ANNEX 3-2. Drainage Scheme

Drainage Scheme

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Drainage Scheme

3.2.1. Estimation of Drainage Discharge

The drainage discharge should be computed for the Project Area and the areas outside Project Area in taking into account the different characteristic features in their runoff patterns.

(1) Drainage from the irrigated paddy fields

Drainage in paddy fields on topographically sloped land takes place, as a rule, in excess water in the fields flowing down from high-elevated fields to low-lying fields. Therefore, the paddy fields extending on the sloped lands like the Project Area can be drained by natural drainage. In such a case, the drained water tends to inundate the low-lying fields, but there will be little fear for inundation damage to the crops grown therein if the inundation remains allowable to the crops.

In general, when paddy plants are flooded over 10 cm deep, the yield would be affected by flooded period and depth to the plants.

In consideration of the above facts, the unit area drainage discharge in the irrigated paddy fields can be obtained in the presumptions below.

- The excess water caused by rainfall in the high-elevated paddy fields is immediately drainaged to the low-lying fields.
- The rain waters falling in the Project Area will be stored in the low-lying areas occupying about 1/A of the total Project Area.
- When heavy rainfall takes place, irrigation is interrupted.
- The water depth on the paddy fields surface n-days often rainfall started is estimated by the following equation:

$$D = A\{R(n, max)t - n(Dc + Cu)\}$$

Where, D : Water depth on the paddy field surface n-days after rainfall started (mm)

R(n, max)t : Maximum rainfall during n-days at 1/T-year excess probability (mm/day)

Dc : Drainage capacity (mm/day)

Cu : Daily consumptive use of paddy (mm/day)

- The low-lying area in the Project Area is assumed to be 1/4 of the total area, that is, A is four.

- A is decided by four (4), but in case of taking this value larger, it is expected that longer-lasting and deeper flood will take place concentratively in the smaller area, and this will result in lower yielding; contrarily in case of taking this value smaller, it is expected that shorter and shallow flood will take place in the larger area and this will reduce the yield decrease rate. Hence, the damage extent to the yield will not so sharply be affected by variation of value of A.

- The value of T, which is commonly determined in terms of economy, is taken by 10 in this study (1/10-year excess probability).

- In general, even if the flood exceeds 10 cm deep above field surface, there will be little damage to paddy plants expected when the flood lasts less than three days and remains less than 20 cm on an average.

Therefore, the following conditions should be provided in order to limit the flood in lasting less than three days with more than 10 cm deep and to keep the flood depth below 20 cm on an average.

$D_1 = A\{R(1, max)T - DC - CU\}$, and

$D_2 = A\{R(2, max)T - 2DC - 2CU\}$,

Where,

$$\frac{D_1 + D_2}{2} = \frac{A}{2}\{R(1, max)T + R(2, max)T - 3DC - 3CU\} < 200$$

The above equation will be arranged by DC, as follows:

$$DC > \frac{1}{3} R(1, max)T + \frac{1}{3} R(2, max)T - \frac{400}{3A} - CU$$

The 1/10-year probable rainfall at Lampang was computed as follows based on the observation records 1952 to 1978.

1/10 Probability Maximum Daily Rainfall R(1, max)10
98.8 mm

1/10 Probability Maximum Two-consecutive-day Rainfall R(2, max)10
125.3 mm

The unit area drainage discharges, employing the above figures, is computed as follows:

$$DC = \frac{1}{3}(98.8 + 125.3) - \frac{400}{3 \times 4} - 5.2$$

$$= 36.2 \text{ mm/day}$$

$$= 4.19 \text{ l/s/ha} = 0.67 \text{ l/s/rai}$$

The value of the unit area drainage discharge, though obtained by 4.19 l/s/ha, will be decreased with the related catchment area becoming larger due to the fact that the rainfalls in the tropical monsoon zone has a specific features of high local intensity which is reduced as the related catchment area becomes larger. The relationship between the catchment area-wise reduction rate and the unit area drainage discharge is as shown below.

Catchment area-wise unit area drainage discharge

Catchment Area (ha)	Reduction Rate	Unit Area Drainage Discharge (l/s/ha)
0 - 320	1.00	4.19
320 - 800	0.90	3.77
800 - 1,600	0.85	3.56
1,600 - 3,200	0.80	3.35
3,200 - 8,000	0.75	3.14
8,000 -16,000	0.70	2.93

(2) Drainage from the area outside Project Area

In studying the on-farm drainage, a particular attention should be paid to those drainage canals which receive a sudden and considerable amount of runoff discharge from the large catchment area outside of the Project Area, and the peak runoff discharge from such catchment areas is estimated by Rational formula as follows:

$$Q = 1/3.6.f.\gamma_t.A$$

Where, Q : Drainage discharge (m^3/s)
f : Runoff ratio = 0.45
rt : Average rainfall intensity within a flood concentration hour (mm/hr)
A : Catchment area (km^2)

$$T = T_1 + T_2$$

Where, T : Flood concentration hour
T_1 : Runoff duration at mountain sides
T_2 : Flowing duration in the river course

The runoff duration at mountain sides can be estimated by the following Kerbay's Formula:

$$T = (2/3 \times 3.28 \times l \times \frac{n}{\sqrt{s}})^{0.467}$$

Where, l: Runoff distance at mountain sides (m)
s: Average slope
n: Delaying coefficient (similar to roughness coefficiencies) = 0.60

Flowing duration in the river course can be obtained by Rziha's Formula as follows:

$$T_2 = L/W$$

$$W = 20(H/L)^{0.6}$$

Where, W: Velocity (m/sec)
L: Horizontal river length for flowing (m)
H: Elevation difference between upstream and downstream point (m)

Average rainfall intensity within flood concentration hour (rt) can be obtained by the following equation:

$$r_t = \frac{r_{24}}{24} \left(\frac{24}{T} \right)^n$$

Where, r_{24}: Probable daily rainfall
n : 0.5

Table 3-2-1 shows the design peak discharge for the drainage canal Nos. 3, 5 , 7, & 9, which have their catchment areas outside the Project Area. The reduction rate against the related catchment areas should also be applied to this computation.

3.2.2. Main Drainage System Planning

In the Project Area 11 main drainage canals illustrated in Figure 3-2-1 would be improved, and the Mae Poon and the Mae Pung canals, which have been concurrently used as irrigation and drainage canals, would be improved to function as drainage canals only with the existing facilities such as weir to be eliminated.

The total length and the catchment areas of the respective main drainage canals are shown as follows:

Name of Canal	Length to be Improved (m)	Catchment Area	
		Inside (ha)	Outside (ha)
No. 1	3,300	272	-
No. 2	2,900	241	-
No. 3	3,300	411	1,213
No. 3-1	1,000	(227)	-
No. 4	12,850	6,105	-
No. 5	16,650	3,998	1,925
No. 5-1	2,600	(195)	1,120
No. 6	5,600	513	-
No. 7	2,500	103	5,263
No. 8	8,400	1,178	-
No. 9	1,850	153	620
Total	60,950	12,974	10,141

3.2.3. Reviewal of Main Drainage Sluice

(1) Water level of the Wang River

Observation of the water level of the Wang River has been carried out at Lampang city and in Amphoe Ko Kha and the relevant data are shown in Table 3-2-2. The probable water level was estimated below depending upon the data observed at Lampang city because those observed in Amphoe Ko Kha were insufficient for the study.

Probable Year	Discharge
1/2	372
1/5	552
1/10	678
1/20	805
1/50	976
1/100	1,109

The 1/10-year probable river discharge approximates to 704 m^3/s, the discharge in 1973, and consequently the year of 1973 is taken as the standard year. On the other hand, the water level in Amphoe Ko Kha, which has a very high correlationship with that observed at Lampang city, can take the value of 1973 standard year for the study. The water level at the confluence of the Wang River and the drainage canal can be estimated based on the data obtained for the both gauging points (Figure 3-2-2)

(2) Necessity of the drainage sluice

The comparative study on water level estimated in the above with estimated water levels at the terminals of the respective drainage canals has suggested that there would be no problem with drainage at the upstream from Lampang city, whereas the Canal Nos. 4, 5 & 8, which are located at the downstream from the city, would cause higher outer water level than inner water level. Therefore, it will be necessary to provide the drainage sluice with these canals. However, further study is required for the detailed planning of the sluice due to lack of data and information about river slope of the Wang River, elevation of drainage canals at their terminals.

3.2.4. Physical Planning for Drainage

Design discharges and dimensions of main drainage canals are shown as follows:

Canal Name	Portion	Discharge (m^3/s)	Slope	Bottom Width (m)	Water Depth (m)	Velocity (m/s)
No. 1	0 - 2,500	4.9	1/500	2.0	1.23	1.04
	2,500 - 3,300	0.5	"	0.5	0.60	0.59
No.2	0 - 2,000	1.0	1/1,000	1.0	0.83	0.54
	2,000 - 2,900	0.3	1/600	0.3	0.55	0.49
No.3	0 - 1,370	31.9	1/550	7.0	2.05	1.55
	1,370 - 3,300	0.7	1/1,000	0.5	0.82	0.50
No.3-1	0 - 1,000	31.0	1/600	6.0	2.20	1.51
No. 4	0 - 2,360	19.2	1/860	5.0	2.03	1.18
	2,360 - 4.920	17.6	1/1,600	4.5	2.37	0.92
	4,920 - 8,700	15.4	"	4.0	2.31	0.89
	8,700 -10,550	11.2	"	4.0	1.97	0.82
	10,550 -12,850	8.9	"	3.5	1.83	0.78
No. 5	0 - 1,800	61.0	1/2,000	12.0	3.24	1.12
	1,800 - 7,400	60.3	1/830	10.0	2.75	1.55
	7,400 -12,950	55.0	1/830	10.0	2.60	1.52
	12,950 -16,650	32.2	1/700	7.0	2.18	1.43

(cont'd.)

No. 5-1	0 - 2,600	18.4	1/700	5.0	1.88	1.25
No. 6	0 - 2,350	5.8	1/1,000	3.0	1.38	0.83
	2,350-5,600	5.0	1/450	2.0	1.21	1.09
No. 7	9 - 2,500	70.5	1/900	10.0	2.82	1.54
No. 8	0 - 1,850	4.2	1/1,000	2.5	1.25	0.77
	1,850 - 3,600	3.8	"	"	"	"
	3,600 - 6,600	2.8	1/800	1.5	1.14	0.76
	6,600 - 8,400	1.1	1/700	1.0	0.79	0.63
No.9	0 - 1,850	13.7	1/600	4.0	1.72	1.21

Calculation of Peak Discharge of Main Drainage Canal

Drainage Canal	Drainage Area	Reducing factor	Arrival time of flood									Rainfall intensity	Drainage discharge
			ℓ	S	T_1	H	L	W	T_2	T	T	γt	Q
	km^2		m		min	m	m	m/s	min	min	hr	mm/hr	m^3/s
No.3	12.13	0.85	400	0.6000	21.0	250	6,000	4.08	24.5	45.5	1.0*	20.2	26.6
No.5	19.25	0.80	1,000	0.1500	44.5	150	8,000	2.74	48.7	93.2	1.6	15.9	30.6
No.7	51.63	0.75	1,000	0.0800	51.5	250	17,000	2.43	116.6	168.1	2.8	12.0	59.2
No.9	6.23	0.90	700	0.0286	55.5	35	6,000	1.53	65.4	120.9	2.0	14.3	10.0

* One (1.0) hour is adopted because calculated value is less than 1.0 hour.

Extreme Momentary Discharge Records at
Kittikhachon II Bridge

Year	Date	Discharge (cu.m/s)	Water Level (M.S.L.)
1952	Sep. 22	787	233.91
1953	Sep. 16	450	232.69
1954	Oct. 9	495	232.88
1955	Sep. 1	392	231.86
1956	Aug. 16	665	233.59
1957	Sep. 3	465	233.21
1958	Oct. 27	181	231.24
1959	Sep. 10	366	232.41
1960	Oct. 22	542	232.87
1961	Aug. 23	808	234.17
1962	Oct. 16	453	232.71
1963	Oct. 30	554	233.16
1964	Oct. 4	365	232.30
1965	Oct. 28	408	232.51
1966	Sep. 2	202	231.37
1967	Sep. 26	522	232.27
1968	Sep. 14	166	230.43
1969	Oct. 3	284	231.59
1970	Aug. 21	418	232.38
1971	Aug. 28	445	232.28
1972	Oct. 5	201	230.59
1973	Aug. 29	704	232.95
1974	Aug. 18	211	230.79
1975	Aug. 30	307	232.19
1976	Oct. 29	202	230.71
1977	Oct. 30	318	231.34
1978	Oct. 13	211	230.80

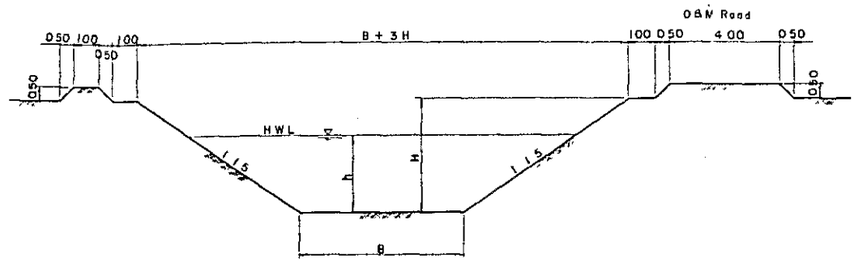
Data Source: RID Hydrological Section.

DIMENSION TABLE

Drainage No	Length (km)	Discharge (m^3/s)	Slope I	h (m)	B (m)	H (m)
NO 1	2 50	4 9	1/500	1 23	2 0	1 5
	0 80	0 5	1/500	0 60	0 5	1 0
	(3 30)					
NO 2	2 00	1 0	1/1,000	0 83	1 0	1 3
	0 90	0 3	1/600	0 55	0 3	1 0
	(2 90)					
NO 3	1 37	31 9	1/550	0 05	7 0	2 6
	1 93	0 7	1/1,000	0 82	0 5	1 2
	(3 30)					
NO 3-1	1 00	31 0	1/600	2 20	6 0	2 7
	(4 30)					
NO 4	2 36	19 2	1/860	2 03	5 0	2 6
	2 26	17 6	1/1,600	2 37	4 5	2 6
	3 78	15 4	1/1,600	2 31	4 0	2.6
	1 85	11 2	1/1,600	1 97	4 0	2 3
	2 30	8 9	1/1,600	1 83	3 5	2 3
	(12 85)					
NO 5	1 80	61 0	1/2,000	3 24	12 0	3 6
	5 60	60 3	1/830	2 75	10 0	3 1
	5 55	55 0	1/830	2 60	10.0	3 0
	3 70	32 2	1/700	2 18	7 0	2.5
	(16 65)					
NO 5-1	2 60	18 4	1/700	1 88	5 0	2 2
	(19 25)					
NO 6	2 35	5 8	1/1,000	1 38	3 0	2 5
	3 25	5 0	1/450	1 21	2.0	1 8
	(5 60)					
NO 7	2 50	70.5	1/900	2 82	10 0	3 3
NO 8	1 85	4.2	1/1,000	1 25	2 5	1 6
	1 75	4 2	1/1,000	1 25	2 5	1 6
	3 00	2 8	1/800	1 14	1.5	1 5
	1.80	1 1	1/700	0 79	1 0	1 1
	(8.40)					
NO 9	1.85	13 7	1/600	1 72	4 0	2 1
Total	60 95					

CROSS SECTION OF DRAINAGE CANAL

No Scale



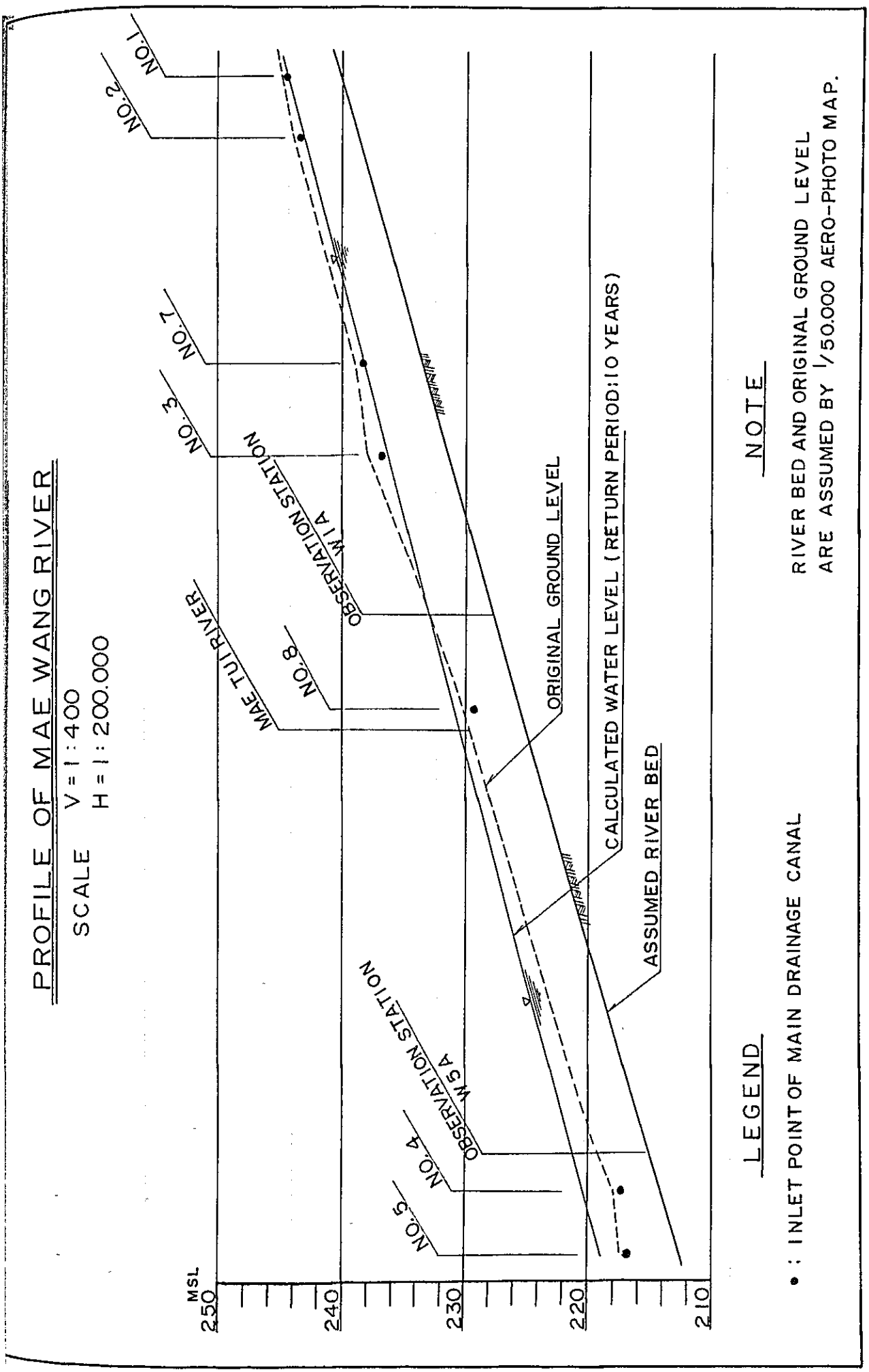
KINGDOM OF THAILAND
MINISTRY OF AGRICULTURE AND CO OPERATIVES
ROYAL IRRIGATION DEPARTMENT

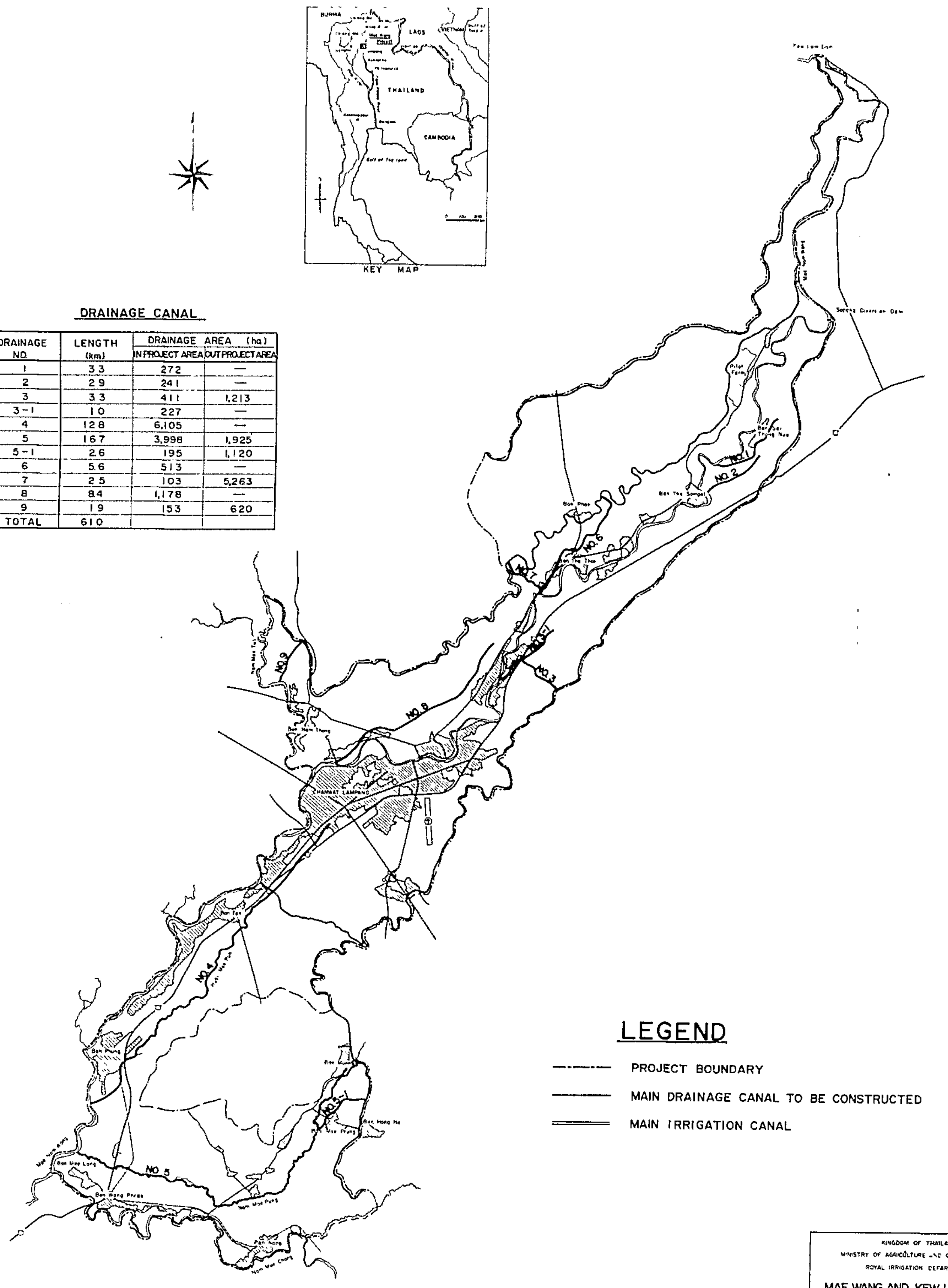
MAE WANG AND KEW LOM PROJECT
TYPICAL SECTION OF
MAIN DRAINAGE CANAL

DESIGNED	SUBMITTED
DRAWN	REVIEWED
TRACED FONGCHAN	RECOMMENDED
CHECKED	APPROVED

JAPAN INTERNATIONAL COOPERATION AGENCY

DATE REVIEWED


PROFILE OF MAE WANG RIVER
SCALE V = 1 : 400
H = 1 : 200.000
NO.1
NO.2
NO.3
NO.7
NO.8
NO.4
NO.5
OBSERVATION STATION W1A
OBSERVATION STATION W5A
MAE TUI RIVER
ORIGINAL GROUND LEVEL
CALCULATED WATER LEVEL (RETURN PERIOD:10 YEARS)
ASSUMED RIVER BED
MSL
250
240
230
220
210
LEGEND
• : INLET POINT OF MAIN DRAINAGE CANAL
NOTE
RIVER BED AND ORIGINAL GROUND LEVEL
ARE ASSUMED BY 1/50.000 AERO-PHOTO MAP.



DRAINAGE CANAL

DRAINAGE NO.	LENGTH (km)	DRAINAGE AREA (ha) IN PROJECT AREA	OUT PROJECT AREA
1	3.3	272	—
2	2.9	241	—
3	3.3	411	1,213
3-1	1.0	227	—
4	12.8	6,105	—
5	16.7	3,998	1,925
5-1	2.6	195	1,120
6	5.6	513	—
7	2.5	103	5,263
8	8.4	1,178	—
9	1.9	153	620
TOTAL	61.0		

LEGEND

- PROJECT BOUNDARY
- MAIN DRAINAGE CANAL TO BE CONSTRUCTED
- MAIN IRRIGATION CANAL

KINGDOM OF THAILAND
MINISTRY OF AGRICULTURE AND CO-OPERATIVES
ROYAL IRRIGATION DEPARTMENT

MAE WANG AND KEW LOM PROJECT
PROPOSED MAIN
DRAINAGE SYSTEM

JAPAN INTERNATIONAL COOPERATION AGENCY

ANNEX 4. LAND CONSOLIDATION SCHEME

LAND CONSOLIDATION SCHEME

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4.1. Present Situation of Land Consolidation in Thailand

4.1.1. Historical background

In Thailand, the necessity of land consolidation has been discerned long time before the Land Consolidation Act was proclaimed in 1974, and acceleration of the land consolidation projects has been strongly adovocated in the recent years.

The projects formulated under the Land Consolidation Act total six in number, as of the end of September, 1979, covering the objective areas of about 200,000 ha. Out of the above total objective areas, about 57,000 ha have been completed in their implementation.

On the other hand, the Ditches and Dykes Project Law was issued in 1962 so that the irrigation water can be properly supplied to each farm plot by provision of farm ditches as well as main irrigation canals.

Ninety two projects have been undertaken on the basis of this law, covering about 2,069,000 ha of the total beneficial areas, out of which about 1,261,000 ha had been completed in their implementation as of the end of September 1979.

The on-farm development in Thailand, which is one of mainstays in Government's policy of agriculture, has been positively promoted, playing a vitally important role to grade up the on-farm facilities.

The approach and implementation method of the land consolidation projects would be firmly established after making various studies and improvements with trial-and-error process experienced in the initial stage as well as those of the other kinds of projects had been done.

As known already, the land consolidation projects have a characteristic feature to grade up the farm lands -- the foundation of agri-

cultural production, and to provide and improve the related on-farm facilities.

The land consolidation projects, as a general rule, should be formulated on the long-term basis and implemented in the phasing-development manner in taking into account the farmers' requirements, consensus of opinion, project economy, benefits, etc.

The Thai authorities concerned, assessing the results obtained from the projects based on the Ditches and Dykes Projects Law, have been seeking for the best suited method of land consolidation projects for gaining the maximum benefit in the more smooth execution within the extent prescribed in the Land Consolidation Act, in duly considering the details of the projects from technical, social and economical viewpoints.

4.1.2. The Government's basic approach to the Project

The Central Land Consolidation Committee has adopted the following view on the phasing development of the land consolidation projects. (Referred to the mimutes of the meeting held on 30 Oct., 1978-8/1978 session)

The on-farm development scheme for the agricultural areas shall provisionally involve both the intensive method and the extensive method.

The intensive method is to make a comprehensive farm land consolidation by arranging the plot areas and shape with levelling, constructing and improving the farm ditches, drains and roads. Therefore, the farm lands to apply this method should be the areas providing the highest potential to generate the maximum benefit from the complete land consolidation works.

On the other hand, the extensive method is in principle to provide

such on-farm facilities as farm ditches, drains and some farm roads in need without implementing land levelling. This method would be applied to those areas where over-investment is expected when the complete land consolidation is executed, or even when only the partial improvement and rehabilitation of the on-farm facilities are required. In the case of improvement or rehabilitation, the facilities in the land consolidation should be constructed in higher grade than those to be provided in the Projects by Ditches and Dykes Project Law.

The view of the said Committee is that theoretically it is not desirable to specify the development method into two, the intensive and the extensive, and the complete land consolidation by intensive method should be adopted to the possible extent; however, the approach to the projects might have to be variable to meet the conditions of the sites in many respects. Furthermore, the view prescribes that the development method to be applied should allow the year-round irrigation and drainage to be secured in the project areas, and more than 70 percent of the beneficiaries lands in one project area should be supplied with water directly from canals or ditches, and the remaining 30 percent lands, would be irrigated indirectly in plot-to-plot method according to the topographical conditions.

At present, therefore, the land consolidation projects have been implemented by the most suited method to the local conditions prevailing in the respective project areas according to the above Committee's view.

4.2. Present Conditions of the Project Area

4.2.1. General topography of the Project Area

The study on the topography and the inclination of the project area is one of the important items for planning the land consolidation scheme.

The Mae Wang-Kew Lom Project Area can be divided into three areas, the Mae Wang Area along the Wang river, Mae Pung Area located in the South of the Project Area and the Kew Lom Extension Area for new reclamation area.

In the Mae Wang Area, the paddy fields extend on the gentle slope in the low-lying part along the Wang river, while the paddy fields and upland fields along the main canals on both the left and the right banks extend on the slope ranging from 1/100 to 1/200 in direct angle to the Wang river and the plot-to-plot irrigation is carried out in these area.

The Mae Pung Area providing paddy fields has a relatively gentle slope excepting for some hill-foot parts.

The Kew Lom Area consisting of some existing cultivated lands, waste lands and forest with intricated topographical conditions, and the land reclamation has been carried out by the farmers concerned.

In general, the land levelling cost, being borne by the farmers, occupies 35 to 45 percent of the total land consolidation cost. The topographical inclination and the land consolidation method to be applied have a close relationship in terms of the benefit evaluation of the project, etc.

Under the due consideration on the above matters, land slope of the paddy fields in the Project Area was classified on the basis of the 1/10,000 topo-maps and the results are shown in Table 4-1.

4.2.2. Topography and soils in the Sample Areas

The purpose of selected five Sample Areas in the Project Area is to find the best suited land consolidation method to the conditions in the Project Area in studying various factors dominant in the selected areas and to estimate the respective construction costs for

the Sample Areas representing different conditions in the Project Area. The location of selected samples is shown as Figure 1-2-1.

The Project Area has quite variable conditions in land holdings, land use and topography in the respective parts. In view of these different conditions, the following five Sample Areas have been selected, and the topographical and cadastral surveys have been made for them. The results are shown as below.

Sample Area	Zone No.	Acreage (ha)	Average Land Slope	Present Land Use (%) Paddy Fields	Upland Fields	Forests
1	12	220	1/20-1/200	76	12	12
2	12	210	1/10-1/180	51	12	37
3	2	140	1/100-1/200	100	0	0
4	9	140	1/800-1/1000	100	0	0
5	4.7	170	1/50-1/250	100	0	0

In most parts of the Sample Areas No. 1 and 2, belonging to the Kew Lom Extension Area, the land reclamation in natural slope has been carried out or the waste lands are left intact excepting some existing paddy fields and relatively low-lying newly reclaimed fields, and the topographical conditions in the areas are considerably intricated. Providing new on-farm facilities, however, will allow the said Sample Areas to have the more effective land use and land reclamation.

In the Sample Area No. 3 with comparatively steep slope, located along the Mae Wang left bank main canal, most of the paddy fields are irrigated by plot-to-plot method excepting for only a few fields irrigated from the canal. The land in this Area inclines simply in one direction and a plan for irrigation and drainage would be made in a regular and common method.

The Sample Area No. 4, located far from the Mae Wang right bank main canal, extends flat providing many paddy fields, and the main drainage canal runs through the center of this Area.

The Sample Area No. 5, to which the irrigation water is supplied from the Mae Pung Main canal, is located in the center of the Project Area with transitional land slope from steep mountain side to the flat paddy field area.

All the Sample Areas provide favourable soil conditions to farming as detailed in 3.2.3 in the main report. The followings are the summary of the important points to be carefully studied for implementing the land consolidation of the Sample Area.

i) In the Sample Areas No. 1 and No. 2, careful levelling works will be required for slightly-high elevated parts or hill sides where there occur gravels, fractured limestones and pisolite layers about 1.0 m below the ground surface.

ii) In the eastern corner of the Sample Area No. 5, ditribution of gravel soils is observed at surface layers.

iii) Generally, there is little necessity for top soil treatment in land levelling because the effective surface soils develop thick in the areas. However, the top soils sometimes are cut away in levelling works for land consolidation and the sub-surface layers or deep layers to be exposed may be used as top soils after implementation of the works.

In such cases, more application of organic matters and fertilizers than that at usual level should be carried out for several years after land consolidation to retain the soil fertility; otherwise the decrease in harvest would be unavoidable for some years.

4.2.3. Evaluation of the Pilot Farm

1) Introduction

The Pilot Farm Demonstration has been established in the northern part of the Project Area for the purpose of promotion of land consolidation project.

The construction works has been performed with acreage of about 100 hectares in 1978 on the force account basis of Thai government. Number of farmers concerned in the pilot area are about 150 farm families, and the average land distribution the Pilot Farm is about 0.68 hectares (4.3 rai) per family.

Irrigation water of the objective area has been supplied from the Mae Wang Right main canal and the cropping pattern in the area is almost paddy in the wet season and paddy, soybean, peanuts and garlic in the dry season, respectively.

Water management at on-farm level has been carried out under rotational irrigation system along with guidance of the Mae Wang O & M official concerned.

2) Evaluation of technical aspect

The necessary field survey and detailed design of land consolidation works in the area have been executed by the government officials concerned, MOAC. Alignments of the irrigation ditches, drains and farm roads at on-farm level are well arranged with proper interval and density taking into consideration the local conditions and land properties.

As the results of the construction works completed, however, there are some issues pointed out as below to give notices for implementing the projects of this kind.

i) There are no remarkable matters on the plot arrangements with land substitution. However, the sub-plot arrangement,

which divides the plot into smaller size of plots so as to reduce land levelling volume, should be reconsidered on the rather small plots provided compared with those in other similar projects in Thailand.

ii) Furthermore, there are some inadequate paddy lands where land levelling works are made so improperly even in completion of the works and some of paddy fields are at higher elevation compared with full water supply level in the ditches.

iii) The check structures have been provided sparsely in the irrigation ditches. It is necessary to install them much more so as to well perform the water management at on-farm level. Besides, farm inlets needs some stop-logs at their entrance portion for controlling discharge.

iv) In connection with item ii), some leading ditches as well as drains should be provided for those sub-plots. Otherwise, the water controls of these plots are very difficult.

v) For improving above mentioned unsuited conditions, the earth moving computation for determining proposed paddy field elevation should be conducted in advance to construction works.

3) Evaluation of agro-economic aspect

The Pilot Farm, which was completed in the previous year, has not exerted yet remarkable effects in various terms of farming practices, agricultural production, socio-economy, etc.

The summary of interview survey conducted by the RID staff concerned are as follows.

Selected sample farmers in this pilot area were only five farmers in the total number of one hundred surveyed farmers.

The paddy cropping acreages are about 95 percent in the wet season in 1978 and about 78 percent in the dry season in 1979 for

their paddy lands, respectively. Other major crops are peanut and garlic.

The utilization ratio of paddy lands is quite high compared with average ratio in the Project Area. It may result from the effect of land consolidation works.

The average yields of paddy were 3.22 ton per hectare in the wet season and 1.55 ton per hectare in the dry season, respectively. Small amount of yield in dry season paddy seems depending on the unexperienced practice.

4.2.4. Farmers' attitude toward land consolidation project

According to interview with 100 selected farmers from the farm households of 20 towns and villages in the Project Area, the conscious or attitude of farmers toward the land consolidation project was clarified as following summaries.

i) Irrigation water

Approximately 33 percent of interviewees has complained about water shortage in the wet season and 56 percent in the dry season. Most of these farmers seems to belong to the Mae Pung Area. About 73 percent of these farmers complaining about water shortage wishes to construct the irrigation facilities.

ii) Flood damages

Approximately 23 percent of the interviewees has suffered more or less from the flood damages in their fields. However, it seems that the damages of the fields are very limited against the whole farm lands in the Project Area.

iii) Right-of-way for farm ditches and drains

The farmers' opinions invited on the right-of-way for the farm ditches and drains are summarized as follows.

Offering without any compensation:	55%
Offering with compensation:	11%

Subject to Governmebt's policy:	15%
Others:	19%

iv) Requirement for farm roads and the design width

About 78 percent of the interviewees has no access roads to their farm lands, and the remaining 22 percent of them appears to possess their lands along the existing community roads or farm roads (including pilot farm roads). Sixty-eight percent of the 78 percent farmers whishes to provide new farm roads for hauling their farm products.

The farmers who expect 3.0 m wide road occupy 25 percent, those who expect 4.0 m wide road occupy 40 percent and those who expect 5.0m wide road occupy 5.0 percent, respectively, and 70 percent of the total 68 farmers wishes to have the farm roads with width of 3.0m to 5.0m.

v) Right-of-way for farm roads

The farmers' opinions on the right-of-way for the farm roads are summarized as follows.

Offering without any compensation:	60%
Offering with compensation:	15%
Others:	25%

vi) Levelling works by farmers' own fund

About 75 percent of the interviewees wishes to carry out land levelling if possible only in future, although 14 percent eagerly wishes to implement land levelling as soon as possible. Under the circumstances, it is presumed that land levelling is difficult to be implemented by farmers' own funds.

As a result, it is considered that the farmers have not had sufficient understandings on the details of the land consolidation project but have earnest wishes for provision of the irrigation/ drainage facilities and farm roads.

4.3. Guideline of Designing the Land Consolidation Project

4.3.1. Basic concept of the on-farm development

In General, plan formulation of the land consolidation projects requires the considerations summarized as follows.

i) Technical aspects

Topographical conditions, conditions of existing irrigation/ drainage facilities, soils, road networks, operation and maintenance of the facilities, etc.

ii) Socio-economic aspects

Present situation of cropping pattern and extension services, agricultural cooperatives and agricultural credits, present status of land holdings, investments to improvement works for existing facilities and expected benefit therefrom, the farmers' attitude and requirements for the projects, government's subsidizes for the cost to be borne by farmers, etc.

The land consolidation projects aim at comprehensive and harmonious upgrading of the rural environment. The projects, therefore, should be formulated on the basis of the above various matters closely relating to the long-term prospect under mutual good understanding of the government and the farmers concerned. At the same time, in taking due consideration on the particular local features and socio-economic conditions prevailing in the areas, it is deemed necessary to adopt the staging development for successful implementation of the projects.

In the Mae Wang - Kew Lom Project, it will be necessary to frame up a staging development plan based on the following points, in taking into account the project investment and benefit, alleviation of construction costs as well as farmers' burden, farmers' understanding on the project as well as their requirements, etc.

i) The works which will be easily improved even after the Proejct is completed.

ii) The works which will be difficult or impossible to be improved after the Project is completed.

Concretely speaking, canal lining, road paving and leveling works in the flat lands can be specified into the former item (i); these works can be implemented with the minimum available investment for the time being and upgraded some day in future when the related farmers can secure the steady growth of their economy.

The design of farm plots, canal alignment, land rearrangement through exchanging the lands and adjustment of land holdings can be specified into the latter item (ii); it is considered ideal that these works are built in a provisional design as fundamental matters planned in the Project formulation.

In recongnition of the above fundamental factors, the design criteria should be prepared for the total project as well as the Sample Area so that the most effective land consolidation scheme can be established for the Mae Wang-Kew Lom Project.

4.3.2. Design criteria

The design criteria for land consolidation of the Mae Wang-Kew Lom Project were established on the basis of topography, soil conditions, land holdings, farming conditions and present practices of irrigation and drainage in the Project Area.

The major items composing the criteria are shown as below.

i) Guideline for reparcelling and standard shape of plot
ii) Irrigation scheme
iii) Drainage scheme
iv) Road scheme

v) Layout of canals and roads (based mainly on extensive method)

vi) Structures

i) Guideline for reparcelling and standard shape of plot

The average land holdings in the Project Area are about 1.3 ha/farmer, which is far below the national average of land holdings in Thailand.

The public lands for canals and roads for land consolidation scheme shall be reserved by collective reduction of the lands obtained from the land exchange.

The land reduction rate in the Project should be minimized in due consideration on the public land ratio prescribed in the law, traditional ratio applied in other projects, and so forth.

Plot reparcelling by intensive method shall be carried out according to the following criteria, in taking into consideration operation and maintenance of the irrigation/drainage facilities, land slope of the areas, construction costs, etc. in addition to the above-mentioned condition.

Land Slope	Standard Plot (Length-of-Run) x (Width)	Acreage ha	Acreage rai
1/200 - 1/500	(100-140^{m}) x (30-40^{m})	0.30-0.56	1.88-3.50
1/500 - 1/1000	(130-150^{m}) x (40-50^{m})	0.42-0.75	2.63-4.69
below 1/1000	(130-150^{m}) x (50-60^{m})	0.65 0.90	4.06-5.63

Thereby, the plot surrounded by the farm ditch and drain should have the length-of-run of about 100-150 m and the width of about 30-60 m.

ii) Irrigation scheme

The irrigation scheme in this paragraph was established to be

applied to the on-farm facilities according to the basic dimensions described in 4.2.3 of the main report.

A. Water requirements

As a general rule, the estimate of water requirements and the determination of facilities sections in on-farm level should be made based on the study on the peak discharges in both the dry and the wet seasons for every blocks because the seasonal difference exists in the kinds of crops grown and the cropping acreages.

The capacity of the main canal requiring for number of days for land preparation was determined to cover 30 days in considering traditional farming practicies, the proposed cropping pattern and repairing period for the facilities. However, the capacity of the on-farm facilities should be determined to cover a shorter period than the above period the taking into account the respective irrigation blocks.

When the rotational irrigation method is applied, the capacity of the related on-farm facilities should be determined to meet the rotational irrigation performance.

In this Project, the capacity of the terminal facilities (downstream of lateral canals) was determined to cover 20 days of land preparation period in taking into consideration the actual results, experiences in other projects in Thailand.

A.1. Consumptive use of water by paddy and upland crops, and percolation

The crop-wise consumptive use is tabulated in Table 3-1-2. Percolation in the paddy field was estimated at 1 mm/day on the basis of the values measured in the fields and existing data obtained in the other project areas.

A.2. Integrated irrigation efficiency

The integrated irrigation efficiency for paddy and upland crops would apply the following values. In the following table, the convey-

ance efficiency is included in the value of the field efficiency.

Integrated irrigation efficiency

Crops	Field Efficiency	Operational Efficiency	Integrated Efficiency
Paddy rice	0.70	0.95	0.67 (Ep)
Upland crops	0.60	0.95	0.57 (Eu)

A.3. Estimation of irrigation water requirements

In principle, the water requirements in the areas with mixed-cropping of paddy and upland crops is estimated by the following equation.

$$Qi = Ap \cdot qpi + Au \cdot qui$$

Where; Qi: Water requirement (m^3/sec)
Ap: Area cropped with paddy (ha)
qpi: Unit water requirement for paddy (m^3/sec/ha)
qp_1: Unit water requirement for puddling (")
qp_2: Unit water requirement of paddy in growing stage (m^3/sec/ha)
qui: Unit water requirement for upland crops
qu_1: Unit water requirement of upland crops for land preparation period of paddy cropping (m^3/sec/ha)
qu_2: Unit water requirement of upalnd crops in growing stage (m^3/sec/ha)
Au: Area cropped with upland crops (ha)
i: indicating cropping season by 1 and 2

The unit water requirements are computed by the following equations.

$$qp_1 = \frac{D_L + (n-1)(D_E + Dp)}{8,640 \times n \times Ep} \qquad qp_2 = \frac{D_E' + Dp}{8,640 \times Ep}$$

Where; qp_1: Unit water requirement for puddling (m^3/sec/ha)
D_L: Water requirement for puddling (mm)
n: Number of days for land preparation (day)
D_E: Evapotranspiration in transplanting stage (mm/day)
Dp: Percolation (mm/day)
Ep: Integrated irrigation efficiency
qp_2: Unit water requirement in growing stage (m^3/sec/ha)
D_E': Evapotranspiration in crop growing stage (mm/day)

$$qu_1 = \frac{Du}{8,640 \times Eu} \qquad qu_2 = \frac{Du'}{8,640 \times Eu}$$

Where; qu_1: Unit water requirement of upland crops for land preparation period of paddy crop (m^3/sec/ha)
qu_2: Unit water requirement of upland crops in crop growing stage (m^3/sec/ha)
Du: Consumptive use of upland crops (Transplanting stage) (mm/day)
Du': Consumptive use of upland crops (Growing stage) (mm/day)
Eu: Integrated irrigation efficiency

Peak water requirement for each crops season

Cropping Season	Season	D_L	D_E	D_E'	Dp	n	Ep	qpi
Water requirement for paddling	(Feb.2) Dry	200	3.5	-	1.0	20	0.67	0.0025
	(Jul.3) Wet	200	2.3	-	1.0	20	0.67	0.0023
Water requirement in crop growing stage	(Apr.1) Dry	-	-	6.7	1.0	-	0.67	0.0013
	(Oct.3) Wet	-	-	3.5	1.0	-	0.67	0.0008

Cropping Season	Season	Du	Du'	Eu	qu_1	qu_2
Water requirement for land preparation period	(Feb.2) Dry	2.8	-	0.57	0.0006	-
	(Jul.3) Wet	1.5	-	0.57	0.0003	-
Water requirement in crop growing stage	(Apr.1) Dry	-	4.2	0.57	-	0.0009
	(Oct.3) Wet	-	1.2	0.57	-	0.0002

A.4. Estimate of integrated water requirements

According to the season-wise unit water requirements and the proposed cropping pattern, the maximun water requirements necessary for determing the sections of the terminal facilities is considered to take place in the puddling stage in the wet season paddy cropping. Thereby, the following equation shall be adopted for estimating the necessary discharge for determination of the canal section.

$$Q = q_{pl} \cdot Ap + q_{ul} \cdot Au$$
$$= 0.0025 \cdot Ap + 0.0006 \cdot Au$$

Where; Q: Max. water requirement (m^3/sec)
Ap: Area cropped with wet season paddy (ha)
Au: Area cropped with wet season upland crops (ha)

B. Hydraulic computation and design of canal section

B.1. Hydraulic computation

The hydraulic computation was made by Manning's formula to determine the section of the canals.

$$Q = AV = \frac{1}{n} R^{\frac{2}{3}} \cdot I^{\frac{1}{2}} \cdot A$$

Where; Q: Discharge (m^3/sec)
A: Flow section (m^2)
V: Average velocity (m/sec)
n: Coefficient of roughness
Concrete lining canal: 0.014
Earth ditch: 0.035
R: Hydraulic radius (m) = $\frac{A}{S}$
S: Wetted perimeter (m)
I: Gradient

B.2. Maximum allowable velocity

The maximum allowable velocity in the canals shall be decided according to the following standards, although varies by soil conditions of the canals.

Soil conditions	Flow velocity (m/sec)
Sandy silt	0.45
Loam	0.75
Silty loam	0.90

B.3. Canal sections

The embankment slope for irrigation and drainage canals was in principle determined by 1.0 : 1.0.

iii) Drainage scheme

The following drainage scheme was formulated to be applied to the terminal drainage facilities based on the dimensions described in paragraph 4.2.4. of the main report.

A. Unit area drainage discharge

Most of the lands in the Project Area are categorized into either farm lands or residential lots, and the on-farm level drainage system can only drain the run-off discharge inside the on-farm areas in the Project because the run-off from the areas outside Project Area is intercepted by the Mae Wang, Kew Lom and Mae Pung main irrigation canals. The unit area drainage discharge for the case was taken by 0.0042 m^3/sec/ha as quoted before.

B. Designed drainage discharge

The peak drainage discharge can be obtained by the following equation.

$Q = A \cdot qo$

Where; Q: Designed drainage discharge (m^3/sec)
A: Proposed drainage area (ha)
qo: Unit area drainage discharge (m^3/sec/ha)

C. Design for typical section of the drainage canal

The hydraulic computation and design for typical section of the drainage canals were made by the same manner that was adopted for the determination of the typical section of the irrigation canal. Only the special condition given to the drainage canal design was the maximum velocity, which was taken by the value 1.5 times at the peak run-off period as large as that for the irrigation canal.

iv) Road Scheme

A. Proposed farm road type and density of its network

In the Project Area the major road networks have been well established but a very few farm roads. The farm roads play such a vitally important role that the irrigation/drainage facilities do. The Project planned to provide two types of roads; rural roads and farm roads. The rural roads are considered as major roads in the Project Area, linking existing community roads (trunk roads) with proposed farm roads or existing village roads. The farm roads, directly concerned with agricultural production, would be provided in principle along the irrigation canals in the land consolidation area, and may constructed along the drainage canals, if necessity arises.

In the areas where the extensive development method is applied, the necessary farm roads would be provided, though in the minumum extent, so as to carry out the effective operation and maintenance services for the facilities.

B. Road width

The road width available, in general, is determined in considering the kinds of vehicles passing, traffic frequency, construction costs, and easiness in operation and maintenance of the terminal facilities.

In the Project Area, a considerably intensified farming has been practised with small land holding on an average and it is expected that the farm mechanization would be introduced in the lower extent than in other areas of the country.

On the other hand, the interview survey conducted during the current study revealed that many of farmers had wishes to provide the roads with width ranging from three to five meters, particularly 4.0 m wide roads.

Under the situation, the proposed road width was decided by 4.0 m as detailed below in taking account for availability for a hand-tractor and an ox-cart to pass each other.

Effective width of hand tractor	1.30 m
" " of ox-cart	1.30 m
Medial clearance between vehicles	0.50 m
Outer allowance of both side of road	0.60 m (0.30 + 0.30)
Total	3.70 m

Therefore, all of the proposed roads should provide the width of 4.0 m.

C. Road height

The road was designed to have a surface elevated by 0.50 m high from the ground surface of the paddy fields.

v) Layout of canals and farm roads

A. Irrigation canals

As a general rule, the irrigation canals should possibly avoid to provide through the irrigation blocks but along the boundaries of the respective land holdings.

A standard commanded area by a farm ditch should be about 300 rai (about 50 ha), and a sub-ditch should be provided to avoid direct diversion from the canals, if the commanded area exceeds 300 rai.

When a ditch exceeds 1.0 Km in length to cover more than 300 rai, the extended part of the ditch over 1.0 Km should be concrete-lined.

If there are any plots to be uncovered by the above irrigation network, additional small ditches should be provided in order that the plot-to-plot irrigation can be avoided. A careful study should be made to determine the layout of these canals and ditches so as to most effectively utilize the existing canals.

B. Drainage canals

The drainage canals provided in the area adopting the extensive development method, in general, do not need to drain each plot directly. The proposed drainage canals would be constructed in order to be connected with the existing drainage canals, proposed main drainage canals, and also constructed in those areas with the drainage area of about 30-50 rai (5-8 ha) at the starting point.

The layout of the drainage canals should be carefully studied in the same consideration that the layout of the irrigation canals was studied. The 200-300 m intervals should be placed, as a general rule, between the drainage canals.

C. Farm roads

The 3-4 meter wide roads would be provided, if necessary, along the irrigation canals so as to link with the village roads or the O & M roads constructed along the main canals.

vi) Structures

In the proposed land consolidation area, the following structures relating to the irrigation/drainage canals and roads would be provided.

A. Constant head orifice (C.H.O.)

The constant head orifice is a structure to divert water from the main or the lateral canals, installed at the starting point of irrigation ditch. The C.H.O. should provide the control gate, and one or a pair of concrete pipe would be provided according to the controlled discharge in the culvert portion downstream of the gate.

B. Division box

The division box is a structure to divert the water from a leading ditch to a farm ditch, installed at that distribution point.

C. Culvert

The culvert is provided at the point where the farm ditches or drains cross the roads, and the culvert diameter will be determined according to the length of culvert and water level difference between the upstream side and downstream side of the said culvert.

D. Farm entrance

The farm entrance is a kind of culvert to be placed at the crossing point of the access road to the farm plot and the said ditch. The length of culvert will be 4-6 m in taking the account the kinds of vehicles to pass over or traffic frequency. The suitable intervals between the farm entrance will be about 200 m or the distance between the two or three land holdings.

E. Check structure

The check structure function to secure the water level to be required for necessary amount of water intake or to control the water level for executing the rotational irrigation. The check structure will be provided at every 250-300 m intervals, and can be installed together with drop structure, if any in the ditch, in due consideration on the intervals between these facilities.

F. Farm inlet

The farm inlet is a structure to supply the water to each farm plot from the farm ditch. The 200 mm concrete pipe will be placed for the purpose at the interval of one farm inlet for about five rai farm plots, and the one farm inlet should be co-used if the commanding plot size is below five rai.

4.4. Detailed Design for the Sample Area

4.4.1. Approach to the study

As mentioned in paragraph 4.2.1, and 4.2.2. of the Annex, the areas commanded by the respective irrigation system in the Project Area provide different conditions of topography and land slope. The study for the selected Sample Areas should be made on the basis of their different topographical conditions and present land use.

Case-A (Extensive development method)

A-1. Sample Area No. 1 and 2

The Sample Areas No. 1 and 2, belonging to the Kew Lom Extension Area, include paddy fields, upland fields, and forest lands to be reclaimed in their co-existence. The said Areas seem to be difficult in implementing the complete land consolidation works because of the intricated topography and the complicated land use in the Areas.

Fundamentally, the development plan of the Areas shouldbe made

with the idea that the lands irrigable by gravity system from the respective lateral canals shall be used as paddy fields, and the lands elevated higher than the water level availably by the canals shall be used as upland fields.

Since the upland field would be irrigated by pumps in future, the canal section should be designed to cover sufficient capacity to meet the said requirements, although the current study will not detail on the matter.

Therefore, the physical planning will be made on study of irrigation/drainage canals, roads and their related structures.

A-2. The Sample Areas No. 3 and 5

The Sample Areas No. 3 and 5, belonging to the Mae Wang Area and the Mae Pung Area, provide a relatively steep slope and intricated topography. Thereby, the construction cost seems to be rather high because the earth moving volume is estimated at 120-150 m^3 per rai in land levelling works and there are some technical problems expected in the top soil treatment.

Under the circumstances, the study will be made only for construction or rehabilitation of irrigation/drainage canals, road construction and provision of their related structures in the same manner that is proposed for the Case A-1.

A-3. The Sample Area No. 3

The physical planning will be made in the same manner that is proposed for the case A-2. The whole land in this Area topographically inclines in one direction and there will be a possibility to carry out land levelling works in future. Thereby, the layout of the proposed facilities such as canals and roads should be carefully studied so that they can be utilized to the maximum extent after land levelling executed.

Under such consideration, the proposed canal would be planned to be provided through the central part of the Area in taking into account being used together with existing canals.

Case-B. Intensive development method

B-1. Sample Area No. 4

The Sample Area No. 4, located in the low-lying flat land, represents the paddy field areas of the Project Area. Hence, the complete land consolidation works (Intensive development methods) can be implemented for the Area.

However, a careful study should be made on relationship between construction of the proposed facilities and rehabilitation of the existing main facilities as well as how to treat the problem of proposed canal spaces because the main drainage canal is running through the center of the Area.

B-2. Sample Area No. 5

The land slope of this Area is specified in details to be tabulated as follows.

Slope	Acreage (ha)	Percentage (%)
1/50 -1/150	49.3	35.5
1/100-1/150	38.9	28.0
1/150-1/250	50.7	36.5
Total	138.9	100.0

The study would be made in the same manner that is proposed for the Case B-1, including land levelling works and construction of other facilities required.

The detailed study of this Area will enable to find the fundamental development policy of the total Project Area in comparative study of

the results with those in Case A-1 as well as the comparison among slope-wise construction costs.

4.4.2. Detailed design

The results of the detailed design made along with the guideline set up through the previous study are shown as follows and the related drawings are attached hereto (Figure 4-1 to 4-9).

i) Density of road and canal networks, and earth moving volume in land levelling

In applying the extensive development method, the layout of irrigation canals in the Case A-1, -2 and -3 was made so that the lands held by more than 70 percent of the farmers in the respective areas can be irrigated directly from these canals. The drainage canals and the roads were planned to be constructed in the minimum extent in taking into account utilization of the existing facilities.

For the case B-1 and -2, the intensive method was applied on the basis of the design criteria and the topographical conditions and the public land ratio prevailing in the respective areas.

The road and canal networks in each case, and the earth moving volume in land levelling works for the Case B areas are illustrated in the following table. For references, the Sample Area No. 5 was divided into three blocks according to the land slope of the area.

Density of canal and road networks

Case	Sample Area No.	Earth Moving Volume (m^3/ha)	Farm Road (m/ha)	Irrigation Canal (m/ha)	Drainage Canal (m/ha)	Structures (per hectare)	Remarks
A-1	No. 1	-	18.9(2.2)	52.5(52.5)	18.8(1.6)	1.5	
"	No. 2	-	38.8(0)	59.2(59.2)	22.3(1.3)	1.5	
A-2	No. 3	-	27.9(7.3)	72.4(72.4)	26.7(12.2)	3.7	
"	No. 5	-	21.5(9.1)	67.7(67.7)	31.0(0)	2.5	
A-3	No. 3	-	28.6(8.0)	70.7(70.7)	54.2(37.9)	3.4	
(Average)		-	27.1	64.5	30.2	2.5	
B-1	No. 4*	393	57.8	57.9	37.7	2.2	
B-2	No. 5*	785	61.0	66.9	47.0	3.2	
"	"	388	61.5	76.9	45.3	3.4	Sople 1/150-1/250
"	"	700	64.6	69.2	45.0	3.0	1/100-1/150
"	"	1,261	57.5	58.7	49.7	3.0	1/50-1/150
(Average)[1/]		589	59.4	62.4	42.4	2.7	

The average values of[1/] were obtained from these values in the areas marked with *. The figures in the parenthesis indicate quantity to be constructed.

In the Areas where the extensive development mehtod will be applied, the ratio of the lands to be irrigated directly from the canals is as shown in the following table, and this canal planning was made to meet the design criteria provisionally prepared by the Thai Authoritie concerned.

Situation of irrigation by provided canal networks in Sample Areas

Case	Sample Area No.	Number of Land Owner: Total: No. of Land Owners	Total: %	Direct Irrigation: No. of Land Owners	Direct Irrigation: %	Indirect Irrigation: No. of Land Owners	Indirect Irrigation: %
A-1	No.1	160	100	121	76	39	24
"	No.2	143	100	107	75	36	25
A-2	No.3	270	100	195	72	75	28
"	No.5	257	100	185	72	72	28
A-3	No.3	270	100	196	73	74	27

ii) The public lands ratio for on-farm facilities

The public lands to be required for providing various facilities in each case, are tabulated in the Table 4-2. The ratio of the public land to be required for the Case A-1, -2 and -3 is estimated at 4.8 percent on an average, and the land reduction rate is 2.4 percent on an average. The same ratio for the Case B-1 and -2 is estimated at 6.1 percent and the reduction rate is 4.1 percent on an average.

For the Project Area when the average land holdings per farmer is comparatively small, it is necessary that the physical planning is so designed as to minimize the ratio of public land and maximize the project effect.

The study to minimize the public land ratio in the Sample Areas with rather intricated topography has resulted in finding that the said ratio should be kept at least about five percent for the extensive development method and about 6.5 - 7.0 percent for the intensive development method.

iii) Study on construction cost and technology to be applied

The construction cost estimate was made by applying the unit price of fiscal 1980 on the RID force account basis. The results are shown in the table 4-3.

The study on the density of the proposed road and canal networks and the construction cost has revealed the following matters on on-farm development method in the Project Area.

Case A-1: In the Sample Areas No. 1 and 2 which belong to the Kew Lom Extension Area, the relatively well arranged road networks under the Settlement Programme and the more density provided lateral canal networks than in the other zones can reduce the construction cost as compared with that in the other costs. Furthermore, the large land holdings per family as compared with those in the other zones, and farm lands of each owner located concentratively can save the proposed structures in number. The cost required for the unit area (ha) was estimated at 6,893 Baht (฿1,102/rai).

Case A-2: The Sample Areas No. 3 has an average land slope of 1/120, located along the lateral irrigation canal. Thereby, the construction cost of the structures accounts for 65.5 percent of the total construction cost.

The areas extending along the existing main canals on the left and the right banks of the Wang river have the land slope similar to this area would require almost the same amount of the cost for the construction works.

The construction cost per unit area (ha) was estimated at 11,498 Baht (฿1,839/rai).

In the Sample Area No. 5 the land slop varies from 1/50 to 1/250, but the average construction cost was estimated at ฿8,549/ha (฿1,367/rai), which is lower than that of the Sample Area No. 3.

Case A-3: The construction cost was estimated at 13,599 Baht per hectare, which resulted from the fact that the total length of the drainage canals has become longer than that in the Sample Area No. 3 in the Case A-2. The development method to be applied would allow the proposed facilities such as canals and roads to be utilized even after plot rearrangement and levelling implemented in future.

Some of the structures to be constructed, however, would have to be rehabilitated for the further development of the Project. In the case, the amount of further investment would be equivalent to 30 percent of the total construction cost for the current scheme.

The implementation of the proposed method would divide the lands held by 69 farmers (25.5%) out of 270 farmers by construction of canals. Furthermore; there is a tendency that the offerers of the lands for public lands may be designated to some particular group of farmers compared with Case A-2. There are the problems to be considered before implementation.

Case B-1: The Sample Area No. 4 extends flat with average land slope of 1/800, and the construction cost was estimated at 14,055 Baht per hectare (฿2,248/rai). The cost for land levelling occupies about 31 percent of the total construction cost.

In the land consolidation works, to minimize the land levelling cost including land clearing cost, would contribute the cost recovery and stabilization of farm economy.

Case B-2: The Sample Area No. 5, having land slope varying from 1/50 to 1/250, will be sub-divided into three, the area with slope of 1/50-1/150, the area with slope 1/100-1/150 and the area with slope of 1/150-1/250. The cost estimats for the Area was made according to these sub-divisions.

In general, the earth moving volume in land levelling works is estimated at 350-500 m^3 per hectare (60-80 m^3/rai) and the construction cost of the land levelling accounts for about less than 40 percent of the total cost in most cases.

In this Area, the land levelling cost for the area with slope of 1/100-1/150 was estimated at 35 percent of the total cost, and that for the area with slope fo 1/50-1/150 was estimated at slightly higher than 49 percent of the total cost. These land levelling costs are considered higher than the average, pushing up the total construction cost.

The construction cost for the area with slope 1/150-1/250 was estimated at 17,709 Baht per hectare (฿2,833/rai) and the land levelling cost occupies about 25 percent of the total cost.

The said construction cost would be a cieling amount of the investment as compared with actual results obtained in the other projects in Thailand, even if the Project Area might be further developed under more intensified agriculture.

4.5. Approach to the Land Consolidation and Proposed Acreage for the Scheme

4.5.1. Determination of the land consolidation method

According to the results of the detailed design for the Sample Areas, the land consolidation works would be implemented, in principle, by extensive development method for the areas with land slope of more

than 1/200 while by intensive development method including land levelling for the areas with land slope of less than 1/200.

The former plan is further specified into the following three methods;

i) Areas with land slope of more than 1/100 -- E1

The objective areas of this type of development extends in the Kew Lom Extension Area and along the left and the right bank Mae Wang main canals as shown in Map 4-1, and Table 4-1.

For the areas in zone No. 1-10, the method applied in the Sample Area No. 3 of the Case A-2 would be used as its basis, excluding zone No. 12.

ii) Areas in the Kew Lom Extension Area -- E2

For the areas in this Area where the topographic and land slopes are intricated and variable, the method applied to the Sample Area No. 2 of the Case A-1 would be used for all the areas in zone No. 12.

iii) Areas with land slope 1/100 - 1/200 -- E3

The method applied to the Sample Area No. 5 of the Case A-2 would be used for the areas of zone No. 1 - 10, excepting for zone No. 12.

The intensive method to be used can be specified into the following two types.

iv) Areas with land slope of 1/200 - 1/500 -- I1

The method applied to the areas with land slope of 1/150-1/250 in the Sample Area No. 5 of the Case B-2 would be used for the areas with the land slope mentioned above, excepting for zone No. 12.

v) Areas with land slope of less than 1/500--I2

The method applied to the Sample Area No.4 of the Case B-1 would be used for all paddy fields excepting for the areas quoted in the above i) - iv).

The irrigation facilities for the upland fields will not be provided in this Project in principle. The upland fields will be irrigated by furrow irrigation method. For the upland cropping as the second cropping in the dry season the flooding furrow irrigation will be carried out with ridges in the paddy fields.

The upland fields of 1,090 ha (62.3%) out of the total 1,750 ha are located in the zone No.12, and the remaining upland fields (660 ha) and the orchards (250 ha) are located around the housing lots and in other high lying lands sporadically. For these upland fields, manpower irrigation or pumping irrigation will be available by water intake from the on-farm irrigation facilities in the paddy fields, if necessity arises.

The investment to these upland fields is little expected to generate benefit to cope with its invested amount. Therefore, the plan for the purpose has not been formulated in the Project.

4.5.2. Proposed acreage for the scheme

According to the development method mentioned above, Table 4-1 is rearranged by the respective methods to obtain the following Table. As a result, the ratio of the extensive method application and the intensive method application for the implementation becomes 50 percent each. For references, the New City Planning Project Areas, in Table 4-1, included in the zone No.2 and 3 are excluded because no investment will be made for land improvement purpose.

ANNEX 4
Table 4-1

Land Slope Classification of Rice Field

(Unit: hectare)

No. of Zone	Land slope: Less than 1/1,000		1/1,000-1/500		1/500-1/200		1/200-1/100		More than 1/100			
1	0	-	443	-	90	-	482	-	0	-	1,015	-
2	0		245	-	64	(19)	428	-	106	(47)	843	(66)
3	37	(37)	802	(403)	14	(14)	343	(297)	579	(138)	1,775	(889)
4	9	-	0	-	55	-	150	-	409	-	623	-
5	124	-	235	-	322	-	463	-	239	-	1,383	-
6	0	-	497	-	768	-	336	-	6	-	1,607	-
7	368	-	306	-	206	-	56	-	0	-	936	-
8	505	-	181	-	157	-	14	-	43	-	900	-
9	367	(79)	0	-	432	(17)	335	(3)	106	-	1,240	(99)
10	130	(128)	55	(9)	269	(63)	164	(20)	9	(2)	627	(222)
12	0	-	0	-	315	-	798	-	1,338	-	2,451	-
Total	1,540	(244)	2,764	(412)	2,692	(113)	3,569	(320)	2,835	(187)	13,400	(1,276)
Proportion(%)	11.5	(19.1)	20.6	(32.3)	20.1	(8.8)	26.6	(25.1)	21.2	(14.7)	100.0	(100.0)

Note: The figures in the parenthesis are the area covered by City Planning Programme.

Acreage Estimation Table for Each Sample

(Unit: Hectare)

Case	Sub-case	Sample No.	Present Land Use				Proposed Land Use				Reduction Ratio% (9)=(8)-(4)	Remarks
			Farm Land (1)	Road Canal (2)	Total (3)=(1)+(2)	Public Land Ratio% (4)=(2)/(3)	Farm Land (5)	Road Canal (6)	Total (7)=(5)+(6)	Public Land Ratio% (8)=(6)/(7)		
A-1	A-1-1	No.1	183.2	5.3	188.5	2.8	177.9	10.6	188.5	5.6	2.8	
	A-1-2	No.2	163.4	3.0	166.4	1.8	158.4	8.1	166.4	4.9	3.1	Average ≒ 2.4%
A-2	A-2-2	No.3	104.9	2.4	107.3	2.2	102.2	5.1	107.3	4.8	2.6	
	A-2-4	No.5	144.7	4.4	149.1	3.0	144.2	.49	149.1	3.3	0.3	
A-3	A-3-2	No.3	104.9	2.4	107.3	2.2	101.6	5.7	107.3	5.3	3.1	
B-1	B-1-1	No.4	84.9	1.6	86.5	1.8	81.2	5.3	86.5	6.1	4.3	
	Including Main drain	No.4	84.8	3.7	88.5	4.2	81.1	7.4	88.5	8.4	4.2	Average ≒ 4.1%
B-2	B-1-2	No.5	144.7	4.4	149.1	3.0	138.9	10.2	149.1	6.8	3.8	

Summary of Construction Cost for RID' Force Account Basis

(Unit: Baht per Hectare)

Case	Sample No.	Land Clearing		Land Levelling		Farm Road		Irrigation Ditch		Drain Ditch		Structures		Total Cost	
		%	Amount	%	Amount	%	Amount	%	Amount	%	Amount	%	Amount	%	Amount
A-1	No.1	-	-	-	-	1.7	90	42.8	2,232	0.2	12	55.3	2,892	100	5,226
A-1	No.2	-	-	-	-	-	-	40.9	2,820	0.1	10	59.0	4,063	100	6,893
A-2	No.3	-	-	-	-	1.9	214	31.7	3,644	0.9	99	65.5	7,541	100	11,498
A-2	No.5	-	-	-	-	6.7	574	40.7	3,477	-	-	52.6	4,498	100	8,549
A-3	No.3	-	-	-	-	3.7	502	27.8	3,784	2.4	330	66.1	8,983	100	13,599
B-1	No.4	5.7	806	25.7	3,602	17.9	2,519	13.2	1,851	1.9	270	35.6	5,007	100	14,055
B-1	No.5 (Average)	3.8	806	34.1	7,325	11.3	2,428	8.3	1,794	1.6	342	40.9	8,791	100	21,486
B-1	No.5 (1/150-1/150)	4.6	806	20.5	3,624	12.8	2,266	8.4	1,497	2.0	353	51.7	9,163	100	17,709
B-1	No.5 (1/100-1/150)	3.8	806	31.0	6,535	12.4	2,615	8.7	1,825	1.6	329	42.5	8,967	100	21,077
B-1	No.5 (1/50-1/150)	3.1	806	45.7	11,755	9.5	2,449	8.1	2,076	1.3	341	32.3	8,270	100	25,697

Method-wize Acreage for the Scheme

Unit: hectare

Zone No.	Extensive Method				Intensive Method			
	E1	E2	E3	Sub-total	I1	I2	Sub-total	
1.	0	0	482	482	90	443	533	1,015
2.	59	0	428	487	45	245	290	777
3.	441	0	46	487	0	399	399	886
4.	409	0	150	559	55	9	64	623
5.	239	0	463	702	322	359	681	1,383
6.	6	0	336	342	768	497	1,265	1,607
7.	0	0	56	56	206	674	880	936
8.	43	0	14	57	157	686	843	900
9.	106	0	335	441	432	367	799	1,240
10.	9	0	164	173	269	185	454	627
12.	0	2,451	0	2,451	0	0	0	2,451
Total	1,312	2,451	2,474	6,237	2,344	3,864	6,208	12,445
%	10.5	19.7	19.9	50.1	18.8	31.0	49.9	100.0

CASE A-1-1, SAMPLE NO 1

CADASTRAL LEGENDS

TOPOGRAPHY LEGENDS

DESIGN LEGENDS

KINGDOM OF THAILAND
MINISTRY OF AGRICULTURE AND CO-OPERATIVES
ROYAL IRRIGATION DEPARTMENT

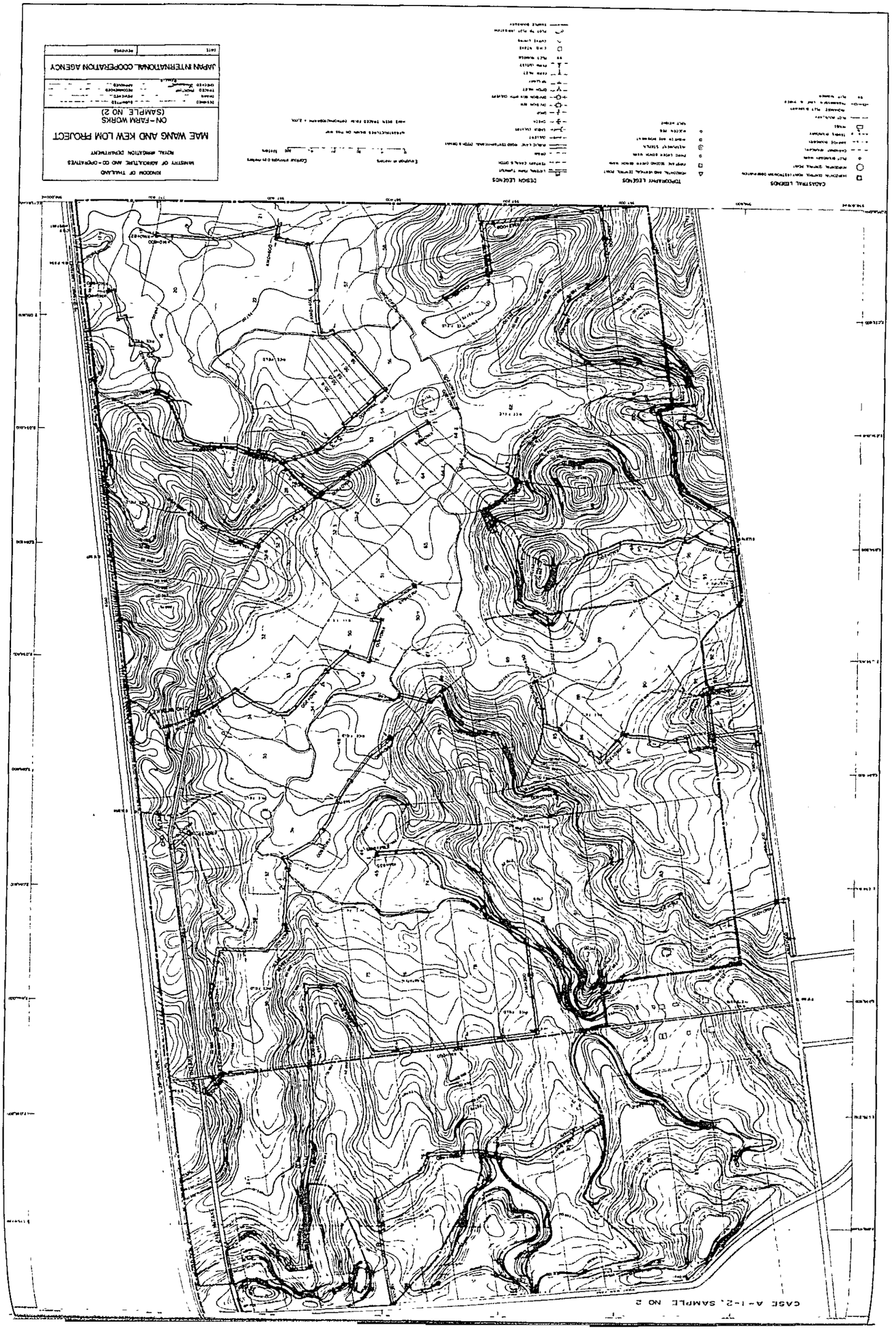
MAE WANG AND KEW LOM PROJECT

ON-FARM WORKS
(SAMPLE NO 1)

JAPAN INTERNATIONAL COOPERATION AGENCY

ANNEX 4
Figure 4-1

ANNEX 4
Figure 4-2



CASE A-2-1, SAMPLE NO 3

CADASTRAL LEGENDS

TOPOGRAPHY LEGENDS

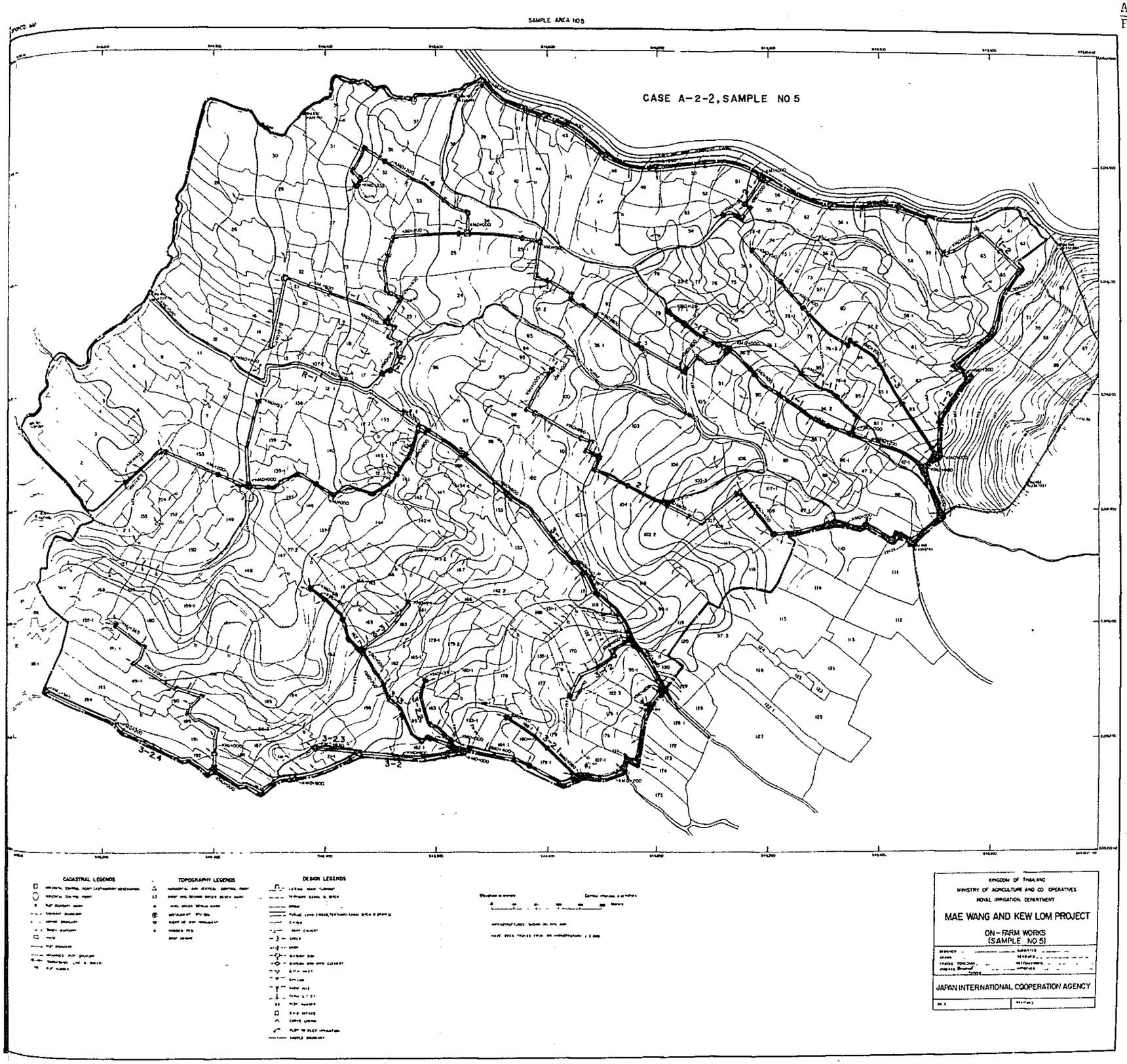
DESIGN LEGENDS

KINGDOM OF THAILAND
MINISTRY OF AGRICULTURE AND CO-OPERATIVES
ROYAL IRRIGATION DEPARTMENT

MAE WANG AND KEW LOM PROJECT

ON-FARM WORKS
(SAMPLE NO 3)

JAPAN INTERNATIONAL COOPERATION AGENCY


SAMPLE AREA NO 5
CASE A-2-2, SAMPLE NO 5
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TOPOGRAPHY LEGENDS
DESIGN LEGENDS
KINGDOM OF THAILAND
MINISTRY OF AGRICULTURE AND CO OPERATIVES
ROYAL IRRIGATION DEPERTMENT
MAE WANG AND KEW LOM PROJECT
ON-FARM WORKS
(SAMPLE NO 5)
JAPAN INTERNATIONAL COOPERATION AGENCY

CASE A-3 SAMPLE NO 3

DRAIN OUTLET

DRAIN OUTLET

DRAIN OUTLET

CHQ INTAKE

CHQ INTAKE

CHQ INTAKE

CHQ INTAKE

CADASTRAL LEGENDS

- HORIZONTAL CONTROL POINT (ASTRONOMIC OBSERVATION)
- HORIZONTAL CONTROL POINT
- PLOT BOUNDARY MARK
- CHAMBARI BOUNDARY
- SAMPLE BOUNDARY
- TAMBOL BOUNDARY
- HOUSE
- PLOT BOUNDARY
- UNDRAWED PLOT BOUNDARY
- TRANSMISSION LINE & TOWER
- 99 PLOT NUMBER

TOPOGRAPHY LEGENDS

- HORIZONTAL AND VERTICAL CONTROL POINT
- FIRST AND SECOND ORDER BENCH MARK
- THIRD ORDER BENCH MARK
- INSTRUMENT STATION
- RIGHT OF WAY MONUMENT
- WOODEN PEG
- SPOT HEIGHT

DESIGN LEGENDS

- LATERAL FARM TURNOUT
- TERTIARY CANAL & DITCH
- DRAIN
- PUBLIC LAND (ROAD,TERTIARY CANAL,DITCH & DRAIN)
- CULVERT
- CHECK CULVERT
- CHECK
- DROP
- DIVISION BOX
- DIVISION BOX WITH CULVERT
- DITCH INLET
- SPILLWAY
- FARM INLET
- FARM OUTLET
- 99 PLOT NUMBER
- CHQ INTAKE
- TURNOUT LIVING
- PLOT TO PLOT IRRIGATION
- SAMPLE BOUNDARY

Elevation in meters — Contour Interval 0.25 meters

0 40 80 120 160 200 Meters

INFRASTRUCTURE SHOW ON THIS MAP HAVE BEEN TRACED FROM ORTHOPHOTOGRAPH 1 : 2,000

KINGDOM OF THAILAND
MINISTRY OF AGRICULTURE AND CO-OPERATIVES
ROYAL IRRIGATION DEPARTMENT

MAE WANG AND KEW LOM PROJECT

ON-FARM WORKS
(SAMPLE NO 3)

DESIGNED	SURVEYED
DRAWN	REVIEWED
TRACED SAOWANI	RECOMMENDED
CHECKED	APPROVED

JAPAN INTERNATIONAL COOPERATION AGENCY

DATE	REVIEWED

ORTHOPHOTO MAP

SAMPLE AREA NO 4

CADASTRAL LEGENDS

- HORIZONTAL CONTROL POINT (ASTRONOMY OBSERVATION)
- HORIZONTAL CONTROL POINT
- PLOT BOUNDARY MARK
- CHANGWAT BOUNDARY
- AMPHOE BOUNDARY
- TAMBOL BOUNDARY
- HOUSE
- PLOT BOUNDARY
- UNSURVEYED PLOT BOUNDARY
- TRANSMISSION LINE & TOWER
- 99 PLOT NUMBER

TOPOGRAPHY LEGENDS

- HORIZONTAL AND VERTICAL CONTROL POINT
- FIRST AND SECOND ORDER BENCH MARK
- THIRD ORDER BENCH MARK
- INSTRUMENT STATION
- KNOT OF GRT MONUMENT
- WOODEN PEG
- SPOT HEIGHT

DESIGN LEGENDS

- LATERAL FARM TURNOUT
- TERTIARY CANAL & DITCH
- DRAIN
- PUBLIC LAND (ROAD TERTIARY CANAL DITCH & DRAIN)
- CULVERT
- CHECK CULVERT
- CHECK
- DROP
- DIVISION BOX
- DIVISION BOX WITH CULVERT
- DITCH INLET
- SPILLWAY
- FARM INLET
- FARM OUTLET
- 99 PLOT NUMBER

SCALE 1 2,000

Elevation in meters — Contour intervals are meters

0 40 80 120 160 200 Meters

INFRASTRUCTURES SHOWN ON THIS MAP HAVE BEEN TRACED FROM ORTHOPHOTOGRAPH 1 8,000

KINGDOM OF THAILAND
MINISTRY OF AGRICULTURE AND CO-OPERATIVES
ROYAL IRRIGATION DEPARTMENT

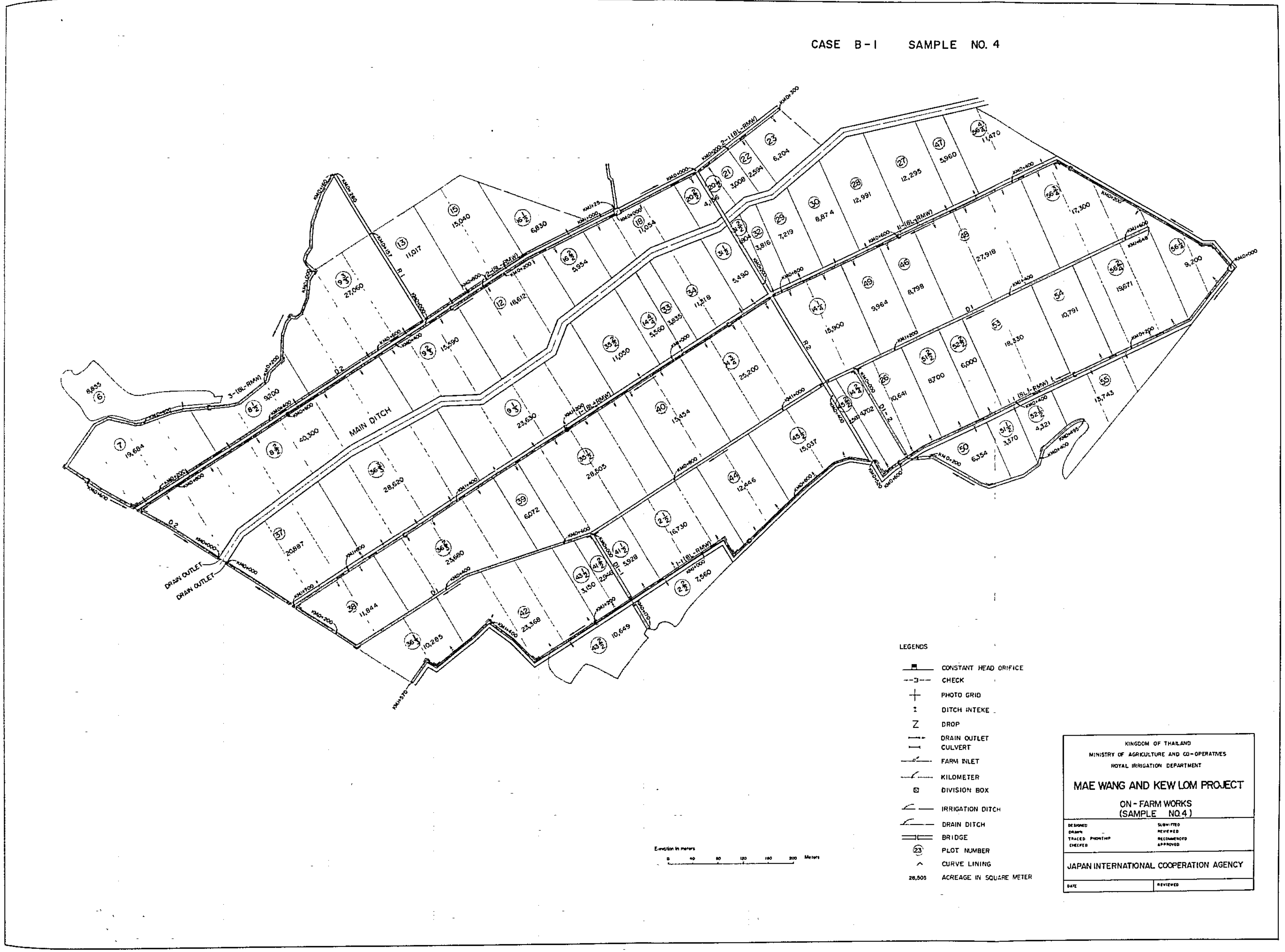
MAE WANG AND KEW LOM PROJECT

ON-FARM WORKS

DESIGNED	SURVEYED
DRAWN	REVIEWED
TRACED 70%	RECOMMENDED
CHECKED	APPROVED

JAPAN INTERNATIONAL COOPERATION AGENCY

DATE | APPROVED


CASE B-1 SAMPLE NO. 4
MAIN DITCH
DRAIN OUTLET
DRAIN OUTLET
LEGENDS
CONSTANT HEAD ORIFICE
CHECK
PHOTO GRID
DITCH INTEKE
DROP
DRAIN OUTLET
CULVERT
FARM INLET
KILOMETER
DIVISION BOX
IRRIGATION DITCH
DRAIN DITCH
BRIDGE
PLOT NUMBER
CURVE LINING
28,505 ACREAGE IN SQUARE METER
KINGDOM OF THAILAND
MINISTRY OF AGRICULTURE AND CO-OPERATIVES
ROYAL IRRIGATION DEPARTMENT
MAE WANG AND KEW LOM PROJECT
ON-FARM WORKS
(SAMPLE NO.4)
JAPAN INTERNATIONAL COOPERATION AGENCY

SAMPLE AREA NO.5

CASE B-2 SAMPLE NO 5

CADASTRAL LEGENDS

TOPOGRAPHY LEGENDS

DESIGN LEGENDS

KINGDOM OF THAILAND
MINISTRY OF AGRICULTURE AND CO OPERATIVES
ROYAL IRRIGATION DEPARTMENT

MAE WANG AND KEW LOM PROJECT

ON-FARM WORKS
(SAMPLE NO.5)

JAPAN INTERNATIONAL COOPERATION AGENCY

CASE B-2 SAMPLE NO. 5

LEGENDS

- CONSTANT HEAD ORIFICE
- HOUSE
- PHOTO GRID
- DITCH INTEKE
- DROP
- DRAIN OUTLET
- CULVERT
- FARM INLET
- KILOMETER
- DIVISION BOX
- IRRIGATION DITCH
- DRAIN DITCH
- BRIDGE
- (23) PLOT NUMBER
- CHECK
- CURVE LINING
- 5320 ACREAGE IN SQUARE METER

KINGDOM OF THAILAND
MINISTRY OF AGRICULTURE AND CO OPERATIVES
ROYAL IRRIGATION DEPARTMENT

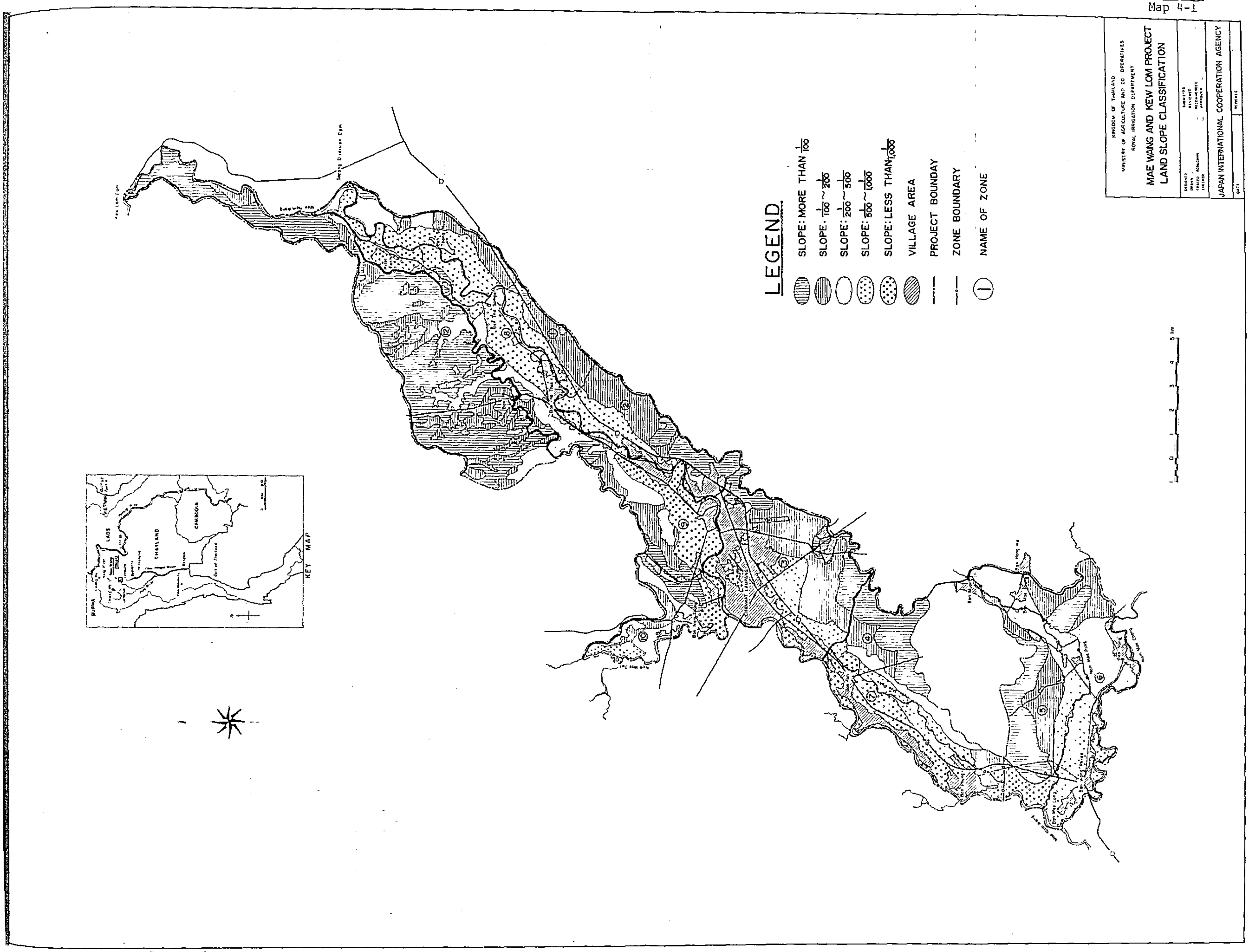
MAE WANG AND KEW LOM PROJECT

ON-FARM WORKS
(SAMPLE NO.5)

DESIGNED	SUBMITTED
DRAWN	REVIEWED
TRACED /ONGCHAN	RECOMMENDED
CHECKED	APPROVED

JAPAN INTERNATIONAL COOPERATION AGENCY

DATE	REVIEWED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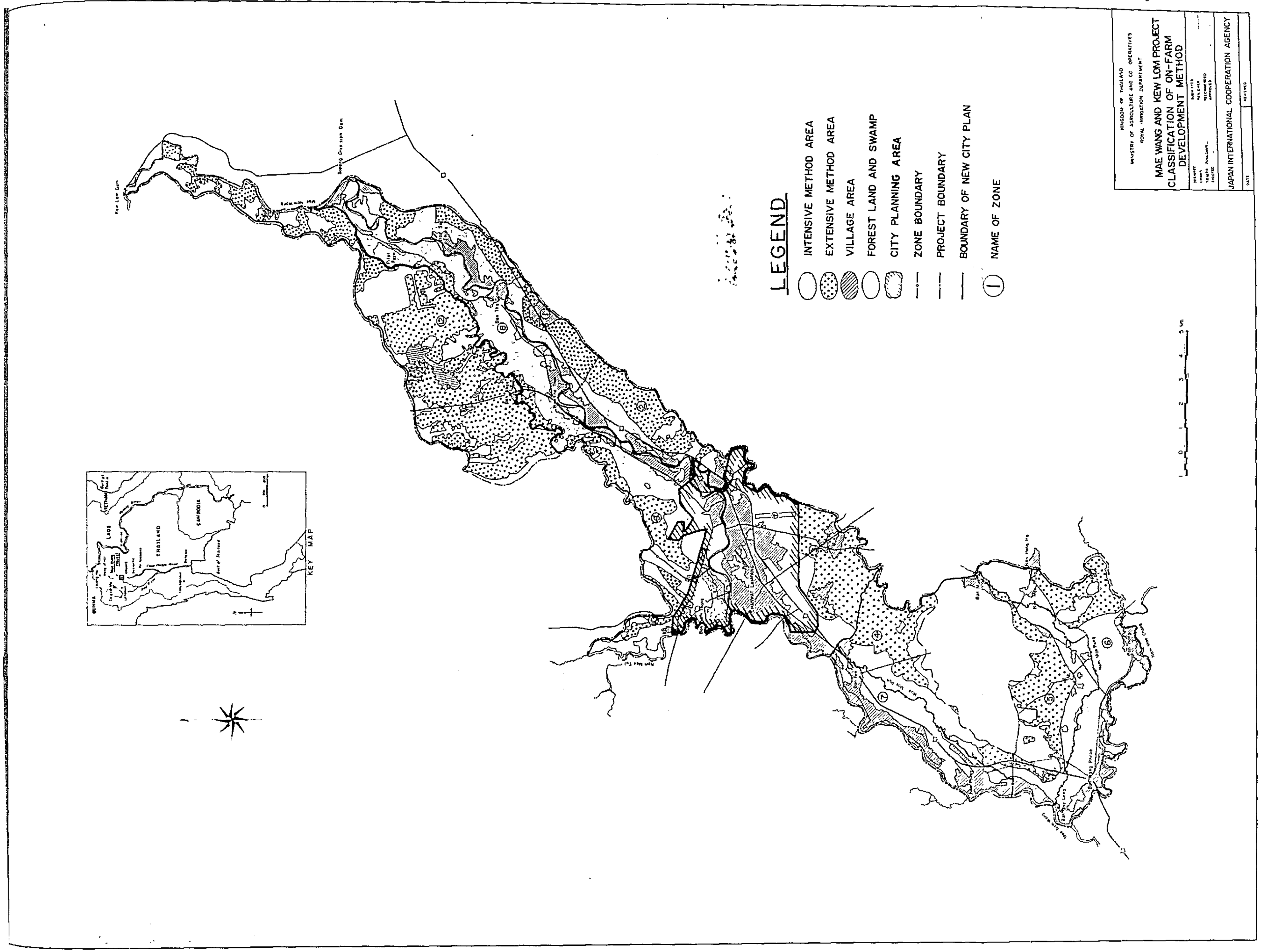
MINISTRY OF AGRICULTURE AND CO OPERATIVES
ROYAL IRRIGATION DEPARTMENT
MAE WANG AND KEW LOM PROJECT
LAND SLOPE CLASSIFICATION
JAPAN INTERNATIONAL COOPERATION AGENCY
LEGEND
SLOPE: MORE THAN 1/100
SLOPE: 1/100 ~ 1/200
SLOPE: 1/200 ~ 1/500
SLOPE: 1/500 ~ 1/1000
SLOPE: LESS THAN 1/1,000
VILLAGE AREA
PROJECT BOUNDARY
ZONE BOUNDARY
NAME OF ZONE
KEY MAP
BURMA
LAOS
THAILAND
CAMBODIA
VIETNAM


KINGDOM OF THAILAND
MINISTRY OF AGRICULTURE AND CO OPERATIVES
ROYAL IRRIGATION DEPARTMENT
MAE WANG AND KEW LOM PROJECT
CLASSIFICATION OF ON-FARM DEVELOPMENT METHOD
JAPAN INTERNATIONAL COOPERATION AGENCY
LEGEND
INTENSIVE METHOD AREA
EXTENSIVE METHOD AREA
VILLAGE AREA
FOREST LAND AND SWAMP
CITY PLANNING AREA
ZONE BOUNDARY
PROJECT BOUNDARY
BOUNDARY OF NEW CITY PLAN
NAME OF ZONE
KEY MAP
THAILAND
CAMBODIA
LAOS
BURMA

ANNEX 5. AGRICULTURAL PLAN

AGRICULTURAL PLAN

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List of Tables

AGRICULTURAL PLAN

5.1. Agricultural Production

The Project Area is not sufficient in irrigation water supply at present. It is, however, expected that about 80 percent of the arable land is irrigable even during the dry season, when the Project is completed. Cropping intensity, accordingly, will be increased from about 130 percent to 180 percent at the completion of the Project, and agricultural production of the Project Area as a whole will greatly increase. Furthermore, when irrigation water supply is secure, efficiency of such agricultural inputs as fertilizers and agricultural chemicals should be increased, thus increasing the agricultural production phenomenally. However, marketing system is not well developed in Thailand and very often, prices of agricultural products are kept too low and those of agricultural inputs too high. This has prevented the establishment of irrigation system from bringing about its full benefit. This must be fully taken into account and it is hoped the fully operative agricultural cooperative is set up to rectify the above mentioned defect. It will be needless to state that law of diminishing return is at work in all the agricultural productions and therefore a maximum production does not always mean a maximum profit. In Thailand this is particularly true because prices of various agricultural inputs are very expensive. As known from Table 5-2, yield of paddy increases with the increase in the amount of fertilizers added. But economic return attain maximum at a comparatively small dose and it begins to decrease gradually and turn to losses at higher doses of fertilizers. As in the case of Table 1 in which local variety of paddy was used, cases of positive economic return are rather rare, though there was surely yield increase.

Taking into the above mentioned points into account the target yields of various crops at the time of completion of the Project operation was set up, as shown below, based upon the experiments to

be described later.

The present and target yields of various crops (1979 - 1990)

	Crops Season Product Shape	Yield (kg/ha) Present	Target	Percent yield increase
1	Paddy, wet, air dry paddy	2,845	4,000	40
2	paddy, dry, air dry paddy	2,365	4,500	90
3	Peanut, wet, In shell, fresh	2,400	3,120	30
4	Peanut, dry, In shell, fresh	3,429	4,458	30
5	Tobacco, dry, Fresh leaves	10,884	12,021	10
6	Soy bean, dry, Air dry	1,499	1,964	30
7	Chilli, dry, Fresh	2,601	3,407	30
8	Sugar cane, whole year	28,607	34,602	20
9	Garlic, dry, Fresh	4,772	6,253	30
10	Pineapple, whole year	13,311	16,100	20
11	Cabbage, dry, Fresh	7,969	16,066	200

In planning the production increase, experiments conducted on farmers' fields in the Project Area were taken as basis. Especially, those experiments done with aid of FAO were given first importance as the significance of the experiments were strictly evaluated. These are carried in the Technical Report No.3 (1970) and No.6 (1972) of the FAO/UNDP/SF Soil Fertility Research Project in Thailand. Where relevant experimental data are not available from the Project Area in relation to spacing, seeding rate, fertilization, control of weed, diseases and pests, references were made to the reports of FAO Project, Coordination of Plant Production Research in Thailand, Working paper No.1 (Rice) No.3 (Legumes). These papers cover nearly all the experiments done in Thailand with respect to the crops concerned. As for garlic, chilli, and pineapple, the above-mentioned reports do not deal with them. Accordingly, relevant materials were obtained from Horticalture Division, DA, MOAC.

5.2. Agriculture Practice of Major Crops

a) Increase in yield per unit area of wet season paddy

Variety

Farmers of the Project Area are now growing traditional varieties of glutinous rice, chiefly Nio Sanpatong and do not seem to be interested in growing improved varieties of glutinous rice such as RD 2 and 4. This is mainly because palatability of Nio Sanpatong is excellent and its yield is comparable to improved varieties, at least under conditions of no fertilizer application, on which they are at present grown. This is clearly known by comparing the yield of no fertilizer treatments in Table 5-1 and 5-2. In the Central Plain, farmers started to turn to improved varieties of non-glutinous rice (RD 1 and 3) as soon as they appeared. However in the Project Area, farmers did not turn to RD 2 and 4. The reason for this is that RD 1 and 3 were much superior to the traditional varieties whilst RD 2 and 4 were not.

However, they should turn to improved varieties in the long run for two reasons. Firstly, traditional varieties are strongly sensitive to photoperiod and its harvest time is invariably in December regardless of transplanting time. This makes very difficult the rotation of crops which will be essential in intensive agriculture in future. Even now, for example, tobacco leaves and garlic of good quality are difficult to obtain as they must be planted in December after the harvest of Nio Sanpatong. If non-sensitive improved paddy varieties were grown, these difficulty can be easily solved by transplanting them earlier. For example, if RD 7 which is grown now in the Project Area in the dry season is transplanted on July 1, it can be harvested on October 10. The second reason why Nio Sanpatong is not commendable is that its response to fertilizers is small. This can be known by comparing Table 5-1 and 5-2.

Supeiority of improved varieties becomes more evident if the response to fertilizers of RD 1 or 7 are referred. At present, breeders of Rice Division of MOAC are trying to create a new variety of glutinous

rice from the mutate of RD 1. This new strain is said to be excellent in palatability, on top of its high yielding capability. At the time of its expected appearance as RD 10 in the immediate future, it should be introduced to the farmers of the Project Area. At the present time, however, the reaction of the farmers to the new variety is not known. Accordingly, it was planned in the present Project on the assumption that farmer will invarialby grow Nio Sanpatong and other traditional varieties for some time to come.

Fertilizer application

In view of the results shown in Table 5-1, it is recommended, 50 kg per hectare each of nitrogen (N) and potash (K_2O) be applied. Response of phosphorus is insignificant statistically, therefore it has not to be applied. According to the study of S.Motomura (The report of the joint research work on the study on advance in rice production by soil management. TARC. MAF. Japan. 1973), soils of Lampang area are rich in available P even to the lowest layer (Table 5-3). Accordingly it is presumed that yield decrease due to phosphrus deficiency is unlikely even if paddy is grown without phosphorus application for considerable number of years. Response to potash, though insignificant, is higher than that to phosphorus and available K is 80 ppm which is below the widely-accepted critical point of 100 ppm. Furthermore, as will be shown later, potash is significantly effective to legumes. This was also taken into account.

As the soil texture of Lampang area is quite variable place by place owing to its basin structure, further detailed study must be done by extension service in its demonstration experiments with respect to the response of phosphorus and potash. Details of this kind of experiments are to be given in the chapter of extension.

As for the method of applying nitrogen which is indispensable everywhere in the project area, one half should be applied as basic dressing immediately before the last puddling to secure deep placement

and the remaining half be applied at the time of initiation of primordial panicle, that is to say, 25 days before flowering or specifically in the case of Nio Sanpatong towards October 1.

Transplanting time

As for the best transplanting time for photoperiod-sensitive traditional varieties, especially for glutinous ones which are all early maturing, it is best to transplant in August as shown in Table 5-4. In this table, September means September 1, August means August 1 and so on. Drastic yield decrease will be observed if transplanting is done as late as September 10 or later than that. This is because vegetative growth period becomes too short to bear enough number of panicles in full size. .

Diseases and pest

Climate of Thailand is too hot to cause epidemics of blast except for exceptionally cool year. On top of this climatic advantage, indica varieties are inherently resistant to blast disease.

Bacterial leaf blight, on the other hand, is quite often causes damage and Nio Sanpatong is also susceptible. However, it does not pay usually to prevent this disease by spraying chemicals. It is rather commendable to prevent the disease by cultural practices. Farmers usually grow nitrogen-starved hardy seedlings, do not deeply irrigate the nursery, and after pulling out the seedlings, do not float them in water. They rather leave them stacked on the ground even under intense sun. These practices seem to mitigate leaf blight infection.

In the Project Area, "Baka-Nae" disease-affected rice plants were widely observed and substantial damage was expected in some cases. This disease can be easily eradicated by seed sterilization and the treatment is economically feasible. With the help of

pathologists, it should therefore be eradicated.

If the various measures mentioned above are followed by farmers, yield is expected to increase from the present 2,845 kg/ha to 4,000 kg/ha. Furthermore, if RD 10 is accepted when it is released, 4,500 kg/ha will be easy to obtain by just increasing nitrogen dose from 50 kg to 75 kg/ha.

b) Increase in yield per unit area of dry season paddy

As stated previouly, survey of farmers' yield of dry season paddy revealed that it is inferior to wet season rice in yield. This is presumed to be due to inexperience in growing technique in the Project Area. Average yield of wet season rice of Thailand as a whole is about 1,900 kg/ha whilst that of dry season rice is about 2,800 kg/ha. In wet season rice, low yield of Northeastern Thailand greatly affect the average whilst in dry season practically no paddy is grown in the Northeast. In this sense, the comparison is not fair. However when the same variety of paddy is grown on the same site with the same amount of fertilizers, during the wet and dry season, the results are as shown in Table 5-5. Except Khlong Luang where soil is strongly acid and release of nutrients by the decomposition of soil organic matters under high temperature of the dry season is low, usually much higher yield can be expected in dry season than in wet season. Soil of the Project Area are riverine alluvium and quite similar to those of Chainat in the table. Therefore yield of dry season paddy should be as high as 5,000 kg/ha instead of 2.3 ton farmers obtain at present. Some discussion is to follow as to why the yield of dry season paddy is so low.

Varieties

Farmers of the Project Area grow RD 7 during the dry season. This choice is correct because RD 7 is comparable to RD 1 in rice yield. On top of this, RD 7 is resistant to bacterial leaft blight

whilst RD 1 is not.

Seedling age

Farmers have long grown photoperiod-sensitive varieties and have established practices to enable the paddy plant to make enough vegetative growth. Under the circumstances they could have been indifferent to seedling age. However, for varieties such as RD 7 which is insensitive to photoperiod, seedling age has much to do with rice yield, as shown in Table 5-6. As seedling age increases, yield decreases. This is because if seedling age increases vegetative growth period becomes too short. Enough number of fully developed panicles can not be obtained if seedling age exceeds optimum length which is about 25 to 30 days. As can be known from the table, decrease in yield due to old age of seedlings can be mitigated by increasing the number of seedlings per hill. But this can not be the real solution. If such variety as RD 7 is kept in the nursery more than 50 days, abnormal flowering will occur in the nursery. If not, the paddy plant will flower soon after transplanting. Department of Agriculture, therefore, recommends farmers to transplant seedlings of 25 days old. This recommendation must be strictly followed.

Fertilizer

For dry season rice, farmers apply "Ammophos" (16-20-0) in compliance to government recommendation. This requires reconsideration. As shown in the section of wet season paddy, response of paddy to phosphorus and potash in the Project Area is small (Table 5-1 and 5-2). Taking into account the result of fertilizer experiment on RD 2, rate of fertilizers should be 75-38-0 kg/ha (N-P_2O_5-K_2O). As for the timing of fertilizer application, one half of nitrogen and all of phosphorus should be applied immediately before transplanting and the other half of nitrogen should be applied 25 days before flowering or, 50 days after transplanting assuming 25-day old seedlings of RD 7 are to be transplanted.

According to S.Motomura (ibidem), available SiO_2 content is 59 ppm and rather small. In temperate country, this amount indicates the necessity of silicate application. But in tropical Thailand, soil minerals decomposes rapidly and application is not thought necessary.

Damages by diseases and pests, birds and rats

Thanks to high light intensity, damages by diseases are not heavy during the dry season. But insect damage can be heavier. Some farmers involved in the survey reported that damage by stem-borers are mainly responsible for low yield. In such cases, spraying of "Sumithion" or soil application of BHC is necessary. K.Yasumatsu, Colombo Plan Expert on the study of natural enemy, Rice Protection Center, states that prevention of stem-borer damage can be effected by irrigating the paddy field more than three weeks ahead of transplanting. During the dry season, larvae of stem-borers remain in the rice stubble in dormant state. By irrigation they are activated. If seedlings are immediately transplanted, active larvae attack seedlings. But if there is some time before transplanting they attack weeds which harbor natural enemies of the stem-borers. According to Yasumatsu, there are many species of natural enemies of stem-borers in Thailand and usually stem-borer damages are not so heavy for this reason. In countries such as Thailand where agricultural chemicals are so expensive that they become sometimes prohibitive just for economic reasons, this method is worthwhile trying.

Besides stem-borer damages, those by birds and rats are reported also. There is no conceivable reason why such damages should be specifically severe to the Project Area. In all probability, damages are conspicuous only because dry season paddy acreage is rather small and damages are due to concentrated attack. Since 1969 when photoperiod insensitive, high yield varieties were released by the government for the first time, dry season paddy acreage has increased steadily and rapidly to 400,000 ha, with no

wide-ranging damages by stem-borers, birds and rats and prospects are that there will be further big increase. This is a good indication that if dry season paddy acreage is increased to 5,000 ha in the Project Area as planned, stem-borers, birds and rats will be not much of a problem.

c) Peanut and soybean

Variety

For soybean there is no problem as SJ 4 is exclusively grown. This is the latest variety and best in yield and disease resistance.

As for peanut, a local variety is grown. And this has been so well established that it is nowadays called nationwide as variety Lampang. But some foreign varieties were found by experiments superior in yield to Lampang. Further examination is necessary.

Fertilizer

As for nitrogen, recourse must be had to Rhizobium. Legumes have long been grown in the Project Area and there must be enough Rhizobia in the soil. But the suitable strain is different from crop to crop. Therefore the adequate strain must be obtained each time of planting from Rhizobium Laboratory of Agricultural Chemistry Division, Dept of Agriculture.

As for the effect of phosphorus and potassium, as shown in Table 5-7, that of potassium is much bigger than phosphorus. Economical consideration indicates that single application of potassium, at the rate of 75 kg/ha is the most profitable. In this respect it is reminded that in Thailand the price of fertilizers whose demand is rather small is unduly high. Purchase of potassium chloride may be the case in point. If so there is no point of sticking to potassium chloride. A compound fertilizer with the formula of

4-16-24-4 ($N-P_2O_5-K_2O-MgO$) which is widely used in the Project Area as a fertilizer for tobacco can be a good substitute. Of the various components of this fertilizer, nitrogen can be a starter, and phosphorus is significantly effective, though less responsive. Accordingly its use may be slightly less economical but should be duly profitable.

It was observed that wood is still in use as fuel by farmers in the Project Area. Wood ash can be a good fertilizer for legumes as it contains lots of potassium and substantial amount of phosphorus. Wood ash should be kept in bags without being moistened.

Farmers of the Project Area have an established practice of spreading rice straw to protect early growth of legumes and garlic. This practice is commendable from the viewpoint of fertilization as rice straw contains at least one percent of water soluble K_2O.

Weeding

There will be a profuse growth of weeds under upland conditions if the land is irrigated. Therefore, in growing legumes under irrigation weed growth is inevitable. Accoring to the result of experiments on the effect of weeding, yield was doubled in some cases by just hand-weeding once, in comparison to no weeding. Therefore weeding is indispensable.

d) Garlic

Garlic growth requires cool climate. Under conditions of Thailand, seven Changwats in the North and Changwats Surin and Sisaket in the Northeast are noted as suitable producer of garlic in the country. For garlic to continue vegetative growth, temperature between 12°C and 18°C is necessary. Garlic should start growth of bulbs after 45 to 50 days of vegetative growth. However, if the average temperature exceeds 20°C bulbs start to grow even within 40 days of vegetative growth. In such a case, vetetative

growth is not enough and bulbs inevitably become small. Such Physiological reaction of this crop to temperature must be the first consideration above all other growing conditions. For this reason, under the climatic conditions of northern Thailand, seeds should be sown at the beginning of November. But as a matter of fact, rice is still standing at this time, and it is impossible. Tobacco requires also to be planted as early as possible as described earlier. By the guidance of Tobacco Monopoly, tobacco is in fact planted as early as possible, after paddy. But survey has revealed farmers usually plant garlic in January. Though it is done before the planting of legumes and dry season paddy, it is not early enough. Farmers must be taught that garlic should be planted earlier. Because if they plant garlic in January, within 50 days it will be March when temperature will be above 30°C. Garlic is a quite profitable crop. Therefore if it is planted at proper time, with the application of fertilizers at the rate of 50-25-25 of $N-P_2O_5-K_2O$, substantial income increase can be expected.

ANNEX 5
Table 5-1

Effect of Various Formulae of Fertilizers on the Yield of Nio Sanpatong Rice

Soil Series: Lampang — Centre: Chiang Mai

Number of Trials: 10 — Sub-centre: Lampang

Treatment Kg per hectare			Kg per Hectare		Baht per Hectare			Baht returned per 100 Baht spent
N	P_2O_5	K_2O	Yield S.E.±118	Increase over Control	Value of Yield Increase	Cost of Treatment (Baht)	Gross Profit	
0	0	0	3183	-	-	-	-	-
25	25	25	3892	709	638	417	221	153
25	25	50	3563	380	342	495	Loss	69
25	50	25	3654	471	424	577	Loss	73
25	50	50	3772	589	530	655	Loss	81
50	25	25	3627	444	400	597	Loss	67
50	25	50	3943	760	684	675	9	101
50	50	25	3805	622	560	756	Loss	74
50	50	50	3889	706	635	834	Loss	76
25	25	0	3634	451	406	339	67	120
50	50	0	3634	491	442	678	Loss	65
25	0	25	3533	350	315	258	57	122
50	0	50	3953	770	693	515	178	135
0	25	25	3449	266	239	238	1	100
0	50	50	3210	27	24	475	Loss	45
Mean			3652	530 = 16%		+At 0.9 Baht / kg		

L.S.D. 5% 332 kg/ha 1% 438 kg/ha

Main Effects - Kg per hectare

	N_{25}-0	N_{50}-N_{25}	P_{25}-0	P_{50}-P_{25}	K_{25}-0	K_{50}-K_{25}
Response	502**	96	174	24	194	47
L.S.D. 5%	234		234		234	

Effect of Various Formula of Fertilizers on the Yield of RD 2 Rice

Soil Series: Lampang — Centre: Chiang Mai

Number of Trials: 11 — Sub-centre: Lampang

Variety: RD2

Treatment Kg per hectare			Kg per Hectare		Baht per Hectare			Baht returned per 100 Baht spent on Treatment
N	P_2O_5	K_2O	Yield S.E.±120.0	Increase over Control	Value of Yield Increase+	Cost of Treatment	Gross Profit	
0	0	0	3193	-	-	-	-	-
0	38	0	3114	-79	-	239	Loss	-
0	75	0	3209	15	11	479	Loss	2
38	0	0	3817	623	436	269	167	162
38	38	0	3957	764	535	508	27	105
38	75	0	3844	651	456	748	Loss	61
75	0	0	4089	895	627	538	89	117
75	38	0	4458	1265	886	777	109	114
75	75	0	4266	1073	751	1017	Loss	74
38	75	25	3805	611	420	826	Loss	52
75	75	75	4419	1225	858	1095	Loss	78
75	75	50	4660	1467	1027	1173	Loss	88
Mean			3903	774 = 24 percent		+At 0.70 baht per Kg		

C.V. 10.2 per cent — S.E. of a difference ± 169.7 Kg per hectare

L.S.D. 5 per cent : 336 Kg per hectare; 1 per cent : 445 Kg per hectare

Main Effects- Kg per hectare

	$N_{38}-N_0$	$N_{75}-N_{38}$	$P_{38}-P_0$	$P_{75}-P_{38}$	$K_{25}-K_0$	$K_{50}-K_{25}$
Response	701**	398**	144	-70	57	242
S.E.	±98.0		±98.0		±120.0	±169.7
L.S.D. 5 per cent	194		194		-	336
1 per cent	257		-		-	-

Anaylsis of Paddy Soil in Amphoe Muang Lampang

Horizon		Apg	Dlg	B2g	DCg
Depth (cm)		0-13	13-24	24-39	39-65
Total nitrogen (%)		0.110	0.056	0.045	0.047
Total carbon (%)		1.410	0.637	0.427	0.428
C:N ratio		12.8	11.4	9.5	9.1
Humus (%)		2.43	1.10	0.74	0.74
Exchangeable bases me/100 g	Ca	5.46	-	-	-
	Mg	2.06	-	-	-
	Na	0.73	-	-	-
	K	0.17	-	-	-
CEC me/100 g		12.85	-	-	-
Base saturation degree (%)		65.5	-	-	-
Free iron oxide Fe_2O_3 (%)		0.61	0.69	0.61	0.74
Easily reducible MnO_2 ppm		456	456	399	741
Available NH_4-N ppm		62.4	-	-	-
Total P_2O_5		0.048	0.038	0.045	0.055
Available P_2O_5 ppm		22.7	26.9	28.5	33.3
Total K_2O (%)		650	583	723	722
Available K_2O ppm		80	-	-	-
Available SiO_2 ppm		59	-	-	-
Absorption coefficient mg/100 g	NH_4-N	-	-	-	-
	P_2O_5	-	-	-	-

Productive Capability Classification

Simplified code formula	For paddy rice	IIrfn
	For upland crops	IIItIIpwfn

Effect of Transplanting Time and Mode of Nitrogen Application on Yield of Paddy (kg/ha)

Location	Fertilizer Treatment	Transplanting Time July	August	September	Mean
	Nitrogen (basal only)	2,493	3,095	3,224	2,938
Sakon	Nitrogen (split)	3,550	3,404	3,138	3,364
Nakhon	No Fertilizer	1,953	2,743	2,028	2,241
	Mean	2,665	3,081	2,797	2,848
	Nitrogen (basal only)	2,760	2,894	3,227	2,961
Khon	Nitrogen (split)	2,987	3,499	3,116	3,200
Kaen	No Fertilizer	1,645	2,430	2,107	2,061
	Mean	2,464	2,941	2,816	2,740.
	Nitrogen (basal only)	3,924	3,711	3,982	3,872
Chiang	Nitrogen (split)	3,563	3,976	3,798	3,779
Mai	No Fertilizer	3,385	4,113	3,404	3,634
	Mean	3,624	3,934	3,728	3,762

Remark Transplanting was done on the first day of each month, even September 1 is rather late for good yield Further delay greatly decreases the yield owing to shortening of vegetative growth, just as the too old seedlings in Table 5-6.

Response of RD 1 Rice to Nitrogen in the Wet and Dry Seasons (kg/ha)

Location	Fertilizer N kg/ha	Wet Season	Dry Season	Balance
	0	4,195	5,184	989
Chainat	37.5	4,653	5,513	860
	75.0	4,774	5,754	980
	0	2,689	4,281	1,592
Suphan Buri	37.5	3,906	5,351	1,445
	75.0	4,668	5,937	1,269
	0	2,585	2,555	-30
Khlong Luang	37.5	3,390	3,405	15
	75.0	4,064	4,112	48

Source FAO/UNDP/SF Soil Fertility Research Project Research Experiment on Rice By J.Takahashi

Remark Experiment was replicated four times and continued for three years.

Effect of Seedling Age and Number of Seedlings per Hill on the Yield of RD 1 Rice (Grain Yield in kg/ha)

Number of Seedlings Per Hill	Age of Seedlings in Days				
	20	30	40	50	Mean
1	5,654	6,013	5,722	4,712	5,525
3	5,422	6,260	5,732	4,985	5,600
5	5,614	5,962	5,821	4,962	5,590
7	5,472	5,955	5,987	5,250	5,666
Mean	5,541	6,047	5,816	4,977	5,595

	5%	1%
L.S.D. for any two of 16 means	430	574
L.S.D. for any two means of means	215	287
C.V. per cent	5.4	

Source: FAO/UNDP/SF Soil Fertility Research Project
"Research Experiment on Rice By J. Takahashi"

Effect of Various Formulae of Fertilizers on the Yield of Peanut

Peanut (Dry Season: Irrigated) SET 1.1

Soil Series: Hang Dong — Centre: Chiang Mai

Number of Trials: 16 — Sub-centre: Lampang

Treatment Kg per hectare			Kg per Hectare		Baht per Hectare			Baht returned per 100 Baht spent on Treatment
N	P_2O_5	K_2O	Yield S.E. ±97.8	Increase over Control	Value of Yield Increase+	Cost of Treatment	Gross Profit	
0	0	0	2261	-	-	-	-	-
0	38	0	2402	140	210	239	Loss	88
0	75	0	2532	271	406	479	Loss	85
0	0	38	2621	360	540	117	423	462
0	38	38	2928	667	1000	357	643	280
0	75	38	2954	693	1040	596	444	174
0	0	75	2907	646	969	235	734	412
0	38	75	2960	699	1048	474	574	221
0	75	75	3217	956	1434	713	781	201
6	75	38	3236	975	1462	641	821	228
0	75	75	3305	1044	1566	758	808	207
12	75	75	3378	1117	1676	803	873	209
Mean			2892	668 = 30 per cent				

+At 1.50 baht per Kg for unshelled peanut.

C.V. 13.5 per cent — S.E. of a difference ± 138.4 Kg per hectare

L.S.D. 5 per cent: 273 Kg per hectare; 1 per cent: 361 Kg per hectare

Main Effects - Kg per hectare

	$P_{38}-P_0$	$P_{75}-P_{38}$	$K_{38}-K_0$	$K_{75}-K_{38}$	N_6-N_0	$N_{12}-N_6$
Response	167*	138	436**	193*	185	73
S.E.		±79.9		±79.9	±97.8	±138.4
L.S.D. 5 per cent		158		158	193	-
1 per cent		208		208	-	-

Physical Inputs per Hectare by Crop

		Unit	1 Paddy (Wet Season)	2 Paddy (Dry Season)	3 Peanut (Wet Season)	4 Peanut (Dry Season)	5 Tobacco	6 Soybean	7 Chilli	8 Garlic	9 Sugarcane	10 Orchard -Pineapple-	11 Vegetable -Cabbage-
Present							(Unit: seedling)				(Unit: pieces)	(Unit: shoots)	(Unit: seedling)
1. Seed		kg	76	76	128	158	3,250	34	5	233	28,500	26,200	40,000
2. Fertilizer	Ammonium phosphate	kg	6	95	-	-	-	20	-	35	67	-	170
	Ammonium sulphate	kg	-	-	-	-	-	-	370	-	-	160	-
	4-16-24-4(Mg)	kg	-	-	-	-	500	-	-	-	-	-	-
3. Pesticide	Inspecticides	₿	-	34	-	-	497	34	418	203	-	-	678
4. Mechanical Percentage	Cultivation -Animal	% area	80	80	100	100	100	100	100	100	100	100	100
	-Machine	% area	20	20	-	-	-	-	-	-	-	-	-
Without Project													
1. Seed		kg	76	76	128	158	3,250	34	5	233	28,500	26,200	40,000
2. Fertilizer	Ammonium phosphate	kg	6	95	-	-	-	20	-	35	67	-	170
	Ammonium sulphate	kg	-	-	-	-	-	-	370	-	-	160	-
	4-16-24-4(Mg)	kg	-	-	-	-	500	-	-	-	-	-	-
3. Pesticide	Insecticides	₿	-	45	-	-	695	45	585	283	-	-	949
4. Mechanical Percentage	Cultivation -Animal	% area	80	80	100	100	100	100	100	100	100	100	100
	-Machine	% area	20	20	-	-	-	-	-	-	-	-	-
With Project													
1. Seed		kg	50	50	120	120	3,250	33	5	300	14,000	24,700	40,000
2. Fertilizer	Ammonium sulphate	kg	250	375	-	-	-	-	250	250	190	190	375
	Super phosphate	kg	-	100	-	-	-	-	68	68	103	103	103
	Potash	kg	83	-	125	125	-	125	42	42	83	83	63
	4-16-24-4(Mg)	kg	-	-	-	-	600	-	-	-	-	-	-
3. Pesticide	Inspecticides	₿	-	54	-	-	799	54	673	325	-	-	1,092
4. Mechanical Percentage	Cultivation -Animal	% area	70	70	70	70	70	70	70	70	70	70	70
	-Machine	% area	30	30	30	30	30	30	30	30	30	30	30

Average Monthly Manpower Requirements by Crop (Man-days/ha)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1. Paddy (Wet Season)													
Present	4.4			0.5	5.4	18.6	24.5	14.8	3.7	2.0	19.3	25.8	119.0
Without Project	4.8			0.5	5.5	18.7	24.7	15.1	3.9	2.1	21.3	28.4	125.0
With Project						8.2	29.7	24.5	4.3	1.5	36.3	35.5	140.0
2. Paddy (Dry Season)													
Present	12.1	35.7	16.9	8.4	40.8	10.8	2.3						127.0
Without Project	12.2	35.9	17.5	9.0	44.9	11.9	2.5						133.9
With Project	11.5	31.6	23.8	10.9	2.5	86.5	14.4						181.2
3. Peanut (Wet Season)													
Present	2.6	27.2	18.6	34.6	33.9	15.8	10.9	12.4					156.0
Without Project	2.7	28.6	19.5	36.3	34.0	16.2	11.3	12.9					161.5
With Project						8.2	21.7	23.9	10.3	9.6	40.0	39.9	153.6
4. Peanut (Dry Season)													
Present	38.8	14.2	13.4	57.0	10.6	2.5				1.6	1.1	19.8	159.0
Without Project	39.1	14.6	14.1	59.9	11.1	2.6				1.6	1.1	19.9	164.0
With Project	13.1	46.4	10.6	23.7	76.5	10.9							181.2
5. Tobacco													
Present	36.4	38.6	27.0	24.9			2.0	125.5	65.6	34.9	28.3	73.8	457.0
Without Project	37.2	39.6	27.8	25.6			2.0	128.0	67.6	36.0	28.6	74.8	467.2
With Project	53.9	27.9	33.0	42.9	30.1	8.6	21.1	27.7	44.2	32.0	94.4	55.2	471.0
6. Soybean													
Present	41.1	9.4	4.3	29.5	7.5			93.9	49.8	131.3		7.2	374.0
Without Project	41.2	9.6	4.6	31.0	7.9			95.1	52.4	137.8		7.3	386.9
With Project	10.0	25.3	18.4	1.6	27.0	36.6	32.0	51.1	29.1	29.2	140.4	33.3	434.0
7. Chilli													
Present	118.3	122.2	97.2						4.2	72.8	127.3	102.0	644.0
Without Project	123.5	128.3	102.1						4.4	74.5	130.9	107.1	670.8
With Project	19.5	23.9	67.7	79.8	97.1	30.7	19.9	91.4	111.5	138.2	54.9		734.6
8. Garlic													
Present	75.6	23.4	39.4	3.1	0.1					1.9	5.1	53.4	202.0
Without Project	76.8	24.3	41.4	3.2	0.1					1.9	5.2	53.8	206.7
With Project	51.9	10.1	40.9	33.2							19.4	56.8	212.3
9. Sugarcane													
Present	3.1	27.2	18.9	48.2	40.0	23.0	1.6	8.3	4.2	3.0	0.5		178.0
Without Project	3.2	28.6	19.8	49.9	40.4	24.0	1.7	8.6	4.4	3.2	0.5		184.3
With Project	58.6	45.8	20.8	11.7	5.6	5.5	5.4	5.4	5.4	3.9	0.7	25.5	194.3
10. Orchard -Pineapple-													
Present		2.5	2.4	16.9	27.6	7.1	18.4	20.8	6.6	0.8	5.4	0.5	109.0
Without Project		2.5	2.5	17.2	28.9	7.2	19.2	21.8	6.9	0.8	5.5	0.5	113.0
With Project	0.9	0.9	17.5	20.8	26.7	32.7	16.1	3.2	0.9	0.9	0.9	0.9	122.4
11. Vegetable -Cabbage-													
Present	48.6	49.3	19.2	59.3	7.9	57.9	50.7			11.3	55.7	21.2	381.0
Without Project	50.5	51.2	19.7	61.0	8.2	60.1	52.6			11.4	57.1	22.3	394.1
With Project	74.5	46.0	17.0	24.9	59.9	69.4	43.4			18.0	23.0	61.9	438.0

Monthly Manpower Requirements by Crop

(1,000 mandays)

Crops			ha	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1. Paddy (Wet Season)	Present	(P)	11,993	53	-	-	6	65	223	294	177	44	24	231	309	1,427
	Without Project	(WO)	11,993	58	-	-	6	66	224	296	181	47	25	255	341	1,499
	With Project	(W)	12,729	-	-	-	-	-	104	378	312	55	19	462	452	1,782
2. Paddy (Dry Season)	P		460	6	16	8	4	19	5	1	-	-	-	-	-	58
	WO		460	6	17	8	4	21	5	1	-	-	-	-	-	62
	W		4,504	52	143	107	49	11	390	65	-	-	-	-	-	816
3. Peanut (Wet Season)	P		391	1	11	7	14	13	6	4	5	-	-	-	-	61
	WO		391	1	11	8	14	13	6	4	5	-	-	-	-	63
	W		315	-	-	-	-	-	3	7	8	3	3	13	13	49
4. Peanut (Dry Season)	P		1,243	48	18	17	71	13	3	-	-	-	2	1	25	198
	WO		1,243	49	18	18	74	14	3	-	-	-	2	1	25	204
	W		2,942	39	137	31	70	225	32	-	-	-	-	-	-	533
5. Tobacco	P		779	28	30	21	19	-	-	2	98	51	27	22	57	356
	WO		779	29	31	22	20	-	-	2	100	53	28	22	58	364
	W		1,131	61	32	37	49	34	10	24	31	50	36	107	62	533
6. Soybean	P		590	24	6	3	17	4	-	-	55	29	77	-	4	221
	WO		590	24	6	3	18	5	-	-	56	31	81	-	4	228
	W		1,002	10	25	18	2	27	37	32	51	29	29	141	33	435
7. Chilli	P		204	24	25	20	-	-	-	-	-	1	15	26	21	131
	WO		204	25	26	21	-	-	-	-	-	1	15	27	22	137
	W		751	15	18	51	60	73	23	15	69	84	104	41	-	552
8. Garlic	P		518	39	12	20	2	0	-	-	-	-	1	3	28	105
	WO		518	40	13	21	2	0	-	-	-	-	1	3	28	107
	W		1,425	74	14	58	47	-	-	-	-	-	-	28	81	303
9. Sugarcane	P		195	1	5	4	9	8	4	0	2	1	1	0	-	35
	WO		195	1	6	4	10	8	5	0	2	1	1	0	-	36
	W		190	11	9	4	2	1	1	1	1	1	1	0	5	37
10. Orchard -Pineapple-	P		342	-	1	1	6	9	2	6	7	2	0	2	0	37
	WO		342	-	1	1	6	10	2	7	7	2	0	2	0	39
	W		334	0	0	6	7	9	11	5	1	0	0	0	0	41
11. Vegetable -Cabbage-	P		699	34	34	13	41	5	40	35	-	-	8	39	15	266
	WO		699	35	36	14	43	6	42	37	-	-	8	40	16	275
	W		848	63	39	14	21	51	59	37	-	-	15	20	52	371
Total Manpower Requirement	P		17,414	258	158	113	189	137	285	343	344	128	155	324	459	2,895
	WO		17,414	267	163	118	197	142	288	347	351	134	162	350	493	3,014
	W		26,171	324	416	327	307	431	669	564	473	222	208	811	699	5,451

Present and Target Agricultural Productions

Crops	Present			Target			Yield per Unit acreage	Increased Production
	Yield (ton/ha)	Cropping acreage (ha)	Production (1,000ton)	Yield (ton/ha)	Cropping acreage (ha)	Production (1,000ton)	(%)	(1,000ton)
Paddy (Wet season, L.V.)	2.85	11,993	34.2	4.00	13,660	54.6	40	20.4
" (Dry season, RD7)	2.37	460	1.1	4.50	4,709	21.2	90	20.1
Groundnut (Wee season, shelled, raw)	2.40	391	0.9	3.12	315	1.0	30	0.1
" (Dry season, shelled, raw)	3.43	1,243	4.3	4.49	3,088	13.9	54	9.6
Tobacco (Unprocessed)	10.88	779	8.5	12.02	1,237	14.9	10	6.4
Soybean (Wind-dry)	1.50	590	0.9	1.96	1,137	2.2	30	1.3
Chilli (Unprocessed)	2.60	204	0.5	3.41	751	2.6	30	2.1
Sugarcane (Unprocessed)	28.61	195	5.6	34.60	190	6.6	20	1.0
Garlic (Bulb)	4.77	518	2.5	6.25	1,562	9.8	30	7.3
Pineapple (one-year fruit)	13.31	342	4.6	16.10	334	5.4	20	0.8
Cabbage (Representative vegetable)	7.97	699	5.6	16.07	859	13.8	200	8.2
Total		17,414	68.7		27,850	146.0		77.3

ANNEX 6. IMPLEMENTATION PROGRAMME AND PROJECT COST

IMPLEMENTATION PROGRAMME AND PROJECT COST

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Implementation Programme and Project Cost

6.1. Implementation Method and Programme

6.1.1. Work volume and implementation method

The planned construction works for the main irrigation/drainage facilities and on-farm development are summatized as follows.

Main System Improvement

Main Irrigation Canals	100.12 km
Lateral Irrigation Canals	79.65 "
Main Drainage Canals	61.00 "
Total	240.77 "

On-farm Development

Intensive Development	6,208 ha
Extensive Development	6,237 "
Total	12,445 "

The construction works in Thailand commonly are implemented in the dry season. About 30 percent of farm lands in the Project Area have neen under dry season cropping. Consequently, the construction works should be carried out to possibly shorten interruption of water supply and to minimize the adverse effect to the dry season cropping. Thereby, the on-farm development works relating to the construction and/or inptovement works for the main facilities should be executed simultaneously to be completed in the same year.

The construction works in general are carried out both on the force account basis by RID and the contract basis by tender so as to make a smooth progress of the works. Especially, the works for the Mae Wang left canal, which commands the beneficial areas with high intensity of dry season cropping and is utilised as the source of Lampang municipal water supply, should be implemented mainly on the contract basis so as to be completed within one dry season.

The construction period for the whole Project is designed by five years in considering the actual results in the past in other project and quick yielding of the Project.

The force-account-basis works should remain in the extent executable by numbers and mobility of the machinery to be procured for the Project in taking into account the depreciation of the cost and their economy. Under the situation, it is suggested that the shortage in number of machinery in the full-scale implementation should be covered by appropriation of machinery from the RID Tractor Centre. The works that will be beyond the RID's machinery availability should be executed on the contract basis for curtailing the construction period and upbringing the local contractors. The general labour forces to be required in the construction works should be supplied by the beneficiary farmers to expend the employment opportunities. The annual implementation programme by force-account-basis works and the contract-basis works is illustrated in Table 6-1.

6.1.2 Implementation programmes

Project implementation can be specified into two stages, the preparatory period for surveying and designing, and construction period. The topo-maps and cadastral maps necessary for on-farm development will be developed using the aerialphoto maps. As the records on mapping works suggest that mapping takes about one year to be developed from the aerial photos taken in the dry season of the first project year, two years would be required for preparation works including design and procurement of machinery and equipment. The execution schedule of the whole Project works is shown in Figure 7-3.

(1) Surveying and mapping

Surveying to be required for the Project implemnetation is the aforesaid topo-and cadastral-maps (Scale at 1/4,000 or 1/2,000) and route survey for canal facilities.

The combined maps, which can be developed in combining the topo-maps and the cadastral maps prepared for on-farm development, will be very useful for the study of the on-farm development schemes.

(2) Design

Various design works will have to be completed by the end of the fiscal year (Aug. or Sept.) preceding one year to the implementation of the respective construction works, in taking into account the procedures necessary for contracting with contractors. The Design Division, RID, will be fully responsible for designing the main irrigation/drainage facilities. The Project office will be responsible for designing the on-farm development under the elaborate guidance of the well-experienced staff of the Land Consolidation Section, RID.

For successful negotiation with farmers for land exchange which will be held simultaneously with the related design works, it is indispensable to have from time to time cooperation and assistance by the staff of Land Consolidation Office and the Land Department of the Ministry of Interior. RID's staffing plan for thses works should be established in well advance to their implementation.

(3) Procurement of machinery and equipment

The procurement of the machinery and equipment to be required for smooth execution of the construction works should be started in following the procedures in the latter half of the first Project year and all the machinery and equipment should be ready for use by the end of the second Project year.

(4) Work schedule

The work schedule for construction is as shown in Table 6-1.

6.2. Project Cost Estimates

The construction cost was estimated on the basis of unit prices as of October, 1979 (FY 1980) and the coversion rate applied is US$1,00 to ฿20.00. The components of the Project cost are the construction cost, O & M cost, managerial cost, procurement cost, consultants cost, contingency for engineering cost and contingency for price escalation.

The Project cost totals 697.6 million Baht, including 390.12 million Baht of the local currency portion and 374.8 million Baht in equivalence of the foreign currency portion. Fifty percent of foreign currncy portion covers the procurement of machinery and equipment for construction and O & M services, and purchase of materials such as steel bar, cement, fuel-oil, etc., and the remaining 50 percent covers depreciation cost of machinery and equipment, and so forth.

Construction Schedule

Construction Item	FY1983 F.B.	FY1983 C.B.	FY1984 F.B.	FY1984 C.B.	FY1985 F.B.	FY1985 C.B.	FY1986 F.B.	FY1986 C.B.	FY1987 F.B.	FY1987 C.B.	Total F.B.	Total C.B.
1. Main irrigation system (km)												
Mae Wang Left	9.20	24.69	4.51	0	0	0	0	0	0	0	13.71	24.69
Mae Wang Right	0	0	5.20	8.43	11.70	9.96	0	0	0	0	12.03	18.39
Mae Pung Main	0	0	0	5.61	0	0	0	0	0	0	0	5.61
Mae Pung Left	0	0	0	0	0	0	6.52	0	0	0	6.52	0
Mae Pung Right	0	0	0	0	0	0	0	12.30	0	0	0	12.30
Link canal	0	0	0.	0	0	0	0	0	2.00	0	2.00	0
Lateral canal	5.00	2.20	22.30	1.40	11.70	9.90	13.75	13.20	0	0	52.75	26.70
Total	14.20	26.89	32.01	15.44	23.40	19.86	20.27	25.50	2.00	0.00	87.01	87.69
2. Main drainage system (km)	0	10.5	0	0	0	31.2	0	0	0	19.3	0	61.0
3. On-farm development (ha)												
Intensive I1	90	45	55	157	475	432	0	0	768	322	1,388	956
" I2	443	245	408	686	859	367	0	0	497	359	2,207	1,657
Extensive E1	0	59	850	43	9	106	0	0	6	239	865	447
" E2	0	0	0	0	0	0	2,451	0	0	0	2,451	0
" E3	482	428	196	14	220	335	0	0	336	463	1,234	1,240
Total	1,015	777	1,509	900	1,563	1,240	2,451	0	1,607	1,383	8,145	4,300
Zone NO.	1	2	3.4	8	7.10	9	12	-	6	5		
4. Right of way (ha)	28.2	0	34.9	0	89.9	0	36.3	0	53.7	0	243.0	0

F.B. = Force Account Basis C.B. = Contract Basis

ANNEX 6
Table 6-2

Project Cost Estimates

Item	Quantity	Units	Costs Foreign	Local	Total
			(฿ 1,000)		
A. Irrigation & Drainage Systems					
1. Irrigation systems					
a. Mae Wang Left Bank Canal	38.40	km	14,917	38,528	53,445
b. Mae Wang Right Bank Canal	35.29	"	12,019	29,921	41,940
c. Mae Pung Main Canal	5.61	"	2,463	5,293	7,756
d. Mae Pung Left Bank Canal	6.52	"	1,660	3,739	5,399
e. Mae Pung Right Bank Canal	12.30	"	4,031	8,902	12,933
f. Link Canal	2.00	"	552	1,408	1,960
g. Lateral Canal Systems	79.65	"	15,775	34,397	50,172
Sub-total	179.77	"	51,417	122,188	173,605
2. Drainage Systems					
a. Main Drainage Canal (9 routes)	61.00	km	7,213	11,481	18,694
Sub-total	61.00	"	7,213	11,481	18,694
3. Land Acquisitions					
a. Irrigation system	116.4	ha	-	7,276	7,276
b. Drainage system	126.6	"	-	7,910	7,910
Sub-total	243.0	"	-	15,186	15,186
Total			58,630	148,855	207,485
B. On-farm Development					
1. Intensive Development Method					
I1	2,344	ha	19,591	30,275	49,866
I2	3,864	"	31,191	37,005	68,196
Sub-total	6,208	"	50,782	67,280	118,062
2. Extensive Development Method					
E1	1,312	ha	4,939	11,751	16,690
E2	2,451	"	6,549	10,346	16,895
E3	2,474	"	7,598	17,230	24,828
Sub-total	6,237	"	19,086	39,327	58,413
Total	12,445	ha	69,868	106,607	176,475
C. O & M Facilities					
1. Project Head Quarters	1.0	L.S.	1,200	4,800	6,000
2. O & M Office Improvement	1.0	"	200	800	1,000
3. O & M Equipment			7,200	800	8,000
Total			8,600	6,400	15,000
D. Engineering Administration (10%)			-	25,148	25,148
E. Physical Contingencies (10%)			13,702	42,780	56,482
F. Construction Equipment			93,300	4,660	97,960
G. Consultants Services, Training			23,280	4,770	28,050
Total (A-G)			267,380	339,220	606,600
H. Expected Price Escalation (15%)			40,100	50,900	91,000
Grand Total			307,480	390,120	697,600

Annex 6
Table 6-3

Construction Cost of Main System Improvement Works

Year	Item	Force Account Basis				Contract Basis				Total			
		L (km)	F.C.	L.C.	Total	L (km)	F.C.	L.C.	Total	L (km)	F.C.	L.C.	Total
1983	Mae Wang Left	9.20	3,863	9,518	13,381	24.69	10,258	27,128	37,386	33.89	14,121	36,646	50,767
	Lateral	5.20	948	2,105	3,053	2.20	513	1,118	1,631	7.40	1,461	3,223	4,684
	Main drainage	0	0	0	0	10.50	984	1,436	2,420	10.50	984	1,436	2,420
	Total		4,811	11,623	16,434		11,755	29,682	41,437		16,566	41,305	57,871
1984	Mae Wang Left	4.51	796	1,882	2,678	0	0	0	0	4.51	796	1,886	2,678
	Mae Wang Right	5.20	1,835	4,682	6,517	8.43	3,039	8,132	11,171	13.63	4,874	12,814	17,688
	Mae Pung Main	0	0	0	0	5.61	2,463	5,293	7,756	5.61	2,463	5,294	7,756
	Lateral	22.30	4,021	8,568	12,589	1.40	552	1,252	1,804	23.70	4,573	9,820	14,393
	Total		6,652	15,132	21,784		6,054	14,677	20,731		12,706	29,809	42,515
1985	Mae Wang Right	11.70	3,273	8,876	12,149	9.96	3,872	8,231	12,103	21.66	7,145	17,107	24,252
	Lateral	11.70	1,862	4,162	6,024	9.90	2,201	4,716	6,917	21.60	4,063	8,878	12,941
	Main drainage	0	0	0	0	31.20	3,612	5,370	8,982	31.20	3,612	5,370	8,982
	Total		5,135	13,038	18,173		9,685	18,317	28,002		14,820	31,355	46,175
1986	Mae Pung Left	6.52	1,660	3,739	5,399	0	0	0	0	6.52	1,660	3,739	5,399
	Mae Pung Right	0	0	0	0	12.30	4,031	8,902	12,933	12.30	4,031	8,902	12,933
	Lateral	13.75	2,462	5,739	8,201	13.20	3,216	6,737	9,953	26.95	5,031	12,476	18,154
	Total		4,122	9,478	13,600		7,247	15,639	22,886		11,369	25,117	36,486
1987	Link canal	2.00	552	1,408	1,960	0	0	0	0	2.00	552	1,408	1,960
	Main drainage	0	0	0	0	19.30	2,617	4,675	7,292	19.30	2,617	4,675	7,292
	Total		552	1,408	1,960		2,617	4,675	7,292		3,169	6,083	9,252
	Grand total		21,272	50,679	71,951		37,358	82,990	120,348		58,030	133,669	192,299
											30.5%	69.5%	100%

Construction Cost of Land Consolidation Works

Year	Type	Acreage	F.C.	L.C.	Total	Acreage	F.C.	L.C.	Total	Acreage	F.C.	L.C.	Total	Remarks
1983	I1	90	728	866	1,594	45	559	631	1,190	135	1,287	1,497	2,784	
	I2	443	3,399	2,829	6,228	245	2,999	2,497	5,496	688	6,398	5,326	11,724	
	E1	0	-	-	-	59	315	575	890	59	315	575	890	
	E3	482	1,591	2,530	4,121	428	1,885	3,044	4,929	910	3,476	5,574	9,050	
	Total	1,015	5,718	6,225	11,943	777	5,758	6,747	12,505	1,792	11,476	12,972	24,448	
1984	I1	55	445	529	974	157	1,949	2,203	4,152	212	2,394	2,732	5,126	
	I2	408	3,130	2,605	5,735	686	8,397	6,992	15,389	1,094	11,527	9,597	21,124	
	E1	850	3,562	6,213	9,775	43	230	419	649	893	3,792	6,632	10,424	
	E3	196	647	1,029	1,676	14	62	99	161	210	709	1,128	1,837	
	Total	1,509	7,784	10,376	18,160	900	10,638	9,713	20,351	2,409	18,422	20,089	38,511	
1985	I1	475	3,843	4,570	8,413	432	5,362	6,063	11,425	907	9,205	10,633	19,838	
	I2	859	6,590	5,485	12,075	367	4,492	3,741	8,233	1,226	11,082	9,226	20,308	
	E1	9	38	66	104	106	566	1,032	1,598	115	604	1,098	1,702	
	E3	220	726	1,155	1,881	335	1,475	2,382	3,857	555	2,201	3,537	5,738	
	Total	1,563	11,197	11,276	22,473	1,240	11,895	13,218	25,113	2,803	23,092	24,494	47,586	
1986	E2	2,451	7,951	8,944	16,895	0	0	0	0	2,451	7,951	8,944	16,895	
1987	I1	768	6,213	7,389	13,602	322	3,997	4,519	8,516	1,090	10,210	11,908	22,118	
	I2	497	3,813	3,173	6,986	359	4,395	3,659	8,054	856	8,208	6,832	15,040	
	E1	6	25	44	69	239	1,277	2,328	3,605	245	1,302	2,372	3,674	
	E3	336	1,109	1,764	2,873	463	2,039	3,292	5,331	799	3,148	5,056	8,204	
	Total	1,607	11,160	12,370	23,530	1,383	11,708	13,798	25,506	2,990	22,868	26,168	49,036	
Grand Total		8,145	43,810	49,191	93,001	4,300	39,999	43,476	83,475	12,445	83,809	92,667	176,476	

Equipment, Vehicles for Construction

Item	Quantity	Unit Cost	Total Cost
		(฿ 1,000)	
1. Foreign currency portion			
Tractor, crawler, 140HP	6	1,170	7,020
Tractor, swampy, 140HP	2	1,290	2,580
Scrap-dozer, crawler 6.4m³	2	2,190	4,380
Motor scraper, 11cu.yd.	5	4,280	21,400
Dragline, crawler, 1.20m	2	4,310	8,620
Backhoe, crawler, 3/4cu.yd.	12	1,380	16,560
Truck, dump, 6ton	27	340	9,180
Motor grader, 110HP	4	870	3,480
Roller, tire, 15ton	5	640	3,200
Truck, water tank	2	300	600
Truck, fuel	1	580	580
Truck, field greasing	1	1,500	1,500
Truck, pick-up, 3/4ton, 4 x 4	10	80	800
Station wagon, 4 x 4	4	250	1,000
Concrete mixer 140L	10	25	250
Sub-total			81,150
Spare parts (15%)			12,150
Total			93,300 (US$ 4,665,000)
2. Local currency portion			
Trancportation	L.S.		1,400
Delivery charge	L.S.		1,860
Others	L.S.		1,400
Total			4,660
Grand Total			97,960

Equipment for Operation and Maintenance

Item	Quantity	Unit Cost (฿ 1,000)	Total Cost (฿ 1,000)
1. Foreign currency portion			
Backhoe 0.35m	1	920	920
Tractor, crawler 140HP	1	1,170	1,170
Grader 110HP	1	870	870
Loader 1,60m	1	1,060	1,060
Jeep 1,500cc	4	200	800
Dump truck 6ton	2	340	680
Pick up truck 0.75ton	4	100	400
Concrete mixer 140L	2	25	50
Pump 100mm	5	22	110
Motor cycle 75cc	30	14	420
Spare parts	L.S.		720
Total			7,200
			(US$ 360,000)
2. Local currency portion			
Transportation	L.S.		250
Delivery charge	L.S.		300
Others	L.S.		250
Total			800
Grand Total			8,000

ANNEX 6
Table 6-7

Cost of Consulting Services and Trainings

A. Consulting Services	
1. Foreign Currncy Portion	
1.1 Remuneration (Foreign consultants=150MM)	US$ 1,050,000
1.2 Out-of-pocket expenses	US$ 55,000
a. International travel expenses	(20,000)
b. Reimbursable cost item & others	(35,000)
1.3 Contingencies	US$ 115,000
Sub-total	US$ 1,220,000
	(฿ 24,400,000)
2. Local Currency Portion	
2.1 Remuneration (Local consultants=100MM)	฿ 2,000,000
2.2 Living allowance and quarter	฿ 1,500,000
2.3 Local communication, transportation	฿ 500,000
2.4 Printing of reports	฿ 300,000
2.5 Contingencies	฿ 430,000
Sub-total	฿ 4,730,000
Total	฿ 29,130,000
B. Trainings	
1. Foreign currecry portion	
1.1 Internationl travel expenses	US$ 8,000
1.2 Per-diem (US$ 50 x 8 person x 60 days)	US$ 24,000
1.3 Other cost	US$ 8,000
1.4 Contingencies	US$ 4,000
Sub-total	US$ 44,000
	(฿ 880,000)
2. Local currency portion	
2.1 Preparation expenses	฿ 40,000
Sub-total	฿ 40,000
Total	฿ 920,000
Grand total	฿ 30,050,000

Operation and Maintenance Cost

1. Operation Cost

1.1. Salaries and wages	Cost(฿ 1,000)
Staffs - 40	1,200
Permanent Employee (A) - 23	552
Ditto (B) - 98	1,176
Laborers, operator - 75	900
Sub-total	3,828
Foremen, Common Irrigator - 480	1,728
Sub-total	1,728
Total	5,556
1.2. Materials and supplies	
Fuel and oil	200
Office supplies	100
Total	300

2. Maintenance Cost

Main System Improvement	950
On-farm Level	1,540
Total	2,490
Grand Total	8,346
O.M cost per ha	฿ 542/ha

Annual Expenditures Schedule

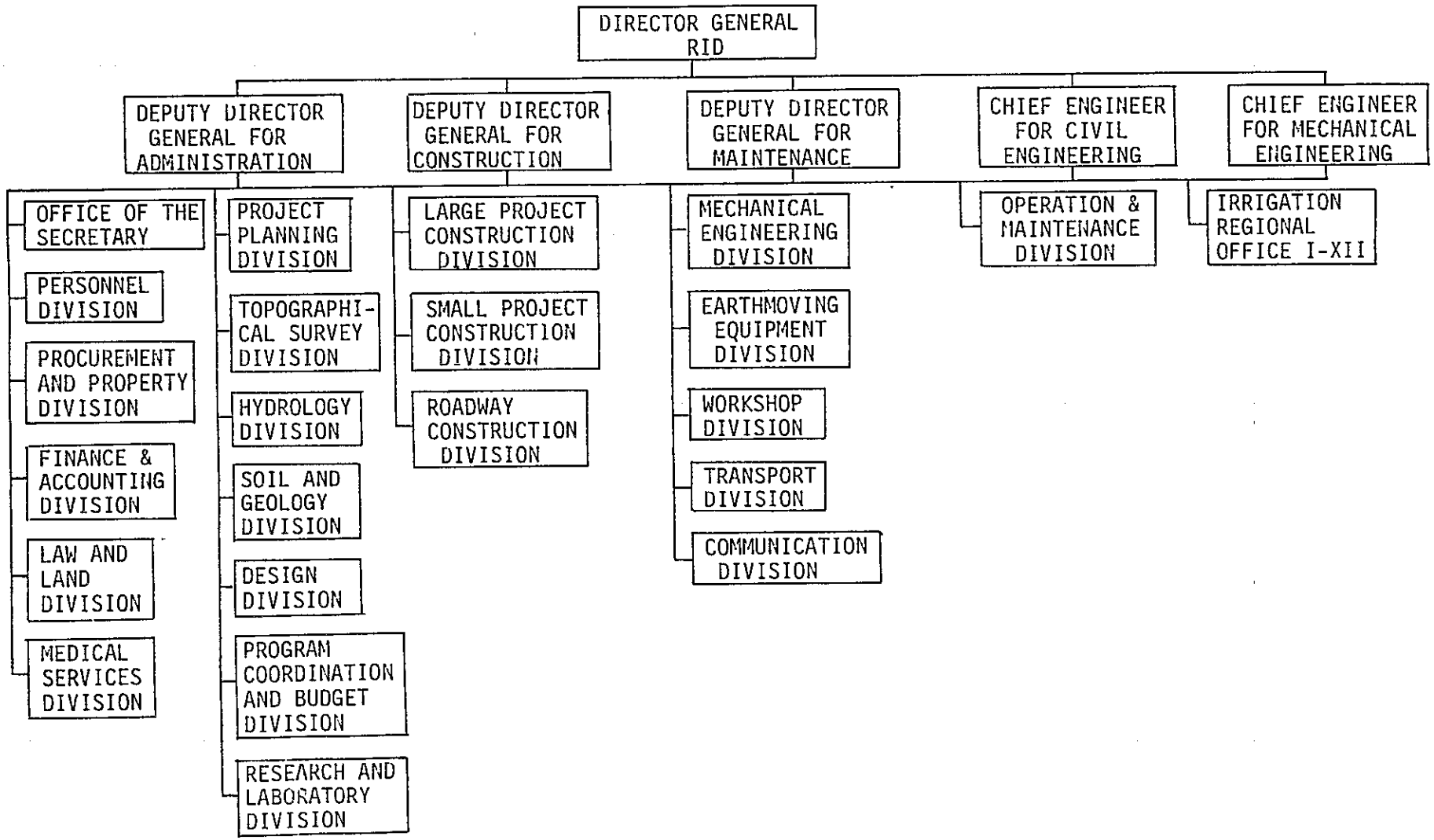
Unit : Million Baht

Item	Total	1st	2nd	3rd	4th	5th	6th	7th
1. Irrigation system	173.61	-	-	55.45	42.52	37.19	36.49	1.96
2. Drainage system	18.69	-	-	2.42	-	8.98	-	7.29
3. On-farm Development	176.47	-	-	24.45	38.51	47.58	16.89	49.04
4. Land acquisitions	15.19	-	-	1.76	2.18	5.62	2.27	3.36
Sub-total	383.96	-	-	84.08	83.21	99.37	55.65	61.65
5. O & M facilities	15.00	4.00	2.00	-	1.00	-	8.00	-
6. Physical contingecies	38.85	0.60	2.00	8.41	8.42	7.94	5.57	5.91
7. Engineering Administration	42.78	8.78	4.00	6.00	6.00	6.00	6.00	6.00
8. Construction equipment	97.96	20.00	77.96	-	-	-	-	-
9. Consultants services	28.05	4.05	4.00	4.00	4.00	4.00	4.00	4.00
Sub-total	222.64	37.43	89.96	18.41	19.42	17.94	23.57	15.91
Total	606.60	37.43	89.96	102.49	102.63	117.31	79.22	77.56

ANNEX 7. IMPLEMENTATION

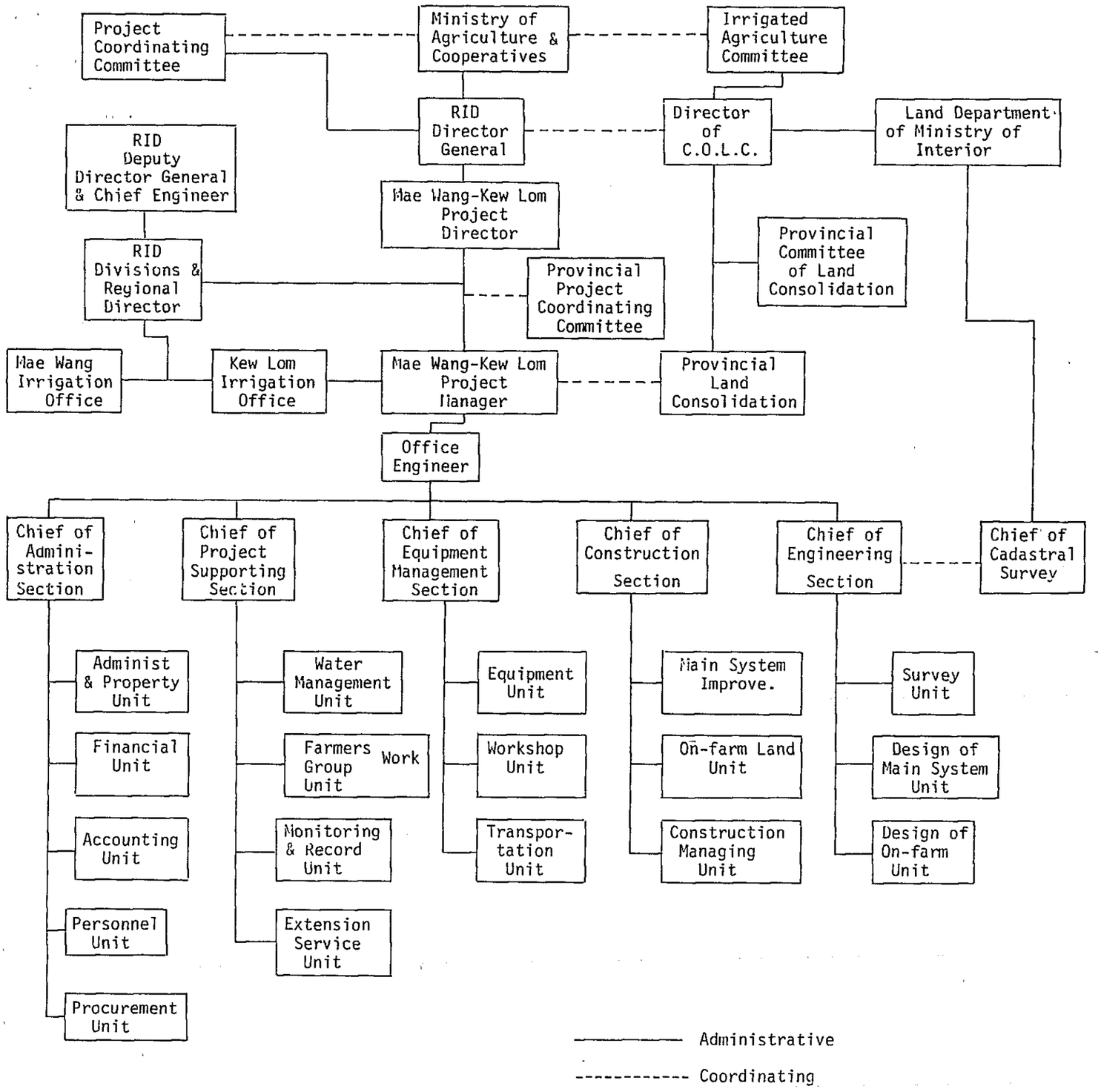
List of Figures

RID ORGANIZATION

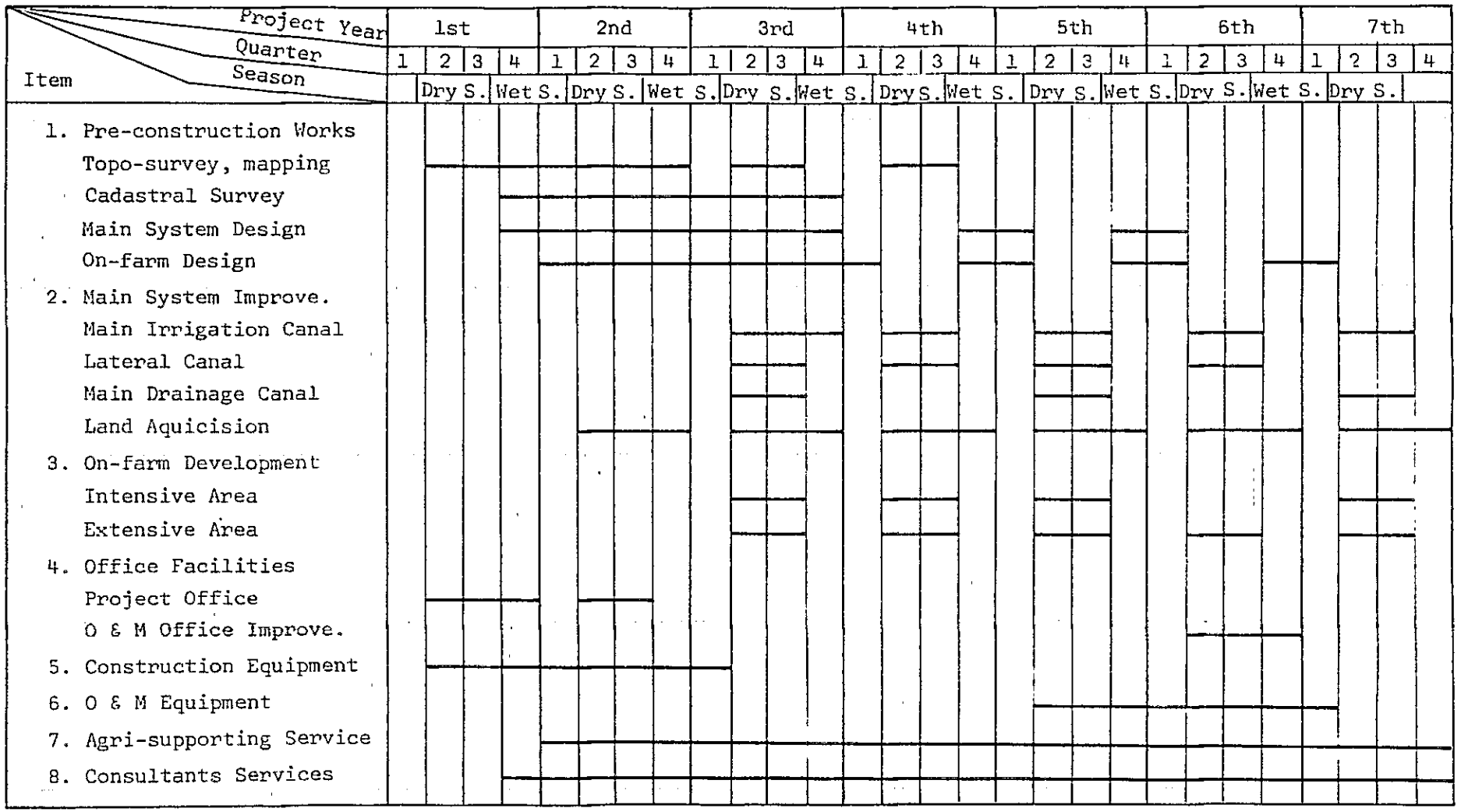


ANNEX 7
Figure 7-1

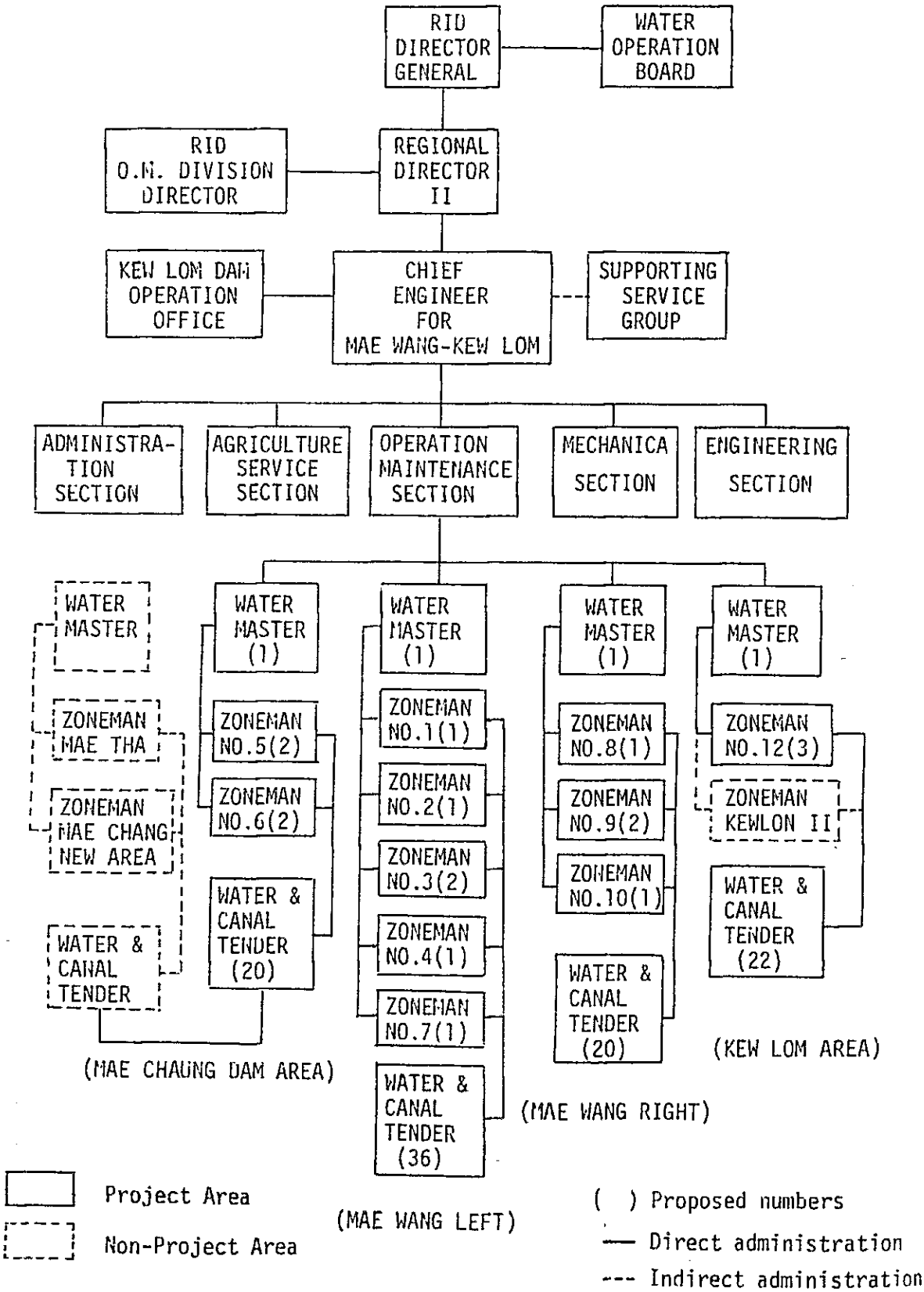
Proposed Organization of Project Implementation



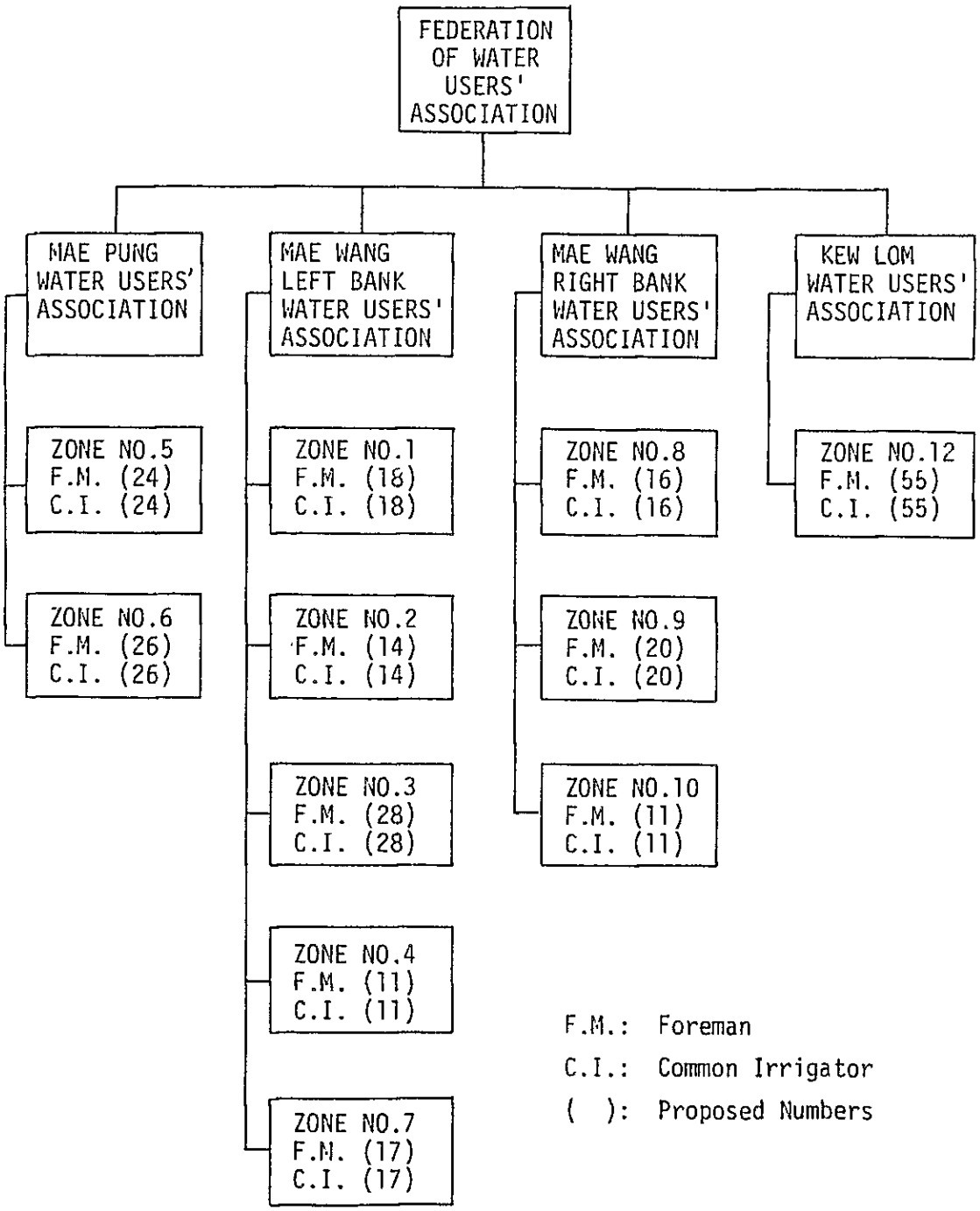
Project Implementations Schedule (Mae Wang-Keu Lom Project)



Proposed Organization on Operation & Maintenance



Proposed Farmers' Organization on Operation and Maintenance



ANNEX 8. PROJECT EVALUATION AND FARM ECONOMY

PROJECT EVALUATION AND FARM ECONOMY

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PROJECT EVALUATION AND FARM ECONOMY

8.1. Project Evaluation

8.1.1. Benefits

The benefit stream from crop production is given in Table 8-9 for Case I, Table 8-11 for Case II, respectively. The expected crop yields, and the prices of farm inputs and outputs and labour requirements are used to calculate the benefits (Table 8-1, 8-7).

8.1.2. Economic Internal Rate of Return

For making economic evaluation of the project, the official exchange rate in Thailand may understate the actual economic value of foreign exchange. Specific conversion factors for broad categories of goods and services by the project were used to express all values of the common unit. These factors used in converting domestic into border prices as well as other national parameters used in the eocnomic analysis are followings.

List of National Parameters

Standard conversion factor		0.79
Conversion factor for	- Consumption	0.96
	- Fertilizer	0.92
	- Insecticide	0.88
	- Construction	0.74
	- Government services	0.65
	- Trade	0.47
	- Transport	0.76
	- Agricultural machinery	0.88
	- Draft animals	1.01

Source: Irrigation Project Appraisal Report in Thailand by World Bank

8.2. Farm Economic Survey

8.2.1. Farmland

The farm economic survey conducted by RID in August 1979 gave some economic indications related to agriculture in the Project Area as follows:

Total area held by 100 surveyed farmers in 198.80 hectares, but, real operated agricultural land is 170.62 hectares. The major part of agricultural and is 140.70 hectares under paddy cropping. The second is 28.56 hectares under upland cropping.

Utilization of Farmland

Unit: ha

	Agricultural Land					
Type of land	Paddy	Upland	Orchard or pasture	total	Others	Total
Total area	140.70	28.56	1.36	170.62	28.18	198.80
Area per farm	1.41	0.29	0.01	1.71	0.28	1.99

Various kinds of crops are planted in this Project Area. The surveyed 100 farmers harvested 20 kinds of crops in wet season and 17 kinds in dry season.

Annual Planted Area by Crops

Unit: ha

Crops	Wet Season	Dry Season	Total	Remarks
Paddy	138.62	11.88	150.50	
Peanut	3.64	16.72	20.36	Utilization rate
Tobacco	0.32	5.72	6.04	of agricultural
Soybean	0.04	10.88	10.92	land ... 133%
Chilli	0.12	0.04	0.16	(227.36ha/170.62ha)
Garlic	-	10.50	10.50	
Sugarcane	11.92	-	11.92	
Pineapple	7.04	-	7.04	
Vegetable	1.52	5.44	6.96	
Orchard	1.68	-	1.68	
Others	0.62	0.66	1.28	
Total	165.52	61.84	227.36	

The utilization rate of agricultural land is 133%.

8.2.2. Farm income

The total farm income is 11,894 Baht per farm and it is derived from combination of net agricultural income 7,290 Baht and non-agricultural income 4,604 Baht.

(a) Agricultural income

The gross cash income from crop production per farm on an average farm size 1.7 ha (10.7rai) was estimated at 9,110 Baht and cash cost at 1,820 Baht. Consequently the net cash income from agriculture is 7,290 Baht.

Average Gross Cash Income per Farm Household

Crop	Production kg	Sold kg	Price Baht/kg	Value Baht	Remark
Paddy (Wet)	3,934	777	2.38	1,849	1/ Dried Peanut Price
Paddy (Dry)	291	179	2.28	408	
Peanut	212	193	4.13 1/	797	
Tobacco	536	536	1.84	986	
Soybean	68	66	7.72	510	
Chilli	11	10	3.87	39	
Garlic	137	91	8.48	772	
Others	---	--	--	3,749	
Total				9,110	

Production Cost for Crop Production

(Unit: Baht/farm)

Crop	Fertilizer	Agro-chemicals	Hired Labor	Total
Paddy (Wet)	-	-	900	900
Paddy (Dry)	45	5	65	115
Peanut	-	-	20	20
Tobacco	175	25	60	260
Soybean	5	5	30	40
Chilli	-	5	-	5
Garlic	15	-	65	80
Others	165	90	145	400
Total	405	130	1,285	1,820

(b) Non-agricultural income

The average non-agricultural income per farm is 4,605 Baht. Fifty-five percent total non-agricultural income is owe to labor income by the head of household.

Non-agricultural Income per Farm

Kind of Work	The head of household		The other member of household		Total	
	Days worked mandays	Income ฿	Days worked mandays	Income ฿	Days worked mandays	Income ฿
Agri-employee	1.7	39	2.8	50	4.5	89
Trading	9.6	469	27.7	757	37.3	1,226
Hired labor	34.6	2,030	52.7	1,259	87.3	3,289
Total	45.9	2,538	83.2	2,066	129.1	4,604

8.2.3. Living cost

The average living cost per household is 11,405 Baht per year. Food expenditure is 5,975 Baht at 52% of living cost.

Farm Living Cost by Farm Size

Baht/year

Item	Average	Less than 6 rai	6rai - less than 10 rai	10 rai -
Food	5,975	5,960	5,855	6,025
Clothing	1,340	1,240	1,015	1,505
Housing	1,520	30	150	2,595
Medical care	525	750	330	515
Education	1,455	1,970	1,445	1,270
Social Expenditure	540	590	445	560
Taxes	50	20	20	75
Total	11,405	10,560	9,260	12,545

8.3. Estimation of Model Farm Budgets

Farm Budget was estimated in the assumption as follows:

(1) Inputs and Outputs Prices

Inputs and outputs financial prices at farm were applied to calculating net agricultural income. Current retail prices were used for input goods (fertilizer etc.) and current farm gate prices were used for output goods (agricultural products).

(2) Labor Costs

The hired labor cost was estimated as the labor costs. Quantity of hired labor means the total of the labor requirements over the available family labor force in each month. Thirty Baht per man-day was used as the wage rate.

(3) Time of Comparison

Input, outputs and labor cost are applied to the model farms at Present, Without Project and With Project.

(4) Project Charge

For the model farm at With Project, ability of payment was calculated in regard to repayment of on-farm development costs and expenditures for operation and maintenance costs. The annual project charge for farmers was estimated in the assumption as follows.

1) The half of model farm benefit area is located in the intensive development area and the remaining is in the extensive development area.

2) The on-farm development cost liable to repayment by beneficiary is 100 percent of land leveling cost and 10 percent of public facilities cost. The terms of repayment grace are that i) the rate of compound interest is 12 percent per annum, ii) period is three years after the project completion and iii) repayment is made installment for fifteen years

3) Operation and maintenance cost liable to payment of farmers is 100 percent of on-farm level cost.

Structure of paddy price

	Present (1980)		Future (1990)	
	Financial	Economic	Financial	Economic
Bangkok FOB price US$ @ton	308	308	368.5	368.5
Baht @ton	6,160	6,160	7,370	7,370
Rice premium	660	-	750	-
Export duty	255	-	300	-
Municipal tax	10	-	15	-
Exporter's margin a/	400	190	450	210
Wholesaler's margin b/	170	115	185	125
Transport and handling c/	380	290	460	350
Ex-mill price of rice	4,285	5,565	5,210	6,685
Ex-mill price of paddy	2,825	3,670	3,435	4,410
Milling cost d/	120	100	150	120
Miller's margin	220	100	265	120
Milling tax	60	-	70	-
Transport to mill c/	50	40	60	50
Input price of paddy at mill	2,375	3,430	2,890	4,120
Merchants margin	300	-	360	-
Price of by-product	200	200	240	240
Farm gate price of paddy	2,275	3,630	2,770	4,360

Note: a/ Conversion factor of 0.47 was used for converting financial price into economic price.

b/ Conversion factor of 0.69 was used for converting financial price into economic price.

c/ The conversion factor for transports etc. was put 0.76 to use.

d/ The conversion factor for industry was put 0.8 to use.

Structure of Peanut Price

	Present (1980)		Future (1990)	
	Financial	Economic	Financial	Economic
Bangkok FOB price US$ @ton	579	579	808.5	808.5
Baht @ton	11,580	11,580	16,170	16,170
Export tax	490	-	310	-
Exporter's margin[a/]	400	190	450	210
Wholesaler's margin[b/]	400	275	505	350
Transport and handling[c/]	380	290	460	350
Price of without shell	9,910	10,825	14,445	15,260
Price of with shell	6,440	7,035	9,390	9,910
Shelling cost[d/]	500	400	480	385
Shelling factory's margin	350	155	420	190
Tax	170	-	165	-
Transport to shelling factory[c/]	100	75	120	90
Input price of peanut at factory	5,320	6,405	8,205	9,245
Merchants margin	500	-	600	-
Farm gate price of peanut -dried-	4,820	6,405	7,605	9,245
Farm gate price of peanut -fresh-	2,410	3,200	3,800	4,620

Note: a/ Conversion factor of 0.47 was used for converting financial price into economic price

b/ Conversion factor of 0.69 was used for converting financial price into eocnomic price.

c/ The conversion factor for transports etc. was put 0.76 to use.

d/ The conversion factor for industry was put 0.8 to use.

Structure of Sugarcane Price

	Present (1980)		Future (1990)	
	Financial	Economic	Financial	Economic
International Price				
US$ @ton	225.5	225.5	337.8	337.8
Baht @ton	4,510	4,510	6,760	6,760
Production cost	1,540	1,540	2,000	2,000
Transport and handling[a/]	380	290	460	350
Miller's margin[b/]	30	-	800	-
Exporter's margin[b/]	80	-	400	-
Export tax	-	-	760	-
Total cost	2,030	1,830	4,420	2,350
Price of sugar	2,480	2,680	2,340	4,410
By product	870	870	1,200	1,200
Farm gate price of sugar	3,350	3,550	3,540	5,610
Price of cane	285	300	300	480

Note: a/ Conversion factor of 0.76 was used for converting financial price into economic price.

b/ The conversion factor of 0.46 was used for trade.

Farm-gate Prices of Inputs and Outputs

Unit: Baht @ton

Inputs and Outputs	1980 Financial	1980 Economic	1990 Financial	1990 Economic
Crops				
Paddy	2,275	3,630	2,770	4,360
Peanut -fresh in shell-	2,410	3,200	3,800	4,620
Tobacco -fresh-	1,825	1,825	2,780	2,78-
Syobean	8,140	8,140	12,350	12,350
Chilli -fresh-	4,095	4,095	6,210	6,210
Garclic -fresh-	8,935	8,935	13,560	13,560
Sugarcane	285	300	300	480
Orchard (Pineapple)	1,920	1,920	2,930	2,930
Vegetable (Cabbage)	2,050	2,050	3,110	3,110
Seed or Seedling				
Paddy	2,200	3,600	2,900	4,500
Peanut	3,300	4,600	3,900	4,800
Toabacco (1,000 seedling)	270	378	319	446
Soybean	5,600	7,900	6,600	9,300
Chilli	50,000	70,000	59,000	83,000
Garlic	30,000	42,000	35,000	50,000
Sugarcane (1,000 seedling)	70	78	83	116
Orchard (1,000 seedling)	75	105	89	124
Vegetable (1,000 seedling)	13	19	16	22
Fertilizer				
Ammonium phosphate (16-20-0)	5,180	4,650	7,000	6,285
Ammonium sulphate (22-21%, N)	3,210	2,880	4,330	3,890
Potash (60%, K_2O)	4,560	4,090	6,160	5,530
Super phosphate (36-38%, P_2O_5)	5,800	5,210	7,840	7,035
N-P-K-Mg (4-16-24-4)	6,740	6,050	9,1-0	8,170

Note: Prices expressed in 1980 constant values.

Economic Crop Production Costs (excluded labor cost)

Unit: Baht @ha

Item	1 Paddy (Wet Season)	2 Paddy (Dry Season)	3 Peanut (Wet Season)	4 Peanut (Dry Season)	5 Tobacco	6 Soybean	7 Chilli	8 Garlic	9 Sugarcane	10 Orchard -Pineapple-	11 Vegetable -Cabbage-
Present											
Cultivation	478	478	232	232	333	232	333	333	232	232	333
Seed (Nursey)	274	274	589	728	1,229	269	350	9,786	741	720	742
Fertilizer	28	440	-	-	3,024	93	1,066	163	312	461	791
Chemicals	-	30	-	-	440	30	370	180	-	-	600
Others	1,170	808	819	960	3,344	416	3,171	4,478	1,050	1,152	614
Total	1,950	2,030	1,640	1,920	8,370	1,040	5,290	14,940	2,335	2,565	3,080
Without Project											
Cutivation	478	478	232	232	333	232	333	333	232	232	333
Seed (Nursery)	342	342	614	758	1,450	316	415	11,650	827	812	876
Fertilizer	38	597	-	-	4,085	126	1,439	220	421	622	1,068
Chemicals	-	40	-	-	615	40	518	250	-	-	840
Others	1,282	973	844	990	4,322	476	4,055	5,337	1,210	1,354	773
Total	2,140	2,430	1,690	1,980	10,805	1,190	6,760	17,790	2,690	3,020	3,890
With Project											
Cultivation	507	507	375	375	446	375	446	446	375	375	446
Seed (Nursery)	158	158	576	576	1,450	307	415	15,000	406	767	876
Fertilizer	1,432	2,163	691	691	4,902	691	1,683	1,683	1,923	1,923	2,643
Chemicals	-	48	-	-	707	46	596	288	-	-	966
Others	1,533	1,224	928	1,088	4,755	521	4,460	5,873	1,331	1,490	1,019
Total	3,630	4,100	2,570	2,730	12,260	1,940	7,600	23,290	4,035	4,555	5,950

Financial Crop Production Costs (excluded labor cost)

Unit: Baht @ha

Present											
Cultivation	730	730	230	230	330	230	330	330	230	230	330
Seed (Nursery)	167	167	422	521	878	190	250	6,990	500	490	530
Fertilizer	31	492	-	-	3,370	104	1,188	181	347	514	881
Chemicals	-	34	-	-	497	34	418	203	-	-	678
Others	1,227	847	858	1,009	3,510	437	3,329	4,701	1,103	1,206	641
Total	2,155	2,270	1,510	1,760	8,585	995	5,515	12,405	2,180	2,440	3,060
Without Project											
Cultivation	730	730	230	230	330	230	330	330	230	230	330
Seed (Nursery)	220	220	500	615	1,035	225	295	8,155	590	580	640
Fertilizer	42	665			4,550	140	1,602	245	470	693	1,190
Chemicals	-	45	-	-	695	45	585	283	-	-	949
Others	1,343	1,020	885	1,040	4,535	500	4,258	5,602	1,410	1,422	811
Total	2,335	2,680	1,615	1,885	11,145	1,140	7,070	14,615	2,700	2,925	3,920
With Project											
Cultivation	775	775	575	575	680	575	680	680	575	575	680
Seed (Nursery)	145	145	470	470	1,035	220	295	10,500	290	550	640
Fertilizer	1,593	2,408	770	770	5,460	770	1,874	1,874	2,140	2,140	2,819
Chemicals	-	54	-	-	799	54	673	325	-	-	1,092
Others	1,607	1,278	970	1,140	4,991	546	4,678	6,161	1,230	1,345	1,069
Total	4,120	4,660	2,785	2,955	12,965	2,165	8,200	19,540	4,235	4,610	6,300

Economic Cost of Farm Labor

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Total manpower requirement (1,000 manday)	P	258	158	113	189	137	285	343	344	128	155	324	459	2,895
	WO	267	163	118	197	142	288	347	351	134	162	350	493	3,014
	W	324	416	327	307	431	669	564	473	222	208	811	699	5,451
Average wate rate (Baht/manday)	P	13	11	10	11	10	14	15	15	10	11	15	19	14
	WO	12	10	10	11	10	13	14	14	10	10	14	18	13
	W	13	14	13	12	15	21	18	15	11	11	26	22	18
Economic cost of farm labor (Million Baht)	P	3.35	1.74	1.13	2.08	1.37	3.99	5.15	5.16	1.29	1.71	4.86	8.72	40.55
	WO	3.20	1.63	1.18	2.17	1.42	3.74	4.86	4.91	1.34	1.62	4.90	8.87	39.84
	W	4.05	5.83	4.14	3.68	6.25	14.04	9.87	7.33	2.44	2.28	21.09	15.38	96.38

Note: P = Present, WO = Without Project, W = With Project

Economic Cost and Return, Case I

Year	Cost		Incremental Benefits	Benefit-Cost	Discount Rate	
	Construction Cost	O & M Cost			27%	28%
	---------- Million Baht ----------					
1981	27.70	0	-	Δ 27.70	Δ 21.81	Δ 21.62
1982	66.57	0	-	Δ 66.57	Δ 41.27	Δ 40.63
1983	75.84	0.92	Δ 6.97	Δ 83.73	Δ 40.88	Δ 39.92
1984	75.95	2.49	Δ 7.06	Δ 85.50	Δ 32.87	Δ 31.85
1985	86.81	3.88	33.00	Δ 87.69	Δ 17.46	Δ 16.79
1986	58.62	5.47	89.67	25.58	6.10	5.82
1987	57.39	6.90	142.31	78.02	14.64	13.86
1988	-	6.90	187.82	180.92	26.74	25.11
1989	-	6.90	196.28	189.38	22.04	20.53
1990	-	6.90	201.97	195.07	17.87	16.52
1991	-	6.90	204.33	197.43	14.23	13.05
1992-2030	-	6.90	206.42	199.52	53.31	47.15
Total	448.88				0.64	Δ 8.77

$$EIRR = 27\% + \frac{0.64}{0.64 + 8.77} \times 1\% = 27.1\%$$

ANNEX 8
Table 8-9

Incremental Benefits, Case I

Unit: Million Baht

Year	Without Project				With Project				Incremental Benefits
	Gross Value of Production	Production Cost: Input Material Costs	Production Cost: Labor Costs	Net Value of Production	Gross Value of Production	Production Cost: Input Material Costs	Production Cost: Labor Costs	Net Value of Production	
1982	226.94	48.21	40.43	138.30	226.94	48.21	40.43	138.30	0
1983	235.53	48.92	40.37	146.24	225.05	39.75	46.03	139.27	6.97
1984	244.12	49.63	40.31	154.18	244.22	45.48	51.62	147.12	7.06
1985	252.72	50.34	40.25	162.13	309.93	57.63	57.22	195.13	33.00
1986	261.31	51.05	40.20	170.06	398.15	75.61	62.81	259.73	89.67
1987	269.91	51.76	40.14	178.01	482.15	93.42	68.41	320.32	142.31
1988	278.50	52.47	40.08	185.95	559.14	111.37	74.00	373.77	187.82
1989	287.10	53.18	40.02	193.90	591.43	121.65	79.60	390.18	196.28
1990	295.69	53.90	39.96	201.83	617.42	128.43	85.19	403.80	201.97
1991	304.29	54.47	39.90	209.92	638.21	133.17	90.79	414.25	204.33
1992	312.88	55.04	39.84	218.00	656.94	136.14	96.38	424.42	206.42

Economic Cost and Return, Case II

Year	Cost		Incremental Benefits	Benefit-Cost	Discount Rate	
	Construction Cost	O & M Cost			25%	26%
	---------- Million Baht ----------					
1981	27.70	0	-	Δ 27.70	Δ 22.16	Δ 21.99
1982	66.57	0	-	Δ 66.57	Δ 42.60	Δ 41.93
1983	92.12	0.92	Δ 6.97	Δ 100.01	Δ 51.21	Δ 49.99
1984	92.23	2.49	Δ 7.06	Δ 101.78	Δ 41.96	Δ 40.39
1985	103.09	3.88	33.00	Δ 73.97	Δ 24.24	Δ 23.29
1986	74.90	5.47	89.67	9.30	2.44	2.32
1987	73.67	6.90	143.34	62.77	13.16	12.45
1988	-	6.90	192.13	185.23	31.08	29.16
1989	-	6.90	203.13	196.23	26.33	24.51
1990	-	6.90	211.39	204.49	21.96	20.29
1991	-	6.90	215.75	208.85	17.94	16.44
1992-2030	-	6.90	218.53	211.63	72.69	63.93
Total	530.28				3.43	Δ 8.49

$$EIRR = 25\% + \frac{3.43}{3.43 + 8.49} \times 1\% = 25.3\%$$

ANNEX 8
Table 8-11

Incremental Benefits, Case II

Unit: Million Baht

Year	Future Without Project				Future With Project				Incremental Benefits
	Gross Value of Production	Production Cost: Input Material Costs	Production Cost: Labor Costs	Net Value of Production	Gross Value of Production	Production Cost: Input Material Costs	Production Cost: Labor Costs	Net Value of Production	
1982	226.94	48.21	40.43	138.30	226.94	48.21	40.43	138.30	0
1983	235.53	48.92	40.37	146.24	225.05	39.75	46.03	139.27	6.97
1984	244.12	49.63	40.31	154.18	244.22	45.48	51.62	147.12	7.06
1985	225.72	50.34	40.25	162.13	309.98	57.63	57.22	195.13	33.00
1986	261.31	51.05	40.20	170.06	398.15	75.61	62.81	259.73	89.67
1987	269.91	51.76	40.14	178.01	484.38	94.62	68.41	321.35	143.34
1988	278.50	52.47	40.08	185.95	566.03	114.05	74.00	377.98	192.03
1989	287.10	53.18	40.02	193.90	601.55	124.92	79.60	397.03	203.13
1990	295.69	53.90	39.96	201.83	630.65	132.24	85.19	413.22	211.39
1991	304.29	54.47	39.90	209.92	653.83	137.37	90.79	425.67	215.75
1992	312.88	55.04	39.84	218.00	673.40	140.49	96.38	436.53	218.53

ANNEX 8
Table 8-12

Incremental Benefits, Case I

(2-years delay in reaching full benefit)

Unit: Million Baht

Year	Future Without Project				Future With Project				Incremental Benefits
	Gross Value of Production	Production Cost: Input Material Costs	Production Cost: Labor Costs	Net Value of Production	Gross Value of Production	Production Cost: Input Material Costs	Production Cost: Labor Costs	Net Value of Production	
1982	226.94	48.21	40.43	138.30	226.94	48.21	40.43	138.30	0
1983	235.53	48.92	40.37	146.24	225.05	39.75	46.03	139.27	6.97
1984	244.12	49.63	40.31	154.18	244.22	45.48	51.62	147.12	7.06
1985	252.72	50.34	40.25	162.13	309.93	57.63	57.22	195.13	33.00
1986	261.31	51.05	40.20	170.06	397.23	75.61	62.81	258.81	88.75
1987	269.91	51.76	40.14	178.01	469.01	93.42	68.41	307.18	129.17
1988	278.50	52.47	40.08	185.75	552.15	111.37	74.00	366.78	180.83
1989	287.10	53.18	40.02	193.90	581.52	121.65	79.60	380.27	186.37
1990	295.69	53.90	39.96	201.83	605.83	128.43	85.19	392.21	190.38
1991	304.29	54.47	39.90	209.92	628.27	133.17	90.79	404.31	194.39
1992	312.88	55.04	39.84	218.00	649.57	136.14	96.38	417.05	199.05
1993	312.88	55.04	39.84	218.00	653.97	136.14	96.38	421.45	203.45
1994	312.88	55.04	39.84	218.00	656.94	136.14	96.38	424.42	206.42

ANNEX 8
Table 8-13

Incremental Benefits, Case II

(2-years delay in reaching full benefit)

Unit: Million Baht

Year	Future Without Project				Future With Project				Incremental Benefits
		Production Cost				Production Cost			
	Gross Value of Production	Input Material Costs	Labor Costs	Net Value of Production	Gross Value of Production	Input Material Costs	Labor Costs	Net Value of Production	
1982	226.94	48.21	40.43	138.30	226.94	48.21	40.43	138.30	0
1983	235.53	48.92	40.37	146.24	225.05	39.75	46.03	139.27	6.97
1984	244.12	49.63	40.31	154.18	244.22	45.48	51.62	147.12	7.06
1985	252.72	50.34	40.25	162.13	309.98	57.63	57.22	195.13	33.00
1986	261.31	51.05	40.20	170.06	397.38	75.61	62.81	258.96	88.90
1987	269.91	51.76	40.14	178.01	480.70	94.62	68.41	317.68	139.67
1988	278.50	52.47	40.08	185.95	559.06	114.05	74.00	371.01	185.06
1989	287.10	53.18	40.02	193.90	591.66	124.92	79.60	387.14	193.24
1990	2095.69	53.90	39.96	201.83	618.50	132.24	85.19	401.07	199.24
1991	304.29	54.47	39.90	209.92	642.03	137.37	90.79	413.87	203.95
1992	312.88	55.04	39.84	218.00	664.46	140;49	96.38	427.59	209.59
1993	312.88	55.04	39.84	218.00	669.91	140.49	96.38	433.01	215.04
1994	312.88	55.04	39.84	218.00	673.40	140.49	96.38	436.53	218.53

Crop Budgets 1/

Item		1 Paddy (Wet Season)	2 Paddy (Dry Season)	3 Peanut (Wet Season)	4 Peanut (Dry Season)	5 Tobacco	6 Soybean	7 Chilli	8 Garlic	9 Sugarcane	10 Orchard -Pineapple-	11 Vegetable -Cabbage-
Present												
Yield	ton/ha	2.8	2.4	2.4	3.4	10.9	1.5	2.6	4.8	28.6	13.3	8.0
Farm-gate Price	฿/ton	2,275	2,275	2,410	2,410	1,825	8,140	4,095	8,935	285	1,920	2,050
Gross Value of Production	฿/ha	6,370	5,460	5,784	8,194	19,893	12,210	10,647	42,888	8,151	25,536	16,400
Production Cost, exclude Labor	฿/ha	2,155	2,270	1,510	1,760	8,585	995	5,515	12,405	2,180	2,440	3,060
N.V.P. Without accounting for Labor	฿/ha	4,215	3,190	4,274	6,434	11,308	11,215	5,132	30,483	5,971	23,096	13,340
Labor Requirements	manday/ha	119.0	127.0	156.0	159.0	457.0	374.0	644.0	202.0	178.0	109.0	381.0
Without Project												
Yield	ton/ha	3.0	2.5	2.5	3.5	11.0	1.5	2.7	4.9	29.0	13.7	8.2
Farm-gate Price	฿/ton	2,770	2,770	3,800	3,800	2,780	12,350	6,210	13,560	300	2,930	3,110
Gross Value of Production	฿/ha	8,310	6,925	9,500	13,300	30,580	18,525	16,767	66,444	8,700	40,141	25,502
Production Cost, exclude Labor	฿/ha	2,335	2,680	1,615	1,885	11,145	1,140	7,070	14,615	2,700	2,925	3,920
N.V.P. Without accounting for Labor	฿/ha	5,975	4,245	7,885	11,415	19,435	17,385	9,697	51,829	6,000	37,216	21,582
Labor Requirements	manday/ha	125.0	133.9	161.5	164.0	467.2	386.9	670.8	206.7	184.3	113.0	394.1
With Project												
Yield	ton/ha	4.0	4.5	3.1	4.5	12.0	2.0	3.4	6.3	34.6	16.1	16.1
Farm-gate Price	฿/ton	2,770	2,770	3,800	3,800	2,780	12,350	6,210	13,560	300	2,930	3,110
Gross Value of Production	฿/ha	11,080	12,465	11,780	17,100	33,360	24,700	21,114	85,428	10,380	47,173	50,071
Production Cost, Exclude Labot	฿/ha	4,120	4,660	2,785	2,955	12,965	2,165	8,200	19,540	4,235	4,610	6,300
N.V.P. Without accounting for Labor	฿/ha	6,960	7,805	8,995	14,145	20,395	22,535	12,914	65,888	6,145	42,563	43,771
Labor Requirements	manday/ha	140.0	181.2	153.6	181.2	471.0	433.8	734.6	213.3	194.3	122.4	438.0

1/ Financial prices and costs are used.

Project Charges

Item	Table Cost ฿/ha	Calculating Process	Project charge ฿/ha/year
A. On-farm development cost		Total amount of refund	
A1. Intensive development area		(4,418x1.0+11,017x0.1) x 0.5	
a. land leveling cost	4,418	+8,519 x 0.1 x 0.5 = 3,186	1,630
b. public facilities cost	11,017	Annual amount of refund	
A2. Extensive development area		$\frac{3,186\ (1+0.12)^{18}}{15} \doteqdot 1,630$	
a. public facilities cost	8,519		
		฿/year	
B. O & M cost			
B1. On-farm level cost	3,268,000	$\frac{3,268,000}{15,400} \doteqdot 210$	210

Farm Budget - 0.7 ha (4.4 rai) Farm

Item	Unit	Present				Without Project				With Project			
		I		II		I		II		I		II	
		Wet Season	Dry Season	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Cropping													
Paddy	ha	0.7	0.2	0.7	-	0.7	0.2	0.7	-	0.7	0.6	0.7	-
Peanut	ha	-	-	-	-	-	-	-	-	-	-	-	0.1
Tobacco	ha	-	-	-	-	-	-	-	-	-	-	-	0.1
Soybean	ha	-	-	-	0.1	-	-	-	0.1	-	-	-	0.1
Chilli	ha	-	-	-	-	-	-	-	-	-	-	-	-
Garlic	ha	-	-	-	0.1	-	-	-	0.1	-	-	-	0.2
Intensity	%	129		129		129		129		186		186	
Gross value of production	฿	5,550		9,970		7,200		14,315		15,235		32,355	
Production cost exclude labor	฿	1,960		2,160		2,170		3,210		5,680		8,600	
Hired labor	฿	-		-		-		-		-		-	
Land tax[a/]	฿	35		35		55		55		55		55	
Interest[b/]	฿	45		50		50		75		245		370	
Net value of production before project charge	฿	3,510		7,725		4,925		10,975		9,255		23,330	
Project charge													
On-farm development cost[c/]	฿	-		-		-		-		1,140		1,140	
O & M Cost[d/]	฿	-		-		-		-		145		145	
Net value of production after project charge	฿	3,510		7,725		4,925		10,975		7,970		22,045	

* Rounded to nearest ฿5.

a/ Present ฿ 8/rai, future ฿ 12/rai

b/ Interest charge at 6% (1% per month). It is assumed that 50% of farmers borrow 80% of their cash needs at present and 80% would borrow 90% of their cash needs in future.

c/ ฿ 1,630/ha d/ ฿ 210/ha

Farm Budget - 1.3 ha (8.1 rai) Farm

Item	Unit	Present I Wet Season	Present I Dry Season	Present II Wet	Present II Dry	Without Project I Wet	Without Project I Dry	Without Project II Wet	Without Project II Dry	With Project I Wet	With Project I Dry	With Project II Wet	With Project II Dry
Cropping													
Paddy	ha	1.3	0.4	1.3	-	1.3	0.4	1.3	-	1.3	1.0	1.3	-
Peanut	ha	-	-	-	0.1	-	-	-	0.1	-	-	-	0.1
Tobacco	ha	-	-	-	0.1	-	-	-	0.1	-	-	-	0.2
Soybean	ha	-	-	-	0.1	-	-	-	0.1	-	-	-	0.3
Chilli	ha	-	-	-	-	-	-	-	-	-	-	-	0.1
Garlic	ha	-	-	-	0.1	-	-	-	0.1	-	-	-	0.3
Intensity	%	131		131		131		131		177		177	
Gross value of production	฿	10,465		16,600		13,575		23,685		26,860		57,935	
Production cost exclude labor	฿	3,710		5,175		4,110		5,915		10,015		15,575	
Hired labor	฿	-		-		-		-		875		2,525	
Land tax[a/]	฿	65		65		95		95		95		95	
Interest[b/]	฿	90		125		100		140		430		670	
Net value of production before project charge	฿	6,600		11,235		9,270		17,535		15,445		39,070	
Project charge													
On-farm development cost[c/]	฿	-		-		-		-		2,120		2,120	
O & M cost[d/]	฿	-		-		-		-		275		275	
Net value of production after project charge	฿	6,600		11,235		9,270		17,535		13,050		36,675	

* Rounded to nearest ฿5

a/ Present ฿ 8/rai, future ฿ 12/rai

b/ Interest chared at 6% (1% per month). It is assumed that 50% of farmers borrow 80% of their cash needs at present and 80% would borrow 90% of their cash needs in future

c/ ฿ 1,630/ha

d/ ฿ 210/ha

Farm Budget - 2.5 ha (15.6 rai) Farm

Item	Unit	Present I Wet Season	Present I Dry Season	Present II Wet	Present II Dry	Without Project I Wet	Without Project I Dry	Without Project II Wet	Without Project II Dry	With Project I Wet	With Project I Dry	With Project II Wet	With Project II Dry
Cropping													
Paddy	ha	2.5	0.8	2.5	-	2.5	0.8	2.5	-	2.5	20.0	2.5	-
Peanut	ha	-	-	-	0.2	-	-	-	0.2	-	-	-	0.4
Tobacco	ha	-	-	-	0.2	-	-	-	0.2	-	-	-	0.5
Soybean	ha	-	-	-	0.2	-	-	-	0.2	-	-	-	0.5
Chilli	ha	-	-	-	0.1	-	-	-	0.1	-	-	-	0.3
Garlic	ha	-	-	-	0.1	-	-	-	0.1	-	-	-	0.3
Intensity	%	132		132		132		132		180		180	
Gross value of production	฿	20,293		29,335		26,315		41,575		52,630		95,530	
Production cost exclude labor	฿	7,205		9,445		7,980		10,840		19,620		27,370	
Hired labor	฿	240		1,290		450		1,680		3,660		11,340	
Land tax[a/]	฿	125		125		185		185		185		185	
Interest[b/]	฿	175		225		190		260		845		1,180	
Net value of production before project charge	฿	11,013		17,765		16,060		28,390		28,320		55,455	
Project charge													
On-farm development cost[c/]	฿	-		-		-		-		4,075		4,075	
O & M cost[d/]	฿	-		-		-		-		525		525	
Net value of production after project charge	฿	11,013		17,765		16,060		28,390		23,720		50,855	

* Rounded to nearest ฿

a/ Present ฿ 8/rai, future ฿ 12/rai

b/ Interest charged at 6% (1% per month). It is assumed that 50% of farmers borrow 80% of their cash needs at present and 80% would borrow 90% of their cash needs in future

c/ ฿ 1,630/ha

d/ ฿ 210/ha

Figure 8 - 1 Typical Opportunity Cost Curves For Farm Labor

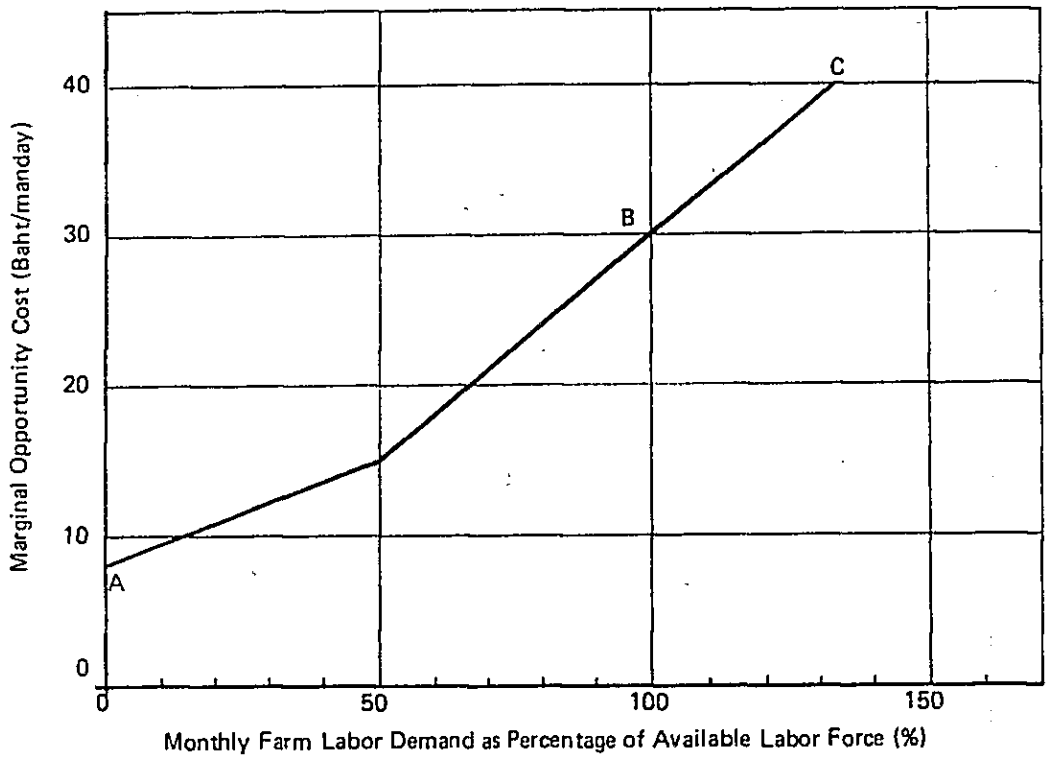
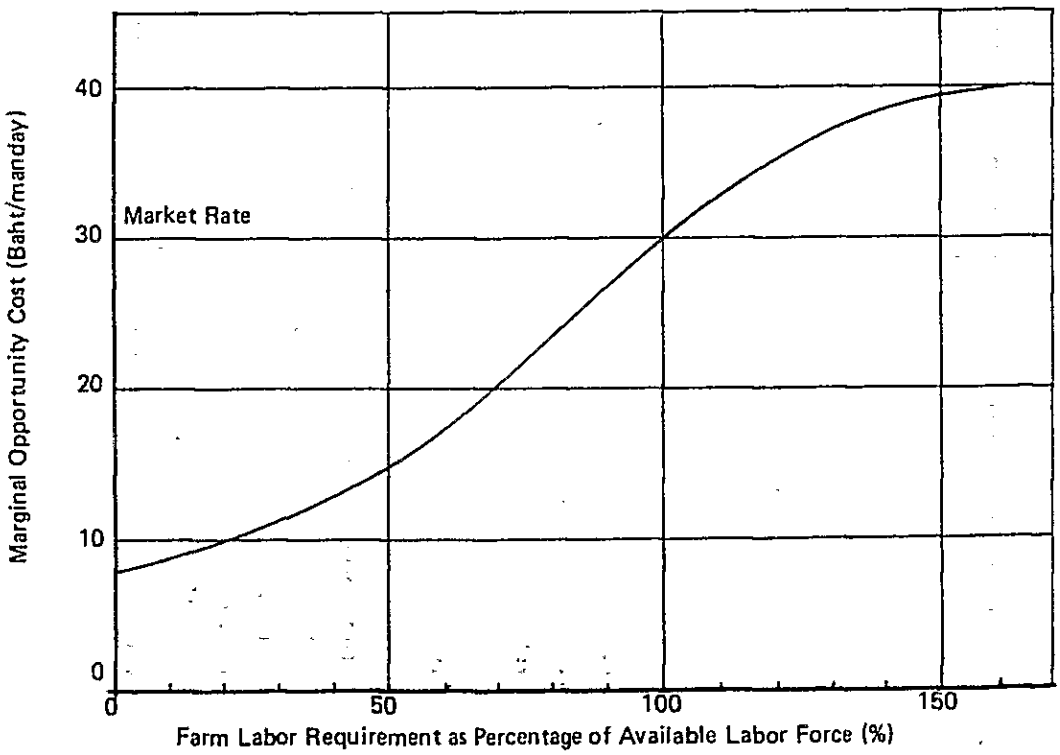


Figure 8 - 2 Opportunity Cost Curves For Farm Labor



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