4.3.2. Assessment on the Existing Pumping Projects

A. The NEA Pumping Projects

Three pumping irrigation projects are under implementation by the National Energy of Administration (NEA) in the eastern portion of the proposed Project Area as their irrigation areas and major facilities are summarized below;

Project Name	Irrigation Area (ha)	Area included in the Project Area (ha)	Main Facilities Pump	Canal (m)
Ban Tao Pun	672	672	Floating type Dia 300 m/m 90 KW, 2 units	4,075
Ban Song Khon	560	560	Inclined type Dia 300 m/m 100 KW, 2 units	4,150
Ban Ta Toom	1,280	257	Floating type Dia 300 m/m 90 KW, 3 units	9,700
Total	2,512	1,489		

The NEA has scheduled to complete these pumping irrigation projects and start operation at the end of April 1982. To determine whether these pumping project facilities should be integrated in the Project facilities or shall be operated independently from the Project in future, a comparative study has been conducted from the technical and economic points of view in consideration of the entire Project, basically assuming the following two cases;

- To dismantle partially facilities constructed or to be constructed under the pumping irrigation projects, and instead, to include the service areas of such facilities in the Project.

- To operate the pumping irrigation project facilities in future separately and independently from the Project.

A.1. Case Study

On top of the above-mentioned two cases, further two cases were assumed taken into consideration 553 ha of farm lands, a part of the Project Area adjacent to the NEA pumping project, and the case study has been made for the following four cases;

Case 1 To dismantle pumping stations of NEA projects, and to utilize canals and their incidental facilities to the maximum extent possible for the Project.

Case 2-1 To irrigate service areas of NEA projects by NEA project facilities, and to irrigate the farm lands of 553 ha adjacent to the NEA project by Kaeng Khoi pumping station and the proposed main canal.

Case 2-2 To irrigate service areas of NEA projects by NEA project facilities as mentioned in Case 2-1, and to irrigate the farm lands of 553 ha in question by an independent pumping station and its irrigation system that will be installed separately from the Kaeng Khoi pumping station, but included in the Project.

Case 2-3 To irrigate service areas of NEA projects by NEA project facilities as made in Case 2-1, and to install new pumping facilities at the same site of Ban Tao Pun pumping station of NEA for irrigation of the farm lands in question for which canal sections under the NEA project will be enlarged to meet the increased irrigation requirement.

The NEA projects have employed a different unit water requirement, irrigation canal intensity and the other design criteria in their irrigation schemes from these employed in the Project.

Under the situations, NEA irrigation plans for these projects were revised based on these factors having been employed in the Project planning, and the case study has been conducted based on the same design criteria for irrigation, that is, by assuming the installation of supplemental pumping stations, widening and heightening of canals and additional construction of lateral and sub-lateral canals in NEA project areas.

A.2. Results of the Case Study and Conclusion

Results of the case study are summarized below;

(Unit: 1,000 Baht)

Item	Case-1	Case-2-1	Case-2-2	Case-2-3
Construction cost	409,899	412,059	410,645	410,203
O & M cost	13,015	13,955	14,059	14,059
IRR (%)	18.2	18.0	18.1	18.1

Further details of the case study are shown in Table A.4.3-1 to A.4.3-3 of Appendix IV.

The above-tabulated results suggest the following;

1. The four cases are hardly different each other in the construction cost for the entire Project Area.

2. The difference in the O & M cost reflects on the internal rate of return, however, from a large view, the four cases are hardly different in the aspect of economic comparison.

3. On the other hand, operation and maintenance of pumping facilities with different types in different places will be technically not so easy even if the organizations in charge of O & M will be unified, resulting in probable unforeseeable troubles.

Taking into consideration all of the above-mentioned, it might be most effective from the view points of national economy and farm economy to integrate NEA project facilities to the maximum extent possible into the Project, to irrigate the entire Project Area by the proposed pumping station for the Project, and to entrust the operation and maintenance of irrigation facilities to RID.

B. The Agricultural Cooperatives Pumping Projects

B.1. General

Table A.3.3-1 in Appendix III shows the seven pumping projects of agricultural cooperatives that are located within the Project Area. The construction of some of them has been already completed, and the others are under construction as of the study period. The construction or operation and maintenance of these project facilities are made by members of agricultural cooperatives at their own expense.

Out of the above-mentioned seven projects, four projects located in the eastern portion of the Project Area will be integrated in a NEA project, and the existing facilities of these projects will be improved or removed in near future.

Therefore, the assessment is hereinafter made for the three pumping projects related to Amphoe Sao Hai only, excluding the said four, in order to decide whether these projects should be integrated in the Project or should be separately maintained after the implementation of the Project.

As regards Tambon Ban Yang in total, two pumping stations are equipped with three units of pump with the bore diameter of 500 mm to irrigate paddy fields of about 670 ha (4,200 rai), however, these pumps should be renewed judging from the following:

- The pumping facilities have been deteriorated to a considerable extent due to 13 years' operation;
- Irrigation water will be supplied to the project area through the Project facilities after the completion of the Project that is scheduled in 1987; and
- Diesel engines are used as the prime mover of pumps, resulting in an increasing repair cost in future.

As regards Tambon Ton Tan project, canal networks are presently under construction. The construction works are scheduled to be completed in 1982. On the other hand, the pumping station constructed under the project has already started irrigation water supply to some parts of the project area since 1979. Two units of pump with the bore diameter of 500 mm have been installed at the pumping station. Their motive power are an electric motors. The service area of the project extends to National Road 3048 acrossing

the Pak Bang river. However, the canal alignment now under implementation cannot be said all adequately made.

Taking into account the utilization of the project facilities, the irrigation plan for the Project should be formulated to establish the most rationalized irrigation system.

B.2. Utilization of the Existing Pumping Station in Tambon Ton Tan

Irrigation water will be supplied to the relevant area through 4L and 6L lateral canals taking into consideration the irrigation and drainage plan for the entire Project, topographic condition of the area and on-farm development in future.

If the pump facilities of Tambon Ton Tan are separated from the Project facilities, the capacity of the main canal up to KM14 + 750, lateral canals of 4L and 6L and Kaeng Khoi pumping station could be decreased to an extent, resulting in the lower construction cost by about 14 million Baht.

On the other hand, the investment of the cooperative to this project are estimated at 20 million Baht in total including the cost to be invested during 1982.

However, the benefit accruing from irrigation water supply through the cooperatives' facilities will be obtained from 1982 whereas it is scheduled that the benefit accruing from irrigation through the Project facilities will be secured from the year 1987.

Under the situations, it is necessary to take into consideration the depreciation cost of pumps during the five years period from 1982 to 1986 and dead cost for the remaining durable life of the said cooperatives' facilities after the year 1987 except the pumping

plants. The total of their cost is estimated at about 4.6 million Baht.

The difference of the Project costs in the two plans is about 1.5 million Baht as shown below:

(Unit: Baht 1,000)

Item	Integration	Separation
KKBM Project	406,037	392,202
Cooperative Project	-	19,970
Depreciation/Dead	4,612	-
Total	410,649	412,172
Annual O/M cost	13,014	13,031

The breakdown of the above-tabulated figures is shown in Tables A.4.3-4 and A.4.3-5, Appendix IV.

As mentioned above, the economic comparison of the two plans does not result in a great difference, however, the integration plan is judged to be more advantageous than the separation plan in the following aspects:

- Rationalization of the Project facilities in the entire Project basis;
- Further development in future; and,
- A decrease of farmers burden for the cooperatives project implementation and O & M cost of their facilities.

4.3.3. Irrigation Plan

A. Proposed Irrigable Area

The proposed total irrigable areas has been decided based on the availability of water resources and on the proposed land use, and summarized below;

Season	Paddy	Upland Crops	Total
Wet	13,680 ha	480 ha	14,160 ha
	(85,500 rai)	(3,000 rai)	(88,500 rai)
Dry	2,800 ha	-	2,800 ha
	(17,500 rai)		(17,500 rai)
	16,480 ha	480 ha	16,960 ha
Total	(103,000 rai)	(3,000 rai)	(106,000 rai)

B. Diversion Water Requirement (Design Discharge)

The diversion water requirement for the Project in both wet and dry cropping seasons has been estimated based on the proposed irrigable area and the unit water requirement of respective crops which has been already discussed in the previous paragraph. In general, the capacity of irrigation facilities such as pumping plants and irrigation canals is computed based on the diversion water requirement taking into account no effective rainfalls.

Therefore, the design discharge of irrigation facilities are estimated by the following formula;

$$Q = Ap \times qp + Au \times qu$$

Where, Q: Total peak diversion discharge (cu.m/sec)

Ap: Irrigable area of paddy fields (ha)

Au: Irrigable area of upland fields (ha)

qp: Unit diversion water requirement in paddy fields (cu.m/sec/ha)

qu: Unit diversion water requirement in upland fields (cu.m/sec/ha)

The peak design discharge at the upstream most of the main irrigation canal is estimated at 17.618 cu.m/sec in wet seasons and at 4.816 cu.m/sec in dry seasons, respectively.

C. Arrangement and Design of Irrigation Facilities

C.1. Basic Concept of Facility Arrangement

The main irrigation facilities of the Project will be composed of Kaeng Khoi pumping station of 17.618 cu.m/sec in capacity which will be installed near Kaeng Khoi town, and the main, lateral and sub-lateral canals inclusive of their appurtenant structures.

The right bank of the Pasak river three kilometers upstream of Kaeng Khoi town has been selected as the site of this pumping station based on the case study mentioned previously. Irrigation water will be lifted at the pumping station, diverted to the main canal to be constructed along the northern Project boundary, and conveyed to the lateral and sub-lateral canals, branch canals of the main canal.

The alignment of the lateral and sub-lateral canals has been made taking into consideration the topographic conditions, drainage canals and road networks to be constructed as well as the location of service areas. Furthermore, a service acreage at the terminal point of the lateral or sub-lateral canals is, as a rule, determined about 100 ha based on RID's standard. The proposed irrigation canal routes are shown in Figure 4-2.

C.2. Hydraulic Design

In determining the canal capacity, the Manning's Formula was

applied to compute the canal discharge as follows;

$$Q = V \times A, \quad V = 1/n \times R^{2/3} \times I^{1/2}$$

where, Q: Design discharge (cu.m/sec)
A: Sectional area of the canal (sq.m)
V: Averaged velocity (m/sec)
n: Roughness coefficient of the canal
R: Hydraulic radius (m)
I: Hydraulic gradient

The roughness coefficient of concrete lining canals is adopted by 0.016 as currently having been employed by RID. The allowable maximum velocity is, in principle, decided by 1.50 m/sec to secure stabilized flows.

C.3. Typical Cross-section of the Canal and Feeder Roads

To minimize the conveyance loss and to materialize the easy operation and maintenance, the main irrigation canal as well as lateral and sub-lateral canals shall be provided with concrete lining. The canal section has been determined taking into account the discharge, topographic and geological conditions along the canal routes and easier construction, and is shown below;

° Canal side slope:	1:1 to 1:1.5
° Ratio of bottom width to water depth	1 : 1 to 2 : 1
° Free board	0.15 m to 0.45 m
° Berm height (from water surface)	0.6 m to 1.0 m
° Thickness of concrete lining	5 cm to 7 cm

Feeder roads to be constructed along the main canal and selected large lateral canals shall be six meters wide, and provided with

laterite pavement for easy operation and maintenance and for improvement of local road conditions. In case of the main canal, the feeder road will be provided on the left bank to ease operation and maintenance of turnouts.

D. Considerations on the Dry Season Cropping and its Irrigation Method uner the Limited Water Resources

The proposed average cropping acreage in the dry season has been determined about 2,800 ha (17,500 rai) or equivalent to 20 percent of total irrigable area in the Project.

The following points should be considered to decide the cropping area of the dry season paddy when the dry season crops are introduced to the area where the water resources are limited and on-farm facilities, especially irrigation ditches, are not consolidated.

i) Proper distribution of irrigation water and operation and maintenance for the facilities,

ii) Relationship between proposed area and irrigation systems,

iii) Extension and promotion on the farming technology, distribution and preparation of high quality seeds,

iv) Farmers' requirement on the dry season cropping and the principle of equal opportunity, and

v) Consideration of damages from the harmful birds or insects such as sparrows, rats and stem borer.

If dry season paddy was planted sporadically in the entire project area, the water management for the area where the irrigation facilities are inadequate provided will be rather difficult, and the

area will suffer from several damages by harmful birds and insects. Besides, in the conditions of limited plantation, the equal opportunity of cropping should be considered to be given to the beneficial farmers concerned.

Therefore, following methods are recommended in taking into account the above mentioned conditions.

- The dry season cropping acreage and location to be planted in each year should be decided for every zone at the same rate of 20 percent.

- The location of the proposed area in each zone should be determined at the rate of about 20 percent by the related zone man after consultation is made with the Project Engineer and related Water Master of the Operation and Maintenance Office. In this case, rotational plantation method of once for five years should be considered in each zone.

4.4. Drainage Scheme

4.4.1. Concept of Drainage Scheme

Meandering and having inadequate sectional capacities, the natural rivers and streams that will be utilize as the main drainage canals in the project run all together to the Pasak river. As a result, runoff water spreads over paddy fields and inundates them during and some time after a consecutive rainfall.

Under the circumstances, it should be scheduled to improve or construct drainage facilities in the Project so as to decrease inundation damages on HYV in wet seasons.

4.4.2. Drainage Modulus

The probability computation of consecutive rainfalls has been made based on daily rainfall data observed at Saraburi meteorological station as shown below;

(Unit: mm)

Return Period	Consecutive Rainfall			
	2 days	3 days	4 days	5 days
3	128.3	144.2	160.2	176.5
5	145.7	163.6	181.2	197.8
10	168.5	189.2	207.6	223.6
20	191.0	215.1	232.8	247.3
50	221.6	250.5	265.6	277.3

The basic concepts in determination of drainage modulus are described below;

i) The four-day consecutive rainfall with 1/5 year probability is employed as the design rainfall in formulating the drainage plan;

ii) The detention depth on paddy fields of 100 mm is permissible, therefore, an excess water over 100 mm will be drained out excepting that on upland fields.

As a result of estimation, the peak drainage modulus can be roughly computed at 4.1 lit/sec/ha for paddy fields and 5.4 lit/sec/ha for upland fields, respectively. The precipitation in a comparatively large drainage area in Thailand is characterized by uneven distribution in the entire area. Therefore, the peak design discharge to be drained out from a large drainage area is estimated based on the following reduction ratios;

Reduction Ratio on Peak Drainage Discharge

Ranging of Drainage Area		Reduction Ratio
0 - 2,000 rai	(0 - 300 rai)	1.00
2,000 - 5,000 "	(300 - 800 ")	0.90
5,000 - 10,000	(800 - 1,600 ")	0.85
10,000 - 20,000	(1,600 - 3,000 ")	0.80
20,000 - 50,000	(3,000 - 8,000 ")	0.75
50,000 - 100,000	(8,000 - 16,000 ")	0.70
Over 100,000	(Over 16,000)	0.65

4.4.3. Drainage Planning

A. Arrangement of Main Drainage Facilities

The main drainage canals after completion of the Project will consist of the Pak Bang river and the Nong Luang river which, having an nearly sufficient canal capacities to cope with the proposed peak discharge.

Rivers and streams which join the Pak Bang river and the Nong Luang river, however, have inadequate canal capacities and unstabilized canal routes at present. It is, therefore, necessary to improve these rivers and streams to decrease inundation damages in lowlying paddy fields. The improvement of seven canal routes is proposed as shown in Figure 4-3.

B. Hydraulic Design

The Manning formula has been employed to compute discharges in determination of canal capacities as made for irrigation canals. The roughness coefficient of canals has been determined at 0.025 for earth canals, and the maximum allowable velocity at 0.70 m/sec in consideration of soil condition, however, the velocity 1.5 times as

high as the above-mentioned velocity that will occur when the maximum design discharge appears could be allowable. The cross sectional canal slope of 1 to 1.5 will be employed for earth canal, and the free board of the canals will range from 0.30 to 1.20 m depending on the design discharges with O & M roads of 4.0 m wide along the canals.

C. Main Drainage Sluice

C.1. Flood Damage caused by Pasak River

The lowlying paddy areas located along the Roeng Rang river and Nong Luang river at the western part of the project area suffered inundation damages due to flooding as caused by back water of Pasak river during flood period.

Almost no flood damage data of paddy is available. There was a big flood in 1978, which marked the maximum water level of 12.50 m in elevation and its inundation area is estimated at about 5,000 ha. In recent ten years, there were floods in 1972 and 1980. The inundation area is estimated at 1,100 ha (maximum inundation water level, MSL 10.20 m) in 1972 and at 800 ha (maximum inundation water level, MSL 9.90 m) in 1980 respectively.

The paddy field area located along the Pak Bang river are situated on the comparatively high portion having an elevation of 12.00 m (MSL). Accordingly, the probability of floods is very few and the flood damages are relatively small.

C.2. Installation of Reverse Drainage Sluice

According to the hydrograph observed at Rama VI Barrage in the Pasak river, it shows that 1) there is a certain time lag between the rainfall and peak river discharge, and 2) the high water levels of

the Pasak river are almost lasting for seven days to fifteen days. This means that even if the drainage sluice installed, it can not directly drain the runoff to river side except for by using pumps due to its outside water level is higher than that of inside water level.

Therefore, in the determination of section of drainage sluice, the average water level of 8.30 m (MSL) at the influence of Nong Luang and Pasak river is calculated based on the hydrological data observed at Rama VI Barrage except for peculiar high water level. And it should be provided enough cross-section so as to drain runoff during peak period. Thus, the proposed drainage sluice is determined by the size of 2.50 m x 2.50 m x 3 rows. The results of detailed study are given in Appendix IV.

4.5. On-farm Development Scheme

4.5.1. Necessity of On-farm Facilities

As mentioned in paragraph 3.2., no farm land consolidation has been made in the Project Area up to the present. The on-farm development aims to establish highly modernized farm management and to increase the agricultural production through introduction of double cropping, more effective water utilization than the present one and upgrading of farm techniques. All of these will be assured by improvement of farm lands, that is, the related on-farm facilities as well as consolidation of the main irrigation and drainage facilities.

The Government of Thailand has been promoting land consolidation projects along with its staging development plans having been prepared to meet the respective local requirements through assessing the results of completed on-farm development schemes (ditches and dykes projects) and infrastructural facilities projects.

The Kaeng Khoi - Ban Mo Pumping Irrigation Project has been provided with no systematic and stable irrigation and drainage facilities, and left behind in the irrigated agricultural development for the year-round irrigation expect limited areas having the cooperatives' pumping facilities.

In the course of the feasibility study for the Project, both the Government of Thailand and the Survey Team confirmed that the establishment of a demonstration farm would play a significant role in successful implementation of the overall Project and in encouraging farmers in introducing the irrigated agriculture with modernized farming techniques, new crops and new varieties of crops, and in education of farmers on proper water management for effective utilization of limited water resources.

4.5.2. Scheme Components and Site Selection

The Project will allow, after its completion the beneficial farmers to convert their traditional rainfed paddy mono-cropping to the irrigated agriculture of paddy and upland crops through the year-round irrigation to the maximum extent possible.

Farmers shall acquire knowledges and techniques in water management, in selection of suitable crops for cropping, in application of fertilizers and agricultural chemicals and in farm mechanization. The following schemes are set up to realize the above-mentioned purposes.

i) Site of the Demonstration Farm

The net irrigable area of about 260 ha enclosed by the lateral canal 4L, the National Road No. 1 and the Hae river (upstream of Pak Bang river) has been selected as the site of the demonstration farm taking into account the convenience in water supply, transportation

and so forth. The construction works for both main irrigation and drainage facilities and on-farm facilities will be implemented within a two-year period from the third to fourth Project years.

ii) Demonstration Scheme

The following schemes are established for education and training of beneficial farmers and demonstration to them:

- To construct the on-farm facilities inclusive of irrigation and drainage ditches and farm roads in the selected farm land; and,
- To demonstrate favorable results of researches on fertilization and agricultural chemical application and selection of suitable crops to the Project Area.

The model design of this demonstration farm is illustrated in Figure A.4.6-1 and A.4.6-2 of Appendix IV.

4.6. Agricultural Development Plan

4.6.1. Proposed Land Use

Both the present and the proposed land uses were determined, according to the land use survey, irrigation water requirements, field conditions, etc., as follows;

Table 4-6 Proposed Land Use

(Unit: ha)

Land Category	Present	Proposed	Balance
Paddy Field	14,110	13,680	Δ 430
Upland Field	490	480	Δ 10
Sub-total	14,600	14,160	Δ 440
Forest	920	920	-
Residential Lots	660	660	-
Road and Others	210	650	440
Sub-total	1,790	2,230	440
Total	16,390	16,390	0

The gross Project Area is about 16,390 ha (102,400 rai), inclusive of the present cultivated land of about 14,600 ha (91,300 rai). The study on the Pasak river discharge available and the expected effective rainfall has resulted in the proposed irrigable area by 100 percent in the wet season and 20 percent in the dry season, respectively. The Project will provide the pumping station and the main and lateral canals, however, excludes the land consolidation plan from its components. Under the circumstances, the existing upland fields (3.4 percent of the total cultivated lands), which are unsuitable to paddy fields due to undulating topographical conditions, will remain as the upland fields even after the Project.

The proposed cultivable land will amount to 14,160 ha after reducing the paddy fields of 430 ha and the upland fields of 10 ha for the lots of the canals and roads. The reduction rate of the cultivable lands was estimated at 3.0 percent.

4.6.2. Proposed Cropping Pattern

A. Crop Selection

The major crops presently grown in the Project Area are paddy in the wet season and the dry season and maize in the upland fields. This long-lasted cropping pattern is considered to be familiar with the local farmers in terms with farming practices.

The paddy rice is the top-ranking export-oriented farm product in Thailand and maize also ranks high as the export products as well as cassava and rubber. Therefore, the production increase of these crops will meet the national requirements.

Although no large difference exists in water requirements between the paddy cropping and upland cropping, the paddy cropping is deemed advantageous in the Project in view of the various local conditions. Consequently, the Project proposes paddy, maize and groundnuts as the wet season crops in due consideration of farmers cultivation experience, crop profitability, irrigation effects, contribution to national economy, etc. As regards the dry season crop, paddy of H.Y.V. is recommended taking into consideration its high profitabilily and adaptability to the local climatic conditions mentioned below.

B. Varieties

The RD25 is proposed to be introduced into the Project Area. The RD25, developed by breeding the Khao Dok Moli 105/IR2061 as matrilineal variety with Khao Dao Mali 105/IR26 as patroclinal variety, has recently been encouraged for its diffusion by the Ministry of Agriculture and Cooperatives.

The RD25 plant matures 110 to 120 days in transplanting method, while 95 to 100 days in broadcasting method. The plant grows up to about 100 cm in full growth.

On the other hand, the local varieties to be cropped in the Area are Kho Roung 89, Nang Malo 4, Khao Dok Moa, etc. that have been traditionally grown in the Central Plain as representative varieties. The non-photosensitive varieties should be adopted for the dry season cropping since the growing period of the dry season paddy falls on the transitional stage from short daytime to long. Variety of maize to be cropped is SW1 that is cropped in the experimental station in Lopburi, and also that of groundnuts are Lonyun varieties that have high fertilization response. Outlines of each varieties of rice are shown in table A.3.5-1, Appendix III.

C. Proposed Cropping Acreage and Cropping Pattern

The Project, as mentioned previously, excluding the land consolidation scheme and having a restriction in available amount of water diverted from the Pasak river, will provide a cropping pattern with little difference from the present one. The Project, however, will stabilize the paddy cultivation in the Area because the stable water will permit the cropping calendar to be free from effect of the rainfalls and to be fixed reasonably. The proposed cropping calendar is illustrated in Figure 4-4.

The wet season paddy cropping was determined to grow the HYV and the local varieties (LV) in paddy fields of 6,480 ha, respectively, in considering various conditions, such as drainage, soils, and, adaptability of the varieties, etc. Maize and groundnuts will be grown in almost the same areas of 430 ha and 50 ha as at present, respectively.

The dry season paddy cropping will be carried out with HYV in the fields of 2,800 ha, about 20 percent of the total cultivable lands, in taking into account the availability of the water resources in the Pasak river.

As a result, the cropping intensity computed on the basis of the total cropping acreage in both the dry and the wet seasons was estimated at 98 percent in the present farming practices and 120 percent in the proposed ones, respectively. Specifically, for the wet season cropping, the Project will allow the intensity to be increased to 100 percent from 93.2 percent at present, while for the dry season to 20 percent (2,800 ha) from 4.7 percent (680 ha) at present. Hence, it can be clearly learned that the expansion of the dry season cropping acreage greatly contributes to improvement of the total cropping intensity. The specific cropping acreages are tabulated as follows.

Proposed Cropping Acreage

Wet Season Paddy (LV)	6,840 ha	(42,750 rai)	(40.3%)
Paddy (HYV)	6,840 "	(42,750 ")	(40.3%)
Maize	430 "	(2,688 ")	(2.5%)
Groundnuts	50 "	(312 ")	(0.3%)
Sub-total	14,160 "	(88,500 ")	(83.4%)
Dry Season Paddy (HYV)	2,800 "	(17,500 ")	(16.6%)
Total	16,960 "	(106,000 ")	(100.0%)

Cropping Intensity: 16,960/14,160 x 100 = 120%

4.6.3 Input Materials and Labor Requirements

A. Farming Materials

The proposed input amounts for paddy cropping, such as fertilizers, agri-chemicals like pesticide and herbicides were studied in reference to the report entitled "Rice and Rice

Cultivation" prepared by Suphanburi Rice Experiment Station. The recent hasty price soar of the agri-chemicals has compelled the local farmers to reduce the input amounts for cost cut. The proposed input plan was made up in the slightly conservative level in taking into account the continuous price soar of these materials. Such a conservative level of the input materials is expected to have a supply with plant nutrients from the river to the Project Area which depends its water sources upon the Pasak river. As shown in Table A.3.5-3 in Appendix hereto, the Pasak river water contains much more nutrients in almost of all essential items than those contained in the presentative 30 rivers in the country, although Na content is slightly less than the average.When taking the expected irrigation water amount for one paddy cropping in the Project by 1,000 mm, for instance, the Pasak river water will be able to supply the nutrients of $CaCo_3$ by 495.0 kg, K_2O by 30.2 kg and SiO_2 by 160.0 kg per hectare.

The following table illustrates the proposed input materials and their amounts.

Input Materials by Crops

(Unit: kg/ha)

	Wet Season				Dry Season
	Paddy(LV)	Paddy(HYV)	Maize	Groundnuts	Paddy(HYV)
Seed	55	50	10	110	50
Ammophos (16-20-0)	147	137	200*	-	148
Ammonium Sulfate (N 20%)	79	123	-	-	135
Potassium Chloride (K_2O 60%)	-	-	-	125	-
Asodrin	-	-	8	6	-
Padan Mipcin	30	30	-	-	30
Saturn	15	15	-	-	15

Note: * Applied Ammophos (20-11-11) to Maize

B. Labor Requirements

The discussion of the labor is led by the farm mechanization

because the farm labor requirements are deeply concerned with the extent of the farm mechanization.

The premises that are required for the labor balance study are the present conditions of farm economy, the kinds and types of the farming machinery currently available by the local farmers, field conditions and the farmers' attitude toward the farm mechanization.

For the paddy cropping, the popular small-size power tillers (8-10 Hp), which are less labor-saving machinery than the large-size machinery, will be effective and practical in economy to alleviate the cost. For the upland cropping, the large-size tractors which have been operated in the Area, will be used, for not only plowing and land preparation but also ridging works to secure higher irrigation efficiency so that more labor-saving can be achieved.

Along with the above plan, the proposed labor requirements per hectare and the mechanization program are shown in the following table. The detailed table on the monthly basis can be referred to Table A.4.7-3 and Table A.4.7-4 in Appendix IV.

Labor Requirement per ha

Crops	Human power man.day/ha (per rai)	Machine hour/ha (per rai)
Wet season paddy (HYV)	99.4 (15.9)	66.2 (10.6)
Wet season paddy (LV)	99.5 (15.9)	66.2 (10.6)
Maize	41.4 (6.6)	15.8 (2.5)
Groundnuts	102.8 (16.4)	15.8 (2.5)
Dry season paddy (HYV)	99.3 (15.9)	66.2 (10.6)

The peak labor requirement appears in August, when the hired labor from the other areas will be required due to labor shortage

that has taken place. The busiest machine operation will also be in July and August, when the two-wheel tractors will be needed by 1,009 in number (See Table A.4.7-5, Appendix IV)

The number of the tractors available at present is 1,336, and it is expected that there is little trouble in the practical farming works, although some rental plowing may be necessary.

4.6.4. Crop Production

A. Target Yield

The paddy yield increase, without the Project would be dependent only upon the so-called natural increase. The Project, however, will enable to carry out an intensive farming management with highly efficient irrigation to secure the yield increase to a considerable extent.

The target yield was determined in taking into account the analysis result of the Amphoe-wise present yield data, the actual yield in the existing irrigated fields near the Project Area (See Table A.3.5-2 and Table A.3.5-3, Appendix), the expecting upgrade of the farming techniques, furthering effect of the extension activities, the increasing effect of the irrigation by the Project, etc. Table 4-7 shows the target yield set by the Project.

The target yield proposed for the Project was determined at the slightly lower level than that anticipated in due consideration of the following factors; a little lack of water arises at puddling period in wet season in case of irrigation plan of this project, the land consolidation is excluded, the terminal water conveyance facilities are not provided, and the farming size per farm household is little bit large for intensive farming average.

The fertilization, on the other hand, was designed to be slightly conservative as mentioned already. Figure A.3.7-1 and Table A.3.7-1 in Appendix suggests, however, that the designed fertilization will enable to reach the target yield. And it will take about six years to successfully realize the target yield in view of the thorough diffusion of the techniques of the farming management and water management to the local farmers. The proper agri-supporting services, therefore, will be essential to achieve the target through positive extension services, appropriate supply of funds, etc.

B. Crop Production

The Project Area, unfavourable in the water supply conditions, has generated its cropping intensity by 98 percent only through wet and dry season. In particular, the dry season cropping intensity, as low as 4.7 percent due to limit in cropping to paddy, has seriously affected to reduce the total cropping intensity. The pumping irrigation scheme of the Project will allow to secure successful irrigation water supply and to realize the cropping intensity by 120 percent in total. Consequently, it is anticipated that the agricultural production will be increased together with increase in input amount of fertilizers and agri-chemicals. Table 4-7 shows the present and the proposed agricultural production in the Project Area.

4.6.5. Agricultural Extension Services

The agriculture in the Project Area has been carried out in the wet season paddy growing. The existing irrigated areas, however, cover only 14 percent of the total cultivated lands. Under the circumstances, the powerful extension services should be rendered in giving a sufficient knowledge and techniques on the irrigated paddy growing to the farmers who are not good at these farming works; specifically, the proper water management to be conducted in

corresponding to the growth stages of paddy plants, adequate fertilization and pesticides application, and so forth.

For the dry season paddy cropping with the present cropping intensity by 4.7 percent, the farmers seem to have not established the farming techniques so firmly as for the wet season cropping. Consequently, the experimental station and the extension agents under close cooperation should render a thorough extension services for the dry season paddy cropping. There are many ways considered, such as regular visits to individual farmers, farmers' meeting, circulation of pamphlets, provision of demonstration farms, etc. among which the guidance and demonstration by those successful farmers in the agriculture advanced areas like Sao Hai will be most effective.

As mentioned in 4.7. Chapter IV, a proposed demonstration farm of 260 ha under the control of the Project Supporting Section in the proposed organization of project implementation and the Agriculture Services Section in the organization of O & M is to be provided along the national highway No.1, aiming at giving full understanding on the irrigated paddy growing techniques such as water management, fertilization and other practices by the farmers' visit to the said farm. In the demonstration farm, there will various tests and comparative experiments to be carried out, such as nursing period required, changes in yield by different transplanting times, frequency in pest controls, comparison of manual weeding with application of weed killers, various planting densities, change in growth and yield by different combinations of three-elements of fertilizers and so forth. And these tests and experiments will be preferably made for the HYV and the LV as well as for the dry season and the wet season, respectively. It is desirable to carry out these tests continuously even after the completion of the Project.

A variety of combinations of the three elements of fertilizers are available in simple forms shown below.

(Unit: kg/ha)

Sample lot	N	P_2O_5	K_2O
Non-fertilization	0	0	0
Non-dosing with N	0	50	50
Non-dosing with P_2O_5	50	50	0
Non-dosing with K_2O	50	50	0
Full-fertilization	50	50	50

Such intensive activities of extension agents will enable the farmers to realize the target yield with the advanced knowledge fully utilized.

When executing these works, the number and the quality of the extension agents should be uplevelled to meet the requirements for more frequent services and higher techniques than at present.

Successful extension services will be secured through the close coordination with the related experimental institute, and the effective administrative guidance by the Department of Agriculture Extension.

4.6.6. Upbringing and Strengthening of the Agricultural Cooperatives

The agricultural cooperatives should play a vital role in crediting, input materials supply the farmers and purchase / sales of the farm products; actually, however, the crediting service has recently because a major work, while supply of the input material and marketing of the products which are important to the farmers have been prone to be neglected.

The Project will allow the farmers to carry out the intensive farmings which will inevitably require the increase in the input

materials. Under the situation, the cooperatives should make an effort to expand and strengthen the organization so that the member farmers can carry out the intensive farming without any troubles in supply with materials and marketing of the products. To cope with the situation, the organizations should be brought up and reinforced comprehensively for meeting increasing requirements of input materials supply, collection and forwarding of the products, short and medium-term credits, etc.

The fields to be reinforced intensively will be as follows;

- to ensure the staff increase to meet expansion of the works,
- to expand the capacity for crediting of the farm management funds,
- to increase in the sales and supply of the input materials,
- to consolidate the efficient marketing system (collecting and forwarding the products), and
- to provide a well functioning deposit services for the member farmers.

4.7. Physical Plan

4.7.1. Irrigation Facilities

A. Pumping Station

A.1. Site Selection for the Pumping Station

The right bank of the Pasak river in the vicinity of Ban That To village has been selected for the site of pumping station. This site is located about three kilometers upstream of Amphoe Kaeng Khoi.

At this site, the Pasak river course is straight, and its water route is stabilized. Furthermore, no bank erosion is observed around

the proposed site.

The ground surface at the site on which pumps will be installed at 21.50 m in elevation, therefore, the delivery level of water at the upstream most of the main canal will be 22 m in elevation.

Aparting from the above-mentioned, a local road of about six meters wide runs near the site, resulting in easy hauling of pump equipment and construction materials, etc.

A.2. Foundation of the Proposed Pumping Station

The drilled log of W-36 (MC86 SBR 4) that is located on the Pasak river about 800 m distant from the site is available for a preliminary-level study on the foundation conditions of the site.

As per the above-mentioned log, the geological formation at the site and its neighborhood is tabulated below;

Drilled Log of Well No. W-36 (MC86 SBR4)*

Elevation	Depth	Geology	Description
5.0 to 20.0 m	50 ft (15 m)	Clay	Dark gray to brown in color, silty, slightly calcareous, mottled feldspars, plastic, compact.
3.5 to 5.0 m	55 ft (16.5 m)	Gravel	Various colors, pebbly, 3 to 8 mm, angular to sub-rounded, fairly well sorted, composed of quartz chert and sandstone

0.5 to 3.5 m	65 ft (19.5 m)	Rock (Andesite)	Greenish gray, aphanitic texture moderately hard to hard, veiws composed of pyroxen, amphibole, feld-spars, dark minerals, calcite

* Data source: Department of Mineral Resources

Since no indications on elevation is given in the said log, reference was made to a 1/10,000 topographic map covering the site. The sill of the proposed pumping station is 2.50 m in elevation. So that the sill might come in contact with base rocks, there would be no problems in respect of the bearing capacity of the foundation.

For the suction pit of the pumping station, however, excavation as deep as 19.00 m from the ground surface will be required, resulting in some earth pressure caused by backfilling for the side wall. Some countermeasures against the probable earth pressure should be taken as a must to secure the stability of foundation at the site.

A.3. Selection of Pump Type

i) High and low water levels at the suction pit

The Pasak water level has not been observed at the proposed pumping station site, therefore, the high and low water levels of the river at the site are estimated based upon the observation records at Rama VI barrage and at S2 gauging station from 1951 to 1980 which are located downstream of the site.

The site being located about 54 km upstream of Rama VI barrage, the highest water level and the proposed low water level at the site

are estimated at 21.63 m (MSL) and 6.30 m (MSL), respectively. The detail is shown in Tables A.4.4-1 and A.4.4-2, and Figure A.4.4-1 of Appendix IV.

ii) Determination of pump type

The delivery water surface of the pump should be kept higher than the designed water level of 22 m in elevation at the upstream most of the main irrigation canal. The actual lifting head is roughly computed at 15.7 m from the low water surface of the Pasak river (6.30 m) and the above-mentioned designed water level of the main canal (22.00 m).

Furthermore, taking into consideration the ground elevation of the site on the right bank of the Pasak river (about 21.50 m in MSL) and the highest water surface of the Pasak river (21.63 m), the floor elevation of the pumping station has been determined at 23.00 m in elevation.

Under the circumstances, a centrifugal pump or a mixed flow pump both of the vertical type could be selected for this pumping station in consideration of the widely fluctuating water head and possible cavitation. A comparative study on the two pumps has revealed that the mixed flow pump is more advantageous than the centrifugal one in pump performance, operation and maintenance and construction cost, etc.

As regards the mixed flow pump of incline type, a study indicates that it will have some defects in technical and economic aspects if employed at the site. The detailed description on the comparative study is made in Table A.4.4-3 of Appendix IV.

A.4. Determination of Pump Units

The data on existing pumping stations constructed by RID indicates that the largest has a bore diameter of 900 mm (36"), capacity of 2.25 cu.m/sec and output of 450 Hp as of the study period.

Meanwhile, the water requirement in irrigation periods on both monthly and bi-monthly basis widely varies depending upon growing stages of crops and effective rainfalls during the time, and the pump operation has been made to meet such varying requirement by means of adopting a plural number of pump units and by operating each unit under time-control. For convenience in operation and maintenance, the same bore diameter of pump is generally adopted.

Taking into consideration the above-mentioned pump operation, a comparative study on the necessary number of pump units has been made from the view points of pump plant cost, construction cost of station and O & M cost. Based on this study, it is proposed to install seven units of pump with the same bore diameter of 1,000 mm and the power input of 560 KW (750 HP)..

A.5. Specifications of the Proposed Pumping Plant

The specifications of the pumping plant are as follows;

°	Maximum capacity:	17.6 cu.m/sec
°	Highest water level of the Pasak river:	21.63 m (MSL)
°	Lowest water level of the Suction Pit:	6.00 m (MSL)
°	Delivery water level:	22.00 m
°	Actual head:	16.00 m
°	Total head:	16.50 m

°	Suction bell elevation:	5.00 m
°	Bottom elevation of suction pit:	3.50 m
°	Base elevation of motor installation:	23.00 m
°	Bottom elevation of delivery pool:	19.50 m
°	Sill elevation of main canal:	20.00 m
°	Pump type:	vertical, mixed flow pump
°	Pump bore:	1,000 mm
°	Number of pump units:	7 units
°	Capacity per unit:	2.5 cu.m/sec
°	Output of electric motor:	560 KW (750 HP)

A.6. Structure of Pumping Station

The pumping station will be construction about 80 m distant from the present river course of the Pasak in order to avoid the erosion of river bed and bank and the construction of a large coffer dam to cope with floods of the Pasak river in the construction period.

The suction water level in the suction pit will vary ranging from the lowest water level of 6.00 m to the highest water level of 21.63 m. The motor base shall be installed at 23.00 m in elevation, so that, the hight of suction pit will become 19.50 m (23.00 m - 3.50 m = 19.50 m). As regards the width of suction pit, 21.00 m wide will be required to install seven units of pump with a diameter of 1,000 mm.

To meet the above-mentioned requirements, a pumping station of reinforced concrete will be built with the battress type wall on the mountain side.

Judging from the above-mentioned preliminary-level study on the foundation, it is anticipated that this structure will be directly placed on base rocks, therefore, no foundation treatment has been taken into consideration.

A considerably big quantity of sedimentation is anticipated to appear in the suction pit and in the front pool. Therefore, facilities to remove sediment shall be installed inclusive of a movable sand pump that travels on the beam over the front pool.

The pump house will be of reinforced concrete structure equipped with a 15 ton crane for maintenance of pumps, and will have a house coverage of 350 sq.m to accommodate electric equipment, operation equipment and repairing yard.

The layout of the main pumping station is illustrated in Drawing No. D101, D102 and D103.

B. Irrigation Canal

B.1. Canal Alignment

i) The main irrigation canal will extend from Kaeng Khoi pumping station toward the west along the northern boundary of the Project Area, and joint the Roeng Rang river after running along the upland field area that occupies the western part of the Project Area.

ii) In total, 12 lateral canals will diverge from the main irrigation canal, out of which three will be given a comparatively large conveyance capacity in order to minimize crossings with National Roads No.1 and No.3048 as well as with the Hae river and the Pak Bang river flowing from east to west across the Project Area.

iii) The above-mentioned lateral canals and 16 sub-lateral canals are so aligned that the direct diversion of water from the main and lateral canals can be avoided as much as possible in order to materialize a rationalized water managemnt, taking into consideration the standardized irrigation block of about 100 ha, topographic conditions and drainage systems.

The irrigation canal system based on the above-mentioned is shown in Table 4-8.

B.2. Appurtenant Structures

In consideration of the prevailing topographic conditions and the existing facilities and for the purpose of irrigation water intake and control in the Project Area, the following major structures will be required for the canal networks;

- Syphon..... Where canals cross rivers or roads
- Culvert..... Crossing with roads
- Turnout..... Diversion from canal. Head gates for large canals and the double orifice for field turnout.
- Check gate..... To be installed at the terminal points and/or midway as required of main and lateral canals to dam up the water level allowing diversion.
- Waste Way..... For the points where canal section be scaled down at the vicinity of rivers or drainage canal.
- Bridge..... To be provided for the canals with larger section for every 3 km.
- Pipe culvert..... or Inlet For small scale drainage and disposal of borrow pit water as required.

4.7.2. Drainage Facilities

The proposed drainage canals to be improved or constructed are as follows:

Table 4-9 Proposed Drainage Canal

Name of Canal	Drainage Area (km^2)	Peak Design Discharge (m^3/s)	Length (m)	Name of Main Drain
No.1	P 8.0 U - T 8.0	- - 2.98	2,000	Nong Luang
No.2	P 68.8 U 56.2 T125.0	- - 42.06	4,600	Nong Luang
No.3	P 30.5 U 38.2 T 68.7	- - 24.85	6,000	Nong Luang
No.4	P 28.3 U 14.2 T 42.5	- - 14.50	3,000	Pack Bang
No.5	P 11.1 U 0 T 11.1	- - 3.91	2,000	Pak Bang
No.6	P 10.0 U - T 10.0	- - 2.52	2,200	Pak Bang
No.7	P 9.0 U - T 9.0	- - 3.17	2,000	Pak Bang

Note: P: Paddy field, U: Upland field, T: Total area

4.8. Cost Estimate

4.8.1. Basic Concept on Cost Estimate

The construction works will be conducted on contract basis following the Governmental policies currently enforced in Thailand. The whole construction works are proposed to be completed within the five-year period from the third to seventh Project years taking into consideration the quantity of works, budgetary support in Baht and staffing capability of RID. Alternative studies on implementation methods of construction works and periods are discussed in Appendix IV for reference.

The Project cost consists of the costs for survey and design (preparatory works), civil works, procurement of equipment, land acquisition, Project facilities, supporting services, administration, consulting services as well as of the physical and price contingencies. The major cost components of each item are described below;

A. Cost of Civil Works

This item includes the construction costs for the Project which is estimated based on respective unit costs including construction materials, fuel and oil, labor, and depreciation and repairing cost of the construction equipment. The civil works are composed of the following;

i) Main Pumping Station: to include the suction pit with the intake pool, delivery pit and pump house

ii) Irrigation canal: to include the construction works of the main, lateral and sub-lateral canals and related structures such as culverts, checks, bridges,

wasteways, syphones, turnouts (CHO) and field turnouts.

iii) Drainage canal: to include the construction works of the main drainage canal and related structures such as culverts, bridges and drops.

iv) Demonstration farm: to include construction works of ditches and drains, farm roads and structures except land levelling works.

v) Transmission line: transmission line from Kaeng Khoi substation to the pumping station.

B. Procurement of Equipment

The procurement of equipment covers the main pumping plants, sluice gate, office equipment and operation and maintenance equipment for the post-Project. The cost of equipment and spare-parts is estimated based on CIF Bangkok including only the inland transportation cost of them.

C. Land Acquisition Cost

This item includes the cost required in procurement of the land to be occupied by irrigation and drainage canals which will be constructed in the Project excepting the land for on-farm level facilities.

D. Cost for the Project Facilities

This item covers the construction cost of buildings for the Project office, warehouse, water and electric supply facilities and the expenditure for office furnitures.

E. Cost for Supporting Services

This item covers the cost for agricultural supporting services necessary for smooth implementation of the Project

F. Administration Cost

This cost is estimated at 10 % of the above-mentioned investment cost items A to E, taking into account actual costs required in similar projects to the Project.

G. Consultants Services

The engineering fee for the consulting services by both foreign and local consultants and the cost for overseas training of the Governmental officials.

H. Physical Contingency

The allocation of contingencies is made to cover minor differences between the actual and estimated quantities, unexpected difficulties in construction works and so forth. The contingency equivalent to 10 % of the above-mentioned items has been employed.

I. Price Escalation

Price escalation of 8.0 - 6.0 percent per annum for the foreign currency portion and 8.4 percent for the local currency portion are allowed repectively. Therefore, the adopted percentage of the total price escalation is estimated at 42.5 percent.

J. Unit Cost

The cost of construction materials, labour and equipment to be

used for the Project is estimated on the basis of the prices employed by RID 1981.

4.8.2. Total Investiment Cost and Disbursement Schedule

The total investment cost, including the cost for price escalation but excluding the interest during the construction period, is estimated at 935.8 million baht (equivalent to US$ 40.7 million), of which about 373.3 million bath will be foreign currency component and about 562.5 million shares local currency component respectively. The break down table is shown in Table 4-10, and detailed costs are shown in Table A.4.8-7 to A.4.8 -11, in Appendix IV.

The disbursement schedule of project cost, which was followed implementation schedule mentioned later on, is shown in Table 4-11.

Table 4-3 Current Irrigation Area of Existing Project

(Unit : hectare)

Name of Project		Wet	Dry Season			
Name of canal	Sub-area	Season	1978	1979	1980	1981
Chainat-Pasak	Manorom	30,720	2,853	12,722	280	3,517
	Chong Khai	38,080	5,979	6,914	170	4,539
	Khok Kathiam	31,360	1,838	1,256	-	3,012
	Roeng Rang	27,680	856	1,552	-	3,928
	TOTAL	127,840	11,526	22,444	450	14,996
	(Proportion)	(100)	(9.0)	(17.6)	(0.4)	(11.7)
Raphiphat	Nakhon Luang	35,200	443	1,336	92	1,239
	Tha Luang	36,160	1,357	4,017	198	5,650
	North Rangsit*	38,640	9,465	9,900	2,187	9,930
	TOTAL	110,000	11,265	15,253	2,477	16,819
	(Proportion)	(100)	(10.2)	(13.9)	(2.3)	(15.3)
	Grand total	237,840	22,791	37,697	2,927	31,815
	(Proportion)	(100)	(9.6)	(15.8)	(1.2)	(13.4)

The averaged cropping acreage in current four year for dry season indicates about 23,800 ha. (10% of total irrigable area).

Note: *; Total commanded area of North Rangsit is assumed about 50 percent of original total area 72,640 ha. which was irrigated by other water resources in some part.

Table 4-4 Tentative Alternative Plan on Main Irrigation Systems

Alternative	Project Boundary	Pumping Station	Irrigable Area (ha)	Discharge (m^3/sec)	Water Level Suction (m)	Water Level Delivery (m)
1 - 1	Kaeng Khoi town to national road No. 3022	Kaeng Khoi	14,160	17.50	6.8	22.0
1 - 2	Ditto	Kaeng Khoi (1)	9,870	12.25	6.8	22.0
		Ban Nong Bo Phrong (2) (High lifting head)	2,300	2.85	4.7	18.0
		Ban Nong Bo Phrong (3) (Low lifting head)	1,990	2.40	4.7	13.0
2	Ditto	Ban Huai Noi (1) (High lifting head)	7,300	9.00	6.0	22.5
		Ban Huai Noi (2) (Low lifting head)	6,860	8.50	6.0	17.0
3 - 1	Kaeng Khoi town to Chainat-Pasak Canal	Kaeng Khoi	13,440	16.70	6.8	20.0
3 - 2	Ditto	Kaeng Khoi (1)	11,030	13.70	6.8	20.0
		Ban Nong Bo Phrong (2)	2,410	3.00	4.7	16.0

Table 4-5. Summary of Construction Cost and Operation and Maintenance Cost

(Unit : Thousand Baht)

Alternative	Irrigable Area (ha)	Pumping Plant	Canal * Cost	Sub-total	Unit Cost per ha	O&M Cost per year	Unit Cost per ha	Total** Amount	Unit Cost per ha	Proportion %
1 - 1	14,160	78,230	278,010	356,240	฿ 25,158	6,770	฿ 478	303,691	฿ 21,447	100
1 - 2	14,160	187,700	277,350	465,050	฿ 32,843	7,348	฿ 519	387,557	฿ 27,370	128
2	14,160	225,330	251,940	477,270	฿ 33,706	7,960	฿ 562	400,244	฿ 28,266	132
3 - 1	13,440	77,230	302,650	379,880	฿ 28,265	5,890	฿ 438	315,910	฿ 23,505	110
3 - 2	13,440	111,370	290,970	402,340	฿ 29,936	6,260	฿ 466	334,716	฿ 24,904	116

* Land acquisition cost included in the canal cost is within an extent about 14,640 to 16,390 thousand Baht respectively.

** Present worth values of each alternative were computed by discounting the respective cost stream with ten (10) percent of discount rate over 22 years, assuming a durable life of pumping equipments to be twenty (20) years and construction period with five years. (Refer to Table A.4.2-6, in Appendix IV)

Table 4-7. Present and Proposed Production

	Crops	Present Cropped Area ha	Present Yield ton/ha	Present Production ton	Proposed Cropped Area ha	Proposed Yield ton/ha	Proposed Production ton	Increased Rate of Yield %	Increased Production ton	Remarks
	Paddy (LV, TP)	9,050	1.8	16,290	6,840	3.3	22,572	83	6,282	
	" (HYV, ")	1,160	2.4	2,784	-	-	-	-	-	Rain-fed
Wet Season	" (HYV, ")	2,000	2.6	5,200	6,840	4.0	27,360	54	22,160	Irrigated
	" (LV, BC)	940	1.6	1,504	-	-	-	-	-	
	Maize	410	2.0	820	430	2.7	1,161	35	341	
	Groundnuts	50	1.8	90	50	2.6	130	44	40	
Dry Season	Paddy (HYV, TP)	680	3.2	2,176	2,800	4.2	11,760	31	9,584	
	Total	14,290			16,960					

Notes: LV : Local Variety
HYV : High Yield Variety
TP : Transplanting Method
BC : Broadcasting Method

Table 4-8 Specification of Irrigation Canal

Name of Canal	Length (m)			Max. Discharge (cu.m/sec)
	Main	Lateral	Sub-lateral	
Main	35,350			17.62
1L		2,750		0.27
2L		500		0.17
3L		10,600		2.12
1R-3L			2,800	0.16
1L-3L			925	0.39
2R-3L			1,500	0.43
2L-3L			2,600	0.20
1L-1L-3L			1,500	0.12
4L		13,000		2.82
1R-4L			2,300	0.35
1L-4L			4,000	0.56
2L-4L			2,500	0.24
1L-1R-4L			1,300	0.15
5L		1,900		0.44
6L		15,000		3.89
1R-6L			2,700	0.33
2R-6L			2,500	0.45
1L-6L			3,700	0.43
2L-6L			1,500	0.27
3L-6L			2,000	0.25
4L-6L			1,600	0.21
1R-1L-6L			1,800	0.21
7L		2,400		0.38
8L		2,300		0.58
9L		3,700		0.59
10L		6,500		1.95
1L-10L			4,400	0.83
1L-1L-10L			1,800	0.34
11L		8,350		0.97
1L-11L			1,600	0.11
12L		2,200		0.16
Total	35,350	69,200	43,025	

Table 4-10 Project Cost

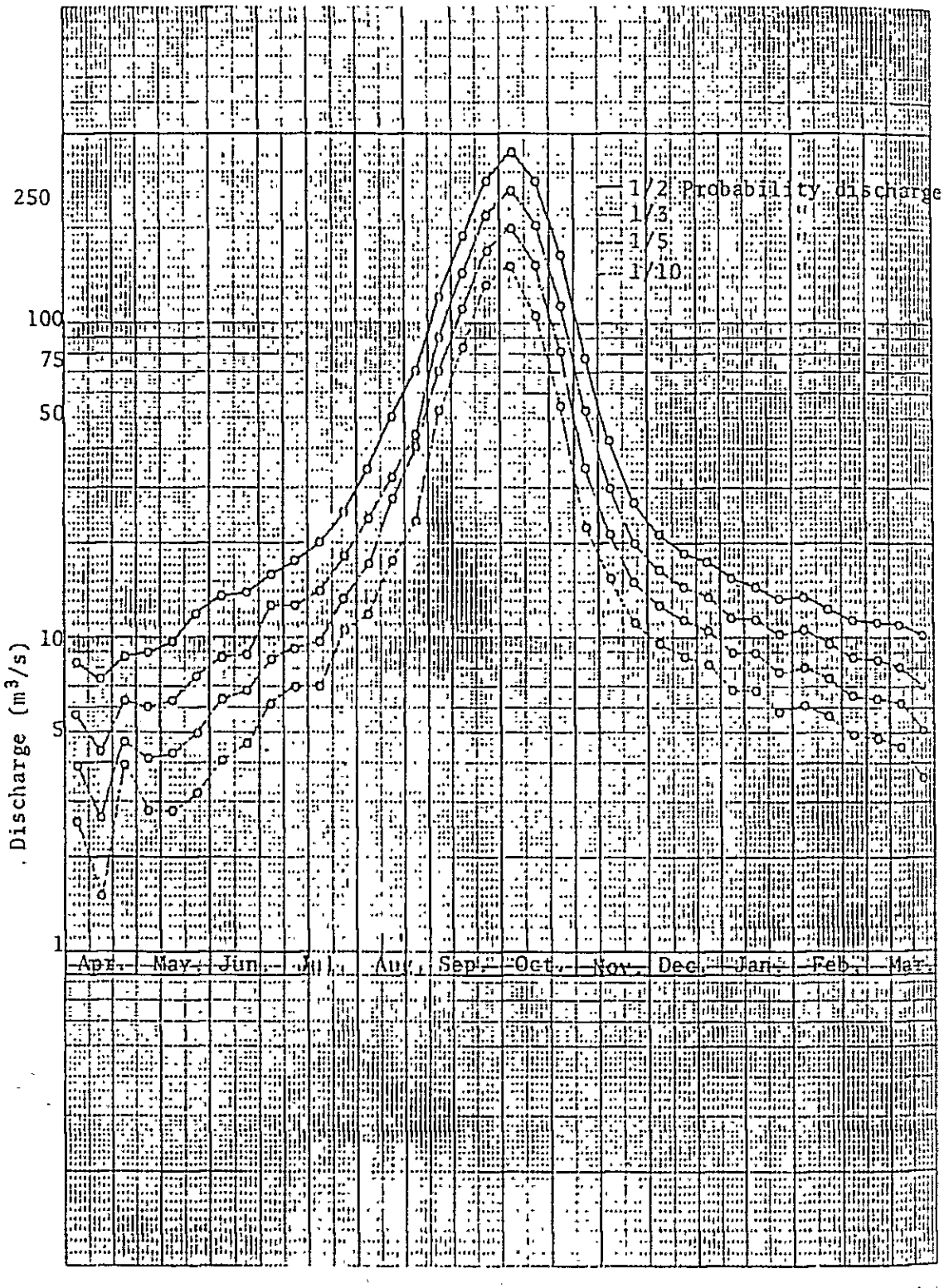
Description	Quantity	Unit	Cost (฿1,000) Foreign	Local	Total
1. Survey and Design	1	L.S.	-	11,000	11,000
2. Civil Works					
2.1. Pumping station	1	Place	10,682	20,477	31,159
2.2. Irrigation canal	148	km	113,830	201,090	314,920
2.3. Drainage canal	22	km	27,828	17,322	45,150
2.4. Demonstration farm	260	ha	1,211	2,689	3,900
2.5. Transmission line	5	km	-	3,620	3,620
Sub-total			153,551	245,198	398,749
3. Procurement of Equipment					
3.1. Pumping plants	1	L.S.	52,465	5,000	57,465
3.2. Gate	1	L.S.	1,020	280	1.300
3.3. Office equipments	1	L.S.	2,900	100	3,000
3.4. O & M equipments	1	L.S.	8,100	900	9,000
Sub-total			64,485	6,280	70,765
4. Land Acquisition	1	L.S.	-	17,300	17,300
5. Project facilities	1	L.S.	-	5,000	5,000
6. Supporting Services	1	L.S.	-	2,400	2,400
7. Administration	1	L.S.	-	50,526	50,526
8. Consulting Services	1	L.S.	31,760	9,340	41,100
Total (1 - 8)			249,796	347,044	596,840
9. Physical Contingency (10%)	1	L.S.	24,980	34,680	59,660
Total (1 - 9)			274,776	381,724	656,500
10. Price Escalation	1	L.S.	98,570	180,730	279,300
Ground total (1 - 10)			373,346 (39.9%)	562,454 (60.1%)	935,800 (100.0%)

Table 4-11 Disbursement Schedule of the Project

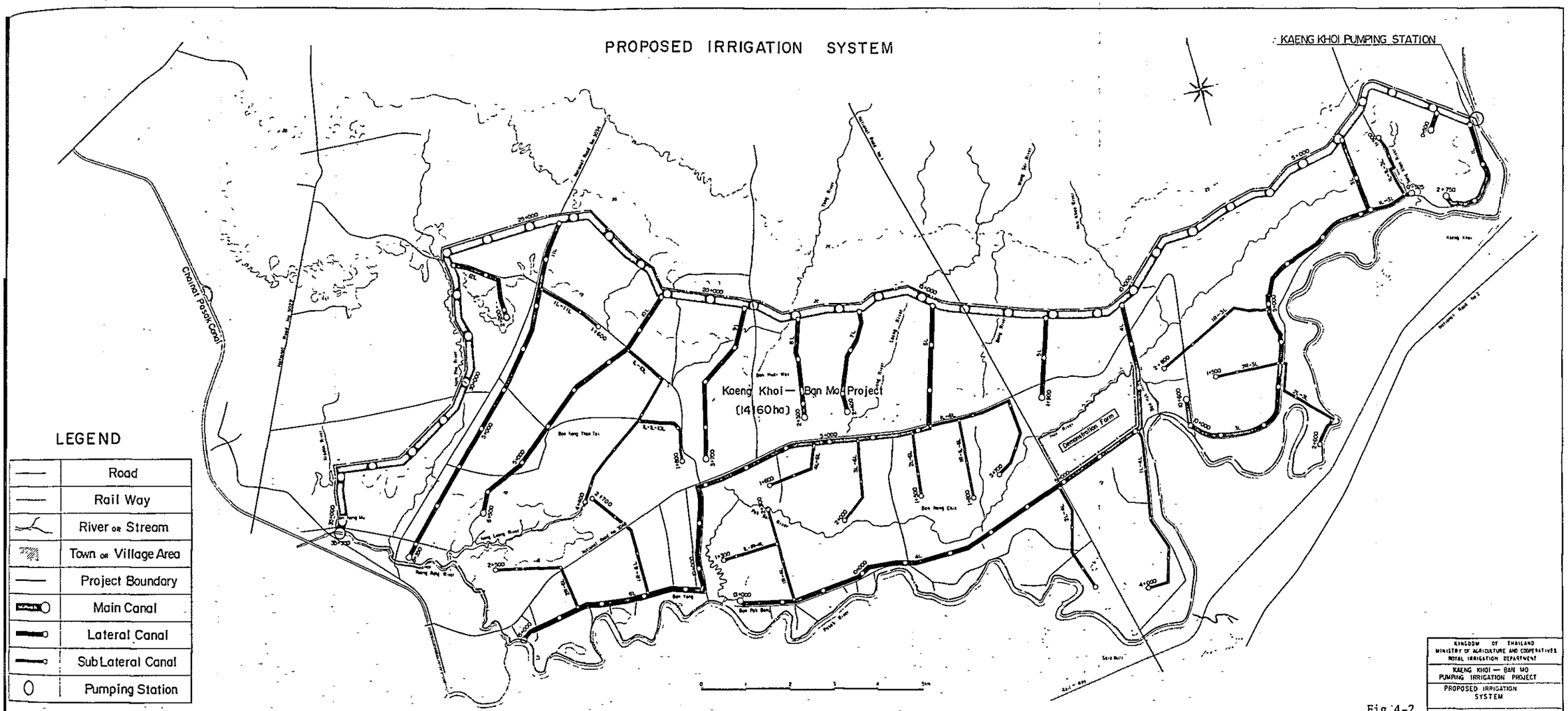
(Unit: ฿ 1,000)

Description	FY1982 F.C.	FY1982 L.C.	FY1983 F.C.	FY1983 L.C.	FY1984 F.C.	FY1984 L.C.	FY1985 F.C.	FY1985 L.C.	FY1986 F.C.	FY1986 L.C.	FY1987 F.C.	FY1987 L.C.	FY1988 F.C.	FY1988 L.C.	TOTAL F.C.	TOTAL L.C.	TOTAL Total
1. Survey Design	-	2,500	-	3,000	-	3,000	-	1,000	-	600	-	500	-	400	-	11,000	11,000
2. Civil Works																	
2.1 Pumping Station	-	-	-	-	6,856	13,143	3,826	7,334	-	-	-	-	-	-	10,682	20,477	31,159
2.2 Irrigation Canal	-	-	-	-	14,058	20,766	18,842	27,833	29,087	42,964	23,629	34,902	15,249	22,524	100,865	148,989	249,854
2.3 Irri. Structures	-	-	-	-	1,801	7,243	2,438	9,795	3,734	15,005	3,034	12,191	1,958	7,867	12,965	52,101	65,066
2.4 Drainage Canal	-	-	-	-	-	-	2,351	1,062	11,760	5,309	7,056	3,185	5,317	2,400	26,484	11,956	38,440
2.5 Drai. Structures	-	-	-	-	-	-	134	537	673	2,682	403	1,610	134	537	1,344	5,366	6,710
2.6 Demonstration Farm	-	-	-	-	-	-	1,211	2,689	-	-	-	-	-	-	1,211	2,689	3,900
2.7 Transmission Line	-	-	-	-	-	-	-	3,620	-	-	-	-	-	-	-	3,620	2,620
Sub-total	-	-	-	-	22,715	41,152	28,802	52,870	45,254	65,960	34,122	51,888	22,658	33,328	153,551	245,198	398,749
3. Procurement																	
3.1 Pump Plants	-	-	-	-	52,465	-	-	5,000	-	-	-	-	-	-	52,465	5,000	57,465
3.2 Gates	-	-	-	-	-	-	-	-	-	-	1,020	-	-	280	1,020	280	1,300
3.3 Project Equipment	-	-	-	-	2,900	100	-	-	-	-	-	-	-	-	2,900	100	3,000
3.4 O.M. Equipment	-	-	-	-	-	-	-	-	-	-	-	-	8,100	900	8,100	900	9,000
Sub-total	-	-	-	-	55,365	100	-	5,000	-	-	1,020	-	8,100	1,180	64,485	6,280	70,765
4. Land Aquisition	-	-	-	1,560	-	3,110	-	5,360	-	4,670	-	2,600	-	-	-	17,300	17,300
5. Project Facilities	-	1,000	-	4,000	-	-	-	-	-	-	-	-	-	-	-	5,000	5,000
6. Supporting Services	-	-	-	400	-	400	-	400	-	400	-	400	-	400	-	2,400	2,400
7. Administration	-	350	-	896	-	12,584	-	9,343	-	11,688	-	9,053	-	6,612	-	50,526	50,526
8. Consulting Services	-	-	7,000	1,300	7,000	1,300	6,960	2,040	5,000	1,400	2,400	2,100	3,400	1,200	31,760	9,340	41,100
Total (1 - 8)	-	3,850	7,000	11,156	85,080	61,646	35,762	76,013	50,254	84,718	37,542	66,541	34,158	43,120	249,796	347,044	596,840
9. Physical Contingency	-	385	700	1,116	8,508	6,165	3,576	7,601	5,025	8,472	3,755	6,654	3,416	4,287	24,980	34,680	59,660
Total (1 - 9)	-	4,235	7,700	12,272	93,588	67,811	39,338	83,614	55,279	93,190	41,297	73,195	37,574	47,407	274,776	381,724	656,500
10. Price Escalation	-	356	1,201	2,148	21,806	18,580	12,313	31,857	21,890	46,315	19,905	45,527	21,455	35,947	98,570	180,730	279,300
Grand Total (1 - 10)	-	4,591	8,901	14,420	115,394	86,391	51,651	115,471	77,169	139,505	61,202	118,722	59,029	83,354	373,346	562,454	935,800

Fig. 4-1 Probable Discharge of Pasak River at S2 Gauging Station



PROPOSED IRRIGATION SYSTEM



LEGEND

	Road
	Rail Way
	River or Stream
	Town or Village Area
	Project Boundary
	Main Canal
	Lateral Canal
	Sub Lateral Canal
	Pumping Station

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ROYAL IRRIGATION DEPARTMENT

KAENG KHOI — BAN MO
PUMPING IRRIGATION PROJECT

PROPOSED IRRIGATION SYSTEM

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.4-2

PROPOSED DRAINAGE SYSTEM

LEGEND

- MAIN CANAL (EXISTING)
- MAIN CANAL
- DRAINAGE SLUICE
- PROJECT BOUDARY

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ROYAL IRRIGATION DEPARTMENT

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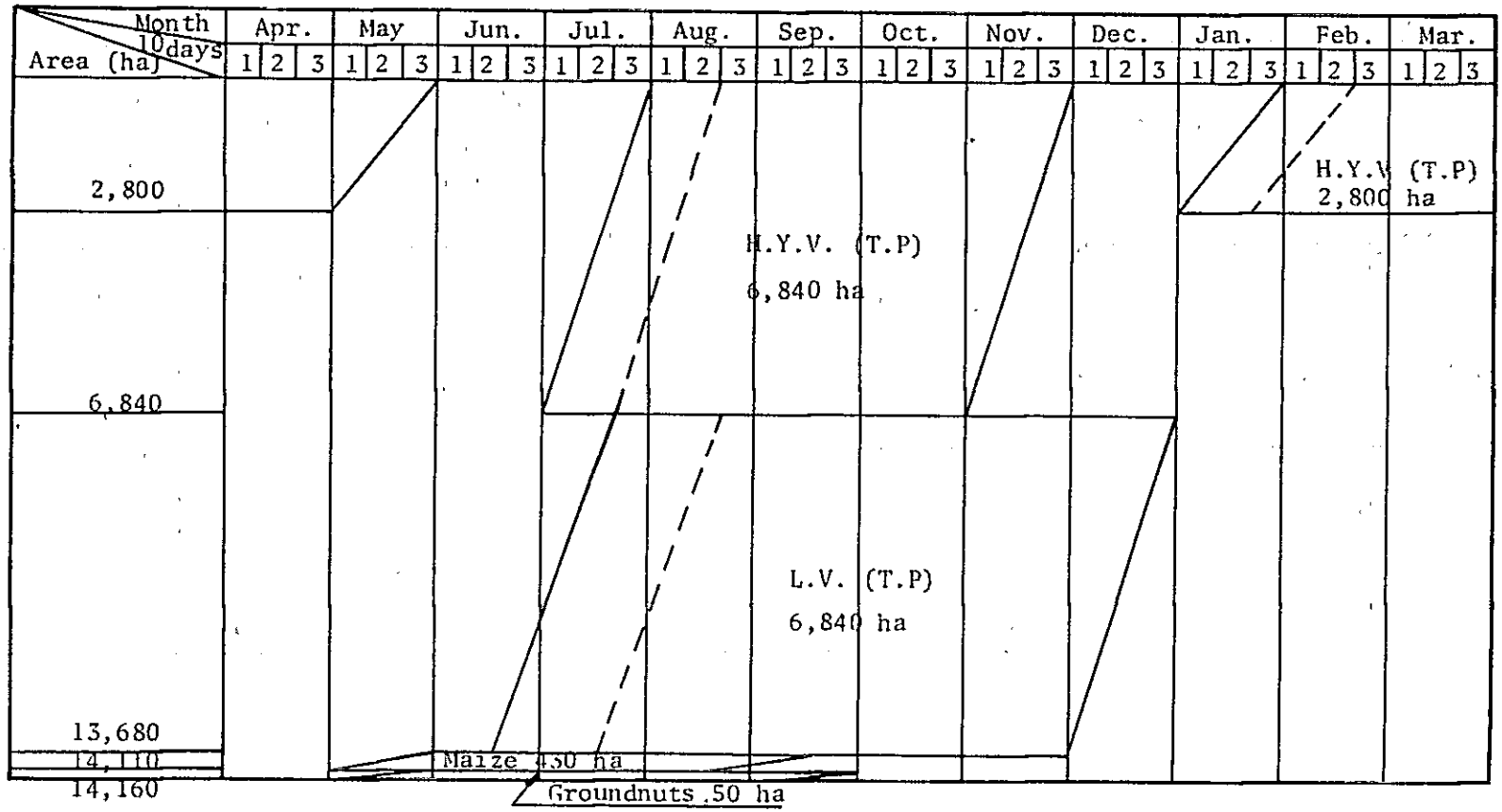
PUMPING IRRIGATION PROJECT

PROPOSED DRAINAGE SYSTEM

Fig.4-3

Fig. 4-4 Proposed Cropping Calender



H.Y.V: High Yielding Variety
L.V: Local Variety
T.P: Transplanting Method

V. PROJECT IMPLEMENTATION AND OPERATION & MAINTENANCE

V. PROJECT IMPLEMENTATION AND OPERATION & MAINTENANCE

5.1. Executing Body and Its Organization

The major construction works of the Project will be made for the main pumping station, main and lateral canals and main drainage canal inclusive of drainage sluices. The Royal Irrigation Department (RID), which has prominent experience in the similar-natured projects to the Kaeng Khoi-Ban Mo Pumping Irrigation Project, should be responsible for the execution of the Project. The proposed organization of the executing body is illustrated in Figure 5-1.

Project organizations for implementation of RID projects are usually lined up by the Project Director, Project Manager, Office Engineer and Section Chiefs. The Project Director is comprehensively responsible for the project implementation. The Project Manager is, under the control of the Project Director, fully responsible for execution of the project works. The Office Engineer is assigned to assist the Project Manager in overall project works.

The Administrative Section will be responsible for administration property, accounting, personnel affairs, procurement and the other miscellaneous matters.

The Engineering Section is in charge of necessary topographic survey for design of canal systems under the cooperation of the Survey Division of RID head office, detailed design of main irrigation and drainage facilities under the supervision of the Design Division of RID head office, and arrangement for land acquisition.

The Construction Section is in charge of construction supervision and inspection of the works on contract basis, repairing works and water and electric supply.

The Control Section is responsible for construction planning, preparation of tender documents inclusive of specifications and cost estimate, and budget allocation schedule.

The Project Supporting Section is in charge of carrying out education of beneficial farmers on water management, keeping records not only of the progress of civil works but also of agricultural development inclusive of that of socio-economic sectors during the course of implementation of project works, and also for establishment of farmers' organizations and execution of agricultural extension services together with related agencies concerned of MOAC.

The Project Coordinating Committee in local level is organized by RID's Project Manager as Chairman, representatives of the local Agricultural Extension Office, the Agricultural Cooperative Promotion Office and BAAC' Saraburi branch manager, and furthermore, the Consultants staff and RID Regional Director as observers, if necessary.

The Committee meeting is held twice a month for the project execution and assessment. In this meeting, the following matters are discussed for deepening the mutual understanding;

- Assessment of actual results;
- Implementation schedule;
- Extension services;
- Upbringing of the cooperatives;
- Education and training in water management techniques; and,
- Other works related to the projects.

This kind of meeting is quite indispensable to secure the smooth progress of the works.

The Construction Supervision Committee is also set up to check the work progress and quality of work performed by contractors under the chairmanship of a related division director of RID.

5.2. Project Implementation Schedule

5.2.1. Implementation Program

The major work items of the Project consists of the survey and design, establishment of the Project office, construction works, procurement of equipment, agricultural supporting services and consulting services. The time schedule of the respective work items has been worked out based on the basic concept hereinafter mentioned, and the proposed Project implementation schedule is shown in Figure 5-2.

A. Survey and Design

Surveys for the major canal alignment inclusive of vertical control for the entire Project Area should be start in the first Project year. In parallel with the detailed design of irrigation and drainage facilities, the survey works for the remainder will be carried out prior to the commencement of the scheduled construction works.

The detailed design and preparation of the tender documents should be possibly completed within the previous fiscal year of starting implementation. Therefore, the design work schedule shall be established following the construction schedule in advance.

B. Establishment of the Field Office

The Field Office of the Project will be located in the Project site taking into account the convenience for future operation and maintenance of the Project facilities. The construction works for the Field Office buildings will start the first Project year so as to implement the Project works smoothly.

C. Construction Schedule

The construction works will be carried out on contract basis following the current Governmental policy, and will be commenced from the third Project year, taking into consideration the above-mentioned pre-construction works. It is proposed to complete in five years as discussed in the following paragraph, taking into account the quantity of works, staffing capacity of RID and tendency of the budgetary support in Baht and so forth.

As Figure 5-2 shows, the construction works will be implemented starting from the areas where quick yielding and effect of the Project can be anticipated to be easily attained. Furthermore, most construction works in Thailand are commenced in dry seasons from January. It takes more than three months to complete the bidding procedures of contract basis. Therefore, the said administrative arrangement should be commenced from the early part of October after completion of the preparatory works for this.

D. Procurement of Equipment

The main pump plant, vehicles, office instruments for the Project implementation, and O & M equipment for the post-Project will be procured under the Project. Specially for procurement of the main pump plant, tendering procedures shall start in the beginning of the third Project year, and the installation of pump plant should be also

completed before the end of fourth project year so as to irrigate the areas where the construction of canal systems have been completed.

Procurement of operation and maintenance equipment will start from the sixth Project year, and inspection and inland transportation to the Project site of the equipment shall be completed within the seventh Project year, that is, within the effective period of foreign loans.

E. Agricultural Supporting Services

The agricultural supporting services such as extension of farm techniques, strengthening of cooperative activities and training of beneficiary farmers in water management techniques will be rendered from the third Project year, and it is desirable to continue such services even after the completion of the Project works, if necessary.

F. Consulting Services

The consulting services to assist the Thai officials concerned in design, preparation of tender documents and agricultural supporting services shall necessarily start in the beginning of the second Project year, and the consultants personnel both foreign and local will render services up to the completion of the Project works.

5.2.2. Optimum Construction Schedule

As the basic concept as regards the implementation program is mentioned in the previous paragraph, the realistic schedule for construction works should be established.

The construction period has been determined at a five-year period, taking into account the actual tendency in budgetary arrangement for similar-natured irrigation projects, the yearly budget allocation and the total Project cost could be tabulated as follows;

(Unit: Baht 1,000)

Project year	Foreign	Local	Total	Percent
1982	-	4,591	4,591	0.5 %
1983	8,901	14,420	23,321	2.5 %
1984	115,394	86,391	201,785	21.6 %
1985	51,651	115,471	167,122	17.9 %
1986	77,169	139,505	216,674	23.1 %
1987	61,202	118,722	179,924	19.2 %
1988	59,029	83,354	142,418	15.2 %
Total	373,346	562,454	935,800	100.0 %

As shown in the above table, the required budget allocation in local currency portion at the peak time amounts to about 140 million Baht with the necessary contingency. The tentative yearly construction schedule in the five years is illustrated in Figure 5-3.

The actually allocated local budgets to 20 similar project presently under the operation by RID are not more than 100 million Baht excepting some specified irrigation projects in fiscal year 1981. Therefore, the construction period of five years exclusive of the period for pre-construction works is recommendable to be employed for the Project.

5.3. Operation and Maintenance

5.3.1. Zoning of the Project Area

In general, the service unit for operation and maintenance is

determined based on the irrigation networks with a commanding area of 1,600 ha (10,000 rai) as a general standard of RID, length of canals and number of facilities.

The Project Area having a cultivable land of about 14,000 ha has been divided into eight zones taking into account the canal networks and their location and boundary as illustrated in Figure 5-4. Besides, the commanding acreage and canal length in each zone are summarized below, and details of them are shown in Table A.5.1-1 of Appendix V.

Zoning for O & M and Canal Length

Zone	Acreage		Main & lateral	Sub-lateral	Total
	ha	rai	km	km	km
1.	2,042	(12,760)	17.55	9.33	26.88
2.	1,453	(9,080)	12.90	-	12.90
3.	2,241	(14,010)	3.00	10.10	23.10
4.	1,715	(10,720)	12.00	10.60	22.60
5.	1,368	(8,550)	3.20	5.20	8.40
6.	1,526	(9,540)	13.40	-	13.40
7.	1,652	(10,330)	9.50	6.20	15.70
8.	2,163	(13,510)	23.25	1.60	24.85
Total	14,160	(88,550)	104.80	43.03	147.83

5.3.2. Organization for Operation and Maintenance

The proposed organization for operation and maintenance of the Project is illustrated in Figure 5-5. The Project Engineer will be fully responsible for overall operation and maintenance of the Project facilities under the control of Director of the Irrigation Regional Office, No. 8.

The Kaeng Khoi - Ban Mo O & M Office will have five sections in charge of the administrative, agricultural services, operation and maintenance, mechanical, and engineering under the Project Engineer.

Three Water Masters will be assigned under the O & M Section. No. 1 Water Master will be in charge of operation and maintenance of the pumping station. No. 2 and No. 3 Water Masters will supervise each four zonemen, that is for No. 1 to No. 4 zones and for No. 5 to No. 8 zones, respectively. Besides, one zoneman will control about eight Common Irrigators each of whom will be responsible for about 200 ha of farm lands. The number of Common Irrigators to be assigned to the Project will be about 64 persons judging from the canal density and acreage under responsibility as described below;

Zone No.	Acreage (ha)	Canal length (km)	Common I. per 3 km (persons)	Common I. per 200 ha (persons)	Common I. Recommended. (persons)
1.	2,042	26.88	9	10	10
2.	1,453	12.90	5	7	6
3.	2,241	23.10	8	11	10
4.	1,715	22.60	8	9	9
5.	1,368	8.40	3	7	5
6.	1,526	13.40	5	8	7
7.	1,652	15.70	6	8	7
8.	2,163	24.85	9	11	10
Total	14,160	147.83	53	71	64

On the other hand, O & M and water management in on-farm level will be carried out by beneficiary farmers themselves under the guidance and training of RID staff concerned.

The RID' O & M office will be in charge of the O & M of the irrigation facilities upstream of the constant head orifices (CHO) which will be installed at every main, lateral and sub-lateral canals.

In principle, farmers' O & M group which is organized by farmers having their fields in the commanded area of a canal will be responsible for O & M of the canal facilities downstream of the CHO.

Under the conditions, one group will consist of about 15 farm households among whom one farmers' foreman will be selected. The farmers' foreman will be in charge of both O & M and water management and concurrently coordinating the works among extension agencies, cooperatives and the member farmers.

5.3.3. Management

The Project Engineer of the Kaeng Khoi - Ban Mo O & M Office (hereinafter called "the Project Engineer") will be responsible to make report to the Chao Phraya Basin Operation Center and Regional Director of RID, Lopburi, regarding the irrigation water requirements together with cropping areas which will increase in parallel with the progress in the Project works, and be responsible to study and execute various works such as water utilization programming, repairing and improving facilities and so forth in close consultation with the project engineers of Rama VI barrage and Khlong Phrieo O & M projects.

The Administration Section will be in charge of general matters inclusive of budgeting, accounting, personnel affairs and management of the office properties. The Mechanical Section will be responsible for operation and maintenance of equipment and vehicles, etc., under the Office, and formulate a plan for mobilization of equipment. The

Engineering Section will be responsible for survey, design, construction and improvement of canals and related facilities inclusive of repairing works. The Agricultural Service Section shall play an important role to work out cropping plans by service areas, to secure coordination with and among the other agencies and offices, to plan farmers' education and training, and to conduct the yield surveys, etc.

The O & M Section will be responsible to carry out water management and general O & M of the facilities based on the O & M guideline mentioned below;

The Water Masters assigned to the pumping station and the entire areas will be responsible for guidance and supervision of the Zonemen and Common Irrigators in the respective areas in charge.

The major tasks are shown below;

i) In consultation with the Agricultural Service Section staff, to determine an irrigation requirement in the area in charge based on a cropping pattern best suited to the respective farm fields.

ii) To measure and control the water to be supplied at the diversion points so as to meet the water requirement keeping the losses at minimum.

iii) To prepare a pump operation schedule and rules based on the irrigation requirements and cropping patterns furnished by the other Water Masters. (duty of the Water Master in charge of O & M of the pumping plant)

iv) To measure and record the discharges from the pumping station on the supply basis, and prepare discharge data so

as to materialize a proper water management and economic pump operation in future.(do)

v) To prepare a report particularly on irrigated acreage and farm practices in both wet and dry seasons during the specified periods, for instance, land preparation, growing and harvesting periods.

vi) To give guidance and supervision to farmers' foremen in water management and O & M of on-farm facilities.

Zonemen and Common Irrigators should assist Water Master in carrying out proper water distribution in the area in charge and in giving guidances to farmers' groups.

5.3.4. Required Equipment, Facilities and Staff

A. Operation and Maintenance Office

The O & M Office will be responsible in utilization of the Project office after completion of the construction works. The location of the Project office should be determined taking into consideration the convenience not only in construction works but also in water management and O & M.

B. Operation and Maintenance Equipment

The following equipment are recommended to be introduced for operation and maintenance;

Equipment	Quantity
Backhoe, 0.35 cu.m	1
Tractor, crawler type, 140 Hp	1
Grader, 110 Hp	1
Loader, 1.6 cu.m	1
Dump truck, 6 tons	2
Truck, pick-up, 3/4 tons	8
Concrete mixer, 140 lit	2
Pump, 100 mm	5
Station wagon	2
Motor cycle, 75 cc	64
Spare parts	L.S.
Communication facilities	L.S.

C. Staffing

The following staffing will be required to meet the requirement in O & M and education of the beneficiary farmers.

Designation	Officer	Permanent Employee	Temporary Employee
Office Engineer	1	-	-
Section Chief	5	-	-
Administrative Section	-	2	4
Agricultural Sect'n	-	2	2
O & M Section	1	3	3
Mechanical Section	-	2	6
Engineering Section	-	2	5
Water Master	-	3	-
Zoneman	-	8	-
Pump Operator	-	3	-
Common Irrigator	-	16	64
Total	7	41	84

5.3.5. Annual Operation and Maintenance Cost

The operation and maintenance cost per annum has been estimated based on the zoning plan, proposed organization, required man-power, capacity of the pumping plant and its operation hours as shown below; and the detail of the operation cost (electric fee) and the annual pump operation hours are shown in Tables A.5.1-2 and A.5.1-3, respectively.

(Unit: 1,000 Baht)

Item	Amount	Remarks
A. Salaries and wages		
Officers	420	7 P x 60,000 Baht/P
Permanent employees	1,476	41 P x 36,000 Baht/P
Temporary employees	1,512	84 P x 18,000 Baht/P
Sub-total	3,408 (240)	
B. Supply of materials	366 (26)	
C. Maintenance cost		
Pumping plants	540	
Canal systems	420	
Sub-total	960 (68)	
D. Operation cost	8,366 (591)	
Total	13,100 (925)	

The above figures in parenthesis indicate the annual cost per hectare in Baht.

5.4. Consultants Services

The Royal Irrigation Department of Thailand has rich experience, with capable staff, in planning, designing and implementing of irrigation and drainage development projects. Recently, however, this kind of projects are rapidly increasing in number so RID cannot assign well-experienced officials to all its projects.

Under the circumstances, it is considered necessary to employ consultants personnel prominent in the field of planning, detailed design, preparation of tender documents, construction supervision and agricultural supporting services, and let them assist the Governmental official in execution of the Project works.

Totally 230 man-months of consultants services will be required for the Project implementation, inclusive of about 110 man-months of consultants services by local staff, covering the overall Project works such as design, mechanical, electrical engineers, geologist, specification writers, agronomist, agro-economist, equipment engineer and construction supervisor, taking into consideration the necessity to upgrade the technology of the Thai local consultants personnel.

Furthermore, it has been planned to dispatch eight Thai Government officials abroad to make study for a two- to eight- month period in the fields of computer programming, design inclusive of that of pumping plants, water management including collection of water charge and on-farm development, etc., to be helpful in the Project implementation.

The tentative manning schedule of consultants services for the Project is illustrated in Figure A.5.1-1 of Appendix V.

Fig. 5-1 Proposed Organization of Project Implementation

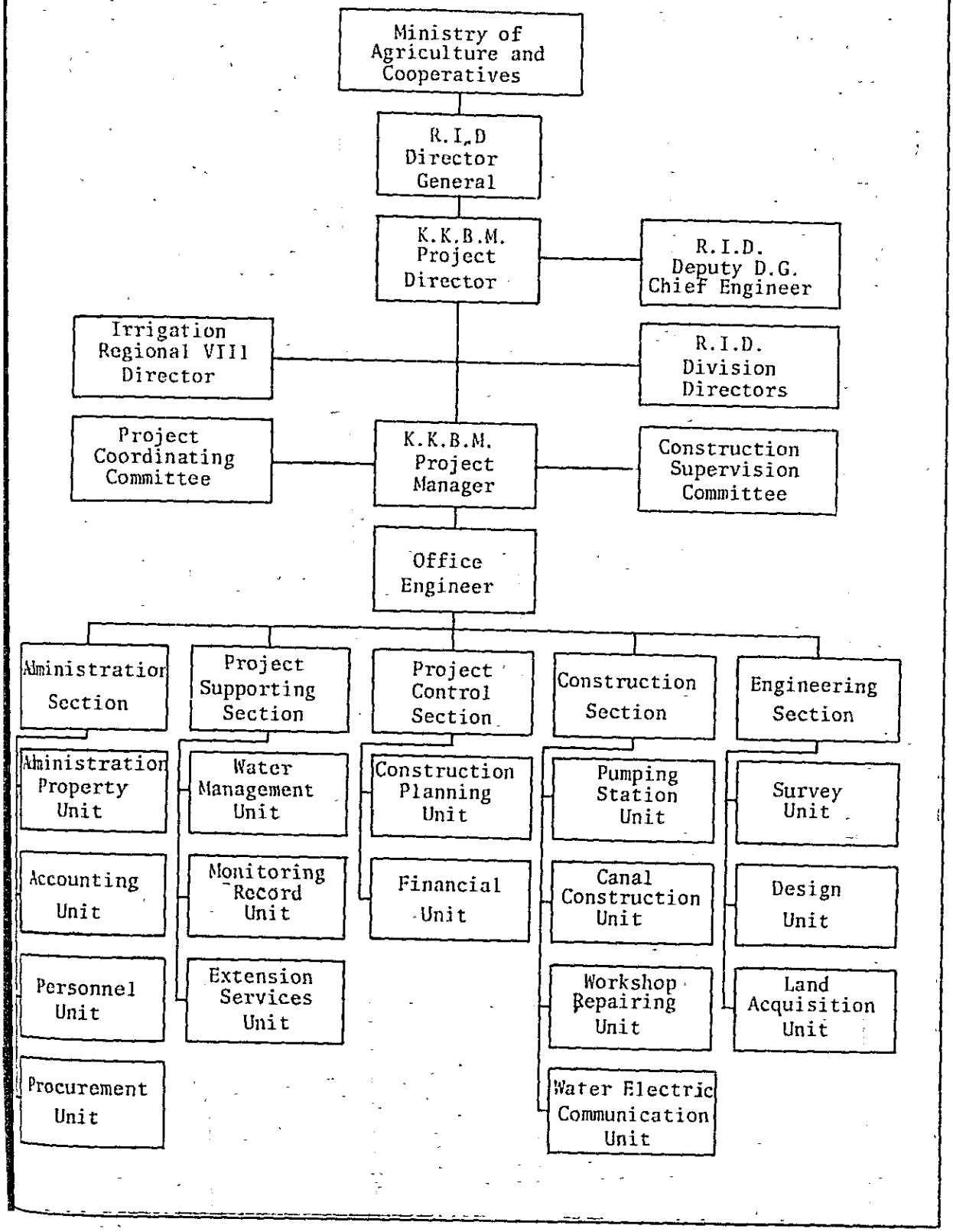
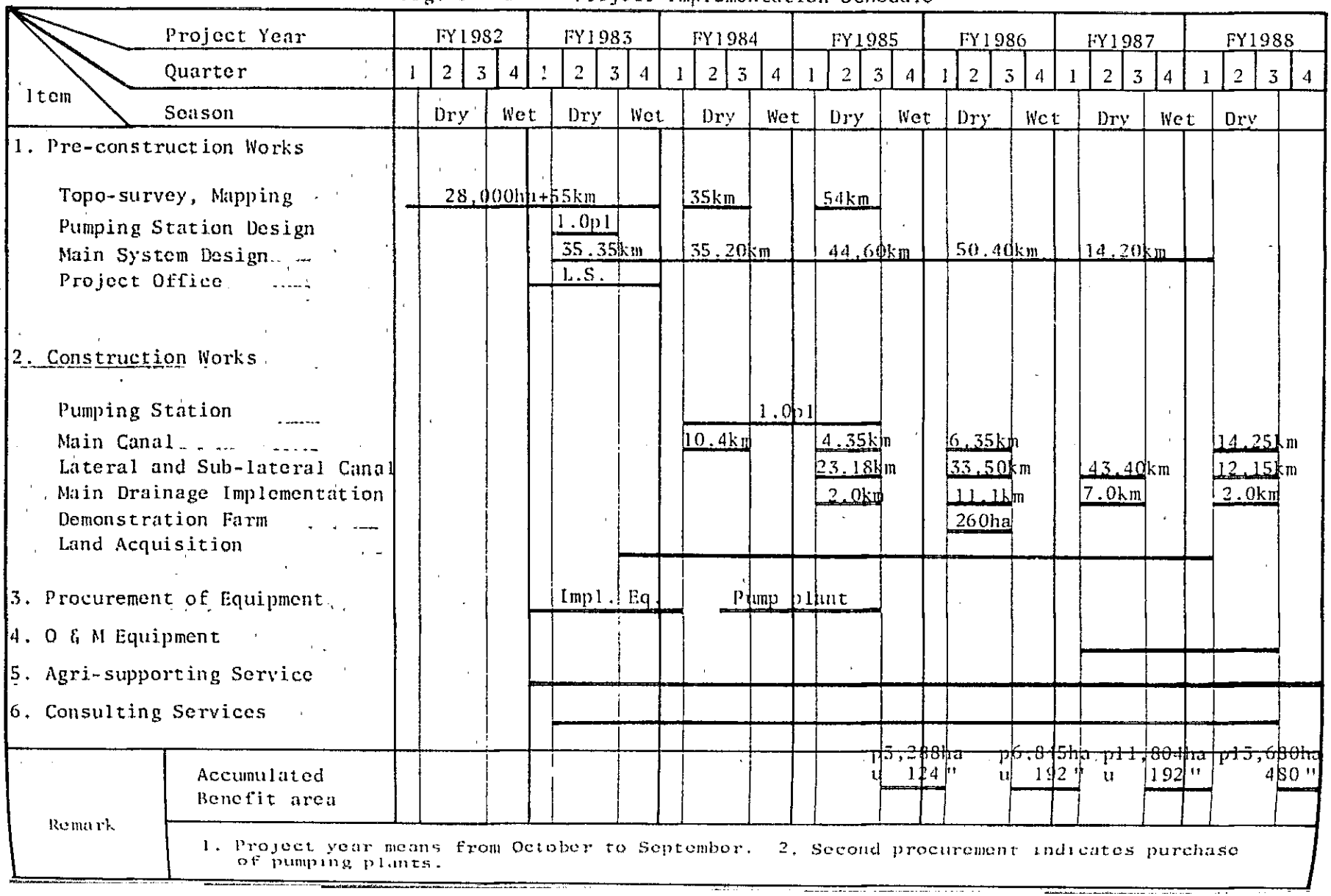


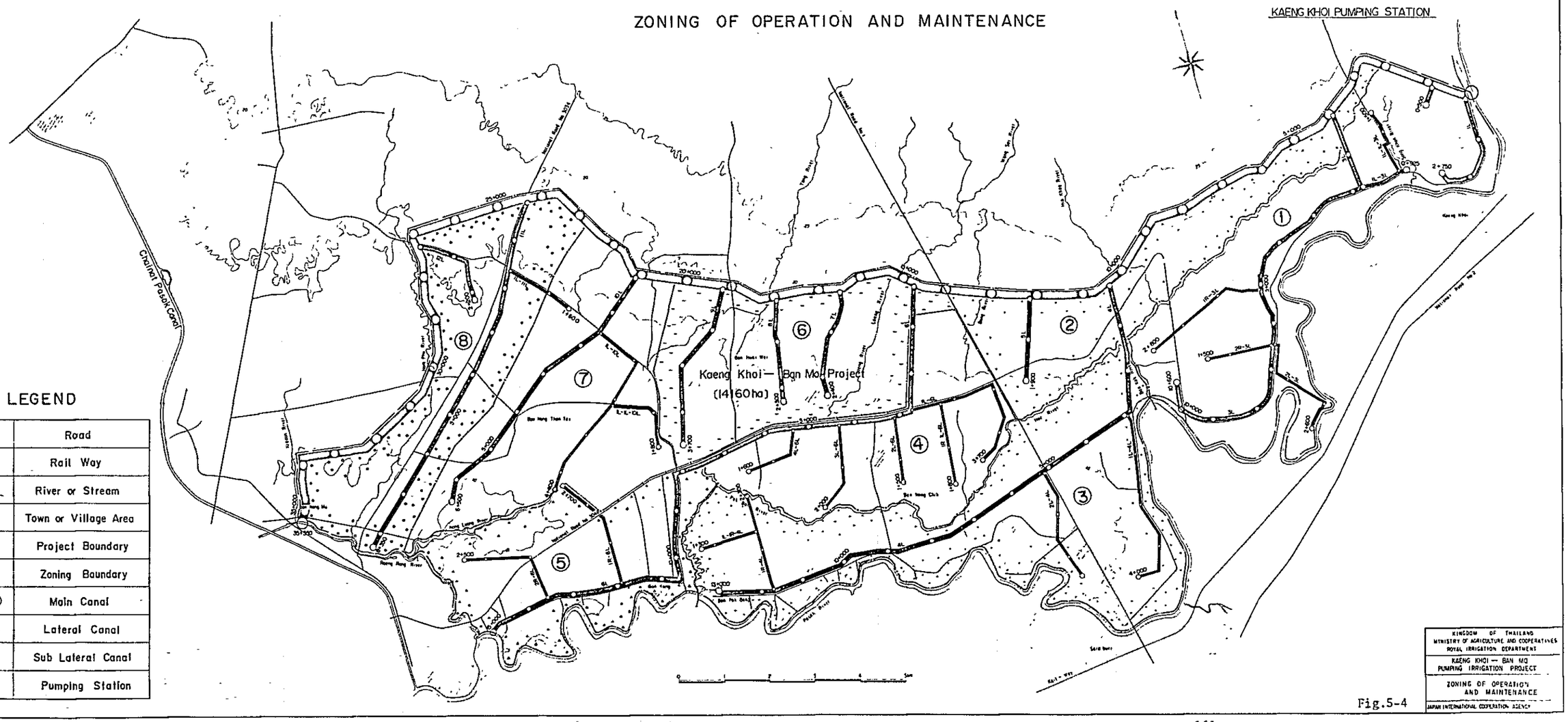
Fig. 5 - 2 Project Implementation Schedule



1. Project year means from October to September. 2. Second procurement indicates purchase of pumping plants.

Fig. 5-3 Yearly Construction Schedule of Canal

ZONING OF OPERATION AND MAINTENANCE



LEGEND

	Road
	Rail Way
	River or Stream
	Town or Village Area
	Project Boundary
	Zoning Baundary
	Main Canal
	Lateral Canal
	Sub Lateral Canal
	Pumping Station

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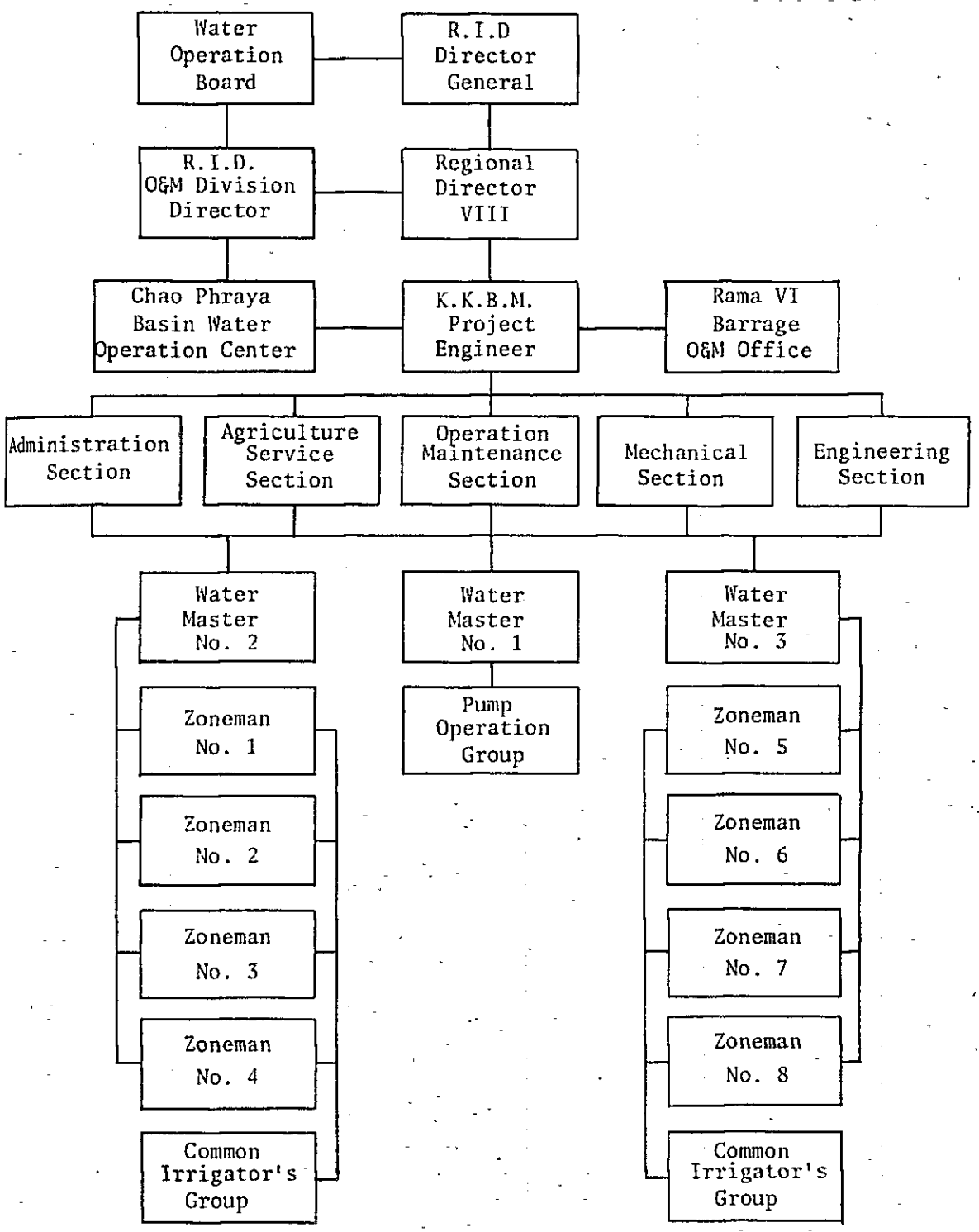
PUMPING IRRIGATION PROJECT

ZONING OF OPERATION AND MAINTENANCE

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.5-4

Fig.5-5 Proposed Organization of Operation and Maintenance



VI. PROJECT JUSTIFICATION

VI. PROJECT JUSTIFICATION

6.1. General Description

6.1.1. Objective and Component of the Project

At present, the cultivable land is mostly under rainfed condition in the proposed project area, except about 3,000 ha which can be served by small pumps along the Pasak River. But out of the 3,000 ha, about 2,000 ha in wet season and 680 ha in dry season are annually irrigated according to the cropping data obtained from the related Amphoe Agricultural Extension offices to the Project Area.

The main objective of the proposed project is to make irrigation water available for the whole cultivable land throughout wet season as well as to supply irrigation water during dry season as much as the water resource of Pasak River permits.

The component of the proposed project consists of:

i) construction of a pumping station with maximum capacity of 17.6 m^3/sec;

ii) construction of irrigation networks with 148 km of total canal length,

iii) improvement of drainage canal with total length of 22 km,

iv) construction of a demonstration farm of 260 ha with on-farm facilities, and

v) strengthening of agricultural supporting services.

6.1.2. Project Benefit

Since the main objective of the project is to supply irrigation water for the total cultivable land of 14,160 ha, the primary benefit of the project would be measured through an incremental agricultural production between two cases of "with project" and "without project".

On the basis of the proposed cropping patterns and the target yields of crops with and without project, the following incremental agricultural production would be expected at the full development stage of the project;

Incremental Agricultural Production

(Unit: 1,000 tons)

Crop	Without	With	Increment
Paddy	31.0	61.7	30.7
Maize	0.9	1.2	0.3
Groundnuts	0.1	0.13	0.03

6.2. Economic Evaluation

6.2.1. Method of Evaluation

For an economic evaluation, it seems presently most appropriate to work out an economic internal rate of return (E.I.R.R.) which can be computed by discounting both streams of economic cost and benefit with several discount rates over a project life, and to make sensitivity analysis which examines the economic internal rate of return by changing key factors of the project such as project cost, project benefit, target yield, and so on.

In order to determine a project life for an evaluation, it should be taken into account that there are various project facilities with respective durable life. In this proposed project,

most of all facilities has enough durable life of 50 years except some part of pumping equipments and O & M equipments for which replacement costs should be considered.

6.2.2. Prices and Conversion Factor

All prices have been estimated on the basis of the available information and data so far obtained up to July 1981. For both present and future prices of agricultural products such as paddy, maize and groundnuts, reference has been made to "Price Prospects for Major Primary Commodities" published by IBRD, January 1980.

In order to convert financial prices into economic ones, the following conversion factors have been taken into account;

Standard conversion factor	0.79
Conversion factor for Consumption	0.96
" " Middleman, wholesaler, exporter's margin	0.69
" " Rice miller's margin	0.72
" " Construction	0.74
" " Government services	0.65
" " Agricultural machinery	0.88
" " Fertilizer	0.92
" " Insecticide	0.88
" " Draft animals	1.01
" " Transport and handling	0.76
" " Pumping of water	0.85

Table 6-1 summarizes both economic and financial farmgate prices of agricultural input/output at 1981 constant prices. Price structures of paddy, maize and groundnuts are compiled in Table A.6.1-1 to A.6.1-3, respectively in Appendix VI.

Similarly analysis on an economic cost of farm labor is discussed in Appendix 6.2.

6.2.3. Economic Benefit

(a) Economic production cost

Generally, a crop production cost consists of input material and labor including animal and mechanical power. On the basis of data on crop production cost prevailing in Changwat Saraburi, field survey and the results of experiment made under Department of Agriculture, crop production costs have been estimated and summarized in Table 6-2, and economic production cost of each crop is detailed in Table A.6.3-1 to A.6.3-6 in Appendix VI.

(B) Net production value

A net production value of crop is obtainable by subtracting a crop production cost from a gross production value which is a product of yield and unit price of crops.

Based on the proposed cropping patterns with and without project, target yield and the economic production cost, net production values with and without project and its increment have been worked out as summarized in the following, of which details are given in Table A.6.3-7 in Appendix VI.

Crop	Net Production Value		
	Without	With	Increment
	(฿1,000)	(฿1,000)	(฿1,000)
Wet Season			
- Paddy	124,674	225,200	100,526
- Maize	1,679	2,212	533
- Groundnuts	131	170	39

Sub-total	126,484	227,582	101,098
Dry Season			
- Paddy	11,910	55,972	44,062
Total	138,394	283,554	145,160

Thus, the total incremental net production value of ฿145,160,000 is considered the economic benefit of the proposed project, after full development stage of the project.

(C) Benefit accrual

According to the construction schedule, some part of the project area can be irrigated from wet season in FY1985 just after installation of pumping facility, and after that irrigable area will increase year by year through expansion of irrigation canal network. Table 6-3 shows phasing of irrigable area during the construction period.

On the other hand, it is assumed that it would take six years to attain the proposed target yields of crops after the beginning of irrigation water available to farm land.

6.2.4. Economic Cost

(A) Initial cost

By deducting a price contingency and a land acquisition cost from the estimated financial initial cost and by applying the conversion factor for construction to the construction works of the local currency portion, the conversion factor for government services to the cost of supporting services, and the standard conversion factor to the local currency portion of the cost of consulting services, the economic initial cost can be worked out.

For the proposed project, Table 6-4 gives summary of both the financial and the economic initial costs, and Table A.6.3-8. of Appendix VI details the economic ones with disbursement schedule during the construction period.

(B) Operation and maintenance cost

By applying similar method as mentioned above, the economic cost for operation and maintenance of the project facilities can be estimated, amounting to ฿11,561,000 annually, after full development of the project.

(C) Replacement cost

Replacement costs for those facilities and equipment which have shorter durable life than the evaluation period, must be taken into account in the economic cost.

The following is summary of replacement costs incurred by the proposed project.

	Durable Life (yrs.)	Replacement Cost (฿1,000)
O & M Equipment	10	8,100
Pump	20	15,000

6.2.5. Economic Internal Rate of Return

On the basis of the estimated economic cost and benefit, Table 6-5 indicates streams of them and net benefit over 50 years of the evaluation period, based on which present worth values are computed by discounting these streams with several discount rates. Tables 6-6 and 6-7 show the present worth values of economic cost and benefit, respectively.

Table 6-8 summarizes the total present worth value of cost and benefit as well as benefit cost ratio at respective discount rate, and the economic internal rate of return can be calculated at 16.9 percent as shown in Fig.6-1.

6.2.6. Sensitivity Analysis

Sensitivity analysis is the effective measures of testing the riskness of this project. Analysis has been made on the following items;

° Cost increase

The project involves the considerable amount of the initial investment cost which is spread over a number of year. Thus, sensitivity tests should be made on increase of the initial investment cost by 10 percent and 20 percent.

° Delay in completion of construction works

Generally, many projects might not be implemented as schedule envisaged in the feasibility study. The effect of sensitivity analysis on this indicator is estimated in case of two years extension of construction period.

° Crop yield

The target yield of crops is also very important factor of the project, thus sensitivity test is made in case of 10 percent decrease in the proposed target yield of paddy.

° Project benefit

Sensitivity test is made in case of 10 percent and 20 percent decrease of the project benefit, taking into consideration

uncertainty in estimation of future prices of agricultural input/output.

° Including on-farm development

Implementation of the land consolidation works is very important role for the irrigated agricultural development project. The economic evaluation is made in case of execution of on-farm development works in the entire Project Area.

The result of sensitivity analysis is summarized below and supporting data on the analysis are compiled in Appendix 6.4.

Item	E.I.R.R.(%)
1. Original	16.9
2. Initial Investment Cost	
10% increase	15.7
20% increase	14.7
3. Two years Extension of Construction Period	15.6
4. 10% Decrease in Paddy Yield	12.4
5. Project Benefit	
10% decrease	15.4
20% decrease	13.8
6. Including on-farm development	14.3

6.3. Farm Budget and Repayment Capacity

Representative farm size has been calculated by using the land use pattern with and without project, and the present number of farm household in the project area. The representative farm size and cropping pattern with and without project are summarized below.

(unit: ha)

	Without Project	With Project
1. Farm Size	4.0	3.9
2. Cropped Area		
Wet Season		
Paddy (transplant)		
L.V.	2.34	1.88
H.Y.V. (Rainfed)	0.46	-
H.Y.V. (Irrigated)	0.55	1.88
Paddy (broadcast)	0.26	-
Maize	0.12	0.14
Sub-total	3.73	3.90
Dry Season		
Paddy (H.Y.V.)	0.19	0.77
Total	3.92	4.67
3. Cropping Intensity (%)	98%	120%

On the basis of the financial prices of agricultural input/output, target yield of crops and financial crop production cost, Table 6-9 summarizes results of the farm budget analysis, showing ฿25,824 of farm family surplus without considering any off-farm income would be expected after full development stage of the project, of which a half, or ฿12,912 could be considered farmers' repayment capacity.

Total operation and maintenance cost of the project is estimated at ฿13,100,000 in financial terms equivalent to ฿925 per ha or ฿3,579 per farm with project case which can be born by farmers with their repayment capacity of ฿12,912.

Assuming repayment period of 10 years with interest rate of 12 percent per annum, about 20 percent of the total initial investment cost could be chargeable to farmers with the remaining repayment capacity after paying the operation and maintenance cost.

6.4. Assessment and Prospectation on Environmental Impact by the Agricultural Development

6.4.1. General

The followings are the summary of the expected environmental impacts by implementation of the agricultural development including improvement of irrigation and drainage conditions:

i) Conversion of the land use plan
ii) Transportation scheme
iii) Water utilization scheme
iv) Application of agri-chemicals and water quality

The discussions were made as follows on prospectation and assessment for above mentioned major elements.

6.4.2. Conversion of the land use plan

As mentioned previous paragraph, the land use plan for the Project Area will have no conversion except some areas where the season cropping is increased and those occupied by the irrigation and drainage canals to be newly constructed. The proposed upland areas which will be irrigated, however, will have give consideration on the soil conservation against erosion by the irrigation water because the water supply to the fields will be made by the gravitational method (furrow irrigation method).

6.4.3. Transportation scheme

The road networks in the Project Area are comparatively well arranged except the eastern portion. It will be more intensively developed with high road density after completion of the proposed irrigation and drainage canals with roads. In the case, the irrigation and drainage conditions of the farm lands around the canal

systems will quite change. Therefore, it should consider not only convenience of the improved transportation conditions by the roads but also environmental improvement of the lands by provision of appropriate facilities.

6.4.4. Water utilization scheme

As discussed already in the paragraph on the availability of water resources, the water resources for the Project and related projects covering about 260,000 ha in total are almost availed for both the wet and dry seasons by better water management. The other water usages, such as domestic water and industrial supply, are quite small in amount, less than 1.0 cu.m per sec., and there will be no negative effects brought about in future.

6.4.5. Application of agri-chemicals and water quality

A little dosing of fertilizers and other agri-chemicals has been carried out in the Project Area; particularly, the agri-chemicals have been not so much dozed as the fertilizers due to expensiveness, and hence, some farmers have actually applied these chemicals less than the necessary amount suggested by the experimental station and the extension offices. Under the circumstances, the proposed high target yield through effective irrigation water supply and the intensive paddy farming provided by the Project will require more adequate fertilization to meet the prerequisite for the successful new farming. Therefore, it is necessary to carefully study the effects of these chemicals to the environment, specifically to fisheries and drinking water in due consideration of the increase in the dosing amount of the fertilizers and the addition of herbicides that have not been used yet in the Project Area.

The effects given by the herbicides and other chemicals should be more carefully studied than the fertilizers which are innoxious. Saturn herbicide will be used in the Project. The Saturn is a

non-hormon-type translocatable herbicide, which is efficacious to kill the weeds in their germination or early growing stage by spraying before or immediately after paddy transplanting. The Saturn is comparatively low toxic to fish in ranking B in the toxicity increase. Therefore, wide-area dosing of this herbicide should be carefully carried out, although ordinary level dosing will not seriously affect fish.

The critical concentration of the dust-type Saturn (element = 1.5%) is 12.8 ppm in the fields, whereas the allowable concentration to carp is said to be between 0.5 and 10 ppm. The Project designed the input amount of the Saturn by 15 kg per ha in being sprayed immediately after transplanting, and when taking the water depth in the fields at this stage by 10 cm, the Saturn concentration is estimated at 0.23 ppm which ranges in the allowable concentration even to carp. Spraying, however, should be carefully carried out lest that the chemical should run into the rivers and fish ponds adjacent to the fields through well-controlled drainage as well as that one spray should cover the wide area.

Mipcin (element = 4.4%), an agri-chemical toxicity ranking B in the same level as Saturn, is said to have the critical concentration by 5.0 ppm. The Mipcin is designed to be sprayed 30 kg per ha in the Project, and the chemical concentration in the fields, when taking the water depth by 10 cm, was estimated at 1.32 ppm which ranges in the allowable concentration. Spraying, however, should be carried out to the flooded fields and a particular attention should be given to the drainage control for four to five days after spraying as well.

Table 6-10 shows toxicity to fishes of various agricultural chemicals, and the toxicity is explained as follows;

Toxicity to fish

Rank A: An ordinary amount of dosing will have no problems in its toxicity to fish (carp affected by concentration more than 10 ppm,

water flea affected by concentration more than 10 ppm.)

Rank B: An ordinary amount of dozing will given little effect to fish, but dosing for a wide area should be carried out with a great care. (Carp affected by concentration ranging from 10 ppm to 0.5 ppm - chemicals specified in this rank will be more toxic to water flea, although less toxic to carp by allowance of 10 ppm) greater care.

Rank C: Dosing should be prohibited in the areas where the chemicals may be sprayed over or discharged into rivers, lakes and swamps, sea waters or fish pond waters. Even in the elsewhere defined as above, one dozing for a wide area should be refrained from.

a. The greatest care should be given to the after-dosing treatment that the water for cleaning the tools and vessels used for spraying should not be discharged into the running water and also the residual chemicals and the containers of chemicals should be buried into the earth so as to prevent fish from being affected. (Carp affected by concentration less than0.5 ppm).

Rank D: (Specially designated and restricted chemicals)
Since the chemicals specified in this rank are water polluting chemicals, dozing should be prohibited in the areas where the chemical dosing is banned. Even in the areas where the chemical dosing is permitted, the regulations for application should be stringently observed.

6.5. Socio-economic Impact

6.5.1. General

While the project benefit has been measured by only the tangible benefit acrrued from the incremental agricultural production, the following socio-economic impacts would be expected through the implementation of the proposed project.

- o Increase of employment opportunity
- o Expansion of agri-business
- o Increase in farmers' disposal income
- o Improvement of transportation network

6.5.2. Increase in Employment Opportunity

The farming labor demand has been projected to increase the annual total man-day of 1,201,200 without project case to 1,661,500 man-days with project case. Out of the difference of labor demand between with and without project, about 380,000 man-days could be absorbed by the farmer's own labor and only increase of 80,000 man-days for hired labor would be required, that would result in increase of farmers' disposal income in the project area.

6.5.3. Expansion of Agri-Business

Through implementation of the proposed project, paddy production will increase by about 30,000 tons, and considerable increase in agricultural input will be required. Consequentially, processing and marketing sectors of both agricultural input/output would be expanded together with providing more new employment opportunity in these sectors.

6.5.4. Increase in Farmers' Disposal Income

According to the farm budget analysis, a farm family surplus will increase ฿451 without project to ฿25,824 with project, without considering any off-farm income. Although the farmers may bear a half of the farm family surplus for repayment of the operation and maintenance cost as well as a part of the initial investment cost, they would be able to enjoy better living standard with incremental disposal income of ฿12,461.

6.5.5. Improvement of Transportation Network

After completion of the proposed project, the road network would be considerably improved by those maintenance roads which will be constructed along the irrigation and the drainage canals.

By using the new road network together with the present one, transportation of agricultural input/output would speed up, and daily activities of inhabitants would get much convenient.

Table 6-1 Economic and Financial Farmgate Prices
(at constant 1981 prices)

	Unit	1981		1990	
		Financial	Economic	Financial	Economic
Crop					
Paddy	฿/ton	3,720	5,190	5,160	6,800
Maize	฿/ton	2,620	3,205	3,340	3,995
Groundnuts	฿/ton	3,845	4,355	3,985	4,545
Seed					
Paddy (HYV)	฿/kg	5	6	6	7.2
Paddy (LV)	฿/kg	4	5.5	4.8	5.8
Maize	฿/kg	5	6	6	7.2
Groundnuts	฿/kg	10	12	12	14.4
Fertilizers					
Ammophos	฿/kg	6	5.5	7.2	6.6
Ammonium Sulfate	฿/kg	4	3.7	4.8	4.4
Potassium Chloride	฿/kg	7.5	6.9	9.0	8.3
Agr. Chemicals					
Padan Mipcin	฿/kg	20	17.6	20	17.6
Saturn	฿/kg	17.5	15.4	17.5	15.4
Asodrin	฿/kg	220	193.6	220	193.6
Labor					
Without Project	฿/man-day	35	-	44	24
With Project	฿/man-day	35	-	44	30
Animal & Machineries					
Draft Cattle	฿/head/day	45	45.5	54	54.5
Two-wheel Tractor	฿/hour	45.1	39.7	54.1	47.6
Thresher	฿/hour	44.5	39.2	53.4	47.0
Harrowing	฿/hour	150.7	132.6	180.8	159.1
Ridging	฿/hour	157.0	138.2	188.4	165.8
Pumping (wet)	฿/ha	363	308.6	436	371.0
Pumping (dry)	฿/ha	600	510.0	720	612.0
Fertilizing	฿/hour	7.2	6.3	7.6	6.7
Duster	฿/hour	6.1	5.4	6.5	5.7
Trailer	฿/hour	65.4	57.6	69.1	60.8

Table 6-2 Summary of Economic Production Cost

(Unit: ฿/ha)

Crop	Seed	Fertilizers	Agr. Chemicals	Labor	Agr. Machine	Animal	Pump	Others	Total
Without Project									
Wet Season									
Paddy (T.P.)									
LV	406	809	53	2,093	1,502	267	-	154	5,284
HYV (Rainfed)	432	990	53	2,129	1,317	256	-	155	5,332
HYV (Irrigated)	432	990	53	2,129	1,317	256	371	166	5,714
Paddy (B.C.)	522	770	2	953	1,117	1,226	-	138	4,728
Maize	130	26	1,162	1,536	907	409	-	125	4,295
Groundnuts	1,728	26	-	3,391	350	796	-	189	6,480
Dry Season									
Paddy	432	1,210	53	2,126	1,317	256	612	180	6,186
With Project									
Wet Season									
Paddy									
LV	319	1,318	759	2,985	2,651	-	-	241	8,273
HYV	360	1,455	759	2,982	2,651	-	-	246	8,443
Maize	72	1,320	1,549	1,242	1,296	-	-	164	5,643
Groundnuts	1,584	1,038	1,162	3,084	1,296	-	-	245	8,409
Dry Season									
Paddy	360	1,571	759	2,979	2,651	-	-	250	8,570

Table 6-3 Phasing of Irrigable Area with Project

(Unit: ha)

Year	Phase I	Phase II	Phase III	Phase IV	Total
Wet Season Cropping					
1985	3,412	-	-	-	3,412
1986	3,412	3,625	-	-	7,037
1987	3,412	3,625	4,959	-	11,996
1988 and further	3,412	3,625	4,959	2,164	14,160
Dry Season Cropping					
1985	2,800	-	-	-	2,800
1986	1,358	1,442	-	-	2,800
1987	795	846	1,159	-	2,800
1988 and further	675	717	980	428	2,800

Table 6-4 Summary of Initial Cost

(Unit: ₿1,000)

Description	Financial			Economic		
	F.C.	L.C.	Total	F.C.	L.C.	Total
1. Preparation	-	11,000	11,000	-	8,140	8,140
2. Civil Works	153,551	245,198	398,749	153,551	181,446	334,997
3. Equipment	64,485	6,280	70,765	64,485	4,647	69,132
4. Land Acquisition	-	17,300	17,300	-	-	-
5. Project Facility	-	5,000	5,000	-	3,700	3,700
6. Supporting Services	-	2,400	2,400	-	1,560	1,560
Sub-total	218,036	287,178	505,214	218,036	199,493	417,529
7. Administration	-	50,526	50,526	-	41,754	41,754
8. Consulting Services	31,760	9,340	41,100	31,760	7,379	39,139
9. Total (1 to 8)	249,796	347,044	596,840	249,796	248,626	498,422
10. Physical Contingency	24,980	34,680	59,660	24,980	24,862	49,842
11. Price Contingency	98,570	180,730	279,300	-	-	-
12. Grand Total (9 to 11)	373,346	562,454	935,800	274,776	273,488	548,264

Table 6-5 Streams of Cost and Benefit

***** STREAMS OF PROJECT COST AND BENEFIT *****

(UNIT: THOUSAND BAHT)

PROJECT YEAR	PROJECT COST				PROJECT BENEFIT	NET BENEFIT
	INITIAL COST	REPLACE. COST	O & M COST	TOTAL		
1	3134	-	-	3134	-	-3134
2	15412	-	-	15412	-	-15412
3	143244	-	-	143244	-	-143244
4	97307	-	6614	103921	10262	-93659
5	121386	-	8302	129688	21005	-108683
6	94209	-	10579	104788	38241	-66547
7	73572	-	11562	85134	61647	-23487
8	-	-	11562	11562	89573	78011
9	-	-	11562	11562	115105	103543
10	-	-	11562	11562	133424	121862
11	-	-	11562	11562	142943	131381
12	-	-	11562	11562	145160	133598
13	-	-	11562	11562	145160	133598
14	-	-	11562	11562	145160	133598
15	-	-	11562	11562	145160	133598
16	-	-	11562	11562	145160	133598
17	-	8100	11562	19662	145160	125498
18	-	-	11562	11562	145160	133598
19	-	-	11562	11562	145160	133598
20	-	-	11562	11562	145160	133598
21	-	-	11562	11562	145160	133598
22	-	-	11562	11562	145160	133598
23	-	-	11562	11562	145160	133598
24	-	15000	11562	26562	145160	118598
25	-	-	11562	11562	145160	133598
26	-	-	11562	11562	145160	133598
27	-	8100	11562	19662	145160	125498
28	-	-	11562	11562	145160	133598
29	-	-	11562	11562	145160	133598
30	-	-	11562	11562	145160	133598
31	-	-	11562	11562	145160	133598
32	-	-	11562	11562	145160	133598
33	-	-	11562	11562	145160	133598
34	-	-	11562	11562	145160	133598
35	-	-	11562	11562	145160	133598
36	-	-	11562	11562	145160	133598
37	-	8100	11562	19662	145160	125498
38	-	-	11562	11562	145160	133598
39	-	-	11562	11562	145160	133598
40	-	-	11562	11562	145160	133598
41	-	-	11562	11562	145160	133598
42	-	-	11562	11562	145160	133598
43	-	-	11562	11562	145160	133598
44	-	15000	11562	26562	145160	118598
45	-	-	11562	11562	145160	133598
46	-	-	11562	11562	145160	133598
47	-	8100	11562	19662	145160	125498
48	-	-	11562	11562	145160	133598
49	-	-	11562	11562	145160	133598
50	-	-	11562	11562	145160	133598

Table 6-6 Present Worth of Cost

*** PRESENT WORTH OF COST ***

(UNIT: THOUSAND BAHT)

YEAR	C.STREAM	11.00 %	12.00 %	13.00 %	14.00 %	15.00 %	16.00 %	17.00 %	18.00 %	19.00 %	20.00 %
1	3134.	2823.	2798.	2773.	2749.	2725.	2702.	2679.	2656.	2634.	2612.
2	15412.	12509.	12286.	12070.	11859.	11654.	11454.	11259.	11069.	10883.	10703.
3	143244.	104739.	101958.	99276.	96686.	94185.	91770.	89438.	87183.	85003.	82896.
4	103921.	68456.	66044.	63737.	61530.	59417.	57395.	55458.	53601.	51822.	50116.
5	129688.	76964.	73589.	70390.	67356.	64478.	61746.	59152.	56688.	54346.	52119.
6	104788.	56024.	53089.	50332.	47740.	45303.	43009.	40851.	38817.	36900.	35093.
7	85134.	41006.	38510.	36187.	34023.	32005.	30123.	28366.	26726.	25193.	23759.
8	11562.	5017.	4670.	4349.	4053.	3780.	3527.	3293.	3076.	2875.	2689.
9	11562.	4520.	4169.	3849.	3555.	3287.	3040.	2814.	2607.	2416.	2241.
10	11562.	4072.	3723.	3406.	3119.	2858.	2621.	2405.	2209.	2030.	1867.
11	11562.	3668.	3324.	3014.	2736.	2485.	2259.	2056.	1872.	1706.	1556.
12	11562.	3305.	2968.	2667.	2400.	2161.	1948.	1757.	1587.	1434.	1297.
13	11562.	2977.	2650.	2361.	2105.	1879.	1679.	1502.	1345.	1205.	1081.
14	11562.	2682.	2366.	2089.	1847.	1634.	1448.	1284.	1139.	1012.	901.
15	11562.	2417.	2112.	1849.	1620.	1421.	1248.	1097.	966.	851.	750.
16	11562.	2177.	1886.	1636.	1421.	1236.	1076.	938.	818.	715.	625.
17	19662.	3335.	2864.	2462.	2120.	1827.	1577.	1363.	1179.	1022.	886.
18	11562.	1767.	1504.	1281.	1093.	934.	799.	685.	588.	505.	434.
19	11562.	1592.	1342.	1134.	959.	812.	689.	585.	498.	424.	362.
20	11562.	1434.	1199.	1003.	841.	706.	594.	500.	422.	357.	302.
21	11562.	1292.	1070.	888.	738.	614.	512.	428.	358.	300.	251.
22	11562.	1164.	956.	786.	647.	534.	442.	366.	303.	252.	209.
23	11562.	1049.	853.	695.	568.	465.	381.	312.	257.	212.	175.
24	26562.	2170.	1750.	1414.	1144.	928.	754.	613.	500.	408.	334.
25	11562.	851.	680.	545.	437.	351.	283.	228.	184.	149.	121.
26	11562.	767.	607.	482.	383.	305.	244.	195.	156.	126.	101.
27	19662.	1175.	922.	725.	572.	452.	357.	284.	225.	179.	143.
28	11562.	622.	484.	377.	295.	231.	181.	143.	112.	89.	70.
29	11562.	561.	432.	334.	259.	201.	156.	122.	95.	75.	58.
30	11562.	505.	386.	296.	227.	175.	135.	104.	81.	63.	49.
31	11562.	455.	345.	262.	199.	152.	116.	89.	68.	53.	41.
32	11562.	410.	308.	231.	175.	132.	100.	76.	58.	44.	34.
33	11562.	369.	275.	205.	153.	115.	86.	65.	49.	37.	28.
34	11562.	333.	245.	181.	134.	100.	74.	56.	42.	31.	23.
35	11562.	300.	219.	160.	118.	87.	64.	47.	35.	26.	20.
36	11562.	270.	196.	142.	103.	75.	55.	41.	30.	22.	16.
37	19662.	414.	297.	214.	154.	112.	81.	59.	43.	32.	23.
38	11562.	219.	156.	111.	80.	57.	41.	30.	21.	16.	11.
39	11562.	197.	139.	98.	70.	50.	35.	25.	18.	13.	9.
40	11562.	178.	124.	87.	61.	43.	31.	22.	15.	11.	8.
41	11562.	160.	111.	77.	54.	38.	26.	19.	13.	9.	7.
42	11562.	144.	99.	68.	47.	33.	23.	16.	11.	8.	5.
43	11562.	130.	88.	60.	41.	28.	20.	14.	9.	7.	5.
44	26562.	269.	181.	123.	83.	57.	39.	27.	18.	13.	9.
45	11562.	106.	71.	47.	32.	21.	15.	10.	7.	5.	3.
46	11562.	95.	63.	42.	28.	19.	13.	8.	6.	4.	3.
47	19662.	146.	96.	63.	42.	28.	18.	12.	8.	6.	4.
48	11562.	77.	50.	33.	21.	14.	9.	6.	4.	3.	2.
49	11562.	70.	45.	29.	19.	12.	8.	5.	3.	2.	2.
50	11562.	63.	40.	26.	17.	11.	7.	5.	3.	2.	1.
TOTAL	1144887.	416043.	394335.	374665.	356711.	340224.	325008.	310904.	297779.	285525.	274053.

Table 6-7 Present Worth of Benefit

*** PRESENT WORTH OF BENEFIT ***

(UNIT: THOUSAND BAHT)

YEAR	B.STREAM	11.00 %	12.00 %	13.00 %	14.00 %	15.00 %	16.00 %	17.00 %	18.00 %	19.00 %	20.00 %
1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4	10262.	6760.	6522.	6294.	6076.	5867.	5668.	5476.	5293.	5117.	4949.
5	21005.	12465.	11919.	11401.	10909.	10443.	10001.	9581.	9182.	8802.	8441.
6	38241.	20445.	19374.	18368.	17422.	16533.	15696.	14908.	14166.	13466.	12807.
7	61647.	29693.	27886.	26204.	24637.	23175.	21813.	20541.	19353.	18242.	17205.
8	89573.	38868.	36177.	33694.	31401.	29282.	27322.	25509.	23830.	22274.	20832.
9	115105.	44998.	41508.	38317.	35396.	32720.	30267.	28017.	25951.	24053.	22308.
10	133424.	46990.	42959.	39305.	35990.	32980.	30245.	27757.	25493.	23430.	21549.
11	142943.	45354.	41093.	37265.	33823.	30725.	27934.	25417.	23145.	21093.	19238.
12	145160.	41493.	37259.	33490.	30129.	27132.	24454.	22061.	19919.	18001.	16281.
13	145160.	37381.	33267.	29637.	26429.	23593.	21081.	18855.	16880.	15126.	13567.
14	145160.	33677.	29703.	26227.	23184.	20515.	18173.	16116.	14305.	12711.	11306.
15	145160.	30339.	26520.	23210.	20337.	17839.	15667.	13774.	12123.	10682.	9422.
16	145160.	27333.	23679.	20540.	17839.	15513.	13506.	11773.	10274.	8976.	7851.
17	145160.	24624.	21142.	18177.	15648.	13489.	11643.	10062.	8707.	7543.	6543.
18	145160.	22184.	18877.	16086.	13727.	11730.	10037.	8600.	7379.	6339.	5452.
19	145160.	19985.	16854.	14235.	12041.	10200.	8653.	7351.	6253.	5327.	4544.
20	145160.	18005.	15048.	12598.	10562.	8869.	7459.	6283.	5299.	4476.	3786.
21	145160.	16221.	13436.	11148.	9265.	7713.	6430.	5370.	4491.	3762.	3155.
22	145160.	14613.	11996.	9866.	8127.	6707.	5543.	4589.	3806.	3161.	2629.
23	145160.	13165.	10711.	8731.	7129.	5832.	4779.	3923.	3225.	2656.	2191.
24	145160.	11860.	9563.	7726.	6254.	5071.	4120.	3353.	2733.	2232.	1826.
25	145160.	10685.	8539.	6837.	5486.	4410.	3551.	2866.	2316.	1876.	1522.
26	145160.	9626.	7624.	6051.	4812.	3834.	3062.	2449.	1963.	1576.	1268.
27	145160.	8672.	6807.	5355.	4221.	3334.	2639.	2093.	1664.	1325.	1057.
28	145160.	7813.	6078.	4739.	3703.	2899.	2275.	1789.	1410.	1113.	881.
29	145160.	7039.	5427.	4194.	3248.	2521.	1961.	1529.	1195.	935.	734.
30	145160.	6341.	4845.	3711.	2849.	2192.	1691.	1307.	1012.	786.	612.
31	145160.	5713.	4326.	3284.	2499.	1906.	1458.	1117.	858.	661.	510.
32	145160.	5147.	3863.	2906.	2192.	1658.	1257.	955.	727.	555.	425.
33	145160.	4637.	3449.	2572.	1923.	1442.	1083.	816.	616.	466.	354.
34	145160.	4177.	3079.	2276.	1687.	1254.	934.	697.	522.	392.	295.
35	145160.	3763.	2749.	2014.	1480.	1090.	805.	596.	443.	329.	246.
36	145160.	3390.	2455.	1783.	1298.	948.	694.	510.	375.	277.	205.
37	145160.	3054.	2192.	1577.	1139.	824.	598.	435.	318.	233.	171.
38	145160.	2752.	1957.	1396.	999.	717.	516.	372.	269.	195.	142.
39	145160.	2479.	1747.	1235.	876.	623.	445.	318.	228.	164.	119.
40	145160.	2233.	1560.	1093.	769.	542.	383.	272.	193.	138.	99.
41	145160.	2012.	1393.	967.	674.	471.	330.	232.	164.	116.	82.
42	145160.	1813.	1244.	856.	591.	410.	285.	199.	139.	97.	69.
43	145160.	1633.	1110.	758.	519.	356.	246.	170.	118.	82.	57.
44	145160.	1471.	991.	671.	455.	310.	212.	145.	100.	69.	48.
45	145160.	1325.	885.	593.	399.	269.	182.	124.	85.	58.	40.
46	145160.	1194.	790.	525.	350.	234.	157.	106.	72.	49.	33.
47	145160.	1076.	706.	465.	307.	204.	136.	91.	61.	41.	28.
48	145160.	969.	630.	411.	269.	177.	117.	77.	51.	34.	23.
49	145160.	873.	563.	364.	236.	154.	101.	66.	44.	29.	19.
50	145160.	787.	502.	322.	207.	134.	87.	57.	37.	24.	16.
TOTAL	6273440.	657123.	571002.	499472.	439513.	388840.	345693.	308702.	276785.	249091.	224932.

Table 6-8 Calculation of Internal Rate of Return

***** CALCULATION OF INTERNAL RATE OF RETURN *****

(UNIT: THOUSAND BAHT)

DISCOUNT RATE	+++++ PRESENT WORTH BENEFIT	+++++ COST	B/C RATIO
11.00 %	657123.	416043.	1.58
12.00 %	571002.	394335.	1.45
13.00 %	499472.	374665.	1.33
14.00 %	439513.	356711.	1.23
15.00 %	388840.	340224.	1.14
16.00 %	345693.	325008.	1.06
17.00 %	308702.	310904.	0.99
18.00 %	276785.	297779.	0.93
19.00 %	249091.	285525.	0.87
20.00 %	224932.	274053.	0.82

INTERNAL RATE OF RETURN ---------- 16.9 %

Table 6-9 Preliminary Estimate of Farm Budget

	Without Project	With Project
1. Farm Size (ha)	4.0	3.9
2. Cropping Intensity (%)	98	120
3. Farm Family Income (฿)		
- On-farm Income	42,832	83,815
- Off-farm Income	8,301 1/	-
- Total	51,133	83,815
4. Expenditures (฿)		
- On-farm Cash Expenditures	13,655	27,293
- Cost of Hired Labor	3,810	5,663
- Land Tax 2/	125	244
- Household Expenditures 3/	24,791	24,791
- Total	42,381	57,991
5. Farm Family Surplus (฿)	8,752	25,824

Note: 1/ Based on the result of 30 farms survey

2/ ฿5.0 per rai for without project case and ฿10.0 per rai for with project case

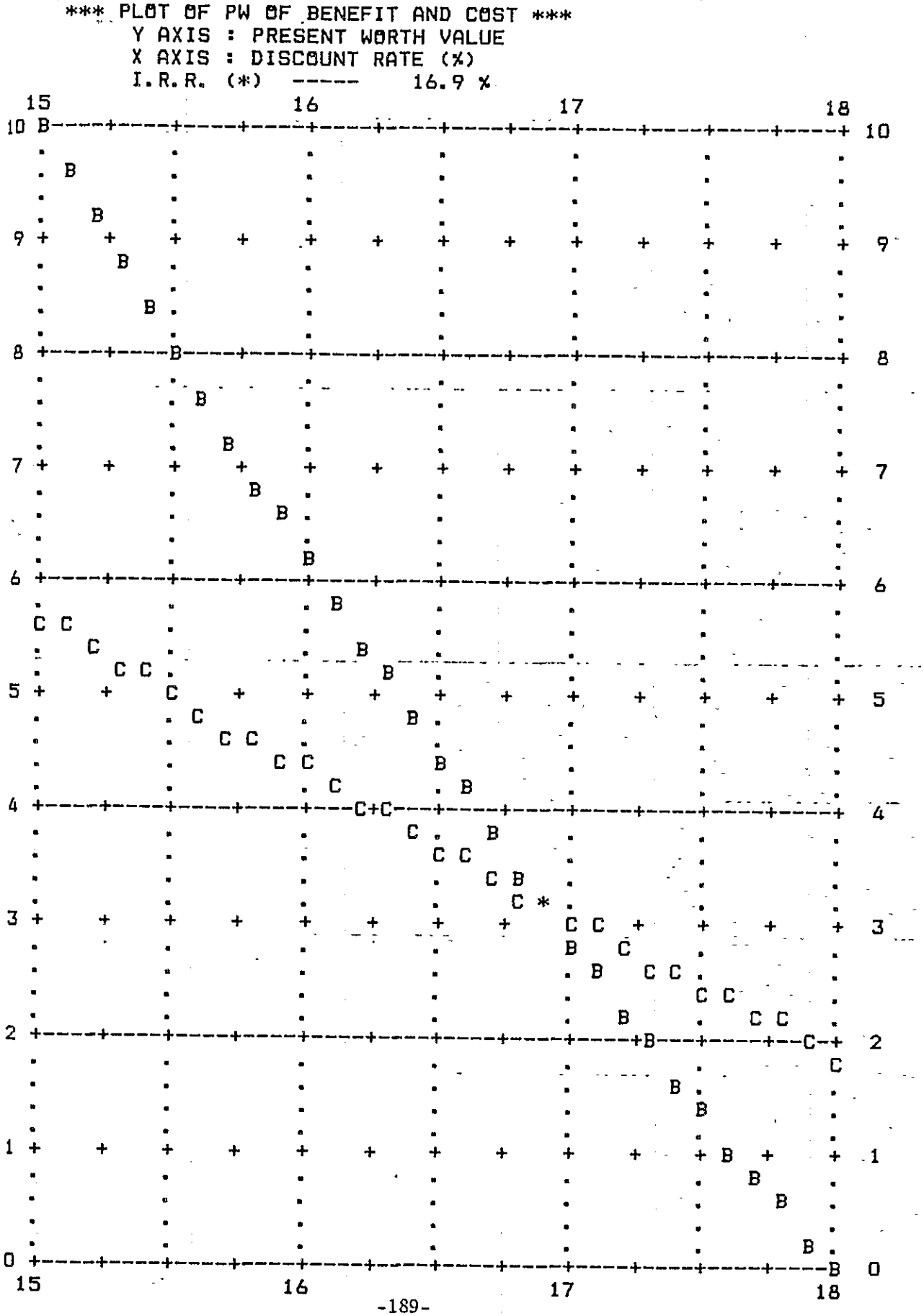
3/ Average household cash expenditures of 30 farms Surveyed (฿17,268 per family) multiplied by annual growth rate of consumption (4.1% per annum) over 9 years, which has been estimated by I.B.R.D.

Table 6-10 Toxicity for Fishes of Each Agri-chemicals

Name of Agri-chemicals	Element (%)	Toxicity for Fishes	Safety Concentration (ppm)
Fungicides			
Kitazin P	1.5	B	under 6.3
Polyoxin	0.35	A	20.0
Casmin	0.20	A	20.0
Organic Arsenic Compound		A	5.0
Insecticide			
Padan	4.0	B	0.65 — 0.39
Spanon	3.0	A	under 5.0
Diazinon	3.5	B	4.0
Sumithion	2.0	B	2.15
Baytex	5.0	B	1.8
*Mipcin	4.4	B	5.0
Herbicides			
MO	9.0	A	5.0
NIP	7.0	B	5.0
Hicut	0.7	B	5.0
*Saturn	1.5	B	12.8
2.4-PA	1.5	B	18.0

Note *: Agri- chemicals applied in the Project.

Fig.6-1 Plot of Present Worth of Benefit and Cost



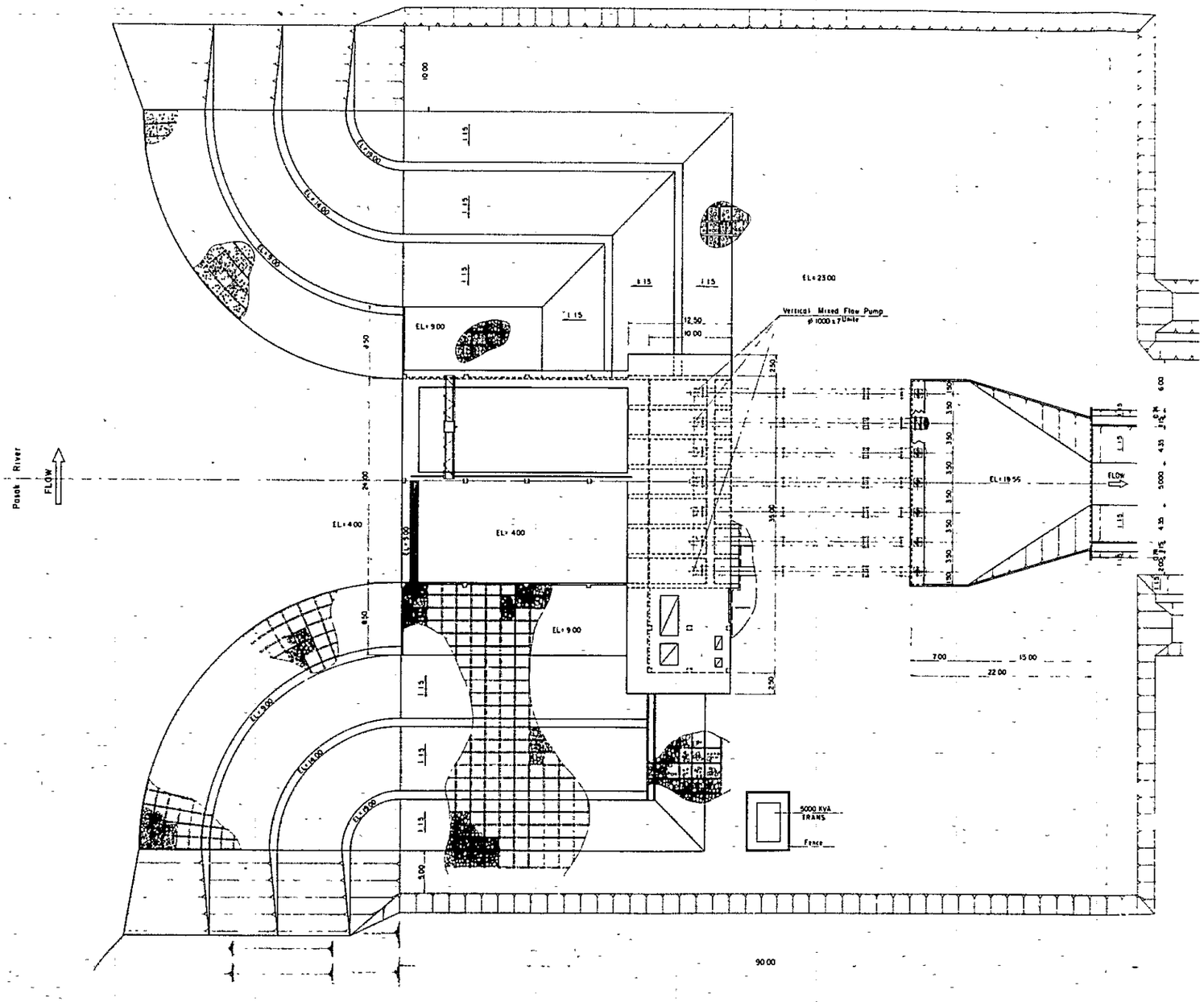
LIST OF DRAWINGS

LIST OF DRAWINGS

Drawing No.	D101	Kaeng Khoi Pumping Station (Plane)
	D102	" (Side View)
	D103	" (Front View)
	D104	Schematic Chart of Irrigation System
	D105	Profile of Irrigation Canal Main (1)
	D106	" Main (2)
	D107	"(1L, 2L, 3L, 1L-3L, 1L-1L-3L)
	D108	"(1R-3L, 2R-3L, 2L-3L, 4L)
	D109	"(1L-4L, 2L-4L, 1R-4L,1L-1R-4L,5L)
	D110	"(6L, 1L-6L, 1R-1L-6L, 2L-6L,3L-6L)
	D111	"(4L-6L, 1R-6L, 2R-6L, 7L, 8L, 9L)
	D112	"(10-L, 1L-10L, 1L-1L-10L, 11L)
	D113	"(1L-11L, 12L)
	D114	Profile of Drainage Canal (Main)
	D115	Standard Section of Irrigation Canal
	D116	Syphon
	D117	Concrete Box Culvert
	D118	Distributor
	D119	Constant Head Orifice
	D120	Turnout
	D121	Waste Way
	D122	Main Drainage Sluice

KAENG KHOI PUMPING STATION

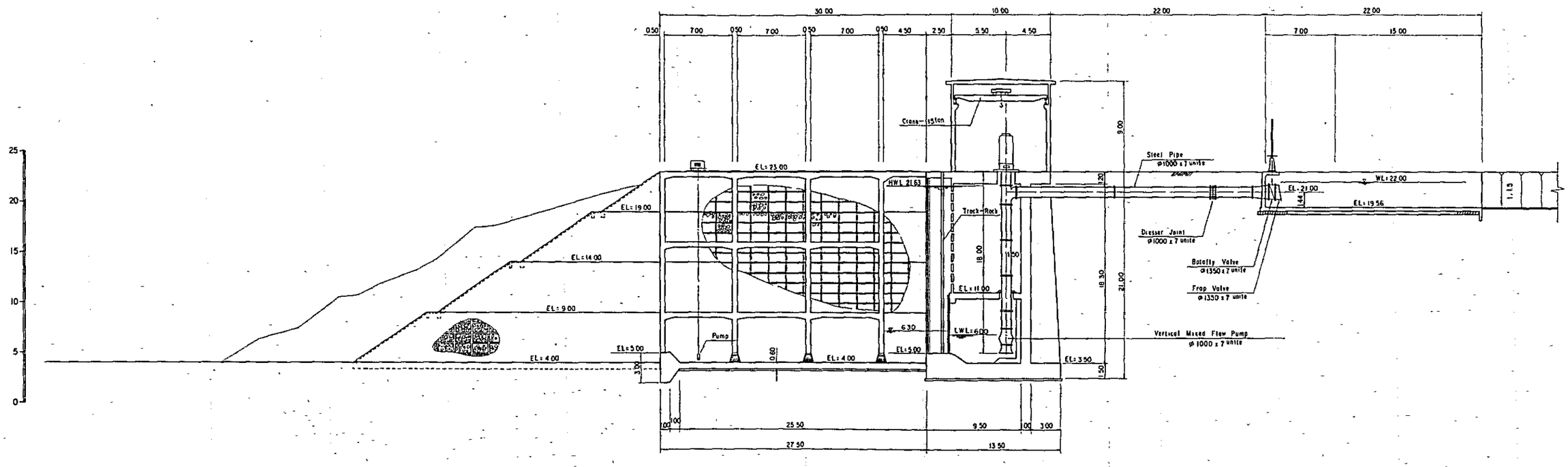
PLANE



KINGDOM OF THAILAND MINISTRY OF AGRICULTURE AND COOPERATIVES ROYAL IRRIGATION DEPARTMENT	
KAENG KHOI – BAN MO PUMPING IRRIGATION PROJECT	
KAENG KHOI PUMPING STATION (PLANE)	
JAPAN INTERNATIONAL COOPERATION AGENCY	D-101

KAENG KHOI PUMPING STATION

SIDE — VIEW



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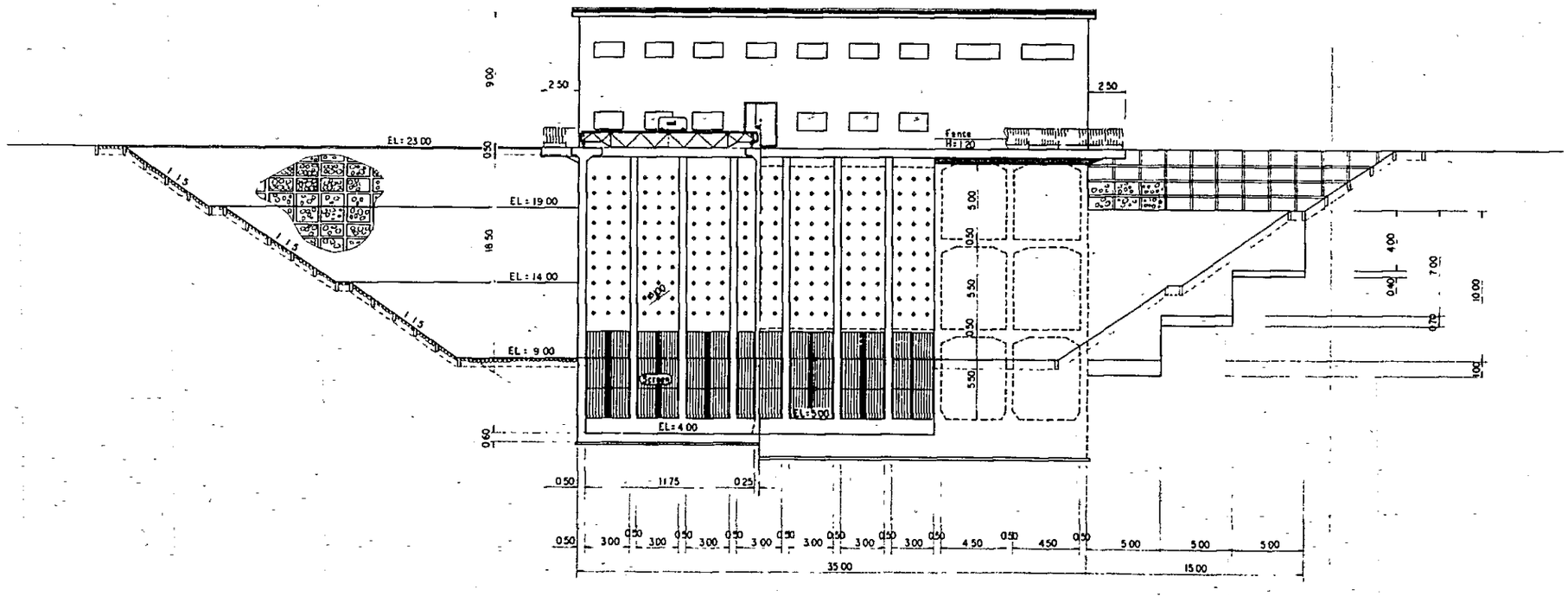
KAENG KHOI — BAN MO PUMPING IRRIGATION PROJECT
KAENG KHOI PUMPING STATION (SIDE — VIEW)
JAPAN INTERNATIONAL COOPERATION AGENCY D-102

KAENG KHOI PUMPING STATION

FRONT – VIEW



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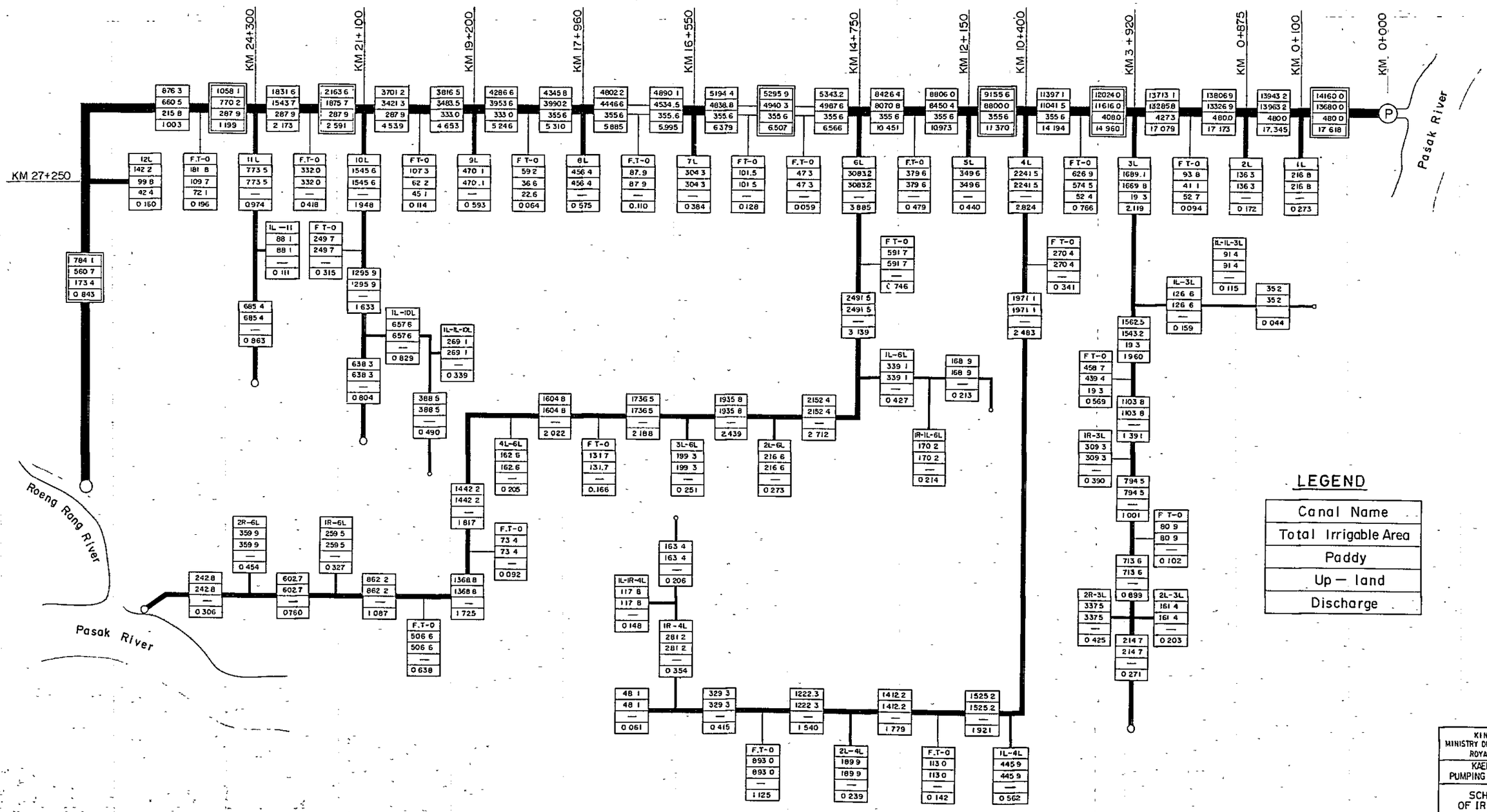
KAENG KHOI – BAN MO PUMPING IRRIGATION PROJECT
KAENG KHOI PUMPING STATION (FRONT-VIEW)
JAPAN INTERNATIONAL COOPERATION AGENCY D-103

SCHEMATIC CHART OF IRRIGATION SYSTEM

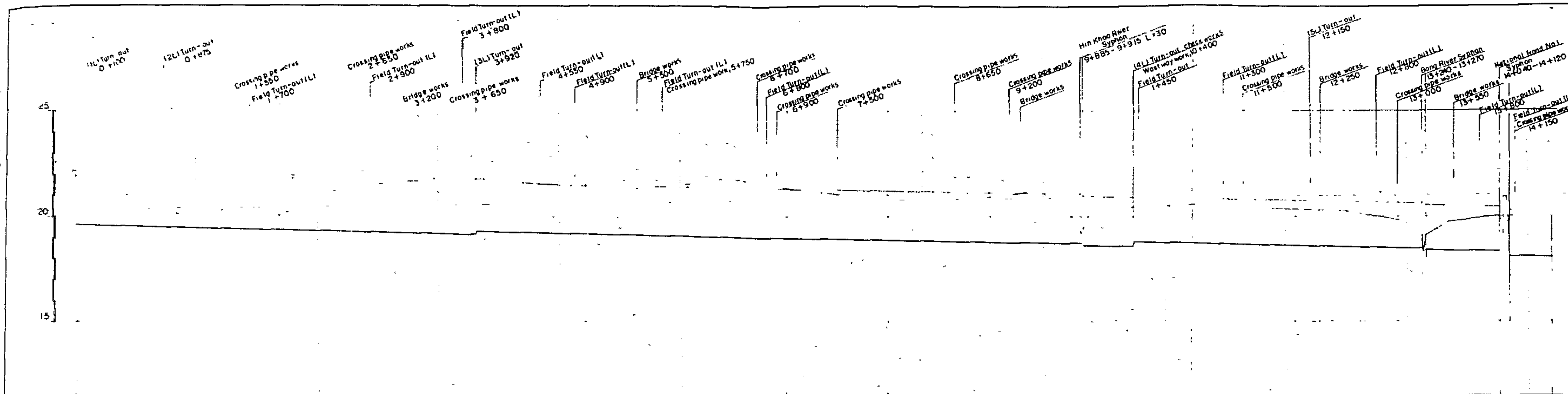


KINGDOM OF THAILAND
MINISTRY OF AGRICULTURE AND COOPERATIVES
ROYAL IRRIGATION DEPARTMENT

KAENG KHOI — BAN MO
PUMPING IRRIGATION PROJECT

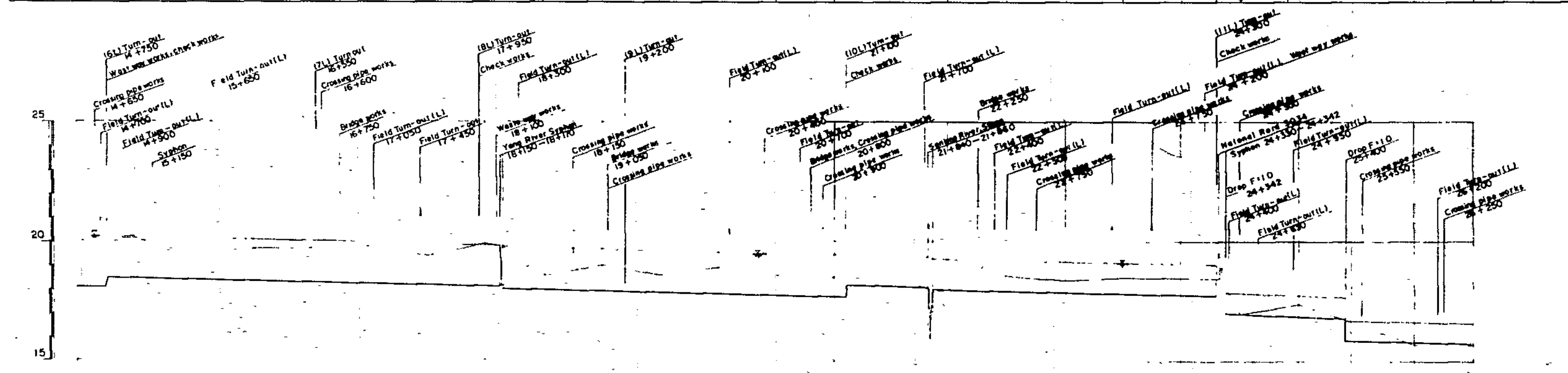
SCHEMATIC CHART
OF IRRIGATION SYSTEM

JAPAN INTERNATIONAL COOPERATION AGENCY D-104



STATION NO	DISTANCE	GROUND EL	WATER SURFACE EL
0+000	0.00	21.5	22.00
0+100	100.0	21.5	21.99
0+500	400	21.0	21.95
0+875	375	20.3	21.91
1+000	125	20.1	21.90
1+500	500	20.3	21.85
2+000	500	20.0	21.80
2+500	500	21.0	21.75
3+000	500	21.5	21.70
3+500	500	21.7	21.65
3+920	420		21.61 / 21.62
4+000	80	21.7	21.61
4+500	500	21.5	21.56
5+000	500	21.4	21.51
5+500	500	21.3	21.46
6+000	500	21.5	21.41
6+500	500	21.7	21.36
7+000	500	21.3	21.31
7+500	500	21.0	21.26
8+000	500	21.0	21.21
8+500	500	20.9	21.16
9+000	500	20.9	21.11
9+500	500	21.2	21.06
9+800	300	20.00	21.03
9+900	100	19.20	
10+000	100	20.4	20.90
10+400	400		20.86
10+500	100	20.4	20.85
11+000	500	20.5	20.80
11+500	500	20.3	20.75
12+000	500	20.3	20.70
12+150	150		20.69
12+500	350	20.2	20.65
13+000	500	19.8	20.60
13+240 / 13+255 / 13+270	240 / 15 / 15	[illegible] / 19.0	20.58 / 20.47
13+500	230	19.7	20.45
14+000 ... 14+120	500 / [illegible]	20.0 / [illegible] / 20.0	20.40 / 20.40 / 20.25
14+500	425	20.1	20.22

SLOPE: 1/10000



STATION NO	DISTANCE	GROUND EL	WATER SURFACE EL
14+500	425	20.1	20.22
14+750	250		20.19 / 20.20
15+000	250	20.1	20.17
15+500	500	19.4	20.12
16+000	500	19.7	20.07
16+500 / 16+550	500 / 50	19.7	20.02 / 20.02
17+000	450	19.8	19.97
17+500	500	19.4	19.92
17+950 / 18+000	450 / 50	19.9	19.88 / 19.87
18+150 / 18+160 / 18+170	150 / 10 / 10	[illegible]	19.86 / 19.76
18+350	180	19.0	
18+500	150	18.6	18.73
19+000	500	19.0	19.68
19+200	200		19.66
19+500	300	18.6	19.63
20+000	500	18.9	19.58
20+500	500	18.6	19.53
21+000	500	18.5	19.48
21+100	100		19.47 / 19.48
21+500	400	18.6	19.44
21+840 / 21+850 / 21+860	340 / 10 / 10	18.4 / [illegible]	19.41 / 19.30
22+000	140	18.0	19.29
22+300 / 22+350	300 / 50	19.0 / 19.0	19.26 / 19.25
22+500	150	18.6	19.24
23+000	500	18.4	19.19
23+500	500	18.5	19.14
24+000	500	18.5	19.09
24+330 / 24+342	330 / 12	18.5 / 18.5 / 18.5	18.94 / 17.94
24+500	158	17.0	17.92
25+000	500	17.4	17.82
25+400	400		17.74 / 16.74
25+500	100	16.6	16.72
26+000	500	15.7	16.62
26+500	500	15.7	16.52

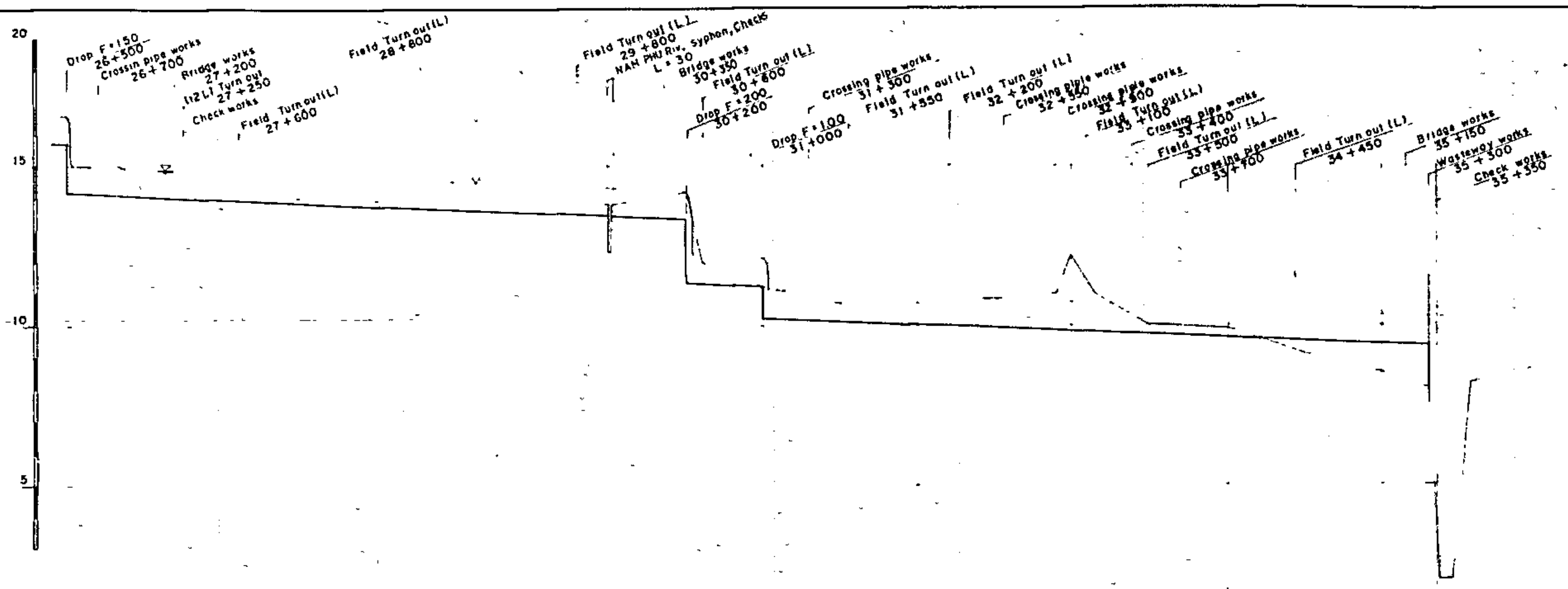
SLOPE: 1/10000, 1/5000

KINGDOM OF THAILAND
MINISTRY OF AGRICULTURE AND COOPERATIVES
ROYAL IRRIGATION DEPARTMENT

KAENG KHOI — BAN MO
PUMPING IRRIGATION PROJECT

PROFILE OF IRRIGATION CANAL
MAIN (1)

JAPAN INTERNATIONAL COOPERATION AGENCY D – 105



SLOPE	1/5000										
WATER SURFACE EL	15.32 15.02	14.92	14.87 14.86	14.83	14.73	14.63	14.53	14.43	14.33 14.30	14.21 12.19	12.11 11.11
GROUND EL	15.7	14.7		13.7	14.0	13.9	13.5	13.9	13.8(U) 12.3(D) 12.3(D) 13.8(U)	14.2 12.0	11.2
DISTANCE	500	500	250	250	500	500	500	500	500 15	485 100	400
STATION NO	26+500	27+000	27+250	27+500	28+000	28+500	29+000	29+500	30+000 30+015	30+500 30+600	31+000

SLOPE											
WATER SURFACE EL	11.01	10.91	10.81	10.73 10.71	10.68	10.61	10.51	10.41	10.31	10.25 10.24	
GROUND EL	10.7	10.7	10.8	11.0 12.2	11.0	10.0	9.9	9.1	8.5	8.0 2.0	
DISTANCE	500	500	500	400 100	150	350	500	500	500	300 50	
STATION NO	31+500	32+000	32+500	32+900 33+000	33+150	33+500	34+000	34+500	35+000	35+300 35+350	

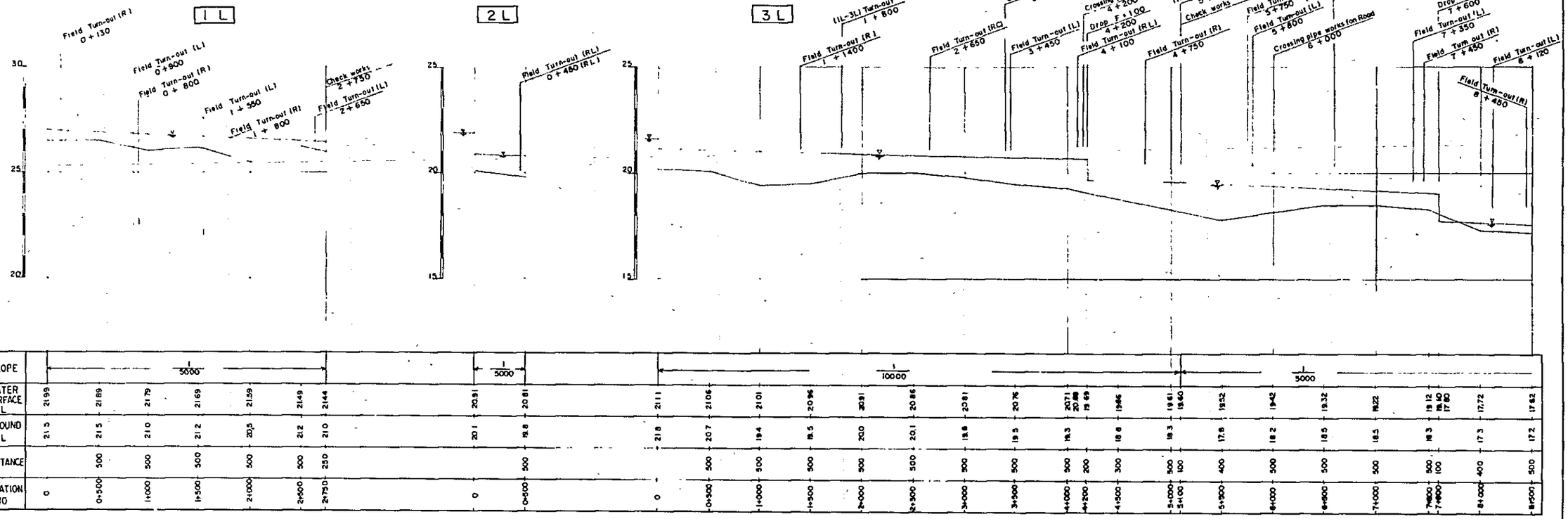
SLOPE	
WATER SURFACE EL	
GROUND EL	
DISTANCE	
STATION NO	

KINGDOM OF THAILAND
MINISTRY OF AGRICULTURE AND COOPERATIVES
ROYAL IRRIGATION DEPARTMENT

KAENG KHOI — BAN MO
PUMPING IRRIGATION PROJECT

PROFILE OF IRRIGATION CANAL
MAIN (2)

JAPAN INTERNATIONAL COOPERATION AGENCY D-106

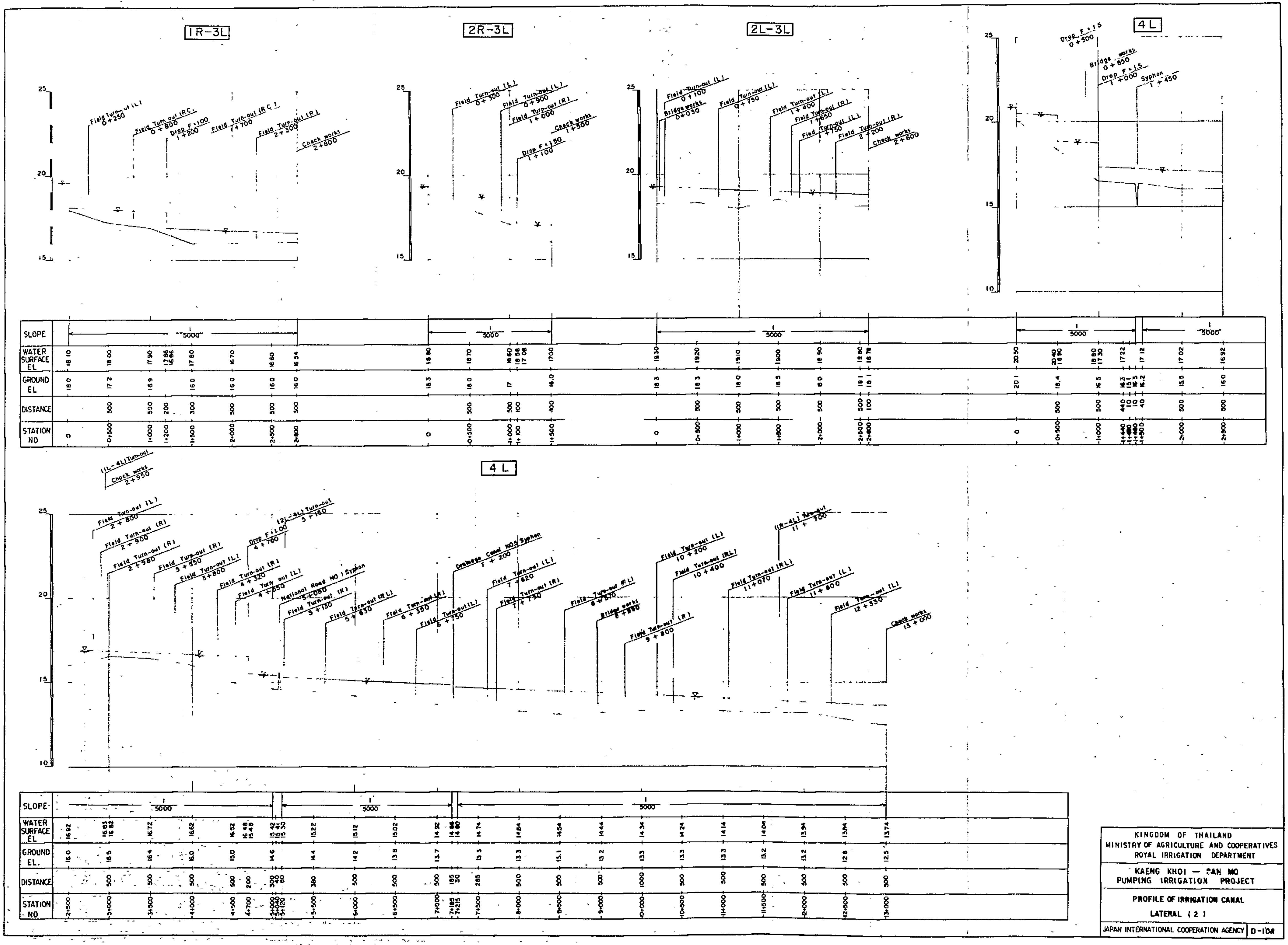


KINGDOM OF THAILAND
MINISTRY OF AGRICULTURE AND COOPERATIVES
ROYAL IRRIGATION DEPARTMENT

KAENG KHOI — SAN MO
PUMPING IRRIGATION PROJECT

PROFILE OF IRRIGATION CANAL
LATERAL (1)

JAPAN INTERNATIONAL COOPERATION AGENCY | D-107



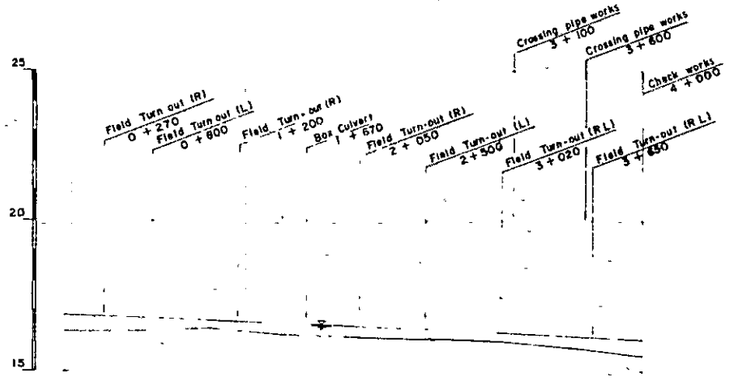
KINGDOM OF THAILAND
MINISTRY OF AGRICULTURE AND COOPERATIVES
ROYAL IRRIGATION DEPARTMENT

KAENG KHOI — BAN MO
PUMPING IRRIGATION PROJECT

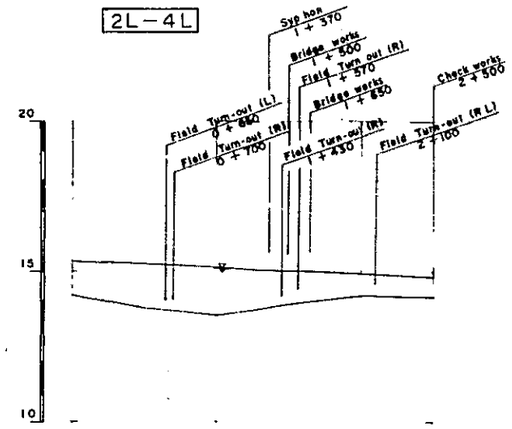
PROFILE OF IRRIGATION CANAL
LATERAL (2)

JAPAN INTERNATIONAL COOPERATION AGENCY | D-108

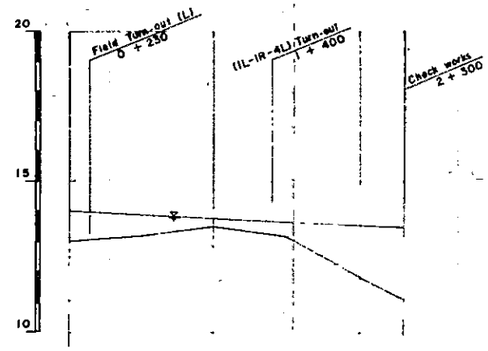
1L-4L



2L-4L

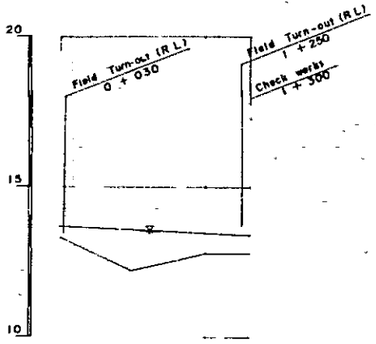


1R-4L

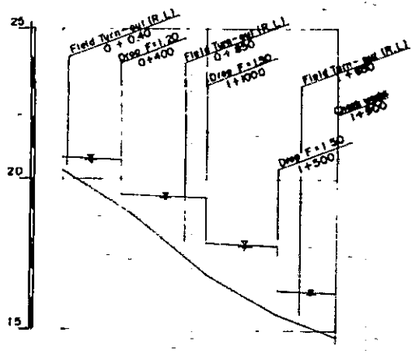


SLOPE		1/5000									1/5000							1/5000				
WATER SURFACE EL	16.83	16.73	16.63	16.53	16.43	16.33	16.23	16.13	16.03	15.29	15.19	15.09	14.99	14.89	14.80	14.00	13.90	13.80	13.70	13.60	13.54	
GROUND EL	16.3	16.3	16.4	16.2	16.1	16.1	16.0	15.8	15.5	14.2	13.8	13.5	13.9	14.2	14.2	13.0	13.2	13.5	13.2	11.8	11.1	
DISTANCE		500	500	500	500	500	500	500	500		500	500	500	500	500		500	500	500	500	300	
STATION NO	0	0+500	1+000	1+500	2+000	2+500	3+000	3+500	4+000	0	0+500	1+000	1+500	2+000	2+500	0	0+500	1+000	1+500	2+000	2+300	

1L-1R-4L



5L



SLOPE		1/5000									1/5000											
WATER SURFACE EL	13.68	13.58	13.48	13.42						20.69	20.61 / 19.39	19.29 / 17.79	17.68 / 16.19	16.11								
GROUND EL	13.3	12.2	12.8	12.8						20.3	18.8	16.8	15.5	14.7								
DISTANCE		500	500	300							400	100	500	500	400							
STATION NO	0	0+500	1+000	1+300						0	0+400	0+500	1+000	1+500	1+900							

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KAENG KHOI — BAN MO
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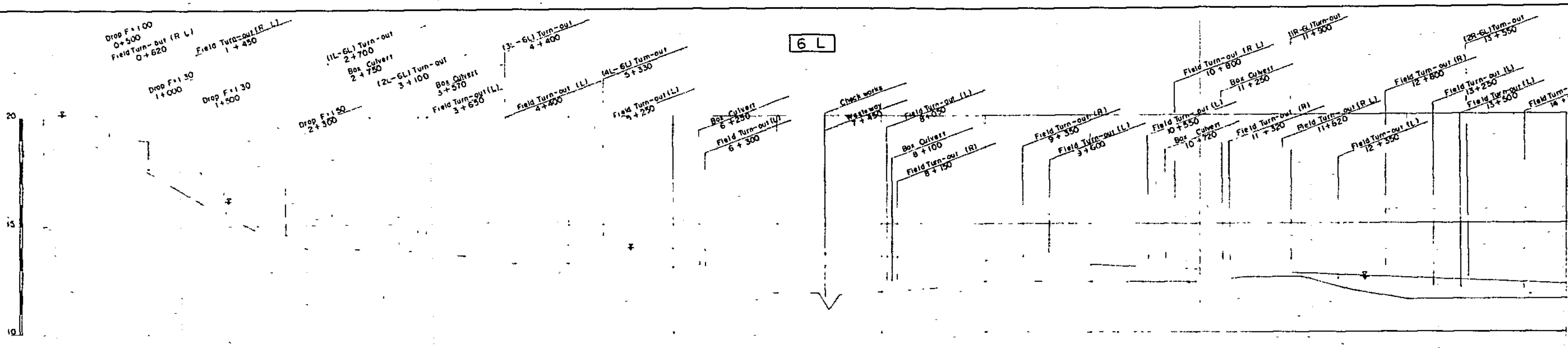
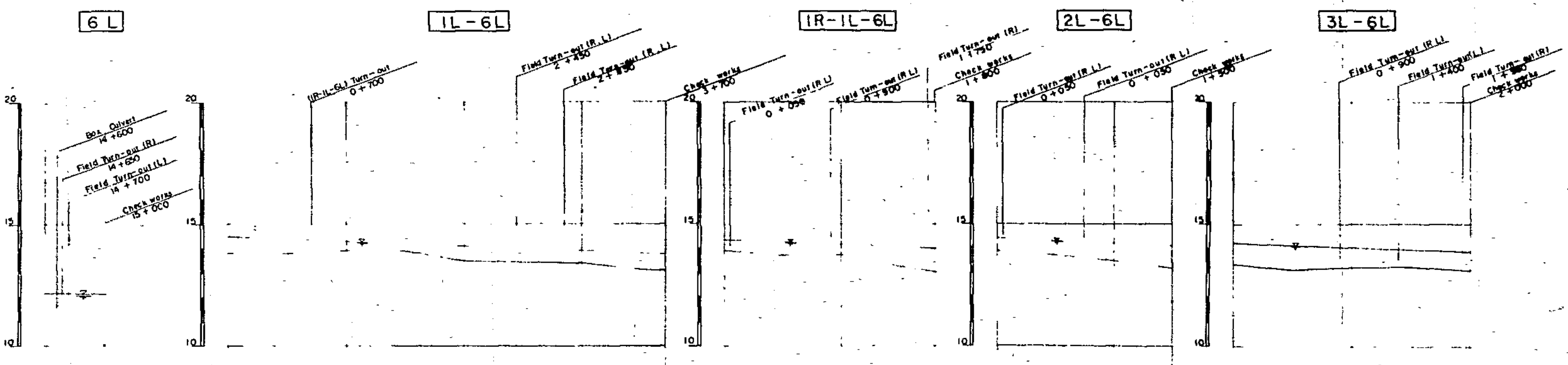
PROFILE OF IRRIGATION CANAL
LATERAL (3)

JAPAN INTERNATIONAL COOPERATION AGENCY | D-109



SLOPE	1/5000															
WATER SURFACE EL	2017	2007 1907	1897 1767	1757 1627	1617	1611 1461	1457	1447	1437	1427	1417	1407	1397	1387	1377	1367
GROUND EL	19.8	18.7	17.5	16.0	14.8		13.9	13.9	13.8	13.6	13.2	13.2	13.2	13.0	11.9	11.8
DISTANCE		500	500	500	500	300	200	500	500	500	500	500	500	500	500	500
STATION NO	0	0+500	1+000	1+500	2+000	2+300	2+500	3+000	3+500	4+000	4+500	5+000	5+500	6+000	6+500	7+000

SLOPE																		
WATER SURFACE EL	13.58	13.59	13.58	13.56	13.48	13.38	13.28	13.18	13.08	12.98	12.88	12.78	12.68	12.58	12.48	12.38	12.28	12.18
GROUND EL	11.8	11.7	11.0	11.7	11.8	12.0	12.3	12.3	12.3	12.3	12.3	12.5	12.5	11.9	11.5	11.5	11.5	11.5
DISTANCE	400	50	50	100	400	500	500	500	500	500	500	500	500	500	500	500	500	500
STATION NO	7+400	7+450	7+500	7+600	8+000	8+500	9+000	9+500	10+000	10+500	11+000	11+500	12+000	12+500	13+000	13+500	14+000	14+500



SLOPE	1/5000	
WATER SURFACE EL	12.18	12.08
GROUND EL	11.5	10.0
DISTANCE		500
STATION NO	14+500	15+000

SLOPE	1/5000								
WATER SURFACE EL	14.53	14.43	14.33	14.23	14.13	14.03	13.93	13.83	13.79
GROUND EL	13.8	13.8	13.9	13.9	13.5	13.4	13.4	13.2	13.1
DISTANCE		500	500	500	500	500	500	500	200
STATION NO	0	0+500	1+000	1+500	2+000	2+500	3+000	3+500	3+700

SLOPE	1/5000				
WATER SURFACE EL	14.39	14.29	14.19	14.09	14.03
GROUND EL	13.9	13.7	13.7	14.2	14.5
DISTANCE		500	500	500	300
STATION NO	0	0+500	1+000	1+500	1+800

SLOPE	1/5000			
WATER SURFACE EL	14.45	14.35	14.25	14.15
GROUND EL	13.9	13.7	13.5	13.2
DISTANCE		500	500	500
STATION NO	0	0+500	1+000	1+500

SLOPE	1/5000				
WATER SURFACE EL	14.19	14.09	13.99	13.89	13.79
GROUND EL	13.3	13.1	13.2	13.2	13.1
DISTANCE		500	500	500	500
STATION NO	0	0+500	1+000	1+500	2+000

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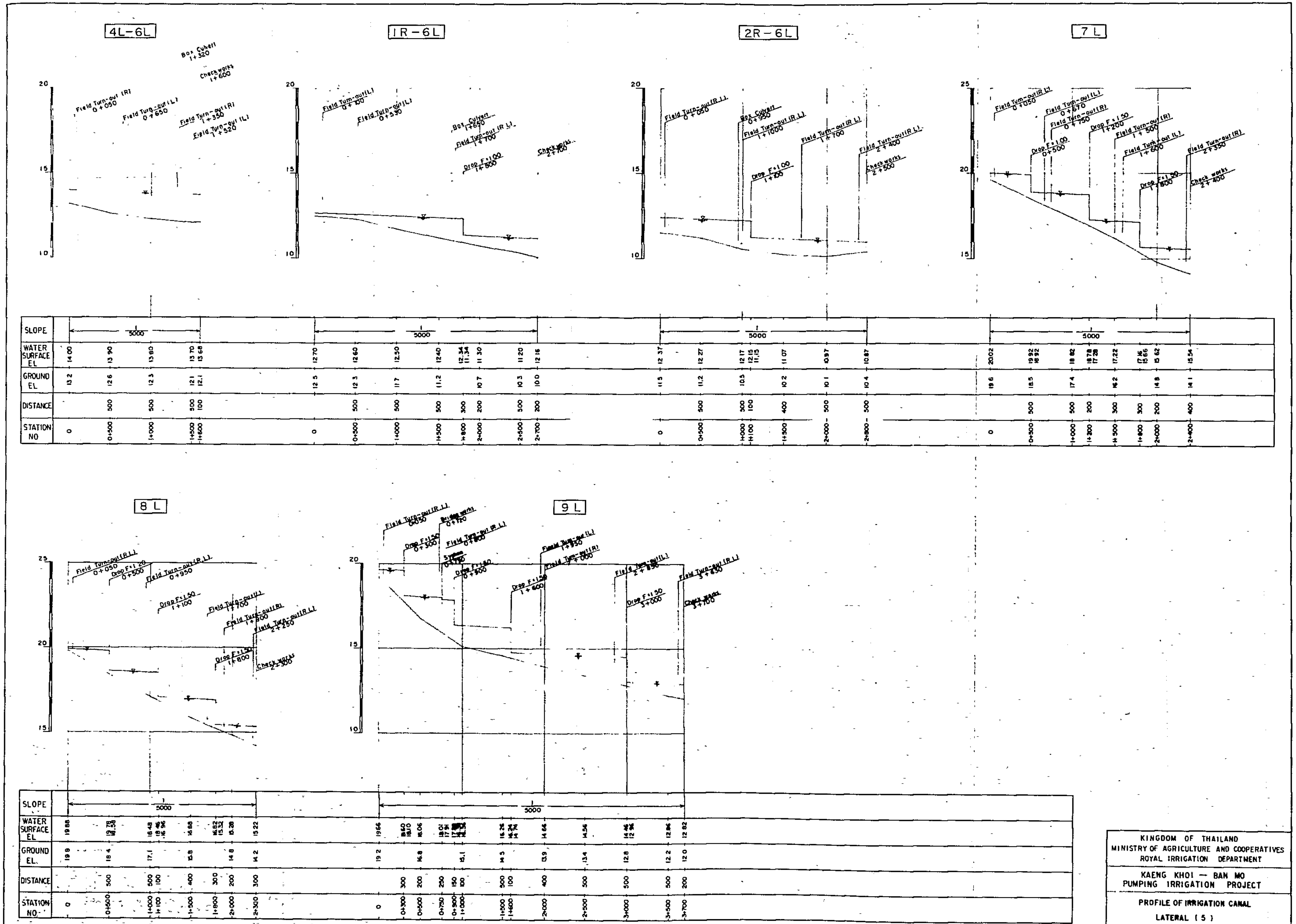
KAENG XHOI — BAN MO
PUMPING IRRIGATION PROJECT

PROFILE OF IRRIGATION CANAL
LATERAL (4)

JAPAN INTERNATIONAL COOPERATION AGENCY | D-110

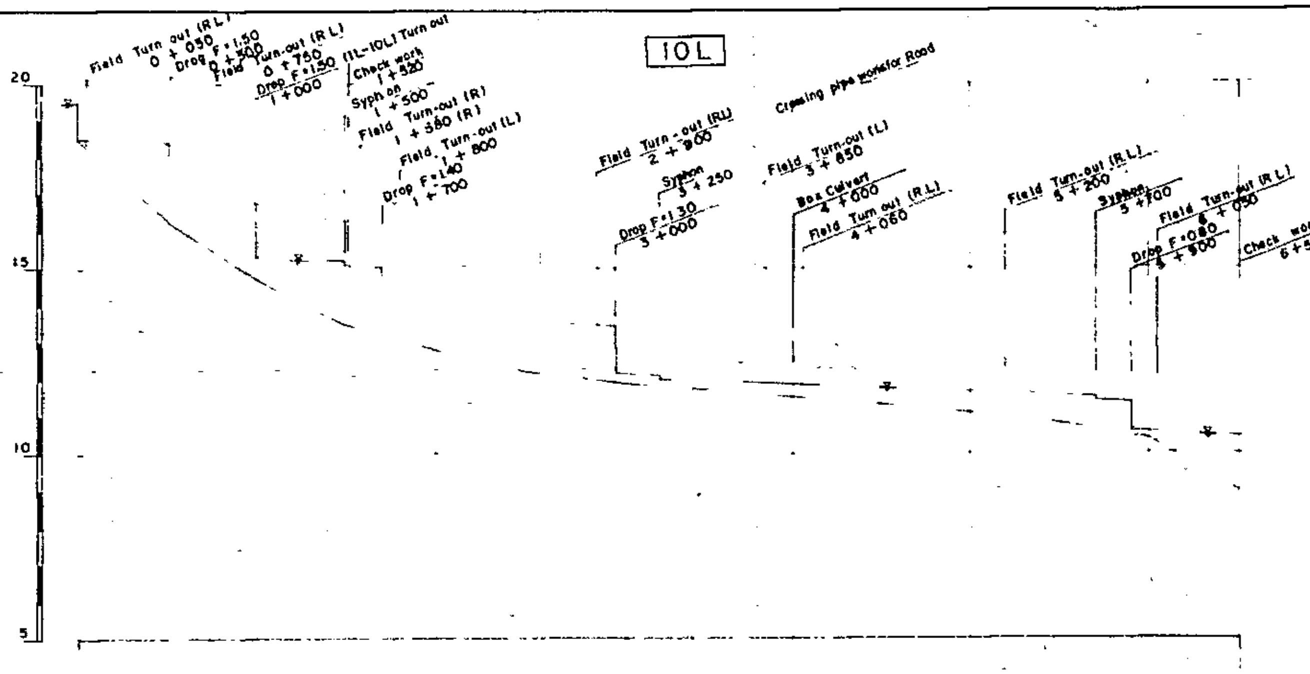


KINGDOM OF THAILAND
MINISTRY OF AGRICULTURE AND COOPERATIVES
ROYAL IRRIGATION DEPARTMENT

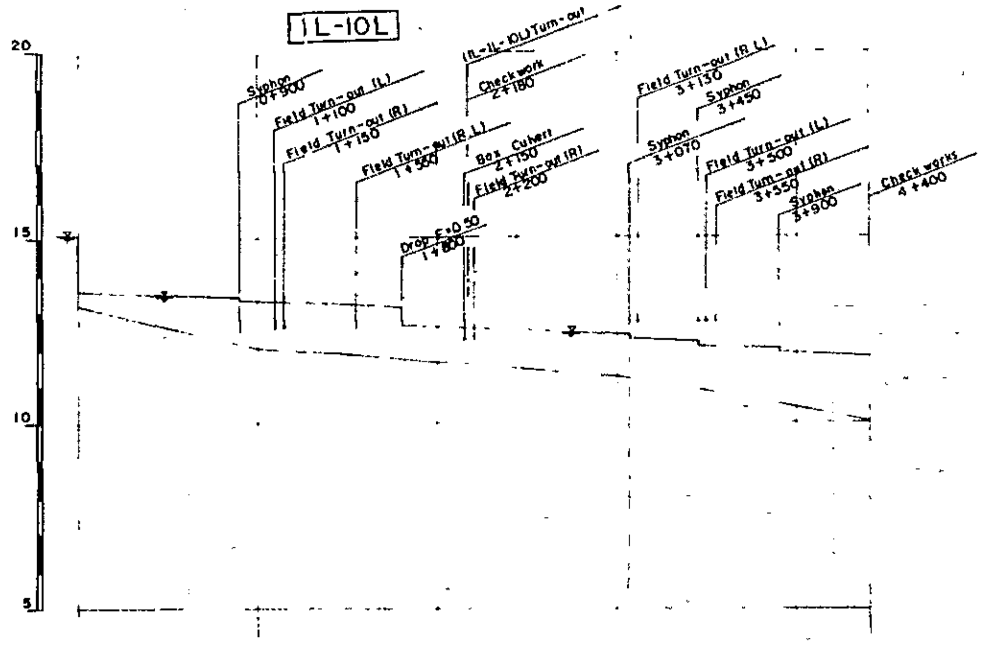
KAENG KHOI — BAN MO
PUMPING IRRIGATION PROJECT

PROFILE OF IRRIGATION CANAL
LATERAL (5)

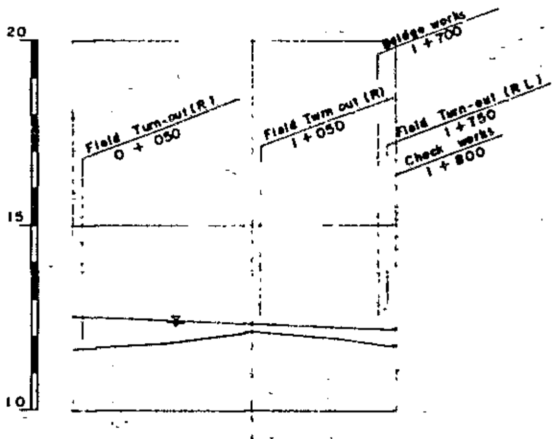
JAPAN INTERNATIONAL COOPERATION AGENCY | D-111



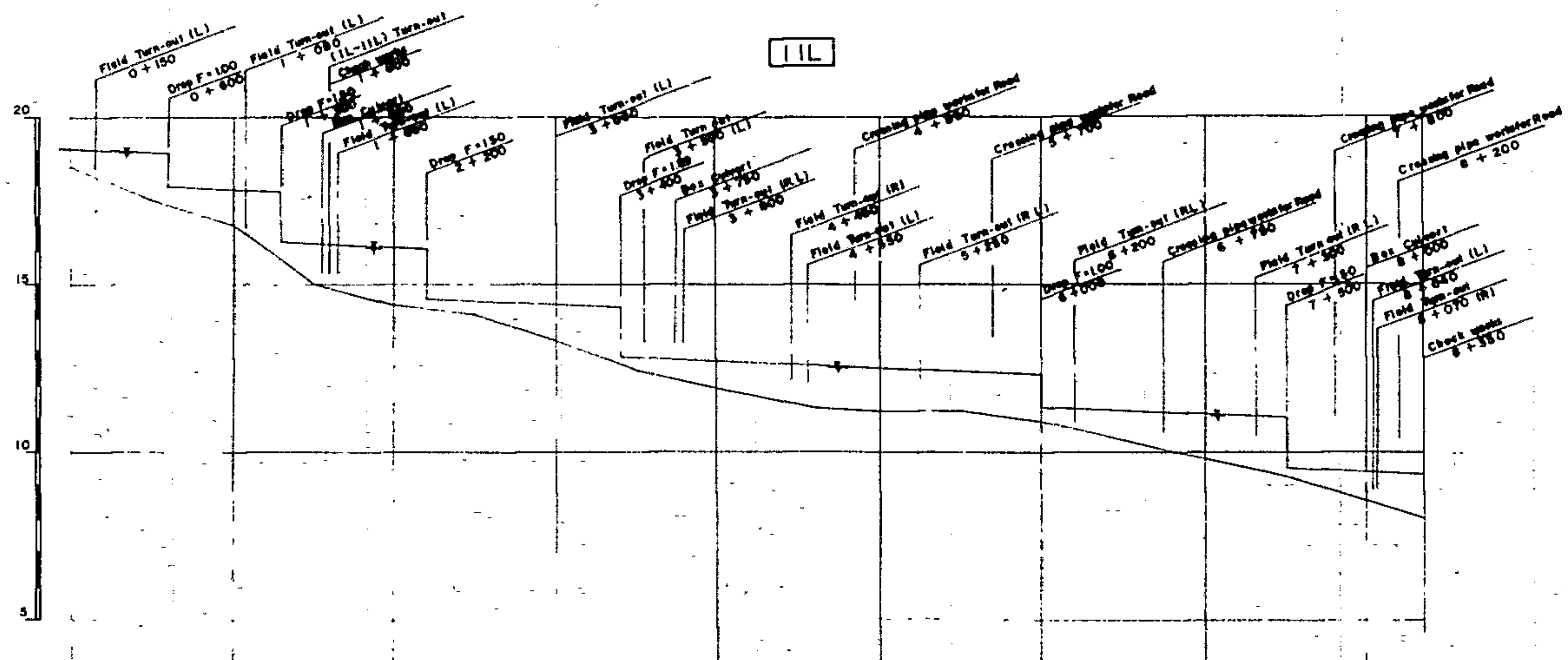
SLOPE	1/5000																
WATER SURFACE EL	18.48	18.38 16.38	16.78 15.28	15.18 15.00	15.04 13.64	13.58	13.48	13.38 12.08	12.03 11.93	11.88	11.78	11.68	11.58	11.48	11.44 11.34	11.30 10.50 10.48	10.38
GROUND EL	18.5	16.2	14.7	13.5		12.8	12.3	11.9		11.7	11.5	11.3	11.1	10.8		10.3	9.0
DISTANCE		500	500	500	200	300	500	500	250	250	500	500	500	500	200	200 100	500
STATION NO	0	0+500	1+000	1+500	1+700	2+000	2+500	3+000	3+250	3+500	4+000	4+500	5+000	5+500	5+700	5+900 6+000	6+500



SLOPE	1/5000										
WATER SURFACE EL	13.58	13.48	[illegible]	13.16	13.12 12.62	12.58	12.48	12.38 12.37 12.27	12.18 12.08 12.08	12.00 11.90 11.88	11.80
GROUND EL	13.2	12.6	12.0	11.8		11.6	11.4	11.2	10.8	10.4	10.0
DISTANCE		500	400 100	500	300	200	500	500 70	380 50	400 100	400
STATION NO	0	0+500	0+900 1+000	1+500	1+800	2+000	2+500	3+000 3+070	3+450 3+500	3+900 4+000	4+400



SLOPE	1/5000				
WATER SURFACE EL	12.54	12.44	12.34	12.24	12.14
GROUND EL	11.6	11.8	12.1	11.9	11.7
DISTANCE		500	500	500	300
STATION NO	0	0+500	1+000	1+500	1+800



SLOPE	1/5000																		
WATER SURFACE EL	19.06	18.96 18.84 17.94	17.86	17.80 16.30	16.26	16.16	16.12 14.62	14.56	14.46	14.38 12.86 12.86	12.76	12.66	12.56	12.46	12.36 11.36	11.26	11.16	11.06 9.56	9.46	9.36
GROUND EL	18.5	17.5	17.0		15.0	14.4		14.1	13.3	12.4	11.9	11.3	11.2	11.2	10.9	10.3	9.8	9.2	8.5	8.0
DISTANCE		500 100	400	300	200	500	200	300	500	500	500	500	500	500	500	500	500	500	500	350
STATION NO	0	0+500 0+600	1+000	1+300	1+500	2+000	2+200	2+500	3+000	3+500	4+000	4+500	5+000	5+500	6+000	6+500	7+000	7+500	8+000	8+350

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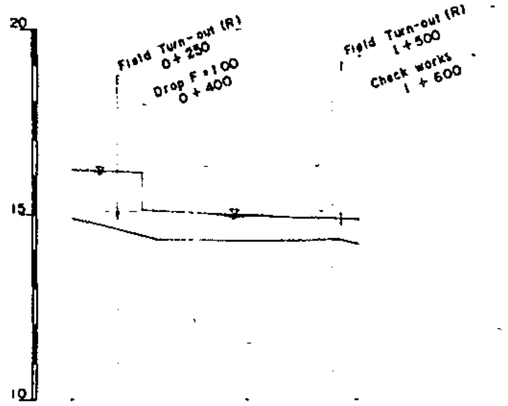
KAENG KHOI — BAN MO
PUMPING IRRIGATION PROJECT

PROFILE OF IRRIGATION CANAL
LATERAL (6)

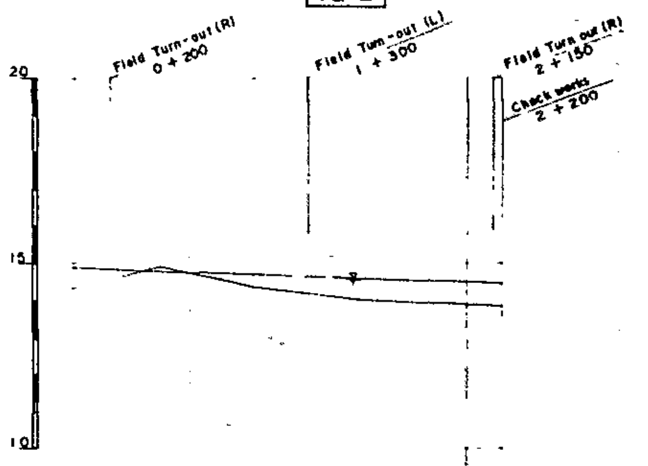
JAPAN INTERNATIONAL COOPERATION AGENCY | D-112

1L -11L



SLOPE	← 1/5000 →					
WATER SURFACE EL	16.24	16.16	15.14	15.04	14.94	14.92
GROUND EL	14.9		14.3	14.3	14.3	14.2
DISTANCE		400	100	500	500	100
STATION NO	0	0+400	0+500	1+000	1+500	1+600

12L



SLOPE	← 1/5000 →					
WATER SURFACE EL	14.88	14.78	14.68	14.58	14.48	14.46
GROUND EL	14.3	14.9	14.3	14.0	13.9	13.8
DISTANCE		500	500	500	500	200
STATION NO	0	0+500	1+000	1+500	2+000	2+200

SLOPE	
WATER SURFACE EL	
GROUND EL.	
DISTANCE	
STATION NO.	

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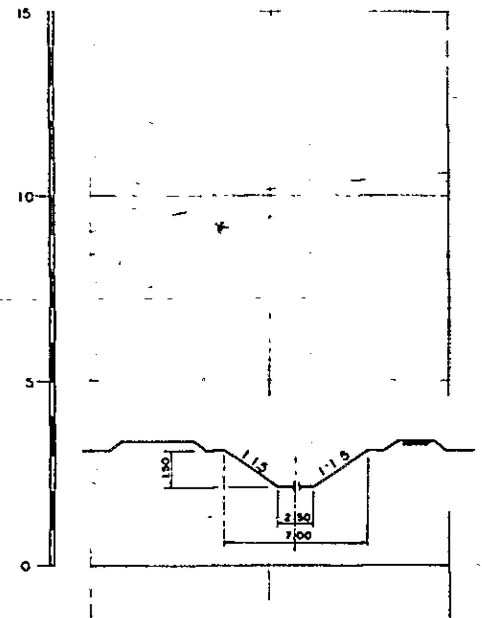
PUMPING IRRIGATION PROJECT

PROFILE OF IRRIGATION CANAL
LATERAL (7)

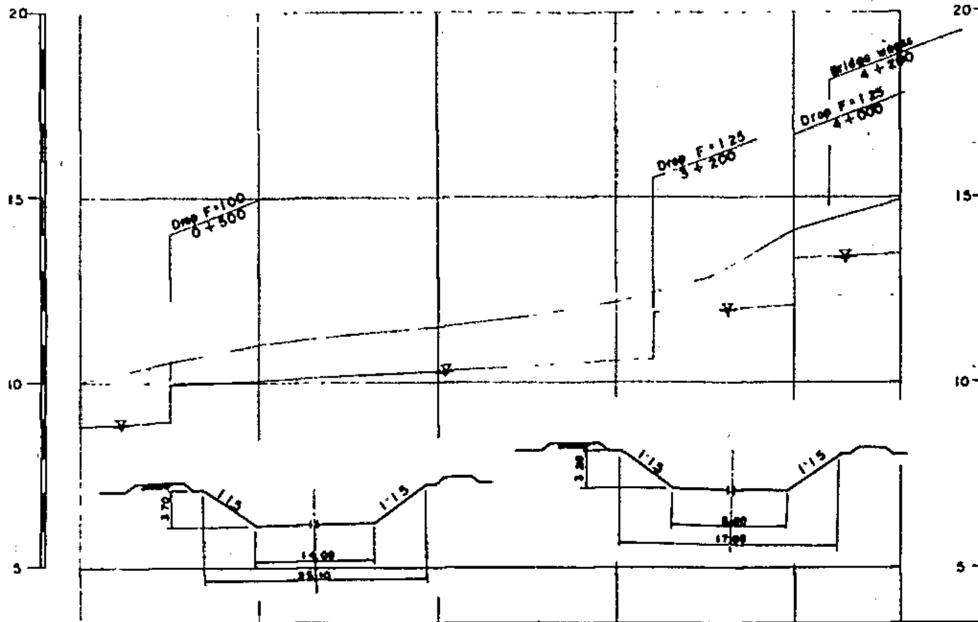
JAPAN INTERNATIONAL COOPERATION AGENCY | D-113

NO 1



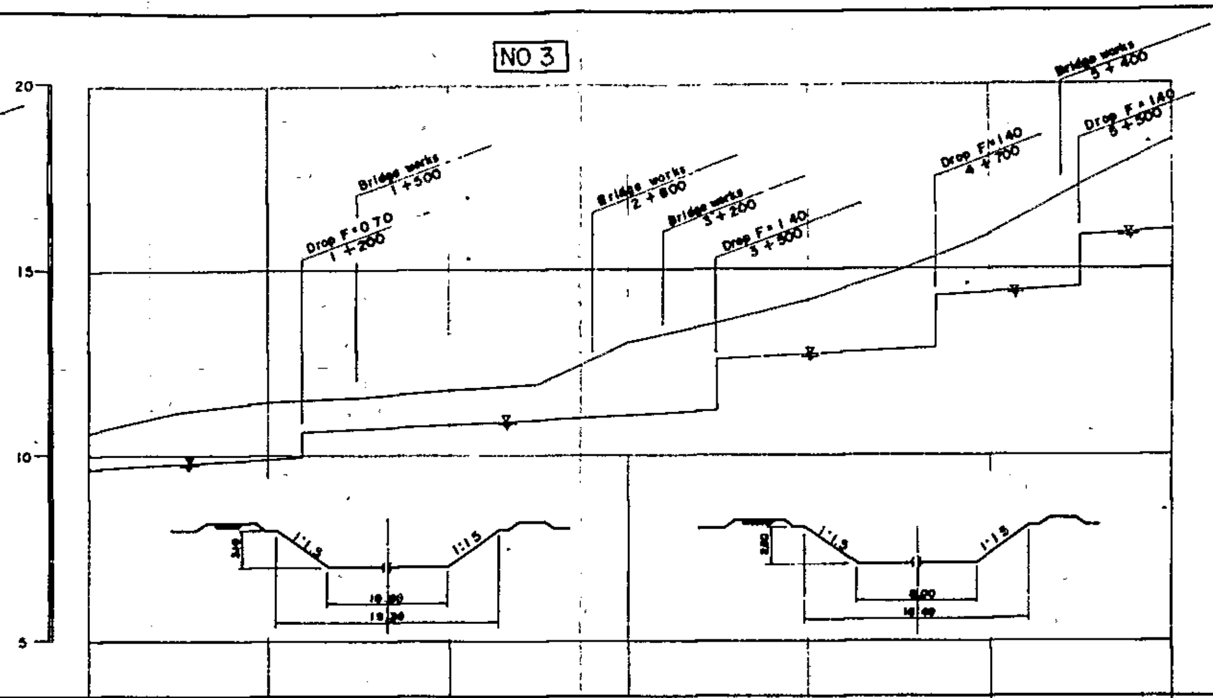
SLOPE	1/1000				
WATER SURFACE EL	8.40	8.90	9.40	9.90	10.40
GROUND EL	9.0	9.5	10.1	10.4	10.6
DISTANCE		500	500	500	500
STATION NO	0	0+500	1+000	1+500	2+000

NO 2



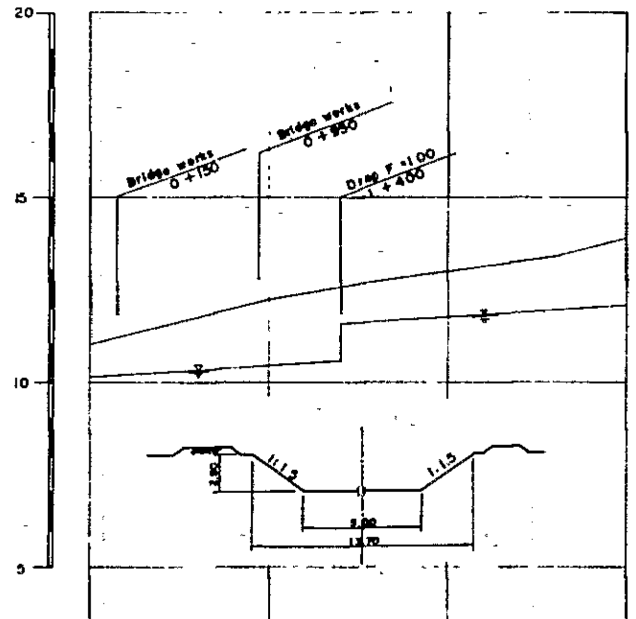
SLOPE	1/5000	1/4000									
WATER SURFACE EL	8.80	[illegible]	10.03	10.15	10.28	10.40	[illegible]	[illegible]	11.30	[illegible]	[illegible]
GROUND EL	10.0	10.5	11.0	11.3	11.5	11.8	12.1		12.8	14.1	14.8 14.9
DISTANCE		500	500	500	500	500	500	200	300	500	500 100
STATION NO	0	0+500	1+000	1+500	2+000	2+500	3+000	3+200	3+500	4+000	[illegible]

NO 3



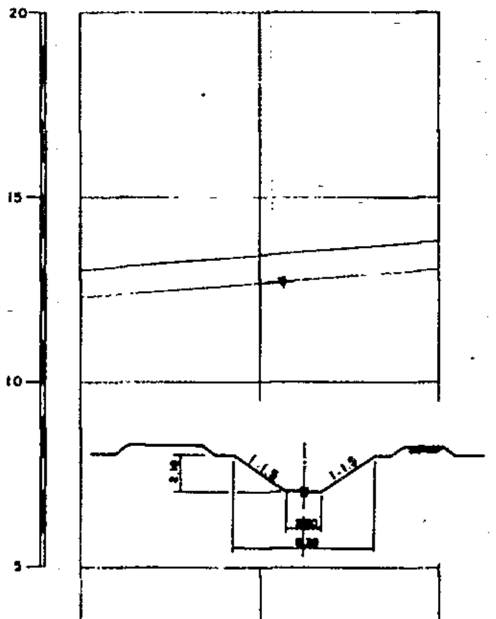
SLOPE	1/4000											1/3000		
WATER SURFACE EL	9.40	9.75	[illegible]	[illegible]	[illegible]	10.80	[illegible]	11.66	[illegible]	12.70	12.83	[illegible]	14.38	[illegible]	16.09
GROUND EL	10.0	11.1	11.3		11.5	11.7	11.9	13.0	13.8	14.1	14.9		15.9	17.2	18.4
DISTANCE		500	500	200	300	500	500	500	500	500	500	200	300	500	500
STATION NO	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4+700	[illegible]	[illegible]	[illegible]

NO 4



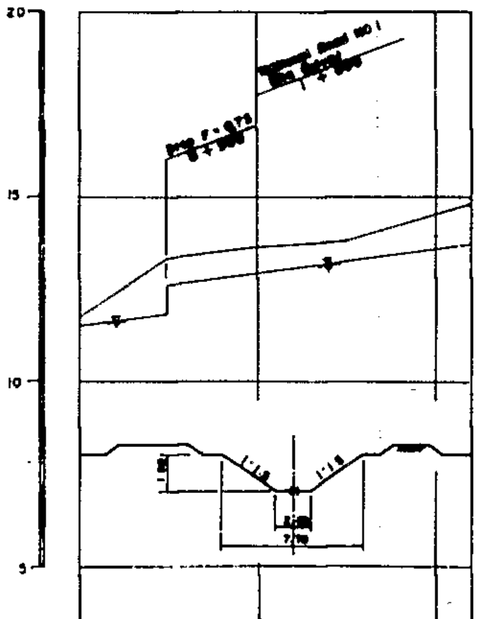
SLOPE	1/3000							
WATER SURFACE EL	10.10	10.27	10.44	10.57 11.57	11.60	11.77	11.94	12.11
GROUND EL	11.0	11.6	12.0		12.6	13.0	13.4	13.9
DISTANCE		500	500	400	100	500	500	500
STATION NO.	0	0+500	1+000	1+400	1+500	2+000	2+500	3+000

NO 5



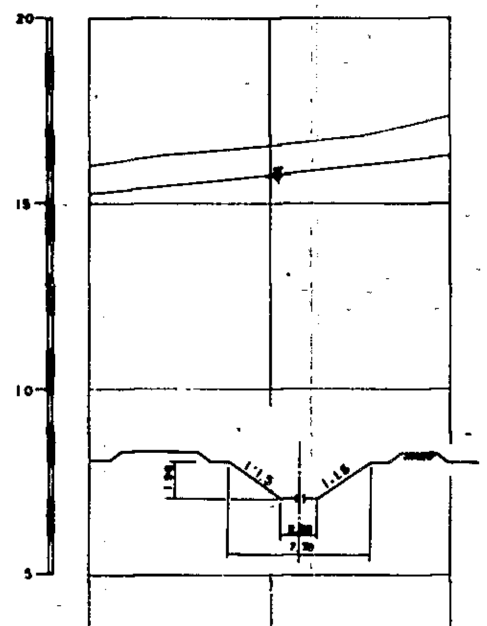
SLOPE	1/2500				
WATER SURFACE EL	12.25	[illegible]	[illegible]	[illegible]	13.05
GROUND EL	13.0	13.2	13.4	13.6	13.8
DISTANCE		500	500	500	500
STATION NO.	0	0+500	1+000	1+500	2+000

NO 6



SLOPE	1/1500					
WATER SURFACE EL	11.47	[illegible]	[illegible]	13.21	13.54	13.67
GROUND EL	11.7	[illegible]	13.6	13.8	14.5	14.8
DISTANCE		500	500	500	500	200
STATION NO.	0	0+500	1+000	1+500	2+000	2+200

NO 7



SLOPE	1/2000				
WATER SURFACE EL	[illegible]	15.50	15.75	16.00	[illegible]
GROUND EL	16.0	16.3	16.5	16.8	17.3
DISTANCE		500	500	500	500
STATION NO.	0	0+500	1+000	1+500	2+000

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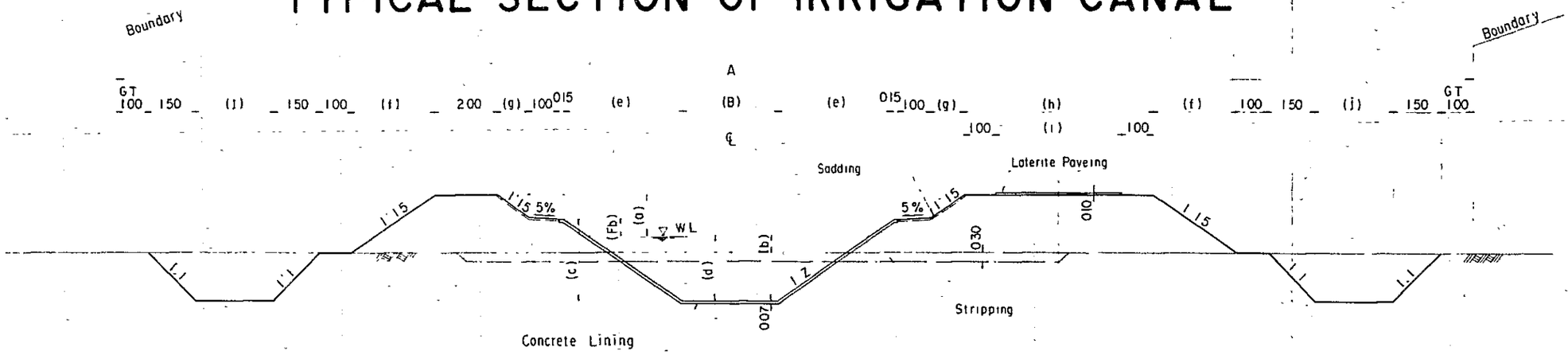
ROYAL IRRIGATION DEPARTMENT

KAENG KHOI — BAN MO
PUMPING IRRIGATION PROJECT

PROFILE OF DRAINAGE CANAL

JAPAN INTERNATIONAL COOPERATION AGENCY | D-114

TYPICAL SECTION OF IRRIGATION CANAL



Note . (1) Roughness (n) = 0.016

(2) Type E, F and G have no laterite paveing

TYPE \ DESCRIPTION	DISCHARGE (m^3/sec)	SLOPE	(B) BOTTOM WIDTH (m)	(d) WATER DEPTH (m)	(Fb) FREE BOAD (m)	Z Side Slope	(V) VELOCITY (m^3/sec)	A Total Width	(a)	(b)	(c)	(e)	(f)	(g)	(h)	(i)	(j)
									GT								
A	17.618	1/10,000	5.00	2.44	0.46 (0.45)	1.5	0.83	47.0	1.00	0.50	2.90	4.35	2.25	0.74	6.00	4.00	3.3
B	14.960	1/10,000	4.50	2.33	0.47 (0.45)	1.5	0.80	47.0	1.00	〃 0.50	2.80	4.20	2.25	0.72	6.00	4.00	3.9
C	11.370	1/10,000	4.00	2.12	0.48 (0.45)	1.5	0.75	47.0	0.90	〃 0.50	2.60	3.90	2.10	0.56	6.00	4.00	4.1
D	6.507	1/10,000	3.00	1.77	0.33 (0.30)	1.5	0.65	43.0	0.75	〃 0.50	2.10	3.15	1.88	0.56	6.00	4.00	4.2
E	4.00>Q>3.00	1/5,000	2.00	1.33>d>1.15	(0.30)	1.5	0.54～0.48	34.0	0.75	〃 0.30	1.70	2.55	1.58	0.60	3.00	1.00	2.2
	3.00>Q≧2.00	1/10,000		1.37>d>1.12													
F	3.00>Q≧2.00	1/5,000	1.50	1.26>d>1.04	(0.30)	1.5	0.49～0.41	33.0	0.75	〃 0.30	1.55	2.33	1.58	0.60	3.00	1.00	2.5
	2.00>Q≧1.00	1/10,000		1.23>d>0.87													
G	Q < 1.00	1/5,000	1.00	(d) < 0.93	(0.15)	1.0	V < 0.54	30.0	0.60	〃 0.30	1.10	1.65	1.35	0.60	3.00	1.00	2.5

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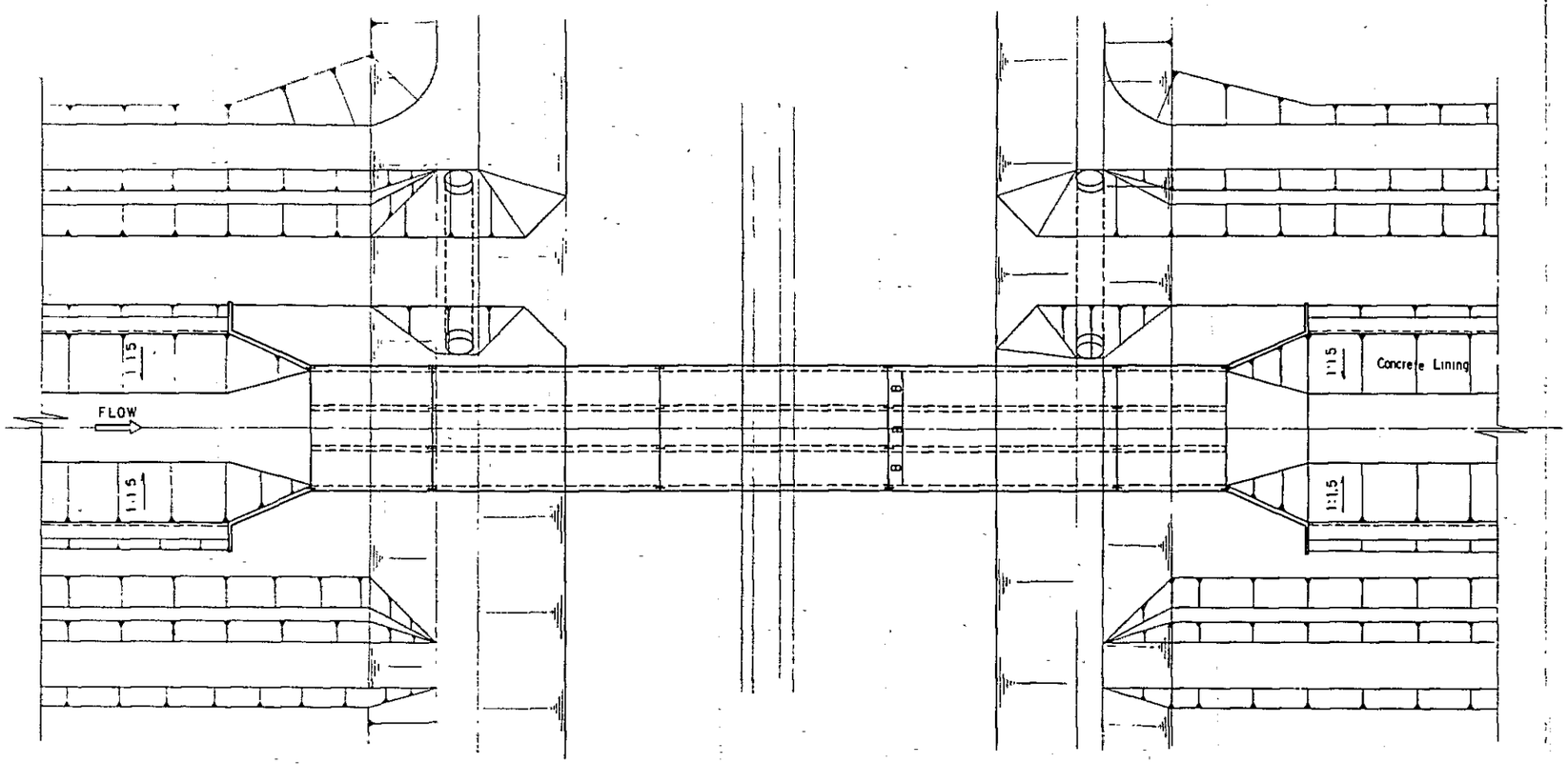
ROYAL IRRIGATION DEPARTMENT

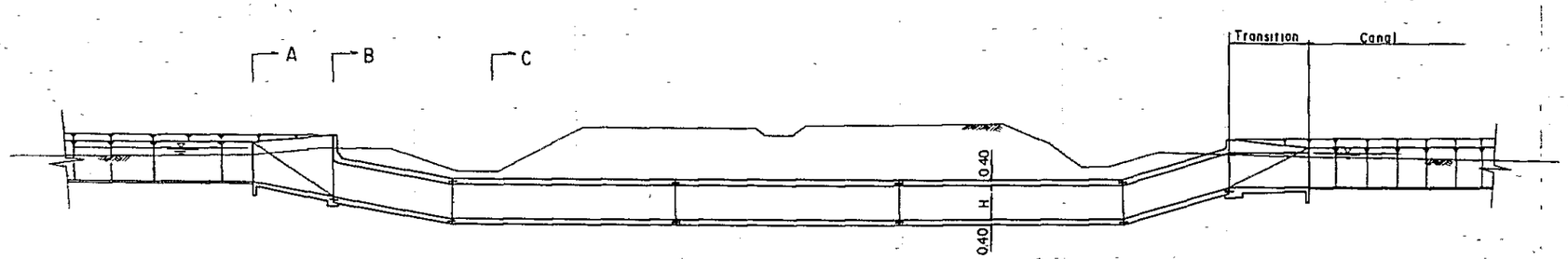
KAENG KHOI – BAN MO
PUMPING IRRIGATION PRJECT

TYPICAL SECTION
OF IRRIGATION CANAL

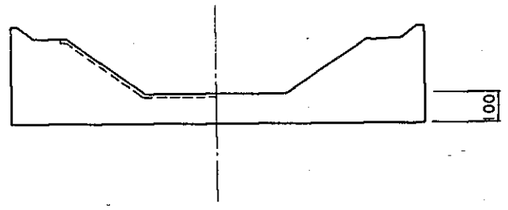
JAPAN INTERNATIONAL COOPERATION AGENCY | D-115



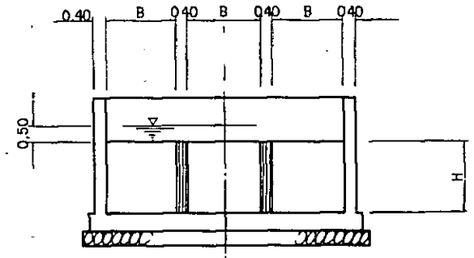
PLANE



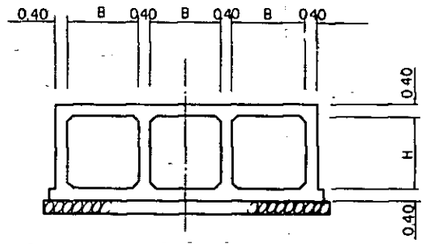
SIDE-VIEW



SECTION 'A-A'

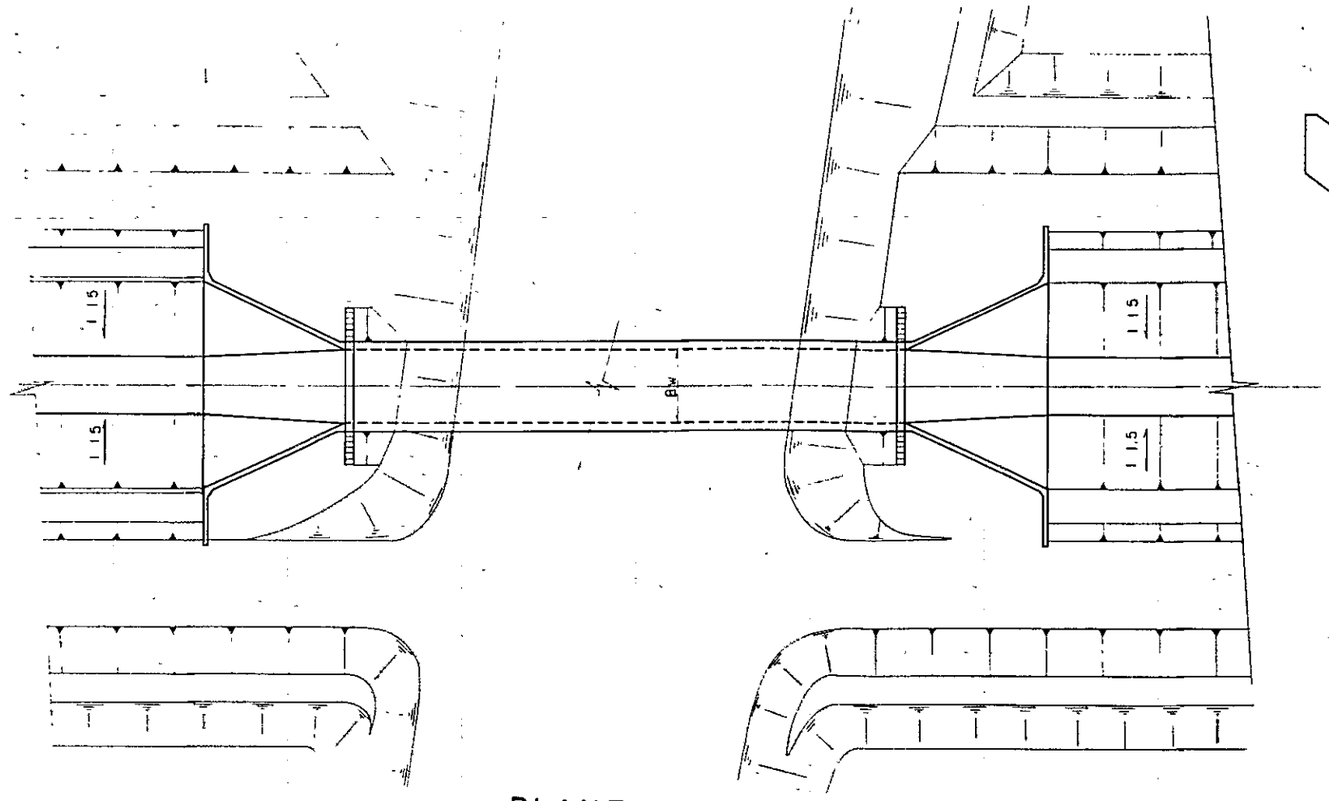


SECTION 'B-B'



SECTION 'C-C'

KINGDOM OF THAILAND MINISTRY OF AGRICULTURE AND COOPERATIVES ROYAL IRRIGATION DEPARTMENT
KAENG KHOI — BAN MO PUMPING IRRIGATION PROJECT
TYPICAL DRAWING OF SYPHON
JAPAN INTERNATIONAL COOPERATION AGENCY | D—116



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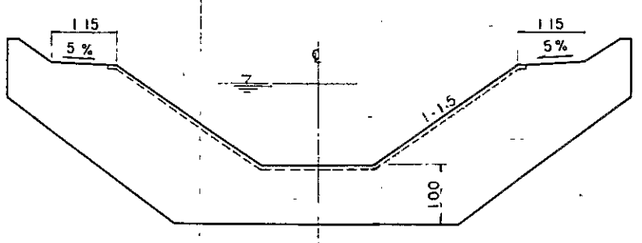
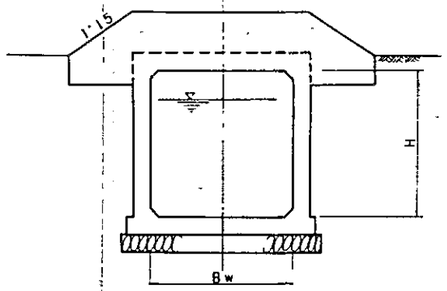
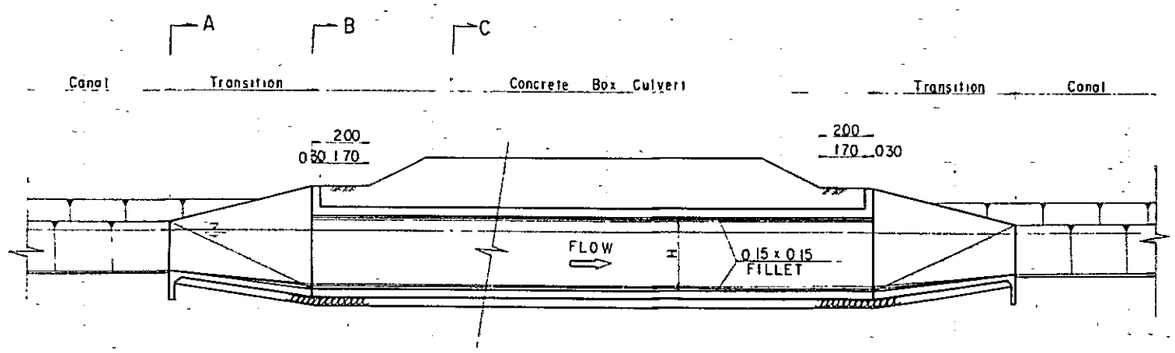


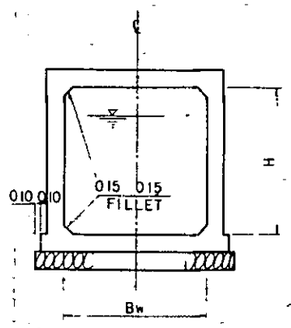
SECTION 'A-A'



SECTON 'B-B'

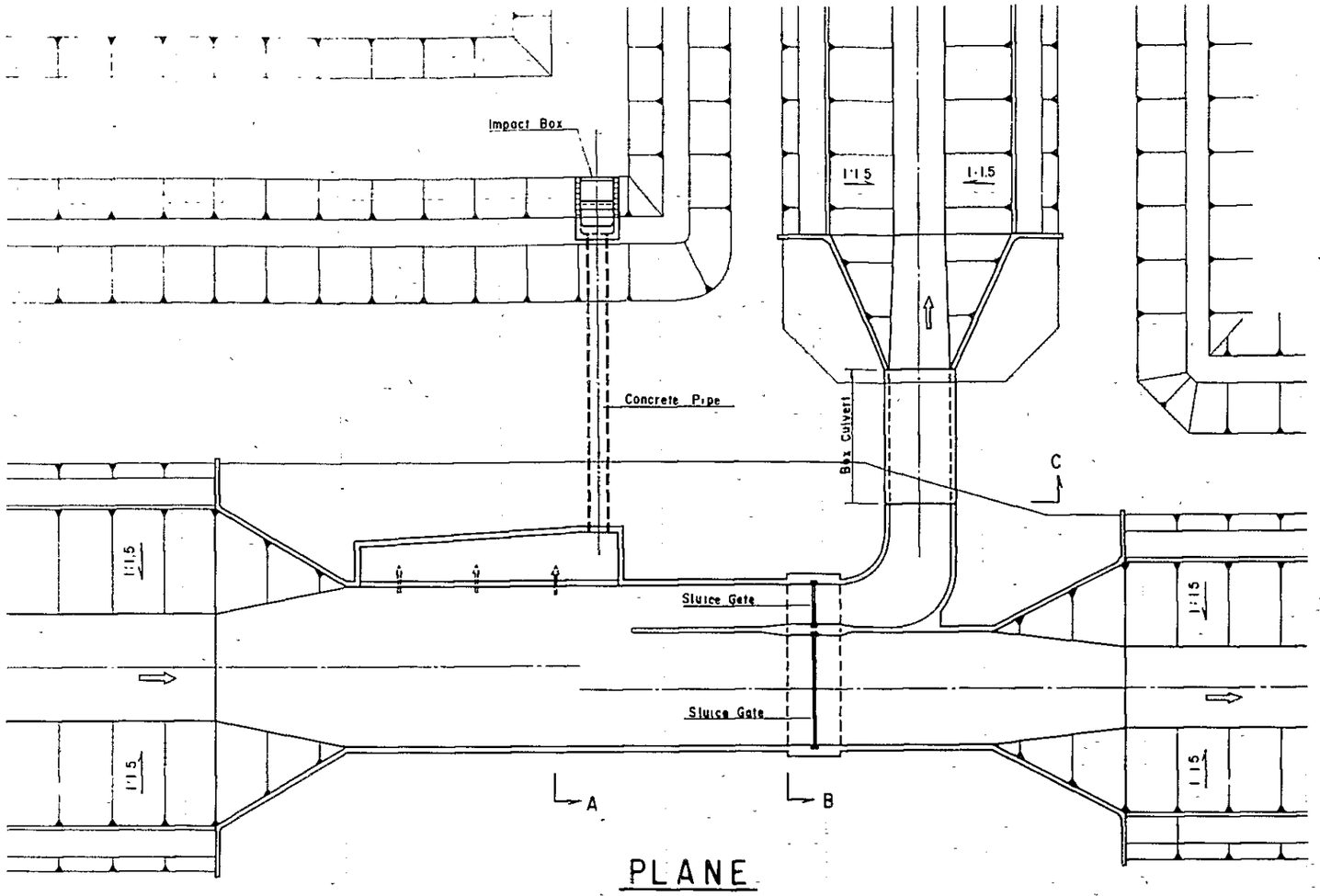


SIDE-VIEW



SECTON 'B-B'

KINGDOM OF THAILAND MINISTRY OF AGRICULTURE AND COOPERATIVES ROYAL IRRIGATION DEPARTMENT
KAENG KHOI — BAN MO PUMPING IRRIGATION PROJECT
TYPICAL DRAWING OF CONCRETE BOX CULVERT
JAPAN INTERNATIONAL COOPERATION AGENCY | D — 117



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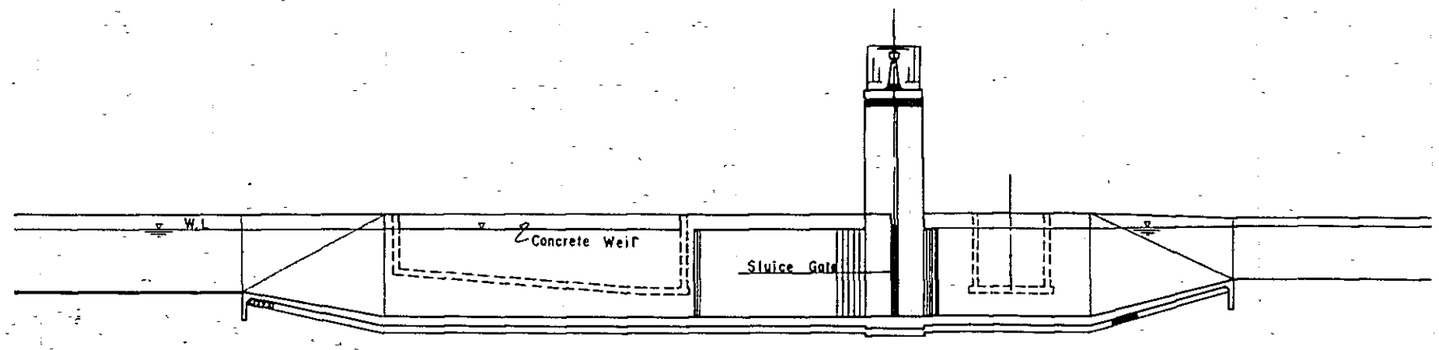
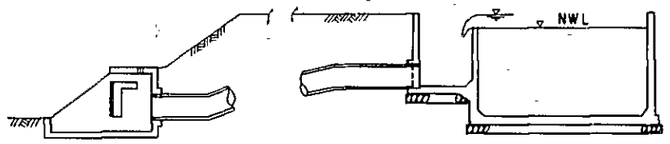
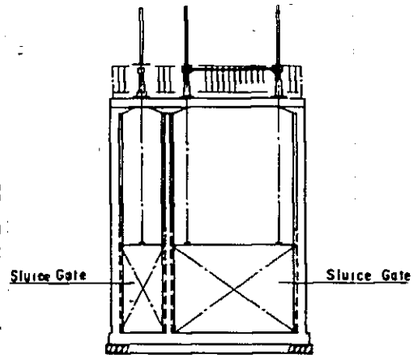




SECTION 'A-A'



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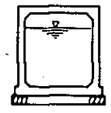
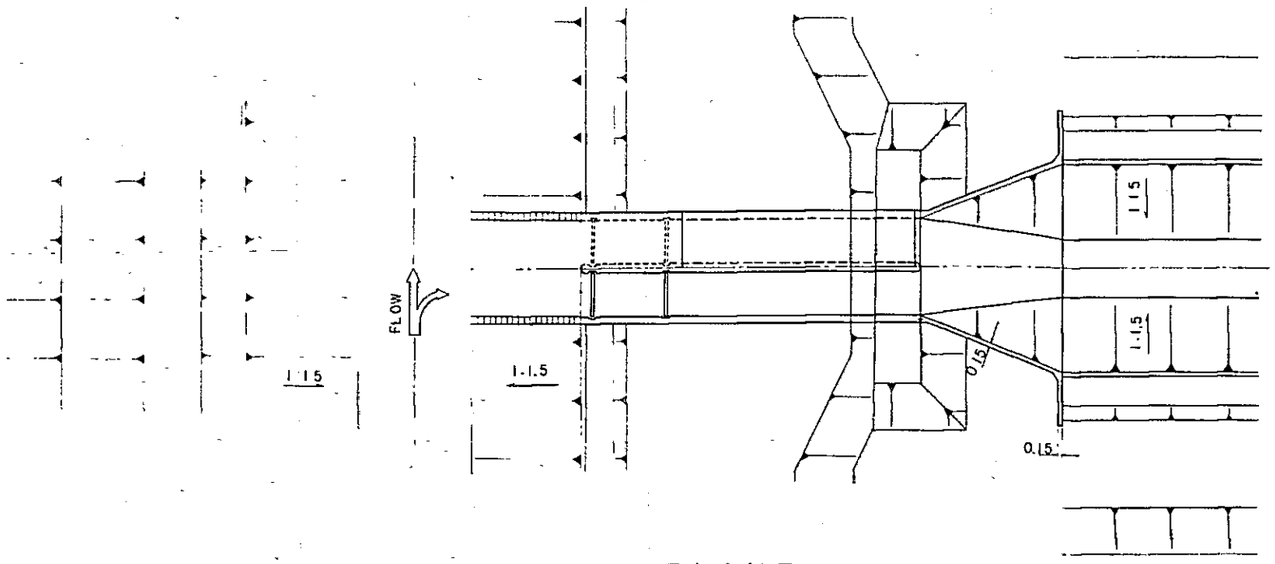


SECTION 'C-C'

KINGDOM OF THAILAND MINISTRY OF AGRICULTURE AND COOPERATIVES ROYAL IRRIGATION DEPARTMENT	
KAENG KHOI – BAN MO PUMPING IRRIGATION PROJECT	
TYPICAL DRAWING OF DISTRIBUTOR	
JAPAN INTERNATIONAL COOPERATION AGENCY	D – 118



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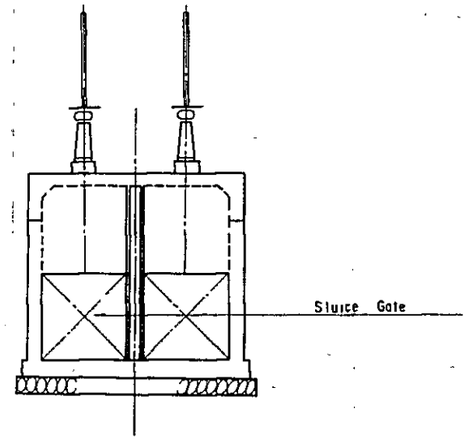
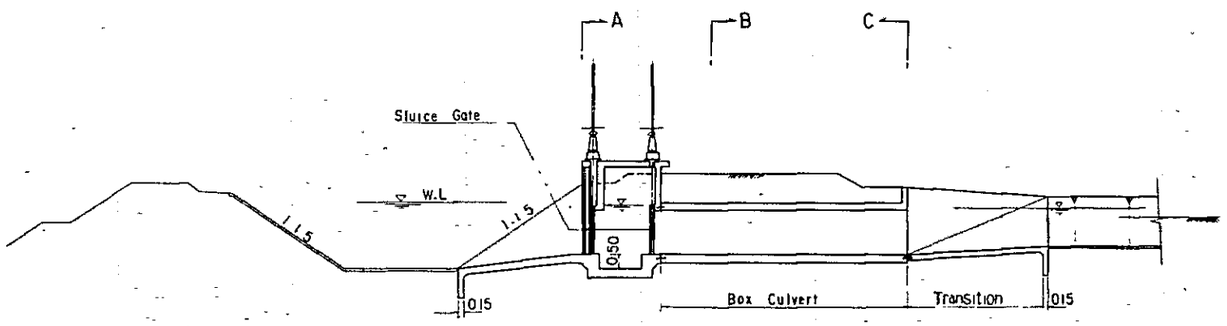
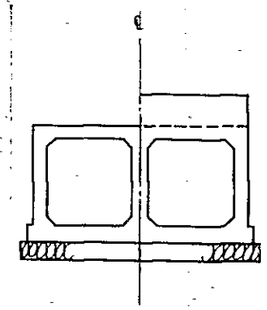


SECTION A-A



SIDE-VIEW



SECTION B-B

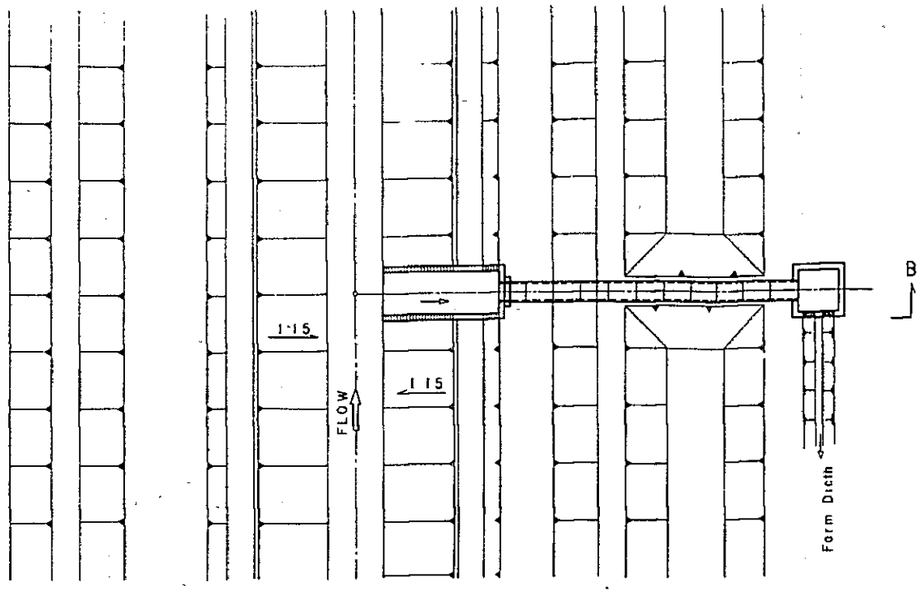
SECTION C-C

KINGDOM OF THAILAND
MINISTRY OF AGRICULTURE AND COOPERATIVES
ROYAL IRRIGATION DEPARTMENT

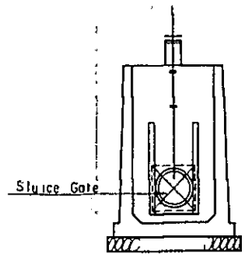
KAENG KHOI — BAN MO
PUMPING IRRIGATION PROJECT

TYPICAL DRAWING OF
CONSTANT HEAD ORIFICE(I)

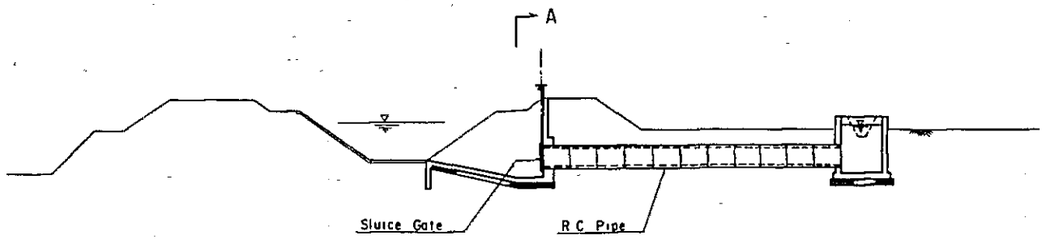
JAPAN INTERNATIONAL COOPERATION AGENCY | D-119



PLANE



SECTION 'A-A'



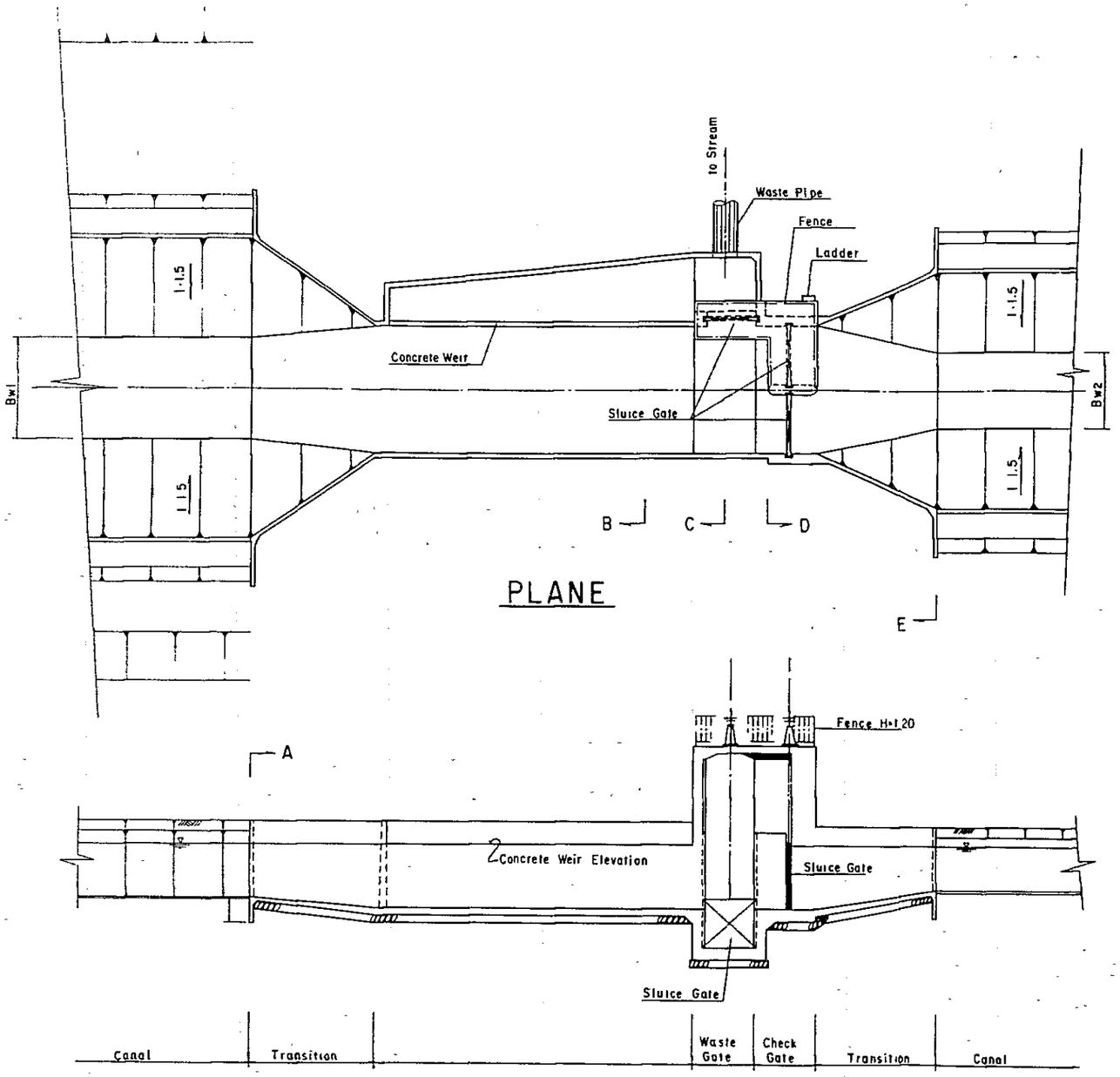
SIDE-VIEW

KINGDOM OF THAILAND
MINISTRY OF AGRICULTURE AND COOPERATIVES
ROYAL IRRIGATION DEPARTMENT

KAENG KHOI – BAN MO
PUMPING IRRIGATION PROJECT

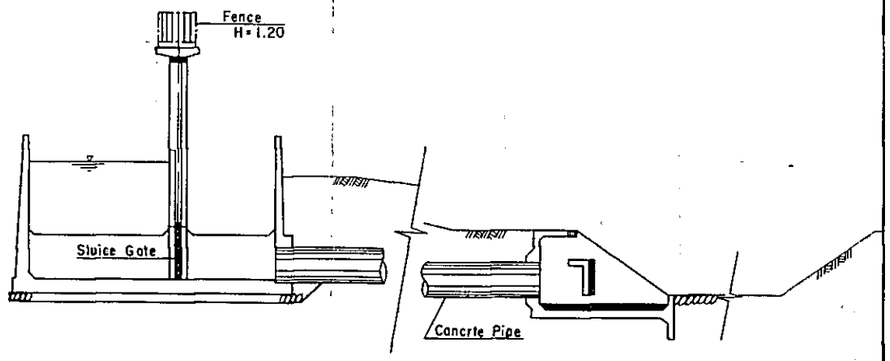
TYPICAL DRAWING OF
TURN OUT

JAPAN INTERNATIONAL COOPERATION AGENCY | D-120

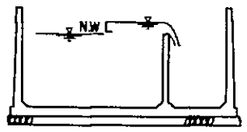


PLANE

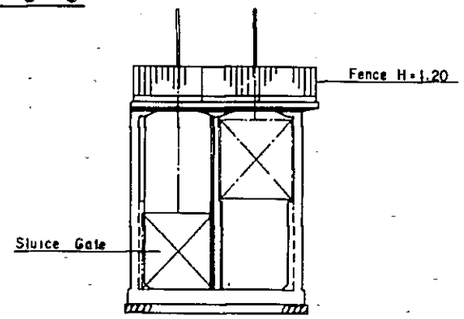
SIDE-VIEW



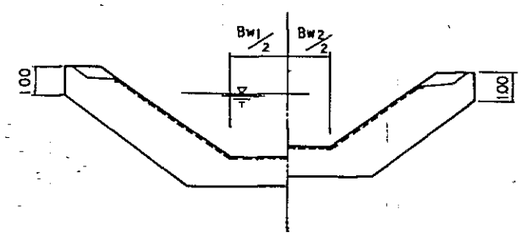
SECTON 'C-C'



SECTION 'B-B'



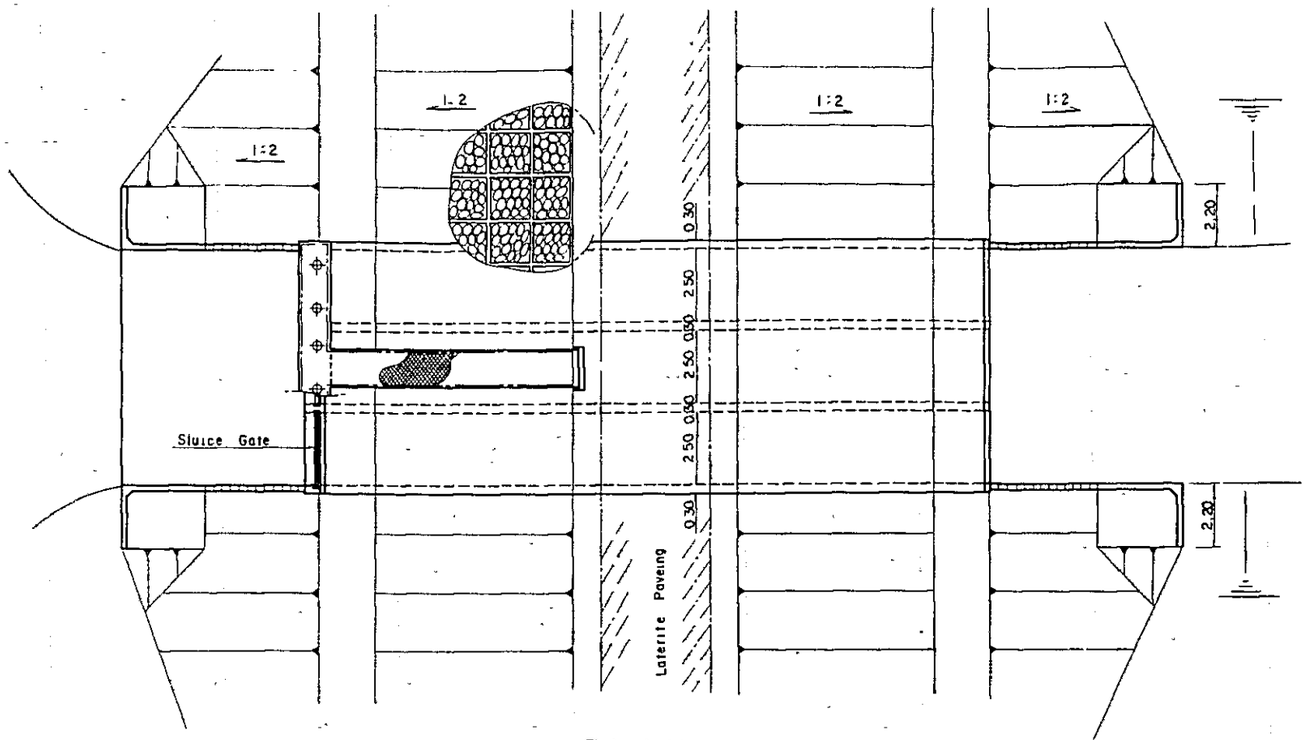
SECTION 'D-D'



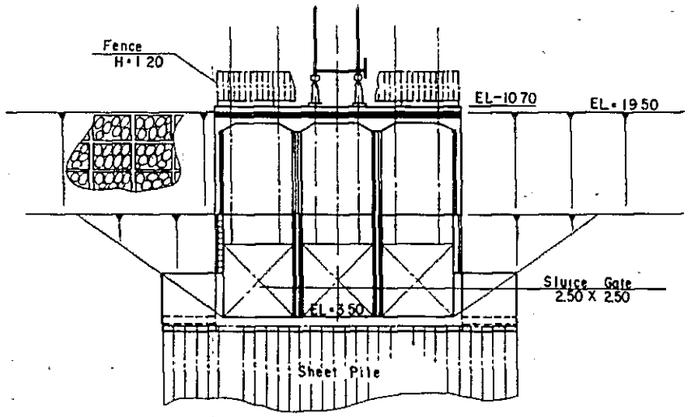
SECTION 'A-A'

SECTION 'E-E'

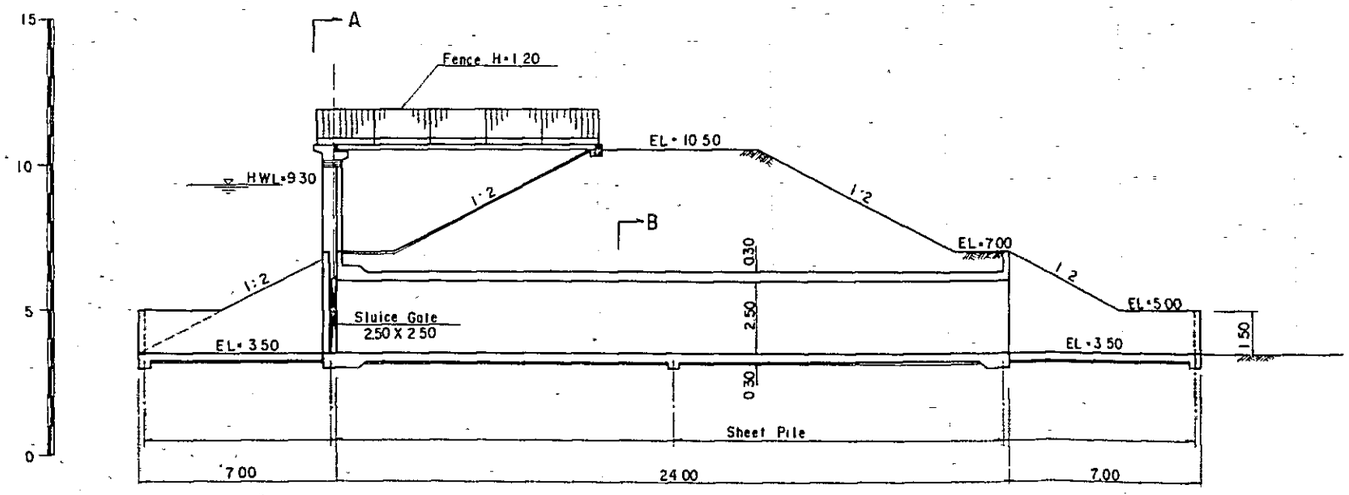
KINGDOM OF THAILAND MINISTRY OF AGRICULTURE AND COOPERATIVES ROYAL IRRIGATION DEPARTMENT	
KAENG KHOI – BAN MO PUMPING IRRIGATION PROJECT	
TYPICAI DRAWING OF WASTE WAY	
JAPAN INTERNATIONAL COOPERATION AGENCY	D – 121



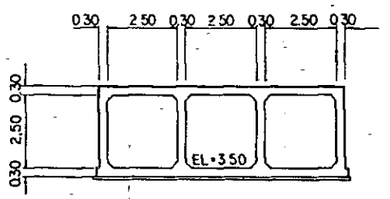
PLANE



SECTION 'A-A'



SIDE-VIEW



SECTION 'B-B'

KINGDOM OF THAILAND MINISTRY OF AGRICULTURE AND COOPERATIVES ROYAL IRRIGATION DEPARTMENT	
KAENG KHOI – BAN MO PUMPING IRRIGATION PROJECT	
TYPICAL DRAWING OF MAIN DRAIN SLUICE	
JAPAN INTERNATIONAL COOPERATION AGENCY	D – 122