacity at retention level	265 MCM
Sediment storage:	10 MCM

Active storage:	255 MCM
Available drawdown:	35.50 m
Average annual inflow:	406 MCM
Water surface area at retention level	16 sq.km

3) Service Spillway

Type: Chute spillway, reinforcement concrete	
	4.00 x 41.00 x 191.70 m
Maximum discharge:	1,035 cu.m/sec
Spillway gate:	3 radial gates
	12.50 m wide x 5.00 m high
Reinforcement concrete bridge	H 20 -s 16 - 44 loading
	9.00 x 41.00 m

4) River Outlet

Type: Reinforcement concrete conduit with steel liner	
Dimension:	I.D. 2.50 x 295 m long
High pressure gate:	1.50 x 1.50 m
Maximum discharge:	47 cu.m/sec

5) Emergency Spillway

Type: Reinforcement concrete weir, crest length 120 m	
Excavated channel:	120.00m wide x 2.50m deep x 2,500.00m long
Maximum discharge:	535 cu.m/sec

6) Left Canal Outlet

Type: Reinforcement concrete conduit with steel liner	
Dimension:	I.D. 0.80 x 380m long
Maximum discharge:	3.8 cu.m/sec

7) Right Canal Outlet

Type: Reinforcement concrete conduit with steel liner	
Dimension:	I.D. 0.80 x 200m long
Maximum discharge:	4.27 cu.m/sec

9) Hydro-Electric Works

Intake conduit:	I.D. 2.50m
Generator	3-5 megawatts (24.50 million kilowatt-hours year)
Turbine discharge:	15 cu.m/sec at EL + 390.00

9) Distribution and Drainage Systems

Command area:	30,000 rai
Length of 2 main canals:	26.30 km
Length of 11 lateral and tertiary canals	33.65 km
Total length of all 13 canals	59.95 km

e) Kud Multipurpose Project

The Feasibility Study for Kud Multipurpose Project was prepared by Electroconsult Engineering, Switzerland (ELC) in association with Southeast Asia Technology Co. Ltd., Kingdom of Thailand (SEATEC) in 1981. The Project may cover the following study items;

- review and evaluation of existing data and previous studies of Upper Ping river
- identification of alternatives through investigation of irrigation and agriculture items in the proposed development area
- optimization and selection of the most desirable solution and definition
- development of selected design at feasibility level and analysis and computation for power and irrigation costs and benefits
- assessing and documenting the environmental and social impact of the Project
- to carry out economic and financial analysis

The studies concluded as follows;

- the Mae Taeng river can be safely and conveniently dammed at the Sop Kai site using a rockfill dam to impound 450 MCM of water. This may be regulated to irrigate 38,100 ha (238,000 rai) all year round with a cropping intensity of 200 percent, incorporating 25 - 35 percent transplanted rice in the dry-season crop mix.

- operation of the Sop Kai reservoir will reduce flood damage in the Chiang Mai plain by 34 percent.

- installed generating capacity of the Kud powerhouse will be 67 MW, yielding 240 GWh/year of firm energy plus 26 GWh/year secondary energy. Yearly average plant factor will be 0.41 and minimum monthly plant factor 0.25.

- it is proposed to devote waters regulated by the Sop Kai reservoir to the Irrigation of lands as below.

Mae Taeng sub-area	23,000 ha (144,000 rai)
Mae Faek sub-area	1,900 ha (12,000 rai)
People's Area	7,400 ha (46,000 rai)
Mae Kuang sub-area	3,200 ha (20,000 rai)
Mae Kuang extension	2,600 ha (16,000 rai)
Total	38,100 ha (238,000 rai)

f) Freshwater Fisheries

Consumption of fish meat in the Project area on the capita basis is said to be below that of most other areas in Thailand. This appears to be due to an inadequate local supply system.

Without Project, the present relatively low annual per capita consumption of fishment in the Project Area is expected to remain unchanged. In the Project Area, an increasing demand will result from population growth, and could probably be supplied from more intensive use of existing water resources within the Project Area.

With Project, the water resources available for freshwater fisheries development will increase in the Project Area, year by year. The Mae Kuang reservoir is the largest and the most important water resources in the area. Also the main and secondary irrigation canals will be usable for freshwater fisheries. If the existing ponds for fish culture widely distributed in various places in the area are improved and the construction of new ponds is promoted, the water resources for fish culture are expected to be increased remarkably in production. As a result, fish will become continuously available not only in the Project Area, but also in the major consuming areas around the Project Area including Chiang Mai city.

According to the Chiang Mai Inland Fisheries Station, in the waters of the Mae Ping flowing down along the Project Area more than 70 species of native fish are seen. Such species of the fish are said to be seen also in the Mae Kuang river. It is desirable to promote experiments and researches concerned with local species, as well as the related surveys and investigations on freshwater fisheries' development.

3.8.2. Outstanding Issue for Planning of the Project

As a result of the Kud Multipurpose Project study, it appeared that after the completion of Mae Ngat and Kud Reservoirs, there would be a surplus of flow in the Mae Ping at a probable rate of 11.2 cu.m/sec.

RID decided to allocate directly this flow to supply the lower end of the existing Mae Faek and Mae Kuang areas. The Mae Kuang Project Area fed by the diversion dam on the Mae Ping at San Pi Sua would be 3,168 ha in the Existing Irrigated Area and 2,592 ha in the Downstream Area or 5,760 ha in total. The deducted area was excluded from the original Mae Kuang Project Area as a result of the second stage survey.

CHAPTER IV THE PROJECT

CHAPTER IV THE PROJECT

4.1 Objectives and Components of the Project

4.1.1 Objectives

Thailand has achieved a steady economic development since launched the First Economic and Social Development Plan in 1961. Actually, the national economic growth has resulted in US Dollars 199 in the nominal gross domestic products per capita in 1970 and US Dollars 603 in 1979 which tripled that in 1970. However, the gross products per capita greatly differ by regions in Thailand. For instance, the said value in the North Thailand inclusive of the Project Area was US Dollars 439 in 1979, which is converted into 73 percent of the national average and also into only 29 percent of US Dollar 1,508 for the metropolitan zone. About 73 percent of the total population of Thailand lives in rural areas and is engaged in agriculture. Under the situation, an increase in agricultural production will be prerequisite to upgrade the living standard of the people.

Apart from the above, the agricultural development through expanding farm lands has already reached the very limit of development in country. With the understanding of the situations, it has been generally accepted as one of the urgent necessities to increase the productivity of the existing farm lands by introducing the irrigated agriculture.

The Mae Kuang Irrigated Agriculture Development Project was taken up to supply irrigation water to both the Existing irrigated areas by the Mae Kuang diversion weir and the rainfed areas for correcting the disparity in land use and agricultural income between the said two areas through increasing the land productivity and the agricultural income. RID has started the force account basis construction of the irrigation facilities for the Project since 1976.

Blessed with natural conditions such as soil, climate and topography, the Project Area has a great agricultural potentiality It is considered that the agriculture with a high land productivity will be materialized if adequate irrigation facilities are provided

The Project aims i) to intensify the land use and increase the agricultural production through the water resources development by constructing the Mae Kuang dam, ii) to create the employment opportunities throughout the year for farmers in and around the Project Area, and iii) to improve the farm lands for stable production and the living environment for a better living standard of farmers by constructing of irrigation and drainage facilities and road networks together with strengtnening the agricultural extension services.

To attain the objectives of the Project, the following works shall be executed;

i) To construct Mae Kuang dam and the related facilites;

ii) To intensify the land use by introducing high yielding varieties of paddy in the wet season and cash crops in the dry season; and,

iii) To establish farmers' organizations and to strengthen the agricultural extension services.

4.1.2 Project Components

The Project includes the components as follows:

Irrigated Agricutlrue:

To introduce the irrigated agriculture supported by water source facilities, irrigation and drainage canals, roads, and fully organized agricultural extension services.

Flood Control:

To control floods in the Mae Kuang river basin through the operation of the Mae Kuang dam, specially for reducing the flood damage in the lower basin.

Hydropower Generation:

To generate hydropower by utilizing a water head at the Mae Kuang dam.

4.2 Plan Formulation

4.2.1 Land Use Plan

The Project has the gross area of about 37,270 ha, out of which about 20,000 ha is the arable land, and about 17,270 is non-arable lands such as residential area, right-of-ways for the proposed sites of the Project facilities, etc.

The whole arable land will be fully irrigated by gravity in both the wet and the dry seasons. Taking into consideration the limited land area and water resources and a relatively high population density in the Project Area, the land use plan was formulated to satisfy the following requirements,

i) To make the cropping intensity higher with irrigation through the intensive farming; and,

ii) To increase the upland cropping ratio in the dry season rather than paddy cropping ratio in order to irrigate the maximum possible area with limited water resources.

The following table indicates the proposed land use in the project.

Proposed Land Use (Wet Season)

(Unit: ha)

Land Category	Right Bank Area	Existing Irrigated Area	Left Bank Highland and Downstream Area	Total
1. Arable land				
Paddy fields	720	7,000	9,630	17,350
Upland fields	1,480	-	1,170	2,650
Sub-total	2,200	7,000	10,800	20,000
2. Non-arable land	870	7,930	8,470	17,270
Total	3,070	14,930	19,270	37,270

In the entire paddy fields, paddy (glutinous and/or non-glutinous) cultivation is planned in the wet season and also mostly paddy (non-glutinous) cultivation within the limit of irrigation water in the dry season. Besides, such crops in high demand or with high profitability as groundnut, soybean, tobacco, etc., are introduced in taking into account the land conditions.

On the other hand, in the upland fields are proposed to be planted with short-period crops and fruit trees. Double cropping pattern is proposed with one cropping each in the wet and dry seasons except for orchard areas. At a certain limited places within the Project Area triple cropping is practiced at present. However, a triple cropping is a subject to be studied in future when distribution of labours is reviewed, and not taken up as techniques applicable at present.

With such cropping pattern as mentioned above, the cropping intensity in the Project is calculated at 200 percent, excluding orchard areas, whereas 197 percent including orchard areas. Together with introducing double cropping pattern, plowing and mixing of organic matter are required to retain the fertility of the soils

4.2.2 Optimum Scale of Development Plan

An optimum scale of the development plan had been studied in relation to the land use plan as well as the cropping pattern and the available water resources during the First Stage Survey. Namely, the water balance computation on the reservoir had been conducted in considering the water demand derived from the cropping pattern and the reservoir inflow. In this study, four cases in reservoir size and six cases in irrigation demand or 24 cases in total were selected Among the 24 cases, the water balance computation was made only for 12 cases (see Appendix E 1-1).

Taking into account the modification of the Project Area in connection with the Kud Multipurpose Project, the water balance

computations on the reservoir have been carried out for four additional cases basing upon the final cropping pattern. Further details are described in sub-section 4.2.5 - Reservoir Plan. As a result of the study, the optimum scale has been determined as follows:

Reservoir storage capacity	325 MCM
Effective storage capacity	311 MCM
Irrigable area	20,000 ha
Annual average irrigation demand	229 MCM

Besides the irrigation plan, flood control and hydropower generation plans are also incidentally incorporated in this Project but exert no influence to the scale of the development plan.

4.2.3 Development Plan

The whole development scale was determiend as stated in the previous sub-section. The Project Area can be divided into three sub-areas. Corresponding to a water intake and an irrigation system to the sub-areas, three alternatives have been proposed as shown in Figure 4-21.

A hydropower generation plan in details will be separately studied in conformity with the irrigation plan. The careful study focusing to the irrigation plan, therefore, has resulted in that the alternative-2 would be the most economical. The details are presented in sub-section 4.4.2 a) - Proposed Irrigation Canal.

The following table gives merits and demerits for each alternative plan.

Alternative Plan	Merits	Demerits
Plan-1		Annual production of hydro-power is the lowest among three alternative plans
Plan-2	Canal construction cost is lower than that of Alternative Plan-3 by the amount of 24 million Baht	
Plan-3	Annual production of hydro-power is the highest amoung these of the three alternative plans	Canal construction cost is higher than that of the Alternative Plan-2 by the amounts of 24 million Baht, and the existing Pha Teak main canal is requested to be rehabilitated

Based upon the above studies, alternative Plan-2 has been proposed as the project development plan. In case of this plan, the existing Mae Kuang diversion dam, intake gates and main irrigation canals will be used as they are, even after the project, althouth some improvements of such irrigation facilities will be needed.

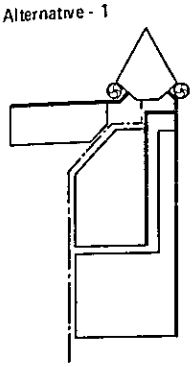
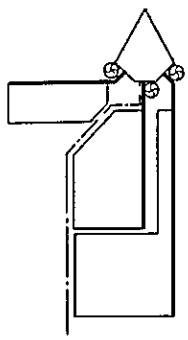
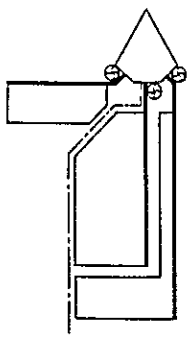
4.2.4 Irrigation Plan

a) Irrigation Area and Cropping Pattern

(1) Irrigation Area

The proposed irrigation areas covered by the Mae Kuang reservoir are decided at 20,000 ha, out of the gross Project Area of about 37,300 ha, based upon the field survey and collected data, and these areas are classified into following three areas in terms of topography as well as the proposed irrigation networks.

FIGURE 4-1 ALTERNATIVE DEVELOPMENT PLAN OF THE PROJECT

Alternatives	Dimension of Plan
Alternative - 1 	a) Area Right Bank Area 2,200 ha Existing Irrigated Area 7,000 ha Left Bank Highland and Downstream Area 10,800 ha b) Number of Intake . 2 place Intake Discharge 1/ - Right Main Canal 1 30 cu m/sec - Existing Main Canal — - Left Main Canal 15.41 cu m/sec c) Hydro-power - Installed Capacity : 3,070 KW - Annual Production . 13,905 MWh
Alternative - 2 	a) Area Right Bank Area · 2,200 ha Existing Irrigated Area : 7,000 ha Left Bank Highland and Downstream Area 10,800 ha b) Number of Intake 3 place Intake Discharge - Right Main Canal : 1 30 cu m/sec - Existing Main Canal 6 29 cu m/sec - Left Main Canal 9 14 cu m/sec c) Hydro-power - Installed Capacity · 3,690 KW - Annual Production : 16,299 MWh
Alternative - 3 	a) Area Right Bank Area 2,200 ha Existing Irrigated Area 14,150 ha Left Bank Highland and Downstream Area 3,650 ha b) Number of Intake : 3 place Intake Discharge - Right Main Canal 1 30 cu m/sec - Existing Main Canal . 12 31 cu m/sec - Left Main Canal . 3 10 cu m/sec c) Hydro-power - Installed Capacity · 4,200 KW - Annual Production : 18,482 MWh

Note. 1/ See Appendix D - 2

Right Bank Area:	2,200 ha
Existing Irrigated Area:	7,000 ha
Left Bank Area and Downstream Area:	10,800 ha
Total	20,000 ha

(2) Cropping Pattern

In the preliminary study on the Mae Kuang Irrigated Agriculture Development Project of which the major objectives are to decide an optimum scale of the Mae Kuang reservoir, the optimum irrigation demand in the normal year has been estimated at about 229 MCM based on the tentative cropping pattern (See Appendix D-3). Taking these into consideration, four cases of alternative studies for determining the proposed cropping pattern were made.

The alternative cropping patterns are formulated in proportion to the dry season paddy areas as shown in Table 4-1. As the results, the Case-4, having 2,500 ha of the dry season paddy field equivalent to 12.5 percent of the Project Area, is recommended as the proposed cropping pattern for the project with the required irrigation demand of about 229.5 MCM on an average for which detailed descriptions will be given in the subsequent paragraph. Figure 4-2 shows the proposed cropping pattern with cropping intensity of 197 percent, which was prepared for the estimation of irrigation water requirements.

b) Irrigation Water Requirements

(1) Potential Evapotranspiration

Reference crop potential evapotranspiration (ETPc), generally recognized as fairly reliable index in calculating consumptive use, can be determined by a number of methods, such as the evaporation measurement with evaporation pan and the application of empirical formula based on the climatological data. In the project, the monthly evapotranspiration was estimated as shown below, by applying

the modified Penman Method, based on the climatological data observed at Chiang Mai station.

Potential Evapotranspiration

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total
LTPc (mm/ month)	105	134	158	168	171	138	136	119	121	125	110	95	1,580
(mm/ day)	3.38	4.80	5.09	5.61	5.53	4.59	4.37	3.85	4.04	4.04	3.68	3.05	4.33

Note: Detailed estimation is given in Appendix D-4.

(2) Consumptive Use

The consumptive use of crops (actual evapotranspiration, (ETa)) can be estimated by multiplying the estimated LTPc values by crop coefficients which express the relationship between the reference crop potential and the actual evapotranspiration during the vegetative stage of the crops. Table 4-2 gives coefficients adopted for the estimation of the consumptive use.

The consumptive use of the crops is estimated by the above procedure mentioned on the daily basis, as shown in Table 4-3.

(3) Crop Water Requirement

Crop water requirement on the monthly basis is estimated based on the proposed cropping pattern. In this estimation, the following values are accounted:

- Percolation rates in the paddy field are decided at 1.5 mm/day throughout the growing period of the paddy in the project. Percolation rates were measured at 11 sites in the existing paddy fields in accordance with the soil classification, and it was found out that average percolation rates are estimated at 1.5 mm/day (see Appendix D-5)

- Additional water supply for land soaking for nursery bed and land preparation:

Item	Wet Season Rice (mm)	Dry Season Rice (mm)
Nursery bed	400	450
Land preparation[1/]	200	230

1/ See Appendix D-6

The estimated crop water requirement for each crop is shown as follows:

Rice		
Wet season rice	:	1,037 mm
Dry season rice	:	1,007 mm
Corn:	:	360 mm
Soybean (1) Groundnut (1)	:	437 mm
Soybean (2)	:	394 mm
Groundnut (2)	:	351 mm
Tobacco (1)	:	249 mm
Tobacco (2)	:	301 mm
Longan	:	1,093 mm

(4) Diversion Water Requirement

Diversion water requirement will be calculated by adding effective rainfall and water losses to the crop water requirement. There are several rainfall stations in and around the Project Area as shown in Figure 3-3. Out of these rainfall stations, the rainfall observed at Doi Saket, San Kamphaeng, Lamphun, and Mae Tha has been used for the estimation of the weighted rainfall by means of the Thiessen Method. The percentage of the Thiessen polygon is as follows: Doi Saket 0.3250, San Kamphaeng 0.4983, Lamphun 0.1667 and Mae Tha 0.0100

The criteria of the effective rainfall and irrigation efficiency used for the estimation are as follows:

Effective Rainfall

Rainfall (R) (mm)	Effective Rainfall (ER)
0 - 10	0
11 - 100	R x 0.80
101 - 200	R x 0.70
201 - 250	R x 0.60
251 - 300	R x 0.55
301 - up	R x 0.50

Note. One of the methods used for RID Projects.

Irrigation Efficiency

Application efficiency:	0.80
Canal efficiency:	0.81
- Conveyance losses:	0.10
- Operation losses:	0.10

Based upon the above procedures, monthly diversion water requirements of 28 years (1952 - 1979) have been estimated for the whole Project Area and each sub-Project Area (See Appendix D-7). Tables 4-4 and 4-5 indicate the results of estimated diversion water requirement in the design year having the return period of 10-year and normal year.

In the estimation of diversion water requirement, no allowance is made for return flows, which probably enter the conveyance system below the major diversion points. This fact leads to the conservative assumption.

For the study on the possibility of return flows in the paddy fields, an area of about 1,000 ha located in the most downstream of the existing irrigated area covered by the Pha Teak irrigation canal, has been selected as a sample area, and the water balance in the area in consideration of inflow and outflow discharges, rainfalls and evapotranspiration in the area has been studied (see Appendix D-8).

According to the study, the return flow ratio has been calculated at the ranges of 20 to 30 percent at present conditions, however, return flows are not taken into account for water balance studies in the project as mentioned above, due to the following reasons, that is, the Project Area is formed to be long and narrow shape in topography with a land slope in a direction of short side and the main irrigation canal will be aligned along the long side. Under the conditions, it will be considered that the possibility of return flow is deemed to be small in the project, from the viewpoint of topography.

c) Design Discharge for Planning of Irrigatoin Canal

(1) Main and Lateral Canal

On the basis of water balance studies for the period of 28 years, 1952 to 1979, the monthly peak discharges corresponding to the third from the highest amounts during the years, which is equivalent to the return period of about 10-year, are tabulated in each sub-project area as shown in Table 4-6, and irrigation water requirement per hectare are estimated by dividing monthly water requirement by monthly cropping areas. As a result, it is revealed that the peak discharge for the both areas of the existing irrigated area and Left Bank and Highland and Downstream Area, prevailing the wet season paddy rice, is calculated in the range of 0.938 lit/sec/ha to 0.943 lit/sec/ha, while the peak discharge of the right bank area is 0.616 lit/sec/ha.

Through the above-mentioned studies, the design discharges for main and lateral canals to meet the irrigation requirements for the return period of 10 years are decided at 1.00 lit/sec/ha for the former area and 0.70 lit/sec/ha for the latter area.

(2) Terminal Irrigation Canals

For the terminal irrigation canals at on-farm level of which construction is not included in the project cost, however, the design discharge of these canals is studied as the referrence.

Terminal irrigation canals should be designed based on the maximum irrigation water requirement to meet the paddy cultivation. Water requirements of the paddy are calculated in the criteria of 10-day interval, and the maximum irrigation water requirement in the both stages of land preparation and crop maintenance are summarized as follows:

Maximum Irrigation Water Requirements

Item	Wet Season Paddy		Dry Season Paddy	
	C.W.R.1/ (mm/day)	I.W.R.2/ (ℓ/sec/ha)	C.W.R. (mm/day)	I.W.R (ℓ/sec/ha)
Land preparation stage	5 71	1.02	10.00	1 79
Crop maintenance stage	6.08	I.09	8.68	I.55

Note: 1/ Crop Water Requirement

2/ Irrigation Water Requirement

Detailed estimations are given in Figure D 9-1 of Appendix D-9.

From the results of the above estimation, the irrigation water requirements in case of the dry season paddy is much higher than those of the wet season paddy, so that the terminal irrigation canals are to be designed based on the maximum irrigation water requirement of the dry season paddy. The canal capacities, furthermore, will be decided by the unit water requirement of 1.55 lit/sec/ha corresponding to those of crop maintenance stage, and those of land preparation stage will be conveyed with the total canal depth including canal freeboard.

d) Depth and Interval of Irrigation Application for Upland Crops

(1) Measurement of Intake Rate

During the field survey, intake rate measurements were made at five sites in the Project Area (see Figure D 10-1, Appendix D-10). two sites in the existing irrigated area, one site in the downstream area and two sites in the right bank area, under dry and wet conditions, in order to pursue an adequate irrigation method and water

amounts to be applied to the crop. The dry conditions mean existing conditions of the field without any water supply and the wet conditions mean the field keeping the water holding capacity after 24 hours of soil saturation.

To measure the intake rate, a cylinder infiltrometer was used and the reading of the water depth within the cylinder was made at the interval of every five to 10 minutes at the initial stage and 30 minute intervals from one hour later.

Results of intake rate measurements are plotted on a logarithmic paper (see Figure D 10-2 to Figure D 10-6, Appendix D-10). Usually, the intake rate plotted against time on logarithmic scale shows a straight line, and therefore, can be presented by the equation of $D = CT^n$. When the observation of intake rate extends over long time, a better representation of the data can usually be obtained by using the equation of $D = CT^n + b$ Since n is negative, an accumulative intake rate (ΣD) decreases with an increase in time of T. Therefore, the intake rate (D) will approach a constant value of b as time increase. Generally, the intake does approach a constant rate, which will be referred to as basic intake rate (Ibi). Caution should be observed in using the basic intake rate for irrigation design such as irrigation method.

The following table gives the obtained basic intake rate, based upon each observation of the intake rate.

Obtained Basic Intake Rate (Wet Conditions)

Observation	Location	Ibi (mm/hr)
No.1	Ban Luang Hua	0.48
No.2	Ban Mae Pong	1.47
No.3	Ban Huai Sai Nua	0.72
No.4	Ban Huai Som	1.19
No.5	Ban Phae	1.17
	Average	1.01

From the above figures, it could be considered in this stage that the furrow irrigation method would be suitable for water supply to the upland crops during the growing season of them, although further studies on upland irrigation will be needed.

In parallel with such measurements of the intake rate, soil samples in the depth of 50 cm with an interval of 10 cm depth were taken to analyze the physical properties of the soils in the field, such as specific gravity, porosity, field capacity, and wilting point.

The analysis results of soils under the wet conditions are summarized as follows:

Physical Properties of Soils[1/]

Depth (cm)	Real Specific Gravity (Sr) (g/cm³)	Apparent Specific Gravity (Sa) (g/cm³)	Porosity[2/] (P) (%)	Field Capacity (Fc) (%)	Wilting[3/] Point (Wp) (%)
10	2.63 (2.59)	1.29 (1.51)	50.8 (41.9)	33.9 (12.4)	16.2 (5.4)
20	2.66 (2.61)	1.39 (1.53)	47.8 (41.5)	31.9 (12.2)	15.1 (5.4)
30	2.67 (2.60)	1.40 (1.52)	47.3 (41.4)	33.7 (11.3)	16.1 (4.9)
40	2.68 (2.60)	1.41 (1.51)	47.6 (41.2)	34.1 (10.5)	16.3 (5.6)
50	2.68 (2.64)	1.39 (1.55)	48.0 (41.4)	37.3 (10.3)	17.9 (4.5)

Note: 1/ Average of five samples

2/ $P = (Sr - Sa) \times 100/Sr$

3/ $Wp = 0.36\ Fc^{1.08}$

( ) shows the figures for the right bank area

Detailed figures are given in lables D 10-7 and D 10-8 of Appendix D-10.

(2) Depth and Interval of Irrigation Application

Depth and interval of irrigation application are determined in the following procedure:

i) Determination an effective root zone

ii) Determination of a moisture extraction pattern

iii) Calculation of available moisture of each soil layer within the effective root zone

iv) Calculation of the total readily available moisture (TRAM), and

v) Determination of depth the depth and interval of irrigation application

i) Depth of Effective Root Zone

The depth of the effective root zone was determined on the basis of field survey and collected data on the root zone, and is shown below

Crops	Depth of Effective Root Zone (cm)
Corn, Groundnuts	50
Garlic, Soybeans, Vegetable	40
Tobacco	60

ii) Moisture Extraction Pattern

Consumptive use of vary depending on the depth of soil. This consumptive rate of soil moisture is the so-called "moisture extraction pattern" which will be determined based upon the field investigation.

Due to the lack of such data concerned, the following pattern was applied.

Percent of Depth (%)	Ratio of Moisture Extraction (%)
0 - 25	40
25 - 50	30
50 - 75	20
75 - 100	10

iii) Available Moisture in Each Soil Layer within Effective Root Zone

Available moisture (A.M.) is obtained from the following equation:

$$A.M. = \frac{1}{100} \cdot \Sigma(Fc - Wp) \cdot Sa \cdot d \ (mm)$$

Where:

Fc: Water holding capacity after 24 hours of soil saturation (%)

Wp: Moisture ratio at wilting point (%)

Sa: Apparent specific gravity (g/cm^3)

d: Depth of soil in each soil layer (mm)

iv) Total Readily Available Moisture (TRAM)

$$\text{In the soil layer concerned, Consumed Moisture} = \frac{\text{Available Moisture}}{\text{Ratio of Moisture Extraction}}$$

The layer presenting the minimum value obtained from the above equatioin is the restricting layer of moisture and its value becomes the total readily available moisture (TRAM), that is, the net amount of water to be replaced is given in the following table.

v) Interval of Irrigation Application

The interval of irrigation application is obtained by dividing the TRAM by the maximum crop evapotranspiration as shown below;

Estimated Irrigation Interval

Upland Crop	TRAM (mm)	Maximum Evapotranspiratioin	Irrigation Interval
Corn, Groundnuts	71.3 (32.8)	5.3	14 (6)
Garlic, Soybean, Vegetable	57.0 (26.3)	5.1	11 (5)
Tobacco	86.5 (32.8)	4.8	18 (6)

Note: ( ) shows figures in Right Bank Area
Detail calculation is given in Table D 10-1 to Table D 10-6 of Appendix D-10.

From the viewpoint of water management, the same interval of irrigation application is favorable, therefore, five-day and 10-day irrigation intervals are adopted for the existing and high and downstream area and right bank area, respectively.

4.2.5 Reservoir Plan

The reservoir simulation study has been conducted on four cases of reservoir sizes to find out an optimum reservoir capacity.

During the first stage survey, a preliminary study was conducted on 12 cases in irrigation demand (See Table E 1-1, Appendix E-1) and four cases in reservoir size or 48 cases in total combination. Out of the 48 cases, 28 cases were selected and simulated in this period.

In the period of the second stage survey, further studies were conducted on four cases in irrigation demand (see 4.2.4 Irrigation Plan) based on final irrigation plan.

a) Water Balance Study

A water balance study on the reservoir has been made with a unit interval of one month during 1952 to 1979. The data of this study are as follows:

Reservoir Size

The reservoir size is determined to be 325 MCM in the First Stage Survey (see Table E 1-1, Appendix E-1). Major dimensions are as below:

Retention Water Level	EL. 390 m
Low Water Level	EL. 350 m
Total Storage Capacity	325 MCM
Effective Storage Capacity	311 MCM

Capacity and Area Curves of Reservoir

See Figure 4-5

Table 4-1 Case Study on Dry Season Paddy Cropping Area

1) Cropping Pattern

(Unit: ha)

Pattern		Case-1		Case-2		Case-3		Case-4	
Wet Season	Dry Season								
Rice	+ Rice	6,570	(32.9%)	5,260	(26.3%)	3,940	(19.7%)	2,500	(12.5%)
Rice	+ Corn	2,160		2,160		2,160		2,160	
Rice	+ Garlic + Vegetable	1,340		1,340		1,340		1,340	
Rice	+ Tobacco	820		820		820		820	
Rice	+ Soybean + Groundnut	6,460		7,770		9,090		10,530	
	Sub-total	17,350		17,350		17,350		17,350	
Soybean	+ Tobacco	440		440		440		440	
Soybean	+ Groundnut	1,540		1,540		1,540		1,540	
	Longan	670		670		670		670	
	Total	20,000		20,000		20,000		20,000	

2) Water Demand

(Unit: MCM)

Case	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total	Remarks
Case-1	33.90	13.03	8.18	32.17	15.17	15.73	30.84	13.53	3.15	9.27	38.40	42.99	256.41	
Case-2	30.57	10.75	8.18	32.17	15.17	15.73	30.84	13.53	3.15	9.53	35.27	40.29	245.25	
Case-3	28.71	8.55	8.18	32.17	15.17	15.73	30.84	13.53	3.17	10.10	33.06	39.77	239.05	
Case-4	25.88	6.10	8.19	32.18	15.17	15.73	30.85	13.54	3.18	10.56	30.16	38.02	229.56	Proposed

Table 4-2 Crop Coefficient

Month	Paddy Wet Season	Paddy Dry Season	Corn	Soybean (1) Groundnut (1)	Soybean (2)	Groundnut (2)	Tobacco (1)	Tobacco (2)	Longan
Jan.			0.40	0.30		1.00	0.70	1.00	0.70
Feb.			1.10	0.50		0.80	1.00	0.90	0.70
Mar.		1.03	0.90	1.00		0.50	0.90		0.70
Apr.		1.28		0.80					0.70
May		1.26		0.50	0.30				0.70
Jun.					0.50				0.70
Jul.	1.00				1.00				0.70
Aug.	1.03				0.80				0.70
Sep.	1.13				0.50				0.70
Oct.	1.21								0.70
Nov.	1.00					0.30		0.40	0.70
Dec.			0.30	0.30		0.50	0.40	0.70	0.70

Table 4-3 Estimated Consumptive Use (Unit: mm/day)

Month	Paddy Wet Season	Paddy Dry Season	Corn	Soybean (1) Groundnut (1)	Soybean (1)	Groundnut (2)	Tobacco (1)	Tobacco (2)	Longan
Jan.			1.55	1.01		3.38	2.37	3.38	2.37
Feb.			5.28	2.40		3.83	4.79	4.31	3.56
Mar.		5.24	4.58	5.09		2.55	4.59		3.56
Apr.		7.18		4.49					3.95
May		6.97		2.76	1.65				3.87
Jun.					2.30				3.21
Jul.	4.37				4.37				3.06
Aug.	3.97				3.08				2.70
Sep.	4.57				2.02				2.83
Oct.	4.89								2.83
Nov.	3.68					1.10		1.17	2.58
Dec.			0.92	0.92		1.55	1.24	2.1	2.14

Table 4-4 Monthly Diversion Water Requirement in Design and Normal Years

(Unit: MCM)

Sub-Project Area	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
1. Design Year													
Right Bank Area	1.06	0.25	0.71	2.64	1.22	1.25	1.65	1.36	1.36	2.67	3.15	2.13	19.46
Existing Irrigated Area	9.79	1.86	2.82	14.14	6.77	9.68	14.92	5.88	0.46	2.85	10.82	14.66	94.65
Left Bank Highland and Downstream Area	12.42	2.65	4.22	20.38	9.73	13.52	20.62	8.68	1.82	6.12	17.36	19.19	136.71
Total	23.27	4.76	7.75	37.16	17.72	24.45	37.19	15.92	3.64	11.64	31.33	35.98	250.82
2. Normal Year													
Right Bank Area	1.25	0.36	0.76	2.32	1.12	0.88	1.40	1.04	1.19	2.49	3.06	2.33	18.18
Existing Irrigated Area	10.88	2.35	2.98	12.22	5.74	6.17	12.35	5.09	0.40	2.52	10.52	15.34	86.56
Left Bank Highland and Downstream Area	13.77	3.39	4.45	17.64	8.31	8.68	17.10	7.41	1.59	5.55	16.58	20.35	124.82
Total	25.88	6.10	8.19	32.18	15.17	15.73	30.85	13.54	3.18	10.56	30.16	38.02	229.56

Table 4-5 Monthly Diversion Water Requirement in Design Year

(Unit: cu.m/sec)

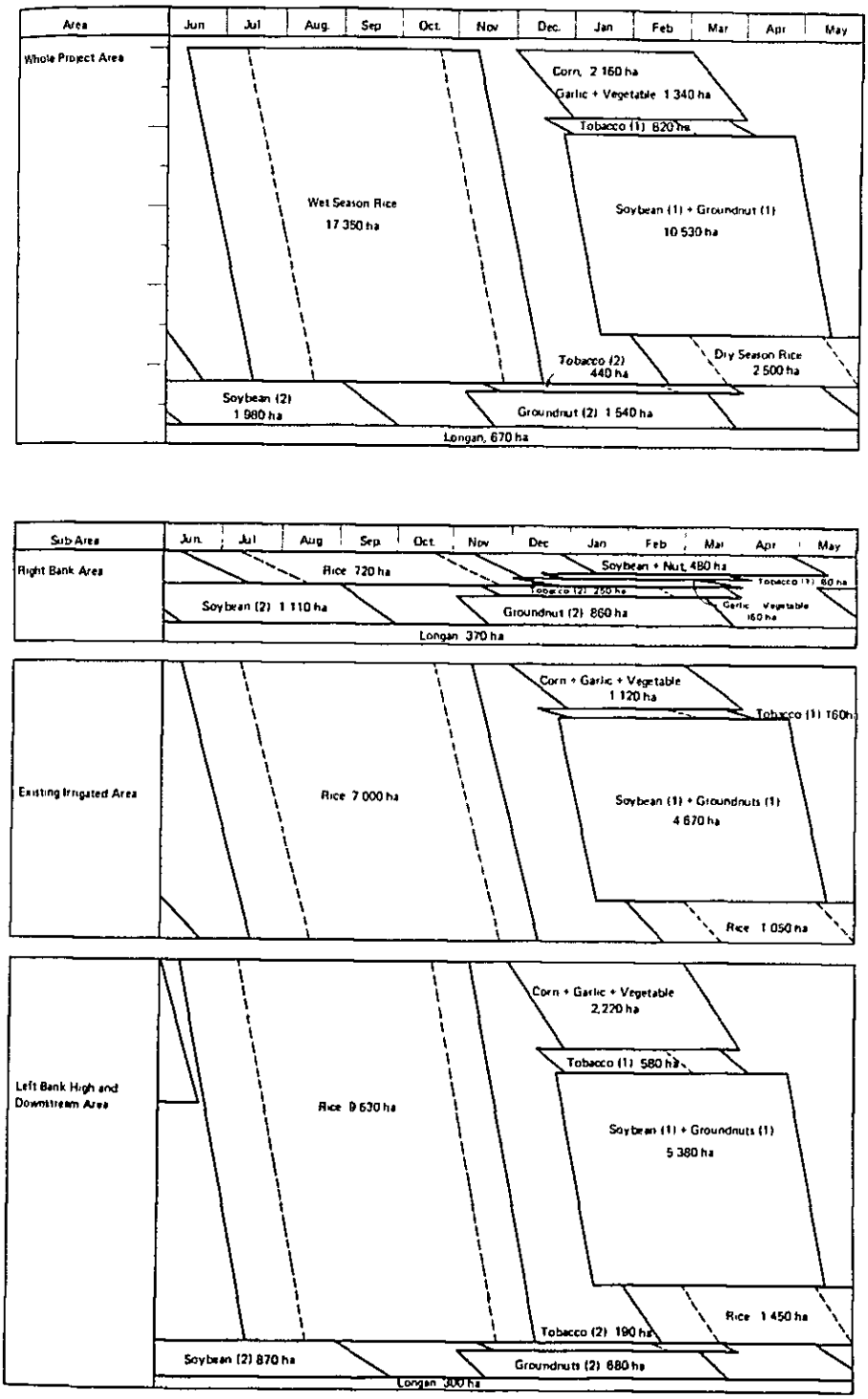
Sub-Project Area	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
Right Bank Area	0.41	0.10	0.27	0.99	0.46	0.48	0.62	0.52	0.51	1.00	1.30	0.80	0.62
Existing Irrigated Area	3.78	0.69	1.09	5.28	2.53	3.74	5.57	2.27	0.17	1.06	4.47	5.47	3.00
Left Bank Highland abd Downstream Area	4.79	0.99	1.63	7.61	3.63	5.22	7.70	3.35	0.68	2.29	7.18	7.17	4.33
Total	8.98	1.78	2.99	13.88	6.62	9.44	13.30	6.14	1.36	4.35	12.95	13.44	7.95

Table 4-6 Monthly Peak Irrigation Water Requirement

Item	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Average
1. Water Demand (cu.m/sec)													
1-1 Design Year1/													
Right Bank Area	0.64	0.19	0.38	1.30	0.50	0.53	0.70	0.52	0.51	1.00	1.30	0.95	
Existing Irrigated Area	5.30	1.11	1.47	6.27	2.90	4.16	6.29	2.26	0.17	1.06	4.47	6.16	
Left Bank Highland and Downstream Area	6.69	1.61	2.20	9.14	4.15	5.80	8.72	3.35	0.67	2.28	7.18	8.11	
Total	12.61	2.92	3.48	15.61	7.55	10.48	15.75	6.14	1.36	4.34	12.81	15.16	
1-2 Normal Year2/													
Right Bank Area	0.47	0.13	0.29	0.87	0.42	0.54	0.52	0.40	0.45	0.93	1.26	0.87	0.58
Existing Irrigated Area	4.20	0.88	1.15	4.56	2.14	2.38	4.61	1.96	0.15	0.94	4.35	5.79	2.75
Left Bank Highland and Downstream Area	5.31	1.27	1.72	6.59	3.11	3.35	6.39	2.86	0.59	2.07	6.99	7.60	3.97
Total	9.98	2.28	3.16	12.01	5.67	6.07	11.52	5.22	1.19	3.94	12.60	14.26	7.28
2. Irrigation Water Requirement (ℓ/sec/ha)													
2-1 Design Year													
Right Bank Area	0.761	0.259	0.243	0.613	0.227	0.322	0.663	0.432	0.321	0.481	0.616	0.664	
Existing Irrigated Area	0.942	0.593	1.105	1.006	0.414	0.594	0.943	0.922	0.245	0.222	0.674	0.980	
Left Bank Highland and Downstream Area	0.952	0.575	0.744	0.938	0.384	0.560	0.920	0.812	0.265	0.284	0.704	0.936	
Total	0.935	0.539	0.595	0.863	0.378	0.551	0.915	0.789	0.282	0.292	0.676	0.926	
2-2 Normal Year													
Right Bank Area	0.561	0.183	0.188	0.408	0.190	0.207	0.493	0.333	0.280	0.447	0.599	0.606	0.375
Existing Irrigated Area	0.725	0.469	0.862	0.732	0.306	0.340	0.691	0.800	0.216	0.197	0.655	0.921	0.575
Left Bank Highland and Downstream Area	0.756	0.451	0.580	0.676	0.287	0.323	0.674	0.692	0.234	0.259	0.686	0.878	0.541
Total	0.740	0.421	0.540	0.664	0.284	0.319	0.670	0.671	0.247	0.265	0.665	0.871	0.530

Note 1/ Return period of 10-year 2/ Return period of 2-year
Underlined figures show the maximum water requirement in each sub-project area

FIGURE 4 - 2 PROPOSED CROPPING PATTERN FOR THE PROJECT



Reservoir Loss

An annual evaporation amount from the reservoir surface is estimated 1,233 mm on an average.

Reservoir Inflow

An average annual reservoir inflow is estimated at 254 MCM. Monthly inflow from 1952 to 1979 is shown in Table 3-6.

Flood Control Capacity

An allowance for the flood control capacity is not specially considered. The reservoir, however, spontaneously provides the flood control function in view of the large reservoir size.

Water Demand

A water demand referes to an irrigation water only. Such demands as living water, factory water and river constraint are deemed negligibly small, and would be covered by a return flow of the irrigation water. The following are the irrigation water demands by cases:

Case	Annual Water Demand (MCM)
Case-1	256
Case-2	245
Case-3	238
Case-4	229

Note: See 4.2.4 Irrigation Plan.

Hydropower Generation

A hydropower generation scheme is proposed in line with the irrigation water release plan. The details are described in Section 4.2.8.

Basing upon the above factors, the water balance study on the reservoir was carried out with an aid of RID computer and program.

As a result of the study, Case 4 is adopted and is identical with a water deficit probability of 1/10 years. Simulation result of Case 4 is illustrated in Figure 4-4. The following table and Figure 4-3 summarize the results of the study on four cases.

Simulation Result

Study Case	Demand (MCM)	Shortage No. of Years (yrs)	Shortage Annual Shortage (MCM)	Spillage No. of Years (yrs)	Spillage Annual Spillage (MCM)	Years in RWL (yrs)	Acceptable
Case 1	256	8	65.2	2	25.3	4	No
Case 2	245	5	59.8	3	37.4	5	No
Case 3	238	4	56.3	3	49.6	5	No
Case 4	229	3	40.1 1/	4	49.6 2/	6	Yes

Remarks: 1/ 1968 16.22 MCM, 1969 88.68 MCM, 1970 15.37 MCM

2/ 1953 21.79 MCM, 1956 9.97 MCM, 1973 90.71 MCM
1975 75.81 MCM

b) Optimum Reservoir Sizing

From the results of the water balance study on the reservoir as mentioned in the previous sub-section, the following are clarified. In case of the droughty year corresponding to the probability of once in ten years for irrigation planning, the optimum reservoir size will correspond to the reservoir capacity of 325 MCM.

On the other hand, the careful studies on the similar reservoir planning performed in Thailand in the past years have been made and it was found out that most of all reservoir has a reservoir capacity of about 1.3 times of an average annual reservoir inflow. The foremen-tioned capacity of 325 MCM corresponds to the 1.22 times of the average annual inflow at the proposed dam site.

Reservoir Capacity and Inflow

Reservoir Name	Purpose	Drainage Area (sq.km)	Storage Capacity Total (MCM)	Storage Capacity Effective (a) (MCM)	Annuan Inflow (b) (MCM)	(a)/(b)
Kang Krachan Dam	I,F,H	2,200	710	640	880	0.72
Krasieo Dam	I,F,D	1,220	240	200	165	1.21
Pranburi Dam	I.F	2,029	650	375	320	1.17
Lam Pao Dam	I,F	5,960	2,450	1,260	1,363	0.92
Lam Phra Phloeng Dam	I,F	807	320	145	116	1.25
Mae Ngat Dam	I,F,H	1,281	265	255	406	0.62
Kiu Lom Dam	I,F,H	2,700	112	106	574	0.18
Huai Luang Dam	I,F,H	666	115	108	233	0.46
Lam Takhong Dam	I,F	1,430	445	290	212	1 37
Nam Un Dam	I,F	1,100	520	475	365	1.30
(Mae Kuang Dam)	I,F,H	569	325	311	254	1.22

Note: Data Source: Construction Division, RID

I : Irrigation

F : Flood Control

H : Hydropower

D : Drainage

The proposed reservoir size has been determined to be 325 MCM taking the following factors into consideration:

- Result of water balance study of the reservoir
- Analysis of the past experiences on reservoir planning in Thailand
- Considerations on the design and construction aspects such as foundation condition, etc.

Major dimensions on reservoir and irrigation are as follows:

Description	Figures
i) Dam Planning	
Top elevation of the dam:	EL 395.00
Retention water level:	EL 390.00
Total storage capacity:	325 MCM
Effective storage capacity:	311 MCM
ii) Irrigation Planning	
Irrigatoin demand:	229 MCM
Cropping intensity:	197%

c) Reservoir Operation

A reservoir operation to the proposed reservoir is easy due to a sufficient scale of the reservoir. The reservoir water will be released in conformity to the irrigation demand. An advance reservoir water release for the flood control is not taken into consideration. The hydropower generation will also be in conformity to the water release for the irrigation demand. An operation of the hydropower plant during wet season would be rather complicated due to a big range of daily fluctuation of water use.

d) Verification of Water Balance Study on the Reservoir

The water balance study on the reservoir during the 28 years has revealed that there is a consecutive 3-year water shortage during 1968 to 1970. This fact was examined whether an ordinary phenomenon or not from the point of long term view. This verification was examined employing a long term rainfall record in Chaing Mai as shown in Figure 4-6. As a result, it has been found that there are three spells of drought years throughout 1906 to 1979, as follows:

1913 - 1916:	4 years
1931 - 1941:	11 years
1957 - 1967:	11 years

The last spell of drought years in above three spells affects the consecutive 3-year water shortage from 1968 to 1970. Therefore, a phenomenon of consecutive drought years is not considered as anomalistic in long term. It is clearly found that the provision of sufficient capacity of reservoir is required to cope with the water shortage in the drought period.

e) Effect to the Bhumiphol Dam

It is necessary to estimate the effect to the Bhumiphol dam by the construction of the Mae Kuang dam. As shown in the following table, the Mae Kuang dam will control about two percent of the drainage area and four percent of the annual mean inflow of the Bhumiphol dam.

	The Mae Kuang Dam[1/] (A)	The Bhumiphol Dam[2/] (B)	A/B
Drainage Area	569 sq.km	26,386 sq.km	2.16%
Annual Mean Inflow	253.62 MCM	6,403 MCM	3.96%
Specific Yield	0.45 MCM	0.24 MCM	1.88

Note) 1/ See Table 3-6 (1952 - 1979)
2/ See Table 3-5 (1952 - 1975)

Stored water at the Mae Kuang dam will be mostly utilized for the irrigation. However, a part of the irrigation water will be expected to be reused in the downstream area as the return flow. The table availability of return flow to be downstream area will be expected at about 68 MCM as shown in the following table. Therefore, the reduction of the annual inflow to the Bhumiphol dam will be 185 MCM[*-1/] equivalent to about three percent[*-2/] of the annual mean inflow of 6,403 MCM.

---

*-1/ 253.62 MCM - 68.25 MCM = 185.37 MCM

*-2/ $\frac{185.37 \text{ MCM}}{6,403 \text{ MCM}} = 2.90\%$

Available Return Flow to the Downstream Area

	Stored Water	Return Flow
Evaporation Loss	12.37 MCM 1/	- MCM
Spillage, Power Release	11.69 MCM 2/	11.69 MCM
Irrigation	229.56 MCM 3/	56.56 MCM 4/
Total	253.62 MCM	68.25 MCM

Note) 1/ See Table E 1-4, Appendix E

2/ 253.62 MCM - (12.37 MCM + 229.56 MCM) = 11.69 MCM

3/ See Table D-7, Appendix D

4/ Return Flow from Irrigation

RF = I (1 - Ei) * Er

= 229.56 * (1 - 0.648) * 0.70 = 56.56 MCM

RF: Return Flow (MCM)

I : Irrigation Water (MCM)

Ei: Irrigation Efficiency (64.8%)
see 4.24 Irrigation Plan

Er: Return Flow Rate (70%)
see Appendix D-8

FIGURE 4-3 NUMBER OF WATER SHORTAGE YEAR OUT OF 28 YEARS

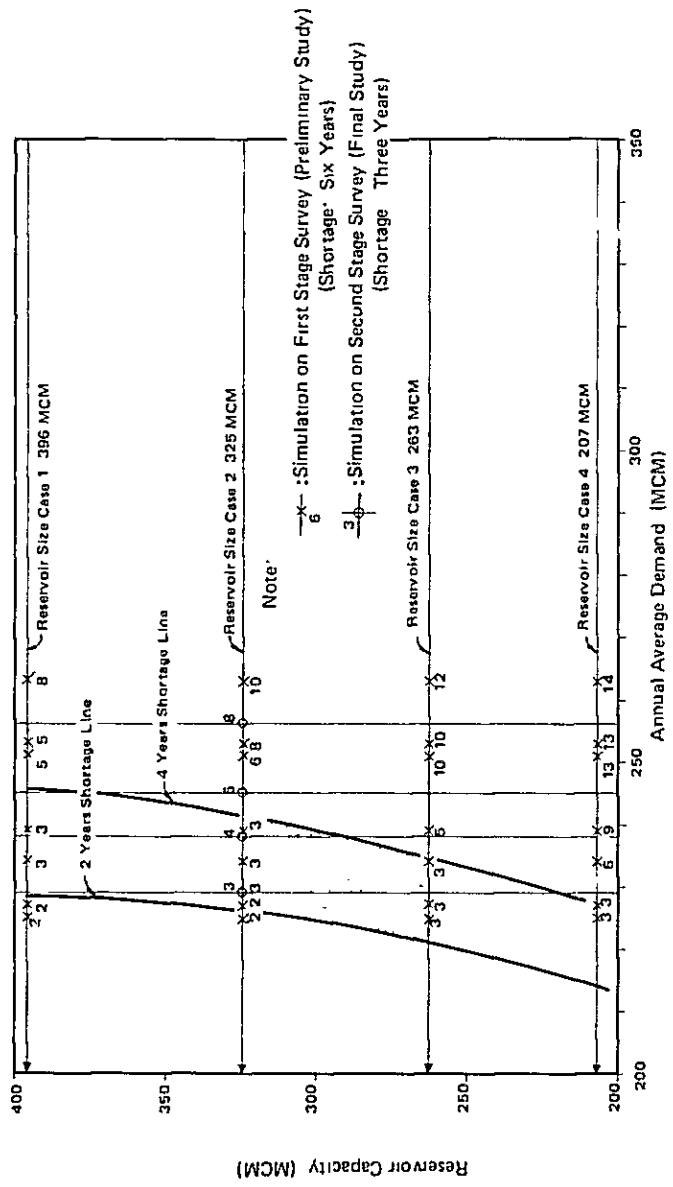
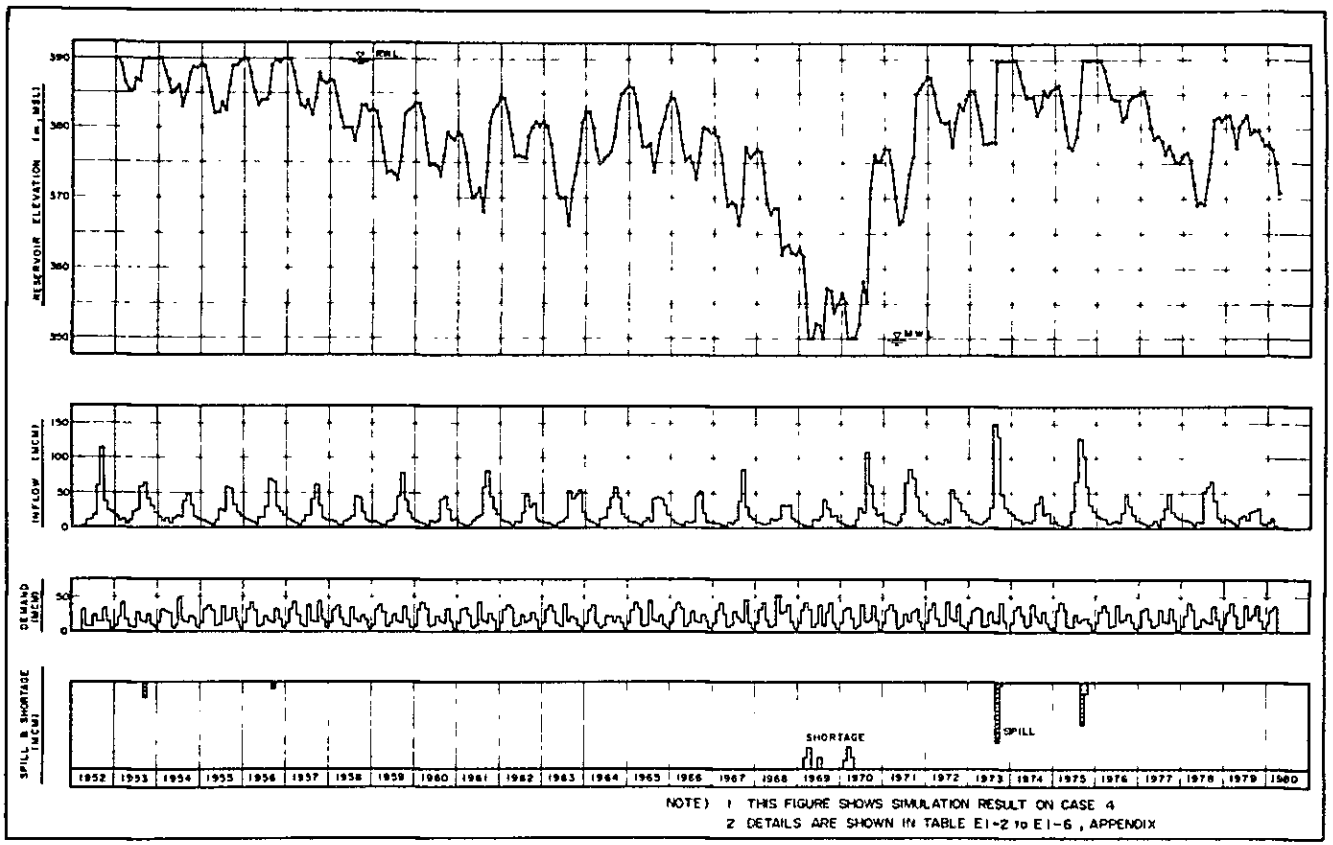


FIGURE 4-4 RESULT OF RESERVOIR OPERATION STUDY



NOTE) 1 THIS FIGURE SHOWS SIMULATION RESULT ON CASE 4
2 DETAILS ARE SHOWN IN TABLE E1-2 to E1-6, APPENDIX

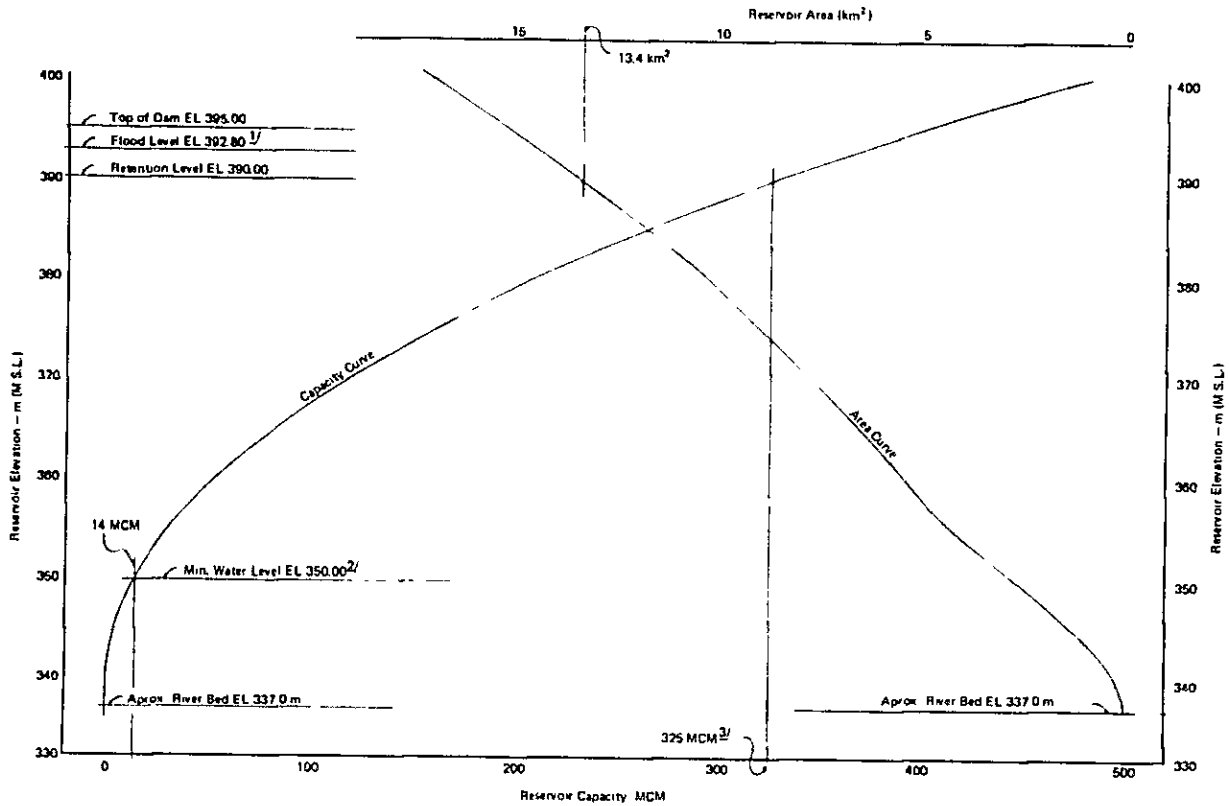
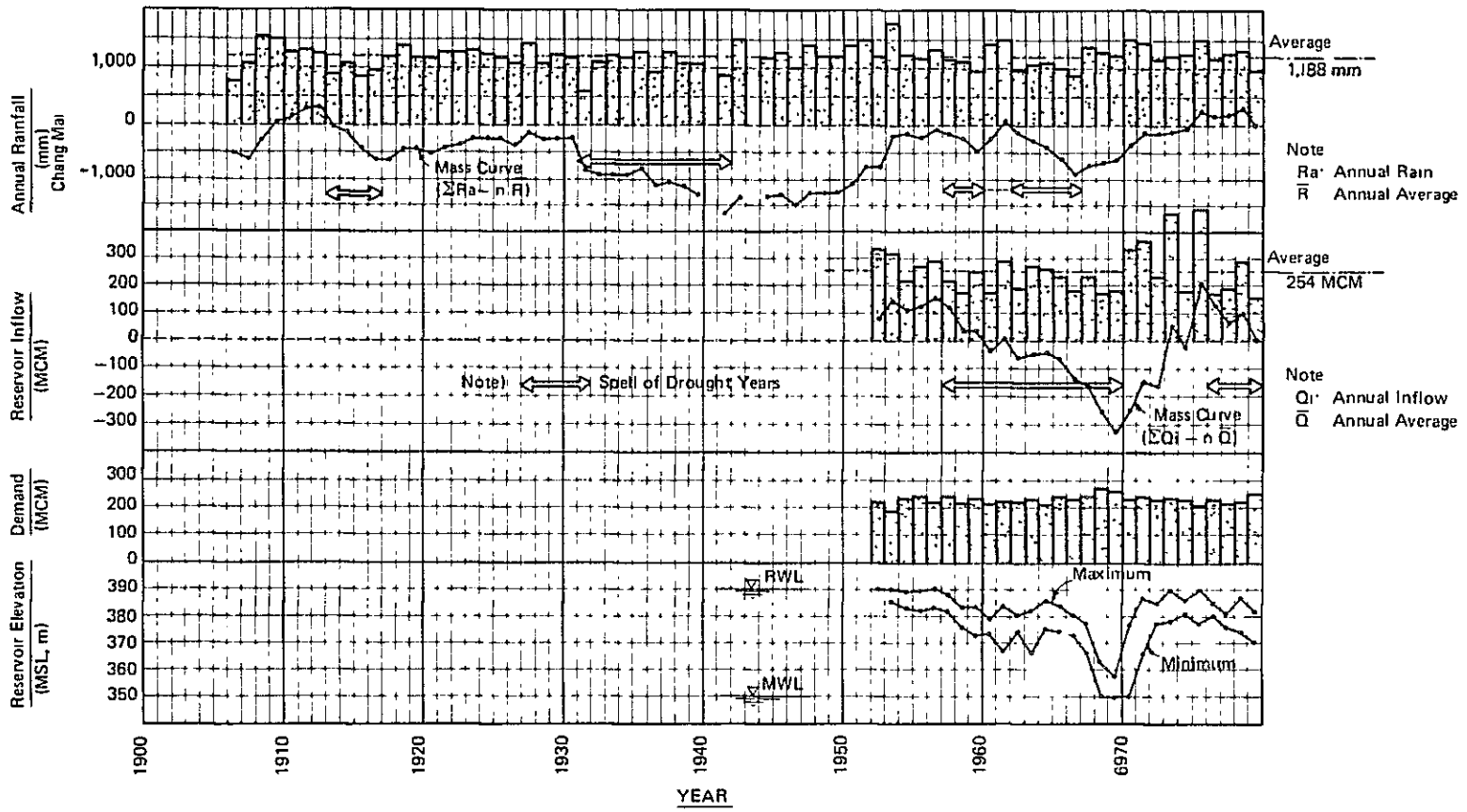


FIGURE 4 5 CAPACITY AND AREA CURVES OF MAE KUANG RESERVOIR 1/

Note 1 ref to Hydrological Characteristic and Water Uses, Mae Kuang Reservoir Project (by Div of Hydrology)
2 EL 350.00 - Bottom elevation of Canal Outlet, Left Saddle Dam
3/ ref to Reservoir Capacity CASE 2

FIGURE 4-6 EVALUATION OF RESERVOIR SIMULATION PERIOD IN LONG TERM



4.2.6. Flood Control Plan

a) Method of Flood Control

There are two methods of flood control. One is a river improvement method and the other is a reservoir storage method. Features of each method are briefly described below.

River Improvement Method

The river improvement method aims at smooth river flow by providing dike, rivetment, dredging and floodway. This method requires a deal of land acquisition and reconstruction of bridge, weir, gate and other river structures.

Reservoir Storage Method

The reservoir storage method can be divided in two ways. One provides a dam or group of dams at upper reaches of a river system. Another builds a retarding basin in the middle reaches of a river Since an extensive land is required to build the retarding basin, it is very difficult in most cases to construct the retarding basin. On the other hand, the reservoir storage method can commonly utilize the stored water for multi-purposes to serve the regional development.

In the Project, irrigation is the primary concern. However, flood control and hydropower generation are also taken into account A benefit from the flood control in the Project would be remarkable because of a big scale in reservoir size in comparison with the river run-off.

b) Flood Control Computation

A flood control computation was conducted according to Figure 4-7. The items 1-4 in Figure 4-7 were quoted from the results of study undertaken by the hydrologist. The flood control computation was carried out on 6 cases of probabilities 1/2, 1/5, 1/10, 1/20, 1/50, and 1/100, each before project and after project or 12 cases in total. A computation procedure is as stated below.

(1) Drainage Basin and Inflow Hydrograph

The P-5 station site located at the Changwat Lamphun was selected as a point of interest in the basin. The west side of the basin is bounded by the national highway route 107 with the Mae Ping river basin, the south by the national highway route 11, and the north and east by the mountain ridges. The following computation was conducted under the conditions that the catchment area at the damsite is 569 sq.km and that at the P-5 station is 1,665 sq.km.

An inflow hydrograph at the P-5 station was obtained from that at the damsite with ratio of the catchment area. However, in case of 1/50 and 1/100 years probabilities, a spillage from the dam was taken into consideration. The spillage amount was roughly estimated by the result of the reservoir operation study and the size of spillway.

(2) Flooding Analysis, Inundation Area and Effect of Reservoir Storage

A flooding analysis, an inundation graph, and an inundation area were based on interviews, site survey, and 1/50,000 and 1/10,000 topo-maps. Figure 4-8 indicates the contour lines which reflect the inundation area. Figure 4-9 also presents a cumulative inundation area by elevation. Table 4-7 was prepared on the basis of Figure 4-8 and represents the areas by elevation.

The flood control computation was carried out by an electronic computer IBM 1130, 8K in RID Computer Center. The result of the computation was summarized in Table 4-8. Table 4-9 presents project effect by flood magnitude. Figure 4-10 illustrates hydrograph and inundation volume in case of 1/100 years probability.

A probability analysis of the flood damage amount at each year was conducted and is shown in Table 4-11 and Figure 4-12. Figure 4-12 illustrates annual flood damage amounts with respect to six return periods.

(5) Flood Record, Flood Damage and Expected Flood Damage Mitigation Amount

A flood record and the flood damage are as set out in section 3.5 (c) - Flood Damage. The result of the flood damage estimation is shown in column (5) of Table 3-10. A relation between the inundation volume and the flood damage is established by means of probability analysis as shown in Figure 4-11. Figure 4-11 is a combined result derived from Figure 4-12, Table 4-8 and Table 4-10.

From these relations, the annually expected flood damage mitigation amount was estimated as shown in Table 4-10, and comes up to 18.38 million Baht or 38 percent reduction of the flooding magnitude, when the probability is upto 1/100 years.

Table 4-7 Basin Area by Elevation

Elevation Range (EL m)	Mae Ping Basin (sq.km)	(%)	Mae Kuang Basin (sq.km)	(%)	Total (sq.km)	(%)
303 - 310	60.1	(17.4)	126.1	(29.2)	186.2	(24.1)
300 - 303	59.2	(17.2)	117.7	(27.2)	176.9	(22.9)
298 - 303	41.2	(12.0)	58.5	(13.5)	99.7	(12.8)
295 - 298	36.3	(10.6)	49.2	(11.4)	85.5	(11.0)
293 - 295	40.8	(11.9)	25.3	(5.9)	66.1	(8.5)
290 - 293	30.6	(8.9)	42.5	(9.8)	73.1	(9.4)
288 - 290	34.7	(10.1)	12.9	(3.0)	47.6	(6.1)
285 - 288	39.8	(11.6)	-		39.8	(5.1)
Below 285	1.1	(0.3)	-		1.1	(0.1)
Total	343.8	(100.0)	432.2	(100.0)	776.0	(100.0)
Below 300	224.5	(54.4)	188.4	(45.6)	412.9	(100.0)

Table 4-8 Summary of Flood Control Computation

Project Status	Case No.	Return Period (year)	Maximum Inflow[1] (cu.m/s)	Outflow Amount (cu.m/s)	Inundated Volume (MCM)	Inundated Depth (m)	Inundated Time[2] (hrs)	Inundated Area (ha)
Before Profect (B)	1	1/2	550	320	8.912	0.94	75	1,878
	2	1/5	962	330	49.825	2.23	162	4,454
	3	1/10	1,334	340	79.445	2.82	198	5,627
	4	1/20	1,790	350	110.655	3.33	240	6,645
	5	1/50	2,519	370	146.030	3.82	258	7,653
	6	1/100	3,116	400	200.875	4.48	294	8,954
After Project (A)	1	1/2	363	320	0.462	0.22	-	420
	2	1/5	633	330	7.787	0.88	69	1,755
	3	1/10	878	340	23.559	1.53	105	3,060
	4	1/20	1,178	350	41.656	2.04	132	4,071
	5	1/50	1,658	370	80.388	2.84	195	5,661
	6	1/100	2,051	400	123.796	3.52	258	7,027
Difference (B) - (A)	1	1/2	188	0	8.450	0.72	75	1,458
	2	1/5	329	0	42.038	1.35	93	2,699
	3	1/10	456	0	55.886	1.29	93	2,567
	4	1/20	612	0	69.019	1.29	108	2,572
	5	1/50	861	0	65.642	0.98	63	1,972
	6	1/100	1,065	0	77.079	0.96	36	1,927

Remarks: 1/ Catchment area at damsite 569.0 sq.km, at point of interest 1,665.0 sq.km

2/ Duration of inundated depth more than 50 cm.

Table 4-9 Project Effect by Flood Magnitude

Return Period	Flood Magnitude			Inundated Volume			Remarks
	Before Project (cu.m/s) (1)	After Project (cu.m/s) (2)	Ratio (2)/(1)	Before Project (MCM) (3)	After Project (MCM) (4)	Ratio (4)/(3)	1/ with spillage
1/2	550	362	0.658	8.912	0.462	0.052	
1/5	962	633	0.658	49.825	7.787	0.156	
1/10	1,334	878	0.658	79.445	25.559	0.297	
1/20	1,790	1,178	0.658	110.655	41.636	0.376	
1/50	2,519	1,658	0.658	146.030	80.388 1/	0.550	
1/100	3,116	2,051	0.658	200.875	123.796 1/	0.616	

Table 4-10 Annual Flood Damage Mitigation Amount

(Unit: million Baht)

Project Status	Suffix No. i (1)	Flood Magnitude Q (2)	Exceeding Probability N (3)	Occurrence Probability Ni - Ni + 1 (4)	Flood Damage L (5)	Average Damage (Li+Li+1)/2 (6)	Annual Damage (4)x(6) (7)	Damage Mitigation Amount Σ(7) (8)
	0	100	1/1 = 1.00	-	0	-	-	-
	1	550	1/2 = 0.50	0.50	3.2	1.6	0.80	0.80
Before	2	962	1/5 = 0.20	0.30	20.0	11.6	3.48	4.28
Project	3	1,334	1/10 = 0.10	0.10	52.4	36.2	3.62	7.90
(B)	4	1,790	1/20 = 0.05	0.05	117.0	84.7	4.24	12.14
	5	2,519	1/50 = 0.02	0.03	290.0	203.5	6.11	18.25
	6	3,116	1/100 = 0.01	0.01	500.0	395.0	3.95	22.20
	1	362	1/2 = 0.50	0.50	0	0	0	0
After	2	633	1/5 = 0.20	0.30	3.6	1.8	0.54	0.54
Project	3	878	1/10 = 0.10	0.10	7.6	5.6	0.56	1.10
(A)	4	1,178	1/20 = 0.05	0.05	16.4	12.0	0.60	1.70
	5	1,658	1/50 = 0.02	0.03	56.4	36.4	1.09	2.79
	6	2,051	1/100 = 0.01	0.01	150.0	103.2	1.03	3.82
	1	188	1/2 = 0.50	0.50	3.2	1.6	0.80	0.80
Difference	2	329	1/5 = 0.20	0.30	16.4	9.8	2.94	3.74
(B) - (A)	3	456	1/10 = 0.10	0.10	44.8	30.6	3.06	6.80
	4	612	1/20 = 0.05	0.05	100.6	72.7	3.64	10.44
	5	861	1/50 = 0.02	0.03	233.6	167.1	5.02	15.46
	6	1,065	1/100 = 0.01	0.01	350.0	291.8	2.92	18.38

Table 4-11 Probability Computation on Flood Damage

(Unit: million Baht)

i	I/N (%)	Xo	Year
1	3.448	152.900	1975
2	6.897	135.236	1973
3	10.345	20.617	1971
4	13.793	20.593	1952
5	17.241	20.226	1977
6	20.690	19.790	1970
7	24.138	18.418	1980
8	27.586	14.249	1966
9	31.034	11.972	1969
10	34.483	9.317	1972
11	37.931	8.190	1976
12	41.379	6.459	1968
13	44.828	4.458	1967
14	48.276	3.558	1960
15	51.724	3.458	1978
16	55.172	2.112	1963
17	58.621	1.725	1962
18	62.096	1.404	1961
19	65.517	1.168	1957
20	68.965	0.0	1953
21	72.414	0.0	1954
22	75.862	0.0	1955
23	79.310	0.0	1956
24	82.758	0.0	1958
25	86.207	0.0	1959
26	89.655	0.0	1964
27	93.103	0.0	1965
28	96.552	0.0	1974
29	100.000	0.0	1979

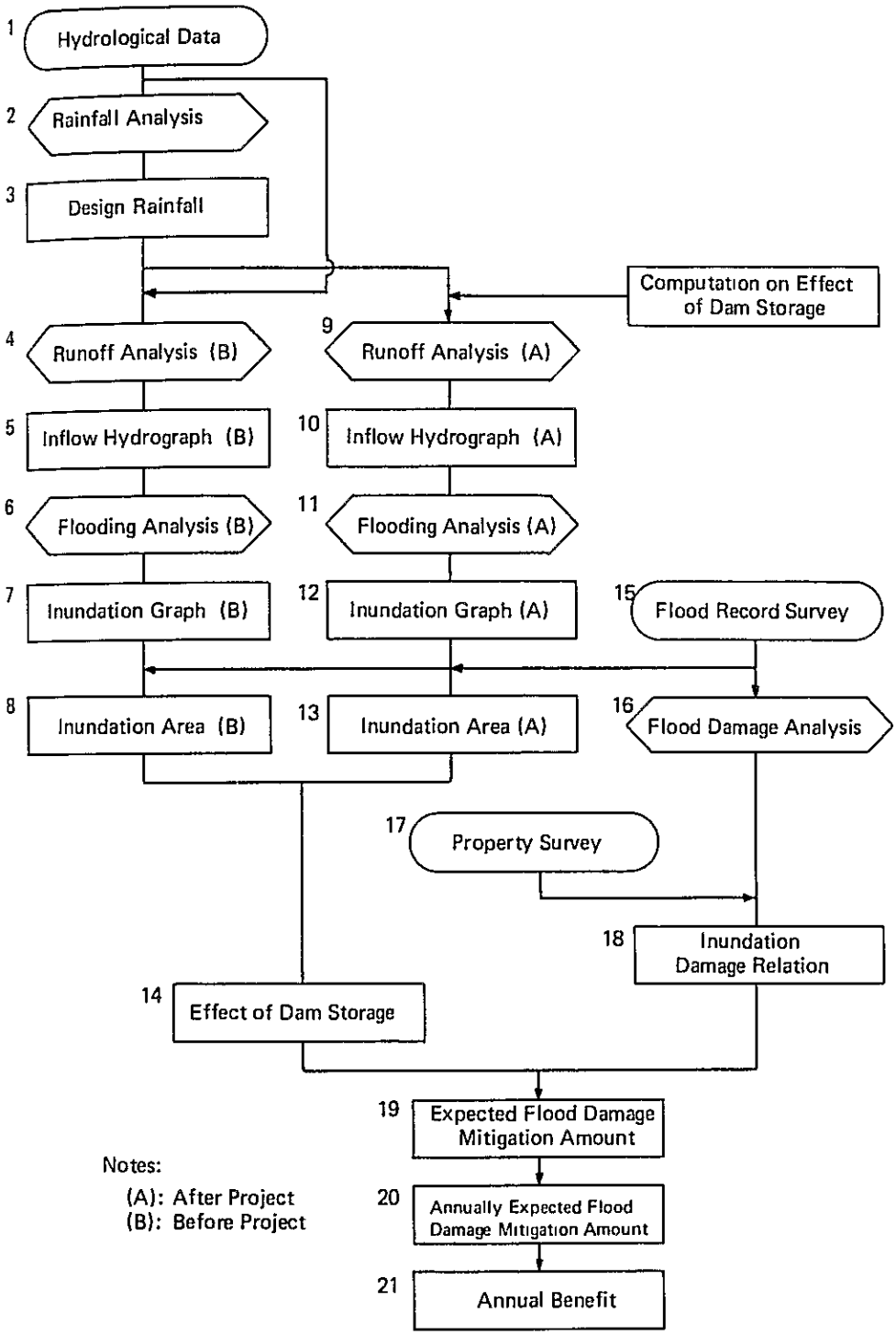
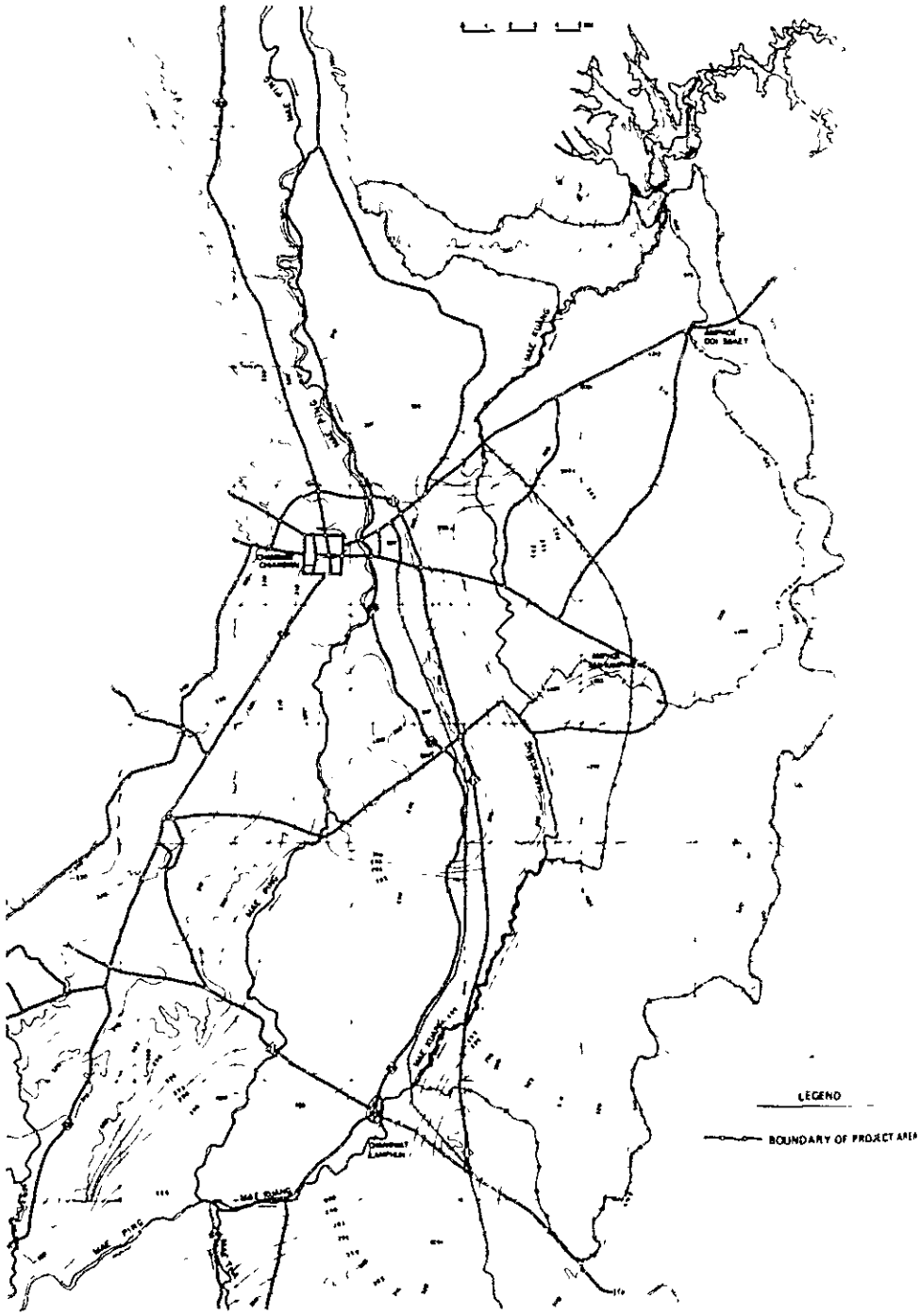


FIGURE 4-7 GENERAL FLOW CHART ON FLOOD COMPUTATION

FIGURE 4 - 8 CHANG MAI VALLEY AND PROJECT AREA



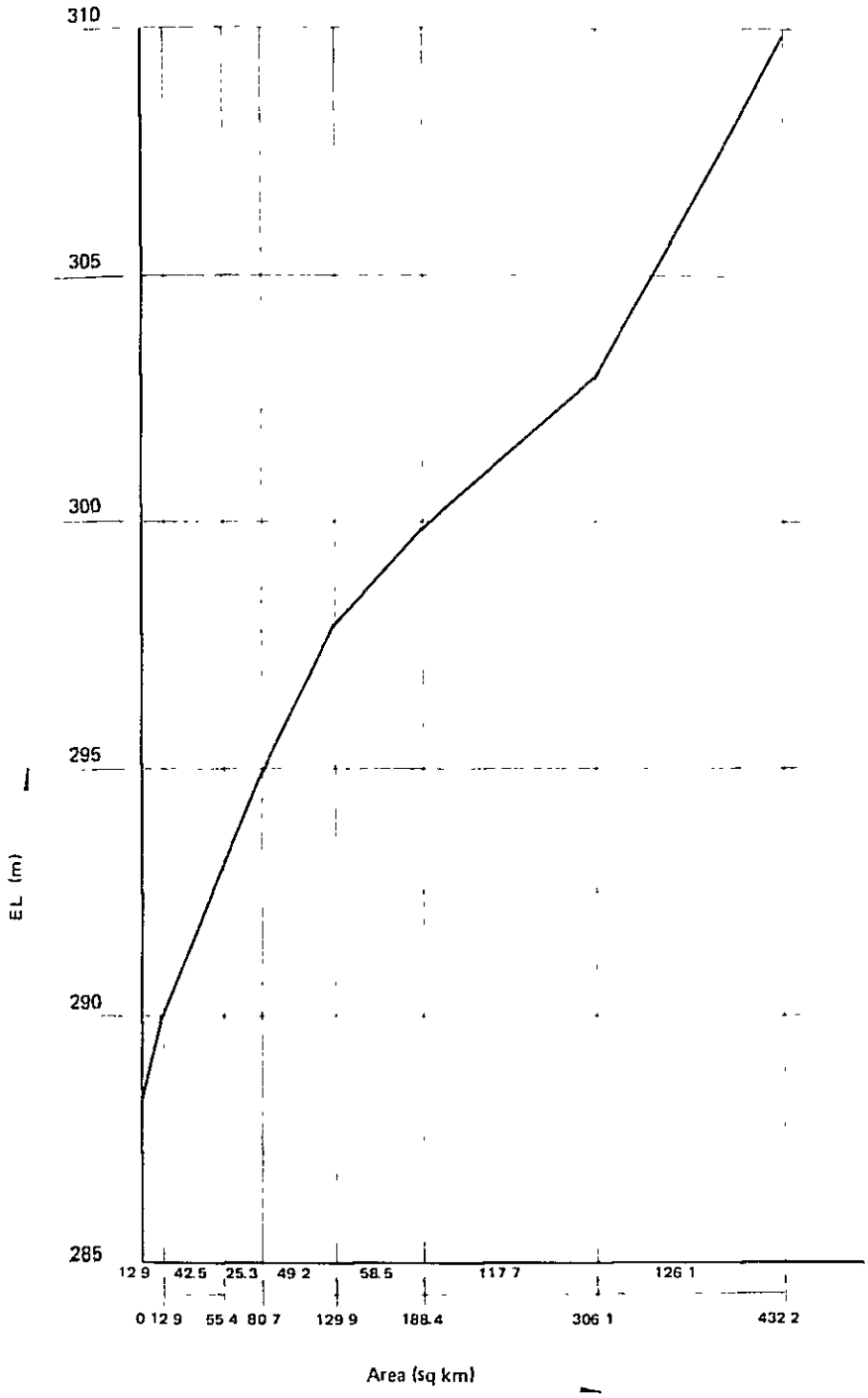


FIGURE 4-9 BASIN AREA BY ELEVATION

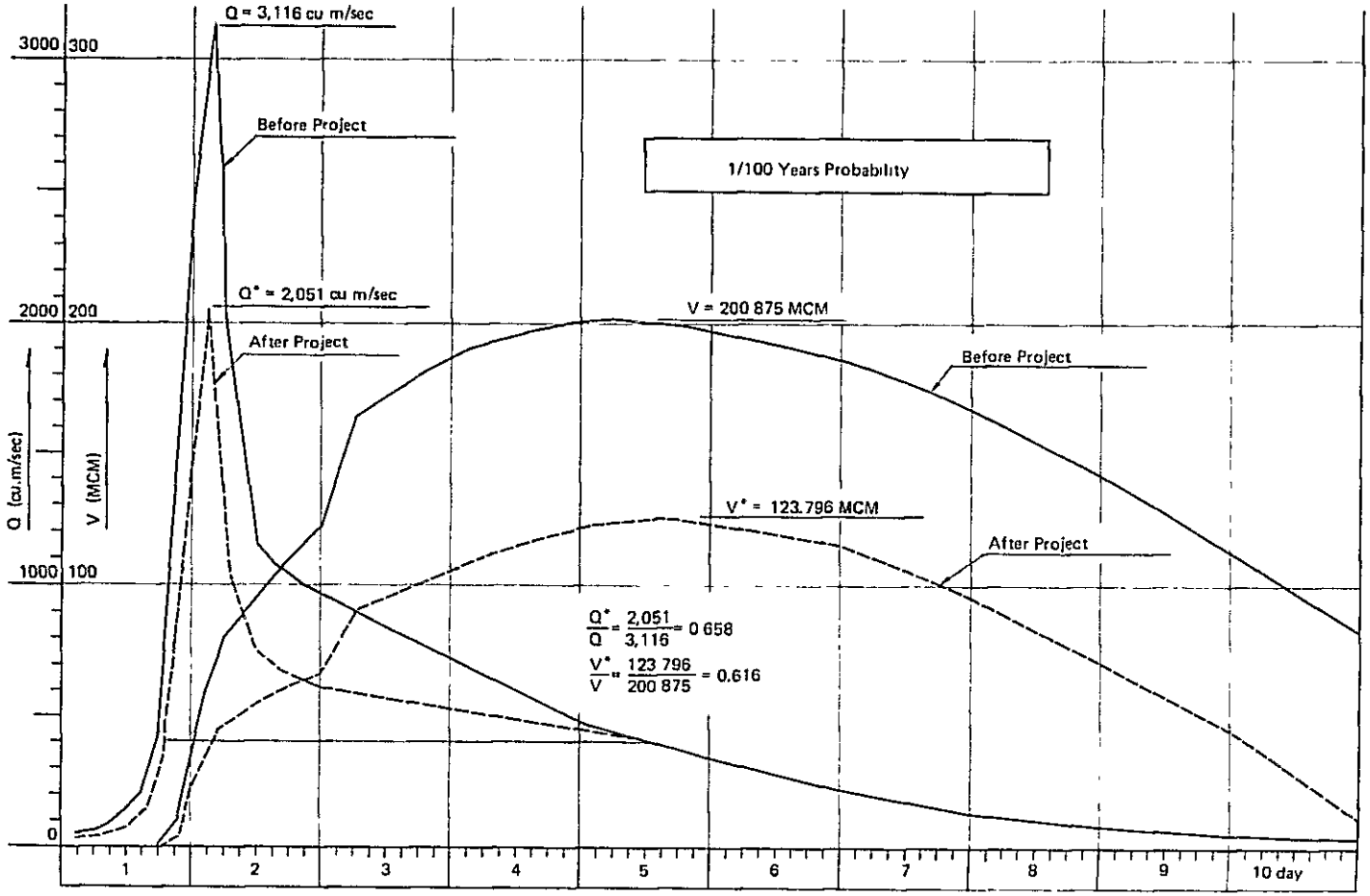
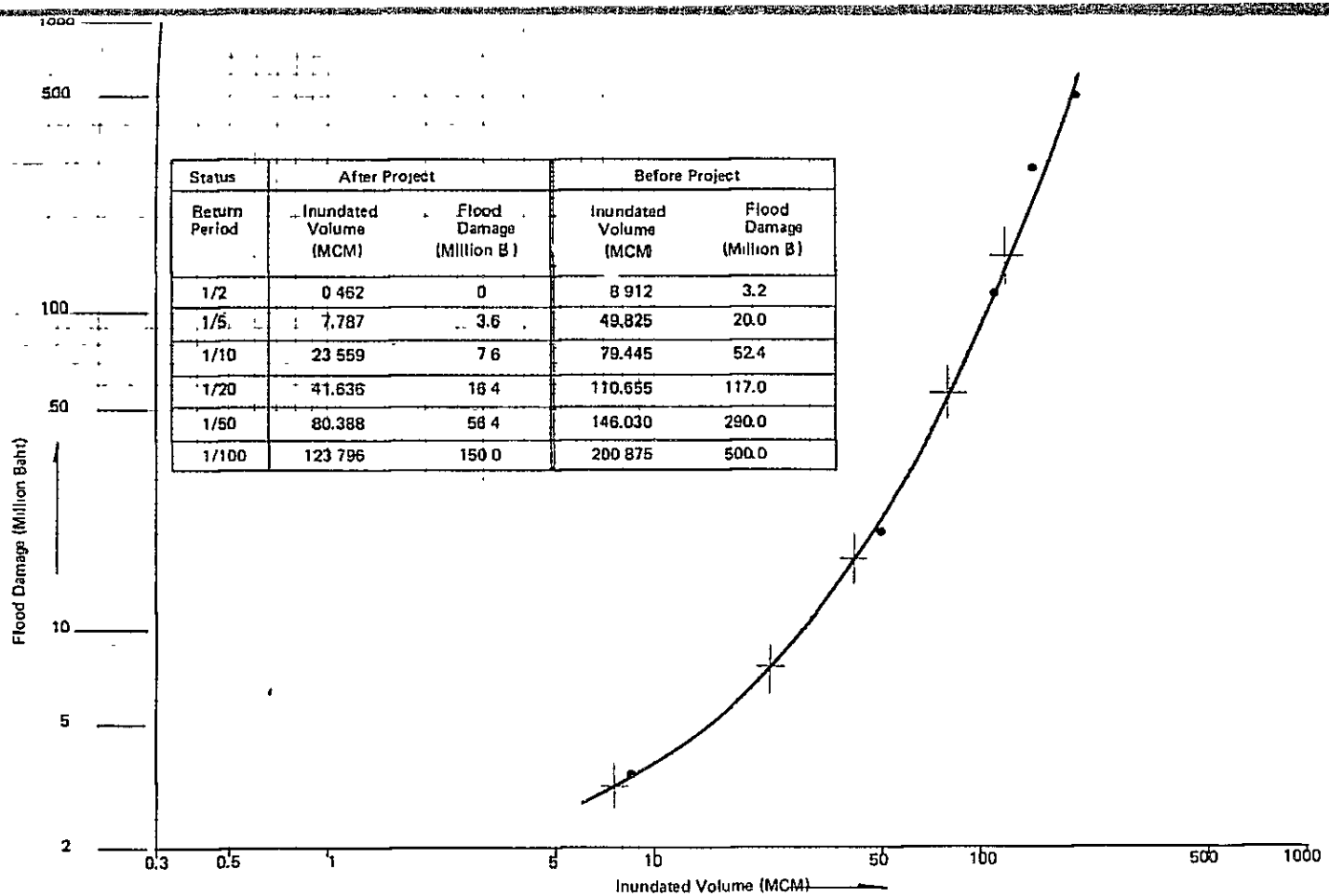


FIGURE 4 10 INFLOW AND INUNDATED VOLUME CURVES



Status	After Project		Before Project	
Return Period	Inundated Volume (MCM)	Flood Damage (Million B)	Inundated Volume (MCM	Flood Damage (Million B)
1/2	0 462	0	8 912	3.2
1/5	7,787	3.6	49,825	20.0
1/10	23 559	7 6	79.445	52.4
1/20	41.636	16 4	110.655	117.0
1/50	80.388	56 4	146.030	290.0
1/100	123 796	150 0	200 875	500.0

FIGURE 4-11 INUNDATED VOLUME AND FLOOD DAMAGE

Return Period	Flood Damage
Year	Million B
1/2	3 2
1/5	20 0
1/10	52.4
1/20	117 0
1/50	290 0
1/100	500 0

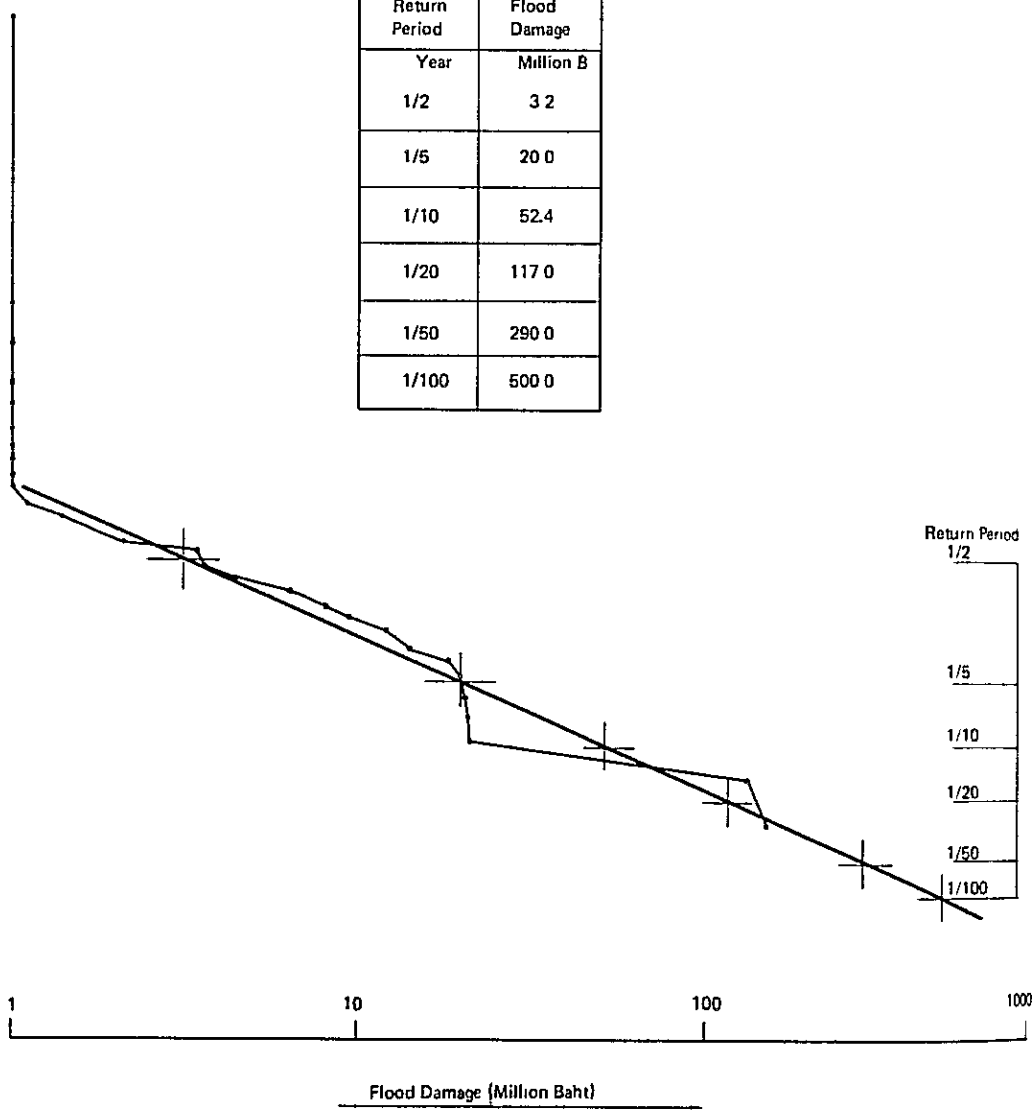


FIGURE 4-12 FLOOD DAMAGE BY RETURN PERIOD

4.2.7 Drainage Plan

a) Design Modulus for Designing Drainage Canals in Paddy Fields

(1) Design Rainfall

Long term rainfall data (1952 - 1979) are available in the Project Area at two stations, namely, Doi Saket and San Kamphaeng. Based upon these rainfall data, probability analysis was made in order to estimate the return period and corresponding magnitude of the rainfall, as shown below;

Probable Rainfall

(Unit: mm)

	Doi Saket			San Kampaheng		
Probability	1-day	2-day	3-day	1-day	2-day	3-day
1/5	108	134	152	102	125	137
1/10	119	150	169	115	140	149

As is seen in the above table, it is found out that the probable rainfall in both cases of return period of five years and ten years is not so much different between the both station rainfalls and also almost all rainfall concentrates within first one day as rainfall characteristics, so that 1-day probable rainfall of 108 mm (return period of five-year) observed at Doi Saket Station is decided at the design rainfall for the drainage planning. The hourly distribution of the selected rainfall was estimated based upon predominant rainfall characteristics in the region.

(2) Method for Estimation of Drainage Modulus

The Project Area is located on a relatively flat area. In such a flat area, the paddy field plays a function to store the rain water.

The drainage mechanism in such flat paddy fields can be explained as follows: the stored water in the paddy field is discharged through notches provided at each plot to a terminal drainage canal of farm

drain. The farm drain is connected to a main farm drain by drain inlet which is facilitated by means of pipes. The notch will control run-off discharge from the paddy fields, and the drain inlet at the end of farm drain will also control the discharge to the main farm drain.

The run-off discharge from paddy fields with the above-mentioned drainage mechanism can be estimated based on the unit hydrograph developed by the Ekdahl's Method. This is a method to calculate the water balance between the inner and the outer water levels, and the basic equation is expressed as follows:

$$1/2\ (I_1 + I_2)\ \Delta t - 1/2\ (O_1 + O_2)\ \Delta t = S_2 - S_1$$

Where:

I_1: Inflow at time t_1

I_2: Inflow at time t_2

O_1: Outflow at time t_1

O_2: Outflow at time t_2

S_1: Field storage at time t_1

S_2: Field storage at time t_2

In accordance with aforementioned drainage mechanism and system in the paddy field, the obtained hourly rainfall for five-year return period was adopted to estimate the run-off discharge q (mm/hr) and flooding water depth H (mm), together with the duration of water stagnation in paddy fields.

In general, even if a paddy field is submerged by excess water of more than 25 cm of standing water depth, paddy grown in the field does not suffer from it in case that its duration is less than three days. In order to satisfy these standards, trial drainage analysis was made by means of varying the dimensions of notch and drain inlet which is the facilities to control the run-off capacity from the field.

Figure 4-13 indicates the analyzed drainage conditions in accordance with the procedure mentioned above in case of drainage area

of 100 ha, and the following shows the result of drainage analysis:

Item	Dimension
1) Maximum run-off discharge	
q (mm/hr)	3.93
Q_o (cu.m/sec/100ha)	1.092
2) Base flow	
Q_b (cu.m/sec/100ha)	0.010
3) Total run-off discharge	
$Q_t = Q_o + Q_b$ (cu.m/sec/100ha)	1.102
4) Maximum Water Depth, H (cm)	15.5

In the above estimation, the base flow of 0.010 cu.m/sec/100ha is adopted, which is equivalent to about 20 percent of the diversion water requirement during the wet season, May to October. As a result, the design drainage modulus of 1.102 cu.m/sec/100ha is computed (see Appendix D-11). The modulus of 1.102 cu.m/sec/100ha could be applied to the restricted narrow areas smaller than 400 ha, which is assumed taking the rainfall locality in the monsoon region into account, but a smaller modulus should be applied to a larger area than the area mentioned above, because the rainfall intensity becomes low in a larger area than 400 ha. Figure 4-14 shows an approximate linear double logarithmic relation between the reduction factor and the area.

When such reduction factor (F) is applied to the area, the discharge criteria for drainage are obtained as shown below:

Discharge Criteria for Drainage

Area (ha)	Drainage Modulus (cu.m/sec/100ha)
0 - 400	1.102
400 - 700	1.060
700 - 1,000	1.031
1,000 - 3,000	0.934

b) Drainage Discharge from Hilly Land

Many small rivers and creeks of which catchment areas are less than 500 sq.km flow into the Project Area in the eastern portions This paragraph will discuss about the storm run-off from hilly land Several procedures, in general, have been applied to estimate the storm run-off from hilly land, but the Rational Method is applied in the Project. The Rational Formula is expressed as follows:

$$Q = 0.2778 \cdot \gamma t(e) \cdot A$$

Where; Q; Peak discharge of storm run-off (cu.m/sec)

$\gamma t(e)$; Effective rainfall intensity within concentration - travel time of water (mm/hr)

A; Catchment area (sq.km)

In the above estimation, one hour rainfall intensity for the five-year probable daily maximum rainfall of 108 mm is estimated at 43.35 mm/hr[1/], and an effective hourly rainfall intensity is estimated at $\gamma t(e)$ = 9.37 mm/hr[2/]

As a result, the specific discharge of the storm run-off from the hilly land is estimated at 2.60 cu.m/sec/sq.km.

1/: One hour rainfall intensity, γt

$$\gamma t = R24 \times 0.4014\ t^{0.287}$$

$$= 108 \times 0.4014 \times 1^{0.287} = 43.35 \text{ mm/hr}$$

2/: Effective hourly rainfall intensity, $\gamma t(e)$

$$\gamma t(e) = 0.0175\ \gamma t^{1.667}$$

$$= 0.0175 \times 43.35^{1.667} = 9.37 \text{ mm/hr}$$

FIGURE 4 13 RUN OFF DISCHARGE IN PADDY FIELD

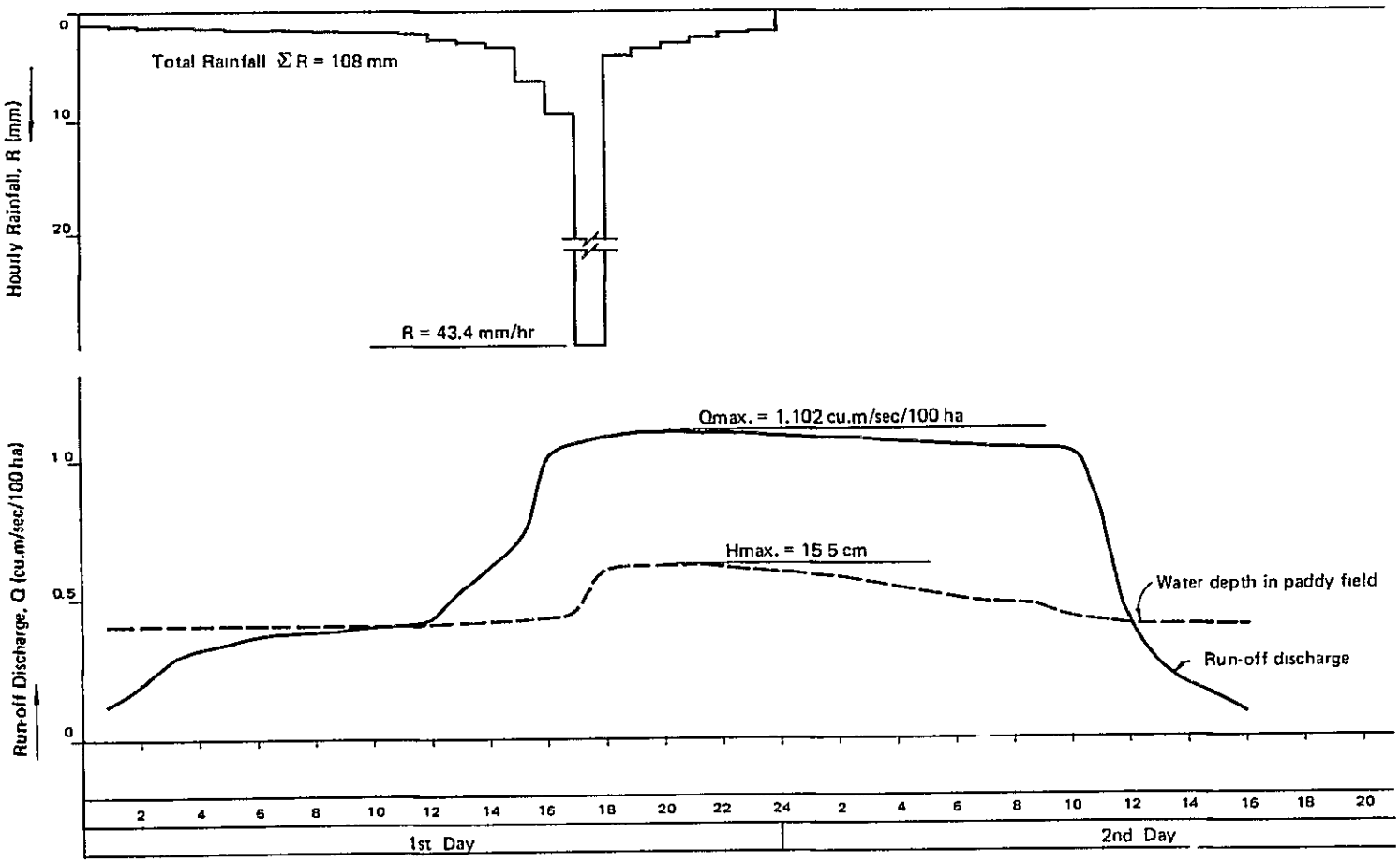
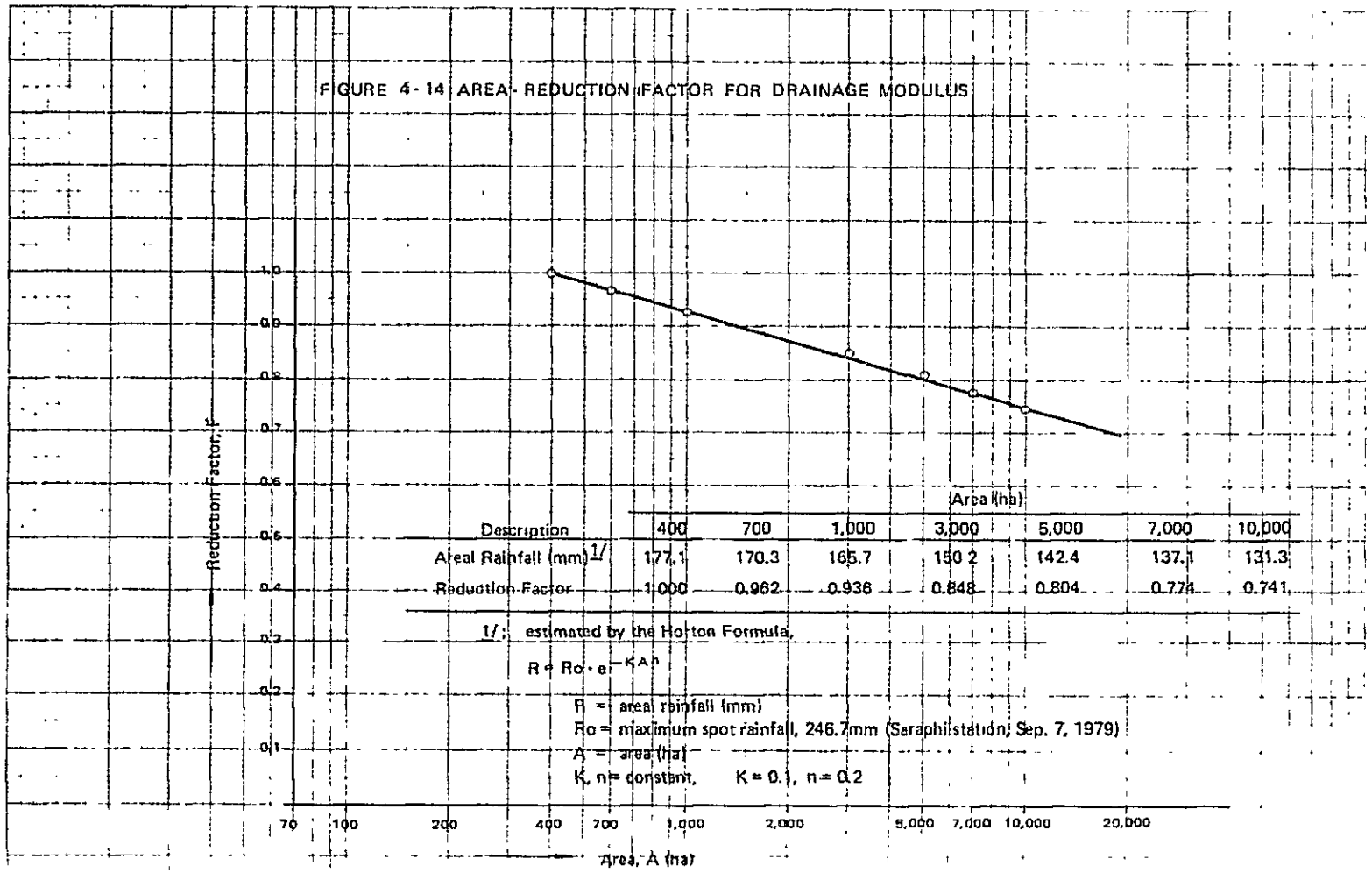


FIGURE 4-14 AREA-REDUCTION FACTOR FOR DRAINAGE MODULUS



Description	Area (ha)						
	400	700	1,000	3,000	5,000	7,000	10,000
Areal Rainfall (mm) 1/	177.1	170.3	165.7	150.2	142.4	137.1	131.3
Reduction Factor	1.000	0.962	0.936	0.848	0.804	0.774	0.741

1/: estimated by the Horton Formula,

$R = Ro \cdot e^{-KA^n}$

R = areal rainfall (mm)
Ro = maximum spot rainfall, 246.7mm (Saraphi station, Sep. 7, 1979)
A = area (ha)
K, n = constant, K = 0.1, n = 0.2

4.2.8 Hydropower Generation Plan

A small scale hydropower generation plan is incidentally proposed to the irrigation water release in this Project. Therefore, a very preliminary study was conducted in this section for references.

Three dams such as the Left Saddle Dam, the Main Dam, and the Right Saddle Dam are proposed to be constructed in this Project. It is conceivable to establish several alternative hydropower plans according to combination of water release courses, available heads and discharges among the three dams as described in the next section.

a) Reservoir Water Release Plan

The following three alternative plans are proposed taking the irrigation water use and the hydropower generation into account. An annual average water release amount comes up to 229 MCM in every alternative. A possibility of the hydropower generation in the Right Bank Area is exceedingly small because the annual average water release amount is as little as 18 MCM only.

Alternative-1: Water Release from Right Saddle and Left Saddle Dams

All water for the Existing Irrigated Area, the Left High and Downstream Area will be released through the outlet facilities installed at the left saddle dam. Power plants at both banks would be installed at an elevation of EL 350 m. An available head in this alternative is the least in comparison with other alternatives due to high location of the power plant. It is possible to utilize again a released water head for the Existing Irrigated Area after the hydropower generation, but it would be economically unfeasible in comparing with the alternative-2. Because the by-pass works for temporary drain of the main dam can be appropriated as the outlet conduit in the alternative-2.

	Annual Average Release Amount (MCM)	Available Head (m)
Left Saddle Dam	211	40
Right Saddle Dam	18	40
Total	229	40

Alternative-2: Water Release from Each Dam

The outlet conduit for the temporary drain of the Main Dam can be used for irrigation water supply of the Existing Irrigated Area The power plant corresponding to the Main Dam could be installed as low as EL 338 m in this alternative. Hence, an available head is bigger than the alternative-1.

	Annual Average Release Amount (MCM)	Available Head (m)
Left Saddle Dam	125	40
Main Dam	86	52
Right Saddle Dam	18	40
Total	229	44.5 1/

Remark: 1/ Weighted average considering release amount

Alternative-3: Water Release from Each Dam

A release amount through the Main Dam conduit which has maximum available head is maximized in this alternative expanding the irrigable area commanded by release water through Main Dam as possible. This alternative would be best one from viewpoint of the hydropower generation plan.

	Annual Average Release Amount (MCM)	Available Head (m)
Left Saddle Dam	42	40
Main Dam	169	52
Right Saddle Dam	18	40
Total	229	48.9

The previous mentioned concept is schematically illustrated in Figure 4-15.

b) Power Output

Major dimensions of the hydropower generation plan are as shown in Table 4-12. An annual electric energy generation is estimated throughout 28 years from 1952 to 1979 and comes up to 18.5 GWh in case of alternative-3 as shown below;

Annual Electric Energy Generation

(Unit: MWh)

	Left Saddle Dam	Main Dam	Right Saddle Dam	Total
Alternative-1	12,837	-	1,068	13,905
Alternative-2	7,846	7,385	1,068	16,299
Alternative-3	2,468	14,946	1,068	18,482

A monthly electric energy generation is governed by the irrigation water use and fluctuates remarkably as shown in Table 4-13. Detail dimension of hydropower plant and monthly power output for 28 years from 1952 to 1979 are shown in Table E 2-1 to E 2-7, Appendix E-2.

Table 4-12 Major Dimension of Hydropower Generation Plants

	Head		Discharge		
	Max. (m)	Design[1/] (m)	Max. (cu.m/s)	Design[2/] (cu.m/s)	Output (kw)
Alternative-1					
Left Saddle Dam	40	27	15.41	12.5	2,840
Right Saddle Dam	40	27	1.30	1.0	230
Total			16.71	13.5	3,070
Alternative-2					
Left Saddle Dam	40	27	9.14	8.0	1,820
Main Dam	52	39	6.29	5.0	1,640
Right Saddle Dam	40	27	1.30	1.0	230
Total			16.73	14.0	3,690
Alternative-3					
Left Saddle Dam	40	27	3.10	2.3	520
Main Dam	52	39	12.31	10.5	3,450
Right Saddle Dam	40	27	1.30	1.0	230
Total			16.71	13.8	4,200

Remarks: 1/ Maximum head x 2/3

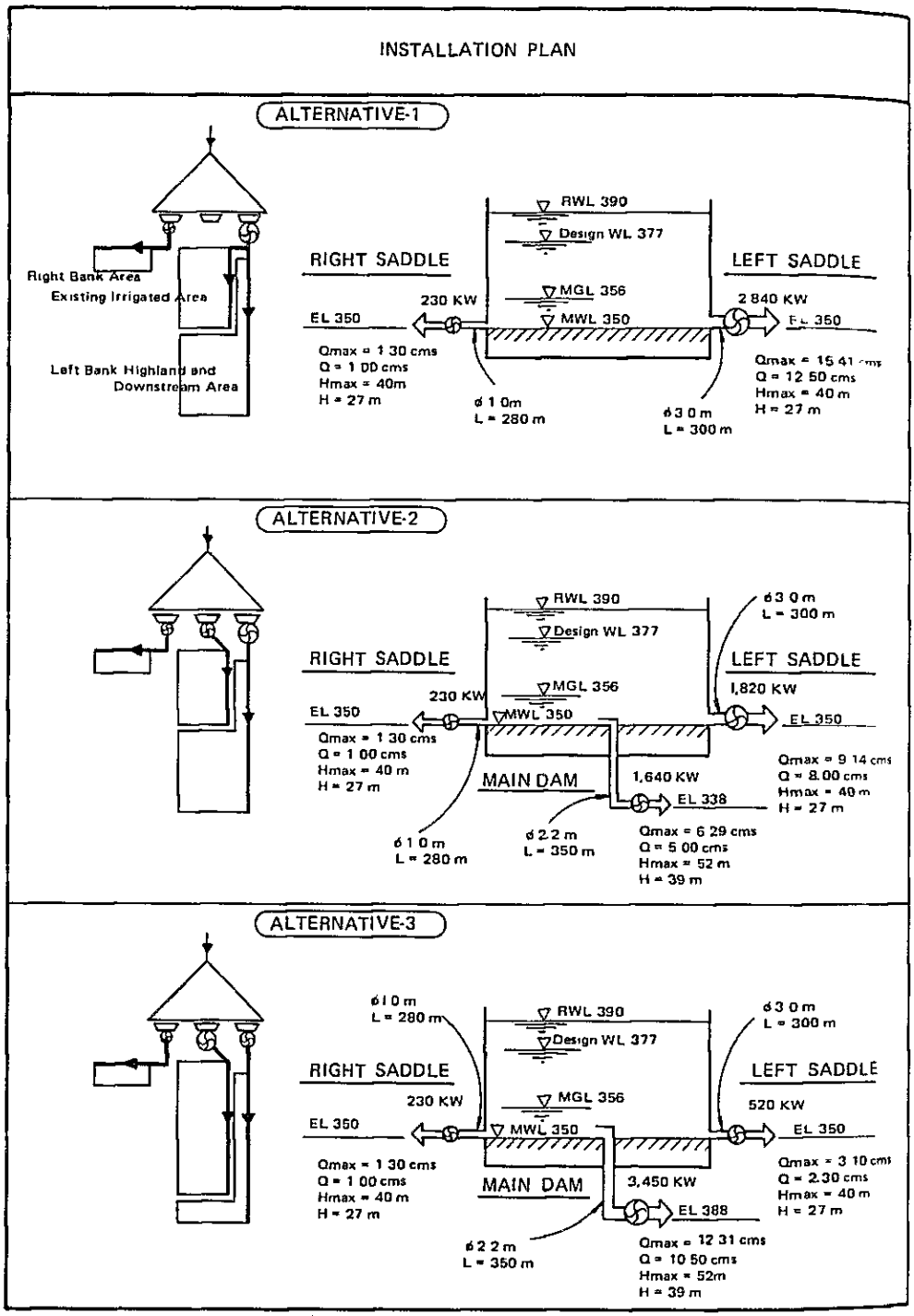
2/ 20% discharge in discharge-duration curve (See Figure 4-16)

Table 4-13 Monthly Electric Energy Generation

(Unit: MWh)

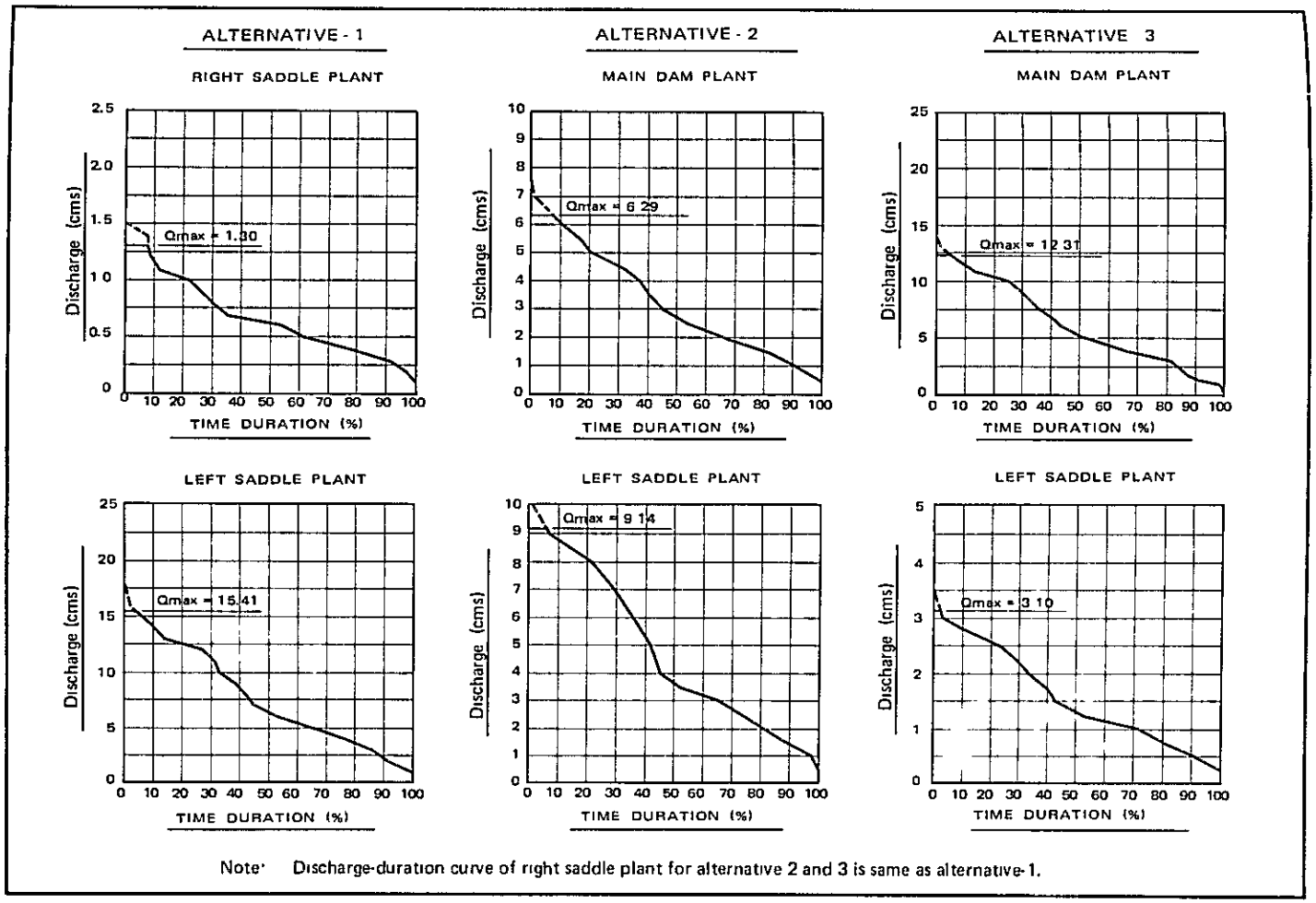
	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
Alternative-1													
Left Saddle Dam	1,425	345	450	1,531	952	1,045	1,821	934	148	604	1,714	1,888	12,857
Right Saddle Dam	68	18	41	118	71	59	96	74	87	154	145	137	1,068
Total	1,493	363	491	1,649	1,003	1,104	1,917	1,008	235	758	1,859	2,025	13,905
Alternative-2													
Left Saddle Dam	800	201	269	936	551	611	1,109	552	140	417	1,090	1,170	7,846
Main Dam	895	199	258	922	539	607	1,056	514	36	254	983	1,122	7,385
Right Saddle Dam	68	18	41	118	71	59	96	74	87	154	145	137	1,068
Total	1,763	418	568	1,976	1,161	1,277	2,261	1,140	263	825	2,218	2,429	16,299
Alternative-3													
Left Saddle Dam	263	64	89	292	184	203	342	184	40	136	323	348	2,468
Main Dam	1,681	397	516	1,858	1,062	1,175	2,123	1,017	147	626	2,035	2,309	14,946
Right Saddle Dam	68	18	41	118	71	59	96	74	87	154	145	137	1,068
Total	2,012	479	646	2,268	1,317	1,437	2,561	1,275	274	916	2,503	2,794	18,482

FIGURE 4-15 INSTALLATION PLAN OF HYDROPOWER PLANTS



Note: Q: Rated Discharge, H: Rated Head

FIGURE 4 - 16 DISCHARGE - DURATION CURVE AT HYDROPOWER PLANT



Note: Discharge-duration curve of right saddle plant for alternative 2 and 3 is same as alternative-1.

4.3 Agricultural Development Plan

4.3.1 Agricultural Production

a) Selection of Crops

In selecting the crops for the Project such condition as suitability to soils and meteorological environments and high marketing potentiality are taken into account. As a result, rice, soybean, groundnut, tobacco, and sweetcorn, and such vegetables as garlic, and cabbage, etc., are recommended.

For the newly developed orchards longan is proposed. Since, these crops have been grown so far both inside and outside of the Project Area, there exist few problems from the viewpoint of cultivation techniques. Out of these crops, rice is means for both self consumption and market, and other crops are mostly for market. The markets are Chiang Mai and Bangkok. However, tobacco is planted for the purpose of exporting

b) Proposed Cropping Pattern

The existing wet season crop is mostly paddy in fields and this practices will not change even after the Project. In the dry season few cropping has been undertaken so far because of non-availability of irrigation water, but various crops are planted in areas suited to the soil conditions.

In the upland fields such a cropping pattern is recommended, that is, a combination of planting soybean and groundnut in high demand as well as with maintaining effective production ability of soils, and tobacco and longan with high profitability. This means the combination of wet season cropping and dry season cropping.

Rice - Rice (Non-glutinous)

This combination is applied at the area where retaining of irrigation water is comparatively easy. However, if this pattern alone

is continued year after year, weed and pest damages become increasingly rampant. Therefore, it is necessary to rotate such a pattern as upland cropping in the dry season.

Rice - Groundnut

This combination is good for sandy soils at the comparatively higher area with good drainage. This combination is effective in retaining good land fertility. Since they are in good demand, the planting areas for groundnut are cared to be planted in wide space.

Rice - Soybean

Different from the above combination, this is suitable for comparatively low area. Profitability is little bit less but the demand is high.

Rice - Sweetcorn

This is good for comparatively low area and is easy cropping pattern. However, marketing is rather unstable.

Rice - Tobacco

This is suitable for the slope of sandy soils with good drainage. In this combination, it is necessary to plant tobacco as soon as possible after harvesting paddy.

Rice - Garlic

This should be undertaken at fertile land. It is not worthy that garlic needs much labours in planting.

Rice - Vegetables

Rice is combined with such vegetables as cabbage, tomato, onion, etc. This needs fertile land. As the profit depend on the cropping management, good experience is indispensable.

Soybean (or Groundnut) - Tobacco

Different from the combination of rice and tobacco, that is advantageous in that adequate time is usable in planting tobacco. The produced soybeans become seeds for the dry season cultivation.

Soybean - Groundnut

This is comparatively easy manageable. This combination is proposed to be combined with any cropping pattern with high profitability.

Longan

It is possible to make high income under the water management is well performed and its productivity is also high.

c) Requirement of Input Materials

Amount of fertilizers in use has been on the increase year after year. This trend is deemed in rapid progress in parallel with an improvement of irrigation facilities. The following table shows the cropwise total amount of fertilizers to be applied in accordance with extension program. And besides, application of lime is necessary to adjust pH value of soil.

Amount of Fertilizers to be applied in the Project Area

Fertilizers	Crops	Acreage Applied (ha)	Amount of Application per Hectare (kg)	Total (ton)
16-20-0	Rice (wet)	17,347	125	2,168
16-20-0	Rice (dry)	2,500	187.5	469
Total				2,637
12-24-12	Soybean (wet)	1,989	187.5	373
12-24-12	Soybean (dry)	7,215	187.5	1,353
12-24-12	Groundnut (dry)	4,751	187.5	891
12-24-12	Sweetcorn (dry)	2,163	312.5	676
Total				3,293
6-15-30	Tobacco (dry)	1,255	750	941
Total				941
15-15-15	Garlic (dry)	989	625	618
15-15-15	Vegetables (dry)	411	625	356
Total				974

The consumption of agricultural chemicals for pesticides is not easy to be figured out since pest damages vary yearly. Therefore, only names of needed chemicals are mentioned by pest damaged as follows:

Crops	Pest	Chemical
Rice	Green Leaf Hopper	Carbaryl
	Stem Borer	Furadan 3G
	Rice Bug	Carbaryl, Malathion
	Rice Gall Midge	Furadan 3G
Soybean	Bean Fly	Furadan 3G
	Leaf Eating Caterpillar	Dimethoate
	Leaf Hopper	Carbaryl
	Aphid	Malathion
	Nemathode	Temik, DD, etc.
Groundnut	Leaf Spot	Benomyl
Vegetable	Cabbage Flea Beetles	Methomyl
	Diamond Black Moth	Methomyl
Tobacco	Nematode	Methyl Bromide

d) Crop Production

Cropwise production amounts are mentioned in the following table. The paddy field of Mae Tang Experiment Station neighbouring the Project Area shows 4.8 to 5.4 ton/ha in the wet season and 3.8 to 4.1 ton/ha in the dry season. However, this is resulted by a good farm management at the small area and the yield in general should be regarded as smaller than this amount.

Crop Production in the Project Area

Crops	Yield per Hectare (ton)	Acreage (ha)	Total Production (ton)	Yield per Hectare (ton)	Acreage (ha)	Total Production (ton)
Rice	4.6	17,347	79,792	4.4	2,500	11,000
Soybean	1.8	1,989	3,580	1.8	7,215	12,987
Groundnut				2.1	4,751	9,977
Tobacco				1.6	1,255	2,008
Sweetcorn				7.1	2,163	15,357
Garlic				6.2	989	6,132
Cabbage				13.3	411	5,466
Longan				3.0	666	1,998

By the past experience the paddy yield in the wet season is designed 4.6 ton/ha (740 kg/rai) prospecting 15 percent decrease and in the dry season 4.4 ton/ha, 10 percent increase in the yield of Mae Tang Experiment Station because in dry season paddy cultivation there remains much room for the development of cultivation techniques, and farmers can easily obtain experiences in these techniques.

4.3.2 Plan for Marketing and Processing of Agricultural Products

a) Marketing of Agricultural Products

Farmers in the Project Area sell their marketable surplus of paddy immediately after harvest to local merchants within the same Amphoe (more than 60 percent) and then local merchants sell the paddy mostly to millers in the City (83 percent). Other storable crops such as soybean, peanuts, mung bean etc. are sold to local merchants

and channeled to either whole salers in the City or merchants from Bangkok and/or other Changwats (See Appendix F-2).

The following facts are envisaged in the primary course of marketing of agricultural products in the area.

i) Since merchants rarely pay before collecting the produce and farmers do not feel obliged to sell to particular buyer and then farmers; bargaining power is felt still maintained in this area.

ii) Most of farmers seek price information only shortly before each sales. They want to have a more accurate idea of the cash crops at selling time than they do for paddy.

iii) Very little marketing services for farm products is provided by the agricultural cooperatives.

iv) Marketing system in this area has no barrier to new entry for anyone including cooperative.

Under these stipulations, it is conceived that still many spaces where entry of cooperatives can be allowed without so much difficulty. However, the fundamental problems for the cooperatives to participate in marketing business in favour of their members are:

° Shortage of operational fund and
° Provision of necessary marketing information to members

The marketing information service, especially for cash crops cannot be by-passed for further development of cooperative activity. The Government has encouraged for cooperatives to collecting the paddy and has given long-term loan to establish paddy warehouse. There are already five warehouses with 2,300 ton capacity in the Project Area owned by cooperatives. However, collected paddy were only 280 ton by cooperative of Doi Saket with 1,000 ton capacity warehouse, 30 ton by cooperative of San Sai with 500 ton capacity and

rice mill with 20 ton per day capacity owned by cooperative of Amphoe Muang Lamphun worked 2 - 3 months only with 20 working day within one month. Every cooperative claimed the shortage of running fund. Running fund is another serious problem on the further development of cooperatives.

b) Processing of Agricultural Products

In consideration of existing rice mill operated by cooperative in Amphoe San Pa Tong which runs successfully with fair amount of profit, there would be reasonable room to have a new establishment of small scale rice mill equipped with newly developed small-scale bran oil extraction device in the Project Area. This new developed bran oil extraction equipment can be utilized to extract oil from oil bearing seed. Rice milling is usually seasonable. In case of special equipment is attached to the mill, it can run throughout year. Such new establishment would pay enough especially in anticipation of increased production of paddy, soybean and peanut. Agricultural processing facilities are not to be large scale. In consideration of the fact that food processing factory mainly for the purpose of processing canned food and fruits and vegetables juice established in Lamphun does not work well due to difficulty of proper collecting materials. Both agricultural products in the area available for processing use and marketing conditions should be carefully taken into account for capacity of establishment.

4.3.3 Farm Management Plan

a) Land Holding Size

There will be no change for a certain period ahead. The land-holding size is about 1.4 ha.

b) Cropping System

Out of the 20,000 ha of the Project Area some 2,650 ha is occupied by upland fields and the rest is used as wet season paddy fields. In other words 1893 farmers, about 13 percent of total

landholdings are upland cropping farmers and the rest, 12,393 farmers are engaged in wet season paddy cultivation.

For these paddy cultivation farmers and upland cropping farmers are to be applied eight cropping systems mentioned Previous section. Table 4-14 and Figure 4-1 show the farm managementwise acreage and number of farm households on the basis of standard farmer who owns 1.4 ha of landholding per household and 4 farm labours.

c) Farm Mechanization Plan and Farm Labours Balance

Farm mechanization is in progress in the surrounding areas including the Project Area. To promote this Project it is necessary to accelerate the farm mechanization due to the following reasons:

- Plowing works can be undertaken as scheduled and in shorter period, the water being available by the irrigation system.
- The time required for plowing works is limited related to the following cropping.
- Since the kind and volume of crops increase due to expanded dry season cultivation, enhancement of efficiency in the works becomes imperative as whole.
- Owing to the water available by the irrigation system increasing supply of fertilizers is required. This could lead to a yield increase with effective pest control. Such control machinery as pesticide sprayers are needed to conduct proper works in proper time.

In short, it is quite natural that farm machinery should be introduced in order to enhance the work efficiency, forced by the fact that the farming works become diversified by complicated cropping due to irrigation. For example, in the case of cropping pattern including garlic that needs intensified labours, the breakdown of farm labours is shown in the two examples of the following table. This table tells farmers to become busy in preparation for garlic bed and ditches and during garlic planting after paddy harvest.

In the proposed farm management, in which case one third of the landholding 0.47 ha (2.9 rai), out of 1.4 ha (8.75 rai) of unit landholding per household with 4 labours, is cultivated with garlic, about 19 mandays are needed in preparation for bed and ditches and about 16 man-days for planting, both at the peak time of busy working. In this case, farm working is a little bit over load to farmer.

Labour Requirement for the Garlic Cropping

(Unit: Man-day/rai)

Works	Example 1	Example 2
Plowing	0.54	0.84
Preparation for garlic bed and ditches	6.66	6.49
Planting	13.34	16.63
Application of fertilizers	0.87	1.39
Irrigation	4.40	5.91
Weeding	2.34	3.31
Harvesting, curing, carrying, selling	13.84	15.34
Total	41.99	49.91
Yield (kg/rai)	418	759

Therefore, farm mechanization is recommended so that labours are economized and an opportunity for new job can be created in the dry season. Thus, new employment can be taken place.

4.3.4 Agricultural Supporting Institution System

Even if on-going irrigation project is to be completed successfully, only supply of water cannot overcome the coming necessities for development of irrigated area in favor of farmers without full support of various kinds of agricultural supporting institutions. It is envisaged that more intensified agricultural practices would become among farmers in the Project Area. Intensive agricultural practices can be done through so called "agricultural package program". All kinds of necessary agricultural inputs should be provided

to farmers backed up by institutional loan, if necessary, and at the same time effective agricultural extension services should be extended to farmers. Furthermore products of expected intensive agriculture should be marketed and processed safely for general demand in both the country and abroad.

In such context, agricultural supporting institutions are usually categorized into three; Extension services including agricultural research work, cooperatives' activities and institutional finance. All these three agricultural supporting institutions should b developed in an interwove manner in the national context and should not be resolved at local level as those in the Project Area.

- Nationwide extension system (Kaset Tambol System) is now under way to be completed in 1982 (see Appendix F-4). (Kaset Tambol system was established in Changwat Chiang Mai in 1979 and in Changwat Lamphun just in 1981)

- Individual coopratives have evolved into multipurpose cooperatives consolidating old type huge number of small credit societies mostly at village basis after establishment of Department of Cooperative Promotion in 1972 and the Government gives special emphasis upon expansion and strengthening their economic power backed up by institutional finance especially by BAAC (see Appendix F-6).

- Institutional finance has developed remarkably after establishment of BAAC in 1966 and credit situation of farmers has already improved as well as incomparably with pre-period of BAAC's establishment. However, it should be found out here that every cooperative in the Project Area is feeling seriously shortage of running funds. It should be resolved at national basis (see Appendix F-8).

Agricultural Supporting Institutions belong to mostly national matters and still these are to be inter-acting each other well synchronizedly. They cannot operate well without any one of them and then it should be well recognized that they cannot be developed

at one corner of the Changwat only. In such background, focussing at local level, the following several points are to be found out in the survey for this time. They are mostly local base matters.

a) Extension Service

Kaset Tambol system in agricultural extension services is scheduled to be completed in 1982 and then one extension officer called Kaset Tambol would come to cover about 1,000 farmers and one Kaset Tambol is to be assigned within boundary one Tambol with exception of plural Kaset Tambols within larger Tambol. It then, recommended that the ratio would be more intensified in number of Kaset Tambol assignment in the Project Area at least in the initial stage of the Project if possible. Because expanded any reason cultivation requires different type of technology for farming pattern to be introduced in the Project Area which had not been accustomed to farmers, especially in the High and Down stream Areas where new type of intensive farming including dry season cropping is expected to be introduced for the first time.

b) Cooperative Activities

It is entirely endorsed that multipurpose cooperative must be main channel through which both intensive agricultural imports is diffused properly to farmers in close cooperation with extension officer and also at the same time agricultural products are marketed and/or processed appropriately backed up financial institution in the coming future of intensified agriculture.

There are, however, several different activities among cooperatives in Changwat Chiang Mai right now. Some of them are rather active and others are less active. Now that formal cooperatives system and activities thereof had been already established, it is responsibility of each individual cooperative in the Project Area how to improve more active business in favour of members modeled after neighbouring active cooperatives in the same Changwat

The underwriting activities may be carried out, for example, as one of individual cooperatives' activities in favour of members.

Seed Multiplication Project

It is expected that enough supply of improved varieties which is to be adopted to the different soil conditions in the Project Area should be necessary as a part of package program of intensive agriculture. Seed multiplication project would be carried out by cooperative under supervision concerned local authorities (Kaset Amphoe and/or Agricultural Experimental Station).

Community Nursery Project

Healthy and strong seedlings will bring about good harvest. It may be one of the cooperative activities to make community nursery bed of improved varieties at the most suitable paddy field location with good water supply so that seedlings of improved varieties will be distributed to member farmers at transplanting time. Individual farmers can save time to select, make and take care of nursery bed, and can have an opportunity to concentrate their efforts for preparation of paddy fields. Such performance of practices may be said to be the start of intensified agriculture.

Custom Hired Services of Agricultural Machinery Project

In anticipation of coming intensified agriculture of the Project Area, various kinds of machineries such as power tiller, farm dryer, etc. are to be introduced. However, they are not needed to be owned by individual farmers themselves, because of too much burden upon them. They may be operated by well trained cooperative staff and/or member on custom hired basis. This is the same principle for cooperative to collect, market and process agricultural products in favour of members.

4.3.5 Pilot Farm

In executing the Project, there remain several problems to be solved pertaining to farming. In the case of single cropping of paddy, farmers are able to do such works as plowing and levelling in considerably free manner to meet the rainfall since following period is rather long. In contrast to this single cropping, however, when the dry season cultivation is made possible due to the improvement in irrigation system, the working period becomes limited. Hence, the workings need efficient way as much as possible. The next problem to be solved is how to recover land fertility since it is decreased by irrigation and frequent harvesting. Accordingly it is necessary to apply soil dressing and compost to recover the fertility. In other words, irrigation development makes it possible to double cropping period and to stable yields, and for this purpose it is necessary to make farmers well versed with different from conventional way and performing reasonable farm management.

Therefore, in prior to the general farming, such an area, when irrigation is rather easily done and soil conditions are medium, must be chosen and high yielding variety, high efficient farm machinery as well as pest control techniques must be introduced under the farm management by systematic way. Thus, the meaning of irrigation development must be understood by the farmers.

In addition to the above, as for the plot size of paddy field a considerably wide space, 200 hectare, for example, may be chosen so that the effect of irrigation water can be realized to a greater extent.

Three recommendable plots were chosen during the period of the survey. Two plots out of them, proposed sites of which are: Ban Ton Pao and Ban Luang Nua have been set up as indicated in Figure 4-18.

Technical requirements for the cultivation at the pilot farm are as follows:

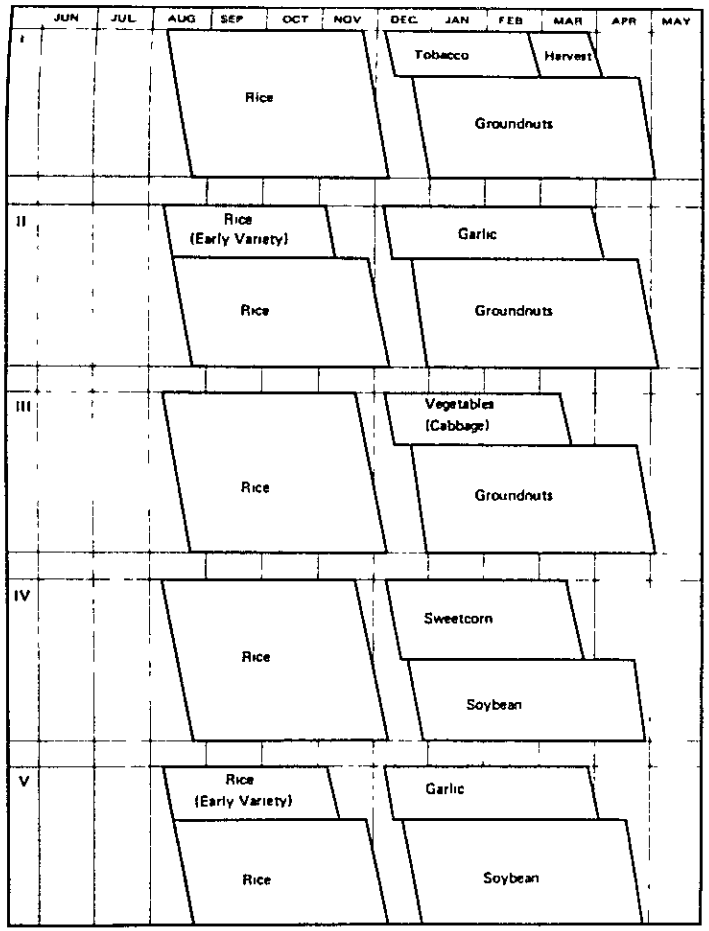
Rice:
- Plowing, levelling and puddling by hand tractor
- Adoption of high yielding varieties with good quality
- Fertilizing and pest controlling
- Increasing land fertility
- Mechanization for harvesting and transportation

Upland Crops:
- Plowing and land preparation by hand tractor
- Adoption of high yielding varieties with good quality
- Fertilizing and pest controlling
- Increasing land fertility
- Mechanization for land managing, harvesting and transportation

Crop Rotation:
- Establishing comprehensive system for preserving yields
- Measuring for increasing land fertility

Table 4-14 Proposed Cropping System

	Cropping System Wet Season + Dry Season	Ratio	Acreage (ha)		No. of Householder	
I	Rice + Groundnut	2/3	240		171	
	Rice + Tobacco	1/3	468		334	
			1,734	2,442	1,239	1,774
II	Rice + Groundnut	2/3	237		169	
	Rice + Garlic	1/3	360		257	
			530	1,130	381	807
III	Rice + Groundnut	2/3	240		171	
	Rice + Vegetable	1/3	459		328	
			533	1,232	381	808
IV	Rice + Soybean	1/2	-		-	
	Rice + Sweetcorn	1/2	1,216		869	
			3,109	4,325	2,221	3,090
V	Rice + Soybean	2/3	-		-	
	Rice + Garlic	1/3	912		651	
			924	1,836	660	1,311
VI	Rice + Rice	2/5	-		-	
	Rice + Soybean	3/5	3,586		2,561	
			2,794	6,380	1,996	4,557
VII	Soybean + Tobacco	1/3	744		531	
	Soybean + Groundnut	2/3	-		-	
			579	1,323	414	945
VIII	Soybean + Groundnut	1/2	740		529	
	Longan	1/2	-		-	
			592	1,332	425	952
Total	Right Bank Area		2,200		1,571	
	Existing Irrigated Area		7,000		5,000	
	Left Bank and Downstream Area		10,800	20,000	7,715	14,286


JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
I
Tobacco
Harvest
Rice
Groundnuts
II
Rice
(Early Variety)
Garlic
Rice
Groundnuts
III
Vegetables
(Cabbage)
Rice
Groundnuts
IV
Sweetcorn
Rice
Soybean
V
Rice
(Early Variety)
Garlic
Rice
Soybean

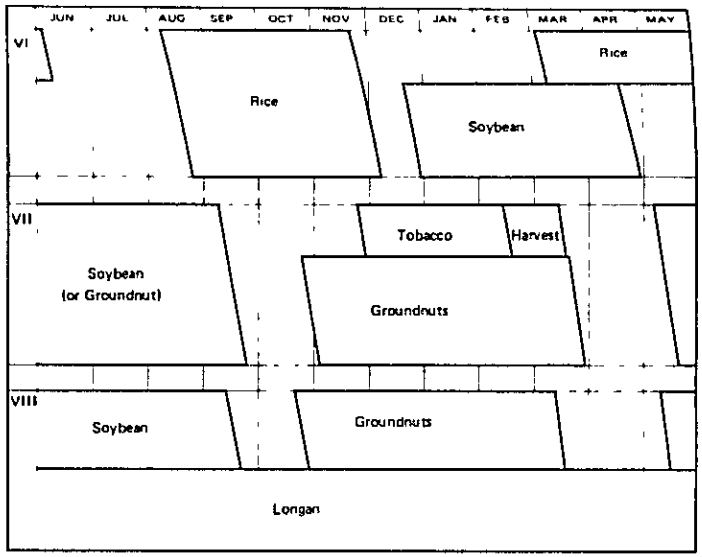
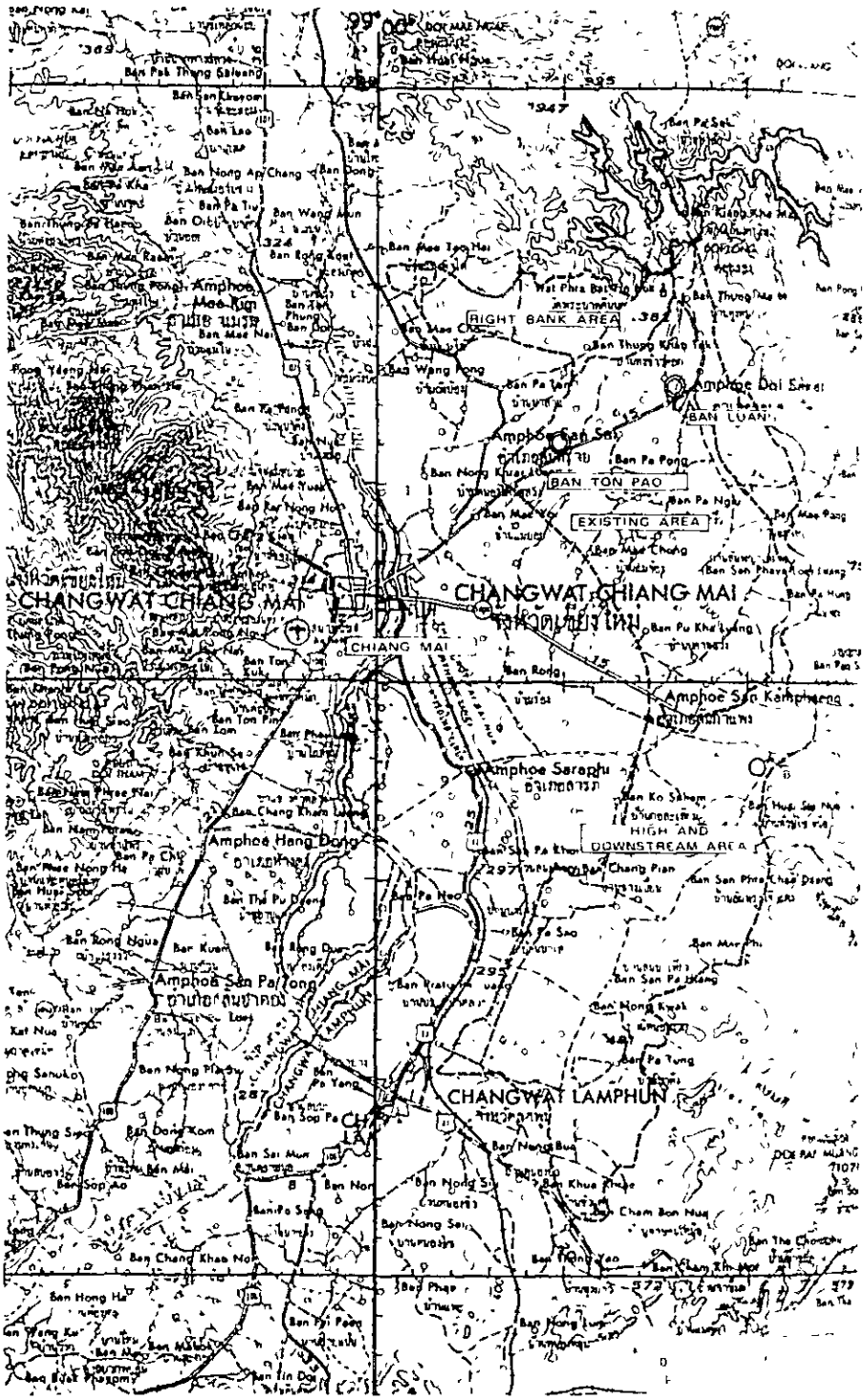

JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
VI
Rice
Rice
Soybean
VII
Soybean
(or Groundnut)
Tobacco
Harvest
Groundnuts
VIII
Soybean
Groundnuts
Longan

FIGURE 4 18 LOCATION MAP OF PILOT FARMS



4.4 Physical Planning

4.4.1 Dam

a) Topography and Geology

Topography

The Mae Kuang damsite is located at the boundary of the Chiang Mai basin and the mountainous area which restricts on east and northeast of the basin.

The Mae Kuang originates at the border mountain range between Chiang Mai Province and Chiang Rai Province and flows down passing through the mountainous area as meandering complicatedly but toward west as a whole, then, down southward, just upstream of the damsite, passing the damsite and pouring into the Chiang Mai basin.

The catchment area of the Mae Kuang is almost all occupied by steep mountainous area. The mountains have summit elevation of 700 to 900 meters, steep slopes and also have an extreme tendency trending NW-SW direction. This topographical tendency is derived from the basic geological structure as described in following clause.

The transition zone from the mountainous area to the Chiang Mai basin along the Mae Kuang, in other words, the contact of the Mae Kuang valley and the Chiang Mai basin extends about 3.5 km wide and within the spread two small mountains are existing. For the wide spread, nevertheless the mouth of the valley is restricted by these mountains, the Mae Kuang has not formed a fan toward the basin.

The Mae Kuang damsite is set just at the mouth of the Mae Kuang valley stitching two small mountains. Because of this situation, the damsite consists of three dams, the Main Dam which dams up the Mae Kuang main flow between these two small mountains and two sub dams which guard an overflow from saddles behind these small mountains. On the other hand, this situation allowed to keep a big storage capacity at immediate upstream of these dams.

Topographic features of each damsite are as follows:

Main Dam	Elevation of river bed is 337 m Height-Span ratio at EL 400 m is 10.2
Left Saddle Dam:	Elevation of river bed is 355 m Height-Span ratio at EL 400 m is 14.4
Right Saddle Dam:	Elevation of river bed is 363 m Height-Span ratio at EL 400 m is 17.8

These height-span ratios indicate that all dams must have a long crest in comparison with their crest highness.

2) Geology[1/]

Geology of the damsite consists of Khaeng Krachan formation (Carboniferous, Palaeozoic) as bedrock and overlying quaternary deposits.

The bedrocks are composed of sandstone, shale, slate, and their alternations, and have a general dips and strikes of N40° - 50°W, 40° - 60°NE. Generally, the rocks are very hard but they have been altered into so cracky and flaky phase because they have been complexly folded and faulted, especially, the slatey strata have been crushed into fine particles in many cases.

Diluvium is distributed in both saddle damsites and alluvium exists in all damsites. These quaternary deposits consist of mainly gravels, sands and silts and these deposits range in thickness from 8 to 16 meters at the Main and the Right Saddle Damsite, and from five to eight meters at the Left Saddle Damsite.

3) Each Damsite

Main Damsite

The bedrock of the Main Damsite is mainly composed of sandstone

---

1/ Details are referred to Appendix G.

and sandy quartzite and rarely intercalates shale beds. The seismic exploration revealed that an elastic wave velocity of the bedrock is about 4.0 km/sec and at the part where there exists intercalated shale beds ranging from 3.0 to 3.3 km/sec. These velocities indicate the rocks are rather hard, but they are presumed not to be tight because a permeability coefficient of the bed is considerably high. The bedrock which has a permeability of 2 - 8 lugeon is dominant in the site but considerable parts of the foundation have a high permeability of more than 10 lugeon, furthermore, some parts of the one have a permeability of more than 100 lugeon. At the damsite two large low-velocity-zones which are regarded as big scaled fault are existing just under its both abutments.

Generally, the thickness of river deposits are large and some part, of which is presumed as the old river route, it exceeds 20 meters. The river deposits are made up largely of sands and contain some silts and clays at their upper part, rather thick gravel layers at their middle and lower parts.

Left Saddle Damsite

The foundation of the Left Saddle Damsite is composed of slate and alternations of slate and sandstones, and contains some sandstone beds intercalated.

At this site, so many faults and sheared-zones are observed and they are presumed to form a fault complex. The foundation of the site has been altered intensively by cutting, by the fault complex, and by subjecting to hydrothermal alternation followed along the complex. The strike of this fault complex is presumed to be N30° - 40°W direction from a macroscopic view, similar to the trend of mountain ranges surrounding the site.

The result of the seismic exploration shows the elastic wave velocities of the bedrocks ranging from 3.2 to 3.5 km/sec. It means, the bedrocks are generally hard, but the result shows also the

existence of many low-velocity-zones simultaneously. Anyhow, almost all results of the field investigation works indicate that the foundation of the site has been heavily disturbed.

The analysis of the permeability tests is also one of them. The foundation of the site has permeability coefficients widely ranging from 0.1 to 200 lugeon. Among them the parts which indicate low lugeon value less than 1.0 lugeon (the parts are mainly correlative with a fault clay or a heavy sheared zone) show also very low critical pressures ranging from 2.0 to 5.0 kg/cm^2. It means a dangerous situation for a dam that the critical pressures of the foundation occupied by these parts will be less than the total water head of a reservoir in case of a large dam.

Right Saddle Dam

The bedrock of the site mainly consists of sandstone and sandy quartzite and contains some shale or slate bed intercalated in right bank.

The elastic wave velocities of the bed rocks range from 3.5 to 4.1 km/sec and these values indicate the bedrocks are of very good quality. However, altogether four low-velocity-zones concentrate at the part of the river bed about 200 meters in width, and at this part a fault complex just similar to the one existing in the Left Saddle Damsite presumes to traverse.

The river deposits are generally thin except at a certain part as mentioned above, the thickness of the deposits is estimated nearly 15 meters.

Although the large parts of the river bed have rather thin overburden, a weathered rock zone which has an elastic wave velocity of about 2.0 km/sec are distributed widely and deeply. Thus, a permeability coefficient of the bedrock is generally high (10 - 15 lugeon, more than 100 lugeon in a part).

b) Embankment Materials[1/]

(1) Borrow Area

The locations of the borrow areas are shown in Figure 4-19.

Borrow area investigations and materials studies being conducted concurrently should be continued furthermore.

The following numerical order of the borrow area is an indication of priority of investigation:

i) Reservoir areas

ii) Downstream areas within the 5 km limit far from the damsite

iii) Another downstream areas

This reconnaissance finds the recommended borrow areas and quarries in addition to the investigated areas up to date.

There are three borrow areas: the downstream area of No.16 borrow area, the area along the access road and Ban Pa Sak Ngam.

The following quarries are recommended for investigation, from an economical standpoint, to reduce the soil materials.

They are the upstream area at the left hand side of the Main Dam, the mountain in front of the Right Saddle Dam and the upstream area at the left side of the Left Saddle Dam.

Subsequent investigation should be conducted to quarry for riprap. Quarry along the road 1019 is recommended.

The rock quality of Ban Pa Sak Ngam and Ban Kat Khi Lek is good. However, areas are far from the damsite.

1/ Details are referred to Appendix II.

The use of materials from excavation for dam, spillways and other appurtenant structures shall also be taken into account.

(2) Materials

Embankment materials from Mae Kuang Dam shall be classified into pervious materials, semi-pervious materials and impervious materials.

Pervious materials and semi-pervious materials are coarse materials. They consist of rock and crushed stone from quarry, sand and gravel from river bed and coarse materials from excavation for spillway and other appurtenant structures. These materials are used for mechanical stability of the dam and free drainage.

Impervious materials are silt and clay or a combination of clay, silt and sand and soil with gravel.

The materials shall be obtained from borrow pits in borrow areas, from excavation for the dam embankment foundation and from excavation area for appurtenant structures.

Soil Materials

Soil materials are generally used for impervious material.

Soil materials must have the required coefficient of permeability and shear strength with a smaller compressibility after compaction, and must be easy to be compacted, and also must not contain a deleterious amount of organic substances.

Matrices of soil materials are sandstone, shale clay-slate and laterite. These soil consist of mostly silt and clay with variety of colour of greyish white, yellowish brown, reddish brown and brown

Natural moisture conditions, which are dry side against optimum water content, indicate that the water would have to be added to

most of the impervious zone.

Relative desirability of soil materials for core shall be recommended as follows:

I[1/]	:	GM GC[2/] Group
II	:	SC, SM Group
III	:	CL, ML Group
IV	:	CH, MH Group

In selecting the type of soil as core, materials should depend on the dam height and quality of materials available. According to RID's planning, only SC and CL shall be available as core materials.

The following criteria[3/] can be proposed to select the core material of soil:

- ° Plasticity index, Ip = Wl - Wp; more than 10 (6)[4/] %
- ° Gravel Content (Minus No.4); less than 50 (65) %
- ° Silt and clay content (Minus No.200); more than 15 (10) %
- ° Coefficient of permeability, k; less than 3×10^{-5} cm/s

Filter Material

Sand and gravel along the Mae Kuang river shall be mostly available for filter materials. Crushed rock can be used for filter materials. These materials are also suitable for concrete aggregate.

1/ Numerical order of group imply the priority of core usage.

2/ Soil classification based on Unified Soil Classification. Source is "Earth Manual" Bureau of Reclamation.

3/ Criteria based on examples of dams in Japan.

4/ (Numeral) shows the limitation. This proposal is one of the countermeasures against shortage amount of soil available in future.

Rock Materials

Rock materials should be sound and durable and should have the required strength and free draining. These materials are used as pervious or semi-pervious materials. Large size rock materials are suitable for outer zones and smaller size for semi-pervious zones in the layout of zone.

Types of rock for Mae Kuang Dams are limestone, sandstone, shale and clay-slate. Weathered sandstone, shale and clay-slate shall be liable to be crushed into small size during the construction or by weathering.

These soft rock materials and materials of diversified quality should be used with care for random zones.

Limestone and fresh sandstone shall be desirable to use as riprap materials and pervious materials.

(3) Quality and Available Quantity of Materials

The quality of materials and quantity economically available at or near the damsite are important factors in selecting the type of dams. Subsequent soil mechanical investigation should be conducted

Conservative estimates of the amount of materials available are required twice of the necessary amount of designing a balanced fill

Soil Materials

Amount of materials at each borrow areas is shown in Table 4-15

One of the most serious problems is shortage of amount of soil materials. This comes from landowner trouble of borrow area and only usage of SC, CL groups, according to RID's original plan.

The following countermeasures shall be recommended:

- Using another type of soil and/or mixing SC and CL with another soil. If necessary, stock pile shall be planned. This mixing method have merits of uniformity of materials, improvement of poor soil and increment of extent of soil type available.
- Using the rock materials and reduce the amount of soil materials in zoning of dams.

Rock Materials

Material investigation shall be initiated to determine the quarry sites and to study materials. Geological reconnaissance finds a lot of sandstone and shale in the reservoir area.

Selecting the quarry in the reservoir shall have the several merits:

- taking countermeasures of shortage of soil materials
- increasing the reservoir capacity
- quarries located at or near the damsite
- excavating the rock mostly by lipper and by a few blasting with a small amount of gunpowder
- decreasing the dam volume by using the rock with higher shear strength and free drainage

(4) Material Testing

Material Testing were executed by the following organizations:

- RID: Research & Laboratory Sect., January 1979
  Report of Soil Test (MEMO 209/2521)
- RID: Technical Division, 1980
  Report of Soil Test (MEMO 175/2522)
- RID: Site Laboratory, January 1978 to October 1980
  Report on Earth Work Control of Left Saddle Dam
- JICA: (contracted by K.E.C.), May 1981
  Factual Report on Soil Engineering Properties of Embankment Materials

° RID: Research & Laboratory Sect., September 1981
Report of Soil Test (MEMO 145/2524) and Rock Test (M-394 CA)

The results of material tests are shown in Table 4-16 and Figure 4-20.

(5) Findings and Recommendations on Embankment Materials

i) Soil materials having more than 50 percent of silt and clay shall be liable to crack in case of dry side compaction.

ii) A lump of soil materials with dry side water content against optimum moisture should be well compacted and be crushed into smaller size, otherwise this material shall cause a lot of settlement after slaking.

iii) Weathered sandstone, shale and clay-slate, being called soft rock, should be used carefully for random zone. Their quality might be diversified during and/or after construction.

iv) Soil of GM, GC, SC, SM, ML, CH and MH shall be available as core and random zone materials.

v) Natural moisture conditions indicate that the water would have to be added to most of the impervious zone.

vi) Amount of materials available shall be required twice of necessary amount in designs.

vii) In selecting the quarry for riprap, geological reconnaissance is required furthermore at or near the damsite.

viii) Material studies should be carried out continuously for grasping the following relations:
Water content, unit density, gravel content versus coefficient of permeability, shear strength and amount of settlement.

ix) Banking test is recommendable to collect the following data during the construction of the Left Saddle Dam:

- ° gravel content versus water content, density, coefficient of field permeability.
- ° number of roller passing versus density under the constant layer thickness
- ° checking the gradation curve before and after compaction for soft rock materials.
- ° compaction equipments are motor scraper, tamping (or sheep-foot) roller, bulldozer, dumptruck, vibrating roller and tamper.

x) geological survey and blasting test for selected quarries shall be recommended to carry out.

xi) Soil testing shall be required to the materials excavated from the dam foundation. Result of testing give the information on disposal of materials.

c) Layout of the Dam and Appurtenant Structures

As shown on the Table 3-15, major structures of the Project are as follows:

Left Saddle Dam:	H = 52m, L = 650m, V = 2.26 MCM
Main Dam:	H = 77m, L = 645m, V = 5.58 MCM
Right Saddle Dam:	H = 41m, L = 655m, V = 1.44 MCM
Left Canal Outlet:	Q max. = 9.14cu.m/sec, D = 3.0m, L = 300m
River Outlet:	Q max. = 6.29cu.m/sec, D = 2.2m, L = 300m
Right Canal Outlet:	Q max. = 1.30cu.m/sec, D = 1.0m, L = 245m
Spillway:	Q max. = 1,452cu.m/sec, Weir L = 150m

The relationships of these structures' elevation are illustrated in Figure 4-21.

(1) Layout of the Dam

Size of the Dam

As mentioned in the section of 4.2.5 b), total storage capacity of the reservoir is planned to be 325 MCM, and as shown in the Figure 4-5, this capacity shall be filled up by the Retention Water Level of 390.00 m.

In additioin to this water level, the overflow water head (Hd) on spillway and the freeboard (Fb) for dam-top together give the elevation of dam-top.

The RID's study[1/] found that Hd = 2.80 m was adequate and the relevant dam design employed Fb = 2.20 m; in other words, the dam height was decided by using the total value of 5.00 m, based on which the Left Saddle Dam construction has been implemented. The value of Hd is also studied and confirmed in the section of 4.4.1 c) (3) and the value of Fb is considered to be reasonable in taking into account the fact that the said value falls in an average range of the values adopted in many fill-type dams in Thailand. The crest elevation of the dam (dam-top) can result in EL 395.0 m, accordingly.

Zoning and Shape of Dam

On the discussion between dam engineers of RID and survey team, it was agreed that the type of the Dam shall be what is called as "Zoned Type". From the viewpoint of embankment material, however, Left Saddle Dam and Right Saddle Dam are similar to what is called as "Homogeneous Type". On the other hand, Main Dam, having its height as high as nearly 80 m, shall be made not only of soil material but also of coarse material at the shell zone. Therefore, it is similar to what is called as "Earth and Rockfill Type".

1/ Report prepared by Division of Hydrology, November 1977

Width of each dam-top are 10 m for Left Saddle and Main Dam and eight m for Right Saddle Dam. Slopes of each dam are 1 3.0 for upstream and 1:2.5 for downstream of both Left and Right Saddle Dams. These are same as RID original and were verified by survey team during the First Stage Survey. At Main Dam, slopes are 1:2.7 for upstream and 1:2.2 for downstream. These are a little steeper than the others, because rock zones are designed to both slopes and these rock zones are expected to have 0.70 - 0.75 of the ratio of internal friction ($\tan \phi$) under the seismic force K = 0.1.

Safety analyses of dam slopes are mentioned in Appendix

As shown in the attached Drawing (Typical Cross Section), widths of core trench or cut-off trench are wider than those of the RID original. And also these depths are more deeper than those in order to contact with solid foundation. It is a result of that studious consideration was paid to the design of core trench or cut-off trench of which inadequate design and insufficient treatment are sometimes suspected of dam failures in the world (see Appendix C).

Drawing MIADP-001, 002, 004, 005 and 007 show the layout of these dams.

(2) Foundation Treatment

The foundation of the damsite should be treated fundamentally with regard to three items, as follows:

i) Cut-off trench for excavating an unconsolidated layer up to contacting a core closely with sound rock.

ii) Curtain grout and blanket grout for preventing a leakage of reservoir water through a dam foundation and a piping at a contact of the core and the foundation.

iii) Fault treatment to improve of a weak and a degenerated zone, and for preventing a leakage of water through the fault zone.

Furthermore, concerning the Left Saddle Dam, following additional treatments will be needed because of its particular geological conditions.

iv) Consolidation grout for improving a quality of the rock foundation, for example, a permeability and a bearing capacity.

v) Relief wells for reducing an uplift pressure of the dam and to observe a leakage of water through the foundation.

The proposed excavation depths for cut-off trench of each damsite should be based on the result of seismic exploration as a rule, that is, the cut-off trench should be excavated up to the surface of the III velocity layer (having an elastic wave velocity of 2.0 - 2.2 km/sec). From the rule, the excavation of 13 - 15 meters in averaged depth and about 20 meters in maximum depth should be needed at the Main Damsite, and in the same manner the excavation of 12 - 15 meters in depth at the Left Saddle and 7 - 10 meters in general depth, about 16 meters in maximum depth at the Right Saddle should be needed. In addition to this, at every damsite a stripping off of top soil about one to two meters in depth should be needed, but at the Main Damsite the stripping off of top soil should be done more deeper than the others because the top soil of the site is very soft and unconsolidated (the depth of stripping off at the site should be needed at least to the bottom of the I velocity layer).

In principle, the curtain grout should be planned at least as three rows, and the blanket grout should be aligned at least as two rows at both sided of the curtain grout rows. A distance of each grout hole is usually three meters but it is better to decide the distance after grouting test at the site. However, for the Left Saddle Dam and a part of the Right Saddle Dam more dense allocation of curtain grout holes than the others should be needed because of their risky geological conditions. The depth of the grout curtain needed at each site is estimated from the "Simond's Formula"; $D = 1/3\ H + C$; in

general. In the formula, as the constant "C:, a value ranging from 10 to 20 meters is usually adopted, but on the case of this damsite the constant has set as one third (1/3) of H max. Thus, the depth of grout curtains are estimated as two thirds (2/3) of H in maximum depth and from 15 to 20 meters in minimum depth at each damsite. The depth of blanket grout holes as an assistant grout for a curtain grout has been estimated as 15 meters in maximum depth and five meters in minimum depth according to the depth of the grout curtain at each damsite.

Concerning a fault treatment, an excavation and replacement method and fault grouting method are commonly used. However, the cost for these treatment is very high, so the treatment method should be studied corresponding to a scale and the characteristics of each fault zone after more detailed investigations.

In case of the Left Saddle Dam, a consolidation grout method has higher availability than any other because there are too many faults to improve. This idea should be adopted at the part of the Right Saddle Damsite.

Relief wells should be allocated at the downstream toe of the dam by 30 to 50 meters interval. The size of the wells need four to five inches in completed diameter and 20 meters in depth. For the relief well the continuous observation system for a water level and water quality shall be needed after its completion.

After that, the alternative study for an earth blanket method in the Main and Right Saddle Dams should be carried out in the term of detail design because at these sites the volume of the excavation shall be very much.

The foundation treatments of three dams are indicated in the attached Drawing MIADP-003, 006, and 008.

(5) Layout of the Spillway

Size of the Spillway

Design discharge of the Spillway can be taken as the result of flood routing by using the Probable maximum flood of which peak inflo is 1,968 cu.m/sec as mentioned in the section of 3.2.2.

Flood routing was made by several values of weir length and resulted as shown below and in Figure 4-22.

Flood Routing

Weir Length (m)	Maximum Discharge (cu.m/sec)	Overflow Head (m)	Storage Level (EL m)	Storage Capacity (MCM)
50	948	4.35	394 35	386.3
100	1,272	3.32	393.32	371.3
150	1,452	2.77	392.77	363.4(adopted)
200	1,576	2.41	392.41	358.3
140	1,419	2.86	392.86	364.6
160	1,482	2.69	392.69	362.3

Type and Alignment of the Spillway

The Spillway shall be situated at near the right abutment of Main Dam as same as RID original. And the alignment is fitting on the straight line between above-said point and the existing irrigation intake (Mae Kuang Diversion Dam).

Type of the Spillway shall be the Gateless Chute type which is one of the most common types in Thailand (see Drawing MIADP-009), and, at the end point of the Chute, there is a Horizontal Apron which shall serve as existing road cross. Finally, at the end point of the Apron, there is a Flip which shall make water flow jumped up and into the Plunging Basin. This basin shall be connected with the existing Diversion Dam by the Tail Race.

Width of the Spillway, 150 m at the point of weir, shall be reduced according to the water flow. It finally becomes 40 m at the end point of the Chute owing to some trial studies of hydromechanics.

By these said conditions mentioned above, water flow dimensions through the Spillway, of which design discharge Qd = 1,452 cu.m/sec are estimated as follows:

Water Flow Through the Spillway

Point	Width of way (m)	Elevation of way (EL m)	Water Depth (m)	Water Velocity (m/sec)
Weir Top	150	390.00	2.12	4.56
Weir Toe	150	387.74	1.10	8.78
H. Apron End	130	387.63	1.45	7.69
Chute	60	361.50	1.08	22.3
Chute End	40	339.00	1.30	27.9
L. Apron End	40	339.00	1.48	24.6
Flip End	40	341.50	1.55	23.4
Jump Peak	-	-	IL 348.8m	-

(4) Layout of the Outlets

Left Saddle Canal Outlets

This Outlet is under construction according to the original design by RID and its principal dimensions are as follows:

Inlet: Screen, Bellmouth (Square-Circle)
Conduit: 3 m diameter, 298 m long, Steel Liner
Outlet: not designed yet

At the original plan of the Project, the designed maximum water to be released from the Left Saddle Canal Outlet was 25 cu.m/sec or 33 cu.m/sec which is reduced to 9.14 cu.m/sec by the survey study. From this point of view, it seems that the diameter of the conduit is seemed to be rather large, but, considering the future programme of power generation, it shall be suitable to save water head loss.

At the Outlet, there shall be two Gates, for control and for emergency, situated near each other. Capacity of the Outlet will be controled by gate size which is studied in some cases as shown below

Capacity of Left Saddle Outlet

Gate Size	Capacity Formula	Necessary Water Level to get 9.14 cu.m/sec
2.0 x 2.0m	$Q = 12.7 \times \sqrt{H}$ [1/]	EL 353± m [2/]
1.5 x 1.5m	$Q = 7.9 \times \sqrt{H}$	EL 354± m [2/]
1.0 x 1.0m	$Q = 3.5 \times \sqrt{H}$	EL 358.3m

Consequently, the gate size of 1.5 x 1.5m is decided to be adequate to release the designed water amounts for irrigation, but for power generation, an additional studies will be needed.

River Outlet

This outlet is additionally proposed in this study by the following reasons:

i) A temporary diversion outlet will be required at least for by-passing the dry season river discharge in order to do the sufficient works in safety.

ii) When releasing the water below Low Water Level is required, this outlet, the lowest outlet in the Project, can function most effectively to discharge the water.

iii) For providing a hydropower facilities at the latter stage, this outlet will function most advantageously in securing a larger water head.

1/ H equals gross water head in meter between reservoir level and outlet level (EL 351.5m)

2/ Open flow

Table 4-15 Borrow Area Investigation

(Unit : cu m)

Investigated Year	Borrow Area	CL	CL-SC	SC	ML	ML-CL	ML-SM	SM	SM-SP	SP	GP GM	Laterite with Clay	Laterite with Silt	Total (m^3)
1977 (2520)[1/]	No 1	18,600			113,500			123,000			6,900			262,000
	2	-			-			-			-			-
	3	26,400			396,000			348,000			-			770,000
	4	1,400			154,000			69,000			-			224,900
	5	197,500			188,000			227,000			-			612,500
	Sub-total	243,900			851,500			767,500			6,900			1,869,800
1978 (2521)[1/]	No. 6	57,600	-	37,800	32,400	9,000	-	149,400	5,400	-	-	-	-	291,600
	7	85,800	-	6,600	77,000	11,000	37,400	99,000	-	19,800	-	13,200	15,400	365,200
	8	195,700	-	58,500	117,000	-	15,700	146,200	-	11,200	13,500	49,500	-	607,730
	9	966,000	28,000	168,000	938,000	-	70,000	546,000	-	28,000	-	392,000	196,000	3,332,000
	10	310,400	-	99,200	179,200	-	-	185,600	-	-	-	112,000	-	886,400
	11	255,000	-	110,000	97,500	-		185,000	-		-	-	-	647,500
	12	322,500	-	187,500	517,500	-	-	990,000	-	-	-	-	-	2,017,500
	13	79,800	-	190,200	100,800	-	-	604,800	-	-	-	-	-	975,600
	14	810,000	-	-	1,545,000	-	510,000	1,920,000	-	-	-		-	4,845,000
	15	63,000	-	109,500	120,000	-	-	236,000	-	-	-	-	-	538,500
	16	453,600	-	93,600	52,300	-	302,400	147,600	-	-	-	68,400	61,200	1,159,200
	17	43,200	-	16,800	8,000	-	53,600	25,200	-	26,400	-	16,500	17,600	185,600
	Sub-total	3,672,600	28,000	1,077,700	3,761,800	20,000	999,100	5,242,800	5,400	85,400	13,500	651,900	290,200	15,851,400

1/ Geotechnical Report, Borrow Area Investigation - MAE KUANG DAM , Chiangmai, Thailand, Soil and Geology Division, March, 1979

Table 4-16

SUMMARY OF SOIL TESTS

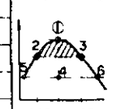
PROJECT: MAE KUANG

(Doi Saket, Chaign Mai, THAILAND)

SAMPLE NO.	UNIFIED SOIL CLASSIFICATION	GRAIN-SIZE ANALYSIS: GRAVEL 4760μm (%)	SAND 74μm (%)	SILT 5μm (%)	CLAY (%)	MAX. PARTICLE SIZE (mm)	CONSISTENCY: LIQUID LIMIT WL (%)	PLASTIC LIMIT Wp (%)	PLASTICITY INDEX Ip	SPECIFIC GRAVITY OF SOIL Gs	FIELD MOISTURE CONTENT Wf (%)	COMPACTION TEST: METHOD ASTM STANDARD	OPTIMUM WATER CONTENT Wopt (%)	MAX DRY UNIT WT γdmax (t/m³)	(Wopt-Wf) (%)	SPECIMEN CONDITIONS: ① VALUE γd/γdmax (%)	DENSITY DRY γd (t/m³)	DENSITY WET γt (t/m³)	WATER CONTENT W (%)	VOID RATIO e₀	DEGREE OF SATURATION Sr (%)	PERMEABILITY TEST: METHOD	COEFFICIENT OF PERMEABILITY K (cm/s)	CONSOLIDATION TEST: PRECON. SOLIDA STRESS (kg/cm²)	COMPRESSION INDEX Cc	COEF. OF CONSOLI. Cv (cm²/s)	Δe at 1.28 kg/cm²	DIRECT-SHEAR TEST: COHESION C (t/m²)	FRICTION ANGLE φ (degree)	TRIAXIAL-UU-TEST: COHESION Cu (t/m²)	FRICTION ANGLE φu (deg)	TRIAXIAL-CU-TEST: COHESION Ccu (t/m²)	FRICTION ANGLE φcu (deg)	UNCONFINED COMPRESSION TEST: qu (t/m²)	ε50 (t/m²)	REMARKS
(BAN PAN Borrow Area)																																					
BP-1	MH	1.6	39.2	18.2	41.0	9.52	55.60	33.13	22.47	2.655 2.668 2.668 (2.660)	14.16 16.84 16.45 (15.81)																											
(Minus NO.4)							Shrinkage Limit 26.25					Ⓐ	28.8	1.463	(+)1.30	① 100	1.463	1.884	28.8 (Wopt)	0.818	93.6	Falling Head	2.1×10⁻⁶	28.0% 1.851	0.04		1.03	50	19.0							
																② −98	1.433	1.803	25.8 (−W98)	0.856	80.1	"	2.1×10⁻⁶	26.1% 1.800	0.07		0.88	(28.48%/1.466/1.883)								
																③ +98	"	1.887	31.7 (+W98)	"	98.5	"	1.2×10⁻⁷	30.9% 1.889	0.04		0.74			Saturated Sample *						
																④ +95	1.389	1.789	28.8 (Wopt)	0.915	83.7	—	—													
(Brown)																⑤ −95	"	1.725	24.2 (−W95)	"	70.4	Fall	1.2×10⁻⁶													
												(RID)* −A−	29.5*	1.460*	(+)13.7*	⑥ +95	"	1.858	33.8 (+W95)	"	98.3	"	2.9×10⁻⁷	32.7% 1.843	0.08		1.09	40	20°	14	0	28	22°			
																													(28.48%/1.392/1.787)		Saturated Sample *						
BP-2	MH	Before Compaction 19.8	24.3	8.9	47.0	19.1				2.630 2.654 2.665						① 100	1.523	1.935	27.1 (Wopt)	0.740	97.0	Fall	4.1×10⁻⁷													
(Minus 3/4")		After Compaction 12.9	28.2	11.9	47.0	12.7	—	—	—							② −98	1.492	1.853	24.2 (−W98)	0.776	82.6	"	1.1×10⁻⁷													
(Brown)										(2.650)						③ +98	"	1.921	28.8 (+W98)	"	98.3	"	2.9×10⁻⁷													
												(RID)* −C−	22.0*	1.680*	(+) 6.2*																					
BP-3 (2.5~30m)	(MH)	—	—	—	—	—	—	—	—	2.81	29.7	Ⓐ	26.5	1.502	(−) 3.2	① 100	1.502	1.900	26.5	0.871	85.5	Fall	2.0×10⁻⁷		0.11		1.07	2.0	26°	6.2	14°	2.5	24°			
(Brown)																② −98	1.472	1.805	22.6	0.909	70.0	"	2.3×10⁻⁷		0.21		1.30	1.5	23°	6.0	22.5°					
																③ +98	"	1.912	29.9	"	92.4	"	2.0×10⁻⁷		0.13		0.99	2.9	24.5°	6.0	14.5°					
																④ +95	1.427	1.805	26.5	0.969	76.8	—	—							(Partial Satur Sample)					
												(SI(e)* −A−	28.5*	1.465*	(−) 1.2*																					
(Huai Hak Borrow Area)																																					
HH-1	SC	34	24	14	28	12.7	37.00	20.61	16.39	2.632 2.610 2.626 (2.623)	39.7 38.5 38.9 (39.0)																											
(Brown)							Shrinkage Limit 26.20																															
from pit AD-3												(RID)* −A−	11.8	1.965	(+) 7.9																					
HH-2	SC	7	32	15	46	9.5	44.00	23.00	21.00	2.628 2.618 2.630 (2.626)	9.75 9.90 9.44 (9.69)																											
(Grey)							Shrinkage Limit 25.64																															
from pit AD-4												(RID)* −A−	16.2*	1.790*	(+) 6.5*																					
HH-3 (0.5~15m)	SM	35	47	11	7	3.81	—	Non Plastic	—	2.67	14.3	Ⓐ	11.0	1.998	(−) 3.3	① 100	1.998	2.218	11.0	0.336	87.5	Fall	1.8×10⁻⁷	0.05	7.4			0.5	42°	7.5	25.5°	5.1	28°			
(Brown)																② −98	1.958	2.134	9.0	0.364	66.0	"	1.6×10⁻⁶					2.0	31.5°	12.0	24°					
																③ +98	"	2.209	12.8	"	94.0	"	1.3×10⁻⁶	0.06	6.5			2.0	35°	7.5	17°					
from pit AD-3																④ +95	1.898	2.107	11.0	0.407	72.2	—	—													
												(Site)* −A−	12.7*	1.930*	(−) 1.6*																					
HH-4 (3.0~40m)	CH	5	36	23	36	19.1	57	28	29	2.69	17.3	Ⓐ	19.6	1.652	(+) 2.3	① 100	1.652	1.976	19.6	0.628	83.9	Fall	2.0×10⁻⁷	0.11	8.6			4.4	24°	7.2	13.5°	4.2	22°			
(Grey)																② −98	1.619	1.891	16.8	0.662	68.3	"	1.0×10⁻⁶					1.2	26.5°	7.5	15°					
																③ +98	"	1.977	22.1	"	89.7	"	5.8×10⁻⁶	0.11	7.5			2.8	25.5°	6.3	11.5°					
from pit AD-4																④ +95	1.569	1.877	19.6	0.714	73.8	—	—													
Pervions Materials											Absorption*																											
SS-1 (Fine Sand)	SP	0	88.9	(11.1)		4.76				2.59	—											Const Head	3.9×10⁻³													
SS-2 (Medium Sand)	SP	13.5	8.6	(5.9)		9.5				2.585	—											Const Head	4.6×10⁻³													
SS-3 (Grauel)	GP	—	—	—	—	—				2.70	0.48*																									
R-1 (Rock)	GP									2.71	0.45*																									
R-2 (Rock)	GP									2.70	0.47*																									

REMARKS

1) Mechanical Prop Testing Point



2) BP-1,2 & HH-1,2 sampled at March, 1981 and tested by KEC, May 1981

3) BP-3 & HH-3,4 sampled at June, 1981 and tested by RID, Sept 1981

4) BP-1, 2, 3 sampled from the same pit

5) HH-1, 3 sampled from the pit of AD-3 and HH-2,4 from the pit AD-4.

1) Filter materials of SS-1,2,3 sampled from Sand Stock Area

2) R-1 & R-2 were lime stone

3) SS-1,2,3 & R-1,2 tested by KEC

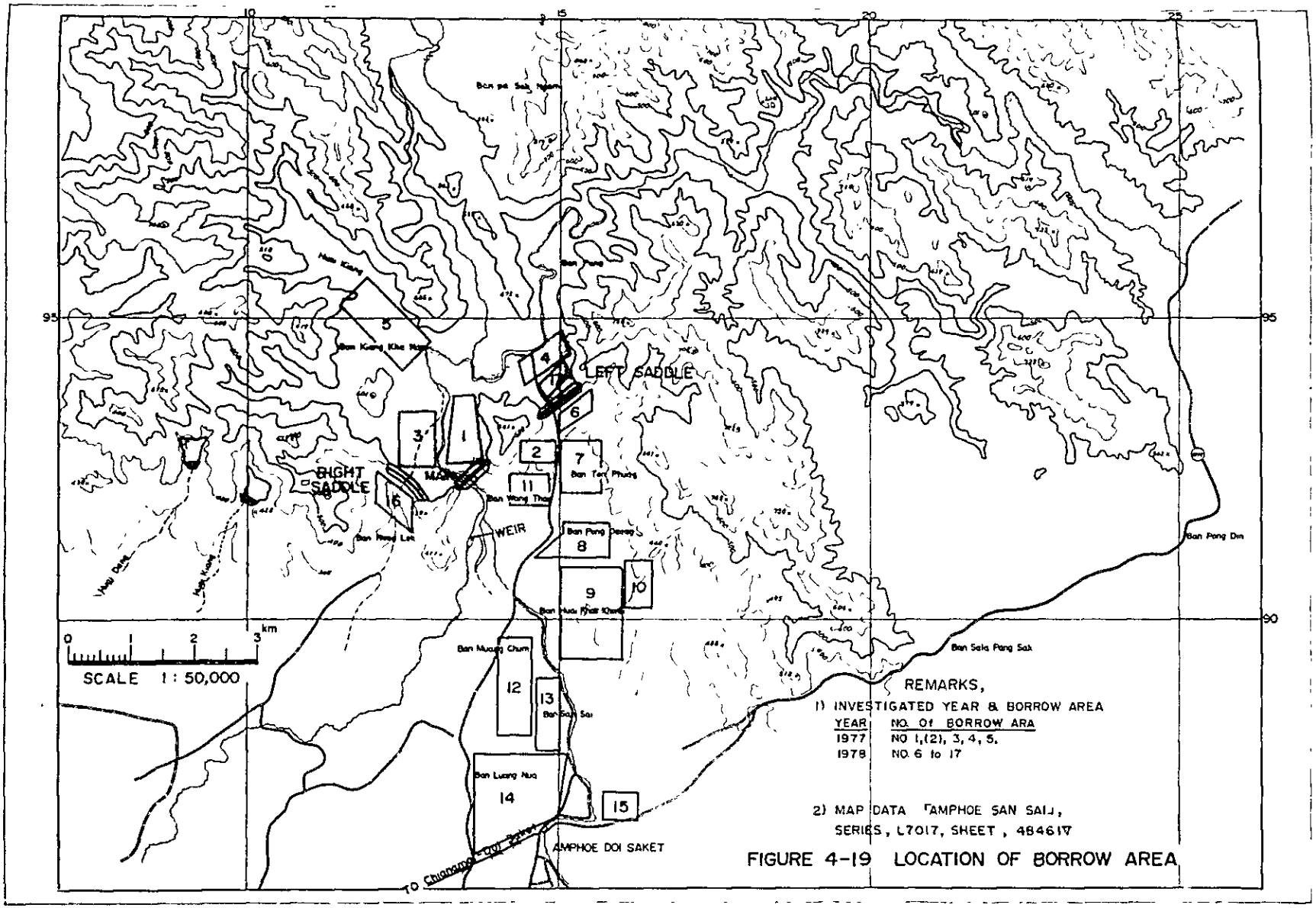
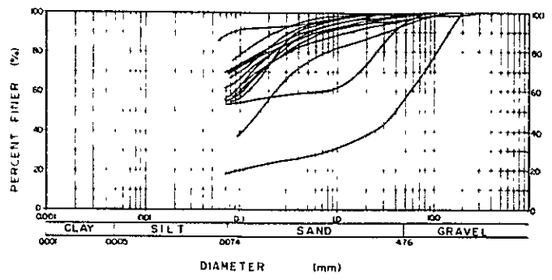
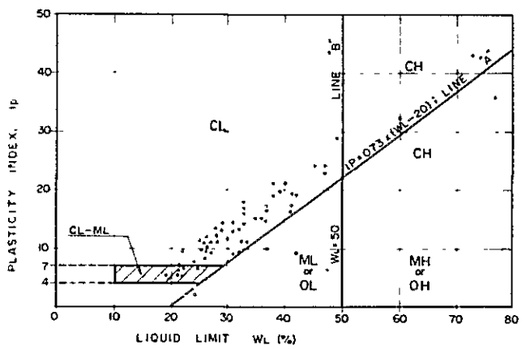


FIGURE 4-19 LOCATION OF BORROW AREA

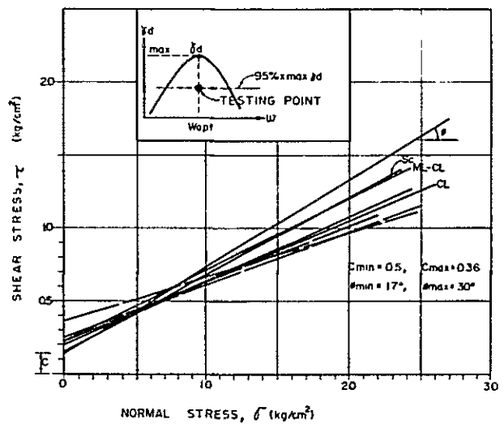
GRAIN-SIZE ANALYSIS



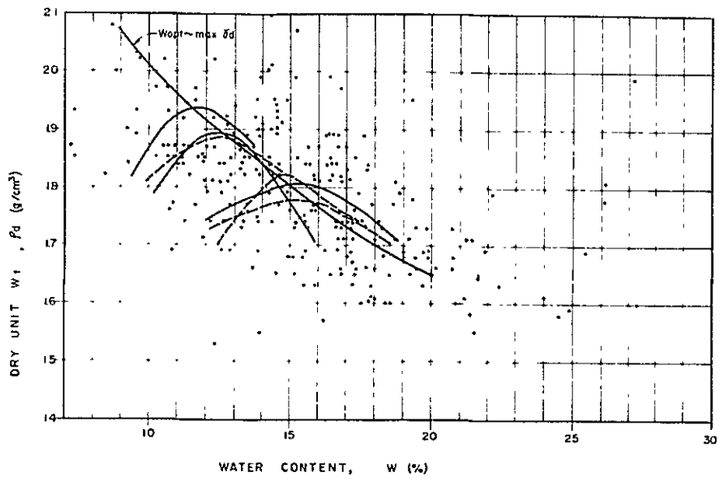
PLASTICITY CHART



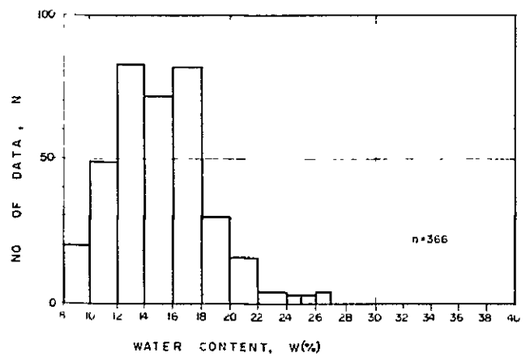
DIRECT-SHEAR TEST



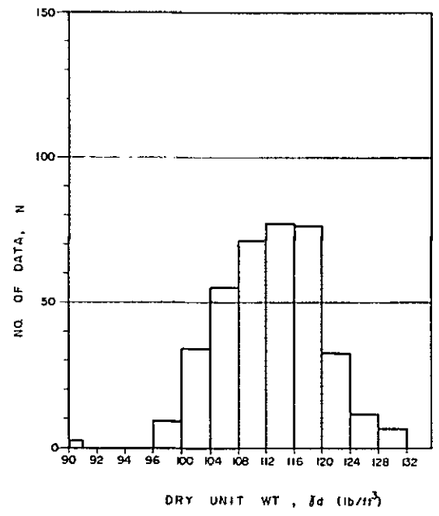
COMPACTION TEST & FILL-DENSITY



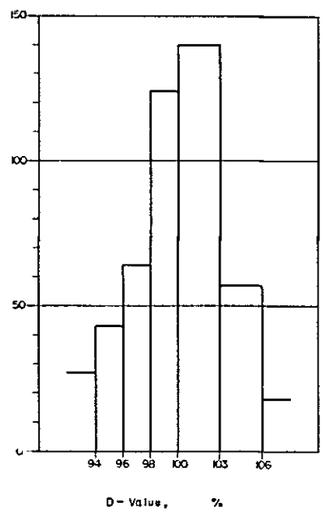
Wf ~ N



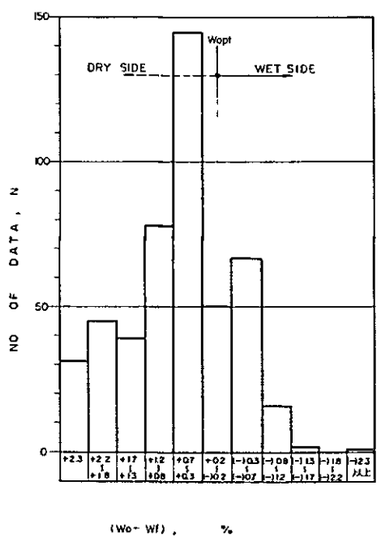
γd ~ N



D-VALUE ~ N

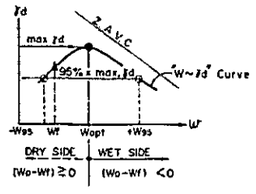


(Wo - Wf) ~ N



REMARKS:

1)



2) $\rho d(t/m^3) = \gamma d\ (lb/ft^3) \times 0.016$02

3) D-Value (%) = $\frac{\gamma d \times 100}{\max \gamma d}$

FIGURE 4-20 SUMMARY OF SOIL TEST

FIGURE 4 21 SITUATIONS OF MAIN STRUCTURES OF MAE KUANG DAM
(DOWNSTREAM VIEW)

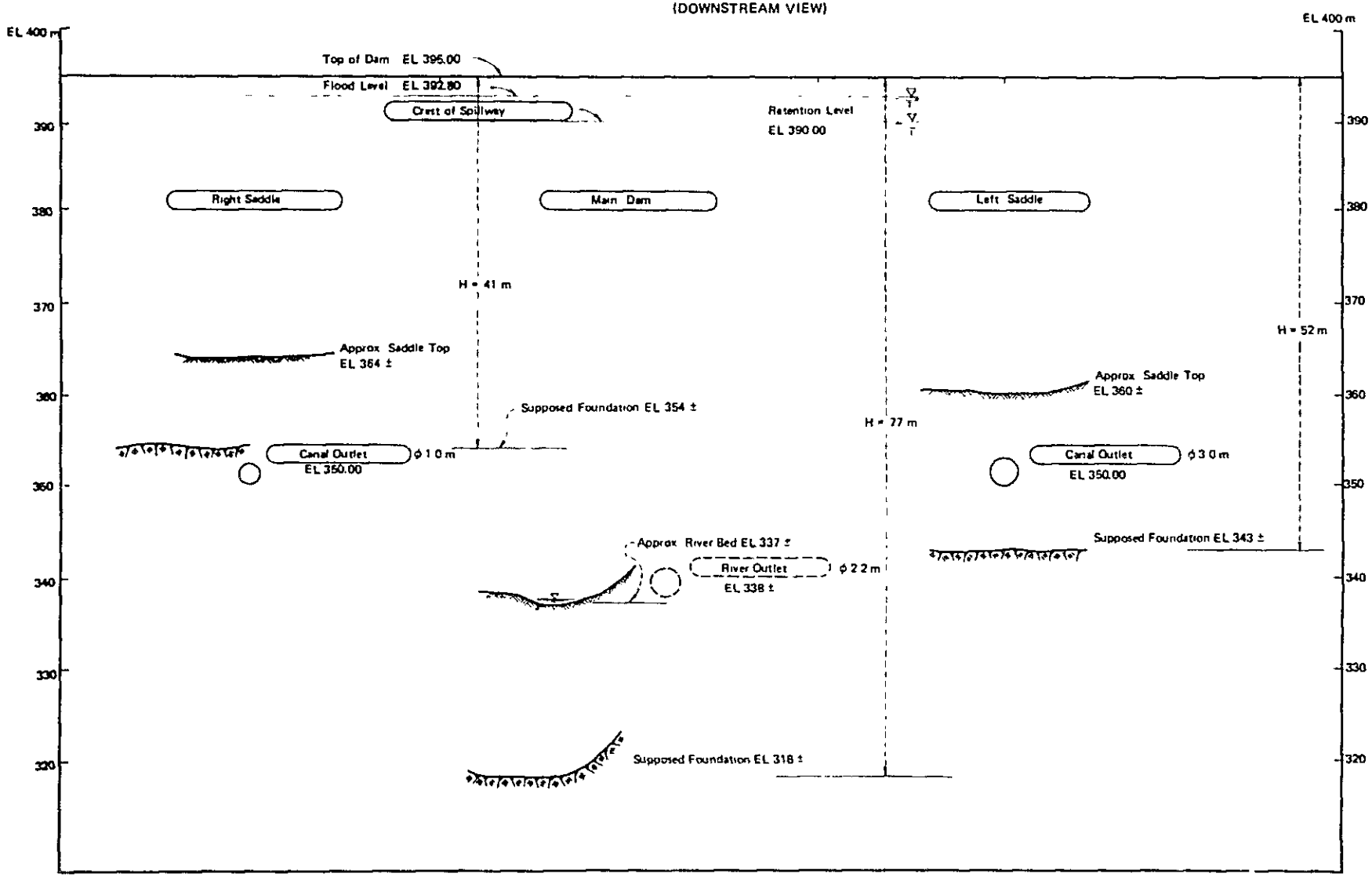


FIGURE 4 - 22 SIZING OF THE SPILLWAY

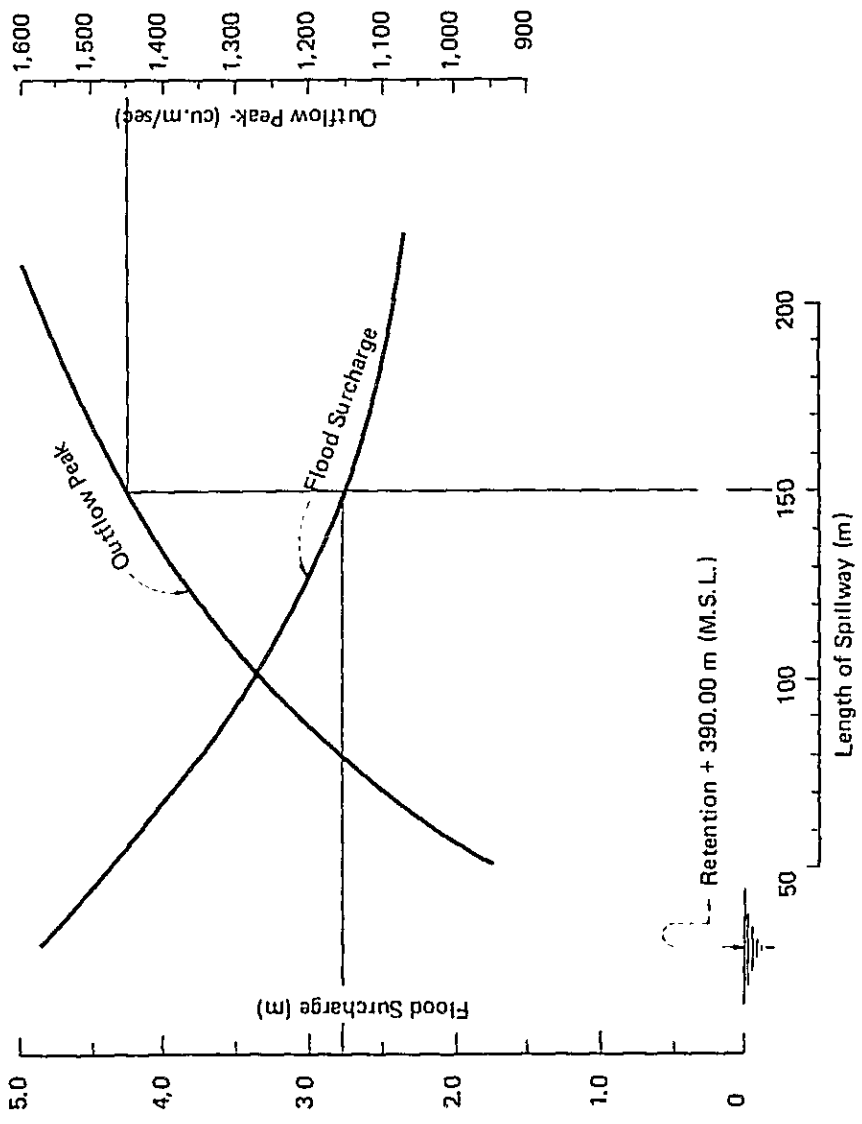
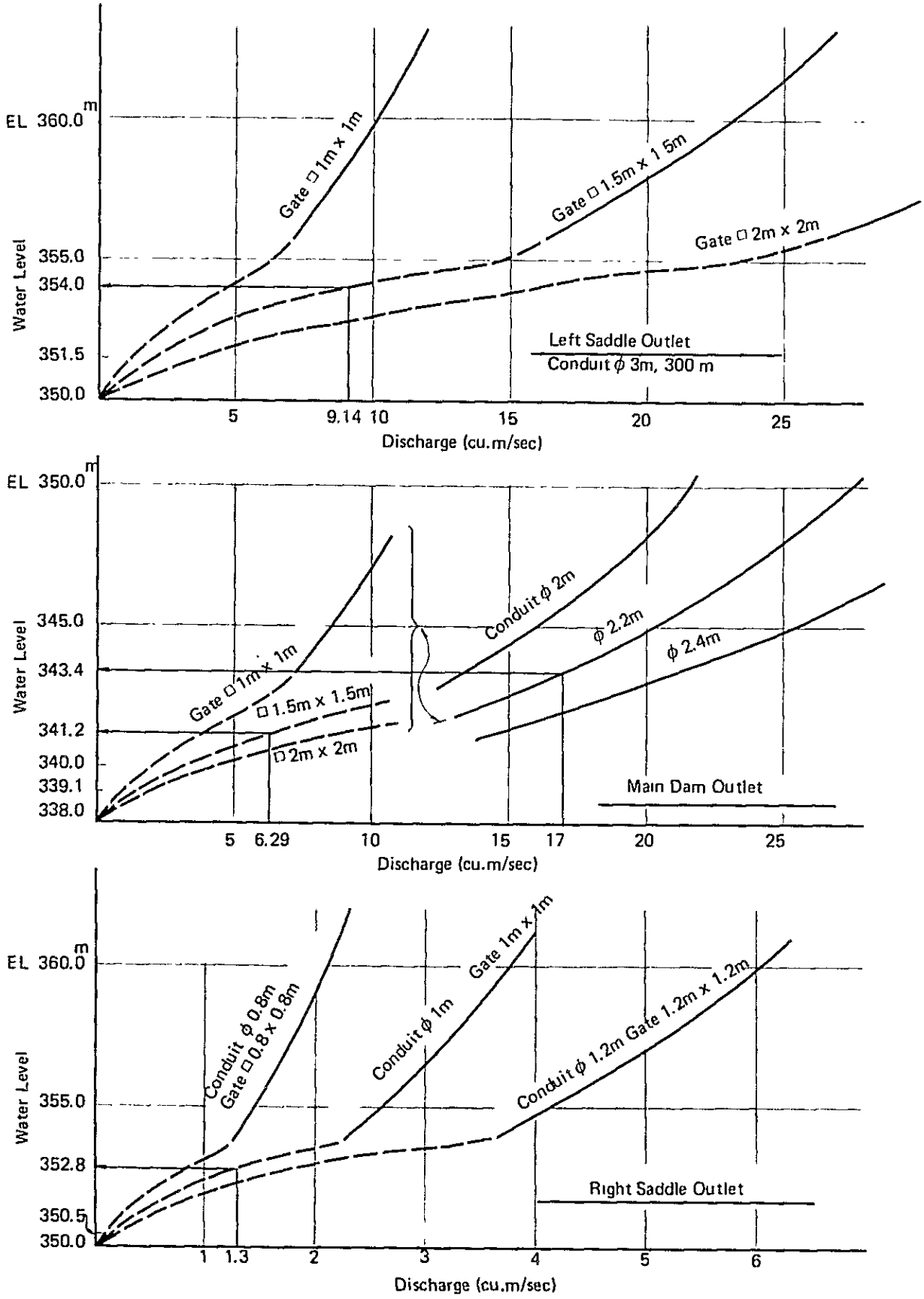


FIGURE 4-23 SIZING OF OUTLETS



Size of this outlet shall be determined by the following two conditions:

Condition 1: Size of the Conduit shall be adequate to discharge the dry season flood of about 17 cu.m/sec (December - March, return period = 20 years) under the water head of four to five meters.

Condition 2: Size of the Gate shall be adequate to discharge the irrigation water of 6.29 cu.m/sec under the water head of two to three meters.

As shown in Figure 4-23, sizes being adequate to above conditions are 2.2 m in diameter for the Conduit and 1.5m x 1.5m square for the Gate.

Right Saddle Canal Outlet

This outlet has been designed having a capacity of 5.5 cu.m/sec but not implemented yet. New capacity is reduced to 1 30 cu.m/sec in this study, therefore, size of the Conduit shall be 1.0 m in diameter and 1.0m x 1.0m square for the Gate.

Typical layout of three Dam Outlets are shown in the attached Drawing MIADP-010.

4.4.2 Irrigation Canals

a) Proposed Irrigation Networks

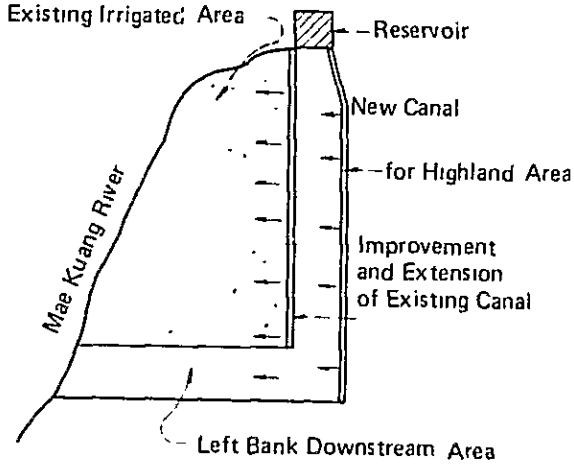
The irrigable area totalling 20,000 ha can be divided into Existing Irrigated Area (7,000 ha), Right Bank Area (2,200 ha) and Left Bank Highland and Downstream Area (10,800 ha).

Right Bank Area must be supplied water by Right Main Canal from Right Saddle Dam as Right Bank Area is topographically independent from the other two areas.

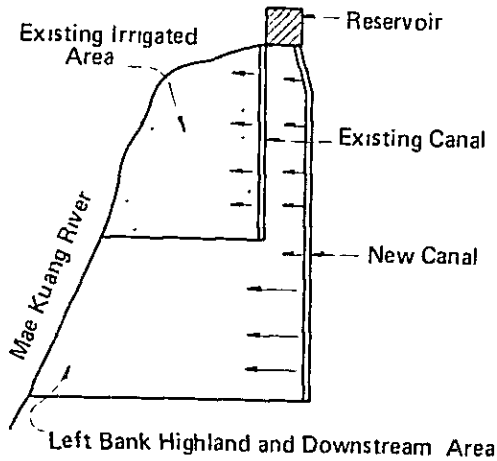
Left Bank Highland and Downstream Area extends to the south of Existing Irrigated Area. Therefore, an alternative study has been conducted to decide the proper irrigation network in the left bank area of the Mae Kuang River. Out of two alternative plans which have been studied, Alternative Plan B had been originally prepared by RId.

The alternative plans are shown in the following figures:

Alternative Plan A



Alternative Plan B



From the results of the alternative study, it has been clarified that Alternative Plan B is the more economical and proper irrigation network. Major dimensions and rough cost estimation on each alternative plan are summarized as shown below.

Description	Plan A	Plan B
Service Area		
Existing Canal	14,150 ha	7,000 ha
New Canal	3,650 ha	10,800 ha
Design Discharge		
Existing Canal	14.15 cu.m/sec	7.00 cu.m/sec
New Canal	3.65 cu.m/sec	10.80 cu.m/sec
Rough Cost Estimation	192,000,000 ฿	168,000,000 ฿

From the above mentioned results, a proposed irrigation network is shown in Figure 4-24 and attached Drawing MIADP-011.

b) Main Irrigation Canals

Three canals have been proposed as main irrigation canal to irrigate the whole of Project Area. Out of three main canals, two canals will be newly constructed for irrigating the Right Bank Area and the Left Bank Highland and Downstream Area. Remaining one will be provided with some improvement making use of the existing irrigation canal.

Main Irrigation Canal

Canal Name	Service Area	Remarks
Left Main Canal	10,800 ha Left Bank Highland and Downstream Area	Newly constructed L = 72 km
Right Main Canal	2,200 ha Right Bank Area	Newly constructed L = 15.4 km
Existing Main Canal	7,000 ha Existing Irrigated Area	Consisting of three existing canals L = 60.55 km Pha Taek Canal ℓ = 27.75 km Muan Wah Canal ℓ = 4.00 km Koh Matan Canal ℓ = 28.80 km

(1) Routes of New Main Canals

The selection of routes has been made from the results of the field survey and 1:10,000 scale topographical maps by paying due attention to the following points:

i) To maintain the highest water level to command larger service area and facilitate gravity irrigation;

ii) To select a course as straight as possible to shorten the distance; and

iii) To balance the volume of excavation and embankment as far as possible to minimize the cost for earth works.

(2) Canal Type and Design Discharge

The new main canal will be lined with concrete, taking the following elements into consideration: the velocity of flow and the permeability of soil which is consisted of sand or sandy soil on the route of canal. The maximum design discharge for each main canal is as follows (see Figure 4-24).

Left Main Canal	Q = 10.80 cu.m/sec
Right Main Canal	Q = 1.54 cu.m/sec
Existing Main Canal	Q = 7.00 cu.m/sec

(3) Cross Section and Length of Canal

The new main canal cross section has been designed under the following criteria:

Flow formula:	Manning Formula ($n = 0.014$)[1/]
Freeboard:	$F = 0.20 + 0.15\ d$[2/]
Where:	F: freeboard (m)
	d: hydraulic depth (m)
Cross section of Canal:	trapezoidal cross section (inside slope: 1:1.5)

Canal lining:	concrete lining canal
Standard longitudinal slope of canal:	Left Main Canal: 1/8,000
	Right Main Canal: 1/10,000
	(see Drawing No.012 and No.013)

Hydraulic computation has been conducted on four selections for the Left Main Canal and on one selection for the Right Main Canal as shown below.

Particulars of Main Canal

Canal	Type	Discharge (cu.m/sec)	Length (km)
Left Main Canal	1	10.800	34.9
	2	8.019	9.9
	3	5.758	10.4
	4	2.780	16.8
Total			72.0
Right Main Canal	1	1.540	15.4

Note: Detail computation is shown in Table G 2-1, Appendix G-2.

Note: 1/ RID Vol. IV Recommended practice for the design of canal systems part L.

2/ RID Vol. IV Recommended practice for the design of canal system part B

(4) Existing Main Canal

The major existing canals (Pha Taek Canal, Muang Wah Canal, Koh Matan Canal and Muang Poa Canal) are capable of flowing the proposed irrigation water, if these canals will be thoroughly maintained and a strict water management system will be introduced in the area after completion of the Project. Therefore, these four canals will not be improved except at some portions where canal has not enough capacity.

The proposed Profile of Left and Right Main Canals are shown in Drawing MIADP-012 and 013.

c) Lateral Canals

(1) Routes of Lateral Canals

The selection of routes has been made on 1:10,000 scale topographical maps by paying due attention to the following points:

i) To maintain the highest water level to command the larger service area and facilitate gravity irrigation;

ii) To pay the consideration for the location of on-farm irrigation canals[1/] which will be prerequisite for the water supply of upland crops in dry seasons.

iii) To select a course as straight as possible to shorten the canal length and connect to other laterals or creeks at the downstream of them for drains of surplus water.

1/ Plan of construction for on-farm facilities such as farm roads, on-farm ditch and on-farm drain is not involved in this project, but the provision of such on-farm facilities is considered to be essential to carry out effectively an irrigated agriculture. Consequently, the constructions of on-farm facilities shall be made together with those of major facilities in the Project.

(2) Cross Section and Length of Canal

The cross section of lateral canal has been decided as follows:

Item	Left Bank Highland and Downstream Area	Right Bank Area
Water requirement	0.001 cu.m/sec/ha	0.0007 cu.m/sec/ha
Cross section	Trapezoidal	Trapezoidal
Canal lining	Concrete lining (hill side) Earth lining (flat ground)	Concrete lining
Hydraulic calculation	Manning Formula (n = 0.014) (n = 0.0225) 1/	Manning Formula (n = 0.014)
Longitudinal slope	1/200 - 1/800	1/150 - 1/200

Note: 1/ RID Vol. IV Recommended practice for the design canal systems Part L

The total length of new laterals is as follows:

Area	Number of Laterals	Total Length (km)
Left Bank Highland and Downstream Area	28 2/	121.7
Right Bank Area	13 3/	24.9
Total	41	146.6

Note: 2/ This number includes eight branches

3/ This number includes three branches

d) Major Related Structures

(1) Head Works

For taking the water from the Mae Kuang River to the Existing Main Canal, the existing Mae Kuang Weir (Pha Taek Weir) will be utilized intactly as mentioned in Section 4.2.3 Development Plan.

(2) Diversion Facilities

As the diversion facilities, diversion works and head-regulators will be installed in main canal. The former works for diverting the water from main canal to lateral with measurement and the latter

works for keeping the water surface in main canal at certain level for operating the diversion works accurately.

The diversion works will be provided as follows:

Canal	Number of Diversion Works
Left Main Canal	71
Right Main Canal	27
Existing Canal	87
Total	185

(3) Siphon

Siphons will be provided at the points crossing major rivers, as follows:

Canal	Number of Siphons
Left Main Canal	15
Right Main Canal	5
Total	20

(4) Regulation Pond

As Left Main Canal will be extended about 70 km in length, it is advisable to provide one or two regulation ponds in order to expect an effective use of water released from Mae Kuang Dam and run-off water from the eastern foothill. However, no economical site for a regulation pond has been found during the survey periods.

(5) Inlet for Run-off Water

A number of inlets will be provided on the new main canals to collect the run-off from foothill through small streams. The inlet would be more economical means than drainage culvert which is installed under the irrigation canal to pass the run-off. Moreover, the inlet is expected to work effectively for using the run-off as additional water source for irrigation in ordinary time. However, the availability of such run-off is not estimated nor expected in this study due to the difficulty in practical use.

(6) Other Structures

Cross structures such as bridge and culvert will be provided on canal for road crossing.

4.4.3 Drainage Canals

a) Proposed Drainage Networks

At present, in the left bank area of the Mae Kuang River, most of the run-off is drained through such rivers as the Mae On, the Mae Thi and the Mae Yak which are tributaries of the Mae Kuang River. And in the Right Bank Area, most of the run-off is drained to the Mae Faek Canal which joins with the Mae Kuang River at the tail of the canal.

The proposed drainage network should follow the present river network as far as possible from the point of economical view.

Considering the dual-purpose function for irrigation and drainage on the proposed main irrigation canals which flow along the hillside, a new drainage networks will be proposed as shown in Figure 4-25.

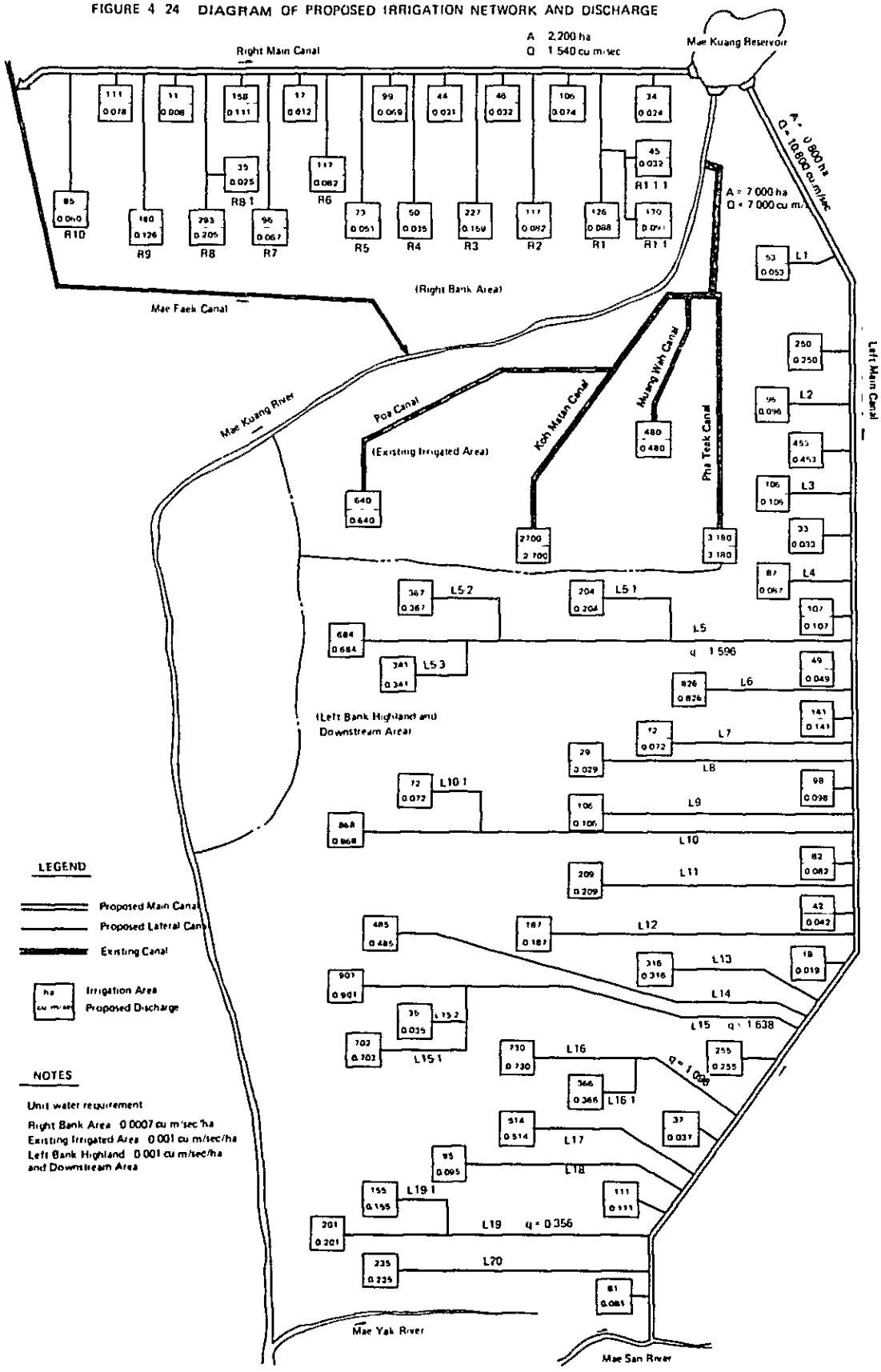
b) Main Drainage Canals

The major rivers in the Project Area will be made good use of as main drainage canal.

These major rivers (see Table G 2-3, Appendix G-2) are capable of flowing the run-off from their drainage areas except at some portions.

The full cross sections (see Table G 2-4, Appendix G-2) of the main irrigation canals are designed in order to be capable of flowing the emergent flow including flood discharge from their drainage areas, and the flood discharge will be released from the spillway to the nearest river.

FIGURE 4 24 DIAGRAM OF PROPOSED IRRIGATION NETWORK AND DISCHARGE



c) Sub-main Drainage Canals and Laterals

The creeks in the Project Area will be made good use as sub-main drainage canals and the lowland streams in the cultivated land will be also made good use as the laterals.

In principle, irrigation and drainage laterals will be provided independently in the Project Area excluding the Existing Irrigated Area. For effective water use, however, the drainage laterals will be connected to irrigation laterals in downstreams.

d) Major Related Structures

As mentioned in Section 4.4.2 d) 3) Siphon, the siphons will be installed for main irrigation canal in order to pass safely the flood discharge of rivers which flow from hill-side and cross the main irrigation canal at 20 places as shown in Figure 4-25. The siphon will be equipped with a spillway and a waste-way to release the surplus water in main irrigation canal caused by flood inflow through inlets from foothill streams. These siphons have been already taken into account of irrigation facilities.

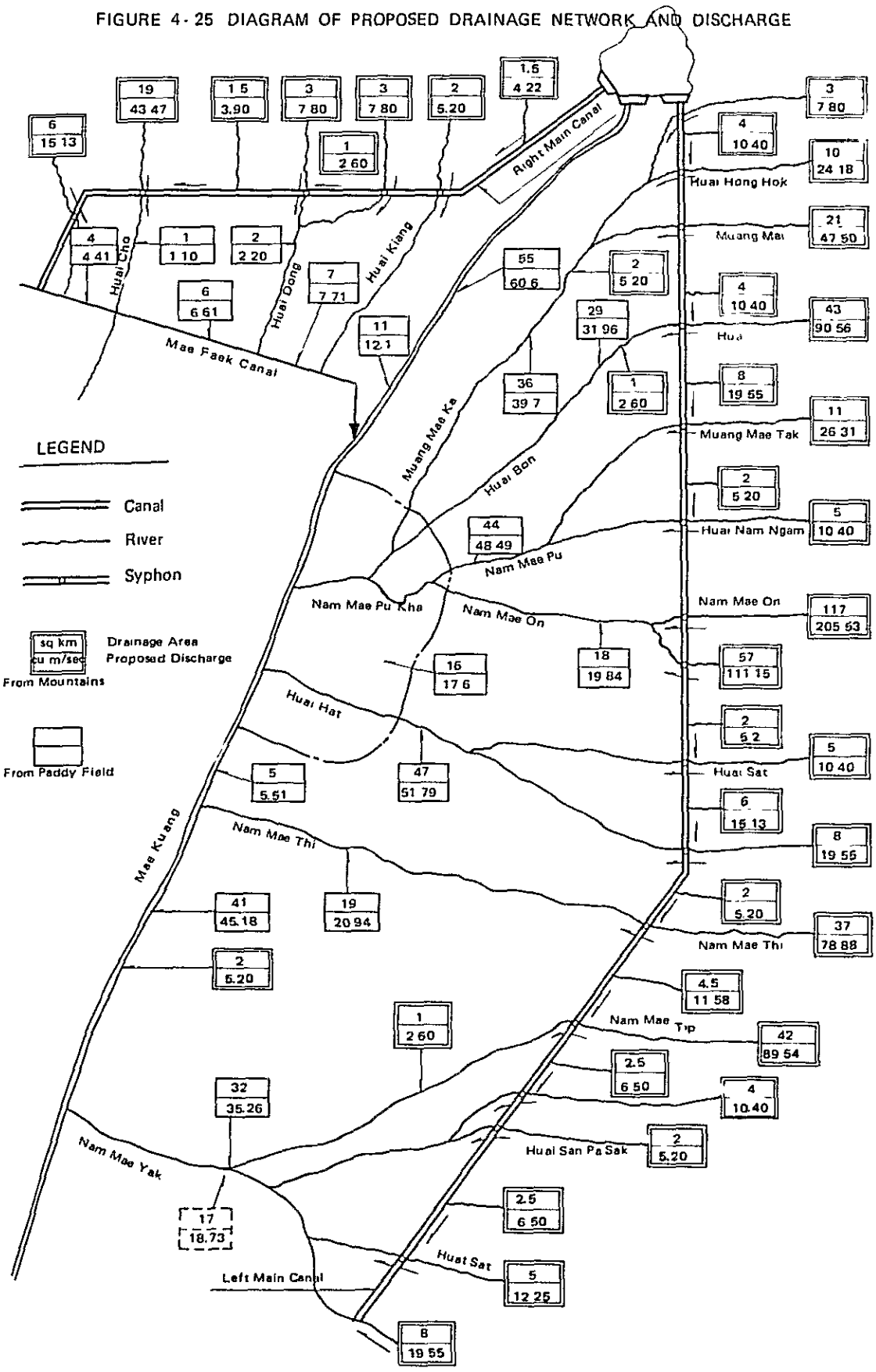
The necks of existing rivers and creeks (outlets, culverts, etc.) should be improved in order to be capable of discharging enough flow to prevent floods.

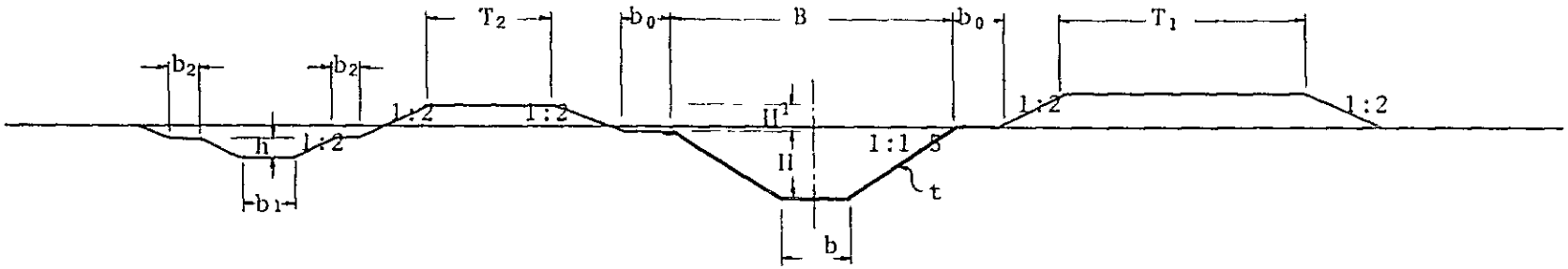
4.4.4 Roads

a) Road Networks

From Chiang Mai to the Project Area, paved provincial roads connecting Doi Saket and San Kamphaeng are available both in the wet and dry seasons. However, the existing road network in the Project Area is not sufficient in its density, especially in the area excluding the Existing Irrigated Area.

FIGURE 4-25 DIAGRAM OF PROPOSED DRAINAGE NETWORK AND DISCHARGE





Name and Section	b	B	H	H^1	t	b_0	T_1	T_2	h	b_1	b_2
Left Main Canal											
No.0 - No. 6 + 280	2.60	10.55	2.65	varies	0.07	4.00	9.00	4.00	0.80	4.00	1.50
- No.34 + 900	2.60	10.55	2.65	varies	0.07	2.00	6.00	3.00	0.60	1.50	1.50
- No.44 + 800	1.90	9.10	2.40	varies	0.07	2.00	6.00	3.00	0.60	1.50	1.50
- No.55 + 200	1.70	8.45	2.25	varies	0.07	2.00	6.00	3.00	0.60	1.50	1.50
- No.72	1.40	6.65	1.75	varies	0.06	2.00	6.00	3.00	0.60	1.50	1.50
Right Main Canal											
No.0 - No.15 + 400	1.60	5.65	1.35	varies	0.05	2.00	6.00	3.00	0.60	1.50	1.50
Lateral	varies	varies	varies	varies	0.05 or 0.00	1.50	4.00	2.00	-	-	-

FIGURE 4-26 STANDARD CROSS SECTION OF CANAL AND ROAD

Therefore, farm roads will be provided along the irrigation canals to connect the villages, farm lands and existing roads. They will make water management and farm works easier.

The length of new farm roads is as follows:

Area	Length (km)
Left Bank Highland and Downstream Area	193.7
Right Bank Area	40.3
Total	234.0

b) Standard Cross Section of Road

The standard cross section of farm road is shown in Figure 4-26.

4.5 Project Cost

4.5.1 Cost Estimation

The Mae Kuang Project had already been commenced partly by RID who drew up the Project Budget Schedule for 12 years from 2519 (1976) to 2530 (1987). However, as the original plan was modified in this study because of some alternations on, for example, dam sizing, dam engineering and distribution system, new estimation has been conducted for the construction rescheduled to begin in 2526 (October 1982). Therefore, new estimation consists of following two portions: one is the sum of expenses for construction works during seven years from 2519 (1976) to 2525 (1982) according to the RID Budget Schedule and the other is the cost for residual works after 2526 (1983).

Former construction works of the Project have been conducted almost by the Force Account and latter works also should be in the same manner except a part of canal works. Therefore, cost estimation method can follow the same way of RID's. But the new estimation for the residual works is enforced to use the rather high unit cost since it is necessary to consider that the condition of works would be more

difficult and severe from the view point of dam engineering.

Additional costs for few items mentioned below have been newly included in new estimation.

° Consulting Services and Training
° Price Escalation
° On-Farm Development (With and Without)

4.5.2 Project Cost

a) Total Project Cost

The total project cost without the cost of On-farm Development is as follows:

Total:	US$185,024,000 (฿3,700,492,000):	100%
Foreign portion:	US$ 77,817,000 (฿1,556,331,000):	42.1%
Local portion:	US$107,207,000 (฿2,144,161,000:	57.1%

The total project cost with cost of On-farm Development is as follows;

Total:	US$204,237,000 (฿4,084,728,000):	100%
Foreign portion:	US$ 84,917,000 (฿1,698,341,000):	41.6%
Local portion:	US$119,320,000 (฿2,386,387,000):	58.4%

Table 4-17 shows the breakdown of the investment costs by major items, and their detailed estimation is given in Appendix I-1, and furthermore, Table 4-18 indicates the investment cost estimated under the conditions that the Main Dam, Right Saddle and Spillway will be constructed by the contract bases.

b) Components of Project Cost

(1) Civil Works

The cost of civil works consist of the following items;

° Pre-Engineering (A)1/

1/ shows the item number of project cost in the project budget of RID

° Preparation (B-8, B-10)
° Main Dam (C-2): including appurtenant structures
° Left Saddle Dam (C-3): -ditto-
° Right Saddle Dam (C-4): -ditto-
° Spillway (C-6):
° Main Canal (D):
° Lateral Canal (D):
° Improvement of Old Facilities (E)
° Others (C-1, 5, 7): geological survey, access-road, bridge etc.

(2) Land Acquisition and Compensation

Land acquisition (H): Lands for the reservoir, damsites, camping area and resettlement area have been almost purchased. The balance is for the land of Main and Lateral canals.

Compensation (Resettlement) (B-9): The resettlement project shall be completed by the end of 2525 (September 1982).

(3) Construction Equipment

Old equipment (F-2): These belong to RID, which are in site at present. They are mostly for earth works.

New equipment: New equipments which are boring and grouting machine, quarrying machine, borrowing machine etc. will be requested additionally. This cost has been estimated by the price of C.I.F. Bangkok.

Transportation (F-3).

(4) Project Facilities (B-1 - B-7)

Among these, the camping facilities have been almost completed. The balance is for the facilities for operation and maintenance.

(5) Project Administration (F-1)

(6) Consulting Services (see Table I 1-10, Appendix I-1)

(7) On-farm Development

On-farm development works, which were not involved in the Project work should be undertaken in accordance with the progress of construction works for main and lateral irrigation canals. Annual developing areas covered by such canal networks to be constructed are planned as follows:

Annual On-farm Development Area

(Unit: ha)

	'82-'83	'83-'84	'84-'85	'85-'86	'86-'87	'87-'88	Total
Area	4,000	4,000	4,000	6,000	1,000	1,000	20,000

An annual development costs for on-farm developments are estimated based upon the above areas and on-farm development cost per hectare, which is given in Table I 1-11, Appendix I-1.

(8) Contingency

About 10 percent of total costs of the items from (1) to (7) mentioned above has been assumed as contingency.

(9) Price Escalation

Price escalation has been estimated at seven percent of total cost of the items from (1) to (8) for the foreign portion and at 15 percent for the local portion.

c) Unit Cost

Unit costs for the estimation of the project cost have been based on the official unit costs of the year 2524 (1981) by RID.

However, from the viewpoint of dam engineering, unit costs will increase in the future by about 25 percent more by the item of the works which will be done from October 1982.

The current unit prices of labors and materials in the project are as follows;

Mae Kuang Project, Unit Prices
(August 1981)

Name	Unit	Price	Name	Unit	Price
Worker	day	฿50 - 100	Cement	40 kg	฿ 72
Foreman	day	73 - 100	Steel bar	kg	9.2
Driver	day	50 - 100	Lumber	m^3	5,000
Operator	day	93 - 150	Sand	m^3	70
Carpenter	day	73 - 150	Gravel	m^3	130
Mason	day	73 - 150	Stone	m^3	160
			Gasoline	ℓ	11.9
			Diesel	ℓ	7.89
			Dynamite	pcs	15
			Detonation cap	pcs	25

(2) Currencies

Shares of foreign currency and local currency in each price and cost are assumed as follows. But, all expenditures until September 1982 are counted into local currency only.

Shares of Currencies

Materials and labors

Name	Foreign Currency (%)	Local Currency (%)	Note
Cement	75	25	Imported
Steel bar, Hardware	70	30	"
Lumber	5	95	"
Gasoline	50	50	"
Diesel	75	25	"
Explosive	95	5	"
Labors	0	100	
Parts of machine	95	5	"

Main works

Name	Foreign Currency		Local Currency	
	Depreciation	Material (%)	Material (%)	Labor (%)
Earth work (man power)	-[1/]	5	10	85
" (machine)	"	50	20	30
Explosive work	"	65	17.5	17.5
Embankment (core)	"	45	17.5	37.5
" (random)	"	45	17.5	37.5
" (transition)	"	50	15	35
" (rock)	"	55	15	30
Foundation work (boring)	"	80	10	10
" (grouting)	"	60	35	5
" (others)	"	50	25	25
Reinforced concrete	"	20	60	20
Mass concrete	"	30	40	30
Steelpipe and gate	"	50	20	30

Note: 1/ Depreciation has been counted in the cost of construction equipment.

Table 4-17 Investment Cost of the Project (Main Dam and Saddles under Force Account)

Description	Total		Foreign Currency		Local Currency	
	฿'000	US$'000	฿'000	US$'000	฿'000	US$'000
1. Civil Works (Sub-total)	1,987,938	99,397	887,243	44,362	1,100,695	55,035
1-1. Pre-Engineering	9,120	456	390	20	8,730	436
1-2. Preparation	4,960	248	3,290	164	1,670	84
1-3. Main Dam	764,046	38,202	379,837	18,992	384,209	19,210
1-4. Left Saddle Dam	356,294	17,815	132,064	6,603	224,230	11,212
1-5. Right Saddle Dam	223,295	11,165	112,712	5,636	110,583	5,529
1-6. Spillway	105,091	5,255	52,853	2,643	52,238	2,612
1-7. Main Canal	266,723	13,336	93,751	4,687	172,972	8,649
1-8. Lateral Canal	117,379	5,869	49,764	2,488	67,615	3,381
1-9. Improvement of Old Facilities	109,000	5,450	46,212	2,311	62,788	3,139
1-10. Others	32,030	1,601	16,370	818	15,660	783
2. Land Acquisition & Compensation (Sub-total)	110,230	5,512	0	0	110,230	5,512
2-1. Land Acquisition	69,410	3,471	0	0	69,410	3,471
2-2. Compensation	40,820	2,041	0	0	40,820	2,041
3. Construction Equipment (Sub-total)	267,760	13,388	203,000	10,150	64,760	3,238
3-1. Old Equipment	57,760	2,888	0	0	57,760	2,888
3-2. New Equipment	200,000	10,000	200,000	10,000	0	0
3-3. Transportation	10,000	500	3,000	150	7,000	350
4. Project Facilities	44,220	2,211	5,740	287	38,480	1,924
5. Project Administration	14,550	727	0	0	14,550	727
6. Consulting Services	146,192	7,310	90,638	4,532	55,554	2,778
(7. On-Farm Development)	(237,500)	(11,875)	(100,691)	(5,035)	(136,809)	(6,840)
Sub-total (1 - 6)	2,570,890	128,545	1,186,621	59,331	1,384,269	69,214
8. Contingency	279,338	13,966	120,997	6,050	158,341	7,916
Sub-total (1 - 6, 8)	2,850,228	142,511	1,307,618	65,381	1,542,610	77,130
9. Price Escalation	850,264	42,513	248,713	12,436	601,551	30,077
Total (1 - 6, 8, 9)	3,700,492	185,024	1,556,331	77,817	2,144,161	107,207
Sub-total (1 - 7)	(2,808,390)	(140,420)	(1,287,312)	(64,366)	(1,521,078)	(76,054)
8'.Contingency	(314,963)	(15,748)	(136,101)	(6,805)	(178,862)	(8,943)
Sub-total (1 - 7, 8')	(3,123,353)	(156,168)	(1,423,413)	(71,171)	(1,699,940)	(84,997)
9'.Price Escalation	(961,375)	(48,069)	(274,928)	(13,746)	(686,447)	(34,323)
Total (1 - 7, 8', 9')	(4,084,728)	(204,237)	1,698,341	(84,917)	(2,386,387)	(119,320)

Table 4-18 Investment Cost of the Project (Main Dam, Spillway and Right Saddle under Contract by International Tender)

Description	Total		Foreign Currency		Local Currency	
	฿'000	US$'000	฿'000	US$'000	฿'000	US$'000
1. Civil Works (Sub-total)	2,206,424	110,321	887,243	44,362	1,319,181	65,959
1-1. Pre-Engineering	9,120	456	390	20	8,730	436
1-2. Preparation	4,960	248	3,290	164	1,670	84
1-3. Main Dam	916,855	45,843	379,837	18,992	537,018	26,851
1-4. Left Saddle Dam	356,294	17,815	132,064	6,603	224,230	11,212
1-5. Right Saddle Dam	267,954	13,398	112,712	5,636	155,242	7,762
1-6. Spillway	126,109	6,305	52,853	2,642	73,256	3,663
1-7. Main Canal	266,723	13,336	93,751	4,688	172,972	8,648
1-8. Lateral Canal	117,379	5,869	49,764	2,488	67,615	3,381
1-9. Improvement of Old Facilities	109,000	5,450	46,212	2,311	62,788	3,139
1-10. Others	32,030	1,601	16,570	818	15,660	783
2. Land Acquisition & Compensation (Sub-total)	110,230	5,512	0	0	110,230	5,512
2-1. Land Acquisition	69,410	3,471	0	0	69,410	3,471
2-2. Compensation	40,820	2,041	0	0	40,820	2,041
3. Construction Equipment (Sub-total)	267,760	13,388	203,000	10,150	64,760	3,238
3-1. Old Equipment	57,760	2,888	0	0	57,760	2,888
3-2. New Equipment	200,000	10,000	200,000	10,000	0	0
3-3. Transportation	10,000	500	3,000	150	7,000	350
4. Project Facilities	44,220	2,211	5,740	287	38,480	1,924
5. Project Administration	14,550	728	0	0	14,550	728
6. Consulting Services	146,192	7,310	90,638	4,532	55,554	2,778
(7. On-Farm Development)	(237,500)	(11,875)	(100,691)	(5,035)	(136,809)	(6,840)
Sub-total (1 - 6)	2,789,376	139,469	1,186,621	59,332	1,602,755	80,137
8. Contingency	312,110	15,605	120,997	6,049	191,113	9,556
Sub-total (1 - 6, 8)	3,101,486	155,074	1,307,618	65,381	1,793,868	89,693
9. Price Escalation	987,168	49,359	248,713	12,436	738,455	36,923
Total (1 - 6, 8, 9)	4,088,654	204,433	1,556,331	77,817	2,532,323	126,616
Sub-total (1 - 7)	(3,026,876)	(151,344)	(1,287,312)	(64,366)	(1 39,564)	(86,978)
8'.Contingency	(347,735)	(17,387)	(136,101)	(6,805)	(211,634)	(10,582)
Sub-total (1 - 7, 8')	(3,374,611)	(168,731)	(1,423,413)	(71,171)	(1,951,198)	(97,560)
9'.Price Escalation	(1,098,276)	(54,913)	(274,928)	(13,746)	(823,348)	(41,167)
Total (1 - 7, 8', 9')	(4,472,887)	(223,644)	(1,698,341)	(84,917)	(2,774,546)	(138,727)