ROYAL GOVERNMENT OF LAOS

THA NGON AGRICULTURAL DEVELOPMENT PROJECT

DESIGN REPORT

MAY 1970

OVERSEAS TECHNICAL COOPERATION AGENCY

TOKYO

ROYAL GOVERNMENT OF LAOS

THA NGON AGRICULTURAL DEVELOPMENT PROJECT

D E S I G N R E P O R T

MARCH 1970

OVERSEAS TECHNICAL COOPERATION AGENCY

T O K Y O

FOREWORD

In recognition of the vital importance of improving food situation of the country, the Royal Government of Laos places great emphasis on the agricultural development, particularly in the Vientiane Plain in which the capital of the kingdom situates.

As a part of the agricultural development program in the Vientiane Plain, the Royal Government requested the Government of Japan to extend technical cooperation for the development of Tha Ngon area which covers about 800 hectares of irrigable land.

In compliance with this request, the Overseas Technical Cooperation Agency, which is the executing agency of the Japanese Government for technical cooperation, dispatched a field survey mission for a period of about one month in January 1968. The team consisted of ten members and headed by Mr. Tatsuichi Fukuzawa, Senior Research Officer, Agricultural Land Bureau, Ministry of Agriculture and Forestry. The team prepared a report on the agricultural development plan based upon the technical and economic feasibility studies of the project, and submitted it to the Royal Government of Laos in March 1968.

Upon receipt of the further request by the Royal Government for a more detailed study, the Japanese Team consisting of ten members headed by Mr. Tatsuichi Fukuzawa was again dispatched to the site for a period of about two months from November 5, 1968, and the field works conducted during that period included the geologic surveys, topographic surveys of the proposed pumping and other main structure sites, and the collection of basic data for preparing the construction plan, tender documents as well as the farming program.

According to the results of these detailed surveys and studies, some revisions have been made in the original development plan and this report, which was based on the designs of the structures, construction plans, estimates of the construction costs, is framed from the said revised plan and includes bidding specifications ready for construction of the project.

The Japanese consulting engineers have already made the feasibility study of the Nam Ngum Multipurpose Development Project from 1959, which involves the agricultural development of the Vientiane Plain also, and the Lao-Japan Agriculture and Livestock Farming Training Center was established near the proposed project area, and at present, 13 members of the Japanese agricultural specialists and the Japanese Overseas Cooperation Volunteers devote themselves there to the study and experiment for the improved irrigation farming including the paddy culture as its main objective, the promotion of livestock farming, etc., and to the training of Laotian farmers.

Furthermore, it is expected that a pilot farm with an appropriate size (about 100 hectares) will be established within the project area with the help of Lao-Japan Agriculture and Livestock Farming Training Center acting as its headquarter, and that the Government of Japan will cooperate in planning, constructing and operating this farm, and also in providing the services of qualified experts and procuring the equipment and facilities necessary for its smooth operation.

The farm will serve for the selection of suitable crop varieties for improved year-round cultivation under irrigation, the setting up of the most profitable cropping pattern and crop rotation, and the training of extension workers and farmers in modern irrigation farming methods and management under the guidance of experts with long experience.

Under such circumstances, this project will be successfully proceeded, and its realization will contribute much to the agricultural development of the Vientiane Plain.

In submitting this report, we wish to express our deep gratitude to Mr. Tiao Somsavath Vonghoth, Director-General of Agriculture, Ministry of the National Economy, Dr. Pane Rassavong, Commissary-General for Planning, Planning Ministry, as well as other officials of the Royal Government for the assistance they have so kindly extended to our team.

We are also grateful to the members of the United States Agency for International Development, the Japanese Embassy in Laos, the Japanese Overseas Cooperation Volunteers and the Lao-Japanese Agriculture and Livestock Training Center for the valuable advice and assistance.

We also wish to record our thanks to Mr. Tatsuichi Fukuzawa, Detailed Design Survey Team Leader, and the members of his team, as well as to the Ministry of Foreign Affairs and Ministry of Agriculture and Forestry, and to Nippon Koei Co., Ltd., for the efforts they dedicated in the preparation of this report.

Shin-ichi Shibusawa
Director-General
Overseas Technical Cooperation Agency

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CHAPTER I

GENERAL DESCRIPTION

1.1 Description of Project Area

The project area -- shown on Fig. 1.1 -- lies in the Vientiane Plain and is located at about 20 kilometers north of Vientiane, the political capital of Laos. The area comprises about 1,000 hectares of land bounded to the north by the Nam Ngum, which is one of the major tributaries of the Mekong, and to the south by the upland, of which 800 hectares are the culturable irrigable area to be developed under this project.

The land, as a whole, is gently sloped toward the H. Nong Sam Kha, which is the only drainage way traversing the project area from east to west through the skirts of the southern upland. Elevations of the land vary from about 161 to 167 meters above sea level. Most of the project area at its central portion is covered with a mixed vegetation of shrubs, reeds and other grasses. To the north on the natural levee of the Nam Ngum and the south on the upland lie the forests.

The soils covering the project area are the recent alluvial immature soils originated from the parent material of fluvial deposits, which was transported rather recently by the Nam Ngum and its tributaries. This soil group can be divided into two subgroups, i.e. the natural levee soils, which occupy the river levee of the Nam Ngum, and the hydromorphic soils, which develop at the back of the natural levee soils. Both soils are considered suitable for agricultural use according to their chemical and physical properties.

Located as it is in the tropical monsoon zone, the area is subjected to two definite seasons, the dry season from November to April and the wet season lasting for the remaining months of the year. The annual rainfall ranges from 1,400 to 2,000 millimeters, about 90 percent of which occurs during the wet season. The monthly mean temperature varies from 21 to 28°C.

The nearest hamlets are B. Lat Khouei, B. Tha Som Mo and B. Tha Ngon from the downstream to the upstream along the right bank of the Nam Ngum, and B. Nong Sam Kha on the southern upland; these hamlets have a total population of about 1,500. B. Tha Ngon is the largest hamlet located at about 3 kilometers west-south-west of the project area, and the National Road connects it with Vientiane.

In despite of such favorable conditions in the natural as well as the socio-economical elements, the area is mostly lain waste, because of shortage of water in the dry season and excessive water in the wet season.

1.2 Outline of Project

In order to develop the potential productivity of the land, it is proposed that an improved agricultural development program should be undertaken, which includes the establishment of irrigation and drainage measures as the key to the development.

The irrigation measures proposed comprise one pumping station, two main canals and other water distribution system with various canal structures.

The water required for irrigation of the land is pumped up from the Nam Ngum, where enough water is available even during the dry season. The location of the pumping station is about 2.5 kilometers downstream of B. Tha Ngon. Three sets of submersible pump driven by electric motor are used for pumping and a regulating pond is provided for the easy operation of pumping plant.

The water lifted up at the pumping station is let through the canal systems to the farmlands. The main canal system includes "the north main canal" running on the natural levee of the Nam Ngum with a length of about 5.9 kilometers and "the south main canal" running along the slope of the southern upland for a distance of about 2.2 kilometers. One lateral, three sub-laterals and many farm laterals are constructed to distribute the water conveyed through the main canals to the individual farms. The length of these canals will

amount to about 41.1 kilometers. All the canals are of earth type with trapezoidal cross section. In relation to the canal system, a large number of structures of various types are provided to control the flow and water level.

The drainage measures are one protective embankment with overflow section, one flood gate and a drainage canal system.

The protective embankment is provided on the natural levee along the Nam Ngum to protect the land against the flood flow of the river, and it ties in to high ground at the southern upland. Its crest elevations are determined so as to protect against about a 8-year flood after the completion of the Nam Ngum Dam. The total length is about 8.3 kilometers.

Along with the establishment of the protective embankment, a flood gate structure is installed at the mouth of the H. Nong Sam Kha. The structure includes the main closure embankment with a height of about 11 meters from the river-bed and a double barrel box culvert with one set of fixed-roller gate in its outlet, and will be operated so as to allow the outflow from the project area and to prevent the inflow from the Nam Ngum.

The proposed drainage canals run generally from north to south or from south to north and join the H. Nong Sam Kha or its small tributaries. As the said natural streams have well-defined channels whose capacities are sufficient for the drainage of the project area, no improvement of the channels are considered. The drainage canals to be constructed are about 34.6 kilometers in total length.

Even though the above three drainage measures are established, it is supporsed that the lower portion of the project area will be inundated during the wet season by the run-off from the H. Nong Sam Kha's basin. Therefore, cropping during August and September is scheduled to be avoided.

In addition, essential to the development of the area is the construction of an adequate road system, and a power distribution line

from Vientiane to the project area. The proposed road system consists of two main roads with a total length of 9.5 kilometers and 47 secondary roads of about 38.7 kilometers in total length. As to the power distribution line, it is planned to construct a distribution line mainly along the Vientiane - Pa Kanioung National Road from the Vientiane Sub-station to the project area, of which the line between Vientiane and B. Tha Ngon is not included in this project. The remaining to be constructed for the project consists of two lines with a total length of about 10 kilometers, which branch off from the said line.

The main features of the project is summarized as shown below.

(1)	Gross irrigable area		970 ha
	Culturable irrigable area		800 ha
(2)	Irrigation pumping plant		
	Pump: Units		3 units
	Type		ϕ500 mm, Submersible pump with 160 kW motor
	Head	actual head	16.80 m
		total head	19.00 m
	Discharge pipeline		ϕ500 mm x 30 m x 3 lines
	Regulating pond		13,000 m^3
	Location of pumping plant		about 2 kilometers N.E.N of B. Tha Ngon
(3)	Irrigation canals		
	Main canal		2 nos
	Length	North canal	5,903 m
		South canal	2,174 m
	Capacity	North canal	860 - 135 ℓ/sec
		South canal	220 - 150 ℓ/sec
	Type		earth canal with trapezoidal cross section
	Related structures		49 nos
	Lateral		1 no
	Length		962 m

	Capacity	280 - 190 ℓ/sec
	Type	Same of main canal
	Related structures	5 nos
Sub-laterals		3 nos
	Length	3,710 m
	Capacity	110 ℓ/sec
	Type	Same to main canal
	Related structures	16 nos
Farm laterals		66 nos
	Length	36,380 m
	Capacity	55 ℓ/sec
	Type	Same to main canal
	Related structures	617 nos

(4) Protective embankment

Length	8,260 m
Crest width	4.0 m
Crest elevation	EL. 167.3 m at the upstream end and EL. 166.8 m at the down-stream end
Overflow section	Crest elevation: 166.44 m, Length: 50 m

(5) Flood gate

Culvert		two-barrel culvert 2.00 m high x 2.40 m wide each
Gate		1 no. 2.00 m x 5.00 m
Embankment	Crest length	150 m
	Crest elevation	EL. 167.50 m
	Maximum height	11.0 m

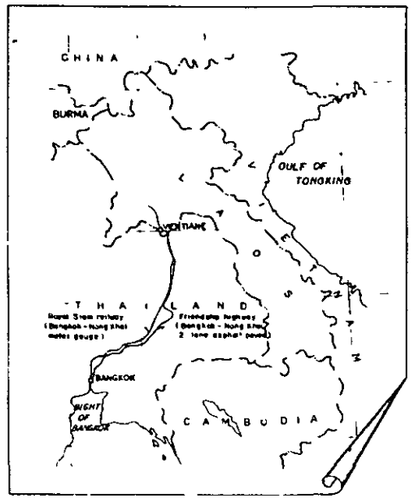
(6) Drainage canals		66 nos
	Total length	34,640 m
	Capacity	20 - 1,000 ℓ/sec
	Type	earth canal with trapezoidal cross section
	Related structures	188 nos

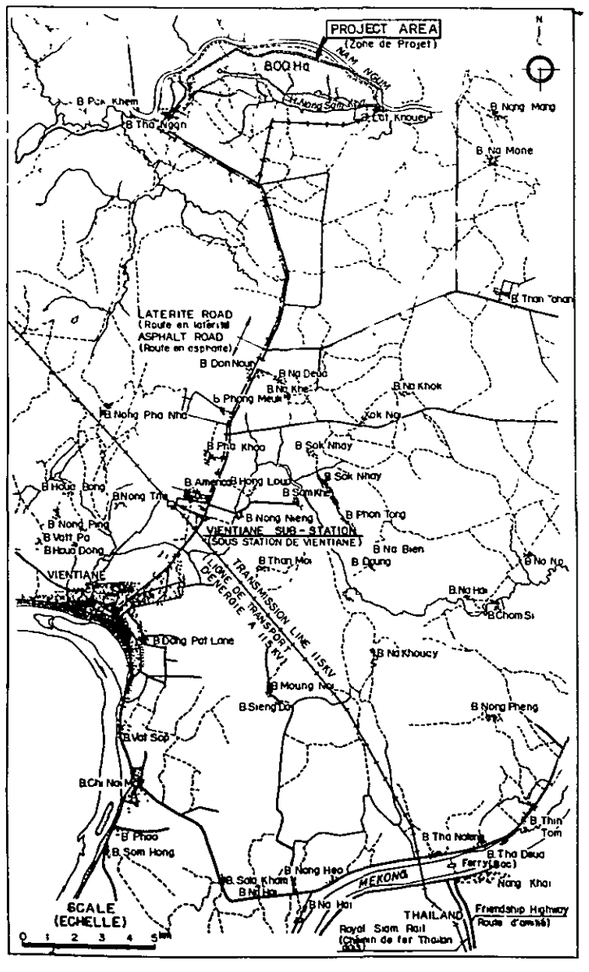
(7) Road system

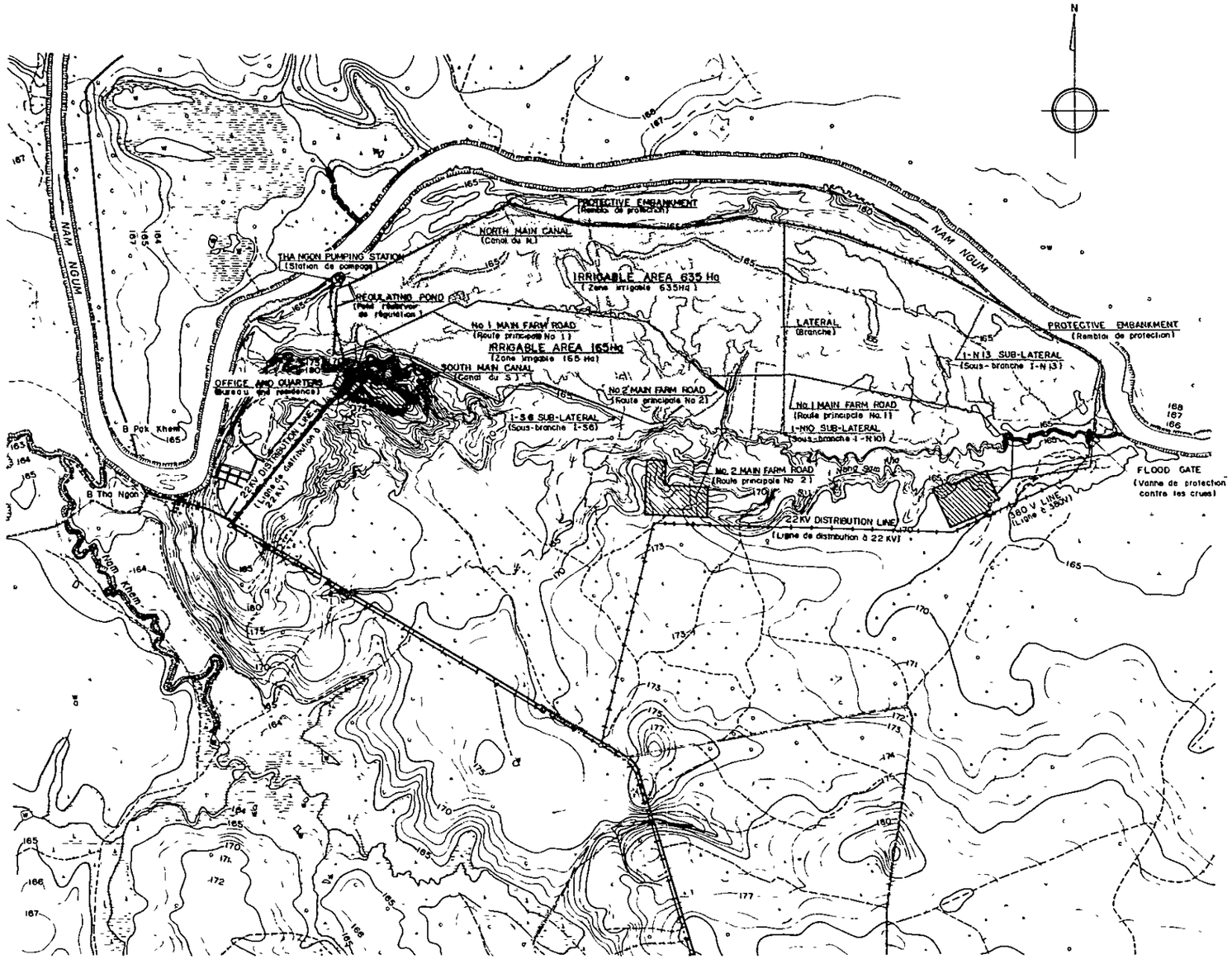
Main road	2 nos
Total length	9,530 m
Width	Total 6.0 m
	Effective 5.0 m
Type	Roads paved with laterite
Structure	4 nos
Secondary road	47 nos
Total length	40,040 m
Width	Total 4.0 m
	Effective 3.0 m
Type	Unpaved roads
Structure	9 nos

(8) Power distribution line

(only for the project)	2 lines
Total length	10 km
Voltage	22 kV







SCALE
0 1 2 km

- Main canal (Canaux principaux)
- Lateral and sub-lateral (Branche et sous-branches)
- Protective embankment (Remblai de protection)
- Main farm road (Routes vicinales principales)
- Power distribution line (Ligne de distribution électrique à 22 KV)
- Power distribution line, not covered this project (Ligne de distribution électrique à 22 KV, non prévue dans ce projet)
- Irrigable area (Zone irrigable)
- Natural stream (Cours d'eau naturels)
- Farmers residential area (Quartier résidentiel des fermiers)

KINGDOM OF LAOS

THA NGON AGRICULTURAL DEVELOPMENT PROJECT

LOCATION MAP
(CARTE DE SITUATION)

DRAWN SUBMITTED

CHECKED APPROVED

OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO MARCH 1969

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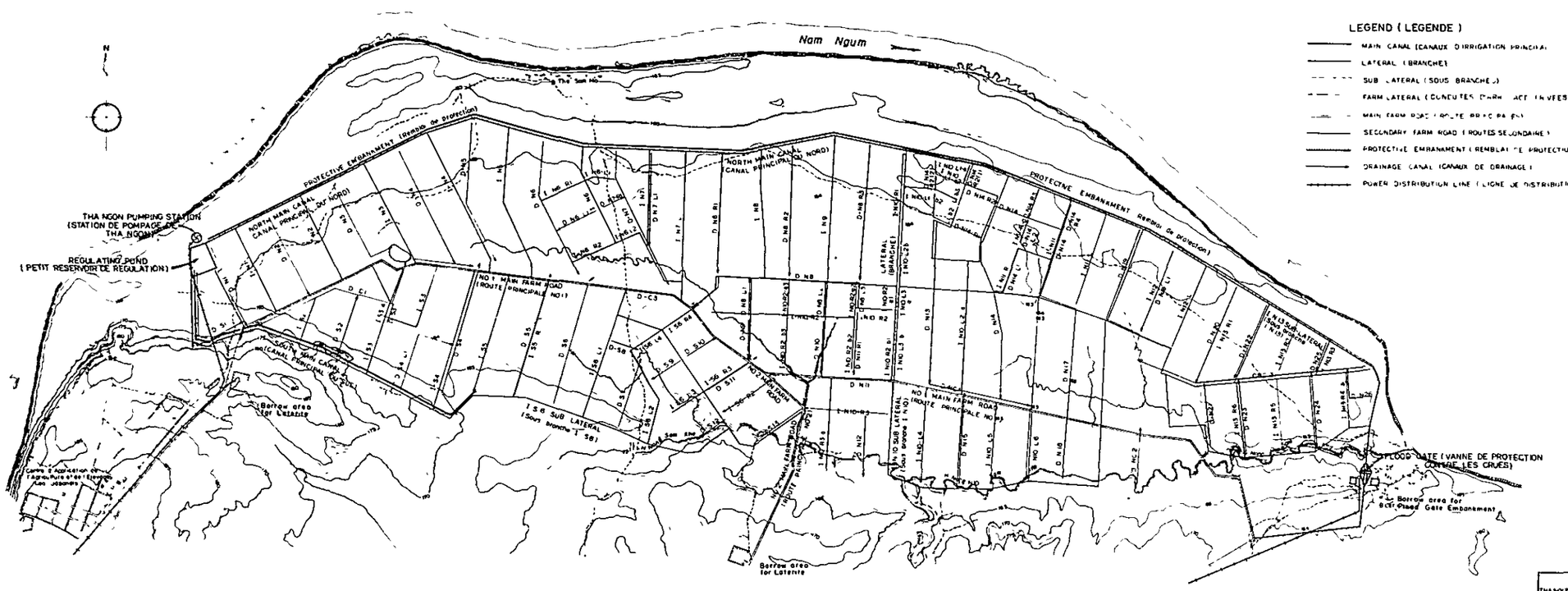
Nam Ngum
N
LEGEND (LEGENDE)
MAIN CANAL (CANAUX D'IRRIGATION PRINCIPAL)
LATERAL (BRANCHE)
SUB LATERAL (SOUS BRANCHE)
FARM LATERAL (CANEUTES D'EXPLOITATION AGRICOLES)
MAIN FARM ROAD (ROUTE PRINCIPALE)
SECONDARY FARM ROAD (ROUTES SECONDAIRES)
PROTECTIVE EMBANKMENT (REMBLAI DE PROTECTION)
DRAINAGE CANAL (CANAUX DE DRAINAGE)
POWER DISTRIBUTION LINE (LIGNE DE DISTRIBUTION
PROTECTIVE EMBANKMENT (REMBLAI de protection)
THA NGON PUMPING STATION (STATION DE POMPAGE DE THA NGON)
REGULATING POND (PETIT RESERVOIR DE REGULATION)
NORTH MAIN CANAL (CANAL PRINCIPAL DU NORD)
NO 1 MAIN FARM ROAD (ROUTE PRINCIPALE NO 1)
NO 2 MAIN FARM ROAD (ROUTE PRINCIPALE NO 2)
LATERAL (BRANCHE) I NO2-20
I S6 SUB LATERAL (Sous branche I S6)
I NO 10 SUB LATERAL (Sous branche I NO 10)
SOUTH MAIN CANAL (CANAL PRINCIPAL DU SUD)
Borrow area for Laterite
Borrow area for Laterite
Borrow area for Earthfill Gate Embankment
FLOOD GATE (VANNE DE PROTECTION CONTRE LES CRUES)
SCALE
KINGDOM OF LAOS
THA NGUN AGRICULTURAL DEVELOPMENT PROJECT
GENERAL PROJECT MAP
(CARTE D'ENSEMBLE DU PROJET)
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CHAPTER II

PROJECT DESIGNS

2.1 Water Requirements

For determination of the adequacy of water supply and for proper design of the canals and structures, estimation of the water requirements has been made as follows:

Comsumptive use of water: As no measured values are available for the determination of the consumptive use of water for the project area, it is estimated based on the relationship between evaporation and consumptive use, which may be expressed by the following formula:

$$U = k \times E$$

Where, U is consumptive use of water, E is evaporation value in depth for the 120-centimeter pan, and k is the empirical consumptive-use coefficient, which is estimated for paddy rice mainly taking into due consideration the experimental studies in Cambodia and Ceylon[/1] as follows:

Consumptive use coefficient for Paddy rice, k

Month	1st			2nd			3rd			4th		
Decade	I	II	III	I	II	III	I	II	III	I	II	III
k	1.05	1.15	1.25	1.35	1.45	1.55	1.64	1.69	1.66	1.57	1.46	-

Deep percolation: The water lost in percolation would be negligible throughout the irrigation period, judging from the soil condition of the project area. However, the deep percolation during the dry season is assumed at 2 millimeters in depth per day for the safety estimation of water requirements.

Water requirement for preparation of paddy field: This requirement is assumed as 150 millimeters in water depth, which will be supplied to the field in 30 day-period.

/1: Hatta, S.; Water Consumption in Paddy Field and Water Saving Rice Culture in the Tropical Zone, Tropical Agriculture, Vol. 11 No.3, 1967.

Murakami, T.; Report on the Water Management for Paddy of the Dry Zone of Ceylon, OTCA, 1966.

Conveyance loss: This loss includes water lost through seepage out of the canals, evaporation and wastewater, and is estimated to be 30 percent of diversion requirement, taking into consideration the soil condition at the canal sites, length and type of the canals, etc.

Effective precipitation: The effective rainfall is calculated by the use of USDA/1 method, but the daily rainfall of less than 5 millimeters is regarded as inefficient.

Based upon the cropping pattern/2 proposed for the project, the water requirements are computed by the above-mentioned procedures and assumptions as given in Table 2.1. In this estimation, both the rainfall and evaporation recorded in Vientiane are used, as no meteorological data are available around the project area.

As shown in Table 2.1, the maximum monthly water requirements take place in April. The value is 1.35 liter per second per hectare, which is used as the basic value for the design of the canals and structures under the project.

Table 2.1 Water Requirement

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Total
(1) Consumptive use of water	60	154	173	147	10	37	213	170	151	28	1,143
(2) Percolation	30	60	60	47	3	14	57	-	-	-	271
(3) Requirement for preparation of field	150	-	-	-	-	100	50	-	-	-	300
(4) Total (1+2+3)	240	214	233	194	13	151	320	170	151	28	1,714
(5) Effective precipitation	24	-	-	-	-	-	77	107	107	24	339
(6) Net water requirements (4 - 5)	216	214	233	194	13	151	243	63	44	4	1,375
(7) Conveyance loss	93	92	101	84	6	65	107	27	19	2	596

(to be continued to the next page)

/1: United States Department of Agriculture

/2: The cropping pattern is illustrated in Fig. 5.1 in Chapter V of the Revised Feasibility Report, March 1969.

(8) Gross water requirements (6 + 7) (mm)	309	306	334	278	19	216	350	90	63	6	1,971
(ℓ/s/ha)	1.19	1.18	1.29	1.07	0.07	0.83	1.35	0.35	0.24	0.02	(0.76)

2.2 Irrigation Facilities

2.2.1 Tha Ngon pumping station

Pump site: The location of the pumping station selected as the most favorable is about 2 kilometers downstream of B. Tha Ngon. The river shore at the site is sloping down to the river-bed at a gradient of about 1:2, and the elevation of the top of the natural levee is about 167 meters.

The pump site consists mostly of clayey soils. Judging from the results of test drilling conducted at a site near B. Tha Ngon/1, these clayey soils would extend to a great depth.

Pumps: The design of the pumping station was made in consideration of the fluctuation of the water level/2 of the Nam Ngum, particularly the safety of the facility in the flood period. From such a viewpoint, comparative studies are made on various types of pump and a number of units, taking due consideration of the type of structures to be provided for each case.

As the result, submersible pumps are adopted for the reasons of low initial cost and the easy operation and maintenance as well as of dependability. Number of the pumps is three including one spare pump.

Each pump with a diameter of 500 millimeters has a capacity of 32.4 cubic meters per minute and 19-meter head, and driven by an electric motor with a capacity of 160 kW which is close-coupled to the pump.

The discharge pipe with a diameter of 500 millimeters for each of the pumps is installed for a distance of about 30 meters between the pumps and the outlet structure. Steel pipe with a thickness of

/1: Referred to Data Book volume II of the Nam Ngum Report, 1962

/2: See Appendix A of this report.

of 8 millimeters including corrosion allowance are used for discharge pipe.

The outlet structure includes a cistern, which is a rectangular structure, 3.00 meters wide, 4.25 meters long and 2.50 meters deep, a Parshall measuring flume with a throat width of 3.0 feet and a 60 meters long concrete flume for the conveyance of pumped water. The structure will be constructed with reinforced concrete, excepting the side walls of concrete flume which will be made of prefabricated concrete blocks.

Sump and Intake: The pumps are installed in the sump with a rectangular section (2.0 meters x 4.9 meters) and a depth of 14 meters, which is recessed back from the river's edge to avoid damages which may be caused by large drift, etc. during the flood period of the Nam Ngum. At the entrance of the sump, one slide gate is installed to facilitate the maintenance of the pumps during the wet season.

The sump is connected with the intake by a single barrel box culvert (1.5 meters x 1.5 meters) with about 20 meters long. The intake has two screens 1.25 meters x 1.90 meters each to prevent obstacles from getting into the pumps, one slide gate with the same dimension as for the above gate for maintaining the culvert and settling basin.

All these structures are of reinforced concrete structures and are designed for the maximum water requirements of 1.08 cubic meters per second and the minimum water level of the Nam Ngum, which is determined at EL.152 meters based on the hydrograph at B. Tha Ngon.

Control House: The control house is provided on the natural levee, about 10 meters away from the sump. It consists of a single rectangular mass 8.80 meters long, 4.70 meters wide and 3 meters high, and contains the rest and the tool rooms at the eastern and the western sides, respectively. In the middle part of the house, switch boards are installed.

Just adjacent to the control house, a garage, 4.5 meters x 6.0 meters, with concrete floor is provided, in which the maintenance

of the pumps including the repairing of minor items can also be done.

The control house and garage are of reinforced concrete structures, and the floor elevation of both structures is determined at 168.0 meters based upon the flood stage of the Nam Ngum.

Power for the pump motors and the lighting of the control house is supplied from the outdoor switchyard to be located near the control house. The switchyard (11 meters x 5 meters) contains 500 KVA transformer (3-Phase, 22 KV/380-220 V) with switchgear, and its floor elevation is the same as that for the control house.

Regulating Pond: For the easy operation of pumps and for the effective use of pumped water, a regulating pond is installed at the end of the concrete flume of the outlet structure. The pond is of trapezoidal shape encircled by about 2.5-meter high embankment and it has an available capacity of about 13,000 cubic meters between Low Water Level of 167.45 meters and High Water Level of 168.20 meters, which is determined based mainly upon the monthly variation of water requirements.

Two regulators are provided at the north and south ends of the regulating pond, respectively. The north regulator releases about 0.86 cubic meter per second of discharge in the maximum to the north main canal which commands about 640 hectares of irrigable land, and the south regulator about 0.22 cubic meter per second to the south main canal, (the commanded area: 160 hectares). The regulators are of single barrel type and they have steel slide gates at their inlets.

One spillway structure is provided on the southern bank of the regulating pond. The spillway is of overflow type concrete structure with a crest length of 4.0 meters, which is sufficient to discharge the full design capacity of the inflow from the pumping plant.

2.2.2 Irrigation canal system

The irrigation canal system for the project consists of main canals, a lateral, sub-laterals and farm laterals with related structures of various types.

Main Canals: Two main canals i.e. North main and South main, will be installed from the topographical viewpoint of the project area, which consists of low relieved lands sloping down to its center from both the natural levee on the north and the elevated land on the south. The north main canal begins from the eastern edge of the regulating pond and runs to east on the natural levee of the Nam Ngum for a distance of about 5.9 kilometers. The south main canal with a length of about 2.2 kilometers extends to about 300 meter south of the regulating pond, then turns to east and runs along the slope of the southern upland. The canals take in the design discharges of 0.86 and 0.22 cubic meter per second for the north and the south canals respectively. The water surface elevations at their heads are 167.5 meters for the north canal and 166.5 meters for the south canal. No direct irrigation will be permitted from these canals.

Lateral: One lateral will be constructed at the middle part of the project area, taking off from the north main canal. The canal starts from the point No.86 + 12.16 on the north canal and flows to the south for about 960 meters long, commanding about 210 hectares of irrigable land. No direct irrigation will also be allowed from this canal.

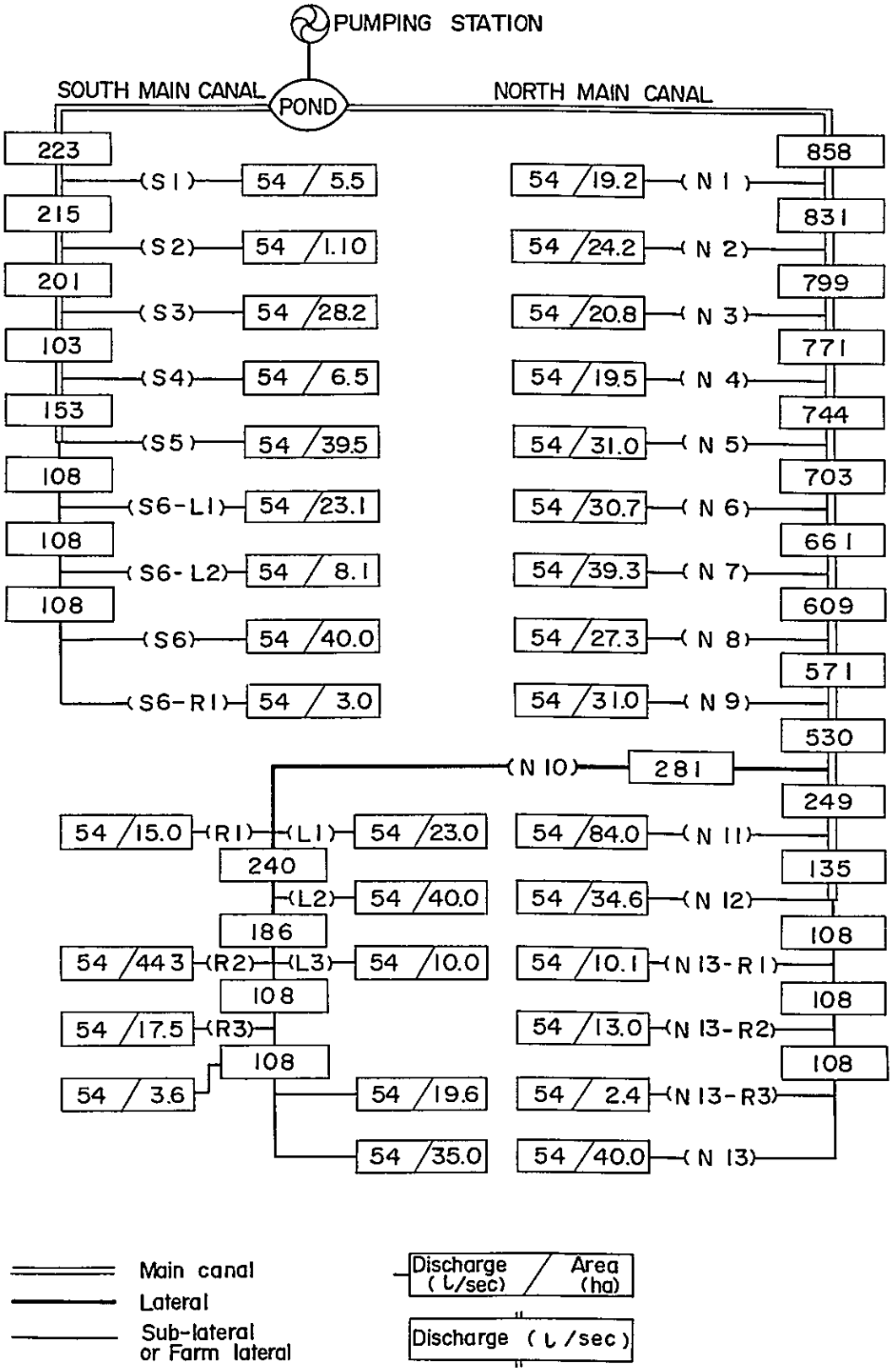
Sub-laterals and farm laterals: Branching off from the main canals or lateral mentioned above, many sub-laterals and farm laterals will be installed to carry the water near and to the individual fields. The sub-laterals required consist of three lines, one for each main canal and lateral, with a total length of about 3,710 meters. The number of the farm laterals is 66, the total length of which will amount to about 36,400 meters. The design capacity is determined at 108 and 54 liters per second for the sub-lateral and farm lateral, respectively.

(1) Canal Section

All the irrigation canals are of unlined earth type with a trapezoidal section. The inside slope of the canal section is 1:1.5 for the main canals and lateral, and 1:1.0 for the others. The hydraulic capacities of the canals (shown in Table 2.2) are based on the maximum monthly water requirements of the irrigable land and the assumed irrigation method/1. The canal section is established based on the Manning's

/1: Referred to Section 2.4.2.

Table 2.2 DESIGN DISCHARGE IN IRRIGATION CANAL



formula with an assumed roughness coefficient of 0.03. The longitudinal slopes range from 1/2,500 to 1/4,000 for the main canals and from 1/200 to 1/2,500 for the others, depending upon the available head at each canal route. The canal velocity will not exceed 0.75 meter per second for any of canal sections, and the sections, where the canal velocity is extremely low, are designed so as to have a high hydraulic efficiency to increase the canal velocity as much as possible.

The bottom width of canals varies from 0.7 to 0.3 meter, and the water depth from 1.0 to 0.2 meter. Freeboard is assumed as 0.3 meter in its minimum for the main canals and lateral, and 0.2 meter for the remaining canals. The canal sections are classified into some types, according to their dimentions. Table 2.3 contains informations regarding the adopted sections.

(2) Canal structures

In conjunction with the irrigation canals, various structures are required for conveying the water across the road or drainage course, for controlling the water surface or discharge and for preventing damages to the canal system by flooding etc. The canal structures contemplated for the project involve lateral and farm turnouts, division boxes, check structures, spillways, drainage crossings and culverts.

Turnout and Division Box: Turnouts and division boxes are provided to divert the water to the other canal systems or individual farms. Turnouts involve 1 lateral turnout which diverts the water from the main canal to the lateral and 19 farm turnouts from the main canals and lateral to sub-laterals or farm laterals. The lateral turnout is of the rectangular open type concrete structure, which is designed for a capacity of 316 liters per second. The farm turnouts consist of two types, depending upon their localities. One has a reinforced concrete pipe through the canal bank, and the other is of the same type as that for the lateral turnout. Each of these turnouts is controlled by a calibrated slide gate installed at a cantilevered head-wall structure.

Division boxes are used to distribute flow to several farm laterals or individual farms. The division box is formed of concrete

Table 2.3 Type, Location and Dimensions of Typical Canal Sections

Canal System	Type of Canal	Dimensions				Hydraulic Properties				Location and length	
		Bottom Width	Water Depth	Height of Bank	Sode Slope	Q (m^3/sec)	A (m^3)	V (m/sec)	S	Location	Length
		(m)	(m)	(m)							(m)
North Main	Type - A	0.70	1.07	1.40	1 : 1.5	0.857	2.47	0.35	0.00025	No.1+34.00 - No.13+7.05	573.05
	- B1	0.60	1.06	1.35	1 : 1.5	0.798	2.24	0.34	0.00025	No.13+7.05 - No.56+27.07	2,170.02
	- B2	0.60	0.92	1.25	1 : 1.5	0.615	1.82	0.32	0.00025	No.56+27.07 - No.86+16.91	1,489.84
	- C	0.40	0.64	0.95	1 : 1.5	0.253	0.87	0.29	0.00033	No.86+16.91 - No.107+1.88	1,034.97
	- D	0.30	0.52	0.85	1 : 1.5	0.137	0.56	0.25	0.00033	No.107+1.88 - No.119+43.10	641.22
South Main	Type - C	0.40	0.58	0.95	1 : 1.5	0.225	0.74	0.30	0.00040	No.3+31.77 - No.32+3.51	1,421.74
	- D	0.30	0.54	0.85	1 : 1.5	0.163	0.60	0.28	0.00040	No.32+3.51 - No.47+9.00	755.49
Lateral	Type - E	0.30	0.53	1.00	1 : 1.5	0.234	0.56	0.44	0.00100	.....	962.00
Sub-lateral	Type - F	0.40	0.48	0.65	1 : 1.0	0.108	0.422	0.33	0.00067	.....	3,786.85
Farm lateral	Type - G	0.30	0.40	0.50	1 : 1.0	0.054	0.28	0.22	0.00040	.....	3,020.00
	- H	0.30	0.27	0.40	1 : 1.0	0.054	0.15	0.38	0.00170	.....	33,362.35

structure, and wooden plates are installed at its outlets. All the farm trunouts and division boxes are designed for a capacity of 54 or 108 liters per second.

Dimensions and other informations for the turnouts and division boxes are given in Table 2.4 and 2.5.

Table 2.4 Turnouts on the Irrigation Canals

Canal System	No.	Location	Design Discharge (m^3/sec)	Dimensions	Gate Type	Remarks
North Main	N-1	No.4+35.80	0.054	ϕ200mm x 2.500m	C	Concrete pipe
	-2	No.13+1.30	"	" "	"	"
	-3	No.21+16.80	"	" x 2.000m	"	"
	-4	No.29+32.38	"	" "	"	"
	-5	No.39+26.45	"	" "	"	"
	-6	No.48+5.08	"	" "	"	"
	-7	No.56+21.57	"	" x 2.500m	"	"
	-8	No.69+11.07	"	" x 2.000m	"	"
	-9	No.77+41.00	"	" "	"	"
	-10	No.86+12.16	0.316	700 x 700 x 2.050m	B	Box culvert
	-11	No.106+48.13	0.111	ϕ300 x 2.000m	C	Concrete pipe
	-12	No.119+33.40	0.054	ϕ200 x 2.000m	"	"
South Main	S-1	No.3+44.57	0.054	ϕ200 x 2.000m	C	Concrete pipe
	-2	No.27+31.07	"	" x 6.000m	"	"
	-3	No.32+0.46	"	" "	"	"
	-4	No.40+22.04	"	" x 5.000m	"	"
	-5	No.47+8.41	"	" "	"	"
Lateral N10-1		No.4+12.00	0.054	ϕ200 x 5.500m	C	Concrete pipe
	-2	No.9+55.00	0.111	ϕ300 x 5.500m	"	"
	-3	No.9+55.00	0.054	ϕ200 x 5.500m	"	"

Remarks: Gate type B ..... Rectangular slide gate without upper side sealing

Gate type C ..... Circular slide gate

Table 2.5 Division Boxes on the Irrigation Canals

Type	Numbers			Remarks
	North Main System	South Main System	Lateral System	
A-1	13	3	7	2-way type
-2	32	11	19	"
-3	40	26	37	3-way type
-4	2	2	1	2-way type & 0.5m high drop
-5	2	7	1	3- " " " " "
Sub total	89	49	65	
B-1	5	1	-	2-way type with pipe culvert
-2	44	36	44	" " "
-3	117	25	28	3-way type with pipe culvert
-4	1	-	-	2-way type & 0.5m high drop with pipe culvert
-5	6	4	3	" " "
-6	18	4	1	3-way type & 0.5m high drop with pipe culvert
Sub total	191	70	76	
C-1	3	1	5	2-way type
-2	3	4	2	" "
-3	3	2	14	2-way type with pipe culvert
Sub total	9	7	21	
D-1	2	2	-	2-way type
-2	2	1	-	2-way type with pipe culvert
Sub total	4	3	-	
E-1	1	-	-	2-way type
-2	2	-	-	" "
Sub total	3	-	-	
Total	296	129	162	

Note: Type A to C are applied for the farm laterals, and Type D and E are for the sub-laterals.

Check structure

Checks are required in order to secure enouth water head for diverting water at turnouts and/or to close off the canals in case water is not needed temporarily, or in case of canal maintenance.

Eight check structures are constructed on the main canals at about 800 meter intervals, taking into due consideration the canal slope. For the lateral, one check is installed at the end of the canal.

The check structures are of monolithic concrete construction and rectangular in cross section, and are equipped with steel slide gates

or stoplogs. Most of the structures are constructed with box culverts as monolithic structures.

Location, design discharge and dimensions of the check structures are shown in the following table.

Table 2.6 Check Structures on the Irrigation Canals

Canal System	No.	Location	Design Discharge (m^3/sec)	Dimensions Height	Width	Length	Type of Gate	Remarks
North Canal	1	No.21+18.25	0.798	1.200m	x 1.200m	x 4.500m	B	
	2	EC 3	0.703	"	x "	x 7.000m	"	
	3	No.69+12.52	0.616	1.100m	x 1.000m	x 5.500m	"	
	4	No.86+14.61	0.537	0.800m	x 0.800m	x 5.500m	"	
	5	No.107+0.18	0.253	0.700m	x 0.700m	x 7.500m	"	
	6	No.119+43.10	0.108	0.650m	x 0.400m	-	Stop log	
South Canal	1	No.32+0.96	0.163	0.700m	x 0.700m	x 1.000m	B	
	2	No.47+9.00	0.157	0.650m	x 0.400m	-	Stop log	
Lateral		EP.	0.108	0.600m	x 0.400m	-	"	

Remarks: Gate type B ..... Rectangular slide gate

Spillway

Side spillways are installed to protect the main canals from overflow in cases the discharge more than the design discharge of the canal sections in occurred and of surge due to sudden reductions in downstream withdrawals. Crest length of the spillway is based on the difference between the design discharge and the maximum discharge which can be allowed at the canal sections.

The spillway is concrete-lined structure placed on the canal bank with a stoplog on its crest, and it has a stilling basin at its end. The excess water through the spillway is discharge into a drainage channel to be provided. The following table shows the dimensions and other important items of spillways.

Table 2.7 Side Spillway on the Irrigation Canals

Canal System	No.	Location	Design Discharge (m^3/sec)	Dimensions Crest length	Dimensions Overflow depth	Remarks
North Canal	1	No.1+44.60	0.836	2.500 m x	0.700 m	Stoplog
	2	No.25+31.00	0.564	2.300 m x	0.570 m	"
	3	No.52+20.30	0.685	2.000 m x	0.680 m	"
	4	No.73+32.50	0.767	2.300 m x	0.640 m	"
	5	No.102+44.80	0.302	1.600 m x	0.500 m	"
	6.	No.115+20.00	0.240	1.300 m x	0.510 m	"
South Canal	1	No.10	0.389	1.500 m x	0.610 m	"
	2	No.36+4.00	0.259	1.400 m x	0.510 m	"

Drainage crossing

In natural rivers or depressions, drainage culverts under the irrigation canals are provided in order to pass the run-off from its contributing drainage area. For the north main, no drainage crossings are necessary as the canal runs on the natural levee. Number of the drainage crossings to be constructed is four on the south main canal, one on the sub-lateral and one on the farm lateral, and they are designed on the flood discharge estimated for the probable daily rainfall with a one-in-five years frequency and for 12-hour retardation. All the drainage crossing are of single barrel section with corrugated metal pipe.

The following table shows the dimensions and other informations of the drainage crossing.

Table 2.8 Drainage Crossing on the Irrigation Canals

Canal System	No.	Location	Design Discharge (m^3/sec)	Dimension Dia.	Dimension Length	Remarks
South Canal	1	No.17	0.294	ϕ600mm x	11.520m	Corrugated metal pipe
	2	No.25+40.00	0.184	ϕ600mm x	11.483m	"
	3	No.36+13.50	0.416	ϕ600mm x	11.658m	"
	4	No.44	0.172	ϕ600mm x	10.753m	"
Sub-lateral		-	0.292	ϕ1,000mm x	13.000m	"
Farm lateral		-	0.110	ϕ600mm x	8.700m	"

Culverts: Culverts for the irrigation canals are divided into two types i.e. the concrete box and the precast concrete pipe types.

The concrete box culverts are provided on the main canals and lateral for passing the canal flow under the farm roads to be constructed. The number of the box culverts is 19, of which 6 culverts are constructed with check structures as mentioned previously. Culverts for the sub-laterals and farm laterals are of the precast concrete pipe type.

Table 2.9 Culverts on Irrigation Canal

Box culvert

Canal System	No.	Location	Design Discharge (m^3/sec)	Dimensions Height	Width	Length	Remarks
North Canal	1	No.4+37.30	0.743	1.300 m	x 1.300 m	x 4.500 m	Secondary road
	2	No.13+3.05	"	1.200 m	x 1.200 m	x 4.500 m	"
	3	No.29+34.63	0.645	"	"	"	"
	4	No.39+28.70	"	"	"	"	"
	5	No.56+23.57	0.573	1.100 m	x 1.100 m	x 5.000 m	"
	6	No.60+36.87	"	"	"	"	"
	7	No.77+43.25	0.522	"	"	x 5.500 m	"
	8	No.94+19.24	0.219	0.800 m	x 0.800 m	x 5.500 m	"
	9	No.98+33.38	"	"	"	"	"
	10	No.115+23.08	0.119	0.700 m	x 0.700 m	x 6.500 m	"
South Canal	1	No.10+30.00	0.187	"	"	x15.000 m	"
	2	No.16	"	"	"	x 6.000 m	"
Lateral	1	No.7+96.00	0.155	"	"	x 5.000 m	"

Pipe culvert

Type	Dimensions Dia. of pipe	Length	Number North Main system	South Main system	Lateral system	Remarks
A1	ϕ 600 mm	x 7.00 m	2	-	-	Secondary road
A2(1)	ϕ 600	x 4.00	1	1	-	"
A2(2)	ϕ 600	x 6.00	-	1	-	Main road
B1	ϕ 300	x 6.00	3	-	2	"
B2	ϕ 300	x 4.00	7	4	4	Secondary road
B3	ϕ 300	x 3.00	8	4	4	Access for farm lot

Drop: Drop structures are constructed to protect the canal bases against scouring where the water surface must be lowered for the topographic reason. The drop is of vertical concrete type with a rectangular control section. Its lower end is protected by the concrete lining for a sufficient distance. Number of the drop structures to be constructed is three on the farm lateral.

Table 2.10 Drop Structures on the Irrigation Canals

Canal System	Type	Nos.	Design Discharge	Dimention Height	Dimention Width	Remarks
Farm Lateral	1	3	0.048 m^3/sec	0.50 m	0.50 m	South Main System

2.3 Drainage Facilities

The drainage facilities required for the project involve the drainage canal system, flood gate and protective embankment. The drainage canal system is proposed for draining any surplus water from the fields as speedily as possible, and the latter two are installed for preventing the project area from the flood water of the Nam Ngum.

2.3.1 Drainage canal system

The project area is drained naturally by the H. Nong Sam Kha and its small tributaries, and generally, they have well defined natural channels with enough capacity to drain the water from its drainage area including the project area. Accordingly, no improvement of the channel is contemplated on the greater part of the streams.

The proposed drainage canal system is planned to connect the farm lots with the above natural streams. The canals are installed almost perpendicularly to the natural stream with an approximate interval of 200 or 400 meters so as to face each of the farm lots. Number of the drainage canals is 66, and its total length is 34.6 kilometers.

The canal sections are the same type as for the main irrigation canals with an exception that the inside slope of 1:1 is adopted for the drainage canal. The design capacity of the canal depends on their contributing drainage area, and it is determined for 9 liters per second per hectare based on the surdace runoff calculated from 10-year daily probable rainfall of 100 mm/1 and 24-hour retardation.

The longitudinal slopes of the canals range from 1/100 to 1/1,500 depending upon the natural slopes of the ground. The depth is 0.20 to 1.50 meters, and the design of the sections is based on the Manning's formula, n = 0.03.

/1: 10-year probable daily rainfall of 100 mm is estimated from the daily rainfall records at Vientiane Station, excepting those during August and September.

Structures

Structures for the drainage canals consist of culverts and drops. The drainage culverts are installed to carry drainage water across the farm roads. The culverts are of single barrel type consisting of corrugated metal pipe with a diameter of 600 to 1,000 millimeters.

The drops are provided to avoid excessive slope in the drainage canal. The type is similar to that for the irrigation canals.

Table 2.11 Structures on the Drainage Canal

Culvert

Type	Dimensions: Dia. of pipe	Dimensions: Length	Design Discharge	Number	Remarks
1	ϕ 600 mm	x 10.00 m	50 - 300 ℓ/sec	14	Main road
"	ϕ1,000 mm	x 10.00 m	1,000 "	3	"
2	ϕ 600 mm	x 8.00 m	20 - 350 "	24	Secondary road
"	ϕ1,000 mm	x 8.00 m	350 - 1,150"	9	"
3	ϕ 600 mm	x 7.00 m	20 - 300 "	124	Access for farm lot
"	ϕ1,000 mm	x 7.00 m	550 - 950 "	10	"

Drop structure

Type	Dimensions: Drop height	Dimensions: Width	Design Discharge	Number	Remarks
I	1.00 m	0.50 m	160 - 190 ℓ/sec	2	
II	0.50 m	0.50 m	230 - 290 ℓ/sec	2	

2.3.2 Flood gate

One flood gate is provided to prevent the back-flowing of water from the Nam Ngum into the project area through the H. Nong Sam Kha during the flooding period of the Nam Ngum. The location of the structure is about 300 meters upstream of the mouth of the H. Nong Sam Kha.

The flood gate consists of earth embankment portion and culvert portion. The earth embankment for perfect protection against the back-flowing has a crest width of 4 meters, a height of 11 meters (from the river bed) and a longitudinal length of 150 meters. The crest elevation is 167.50 meters.

A slope of 1:3.0 is adopted for the inner and outer sides of the embankment, and soil-cement[/1] coating to a thickness of about 1.0 meter

/1: 5 percent of cement content.

is applied to stabilize the slopes, based upon the results of the soil test[1], which shows that the soils to be used for the embankment will be clay or silty-clay with high expansibility. At both abutments, the embankment is connected with the protective embankment, which is described in the following Section.

The culvert portion is installed on the left bank side of the embankment. It is of double-barrel box type with 2.00 meter height and 2.40 meter width each, and its length is about 33 meters. At the inlet of the culvert, an approach channel with a length of about 10 meters is provided, and the outlet structure consists of a 13-meter long inclined open channel and 10-meter long stilling basin for energy dissipation.

One fixed roller gate 2 meters high and 5 meters wide (total weight, 5,000 kg) is installed at the outlet of the culvert. The hoist is operated by one electric motor (1.5 kW, 6P) and placed on the deck formed of steel plates and I-beams. The lifting speed and height are 0.3 meter per minute and 2.5 meters, respectively.

Operation of the gate should be made so as to allow the outflow from the project area and to prevent the inflow from the Nam Ngum.

2.3.3 Protective embankment

The embankment for preventing flood inflow into the project area from the Nam Ngum (herein referred to as "protective embankment") is constructed along with the above-mentioned flood gate. The embankment is erected on the natural levee along the Nam Ngum and tied in to high ground on the south of the project area.

Its crest elevation is decided at 167.30 and 166.80 meters at the upstream and lower-stream ends, which are considered sufficient to protect against the eight-year flood after the completion of the Nam Ngum dam, allowing 50 centimeters of freeboad. The embankment has a overflow section (breaching section) on its downstream portion. The crest length of the overflow section is determined at 50 meters, and its crest elevation is 166.30 meters.

/1: The results of the soil test are described in Appendix B.

The crest width of the embankment is 4 meters for all its sections to permit movement of cars, trucks and farm machineries as well as maintenance equipments. Bank slope adopted is 1:2.0 both for inner and outer sides, and the slopes are sodded to prevent erosion. The length is about 8.3 kilometers, excluding the flood gate portion.

2.4 Farm Road and Field Layout

2.4.1 Farm road

The necessity of farm roads depends on the performance of proper operation and maintenance of the irrigation system as well as the irrigation farming in the project area. The farm roads consist of the main roads and the secondary roads.

The former will secure traffic between the farmer's residential areas to be located on the southern upland and the outside of the project area. The main road network involve two lines such as the No.1 main road running from east to west through the center of the project area and the No.2 road branching off from the No.1 road. The width is 6 meters including 0.50 meter of shoulder width on both sides. The surface is paved with laterite materials to a thickness of 0.15 meter.

The secondary roads are provided for traffic between the main roads and the individual farms. Most of the roads are constructed almost perpendicular to the main roads along the farm laterals with at least one secondary road to face one farm lot. These roads are of unpaved type with a total width of 4.00 meters.

The average height from the ground surface is about 0.3 and 0.5 meter for the secondary and main roads, respectively. The crossfall is taken as 5 percent for both roads, and the maximum longitudinal slope is 1:10.

Numbers and length of the farm roads are as follows:

Roads	Numbers	Total length
Main road	2	9,530 m
Secondary road	47	40,040 m

Bridges or culverts are required where the above roads cross over the H. Nong Sam Kha and its tributaries, depending upon the drainage area of the streams at the site.

The number of road bridges to be constructed is seven, of which four are on the main roads and the remaining three on the secondary roads. All the bridges are provided with concrete slabs and beams, with abutments and piers supported on reinforced concrete bearing piles. The structures are designed for a concentrated line load of 6 or 12 tons.

The bridges have an effective roadway width of 3.0 meters and are provided with 30-centimeter high handrails along both sides of the bridges. With respect to the span length and the span number, the road bridges are divided into three types as shown in Table 2.12.

6 culverts are provided under the secondary roads. The culverts are of single or double barrel pipe section formed of corrugated metal pipe with a diameter of 1,000 millimeters. Types and dimensions of the culverts are given in the same table.

Table 2.12 Structures on the Farm Road

Bridge

Type	Dimension			Numbers	Remarks
	Width	Total length	Span number		
A	3.00 m	10.00 m	1	2	Design load; 12 ton
B	"	20.00 m	2	2	" ; "
C	"	7.00 m	1	3	" ; 6 ton

Culvert

Type	Dimension		Design Discharge	Numbers	Remarks
	Dia.	Length			
1	ϕ1,000	10.5-12.0 m	900-2,000 ℓ/s	2	Single barrel
2	ϕ1,000	7.5-11.5 "	2,000-3,800 "	4	Double barrel

2.4.2 Field layout and irrigation method

The farmland developed under the project is divided into smaller farming blocks in view of the irrigation system, and each farming block consists of several field lots. The field lot will have relatively large acreage of 1 hectare, 200 meters long and 50 meters wide in its typical shape. Each field lot faces to the farm road, farm lateral and drainage canal in its shorter sides and the border is built on both longer sides.

The irrigation water through the farm laterals is diverted to the field at the division boxes to be installed for each of the field lots. The intermittent flooding irrigation method will be mainly applied for the project, which is considered most feasible as far as rice is concerned. Four farm lots will be irrigated for 24 hours, and the irrigation interval of 10 days will be adopted.

As to the drainage of fields, excess water will be drained by cutting the ditch-side border of the drainage canal or through the concrete pipe with a diameter of 20 centimeters under the farm road. Further, the farmers should provide a field drain along the longer side of the farm lot by themselves, if necessary.

Access structures will also be provided for the passage of farm machineries and farmers on the farm laterals or drainage canals. The structure consists of precast concrete pipe or corrugated metal pipe with diameters ranging from 300 to 1,000 millimeters.

2.5 Power Distribution Line

The 22 KV line from the Vientiane substation to B. Tha Ngon (hereinafter called as the main line) is to be constructed separately from this project.

The line to be constructed in this project consists of two lines, namely the west line and the east line. The west line is about 3 kilometers long. It extends from the main line and runs along the existing road near the Lao-Japan Agriculture and Livestock Farming Training Center up to the Tha Ngon pumping station. The east line, which

branches off from the main line at the point about 4 kilometers south-east from B. Tha Ngon, runs to the north direction, then turns to the east and extends to the flood gate. Its length is about 7 kilometers.

The lines are of overhead single circuit, three-phase three-wire system with an overhead earthwire. The conductors will be supported by pin type insulators on the straight line and tensioned by suspension insulators on angle supports of galvanized steel tubular poles, at a 80 meters span. Hard-drawn aluminium stranded conductor of 55 sq.mm will be used.

Disconnecting switches are provided at branching-off points from the main line for easy repairing and maintenance of the branched-off lines.

CHAPTER III

CONSTRUCTION PLAN AND EQUIPMENTS

3.1 General

The construction period for the Tha Ngon Project is estimated at about 24 months including the time necessary for the preparatory works, priming test and subsequent adjustments. The tentative construction schedule for the project is as illustrated in Fig. 3.1.

In planning the construction schedule, the following items are mainly taken into consideration:

(1) Rainy days: As few records of rainy days are available in the project area, the records at the Vientiane meteorological station are used. The following table shows the average monthly rainy days by each intensity during the period from 1958 to 1967.

Rainy days at Vientiane

	Month	Intensity	Rainy Days	Total rainy days		Month	Intensity	Rainy Days	Total rainy days
DRY SEASON	NOV.	mm 1.0-10.0 10.0-30.0 30.0-	1.3 0.3 -	1.6	WET SEASON	MAY	mm 1.0-10.0 10.0-30.0 30.0-	7.2 3.8 2.3	13.3
	DEC.	1.0-10.0 10.0-30.0 30.0-	0.3 - -	0.3		JUN.	1.0-10.0 10.0-30.0 30.0-	10.0 4.0 2.4	16.5
	JAN.	1.0-10.0 10.0-30.0 30.0-	0.2 0.1 0.1	0.4		JUL.	1.0-10.0 10.0-30.0 30.0-	8.7 5.0 2.6	16.3
	FEB.	1.0-10.0 10.0-30.0 30.0-	1.3 0.3 -	1.6		AUG.	1.0-10.0 10.0-30.0 30.0	9.8 5.9 3.4	19.1
	MAR.	1.0-10.0 10.0-30.0 30.0-	1.9 0.3 0.2	2.4		SEP.	1.0-10.0 10.0-30.0 30.0-	7.9 5.6 3.6	17.1
	APR.	1.0-10.0 10.0-30.0 30.0-	3.3 2.7 0.9	6.9		OCT.	1.0-10.0 10.0-30.0 30.0-	4.3 2.0 0.6	6.9
Total (Dry season)				13.2	Total (Wet season)				89.2

(Remarks: Excluding the rainfall less than 1.0 mm)

(2) Water level of the Nam Ngum: The water level of the Nam Ngum has been observed at Tha Ngon gaging station from 1960. The average water level during the period from 1960 to 1967 is shown in the following table.

Water Level at Tha Ngon

MONTH	WATER LEVEL (EL. m)	MONYH	WATER LEVEL (EL. m)
JAN.	153.30	JUL.	160.65
FEB.	152.97	AUG.	162.09
MAR.	152.76	SEP.	163.02
APR.	152.72	OCT.	157.95
MAY	153.37	NOV.	155.17
JUN.	157.45	DEC.	153.83
Annual mean			156.28

3.2 Construction Plan

Major construction works for the project comprise the establishment of irrigation and drainage systems including an irrigation pumping station, protective embankment, flood gate and farm road network, and the land preparation works for the irrigable area of 800 hectares.

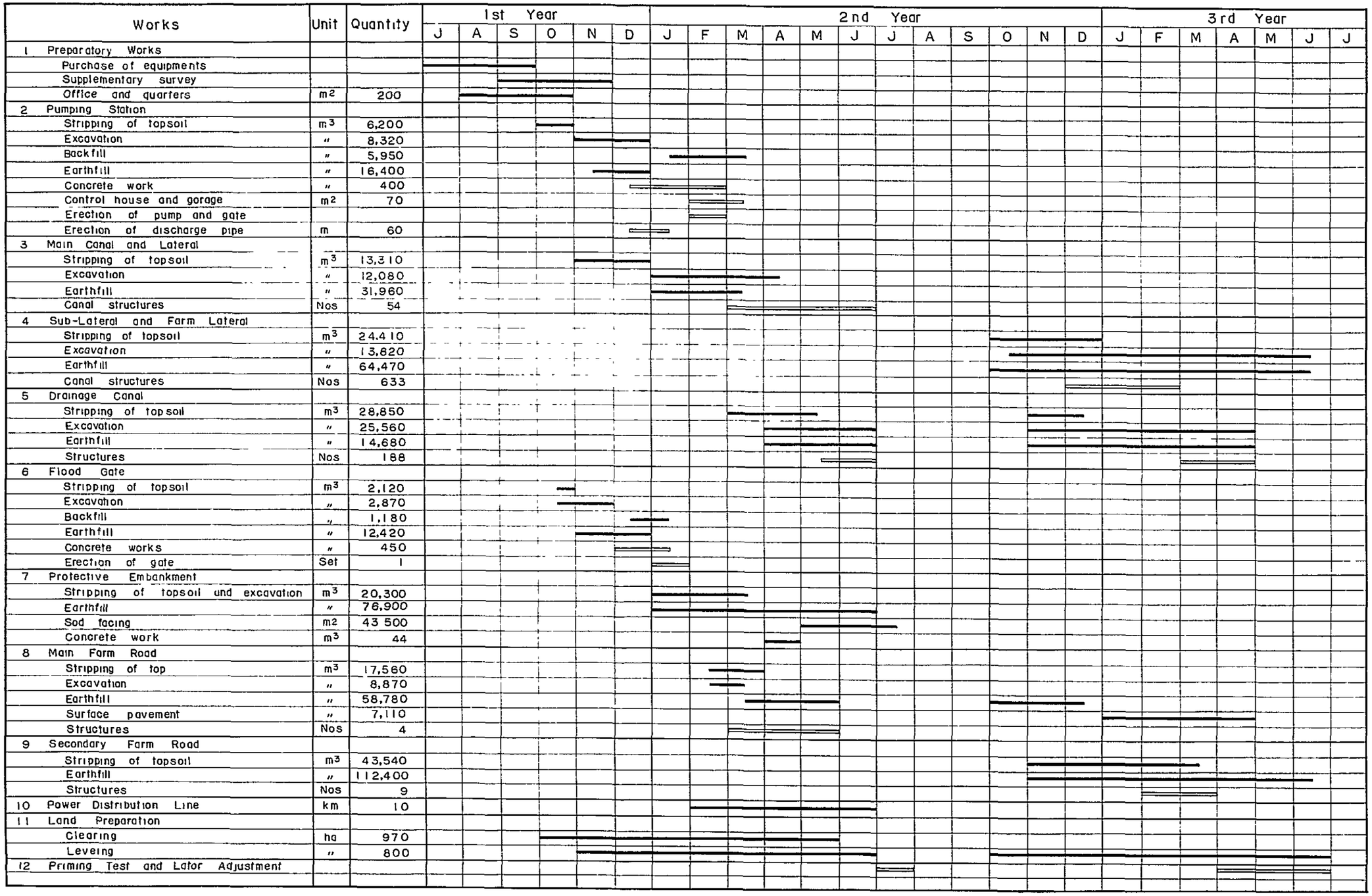
The construction of the pumping station, main and lateral irrigation canals, protective embankment and flood gate should be finished in the first dry season. Construction of the main roads and a part of drainage canals will be commenced and partly finished in the first dry season. The land preparation work is planned to be carried out during nearly full construction period of 24 months. Sub-laterals, farm laterals, secondary roads and a greater part of drainage canals will be constructed in the second dry season.

3.2.1 Tha Ngon pumping station and regulating pond

The principal works involved in the construction of the pumping station are the excavation, earthfill and concrete works, and installation works for pumps, motors and their attachements including the

Fig. 3.1. CONSTRUCTION SCHEDULE FOR THA NGON PROJECT

Works	Unit	Quantity
1 Preparatory Works		
Purchase of equipments		
Supplementary survey		
Office and quarters	m²	200
2 Pumping Station		
Stripping of topsoil	m³	6,200
Excavation	"	8,320
Backfill	"	5,950
Earthfill	"	16,400
Concrete work	"	400
Control house and gorage	m²	70
Erection of pump and gate		
Erection of discharge pipe	m	60
3 Main Canal and Lateral		
Stripping of topsoil	m³	13,310
Excavation	"	12,080
Earthfill	"	31,960
Canal structures	Nos	54
4 Sub-Lateral and Farm Lateral		
Stripping of topsoil	m³	24,410
Excavation	"	13,820
Earthfill	"	64,470
Canal structures	Nos	633
5 Drainage Canal		
Stripping of topsoil	m³	28,850
Excavation	"	25,560
Earthfill	"	14,680
Structures	Nos	188
6 Flood Gate		
Stripping of topsoil	m³	2,120
Excavation	"	2,870
Backfill	"	1,180
Earthfill	"	12,420
Concrete works	"	450
Erection of gate	Set	1
7 Protective Embankment		
Stripping of topsoil und excavation	m³	20,300
Earthfill	"	76,900
Sod facing	m2	43 500
Concrete work	m³	44
8 Main Farm Road		
Stripping of top	m³	17,560
Excavation	"	8,870
Earthfill	"	58,780
Surface pavement	"	7,110
Structures	Nos	4
9 Secondary Farm Road		
Stripping of topsoil	m³	43,540
Earthfill	"	112,400
Structures	Nos	9
10 Power Distribution Line	km	10
11 Land Preparation		
Clearing	ha	970
Leveing	"	800
12 Priming Test and Lator Adjustment		



Remarks : ——— Earth work
═══ Concretework and others

discharge pipelines. These works will require about 5.5 months from the beginning of October in the first year to the middle of March of the second year.

Topsoil stripping for the pumping site including that for the regulating pond will be conducted from October in the first year. Following the topsoil stripping, excavation works for the intake, culvert and sump will be performed and completed by the end of December of the first year. A part of the materials either stripped or excavated at these sites should be availed for the coffering work in the Nam Ngum. The coffering work will be concurrently performed with the excavation work so as not to allow inflow of water to the sites. For the effective operation of unwatering within the coffered area, drainage pumps with sufficient capacity should be utilized.

Earthfilling for the regulating pond and the control house will also be commenced, just after the completion of the stripping work and completed by the end of December in the first year.

Concrete work for the pumping structure including the regulators for the regulating pond will be done from the middle of December in the first year to the end of February in the second year. The intake and culvert for the pumping station should be constructed prior to the concrete works for the sump, which will be conducted keeping pace with backfilling for these structures.

Building work for the control house will be done during 1.5 month from February to the middle of March in the second year. The installation work for installing three units of pump and their attachment as well as gates for intake, sump and regulators is scheduled to be done in February of the same year. Furthermore, it is noteworthy that about six month period will be required for manufacturing the pumps and their accessories, excluding the time necessary for their transportation. Therefore, it is advisable to place orders for these equipments at least ten months prior to their installation work.

As to the construction machineries employed for the construction work of the pumping station, bulldozers will be the main machinery for

the earth works including topsoil stripping, excavation and earthfilling, excepting the excavation works for the sump, intake and culvert which should be performed by the use of dragline. Compaction of earthfills will be carried out by tamping rollers pulled with ' ..er, and for concrete mixing, concrete mixers will be employed.

3.2.2 Irrigation canal system

The irrigation canal system comprises two main canals of about 8.1 kilometers in total length, about 1.0 kilometer-long lateral, about 3.7 kilometer-long sub-laterals and many farm laterals, about 36.4 kilometer-long. In conjunction with these canals, various canal structures such as turnouts, division boxes, spillways, check structures, etc., are also constructed.

Construction of the main and lateral canal system is scheduled to be carried out in the first dry season so that the trial cultivation will be partially possible on the irrigable land in the second dry season. The sub-laterals and farm laterals will be constructed in the second dry season. Generally, construction of these canals should be proceeded from the u.per part downword.

As regards the construction of the main and lateral canals, topsoil stripping will be started at the beginning of November and completed by the end of December in the first year. Following the topsoil stripping, earthfilling up to the water surface line of the contemplated canals (hereinafter called "Embankment-A") will be conducted for the whole canal route. The embankment-A will be built of materials excavated from borrow pits paral. ..ng the canal line. These works including stripping of top soil will be performed by bulldozers.

Compaction of the embankment will be done mainly by tamping roller. These works for the north main canal and a part of the south main canal will be performed simultaneously with those for the protective embankment to be constructed along the main canals. The excavation work for the canals will be done by drag shovel, filling the excavated materials on both banks of the canal (Embankment-B), and the final shaping of the canal section will be done by man-power.

The construction period for these earth works excluding stripping work will be about 3.5 months from January to April in the second year.

Construction of the canal structures which involves concrete work can be done in all seasons throughout the year. Therefore, this work is scheduled to be carried out even during the rainy season, namely from the beginning of March to the end of June in the First year. Taking into consideration the isolated locality of the structures which are scattered along the canal route, transit mixer will be utilized for mixing concrete.

As to the sub-laterals and farm laterals, the construction work will be carried out in the second dry season during the period from October in the second year to June in the third year. Similarly to the main canal, embankment-A for the these canals will be constructed with using the bulldozers. However, the excavation and embankment-B will be done by man-power instead of drag shovel.

3.2.3 Drainage canal systems

Construction of the drainage canal system will be carried out during the 10-month period from March of the second year to April of the third year, avoiding four months in the wet season. The construction work will be generally proceeded in parallel with the land preparation work, but some of the canals will be constructed prior to the land preparation work for the effective operation of the work at the beginning of the dry season.

The excavation work for the drainage canals will be mostly carried out by drag shovels, and the final shaping of the canal sections will be by man-power.

3.2.4 Flood gate

Construction of the flood gate should be completed in the first dry season to protect the flood inflow from the Nam Ngum in the wet season during the construction period.

Topsoil stripping for the site will be commenced at the middle of October and completed at the end of the said month of the first year. This work will be done by bulldozer. Following the topsoil stripping, the excavation work for the culvert will be conducted during about 1.5 months. Bulldozer will be used for the excavation of soil up to a depth of 2 or 3 meters from the ground surface, and then, the excavation work will be made by drag shovel. Man-power will be used for the excavation of cut-off.

The excavated materials will be used partially for the embankment of main closure or for the coffering work and the remainings will be reserved for backfilling. Concrete work will follow the excavation work and will be completed by the middle of January in the second year.

The earthfilling for the main closure will be carried out from the beginning of November to the end of December in the first year mainly by the use of bulldozers. The filling materials can be obtained at borrow pits near the job site. The compaction of the materials will be carefully done by means of tamping roller by regulating moisture content of the materials. Backfilling for the culvert will also be done by the bulldozer and compacted in the same manner as the main closure, excepting the compaction near the structure which should be done by rammer.

In the final step, the installation work for fixed-roller gate with hoist including other miscellaneous metal works will be carried out during one month in January of the second year.

On the other hand, it should be considered that about six months will be required for manufacturing the gate and its accessories, excluding the time for their transportation.

3.2.5 Protective embankment

Construction of the protective embankment should be commenced in the first year and completed before the beginning of the flood season of the Nam Ngum to protect the project area from the flood flow.

The construction work will be done from the upstream and to the downstream end. Topsoil stripping of the embankment for the first 6.3-kilometer portion will be performed simultaneously with that for the main irrigation canals. The remaining part will follow the above work and will be completed by the middle of March in the second year.

Earthfilling for the embankment will be carried out during 6 months from the beginning of January to the end of June in the second year. The material for the earthfilling will be excavated mainly from a borrow pit parallel to the embankment, though the excavated materials obtained by the construction of the abovementioned irrigation canals will be utilized as much as possible.

As to the construction machineries, bulldozers and tamping rollers will be used for earthfilling including the excavation work at the borrow pit and for compacting it, respectively.

3.2.6 Farm roads

Farm roads are divided into two such as the main farm roads with a total length of about 9.5 kilometers and the secondary farm roads about 40.0 kilometer long.

As regards the main farm roads, the construction work will be performed both in the first and second dry seasons. Topsoil stripping will be executed by the bulldozers during about 2.5 months in total from the middle of February to the end of March and in October of the second year. The filling work will follow the stripping work and it will be carried out from the middle of March to the middle of December in the second year, while about 4 months during the wet season are intermitted.

Filling will be performed by bulldozer. The materials for filling will be excavated mainly from the borrow pit along the roads. The excavated materials at the side ditches or the drainage canal provided along the roads will also be used as much as possible. Further, the surplus soils resulting from the land preparation work may be available for filling. The compaction of fill will be done by the tamping roller pulled with bulldozer.

Finally, metalling of the road surface will be carried out from the beginning of January to the end of April in the second year. The material for metalling is laterite to be obtained at the southern upland of the project area within 2-kilometer distance from the road sites. The materials will be tansported by dump trucks to the construction site, and compaction of the material will be done by vibrating roller.

Construction of bridges and culverts for the main farm road is scheduled to be completed before the wet season in the second year, namely the construction work will be performed from the beginning of April to the end of June in the second year. Topsoil stripping as well as excavation work for the structure sites will be done simultaneously with those for the main roads.

As to the secondary farm woads, their construction work will be carried out in the second dry season keeping pace with the construction of farm laterals. Construction method of these farm roads is almost similar to that of the main farm roads, except for metalling on the surface, which is not required in the construction of the secondary roads.

Topsoil stripping and excavation works are started by using bulldozers at the beginning of November of the second year. These works are scheduled to finish in late March of the third year. The materials stripped should be availed for land preparation of cropping field if suitable.

Filling for the roads will follow the stripping work and will be completed by the middle of June of the third year. Filling material will be obtained from the excavation of canals along the roads and from the excavation of land preparation work. As in the main farm roads, compaction of the fill material will be done by tamping roller pulled with bulldozer.

As to bridges and culverts constructed in relation to the secondary roads, their construction work will be performed during two months from February to March in the third year.

3.2.7 Land preparation

The major works of land preparation are land clearing and leveling.

The land clearing consists of tree felling, stumping, bush or thicket burning and removal of large trash of trees. A greater part of these works will be carried out mainly by using the bulldozer during the first dry season. The land leveling work, which as a rule will follow the clearing work, consists of the moving of soil to produce a level land surface. Scrape-dozer will be used for these works.

The land preparation work will be started at the beginning of November of the first year and continued to the end of June of the third year.

In planning the schedule for the land preparation work, the following table, which shows acreage of the lands by each vegetation and land slope, is taken into consideration.

Section	Area (ha)	Vegetation	Land slope
A	200	Forest	1/100-1/1,000
B	170	Shrub	less than 1/1,000
C	600	Grass	1/50-1/2,000

3.3 Construction Facilities

3.3.1 Access road

The project area is connected with B. Tha Ngon by the existing road. The road will be improved as an access road.

In the project area, the existing ox-cart roads are available along the contemplated north main canal and protective embankment sites. These roads should be temporarily improved to permite movement of construction machineries prior to the main construction work.

3.3.2 Office and quarters

The office and quarters for the supervising personnel for the

construction work will be constructed at a site about 800 meters south of the contemplated pumping station. The buildings are as follows:

Building	Floor area (m^2)	Nos.
1. Office	78.0	1
2. Residence	82.5	1
3. Garage	36.0	1

Construction work for these buildings should be commenced in advance to the other works, and it is scheduled to be carried out during three months from the beginning of August to the end of October in the first year. These buildings will be used by the personnel responsible for maintenance and operation of the irrigation and drainage systems after the completion of the construction works.

In addition, temporary buildings for construction use will be constructed by the contractor.

3.4 Construction Machineries

The construction machineries listed in the following table are required for the construction of the Project.

Description		Nos.
1. Power shovel	0.6 m^3	2
2. Tractor shovel	0.7 m^3	1
3. Angledozer	21 t	6
4. "	18 t	3
5. "	5 t	3
6. Scrapedozer	6.4 m^3	5
7. Attachment for shovel and angledozer		L.S.
8. Dump truck	6 t	2
9. Tamping roller		2
10. Vibrating roller		1
11. Vibratory plate compactor		3

(to be continued)

	Description		Nos.
12.	Rammer		L.S.
13.	Transit mixer	0.8 m^3	1
14.	Concrete mixer	0.3 m^3	2
15.	"	0.12 m^3	2
16.	Concrete vibrator		L.S.
17.	Water truck	1,500 U.S.Gal.	2
18.	Ordinary truck	5 t	2
19.	Water pump		L.S.
20.	Belt conveyer		L.S.
21.	Sedan		1
22.	Jeep		1

3.5 Construction Materials

The main construction materials required for the construction works are summarized as follows;

	Item	Unit	Quantity
1.	Cement	ton	1,010
2.	Reinforcement bar	ton	125
3.	Nail and wire	ton	7.8
4.	Other steel	ton	7.6
5.	Steel pipe	ton	9
6.	Corrugated metal pipe	ton	101
7.	Gate and hoist	ton	29
8.	Pumping equipment	ton	24
9.	Distribution line and equipment	ton	120
10.	Fuel and oil	kl	590
11.	Gravel	m^3	1,900
12.	Sand	m^3	1,100
13.	Laterite	m^3	7,110
14.	Timber	m^3	740
15.	Concrete block	nos.	3,700

The quantity of the major construction works is estimated as follows;-

	Work	Unit	Quantity
1.	Stripping	m^3	155,900
2.	Excavation of earth	m^3	74,100
3.	Earthfill	m^3	388,300
4.	Earth moving	m^3	493,700
5.	Backfill	m^3	9,800
6.	Sod facing	m^2	48,300
7.	Concrete	m^3	2,100
8.	Concrete block masonry	m^2	250
9.	Soil-cement	m^3	3,990
10.	Form for concrete	m^2	11,610
11.	Reinforcement bar placing	ton	125
12.	Concrete pipe placing	m	3,473
13.	Corrugated metal pipe placing	m	1,532
14.	Concrete pile	Nos	141
15.	Land clearing	ha	970
16.	Power destribution line	km	10

3.6 Compensation

As the job sites are mostly located on the unexploited lands, serious troubles of compensation for lands, rights and house are not expected. However, some form of compensation should be considered for the peoples who have houses in or adjacent to the project area or arable lands cultivated every year. Such problem should be solved prior to the construction works.

CHAPTER IV

COST ESTIMATE

4.1 Construction Cost

The total construction cost of the project is estimated at 1,190,000 U.S. dollars equivalent comprising 816,000 U.S. dollars with in foreign currency and 347,000 U.S. dollars in domestic currency as shown in Table 4.1. The breakdown of the construction works is as given in Appendix C.

The cost estimate is carefully prepared, using the quantities obtained in this design work, so as to include all the costs related to the construction of the project, and this estimate is made under the following conditions.

1) An exchange rate of 500 kips per 1 US dollar is used.

2) Import duties on the equipment, materials and supplies and taxes on technical services by the foreign personnel are not included.

3) The labour cost is based on the wages listed on Table 4.2.

4) The following main materials are estimated in domestic currency, and the remaining in foreign currency.

   1. Wooden materials
   2. Nails, iron wire and miscellaneous minor metal materials
   3. Fuel and oil
   4. Sand and gravel

Table 4.1 Estimate of Construction Cost

(Cost in U.S.$)

Item	Total Amount	Foreign Currency	Domestic Currency
I. Preparatory works including access roads, permanent and temporary buildings.	35,000	16,200	18,800
II. Irrigation and Drainage Facilities			
A. Tha Ngon Pumping Station	141,900	121,800	20,100
A-a Intake, Sump and Outlet Structure	35,200	25,000	10,200
A-b Control House and Garage	8,200	3,500	4,700
A-c Discharge Pipeline and Pumping Equipment	90,200	88,200	2,000
A-d Regulating Pond	8,300	5,100	3,200
B. Irrigation Canals	107,650	49,750	57,900
B-a Main Canals and Lateral	51,750	35,500	16,250
B-b Sub-laterals	5,600	1,350	4,250
B-c Farm Laterals	50,300	12,900	37,400
C. Drainage Canals	38,550	27,900	10,650
D. Farm Roads	40,000	11,100	28,900
D-a Main Farm Roads	18,400	4,700	13,700
D-b Secondary Farm Roads	21,600	6,400	15,200
E. Protective Embankment	18,200	8,000	10,200
F. Flood Gate	40,150	27,100	13,050
G. Land Preparation	41,400	6,350	35,050
H. Power Distribution Line	107,500	77,800	29,700
III. Depreciation and Maintenance Costs of Construction Machineries	316,250	253,000	63,250
Sub-total	886,600	599,000	287,600
IV. General Expense and Engineering Services	136,000	103,000	33,000
V. Contingency and Reserves (about 10% of Direct Cost)	87,400	59,000	28,400
Total	1,110,000	761,000	349,000
VI. Interest during Construction (about 7% of Total Cost)	80,000	55,000	25,000
GRAND TOTAL	1,190,000	816,000	374,000

Table 4.2 Labor Wages used in the Cost Estimate

Item	Rate per day (8 hours) (kip)
1. Ganger (Foreman)	1,000
2. Labor	500
3. Carpenter	1,500
4. Ass. carpenter	600
5. Truck driver	1,000
6. Mechanic	2,000
7. Electrician helper	600
8. Welder helper	600
9. Store keeper	600
10. Heavy machine operator	2,000
11. Steel worker	1,500
12. Electrician	2,000
13. Welder	2,000
14. Plumber	2,000
15. Ass. heavy machine operator	1,500
16. Ass. truck driver	600
17. Small machine operator	600

4.2 Annual Operation and Maintenance Cost

The operation and maintenance of irrigation and drainage facilities will be made by the farmer's organization such as irrigator's association to be established under the supervision of the Government. The organization will be in charge of the operation and maintenance of the main facilities such as the pumping station, main and lateral

irrigation canals, protective embankment, flood gate and main farm roads. The other minor structures including the sub-laterals, farm laterals, drainage canals and secondary farm roads should be operated and maintained by the farmers related to the facilities under the guidance of the above farmer's organization.

The organization will require the annual expenses itemized in the following table.

Items	Cost in US$
1) Personnel expenses	
1-Manager	1,600
1-Mechanical engineer	1,000
1-Irrigation engineer	1,000
2-Ditch rider	1,200
1-Accountant	1,000
1-Driver	400
2-Laborer	600
Sub-total	6,800
2) Office expenses including depreciation cost of buildings, vehicles, and consumables.	
US$250/month x 12 month	3,000
3) Repairing costs including depreciation cost of construction machineries, labour cost and supply cost (Direct Construction Cost x 0.65%)	5,200
4) Electric power for pumping or other uses	
750,000 kWh @ US$0.01	7,500
5) Miscellaneous items	500
Total	US$23,000

APPENDIX A

METEOROLOGY AND HYDROLOGY

A.1 General

No meteorological records in the project area are available, excepting a few data obtained in the Lao-Japan Agriculture and Livestock Farming Training Center which is located just adjacent to the project area. Therefore, the records in Vientiane are mainly employed for the project planning.

As to the hydrological data, water level of the Nam Ngum has been observed at B. Tha Ngon and B. Pa Kanioung since 1960. However, there are no reliable data on the small tributaries of the Nam Ngum around the project area.

A.2 Meteorology

(1) Temperature

Temperature in this district is fairly constant in the monthly average value, showing the maximum value of 29°C in April and the minimum, 21°C in January. However, the daily variation of temperature is remarkable and the variation during the dry season is greater than during the wet season. Annual mean temperature is about 26°C.

The temperature records at Vientiane and B. Tha Ngon are shown in the following table.

Table A.1 Monthly mean temperature (°C)

Month	Vientiane			Tha Ngon		
	Monthly mean	Average high	Average low	Monthly mean	Average high	Average low
Jan.	21.3	28.0	14.6	21.8	29.5	14.0
Feb.	23.8	29.6	18.0	22.7	29.7	15.6
Mar.	27.4	32.8	21.9	27.6	34.6	20.6
Apr.	29.0	34.5	23.5	27.8	34.0	21.6
May	28.5	32.8	24.2	28.3	34.0	22.6
June	28.1	31.4	24.7	27.9	32.2	23.6
July	27.8	31.0	24.5	28.7	33.7	23.6
Aug.	27.5	30.5	24.4	28.4	32.9	23.8
Sept.	27.3	30.6	24.0	27.7	32.4	23.0
Oct.	26.5	30.6	22.4	26.4	32.1	20.7
Nov.	24.5	29.8	19.2	25.5	31.8	19.1
Dec.	21.9	28.1	15.6	20.9	28.1	13.6
Annual mean	26.1	30.8	21.4	26.1	32.0	20.2
Observed period	1954 - 66			1967 - 68		

The highest and lowest temperatures recorded in Vientiane during the period from 1954 to 1966 were 40.7°C and 3.1°C, respectively.

(2) Evaporation

The evaporation records at Vientiane and B. Tha Ngon are available as shown in the following table.

Table A.2 Mean Daily Evaporation

Month	Vientiane (mm)	Tha Ngon (mm)
Jan.	3.2	4.4
Feb.	3.6	4.8
Mar.	4.2	6.0
Apr.	4.5	5.1
May	3.5	4.3

(to be continued)

Month	Vientiane (mm)	Tha Ngon (mm)
June	2.8	2.7
July	2.4	3.6
Aug.	2.1	3.3
Sept.	1.9	3.2
Oct.	2.4	4.4
Nov.	2.6	4.2
Dec.	2.7	4.0
Mean	3.0	4.2
Period of observation	1956 - 67	1967 - 68

The above values in Vientiane are measured by 120 centimeter diameter (Class A) pan, while those in Tha Ngon by small pan with a diameter of 30 centimeters.

(3) Rainfall

i) Mean monthly rainfall and number of rainy days: The mean monthly rainfall and number of rainy days observed in Vientiane and B. Tha Ngon are as follows:

Table A.3 Mean Monthly Rainfall and Rainy days

Month	Vientiane		Tha Ngon	
	Rainfall(mm)	Rainy days	Rainfall(mm)	Rainy days
Jan.	7.8	0.4	2.8	0.6
Feb.	14.1	1.6	30.5	2.6
Mar.	25.0	2.4	92.6	4.0
Apr.	70.6	6.9	185.5	10.5
May	243.4	13.3	293.0	13.5
June	270.7	16.5	315.0	17.3
July	266.8	16.3	270.0	14.3
Aug.	312.7	19.1	356.5	18.5
Sept.	354.7	17.1	364.5	18.3
Oct.	87.7	6.9	83.4	6.5

(to be continued)

Month	Vientiane		Tha Ngon	
	Rainfall(mm)	Rainy days	Rainfall(mm)	Rainy days
Nov.	19.5	1.6	4.2	1.3
Dec.	2.3	0.3	1.7	0.3
Total	1,675.3	102.4	1,999.7	107.7
Period of observation	1914 - 66		1967 - 68	

From the above table, it can be clearly understood that the period from April to September is the wet season, and the remaining the dry season.

ii) Intensity of Rainfall: The maximum daily rainfall observed in Vientiane during the period from 1914 to 1967 was 138.7 millimeters. The following table shows the probable maximum daily rainfall in Vientiane.

Table A.4 Probable maximum daily rainfall

Recurrence Interval	Rainfall (mm)
5	115
10	126
20	135
50	145

A.3 Hydrology

(1) Water level of the Nam Ngum

The water levels of the Nam Ngum have been observed at Tha Ngon gaging station since 1960 as shown on Drawings No. 11002.

As to the flood stage of the Nam Ngum, the following table shows the maximum flood stage in each year and the probable maximum flood stage estimated based upon the said flood stages.

Table A.5 Maximum flood stages and the probable maximum flood stages at Tha Ngon

Year	Flood stage (EL. m)	Return period (year)	Flood stage (EL. m)
1960	165.59	2	166.2
1961	167.17	5	167.3
1962	163.90	10	167.8
1963	167.42	20	168.2
1964	165.99	50	168.7
1965	165.80		
1966	168.50		
1967	165.52		

(2) Quality of river water

According to the Report on the Nam Ngum Project, 1962, the quality of river water analysed in the laboratory is shown below.

Table A.6 Quality analysis of water

Date	Aug. 1 1962	Oct. 12 1961	Nov. 6 1961	Sept.14 1962	Sept.14 1962
Ca (mg/ℓ)	12.0	8.8	8.4	16.6	15.5
Mg (")	3.6	2.9	2.4	1.2	1.6
Cl (")	3.5	3.5	7.1	14.2	14.2
SiO_2 (")	19.5	15.6	19.5	23.4	26.0
Fe (")	0.5	0.1	0.1	0.2	0.5
NH_4 (")	0.2	0.4	0.5	0.5	0.8
Consumption of $KMnO_4$	8.6	8.6	17.2	17.2	18.3
Evaporation residium	99	160	110	-	-
Suspended soil	32	46	75	-	-
pH	(2.2)	7.5	7.9	6.4	6.8

(Sampling site; Ban Tha Ngon)

(3) Flooding water in the project area

The flood gate will be provided at the mouth of the H. Nong Sam Kha to prevent backflow of the Nam Ngum during its flooding period. Consequently, it is considered inevitable that the project area is inundated by the run-off from the H. Nong Sam Kha's basin during the said period when gravity flow through the gate is impossible.

Estimation of the run-off of the H. Nong Sam Kha and the flooding water level based upon it is carried out in relation to the water level of the Nam Ngum as described hereunder.

As there are no measured value of the run-off of the H. Nong Sam Kha, it is estimated under the following assumptions.

(a) Daily rainfall recorded at Vientiane is used.

(b) Run-off coefficient for a single daily rainfall is estimated based on the assumed relationship between the run-off coefficient and the three days' rainfall as shown in the following table.

3 days' Rainfall(mm)	less than 10	10-30	30-50	50-100	100 -200	200 -300	more than 300
Run-off Coefficient(%)	0	10	30	50	80	90	95

(c) Distribution ratio which shows the percentage of the total run-off that occurs in each day after the rainfall and is assumed as follows.

Daily Rainfall(mm)	1st day	2nd day	3rd day	4th day
less than 30	100%	- %	- %	- %
30 - 50	70	30	-	-
50 - 100	60	30	10	-
more than 100	50	30	15	5

(d) Catchment area of the H. Nong Sam Kha at its mouth is 23.6 square kilometers.

On the other hand, the water level of the Nam Ngum is given in Drawings No. 11002 for the 8-year period from 1960 to 1967.

From the aforementioned run-off estimated and the water level of the Nam Ngum, the flooding water level in the project area is calculated as shown in Fig. A.1.

This calculation is carried out under the assumption that the flood gate is operated adequately and that the water levels of the Nam Ngum at the mouth of the H. Nong Sam Kha will correspond to those at Tha Ngon less 1 meter,/1 and the elevation-volume and elevation-area curves (Fig. A.2) made from the map with a scale of 1 on 5,000 are used.

As seen in Fig. A.1, the maximum flooding water level occurs in August or September in each year, and the values are summarized as follows.

Year	Month	Water level (m)	Submerged area (ha)
1960	Sept.	164.48	840
1961	Sept.	164.19	750
1962	Aug.	162.76	180
1963	Aug.	163.26	420
1964	Sept.	162.92	280
1965	Aug.	163.35	450
1966	Sept.	164.87	940
1967	Sept.	163.95	670
Mean		163.72	580

/1: This figure is obtained by adding 0.5 meter of water head between B. Tha Ngon and B. Lat Khouei and 0.5 meter which is expected to be regulated by the construction of the Nam Ngum Dam.

Based on the above table, the probable maximum flooding water level is calculated as follows.

Return period (year)	Flooding water level (EL. m)	Submerged area (ha)
2	163.8	600
5	164.6	880
10	165.0	970
20	165.3	1,040
50	165.6	1,110

Fig. A.1 FLOODING WATER LEVEL IN THE PROJECT AREA

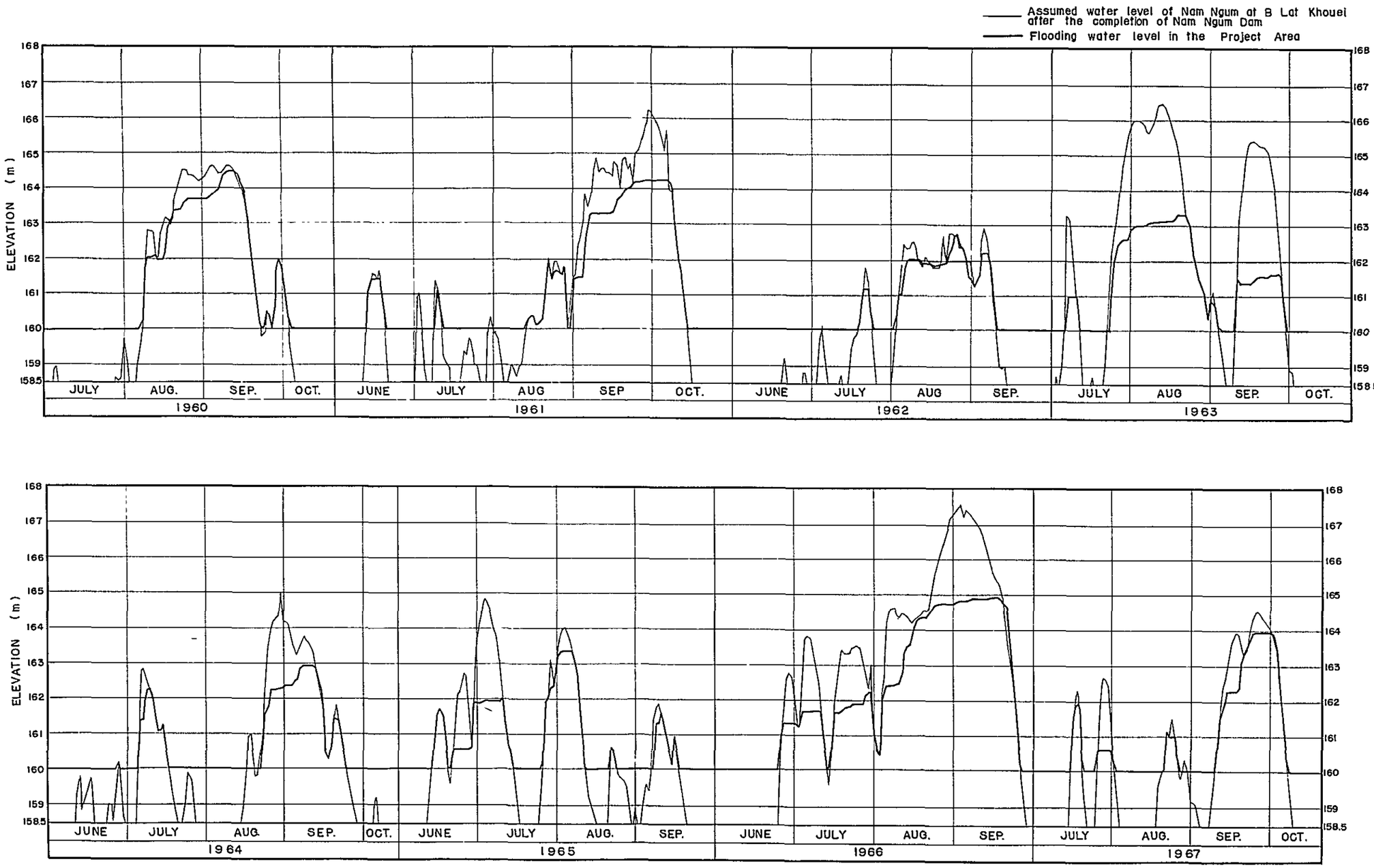
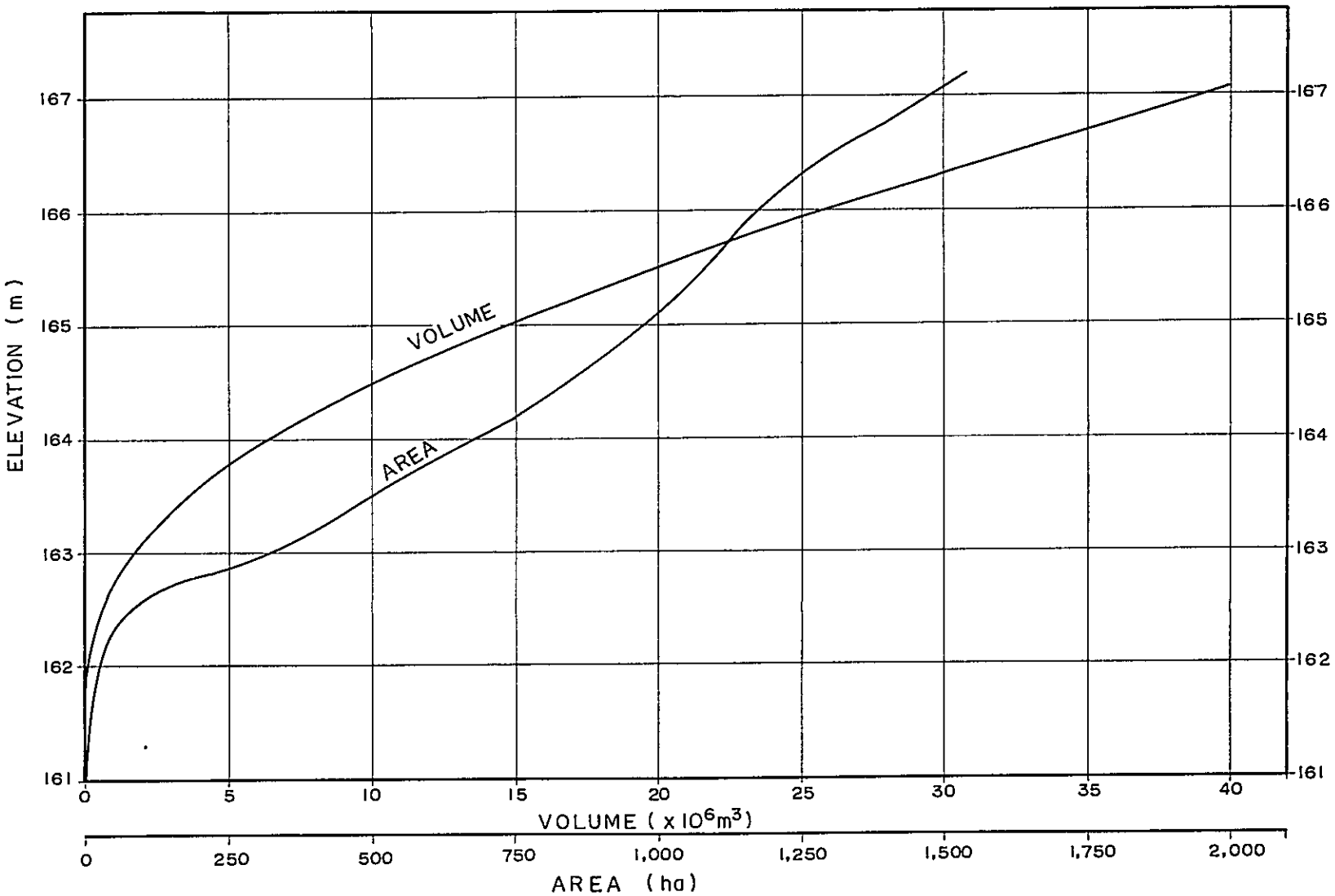


Fig. A. 2 ELEVATION- VOLUME AND ELEVATION- AREA CURVES OF THE PROJECT AREA



APPENDIX B

INVESTIGATIONS

B.1 Topographic Survey

Topographic map of a scale of 1:20,000 established under U.N. Special Fund Nam Ngum Project in 1961 is available for the Tha Ngon Project. However, this map is not sufficient for the detailed planning and designing of the project.

Consequently, investigations and surveys were carried out for making the detailed topographic map on the whole project area as well as on the main structure sites. These are:

i) Ground control survey for the aerial photo[/1] mapping of the Project area, about 10 square kilometers.

ii) Detailed topographic survey of the pumping and flood gate sites.

iii) The route location survey and detailed topographic survey for the North and South main canals, and protective embankment.

The field works were carried out during two periods, i.e. the one month period from 2nd January 1968 and about two months from 5th October to the end of December, 1968. The datum point for levelling is V-635 (EL.160.060 meters) at the Tha Ngon gaging station, and leveling was extended over about 20 kilometers along the contemplated main canals, laterals and protective embankment. The concrete bench marks of 16 posts were set up on these lines and the results are shown in Table B.1.

B.2 Test Pitting and Soil Test

Test pitting was undertaken at 10 points for the proposed main canal and other main structure sites to investigate the character and structure of their foundation. As the results, it was confirmed that the homogeneours soil layer, which consists of clay or silty clay, extends to the depth more than 3.0 meters.

/1: The aerial photograph taken in February, 1967, which was obtained from USAID.

A soil sample at each of the selected three test pits was taken for the soil test in the laboratory, and the results are summarized as shown in Table B.2.

Table. B.1 Results of Bench Mark

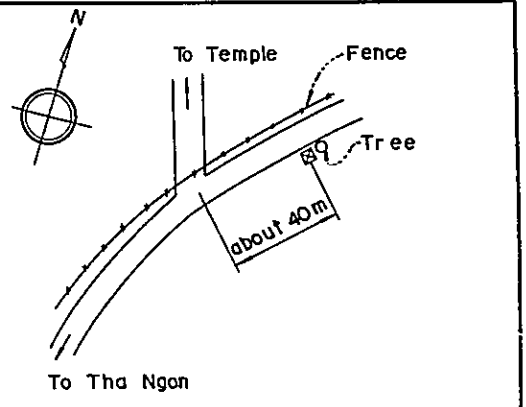
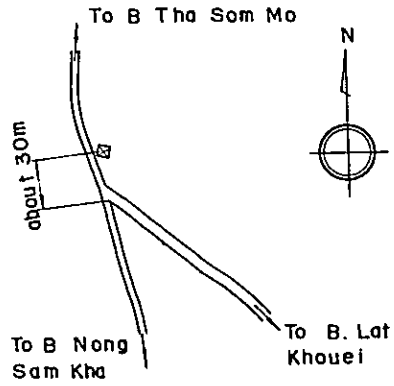
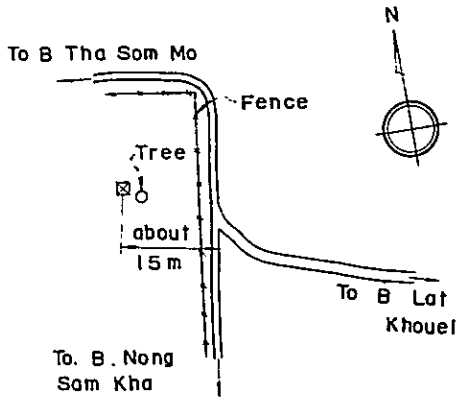
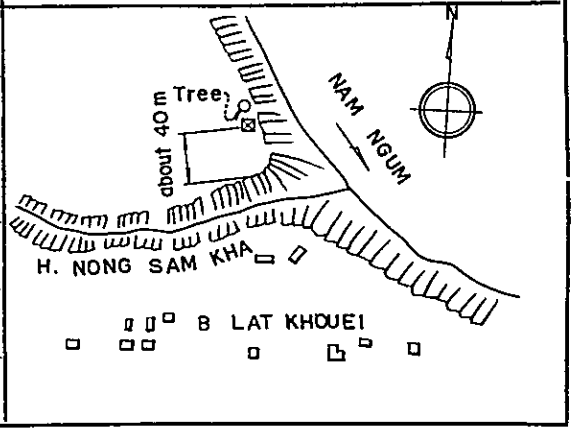
B. M. No.	DESCRIPTIONS		SKETCH
No. 1	ELEVATION	165. 547	
	LOCATION	about 1.6 km north - east of Lao - Japan Center	
	ESTABLISHED ON	JAN. 1968	
	CARVED ELEVATION		
No 2	ELEVATION	165. 167	
	LOCATION	about 400 m south of B Tha Som Mo	
	ESTABLISHED ON	JAN. 1968	
	CARVED ELEVATION		
No 3	ELEVATION	164. 809	
	LOCATION	about 2 km. N.N E of B Tha Som Mo	
	ESTABLISHED ON	JAN 1968	
	CARVED ELEVATION		
No. 4	ELEVATION	164 407	
	LOCATION	about 200 m north of B. Lat Khouei	
	ESTABLISHED ON	JAN. 1968	
	CARVED ELEVATION		

Table B.1. Results of Bench Mark (Continued)

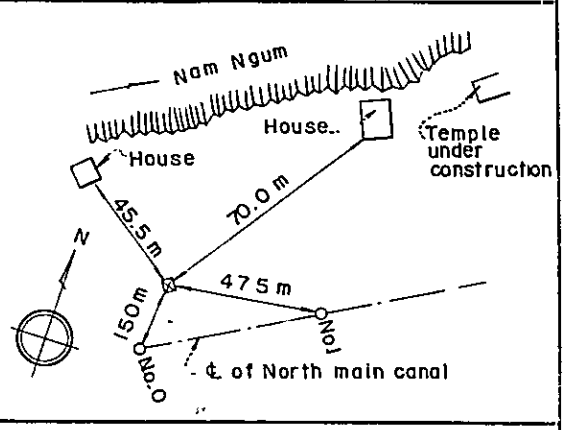
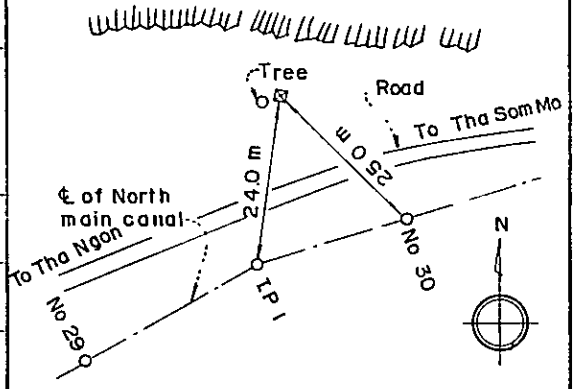
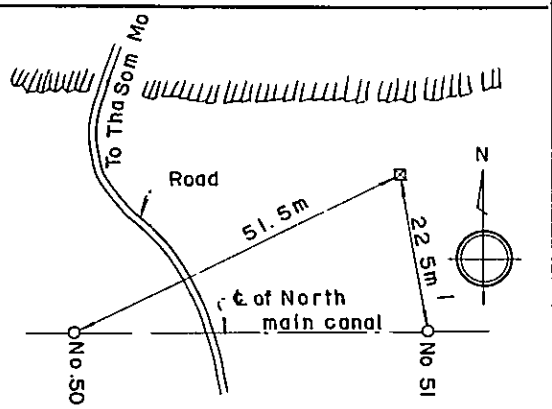
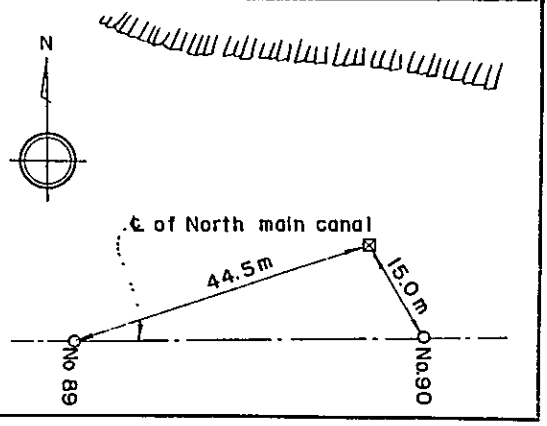
B. M. No.	DESCRIPTIONS		SKETCH
N - 1	ELEVATION	166. 464	
	LOCATION	about 1.5 km N.E.N of Lao-Japan Center	
	ESTABLISHED ON	DEC. 1968	
	CARVED ELEVATION		
N - 2	ELEVATION	166.368	
	LOCATION	about 800 m S.W S. of B Tha Som Mo	
	ESTABLISHED ON	DEC. 1968	
	CARVED ELEVATION		
N - 3	ELEVATION	166 375	
	LOCATION	about 300 m south of B. Tha Som Ho	
	ESTABLISHED ON	DEC. 1968	
	CARVED ELEVATION		
N - 4	ELEVATION	165 798	
	LOCATION	about 2.2 km S.E.S of B. Tha Som Mo.	
	ESTABLISHED ON	DEC. 1968	
	CARVED ELEVATION		

Table B.1. Results of Bench Mark (Continued)

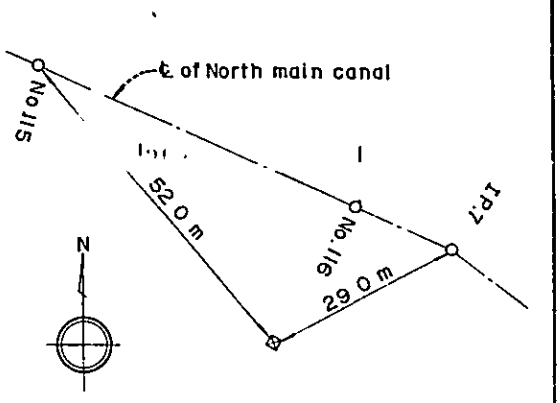
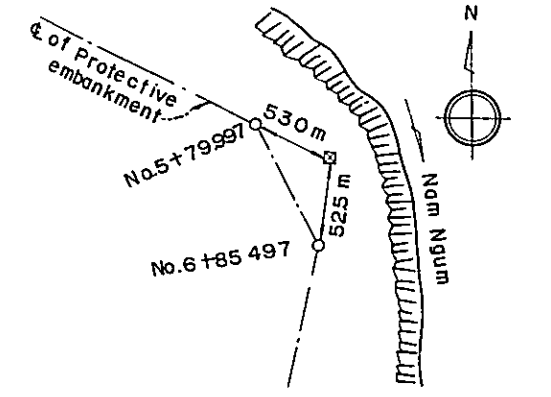
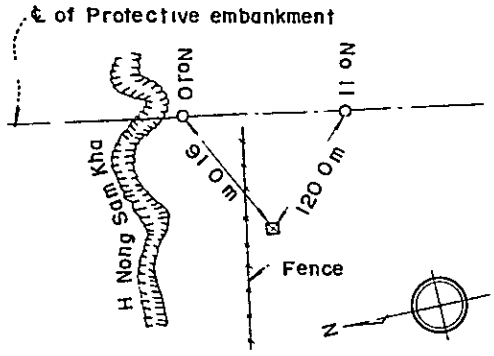
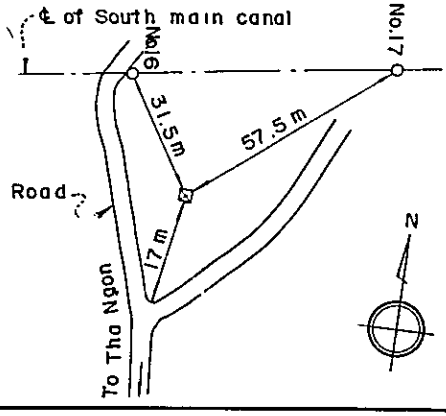
B. M. No.	DESCRIPTIONS		SKETCH
N-5	ELEVATION	65. 557	
	LOCATION	about 2.1 km north-west of B Lat Khouei	
	ESTABLISHED ON	DEC 1968	
	CARVED ELEVATION		
N-6	ELEVATION	164 970	
	LOCATION	about 700 m north of B Lat Khouei	
	ESTABLISHED ON	DEC 1968	
	CARVED ELEVATION		
N-7	ELEVATION	164. 311	
	LOCATION	about 300 m west of B Lat Khouei	
	ESTABLISHED ON	DEC 1968	
	CARVED ELEVATION		
S-1	ELEVATION	167. 320	
	LOCATION	about 1 2 km north – east of Lao-Japan Center	
	ESTABLISHED ON	DEC. 1968	
	CARVED ELEVATION		

Table B. I. Results of Bench Mark (Continued)

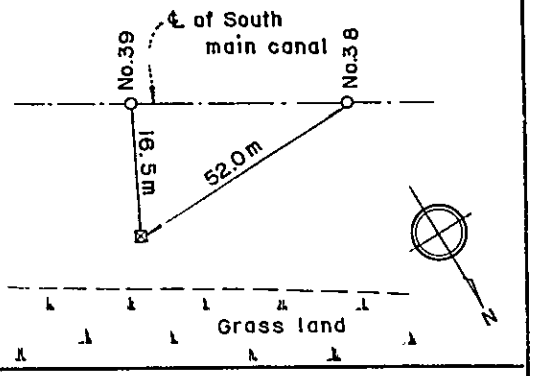
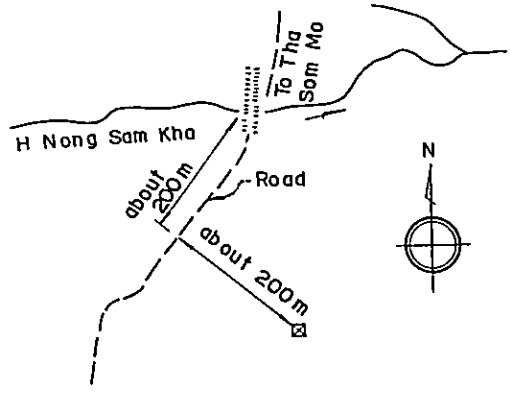
B. M. No.	DESCRIPTIONS		SKETCH
S-2	ELEVATION	165 373	
	LOCATION	about 1.9 km N.E.E of Lao-Japan center	
	ESTABLISHED ON	DEC. 1968	
	CARVED ELEVATION		
S-3	ELEVATION	168.086	
	LOCATION	about 2.1 km N.EE of Lao-Japan center	
	ESTABLISHED ON	DEC.1968	
	CARVED ELEVATION		
S-4	ELEVATION	166.758	
	LOCATION	about 2 4 km N.E E.of Lao-Japan center	
	ESTABLISHED ON	DEC- 1968	
	CARVED ELEVATION		
S-5	ELEVATION	169.442	
	LOCATION	about 3.1 km west of Lao-Japan center	
	ESTABLISHED ON	DEC. 1968	
	CARVED ELEVATION		

Table B.2 Summary of Soil Test

Sample No.	1	2	3	(Remarks)
Depth (m)	2.0	1.6	2.0	
Observation	Clay (Red)	Clay (Dark Yellow)	Clay (Brown)	
Properties				
Natural water content W(%)	18.6	21.00	24.53	
Specific gravity	2.78	2.73	2.79	
Grain Size				
Proportion, Gravel(%)	-	-	-	
Sand (%)	11	3	1	
Silt (%)	52	61	69	
Clay (%)	37	36	30	
Max. diameter (mm)	0.250	0.105	0.074	
60% " (mm)	0.05	0.016	0.037	
10% " (mm)	-	-	-	
Classification	Clay	Silty clay	Silty clay	
Consistency				
Liquid limit (%)	64.80	47.70	62.25	
Plastic limit(%)	23.78	16.68	29.49	
Plasticity index	41.02	31.02	32.76	
Flow index	23.27	35.05	20.50	
Permeability (cm/sec)	4.07×10^{-7}	7.43×10^{-8}	8.09×10^{-7}	
Compaction				
Optimum water content	21.0	19.0	24.2	
Max. density (g/cm^3)	1,642	1,657	1,568	
Shearing Strength				
Triaxial compression				
Cohesion (kg/cm^2)	1.20	1.00	1.16	(Unsaturated
Internal friction angle	$22^o5'$	$4^o27'$	$16^o45'$	Undrained shear test)
Cohesion (kg/cm^2)	0.16	0.77	1.96	(Saturated
Internal friction angle	$18^o34'$	$4^o51'$	$14^o12'$	Undrained shear test)
Swelling Test (%)	9.45	7.00	8.00	(for 5 days)

location of Sampling site: No.1 ... about 300 meters southeast of the end point of the proposed south main canal. No.2 ... about 700 meters southeast of the end of the said canal. No.3 ... about 50 meters west of the proposed flood gate site.

I. PREPARATORY WORKS

Item No.	Work	Unit	Quantity	Cost in US dollar			
				Foreign Currency		Domestic Currency	
				Unit Price	Amount	Unit Price	Amount
A	Purchaser's Office and Quarters	For the lump sum			1,900.00		9,100.00
B	Temporary Building for Construction Use						
B-1	Constructing, maintaining and repairing contractor's office and quarter including water supply and access road.	For the lump sum			500.00		4,500.00
B-2	Constructing, maintaining and repairing warehouse	For the lump sum			300.00		2,700.00
B-3	Constructing, maintaining and repairing motor-poor and repair shop	For the lump sum			2,000.00		500.00
	Sub-total				2,800.00		7,700.00
C	Electric Power Supply System for Construction Use						
C-1	Furnishing and installing electric power supply system	For the lump sum			11,500.00		500.00
C-2	Operating, maintaining and repairing electric power supply system	For the lump sum			-		1,500.00
	Sub-total				11,500.00		2,000.00
	T O T A L				16,200.00		18,800.00

II. IRRIGATION AND DRAINAGE FACILITIES

Item No.	Work	Unit	Quantity	Cost in US dollar: Foreign Currency Unit Price	Foreign Currency Amount	Domestic Currency Unit Price	Domestic Currency Amount
(A)	Tha Ngon Pumping Station						
A-a	Intake, Sump & Outlet Structure						
a.1	Stripping of topsoil	m^3	500	0.012	6.00	0.08	40.00
a.2	Excavation, type C	m^3	7,200	0.06	432.00	0.10	720.00
a.3	" Type D	m^3	60	0.01	0.60	0.055	3.30
a.4	Earthfill, type A	m^3	2,500	0.016	40.00	0.091	227.50
a.5	Backfill by machinery	m^3	5,080	0.007	35.56	0.10	508.00
a.6	Backfill by hand tool	m^3	30	0.015	0.45	0.215	6.45
a.7	Concrete, type B	m^3	285	9.10	2,593.50	8.60	2,451.00
a.8	" type D	m^3	15	5.45	81.75	8.80	132.00
a.9	Hollow concrete block, 10 cm thick	m^2	84	0.25	21.00	2.95	247.80
a.10	Soil-cement protection	m^3	420	0.62	260.40	0.54	226.80
a.11	Form for concrete	m^2	1,333	-	-	2.80	3,732.40
a.12	Reinforcement bars	ton	25.7	160.00	4,112.00	23.50	603.95
a.13	Metal works	kg	220	0.23	50.60	0.03	6.60
a.14	Wooden pile, ℓ = 2,500, ϕ150	nos	6	-	-	2.30	13.80
a.15	Screen, 1.25^m wide x 1.95^m high	set	2	1,050.00	2,100.00	45.00	90.00
a.16	Gate & hoist, 1.50^{m}wide x 1.50^{m}high	set	2	6,500.00	13,000.00	100.00	200.00
a.17	Miscellaneous works	For the lump sum			2,266.14		990.40
	Sub-total				25,000.00		10,200.00

Item No.	Work	Unit	Quantity	Cost in US dollar			
				Foreign Currency		Domestic Currency	
				Unit Price	Amount	Unit Price	Amount
A-b	Control House						
b.1	Excavation, type D	m^3	140	-	-	0.65	91.00
b.2	Backfill by hand tools	m^3	95	0.015	1.43	0.215	20.43
b.3	Gravel for foundation and floor slab	m^3	18	-	-	4.55	81.90
b.4	Concrete, type B	m^3	85	9.10	773.50	8.60	731.00
b.5	Form for concrete	m^2	350	-	-	2.80	980.00
b.6	Reinforcement bars	ton	7.8	160.00	1,248.00	23.50	183.30
b.7	Hollow concrete block, 15 cm thick including reinforcement bars	m^2	100	0.45	45.00	4.10	410.00
b.8	Plastering cement mortar to floors, walls and ceiling	m^2	350	0.27	94.50	0.73	255.50
b.9	Plastering water-proof cement mortar to roof	m^2	110	0.27	29.70	0.93	102.30
b.10	Carpentry works consist of ceiling bed, wall frames, wooden shelf, etc.	m^3	1.3	-	-	70.00	91.00
b.11	Applying plywood for interior finishing	m^2	55	-	-	2.00	110.00
b.12	Metal works including duct cover, rain leader, roof drain, etc.	kg	210	0.23	48.30	0.03	6.30
b.13	Furnishing and installing steel doors and steel glazed windows including accessories	m^2	14	-	-	28.00	392.00
b.14	Furnishing and installing sheet glass, to windows and doors with putty	m^2	6.0	-	-	25.00	150.00

Item No.	Work	Unit	Quantity	Cost in US dollar			
				Foreign Currency		Domestic Currency	
				Unit Price	Amount	Unit Price	Amount
b.15	Painting two coats of oil paint on metal and wooden surfaces	m^2	90	-	-	0.33	29.70
b.16	Painting three coats of vinyl emulsion paint on cement mortar	m^2	60	-	-	0.80	48.00
b.17	Barbed wire fencing	m	40	-	-	10.00	400.00
b.18	Lighting equipment	For the lump sum			1,095.00		357.00
b.19	Miscellaneous works	"			164.57		242.57
	Sub-total				3,500.00		4,700.00
A-c	Discharge Pipeline and Pumping Equipment						
c.1	Concrete, type B	m^3	30	9.10	273.00	8.60	258.00
c.2	" , type C	m^3	5	7.60	38.00	8.80	44.00
c.3	" , type D	m^3	3	5.45	16.35	8.00	24.00
c.4	Form for concrete	m^2	117	-	-	2.80	327.60
c.5	Reinforcement bars	ton	0.7	160.00	112.00	23.50	16.45
c.6	Furnishing and installing water pumps and electric motors including accessories	set	3	23,200.00	69,600.00	200.00	600.00
c.7	Furnishing and installing oil tank and accessories	set	3	850.00	2,550.00	20.00	60.00
c.8	Furnishing and installing discharge pipes and accessories	set	1	11,200.00	11,200.00	480.00	480.00
c.9	Furnishing and installing loose type connection joint	set	3	340.00	1,020.00	20.00	60.00
c.10	Furnishing and installing flexible joint	set	3	1,100.00	3,300.00	20.00	60.00

Item No.	Work	Unit	Quantity	Cost in US dollar: Foreign Currency Unit Price	Foreign Currency Amount	Domestic Currency Unit Price	Domestic Currency Amount
c.11	Miscellaneous works	For the lump sum			90.65		69.95
	Sub-total				88,200.00		2,000.00
A-d	Regulating Pond						
d.1	Stripping of topsoil	m^3	5,700	0.012	68.40	0.080	456.00
d.2	Excavation, type A	m^3	730	0.01	7.30	0.055	40.15
d.3	" , type D	m^3	100	-	-	0.65	65.00
d.4	Earthfill, type A	m^3	13,910	0.016	222.56	0.091	1,265.81
d.5	" , type B-2	m^3	20	-	-	0.24	4.80
d.6	Backfill by hand tools	m^3	30	0.015	0.45	0.215	6.45
d.7	Sod facing	m^2	3,980	0.12	477.60	0.002	7.96
d.8	Concrete, type B	m^3	32	9.10	291.20	8.60	275.20
d.9	" , type C	m^3	1	7.60	7.60	8.80	8.80
d.10	" , type D	m^3	1	5.45	5.45	8.00	8.00
d.11	Hollow concrete block, 10 cm thick	m^2	15	0.25	3.75	2.95	44.25
d.12	Solid concrete block, 5 cm thick	m^2	49	0.40	19.60	1.30	63.70
d.13	Form for concrete	m^2	228	-	-	2.80	638.40
d.14	Reinforcement bars	ton	1.9	160.00	304.00	23.50	44.65
d.15	Concrete pipe, ϕ600	m	7.5	6.65	49.88	3.10	23.25
d.16	Gates and hoists	set	2	-	3,400.00	-	50.00
d.17	Miscellaneous works	For the lump sum		-	242.21		197.58
	Sub-total				5,100.00		3,200.00
	Total				121,800.00		20,100.00

Item No.	Work	Unit	Quantity	Cost in US dollar			
				Foreign Currency		Domestic Currency	
				Unit Price	Amount	Unit Price	Amount
(B)	Irrigation Canals						
B-a	Main Canals and Lateral						
a.1	Stripping of topsoil	m^3	11,300	0.012	135.60	0.080	904.00
a.2	Excavation, type A	m^3	600	0.010	6.00	0.055	33.00
a.3	" , type B-1	m^3	10,620	0.040	424.80	0.065	690.30
a.4	" , type D	m^3	860	-	-	0.650	559.00
a.5	Earthfill, type A_o	m^3	3,500	0.018	63.00	0.113	395.50
a.6	" , type A	m^3	24,070	0.016	385.12	0.091	2,190.37
a.7	" , type B-1	m^3	7,660	-	-	0.240	1,838.40
a.8	" , type B-2	m^3	500	0.015	7.50	0.215	107.50
a.9	Backfill by hand tools	m^3	380	0.015	5.70	0.215	81.70
a.10	Concrete, type B	m^3	253	9.10	2,302.30	8.60	2,175.80
a.11	" , type C	m^3	31	7.60	235.60	8.80	272.80
a.12	" , type D	m^3	1	5.45	5.45	8.00	8.00
a.13	Form for concrete	m^2	2,110	-	-	2.80	5,908.00
a.14	Reinforcement bars	ton	11.7	160.00	1,872.00	23.50	274.95
a.15	Timber for stop-log	m^3	0.1	-	-	45.00	4.50
a.16	Corrugated metal pipe, ϕ600	m	45.5	16.80	764.40	0.70	31.85
a.17	Concrete pipe, ϕ200	m	58	2.45	142.10	1.40	81.20
a.18	" , ϕ300	m	15	3.60	54.00	2.30	34.50
a.19	" , ϕ600	m	5	6.65	33.25	3.10	15.50
a.20	Slide gates and hoists for turnouts and check structures	set	20	-	29,000.00	-	480.00

Item No.	Work	Unit	Quantity	Cost in US dollar			
				Foreign Currency		Domestic Currency	
				Unit Price	Amount	Unit Price	Amount
a.21	Miscellaneous works	For the lump sum			63.18		163.13
	Sub-total				35,500.00		16,250.00
B-b	Sub-laterals						
b.1	Stripping of topsoil	m^3	5,490	0.012	65.88	0.080	439.20
b.2	Excavation, type B-2	m^3	1,760	-	-	0.600	1,056.00
b.3	" , type D	m^3	110	-	-	0.650	71.50
b.4	Earthfill, type A_o	m^3	11,680	0.018	210.24	0.113	1,319.84
b.5	" , type A	m^3	790	0.016	12.64	0.091	71.89
b.6	" , type B-2	m^3	1,500	0.015	22.50	0.215	322.50
b.7	Backfill by hand tools	m^3	60	0.015	0.90	0.215	12.90
b.8	Concrete, type B	m^3	12	9.10	109.20	8.60	103.20
b.9	" , type C	m^3	1	7.60	7.60	8.80	8.80
b.10	" , type D	m^3	3	5.45	16.35	8.00	24.00
b.11	Form for concrete	m^2	200	-	-	2.80	560.00
b.12	Reinforcement bars	ton	0.7	160.00	112.00	23.00	16.45
b.13	Timber for stoplog	m^3	0.1	-	-	45.00	4.50
b.14	Corrugated metal pipe, ϕ1,000	m	13	29.60	384.80	1.40	18.20
b.15	Concrete pipe, ϕ300	m	16	3.60	57.60	2.30	36.80
b.16	" , ϕ600	m	52	6.65	345.80	3.10	161.20
b.17	Miscellaneous works	For the lump sum			4.49		23.02
	Sub-total				1,350.00		4,250.00

Item No.	Work	Unit	Quantity	Cost in US dollar			
				Foreign Currency		Domestic Currency	
				Unit Price	Amount	Unit Price	Amount
B-c	Farm Laterals						
c.1	Stripping of topsoil	m^3	20,920	0.012	251.04	0.08	1,673.60
c.2	Excavation, type B-2	m^3	8,940	-	-	0.60	5,364.00
c.3	" , type D	m^3	3,220	-	-	0.65	2,093.00
c.4	Earthfill, type A	m^3	42,260	0.016	676.16	0.091	3,845.66
c.5	" , type B-2	m^3	8,240	0.015	123.60	0.215	1,771.60
c.6	Backfill by hand tools	m^3	1,250	0.015	18.75	0.215	268.75
c.7	Concrete, type B	m^3	29	9.10	263.90	8.60	249.40
c.8	" , type C	m^3	282	7.60	2,143.20	8.80	2,481.60
c.9	Form for concrete	m^2	4,820	-	-	2.80	13,496.00
c.10	Reinforcement bars	ton	0.3	160.00	48.00	23.50	7.05
c.11	Timber for stoplog	m^3	5.9	-	-	45.00	265.50
c.12	Corrugated metal pipe, ϕ600	m	9	16.80	151.20	0.70	6.30
c.13	Concrete pipe, ϕ200	m	1,310	2.45	3,209.50	1.40	1,834.00
c.14	" , ϕ300	m	1,634	3.60	5,882.40	2.30	3,758.20
c.15	Miscellaneous works	For the lump sum			132.25		285.34
	Sub-total				12,900.00		37,400.00
	Total				49,750.00		57,900.00

Item No.	Work	Unit	Quantity	Cost in US dollar			
				Foreign Currency		Domestic Currency	
				Unit Price	Amount	Unit Price	Amount
(C)	Drainage Canals						
C.1	Stripping of topsoil	m^3	28,850	0.012	346.20	0.080	2,308.00
C.2	Excavation, type B-1	m^3	23,920	0.040	956.80	0.065	1,554.80
C.3	" , type D	m^3	1,640	-	-	0.650	1,066.00
C.4	Earthfill, type B-1	m^3	14,680	-	-	0.240	3,523.20
C.5	Backfill by hand tools	m^3	880	0.015	13.20	0.215	189.20
C.6	Concrete, type B	m^3	8	9.10	72.80	8.60	68.80
C.7	" , type C	m^3	1	7.60	7.60	8.80	8.80
C.8	Form for concrete	m^2	75	-	-	2.80	210.00
C.9	Reinforcement bars	ton	0.4	160.00	64.00	23.50	9.40
C.10	Corrugated metal pipe, ϕ600	m	1,200	16.80	20,160.00	0.70	840.00
C.11	" , ϕ1,000	m	172	29.60	5,091.20	1.40	240.80
C.12	Concrete pipe, ϕ200	m	375	2.45	918.75	1.40	525.00
C.13	Miscellaneous works	For the lump sum			269.45		106.00
	Total				27,900.00		10,650.00

Item No.	Work	Unit	Quantity	Cost in US dollar: Foreign Currency Unit Price	Foreign Currency Amount	Domestic Currency Unit Price	Domestic Currency Amount
(D)	Farm Roads						
D-a	Main Farm Road						
a.1	Stripping of topsoil	m^3	17,560	0.012	210.72	0.08	1,404.80
a.2	Excavation, type A	m^3	8,830	0.010	88.30	0.055	485.65
a.3	" , type D	m^3	40	-	-	0.65	26.00
a.4	Earthfill, type A	m^3	58,780	0.016	940.48	0.091	5,348.98
a.5	Backfill by hand tools	m^3	40	0.015	0.60	0.215	8.60
a.6	Laterite for surfacing	m^3	7,110	0.03	213.30	0.50	3,555.00
a.7	Concrete, type B	m^3	69	9.10	627.90	8.60	593.40
a.8	" , type D	m^3	8	5.45	43.60	8.00	64.00
a.9	Form for concrete	m^2	550	-	-	2.80	1,540.00
a.10	Reinforcement bars	ton	12	160.00	1,920.00	23.50	282.00
a.11	Metal works	kg	960	0.23	221.03	0.03	28.83
a.12	Mortar	m^3	0.3	12.10	3.63	7.40	2.22
a.13	Concrete pile, L=3.00 m	nos	32	9.90	316.80	5.40	172.80
a.14	" , L=5.00 m	nos	4	15.50	62.00	8.60	34.40
a.15	Miscellaneous works	For the lump sum			51.64		153.32
	Sub-total				4,700.00		13,700.00

Item No.	Work	Unit	Quantity	Cost in US dollar			
				Foreign Currency		Domestic Currency	
				Unit Price	Amount	Unit Price	Amount
D-b	Secondary Farm Roads						
b.1	Stripping of topsoil	m^3	43,540	0.012	522.48	0.08	3,483.20
b.2	Earthfill, type A	m^3	112,400	0.016	1,798.40	0.091	10,228.40
b.3	Concrete, type B	m^3	37	9.10	336.70	8.60	318.20
b.4	" , type D	m^3	3	5.45	16.35	8.00	24.00
b.5	Form for concrete	m^2	230	-	-	2.80	644.00
b.6	Reinforcement bars	ton	3.8	160.00	608.00	23.50	89.30
b.7	Metal works	kg	260	0.23	59.80	0.03	7.80
b.8	Mortar	m^3	0.2	12.10	2.42	7.40	1.48
b.9	Concrete pile, L=3.00 m	nos	24	9.90	237.60	5.40	129.60
b.10	Corrugated metal pipe, ø1,000	m	92.5	29.60	2,738.00	1.40	129.50
b.11	Miscellaneous works	For the lump sum			80.25		144.52
	Sub-total				6,400.00		15,200.00
	Total				11,100.00		28,900.00

Item No.	Work	Unit	Quantity	Cost in US dollar			
				Foreign Currency		Domestic Currency	
				Unit Price	Amount	Unit Price	Amount
(E)	Protective Embankment with Breaching Section						
E.1	Stripping of topsoil	m^3	17,900	0.012	214.80	0.080	1,432.00
E.2	Earthfill, type A	m^3	76,900	0.016	1,230.00	0.091	6,997.90
E.3	Sod facing	m^2	43,500	0.12	5,220.00	0.002	87.00
E.4	Excavation, type A	m^3	2,400	0.010	24.00	0.055	132.00
E.5	Concrete, type B	m^3	44	9.10	400.40	8.60	378.40
E.6	Solid concrete block, 10 cm thick	m^2	48	-	-	4.20	201.60
E.7	Form for concrete	m^2	145	-	-	2.80	406.00
E.8	Reinforcement bars	ton	3.3	160.00	528.00	23.50	77.55
E.9	Miscellaneous works	For the lump sum			382.80		487.55
	Total				8,000.00		10,200.00

Item No.	Work	Unit	Quantity	Cost in US dollar			
				Foreign Currency		Domestic Currency	
				Unit Price	Amount	Unit Price	Amount
(F)	Flood Gate						
F.1	Stripping of topsoil	m^3	2,120	0.012	25.44	0.08	169.60
F.2	Excavation, type B-1	m^3	2,740	0.040	109.60	0.065	178.10
F.3	" , type D	m^3	130	-	-	0.65	84.50
F.4	Earthfill, type A	m^3	240	0.016	3.84	0.091	21.84
F.5	" , type C	m^3	8,610	0.021	180.81	0.141	1,214.01
F.6	Backfill by machinery	m^3	1,120	0.007	7.84	0.10	112.00
F.7	Backfill by hand tools	m^3	60	0.015	0.90	0.215	12.90
F.8	Soil-cement protection	m^3	3,570	0.62	2,213.40	0.54	1,927.80
F.9	Concrete, type B	m^3	409	9.10	3,721.90	8.60	3,517.40
F.10	" , type D	m^3	32	5.45	174.40	8.00	256.00
F.11	Form for concrete	m^2	1,340	-	-	2.80	3,752.00
F.12	Reinforcement bars	ton	24.8	160.00	3,968.00	23.50	582.80
F.13	Metal works	kg	80	0.23	18.40	0.03	2.40
F.14	Concrete pile, L=5.00 m	nos	81	15.50	1,255.50	8.60	696.60
F.15	Gate & hoist, B=5.00 m, H=2.00 m	set	1		15,300.00		400.00
F.16	Miscellaneous works	For the lump sum			119.97		122.05
	Total				27,100.00		13,050.00

Item No.	Work	Unit	Quantity	Cost in US dollar			
				Foreign Currency		Domestic Currency	
				Unit Price	Amount	Unit Price	Amount
(G)	Land Preparation						
G-1	Land clearing						
G-1.a	Land clearing for forest	ha	200	5.10	1,020.00	26.90	5,380.00
G-1.b	" for shrub	ha	170	1.80	306.00	9.40	1,598.00
G-1.c	" for grass land	ha	600	-	-	1.00	600.00
G-2	Earth moving	m^3	493,680	0.01	4,936.80	0.055	27,152.40
G-3	Miscellaneous works	For the lump sum			87.20		319.60
	Total				6,350.00		35,050.00

Cost in US dollar

Item No.	Work	Unit	Quantity	Foreign Currency Unit Price	Foreign Currency Amount	Domestic Currency Unit Price	Domestic Currency Amount
(H)	Power Distribution Line						
H.1	22kV distribution line, distribution transformers and others	For the lump sum			53,500.00		24,000.00
H.2	Power receiving equipment at Tha Ngon Pumping Station	For the lump sum			24,300.00		5,700.00
	Total				77,800.00		29,700.00

III. DEPRECIATION AND MAINTENANCE COST OF CONSTRUCTION MACHINERIES

Cost in US dollar

Item	Foreign Currency	Domestic Currency
A. Tha Ngon Pumping Station	11,900.00	3,000.00
B. Irrigation Canals	26,650.00	6,400.00
C. Drainage Canals	11,700.00	2,850.00
D. Farm Roads	53,000.00	12,700.00
E. Protective Embankment with Breaching Section	20,650.00	5,100.00
F. Flood Gate	6,450.00	1,550.00
G. Land Preparation	122,500.00	31,600.00
H. Power Distribution Line	150.00	50.00
T O T A L	253,000.00	63,250.00