DESIGN REPORT

THE TECHNICAL CO-OPERATION PROJECT ON THE IRRIGATED AGRICULTURE DEVELOPMENT IN THAILAND

JULY 1977

JAPAN INTERNATIONAL COOPERATION AGENCY

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FOREWORD

This Survey Team for Detailed Design was engaged in the two-month study, 13 February through 13 April, 1977, in response to the request from the Government of Thailand for Japanese Technical Cooperation on the Irrigated Agriculture Development Project.

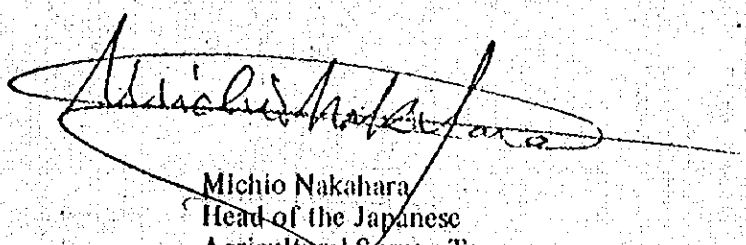
The study aimed at consultation with Thai authorities about the scope of the technical cooperation and approaches of the Government of Japan as well as formulating the master plan of the Cooperation Project and preparation of the final design of the Pilot Farms.

It was really appreciative that the best cooperation and positive response extended by the Government of Thailand and other authorities concerned could make it possible to achieve the goal envisaged and that the Record of Discussion on the Project was signed on 8 April, 1977, by both parties, enabling the Governments of Thailand and Japan to take further steps towards the implementation of the Project.

I, the undersigned, have a great pleasure to submit herewith the study report of the Project, which would help managerially and technically the implementaton of the Project under close cooperation of two countries.

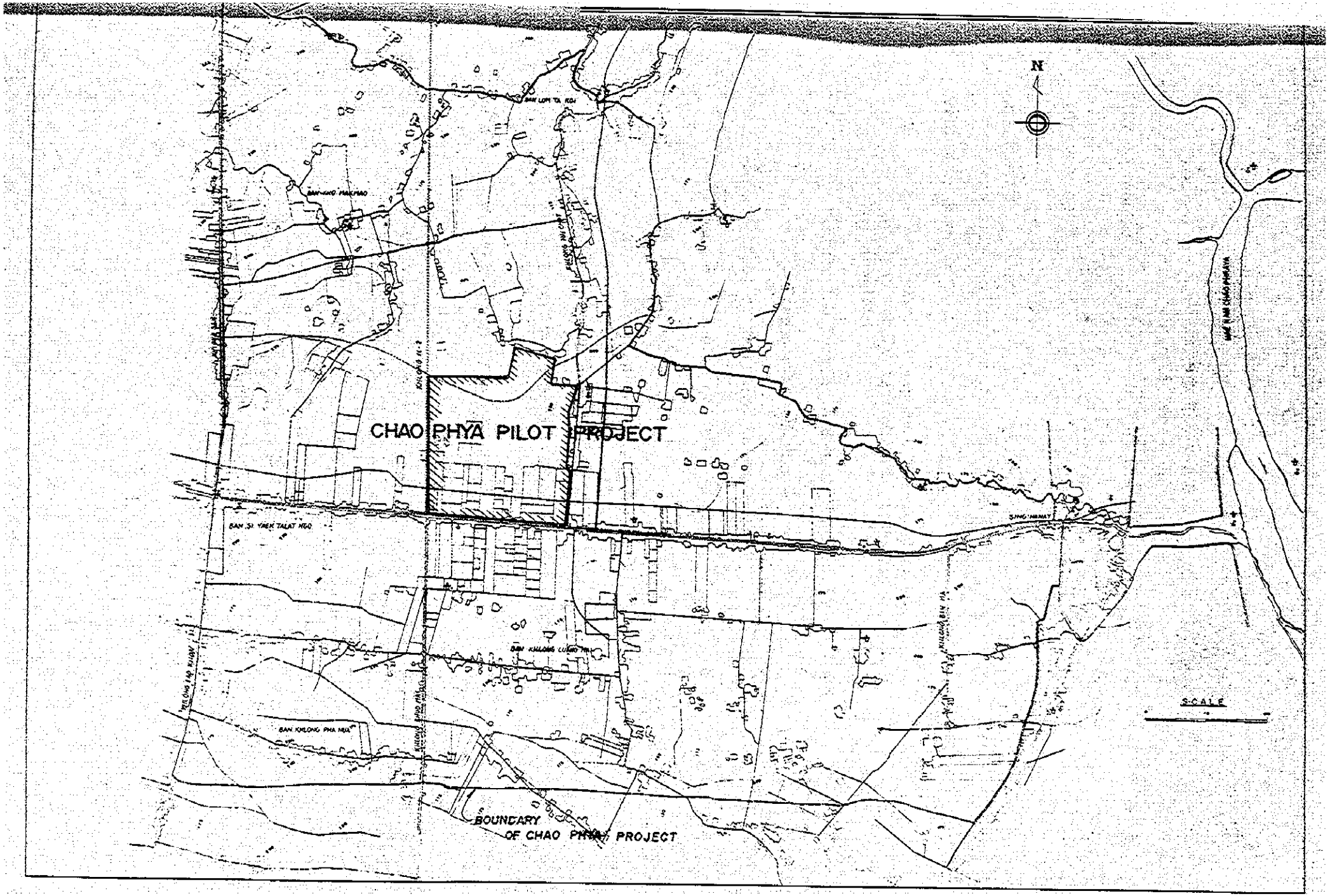
Taking the advantage of this opportunity I sincerely wish to express my heartiest thanks for the kind cooperation and various help given by the Ministry of Agriculture and Cooperatives, Thailand, and its concerned agencies of the Government of Thailand. The assistances extended by the Royal Irrigation Department, Central Land Consolidation Office, Agricultural Land Reform Office, Department of Agriculture and Department of Agriculture Extension were particularly of great help in carrying out the Team's assignment.

Very truly yours,



Michio Nakahara
Head of the Japanese
Agricultural Survey Team

30 July, 1977


N
CHAO PHYA PILOT PROJECT
BAN SI YAEK TALAT NGO
BAN KHLONG PHA NUA
BOUNDARY
OF CHAO PHYA PROJECT
SCALE

C O N T E N T S

CHAPTER 5. PLAN OF TECHNICAL COOPERATION

LIST OF TABLES

LIST OF FIGURES

DRAWINGS

ABBREVIATION

mm	:	millimeter
cm	:	centimeter
m	:	meter
km	:	kilometer
sq.m, m^2	:	square meter
sq.km, km^2	:	square kilometer
rai	:	Thai unit of area, 1 rai = 0.16 ha.
ha	:	hectare
l, lit	:	liter
cu.m, m^3	:	cubic meter
lit/sec	:	liter per second
cu.m/sec	:	cubic meter per second
lit/sec/ha	:	liter per second per hectare
PPM	:	part per million
ton, m.t	:	metric ton
El.	:	elevation above mean sea level
MSL	:	mean sea level
NWL	:	normal water level
FWL	:	full water level
HWL	:	high water level
WL	:	water level
sec.	:	second
min.	:	minute
hr.	:	hour
min.	:	minimum
max.	:	maximum
%	:	percent
No.	:	number
^{o}C	:	degree centigrade
HP	:	horse power
ET	:	evapotranspiration
HYV	:	high yield rice variety
O & M	:	operation and maintenance
FY	:	fiscal year
MOAC	:	Ministry of Agriculture and Cooperatives
ALRO	:	Agricultural Land Reform Office
RID	:	Royal Irrigation Department
CLCO	:	Central Land Consolidation Office
BAAC	:	Bank for Agriculture and Agricultural Cooperatives
Cahangwat	:	province
Amphoe	:	district
Tambon	:	sub-district
Muban	:	village
Khlong	:	canal

CHAPTER 1. PREFACE

1-1. The Outline of Japanese Technical Cooperation Program for Irrigated Agriculture Development in Thailand

1-1-1. The Purpose and Background of the Project

The paddy cultivation in Thailand, which has been carried out in the vast paddy fields of about 6.8 million hectares, produces its annual yield of approximately 12.0 million tons of rice (unhusked rice equivallent), and about one million tons of the annual production have been exported to those Southeast Asian countries which have been suffering from the chronical shortage of foodstuff.

Thus, as compared with other Southeast Asian countries, the Thailand agriculture has been maintaining considerably stabilized paddy production, which, as nucleus of the agriculture, is playing a vitally important role in the national economy, contributing to improvement of the balance of payment to a great extent.

The latest achivement of the country's rice farming depends on not only blessed natural conditions but also the investment made for the infrastructural water utilization facilities since long time before. Particularly, the main irrigation and drainage canals provided by the Royal Irrigation Department have been internationally highly evaluated.

Recently, however, the population of Thailand has been explosively increasing, exceeding three percent of annual growth rate, as those cases in other Southeast Asian countries. If the population is growing on in keeping the current pace, the surplus capacity for rice export will become feeble to face difficulty in the self-sufficiency of rice in the country within less than 10 years.

The Third National Economic and Social Development Plan (1972-1976) involves the schedule for diversification and stabilization of exports by farm production increase and multiple cropping so as to take a countermeasure for expected severe situation.

The farm production increase, particularly in paddy production, will indispensably require production increase per unit acreage and expansion of cropped acreage for double cropping. In order to realize the program, the following measures should be taken:

1) The high yielding varieties (e.g. the RD strain in Thailand) should be introduced to possibly large acreage and the land consolidation should be provided so as to carry out the proper water management.

2) The irrigation water should be secured for dry season cropping and the terminal irrigation facilities should be completely provided for efficient water utilization.

3) The agriculture supporting services should be positively promoted for improvement and extension of the farming techniques and farmers' organization along with the above-menthioned direction.

As mentioned already, since the end of World War II, the consolidation of main irrigation and drainage facilities has been expedited to produce good effect for securing the waters. The better water utilization, however, has not been made yet due to the absence of on-farm facilities such as secondary, and tertiary canals, water intake systems to the fileds and land consolidation.

Then, the Government of Thailand has come to recognize the fact that the increase in paddy yield should inevitably require to realize the on-farm development as early as possible.

Under such circumstances, the Government has formulated the plan of on-farm development, particularly the land consolidation program as core of the plan, (so-called Irrigated Agriculture Development), and took necessary legal and institutional measures in enforcement of Land Consolidation Act (1974) and Agricultural Land Reform Act (1975) for smooth execution of the development program. The Government carried out the administrative reorganization that had transferred the Royal Irrigation Department to have belonged to the Ministry of Interior, into the Ministry of Agriculture and Cooperatives, and newly established the Central Land Consolidation Office in charge of planning and execution of land consolidation projects, and the Agricultural Land Reform Office for promotion of the land reform.

In parallel with those positive measures for irrigated agriculture development, in February 1976, the Government of Thailand requested the Government of Japan, the most advanced country in the on-farm development techniques, to supply the technical cooperation in implementation of the land consolidation program.

The said request of Thailand has certainly come from not only its reliance on Japanese advanced technology but close contacts and mutual good understanding through many symposia and exchange of related engineers between each other.

In the future technical cooperation by Japan, a great care should be exercised on the following points:

1) The land consolidation techniques in Japan, which has been highly developed, should not be applied directly to the case of Thailand, although the Japanese technology will be lessons to the country. In view of economy, special attention should be paid to minimizing the investment per unit acreage, the approach to quick yielding and the large scale extension; 2) as mentioned precedingly, Thailand, as its national policy, is trying to promote multiple cropping as well as production increase of paddy for farmers' income

growth and stabilization together with diversification of farm products for exports. Thus, the land consolidation which will enable to carry out convertible farming between paddy cropping and upland cropping, and also it is required to select the crops suited for the local conditions and to extend the improved farming techniques.

1-1-2. Response to the Request

In response to the request by the Government of Thailand, the Government of Japan dispatched the Preliminary Survey Mission on Irrigated Agriculture Project in Thailand (headed by Dr. T. Kimura) for 25-day assignment period to conduct the field survey and consultation with the Thai Government concerned. These series of activities resulted in enabling the Mission to have full understanding on the purpose and significance of the Project, and come to express keen interest therein. At the same time, it was confirmed that the Project would be materialized under the close cooperation of both countries and the Project Area would be limited to the Greater Mae Klong Basin and the Lower Greater Chao Phya Basin. The Scope of cooperation works were also defined for the Greater Mae Klong Basin, to planning and implementation for establishing two pilot farms and conducting feasibility study for on-farm development with land consolidation and master plan formulation for the total Basin, and for the Greater Chao Phya Lower Basin, to conduting the feasibility study of the West Bank Tract, planning and implementation for establishing two pilot farms.

Along with the fundamental direction the Preliminary Study Mission determined, the Government of Japan dispatched the Feasibility Study Mission (headed by Mr. S. Watanabe), on the irrigated agriculture development project in the West Bank Tract of the Lower Greater Chao Phya for two-month study started from October 1976, covering about 12,000 hectares in that basin. At the end of November, 1976, the 15-day preparatory works were assigned to the Mission (led by Mr. Y. Ohata) to make frame works for the following detailed survey, and the discussion meeting was held to formulate the plan of approach to the final design of the Pilot Farm Program.

And February through April, 1977, the Detailed Survey Mission (headed by Mr. M. Nakahara) carried out the final plan formulation and detailed design for the pilot farms of the Greater Chao Phya and the Greater Mae Klong, and at the same time, the Mission had deliberate consultation with the Thai Government concerned on the implementation of the Pilot program and concluded to sign the Record of Discussions concerning technical cooperation for the irrigated agriculture development in Thailand.

1-2. Outline of Technical Cooperation

On April 8, 1977, agreement was concluded between both countries with the Record of Discussion mutually signed, and the Project plan based on the said agreement was outlined as follows:

The Project aims at, under the close cooperation of both countries, promoting the land consolidation works that will enable to increase in rice production by yield increase per unit acreage and expansion of acreage for paddy double cropping, and contributing to improvement and diffusion of farming techniques together with farmers' organizations.

The Project consists of the Project Center and three sub-projects, namely Chao Phya Pilot Project, Mae Klong Pilot Project, and Experiment and Training Project, expediting the Irrigated Agriculture Development Plan integrally and effectively.

i) The Project Center

The Project Center will be established in Bangkok as the headquarter, and function as below.

(1) To give necessary technical advices for planning and implementation of the Irrigated Agriculture Development Plan in the Lower Greater Chao Phya Basin and the Greater Mae Klong Basin;

(2) To conduct managerial and coordinating works in order to promote smooth and effective implementation of three sub-projects.

ii) The Chao Phya Pilot Project

The Chao Phya Pilot Project of about 500 ha will be set up for agricultural development of the flood irrigation area in Tambol Phraya Banlu, Amphoe Lat Bua Luang, Changwat Ayutthaya.

iii) The Mae Klong Pilot Project

The Mae Klong Pilot Project (No.1) of about 400 ha and the Mae Klong Pilot Project (No.2) of about 500 ha will be set up in Tambol Maungchum and Banmai, Amphoe Tha Muang, Changwat Kanchanaburi and in Tambol Taklamen, Amphoe Tha Maka, Changwat Kanchanaburi respectively for agricultural development by means of multi-cropping.

The activities in the Pilot Projects mentioned in ii) and iii) above are as follows:

(1) To plan of execute the improvement works of agricultural physical infrastructure, such as field rearrangement, farm roads, irrigation and drainage facilities and empoldering dikes (as required in Chao Phya), in each pilot area;

(2) To advise on technical matters to farmers in the pilot areas and staff concerned for effective water management;

(3) To conduct trials with improved agricultural techniques of rice cultivation mainly at the trial farm of about 10 ha;

(4) To provide training and guidance to farmers in the pilot areas and their vicinities on improved agricultural techniques;

(5) To introduce and demonstrate improved agricultural techniques at a few model farms which will be sellected in the pilot areas;

(6) To foster and strengthen farmers' organizations for water management, joint co-operative activities for distribution of agricultural materials, collection and forwarding of agricultural products and other activities necessary in the pilot areas including their vicinities when necessity arises.

The implementation of the Mae Klong Pilot Project (No.2) will be of extensive method.

iv) Experiment and Training Project

The activities of the Suphan Buri Station located in Thambol Rua Yai, Amphoe Muang, Changwat Suphan Buri are as follows:

To conduct experiments and training on improved agricultural techniques for the successful implementation of the Irrigated Agriculture Development in the pilot areas and their vicinities.

The experiment mentioned above will be primarily carried out by the Government of Thailand and the trainees will be agriculture officers and staff concerned.

The Japanese Cooperation to be given in the Project is detailed as follows:

(1) Dispatching the experts: The experts will be dispatched to the Project Center in Bangkok and other three sub-projects, including such long-term assigned staff as Team Leader, Irrigation & Drainage Engineers, Land Consolidation Engineers, Agro-economists, Agronomists, Liaison Officer, etc., but not exceeding 20 members in total.

(2) Machineries, equipment, and agri-chemicals to be granted: The Government of Japan will grant the construction machineries for land consolidation works, farming machines, fertilizers, agri-chemicals and vehicles to be required for the Project execution.

(3) Training and study in Japan: The Thai counterparts personnel assigned to the Project will be trained in Japan to master techniques of irrigation & drainage, paddy cropping, etc. to be necessitated in the Project implementation.

The period of time for this Technical Cooperation is stated as five years.

1-3. General Description of the Survey for Final Design

1-3-1. The Purpose

The Project aims at consolidation of agricultural infrastructures with land consolidation centered in the pilot farms in the Chao Phya and the Mae Klong Districts, involving plan formulation of improvement and extension works on farming techniques and farmers' organization. For the series of services, the Mission has made the deliberate consultation with the Thai Government concerned to finalize the agreement for the scope of cooperation works and approaches to the Project with Record of Discussions mutually signed.

For further references, the final design of the Mae Klong Pilot Farms, No.1 & No.2 Districts will be carried out in September - October, 1977, by another delegation whereas the Mission has conducted the master plan formulation of the Project and the final design of the Chao Phya Pilot Farm Project.

1-3-2. Specified Scope of Services

i) Major issues discussed with the Government of Thailand

(1) Frame-works of the Project (Project Organization, Scale and Location of the Pilot Farms, Executing body of Thai authority concerned, etc.)

(2) The scope of the Japanese cooperation works and approaches to the Project (Field to be covered by cooperation, period of cooperation, members and specialities of the experts to be assigned to the Project, the kinds and quantities of machineries, equipment, other materials to be granted, and the counterparts training program in Japan, etc.)

(3) Direction for final design of pilot farms and planning for improvement of farming techniques and farmers' organization

(4) The Record of Discussions

ii) Survey and study items

(1) Plan for consolidation of agricultural infrastructures

Polder dike scheme
Irrigation scheme
Drainage scheme
Land consolidation scheme
Water management scheme

(2) Plan for farm management

Land use scheme
Proposed cropping pattern
Production amounts of farm products
Labor requirements and agricultural inputs

(3) Agriculture supporting services

Agriculture extension scheme

Trial farms

Farmers' organization

(4) Architecture and facilities

(5) Implementation schedule

(6) Estimate of Project costs

1-3-3. Working Record

The working record of the Mission was summarized in TABLE I-1 on the basis of the results of the discussion with the Thai authorities concerned.

1-3-4. Personnel Organization of the Mission

The personnel organization of the Mission was listed in TABLE I-2.

TABLE I-1 Working Record

Date	Day	Work Item	Description
Feb. 13	Sun.		Arrival in Bangkok
14	Mon.	Team meeting	Arrangements for survey schedule
15	Tue.	Courtesy call to CLCO, RID and ALRO	Courtesy call and explanation of the purpose of the survey and outline of the Projects
16	Wed.	Couresy call to DTEC and Japanese Embassy	ditto
17	Thu.	First joint meeting	The purpose of the study, outline of the projects, system of Japanese Technical Cooperation, request to the Thai Government for facilities for the study, presentation of materials (member list, study schedule, draft R/D, proposed organization chart of the project)
		Meeting with experts	Land consolidation in Thailand
18	Fri.	Team meeting	Arrangements for survey
19	Sat.	Inspection trip	Chao Phya pilot area
20	Sun.	Team meeting	Arrangements for weekly schedule and topographic survey
21	Mon.	Inspection trip	Mae Klong Pilot area
22	Tue.	Meeting with DA	Explanation of draft R/D
		Discussion with ALRO	Boundary and acreage of the project area, location of polder dikes
23	Wed.		Data and information study

Date	Day	Work Item	Description
Feb. 24	Thu.	Meeting with RID	Progress of draft R/D Study
		Meeting with DAE	ditto
		Meeting with Bangkok office, JICA	Location, boundary and acreage of Chao Phya project area
25	Fri.	Discussion with CLCO	Schedule of second joint meeting
		Team meeting	Formulation of approaches to detail design study and schedule of topographic survey
26	Sat.		Preparation of materials for second joint meeting
27	Sun.		ditto
28	Mon.	Discussion with ALRO	Acreage (500 ha) of Chao Phya area
		Meeting with DTEC	Progress of draft R/D Study
Mar. 1	Thu.	Meeting with RID	Necessary arrangement for project implementation
		Meeting with experts	Land consolidation in Thailand
2	Wed.	Second joint meeting	1. Report of the team activities after first joint meeting 2. Discussion on draft R/D 3. Explanation of the outline of project 4. Schedule of the following survey 5. Presentation of materials (outline of project design)
3	Thu.	Meeting with Bangkok Office, JICA	Minutes of second joint meeting
4	Fri.	Team meeting	Schedule of the following study
5	Sat.		Study on the results of second joint meeting

Date	Day	Work Item	Description
Mar. 6	Sun.		Holiday
7	Mon.	Meeting with Bangkok Office, JICA	Arrangements for succeeding weekly schedule
		Meeting with DA	Progress of draft R/D Study and present condition of Suphan Buri Rice Experiment Station
8	Tue.	Discussion with CLCO	Newly proposed acreage (500 ha) of Mae Klong No.2 project area and methods of land consolidation program (extensive method)
		Meeting with DAE	Progress of draft R/D Study
		Meeting with ALRO	Required construction heavy machineries
9	Wed.	Meeting with experts of Mekong Committee	Land consolidation in Thailand
		Meeting with DA	Outline of the project
10	Thu.	Meeting with DA	Technical Cooperation on Suphan Buri Rice Experiment Station
11	Fri.	Discussion with CLCO	Schedule of third joint meeting
		Discussion with ALRO	ditto
		Third joint meeting	Final discussion on draft R/D
		Meeting with Bangkok Office, JICA	Minutes of third joint meeting and schedule of succeeding study
12	Sat.	Team meeting	Preparation of interim reports
13	Sun.		Report making
14	Mon.	Meeting with Bangkok Office, JICA	Minutes of third joint meeting

Date	Day	Work Item	Description
Mar. 15	Tue.	Discussion with CLCO	Construction schedule and construction heavy machineries
16	Wed.	Team meeting	Preparation of interim reports
17	Thu.	Meeting with CLCO	General affairs of the project implementation
18	Fri.	Meeting with CLCO	Budget to be financed by the Thai Government
19	Sat.		Report making of interim reports
27	Sun.		
28	Mon.	Meeting with Bangkok Office, JICA	Schedule of fourth joint meeting
29	Tue.	Contact with authorities concerned	Schedule of fourth joint meeting
30	Wed.		Arrival of Team Leader in Bangkok
31	Thu.	Courtesy call to RID, CLCO and ALRO	Courtesy call, presentation and explanation of second draft R/D
Apr. 1	Fri.	Courtesy call to MOAC	Courtesy call to Dr. Taleroon, explanation of the outline of project and draft R/D
2	Sat.		Report making of interim reports
3	Sun.		ditto
4	Mon.	Fourth joint meeting	Explanation of interim reports and explanation of second draft R/D

Date	Day	Work Item	Description
Apr. 5	Tue.	Meeting with Bangkok Office, JICA	Minutes of fourth joint meeting
6	Wed.		Preparation of R/D and schedule of project implementation
7	Thu.	Meeting with DTEC	Final R/D
8	Fri.	Signature of R/D	
9	Sat.		Holiday
10	Sun.		Holiday
11	Mon.	Meeting with ALRO	Nomination of the project director, supply of equipments and machineries and dispatch of experts
12	Tue.	Meeing with CLCO	ditto
13	Wed.		Return to Japan

TABLE I-2 List of the Japanese Detailed Survey Team

Speciality	Name	Original Position	Assignment Period
1. Team Leader	Mr. Michio Nakahara	Director of Agricultural Development Cooperation Department, JICA	Feb.13 - 30, Mar.30 - Apr.13
2. Land Consolidation	Mr. Mikio Furuya	Director, Okayama Engineering Laboratory, Chugoku-Shikoku Regional Agricultural Administration Bureau, Ministry of Agriculture and Forestry	Feb.13 - Mar. 5
3. Land Consolidation	Mr. Kazushige Torihata	Assistant Head, Design Div., Construction Department, Tohoku Regional Agricultural Administration Bureau, Ministry of Agriculture and Forestry	Mar.1 - Apr.2
4. Irrigation/Drainage	Mr. Yoshihisa Ito	Assistant Head, Engineering Div., Planning Department, Agricultural Structure Improvement Bureau, Ministry of Agriculture and Forestry	Mar.30 - Apr.13
5. Agricultural Extension	Mr. Masahiko Ichikawa	Senior Subject Matter Specialist, Extension Services Div., Agriculture and Forest Department, Saitama Prefecture Government	Feb.13 - Mar.14
6. Agronomy	Mr. Susumu Inoue	Senior Researcher, National Institute of Agricultural Sciences, Ministry of Agriculture and Forestry	Mar.1 - 27
7. Project Planning	Mr. Shigeyoshi Nishiwaki	Assistant Head, International Cooperation Div., International Affairs Div., Economic Affairs Bureau, Ministry of Agriculture and Forestry	Mar.30 - Apr.13

Speciality	Name	Original Position	Assignment Period
8. Project Planning	Mr. Yasuhiko Yamamoto	Senior Staff, Agricultural Development Div., Agricultural Development Cooperation Department, JICA	Feb.13 - Mar.14
9. Irrigation/Drainage	Mr. Kunio Ota	Consulting Engineer, Sanyu Consultants Inc.	Feb.13 - Apr.13
10. Land Consolidation	Mr. Yasuo Matsubara	Consulting Engineer, Sanyu Consultants Inc.	Mar.1 - Apr.13
11. Farm Management	Dr. Yoshihiro Takano	Consulting Engineer, Sanyu Consultants Inc.	Feb.13 - Apr.13
12. Architecture	Mr. Masao Okui	Architect, Sanyu Consultants Inc.	Mar.1 - Apr.13
13. Survey	Mr. Eiji Adachi	Consulting Engineer, Sanyu Consultants Inc.	Feb.13 - Mar.5
14. Coordination	Mr. Shinya Nakai	Staff, Agricultural Development Div., Agricultural Development Cooperation Department, JICA	Feb.13 - Apr.13

CHAPTER 2. CHAO PHYA PILOT FARM PROJECT

2-1. Present Situation of the Project Area

2-1-1. General Descriptions

a. Location and Acreage of the Project Area

The Chao Phya Pilot Farm Project Area is located in the West Bank Tract of the Chao Phya river, about 45 km north of Bangkok and administratively belongs to the Amphoe Lad Bao Laung, Changwat Ayutthaya, extending over Tambol Khu Slod and Tambol Phya Banlu.

The pilot farm project area, original proposed by the Agricultural Land Reform Office, Thailand (hereinafter called ALRO), was about 1,000 ha including three blocks separated by two canals, but the survey carried out by this survey team has resulted in determining the optimum scale of the pilot farm as about 500 ha, which is the central block of the three mentioned above, bounded by the Nai Chat canal in the east, by the IL-2 canal in the west and by the Phraya Banlu canal in the south. On selecting the proposed Chao Phya Pilot Farm, the following essential factors were taken into consideration on stability of water sources, suitable location for pumping station, demonstration effects of the pilot farm as well as its far-reaching effects therefrom, and the harmony with the Irrigated Agriculture Development Project in the West Bank Tract of the Chao Phya river (1977, JICA) which includes this Pilot Farm Project Area.

The roughly square-shaped Project Area is bounded at three sides by canals as mentioned above, and as a result of bounding on the north by a canal and existing cropped lands, the objective acreage has become about 550 ha.

b. Transportation

A general means of transportation in the Project Area is the navigation by boat through the well-provided canal networks, and only one accessible road to the Project Area is an unpaved provincial road running from Ayutthaya to Sena, from which, along the Nai Chat canal, the road leads to the Project Area. In the wet season, however, the provincial road cannot serve the purpose of traffic by cars due to unfavourable road conditions, and even in the dry season, the vehicle transportation except for using four-wheel drive cars is prevented because of difficulty in crossing over the bridges with considerably steep slopes.

Besides the above provincial road, a road links directly Bangkok with the Project Area, but the bridge across the Phraya Banlu canal, running through the southern tip of the Project Area, cannot bear structurally the traffics of vehicles.

c. Socio Economy

Most of the inhabitants in the Project Area are riparians and engaged in agriculture, excepting a very few merchants, laborers, and some engaged in other occupations.

Almost of all inhabitants are Buddhist, and a very few Mahammedan can be found in No.3 and No.4 hamlets in Tambol Phraya Banlu. The Project Area and its vicinity provide neither schools nor hospitals but only one Buddhist temple. And, there are no public facilities provided, such as electric supply, water supply and telephone communication systems. The inhabitants live on rain waters or river waters for their drinking and other living water consumptions.

The survey by the Ayutthaya Agricultural Land Reform Office revealed that the arable lands in cadaster was 508.7 ha in the Project Area, and the farm household numbers 108. The present land tenure is as shown below.

Land Tenure in the Project Area

Independent farmers lands	19%
Tenants lands	81%
	100%

Landed farmers	28 households
Owner tenant farmers	5 "
Tenant farmers	75 "
	108 households

The tenants lands occupy about 80% of the total arable lands. The farm rent is commonly paid in cash at the fixed rate ranging from 90-150 Baht per rai (0.16 ha); mostly 100 Baht per rai applied.

According to the cooperative survey with the ALRO in Ayutthaya on the farm economics, an average number of family members is 6.9 persons, and an average cropping acreage is 37 rai (5.92 ha). The boats owned as daily necessities is 2.6 boats per household on an average, and most of all farm households have radio sets. In the Project Area, no big animal breeding could be seen but some duck-breeding on considerably large scale, more than 1,000 ducks.

2-1-2. Natural Conditions

a. Topography and Soil Conditions

The Project Area is located in the middle of the Central Plain of Thailand belonging to the swampy hinterland that had been formed by the alluvial action of the Chao Phya river. The elevation of the Area measures about EL. 2.0 m and its topographical gradient is extremely gentle but in ranging from 1/5,000 - 1/10,000.

The soil in the Area, which was formed by the alluvial action of saline river waters, is the clayey acid sulphate soil. Much contents of clay allow the soil hardness to vary to the large extent in dry conditions and moist conditions; when moistened, the soil becomes soft, and when dried up, hardened contrarily. The N-value in moist conditions was observed at the range between zero and three to the extent of 10 m below the ground surface.

b. Meteorology and Hydrology

The Project Area is classified as the tropical savanna and has two climatic types, the dry and the wet seasons. The dry season usually lasts six months from May to October while the dry season from December to April. The annual mean rainfall in the west bank tract of Chao Phya river is about 1,300 mm of which about 85 percent falls in the wet season. According to the data at the Phraya Banlu station maximum daily rainfall of 194 mm was observed in 1972.

The fluctuation of monthly mean temperature is extremly small throughout the year and the mean annual temperature is around 28°C.

The hydrology in the area and its vicinity is characterized by habitual inundation occurring during the wet season. Being connected with Chao Phya river through regulating gates, the variation pattern of water level of the canals around the area is widely affected by the change of water level of Chao Phya river. The water level at Sing Ha Nat during January to June is around El. 1.0 m, while the average ground elevation of the area is 2.0 m, and it gradually rises during July to October to arrive at WL. 2.6 m at the maximum in the late November. After that, it rapidly lowers to around WL. 1.0 m owing to opening the regulators during December.

2-1-3. Irrigation and Drainage

In the Project Area the irrigation water sources are the river water of the Chao Phya river and its tributaries which are moderately

controlled by the Sing Ha Nat gate, Mai Khun Salod, etc. The irrigation water is distributed through the Phraya Banlu canal, the southern boundary of the Project Area, and through Mai Chat canal, respectively. At present, extending by one kilometer, the IL-2 canal, the western boundary of the Area, will be excavated for seven kilometers in 1977, and lengthened to 20 kilometers to complete the whole construction works in 1979.

All irrigation and drainage have been carried out by plot-to-plot method, since almost no facilities are available in the Area. In the wet season, the proper water level control of the canals surrounding the Project Area is quite impossible, and the flooding water level in the Chao Phya river affects the Area and its adjacent areas, where the inundation has lasted three to four months about 60 cm deep at maximum. On the other hand, in the dry season, all the control gates are closed, but the lowered water level of the cannals compels it inevitable to irrigate by employing the pumping facilities. Such situation and insufficiently provided irrigation facilities limit the dry season paddy cropping to only those fields along the canals.

2-1-4. Agriculture

a. Land Use

On the assumption that the Project Area would be divided into two parts by the provincial road; the northern part and the southern parts, the present land use is illustrated as shown in TABLE II-1. Most of the Project Area, about 89 percent, is used for paddy fields and about nine percent is used for orchards of citrus fruits.

TABLE II-1. Present Land Use

Land-category	Northern Part	Southern Part	Total
Arable lands	445.2	99.2	544.4
Paddy fields	423.8	66.5	490.3
Upland fields	-	3.8	3.8
Orchards	21.4	28.9	50.3
Embankments	1.5	0.6	2.1
Roads, Canals	5.8	-	5.8
Total	452.5	99.8	552.3

b. Present Cropping Pattern

The main crop in the Area is paddy that is cropped in the suitable method to the water utilization conditions of the Chao Phya river, and there are two cropping methods diffused; the one is conventional broadcasting and the other recently introduced transplanting method. The direct survey in related hamlets revealed the paddy cropping acreages and yields as listed in TABLE II-2.

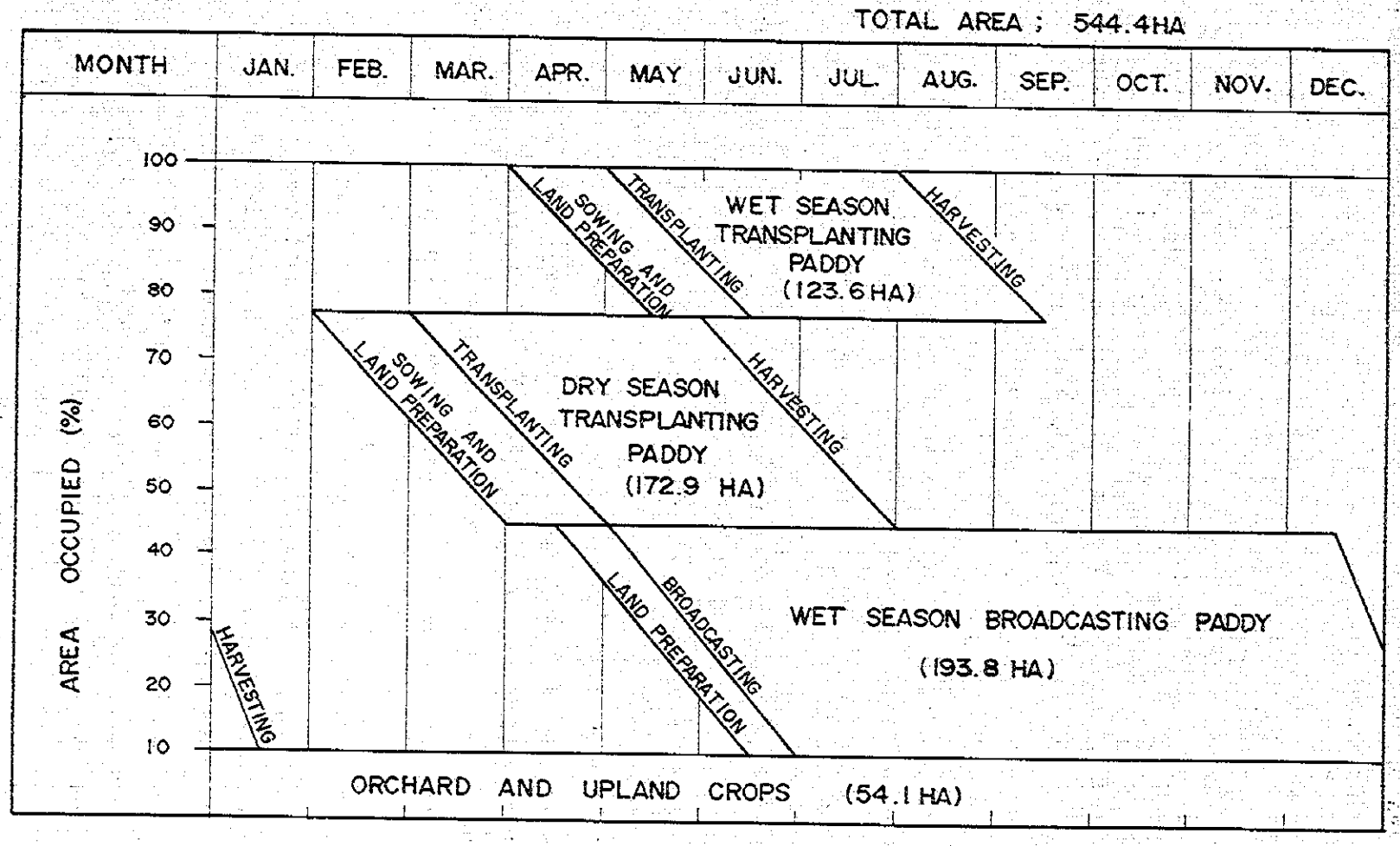
TABLE II-2. Present Paddy Cropping Acreages and Yields

Cropping Method	Acreage (ha)	Yield (t/ha)	Total Production (ton)	Growing Period (days)
Broadcasting	193.8	1.6	310	185
Transplanting				
Dry Season	172.9	3.0	519	130
Wet Season	123.6	2.2	272	125
Sub-total	296.5		791	
Total	490.3	(2.2)	1,101	

In transplanting method, C4 and RD strain (non-photosensitive varieties) are adopted. Transplanted paddy is conveniently specified into two; the dry season paddy which is transplanted before April and the wet season paddy which is transplanted after April and on. Although the dry season paddy produces higher yield than the wet season paddy, a considerably large acreage is cultivated with the wet season paddy. That is because of the fact that the poorly provided terminal irrigation system and the absence of pumping facilities prevent the dry season cropping. The citrus fruits plantation is carried out in providing a small-scale polder dike to protect the orchards from floodings in the wet season and also small-size pumps and ditches for irrigation and drainage.

FIGURE II-1 illustrating the present cropping pattern shows apparently that the double paddy cropping has not been introduced in the Area. That is resulted from a longer growing period of time of

FIGURE II-1 PRESENT CROPPING PATTERN



the local varieties, and floodings in the wet season, the shortage of irrigation water and poorly provided irrigation system for the transplanting new varieties.

c. Input Materials and Labor Force

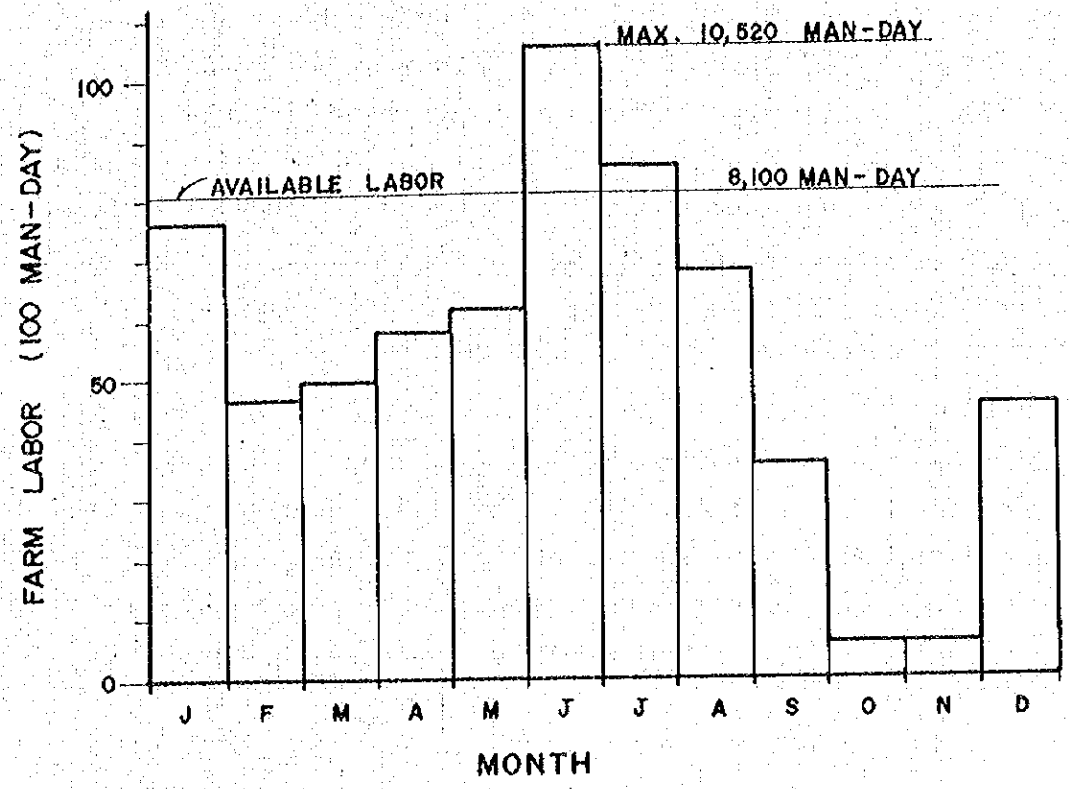
The local variety cropping, which is so-called extensive non-fertilizing farming, has been carried out in a series of works such as plowing, puddling, sowing, and harvesting only, and no other specific farming managements. Even in the transplanting variety cropping, which is a little more intensive as compared with the local varieties, the nitrogen fertilizer has been dosed to the extent of 30 kg/ha. Since the soil in the Area shows poor response to potasium, the nitrogen-phosphate compound fertilizer has been commonly applied. The pest and the weed controls have been carried out to a certain extent with BHC and 2.4.D, both of which are considerable toxic.

The farm households (108 households) in the Area are composed of about 6.9 persons on an average, and the number of persons available as labor force averages at 3.0 persons per household. Based on the present cropping pattern, the monthly required labor forces were estimated to show the result in FIGURE II-2. In comparison with the required labor forces with manpower available, the necessary labor forces will exceed actually available family manpower in respective households in harvesting of the wet season paddy in January and transplanting of the dry season paddy in June through July.

d. Agriculture Extension Services

Although five extension officers are assigned in the Ayutthaya Agriculture Extension Office, it is not expected for them to give satisfactory extension service to the farmers in wide cropped areas (about 220,000 ha) in the Changwat Ayutthaya. In the Extension Office of Amphoe Lad Bao Laung including the Project Area, an office chief, a deputy chief and one extension officer are serving, but it is self-explanatorily difficult for the present staff to cover the services and management of six Tambol in the Amphoe.

FIGURE II-2 PRESENT FARM LABOR REQUIREMENT



The Department of Agriculture Extension has established the farmers' foreman system in each Tambol to strengthen the extension service organization. In the Changwat Ayutthaya, 12 farmers' formen have been already assigned and the one in Amphoe Lad Bao Laung.

The farmers' foremen are selected from the farmers and are in principle the part-time-workers who render services compulsorily in attending the relevant extension offices twice a month. Their main services are to give emergency information to authorized offices concerned, when problems arising on the pests and insects control, and to take quick reactions to the instruction given by the relevant offices. The farmers' foremen can be said to provide dual function as cooperators with the local extension offices and voluntary leaders of the farmers.

There exist 43 farmers groups in the Changwat Ayutthaya, and the authorities concerned have concentrated the effort to giving positive guidance and upbringing of these groups. Every demonstration plot is cropped with the government-recommended varieties (RD strain) and the extension offices concerned circulate pamphlets and/or leaflets in respect to guidance of the cropping in the demonstration plots. The Amphoe Lad Bao Laung extension office plans to provide a demonstration plot in the Area for the guidance of cropping of recommended varieties, but the plan has not been realized up to date.

e. Farmers' Organization

In the Project Area, it is extremely retarded to form farmers' organization. The existing farmers' organizations in Thailand are roughly classified into three: the one is agricultural cooperatives under the administration of the Department of Agricultural Cooperatives Promotion, so-called farmers' group and other is the water management organization under the control of the Royal Irrigation Department (RID).

Agricultural Cooperatives

In accordance with the Agricultural Cooperatives Act enacted in 1968, the Government has been positively extending assistance to integrate the conventional minor farmers' groups to the cooperatives at the Amphoe level.

The Lad Bao Laung Cooperative is handling with credit services only at present, and the entry rate of the farmers is about 30 per cent. One officer in charge of the cooperative services is stationed in the Amphoe office to guide and supervise the crediting services made by the cooperative.

Farmers' groups

At present, in the country there are four kinds of farmers' groups administered by respective authorities that are shown below.

- BAAC (Bank for Agriculture and Agricultural Cooperative)

- MOF (Marketing Organization for Farmers)
- ACFT (Agricultural Cooperative Federation of Thailand)
- DE (Department of Agricultural Extension)

The farmers' groups organized by the BAAC are to be formed for crediting from the BAAC. The MOF, the attached body to the Government, was established to supply farm inputs to the farmers, who form the farmers' group as the base of the body. The ACFT has been trying to organize farmers who do not belong to any groups in the sporadic areas. The farmers' groups the DE administers aim to diffuse the improved farming practices to individual farmers, and one group is composed of about 20 members on the Muban basis. One responsible farmer selected from the members is appointed as the farmers' foreman.

Water management organization

The common irrigators are selected from the farmers on the Tambol basis to make services for operation and maintenance of several terminal diversion facilities under the supervision of the zonemen (officers assigned by RID) in charge of controlling the terminal irrigation facilities.

Besides the above-mentioned farmers' organizations, two kinds of groups are established in the country; one is the housewives group aiming at the bettermen of living, and other is the 4H unit (so-called 4H club) aiming at education of the youths. However, no such groups are organized yet in the Project Area.

f. Marketing and Crediting

The marketing of the farm product in the Area is involved in the Bangkok marketing area, being linked by the navigation through the Chao Phya river and other canals, and the most of the products are directly dealt with in Bangkok market. The paddy produced in the Area is purchased in Phraya Banlu and Kun Salod by four or five merchants, respectively. The market survey in 1977 found the purchasing price at ฿2.0 - 2.2/kg. The farmers have bought fertilizers, agri-chemicals and farm implements in Sena about 20 km north of the Area.

The further survey revealed that about 80 percent of the farm households has gotten debts and 66 percent of these farmers has been loaned by BAAC through the respective cooperatives. The BAAC, established in 1966 by the Government, is centered in the financing agencies for agriculture and agri-industries. The loans are mainly made in short-term (within one year) and medium term (three to five years). The BAAC finances the agriculture cooperatives at nine percent interest. In addition to the above, the credits by the funds in hand of the cooperatives and by the commercial banks are available as well. Except for the above authorized financing agencies, it is reported that some farmers have gotten credits from financial merchants or rice mill managements at 12-20 percent interest per month.

2-2. The Project

2-2-1. Agriculture Development Program

a. Approach

The following skelton plan was made so as to increase the agriculture production in the Project Area.

- To intensify the land use ratio by introduction of double paddy cropping and two crops
- To increase the yield per unit acreage
- To diversify the crops
- To promote the farm mechanization
- To employ the improved farming practices

In order to establish more intensified land use, the agricultural infrastructure should be consolidated with various adversely-acting factors (described in the paragraph on the Present Agriculture 2-1-4) completely eliminated.

The highly intensified land use and the farm mechanization will be available by providing polder dikes which protect the Area from

floodings and land-consolidated cropping plots which include construction of main and terminal irrigation/drainage systems, farm roads, and reparcelling the plots. Such consolidation of agriculture infrastructures will be mentioned in 2-2-2 of the Report.

The key point of the Project is to establish a new farming system that will be acceptable and practicable by the local farmers, after studying various problems in the tropical agriculture. In implementation of the Project, the Suphan Buri Rice Experimental Station will be charged with another services as a training center of the related officials to the conventional experimental works. The training center will have a role as so-called "Agriculture Supporting Service" by extending the improved farming practices obtained from the experiments thereby. The Chapter IV in the Report refers to the operation and management of the Suphan Buri Training Station, and the experiments of availability of improved farming practices, farmers' organization, and extension services will be planned to be shown in 2-2-3.

b. Proposed Land Use

TABLE II-3 shows the proposed land use for realizing the more intensified land use ratio by the paddy double cropping and diversified crops growing.

The land consolidation works will be executed for the existing arable lands, 549.4 ha, and the net arable lands after completion of land consolidation will be 503.5 ha by deducting the public lands use for polder dikes, canals, roads, other facilities, etc. Then, the land deduction ratio will be about 7.5 percent.

The northern part in TABLE II-3, which will be encircled by polder dikes, will be permitted to introduce the short-stalk high yielding varieties (HYV). The southern part, which extends outside the polder dike areas along the Phyraya Banlu canal, will be affected of the flooding from the Chao Phya river even after completion of the Project and hampered to introduce the HYV therein. Then, the conventional

paddy varieties will be cropped in the wet season and the upland crops in the dry season.

The proposed land was planned in reference to the following factors.

- Occupying the most part of the present land use, the paddy fields are taken up as a chief item of the proposed land use in taking into account the conditions of water utilization and the soil properties.
- The Project Area, located within the marketing sphere of Bangkok, the Metropolitan area, provides suited conditions to growing cash crops; then, trial cultivation of other crops than paddy should be carried out in the pilot farm by introducing the land improvement works.
- Inland fisheries and livestock breeding, which are considered available in the Project Area, will be practiced individually depending upon the local conditions.
- To land consolidation to be realized in the Project will allow to introduce the mechanized farming.

TABLE II-3. Proposed Land Use

Land-category	Without Project	With Project		Total
		Northern Part	Southern Part	
Arable land				
Paddy field	490.3	368.1	65.7	433.8
Upland field	3.8	21.0	3.8	24.8
Orchards	50.3	19.8	25.1	44.9
Sub-total	544.4	408.9	94.6	503.5
Facilities lot	-	4.0	-	4.0
Road and canal	5.8	17.2	4.6	21.8
Embankment	2.1	22.4	0.6	23.0
Total	552.3	452.5	99.8	552.3

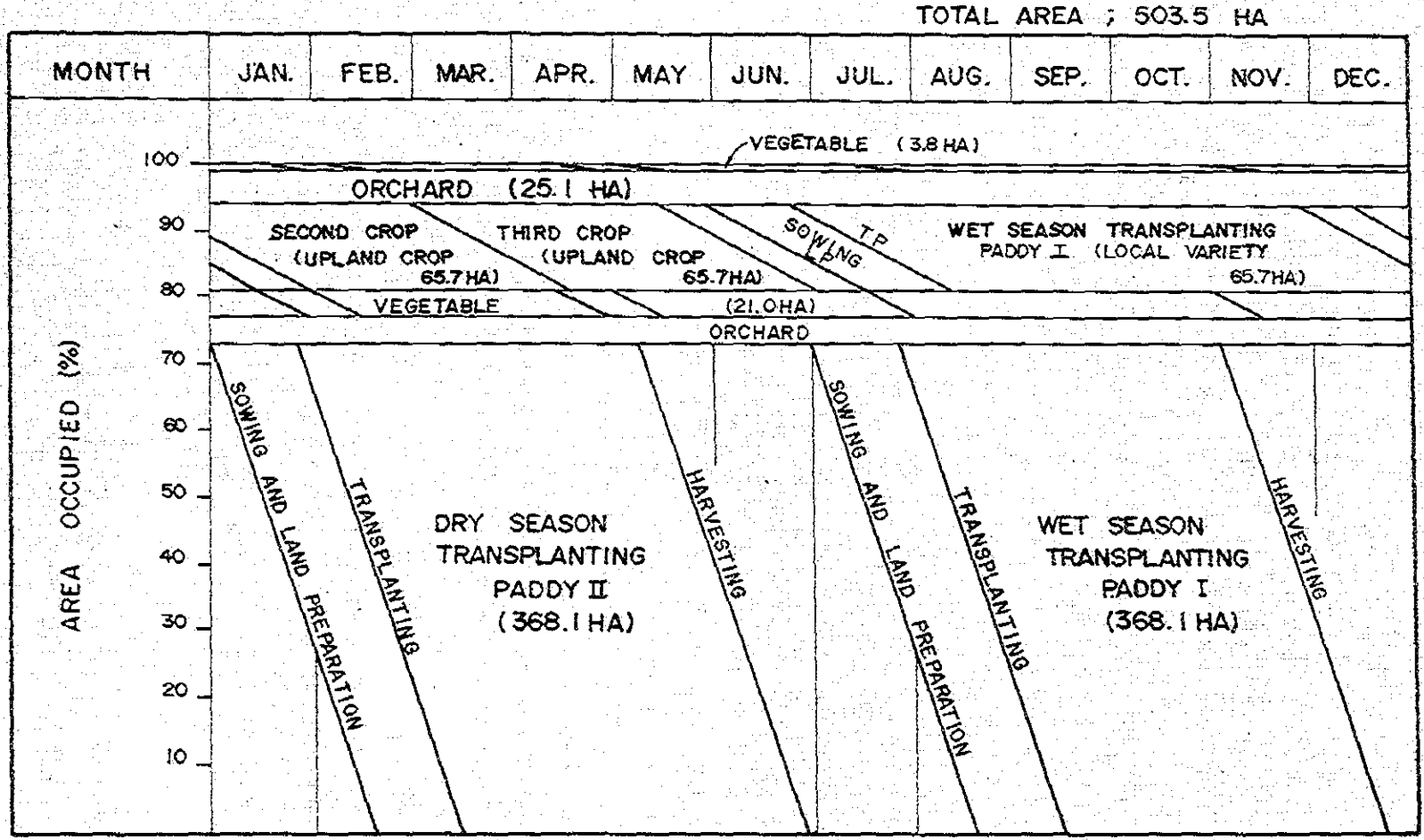
NB: The facilities lot includes the pilot farm plot and the main pumping station plot and the embankment lot includes the acreages for main canal.

c. Proposed Cropping Pattern

In the northern part to be encircled by polder dikes, the paddy double cropping will be centered in the proposed cropping pattern and vegetables will be grown in the upland fields as cash crops. In the southern part, the conventional paddy varieties should be transplanted due to inability to control flooding water level in the wet season. When cropping the paddy with 180 day growing period, it will be difficult to introduce the dry season paddy as the second crop. Being as such, the upland crops with short growing period (about 40 days) will be introduced in double cropping. The pulses, like soybean and mongo bean will be mainly selected as upland crops to retain soil fertility. The citrus fruits will be planted encouragingly in the orchard as they are at present.

In the areas encircled by polder dikes, the high yielding varieties in RD strain, which have been bred in Thailand with non-photosensitivity, early maturity, and short stalks, will be introduced. The growing period of the RD strain is 125 days in the wet season crops and 130 days in the dry season crops. The proposed cropping pattern was so designed that transplanting and harvesting works could be finished within 48 days respectively in all related fields in taking into careful consideration on the well-balanced labor forces supply in the peak period of working time, and the smooth and effective operation of water management. And the proposed cropping pattern provides about two months of period between the first and the second cropping for checking and repairing irrigation and drainage facilities. FIGURE II-3 illustrates the proposed cropping pattern and the cropping calendar.

FIGURE II-3 PROPOSED CROPPING PATTERN



NOTE ; LP : LAND PREPARATION
TP : TRANSPLANTING

d. Agriculture Production

Introduction of improved farming techniques into the Project Area where the agricultural infrastructures will be consolidated, will enable to have an expectation of agriculture production as shown below.

Designed Yields

Crops	ton/ha
Wet season paddy, HYV	4.2
Dry season paddy, HYV	4.7
Wet season paddy, LV	3.0
Soy beans	2.0
Mongo beans	1.2
Cabbages	12.9
Citrus fruits	30.0

In order to realize the designed yields, proper application of the agri-supporting services should be essentially required in giving careful consideration on the following matters. The gross production and the net incremental production, when the Project completed, are shown in TABLE II-4 and 5, respectively.

- Controlled supply of genuine HYV and its regular renewal
- Fertilization according to the new application standard
- Timely and adequate supply of agri-chemical and fertilizers
- Establishment of systematic pest control
- Establishment of countermeasures against low pH values, hardening of soil under dry condition and bearable capacity of soil under wet condition and so forth
- Harvesting in the wet season
- Extension of farming techniques of upland cropping
- Establishment of systematic farm mechanization
- Establishment of marketing system for farm products

TABLE II-4. Designed Gross Agriculture Production

Crops	Northern Part			Southern Part			Total (ton)
	Acreage (ha)	Unit Yields (t/ha)	Yield (ton)	Acreage (ha)	Unit Yields (t/ha)	Yield (ton)	
Paddy							
Wet season	368.1	4.2	1,546	65.7	3.0	197	1,743
Dry season	368.1	4.7	1,730	-	-	-	1,730
Total			3,276			197	3,473
Upland crops							
Pulse	-	-	-	65.7	2.0	131	131
Vegetables	21.0	3x12.9	813	3.8	3x12.9	147	960
Citrus	19.8	30	594	25.1	30	753	1,347

TABLE II-5. Designed Net Incremental Production

(unit: ton)

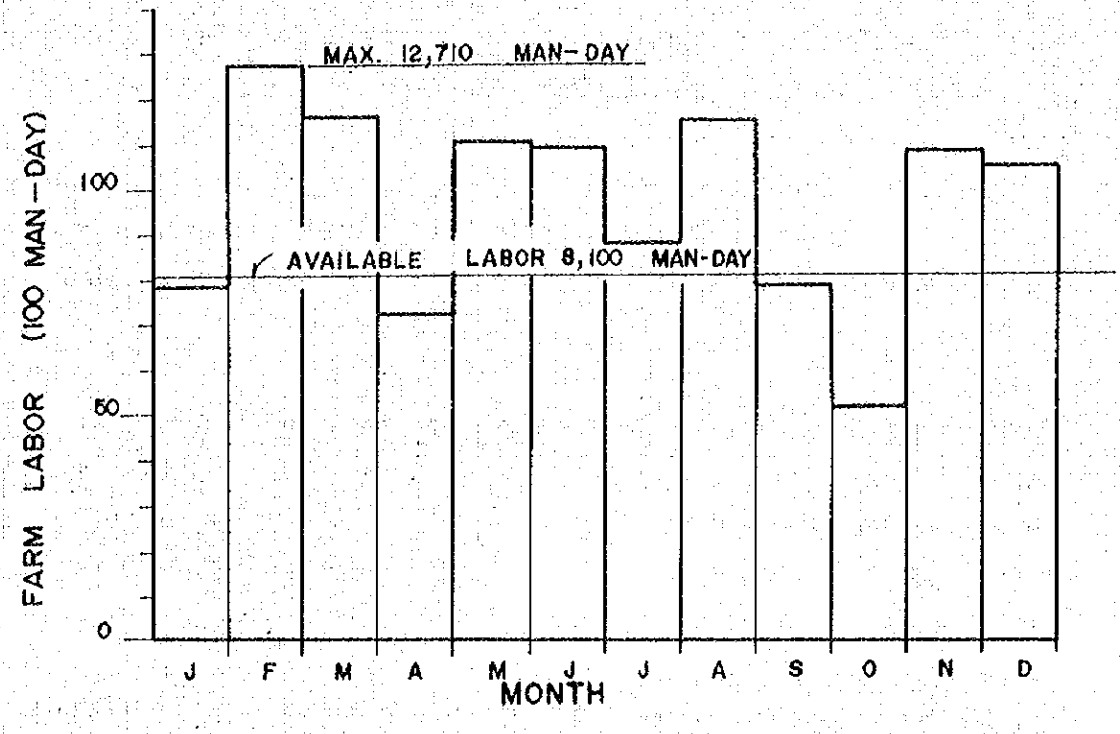
Crops	Present Production	Designed Production	Incremental Production
Paddy	1,101	3,473	2,372
Pulse	19	131	112
Vegetables	-	960	960
Citrus	698	1,347	649

e. Labor Requirements

FIGURE II-4 illustrates the monthly labor requirements on the basis of the proposed cropping pattern. At present, the volume of labor in transplanting and harvesting exceeds the labor forces available. The intensified land use, when the proposed cropping pattern applied, will cause the year-round shortage of labor forces, only depending upon family manpower (average 3 persons per family). The supplemental labor forces from the outside area of the Project will be able to cover the shortage; however, with the development of the Area progressed, the farm mechanization will be inevitably required to meet the designed labor requirements. The cropwise labor requirements on

the basis of per day-per hectare will be 99 persons for high yielding varieties, 124 persons for local varieties and 360 persons for vegetables and citrus fruits cultivation.

FIGURE II-4 PROPOSED FARM LABOR REQUIREMENT



f. Farm Mechanization Program

As mentioned in the previous paragraph, the introduction of paddy double cropping into the Project Area will cause apparently the labor shortage. And in the initial stage of the Project implementation, the comparatively abundant labor forces in the Area and its vicinity will be utilized effectively to apply the labor intensified farming system. The farm mechanization to be introduced in a phase manner, however, will result in not only resolution of labor shortage and release of farmers from heavy labor, but also securing the better works in quality than in the practices by animal and manpower, and reduction of losses in harvesting by conducting timely and appropriate implementation.

i) Phasing mechanization

The farm mechanization will be realized in two phases, since it is expected that the direct introduction of the highly mechanized farming system will face many difficulties in the present situation. Under the circumstances, adequate countermeasures to various problems that may take place in the farm mechanization, will be studied in the course of pilot works in the trial farm in the Project.

In the first phase, medium-size tractors and hand tractors will be employed to carry out the mechanized plowing and puddling. The rotary plow will be preferably employed because a lump of soil, when applying disk plow, will become so large that it will be difficult to make fields properly leveled for effective use of transplanting machines, even if puddling is carried out in the irrigated condition of the fields.

Although the medium-size tractors and the hand tractors will be temporarily introduced as driving machine, the most suitable type and size of the machine and the most reasonable combination of driving machine and working equipment will be decided depending upon the actual results to be obtained from the practices in the pilot works.

In the first phase, the farm mechanization will be realized to the extent that the necessary quality of works can be ascertained to make the integrated mechanized farming practices available in the future.

In the second phase, the integrated mechanization will be practicably realized, including transplanting, harvesting, drying and processing.

ii) Farm mechanization system

The driving machines that are used in the Area at present are 70 HP-class tractors and local-made hand tractors. In the Project, however, the proposed driving machines will be 30 HP-class tractors and

hand tractors in the first step, taking into account the bearable capacity of the soil and quality of the works.

Plowing and puddling

Since the disk harrows, which are currently used in the Area, require much more labors in soil-crushing and levelling works, these will be replaced with the rotary harrows in the Project. The rotary harrows require for two to three times of repeating puddling works, and then it is deemed necessary to make further study on irrigation water control and operation frequency of the said machine for increasing in working efficiency. The rotary blades, which are the consuming part of the machine, will be supplied from Japan for the time being, but it is necessary to provide the supply system of the local-made spare parts in the future.

Transplanting

At present, the transplanting is carried out by manpower, and the mechanized transplanting requires high accuracy of land levelling and the seedling plant for raising the suitable seedlings for the machines. As there are still some technical problems to be solved in the future, the manpower transplanting will be continuously carried out in the first phase of mechanization program under this Technical Cooperation. In consideration of the fact, however, that the mechanized transplanting is very effective in reduction of the labor forces, a trial mechanized transplanting will be conducted in the trial farm in the Project.

Pest control

The transition from the single cropping with low level fertilization to the double cropping with high level inputs is expected to increase damages by attacks of insects and diseases. However, the absence of the forecasting system of the pest in the Area will not allow to readily establish an adequate pest control system. In the early stage of the development, therefore, motor-drive sprayers will be emploied on the case-by-case basis of occurance of the pests.

Harvesting and threshing

In the first phase of mechanization, harvesting and threshing were planned to be carried out by manpower, and in the second phase, combined-harvester will be employed for harvesting and threshing works. Draining the waters out of fields two weeks before harvesting will increase the bearable capacity of the soil and enable to operate the combines on the fields. In the trial farm, the Japanese type combines (small-size) shall be introduced to conduct a trial operation for their availability in the fields.

In comparing losses made during harvesting and threshing by conventional way of farming, with mechanized farming by Japanese type combines, the latter will make more losses in harvesting than the former, but contrarily, much less losses in threshing and hauling harvests. It is reported that the Japanese type combines bring about less losses as a whole, and it is much expected to introduce and extend these small size combines, depending upon their proper application, and well-managed operation and maintenance (O & M). A great care should be exercised to do the timely operation of the combines, because dewy paddy will increase harvesting losses in mechanized harvesting works.

Drying, processing and storage

The introduction of paddy double cropping will inevitably require to harvest in the wet season. In the second phase of mechanization, it is desirable to provide the integrated processing plant for drying-up —— storage —— hulling, as the drying works are planned to be carried out individually by their own dryers in the first phase. Without providing the systematic hulling and storage of the harvests, the farmers will not be able to enjoy their incremental benefits to be resulted from the increasing farm products. In this connection, it will be essentially required to firmly establish the O & M of those facilities and the efficient marketing system for successful operation of the said plants. It is considered necessary to develop such new

marketing channels for supply in bulk as the organized officials related to the Project, like ALRO and RID as well as to try to obtain cooperations from the Farmers Marketing Organization (FMO) and Agricultural Cooperatives Federation of Thailand (ACFT).

g. Input Materials

Timely supply with necessary quantity of agriculture inputs such as agri-chemicals, fertilizers and renewed seeds is quite essential to reach the target in yields. The input materials to be required for the purpose are listed in TABLE II-6.

TABLE II-6. Input Materials

Items	Unit (ton/ha)	Cropping Acreage (ha)	Quantity Required (ton)
Fertilizers			
Dry season paddy	262	368.1	96.4
Wet season paddy			
HYV	220	368.1	81.0
LV	188	65.7	12.4
Upland crops	636	85.5	54.4
Citrus Fruits	1,960	44.9	88.0
Total			332.2
Lime			
Paddy Fields	3,000	368.1	1,104
Uplands & Orchards	6,000	117.2	703
Total			1,807
Agri-chemicals			
Dry season paddy	21.2	368.1	7.8
Wet season paddy			
HYV	21.2	368.1	7.8
LV	63.4	65.7	4.2
Upland crops	372.0	85.5	31.8
Orchards	1,285.0	44.9	57.7
Total			109.3

It is necessary to renew the seed paddy at once every four cropping at least. The pure seeds, which are bred in the Suphan Buri Experimental Station, shall be supplied to the designated model farm for seed multiplication so as to be distributed to individual farmers. The necessary quantities of seeds are shown in TABLE II-7.

TABLE II-7. Necessary Quantities of Seeds

Items	Unit (ton/ha)	Cropping Acreage (ha)	Necessary Quantity (ton)
Wet season paddy (HYV)	0.04	368.1	14.72
Dry season paddy (HYV)	0.04	368.1	14.72
Wet season paddy (LV)	0.04	65.7	2.63
Soybean	0.042	65.7	2.76
Cabbage	0.002	19.8	0.04
Citrus Fruits	560	44.9	25.100

2-2-2. Agricultural Infrastructure Consolidation Program

a. Polder Dikes Scheme

The conventional local paddy varieties cropped in the wet season should be replaced with the new varieties with short maturing (about 130 days) so that the paddy double cropping may be available in the Project Area presently under regular floodings in the wet season. And it is essentially required, for the purpose, that the timely and adequate water control can be conducted smoothly. In the Project, the polder dikes, which can control the flooding waters from the Chao Phya river and its tributaries, should be provided indispensably so as to successfully achieve an end.

Since there extends a densely built-up area along the Phraya Banlu canal, the southern boundary of the Project, the irregular alignment of the dike embankment should be adopted to avoid that area. On the other hand, about 500 m north of the Phraya Banlu canal, there runs a 4.0 m wide provincial road in parallel to the said canal, and the dike

embankment will be made in the better use of the road embankment and its reserved area along the road.

The construction of the dikes will result in providing the arable lands of 408.9 ha within the encircled area and 94.6 ha outside the polder dikes respectively, out of the proposed arable lands, 503.5 ha.

The water levels in floodings had been effectively observed at Sing Ha Nat about eight kilometers apart from the Project Area for the period of 10 years, 1967 through 1976. The probable water level was assumed based on the relevant 10-year records and shown as the table below.

Return Period (year)	Water Level (El m)
2	2.58
5	2.77
10	2.91
15	2.99
20	3.06

The polder dikes are the key facilities to protect the farm lands and irrigation/drainage facilities within the Project Area from the floodings. The dikes should have height sufficiently corresponding to the probable water level of El 2.99 m at 15 year return period, in taking due consideration of the comparatively slow rise of water, properties in the Area, and potential damages. Besides the above factors, the 0.5 m high freeboard was taken into account in referring to the actually applied freeboard in the similar works in Thailand, and the designed crest elevation of the dikes was decided at El 3.50 m. The problem in the O & M of the dikes will not be the affect of the wave by wind, but the rolling-up of the waves caused by navigating motor boats.

The average outer level can be assumed at about El 2.6 m, and the freeboard will be kept at 0.9 m that can stand sufficiently to

the rolling-up of the waves by motor boats. The effective crest width was determined at 4.0 m, and further one meter width was provided on both sides of the crest to make a total width 6.0 m in taking the prudent consideration of the stability of the dikes.

b. Irrigation Scheme

i) Cropwise consumptive use of water

The cropwise consumptive use of water was obtained as a product of the evapotranspiration value (ET) computed by the Penman method and the crop consumption factor. The meteorological data applied in the said computation were the observation data at Suphan Buri, Lop Buri and Bangkok. According to the proposed cropping pattern, the cropwise consumptive use of water was estimated on the half-month basis and the result is shown in TABLE II-8.

TABLE II-8. Cropwise Consumptive Use of Water

(unit: mm/day)

Month	ET	Paddy				Upland Crops		Citrus Fruit
		A	B	C	D	A	B	
J. I	3.9	3.3				3.1		3.1
II	3.9	3.3	3.3			3.1	3.1	3.1
F. I	4.7	4.2	4.0	4.0		3.7	3.7	3.7
II	4.7	5.0	4.2	4.0	4.0	3.7	3.7	3.7
M. I	5.2	6.1	5.5	4.7	4.4	4.2	4.2	4.2
II	5.2	6.2	6.1	5.5	4.7			4.2
A. I	5.7	6.4	6.8	6.7	6.0	4.6		4.6
II	5.7	5.9	6.4	6.8	6.7	4.6	4.6	4.6
M. I	5.0	4.5	5.2	5.7	6.0	4.0	4.0	4.0
II	5.0		4.5	5.2	5.7	4.0	4.0	4.0
J. I	4.6			4.1	4.7	3.7	3.7	3.7
II	4.6				4.1		3.7	3.7
J. I	4.2	3.6						3.4
II	4.2	3.6	3.6					3.4
A. I	4.0	3.6	3.4	3.4				3.2
II	4.0	4.2	3.6	3.4	3.4			3.2
S. I	3.8	4.4	4.0	3.4	3.2			3.0
II	3.8	4.5	4.4	4.0	3.4			3.0
O. I	3.9	4.4	4.6	4.6	4.1			3.1
II	3.9	4.0	4.4	4.6	4.6			3.1
N. I	4.0	3.6	4.1	4.5	4.8			3.2
II	4.0		3.6	4.1	4.5			3.2
D. I	3.9			3.5	4.0			3.1
II	3.9				3.5			3.1

ii) Percolation, water requirements for nursery bed and puddling

It appears that the water percolating of the fields in the Area will be comparatively small due to clayey property of the soil, although no observed date is available. In this scheme, the percolation was estimated at about 1.0 mm per day. In addition to the percolation, the water requirements for nursery bed and puddling was computed at 190 mm as shown below for the whole growing period.

For nursery bed

Acreage nursery bed:	5% of the total acreage of related paddy fields
Water requirements:	300 m
Average water amount:	300 x 0.05 = 15 mm

Land preparation

Pre-irrigation water	15 mm
Land preparation	160 mm
Total	= 190 mm

In the above, however, 15 mm of water for land preparation will not be required in the wet season cropping in due consideration of maximum utilization of the effective rainfall.

iii) Irrigation efficiency

Irrigation water losses are composed of a field application loss and a conveyance loss. The irrigation system to be applied in the Project is detailed in the following paragraph (2-2-2, d), and briefly speaking, the water firstly lifted up by the main pumping station will run through the main canals with dual purpose of irrigation/drainage, and then lifted up again by five pumping stations located in the Area to be distributed to each plot through the lateral canals and ditches. The pumping irrigation will have promising high efficiency in view of the fact that these facilities will enable to properly control water to be supplied and to conduct the rational water management mentioned in the following paragraph (2-2-2, f).

The irrigation efficiency in the Project was estimated at 72 percent in paddy fields and 59 percent in upland fields, respectively.

iv) Peak water requirements

The capacities of pumping facilities and irrigation system will be determined by depending upon the peak water requirements. On the basis of proposed cropping pattern, the water requirements in the paddy field were estimated to be 9.6 mm/day in April I, the latest period of land preparation. Further details are shown in TABLE II-9, which reveal that the peak water requirements as a whole are 0.73 cu.m/s.

TABLE II-9. Peak Water Requirements

Crops	Acreage (ha)	Water Requirements in Depth (mm/day)	Efficiency (%)	Unit Water Requirements (l/s/ha)	Water Requirements (cu.m/s)
Paddy	433.8	9.6	72	1.54	0.67
Others	69.7	4.6	59	0.90	0.06
Total	503.5				0.73

c. Drainage Scheme

The mechanism of discharge of excess water from low-lying flat paddy fields is generally described as follows;

- Excess water overflows from higher paddy fields to lower ones.
- In sloping areas, overflows hydraulically take the mode of broad-crested weirs in free overflow and the discharge is primarily controlled by the upstream water level, but in flat areas, the discharge is affected by the downstream water level with the form similar to broad-crested submerged weirs.
- The lowest-lying paddy fields provide no opportunity for discharging the excess water into any other fields for inundation to take place.

The extent of flood damage to the paddy plants varies with their respective growing stages. The paddy plants immediately after trans-

planting will be damaged a considerably little, but those in tillering stage or flowering stage will be damaged most seriously. The paddy plants can stay alive in floodings for a certain period, if a cusp of the leave shoots out above the water surface to be exposed to the air, from which the plants can receive the oxgen supply.

In 1977, JICA survey team for the study on the irrigated agriculture development project of the west bank tract of the greater Chao Phya, including this Project Area, made a drainage improvement plan of the Area. The design criteria of drainage in this project was established based on the results of the said study as shown below:

Drainage canals

The rainfall, 189 mm (10 year return period, two consecutive days), was provided as the design rainfall, and the unit drainage capacity was decided at 4 ℓ/s/ha under the conditions of average inundation depth of 25 cm and allowable duration period of four days.

d. Development Plan of Irrigation and Drainage System

Irrigation and drainage in technical concept imply not only an adequate and controlled water supply and release but also efficient water management. Efficient water management would results in even higher yields with less water. In order to achieve a higher yield target, it is agronomically necessary to drain the land at least one or two times during growth of the crop: However, this periodical drainage is impossible if water supply is uncertain, or its control is imperfect.

The comparative studies were made on the following alternatives including various combinations of functions of main pumping station and main canals before deciding the irrigation/drainage system of the Project that requires to provide the polder dikes and pumping stations to control the operation of irrigation and drainage.

Alternative	Main Pumping Station	Main Canals	Lateral Canals & Terminal Ditches
1	Two of separate stations for irrigation and drainage	Separation of Irrigation and Drainage	Separation of Irrigation and Drainage
2	One of dual-purpose station for irrigation and drainage	Separation of Irrigation and Drainage	Separation of Irrigation and Drainage
3	- do -	Dual Purpose	Separation of Irrigation and Drainage

Alternative 1.

Installation of two separate pumping stations, one for irrigation at the upstream site of the area and the other for drainage at the downstream site, has an advantage in attaining more complete water management for cultivation. However, construction costs for two pumping stations will certainly be higher than that for a single station of dual-purpose.

Alternative 2.

Since both separate pumping stations, in case of the Alternative 1, will not be operated at the same time and pumping lifts required for irrigation and drainage are almost equal, the pumping plant for drainage which is to be equipped with a capacity around two times of that for irrigation, could be operated for irrigation when irrigation water supply is needed.

In the Alternatives 2, the dual-purposed pumping station is planned to be constructed at the downstream site of the Area in consideration of the fact mentioned above. The topography of the Project Area presents such an extremely gentle slope, 0.5 m differential in elevation, that the construction of the canals, providing sufficient water head to convey the water from the pumping station to the upstream site, is technically feasible.

In this plan, construction cost for one dual-purpose pumping station will certainly be less expensive than that for two of soparate stations. However, the construction cost for main irrigation canals will be higher than that of the Alternative 1, as the main irrigation canals in this plan are to be designed with enough head to against the natural fall of the ground surface. Total construction costs for this plan, however, would be more economical than that of the Alternative 1.

With regard to design of main irrigation canals in the Alternative 2, the followings are to be pointed out; that is, total head required for the main irrigation canals is roughly estimated at 1.2 m (conveyance loss = 4,000 x 1/10,000 = 0.4 m, diversion head at tail reach = 0.3 m, Natural fall = 0.5 m).

The main canals are to be constructed along the proposed polder dikes with a bank height of 1.5 m. The water level to be maintained high in the embankment of main irrigation canal will have harmful influence on the polder dikes which are the main facilities to protect the area from floods. Therefore, careful operation and maintenance will be required, unless the irrigation canals are lined with concrete.

Alternative 3

Along the polder dikes a main canal of a dual-purpose for irrigation and drainage is planned, making economical use of materials to be excavated from the canal site. The water level in the canal is to be controlled by gates and pumping and is kept at 0.4 m lower at least than the surface of paddy fields for effective drainage. For irrigation, the water in the canal will be lifted by five of additional small scale pumps to be installed at appropriate locations.

By fully utilizing the main canal of double purposes for main irrigation canal, higher efficiencies of water management will be attained than those of the Alternative 1 and 2. Construction costs to be added for five additional pumping stations will not exceed the

amount required for an independent main irrigation canals of concrete lining, separate drainage canals and their collateral works in the Alternative 2.

Alternative to be recommended

For these three Alternatives, a careful study was made on the stand-point of the project economy and the special features of the pilot project of the irrigated agriculture development, which requires the well controlled and effective water management. As a result, the Alternative 3 (dual-purpose main pumping station, dual-purpose main canals, and pumping stations exclusive use of irrigation) was strongly recommended.

The Pilot Project Area has almost square shape (2km x 2.5km) and topographical features with little differential of elevation in the Area as well. And the Alternative 3, which aims to empolder the Area with the dikes and the main canals, to advantageously control water level for effective management of irrigation and drainage. The terminal facilities of irrigation and drainage are detailed in the following paragraph (e. Land consolidation scheme), and the pumping stations are explained in 2-2-2, g, respectively.

e. Land Consolidation Scheme

It has been generally accepted that the water control in paddy fields plays a vital role increasing the productivity of paddy. Therefore, implementation of land consolidation has been proposed for the Area, with a view to improve the productivity of labours as well.

The land consolidation includes the following works:

- To provide irrigation canals and ditches
- To provide drainage canals and ditches
- To provide farm road networks
- To reparcel farming plots (rearrangement)

The water supply of comparatively large quantity will be required in two comparatively short periods during a year. During these periods the water should be made available for each farm plot as soon as it is ready for transplanting in accordance with the cropping calendar. However, an irrigation and drainage system can not be based on average conditions. It must be able to supply adequate water for seasonal fluctuating demand and be able to drain rapidly when water is in excess. In order to control the water on the fields independently as required for ideal plant growth, separate ditch systems for irrigation and drainage are proposed.

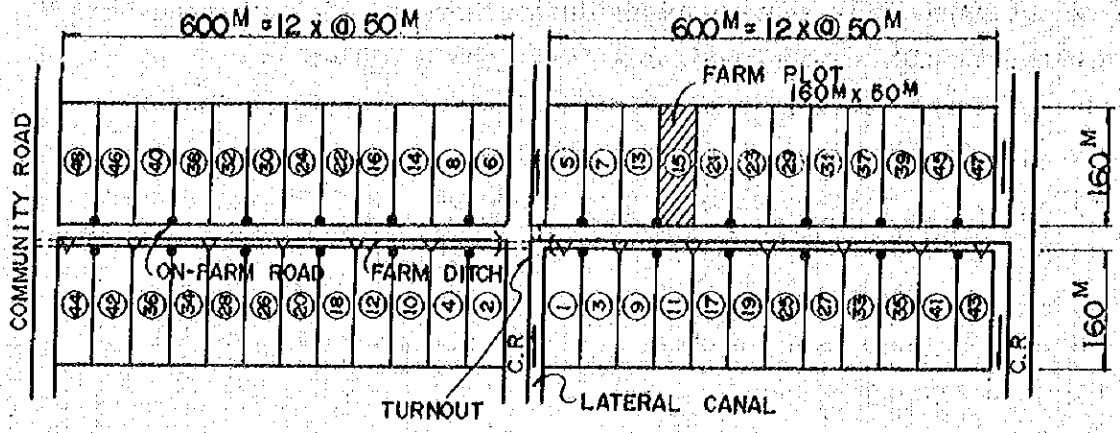
In planning the reparceling of land, the basic plan has been formulated taking the proposed farming practices, irrigation rotation and farming groups into consideration. Based on experiences gained with land consolidation works in Japan and in East Asia, the following are particularly proposed as the fundamental criteria to be adopted for the works in the Project.

Shape of plot

From the viewpoints of exchange and consolidation of farm land, operation efficiency of farming machines and effective water management, the shape of plots should be of uniformed rectangle. So far as conditions permit in water management and levelling accuracy, the possibly longer length of run will be advantageous for reducing the deduction rate of land and efficient operation of farming machines. It is deemed reasonable to take a length of run at 160 m in the Area. The width of plot will be reasonably taken at 50 m in the Area, which extends flat and has no restriction from the topographical conditions.

Unit farm land

For a consideration of the water management, the suitable length of a farm ditch will be 600 m at maximum. The one unit farm land, 19.2 ha, will be composed of 24 plots as illustrated below.



Road

Every plot should face the on-farm road at the shorter side of its plot. The community road, which will be paved with laterite materials, should run along the length of run at 600 m interval. The lower the road embankment height is, the more economical the construction cost and the easier the access of the farming machines will be, while the road embankment should require to have its height to the certain extent that the road surface can keep its bearable capacity in being free from the adverse effect of the water levels in the canals or paddy fields. Then, the road embankment height, in view of soil properties of the Area, was designed to be 0.2 m higher at least than the water level in the canals.

Canal

The farm ditches will be provided along the one side of the on-farm roads. The drainage ditch aims to control the shallow ground water table as well as to drain out the excess water by rainfall as soon as possible. However, as the soil permeability coefficient being in the order of 10^{-5}cm/s, it is hardly expected to lower the shallow groundwater table in the irrigation period.

Water control facilities

With irrigation and drainage facilities provided, the new techniques of water control will be introduced to the Area. The water

control equipments should work as properly as possible by simple operation. The pumping waterintake from the main canals will enable to keep the constant discharge in the lateral canals, whereby the simplified water control will be available in diversion of water from the lateral canals to the ditches and from the ditches to each plot. The water amount to be supplied can be well managed by controlling the operation hours of respective pump units.

One irrigation block (38.4 ha) includes 48 plots which will receive the irrigation water through one turnout installed respectively on the lateral canal.

f. Water Management Program

The water management in the Project Area can be roughly classified into the following three systems by function of the facilities.

Waterintake system.....Main pumping station (dual purpose)

Water conveyance system.....Main canals (dual purpose)

Water distribution system....Secondary pumping station for irrigation, lateral canals, farm ditches, and plots.

Waterintake system

The irrigation water for the Project Area is to be taken from the Nai Chat canal, which links with the Phraya Banlu canal through the regulating gate. The function of the said regulating gate can control the water level in the Nai Chat canal a little higher than that in the Phraya Banlu canal, and the water level in the Nai Chat canal varies with movement of that in the Phraya Banlu canal. The variation pattern of the water level in the Phraya Banlu is in general that the water level stays nearly EL 1.0 m in the dry season (January through June), gradually rises July through October, reaching to about EL 2.6 m, and abruptly lowers up to EL 1.0 m in the mid-November through the end of December. The said pattern is almost stable, although a small margin of error may take place by years in the range of ±0.1 m - ±0.2 m.

In the main pumping station with dual-purpose pump units, the gates should be installed so that the waterintake and drainage can be available by gravity. The water level in the main canal was determined at EL 1.0 m as detailed below, and the water level for starting pumping irrigation of EL 0.8 m.

Water conveyance system

The main canals with dual-purpose of irrigation and drainage will be constructed along the polder dikes. The water level to be kept in the main canals will be a problem in the O & M of the facilities. The lower water level, when adapted, will raise the regulating capacity for flood in the main canal in the wet season and reduce the operation cost of the main pump units, whereas the secondary irrigation pump units should provide higher lift and their operation cost will be increased. On the other hand, the higher water level in the main canal, when adapted, will reduce the operation cost of the main pump units in the wet season and bring about the adverse effect in the dry season.

Based on the variance pattern of outer water level, the following three plans were taken into consideration as the water levels to be maintained in the main canals: 1) The water level is maintained at EL 1.0 m to coincide with that in the Nai Chat canal in the dry season, 2) the water level is maintained possibly higher so that the lift of the irrigation pump units can be minimized to be EL 1.6 m in consideration of the effect of drainage from the paddy fields, and 3) this is a compromised plan of the above two, that is, the water level is maintained at EL 1.6 m during nine months of the dry season (November through July) and at EL 1.0 m during three months of the wet season (August through October).

Every plan cited above has its own merits and demerits, and for the time being, it is recommended to maintain the water level at EL 1.0 m as simple and practical way of operation. To maintain the constant water level at EL 1.0 m will give the main canals flood control capacity of about 874 x 1,000 cu.m, and also during the dry season,

six month, the main pumping station can halt its operation for water-intake because the water level in the Nai Chat canal is maintained at EL 1.0 m.

Water distribution system

The water distribution system composed of two sub-systems, that is, the secondary irrigation pumping stations to take water from the main canals and lateral canals and farm ditches to supply water to the plots. The irrigation pump units will operate to take the constant amount of water from the main canal and the management of water supply will be made by controlling the operating hour of the pumping station. The capacity of the irrigation pump units was designed on the basis of 22-hour operation per day at the peak demand of water.

The water management in the distribution system will be executed based on the unit rotation block including 48 plots (38.4 ha) and in principle, one lateral canal will command three units of irrigation blocks (total acreage: 115.2 ha). It is considered reasonable to form the unit water management organization for every lateral canal, accordingly. In the Project, six unit water management organizations will be built up.

g. Pumping Station

i) Main Pumping Station

Selection of pumping site

The main station will provide the dual-purpose pump units. The main canals also are used with dual-purpose and the water surface slope in the canal appears to keep nearly level. The main pumping site was selected at the west of the regulating gates located in the downstream portion of the Nai Chat canal, taking into account various factors such as stable waterintake from the water source in the dry season, convenience of O & M, and so forth.

Designed water level

The probable water level at 10-year return period was taken up as designed water level in pumping scheme and shown as follows:

	Inner Water Level (EL)	Outer Water Level (EL)
For drainage	1.00 m	2.91 m
For irrigation	0.49 m	1.20 m

Water amount to be lifted

The designed water amounts to be lifted for drainage and irrigation were decided as follows:

	Acreage (ha)	Water Amount (cu.m/s)	(cu.m/min)
For drainage	452.0	1.81	108.5
For irrigation	503.5	0.73	48.9

Kind and type of pump unit

The total lift of the proposed pump will not exceed 4.0 m both in drainage and irrigation. This fact will enable to determine the kind and type applicable to the case; they are of axial flow type and mixed flow type. The dual-purpose facilities of both pump units and canals employed in the Project will bring about a comparatively large fluctuation in suction and delivery elevations. The horizontal mixed flow type of pump units were selected for the Project in considering many factors as suction capacity availability to variable lift, easiness of O & M, and economy.

Number of pumping units

The number of pump units was decided on the basis of the following considerations:

- With the lifted water amount fixed at a certain level, the more numbers of pump units, the higher the construction cost will be required.

- The larger capacity of pump units, the higher operation efficiency and the lower the operation cost will be available.
- It is desirable to provide two pump units or more in accordance with importance of the facilities in consideration of mitigation of risks.
- It will be economical in operation cost to provide several numbers of units with same capacity, or provide more than two different kinds of units, if the seasonal change of demand exists in the water amount to be lifted.
- It is desirable to provide several numbers of the same kind units with same capacity for convenience of O & M and interchangeability of the machine parts.

Only when the control of water to be pumped up is required to meet the seasonal fluctuation of water demand, the more number of pump unit will become economically advantageous. In the Project, however, the sufficient capacity of the main canals can facilitate to control the water to be pumped up by intermittent operation of the pumps. The two pump units of the same kind with the same capacity should be reasonably provided for mitigation of risks and interchangeability of the parts, although the number of pump units should be possibly minimized from the economical point of view.

Bore diameter of the pumps

The bore diameter of the pumps was decided as 700 mm.

Selection of prime mover

The Project Area has not been electrified yet and even the nearest distribution system is about 25 km apart from the Project Area to southeast, and diesel engines should be used for the prime mover of the pumps in avoiding the high construction cost for providing the electric distribution system therein.

Dimension of pumping facilities

The dimensions of the proposed main pumping facilities were determined as follows on the basis of the drainage operation to require the larger water amount and pump lift.

Pump unit:

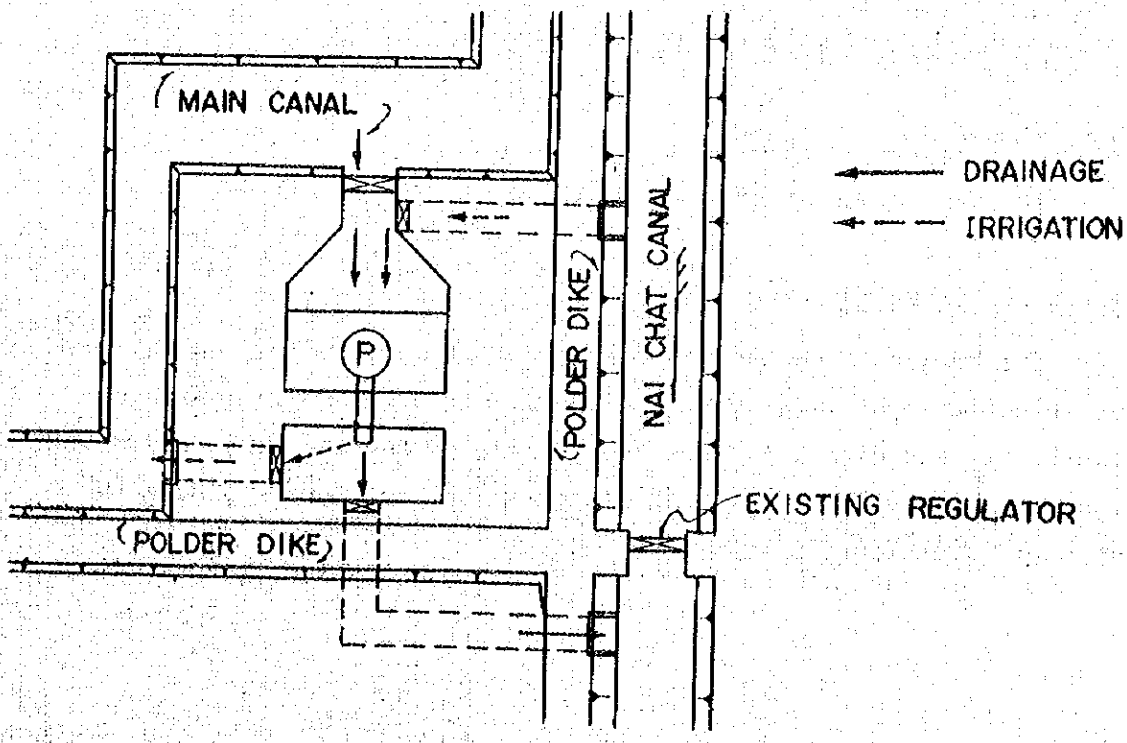
Type:	Horizontal mixed flow type
Bore diameter:	ø700 mm
Numbers required:	Two (2) units
Lifting capacity:	50.2 cu.m/min
Total lift:	2.90 m
Suction level:	EL 0.70 m
Delivery level:	EL 3.10 m

Prime mover:

Type:	Diesel engine
Output:	60 PS

Layout of pumping station

The irrigation and drainage system of the pumping station is illustrated as follows.



ii) Irrigation Pumping Stations

As mentioned previous paragraph 2-2-2, d, five secondary irrigation pumping stations will be constructed in the Area to lift up the water from the main canals.

Type and number of pump units

Specifically, the irrigation pump units, having 2.0 m of a total lift and 10.5 cu.m/min of a pumping capacity, will have small scale and simplified system as compared with those of the main pumping facilities. The vertical pump will be employed in the case in due consideration of the easy operation by their simple structure and economy of construction cost, although the pumping efficiency is lower than that of axial flow type or mixed flow type.

Since sporadic installation of five pumping stations in the Area will play a role for mitigation of risks to some extent, each station will be provided with one pump unit, respectively.

Bore diameter and pumping capacity

The bore diameter of the irrigation pump should be 19 inch (482 mm) with 10.5 cu.m/min of a pumping capacity.

2-2-3. Agriculture Supporting Services

The plan for establishment of agriculture supporting services was formulated to fully promote the farming system with high productivity in the Area immediately after providing such agricultural infrastructure as polder dikes, irrigation and drainage facilities and land consolidation.

The following services will be rendered for the purpose.

- Promotion of land consolidation
- Strengthening of extension of improved farming techniques and training of farmers

- Promotion of organizing farmers' group for rational water management and improvement of the farm management
- Consolidation of systems for input supply, collection of farm products, storage, processing and marketing
- Promotion of farm mechanization
- Improvement of crediting system and encouragement of reservation of farmers' owned capital

The officials concerned, trained in the Suphan Buri Training Center along the prescribed course, will extend services through activities at the trial farms or model farms to be provided in the Project Area, and the works will be initiated in 500 ha of the Project Area and extended to those areas around the Project Area.

a. Trial Farm

The trial farm of about 10 ha will be provided in the southeastern corner of the Area encircled by the polder dikes, and the trial farming with improved techniques will be tested in applicability to the Area and also the practical exercise to the farmers will be carried out.

i) Test for applicability of the improved techniques

Several problems that are expected to be encountered when pumping irrigation is employed in the Area for paddy double cropping, were presented in the previous paragraph 2-2-1 (Farming Scheme).

In the trial farm, many experiments concerned with irrigation and drainage, agriculture, farm machineries, water management, extension services, etc. will conduct the following tests and experiments.

1) Puddling test of the field
2) Land levelling of the field
3) Weed control
4) Seedling raising for transplanting machine
5) Application of transplanting machine

6) Application of harvesting machine
7) Pest control
8) Rodent control
9) Comparative study of varieties
10) Bearable capacity of the soil
11) Water management
12) Surface soil treatment
13) Upland irrigation
14) Under drains
15) Fertilizers responsibility test
16) Improvement of chemical and physical characters on soil

It is essentially required to conduct the trials and experiments about the above items based on the detailed analysis of the existing data and information gained at the Suphan Buri Experimental Station so that the obtained results can be fully utilized in the practical way. Although each expert will decide his own target, it is quite important that every trial and experiment have the close interrelationship among each other for the last end.

ii) Training

The officials trained in the Suphan Buri training center will give guidances and trainings to the farmers' trainees who are selected among those in the Project Area. Such farmers' trainees should be selected one after another from the areas where the land consolidation works are completed. The training, comprising lecturers and practical exercises, should be given in the slack period of farming works which facilitate the farmers to participate in the training at ease.

Major items of training will be 1) water management, 2) preparatory works for establishment of the agriculture cooperatives, 3) operation and management of collective farming works, 4) farm mechanization, and 5) proper field management. The training and lecture should be held on the half-day basis and one training course will last about 10 days. The farmers' trainees that make good records during the course will be appointed as model farmers.

b. Model Farm

The necessary input materials and farming machines will be supplied to the model farms selected in the Project Area to carry out the new farming method with improved techniques. One selected model farmer will manage one model farm and receive concentrated and intensified guidances by the experts assigned to the trial farm.

The agronomist and the agro-economist should be engaged in tracing check of the works so as to evaluate the results obtained from the program. Three model farms (by three model farmers) will be set up in the Project Area, and the following targets in their management will be taken up.

1) Application of the improved techniques to the farmers' level
2) Demonstration of the improved techniques
3) Seed multiplication practices for renewal

The newly developed techniques by the Suphan Buri Experimental Station or other research institutes will be applied to the farmers' level farming in the model farms after confirming their effectiveness resulted in the trial farms. The following items will be practiced as the improvement of the techniques.

1) Seedling raising: Seedling should be raised to meet the rotation irrigation program of 48-day cycle. The target is to rise the seedling up to 20 cm high within two weeks after sowing.

2) Transplanting: Deep transplanting will delay rooting of the plants to bring about the secondary roots, which prevents the plants from tillering.

3) Plowing, puddling, and levelling: Rotary will be used for plowing and puddling in the wet condition of the fields.

4) Fertilization

5) Weed control

6) Pest control

7) Rodent control

8) Harvesting and processing

i) Selection of model farmers

The model farmers should be fairly selected among outstanding good farmers, because the selected farmers could enjoy various advantages and favors to be given by the Project implementation. The general standard for selection is shown as below.

1) Education level of the head of family (at least the graduates of the elementary school)

2) Debts (The debts should not exceed the amount of gross income per annum)

3) Labor forces (The selected farmers can mobilize the labor force more than three persons in the family members)

4) Training (The farmers to be selected should be the well-trained ones in the trial farms)

ii) Management of the model farms

The farmers to be charged in the management of the model farms should prepare the annual cropping schedule every year to get approval by the extension experts and receive proper technical guidances as well as supply of necessary input materials. The fertilizers and other agri-chemicals should be supplied to the model farmers through the organization to be newly established as a link of the Project programs. However, the quantity of inputs should be the same as that to be supplied to the general farmers in the Project Area.

The ownership and the O & M of the farming machines should belong to the preparatory organization of the agriculture cooperatives for the time being. In such a way, the general farmers will be in a position to employ the machines on their necessity on the rental basis,

which will enable the farmers to be relieved from heavy burden of investment for the machines purchase and from the risks of the O & M and the farm management. The mechanized farming in this manner, however, will bring about several problems on reducing their machine utilization efficiency and the management of the mechanization by the preparatory organization of the cooperative, because the machines will be used by the unspecific numbers of farmers. For a consideration of the fact, it is required to place the emphasis on the matter that in the early stage of the farm mechanization the preparatory organization of the cooperatives should try to make the farmers recognize the effectiveness of the mechanization and encourage them to positively employ the machines through educative and demonstrative services.

The farming machines, in principle, should be operated by the model farmers on the reasonable rental basis. If the model farmers have a desire to purchase their own machines, the preparatory organization of cooperative should be required to render services as intermediators for introducing a long-term and low interest credit or installment payment system for the farmers, so as to meet the purpose of the Project. In such case, the private owned machines, if idling time found, will be rented to other farmers in the Area for their much more efficient use.

2-2-4. Farmers' Organization

Since no powerful farmers' organization exist in the Area, the Project aims to positively establish the new organization as well. Establishment of new agriculture cooperatives will be positively promoted along with their upbringing policy of the Department of Cooperatives Promotion, which should assist the farmers to provide the initial investment for establishment of new cooperatives and well-experienced personnel required for operation and management of the cooperarives.

Agriculture cooperatives

The newly established cooperatives should play a vital role to extend the improve techniques and the rational farm management. The small scale of the Project Area, 500 ha only, will not allow the firm and sound body of the independent cooperative to be established, and thus, the preparatory agriculture cooperative should be provisionally provided. This provisional cooprative will be merged into the Agricultural Land Reform Cooperarive (tentative name) that will be formed up in the Irrigated Agriculture Development Project of the West Bank Tract of the Greater Chao Phya. The provisional agricultural cooperative shall have the same and full functions that the Agricultural Land Reform Cooperative, when realized, will provide in aiming to carry out the land consolidation in parallel with the land reform and the water management and collective farming works after completion of the Project.

The above provisional cooperative should be set up under the close cooperation and assistances by various organizations and agencies concerned to produce the best effects in the following manners: a preparatory committee shall be formed with the members of the Ayutthaya Land Reform Committee or some others appointed by the said committee, and the Chairman of the preparatory committee shall be person designated by the Ayutthaya Land Reform Office. The cooperative officer dispatched from the Department of Agricultural Cooperatives Promotion shall be assigned to be the chief of the office of provisional cooperative, and main staff of the office shall be appointed from those of the officers in Changwat and Amphoe. The assigned officers to the office should be trained at the Central Federation of Agricultural Cooperation, Thailand, in Bangkok about activities and services of the cooperatives.

The extension experts should cooporate with the cooperative officers to organize the provisional cooperative in planning of the training program and its realization. The scope of services of the provisional cooperative will be specified as follows:

- To promote smoothly the land reform and land consolidation
- To execute the water management
- To make the timely and smooth supply of inputs materials and to rationalize the collection, storage, processing and marketing of the farm products
- To make a mechanization program and its realization, including operation and maintenance services
- To give guidances and training to the farmers about improved farming techniques
- To give a agriculture crediting services
- To improve the farm management (money-saving, reservation of owned-fund)

During the course of this technical cooperation, however, the education and training of the farmers will be carried out in taking the trial farms as examples in the Project Area. The land consolidation works will be started in the third project year in the five-year technical assistance program, and will be completed in the fifth project year. It will be impossible to reach the ultimate target in the farm production increase during the period of the technical assistance going on, and the provisional cooperative will concentrate its effort to promotion of land consolidation and land reform in the early stage of the project period. The services for water management, collective works, introduction of dry season crops will be given one after another starting with the plot where the land consolidation works will be completed.

As a sub-structure of the provisional cooperative, it is planned to form a farming group; besides this group, the early successful achievement of the Project will require to form the water management organization and farm mechanization organization. It is considered effective for these organizations to be subject to the provisional cooperative.

Farming group

The unit farming group will be formed in the same scale as that of the water management organization, and six farming roups will be formed in the Project Area. The compulsory major functions of the farming group are as follows:

- To prepare cropping program
- To prepare the schedule of irrigation and water control
- To prepare the program and implementation of collective works (seedling raising, transplanting, pest control and mechanized farming)
- To carry out collective purchase of input materials and marketing and sales of farm products.

Water management organization

The Project, involving pumping irrigation and drainage, will introduce the rotation irrigation method so as to rationalize the scale of pumping facilities for effective water management available, and the well control water management organization should be provided for preparation of water management program, operation and maintenance of the related facilities. Based on the water management program, the water management organization including six unit groups will be established in the Area (Refer to 2-2-2, f on water management program). The said water management organization will prepare the water control program in accordance with the cropping schedule made by farming group and render the services in cooperation with the zonemen to be assigned by the RID.

Farm mechanization organization

A lack of farmers' recognition and experience in farm mechanization will inevitably necessitate to organize the farmers' groups and their management for guidance of mechanized cropping and better utilization of the machines, in addition to technical guidance and maintenance service. In the first step of the mechanization, the farming

machines will be employed only in the trial farms for the purpose of testing applicability and demonstrative operation under the intensified guidance of the experts concerned.

It is recommended that the provisional cooperative will process and manage the farming machines in the early stage of the mechanization; on the other hand, however, the farmers groups should be brought up for the extension of the mechanized farming in the Area. In the Project Area, since the land consolidation will be implemented to cover whole fields and provide the favorable conditions for the mechanized farming, it is recommended to form farmers' groups for farm mechanization on the territorial principle basis.

2-2-5. Marketing and Crediting

After completion of the Project, the paddy double cropping and introduction of high yielding varieties would remarkably increase the paddy yields and other farm products to be handled by farmers, and also it is expected to increase in quantity of the input materials and equipments owing to intensified farming practices. Therefore, the relationship between farmers and marketing is expected to become closer than before. Then, in the Project, the comprehensive agricultural cooperatives, dealing with sales of products, purchase of materials and equipments, and crediting services as detailed below, should be established for farmers' own benefits by advantageous commercial activities. Under the present situation, however, the Project Area is too small in its acreage and number of household involved to provide the above mentioned comprehensive agricultural cooperative, and so, for the time being, the provisional cooperative should be organized to manage related services under powerful assistance and administrative guidance by the Department of Agricultural Cooperatives Promotion as mentioned in 2-2-4. At present the BAAC provides the considerable volume of services to the farmers, but in other respect, moneylenders and merchants actually intervene into the farmers' marketing transaction to a considerable extent. When the Project completed, the agricultural cooperatives should be established firmly so as to facilitate to introduce the funds from the BAAC as mach as possible.

In financial operation after completion of the Project- it would be recommended to introduce the guided credit system: that is, for those farmers who want to get loans from the BAAC or any other financial agencies, they shall make an application to the financing agencies as well as the farming schedule. The said farming schedule should be prepared in details under the guidance of the extension agents, referring to the process and program of production and utilization of necessary funds, technical matters, production target, repayment schedule. According to these details, the extension agent will be able to give close and programmed guidance to the farmers who will receive the loan, and the farmers themselves can accomplish the target while making repayments regularly.

2-2-6. Architectural Facilities

The implementation of the technical cooperation in the Chao Phya Pilot Project will require to provide the following facilities:

- Temporary facilities: Temporary Field Office
  Experts' Lodging
  Liaison Office
- Facilities of Trial Farm: Office Building, Workshops
  Warehouse, Sheds, etc.
  and the related lots and other
  public infrastructures

a. Temporary Facilities

i) Location

The temporary field office and the experts' lodging are planned to be located in the compounds of Amphoe office buildings of Lad Bao Laung, 8 km west of the project area along the Phraya Banlu canal. The Thai Government is in a position to provide one of the Amphoe office buildings, so that the experts can use it as a temporary field office with some alteration made to its interior furnishings, and the lodging accommodation will be constructed near the field office.

The liaison office will be placed in a space in the Ayutthaya Land Reform Office by courtesy of the Thai Government, and no alterration is required to this office. Thus, the construction or alteration should be made only for the field office and lodging accommodation.

ii) Transportation and communication facilities

As a means of transportation between the Project site and temporary field office (lodging accommodation as well), the motor boat will be conveniently employed. The communication between the temporary field office and the Ayutthaya liaison office will be made by means of existing telephones in the Amphoe office, if necessary, and no specific communication system will be provided in the Project.

if) Public infrastructure

Electric power

Since the electric power supply is available during a period of time 18:00 through 24:00, the power supply to be required for the necessary facilities in the Project will be made in the effective use of the existing supply system.

Water supply

No water supply system is provided in the Area, and the rain water is used for drinking and the river water for other daily necessity (washing, bathing, etc.) without any processing. A deep well shall be provided for using the groundwater for the experts consumption in their daily life.

Sewage disposal

The raw sewage and waste water have been left to natural penetration or direct disposal to the stream. In the Project, a septic tank for disposal of raw sewage will be constructed lest the present environment and water quality should be polluted.

iv) Outline of architecture

Temporary field office

The proposed building for the temporary field office is of wooden strucrure in single elevated floor (concrete foundation), of which floor area is approximately 80 sq.m. This building was built as a residence and is required to be converted into an office building with partial remodelling works such as electric wiring, interior furnishing, painting, etc.

Experts' lodging accommodation

The experts' lodging is to be used as a temporary residence for week days by the Japanese experts in long-term assignment who will have their own residence in Bangkok, and not designed for family use but for single use. The accommodation should provide six bed rooms, a common use living room, a dining room, a kitchen and a servant quarters. The number of six bedrooms is decided to meet expected numbers of experts making services in the job site at peak time. And the necessary floor areas are 48 sq.m in the first floor and 187 sq.m in the second floor, totaled to 235 sq.m.

b. Facilities in Trial Farm

The trial firm should provide such facilities as management office, various workshops, storehouses, sheds for farming machines, canteen, fuel or other material supply facilities and disposal plant, etc. (including creation of building lots, roads and parkings).

i) Location

The trial farm, about 10 ha, will be constructed at the southeast corner of the Project Area, along the north of the provincial road. The necessary building sites will be selected at the area adjacent to the provincial road in taking into account the accessibility to the farm lots and the flow paths. Furthermore, it is desirable to locate the facilities possibly close to the main pumping station that will

have the same sources of power and water supply as these facilities. That is the reason why the facilities for trial farm was decided at the south east corner of the area, adjacent to the main pumping station.

ii) Lay-out of buildings

Every building and facilities, having its own purpose and function, should be laid out to function as a whole to meet the Project requirements in keeping good interrelation among each other. In lay-out of these facilities, there will be three approaches as follows:

a) Each facility have its own building independently.

b) Several facilities with similar nature are housed in one building to make functionwise groups of buildings.

c) All facilities are housed in one large building which provides several interior blocks by facilities.

In case of b), although working flexibility may be available, the flow paths of work is apt to be confused and the good arrangement is difficult for materials, equipment and other articles. And the case c) should not applied to excepting for necessity requiring for two or three stories buildings due to insufficient construction site reserved or specially for only one building needed in the design aspect.

In the Project, the case a) was adopted in considering the sufficient space available for buildings and simplicity of the construction works. In the lay-out of this case a), it is essential to place every building to make its function fully effective under organic interrelation in each other.

iii) Creation of necessary building lots

The building lots should be embanked and levelled at EL 3.5 m, the same level as that of the polder dike embankment. The embankment materials can be appropriated from the residual materials in dike construction. Roads and parking losts will be paved with laterite materials. The total acreage to be created will be 2.4 ha.

iv) Water and electric supply and disposal

Electricity

Since no electric supply is available in the Project Area at present, the necessary electric power (120 KVA) will be supplied by the diesel to be installed in the main pumping station.

Water

The necessary water (15,100 ℓ/day) will be supplied by pumping up of the groundwater. The groundwater pumped-up will be stored in the storage tank at first, and some water will be distributed to the main pumping station as cooling water of the diesel engines, and other will be distributed to the trial farm by gravity method after re-pumping up to the elevated delivery tank.

Garden irrigation water

The garden irrigation water for lawn, trees and flower beds will be supplied through pipelines after direct pumping-up the water from the canals around the trial farm.

Rain water drainage

The rain water will be collected in the catch box through L-shape side ditches and drained out to the retaining reservoir.

Sewage disposal

To maintain the good environmental condition and quality of water around the trial farm, all waste water will be collected to purification plant to be disposed and discharged to the retaining reservoir through drainage culverts.

v) Outline of buildings

Management office

The management office is a nucleus of the trial farm providing office rooms, conference rooms, lecture rooms for farmers, and

laboratory. The related experts and Thai officers to be assigned in the office will be 5-6 and 10-12 persons, respectively, and the farmer trainees will be 10-20 persons; then the scale of the facilities was designed in reference to the above figures.

Workshops

The trial farm will provide four workshops such as a general workshop, a threshing house, a milling house, and a repairshop.

Sheds

Two sheds will be provided to house tractors, combine harvesters, rice planters, etc. and one garage to house trucks, a light-van and a boat.

Warehouse

The following warehouses will be constructed for various purposes.

- Rice warehouse equipped with airconditioned room for rice storage test available
- Warehouse for farming implements including fertilizers, agri-chemicals
- Warehouse for general use
- Warehouse for fuel oil and others

Shower room and lavatory

The independent buildings for shower and lavatory will be constructed for the trainees and the laborers in the trial farm.

Canteen

For the convenience of taking lunch, and rest, a Thai-style arbor will be constructed and utilized by laborers, trainees, Thai officers and Japanese experts. Such facilities will provide an opportunity to promote friendly relation and mutual understanding among the people concerned.

Others

The miniatured Buddhism temple, so-called "Sangpapoung" in Thai will be placed in a corner of the garden near the entrance, subjected to the custom of the Country. Furthermore, a instrument shelter for weather observation, paddy drying yard, working yard, and a slipway for mooring boats are planned to be provided, and some further spaces should be reserved for the residence for Thai Officials and expansion of the trial farm itself in future.

2-3. Design

2-3-1. Polder Dikes and Main Canals

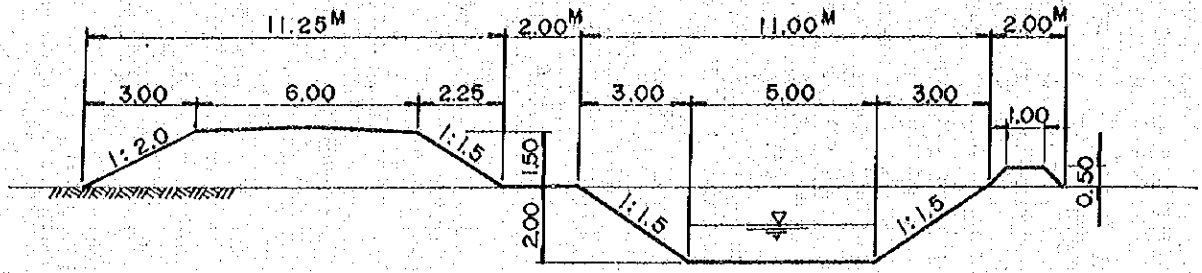
The crest elevation of the polder dikes was designed at EL 3.5 m and the standard embankment height at 1.5 m. The standard cross-section of the dikes was determined as follows:

Side slope:	Outer slope 1:2.0, Inner slope 1:1.5
Crest width:	6.0 m (effective width = 4.0 m)
Pavement:	laterite pavement, 4.0 m wide, 0.15 m thickness

The main canals will be constructed along the polder dikes, and the excavated earth of the canals will be used for the embankment materials for the polder dikes. The main canals will be of earth type with trapezoid section with 2.0 m deep excavation, 5.0 m bottom width and side slope at 1:1.5.

The volume of earth works in construction of dikes and main canals (9,160 m long) was estimated at about 166.8×10^3 cu.m for excavation and at about 102.4×10^3 cu.m for embankment (on the basis of design made by 1/4,000 map).

CROSS SECTION OF POLDER DIKE AND MAIM CANAL



2-3-2. Pumping Stations

a. Main Pumping Station

i) Storage tank

The dimensions of storage tank are shown as below.

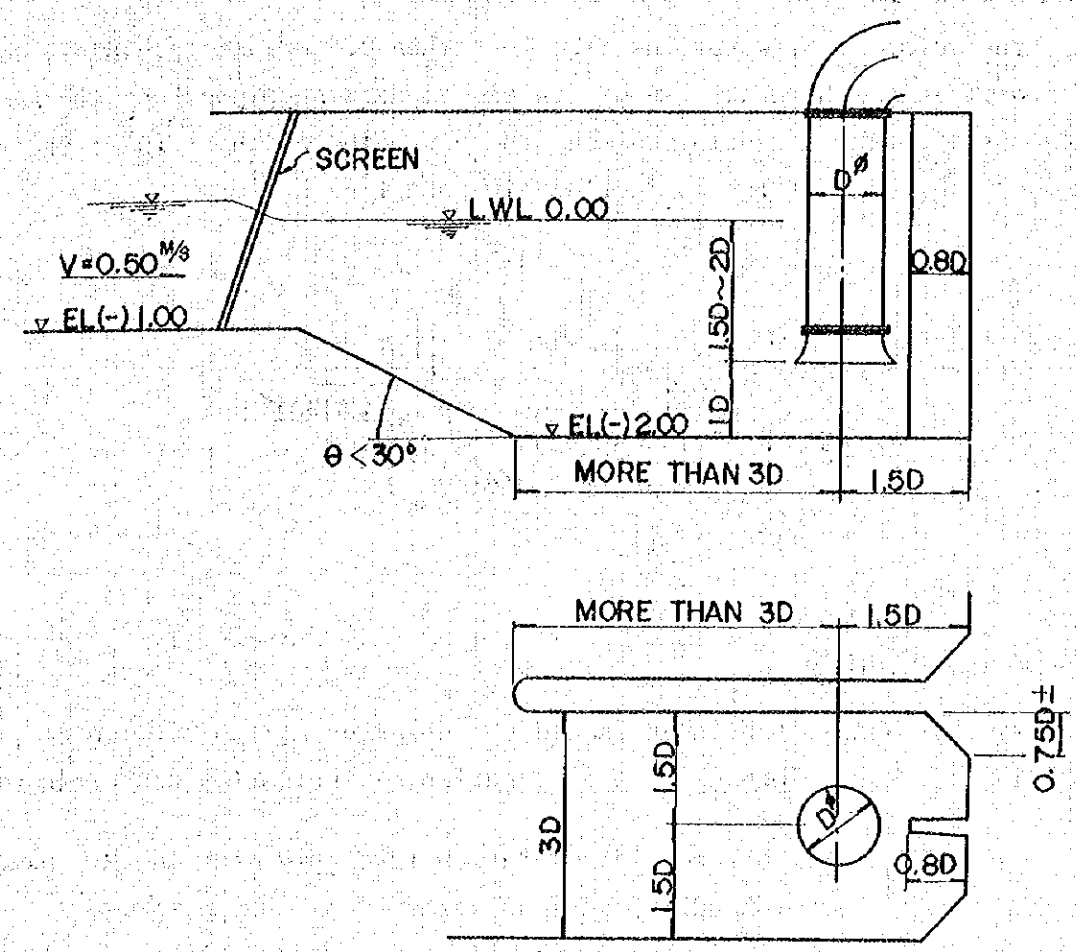
Suction level

For drainage ..... EL 1.00 m - EL 0.30 m = EL 0.70 m

For irrigation ..... EL 0.49 m - EL 0.49 m = EL 0.00 m

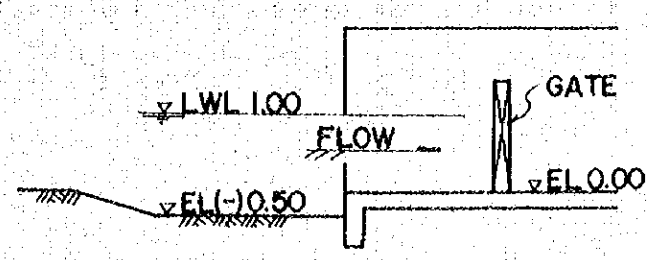
Storage tank

The general idea will be shown in the following illustration.



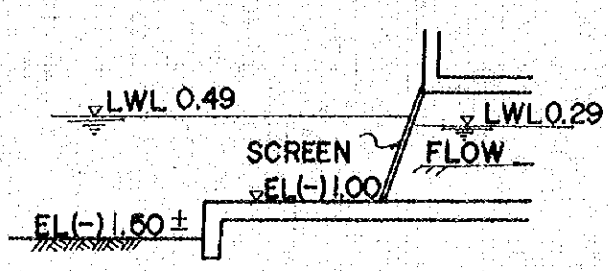
Cross-section of drainage canal

The cross-section of the drainage canal was designed with 4.0 m width and at 0.5 m/s of velocity so that the sand and other particles inflow can be minimized, and the desilting basin with 0.5 m deep shall be provided in the canal in front of the pumping station.



Cross-section of conducting pipe for irrigation

The velocity of water shall be less than 0.5 m/s at the inlet, and contrarily shall be about 1.0 m/s in the conducting pipes lest the sand and other particles should sediment therein. The width of inlet shall be 2.0 m and that of the conducting pipe shall be 1.5 m.



Appurtenant Structures

The following structures should be installed at the portion of storage tank for smooth effective operation of irrigation and drainage.

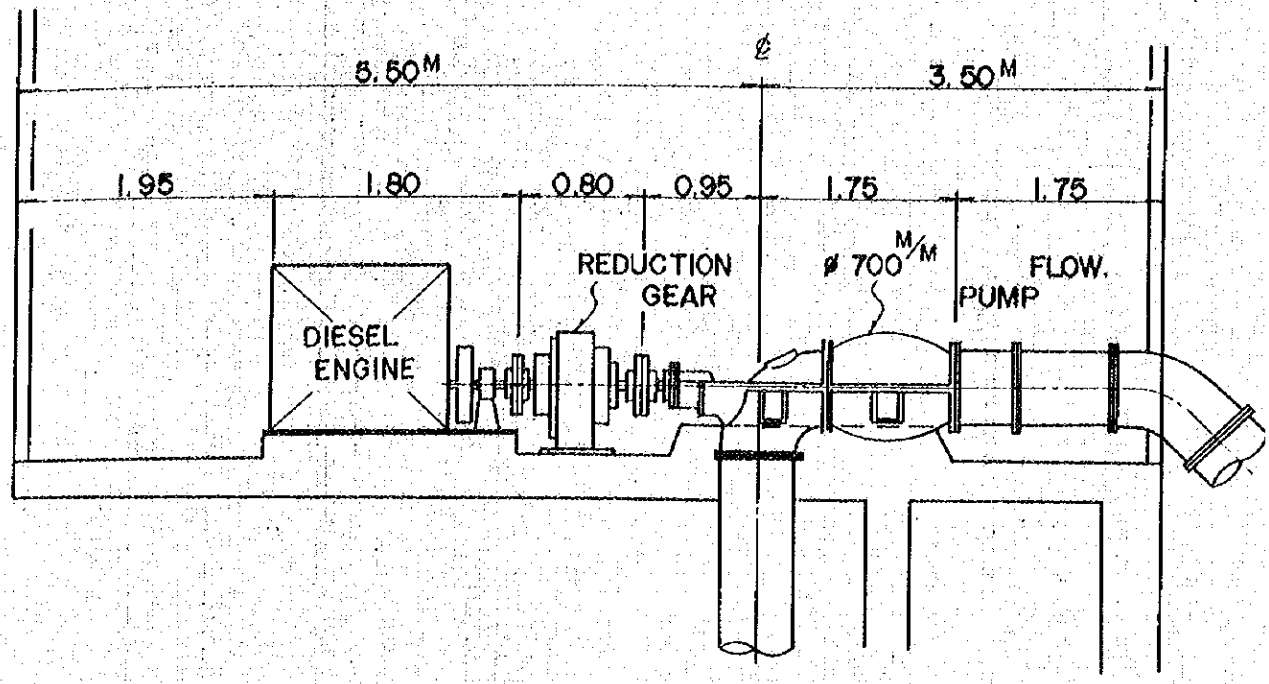
Gate: For alternative operation for irrigation and drainage, the manually operated gates should be installed at the irrigation conducting pipes and drainage canals.

Screen: Screens should be provided at the front of storage tanks and conducting pipes for irrigation not so as to allow the dust and weeds to flow into the facilities.

ii) Pumping stations and buildings

Width of pumping station

The dimensions of pump units, prime movers, speed reduction gears, etc. will determine the width of the main pumping station as follows:

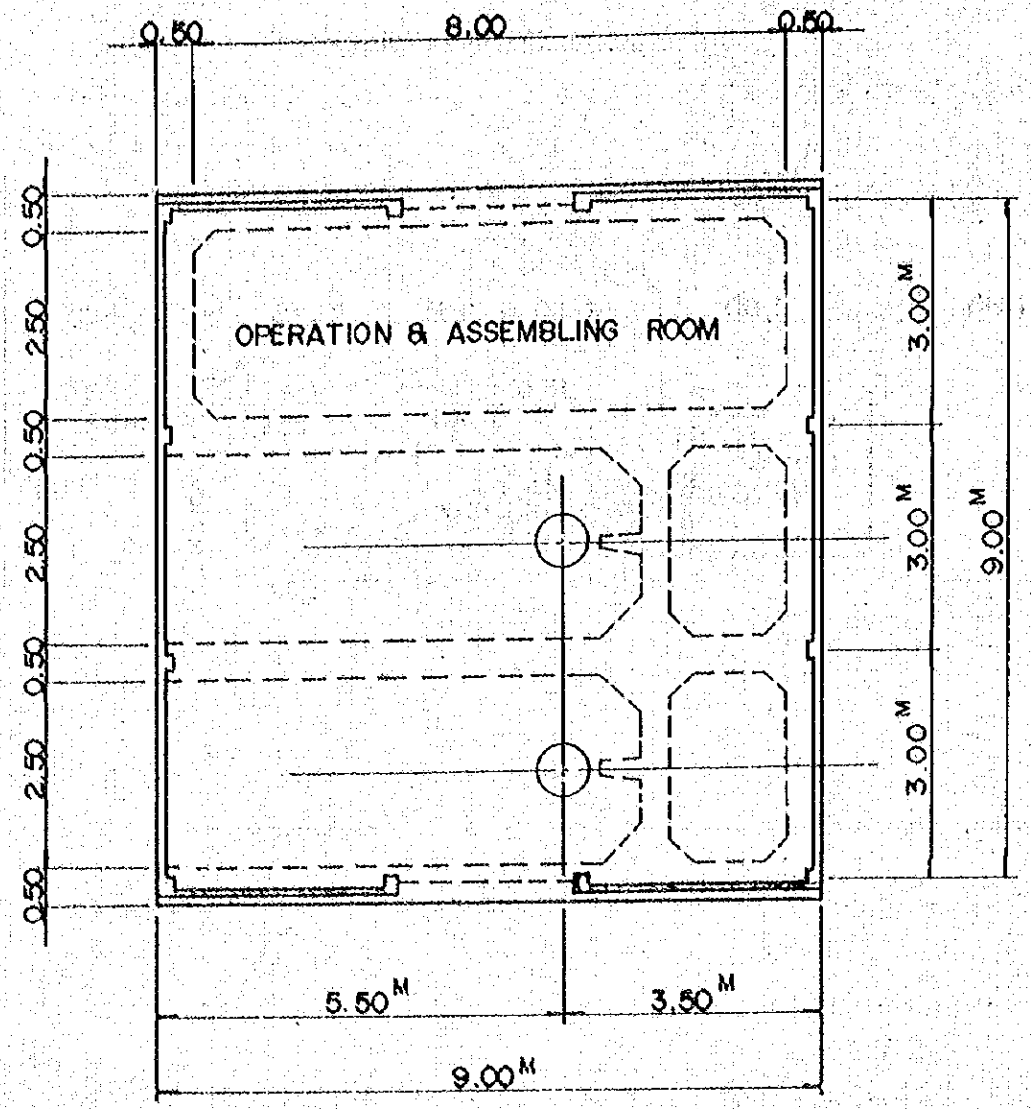


Length of pumping station

The length of the station will be determined as shown in the following illustration, depending upon the spaces reserved for installation of pump units, operation room, and hauling, assembling and dismounting of the machines.

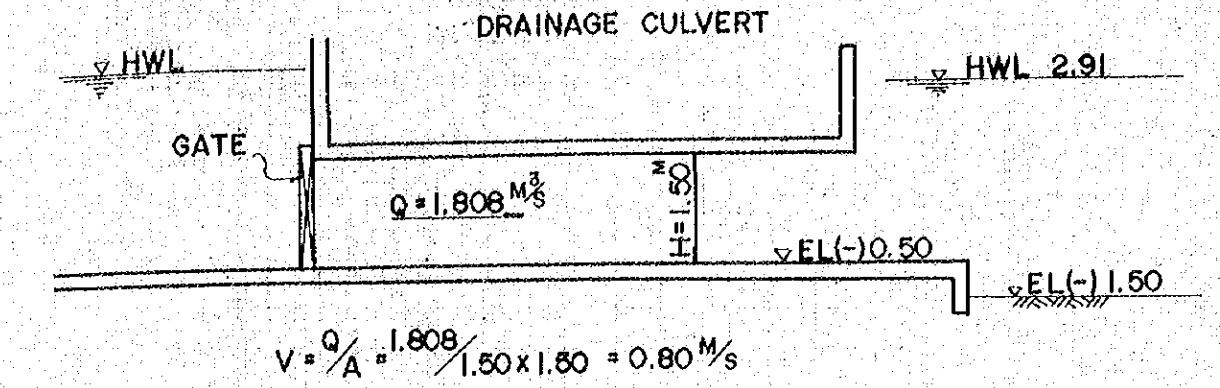
Elevation of building

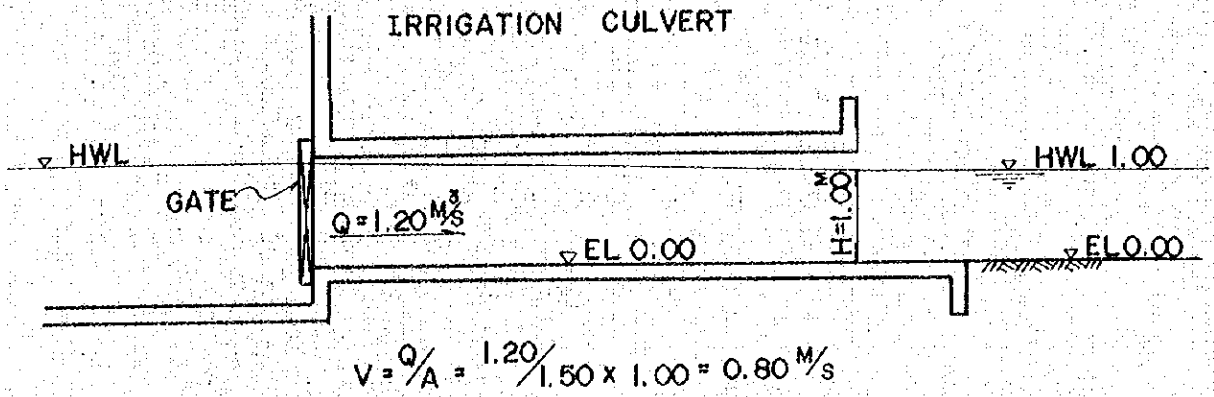
The elevation of the building shall be of 3.5 m height, the same as that of the Polder dikes.



Cross-section of delivery pipes

The delivery pipes are specified into two, the irrigation use and the drainage use, with the cross-section possibly minimized to 1.50 m x 1.50 m. The flow velocity in the pipes will be 0.8 m/s that can meet the design standard.





Appurtenant structures

The manually operated gates, the appurtenant structures to the both delivery tanks, will be installed for switching over the function of the pipes from irrigation use to drainage use and vice-versa.

iii) Foundation treatment

The foundation of the station shall be designed in referring to the results of the bore drilling carried out in the adjacent areas to the station. The relevant drilling data revealed that the considerably soft sandy clayey soil distributed to 10 m deep from the ground surface. It is recommended that the pile foundation should be executed to reach

the bearing layer distributing at EL -10 m as comparatively compact sand layer.

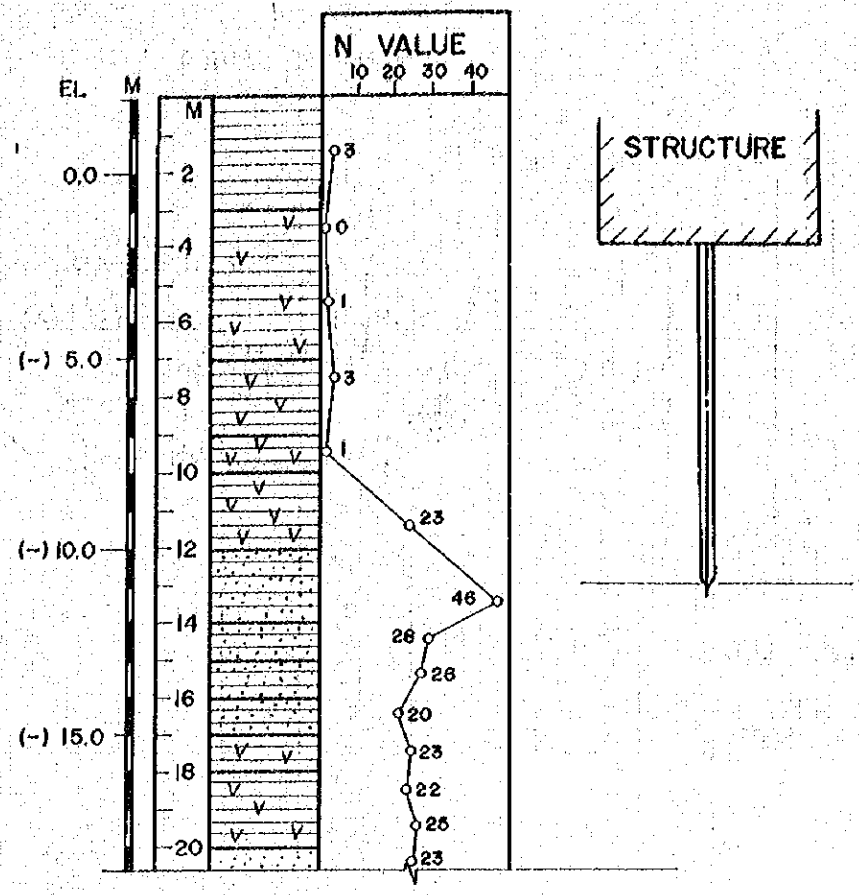
The boaring capacity of the pile is computed by the Meyerhoff's equation.

$$Ru = 40.N.Ap + \frac{1}{5}\bar{N}.As + \frac{1}{2}.\bar{N}c.Ac$$

$$Ra = \frac{1}{3}Ru$$

where: Ru: maximum bearing capacity of pile (t/piece)
N: N-value of foundation at the reach of pile
Ap: cross-section area of the pile top (sq.m)
$\bar{N}s$: average N-value of layers that the pile penetrates
As: U.Ls (sq.m)
Ac: U.Lc (sq.m)
U: circumference of the pile (m)
Ls: length of pile driven into sand layers (m)
Lc: length of pile driven into clay layers (m)
Ra: permissible bearing capacity of pile (t/piece)

The kind of pile to be employed is of 20TPS (20cm x 20cm). In this case, when various factors are Ap = 0.04m sq.m, V = 0.8m, Pile length l = 10.5 m/piece, bearing capacity of pile Rp = 25 t/piece, assuming as $N \fallingdotseq 30$, $\bar{N}s \fallingdotseq 0$, $\bar{N}c \fallingdotseq 0$, the following values can be obtained as Ru = 48 t/piece, and Ra = 16 t/piece. With prudence, however, Ra = 15 t/piece shall be adopted to design the pile foundation to sufficiently bear the loads of structures.



b. Irrigation Pumping Stations

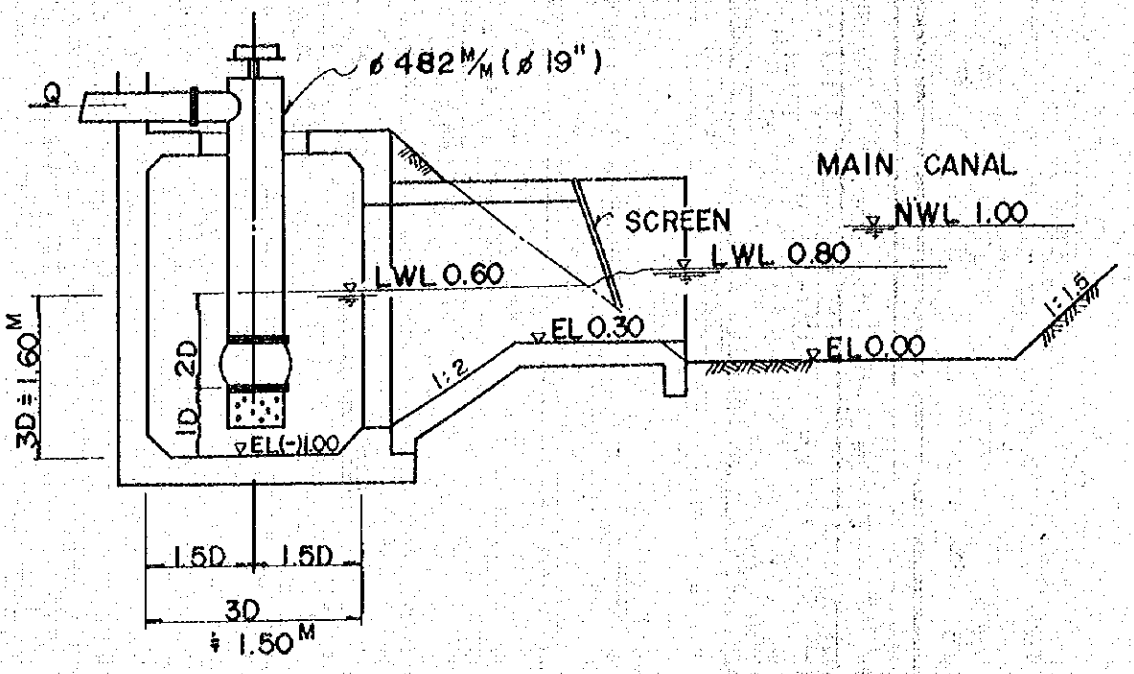
1) Storage tank

Suction level

Since the minimum water level in the main canal is El 0.80 m, the suction level is designed as EL 0.60 in taking into account the screen loss at 0.20 m.

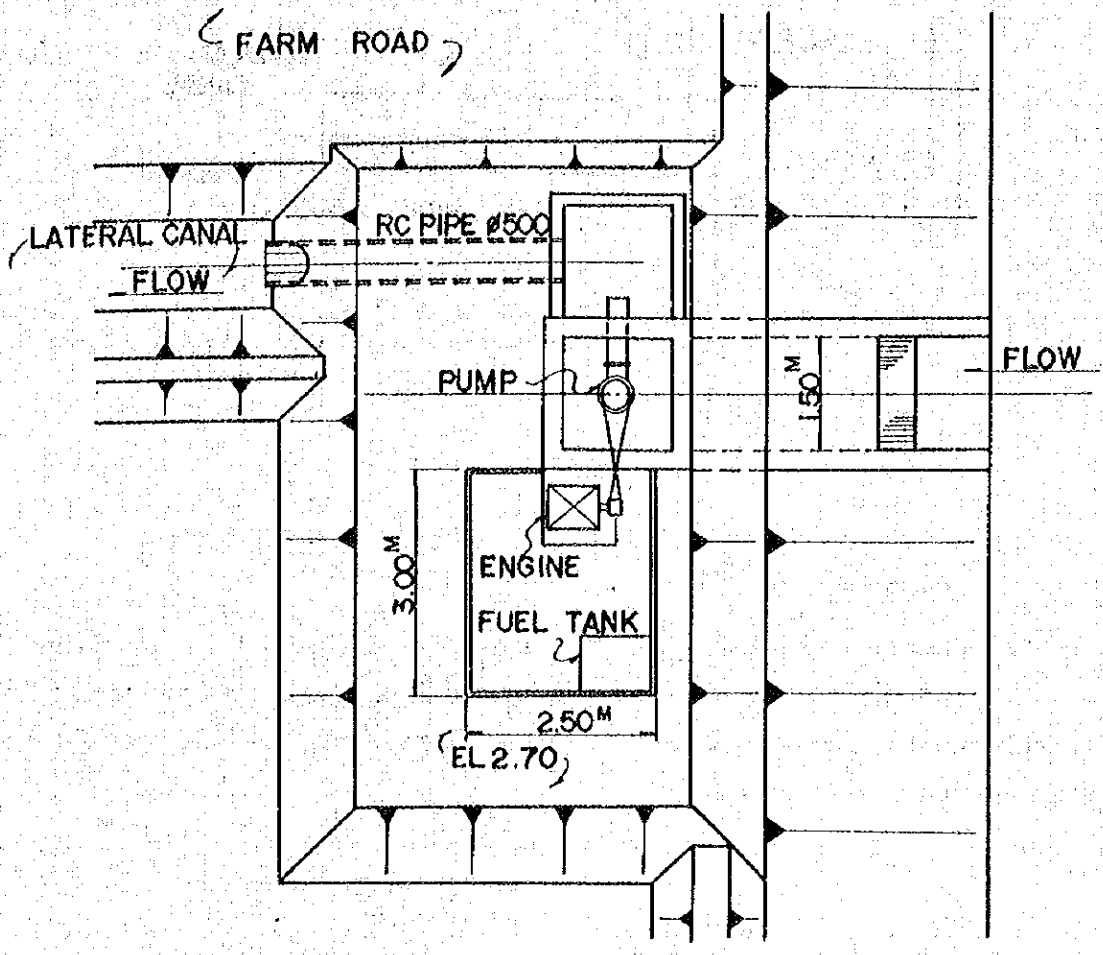
Type of storage tank

The storage tank is designed in the same type as that of the main pumping station as illustrated below.



ii) Pumping statin and buildings

The pump rooms shall have covered structure and the engine rooms together with fuel-oil tanks shall be provided in the building with space of 3.0 m x 2.5 m.



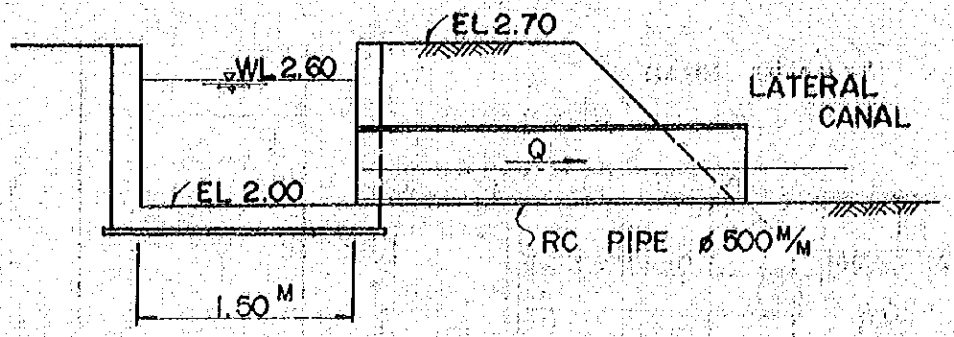
iii) Delivery tank

Delivery level

The delivery level is determined at EL 2.60 m, the same as the designed water level in the lateral irrigation canals.

Type of delivery tanks

The delivery tanks will have the concrete box type (1.5m x 1.5m). The tanks and lateral irrigation canals shall be linked each other by RC pipes which have the bore diameter of 500 mm so as to keep the flow velocity therein at less than 0.9 m/s.



2-3-3. Land Consolidation

a. Irrigation Canals

Conveyance capacity

The conveyance capacity of the canals is determined in depending upon the peak water requirement in depth (9.6 mm/day). The duration of water supply, however, will coincide with the operation hour of irrigation pumps, 22 hr/day.

Canals	Irrigable area (ha)	Irrigation efficiency	Conveyance amount (cu.m/s)
Farm ditches	19.2	0.80	0.029
Lateral canals			
LC-1	38.4	0.72	0.065
LC-2	76.8	0.72	0.129
LC-3	115.2	0.72	0.194

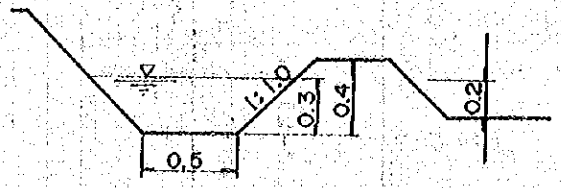
Canal slope

The canal slope in profile was decided at 1/5,000 so that the water level at the pumping station can be maintained at about 0.6 m above the field surface and in the terminal plots at about 0.2 m above the field surface.

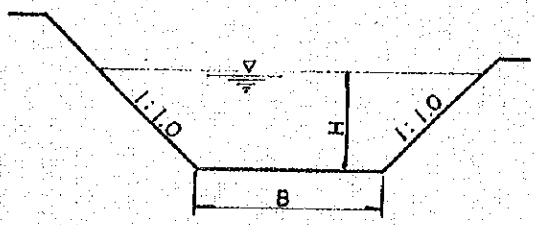
Cross-section of canals

In hydraulic computation, the manning's equation was adopted in taking roughness coefficient at 0.035. The canals shall provide the cross-section with the broader bottom for easy operation and maintenance, rather than that with hydraulical advantage.

FARM DITCH
(UNIT;M)



LATERAL CANAL
(UNIT;M)



	B	H
LC-1	0.70	0.39
LC-2	1.10	0.46
LC-3	1.20	0.55

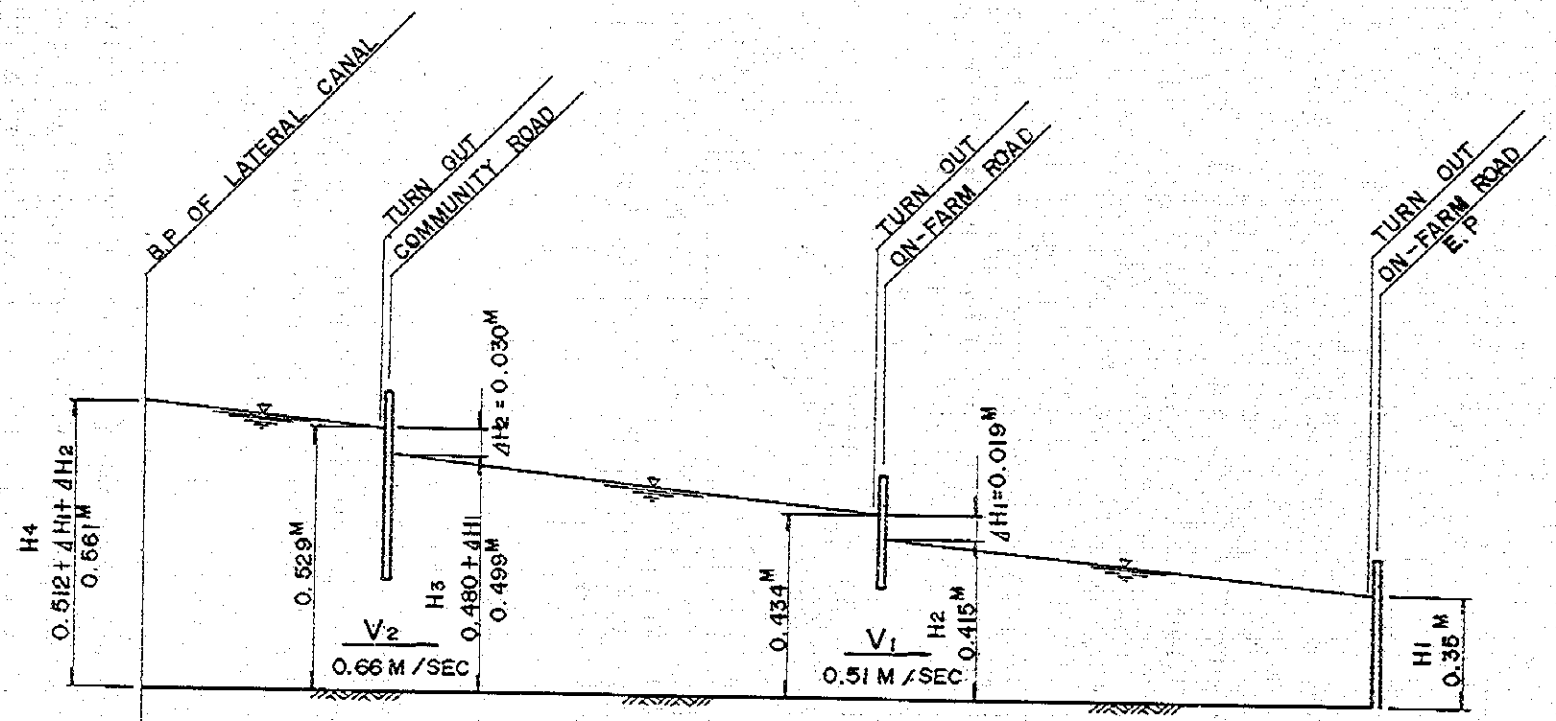
Facilities

Turnouts to be installed along the lateral canals should provide such structures that can possibly minimize the head loss. As the water will be diverted through turnouts in constant quantity, not pershall flume but submerged weir type will be able to function satisfactorily to meet the requirement.

The farming machines will approach to the fields from the farm roads, along the one side of which the irrigation ditches will be provided, and then the access roads should be constructed to bridge over the ditches with reinforced concrete pipes (ϕ350 mm). On the other side of the farm road, inlet works of reinforced pipes (ϕ250 mm) should be provided.

The proposed standard of water head distribution for lateral canals is illustrated in FIGURE II-5.

FIGURE II-5 PROPOSED PROFILE OF TYPICAL LATERAL CANAL



	LATERAL CANAL-3 (L.C-3)		LATERAL CANAL-2 (L.C-2)		LATERAL CANAL-1 (L.C-1)
FLOW CAPACITY	Q=0.194CU·M/SEC		Q=0.129 CU.M/SEC		Q=0.0647 CU.M/SEC
CANAL LENGTH	160 M	6 M	325 M	5 M	325 M
		CULVERT (ø500)		CULVERT (ø400)	
CANAL GRADIENT	I = 1:5000		I = 1:5000		I = 1:5000
AVERAGE DEPTH	D=0.545 M		D=0.467 M		D=0.383 M
VELOCITY	0.20 M/SEC		0.18 M/SEC		0.15 M/SEC

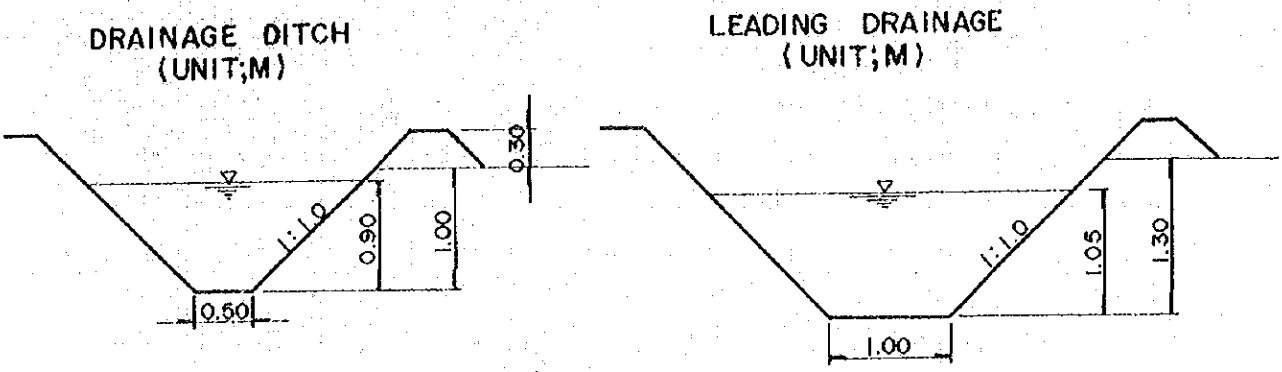
b. Drainage Canals

Drainage capacity of the canals

The designed unit drainage quantity is 6.34 ℓ/s/ha (refer to 2-2-2, c), and the drainage capacity of ditches and lateral drainage canals were determined at 0.243 cu.m/s (38.4 x 0.00634) and 0.487 cu.m/s (76.8 x 0.00634), respectively.

Cross-section of drainage canals

On the basis of canal slope of 1/5,000 and roughness coefficient at 0.04, the cross-section was determined, but the drainage ditches should be excavated 1.0 m deep for a consideration of lowering the groundwater table.



c. Roads

Width

The width of roads was decided as follows:

	Total Width	Remarks
Farm-roads:	3.0 m	Tractor or T-9 ton trucks passable
Community roads:	4.0 m	Tractor or T-9 ton trucks passable each other

Height

Although the lower road surface elevation is convenient in accessing to the fields, it should be elevated, from viewpoint of soil properties and O & M, at least 0.2 m above the water level in the ditches along the farm roads. The elevation of farm roads should be 0.40 m above the field surface, and the community roads along the ditches should have 0.4 m height and others more than 0.50 m.

Loads

The loads by vehicles used in the Project Area is restricted to less than T-9 ton. The vehicles available in the area would be trucks with five ton load at maximum, accordingly. Furthermore, it should be noted that the heavy construction machinary will be prohibited in operation after installation of the irrigation pipes.

d. Land Leveling

On leveling lands, the margin of errors with ±5 cm will be permissible. In the Project, the unit plot is so large by 160 m x 50 m that a great care should be exercised in leveling works. Partial uneveness in the plots will be re-leveled when plowing and puddling are carried out after land consolidation completed.

For some time after completion of the Project, to provide temporary irrigation ditches along ridges will be effective for correct and speedy water control. In the same manner, temporary drainage ditches in the fields will well function for quick drying the paddy fields.

e. Summary of Land Consolidation

Table II-10 shows the total length of the roads and the canals which will be constructed in the land consolidation of arable lands, 458.6 ha, except for the orchards, 44.9 ha, (Designed on the basis of 1/4,000 map).

TABLE II-10 Total Length of Facilities After Land Consolidation

(Unit: m)

Facilities	Northern Part (389.1 ha)	Southern Part (69.5 ha)	Total (458.6 ha)
Road			
Community roads	9,190	2,600	11,790
Farm roads	10,265	2,565	12,830
Total	19,455	5,165	24,620
Irrigation canals			
Lateral	3,220	1,270	4,490
Ditches	14,425	3,895	18,320
Total	17,645	5,165	22,810
Drainage canals			
Lateral	1,585	-	1,585
Ditches	11,385	3,295	14,680
Total	12,970	3,295	16,265

2-3-4. Architectural Facilities

A close care was exercised in designing the facilities on the following basic concepts:

- To harmonize the facilities with the environment
- To design with consideration for facilitating construction works
- To be available in easy procurement of materials
- To possibly reduce construction cost

In view of the above point, all proposed buildings are to be constructed by the conventional method of Thailand with local materials fully utilized.

a. Temporary Facilities

i) Buildings

Temporary field office

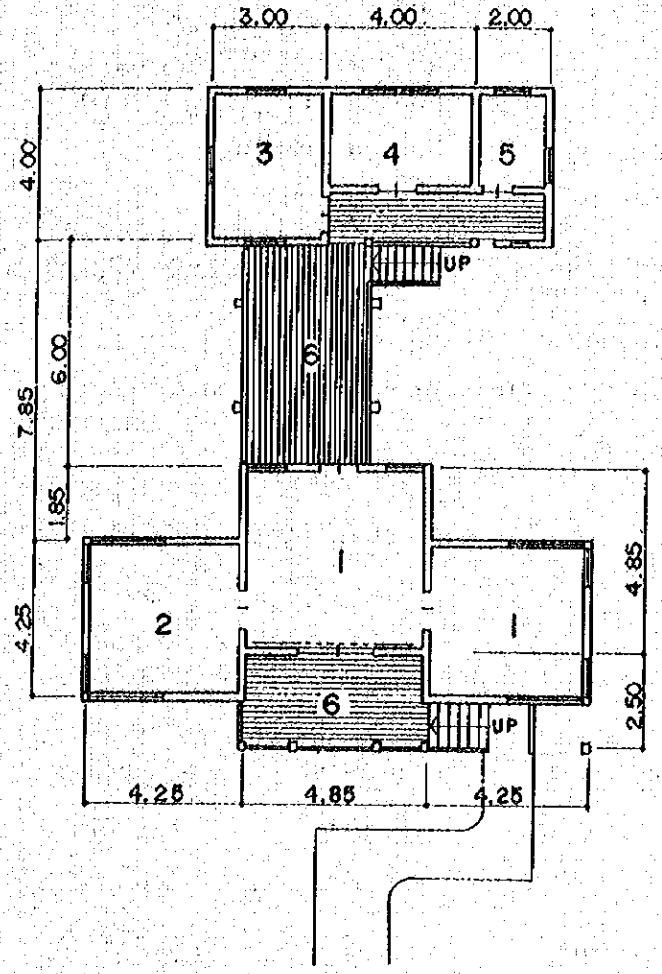
The present status of the Amphoe office building, the proposed temporary field office, is as follows (Refer to Figure II-6):

Building area		116.7 sq.m
Floor area	interior	86.0 sq.m
	terrace	30.7 sq.m
Structure	wooden structure of elevated single floor	
Foundation	reinforced concrete	
Equipment	a simple lighting	
	a Thai style water closet	
Exterior finish	roof	corrugated asbestos sheets
	wall	oil stained wooden siding
	foundation	concrete
Interior finish	ceiling	board ceiling
	wall	non-finish
	floor	wooden flooring

The relevant building will be used as the temporary field office with the following remodeling works.

Interior wall works	- Plywood (lauan) V.P. (4.0 mm thick)
Ceilings	- Paint finish
Fitting works	- Window screen shall be provided with paint finish.
Lighting works	- 15 x 40 W FL and switches and wall consents shall be equipped.
Toilet	- Remodeling of water-closet and fitting work of lavatory bowls.
	- Interior wall finsih with cement tile (h = 1,500) and mortar plaster V.P.
	- Setting work of other sanitary goods and equipments required.

FIGURE II-6 PLAN OF AMPHOE OFFICE
(UNIT ; M)



1 OFFICE ROOM
2 MEETING ROOM
3 SPARE ROOM
4 STORAGE
5 TOILET
6 TERRACE

SCALE 1 / 200

Experts' lodging (Refer to Drawing)

Area:	Building area		187 sq.m
	Floor area	Living-dining room	48 "
		Bed rooms 12 sq.m x 6	72 "
		Bath rooms 6 sq.m x 2	12 "
		Entrance	12 "
		Kitchen	13 "
		Servant quarter	11 "
		Lavatory & others	12 "
		Sub-total	180 sq.m
		Terrace & corridor	55 sq.m
		Grand total	235 sq.m

Number of stories			2 stories
Structure	First floor	Concrete block	48 sq.m
	Second floor		187 sq.m
	Foundation & Columns	Reinforced concrete	
	Foundation pile	Wooden pile (L_1 = 8.0 m)	
	Floor	Wooden framing	
	Roof	Wooden truss	
Equipment	Whole set of water supply, sanitary and drain equipments		
	Whole set of wiring and lighting equipments		
	Two sets of instantaneous gas water heater		
Finish	Refer to Drawing		

ii) Supply and disposal

Water supply

The capacity of daily water supply is as shown below.

Facilities	Objective population	Unit amount of supply	Total amount of supply
Office	8 persons	100 ℓ/day	800 ℓ/day
Lodging	8 "	200 "	1,600 "
Total	16 persons		2,400 ℓ/day

The well water will be pumped by motor drive device, and since the power supply is available only for six hours, the scales of respective facilities were decided as follows based on the schedule of power supply.

Elevated Water Tank

Capacity	2,400 ℓ
Height	12 m
Materials	Steel tank supported by steel structures

Well pump

Capacity	20 ℓ/min (Filling the tank in two hours)
Head (actual head)	42 m
(total head)	53 m
Diameter	32 mm
Power consumption	0.75 kw

Sewage disposal

Two septic tanks with capacity for 10 person are planned to be provided by one each for the office building and lodging.

Power supply

The electric power will be supplied from the distribution facilities located nearest by the building site.

Voltage	220 v
Capacity for office	4 KVA
lodging	11 KVA
pump	1 KVA
Total	16 KVA

b. Trial Farm Facilities

i) Land preparation

Land use of the architectural facilities of the trial farm is designed as follows.

Building area (including berms)	2,600 sq.m
Road & parking	4,530 sq.m
Working yard	650 sq.m
Garden & others	15,880 sq.m
Total	23,660 sq.m

The land for the facilities is designed at EL 3.50 m which should be taken as the level of the street gutter. The elevation of road

center and surroundings of buildings is designed higher than 3.50 m with two to four percent of gradient.

Roads parking and car washing lot are to be paved with asphalt after compaction of 15 cm thick laterite and 5 cm thick sand. Gardens and reserved land for future extention will be turfed, and flower beds and tree planting will be made partially, if necessary.

ii) Design of buildings

The buildings to be constructed in the trial farm are listed below.

Name	Floor Area (sq.m)	Remarks
Management office	512	including 170 sq.m of terrace and corridor
Rice warehouse	60	air conditioners equipped
Threshing house	147	
Rice mill	147	serving dually as hulling plant
General workshop	147	
Repairshop	147	
Agri. machinery shed	294	147 sq.m x 2
Garage	147	serving dually as boat shed
Agr. instruments warehouse	147	
General warehouse	147	
Oil & fuel storage	21	exclusive of car washing lot (300 sq.m)
Canteen	100	
Shower-W.C.	45	
Generator house	35	
Total	2,096 sq.m	

The structure and finishing of the buildings have a little difference in each facility but their outline is as follows:

Structure	Foundation pile	
	Wooden pile	L = 10.0 m
	P.S. concrete pile	L = 15.0 m for rice warehouse, machine shed, garage and repairshop
	Foundation	Reinforced concrete
	Column	Reinforced concrete
	Tie beam	Wooden beam in principle, but steel truss for shed, garage, and repairshop
	Roof Truss	Wooden truss or steel truss
	Wall	Wooden framework concrete block
	Floor	Wooden framing or concrete
Finishing	Roof	Corrugated asbestos sheet
	Exterior wall	Wooden siding or mortar finish
	Column	Concrete without finish, painted

The further details on building design are referred to the Drawings and the following specifications.

Management office

		(sq.m)
Area	Building area	512
	Floor area	512
	Floor area for Director's room	18
	Office room	68
	Meeting room	30
	Leader's room	18
	Experts' room	54
	Laboratory	36
	Preparation room	18
	Lecture room	54
	Locker & shower, W.C.	36
	Others	10
	Sub-total	342
	Terrace & Corridor	170
	Total	512

Number of stories	Two stories elevated single floor
Structure	Wooden structure, partially reinforced concrete Foundation pile: Wooden pile L = 10.0 m
Equipments	Complete set of supply, sanitary drain equipments and electric equipments
Finish	Refer to the Drawings

Rice warehous

The general specifications of the cold storage rooms equipped for the purpose of storage test is as follows.

Structure	75mm thick foamed styrole on concrete block wall of 150 mm thick	
Outside max. temperature	40°C	
Planned room temperature	5°C	15°C
Planned room humidity (variable)	70%	70%
Required cooling capacity	1,200 Kcal/hr	900 Kcal/hr
Cooling units	2 x air-cooled type cooling units of 1,300 Kcal/hr of capacity Power consumption 1.5 KVA/each	
Humidifier	2.5 ∿ 3.0 ℓ/hr, 0.1 KVA 2 sets	

Repair shop

The repairshop is designed in the nonflammable structure as well as the machinery sheds and garage. The fittings of main entrance are to be manual operation steel shutter. A hoist crane with one ton capacity and a one meter deep pit are equipped for the convenience of repair.

iii) Water supply

The followings show in details the water demands of the facilities of the trial farm.

Facilities	ℓ/day
Management office	2,000
Canteen	1,500
Shower-lavatory	2,000
Expected expansion	8,000
Car-washing lot	1,000
Out-door cocks	600
Total	15,100

Total daily consumption 15,100 ℓ

Average consumption per hour 1,890 ℓ

Max. consumption per hour 3,780 ℓ

Momentary max. consumption 5,670 ℓ

Elevated water tank

Capacity: 4,000 ℓ (Consumption for one hour at max. consumption)

Height: 13.0 m (elevation at the bottom of the tank)

Materials & structures: Steel tank supported by steel towering structure

Water lift pumps

Capacity: 100 ℓ/min (momentary max. liftings)

Total head: 25 m

Bore diameter: 40 mm

Power consumption: 1.5 KW

Pump type: Submerged turbine pump

Water reservoir

capacity: 22,000 ℓ (The sume of the half quantity of the total daily consumption of 15,100 ℓ by the facilities and quantity of four hours (4x3,600ℓ) at max. consumption by the main pumping station)

Height: 3,5 m at the bottom elevation

Materials & structures: Reinforced concrete (3.5m x 3.5m x 2.0m)

Well pumps

Capacity:	190 ℓ/min (Filling-up the reservoir within two hours)
Total head:	35 m
Bore diameter:	50 mm
Power consumption:	3.7 kw
Well-diameter:	125 mm
Pump type:	Submerged multi-stage type
Plumbing works:	ϕ65mm, zincing steel pipes (Total length: 500 m)

Garden irrigation water

Water requirement:	5 mm/day x 15,880 sq.m = 80 cu.m/day
Supply hours:	8 hours per day
Supply cocks:	ϕ25mm, nine(9) cocks to be provided and five cocks available to be simultaneous use.
Pumps:	Capacity: 170 ℓ/min
	Head: 20 m
	Power consumption: 1.5 kw
Pressure tank:	Capacity 0.5 cu.m
	Starting pressure 1.6 kg/sq.cm
	Stop pressure 3.0 kg/sq.cm
	Plumbing works ϕ32mm - 65mm, total length 500m

Rain water drainage

L-shape ditches	1,700 m
Drainage basin	70 basins (450 x 450, 600 x 600)
Drain pipes	ϕ150 - 400mm, concrete pipes, total length 600 m

Sewage disposal

Septic tank	Two tanks - the one available for 20 persons capacity and the other available for 30 persons capacity
Drain pipes	ϕ100 mm, concrete pipes, total length 60 m

Electric power supply

The requirement for electric power of each facility is listed below.

Facilities	Capacity (KVA)	Note
Management office	15.6	
Threshing house	9.0	3 phase 380V supplied
Rice mill	9.0	"
General warehouse	9.0	"
Rice warehouse	3.3	Airconditioners equipment
Repairshop	15.0	Electric welding equipment included
Agr. machinery sheds	0.6	0.3KVA x 2
Agr. instruments warehouse	0.3	
Garage	0.3	
Oil-fuel storage (lighting use)	1.0	Out-door lighting
Shower-lavatory	0.6	
Canteen	1.8	
Sub-total	66.5KVA	
Out-door lighting	3.0	120W x 20 places
Pumps	11.2	(well pump 6.2 Lifting pump 2.5 Gardening pump 2.5)
Pumping station	15.0	
Future extension	24.0	
Total	119.7KVA	

Generator	Capacity	60 KVA, 2 units
	Voltage	380 V 3 phase - 4 lines
	Cycle	50 Hz
Engine	Power	85 HP
	Revolution	1,500 R.P.M.
	Fuel	A-type fuel oil
Distribution wiring	Distance	Approx. 470 m
	Poles	14 wooden poles (average 30 m interval)

2-4. Implementation Schedule

2-4-1. Schedules for Operation of Construction Machinery and Earth Moving Works

The crawler type construction machineries will be preferable employed in the job site which will be flooded in the wet season and have soil properties of heavy clay. Some of the bulldozers to be introduced shall be of swamp type. The navigation by the Chao Phya river through the Phraya Banlu canal will facilitate to transport the construction machineries from Bangkok to the job site. The temporary landing plotform should be provided at a place along the Phraya Banlu canal.

The operation schedule of the construction machineries was established in condition of below-mentioned various conditions and actual results in Thailand.

- Conversion coefficient of the soil

Properties	Natural condition	Excavated loose condition	Compacted condition
clay soil	1.00	1.35	0.90

- Operation hours was determined at 10 hours per day in referring to the actual results in Thailand.
- The effective working hours during the construction period were estimated as shown below in referring to the records of rainfall and water levels.

Annual workihg period

Polder dike construction:	5 months (Jan. - May)
Land consolidation works:	5 months (Jan. - May)
Pumping station construction:	8 months (Jan. - Aug.)

a. Polder Dikes and Main Canals

Excavation

The excavated earth from the main canals (166.8 x 10^3 cu.m) will be appropriated to construct the embankment of the polder dikes (102.4 x 10^3 cu.m), and the further residual earth (64.4 x 10^3 cu.m) will be used for the creation of facilities lots of the trial farm (45.3 x 10^3 cu.m) and community road embankment. The excavation will be carried out by the 140 HP class crawler type bulldozers (some swamp type included) and backhoes (0.6 cu.m).

The excavation volumes by respective machineries are shown below.

Machineries	Working volume (1,000 cu.m)	Production (cu.m/hr)
140 HP class bulldozer	91.7	24.5
Swamp type bulldozer	41.7	24.5
Backhoe (0.6 cu.m)	25.1	25.9
Manpower	8.3	
Total	166.8	

Embankment

The polder dikes will be embanked by bulldozers (140 HP) and compacted by tire rollers (10 ton class). The laterite materials for crest surface of embankment will be purchased from the contractors in the line, and placement and compaction will be carried out with the bulldozers and tire rollers in the same manner as in the dikes embankment.

Machineries	Working volume (1,000 cu.m)	Production (cu.m/hr)
Embankment		
Bulldozers (140 HP class)	102.4	23.0
Tire rollers (10 ton)	102.4	23.0
Laterite pavement		
Bulldozers (140 HP class)	5.5	23.0
Tire rollers (10 ton)	5.5	23.0

Residual earth

The residual earth (64,400 cu.m) will be appropriated for the following works, ridges embankment works along the main canals (7,600 cu.m), creation of facilities lots for the tiral farm (45,300 cu.m), and community road embankment (11,500 cu.m), respectively.

Backhoes will load up the earth to dump trucks (8 ton capacity), which will transport it to the job-site, creation of facilities lots for trial farm and community road embankment. The embankment and compaction for the roads will be implemented with bulldozers. And placement of the earth will be made with bulldozers and compaction with tirerollers for creation of the facilities lot of the trial farm.

Machineries	Working volumes (1,000 cu.m)	Production (cu.m/hr)
Creation of facilities lot		
Backhoes (0.6 cu.m)	45.3	25.9
Dump trucks (8 ton)	45.3	
Bulldozers (140 HP)	45.3	23.0
Tire rollers (10 ton)	45.3	23.0
Ridge embankment		
Manpower	7.6	

b. Land Consolidation

Since no detailed topo-maps has been prepared during the service period of the study, the estimate of earth moving volume was made on the sample area basis (100 ha) to assume the figures for final design (458.6 ha).

Land clearing works

Trees, bushes and useless ridges, and other obstacles will be eliminated for clearing the job-site of land consolidation. Some of the bigger trees, which have been indicated by the land owners, are left standing in the field. The bulldozers (140 HP), having working capacity of 1.0 hr/ha, will be employed for land clearing works.

Embankment of farm road and farm ditches

The embankment of farm roads and farm ditches will be made in better utilization of the earth cut-off by the leveling of the fields and excavated earth from the drainage ditches. The crawler type scrape-dozer (6.4 cu.m), which is suitable to transport-action for medium distance and working on the soft ground, will be employed for cutting-off and hauling of the earth. In addition to the said machines, bulldozers (140 HP) for compaction and water-sprinkling car will be required. The specific working volume and efficiency are shown below.

Machineries	Working volume (1,000 cu.m)	Production (cu.m/hr)
Earth cut-off &		
Scrape-dozers (6.4 cu.m)	32.8	77
Embankment & compaction		
Bulldozers (140 HP)	36.4	34
Tire rollers (10 ton)	36.4	34
Transportation of residual earth		
Scrape-dozer (6.4 cu.m)	3.6	51

Excavation of farm and drainage ditches

Since the farm ditches will be provided just along the farm road, the construction works of the farm road and irrigation ditches shall be executed simultaneously. The farm ditches, which are not so deep, will be excavated by manpower. The drainage ditches, 15,600 cu.m will be excavated with backhoes (0.3 cu.m), the working efficiency of which is estimated at 15 cu.m/hr.

Land Leveling

The bulldozers (140 HP) will be employed for land leveling , if the earth hauling distance is not so long. The swamp type bulldozers (140 HP or 200 HP class) may be introduced depending upon the humidity condition of the fields. The leveling works involve the construction of necessary ridges, the required earth volume for which shall be pushed along the alignment of the relevant ridges. Motor-graders (125 HP), after leveling works completed, will do finishing works.

Machineries	Working volume (1,000 cu.m)	Production (cu.m/hr)
Bulldozers (140 HP)	40.0	14
Swamp type bulldozers (140 HP)	40.0	14
Bulldozers (200 HP)	40.0	18.8
Scrape-dozers (6.4 cu.m)	118.5	93
Motor-graders (125 HP)	(458.6 ha)	
Total	238.5	

c. Construction of Pumping Station

The excavation of the main pumping station site will be executed with bulldozers (200 HP) and backhoes (0.6 cu.m). The residual earth will be utilized in the embankment works around the said station (EL 3.5 m).

The foundation pile (L = 10.5 m, 0.2m x 0.2m) will be driven with crane (L = 12 m) and diesel hammer equipped with the backhoe base machines. The concrete works and architectural works will be carried out on the contract basis.

Machineries	Working volume (1,000 cu.m)	Production (cu.m/hr)
Excavation		
Bulldozers (200 HP)	3,463	14.5
Backhoes (0.6 cu.m)	1,160	23.4
Push back		
Bulldozers (140 HP)	3,224	14.5
Residual earth		
Bulldozers (140 HP)	1,399	43.0
Pile driving diesel hammers	311 piles	10 piles/day

2-4-2. Annual Implementation Schedule

The annual implementation schedule was formulated to be shown in TABLE II-11, in taking into account the period of this Technical Cooperation services (5 years), budgetary factor, and effective

operation of the machines to be introduced in the Project.

The construction works of the polder dikes (2,400 m) and main irrigation canals will be implemented simultaneously in the first project year (1977/1978), and the related works will be totally completed in the second project year (1978/1979). The laterite paving works will be completed within a period of time (1978/1979)

In the second project year, the civil works and architectural works of the main pumping station will be finished and one unit of the two pumps will be installed so as to start operation, and the rest one unit in the third year (1979/1980).

As to five irrigation pumping stations, construction works will be proceeded in keeping the pace of implementation of the land consolidation as describing below; that is, in the third project year (1979/1980) one station, in the fourth year (1980/1981) two stations, and in the fifth year (1981/1982) the rest two stations will be provided one after another.

Excepting for orchard areas, the land consolidation works will be executed for total acreage of 458.6 ha, 7.2 ha of which will be used for the trial farm. The staging works land consolidation is scheduled as follows: in the third project year when the polder dikes are totally provided and main pumping station will start operation, 101.7ha will be completed in land consolidation, in the fourth year 194.5 ha, and in the fifth year 155.2 ha, respectively. The annual land consolidation works is scheduled on the basis of the water management organization unit after completion of the Project.

The construction works of the trial farm include the arrangement of trial farm lots, creation of facilities lots, and architectural works of related buildings. The trial farm shall be completed in the first project year so as to produce the good effect at the earliest stage of the project works. However, since the construction of the polder dikes

and pumping station will have not been completed yet in this stage, temporary embankment of flood control and irrigation and drainage pumping facilities should be provided to protect the trial farm from floodings. The creation of facilities lots will be executed in the first and the second year to keep the pace with the process of the polder dikes construction works, and the architectural works will be completed in the second project year.

The construction of the temporary field office and lodging accommodation shall be finished in 1977, before starting construction works of polder dikes and land consolidation.

TABLE 11 Proposed Construction Schedule

Items		1977	1978	1979	1980	1981	1982
1. Polder dike and main canal (9,160 m)			(2,400 m)	(6,760 m)			
Earth works	269,200 cu.m		———	———			
Laterite pavement	5,500 cu.m			———			
2. Pumping station							
Main pumping station	1 station						
Civil and architectural works				———			
Pump equipments	2 sets			———	———		
Irri. pumping station	5 stations				1	2	2
3. Land consolidation works	451.4 ha				101.7 ———	194.5 ———	155.2 ———
4. Trial farm							
Land consolidation	7.2 ha		———				
Facilities lot	2.4 ha		———	———			
Irri. and drainage works			———				
Architectural works	2,096 sq.m			———			
5. Temporary facilities							
Field office	117 sq.m	———					
Field lodging	187 sq.m	———					

2-5. Provisional List of Machineries and Equipment

TABLE 12 List of Materials and Equipment

Items			Total Quantity	Fiscal Year (Japan) 1977	1978	1979	1980	1981
1. Project Administration								
Vehicles		Unit	1	1				
Boats with engines		Unit	2	2				
Meteorologic recorders		L.S.	1			1		
Pump		Unit	1	1				
Stationeries		L.S.	1	1				
2. Agricultural Infrastructure Development								
2-1. Construction Machineries								
Bulldozers	140 ps	unit	5	3	2			
Swamp bulldozers	140 ps	unit	2	1	1			
Bulldozer	200 ps	unit	1			1		
Backhoe	0.3 cu.m	unit	2			1		
Backhoe	0.6 cu.m	unit	2	1	1			
Tired roller	10 ton	unit	2	1	1			
Scrape dozer	6.4 cu.m	unit	2			1	1	
Diesel hammer	1.3 ton	unit	1		1			
Dump truck	8 ton	unit	3	3				
Motor grader	125 ps	unit	1			1		
Water truck	6 ton	unit	1			1		
2-2. Equipment for Irrigation and Drainage								
Pumps	ϕ 700	unit	2		1	1		
Diesel engine	60 ps	unit	2		1	1		
Diesel engine attachment		L.S.	2		1	1		
Diesel generator		unit	1		1			
Vertical pumps	ϕ 482	unit	5			1	2	2
3. Agricultural Supportin Services								
3-1. Trial Farm (Indoor Training)								

Calculator	unit	5		3	1	1	
8mm movie camera and projector	unit	1			1		
Slide projector	unit	1			1		
Blue print instrument	unit	1		1			
Cylinder press	unit	1		1			
Tape recorder	unit	1			1		
Microphone	unit	1			1		
(Indoor Trial)							
Microscope	unit	2			1	1	
Binocular microscope	unit	2			1	1	
Thremo-controll equip.	unit	3			3		
Refrigerator	unit	2		1		1	
Balance	unit	4		2	2		
Moisture meter	unit	2		1	1		
Air conditioner (Seed storage)	unit	2		2			
Humidifier(Seed storage)	unit	2		2			
(Field Trial and Training)							
Trucktor 30 HP	unit	2	1	1			
Tractor attachments	L.S.	3		1	1	1	
Power tiller	unit	2	1	1			
Power attachments	L.S.	3		1	1	1	
Rice planter	unit	5		2	1	1	1
Combine harvester	unit	5			1	2	2
Pest control equipment	unit	5	1	1	1	1	1
Winnower	unit	1		1			
Thresher	unit	1			1		
Rice mill equipment	unit	2			1		1
Pump for irrigation	unit	6	1	1	1	2	1
Pump for drainage	unit	1	1				
Cargo truck	unit	2				1	1
Cargo truck with crane	unit	1	1				
Workshop equipment	L.S.	1			1		
Fertilizer	ton	28		5.1	7.7	7.6	7.6

Agri-chemicals	100kg	25.3	4.7	6.8	6.9	6.9
(Public Utility)						
Pump	unit	3	3			
3-2. Model Farm						
Tructor 30 ps	unit	3		1	1	1
Power tiller	unit	3		1	1	1
Fartilizer	ton	5			2.5	2.5
Agri-chenicals	kg	400			200	200

2-6. Project Cost

The Project cost includes those items of the agriculture infrastructure consolidaiton, the purchase of construction machineries, agricultural supporting services, and the Project Administration. The agricultural infrastructure consolidation is planned to be implemented under direct control of the ALRO, excepting for concrete works. In the estimate of the Project cost, the depreciation cost of the construction machineries to be provided for this Technical Cooperation Project was not calculated but only their O & M cost. The cost for machineries was composed of the costs of machineries and their spare parts on the CIF Bangkok basis (foreign currency portion) and customs duty and other local handling charges equivalent to 25 percent of the CIF prices (local currency portion).

The cost of agricultural supporting services was composed of those costs for construction of the trial farms and its necessary materials, and agricultural input materials for the model farms.

The managerial costs of the Project include the construction cost of the field office, lodging accommodation, engineering costs (survey and design), personnel expense for experts and officials concerned, management cost of the farmers' organization, and miscellaneous office expenses, in addition to those of equipment and materials to be required.

For references, the conversion rate of local currency and foreign currencies was fixed as follows:

฿20.0 = US$1.0 = ¥270

TABLE II-13 Project Cost

(Unit: 1,000 ₿)

Items	Total Cost	Fiscal Year 1977	1978	1979	1980	1981
1. Agricultural Infrastructure Development						
Polder dike	4,682	1,037	3,645	-	-	-
Pumping station						
Main pumping station	(5,468)		(3,841)	(1,627)		
	9,541	-	7,427	2,114	-	-
Irri. pumping stations	(480)			(96)	(192)	(192)
	1,070	-	-	214	428	428
Land consolidation	3,839	-	-	865	1,654	1,320
	(5,948)		(3,841)	(1,723)	(192)	(192)
Total	19,132	1,037	11,072	3,193	2,082	1,748
2. Construction Machinery	(25,428)	(9,630)	(7,074)	(6,510)	(2,214)	
	31,783	12,037	8,842	8,137	2,767	-
3. Agricultural Supporting Service						
Trial farm						
Civil and architecture	(136)	(136)				
	6,737	747	5,990	-	-	-
Equipment	(5,321)	(789)	(964)	(1,514)	(1,089)	(965)
	6,320	909	1,105	1,783	1,334	1,189
Model farm	(712)			(218)	(247)	(247)
	784	-	-	240	272	272
	(6,169)	(925)	(964)	(1,732)	(1,336)	(1,212)
Total	13,841	1,656	7,095	2,023	1,606	1,461
4. Project Administration						
Temporary facilities	720	720	-	-	-	-
Material and equipment	(1,286)	(1,153)		(133)		
	1,477	1,327	-	150	-	-
Managerial Expense	17,647	721	3,624	4,333	4,793	4,176
	(1,286)	(1,153)		(133)		
Total	19,844	2,768	3,624	4,483	4,793	4,176
	(38,831)	(11,708)	(11,879)	(10,098)	(3,742)	(1,404)
Grand Total	84,600	17,498	30,633	17,836	11,248	7,385

Note: Figures in parentheses show the foreign currency and are included in the total.

2-7. Impact of the Project

2-7-1. Farm Budget Analysis

a. Evaluation Method

The comparative study of the investment and the produced benefits, both of which are converted into monetary values, will be commonly used for the evaluation of the projects. This evaluation method, however, will not be applicable to this Project, which is the pilot project aiming at trial farming, demonstration and training as the base for the agriculture development.

Such being the case, the farm budget analysis of the sample farm households shall be an assessment of this Pilot Project that will give an impact to the related farmers' income and farm economy.

b. Selection of Typical Farm Households

The Agricultural Land Reform Office, Changwat Ayutthaya has conducted surveys on land tenure condition and cropping status of the cultivated lands, 508.8 ha, in the Project Area, and the surveys revealed that the landed proprietors were numbered by 77 persons, the landed farmers by 28, owner tenant farmers by five and tenant farmers by 75, respectively. The most of the landed farmers have 10 rai of their fields, and the size of the fields of the tenant farmers is about 20 rai.

The total numbe of farm households is 108 and the total cropped acreage is 3,180 rai, which result in average cropped acreage as about 30 rai per household.

The farm budget analysis of the farm households was conducted in typical three kinds of farmers on the basis of farming size and types; 10 rai (1.6 ha), 20 rai (3.2 ha) and 30 rai (4.8 ha), and proposed cropping types by only paddy cropping, paddy and vegetables, and paddy and citrus fruits plantation, although paddy cropping only at present.

Farming Types	Farming Size (ha) 10 rai	20 rai	30 rai
Paddy Double Cropping	1.6	3.2	4.8
Paddy Double Cropping and Vegetables Triple			
Paddy Field	1.0	2.2	3.8
Upland Field	0.6	1.0	1.0
Paddy Double Cropping and Citrus Fruits			
Paddy Fields	1.0	2.2	3.8
Orchards	0.6	1.0	1.0

c. Farm Income

Gross farm income: The average farm gate prices of the products (1974 - 1976) were taken as the farm products prices, on the basis of which the gross farm income was estimated as shown in Table II-14.

TABLE II-14 Gross Income per Hectare

Items	Paddy Rice: Wet Season Broad-casting	Paddy Rice: Wet Season Trans-planting	Paddy Rice: Dry season (trans-planting	Vegetables	Citrus Fruits
Without Project					
Yield (ton)	1.6	2.2	3.0	-	15.0
Unit Price (฿/ton)	2,200	2,200	2,200	-	3,000
Gross Income(฿/ha)	3,520	4,840	6,600	-	45,000
With Project					
Yield (ton)	-	4.2	4.7	38.8	30.0
Unit Price (฿/ton)	-	2,200	2,200	1,660	3,000
Gross Income(฿/ha)	-	9,240	10,340	64,400	90,000

Production costs: Since the estimate of the farm production costs requires to study the cash flow, the family labor forces shall not be included in the production costs. The land tax will be included in the production costs, but the water charges are not counted due to no payment made at present. The production costs, which excludes the labor cost, were estimated to be listed in Table II-15.

TABLE II-15 Production Costs per Hectare
(Excluding Labor Cost)

(Unit: ₱)

Items	Without Project				With Project			
	W.B.P.	W.T.P.	D.T.P.	C.	W.T.P.	D.T.P.	V.	C.
Seeds	312	108	108	240	104	104	1,989	340
Fertilizer	-	658	658	5,684	878	1,020	10,469	8,120
Agri-chemicals	385	581	581	10,364	763	763	6,655	14,805
Work cow	90	90	90	706	-	-	-	-
Equipments	787	845	845	170	1,063	1,063	2,424	1,240
Others	79	114	114	858	140	148	1,077	1,225
Interest	169	240	240	6,486	225	248	1,809	7,719
Land Tax	41	41	41	41	41	41	82	82
Total	1,863	2,677	2,677	24,549	3,214	3,387	24,505	33,531

Note: W.B.P. = Wet season broadcasting paddy
W.T.P. = Wet season transplanting paddy
D.T.P. = Dry season transplanting paddy
C. = Citrus
V. = Vegetables

Farming labor cost: The cost for the employed laborers shall be computed in the production cost. The balance, subtracting the family labor forces (3 persons/family, 25 days/month) from the cropwise monthly labor requirements is the employed labor forces, and the labor wage is fixed at ₱15/person that is commonly paid in the Project Area and its vicinity.

The employed labor requirements were shown in Table II-16, on the basis of the farming size and type.

TABLE II-16 Employed Labor Requirements

(Unit: man-day)

Farming Size (rai)	Without Project 10	20	30		With Project 10	20	30
W.B.P.	0	26	98	P.	0	14	205
W.T.P.	0	85	241	P. & V.	0	33	310
D.T.P.	0	61	216	P. & C.	0	33	310

Note: W.B.P. = Wet season broadcasting paddy
W.T.P. = Wet season transplanting paddy
D.T.P. = Dry season transplanting paddy
P. = Paddy double cropping
P.& V. = Paddy double cropping and vegetables
P.& C. = Paddy double cropping and citrus

The farm income by farming sizes and types is listed in the following Table II-17, which will reveal the summary of the farm income by sole paddy cropping in "Without" and "With" Project conditions.

Taking an example, the expected farm income of a farm household with 10 rai paddy fields may increase in its amount, about ฿21,000 in "With Project" which will be 3.3 - 7.8 times as much as "Without Project".

The further surveying carried out in the Project Area (sampling households: 27 families) revealed that the average living cost was about ฿15,000 per household.

Then, under the present condition, "Without Project", the farmers that can live on income only from the paddy cropping are those who cultivate the dry season paddy cropping with more than 30 rai, about which TABLE II-18 clarifies.

TABLE II-17 Comparison of Income of Paddy Cropping Farmer

(Unit: ฿)

Cropping Size (rai)	Without Project			With Project
	Wet Season Broadcasting Paddy	Wet Season Transplanting Paddy	Dry Season Transplanting Paddy	Double Cropping
10	2,651	3,461	6,277	20,766
20	4,912	5,647	11,639	41,323
30	6,484	6,767	15,590	59,224
Living Cost	15,000	15,000	15,000	15,000

TABLE II-18 Income and Expenditure of Typical Farm Households

(Unit: B)

Without Project

Farming Size and Type	10 rai (1.6 ha)			20 rai (3.2 ha)			30 rai (4.8 ha)		
	W.B.P.	W.T.P.	D.T.P.	W.B.P.	W.T.P.	D.T.P.	W.B.P.	W.T.P.	D.T.P.
Gross Income	5,632	7,744	10,560	11,264	15,488	21,120	16,896	23,232	31,680
1. Production Cost	2,981	4,283	4,283	6,352	9,841	9,481	10,412	16,465	16,090
Labour Cost	0	0	0	390	1,275	915	1,470	3,615	3,240
Others	2,981	4,283	4,283	5,962	8,566	8,566	8,942	12,850	12,850
2. Net Income	2,651	3,461	6,277	4,912	5,647	11,639	6,484	6,767	15,590

With Project

Farming Size and Type	10 rai (1.6 ha)			20 rai (3.2 ha)			30 rai (4.8 ha)		
	P.	P.& V.	P.& C.	P.	P.& V.	P.& C.	P.	P.& V.	P.& C.
Gross Income	31,328	58,220	73,580	62,656	107,476	133,076	93,984	138,804	164,404
1. Production Cost	10,562	21,304	26,720	21,333	39,522	48,548	34,760	54,239	63,265
Labour Cost	0	0	0	210	495	495	3,075	4,650	4,650
Others	10,562	21,304	26,720	21,123	39,027	48,053	31,685	49,589	58,615
2. Net Income	20,766	36,916	46,860	41,323	67,954	84,528	59,224	84,565	101,139

Note: W.B.P. = Wet season broadcasting paddy rice
W.T.P. = Wet season transplanting paddy rice
D.T.P. = Dry season transplanting paddy rice
P. = Paddy rice double cropping
P.& V. = Paddy rice double cropping & vegetable
P.& C. = Paddy rice double cropping & citrus

d. Balance Sheet of Typical Farm Households

The income and expenditure in agriculture of the typical farm households could be summarized as shown in Table II-19. The O & M cost of irrigation facilities, having not been borne by farmers, was incalculable into the relevant balance sheet in the previous Table II-19. The proposed Pilot Farm Project, however, will require a large amount of investment for providing main pumping station, irrigation pumping stations, polder dikes, irrigation & drainage canals, etc., and the successful implementation of the Project will essentially need to make the better and effective utilization of those water control facilities. A great care should be exercised to execute the rational O & M of the facilities for ultimate purpose. It is reported that the farmers in the Project Area, where they will be able to produce high yieldings by the well-provided water utilization facilities, could bear the necessary water charges as the beneficiaries' obligation.

The problems on water charges, whether or not to collect the charges, how much and what system to be required, will have to be solved by the Thai Government along with its policy.

And the farm budget analysis will be made herein including the O & M cost, which could be borne by farmers as water charges, such running expences, as personnel expenditures, fuel cost, repair cost of facilities and other managerial expences, excepting the cost for renewal of the facilities.

The water charges will be estimated to about ฿1,157 per hectare, if imposed equally to the arable lands.

TABLE II-19 Balance Sheet of Typical Farm Household

(Unit: ฿)

Cropping Acreage (rai)	10			20			30		
1. Farming Size (ha)									
Paddy fields	1.6	1.0	1.0	3.2	2.2	2.2	4.8	3.8	3.8
Upland fields	-	0.6	-	-	1.0	-	-	1.0	-
Orchads	-	-	0.6	-	-	1.0	-	-	1.0
2. Farm Income	20,766	36,916	46,860	41,323	67,954	84,528	59,224	84,565	101,139
3. Living Cost	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000
4. (2-3)	5,766	21,916	31,860	26,323	52,954	69,528	44,224	69,565	86,139
5. O & M Cost	1,852	1,852	1,852	3,703	3,703	3,703	5,555	5,555	5,555
6. (4-5)	3,914	20,064	30,008	22,620	49,251	65,825	38,669	64,010	80,584

2-7-2. Far-reaching Effect of the Project

The direct effect the Project would produce was already evaluated in monetary conversion in the preceding paragraph 2-7-1.

The Project has particular features as pilot works with pretty small area for the irrigated agriculture development project involving fundamental and a great deal of works such as providing necessary agri-infrastructures for paddy double cropping, the trial farm, many farming inputs, model farms, intensive guidance of farming techniques together with efficient agri-supporting services like upbringing of the farmers' organization.

Under those conditions required for successful project execution, the services should be not only rendered to the improvement of the farm management of the farmers in the Project Area, but also expected to produce far-reaching effect as mentioned below.

1) The satisfactory land consolidation will be realized to improve the labor conditions of the farmers facilitating introduction of farm mechanization, and will encourage the farmers for upgrading their living standard through effective water control, demonstration of considerable yield increase.

2) The actual favourable results of improvement of farm management to be gained in the model farms would be recognized by the Government officials concerned, which would promote the extension of the irrigated agriculture.

3) The farmers could live on the agriculture in depending upon the high yieldings and devote themselves to the farming works to result in the upgrade of the farming techniques.

4) The trial farm to be provided in the Project Area shall function as nucleus of the technical guidance for the farmers not only in the Project Area, but in its vicinity.

5) At present the chronic floodings from the Chao Phya river are the major restraint in transportation, daily life of inhabitants, farming activities, etc, and the farmers would recognize the improvement by flood control to be carried out in the Project.

6) The cooperarive services rendered by the experts of both countries, Thailand and Japan, will give direct and practical guidance to the farmers through their activities in trial farm, model farms, land consolidation works, etc, and these close relation between each other will be a great help of mutual understanding.