4.2 Water Resources Development Plan

4.2.1 Surface Water Development Plan

(1) Run-off condition

Nong Khon Kaen

In this area, groundwater is available as a supplemental irrigation water. But, effective use of run-off shall be required to control withdrawal of groundwater. Amount of run-off and rainfall are as follows.

	Annual	Apr. to Aug.	Sep. to Nov.
Rainfall (mm)	1,259	759	452
Run-off (MCM)			
-Noi canal	1.9 - 12.9	0.9 - 6.3	1.0 - 8.6
(Average)	(5.4)	(2.5)	(2.7)
-Ban Mai canal	2.9 - 20.3	1.3 - 10.0	1.5 - 13.5
(Average)	(8.5)	(4.0)	(4.3)

Thung Sai Yart

In this area, water resources for irrigation is surface water and rainfall. These amounts are estimated as follows.

	Annual	Apr. to Aug.	Sep. to Nov.
Rainfall (mm)	1,035	572	429
Run-off (MCM)	19.4 - 57.6	8.5 - 21.2	10.6 - 36.5
(Average)	(40)	(18)	(22)

In this both areas, storage facilities shall be required to use run-off water effectively.

(2) Scale of storage facility

1) Basic concept

The purpose of storage facility is to secure initial water requirement for wet paddy and to extend irrigable area in dry season by using storage water retained at the end of wet season. Scale of storage facility, therefore, is planned based on relation between excess run-off available and extension of irrigable area. Apart from the hydrological conditions, the following constraints are considered from viewpoint of facility construction.

- Taking account of the present flat topographic condition, it will be impossible to construct a large-scale storage facility with full operation throughout the year in the study areas. Surface water, therefore, is stored by some small ponds.

- The larger is capacity of storage pond, the less is utilization efficiency of storage facilities, due to uncertain amount of run-off.

- From viewpoint of land loss for public facilities, area for storage facilities will be limited at 1.0 to 2.0 % of whole area.

- Existing swamps and ponds are usable as a water storage facilities, by means of dredging.

Irrigation water is supplied from ponds to field by two alternative ways:

Plan (1); It is supplied by dual purpose canal leading to pond without any control. Water is lifted by portable pump to field by farmer.

Plan (2); It is lifted by public pump installed at pond to irrigation canal. Lifted water is conducted directly to field by gravity. Effective depth and available volume of pond is larger than the plan (1). But, water management

group is required for fair operation and management of the pump.

Application of these ways has to be examined under the conditions on possibility of water management by farmer in future farming practices. In examination on development model, plan (1) is applied in model (1) and (2), and plan (2) is applied in model (3), taking account of close relation to the composite agricultural infrastructure development.

2) Scale of storage facility

Nong khon Kaen

As a result of water balance study, relation between storage capacity and irrigable area is as follows.

- In Noi canal, maximum irrigable area for wet paddy is around 550 ha with available storage volume of around 0.7 MCM in a normal year, on the assumption that run-off is used effectively during the initial stage of paddy growing.

- In Ban Mai canal, larger scale pumping station is necessary to extent irrigable area due to low-lying canal. In case of portable pump by farmer, irrigable area is limited at around 250 ha along the canal.

Therefore, from viewpoint of amount of water resources available, scale is considered as follows.

- In Noi canal, for the purpose of supplemental water supply for wet season, its scale may be planned at less than 0.7 MCM. In Ban Mai canal, run-off may be utilized effectively by means of large scale pump in wet season regardless of capacity of storage ponds.

- For the purpose of extension of irrigable area in dry season, capacities may be planned at around 2.7 MCM in Noi canal system

and at around 4.3 MCM in Ban Mai canal system.

On the other hand, procurable land may limited at less than 10 to 15 ha in line with the public land for other projected facilities, based on the above consideration, its scale, therefore, is planned at 1.0 to 1.5 MCM.

Capacities by development model are planned as shown in Table 4-4.

Model-2 is applied based on overall examination of development planning (Refer to 4.4).

Storage facilities are consisted of canals and ponds. As a result of study, eleven storage ponds including dredging of the existing swamps are planned and three of them have function as a fishery pond.

It is desirable to dredge around 6 km in length of the canal upstream from the road No. 12 to conduct run-off water smoothly into the study area. In this case, however, it is necessary to make arrangement on intake water with the beneficial farmer along the canal.

Thung Sai Yart

As well as the Nong Khon Kaen, relation between storage capacity and irrigable area has been examined as follows.

- In a normal year, maximum irrigable area is assumed at around 50 to 55 % of whole area, with around 5 MCM of available storage capacity and effective use of run-off at the initial stage of wet season. And, the less is available storage capacity, the less is irrigable area.

- Irrigable area in dry season is dependent on amount of storage water at the end of wet season. Its available amount is estimated at less than around 20 MCM in a normal year, based on run-off analysis.

Table 4-4 Relation between Irrigable Area and Storage Capacity

(Nong Khon Kaen)

Condition	Wet season			Dry season			Surface water storage	
	Irrigable area		Necessary pumping discharge (MCM)	Irrigable area		Necessary pumping discharge (MCM)	Total storage capacity (MCM)	Effective storage capacity (MCM)
	Paddy (ha)	Upland (ha)		Paddy (ha)	Upland (ha)			
Current condition	1,025	24	1.7	490(140)	-	4.3(1.3)	0.43	0.19
Model-(1)	960	70	1.4	-	290	1.6	0.65	0.51
Model-(2)	900	70	0.7	-	410	2.3	0.94	0.71
Model-(3)	900	70	0.2	970		6.0	1.16	0.98

Note: ( ) : Case that the existing pumping discharge is controlled at 3 MCM.
In the model-(3), pumping discharge is expected at more than 6.0 MCM for full irrigation.

(Thung Sai Yart)

Condition	Surface water storage		Irrigable area (ha)			
	Total capacity (MCM)	Effective capacity (MCM)	Wet season		Dry season	
			Paddy	Upland	Paddy	Upland
Current condition	2.4	1.4	200	-	-	-
Model-(1)	2.6	1.9	2,000	-	-	340
Model-(2)	5.0	3.9	2,600	-	-	700
Model-(3)	9.9	8.9	3,100	-	-	1,900

Note: In current condition, irrigable area is limited due to no supply canals from main stream to fields. In each model, irrigable area is based on the assumption that supply canals from storage facilities to fields are provided.

Range of available total capacity, therefore, may be planned at less than 5 MCM for stable water supply of wet paddy and at less than 20 MCM for extension of dry season cropping.

And, storage capacities by development models are planned as shown in Table 4-4, in relation to the other development components and constraints. And, the following problems on surface water development are considered.

- Amount of run-off fluctuates year by year. Therefore, utilization efficiency of pond is lower in case of large capacity pond.

- And, run-off characteristics may be changed by water resources development projects in the upstream basin.

Based on the above consideration, storage capacity is less than 5 to 6 MCM, which is consisted of ponds and canals. As a result of study, sixteen ponds are planned and four of them have function as a fishery pond.

(3) Inland fishery pond

In the both areas, fish culture is practiced by using storage ponds as a side job of agriculture. Inland fishery available in this region, is Nile Tilapia, Common Carp, Thai Carp, Rohu and Chinese Carp, according to the Department of Fishery. Rearing period of these fishes is nearly one year, of which fingerling are to be obtained through DOF in Sukhothai or Phitsanulok. And, excretion of livestock and rice bran are useful as a feed. Ponds shall be planned at the location of easy intake and no flooding, in which no contamination by agricultural chemicals occurs.

4.2.2 Groundwater Resources Development

(1) Nong Khon Kaen

In this area, many aquifers are found and then groundwater resources are relatively abundant. But groundwater level is falling year by year due to overpumping. Therefore, current pumping discharge should be restricted to be less than around 3 MCM of annual recharge.

In this area, there are many aquifers of Pleistocene under Alluvium. But, there is, at present, a little pumping from Pleistocene aquifers as domestic water. Volume of recharge and withdrawal available in this aquifer is unable to be assumed due to insufficient investigation data. But, in Sukhothai Groundwater Development Project (Phase I) in Sawankhalok, 104 deep wells serves for irrigation area of 5,600 ha, under discharging approximately less than annual 40 MCM.

Under the above situations, the following alternative are considered.

Plan-(A); The existing shallow wells are used as they are. But, annual pumping discharge is controlled at less than 3 MCM. In this case, adequate management of pumping shall be required.

Plan-(B); The existing shallow wells are being used as they are, without any control. In this case, construction and rehabilitation of wells and their intake facilities are being repeated by farmer as groundwater level falls.

Plan-(C); Some of public deep wells are constructed to cope with current irrigation demand, of which pumping discharge is expected at more than 3 MCM. In this case, public and private wells are mixed in this area.

Plan-(D); New deep wells are constructed in whole area, which takes discharge from both of shallow and deep aquifers. The existing wells will be closed in order.

Comparison of the above plans is shown as follows:

Plan	Advantage	Disadvantage
(A)	- It's favorable from viewpoint of groundwater management. - less influence to surrounding area	- Difficult to control pumping
(B)	- Same condition as the present.	- Falling of groundwater. - Increase in heavy burden by farmer for improvement of well.
(C)	- Stable water supply	- Fair water management is difficult due to existence of private and common use wells.
(D)	- Stable and sufficient water supply.	- Much influence to groundwater development in surrounding area. - Water management is indispensable.

In the above plans, the (B) is not adopted from viewpoint of groundwater management of shallow well. And, in case of the (C), fair operation and management may not be realizable because of mixed wells. Therefore, (A) and (D) are examined in line with agricultural infrastructure development planning. As a result of study, plan-(A) is applied.(Refer to 4.4).

(2) Thung Sai Yart

Groundwater use for irrigation is currently, not available in this area due to poor aquifer and groundwater resources, according to the result of the test wells and the existing data. It would be, however, possible to expect the discharge from 500 to 1,000 m^3/day from a new deep well, such as the result of test well JT-3. But it is, at present, difficult to limit their specific area with a boundary, because of the lack of groundwater survey. Groundwater use for irrigation, therefore, is not planned in this area.

It is possible to use groundwater for domestic use.

4.3 Agricultural Development Plan

4.3.1 Land Use and Zoning

(1) Land Use

When irrigation and drainage facilities are to be provided in both the study area, the farm land can be alternately used as both paddy and upland fields, from view point of soils in the study areas. Therefore, it is planned to utilize whole farmland as paddy field, except those areas of presently non-cultivable area and for facilities to be newly constructed under the project.

(2) Zoning

The study areas of Thung Sai Yart and Nong Khon Kaen are extending over 33,535 rai (5,365 ha) and 7,283 rai (1,165 ha), respectively. Within these areas, there exist physical and socio-economic differences from part to part. Therefore, it is considered more effective to formulate development plans, taking those speciality prevailing by part into account. In this study, the following physical conditions are taken into account for the zoning;

	Thung Sai Yart	Nong Khon kaen
First Division	1. Western high portion (Over El. 64 m)	1. Northern half (North from high tension line)
	2. Middle portion (El. 58 - 64 m)	2. Southern half (South from the line)
	3. Eastern low portion (Below El. 58 m)	
Second Division	1. Northern part of Sai Yart canal	1. Westside of Noi canal
	2. Between Sai Yart and Wan Tong Daeng canals	2. Eastside of Noi canal
	3. Southern part of Wan Tong Daeng canal	

4.3.2 Crop Selection

(1) Purpose

In order to attain an increase in farm income as the final target of the Project, the crops to be grown in the Area shall be selected to maximize the farm land utilization taking into account the most effective and efficient use of limited water resources, labor forces, the most favourable conditions for crop husbandry in the Area, etc. The wet season paddy cropping, which is the dependable income source of the local farmers, will be vitally important for the both areas in the future as well. Furthermore, the local farm income increase is expected by keeping the paddy yield stable as well as decreasing production cost. In the dry season, upland cropping shall be practiced in the better use of groundwater, surface water and residual moisture in the soils.

(2) Primary selection

Study for crop selection has been made in the premise as follows, in view of local suitability of various crops to be applicable in the area.

- those crops which will be little affected by fluctuating market conditions in their prices throughout the year,
- those crops which will be well-suited to the local soil conditions are free from troubles by consecutive cropping and can maintain/increase soil fertility,
- those crops which will not overlap with preceding paddy cropping in the man power mobilization, and can make farm machinery use more efficient resulted in lower production costs,
- those crops which the Provincial Experimental Station or any other Research Institutes can give constant technical assistance to farmers in their cropping.

1) Soybean

In Sukhothai, soybean is one of the representative upland crops, having average yield of 1.27 ton/ha. And appropriate fertilization and other well-managed farming works will enable to increase the figure to 1.8 - 2.0 ton/ha. In other respect, Sukhothai Province

produces almost one quarter of the national total of soybean with stable producers' price of 6.5 Baht/kg on five-year average basis. The troubles with consecutive cropping of soybean will be avoided with combination of wet season paddy cropping.

On the other hand, soybean plant residues in the fields after harvesting will be plowed into soils to make soils fermented and fertilized, and dosage of nitrogen fertilizer will could be economized.

2) Mungbean

Mungbean is another representative crop in Sukhothai Province. It has a wide range of demand throughout the nation. Mungbean as a legume is well-suited to the paddy field soils of the areas.

The average yield of Mungbean is about 0.7 ton/ha and appropriate fertilization and well-managed farming works will enable to raise its yield to 1.2 - 1.8 ton/ha.

3) Groundnut

Groundnut has a large demand throughout the country, and further extension of this crop is expected in the Saraburi Series and Ban Dan Series soils if the irrigation water be ensured. The Province produces groundnut by 1.45 ton/ha in yield, occupying about 105 % of the national production. The average producers' price is about 6.3 Baht/kg on the five-year average, which is considered reasonable. The nationwide demand is expected to be expanded in future as well.

(3) Secondary Selection

The cropping items and acreages based on the proposed cropping pattern for the both areas will be restricted to a certain extent due to the limited available water resources and various soil conditions.

Screening the candidate crops should be made on the study of those crops expected by farmers and those experienced already as the results of

Farm Survey Conducted under the Project as well as consideration of opinions given by the related provincial officers. Finally, the crops to be introduced have been selected by areas as follows:

(1) Nong Khon Kaen Area

Soybean
Vegetables (Leaf vegetables & fruit vegetables)
Orchard (Mango, Coconut, Bamboo Shoots)

(2) Thung Sai Yart Area

Soybean
Orchard (Pomelo, Lemon, Jackfruit)

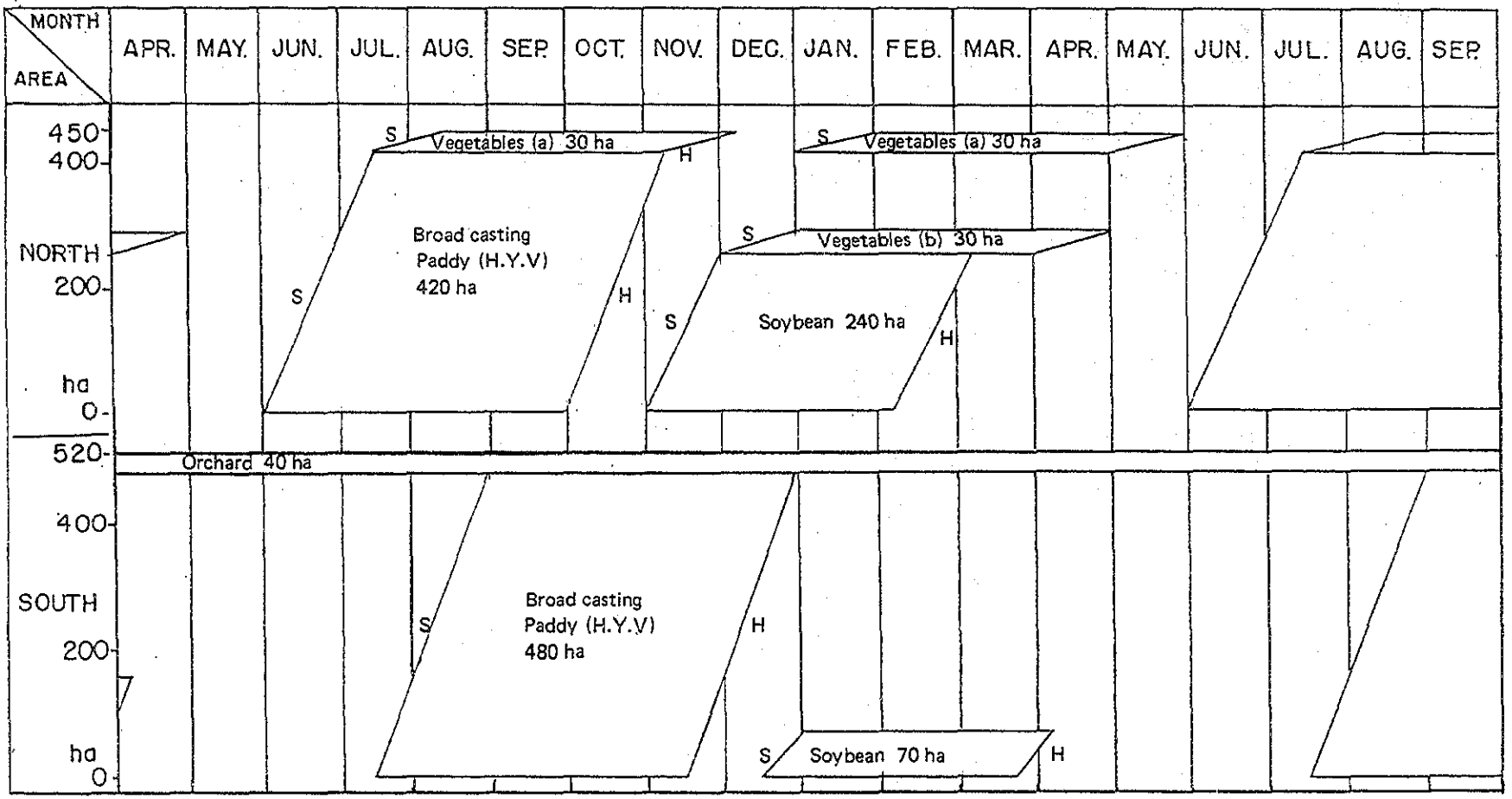
4.3.3 Proposed Cropping Pattern

(1) Nong Khon Kaen

The proposed cropping pattern is illustrated in Figure 4-2, and the cropping plan is made for the blocks which shall be developed by dividing the area into two, the north and the south, and irrigation shall be practiced not by traditional free irrigation from shallow wells, but by planned irrigation for the blocks.

The wet season paddy shall be cropped with storage irrigation and pumping irrigation from shallow wells and HYV shall be introduced for the whole area with broadcasting sowing under irrigation in considering river improvement works to be completed in the Ban Mai canal which will bring the south block free from inundation damages. While, cropping in the dry season shall be of pattern with vegetables, and soybean to be introduced into the north block and only soybean shall be cropped in the south block. And on the right bank of the branching point of Noi canal, orchard shall be developed.

The cropping acreage for the dry season will be fully dependent upon proper pumping amount by the existing shallow wells.



REMARKS : S.....SOWING H.....HARVESTING

Figure 4-2 PROPOSED CROPPING PATTERN FOR NONG KHON KAEN

(2) Thung Sai Yart

In the area, since crop husbandry fully depends its water sources upon farm pond water from surface run-off and residual moisture contents kept in the soils, the proposed cropping pattern has to be the wet season paddy and dry season soybean, all of which shall be grown in the limited beneficial fields of such water resources. The proposed cropping pattern for the area is illustrated in Figure 4-3, and the wet season paddy shall be introduced for the whole area in transplanting method. And the effective and efficient irrigation water use shall be ensured by practicing irrigation from the upstream western part to the downstream eastern part in order.

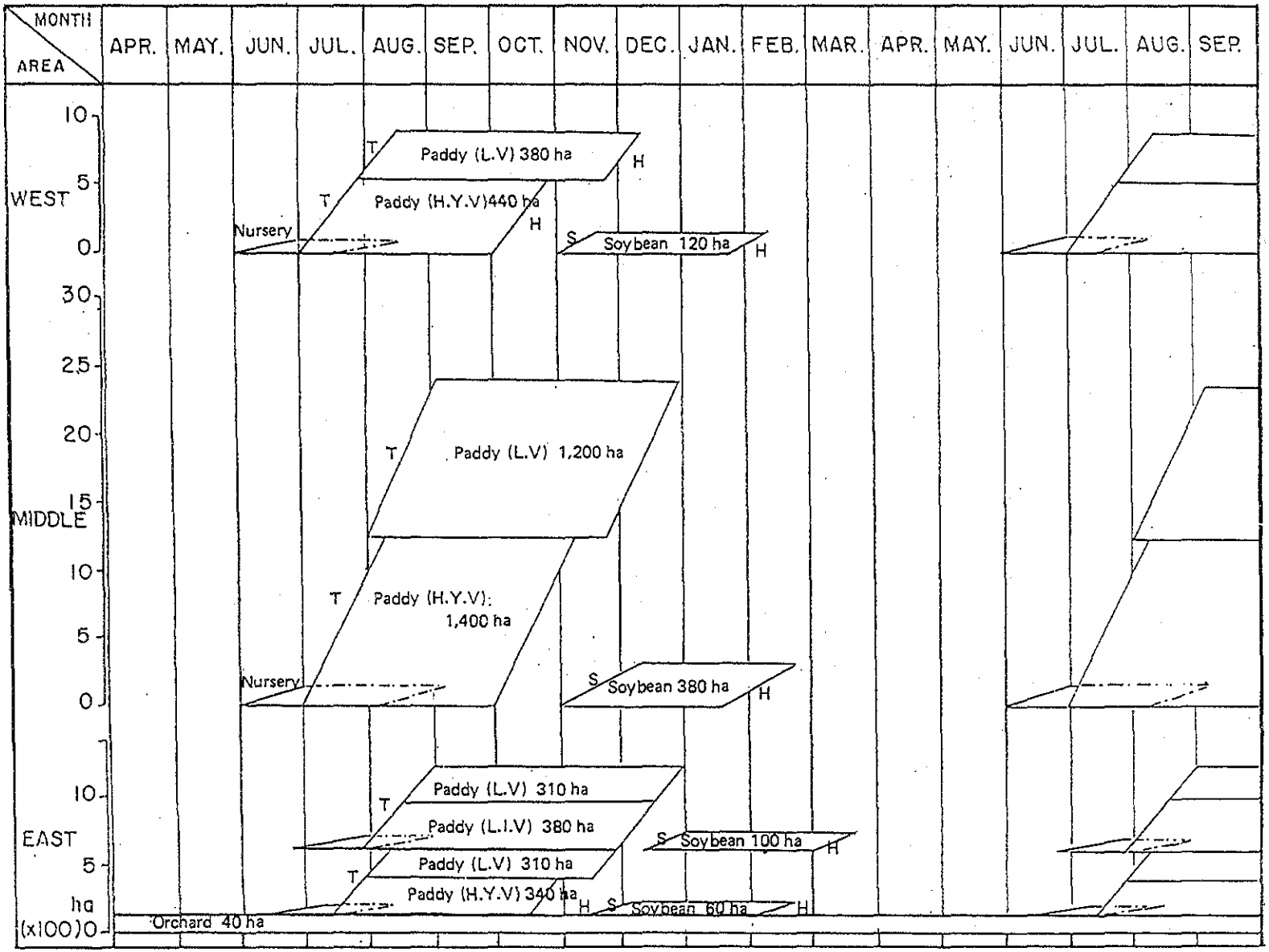
Nursery shall be made in common fields by blocks in taking into account the conditions for effective irrigation for adopting common variety and overall water management. The paddy varieties proposed for each area are HYV for all irrigable fields, and LIV for the eastern part with inundation to various extent so that all of these varieties can have bumper of harvest.

For the dry season cropping, soybean cultivation after paddy shall be introduced in taking into consideration the conditions of irrigation and soil suitability. In the eastern part as well, the well-drained field shall be planted with fruit-trees to form production group.

4.3.4 Farming Pattern and Farm Mechanization

(1) Farming Practice

The cropwise work volume and required labor for the cropping of the proposed cropping practice in the both areas are shown as follows, while those by areas and crops are shown in Appendix C-2.



REMARK : S.....SOWING T.....TRANSPLANTING H.....HARVESTING

Figure 4-3 PROPOSED CROPPING PATTERN FOR THUNG SAI YART

Labor Supply and Requirement

Areas	Monthly Work Vol. (Man/day)	Annual Work Vol. (Man/day)	Max. Labor Requirement (Man/day)	Working Time (Month)	Annual Labor Requirement (Man/day)
N.K.K	27,324	327,888	13,050	10	80,990
T.S.Y Amp. Muang	43,676	524,112	43,350	8	285,150
T.S.Y Amp. B.D.L.H.	22,143	265,716	18,140	10	59,390

The maximum monthly labor requirement appears in those months from August to October. The maximum labor requirement to the monthly work volume by areas is about 48 % in Nong Khon Kaen, 99 % in Amphoe Muang and 81 % in Amphoe B.D.L.H. in Thung Sai Yart, respectively.

The farming pattern by proposed cropping pattern will be as follows by areas.

Areas	Farming Pattern (Average Cropping Area in ha)
North N.K.K	Paddy (2.5) + Soybean (0.9) Paddy (2.5) + Vegetables · b (0.9) Vegetables · a (Wet Season (2.5) + Dry Season (0.9))
South N.K.K	Paddy (2.5) + Soybean (0.9) Paddy (1.6) + Fruit trees (0.8)
West T.S.Y	Paddy (4.4) + Soybean (1.2) Paddy (4.4)
Middle T.S.Y	Paddy (4.4) + Soybean (1.2) Paddy (4.4)
East T.S.Y	Paddy (4.4) + Soybean (1.3) Paddy (3.4) + Fruit trees (1.0) Paddy (4.4)

(2) Farm mechanization

Farm mechanization for the both areas has been studied, taking into account the proposed cropping pattern, most effective and efficient use of the farming machines present available for the wet season paddy

cropping, upland cropping to be introduced, and demand-and-supply balance of labor (Refer to Appendix C-2).

- Paddy cropping

  Nong Khon Kaen: Introduction of HYV for the whole area will enable to shorten the cropping period by about 20 days, and the labor allocation will become easy owing to widening of cropping interval. With broadcasting in flood fields diffused, short paddy varieties can be introduced and manual sickling works at low point of plants from the ground. Such works will result in efficient harvesting by preventing paddy plants from lodging so as to avoid competition of farming labor allocation with easy treatment of residual paddy hills in the fields.

  · Plowing and puddling: Small-size farming machines shall be used for land preparation in the fields, and effective water management shall be made with simple equipment like fields ditches with control boards, and so forth.

  · Pest and weed control: Manual works for granular chemicals will be promoted, but shoulder type power sprayers shall be planned to be introduced.

  · Harvesting and post-harvesting works: Introduction of HYV will enable to practice harvesting and post-harvesting works as sickling paddy plants nearer to the ground - air-drying - threshing in general way. In future, however, binding - air-drying - power threshing system shall be planned along with the proposed cropping pattern.

  Thung Sai Yart: The limited irrigation water resources will be restrictive for introduction of HYV cropping, and the collective nurseries for transplanting shall be encouraged. For the irrigated fields, the harvesting and post-harvesting works shall be improved to introduce the proposed cropping pattern successfully in the same way as that in Nong Khon Kaen.

- Upland cropping

Soybean will be introduced to the both areas in taking into consideration the most effective and efficient use of paddy farming machines as well as the best use of the land available. Due to clayey soils, however, it is difficult to adopt 10 PS machines in the dry condition of the soils. And, the medium-size tractor (5 PS) can be applied to secure the works of plowing in the dry conditions so as to have more adequate sowing ensured. Small-size machines will enable to practice those works of plowing, crushing, leveling, sowing, covering, etc. For the proposed cropping pattern, the existing small-size farming machines are planned.

- Plowing, crashing and leveling: The fields shall be irrigated prior to plowing. The paddy fields in Thung Sai Yart shall be irrigated by flooding with surface flow water in the end of the wet season.

- Sowing: Sowing works will be made by machines with attachment of roll or disk, for the proposed cropping pattern.

- Pest and weed control: Using by shoulder type power sprayers shall be promoted cooperative control mechanical tissue.

- Harvesting works: Sickling will be made in manual works, and harvesting works shall include sickling - drying - threshing (thresher) in the order. The threshers will be operated on the rental basis in the same way as milling machines. Reduction of milling losses shall be secured by introducing less breakable varieties like Nakhon Sawan No. 1.

- Milling works: The large-size milling facilities have already been provided in Sukhothai City, and functional operation of these facilities shall be further studied in the detailed design stage.

- Vegetables and fruits

It is expected to introduce mechanized plowing and land

arrangement for dry season vegetable cropping in the Nong Khon Kaen area with clay loam soils in the Saraburi Series. And for pest and weed control, a further study will be required in the detailed design stage for introduction of large-size fixed type power sprayers (5 - 7 PS).

4.3.5 Crop Yield and Production

The present crop production found by the economic farm survey and that based on the proposed cropping pattern are shown as follows. And the crop production by models are presented in Tables 3-3 and 3-4.

Yield and Production

Crops	Present			Proposed		
	Cropping Acreage (ha)	Yield (t/ha)	Product (t)	Cropping Acreage (ha)	Yield (t/ha)	Product (t)
Paddy						
Broad. & Trans.(LV)	469	2.2	1,063	-	-	-
Broad. & Trans.(HYV)	556	3.3	1,835	900	4.9	4,410
	489*1	4.6	2,249	-	-	-
Sub-total	1,514	3.3	5,147	900	4.9	4,410
Soybean	24*2	1.0	24	310	1.8	550
Vegetables (Leaf vegetables)	-	-	-	60	18.0	1,080
Vegetables (Fruit vegetables)	5*3	23.0	115	30	23.0	690
Fruits (Mango, etc.)	-	-	-	40	15.6 *4	620
Total	1,543			1,340		

Note: *1 ... Dry Season Paddy *2 ... Mungbean *3 ... Watermelon
*4 ... Fruit-trees grown by six-year-old and over.

The proposed land use rate of Thung Sai Yart is about 113 % with 4,800 ha of arable land included.

Crops	Present			Proposed		
	Cropping Acreage (ha)	Yield (t/ha)	Product (t)	Cropping Acreage (ha)	Yield (t/ha)	Product (t)
Paddy						
Transplanting (LV)	5,021	1.0	5,021	1,890	1.2	2,260
				310*1	2.5	770
Transplanting (LIV)	-	-	-	380	3.4	1,290
Broadcasting (HYV)	-	-	-	2,180	4.2	9,150
Sub-total	5,021	1.0	5,021	4,760	2.8	13,470
Soybean	44*2	1.2	52	660	1.8	1,180
Fruits (Pomelo, etc.)	-	-	-	40	15.6 *3	620
Total	5,065			5,460		

Note: *1 ··· By drainage improvement *2 ··· Mungbean
*3 ··· Fruit-trees grown by six-year-old and over.

The proposed crop production will be as follows by crops: paddy increases by about 9,900 ton, and soybean by 1,700 ton. The proposed vegetable production is worked out in view of favourable soil conditions found in Nong Khon Kaen, improvement of irrigation and drainage, demand-and-supply balance of labor, etc. These products will be forwarded to the consumer's market of Phitsanulok City under systematic production groups of each crop.

Farming technology of the crops shall be extended to the local farmers through feed-back of verified results at each pilot farm. And the technology innovation will be made on the following items in future (Refer to Appendix C-2).

- For direct sown paddy in flooded fields, the study shall be made on water control ditches for successful and stable sowing, germination, nursing, etc.

- For paddy harvesting, the study shall be made on appropriate fertilization for preventing lodging with short stem HYV as well as harvesting rich and substantial grains.

- For pest control, study shall be made on encouragement of pest and

insect control in stem borer, etc. so as to have rich panicles with substantial grains.

- For transplanting, the study shall be made on shallow planting with density of 16 hills per square meter and on transplanting with young healthy seedlings of 25 - 30 days of age so as to expedite good growth.

- For soybean varieties, the study shall be made on collective introduction of superior varieties of Nakong Sawan No. 1 and Sukhothai No. 1 as recommended varieties.

- For soybean sowing, the study shall be made on introduction of two-row sowing machines so as to enable to sow and fertilize at the same time with planting density of more than 5 hills per square meter with two rows.

- For vegetable cropping, the study shall be made on straw mulching so as to prevent soil moisture from evaporation in the middle term of plant growing.

- For vegetable and fruits tree cropping, the study shall be made on mulching after flowering stage to protect plants from drought damages as well as from insects in bearing stage.

For pilot farm, well-irrigated and -drained fields shall be selected as pilot farms to make various studies and researches with appropriate on-farm facilities like drains, etc. so as for groups of farmers to make direct investigation and study for new technology.

4.4 Agricultural Infrastructure Development

4.4.1 Basic Development Component

(1) Nong Khon Kaen

As a result of the study, the following improvement shall be required for better agricultural production activities.

- Dredging of Noi canal and construction of weirs for both purposes of drainage and canal storage.
- Dredging of the existing swamps for water storage and inland fishery.
- Construction of dike and sluice gates at terminal points in the Ban Mai canal for protection of flood intrusion from downstream area.
- Construction of farm roads and canals for better farming activities.
- Construction of storage ponds for saving pumping discharge from the existing shallow wells.
- Construction of deep wells as a stable water resources.
- Land leveling for adequate water control.
- Re-allocation of farm plot for effective farming practices.

Development planning includes all or some of the above components, taking account of the present constraints from viewpoints of agricultural development.

Alternative Planning

Scale of development have to be examined, based on the proper investment cost, impact to the surrounding agriculture, capability of farming technique and organizing possibility by farmer after improvement. Therefore, alternative development models has been studied as follows.

In each model, rate of land loss for new construction of public facilities is planned to be less than 7.0 % of whole agricultural land.

Model-(1);

- As a basic improvement of physical condition, (a)Dredging of Noi canal and construction of weirs, (b)Dredging of the existing swamps, (c)Construction of dike and sluice gates at Ban Mai canal, (d) Construction of additional farm roads, are carried out.

- The existing shallow wells are used, under control of annual pumping discharge at less than 3 MCM.

- Farming practices will be unchanged due to no improvement in field. Plot-to-plot irrigation and drainage are applied as the present, by using storage water in the improved swamps and canal. Therefore, beneficial farmer is limited in the vicinity of improved facilities.

Model-(2);

- In addition to the Model-(1), farm roads, canals and ponds are constructed in field. Storage ponds are not provided with pumping stations and water supply is conducted by dual purpose canal leading to ponds. Therefore, irrigation water will have to be lifted from canal to field by portable pump.

- Beneficial farmer and irrigable area are extended along the constructed canals and roads more than the Model-(1).

- The existing wells are used at less than around 3 MCM, as well as the Model-(1).

Model-(3);

- New deep wells are constructed as described in para. 4.2.2. Pumping discharge is expected at more than 6.0 MCM.

- Road and canal networks are required at higher density than the other models, because of operation and maintenance of public wells

and fair water distribution.

- And, plot realignment and land leveling are also required not only for better farming practices but also for equal water allocation by public wells. Whole farmer benefits equally after implementation.

- But, water use groups shall be needed for practice of fair water allocation by using public wells.

Comparison of each model is summarized in Table 4-5. Approximate construction cost is estimated at 2,500, 5,100 and 25,400 baht per rai and rate of land loss is assumed at 2.0, 7.0 and 7.0 % in Model-(1), (2) and (3), respectively. As a result of examination, Model-(2) is proposed based on the following consideration.

- This improvement level is not attended with outstanding contrast to the surrounding agricultural infrastructure.

- More intensive groundwater development such as the Model-(3) will be possively implemented later on a more economical basis.

- Water use groups is reliable, considering that management activities accompanied with facility improvement will be easy for beneficial farmers.

- Investment cost is moderate, compared with the other relevant projects.

(2) Thung Sai Yart

As a result of the study, the following components shall be considered as a basic improvement.

- Dredging of the existing canal for both purposes of drainage and water storage.

- Dredging of the existing swamps for water storage and inland fishery.

- Construction of drainage facilities under the road 1113 to cope with flooding.

Table 4-5 Comparison of Development Model

Model	Advantage	Disadvantage
Nong Khon Kaen		
Model-(1)	- Construction cost is low. - Partial flood condition is improved. - Water use group is unnecessary.	- Agriculture condition is almost same as the present. - Difficult to control pumping.
Model-(2)	- Flooding condition is improved. - Activities of water use group is easier than the model-(3).	- Surface water is unstable. - Utilization efficiency of pond may be low due to uncertain seasonal run-off. - Difficult to control pumping. - Procurable area for new pond.
Model-(3)	- Capable of providing future mechanization and extension of irrigated agriculture. - Water supply is stable.	- Construction is highest. - Water use gruop is indispensable. - Water management activities is most hard. - Utilization efficiency of pond may be low due to uncertain seasonal run-off.
Thung Sai Yart		
Model-(1)	- Construction cost is low. - Partial flood condition is improved. - Water use group is unnecessary.	- Agriculture condition is unchanged. - Water resources for irrigation is still unstable as ther were.
Model-(2)	- Flooding condition is improved. - Activities of water use group is easier than model-(3).	- Procurable area for new pond. - Land loss is much than the model-(1).
Model-(3)	- Flooding condition is improved. - Capable of extending irrigated agriculture.	- Utilization efficiency of pond is lowest due to uncertain seasonal run-off. - Water use group is indispensable. - Construction cost is highest. - Procurable area for pond.

- Construction of farm roads and canals for better farming activities.

- Construction of storage ponds for stable water supply in wet season and extension of dry season cropping.

- Land leveling for effective farming practices and plot realignment for procurement of the various public facilities.

Development planning includes all or some of the above components, as well as the Nong Khon Kaen.

Alternative Planning

Alternative development models have been examined as well as the Nong Khon Kaen.

Model-(1);

- A basic facility for better farming practices, (a)Dredging of the existing canals and swamps, (b)Construction of additional farm roads, (c)Construction of drainage facilities under the road 1113, are planned.

- Borrow pits, improved canals and weirs constructed across the canals are used as they are, a water resources facilities.

- Poor drainage area exists because of no drainage canal within the field.

- Beneficial farmers are so limited along the canal of the irrigable area.

Model-(2);

- In addition to the Model-(1), construction of new ponds, farm roads and dual purpose canals, are planned.

- Irrigation water is lifted by portable pump and plot-to-plot irrigation is applied.

- After improvement, available capacities of ponds and canals extends irrigable area more than the Model-(1).

Model-(3);

- New ponds with pumping station are constructed along the canal, of which available capacity is larger than the model-(2). Irrigation water is supplied to field by irrigation purpose canals.

- In this model, water use groups should be organized by beneficial farmer to operate and manage the pumping station of ponds.

Comparison of each model is shown in Table 4-5. Same as the Nong Khon Kaen, approximate construction cost is estimated at 1,600, 5,700 and 18,100 baht per rai and rate of land loss is assumed at around 1.0, 5.0 and 6.0 % in Model-(1), (2) and (3), respectively. As a result of study, model-(2) is proposed as well as the Nong Khon Kaen, taking account of construction cost, organizing possibility and impact to the surrounding agriculture condition.

4.4.2 Irrigation System Planning

(1) Nong Khon Kaen

In this area, irrigation agriculture shall be practiced in whole area with the existing shallow wells and constructed water resources facilities. For the purpose of that, dual purpose canals are planned to connect with constructed ponds as a irrigation facilities. Four irrigation blocks are planned, considering the topographic condition and road network. But their boundaries are undefined due to conservation irrigation method with connected ponds and canals. In a block, stored surface water may be used preferentially and pumping from shallow wells is controlled possibly, though the distribution of the existing wells is different in each blocks.

Irrigation method is the same as the present, that is, lifted water from the wells is supplied directly into each farm. Storage water

shall be conducted from pond to canal and lifted by portable pumps of farmers from canal to field. In the field not adjacent to canals, irrigation water is supplied by plot-to-plot irrigation.

Amount of pumping discharge from the wells shall be controlled at around 60 % and 47 % of the present in wet and dry seasons in a normal year, since surface water is available with the ponds.

(2) Thung Sai Yart

Limited water resources restricts irrigation agriculture to partial area along the water resources facilities, as mentioned in 4.4.1. Remainder of agricultural land is forced to be rain-fed field. Scale of both areas is deferent year by year in accordance with available amount of seasonal run-off and rainfall. Irrigation method is the same as the Nong Khon Kaen, in which irrigation water is lifted by portable pump. In most of fields, however, plot-to-plot irrigation may be applied. Return flow from upper field is expected as a supplemental water, considering the topographic condition with uniform gentle slope. Canals as a storage facility, therefore, are planned at the lower area in the irrigation block to be capable of repeating water use for downstream block.

Irrigation area is divided into nine blocks, considering road network and the location of existing canals. Their boundaries, however, are undefined each other due to conservation irrigation as same as the Nong Khon Kaen.

(3) Calculation of water requirement

1) Potential evapotranspiration (ETp)

Potential evapotranspiration is estimated by Penman method used generally in Thailand and all climatic information at Phitsanulok observation station is applied.

2) Consumptive use of crop

Consumptive use of crops are estimated by the potential

evapotranspiration (ETp) and crop coefficient (K) by crop growing stages. Estimation has been carried out on a 10-day basis.

3) Field water requirement

Field water requirement is estimated on a 10-day basis under the following conditions and proposed cropping patterns.

- Percolation loss is taken as 1.5 mm per day, based on the soil characteristics.
- Water requirement for nursery bed is 300 mm at the 5 % of transplanting paddy cultivation area.
- Water requirement for land preparation is 180 mm for wet paddy. In case of dry season upland crops, preparatory irrigation shall be required for plowing before cultivation due to the hard soil. Residual soil moisture is available at the initial stage of crop planting of which period is from the end of rainy season to the middle of December based on the soil moisture sampling test. Preparation requirement is assumed at 60 mm for cropping in November and at 90 mm after November.

4) Irrigation water requirement

Irrigation water requirement is calculated based on the field water requirement, available rainfall and irrigation efficiency. Available rainfall is assumed at the rate of 60 to 90 % of monthly rainfall. Irrigation efficiency is applied at 60 %, considering irrigation system with earth canal, shallow well and utilization of portable pump.

Based on the above conditions, annual water requirement is estimated at 592 mm and 599 mm in Nong Khon Kaen and Thung Sai Yart, respectively (Refer to Appendix B-3).

4.4.3 Drainage System Planning

(1) Basic concept

Drainage problem is summarized as follows.

(a) Innundation occurs within whole area due to insufficient drainage capacity to cope with continuously intensive rainfall.

(b) In low-lying area, inundation occurs because of insufficient drainage facilities against intrusion of flooding from outside of study area.

New construction of drainage canal and improvement of the existing facilities to drain excess rainfall and peak drainage discharge, are required for the above problems.

1) Unit drainage discharge for new-construction of canal in the field

Related to paddy field, it is capable of retaining excess water by border. And, it does not suffer inundation damage if inundation depth and its duration are allowable for paddy growing. Therefore, design discharge is estimated, on the assumption that allowable inundation depth is 250 mm and its duration is three-day. In this study, three-day rainfall of 10-year return period is applied. And, unit drainage discharge is designed at 4.7 and 5.3 lit./s/ha in Thung Sai Yart and Nong Khon Kaen, respectively.

In upland, crops, excess water has to be drained rapidly without any severe inundation damage. Unit drainage discharge is estimated at 7.7 lit./s/ha in both areas, based on one-day rainfall of 10-year return period (Refer to Appendix B-3).

2) Peak drainage discharge of canal

Peak drainage discharge in lowest points of both areas is estimated by rational method and run-off simulation model. As a result of study, five-year peak drainage discharge is assumed at 10 m^3/s in Noi canal in Nong Khon Kaen and at 162 m^3/s in Thung Sai Yart.

(2) Drainage system planning

Nong Khon Kaen

Low lying cultivated land adjacent to Ban Mai canal is subject to flooding/inundation, which is brought about by insufficient drainage and intrusion of flooding by backwater from Yom river. High water level of Yom river in downstream of the study area is assumed at 40.0 to 42.0 m during about 1.0 to 1.5 months in flood season. Considering monthly rainfall of 200 to 300 mm, drainage benefit is expected by means of drain of excess rainfall and protection of flood intrusion from outside. For the purpose of that, the following measures are considered.

- New drainage canals are constructed in the field, based on the above unit drainage discharge.

- Noi canal is rehabilitated with peak design discharge of 10 m^3/s. In this case, its capacity is planned as it has storage function for irrigation use, with effective use of the present wide cross section.

- Dikes with elevation of 42.0 m and sluice gates at terminal points are constructed to protect backwater from Yom river.

Thung Sai Yart

Flood damage caused by inflow from upstream basin shall be reduced by means of rehabilitation of the existing facilities, as described in 3.4 of this report. New drainage canal is also necessary for appropriate drainage of excess rainfall. The following measures are planned for drainage problems.

- New drainage canals in field are constructed based on unit drainage discharge, which have simple weir at terminal point to store drainage water for repeating use.

- Existing four canals are to be rehabilitated based on 162 m^3/s of peak design discharge to protect flood intrusion. Weirs are also

installed to have storage function as well as the above.

- Bridges or culverts are constructed under the road 1113 at the terminal points of the existing two canals having no drainage facilities at present. Their design discharge is based on the peak run-off discharge.

Completion of the above construction may cause severe flooding in the downstream area due to much run-off discharge through improved canals. Rehabilitation of the downstream canals leading to Yom river, therefore, shall be also required in future.

4.4.4 Farm Road Plan

Farm road networks are planned in both areas, considering irrigation and drainage system and land consolidation planning. They are consisted of main, lateral and branch roads of 6.0, 4.0 and 3.0 m of width, respectively, some of which are planned to be connected with maintenance banks of dredging canals. Road interval is planned basically based on land consolidation plan, especially the length of long and short sides of farm plot due to no criterion. But, overall plot-reallocation is not involved in consolidation planning of both areas. Road networks, therefore, are planned based on the following consideration.

- Road interval is generally desirable to be from 300 to 600 m, from viewpoints of future farming practices and water management activities. But, the shorter is road interval, the higher is road density and rate of land loss.

- In case of intensive land consolidation planning, road density is more than 40 m/ha.

- Planning should be considered within total land loss of 7 %.

Nong Khon Kaen

Network is planned at intervals of 500 to 700 m and at around 30 m/ha of road density, taking account of the present density of 13.3 m/ha and overall planning of land loss.

Thung Sai Yart

It is planned at intervals of 1,000 to 1,500 m and at around 15 m/ha, considering the present density of 6.2 m/ha and limited irrigation area.

4.4.5 Land Consolidation Planning

Improvement of on-farm facilities shall be required for effective farming practices. The development way has to be planned based on the agricultural target, farmer's intention and its constraints. From viewpoint of technical aspects, the following measures are considered for improvement.

- Construction of systematic irrigation/drainage canals
- Construction of farm roads for farming activities
- Land leveling for adequate water control
- Re-allocation of farm plot for effective farming practices and water use.

In both areas, plot realignment and land leveling for whole area are not planned. Roads and canals, therefore, are basically planned along the present plot boundary. But, planning may be required not along the boundary but within the plot to avoid meandering canal-road system. At that case, disposition for substitute lot is necessary together with procurement of public land for road and canal.

Rate of land loss should be planned to be less than 7.0 % of whole agricultural land. But, some of plot may be forced to supply public land more than 7.0 %, depending on location plan of irrigation and drainage facilities. In any case, arrangement among beneficial farmer shall be required. Land leveling may be carried out in partial area, if necessary. And, partial farm ditch and road into field may be constructed by farmer.

4.5 Rural Infrastructure Development Plan

4.5.1 Rural Water Supply

Rural water supply is regarded as a basic human need and a priority issue in Thailand. Hence, rural water supply facility to improve the current situation of water supply to villagers, schools, health centers, and other public institutions are planned, in this study.

Nong Khon Kaen Area

Because villages in the area is relatively concentrated, a piped water supply system is planned for residents of two villages away from existing water supply system and three other villages without tap in the present service area. The number of population served is 818. To secure a stable water supply, water source is deep well and deep water is drawn by turbine pump. The water is treated by rapid filter with aerator used for piped water supply system in Thailand.

Thung Sai Yart Area

The four larger villages in the area are divided into two groups along the two main roads. Those are Wang Thon Daeng and Sam Nak, and the others are Sai Yart and Rao Rang Ngam. Piped water supply systems are planned for each. The population in each group is 1,277 for the former and 1,098 for the latter. As same as Nong Khon Kaen, the water source is deep well, and rapid filter is employed for water treatment.

Five clusters and one small village (Lan Du) are relatively distant from the four largest villages. To include these villages into the service area demands not only higher construction costs but causes problems in facility management as well. Therefore, public deep well is planned as cooperative water supply facility for each village, and water is drawn by hand pump. Water quality is improved by installing a simple sand filter. The number of wells is determined at 7 to be within 500 m to well.

The piped water supply system is planned on the basis of PWA's design criteria and standard design. ALRO also has expertise in constructing deep well with handpump. Therefore, facility planning is based on its technical knowhow.

PWA and ALRO will take initiative in construction of water supply facility, and it is recommended that the beneficiaries take active part in the construction works to reduce construction cost.

4.5.2 Rural Electrification

Rural electrification is a basic minimum need. In the study, the electrification plan is laid with the following points taken into consideration.

- Rural electrification is a minimum requisite for improvement of living environment.

- Television and radio play the important role of transmitting information on improvement of living standards and health. Stable and cheap electricity supply should be secured for spread of these media.

- Rural electrification is being promoted by Provincial Electricity Authority (PEA), but intensive investment of PEA budget for study area during the next several years is difficult. Hence, it must be included in the plan to promote electrification at an early date.

Electrification of all households is desirable, but complete electrification in the near future is difficult because there are many isolated villages and scattered households. Since the projected electrification rate is 85 % for all of Sukhothai and more than 90 % in the two progressive villages in Nong Khon Kaen, target is planned at 90 %, and the number of households to be supplied electricity is determined at 50 in Nong Khon Kaen and 399 in Thung Sai Yart.

Related to facility planning, the existing 22-KV high-voltage power lines are extended to non-electrified villages, and households served are divided into two groups of less than 20 and less than 30 households. Low-voltage power lines are installed for each group, which then lead to connecting lines with meter installed to each household. In villages already electrified, line is linked to low-voltage lines with extra capacity, if there is no allowance. Electrical power for pubic facilities is supplied from the nearest high-voltage line via a new low-voltage line.

In the electrification work, contribution of beneficiary farmers in form of labor is expected. PEA stipulates allocation of construction cost in an electrification work to be:

- If village residents are to use electricity for domestic purposes, the villagers will contribute 30 % of construction cost excluding connection line and meter (including labor), and PEA to finance 70 %.

- Villagers will bear all costs for the connecting line and meter.

- The entire construction cost for supply to small factories, business offices, and public facilities are paid by the owner.

4.5.3 Social Infrastructure

(1) Education and rural health

Present condition on education such as commuting distance and number of classes, satisfy national requirements.

In the light of the percentage of contraction and infant mortality, the medical care pose no serious problems, and health centers in the area meet standards for equipment and service area. For these reasons, educational and medical facilities will not be included in the study.

(2) Public sanitation

To promote environmental improvement in the areas, the spread of sanitation information and improvement of sanitation facilities are essential. To spread knowledge, radio, television and guidance by health center are expected to play major roles. From viewpoint of facility aspect, to prevent leak of human waste and to clean the environment, toilets with tanks are supplied to all households without it. The number of households to be installed is 60 in Nong Khon Kaen and 518 in Thung Sai Yart. In the planning, installation works shall be done by the beneficiaries themselves.

(3) Rural community

To promote advanced farming and organization of farmers for technology improvement and facility management, it is necessary to secure technological and training activities.

For this reason, multi-purpose halls equipped with technological materials, books and training facilities and meeting facilities for convenient and frequent gatherings, are planned. Considering the size of each village, one multi-purpose hall in Nong Khon Kaen, and one multi-purpose hall and four meeting facilities in Thung Sai Yart, are planned.

To expand publicity activities in the areas, wired broadcasting facilities are installed at each meeting facility, and wireless communication between these facilities is introduced.

4.6 Supporting Services

4.6.1 Necessity

As stated above, farmers have settled and commenced farming independently in the study area. The enquete survey has revealed that farmers point out lack of know how on cultivation of diversified crops as one of constraints against introducing diversified cropping, and they appeal a lack of production credit as one of constraints against general farming practices, because of restriction that farmers could not borrow an institutional credit by using his provisionally allocated land as collateral. As such, the study area has various handicap from viewpoints of farming technology and social solidarity among farmers.

For the realization of the effect arising from an integrated rural development project, it is not always sufficient to provide such hardware as agricultural and rural infrastructure. Further, ALRO is obliged to secure income of beneficial farmers after development of the hardware. In this project, it is prerequisite to place same significance as the hardware on the strengthening and enrichment of software, which includes an agricultural extension on such diversified crops as upland crops and fruits, institutional supporting services including farmers' organization, and so on.

4.6.2 Concrete Measures

For the purpose of strengthening and enriching the software part, it is planned to newly establish "Farmers Training and Strengthening Station (F.T.S.S.)", of which main objectives are (a)systematizing farmers, (b)guiding and training farmers, (c)introducing concept of marketing farm products, and (d)managing demonstration farms. From viewpoint of the project organization, the hardware component of F.T.S.S. shall be implemented under the responsibility of the field sub-project office (ALRO), on the other hand, the software component be managed and supervised by the Project Working Committee (See Figure 5-1). F.T.S.S. is responsible for firstly training those governmental officials concerned who shall be a leader as well as trainer of farmers, secondly

educating and training a leading farmer and thirdly educating and training general farmers. During the project implementation stage, the F.T.S.S. shall look to proper experts including foreign one for assistance, and then the activities shall be succeeded under a leadership of those government officials who would complete the training course. The required experts to be mobilized for F.T.S.S. during the project implementation stage are planned as follows;

One foreign expert: Farmers organization and crediting (25 man-months)

Three Thai experts: Agricultural extension (48 man-months)
Agronomy (25 man-months)
Marketing (25 man-months)

The demonstration farms to be managed under the F.T.S.S. shall take charge to research and experiment on cultivation practices for crops and varieties to be newly introduced as well as substantiate improvement of present cultivation practices, in the farm to be offered by a diligent farmer.

Through the activity of F.T.S.S., various farmers groups shall be established, such as water users' groups for operation and maintenance of irrigation facilities and village water supply systems, crop production groups for management of multi-purpose storages. Each farmers' group shall consist sub-group of the set-up committee for proposed agricultural land reform cooperative who shall generally operate and maintain the project.

As for definite content of the supporting program including establishment of F.T.S.S., shall be prepared by the Project Working Committee by reviewing the basic concept of F.T.S.S. which is compiled in Appendix D-2.

4.7 Proposed Facilities

4.7.1 Agricultural Infrastructure

The design of F/S level was carried out a Nong Khon Kaen Area and Thung Sai Yart Area, according to the development plan of each area. The policies of design are as follows:

- Facilities are to fulfill their function for their own aim.
- Facilities are to be designed following the structural form and criteria in Thailand.

The quantities of agricultural infrastructure of both area in case of development Model-2 are shown in Table 4-6.

Design criteria and form of major facilities are as follows:

(1) Reservoir and swamp rehabilitation

The depth of the reservoir without fish pond is designed at 2.20 m considering the dead water of 0.20 m in depth, and the one with fish pond is to be 2.50 m considering the dead water of 0.50 m in depth. The depth of fish pond is to be 1.00 m with the area of one-third of reservoir bottom, according to the criteria applied by DOF.

Slope gradient of reservoir is designed to be 1:2. At the position inside reservoir in which the leaded water drops down, thickness of 20 cm for riprap and stone pitching are to be planned to protect the scouring.

Reservoir which seems to have a trouble of percolation is to be set up clay coating. The thickness of coating is, about 10 % of water depth, from 0.20 m to 0.25 m.

Swamp rehabilitation is to dig the existing ground with the depth of from 1.0 m to 2.0 m, and to increase the available storage capacity.

The quantities of the proposed reservoirs of both area are as

Table 4-6 Quantities of Construction Facilities

Description	Unit	Quantities	
		Nong Khon Kaen	Thung Sai Yart
1. Agricultural Infrastructure			
1-1. Water Resources Facilities			
- Pond (18 ~472 × 1,000 m³/place)	place	8	14
- Dredging of swamps(depth 1 ~2 m)	〃	2	2
- Weir with gate	〃	2	4
1-2. Irrigation and Drainage Facilities			
- Dual purpose earth canal	m	31,680	63,040
- Road crossing	place	40	29
1-3. Drainage System for Inundation			
- Canal improvement	m	10,000	38,600
- Dike crossing	place	14	30
- Bridge	〃	-	2
1-4. Farm Road			
- Main road (width 6.0 m)	m	3,800	15,400
- Lateral road (width 4.0 m)	m	6,810	3,100
- Branch road (width 3.0 m)	m	14,290	39,200
1-5. Land leveling	ha	110	530
2. Rural Inrastructure			
2-1. Village Water Supply			
- Piped water supply system	place	1	2
- Public use well with handpump	〃	-	7
2-2. Rural Electrification	L.S	1	1
2-3. Public Sanitation(toilet with tank)	set	60	518
2-4. Rural Community Facilities			
- Multi-purpose hall (176~224 m²)	place	1	1
- Meeting hall (126 m²)	〃	-	4
- Broadcasting system	set	1	1
3. Post-Harvest and Marketing Facilities			
- Storage house	place	4	10

follows;

Nong Khon Kaen;

Description	Quantity	Remarks
1. Reservoir Type II	2 place	100 x 150 m
Reservoir Type III	5 "	100 x 100 m
Reservoir Type VII	1 "	200 x 200 m Fish Pond
Total	8 places	
2. Swamp Rehabilitation		
No. 1	1 place	19,200 m² Fish Pond
No. 2	1 "	33,000 m² Fish Pond
Total	2 places	

Thung Sai Yart;

Description	Quantity	Remarks
1. Reservoir Type I	9 place	200 x 200 m
Reservoir Type IV	1 "	600 x 400 m
Reservoir Type V	2 "	400 x 250 m Fish Pond
Reservoir Type VI	1 "	300 x 300 m Fish Pond
Reservoir Type VII	1 "	400 x 250 m
Total	14 places	
2. Swamp Rehabilitation		
RID's Weir	1 place	95,100 m² Fish Pond
Farmer's Dike	1 "	49,000 m²
Total	2 places	

(2) Weir

1) Overflow type weir

Overflow type weir is planned in the improved canal, and it has a function to intake the water to the reservoir easily. Moreover, the storage water in the improved canal is available for irrigation with hand pump facility.

The design criteria and form of overflow type weir are as follows;

a) Structure

The body are filled with earth materials, and the surface is protected with masonry which is the thickness of 0.30 m.

b) Form

Name of Canal	Type	Height	Top Length	Bottom Length
Sra Ket, Sai Yart	I	(H) 1.25 m	(B1) 20 m	(B2) 14 m
W.T.Daeng, M.L.Onn	II	1.45	14	8.2
Noi	III	1.50	16	10

c) Slop gradient

Referring to the existing RID's weir form in Thung Sai Yart Area, the slop gradient is designed to be 1:1.5 on the up-stream side and 1:4.0 on down-stream side, respectively.

2) Weir with gate facilities

The weir with gate facilities is proposed in order to keep away the backwater of Ban Mai canal, in Noi canal which is located along the southern boundary in Nong Khon Kaen Area.

a) Structure

Weir has two slide gate, the dimension of which is 1.0 m x 1.0 m.

b) Weir crossing culvert

Reinforced concrete pipe of diameter 1,000 mm is to be laid under the weir, the length of which is 10 m.

(3) Dual-purpose canal

Dual-purpose canal is constructed along the farm road. The criteria is as follows;

1) Structure and form

The depth of canal is 2.0 m, according to the effective water depth of reservoir.

The width of bottom is 1.0 m, and slop gradient inside is to be 1: 1.0. The longitudinal slope is designed to be 1/3000. The canal is to be constructed as unlined canal.

2) Design canal unit discharge

Design canal unit discharge is to be elected the bigger one, comparing unit area duty of water with unit area drainage discharge.

- Unit area duty of water 3.0 lit/s/ha
- Unit area drainage discharge 4.7 - 5.3 lit/s/ha

Therefore, design canal unit discharge is designed q = 5 lit/s/ha.

3) Capacity of canal

- Capacity of Canal ; Q = 3.4 m^3/s
- Catchment Area ; A = 682 ha (= Q/q)

(4) Road crossing

On the place where the dual-purpose canal is across the farm road, reinforced concrete pipe of diameter 1,000 mm is to be laid.

On the place where the improved canal is across the farm road, reinforced concrete pipes of diameter 1,000 mm x 3 sets are to be laid.

The thickness of 10 cm for riprap and stone pitching are to be planned on the inlet side and outlet side.

(5) Canal improvement

Dredging and dike construction is carried out in order to improve drainage condition and increase canal storage capacity for irrigation on all existing canal in project area.

1) Proposed canal section

Referring to the typical section designed in Thailand, proposed canal section are designed as follows;

- Depth on canal 2.0 m
- Width of berm 1.5 m
- Slope gradient inside canal 1:2.0

2) Dike

The width of top is 3.0 m to keep traffic on dike, however, laterite pavement is not planned.

The quantities of the proposed canal improvement of both area are as follows;

Name of Canal	Type	Length	Remarks
Nong khon Kaen			Width of bottom
-Noi up-stream	IV	4,100 m	20 m
-Noi down-stream	III	1,700 m	10 m
-Ban Mai	V	4,200 m	only dike const.
Thung Sai Yart			
-Sra Ket	II	8,600 m	10 m
-Sai Yat	II	10,000 m	10 m
-W.T. Daeng	I	8,600 m	3 m
-M.L. Onn	I	11,400 m	3 m

3) Dike crossing culvert

Reinforced concrete pipe of diameter 1,000 mm is to be laid under the dike, the length of which is 10 m. And a slide gate of the size 1.0 m x 1.0 m is to be installed at one side.

(6) Bridge

Two bridges are planned on route No. 1113, which is located along the eastern boundary in Thung Sai Yart Area, in order to make drainage condition good.

1) Structure and section

- Structure ; Reinforced concrete box culvert
- Section ; 3.3 m x 3.3 m x 3 series

2) Width of bridge

The width of bridge is 9.0 m, according to the width of route No. 1113.

(7) Farm Road

The width of top and thickness of laterite pavement of main road, lateral road, and branch road are planned as follows;

	Top Width	Pavement Thickness
Main Road	6.0 m	0.20 m
Lateral Road	4.0 m	0.20 m
Branch Road	3.0 m	0.10 m

The quantities of the proposed farm road of both area are as follows;

Description	Nong Khon Kaen	Thung Sai Yart
Main Road		
New construction	-	9,300 m
Rehabilitation	3,800 m	6,100 m
Lateral Road		
New construction	6,810 m	3,100 m
Branch Road		
New construction	14,290 m	38,100 m
Rehabilitation	-	1,100 m

(8) Land leveling

Land leveling is carried out in both area for arrangement of land form and land elevation. According to the existing land gradient, average cut depth is designed as follows;

Area	Average Cut Depth	Working Area
Nong Khon Kaen	0.10 m	110 ha (10% of project area)
Thung Sai Yart	0.20 m	530 ha (10% of project area)

4.7.2 Rural Infrastructure

(1) Rural water supply

1) Piped rural water supply

(a) Design criteria

The plan and design are based on PWA's design criteria and standard design. The outline is as follows.

Target Year: Year 2000

Ratio of population increase

In the said criteria, population growth rate is 1.5 % up to 1990 and 1.0 % up to 1995. In the study, 1.0 % is being applied.

Daily water consumption per capita

Daily average consumption = 50 ℓ cd

Daily maximum consumption = 1.5 average consumption

= 1.5 x 50 → 75 ℓ cd

Pumping hours: Average 10 hours and maximum 15 hours

Storage capacity of tank

Clear water tank: 70% of daily average supply

Elevated tank : 20% of daily average supply

(b) Amount of water supply

The amount is fixed on the basis of projected population (Refer to Appendix B-4).

(c) Water resource facility

Pumping discharge

Amount of water available from a deep well in Thung Sai Yart is assumed to be around 10 m^3/hr.

On the one hand, daily driving time of pump is around 10 hours, and piped water supply facility is standardized by DOH on a 5.0 m^3 basis. Design discharge is, therefore, planned 10 m^3/hr.

Deep well

Three deep wells are located each for three supply system. Depth of is planned to be around 60 m in Nong Khon Kaen and 100 m in Thung Sai Yart. Diameter of casing pipe is 200 mm and its material shall be resin.

Pump for well

Turbine pumps which meet the design discharge of 10 m^3/hr and head of 35 m in Nong Khon Kaen and 50 m in Thung Sai Yart, are selected (Refer to Appendix B-4).

(d) Treatment facilities

Sand filter

Rapid sand filter with capacity of 10 m^3/hr is planned as a water treatment facility.

Clear water tank

The clear water tank is proposed to alleviate and adjust the imbalance between filtration and supply water occasioned by sudden changes in water demand. The storage capacity is planned at 80 m^3, around 70 % of daily average water supply amount.

(e) Elevated tank

Elevated tank is located near the clear water tank. Water is lifted by service pump from the clear water tank up to the elevated tank, and is conveyed through the pipe line by gravity. Height of tank is planned at 17.0 m in H.W.L. and 15 m in L.W.L. over the ground

surface. Storage capacity is 15 m^3 of daily average water supply.

(f) Water transmission pipe line

Route of pipe line

The pipe is laid in the road and depth of laying is 1.0 m on standard.

Type of pipe

PVC is generally used because it can be easily purchased and installed.

Diameter of pipe

It is desired that the water head at the end point of pipe line is higher than 5.0 m. Diameter of pipe is based on the hydraulic examination by Hazen-Williams formula.

(g) Distribution facilities

Distribution pipes branching from transmission line are laid to connect households in village. A group served by a distribution pipe, is consisted of around 15 households.

The diameter of pipe is ϕ 25 mm and the type is PVC.

(h) Service pipe

Service pipes linking the distribution pipes are laid to serve for each household. A meter and a water tap are installed in a service pipe.

The diameter and length of the pipe is ϕ 12.5 mm and the type is PVC.

(i) Water supply facilities

Supply facilities by each system are summarized in Table 4-7.

Table 4-7 Piped Water Supply Facilities

Items	Nong Khon Kaen	Thung Sai Yart(1)	Thung Sai Yart(2)
Service area	Na Taew and other four village	Wang Thong Daeng and Sam Nak	Sai Yart and Rao Rang Ngam
Population served	818	1,277	1,098
Daily maximum water supply	74 m^3/day	129 m^3/day	113 m^3/day
Deep well	ϕ 200, Depth 60 m Pumping discharge = 10 m^3/hr	ϕ 200, Depth 100 m Pumping discharge = 10m^3/hr	
Pump for well	Turbin pump ϕ 50 0.17 m^3/min× 35 m × 2.2 kw	Turbin pump ϕ 50 0.17m^3/min× 50 m × 3.7 kw	
Pump station	Area = 4.0 m × 7.5 m		
Treatment facility	Rapid sand filtration with aerater of 10m^3/hr		
Clear water tank	Concrete structure with storage capacity of 80 m^3		
Service pump for elevated tank	Single suction centrifugal pump ϕ 50× 0.17m^3/min× 22 m× 2.2 kw		
Elevated tank	Concrete structure with storage capacity of 15 m^3 Hight ; H.W.L = G.L + 17.0 m. L.W.L = G.L + 15.0 m		
Transmission pipe	PVC ϕ 50× 2,950 m	PVCϕ 60× 4,300 m	PVCϕ 60× 5,200 m
Distribution pipe	PVC ϕ 25× 1,200 m	PVCϕ 25× 1,800 m	PVCϕ 25× 2,100 m
Service pipe with water tap and meter	PVC ϕ 0.5 inch × 20 m 160 sets	PVCϕ 0.5 inch × 20 m 260 sets	PVCϕ 0.5 inch × 20 m 236 sets

2) Public water supply well

Public well is planned in Thung Sai Yart, based on the standard design of ALRO.

(a) Daily maximum water supply

Daily maximum water supply is estimated at 3.75 m^3/day, based on the daily average consumption of 20 ℓ cd for public water supply facility and projected population of 125 in case of largest village isolated.

(b) Number of well

Location is planned in consideration of adequate interval based on circle of influence and distribution of village. In this study, well is located to be shorter than 500 m in distance between the well and farm house. As a result of study, total of seven are planned. Two of them are in a village along the road and remainder is located respectively in five villages.

(c) Depth of well

Depth is planned at 50 m based on the amount of water supply and hydro-geological cross section.

(d) Diameter of casing pipe

Diameter is 150 mm in consideration of the size of suction pipe for handpump. Type of pipe is PVC.

(e) Drilling diameter of well

Diameter is 350 mm.

(f) Handpump

Handpump used generally in ALRO is adopted.

(g) Treatment facility

Simplified sand filter standardized by ALRO, which is consisted of sand, charcoal and gravel layer, is installed.

(2) Rural electrification

(a) Nong Khon Kaen

High voltage power line (22 kv)

Power line is extended along the road from the terminal of Mai Suk Kasem to Na Taew for electrification in Na Taew.

Low voltage power line

Household served is divided into two groups in which the number of households is less than 20 and 30. Power line with necessary capacity is installed for each groups. Transformer of 20 KVA or 30 KVA is equipped at the beginning of the line. As a result of study, new installation of two lines for each groups is planned in Na Taew.

And, apart from these lines, new line for multi-purpose hall is also planned.

Connecting line to household

Connecting line with electric meter is installed from the nearest low voltage line to each farm house, of which average length is planned at 40 m and the number of line is estimated at 51 sets including one set for multi-purpose hall.

(b) Thung Sai Yart

High voltage power line (22 kv)

For the purpose of electrification in Lan Du, Roa Rang Ngam and other isolated villages, power line is extended from the existing

terminal points to each villages.

Low voltage power line

The number of groups, same as Nong Khon Kaen, is estimated at 17 and 8. Power line is installed for each groups and multi-purpose hall. Meeting hall is also connected from the nearest line.

Connecting line to household

Connecting line is planned at 404 sets including one of multi-purpose hall and four of meeting hall.

(c) Electrification facilities

Projected facilities are summarized as follows.

Items	Nong Khon Kaen	Thung Sai Yart
High voltage line (m)	900	12,300
Transformer (set)		
- 20 KVA	1	17
- 30 KVA	1	8
Low voltage line (m)	1,300	12,000
Connecting line with meter (set)		
- For 10 A	50	403
- For 20 A	1	1

(3) Community Facility

(a) Meeting hall

Location

Four halls are located in each villages in Thung Sai Yart.

Scale

Its scale is estimated on the basis of the number of forecasted participator that is regarded as the same number as households in each villages and area required for one participator. And, to standardized the building, each of halls is planned to be the same

scale. Necessary area is estimated at 124 m^2, based on average number of household in the four villages.

Structure

It is a one-storied house. Design is based on the Example Manual of General Building Construction for Rural Creation Project by Secretary of Prime Minister's Office, as shown in Drawing.

(b) Multi-purpose hall

Location

It is located each in central parts of the both areas.

Scale

Is has some rooms required for various activities, such as training, library and office, etc. In Nong Khon Kaen, required area is estimated at 224 m^2, taking account of various functions for meeting in Na Taew in backward village, as no planning of meeting hall in this area. In Thung Sai Yart, it is around 176 m^2, based on appropriate space for training and other activities.

Structure

It is designed under the same concept as meeting hall.

(c) Communication facility.

Nong Khon Kaen

Wired broadcast system with two speakers is intriduced at along the proposed high voltage power line to Na Taew. And, radio transceiver is equipped in the multi-porpose hall and Tambon office for smooth communication between them.

Thung Sai Yart

As well as Nong Khon Kaen, wired broadcast system is introduced in among proposed meeting halls and villages. Radio transceiver is also equipped in each halls.

(d) Community facilities.

Projected facilities are summarized as follows.

Items	Nong Khon Kaen	Thung Sai Yart
Meeting hall		
- Number of hall(place)	-	4
- Area (m^2)	-	126
- Structure	-	Wooden single story
Multi-purpose hall		
- Number of hall(place)	1	1
- Area (m^2)	224	176
- Structure	Concrete wall	Concrete wall
Wired broadcast system		
- Number of system (set)	1	4
- Length of wire (m)	1,200	7,600
- Number of speaker(set)	2	23
Radio transceiver (set)	2	5

4.7.3 Post-Harvesting and Marketing Facility

The multi-purpose storage is to be built in both area. The capacity of one is 100 ton, and the floor acreage of one is 12 m x 6 m = 72 m^2.

The quantity of the multi-purpose storage is as follows;

Nong Khon Kaen ; 4 houses

Thung Sai Yart ; 10 houses

4.8 Project Cost

4.8.1 Bases of Estimation

(1) Implementation Mode

The implementation of project construction is divided into two modes, force-account basis and contract basis.

Force-account Basis:
The project construction is directly carried out and supervised by the owner, mobilizing staff and using own construction equipment.

Contract Basis:
The project construction will be carried out by entrusting the work to a private company under contract.

Contract basis shall be adopted for the project, taking the following matters into consideration.

a) The project cost on the force account basis may be estimated lower than that on the contract basis due to excluding overhead costs of contractors. However, if the force account basis were taken for the project construction, many types of construction equipment, many engineers, labourers, and materials, in particular, experts and special equipment would be provided by ALRO according to the characteristic of the project. After completion of the project, it would be also difficult to use such equipment and personnel for another project effectively. ALRO will have to provide expenses and equipment maintenance fees during the period for next projects (idling period). Therefore, the force account basis is not economical from the viewpoint of the total cost of project.

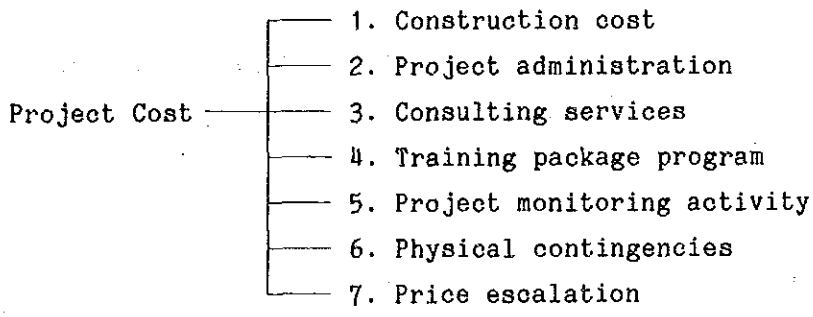
b) The increased capability of private firms will be very useful for the further development of the Thai economy in the future. The technology level of private Thai firms for public works will be increased by executing the works on the contract basis.

c) There are some big firms which have many kind of construction equipment around Sukhothai. The execution of construction works will be implemented easily on contract basis.

d) Most of construction by ALRO in recent year has been implemented on contract basis.

(2) Component of project cost

The component of project cost is consisted of the following items.



1) Construction cost

Construction cost is consisted of material cost, labour cost, machinery cost, and overhead cost of contractor.

2) Project administration

Project administration under construction is consisted of salary of temporary employee, stationary, communication, water and electric supply charge of temporary office, etc.

3) Consulting services

Consulting services are consisted of review of feasibility study, detailed design, tender document, assistance of tendering and awarding and supervision. The cost shall be estimated, usually at 10 % of the project cost.

4) Training package program

The cost of experts on the training package program is estimated based on the number of staff and their expenses.

5) Project monitoring activity

Monitoring team shall be established for the monitor of project progress. The cost of them is estimated based on the number of staff and their expenses.

6) Physical contingencies

There shall be some difference between the planning stage and construction stage due to increase in the acreage of the project area and some modification of structure.

To adopt such a case, the cost shall be estimated, usually, at 10 % of the project cost.

7) Price escalation

Price escalation from the point of cost estimation to project completion is estimated based on the price escalation rate of World Bank's data.

4.8.2 Unit Prices

(1) Unit Price of Materials

The cost of construction work is estimated based on the data collected on prices from ALRO and RID as of December 1989, and the data collected in Sukhothai. The unit cost for the construction works is estimated taking into account the costs such as efficiency of the construction equipment, labour, materials, and operation cost of the construction equipment. Details on the unit prices are compiled in Appendix B-5.

4.8.3 Construction Method and Schedule

(1) Workable term

According to the investigation in Sukhothai, the workable term of earth work in Sukhothai is between the end of October and the end of May next year. It is rather difficult to execute the earth work in the wet season.

(2) Supply of construction materials and equipment

Such major construction materials as sand, gravel, laterite, cement products, etc., are easily procurable around the study area (See Appendix B-5). As for construction equipments, there are several companies which have many kind and number of them around Sukhothai and Phitsanulok.

Major equipments for construction are as follows:

Description	Application
Bulldozer	Excavation, Moving, Spreading, Compaction
Front Loader	Loading
Back hoe	Excavation, Loading
Dump Truck	Hauling
Swamp Bulldozer	Excavation, Moving, Spreading, Compaction
Vibration Roller	Compaction
Motor Grader	Spreading, Grading
Water Tank Truck	Spray

Construction method and combination of equipments for various works, and construction term by equipment capacity are compiled in Appendix B-5.

(5) Construction schedule

In consideration of the huge volume of overall works, construction shall be carried out by dividing three phases in Nong Khon kaen and four phases in Thung Sai Yart. Implemetattion schedule is illustrated in Figure 5-2.

Phasing of Construction

Phase	Nong Khon Kaen	Thung Sai Yart	Implementing Year
I	N-1	T-1	2nd to 3rd year
II	N-2	T-2	3rd to 4th year
III	N-3	T-3	4th to 5th year
IV	-	T-4	5th to 6th year

Note: N- and T- mean the number of construction block (See Appendix B-5)

As for construction sequence in each construction block, principally farm road construction shall be preceded to get the convenience of transporting materials, and then reservoir construction shall follow. In the latter half of the dry season, the swamp rehabilitation and the canal improvement shall be carried out, as the swamps and the canals become dry, in which construction equipments are operated efficiently.

The construction works for village water supply and rural electrification shall be entrusted to PWA and PEA, respectively.

4.8.4 Project Cost

The estimated project cost on the basis of Development Mode-2 is 453,297,000 Baht, of which details are shown in Table 4-8. The exchange rate applied for the cost estimation is Baht 1.00=JYE 5.58 and US$ 1.00=Baht 25.76.

The cost of agricultural infrastructure occupies most of construction cost. The unit construction cost of agricultural infrastructure per rai in Nong Khon Kaen area and Thung Sai Yart area is as follows;

	Unit	Nong K.K.	Thung S.Y.
Agricultural Infrastructure	1,000 Baht	37,150	191,880
Command Area	Rai	7,283	33,535
Construction Cost per Rai	Baht/Rai	5,100	5,700

On the other hand, Table 4-9 shows the disbursement schedule of the project cost over the implementation schedule.

Table 4-8 Project Cost

Description	Quantity	Amount (1,000 Baht)
1. Construction Cost		
1-1 Nong Khon Kaen area		
- Agricultural Infrastructure	LS	37,150
- Rural Infrastructure	LS	5,261
- Post-Harvest & Marketing Facility	LS	1,092
Sub-total		43,503
1-2 Thung Sai Yart area		
- Agricultural Infrastructure	LS	191,880
- Rural Infrastructure	LS	21,027
- Post-Harvest & Marketing Facility	LS	2,734
Sub-total		215,641
1-3 Farmers Training & Strengthening Station	LS	10,000
Sub-total		10,000
Total (1)		269,144
2. Project Administration	LS	4,308
3. Consulting Service		
- Detail Design	LS	8,040
- Supervision	LS	15,430
Sub-total		23,470
Total (1-3)		296,922
4. Training Package Program	LS	24,464
5. Project Monitoring Activity	LS	3,750
6. Physical Contingency	LS	29,692
Total (1-6)		354,828
7. Price Escalation	LS	98,469
Grand Total		453,297

Table 4-9 Annual Project Cost

(Unit: 1,000 Baht)

Description	1991 (1st Year) FC	1991 (1st Year) LC	1992 (2nd Year) FC	1992 (2nd Year) LC	1993 (3rd Year) FC	1993 (3rd Year) LC	1994 (4th Year) FC	1994 (4th Year) LC	1995 (5th Year) FC	1995 (5th Year) LC	1996 (6th Year) FC	1996 (6th Year) LC	Total
1. Hardware Component													
-Nong Khon Kaen area	-	-	5,247	2,520	12,556	5,832	8,997	4,005	2,954	1,392	-	-	43,503
-Thung Sai Yart area	-	-	15,746	6,874	35,942	15,436	32,461	13,049	40,236	15,622	28,909	11,366	215,641
-Farmers T & S Station	-	-	1,099	1,099	5,605	2,197	-	-	-	-	-	-	10,000
Sub-total	-	-	22,092	10,493	54,103	23,465	41,458	17,054	43,190	17,014	28,909	11,366	269,144
2. Administration	-	312	-	936	-	936	-	936	-	812	-	376	4,308
3. Consultant Service													
-Detail design	2,680	-	5,360	-	-	-	-	-	-	-	-	-	8,040
-Supervision	-	-	1,285	-	3,858	-	3,858	-	3,858	-	2,571	-	15,430
Sub-total	2,680	-	6,645	-	3,858	-	3,858	-	3,858	-	2,571	-	23,470
Total (1-3)	2,680	312	28,737	11,429	57,961	24,401	45,316	17,990	47,048	17,826	31,480	11,742	296,922
4. Training Package Program	-	-	2,280	169	9,120	676	7,840	676	1,440	676	1,080	507	24,464
5. Project Monitoring Activity		250	-	750	-	750	-	750	-	750	-	500	3,750
6. Contingency (1-3) x 10%	268	31	2,874	1,143	5,796	2,440	4,532	1,799	4,705	1,782	3,148	1,174	29,692
Total (1-6)	2,948	593	33,891	13,491	72,877	28,267	57,688	21,215	53,193	21,034	35,708	13,923	354,828
7. Price Escalation	361	55	4,935	2,122	14,867	6,408	16,078	6,373	18,304	7,959	14,587	6,420	98,469
	3,309	648	38,826	15,613	87,744	34,675	73,766	27,588	71,497	28,993	50,295	20,343	
Grand Total	3,957		54,439		122,419		101,354		100,490		70,638		453,297

CHAPTER 5 IMPLEMENTATION PROGRAMME

CHAPTER 5 IMPLEMENTATION PROGRAMME

5.1 Implementing Organization

5.1.1 Project Coordinating Committee

The specific feature of the integrated rural development project is, generally, to cover various component. In this project, ALRO could not solely handle all the component including the hardware and the software ones. While most of all the component is under management of Ministry of Agriculture and Cooperatives, the components of rural water supply and rural electrification are to be implemented by PWA and PEA under Ministry of Interior, respectively. In order to smoothly and satisfactorily implement this project, it is, therefore, planned to establish a project coordinating committee at three levels of the government, namely, Project Executive Committee (P.E.C.), Project Coordinating Committee (P.C.C.) and Project Working Committee (P.W.C.). These committees basically have their functions; (a)to formulate policy and/or programme, (b)to coordinate and solve various issues, and (c)to supervise progress of project implementation at the respective level (See Figure 5-1). Composition and responsibility of these committees are detailed in Appendix D-1.

5.1.2 Executing Agency

Under the Project Executive Committee, ALRO shall be an executing agency by appointing a project director who shall be a secretary of P.E.C. as well as a chairman of P.C.C. Under the project director, ALRO shall be fully responsible for the hardware component except the village water supply and the rural electrification with appointment of a project manager and a field project manager. On the other hand, "Farmers Training and Strengthening Station (F.T.S.S.)" shall be responsible for the software component under management and supervision of the Project Working Committee (See Figure 5-1). The F.T.S.S. shall carry out intensive activity for strengthening the software part of the project with technical assistance of experts including foreign one during the project implementation period.

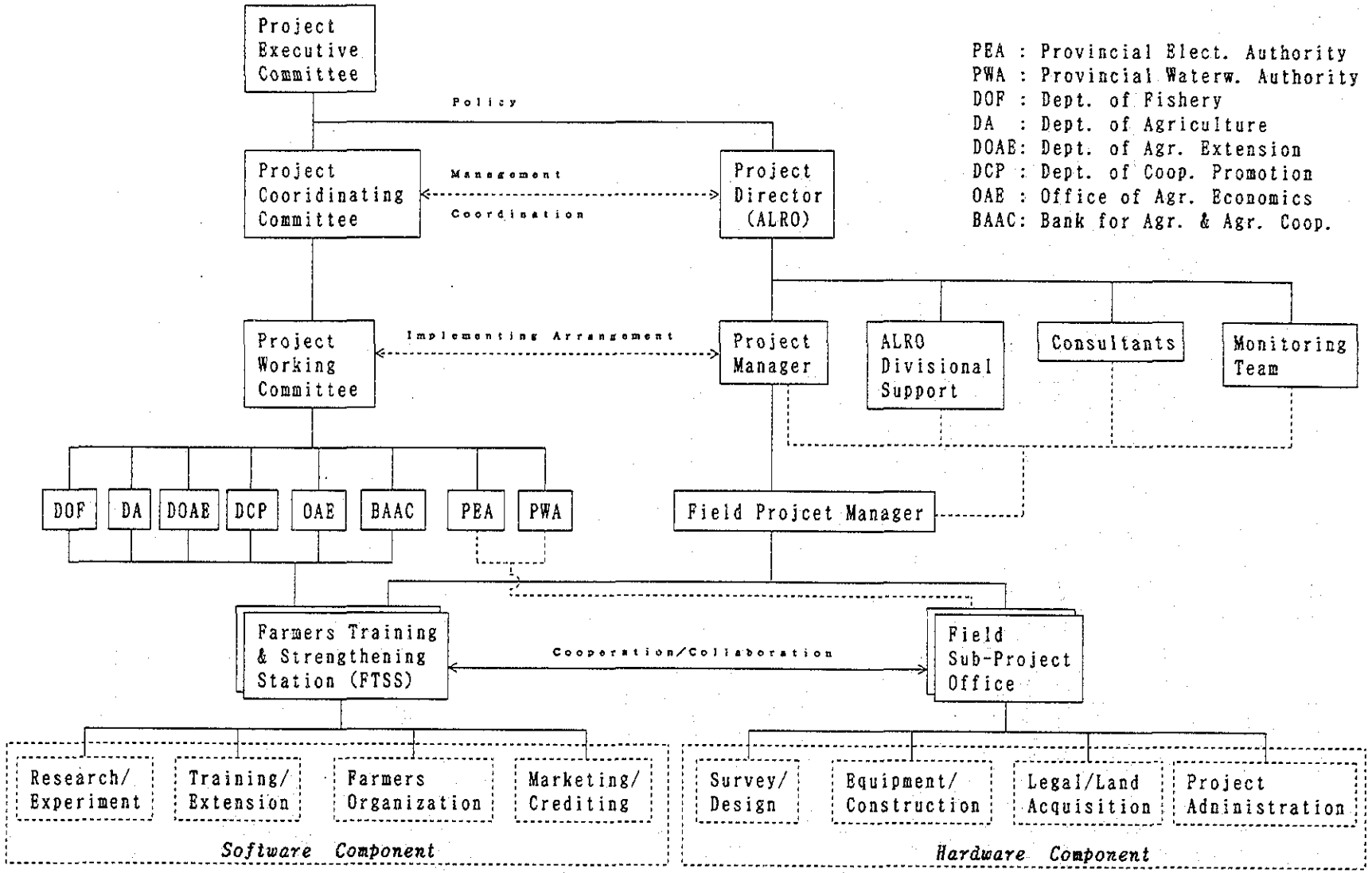


Figure 5-1 ORGANIZATION FOR PROJECT IMPLEMENTATION

In order to assist the project manager and the field project manager, it is planned to mobilize consultants, whose main activity is to provide technical assistance on preparation of detailed design and supporting service program, and supervision of construction works. On the other hand, it is also planned to mobilize a monitoring team whose main activity is to monitor progress of project implementation in comparison of the planned schedule and to review and arrange problems and constraints against project implementation. Through the monitoring activity, it can be obtained valuable information which could contribute to the current project implementation as well as the future similar project as a feedback system. Since this monitoring activity requires fairness, it is desirable to mobilize the third party like a university in Thailand.

5.1.3 Implementation Schedule

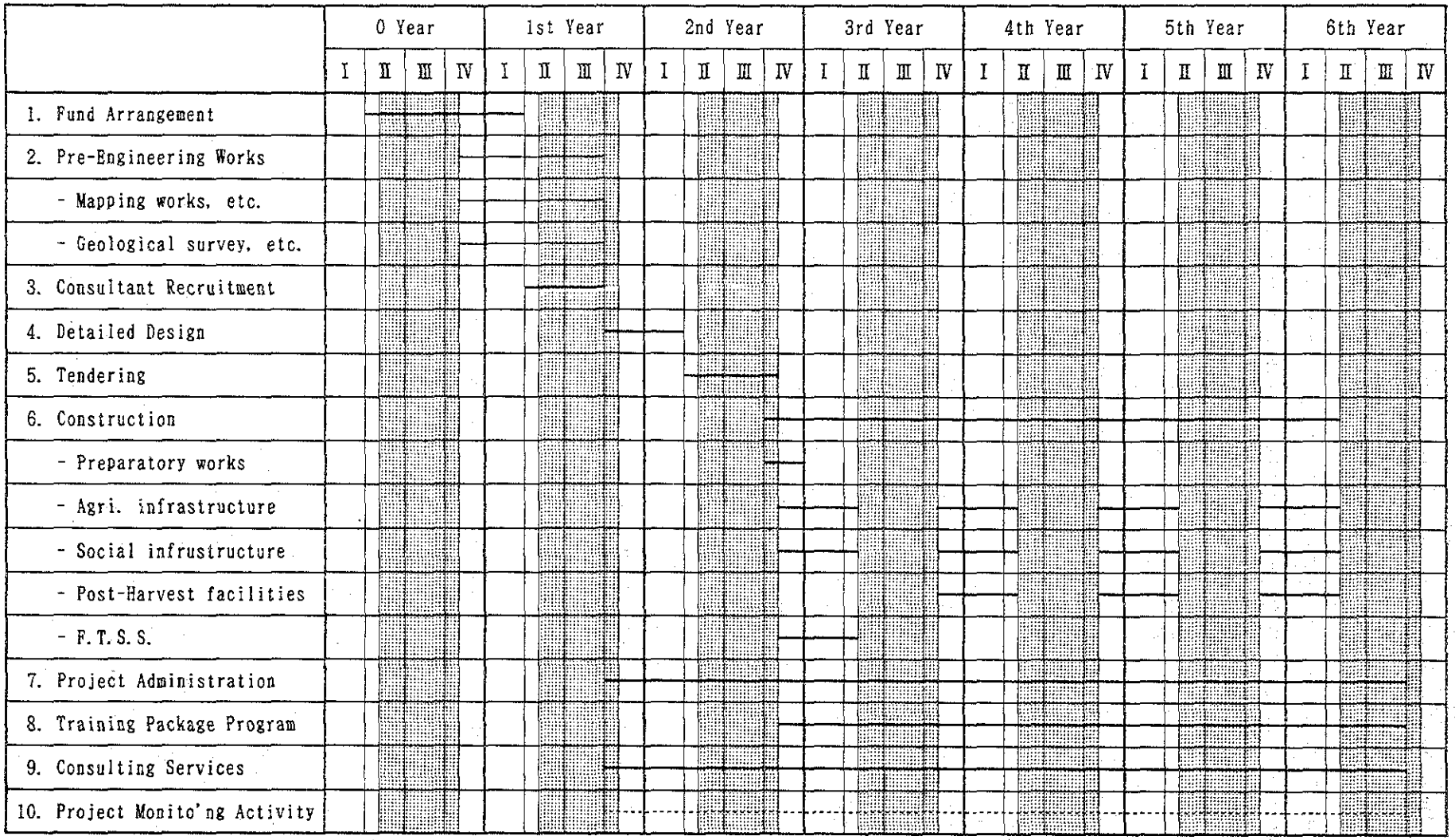
As for overall project implementation schedule, it is planned to allocate seven years after completion of the feasibility study including necessary procedure for fund arrangement, detailed design and tendering. Thus, the real construction period is scheduled for four years as shown in Figure 5-2.

5.2 Organization for Project O & M

5.2.1 Responsible Agency

(1) Establishment of Agricultural Land Reform Cooperative

During the project implementation, in parallel with development and construction of various facilities, intensified program for strengthening and training governmental officials including ALRO staff and farmers, will be carried. Under the program, it can be expected to establish operation and maintenance organization of project facilities by mainly farmers themselves. Although it is one of way to organize the respective O & M organization, because each facility has different beneficiaries, it is more effective and efficient to establish a unified O & M system from viewpoints of effective operation and management of the project. Therefore, it is planned to establish an agricultural land



F.T.S.S.: Farmers' Training and Strengthening Station

Rainy Season

Figure 5-2 IMPLEMENTATION SCHEDULE

reform cooperative in both Nong Khon Kaen and Thung Sai Yart, respectively, under Sukhothai Land Reform Office. In the beginning, these cooperatives would start as set-up committee composing of several farmers' groups as its sub-committee. The farmers' groups responsible for O & M of the respective facility would continue their activity for enrichment of the cooperative's systematization, in parallel with performing their daily obligation. The respective O & M system for the project facility are described below (See Figure 5-3).

(2) Agricultural infrastructure

For operation and maintenance of the agricultural infrastructure shall be taken part by farmers' groups to be systematized by mainly ALRO in both the area. After completion of project construction, the O & M of irrigation facilities shall be carried out by water user groups to be formed by beneficial farmers, and that for roads and drainage facilities be by O & M group in the respective Muban office.

(3) Rural infrastructure

1) Village water supply

a) Piped water supply system

With guidance and assistance from Tambol office and PWA, the O & M shall be carried out by water user group to be formed by beneficiaries. Fir management of the facilities, it is necessary to save O & M cost through maximum utilization of members' assistant labor for operation and inspection of equipment, collection of water charge, adjust and repair works.

b) Common wells

It is necessary to keep environmental condition around the well good as well as to inspect and repair hundpump, and to adjust treatment facility. Therefore, beneficiaries shall be rotationally on duty for the above works.

c) Rural electrification

Since this component is under PEA, O & M of the project facilities

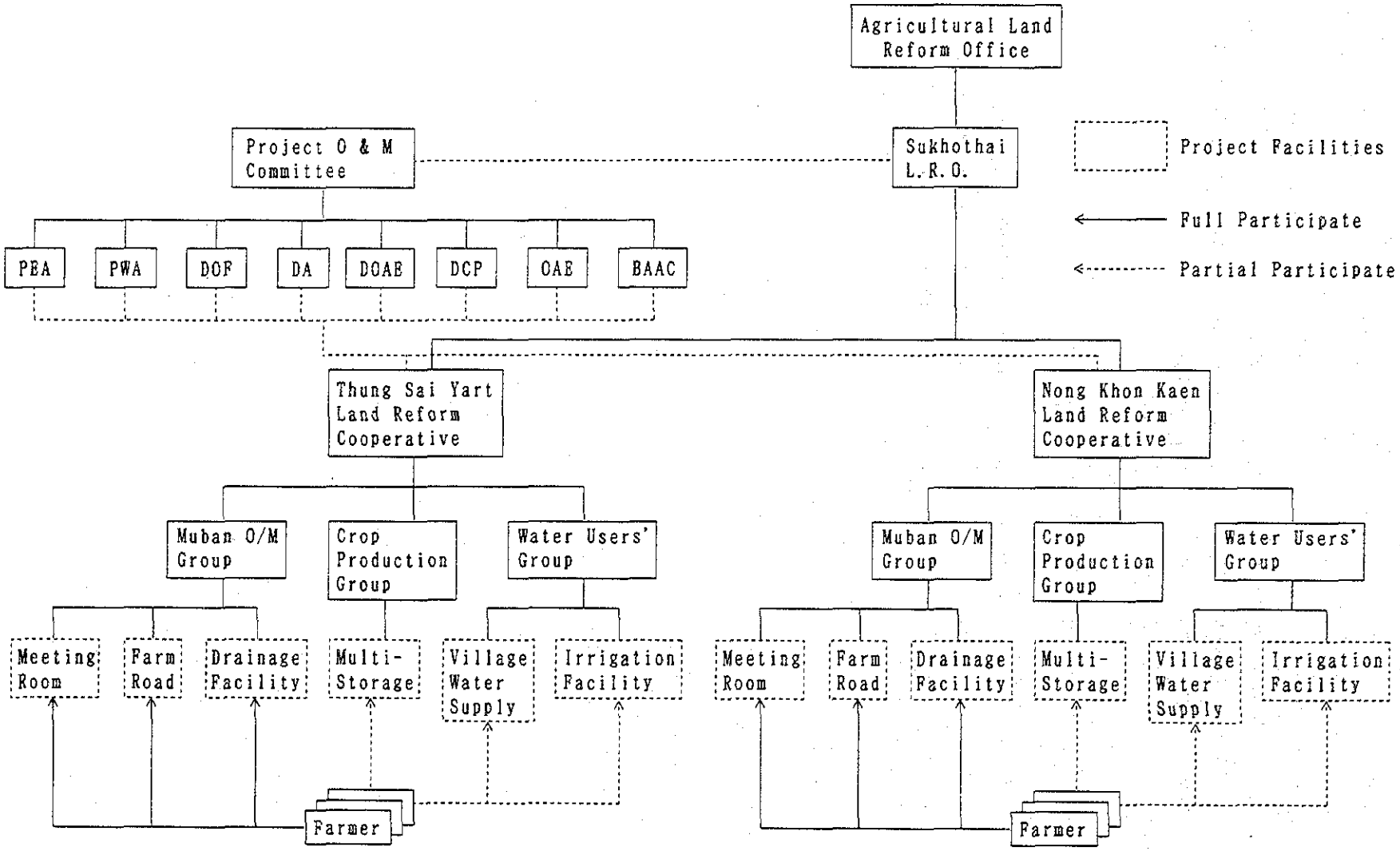


Figure 5-3 ORGANIZATION FOR OPERATION AND MAINTENANCE STAGE

shall be carried out by PEA.

d) Multipurpose hall and meeting room

O & M of the multi-purpose hall be mainly by ALRO during the construction stage, and Amphoe office be after the project implementation. Similarly, O & M of meeting rooms shall be responsible for O & M group of each Muban office.

(4) Post-harvest and marketing facility

O & M of multi-purpose storage shall be carried out by crop production groups during the project implementation and by the land reform cooperative after the project implementation (Refer to Appendix D-3).

(5) Farmers training and strengthening station

Activities of F.T.S.S. shall be taken over by the land reform cooperative with assistance of Sukhothai Land Reform Office as well as those governmental offices concerned.

5.2.2 Operation and Maintenance Cost

The operation and maintenance cost of the project facilities shall be, principally, born by the respective beneficiary under the farmers' groups to be systematized. Annual O & M cost for each facility is estimated in the following.

Agricultural infrastructure	1,020,000 Baht
Rural infrastructure	702,000 Baht
Post-harvest and marketing facility	498,000 Baht
Total	2,220,000 Baht

5.3 Consulting Services

The proposed project involves various components, for which coordination among related agencies shall be required. In this connection and for smooth implementation of the project, engineering consultants shall be mobilized. They are responsible for assisting ALRO in preparation of detailed design and supporting program in F.T.S.S., tendering activity, and supervision of construction works.

CHAPTER 6 PROJECT EVALUATION

CHAPTER 6 PROJECT EVALUATION

6.1 Method of Evaluation

The proposed project shall be comprehensively evaluated from viewpoints of economic, financial, environmental and social impact.

The economic evaluation has been made by calculating an economic internal rate of return (E.I.R.R.) with sensitivity analysis, in which a project cost and a tangible benefit are to be calculated by applying an economic price (accounting price). The E.I.R.R. can be worked out by discounting both streams of economic cost and benefit over a period analysis with several discount rates. On the other hand, a sensitivity analysis is one of method to check the risk of the project to be affected by change of key factors.

In this study, the financial analysis has been carried out to examine possibility whether beneficial farmers can bear such project cost as the initial investment cost and the operation and maintenance cost, through calculating incremental farmers' economic surplus. The prices to be applied for this analysis is derived on the basis of market prices of the respective good and service.

6.2 Prices

All prices to be applied have been estimated on the basis of the recent available information and data so far obtained as of the beginning of 1990. Out of input and output, the internationally traded goods and services have been estimated on the basis of their border prices, by quoting "Price Forecast for Major Primary Commodities" published by the World Bank. In addition, in order to calculate their economic prices of internally traded goods and services, the following conversion factors have been quoted from the recent information provided by the World Bank:

Standard conversion factor	0.92
Conversion factor for consumption	0.95
" " margin of middleman etc.	0.70
" " Construction	0.88
" " Transportation	0.87
" " Farm labour	0.92

Table 6-1 summarizes both economic and financial farmgate prices of agricultural input and output in 1990 constant prices. Calculation basis for some important items are compiled in Appendix C-3.

6.3 Economic Evaluation

6.3.1 Economic Cost and Benefit

After deducting the price contingency (98.47 million Bahts) from the estimated financial initial investment cost (453.30 million Bahts) in Chapter 4 of this report, the economic cost has been estimated at 312.25 million Bahts, by applying the conversion factor of construction. Similarly, the economic cost of operation and maintenance after completion of the project is estimated at 1.954 million Baht per year at full development stage.

Tangible benefits in monetary terms in this project are those arising from crop sector and fishery in storage ponds. In every case, these benefit are calculated as an incremental net production value (N.P.V.) between "with project" case and "without project" case. The crop N.P.V. can be computed by deducting a respective crop production cost from a gross production value (G.P.V.) which is obtained by multiplying crop yield with a respective crop price. That of pond fishery is the difference between a gross production value at one year after release of fingering and cost for the fingering. It is planned that no special care will be carried out after release of fingering. The net production value of the pond fishery accounts for 50 % of its full potentiality, due to lower preciseness of the calculation basis. Table 6-2 summarized these economic benefits.

6.3.2 Economic Internal Rate of Return (E.I.R.R.)

A period of analysis for calculating E.I.R.R. is fixed at 30 years, on the basis of synthetic durable life of various major facilities with premise that every project facility shall be properly operated and maintained. In considering four years of gestation period until attaining full benefit, the E.I.R.R. for the Sukhothai Integrated Agricultural and Rural Infrastructure Development Project is calculated at

Table 6-1 Economic and Financial Farmgate Price
(at constant 1990 prices)

	Unit	Year 2000	
		Financial	Economic
Crop			
Paddy	Baht/ton	3,140	3,620
Soybean	"	6,580	6,440
Mungbean	"	8,000	8,000
Leaf Vegetable	"	2,000	2,000
Fruit Vegetable	"	1,500	1,500
Seed			
Paddy	Baht/Kg	3.5	4.0
Soybean	"	10.0	7.0
Mungbean	"	10.0	10.0
Leaf Vegetable	Baht/dl	200.0	200.0
Fruit Vegetable	"	200.0	200.0
Fertilizer*			
Urea	Baht/ton	7,610	7,350
T.S.P.	"	8,300	8,020
Potassium Chloride	"	5,340	5,140
Nutrient Basis - N	Baht/Kg	16.5	16.0
- P	"	18.4	17.8
- K	"	8.9	8.6
Labor			
Nong Khon Kaen	Baht/man-day	55	45
Thung Sai Yart	"	45	35
Agr. Machinery			
Hand Tractor	Baht/hour	16	13
Medium-size Tractor	"	300	220
Thresher (4 ton/hr)	"	150	120
Pump (Shallow Well)	"	18	13
Pump (Low-lift)	"	14	12

Table 6-2 Annual Agricultural Benefit

(Unit: 1,000 Baht)

	Without Project	With Project	Inorement
Nong Khon Kaen (1,165 ha)			
Paddy	5,868*3	10,061	4,193
Upland Crops	118	983	865
Vegetables	66	1,010	944
Sub-total	6,052	12,054	6,002
(฿ per ha)			(5,152)
Orchard*1	-	1,838	1,838
Inland Fishery (Farm Pond)*2	-	539	539
Total	6,052	14,431	8,379
Thung Sai Yart (5,365 ha)			
Paddy	3,630	24,924	21,294
Upland Crops	324	4,259	3,935
Sub-total	3,954	29,183	25,229
(฿ per ha)			(4,703)
Orchard*1	-	1,838	1,838
Inland Fishery (Farm Pond)*2	-	1,883	1,883
Total	3,956	32,904	28,948

*1 at full production stage (11 to 15 years)

*2 50% of full potentiality

*3 Paddy cropping area during dry season be adjusted by proper pimping amount by exsiting shallow wells

7.9 %.

While the E.I.R.R. of 7.9 % is rather lower than the opportunity cost of capital in Thailand, which is ranging from 10 to 12 %, the E.I.R.R. is, economically, justifiable taking into consideration the nature of the integrated rural development which usually includes intangible benefits in the component of social infrastructure development. In the following sensitivity analysis, an E.I.R.R. of the agricultural infrastructure development shall be calculated.

6.3.3 Sensitivity Analysis

A sensitivity analysis is one of effective method to examine and judge risk of the project during implementation and operation. The sensitivity has been carried out on the following basic factors:

Item	E.I.R.R. (%)
1. Original Case	7.9
2. Agricultural Infrastructure only	9.1
3. Storage amount decreases by 20%	6.3
4. Initial investment increases by 10%	7.0
5. Crop prices decrease by 10%	6.4
6. Crop production cost increase 10%	6.8
7. Crop yields decrease by 10%	5.4
8. Construction period shorten by 1 year	8.6

The above analysis reveals that decrease in crop yields shows highest risk on the project, and also the project economy would lower by decreasing crop yield and crop prices, it is, therefore, prerequisite to attain the strengthening of software component. In addition, it is also important to secure stable water resources for irrigation.

6.4 Financial Analysis

6.4.1 Farm Budget

In order to evaluate a financial impact on beneficial farmers through implementation of the project, farm budget analysis for typical farm has been made in cases of "without" and "with" project. The size of the typical farm has been derived from the farm inventory used for

interview survey, and 25 rais (4.0 ha) in Thung Sai Yart and 16 rais (2.56 ha) in Nong Khon Kaen were obtained. For these farm sizes, the reduction rate of land for the proposed facilities is taken account in case of "with Project".

Typical farming patterns to be applied in this analysis are as follows:

Sub-project	Without Project		With Project	
	Wet Season	Dry Season	Wet Season	Dry Season
Nong Khon Kaen				
- North Block	Paddy(100%)	Paddy(19%) Vege.(1%)	Paddy(100%)	Soybean(27%) Vegeta.(7%)
- South Block	Paddy(100%)	Paddy(10%)	Paddy(100%)	Soybean(15%)
Thung Sai Yart				
- Rainfed Area	Paddy(100%)	-	Paddy(100%)	-
- Irrigated Area	Paddy(100%)	-	Paddy(100%)	Soybean(27%)

As for off-farm income and household expenditure, the results obtained from the farm economic survey for 65 farms are referred. All the prices for calculation of a net production value and a production cost are financial ones on the basis of those market prices.

The preliminary result of the financial analysis is summarised below:

	Thung Sai Yart			Nong Khon Kaen			
	Without	With Project		Without Project		With Project	
		Rainfed	Irrigate	North	South	North	South
1. Farm Size (ha)	4.00	3.79	3.79	2.56	2.56	2.37	2.37
2. Crop Area (ha)	4.00	3.79	4.81	3.08	2.82	3.89	2.73
3. Crop Intens.	100%	100%	127%	120%	110%	164%	115%
4. Farm Income (Baht)							
- Crop	12,560	16,445	52,543	31,980	25,170	58,319	40,729
- Off-farm	13,157	13,157	13,157	20,606	20,606	20,606	20,606
- Total	25,717	29,602	65,700	52,586	45,776	78,925	61,335
5. Famr Expense (Baht)							
- On-farm	3,532	4,637	21,258	16,867	12,123	25,202	14,757
- Hired Labor	-	60	712	-	-	-	-
H.H. Expense	19,053	19,053	19,053	28,822	28,822	28,822	28,822
Total	22,585	23,750	41,023	45,689	40,945	54,024	43,759
6. Farm Surplus	3,132	5,852	24,677	6,897	4,831	24,901	17,756
(Increment)	-	(2,720)	(21,545)	-	-	(18,004)	(12,925)

6.4.2 Repayment Capacity of Farmers and Cost Recovery

As basic data on farmers' repayment capacity, the above farm budget analysis provides one of indicator, in which a part of incremental farm economic surplus by implementation of the project becomes a basis for calculating it. In this case, it is a general rule that a beneficiary who receives higher profit from the project should bear heavier burden of its cost. Supposing the repayment capacity of farmers is 50 % of the incremental farm economic surplus, it could be ranging from 1,360 bahts to 10,772 bahts per farm.

On the other hand, preliminary computation works out 1,820 bahts for farmer with irrigation benefit and 1,296 bahts without that as an annual O & M cost of whole project facilities per beneficial farmer. Therefore, farmers under rainfed condition in Thung Sai Yart is able to bear only the annual O & M cost.

In order to calculate farmers' burden to recover the direct construction cost for the project facilities, the following premises are taken into account: (a)repayment period is 25 years including 4 years' grace period, (b)interest rate is 12.5 % per annum, and (c)interest during the grace period should be included in the principal. Under the said condition, annual amount for the cost recovery is worked out in the following:

	Nong Khon kaen	Thung Sai Yart
Farmers under irrigation	23,217 Bahts	54,455 Bahts
Farmers under rainfed	-	16,782 Bahts

In every case, the cost recovery amount exceeds farmers' repayment capacity, a certain subsidy by the government should be considered by area and farm type. In this study, it is difficult do identify number of farmers by farm type and size, it should be carried out during the detailed design stage to establish the cost recovery program. Furthermore, special consideration to exempt or to reduce the cost recovery amount should be paid that those farmers who are obliged to submit their farm land for public use.

6.4.3 Economic Farm Size

In addition to the cost recovery analysis on the basis of the farm budget for typical farms, an economic farm size has been studied for various cost recovery patterns by sub-project area as well as proposed cropping pattern. The cost recovery cases applied in the analysis are as follows;

Case 1: Annual O & M cost only by beneficial farmer
Case 2: Case 1 plus direct construction cost of post-harvest facility by beneficial farmer
Case 3: Case 2 plus a half of direct construction cost of agricultural infrastructure by beneficical farmer
Case 4: Case 2 plus full of direct construction cost of agricultural infrastructure by beneficial farmer

For basic figures on the present condirtion such as a household expenditure, an off-farm income and a farm economic surplus, reference is made to the result of the farm economic survey.

Table 6-3 shows basic indicators to be applied in this analysis, and the results of the analysis are summarized in Table 6-4, indicating that economic farm sizes in cost recovery case 3 are mostly same as the typical farm sizes under irrigated condition, while it in cost recovery case 2 is same as one under rainfed condition in Thung Sai Yart.

Table 6-3 Basic Indicator for Economic Farm Size Analysis

1. General information

	Nong Khon Kaen	Thung Sai Yart
Project Area (ha)	1,165	5,365
Cultivated Area (ha)	970	4,800
- Irrigated	970	2,600
- Rainfed	-	2,200
No. of Farm	565	753

2. Direct Construction Cost (1,000 Bahts)

	Total Disbursement		Annual Amortization[1]	
	NKK	TSY	NKK	TSY
Agri. Infra.				
- Irrigation	19,837	118,332	4,338	25,874
- Others (Road etc)	17,313	73,548	3,786	16,082
- Sub-total	37,150	191,880	8,124	41,596
Post-Harvest	1,092	2,734	239	597
Total	38,242	194,614	8,363	42,193

Note: [1] Interest: 12.5%, Repayment: 25 years (incl. 4 years grace period)

3. Operation & Maintenance Cost (1,000 Bahts/year)

	Nong Khon Kaen	Thung Sai Yart
Agri. Infra.		
- Irrigation	296	214
- Others (Road etc)	219	291
- Sub-total	515	505
Post-Harvest	213	285
Total	728	790

4. Targeted Farm Economic Surplus (Bahts/family)

Aiming the increment of about 2,000 Bahts per family.

	Nong Khon Kaen		Thung Sai Yart
	North B.	South B.	
- Without Project	6,897	4,831	3,132
- With Project	9,000	7,000	5,000
- Increment	2,107	2,169	1,868

Table 6-4 Financial Analysis on Economic Farm Size

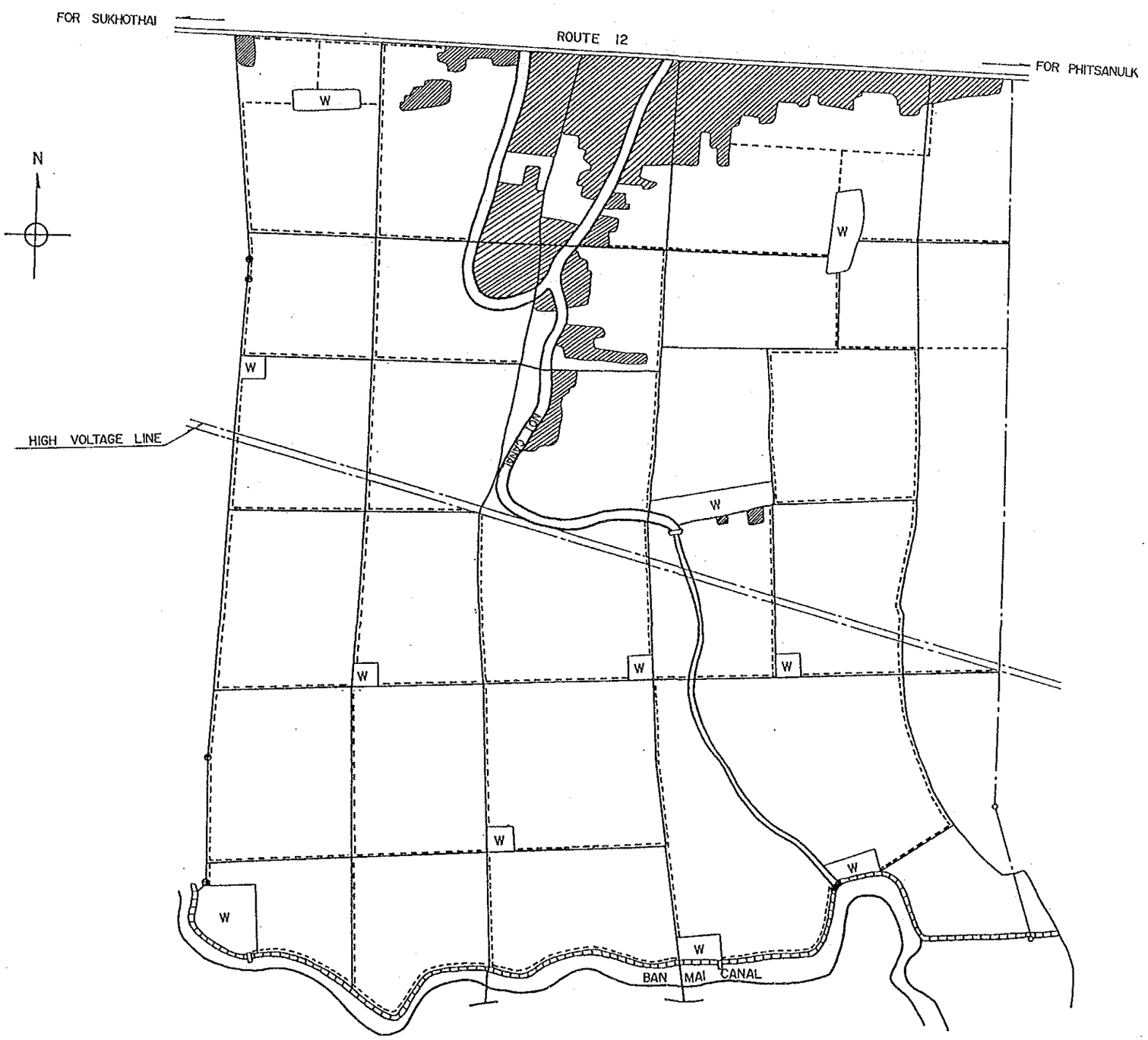
	Nong Khon kaen		Thung Sai Yart	
	North	South	Irrigated	Rainfed
(a) Household Requirement (B/HH)				
- Household Expenditures	28,822	28,822	19,053	19,053
- Targeted Farm Surplus	9,000	7,000	5,000	5,000
- Sub-total	37,822	35,822	24,053	24,053
(b) Off-Farm Income (B/HH)	20,606	20,606	13,157	13,157
(c) Required Farm Income (B/HH)	17,216	17,216	10,896	10,896
(d) Gross Crop Income per ha (B/ha)	12,747	10,951	10,146	3,116
(e) Cost Recovery per ha (B/ha)				
- Case 1	751	751	202	120
- Case 2	997	997	326	224
- Case 3	5,185	5,185	6,977	1,919
- Case 4	9,372	9,372	13,627	3,594
(f) Net Crop Income per ha (B/ha)				
- Case 1	11,996	10,200	9,944	2,996
- Case 2	11,750	9,954	9,820	2,872
- Case 3	7,562	5,766	3,169	1,197
- Case 4	3,375	1,579	- 3,481	- 478
(g) Required Farm Size (ha)				
- Case 1	1.44	1.49	1.10	3.64
- Case 2	1.47	1.53	1.11	3.79
- Case 3	2.28	2.64	3.44	9.10
- Case 4	5.10	9.64	-	-

Cost Recovery - Case 1: O & M cost only
Case 2: O & M cost + Post-harvest
Case 3: O & M cost + Post-harvest + 1/2 of Agr. Infra. cost
Case 4: O & M cost + Post-harvest + Agr. Infra. cost

Note: (c)=(a)-(b), (d),(e): Refer to Appendix C-3-8, (f)=(d)-(e), (g)=(c)/(f)

DRAWINGS

GENERAL PLAN IN NONG KHON KAEN



LEGEND

- W — RESERVOIR
- FARM ROAD
- DUAL-PURPOSE CANAL
- WEIR OVERFLOW - TYPE
- WEIR WITH GATE FACILITY
- DIKE
- VILLAGE

SCALE 1: 10,000

0 500 m.

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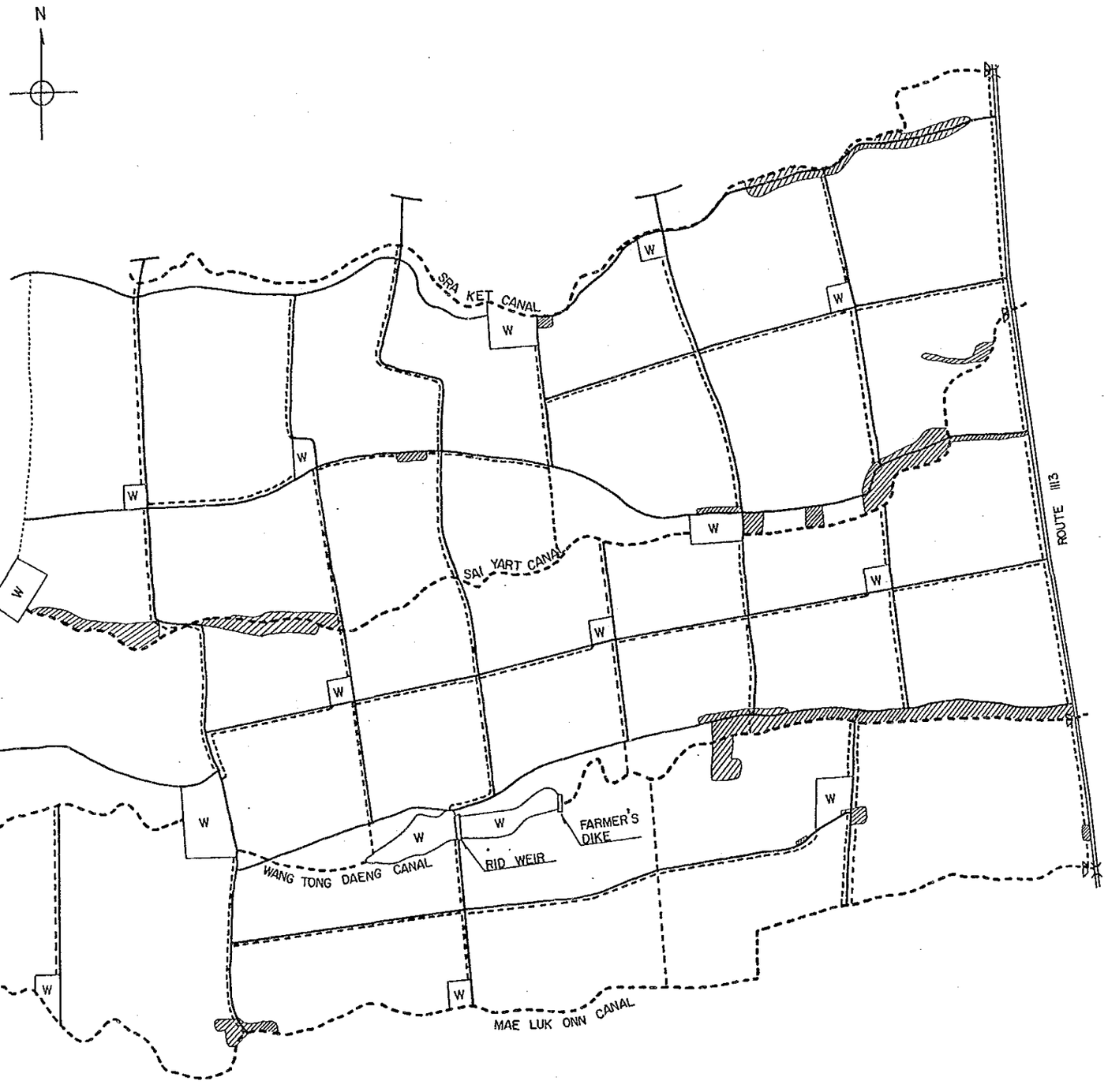
F/S ON SUKHOTHAI INTEGRATED AGRICULTURAL AND RURAL INFRASTRUCTURE DEVELOPMENT PROJECT			
GENARAL PLAN IN NONG KHON KAEN			
DATE	MAR - 1990	DWG	1
JAPAN INTERNATIONAL COOPERATION AGENCY			

GENERAL PLAN IN THUNG SAI YART



LEGEND

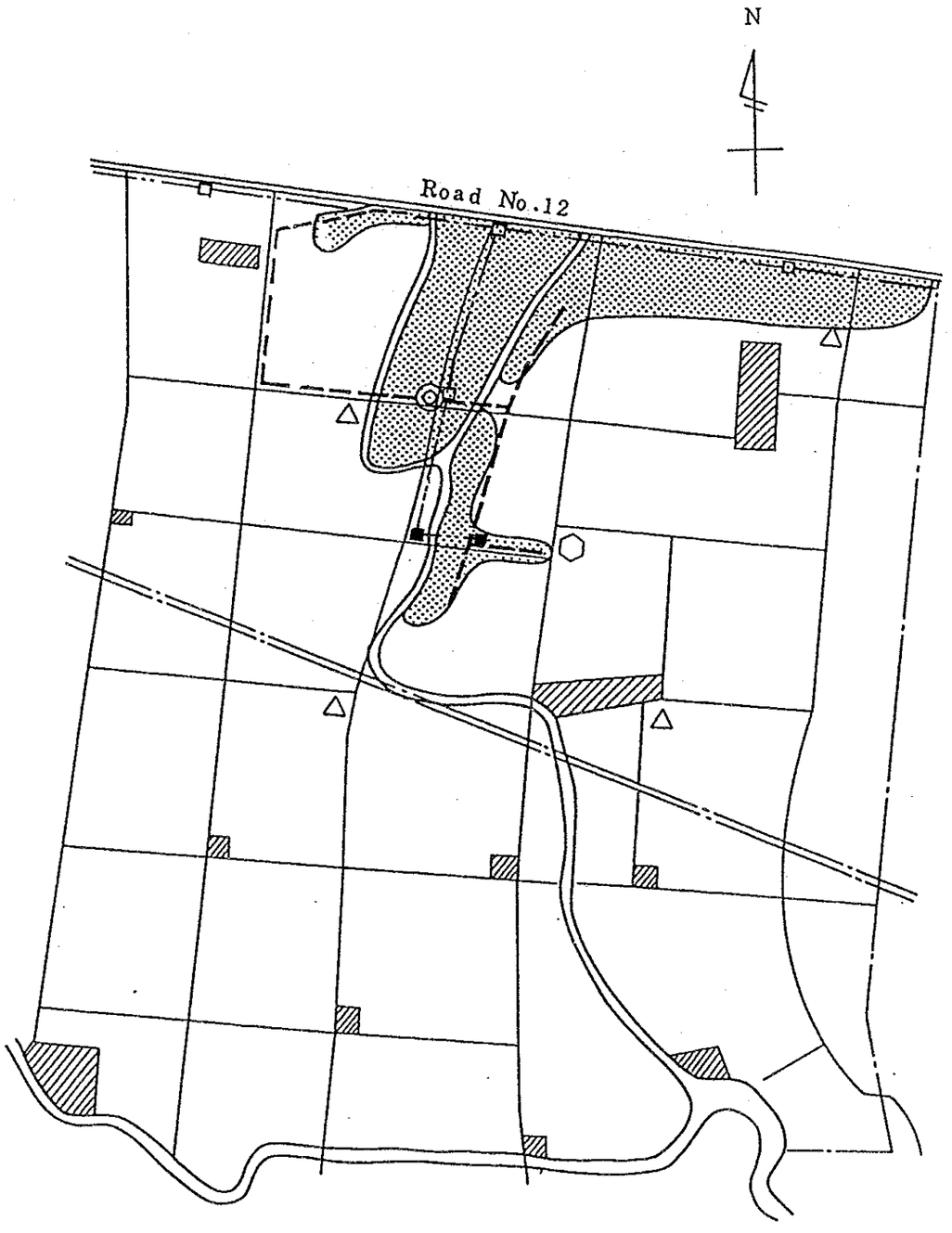
- RESERVOIR
- FARM ROAD
- DUAL-PURPOSE CANAL
- TERMINAL WEIR
- BRIDGE
- VILLAGE

SCALE 1:20,000

0 500 1000 m.

KINGDOM OF THAILAND MINISTRY OF AGRICULTURE AND COOPERATIVES AGRICULTURAL LAND REFORM OFFICE			
F/S ON SUKHOTHAI INTEGRATED AGRICULTURAL AND RURAL INFRASTRUCTURE DEVELOPMENT PROJECT			
GENERAL PLAN IN THUNG SAI YART			
DATE	MAR - 1990	DWG	2
JAPAN INTERNATIONAL COOPERATION AGENCY			

LOCATION MAP OF RURAL INFRASTRUCTURE, POST-HARVEST AND MARKETING FACILITIES



LEGEND

- PROPOSED RURAL INFRASTRUCTURE
- DOMESTIC WATER SUPPLT WITH PIPED SYSTEM
- HIGH-VOLTAGE POWER LINE
- MULTI-PURPOSE HALL
- PROPOSED POST-HARVEST FACILITITY
- MULTI-PURPOSE STORAGE
- MISCELLANEOUS
- ROAD
- CANAL
- EXISTING HIGH-VOLTAGE POWER LINE
- VILLAGE

SCALE

0 ——— 500m

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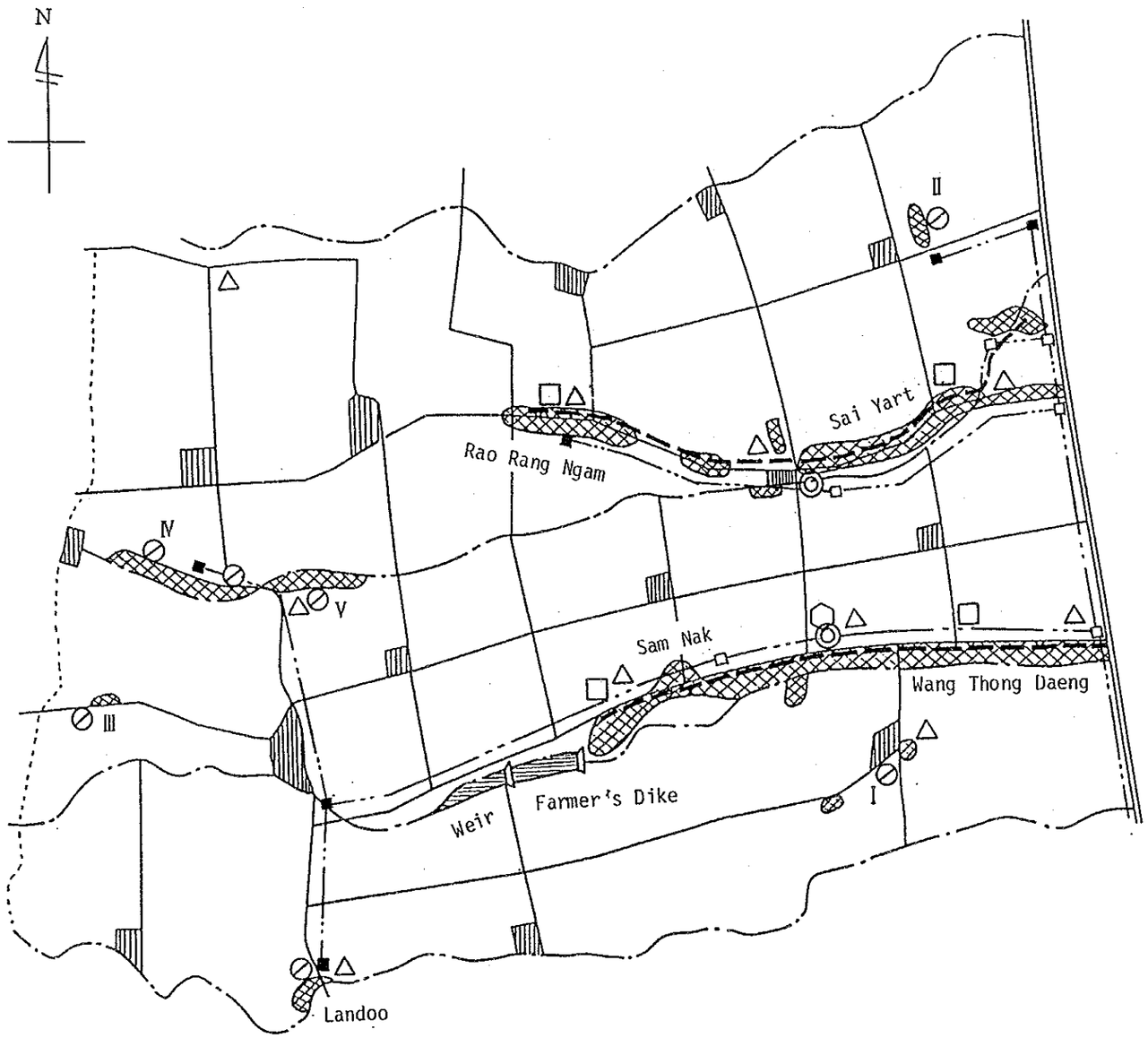
F/S ON SUKHOTHAI INTEGRATED AGRICULTURAL AND RURAL INFRASTRUCTURE DEVELOPMENT PROJECT			
RURAL INFRA. & POST-HARVEST FACILITIES IN NONG KHON KAEN			
DATE	MAR - 1990	DWG	3
JAPAN INTERNATIONAL COOPERATION AGENCY			

LOCATION MAP OF RURAL INFRASTRUCTURE, POST-HARVEST AND MARKETING FACILITIES



LEGEND

- PROPOSED RURAL INFRASTRUCTURE
- DOMESTIC WATER SUPPLT WITH PIPED SYSTEM
- DOMESTIC WATER SUPPLY WITH HAND PUMP
- HIGH-VOLTAGE POWER LINE
- MULTI-PURPOSE HALL
- MEETING HALL
- PROPOSED POST-HARVEST FACILITITY
- MULTI-PURPOSE STORAGE
- MISCELLANEOUS
- ROAD
- CANAL
- EXISTING HIGH-VOLTAGE POWER LINE
- VILLAGE

SCALE

0 2,000m

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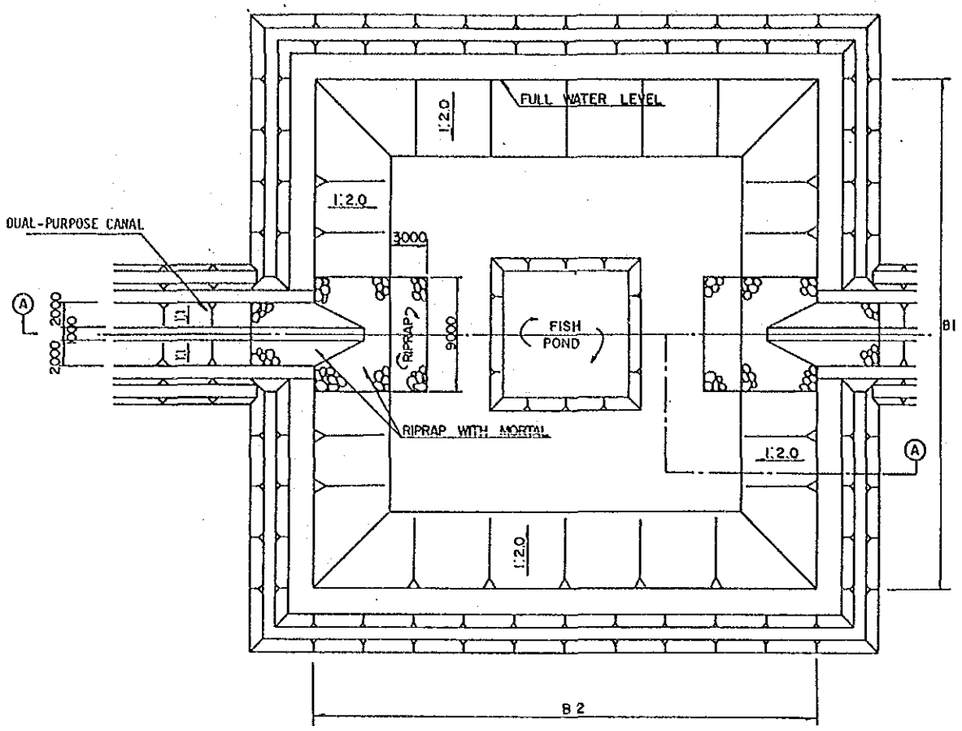
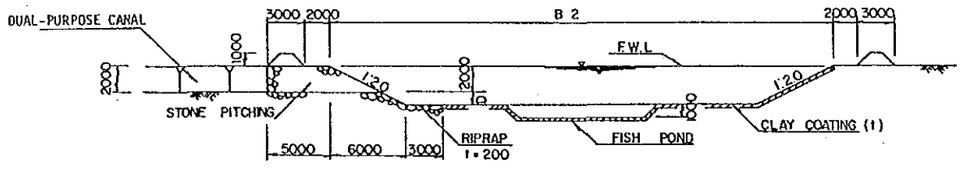
F/S ON SUKHOTHAI INTEGRATED AGRICULTURAL AND RURAL INFRASTRUOTURE DEVELOPMENT PROJECT			
RURAL INFRA. & POST-HARVEST FACILITIES IN THUNG SAI YART			
DATE	MAR - 1990	DWG	4
JAPAN INTERNATIONAL COOPERATION AGENCY			

RESERVOIR



PLAN

SCALE 1:200

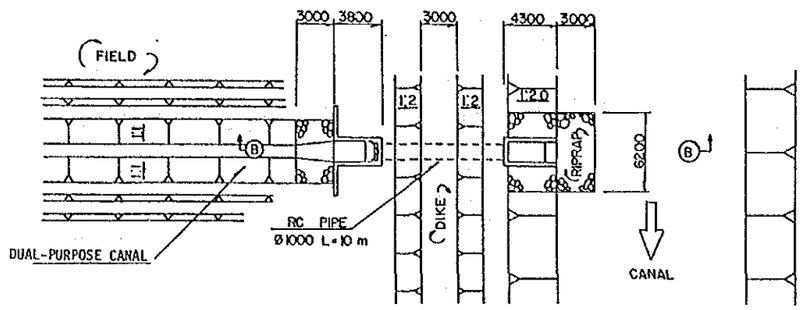


SECTION A-A

SCALE 1:200

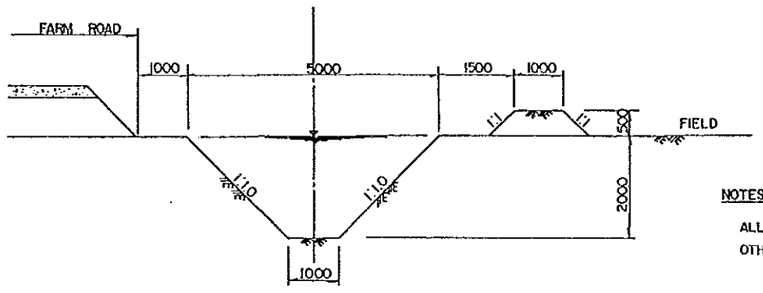
DIKE CROSSING CULVERT

SCALE 1:200



DUAL-PURPOSE CANAL

SCALE 1:50



NOTES

ALL DIMENSIONS ARE IN MILIMETER EXCEPT OTHERWISE SHOWN

(UNIT : m)

TYPE	B1	B2	D1	t
I	200	200	0.20	0.20
II	100	150	0.20	0.20
III	100	100	0.20	0.20
IV	600	400	0.20	0.20
V (F)	400	250	0.50	0.25
VI (F)	300	300	0.50	0.25
VII (F)	200	200	0.50	0.25
VIII	400	250	0.20	0.20

NOTES; (F) MEANS RESERVOIR WITH FISH POND
D1 MEANS DEAD WATER OF RESERVOIR
t MEANS THICKNESS OF CLAY COATING

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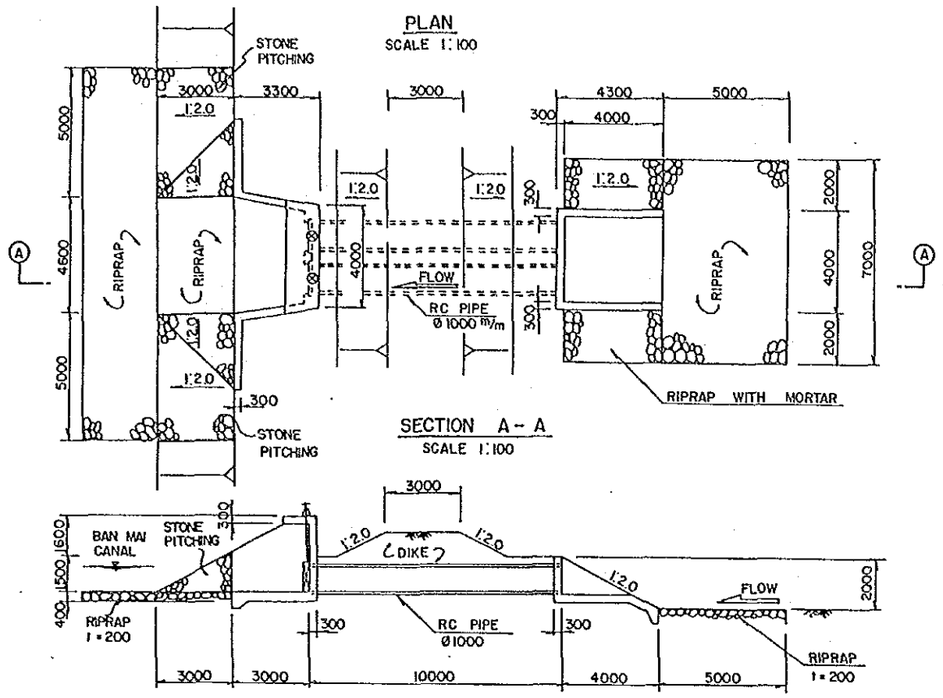
AGRICULTURAL INFRASTRUCTURE
IRRIGATION FACILITIES (1)

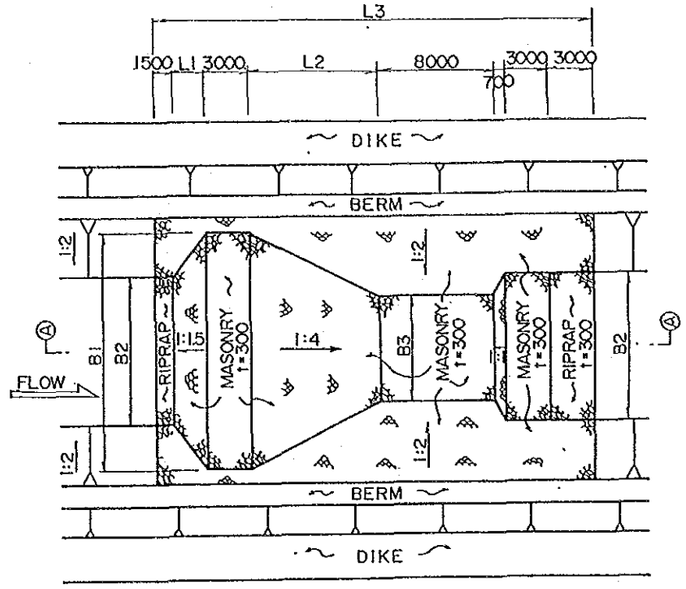
DATE	MAR - 1990	DWG	5

JAPAN INTERNATIONAL COOPERATION AGENCY

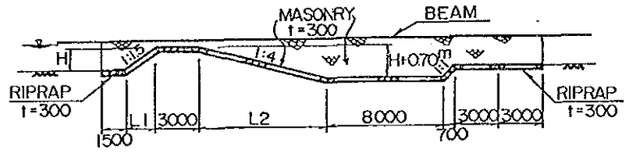
WEIR WITH GATE FACILITY



WEIR OVERFLOW - TYPE



PLAN
SCALE 1:200



SECTION A-A
SCALE 1:200

NOTES

ALL DIMENSIONS ARE IN MILIMETER EXCEPT OTHERWISE SHOWN

(Unit : m)

	TYPE I	TYPE II	TYPE III
B1	20.00	14.00	16.00
B2	14.80	8.20	10.00
B3	12.20	5.40	7.20
H	1.25	1.45	1.50
L1	1.88	2.18	2.25
L2	7.80	8.60	8.80
L3	28.18	29.28	29.55

KINGDOM OF THAILAND
MINISTRY OF AGRICULTURE AND COOPERATIVES
AGRICULTURAL LAND REFORM OFFICE

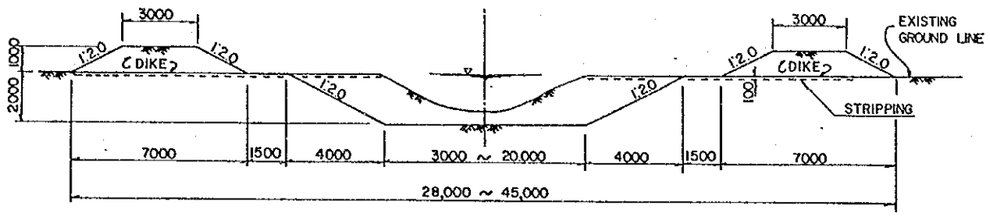
F/S ON SUKHOTHAI INTEGRATED AGRICULTURAL AND RURAL INFRASTRUCTURE DEVELOPMENT PROJECT

AGRICULTURAL INFRASTRUCTURE
IRRIGATION FACILITIES (2)

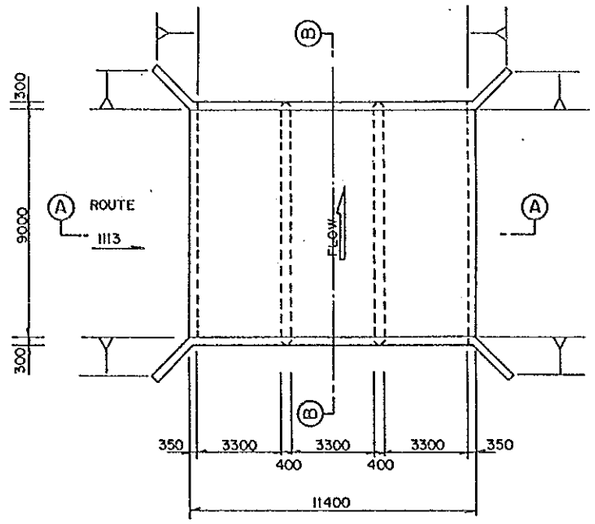
DATE	MAR - 1990	DWG	6

JAPAN INTERNATIONAL COOPERATION AGENCY

CANAL IMPROVEMENT

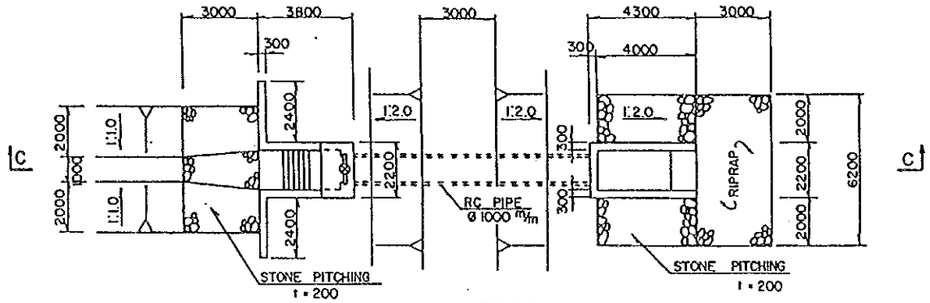


BRIDGE

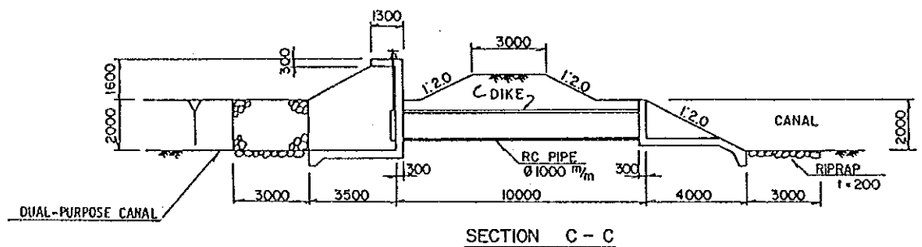


PLAN
SCALE 1:100

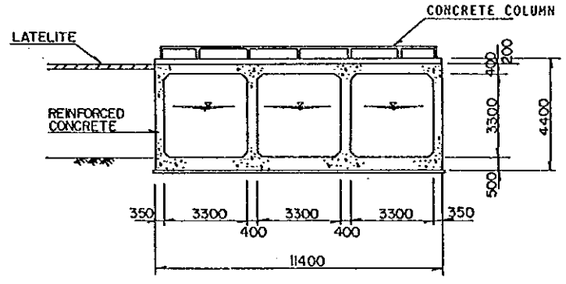
DIKE CROSSING CULVERT



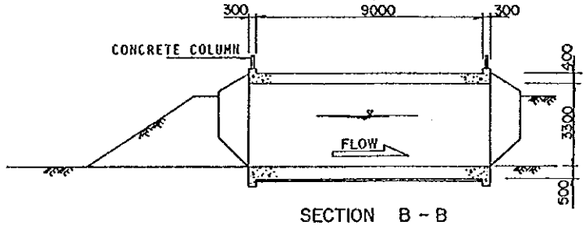
PLAN
SCALE 1:100



SECTION C - C
SCALE 1:100



SECTION A - A
SCALE 1:100



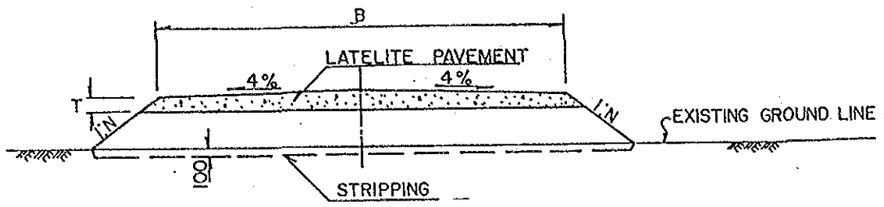
SECTION B - B
SCALE 1:100

NOTES

ALL DIMENSIONS ARE IN MILIMETER EXCEPT OTHERWISE SHOWN

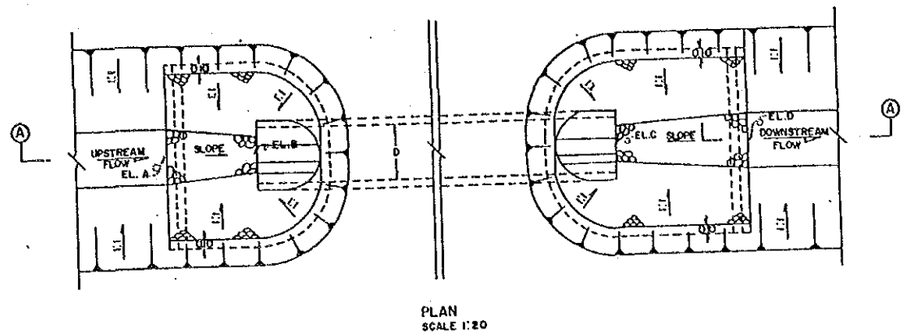
KINGDOM OF THAILAND			
MINISTRY OF AGRICULTURE AND COOPERATIVES			
AGRICULTURAL LAND REFORM OFFICE			
F/S ON SUKHOTHAI INTEGRATED AGRICULTURAL AND RURAL INFRASTRUCTURE DEVELOPMENT PROJECT			
AGRICULTURAL INFRASTRUCTURE DRAINAGE FACILITIES			
DATE	MAR - 1990	DWG	7
JAPAN INTERNATIONAL COOPERATION AGENCY			

FARM ROAD

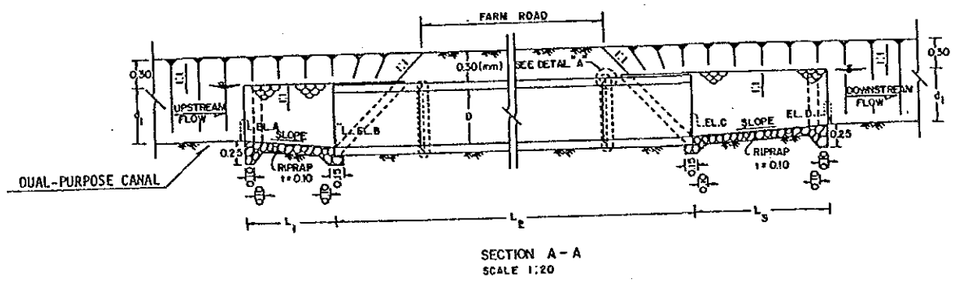


	B	T	N
MAIN F.R	6000	200	1.5
LATERAL F.R	4000	200	1.5
BRANCH F.R	3000	100	1.0

ROAD CROSSING CULVERT(A) ON DUAL-PURPOSE CANAL



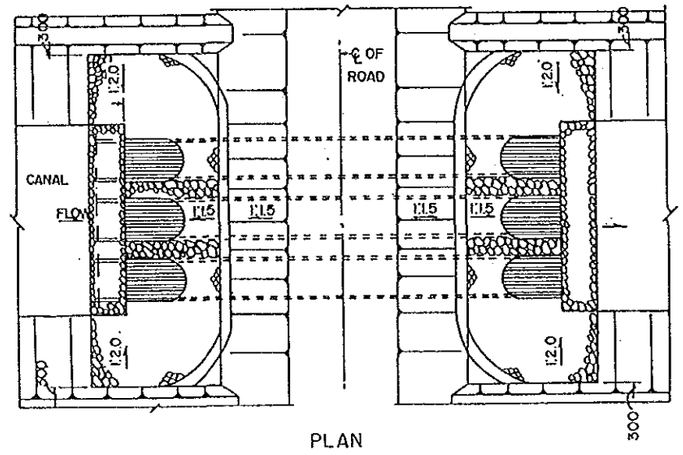
PLAN
SCALE 1:20



SECTION A-A
SCALE 1:20

TYPE	D	L1	L2	L3	d
I	400	800	5m ~ 8m	1200	500
II	600	1200	6 ~ 9	1500	700
III	1000	2000	7 ~ 10	3000	1200

ROAD CROSSING CULVERT(B) ON CANAL



PLAN

NOTES

ALL DIMENSIONS ARE IN MILIMETER EXCEPT OTHERWISE SHOWN

KINGDOM OF THAILAND
MINISTRY OF AGRICULTURE AND COOPERATIVES
AGRICULTURAL LAND REFORM OFFICE

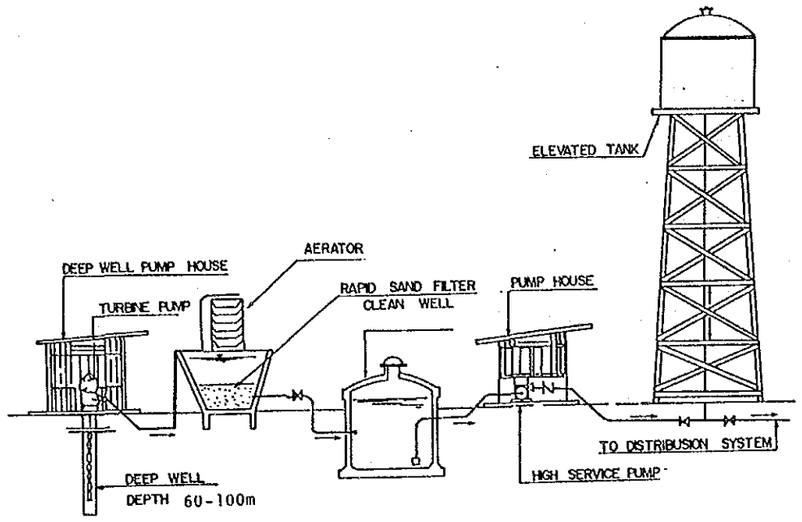
F/S ON SUKHOTHAI INTEGRATED AGRICULTURAL AND RURAL INFRASTRUCTURE DEVELOPMENT PROJECT

AGRICULTURAL INFRASTRUCTURE
FARM ROAD & ROAD CROSSING

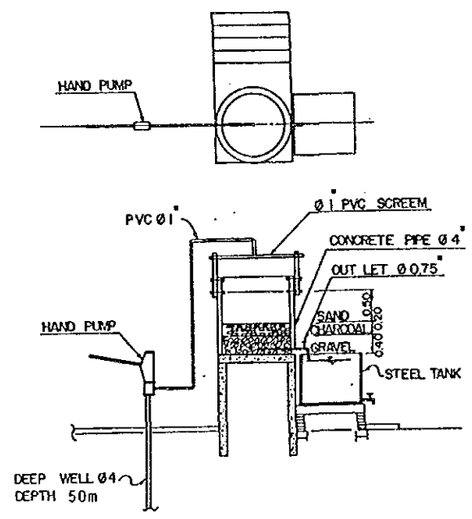
DATE	MAR - 1990	DWG	8

JAPAN INTERNATIONAL COOPERATION AGENCY

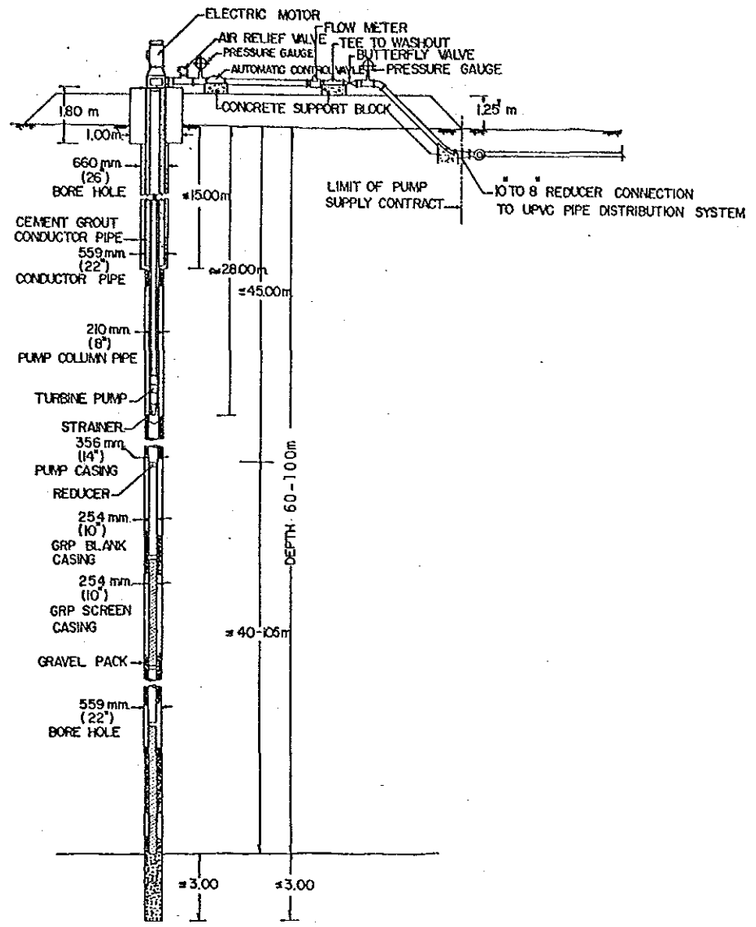
PIPED RURAL WATER SUPPLY



HAND PUMP WITH SAND FILTRATION



DEEP WELL WITH TURBINE PUMP

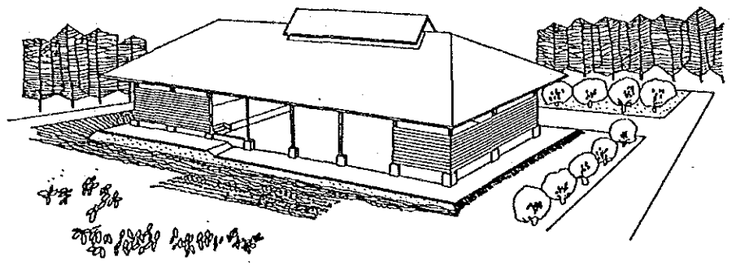


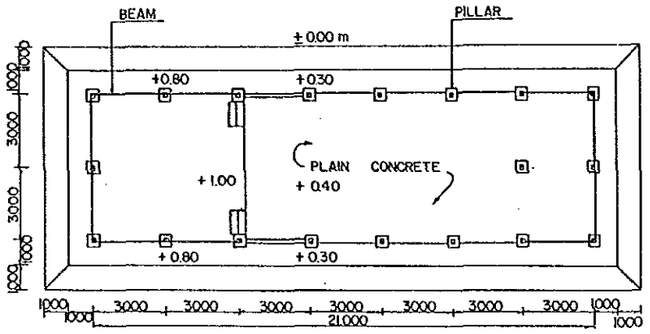
NOTES

ALL DIMENSIONS ARE IN METER EXCEPT OTHERWISE SHOWN

KINGDOM OF THAILAND MINISTRY OF AGRICULTURE AND COOPERATIVES AGRICULTURAL LAND REFORM OFFICE			
F/S ON SUKHOTHAI INTEGRATED AGRICULTURAL AND RURAL INFRASTRUCTURE DEVELOPMENT PROJECT			
RURAL INFRASTRUCTURE DOMESTIC WATER SUPPLY			
DATE	MAR - 1990	DWG	9
JAPAN INTERNATIONAL COOPERATION AGENCY			

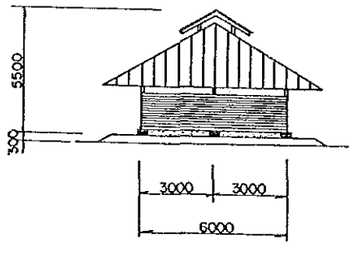
MEETING HALL



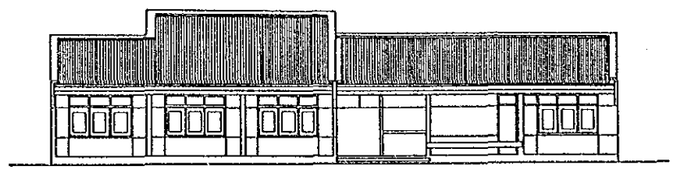


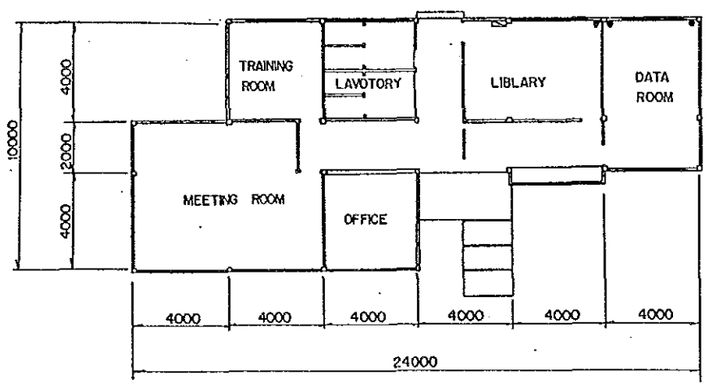
PLAN

SCALE 1 : 100



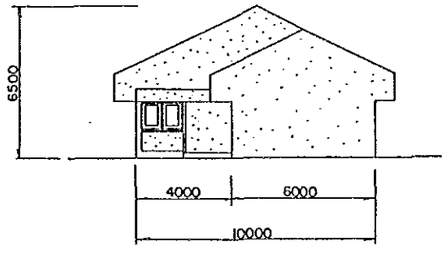
MULTI- PURPOSE HALL





PLAN

SCALE 1 : 100



NOTES

ALL DIMENSIONS ARE IN MILIMETER EXCEPT OTHERWISE SHOWN

KINGDOM OF THAILAND MINISTRY OF AGRICULTURE AND COOPERATIVES AGRICULTURAL LAND REFORM OFFICE			
F/S ON SUKHOTHAI INTEGRATED AGRICULTURAL AND RURAL INFRASTRUCTURE DEVELOPMENT PROJECT			
RURAL INFRASTRUCTURE MEETING FACILITIES			
DATE	MAR - 1990	DWG	10
JAPAN INTERNATIONAL COOPERATION AGENCY			

JICA