FEASIBILITY REPORT

ON

THE STUNG CHINIT MULTIPURPOSE DEVELOPMENT PROJECT

IN

THE KHMER REPUBLIC

JANUARY 1971

Prepared for

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

by

SANYU CONSULTANTS INTERNATIONAL INC.

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PREFACE

The present population of the Khmer Republic is supposed to be about seven millions and almost eighty percent of them agricultural house-holds.

Under the circumstances, the encouragement of agricultural development and the stabilization of farmers' living standards must be the most important strategies for this country.

In August 1967, the Government of Japan offered the Committee for Coordination of Investigations of the Lower Mekong Basin (Mekong Committee), ECAFE to undertake the feasibility survey of the Stung Chinit Project and also the reconnaissance survey of the area south-west of the Great Lake in the Khmer Republic which were contemplated mainly for the establishment of possible irrigation by converting a part of water flow of the Mekong tributaries to the vast areas involved, besides the development of hydro-electric power, fishery and flood control.

During 1968 - 1969, the Overseas Technical Cooperation Agency of Japan (OTCA) organized a team of experts headed by Dr. Hitoshi Fukuda, Adviser to Sanyu Consultants International, Inc. and dispatched them to the project area three times.

The present report is based upon the outcome of the survey carried out by the experts in close cooperation with the Mekong Committee and the Government of Khmer Republic.

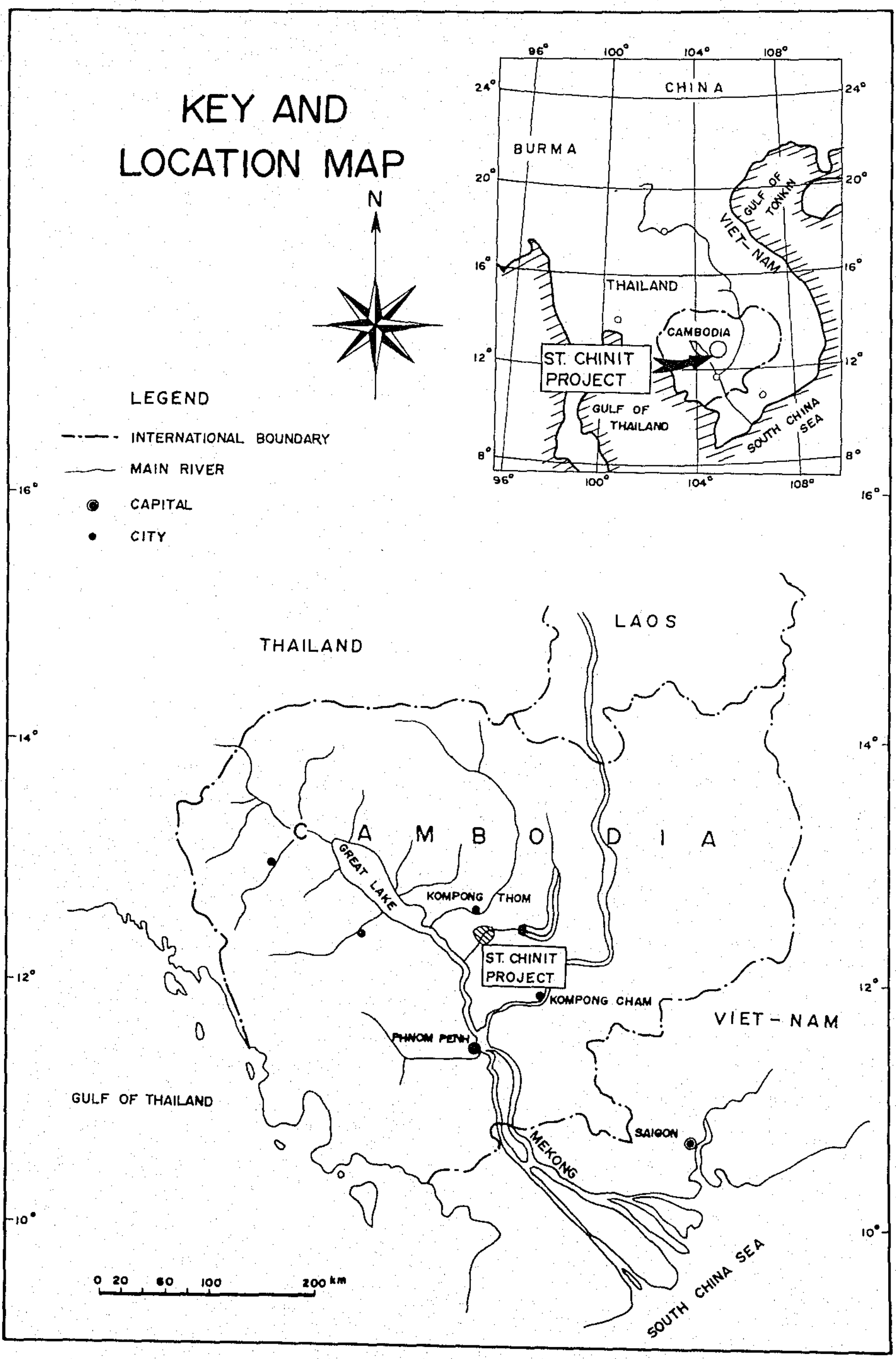
It would be most grateful for us if this report could be highly prized among peoples concerned and contributed to the economic development of the Khmer Republic as well as the promotion of friendly relations between the Khmer Republic and Japan.

Finally, on behalf of the OTCA, I take this opportunity to express my warm gratitude to the Government of the Khmer Republic, the Mekong Committee and other authorities concerned for their kind cooperation and assistance.

January 1971

K. Tatsuke

Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency


KEY AND
LOCATION MAP
N
LEGEND
INTERNATIONAL BOUNDARY
MAIN RIVER
CAPITAL
CITY
CHINA
BURMA
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VIET-NAM
THAILAND
CAMBODIA
ST. CHINIT PROJECT
GULF OF THAILAND
SOUTH CHINA SEA
LAOS
THAILAND
CAMBODIA
GREAT LAKE
KOMPONG THOM
ST. CHINIT PROJECT
KOMPONG CHAM
VIET-NAM
PHNOM PENH
GULF OF THAILAND
MEKONG
SAIGON
SOUTH CHINA SEA
0 20 60 100 200 km

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ABBREVIATIONS

mm .... Millimeter(s)

cm .... Centimeter(s)

m .... Meter(s)

km .... Kilometer(s)

km^2 .... Square kilometer(s)

m .... Cubic meter(s)

ha .... Hectare(s)

gr .... Gram

kg .... Kilogram

ton .... Metric ton(s)

°C .... Centigrade

m/s .... Meter per second

m^3/s .... Cubic meter per second

$m^3/s/day$ .... Cubic meter per second per day

hr .... Hour(s)

kW .... Kilowatt

MW .... Megawatt

kWh .... Kilowatt hour

$ .... U.S. Dollar(s)

EL .... The height above sea level

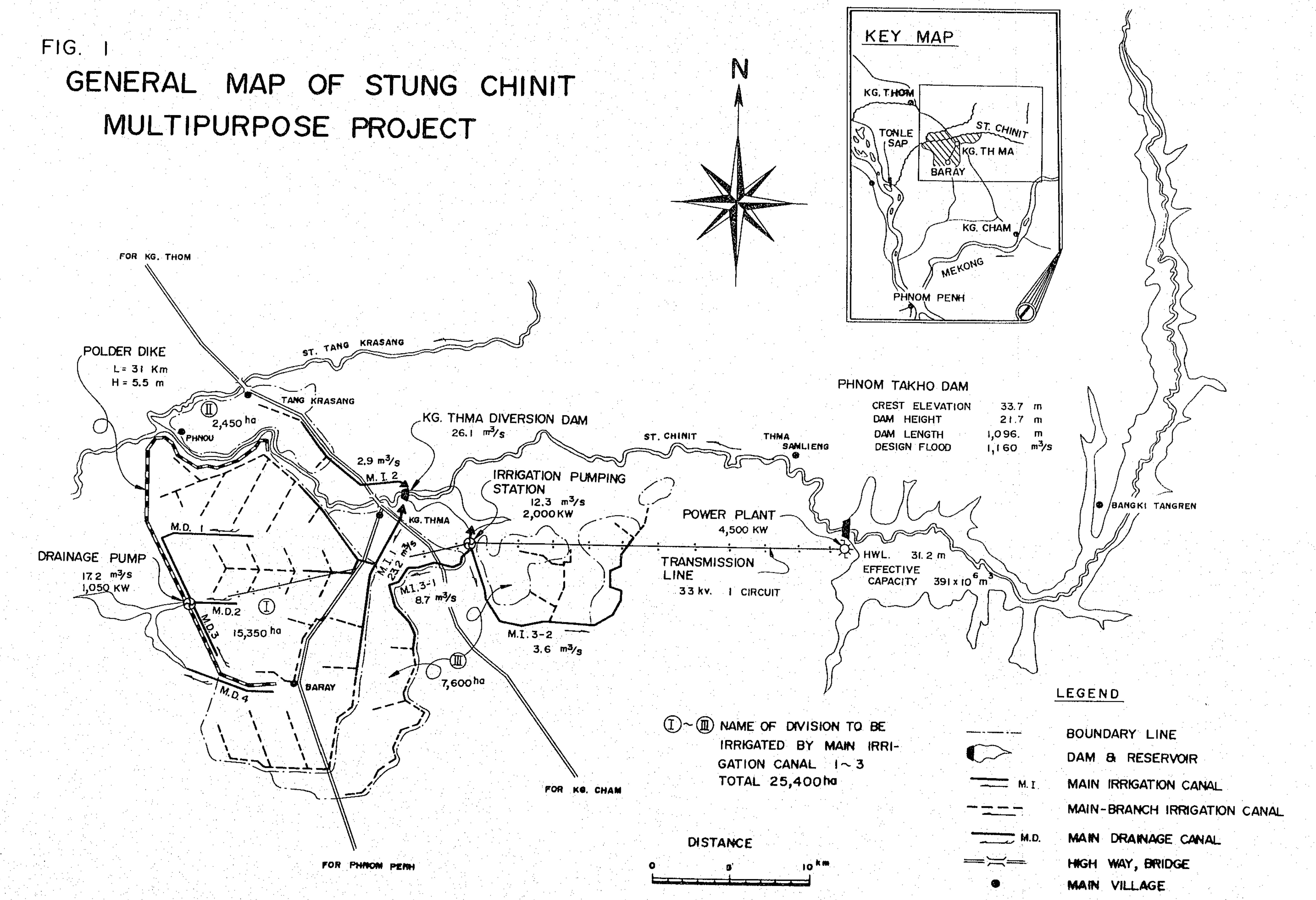
% .... Per cent

ohm/m .... Ohm per meter

micromho/cm .. Micro-mho per contimeter

FIG. 1

GENERAL MAP OF STUNG CHINIT MULTIPURPOSE PROJECT



SUMMARY

Introduction

A reconnaissance survey for the Northern Area of the Great Lake was carried out in 1966-67 by the team consisting of the Mekong Committee Secretariat and the staff organized by Overseas Technical Cooperation Agency, Japan. As a result of the survey, the team recommended that the development project for the Stung Chinit, one of the major tributaries flowing into the Great Lake, should be studied further on the feasibility phase.

In August 1967, the Government of Japan proposed to the Committee to undertake the feasibility study of the Stung Chinit Project. The plan of operation prepared by the Mekong Secretariat was agreed by the riparian countries of the Lower Mekong, as well as the Government of Japan and the Committee, on 15th January 1968.

In February 1968, the field investigation was implemented by a survey team organized by the Overseas Technical Cooperation Agency, Japan. The feasibility study was completed at the end of 1969 in close cooperation with the Government of the Khmer Republic and the Mekong Committee. (The field surveys were conducted by engineers of the Ministry of Agriculture and Forestry of Japan, for soil and fishery, and Sanyu Consultants International Inc., for irrigation, agriculture, power, navigation, flood control, civil engineering and economy.)

The present report has proved the project to be economically and technically feasible, and stated the necessity of the project for expediting the well-balanced regional development in Cambodia.

SUMMARY

I. Scope of the Project

A reconnaissance survey of the area north of the Great Lake resulted in making a recommendation to take immediate action for feasibility survey of the Stung Chinit Project. The project area is 40,000 ha in total, consisted of 12,000 ha on the right bank and 28,000 ha on the left bank of the river below EL 20 m.

The feasibility survey has been carried out on soil, farm management, water utilization, power demand, fishery and so forth within the project area of 48,000 ha below EL 25 m including 40,000 ha mentioned above. Finally, 25,400 ha below EL 25 m has been selected as comparatively effective development area, and the size of the area is considered maximum for the capacity of the water resources.

II. Development Program

II-1. Agricultural development

In order to increase productivity of land and agricultural products, the following measures are adopted:

1) stabilization of paddy in the rainy season
2) paddy fields reclamation from uncultivated lands
3) introduction of double cropping of paddy field both in the rainy and dry season

Generally speaking, target of agricultural development project is not always attained in short time. It is very important for farmers to acquire agricultural techniques before the project is completed. To attain this objective, the extension base farms are planned in the project.

The construction of the project to be carried out for five years is to start with construction of head works and irrigation canals in the down stream area and to end with completion of a storage dam in the upper stream. In the course of development, partial benefit of irrigation and acquisition of agricultural techniques are expected by early completion of head works and canals. Furthermore staged construction will make it easy to appropriate development fund.

(a) Farm-management

The farm-management includes irrigation farming and introduction of the dry seasonal rice with 80 per cent of cropping intensity. In shifting from existing cropping system to the double cropping, IR 5 and Masuri are adopted as the rainy seasonal rice. The present paddy yield of 0.9 - 1.2 ton/ha will be raised to 2.6 - 3.4 ton/ha by introducing irrigation, fertilizers and agricultural chemicals.

Generally, benefit of upland crops is high, but the development scheme does not include upland crops for the time being, due to no diffusion of the crops in the project area. However, the upland crops and cultivation of orchard is likely to be introduced in the near future.

(b) Construction schedule

The following facilities are to be constructed for the implementation of irrigation farming.

Reservoir

The multipurpose dam to be constructed at Phnom Takho will provide total storage capacity of $458 \times 10^6 m^3$ for irrigation and power generation.

Diversion dam

In utilizing the reservoir water, the irrigable area is classified into three divisions; the area below EL 12 m on the left bank to be irrigated by the main canal I is called Division I, the area on the right bank irrigated by the main canal II, Division II, and the area above EL 12 m on the left bank irrigated by the main canal III, Division III. The concrete diversion dam will be constructed at Kompong Thma for the purpose of supplying water to an area of 17,800 ha with less than EL 12 m (Division I and II). Two roller gates of 20 m length and 6.5 m height shall be installed for the dam.

Pumping station for irrigation

A pumping station will be constructed for the purpose of supplying water to an area of 7,600 ha (Division III) at Kompong Thma. The pumping station shall be equipped with two mixed flow pumps of a 1,700 mm diameter each. The construction cost of the pumping station will be less than that of a driving canal from the maindam for gravity irrigation.

Irrigation canals

All canals are of earth type, and total length of main canals is 62.55 km. As the site is covered with laterite soil, the main canals of 31.05 km in hilly land on the left bank are lined with clayey earth. Each canal system is designed to control 10 ha at its terminal.

Drainage canals

To introduce dry season cultivation, drainage facilities will be constructed. The capacity of drainage facilities is to be 12 mm/day to allow flood water depth less than 50 cm on paddy fields. The drainage canal system are designed to control an area of 10 ha at its terminal.

Polder dike

A polder dike is to be built around western part of low land in the project area to develop an arable land of 6,040 ha in the inundated area. Glassland of 3,470 ha in the arable land will be paddy fields for perennial cultivation. The polder dike shall be 5.5 m in height and 31 km in length. The volume of embankment is to be 2,231 x $10^3 m^3$.

Pumping station for drainage

A pumping station for drainage is required to drain rainfall water in the polder area. An intercepting drain is to be constructed along the national high way, which will reduce a catchment area of the pumping station, by separating mountainous area. The drainage pumping station will be equipped with four propeller pumps of 1,600 mm diameter each.

Main features of the project are shown on Table 1.

Table 1 Main features of the project

Items	Unit	Divisions			Total
		I	II	III	
Project Area	ha	15,350	2,450	7,600	25,400
Elevation (Max.)	m	12.0	11.5	22.0	22.0
Water Requirement for Irrigation	m^3/s	23.2	2.9	12.3	38.4
Water level at Intake	m	12.25	12.25	23.8	
Head Works	set	1		-	1
Pumping Station for Irrigation	set	(12.3 m^3/s, 2,000 kW)		1	1
Irrigation Canals (main)	km	23.05	8.45	31.05	62.55
Irrigation Canals (lateral)	km	113.75	18.50	93.90	226.15
Pumping Station for Drainage	set	1	(17.2 m^3/s, 1,050 kW)		1
Drainage Canals	km	78.5	-	81.6	160.1
Polder Dike	km	31.0	-	-	31.0
Reclamation	ha	4,200	450	50	4,700

II-2. Power generation

Main purpose of power generation is rural electrification including agricultural use in operating irrigation and drainage pumps. A 4,500 kW hydro-power station will be installed on the main dam. All facilities necessary for distribution are included in the project.

(a) Power demand

The commencement of power generation is expected at the end of June, 1977, and the power loads are anticipated to be 2,210 kW for general use and 2,130 kW for agriculture use respectively in 1982.

The rate of transmission loss is assumed at 5 per cent and distribution loss at 7 per cent.

(b) Hydro-power station

A 4,500 kW power station is to be set up at the main dam site utilizing the effective reservoir capacity of 391 x $10^6 m^3$ and the maximum available head of 16.3 m. Maximum discharge flow for power generation is 35.5 m^3/sec.

The station is of horizontal shaft tubular type installing two units of each 2,500 kW synchronous generator and two Kaplan turbines.

(c) Transmission, distribution and substation

The transmission lines are to be a 45 km long with 33 kV from the power station to Baray in the service area, while the distribution lines are 15 kV. The voltage of each load for agricultural pumping station is to be 6.3 kV and other loads 380 V or 220 V. The capacity of substation is to be 33 kV/15 kV.

II-3. Fishery

Fishes are very important protein sources for inhabitants in the project area. However, fish catches in dry season become almost nothing. Such being the case, they have to get protein by other means.

The construction of main dam will bring about a great influence to the fish production in both the upper and lower reaches of the river.

(a) Upper reaches

The shallow artificial lake like Phnom Takho reservoir will become a place for fish breeding. There will propagate different species of fish, such as carp, silver carp, tilapia and so forth. In order to increase fish production, gill nets and fishery boats should be prepared. At the same time refrigerators and salting equipments should be installed.

(b) Lower reaches

Fish catches on the lower reaches of the dam shall be prohibited, where adult fishes come up to shoot spawn. In the same way, catching adult fishes on the tributaries should be forbidden. To compensate inhabitants for loss, the main canal will be also utilized for fishery purpose. Namely, nursery ponds, composed of culture and feed ponds, will be provided along the irrigation canal, and propagation of small fishes also be conducted in the ponds.

II-4. Flood control

Inundation by flood sometimes extends to a large area in the river basin and causes poor productivity of land. By mean of flood control operation of reservoir probable flooded area of cultivated land will decrease from 700 ha to 390 ha and damage for public facilities will be reduced to half.

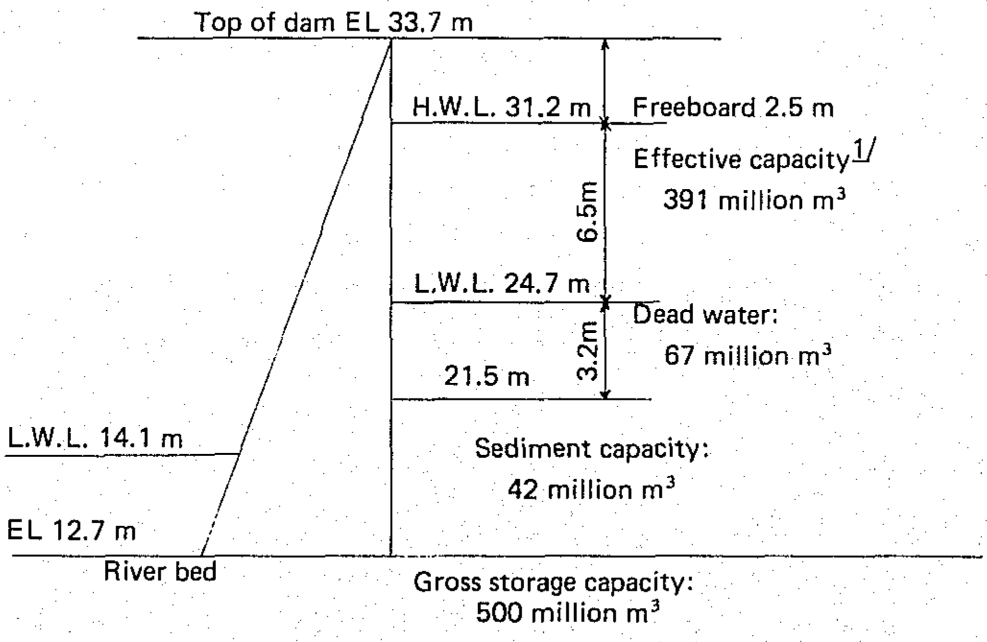
II-5. Multipurpose dam

(a) Required storage capacity

The main dam site at Phnom Takho is selected among 2 proposed sites from viewpoints of topography, geological features, soil conditions and hydrology.

The required storage capacity is 370 x $10^6 m^3$ for agriculture, 300 x $10^6 m^3$ for power generation and 270 x $10^6 m^3$ for flood control. The discharge from the dam is mainly used for irrigation, and the water in the reservoir will be almost empty from June to July. Then, the total required effective storage capacity for three purposes will be 391 x $10^6 m^3$. The capacity of the reservoir is given in Fig. 2.

Fig. 2 Distribution Plan of Reservoir Capacity



1/ This capacity is satisfied with each objective required water quantity, while overlapping each required water quantity.

Irrigation:	370 million m^3
Power:	300 "
Flood control:	270 "

(b) Main structure

The main dam is of a combined type of gravity and earthfill. The expected flood discharge is taken at 1,160 m^3/s with 0.1% excess probability. The main features are summarized in Table 2.

Table 2 Main features of dam

Catchment area: 3,770 km^2

	Type	Height	Crest length	Volume content	Storage capacity
Dam body	Earth-fill	21.7m	1,040m	$540 x 10^3 m^3$	Gross: $500 \times 10^6 m^3$ Effective: $391 \times 10^6 m^3$
Spillway	Concrete gravity	14.0m	56m	$21.5 x 10^3 m^3$	
	Flood discharge facilities			3 roller-gate: 710 m^3/sec 2 conduits: 80 "	
	Emergency spillway (200m wide):			370 "	
	Intake facilities			2 conduits: 35.5 "	

III. Construction cost and schedule

(a) Construction cost

The total cost of the Stung Chinit project is estimated at US$26,220 x 10^3 and its allotment for each purpose is given in Table 3.

Table 3 Construction cost

Unit: $\$10^3$

Development Purpose	Specific cost	Cost of 1/ main dam	Total cost	Remarks
Agriculture	17,680	3,810	21,490	25,400ha, $846/ha
Power generation	2,660	1,580	4,240	4,500kW, ¢2.75/kWh2/
Fishery	1003/	120	220	
Flood control	-	270	270	
Total	20,440	5,780	26,220	F.E. 14,735 L.C. 11,485 equivalent4/

Note: 1/ Cost allocation of main dam is conducted by the method of separable costs-remaining benefits for each purpose.
2/ Including distribution cost.
3/ Facilities for 3 nursery ponds and landing place in the reservoir.
4/ F.E.: Foreign Exchange L.C.: Local Currency, $1=55.5 Riel

Table 4 Construction Schedule

(Unit: $\$10^3$)

Item of Construction	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year	Total Cost
1) Definit Design of the Project									(315) 480
2) Main Dam									(3,935) 5,620
3) Construction for Agriculture									
Land Development			I & II				III		(870) 4,010
Irrigation Canal			I & II				III		(1,570) 3,450
Irrigation Pumping Station							III		(850) 1,170
Drainage Canal							I & III		(840) 1,940
Polder Dike							I		(870) 1,750
Drainage Pumping Station							I		(920) 1,140
Diversion Dam			I, II & III						(810) 1,155
Supervision									(770) 1,140
Contingency									(800) 1,605
Sub-total			1st Stage			2nd Stage			(8,300) 17,360
4) Construction for Power									(2,130) 2,660
5) Construction for Fishery									(55) 100
Total	(105) 600	(105) 160	(1,690) 4,110	(1,815) 3,945	(2,470) 4,450	(4,100) 6,855	(4,450) 6,540		(14,735) 26,220

Note: ( ) shows foreign currency and is included in the total amount.

(b) Construction schedule

A construction period of five years is adequate for the completion of the project. The period is divided into two stages; the 1st stage (1st - 2nd year) and the 2nd stage (3rd - 5th year), and they are primarily intended for the effective extension of irrigation farming. That is, the diversion dam will be completed in the 1st stage, and be made for stabilization of the rainy season cultivation in the major part of Division I and Division II of 14,800 ha. Furthermore, the dry season irrigation will be possible for an area of 5,000 ha by utilizing the natural flow and reserved water by the diversion dam.

At the 2nd stage, the main dam can be completed, the flood of the Stung Chinit can be controlled, and irrigation water for the dry seasonal use is secured for the entire project area of 25,400 ha.

The construction schedule is shown in Table 4.

IV. Benefits

(a) Agriculture

The net benefit from the project area of 25,400 ha will be augmented because of the increase of unit yield by adopting irrigation systems, agricultural chemicals and fertilizers, and of arable land by reclamation which are given in Table 5.

Table 5 Net benefit increased

Divisions	Area (ha)	Net benefit increased (10^3 Riel)		Benefit increased per ha (Riel)	Benefit increased per ha ($)
I	15,350	86,737		5,651	102
II	2,450	9,606		3,921	71
III	7,600	40,770		5,364	97
Total	25,400	137,113	(Average)	5,400	97.3

Note: $1 = 55.5 Riel

The net benefits will be realized in the 5th year after completion of construction, coupled with demonstration and extension effect by the extension base farms which are independently provided. Further, by improving farmers' agricultural techniques and seed varieties, and by introducing upland crops and orchard, the benefit given in Table 5 will be increased at the rate of 2 per cent per annum after the 5th year.

(b) Hydro-power

The benefit from hydro-power generation is estimated to be equivalent to the cost of an alternate diesel power plant with the same capacity. The thermal power cost including distribution is ¢3.00/kWh.

(c) Fishery

Referring to two cases in Thailand, the catch is assumed 0.45 ton/km^2 per month after the completion of the reservoir of which the surface area will be 40 km^2 on an average. The total fishery benefit is, therefore, accumulated to be $11,676 per annum based on unit fishery benefit of 3 Riels/kg.

(d) Flood control

58% of annual flood damages of $37,320 will be prevented by given an appropriate control system.

Table 6 Annual damages and prevention

Unit: $

Items	Paddy	Public facilities	Total
Damages before control	13,730	23,590	37,320
Prevention after control	6,700	14,930	21,630

V. Economic evaluations

The economic evaluation is made by adopting the following items.

Period of Analysis	50 years
Useful Lives	
Dam, Canals, Facilities of Power	50 years
Pumps	25 years
Hydro-power turbine and generator	35 years
Communication facilities, Substation	25 years
Interest rates	
Agriculture	3%
Power-generation	6%
Fishery	3%
Flood control	3%

The result of economic evaluation is shown in Table 7.

Table 7 Economic evaluation

Item	B/C Ratio	Interest Rate (%)	Remarks
Agriculture	2.76	3	IRR[1/] 8.6%
Power generation	1.13	6	Power Cost at Load Center: ¢1.36/kWh and at distributed Site: ¢2.75/kWh
Fishery	1.50	3	
Flood Control	1.70	3	
Total	2.48		

1/ IRR: Internal Rate of Return.

VI. Financial program

The total construction cost including interest $\$2,356 \times 10^3$ during construction period of 5 years is estimated at $\$28,576 \times 10^3$, consisting of the foreign exchange of $\$15,786 \times 10^3$ and the local currency $\$12,790 \times 10^3$.

The foreign exchange component is assumed to be financed by loan, and the local currency component is expected to be borne by the Governmental treasury.

Repayment terms are shown in Table 8.

Table 8 Repayment terms

	Repayment term	Interest rate per annum	Grace periods
(i) Foreign Exchanges (No interest during grace periods)			
Agriculture	30 years	3%	5 years
Power, Dam & Fishery	30 years	5%	3 years
(ii) Local Currency (No interest during grace periods)			
Agriculture	30 years	5%	5 years
Power, Dam & Fishery	30 years	5%	3 years

Schedule of total repayment based on the above conditions is shown in Table 9.

Table 9 Total repayment

(Unit: $\$10^3$

		Total repayment	Annual repayment
Agriculture	(F.E.)	18,390	720
	(L.C.)	20,568	816
		38,958	1,536
Power Fishery & Flood Control	(F.E.)	6,966	258
	(L.C.)	2,295	85
		9,261	343

VII. Recommendations

To realize this regional development project, the following five recommendations are given.

i. Establishment of extension services through extension base farms

ii. Organization of farmers' association

iii. Improvement of marketing systems

iv. Governmental administrative treatment for the project execution

v. Effective financial arrangement

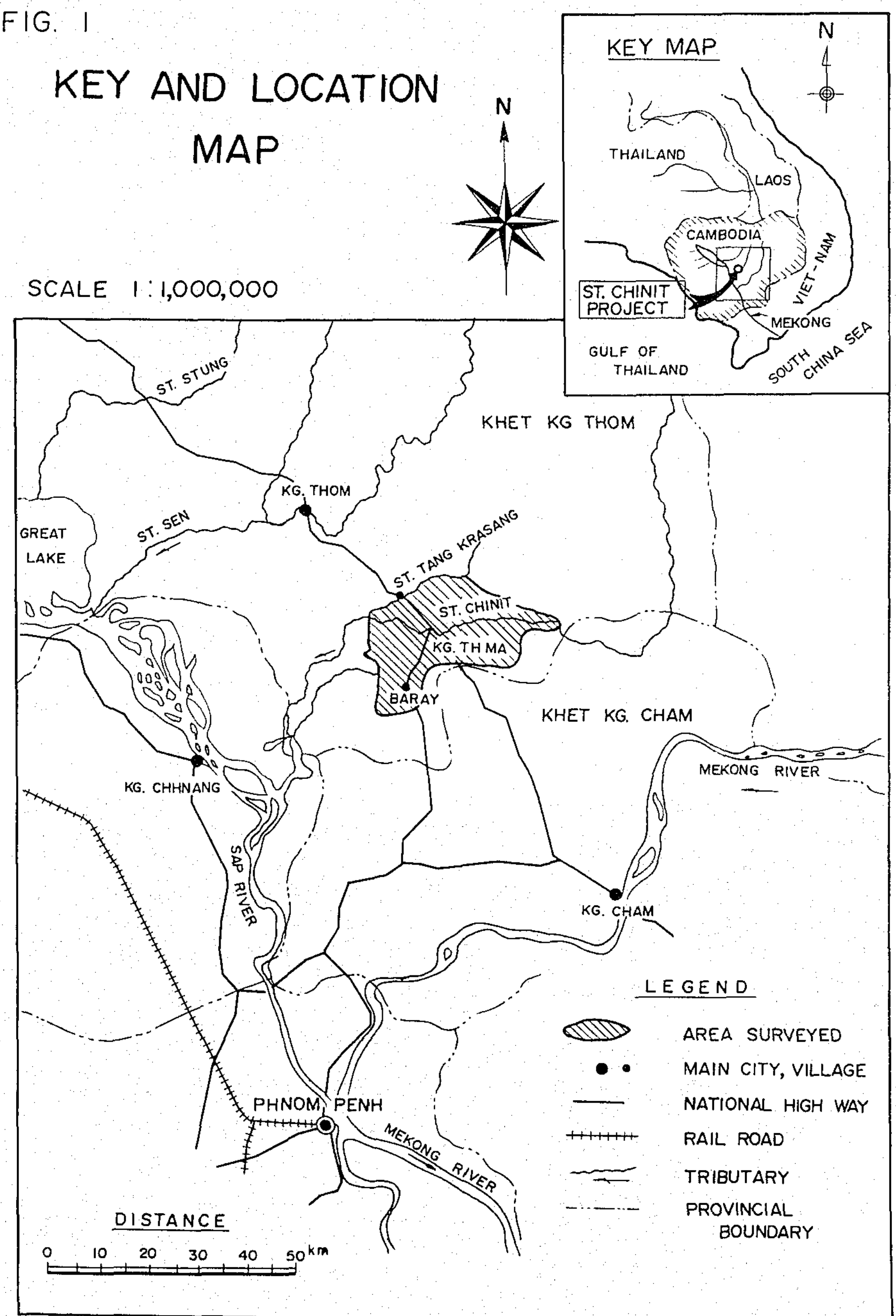
PART I

PROJECT AREA

FIG. 1

KEY AND LOCATION MAP

SCALE 1 : 1,000,000



PART I PROJECT AREA

1-1. Topography

The project area occupies a good part of central Cambodia and lies in the northeast watershed of the Tonle Sap. The area consists of a hilly area ranging from EL 20 to 100 m and an alluvial fan plain with EL below 20 m.

In the hilly area, the river slope of the Stung Chinit is remarkably small (1 : 15,000). The Stung Chinit repeats its meandering, and has been developing a wide flood plain and many ox-bow lakes.

The fan plain area inclines slightly to the west with a slope of 1 to 20,000 and the part of EL below 10 m is inundated by the Great Lake water in the rainy season.

1-2. Climate

The climate of the project area can be divided into two seasons; the rainy and dry seasons. The temperature always keeps high and rice-growing is possible all the year round in view of temperature. In Kg. Thom, the mean temperature is around 27°C. There is little seasonal fluctuation in the temperature, but the daily fluctuation is rather greater than the seasonal one. That is, the difference between night and day sometimes is in the range of 10°C in the dry season.

Table I-1 Monthly Average Temperature in Kg. Thom

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average 1/	25.5	26.9	28.4	29.6	28.2	27.7	27.7	27.6	27.2	27.1	26.7	24.6
Maximum 1/	36.9	38.3	38.1	40.9	39.7	39.2	37.4	36.7	35.5	36.2	34.2	35.5
Minimum 1/	11.7	15.5	18.6	20.4	21.0	21.5	21.3	21.5	20.0	19.3	17.6	11.0

1/ Data taken for 12 years

1-3. Geology

In the central area of Cambodia, the alluvial deposit spreads over the vast area, approximately 100 - 200 km wide, around the Great Lake, the Tonle Sap and the Mekong.

The hilly lands in the project area mostly consist of the decomposed products of basaltic lava, and remarkable laterite is revealed. The other areas besides the above hilly lands consist of the alluvial deposits without exception, and judging from the compactness of these deposits, they are classified into two categories; the young and the old.

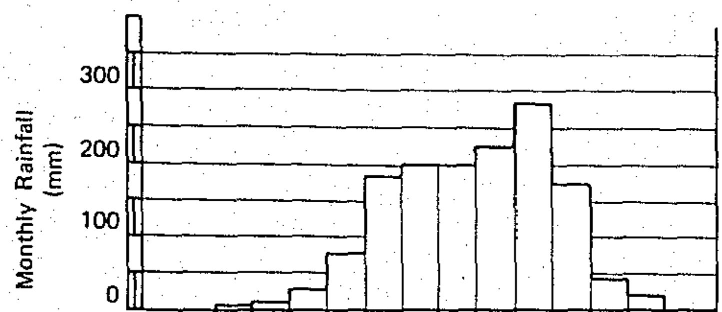
1-4. Hydrology

1-4-1 Rainfall

From the 24-years rainfall records at Baray situated almost in the central part of the survey area, the rainfall feature of this area is summarized as follows:

(a) Average annual rainfall is approx. 1,400 mm, of which 90 per cent is concentrated during six months of the south-western monsoon. The starting of the rainy season differs with the year by one or two months.

Fig. I-I Mean Rainfall at Baray for 24 Years (1926 - 42, 1962 - 68)



Month	J	F	M	A	M	J	J	A	S	O	N	D	Σ
Rainfall (mm)	5	7	27	77	183	199	199	223	283	175	46	22	1,446

Max. 1,803.8 mm in 1926
Min. 887.4 mm in 1936

(b) Even during the rainy season, there is sometimes a droughty spell.

The records of a spell of droughty days during four rainy months of the last 7 years are tabulated as follows: (Table I-2)

Table I-2 Droughty Days

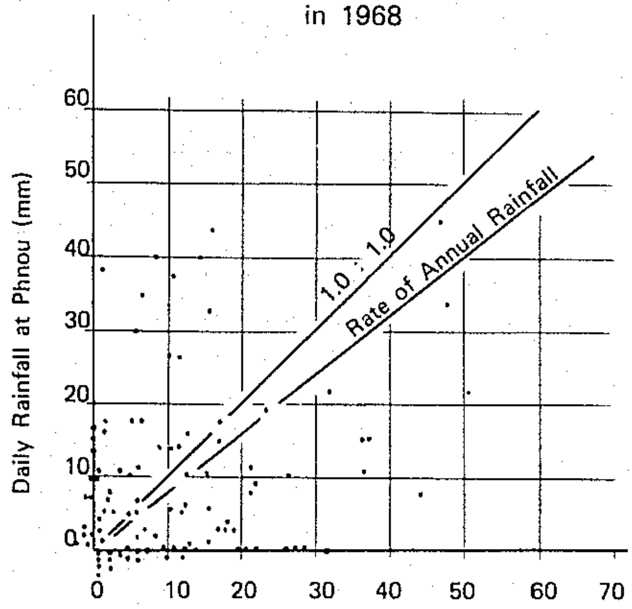
Year	1st	2nd	3rd	4th	Annual Rainfall	Total No. of Annual Rainy days
1962	6	6	4	4	1,773.6 mm	108
1963	12	7	5	5	1,548.2	92
1964	8	6	6	5	1,515.0	83
1965	15	12	11	7	1,602.8	76
1966	12	12	8	8	1,648.0	85
1967	8	5	4	4	1,246.9	94
1968	11	9	8	7	1,252.9	72

The longest droughty period is a 29-days period in 1928. The second and the third longest periods are, in order, periods of 18 days in 1929, and 16 days in 1931 respectively. The droughty duration lasts one or two weeks every year. It may be suggested by this fact that a supplemental irrigation even during the rainy season is important.

(c) The rainfall is of a shower type and distinguished in locality and short in the rainfall period; ordinarily it lasts 1 or 2 hours.

An example the relation between daily rainfall of 1968 in Phum Baray and Phum Phnou is shown in Fig. I-2.

Fig. I-2 Relation of Daily Rainfall between Baray and Phnou in 1968



The distance between Baray and Phnou is only 25 km, but there is no relationship between them in the daily rainfall.

1-4-2. Soil-Water Relation

<u>Percolation</u> The amount of daily percolation of water for the paddy field is on an average 7.0 mm for sandy soil, 5.0 mm for loamy soil and 2.0 mm for clay. Generally speaking, percolation is relatively high on the right bank of the Stung Chinit.

The coefficient of permeability, "K" of Darcy's law, was measured at the site. In general, the coefficient of permeability is as large as 10^{-3} cm/s and, the right bank of the Stung Chinit has high permeability because of sandy soil, such as "K" being within the limits of 10^{-1} ~ 10^{-3}.

Soil Moisture Content For a reference of field irrigation plan, the soil moisture content and the intake rate for each soil group were measured at the site. The results on average value are summarized and given in Table I-3.

Table I-3 Soil Moisture Content and Intake Rate

Soil Group	Moisture in volume %			Basic Intake Rate in mm/hr
	FC	WP	AM	
Grayish Brown Soils coarse texture	13.4	4.1	9.3	10.7
Grayish Brown Soils medium texture	20.7 ~ 24.7	6.7 ~ 8.1	14.0 ~ 16.6	3.5 ~ 9.5
Grayish Brown Soils fine texture	25.6	8.5	17.1	6.6
Vertisol Lithic	28.5	9.4	19.1	154

Note: FC = Field Capacity, measured after 24 hours of watering
WP = Permanent Wilting Point, assumed from FC
AM = Available Moisture, FC - WP

The values of AM of the soil groups correspond with their water holding capacity mainly based on their soil textures. As for the field irrigation method, a furrow irrigation will be applicable for the Grayish Brown Soils according to their basic intake rates, but for the Vertisol which may need a spray irrigation being large of its infiltration.

1-4-3. Ground Water

(a) Survey

The relative survey of ground water has been conducted in order to find a possibility of the utilization of ground water and study subsurface drainage, mainly in the project area.

The survey is composed of the undermentioned items.

(i) Ground Water Table Gauging

(ii) Electric Sounding

(iii) Observations on Depth to Water Table, Temperature and Electric Conductivity

(iv) Pumping Test

These surveyed spots are indicated in Fig. I-3.

(b) Ground Water

The ground water of the project area is generally recognized at the shallow spaces. The depth of ground water table from the groundsurface is almost 2 to 3 m, hardly exceeds 5 m, in the dry season, while it registers 1 to 2 m, in the rainy season, which is very close to the groundsurface.

The ground water is fully utilized for domestic purpose, and shallow wells are dug so as to secure barely enough water in the dry season.

The water level between the dry season and the rainy season rises and falls remarkably, in the range of 1 to 3 m and the water surface rises sharply at the rainfall.

The temperature of the ground water registers 28 ± 5°C (the river water of the Stung Chinit indicates 28.8°C) in the dry season. The electric conductivity of the ground water is generally large; 90 to 1,050 (at 18°C) micromho/cm, and its corresponding salt contents indicate around $1.4 \times 10^{-4} \sim 6.1 \times 10^{-1}$ %.

(c) Aquifer

The aquifer in the project area can be divided into two types.

One is chiefly composed of sandy and gravelly deposits of the alluvium, distributed along the Stung Chinit and in the low lands of almost

EL 20 m below.

According to the result of the electric prospecting and the drilling, this aquifer seems to be developed in two layers, inclining towards the western direction.

The specific yield of the aquifers is small, assumed to be approximately 50 m^3/day/m.

The other type of the aquifer is found in the district higher than EL 20 m. Generally, there are noticed shallow wells for home use in the districts where lateritic layers have been developed and these wells seems to sustain comparatively abundant amount of the ground water.

The lateritic layers are distinguished into two faces. One is the layer, immediate under the top soil, and the other is situated just below the said layer. It is assumed that the upper layer is probably composed of the porous lateritic layer and forms the aquifer. The specific yield of the aquifer is small; approximately 15 m^3/day/m.

From the above facts, it is concluded that the yield of aquifer in the Stung Chinit basin is comparatively small i.e. 260 to 800 m^3/day/km^2, assuming that the draw-down and the influent radius are 5 and 300 m respectively.

(d) Available Ground Water

Potentiality of the ground water utilization for irrigation in the benefited area is studied as follows.

The total amount of the rainfall at Kg. Thma in 1968 (the droughty year of 93%) was measured at 1,253 mm, and the total discharge of the Stung Chinit at the same place is observed at approximately 928 million m^3 or the unit discharge depth 220 mm (catchment area 4,130 km^2). The evapotranspiration is estimated at 995 mm, assumed that it is 50% of the

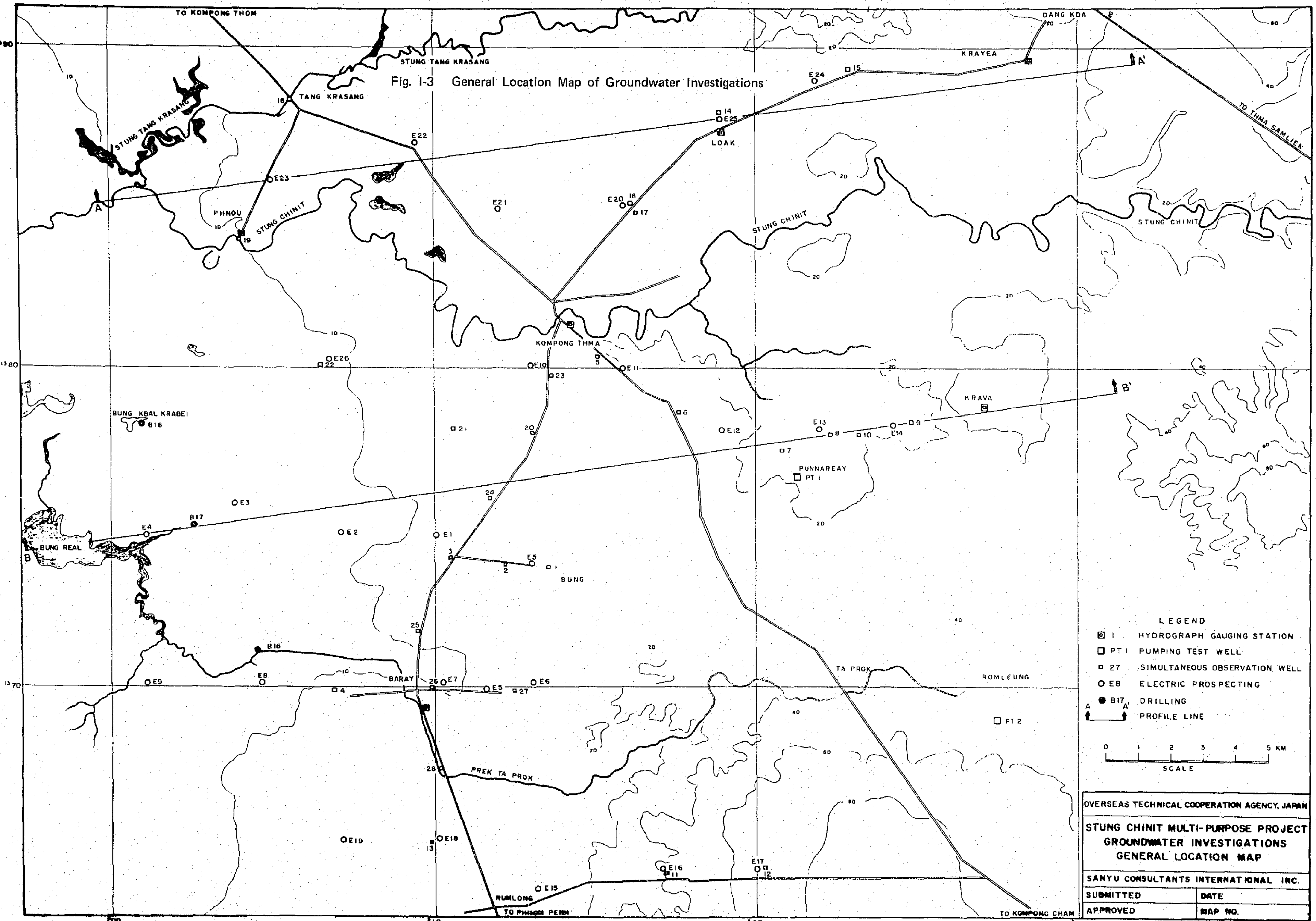


Fig. I-3 General Location Map of Groundwater Investigations

pan evaporation.

Therefore, hydrological balance of the Stung Chinit basin in 1968 is estimated as the following equality, calculating the infiltration at 38 mm.

$$1,253 - 220 - 995 - 38 = 0$$

The storage capacity of the ground water in the project area is assumed from the monthly balance of the ground water as shown in Fig. I-4. The hydrological balance to the aquifer - variation of infiltration - results in the variation of the ground water table according to the effective porosity of the aquifers.

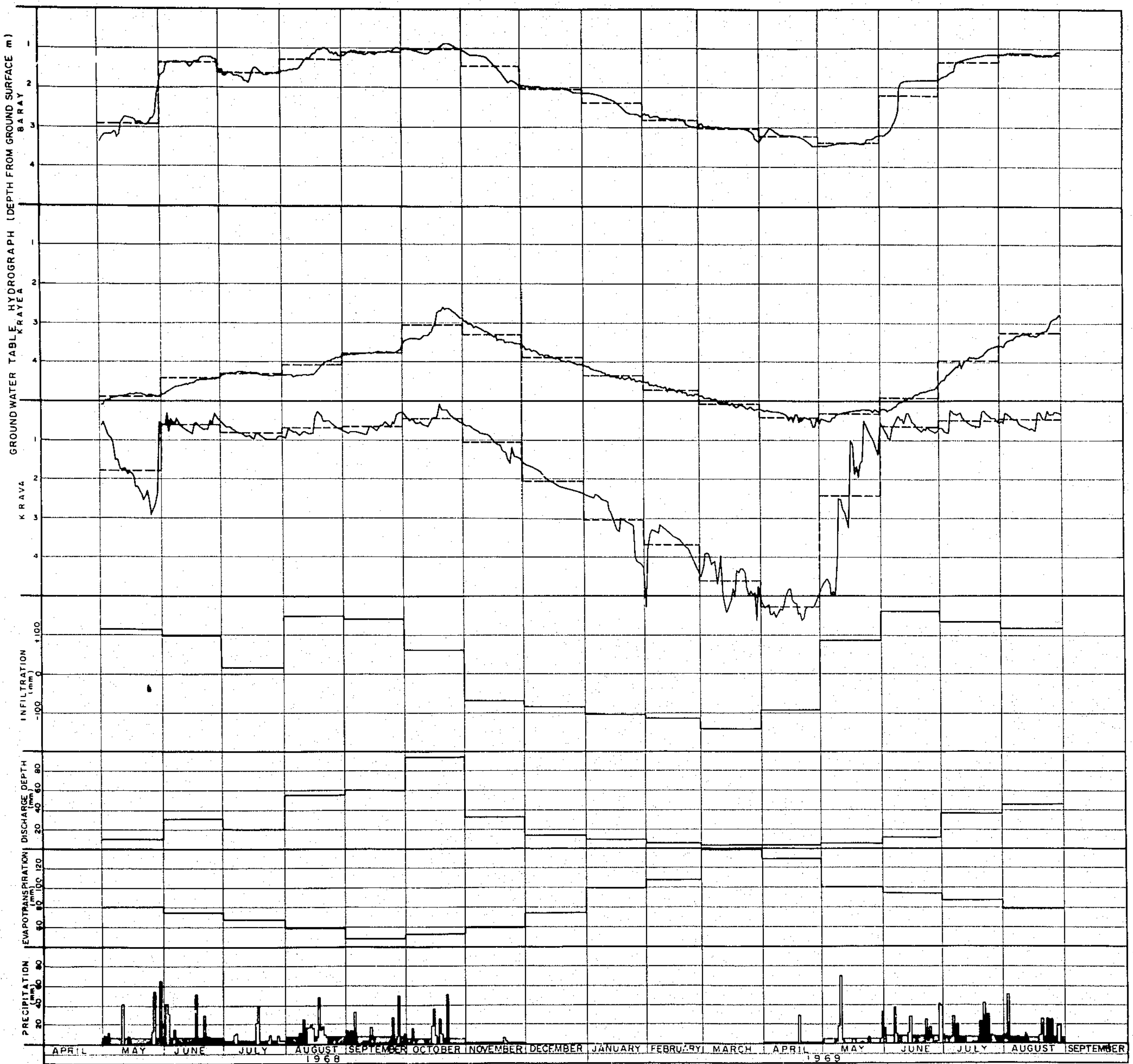
As a results of the monthly analysis of this relationship, it is evident that the variation of the ground water table to the infiltration is approximately 7.15 (= 1/0.14) times as much. Namely the effective porosity is 14%.

The ground water content is 1.4 x $10^6 m^3/km^2$, assuming that the aquifers in the benefited area average 10 m in thickness. Consequently, the ground water content of the whole project area is estimated at 600 x $10^6 m^3$ (The area is around 432 km^2).

The contained ground water can be extracted as much as water supply from the hydrological balance, but this water supply is not distinct. Probably, it is possible to extract and utilize about 10% of the total annual ground water, which is equal to 1.40 x $10^6 m^3$/annum/km^2 (380 m^3/day /km^2).

It is concluded that the ground water utilization for irrigation is not effective, on the basis that this figure is about the same as the rate of the specific yield of aquifer (260 - 800 m^3/day/km^2) as stated in the paragraph of the aquifer and its value is extremely poor.

Fig. I-4 Hydrograph of Groundwater



NOTE

1. DOTTED LINE SHOWN ON COLUMN OF GROUND-WATER TABLE HYDROGRAPH SHOWS MONTHLY AVERAGED LEVEL.
2. AS FOR EVAPOTRANSPIRATION DISCHARGE DEPTH AND INFILTRATION, SEE TABLE- AND
3. SHADED AREA ON COLUMN OF PRECIPITATION SHOWS TOTAL AMOUNT OF THE MONTH.

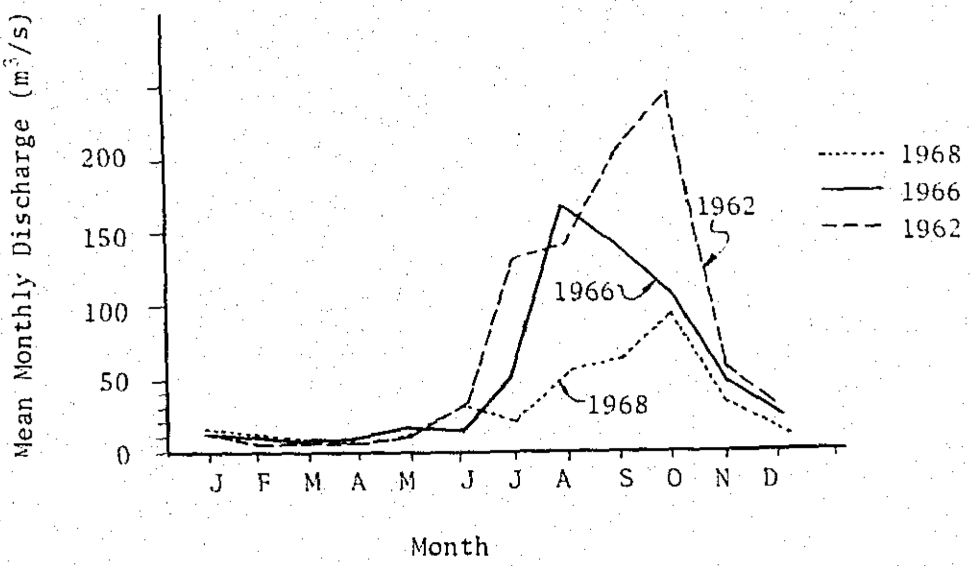
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
STUNG CHINIT MULTI-PURPOSE PROJECT GROUNDWATER INVESTIGATIONS HYDROGRAPHS	
SANYU CONSULTANTS INTERNATIONAL INC.	
SUBMITTED	DATE
APPROVED	DRAWING NO.

1-4-4. Discharge of the Stung Chinit

The Stung Chinit is one of the tributaries of the Tonle Sap (the Great Lake) which has a catchment area of 4,120 km² at the Kg. Thma water gauging station. Between Bangki Tangren (on the upperstream approximately 90 km from Kg. Thma) and Phnou (on the downstream approximately 20 km from Kg. Thma), the river has its width about 60 m - 90 m. There is a little difference in the surface slope between the dry and wet season, but generally it lies within 1/6,000 - 1/11,000, getting gentler to the downstream.

The discharge data of the Stung Chinit since 1962 are available. The annual pattern of the discharge of the Stung Chinit is shown in a Fig. I-5, taking up 1968 as a sample of droughty years, and 1966 as ordinary years, and 1962 as wet years.

Fig. I-5 Hydrograph of the Stung Chinit



The basic annual pattern of the discharge presents a uniformity in recording an increase of discharge from June, and the sharp decrease around October or November, though the difference of annual discharge exists between wet and droughty years. The discharge in the flood season has a great fluctuation according to the year but no remarkable fluctuation is confirmed on the discharge of droughty season, which has a great influence on making the water utilization scheme.

Table I-4 shows the maximum, the minimum, and the annual mean discharge for each year.

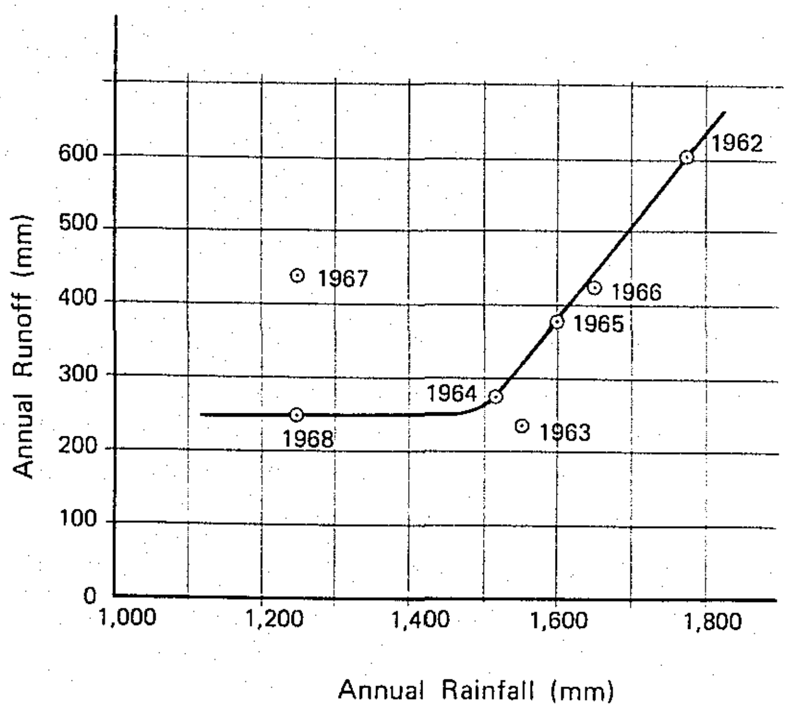
Table I-4 Discharge of the Stung Chinit

(unit: m^3/sec)

Discharge	1962	1963	1964	1965	1966	1967	1968
Maximum	329.0	163.6	130.6	242.0	218.0	241.2	146.5
Minimum	2.6	2.8	2.0	2.6	4.4	4.7	4.3
Mean	71.9	30.3	30.7	44.6	50.2	51.9	29.4

In Fig. I-6, the correlation between the annual rainfall and the runoff is shown in representing the water-depth for the whole catchment area (4,130 km^2). Even in the dry year, approximately 220 mm discharge per annum is expected to be available. The runoff rate in 1967 is rather high in comparison with the rainfall rate, and this is due to the fact that the rainfall in 1967 concentrated during three months from July to September.

Fig. I-6 Annual Rainfall-Runoff Relation



The rainfall at the beginning of the rainy season has a tendency to be absorbed into land as soil moisture, therefore the runoff rate is low. Generally, the monthly runoff rate in the early half of the rainy season is approximately 10% below and it rises in the range of approximately 20% - 40% from the mid-season to the end. (Table I-5).

Table I-5 Annual Runoff

	1962	1963	1964	1965	1966	1967	1968	1969	Mean
Annual Runoff Coefficient (%)	33.8	14.9	17.9	23.3	25.5	35.0	19.5	31.0	24.9
Annual Rainfall(mm)	1,774	1,548	1,515	1,603	1,648	1,247	1,253	1,163	1,469

1-4-5. Inundation

There are two types of flood that affect this area: one is from the Tonle Sap, and the other from the Stung Chinit. The former is caused, in the latter half of the rainy season, chiefly by the adverse flood of the Mekong, which runs into the Great Lake through the Tonle Sap. Consequently, in some cases the inundation by that flood is influenced by the water level of the Great Lake.

According to the records by the gauging station at Luong nearest to the estuary of the Stung Chinit, the peak of the water-level is seen between the end of September and October, and the maximum water level reaches to the elevation of 10 m above sea level. Usually, the highest water level is upto the elevation of 9 m in most of the years. In that case, the project area, approximately 7,000 ha in the west of Baray is inundated and the depth of flooding water reaches about 2.0 m. The floating paddy is mainly planted in the field of 35% of the total inundated area.

On the other hand, the flood from the Stung Chinit arises between July and October, and the cause of the said flood is that the Stung Chinit has no embankment along its course through the plain. On the basis of the water level records of 1968 - 1969 at three gauging stations observed by the Survey Team, the results in the following table are obtained by considering the relationship between the water level and the inundated area referring to the topographical map.

Table I-6 Flooded Area of the Stung Chinit

Water Level at stations Andaot	Kg. Thma	Phnou	Max. Dis-charge at Kg. Thma	Flooded Area Andaot Kg. Thma	Kg. Thma Rightbank	Confluence Leftbank	Total
m	m	m	m^3/sec	ha	ha	ha	ha
15.8	11.0	9.2	150	1,120	420	7,100	8,640
16.8	12.0	10.2	253	1,910	1,190	11,000	14,100
17.8	13.0	11.2	390	6,000*	3,500	12,400	21,900

The figure with a mark * includes 4,100 ha being inundated in Kraya District, the right bank of the river, by the flood from the point about 15 km upstream from Kg. Thma.

Most of the inundated areas extended from Kg. Thma to the confluence of the Stung Chinit and the Stung Tang Krasang, are used for the paddy fields. In those flooded areas, the area at the left bank of the river is overlapped by the floods from the Great Lake and the Stung Chinit in September or October.

In case of a sudden flood, or a flood in July or August arises in this area, where the rice plantation is carried out comparatively late, the rice plantation, the roads, the river course are badly damaged, and in droughty season, there can be seen the inhabitants repairing the roads, executing the groyne in a group work.

Fig. I-7 Days of Inundation of the Stung Chinit

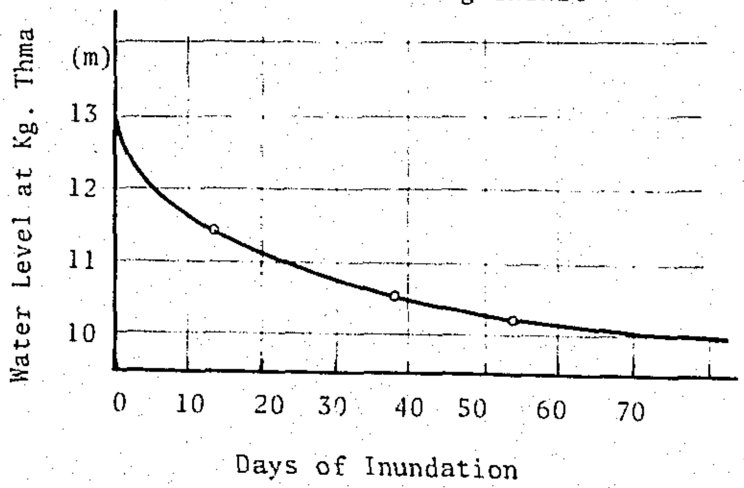
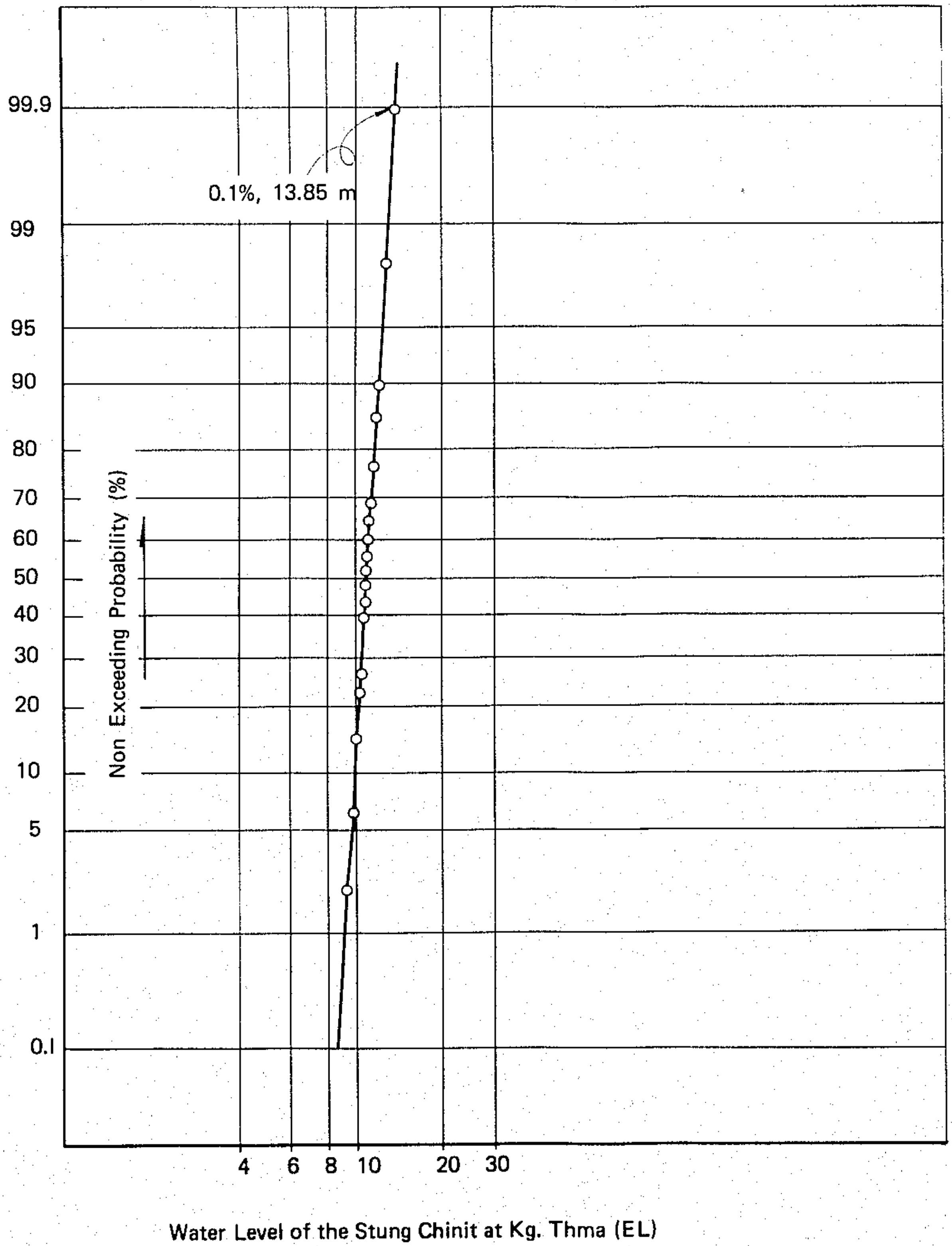


Fig. I-8 Probable Water Level of the Stung Chinit at Kg. Thma



1-5. Soil

1-5-1. Soil Classification and Interpretation

The soils in this project area have been developed in alternating wet and dry seasons from various geologic origins, such as, basic rocks, alluvial deposits and so forth. It is observed that the distribution of soil types is closely related not only to geologic origin and topography but also to vegetation and land use. From such points of view, soil classification follows the rule defined under "Definition of Soil Units for the Soil Map of the World" 1/ . It is unquestionable that soil classification is very helpful not only for the estimation of present soil productivities but also for the approach to agricultural developments in future.

The soils are classified into following five groups and some of them are subdivided, thus eleven families (soil units) are shown in the soil map (Fig. I-9). Survey points, description of profile, analytical results and detailed interpretations are shown in Appendix.

(a) Alluvial Soils

These soils are mainly distributed on natural levees or flood plains of the Stung Chinit and Stung Tang Krasang, and are the immature soils of rather coarse texture, showing only weak profile development. Natural vegetations are clear bush and/or grass. They are subdivided into the following two families by texture.

(a-a) Alluvial Soils of coarse texture (1) (about 13,500 ha)
(a-b) Alluvial Soils of medium texture (2) (about 3,600 ha)

1/ FAO (1966)

(b) Low Humic Gley Soils

(b-1) Grayish Brown Soils

These soils have wide distribution in the area inundated by the Tonle Sap and the alluvial plains of the Stung Chinit and Stung Tang Krasang, and mostly in the area with elevation lower than 15 m. They are characterized by the seasonal alternation of gleyzation under waterlogged condition in wet season and oxidation in dry season. They have gray colored profiles with thready iron mottling in surface-soil and with speckled iron and manganese mottlings in sub-soil. The area of these soils mainly has been used for rice cultivation, but in the inundated area, they mostly remain as grassland. They are subdivided into three families as follows:

(b-1-a) Grayish Brown Soils of coarse texture (3) (about 6,000 ha)
(b-1-b) Grayish Brown Soils of medium texture (4) (about 22,800 ha)
(b-1-c) Grayish Brown Soils of fine texture (5) (about 13,300 ha)

(b-2) Gray Soils (6) (about 3,500 ha)

Distribution of these soils is confined to the alluvial lowland of Khum Banteay Chey, Kg. Cham. They have gray matrix and are fine textured soils, and are mostly utilized as highly productive paddy fields.

(c) Vertisols

These soils are mainly distributed on the plateau derived from basalt and the alluvial lowland adjacent to the plateau. They are heavy textured soils with dark colored surface-soil and gray (often neutral gray) colored sub-soil. They have typical structural units polished to from lustrous surface, so-called slickenside, due mainly to the seasonal alternation of shrinkage and swelling of the soil being dominated by montmorillonitic clay. They are subdivided into the following three families by condition of rock.

(c-1) Vertisols Hydromorphic (7) (about 10,900 ha)

Since these soils appear on the depressed parts of the plateau and alluvial plains adjacent to the plateau, they are annually flooded during common wet season. They have no basement rock within 100 cm from the surface and most of them are utilized as paddy fields, however, their productivity mostly depends on the water-supply conditions connected to micro topography and annual rainfall.

(c-2) Vertisols Lithic (8) (about 7,000 ha)

These soils are seen on the lower middle parts of the plateau and have basement basalt rock within 50 cm from the surface. The vegetation is mostly clear bush wood, while only in slightly depressed parts, rice cultivation has been practiced.

(c-3) Vertisols Cambic (9) (about 6,800 ha)

These soils are distributed on the upper middle parts of the plateau. They are gravel throughout horizons but have no basement rock within 50 cm from the surface. They are partly used for fields but the most part is covered with bush wood.

(d) Latosols (10) (about 12,300 ha)

These soils are chiefly distributed on the upper parts of the plateau higher than 50 m elevation. As well known, they are typical tropical soils having deep red color. They have been exclusively used for rubber plantation due mainly to favorable physical conditions of homogeneous soil deeper than 10 m. While, some sloped parts have been used for banana plantation.

(e) Red Yellow Podzolic Soil (11)

These soils appear on the hilly regions in the eastern part of the project area. They are developed on old lacustrine deposits and have rather sandy texture. Natural vegetation is mostly dense tropical forests.

1-5-2. Soil Productivity

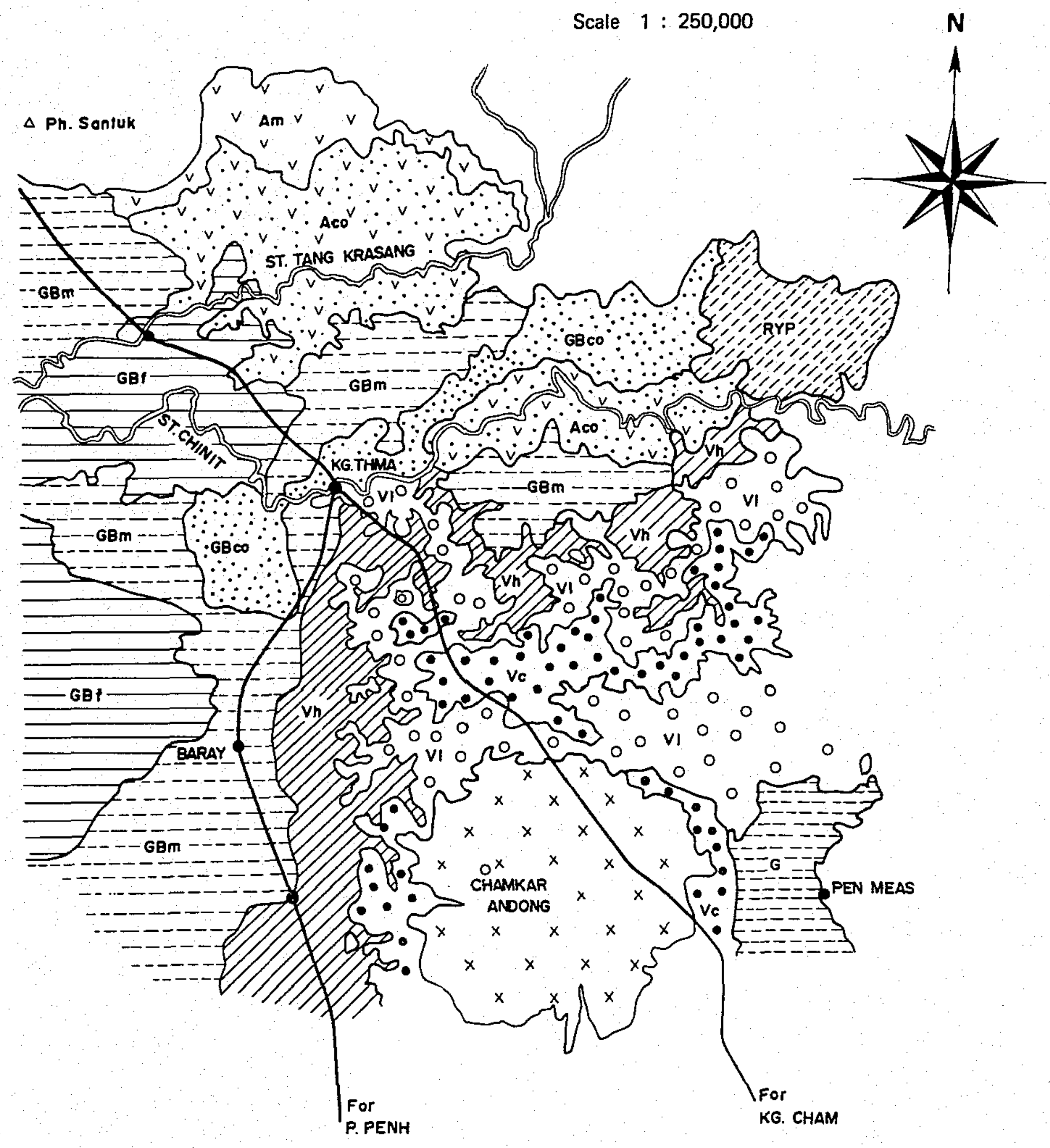
Productivity of soil families is evaluated on the basis of two main factors: that is, land conditions and chemical properties. The former are depth of plowing layer, depth of available soil, soil texture as an index of water permeability and water holding capacity, the latter are natural fertility and nutrient situation based on the values of total nitrogen, exchangeable cation, soil acidity, available phosphate and detailed values are shown in Appendix separately. It is natural that the improvement of land conditions is not always easy but that of chemical properties is possible by cultivation technique, mainly fertilizer application and chemical improvement of soil.

Table I-7 Synthetic Judgements of Soil Productivity

Soil family No.	Name	Land condition	Chemical property	Synthetic judgement 1/
1	Alluvial Coarse	III	III	III
2	Alluvial Medium	II	II	II
3	Grayish Brown Coarse	II	III	II-III
4	Grayish Brown Medium	I-II	II-III	II
5	Grayish Brown Fine	I	II	I-II
6	Gray	I	II	I-II
7	Vertisol Hydromorphic	I-II	I	I-II
8	Vertisol	III	I	II-III
9	Vertisol Cambic	II-III	I	II-III
10	Latosol	I	II	I-III
11	Red Yellow Podzolic	III	III	III

1/ Soils in class I are regarded as good arable alnd without any special practices; Soils in class II have some factors restricting crop production and need some improvements; Soils in class III have many factors restricting crop production and need fundamental improvements.

Fig. I-9 Soil Map of the Stung Chinit Basin



Legend

Aco: Alluvial Soil, Coarse-textured
Am: Alluvila Soil, Medium-textured
GBco: Grayish Brown Soil, Coarse-textured
GBm: Grayish Brown Soil, Medium-textured
GBf: Grayish Brown Soil, Fine-textured
G: Gray Soil
Vh: Vertisol, Hydromorphic
VI: Vertisol, Lithic
Vc: Vertisol, Cambic
L: Latosol
RYP: Red Yellow Podsolic Soil

In the area of Grayish Brown Soils of fine and medium texture in wide plains, land conditions are generally suitable for paddy field. But, two problems are remarked; First, there are some subtle contamination of soil texture, for example, surface-soils in higher places around villages and roads are found rather coarse even in the area of medium or fine textured soils. Second, the time interval for soil drying will become short in case of double croppings of rice, and this matter decreases the drying effects for rice growing. It is expected that such problem reflect not only on the evaluation of productivity but also on the introduction and the guidance of agricultural technique.

In the area of Vertisols, chemical properties are very good but land conditions are not always suitable for paddy fields except Hydromorphic, then the productivity in future will probably depend on water-supply. It is desirable, therefore, that irrigation project could cover these soil areas including Vertisol Hydromorphic. Moreover, it is possible to cultivate some upland crops, such as maize and beans, by irrigation even in the dry season.

In general, the Alluvial Soils and Grayish Brown Soils of coarse texture are not fit for paddy fields. However, poor productivity fields have been partly developed in depressed areas and are always threatened by drought disaster, so it will be desirable to have the irrigation canals to extend into these soil areas not only for crops but also for farmers and stocks.

Latosols and Gray Soils are fertile but some other factors may not be adequate for this project. Red Yellow Podrolic Soils are very poor but are not found in the project area.

In addition, it is considered that the construction of polder dike and roads in inundated area would be rather easy as compared with general polder dike built in the area of sea deposit, because Grayish Brown Soils along the polder dike have been strongly consolidated and contain only small amounts of exchangeable sodium.

Since soil properties, such as texture and so on, are closely related to micro-topography and farmers have made use of such delicate varieties of soils in their agricultural technique, it will be necessary to consider the project to fit the natural land conditions to the greatest extent, especially at the terminal of irrigation canals.

1-6. Land Utilization and Land Possession System

1-6-1. Outline of Land Utilization

The province of Kg. Thom is scarcely populated i.e. 11.6 persons/ km^2, which is being roughly one third of the national average 31.9 persons/km^2 (1962).

The survey area is roughly divided by its elevation into 4. The area above EL 40 m is mountainous and covered with dense forests, of which the south-western part with laterite soil is utilized as rubber and banana plantations. Clear forests spreads around EL 30 m, and the upland crop fields are developed in the hilly land below EL 20 m, which covers the alluvial plain and the foot of mountain. The area below EL 10 m is always inundated by flood from the Great Lake in the rainy season, most of this area is covered by marshy land having some paddy fields.

1-6-2. Farm Utilization

Generally speaking, the problem of land utilization in Cambodia is keenly connected with agriculture, a major part of the project area except the forest zones can be regarded as being used for agriculture production.

The total cultivated area of Srok Baray and Santuc in the project area is 21,804 ha, of which approx. 95 per cent is covered with paddy fields (Table I-8). While upland crop fields with laterite soils are mainly developed in the mountainous regions, and others are vegetable fields around farmers' houses.

Table I-8 Farming Area in Srok Baray and Santuc in ha

Name of Srock	Paddy Field	Upland Field	Total
Baray	12,214	802	13,016
Santuc	8,461	327	8,788
Total	20,675	1,129	21,804

(Presented by the Land Bureau of Kg. Thom Provincial Office.)

Since the project area has no facilities to control water sources, the land utilization for farming has developed mainly under the restriction of hydrologic conditions such as rainfall and flood. Judging from topography, the paddy rice in the wet season is fed by runoff water at the foot of mountain and in hilly lands with high level. Paddy fields in the dry season are fed by water ponded in small areas at the depressed lands along the natural levees. In the inundated areas by the flood water from the Great Lake, floating paddy rice is being planted.

1-6-3. Land Classification

Farm and residential lots are evaluated on the classification of the degrees for tax imposition. In general, the first and second class lands are for residential lots, third and fourth for upland fields and the land in the fifth class for paddy fields.

As stated in 1-5, the land potentiality is classified into 3, depending on soil productivity. Here again considering the backgrounds, agricultural conditions and so forth, the project area is classified into 5 with 11 sections as shown in Table I-9 (refer to Fig. I-10).

Fig. I-10 Land Use

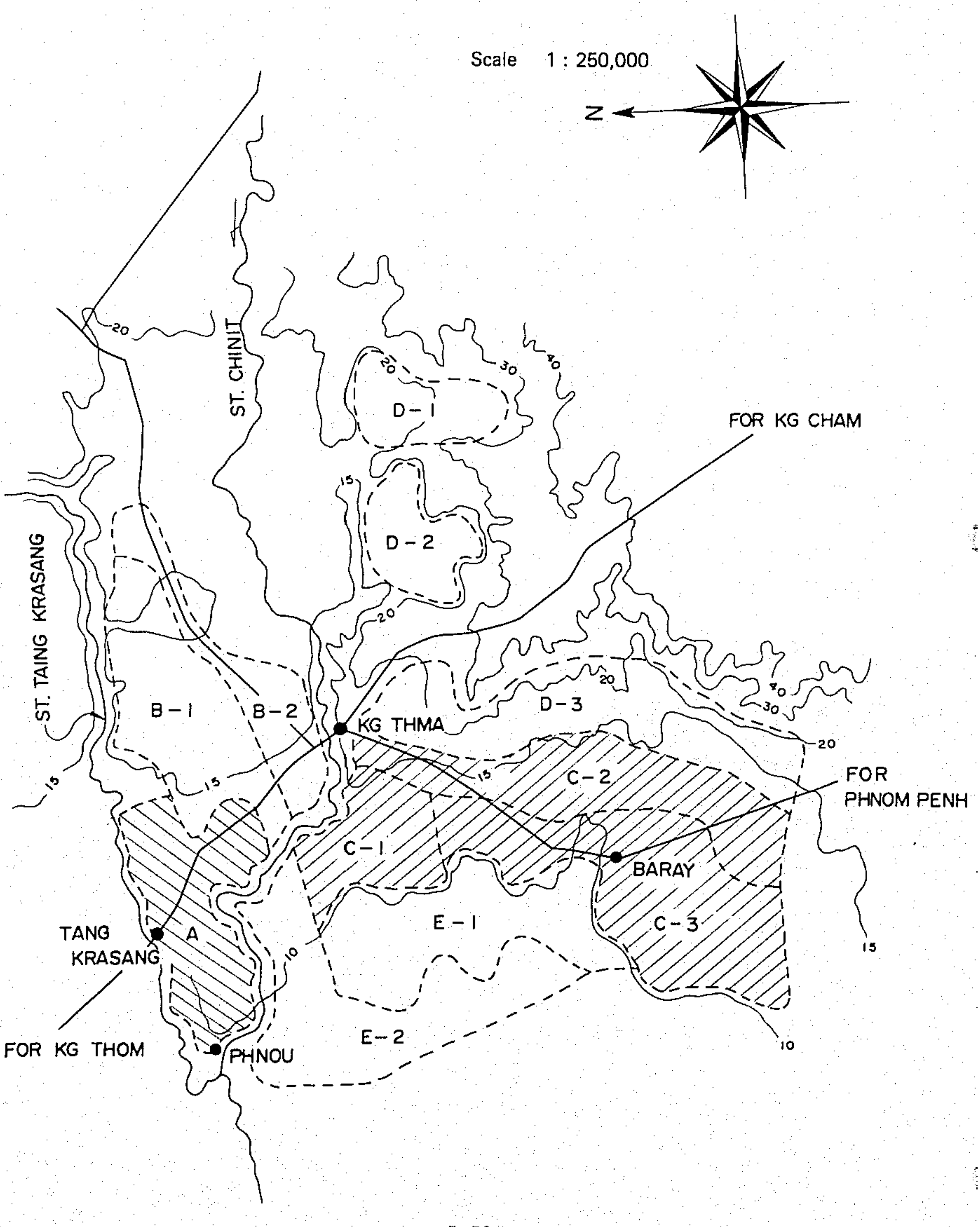


Table I-9 Land Classification and Its Productivity

Section		Backgrounds		Soil		Productivity
A		Right Bank of St. Chinit	Inundated	G. Brown	Fine	I - II
B	B-1	St. Chinit		"	Medium	II
	B-2	"	Bank	"	Coarse	II - III
C	C-1	Left Bank of	"	"	Fine	II - III
	C-2	St. Chinit	Central	"	Medium	I - II
	C-3	"	Lower	"	Fine	II
D	D-1	"	Hilly	"	Medium	II
	D-2	"	"	Vertisol	Fine	I - II
	D-3	"	Central	"	"	I - II
E	E-1	"	Inundated	G. Brown	Medium	II
	E-2	"	"	"	Fine	I - II

1-6-4. Flood and Land Utilization

Flood is usually a big hindrance to land utilization, as mentioned before 1-4-5, flood causes damage against rice crops as well as roads along the Stung Chinit and the Great Lake. One of the features being common to the Mekong delta is that flood has not always caused damage in the field of current agriculture and the silty soil included in the flood is useful for playing a part of fertilizer in present non-fertilized agriculture as well as for supplying water required for farm land.

Floating rice is planted under hard natural conditions given by flood of the Great Lake which repeats every year. However, this kind of land utilization, which is considerably influenced by flood, remain ineffective and unstable, except when flood occurs at proper time.

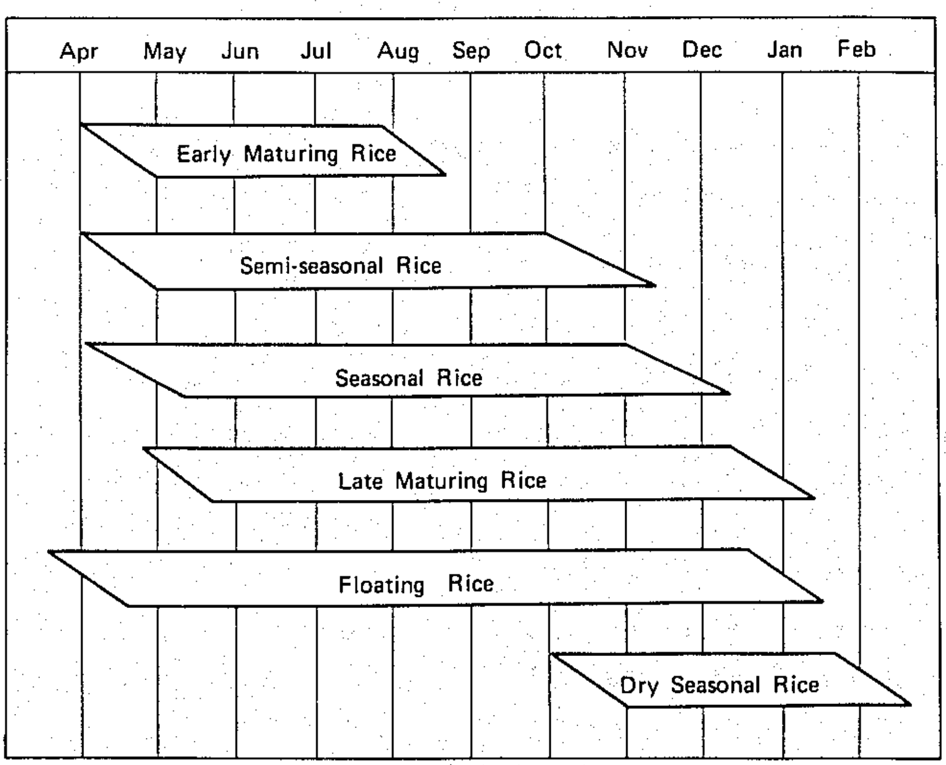
1-6-5. Cropping

Paddy rice is at present raised almost once a year either in rainy or dry season. The following Table I-10 & Fig. I-11 show the classification of 6 varieties of paddy rice at each growth period.

Table I-10 Variety of Rice

Name of Variety	Growth Period
Early maturing rice	3 up to 4 months
Semi-seasonal rice	4 up to 5 months
Seasonal rice	6 months
Late maturing rice	7 up to 8 months
Floating rice	9 months
Dry seasonal rice	4 months

Fig. I-11 Growth Period of Paddy Rice



Only the rainy seasonal rice is planted in this area. The main reason why the dry seasonal rice is not planted in due to lack of irrigation facilities. As the farmers have eagerly desired to install the facilities, it is expected that the dry seasonal rice will be introduced when the facilities are completed, and the existing cultivation of the rainy seasonal rice will be also stabilized by irrigation.

The seasonal rice and the floating rice are cultivated as the rainy seasonal rice, and there are some of the semi-seasonal rice. The floating rice is usually planted in low lands below EL 10 m and above EL 7 m, while the seasonal rice is always planted above EL 11 m. Generally, the seasonal rice has higher yield, but is easily damaged by drought, so irrigation facilities are required. The semi-seasonal rice comes in between the two rices, and its cultivated area occupies only 10 per cent of the area.

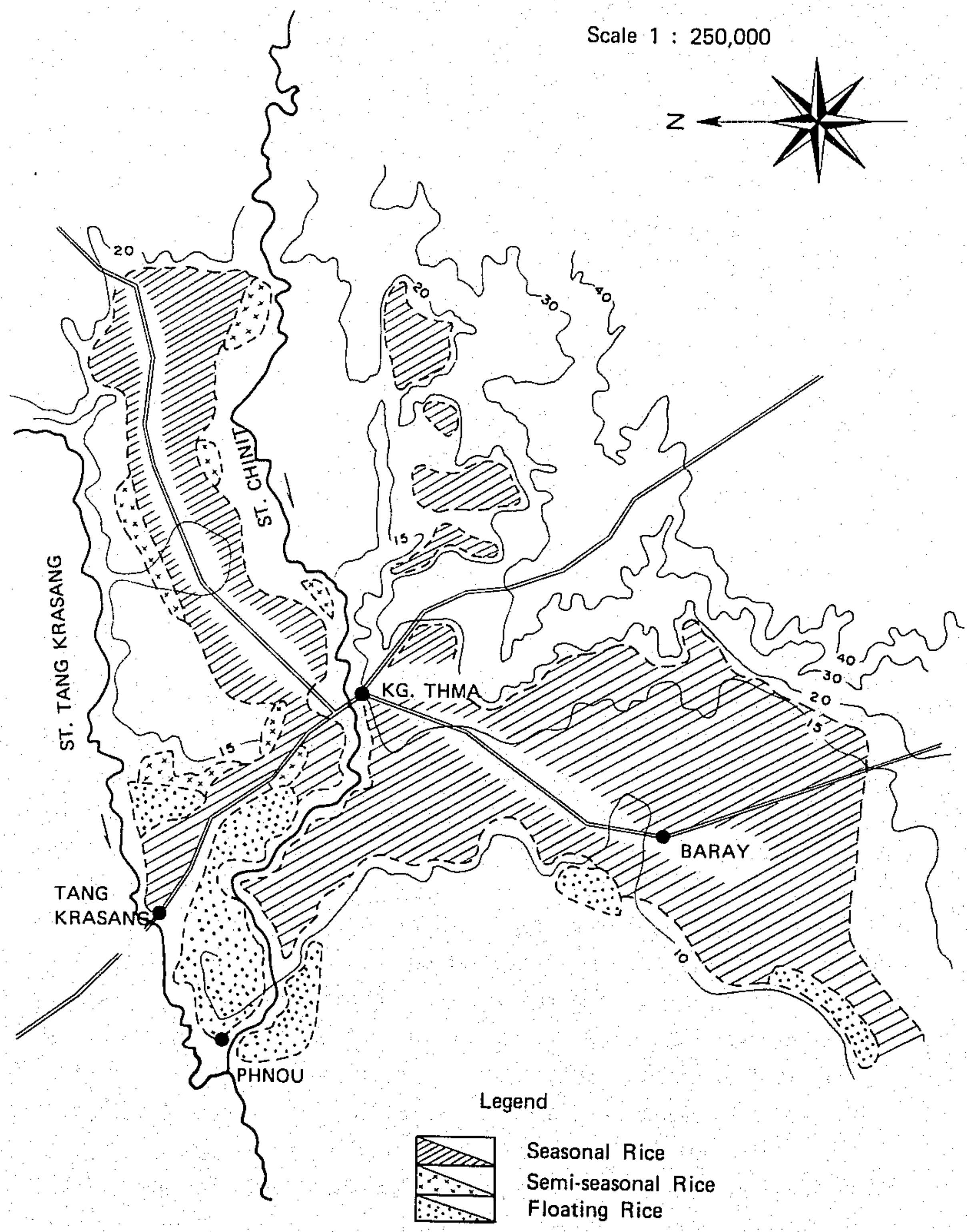
Fig. I-12 shows the planting status of paddy rice.

1-6-6. Land Possession System

In the land possession system of Cambodia, the private land ownership is permitted, except the forest and the field which legally belong to the Government. Furthermore, it has been legalized since 1956 that only the people who have Cambodian nationality are allowed to own the lands and all foreigners are prohibited to possess a land.

In this country, regarding to the land owners, they are divided into two; owners *(proprietaires)* and possessor *(possesseurs)*. Only those who have the lands registered on the cadastre and the lands surved, are considered legally as the *Proprietaires*. Under the regulation of the Civil Law of Cambodia *(Code Civil Cambodgien)*, the possession rights of the immovables cannot be turned into the proprietor rights without registration. Actually such a legal difference, however, matters little and the *Possesseurs* have the same rights and obligation of the

Fig. I-12 Range of Paddy Rice



Proprietairs.

To own the lands, it is legally confirmed by (1) purchase of the lands, (2) succession of the lands, or (3) 5 years' possession and development of the public land and forth, and the land tax is paid for the owned land.

Now, the following explanation is provided for the third case stated above to legalize the land ownership. In case when a Cambodian farmer desires to enlarge his own farm lands, an application for the development of the public land along with the location and acreage of the expected lands must be submitted to a village *(Khum)* office of his residence. The application accepted by *Khum* office is passed on to a provincial *(Khet)* office through a country *(Srock)* office. The application checked by the department of the service of cadastral *(service de cadastre)* in the *Khet* office is sent to the governor *(chanvaykhet)* to obtain the approval for cultivation *(permis de culture)*. In Cambodia, the land disposal up to 300 ha is made without tax and in that case, 10 ha at maximum is approved by *chanvaykhet* for the development, and on the other hand, over 10 ha up to 300 ha is approved by Minister of Agriculture. Further, over 300 ha the tax will be assessed and the cultivation should be approved by the decision of the cabinet meeting including Minister of Agriculture.

The applicant, after obtaining the *Permis de Culture*, can have the possession rights of the lands by successive cropping for 5 years, and the department of the *Service de cadastre* registers the land on the cadastre with its land survey conducted. For those 5 years, no land tax is imposed during the period of the first and second year after development but from the third year onward the tax should be paid. The land possession rights, therefore, is confirmed legally after the land tax is paid for 3 years, from the third year to the fifth year in the development period. The cadastre relating to the newly developed land is in the custody of the *Khum* office to which the said cultivator belongs, and the land tax is paid to the office.

In collecting the land tax, the amount of the tax is determined on the basic rate of the land graded with ten grades, from the first to the tenth. Many lands in the benefited area of this project are in the seventh grade (Tax: annually 24 riel per ha).

There is no restriction in the transfer of the owned land.

1-7. Water Use

1-7-1. Agricultural Water Use

Rainfall Except for a part along the river, all farms having elevation higher than 10 m are rain-fed paddy fields. These rain-fed paddy fields have a different condition of water use according to their location at the right or left bank of the Stung Chinit. The paddy fields on the right bank of the river, very flat in the topography, have no water catchment area in the hinterland. Therefore the irrigation is entirely subject to the rainfall conditions such as the beginning time of the rainy season, its duration, quantity and distribution of rainfall and so forth.

The left bank paddy fields have a mountainous area with rubber and banana plantations, thus some amount of runoff water from the mountainous area can be expected. Therefore, the influence of the rainfall conditions on the paddy fields of the left bank is less than that of the right bank paddy fields. However because of lack of irrigation facilities, rain water is held only in the low lands, so that most of the areas are easily damaged by a drought.

River Flow The rivers in the survey area include the Stung Chinit, the Stung Tang Krasang and the Prek Ta Prok. The Stung Chinit has a basin of $4 \times 10^3 km^2$, with the discharge of approx. $3.0\ m^3/s$ in the dry season.

The vast arable plain is extending below Kg. Thma along the river, but most of the abundant discharge of annual average 30 to 70 m^3/s flows into the Great Lake without any utilization. Since there is no intake facility to keep water level high enough to irrigate the farms, though the amount of discharge is ample, sometimes a damage by drought occurs even in the rainy season. As for the present water use of the Stung Tang Krasang, a tributary of the Stung Chinit, the situation is quite alike.

The Prek Ta Prok is small with the basin of 200 km^2, but its catchment area is composed of some dense forests and plantations. Underground-water fed in the laterite mountains and seeped out in the low-lands, flows down the basin, with a discharge of about 0.4 m^3/s even in the dry season.

Since 1968, Srok Baray Office has started *Samdech Euv* project in order to utilize this discharge, which is the only irrigation and drainage project in this district. This project of 4,000 ha provides irrigation and drainage canals of 8 km to make the dry seasonal paddy cultivation possible, and expedite the drainage of flood from the Great Lake in the late period of rainy season.

<u>Flood Water of Great Lake</u> The area lower than EL 10 m is inundated by flood water from the Great Lake. The floating rice farming has been practiced under such natural environment without providing any preventive measure against the flood which is repeated every year.

The average water depth for the floating rice farming in the area is around 1 to 2 m, and since the watering for plowing is required, the cultivation of the floating rice is restricted only in the low lands.

The floating rice farming is practiced where there is fluctuation of the water level. The floating rice is possible to follow the rise of water level of 15 - 20 cm/day, and it matures even after a lodging of rice stem caused by an abrupt reduction of the water level during the growth period.

1-7-2. Water Right and Custom

There is no codified law concerning the water right of the river. Besides the agriculture, fishery is another industry to utilize the river, which is found here and there around the downstream of the Stung Chinit.

Since the large scaled irrigation farming utilizing the river water is not actually practiced, there is no problem with water between agriculture and fishery. As well, there is no custom for utilizing water for agriculture.

Observing the present operation of the small intake facilities at the downstream of the Stung Chinit, and *Samdech Euv* project of the Prek Ta Prok, it can be said that the order of the water utilization follows the customary practice - Administrative management of the chief of Khum or Phum - over rules the judicial evidence concerning water right.

1-8. Present Conditions of Agricultural Production

1-8-1. Land Possession and Farm Size

Most of the farmers in this project area are owner farmers, and the fact was also clarified by the fact-finding survey to the village. In the inundated area west of Baray is tenant land of about 10% of the entire areas. This situation is mainly due to a shortage of labor of the land owners. However there is no tenant who leases the whole cultivated land from his land owner.

An average farm size in the province of Kg. Thom is 2.59 ha per farm household as shown in Table I-11.

Table I-11 Average farm size

(ha/farm household)

Name of Srok	Area
Baray	2.00
Santuc	1.98
Sandan	2.00
Kg. Svay	3.50
Staung	3.50
Average	2.59

(as of 1968)

Table I-12 shows the average farm size of the Khum included in the project area.

Table I-12 Average Farm Size by Khum

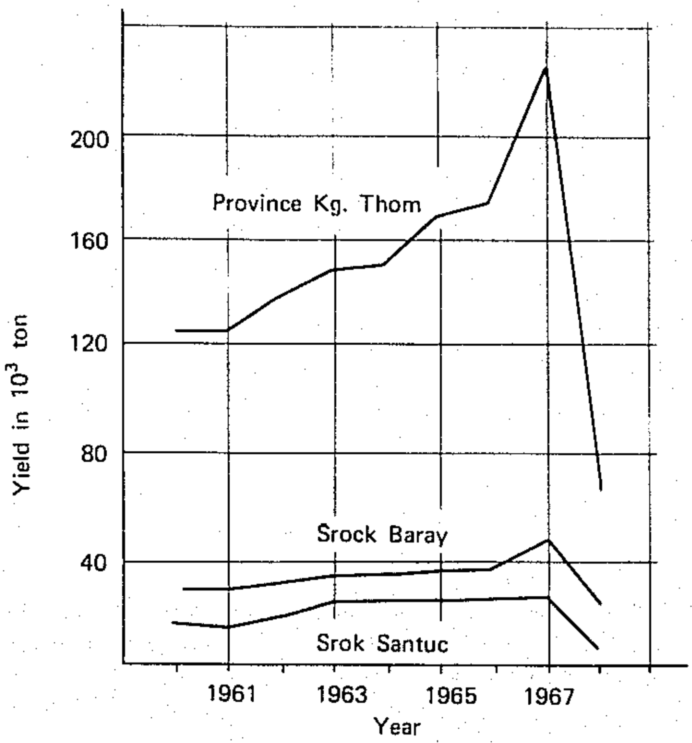
(ha/farm household)

Name of Srok	Name of Khum	Area
Baray	Baray	2.3
	Chong Dang	1.5
	Thnot Chum	3.6
	Chaeung Daeung	1.2
	Krava	0.9
	Beng	0.9
	Kriel	1.3
Santuc	Phnou	Unknown
	Tang Krasang	1.5
	Prusat	1.4
	Kg. Thma	1.8
	Krayea	Unknown

1-8-2. Agricultural Products

The main agricultural product is rice which farmers depend a great deal upon. Fig. I-13 shows totals of yield for the past few years.

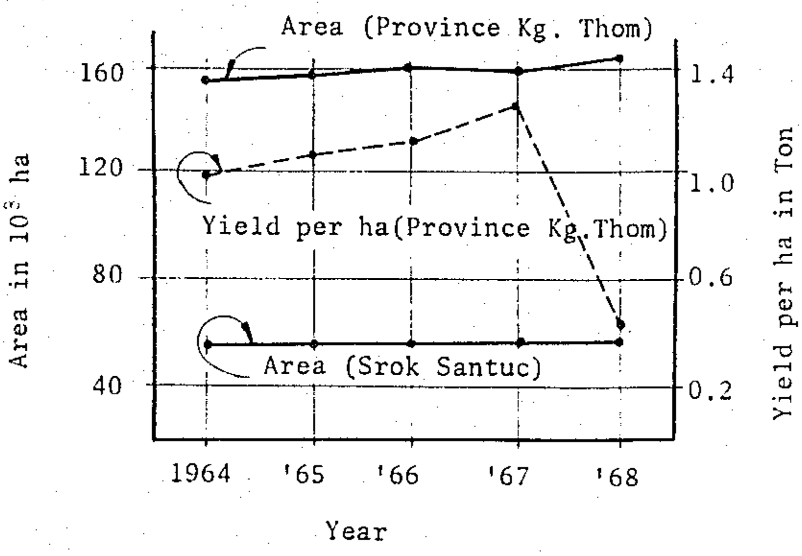
Fig. I-13 Variation of Yield



A total yield varies remarkably according to the status of rainfall. Much yield appeared in 1967 due to favourable conditions of rainfall, but it dropped sharply owing to a shortage of rainfall in 1968.

Cropping area is somewhat increasing. Also the yield per ha trends upward.

Fig. I-14 Variation of Cropping



Most of paddy rice are seasonal rice *(Saison)* and floating rice *(flottant)*.

Few upland crops are cultivated in the area. The main upland products in the province of Kg. Thom are white corn, green beans, sesame and tobacco as shown in Table I-13.

Table I-13 Planting Status of Upland Crop in 1968

Cultures			Srok Baray	Srok Santuc	Province Kg. Thom
White corn	Cultivated area	(ha)	60	11	190
	Production	(t)	72	8	263
	Production	(t/ha)	1.20	0.73	1.46
Green beans	C.	(ha)	2	2	98
	P.	(t)	1	2	51
	P.	(t/ha)	0.50	1.00	0.52
Sesame	C.	(ha)	30	5	51
	P.	(t)	24	2	39
	P.	(t/ha)	0.80	0.40	0.76
Tobacco	C.	(ha)	-	-	49
	P.	(t)	-	-	49
	P.	(t/ha)	-	-	1.00

Agricultural product is the main source of income for farmers. According to the fact-finding survey of village, farmers get only a small amount of income, besides agriculture, from other jobs such as a coolie, fuel collector and so forth.

1-8-3. Livestock

The farmers are breeding livestocks such as cattle, buffalo and so forth. Small size livestock breeding is on the upward trend. Table I-14 shows the livestock breeding status in the province of Kg. Thom.

Table I-14 Number of Livestock, in Kg. Thom, 1968

Cattle	Buffalo	Horse	Pig	Poultry
101,016	53,437	575	51,609	246,172

The number of cattle is around 2.5 head per farm-household. In the inundated area more buffaloes are bred than the cattles. In general the livestock breeding area is, centered on the hillside area, where wildgrass is easily available. The cattle breeding in the inundated area is limited because of lack of man-power. It has been found during the factfinding survey that the house-wives' working hours in the area is longer than that of any other area.

Cattle and buffalo are mainly utilized for plowing land and for transporting agricultural products, while pig and poultry are bred for meat.

Fallowing and harrowing works are conducted twice respectively. The working efficiency varies slightly according to soil texture, but it shows little difference in wet condition of soils. These works are performed by a pair of cattles, and its performing efficiency is roughly shown in the following Table I-15.

Table I-15 Performance Efficiency by Cattles

Item of Work	Performance efficiency ha per day	Number of day per ha one-time	two-times
Plowing	0.2	5	10
Harrowing	0.6	2	4
Total			14

Performance efficiency by a set of 2 full-grown cattles

The livestock is bred by open yard feeding and its fodder is wild-grass. The particular crops for the livestock is not planted here.

When irrigation and drainage facilities are constructed, its effect on livestock breeding is not only to increase the production of rice straw but also to increase available wild grass for fodder around villages along canals.

The breeding number of cattle is on the increase, the trend of which seems useful for an improvement on farmers' food life.

1-8-4. Agricultural Implements

Most of the agricultural implements are home-made, which are operated by human or animal power. There are two kinds of agricultural implements. One is such implements as hoe, sickle, winnowing fan and so on which are operated by human force. The other is plow, harrow, roller etc. drafted by animals.

At the later stage, the tractor will be introduced into the field to increase the efficiency of fallowing work. In a part of the area some farm lands are cultivated by tractor rent for plowing work, and the area using tractor is on the increase. Table I-16 shows the number of tractors by each Srok.

Table I-16 Number of Tractor, 1968

Name of Srok	No. of Tractor	Harvester
Baray	23	
Santuc	8	
Kg. Svay	96	1
Staung	16	
Total	143	1

Since few irrigation facilities are available in this area, even small size pumping equipment or man-operated irrigation implements are not used at present.

1-8-5. Fertilizer and Agricultural Chemicals

It is not clear how much fertilizer and agricultural chemicals are being consumed. However, the consumption can be presumed to be of an extremely small quantity, and the materials are not yet popular among farmers as a mean of agricultural production technique. Cambodia has developed to a stage to manufacture fertilizer in the country, where the consumption is on the increase, and the cost of fertilizer is following a downward trend.

Table I-17 Consumption of Fertilizer in Kg. Thom, 1968

Name of Srok	Urea (Kg)	Phosphate (Kg)
Baray	3,300	8,240
Santuc	1,100	2,800
Sandan	150	350
Kg. Svay	2,900	7,280
Staung	1,750	4,400
Total	9,200	23,070

Most of the farmers use farm manure in lieu of chemical fertilizer. The means of effective use of farm manure shall be studied. By the survey it is found farm manure is not used extensively at the inundated area as done at other areas. The following shows the percentage of the farm-households using farm manure.

Inundated area............... 70%
Plain area.................. 90%
Hilly area.................. 90%

The cost of agricultural chemicals is relatively expensive since all are dependent upon import, and are scarcely used at present. Table I-18 shows the status of agricultural chemicals consumption in the province of Kg. Thom in 1968, where not much chemicals other than DDT are consumed.

Table I-18 Consumed Quantity of Agricultural Chemicals in 1968

Article	Percentage 1/	Quantity (Kg)
DDT	75	4,260
Endrin	19.5	2,894
Malathion		160
Wafarine	10	125

1/ A ratio of farm households who used agricultural chemicals to whole farm households surveyed.

According to the fact-finding survey, about 80 per cent of farm households in the inundated area and about 90 per cent in other areas are using agricultural chemicals.

The main rice-plant diseases are rice blast disease and rice white withering, while the main harmful insects are plant hoppers and rice stem bores.

1-8-6. Farming Management of a Standard Farm Household

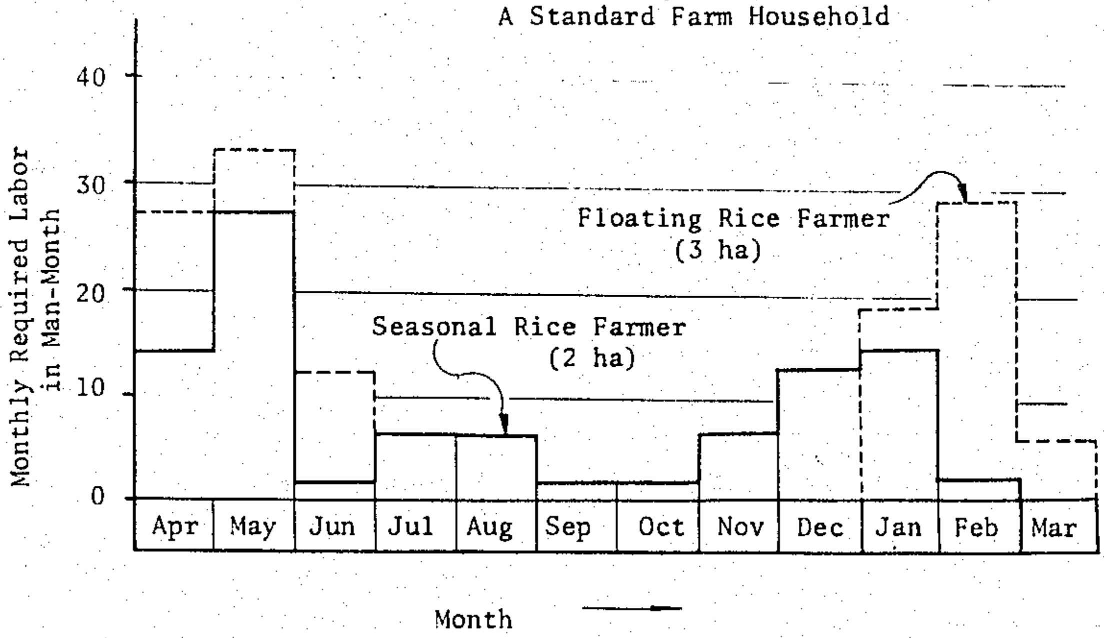
As shown in Table I-19, the farmland, which is managed by a farm household, is an average of 3 ha in the inundated area, 2.5 ha in the plain area and 2 ha in the hilly area.

Table I-19 Farming Management

District	Kind of rice	Farm size, ha per household
A	Floating rice	3.0
	Seasonal rice	2.5
B	Seasonal rice	2.0
C	Floating rice	3.0
	Seasonal rice	2.5
D	Seasonal rice	2.0
E	Uncultivated land	-

Fig. I-15 shows the monthly required labor of the standard farm household.

Fig. I-15 Monthly Required Labor of A Standard Farm Household



The number of family per household is 5.0 persons on an average, of which 2.6 persons are in more than the age of 20. The required labor mentioned above is satisfactory for managing farmland of each farming household.

1-9. Farmer's Willingness to Accept a Rural Development Project

The success of a rural development project will depend greatly upon the inhabitants' willingness to accept it. A survey was made, therefore, to summerize the will of the people such as farmer, housewife, chief of Khum, chief of Phum, primary school, cooperatives, and so forth. Table I-20 shows the number of Phum surveyed and the average farm size.

Table I-20 Phum Surveyed and Farm Size

Location	No. of Phum surveyed	Average farm size, ha
Inundated area	6	5.4
Plain area	9	3.1
Right bank of Stung Chinit	3	4.0
Left bank of Stung Chinit	6	2.6
Hilly area	2	2.3
Total	17	

Farmers have a great desire for realization of an agricultural development project. In view of increasing income from agriculture, farmers are desiring to practice double cropping of rice a year, which will necessitate technical guidance of agriculture for farmers. Top priority is, therefore, given to gradual increase of seasonal rice yield every year. It is of utmost importance for farmers to plant seasonal rice timely for attainment of production increase. Farmers are quite anxious to have irrigation facilities provided particularly on comparatively high places in the mountainous area.

The farm size in the inundated area is larger than that of the non-inundated area. The working hours are on the increase because the farmland is relatively large and far from home hence consuming a great deal of time in commuting. It is, therefore, desirable to save labor of farm work by improvement of roads and rearrangement of the farm lands.

Most of the farmers have participated in the Cooperative's activities. It is obvious that in the near future the whole farmers will become a member of the Cooperative. The Cooperative is contributing to the financing, purchasing of daily products, and is selling paddy rice. Farmers are seeking for the amendment of rice purchasing price and the increase of financing amount.

Agricultural knowledge and techniques will be brought up to date by the farmers through their children who are being taught in the agriculture classes of their schools. Therefore, the agricultural education is considered to be effective for the improvement of agricultural techniques in future.

1-10. System of Agricultural Research, Extension, and Training

The service of agricultural administration belongs to division of the Ministry of Agriculture. In local districts, agricultural offices *(Secteur L' Agricole)* are established, where a few agricultural engineers are engaged in official duties.

The local administrative system is composed of province (Khet), Srok, Khum and Phum in order of superior authorities. The province of Kg. Thom consists of 5 of Srok and 66 of Khum in all. One or two extension workers are working at each Srok Office and are engaged mainly in observing crop conditions. In addition, the extension workers are working at UNICO *(Union des cooperatives)* Office.

In various places of the country there are agricultural experimental stations, including agricultural technical center *(Centre Technique Agricole de l'Amite Khmero-Japonaise)* at Tuol Samlong in the province of Battambang. In the province of Kg. Thom an agricultural experimental station is established at Santuc, where a test is being made on field crop and fruit trees covering 5 ha in all.

Two agricultural universities are established in Cambodia, one in Phnom-Penh and the other in Kg. Cham, and most of the graduates are employed by the Ministry of Agriculture.

Agricultural education is being given positively during the period of compulsory education. In primary school agricultural education is imposed on children in a few hours per week. A practical training farm covering 5-6 ha is established, where irrigation for farming is introduced and fertilizer is used.

The means of the general agricultural promotion for local people are the widespread of the activities of the Ministry of Agriculture on agricultural information and technical problems broadcasted from Phnom Penh, and distribution of pamphlets and posters, establishment of show rooms (a part of which is always used for agricultural organization) for agricultural products.

1-11. Distribution of Farm products and Co-operatives

The rice collecting system has two channels; the one is operated by the Chinese merchants, who have handled it for a long time, and the other is done by the OROC *(Office Royal de Coopération)* and its substructure, the farmers' co-operatives as one of the governmental representative organization. So far, most of rice had been collected by the Chinese merchants. Recently, however, the collection by the OROC organization is sharply increased in quantity especially of the export rice.

Table I-21 Present Status of Agricultural Co-operation Association

Name of Co-operation	Members	Capital	Member's Contribution	Cost of Equipment		Operation Fund
				Office	Storehouse	
		Riel	Riel	Riel	Riel	Riel
Srok Santuc						
Taing Krasang	551	55,750	-	20,866	67,605	80,307
Phnou	153	17,100	16,400	-	32,155	-
Kg. Thma 1/	700	70,000	-	-	-	-
Srok Baray						
Thnot Chum	254	25,400	19,920	-	44,640	5,413
Triel Rumlong	500	57,700	78,000	40,373	63,600	8,674
Triel Salakhum	470	68,900	26,000	-	73,906	-
Triel Kdei Tachen	428	25,000	25,900	20,606	52,210	-
Chhouk Ksach	628	80,900	51,400	64,735	74,712	137,616
Baray	366	42,600	34,880	45,174	63,117	36,372
Beng	490	49,400	24,426	18,394	22,719	-
Chong Daung	684	74,500	65,120	14,058	99,857	20,418
Prey Tatras	269	27,100	19,000	-	50,653	-
Trapeang Chrey	223	22,300	29,450	2,000	58,699	-
Choeung Doeung	398	40,100	41,895	-	43,657	-
Krava	245	24,700	49,063	19,055	51,667	-
Prey Roleap	138	13,800	27,876	-	32,753	-

N.B; These figures are offered in the research of the OROC office of Khet Kg. Thom

1/ Not joined OROC

The village co-operatives as the substructure of OROC, are directly related to the farmers and are acting in giving credits, assisting producting works, collecting agriculture products, and other various works.

Now, taking an example of it in Khet Kg. Thom, the Khet has 60 villages in total and 40 villages out of them have their cooperatives. The study on the present co-operatives in both villages of Srok Baray and Srok Santuc, which are included in the beneficial area of the project, are given in Table I-12. Generally one village has one co-operative each in most cases. But in Triel Village, three co-operatives are organized, and two each in Balaing, and Krava. Most of the co-operatives have one office building and one storehouse.

The UNICO *(Union des Co-operatives)* is organized with such co-operatives in every Khet. The UNICO is mainly acting in collecting the agricultural products, giving credits, and so forth. At present, Khet Kg. Thom has one UNICO, which is consisting of 24 co-operatives, and the amount of its capital is 101,000 Riel.

1-12. Electric Power

(a) Supply Capacity

Generally, the main cities in Cambodia obtain their electric supply independently from their own diesel plants. Among those cities, phnom-Penh and its surroundings get a part of their supplies from a steam power station and a hydraulic power station as well.

At present, Cambodia has no transmission network covering the whole country, but only a 110 KV, 1-circuit transmission line (total running about 110 km) from the foregoing hydraulic power station (Kirirom No.1) to Phnom-Penh.

That is mainly because the scale of diesel plant belonging to each city is so small and the distance between power plants is so far that the independent supply system in each city is much more economical.

(b) Organization of Electric Power Industry

In Cambodia, the total electric supply except Battambang, is made by *Eléctricité de Cambodge* (EDC), and only in Battambang by *France Khmeré de Eléctricité de Battambang* (FKEB).

The control over those electric supply industries is secured by the department of *Service de Control des Eau et le Eléctricité* in *Ministre de Travaux Publics* (TP).

TP is taking charge of planning the electric supply, assuming the coming power demand and planning the development of the electric power equipments; and furthermore, the new construction of the large scale power station, and the power increase of the existing stations are excuted by the department. TP controls the collection of charge and the maintenance of the instrument capacities by the electric companies.
The foregoing power station Kirirom No.1, and the receiving station in Phnom-Penh and the transmission line (110 KV) between them are operated and maintained by TP.

The power output by the generation equipment in Cambodia as of the end of 1968 is shown in the Table I-22.

Table I-22 Power Output by Generation Equipments

(Unit : KW)

Classification	Hydraulic Power	Steam Power	Diesel	Total
TP	10,000			10,000
EDC		21,000	32,890	53,890
FKEB			2,175	2,175
Total	10,000	21,000	35,065	66,065

(c) Trend of Power Demand

The transition of power generation in Cambodia for the last 10 years is presented in Appendix, and the annual increase rate of the power by ready-installed equipment is between 5 - 10 per cent, the annual power loss factor between 15 - 20 per cent and the annual load factor between 30 - 50 per cent.

The rather large rate in the loss factor comes from the poorly equipped distribution facilities and their sub-facilities. The daily load factor keeps its level at approximately 40 to 50 per cent. The specifications of the loads are shown as the private domestic use, lighting of public way, public domestic use, and public and private use for the motor-power, The private domestic use accounts for approximately 60 per cent of total power use. What is important is that main industries supply the power by their own power stations

EDC is now making the effort to include the loads supplying by those private power stations. The total output by the private power stations in Cambodia is between 20 - 30 MW (Ref. The Sambor feasibility report by the Japanese OTCA Survey Team in 1967.) According to the Appendix, the supply amount of the power by EDC has been decreased since 1963, and the fact tells that the motor load is switched from the supply by EDC to that by private power generation.

(d) Power Cost

In the thermal power station, belonging to EDC, in Kandal Province, the suburbs of Phnom-Penh, the average original power cost from January to March, 1968, by the steam unit (6 MW x 3) was calculated as 1.53 Riel/kW, in which the cost equivalent to the fuel charge, 0.595 Riel/kWh is included.

Furthermore, the cost of power generation in the Kirirom No.1 hydraulic power station operated by TP is 0.38 Riel/kWh at the generating stage, 0.5 Riel/kWh at the input to the Phnom-Penh receiving substation after running through the 110 kV transmission lines, and the selling price to EDC from TP at the receiving stage in the diesel plant of EDC is approximately 1.0 Riel/kWh. (The Kirirom No.1 hydraulic power station, the first hydraulic power plant in Cambodia, started the operation in 1968 and the installed capacity is 10 MW, and average annual power generation is 49,700 MWh. $8,981,781 was required for the construction cost.)

On the other hand, the power cost generated at the diesel plant in Kg. Cham, operated by EDC, (Installed capacity: 785 kW) is 2.7 Riel/kWh. The distributed power cost is 4.632 Riel/kWh.

(e) Power Rate

The power rate by EDC is fixed as following Table I-23.

Table I-23 Power Rate by EDC

(Riel/kWh)

Use	Phnom-Penh	Kandal Province	Others
Private domestic use	3.064	3.171	6.337
Lighting of public way	2.873	2.953	5.470
Public building domestic use	3.046	3.136	6.153
Electro-motive force for private use; High voltage	1.778	1.778	4.370
Low voltage	2.251	2.261	5.003
Electro-motive force for public use; High voltage	1.778	1.778	3.933
Low voltage	2.301	2.311	4.786

Also FKEB fixes on the rate as follows.

Table I-24 Power Rate by FKEB

(Riel/kWh)

Use		Battambang
Administration	Lighting	6.484
	Motor	5.119
Private	Lighting	6.714
	Motor	5.186

(f) Power Supply for the Project Area

The power supply areas in the project are along the Stung Chinit, Kg. Thma, Baray, Tang Krasang and their surrounding areas, approximately within the limits of 250 km^2, and at present the various diesel plants with some ten kW supply the villages with electric power for mainly lighting load.

The equipment is so unstable in operation and the voltage is so low that the reliability of power use is also very low.

Some households have installed private power generators. The power charge for domestic lighting use is collected monthly, based on the classification and numbers of the lamps with fixed rate. Such being the case, the areas in the project are mostly considered as an unelectrified area at present.

As for the power equipment increase plan in Cambodia, Phnom-Penh and its surrounding area, and the looped supply system connecting Sihanouk-Ville, Kampot, Takeo are given top priority in their construction, and further, the effort is concentrated on the development of the power sources for those cities.

As a result of them, it can be considered that the project areas will have no possibility to be covered by the power supply system from the central system of Cambodia, nor prospected to be supplied the power by the diesel power by EDC of Kg. Cham or Kg. Thom for the time being.

1-13. Fishery

At the upstream of Kg. Thma many fishermen go fishing from the downstream at the end of the rainy season, so that a rather long distance from Kg. Thma to Thma Samlieng is crowded with them. On the other hand, in the dry season, only one fishman lives at Thma Samlieng. There are swamps filled with water throughout the year at the downstream of Kg. Thma, where some fishermen operating drag nets with their families, many petty fishermen operating casting nets or long lines can been seen.

1-13-1. Sites Surveyed.

Five sites were selected in the areas concerned with the Stung Chinit project, and the fishery conditions of each site were surveyed as follows;

1.	Proposed reservoir area;	Bangki Tangren
2.	Proposed damsite;	Kg. Krabei
3.	Midstream;	Thma Samlieng
4.	Proposed irrigation area;	Kg. Thma
5.	Proposed polder dike area;	Kg. Thma - Tang Krasang

These sites expand from the upstream area to the downstream area in order, which occupy the main part of the project area. Therefore by studying the conditions of each area the transition and other relation of fishery from the basin near mountain to the inundated area can be found.

1-13-2. Fish Species

As the result of the actual and interview surveys 8 species at the proposed reservoir area and 50 species at the proposed damsite were clarified.

By the interview with a full-time fisherman at Thma Samlieng mid-stream, 48 species were enumerated of which important species were limited to 10 as shown in Table I-25. It is of great interest that any of the most important fishes over Cambodia are not included in them.

Table I-25 Main Fishes of the Stung Chinit

Name of species	Name on the site
Ophycephalus striatus	T. Ros, T. Phtok
Ophycephalus micropeltes	T. Chhdor, T. Ros
Macrones nemurus	T. Chlaing
Hampala macrolepidota	T. Khman
Notopterus notopterus	T. Slat
Cirrhinus jullieni	T. Riel
Anabas testudineus	T. Kranh
Ompok bimaculatus	T. Kraman
Oxygaster oxygastroides	T. Chanteas phluk
Thynni chthys thynnoides	T. Linh

1-13-3. Fishing tools

Since the Stung Chinit presents precisely the river pattern at the upstream of Kg. Thma, there are few fish species as stated above, so that the fishermen can not use anything but a few tools such as a long line and a basket trap for the daily use. Also the number of such tools are few.

Since the water velocity of the downstream of Kg. Thma becomes slow and the water tends to stagnate, there are many fishes which live in the stagnant water, so that many fishermen use a long line, a scoop basket and a casting net.

1-13-4. Distribution

As stated above, since fishery is merely a side-job for the people around the upstream, majority of the fresh fish, 'Nucmum' and 'Prahoc' consumed by them throughout a year were purchased from the surrounding fishing villages of Kg. Thma and Kg. Thom, though some of them are provided by themselves.

On the contrary, since there are many fishermen in the downstream area of Kg. Thma, the fish is transported to Kg. Thma and Kg. Thom.

Usual consumed amount of the fresh fish and 'Nucmum' by farmers in the area is shown in Table I-26.

Table I-26 Consumed amount of Fresh Fish and 'Nucmum' by farmers

(in Riel)

No.	'Nucmum'	Fresh fish
1	360	5,475
2	87	1,800
3	-	3,650
4	360	5,475
5	-	1,560
Average	270	3,592

1-13-5. Conclusion

(1) It is clear that when the water level rises up in the rainy season,

a great deal of fish migrate from the Great Lake into the river and they deposit spawn at the far upstream around Bangki Tangren, as well as the main stream of the Mekong.

(2) Reproduced fish faunas grow rapidly during the rainy season, and then migrate to the downstream in masses early in the dry season.

(3) In the dry season the proposed damsite is crowded with the fishermen who come from the downstream of Kg. Thma, and on the contrary, no fishing is found there in the other season.

(4) Around the proposed irrigation and polder areas downstream of Kg. Thma, there are many full-time fishermen in proportion to the number of fish there. Therefore, a deliverate fishery policy should be planned in these areas.

(5) During the dry season, a poison is sometimes poured into the river in a large scale, by which many fish are killed. This is the serious problem for the fish fauna propagation to be considered hereafter.

(6) The result of these investigation is summarized in Table I-27.

1-14. Navigation

1-14-1. Present Navigation of Stung Chinit

In this country, the waterways are important for transportation system. The navigation utilization of the Stung Chinit is high in the frequency of lumber transportation, but low in commercial and passenger transportation at present.

Lumber transportation The forests of the Stung Chinit basin are maintained by the *Service des Eaux Forests et Chase*, Kg. Thma as reserved

Table I-27 Present Fishery Conditions

No.	Name of Village	Population	No. of fish species	No. of fisherman	Fishing tools	Marketing	Remarks
1	Bangki Tangren	230	8	none	Long line, Trap	Purchase from Prek Son Ke	Fish fauna seems to migrate from the Tone Le Sap
2	Kg. Krabei	60	35	none	Boats 20 Long line	From Kg. Thma	
3	Thma Samlieng	-	48	1	Motor boat, Trap, Long line, Casting net	Mainly from Kg. Thma, sometime self-supply	
4	Kg. Thma	-	Many	Many	Long line, Drifting, Gill net, Scoop trap Trap, Dragnet	Self supply & Purchase	
5	Kg. Thma - Tang Krasang	-	Many	Many		Delivery to Kg. Thma & Kg. Thom	

forests. And the woods are cut under the control of the office. Total amount of the wood production during the last five years is shown in Table I-28 for each basin.

Table I-28 5-Year Total Amount of Wood Production

Unit: m^3

Name of Basin	1964	1965	1966	1967	1968
St. Chinit	10,294	5,183	9,732	10,291	3,867
St. Sen	-	-	-	-	12,437
Tonle Mekong	-	-	-	-	-
Total	10,294	5,183	9,732	10,291	16,304

Presented by the *Service des Eaux Forests et Chase, Kg. Thma.*

Most of the lumbered trees are carried to the Stung Chinit through its tributaries, where they are put together in the form of rafts. Some of them floating down along the Stung Chinit are landed at Phum Thma Samlieng - 15 km downstream of the dam site - and carried by truck. The other floats down the river, passing Kg. Thma, through the Tonle Sap, to Phnom-Penh which is a main collection and distribution center.

A standard party of unit raft composed of 6 to 8 of tied several lumbers of 10 m wide and 15 m long, is ridden by around ten rafters. It takes 3 days from Phum Thma Samlieng to Phum Kg. Thma, and furthermore average 2 weeks from the latter to Phnom-Penh. It takes about one day after landing at Phum Thma Samlieng to be carried by truck to Phnom-Penh.

The total amount of the lumbers carried by truck is not recorded in particular. Not being recorded especially, the amount of lumber carried by truck is assumed 10% of whole amount considering the numbers most of the wood production are carried by the waterways.

Groceries and Passenger transportation. The Stung Chinit is hardly utilized for groceries and passenger transportation. The navigation frequency from Phum Kg. Thma to the upper stream is scanty because there exists few farms and no main villages. Also that is because a forest road for truck transportation is more convenient than the navigation by the Stung Chinit.

The navigation from Kg. Thma toward the Great Lake is utilized for groceries and passenger transportation to fishing villages during the rainy season, but its scale is small. There is no regular service, but mainly local retail dealers optionally ride rental motor boats.

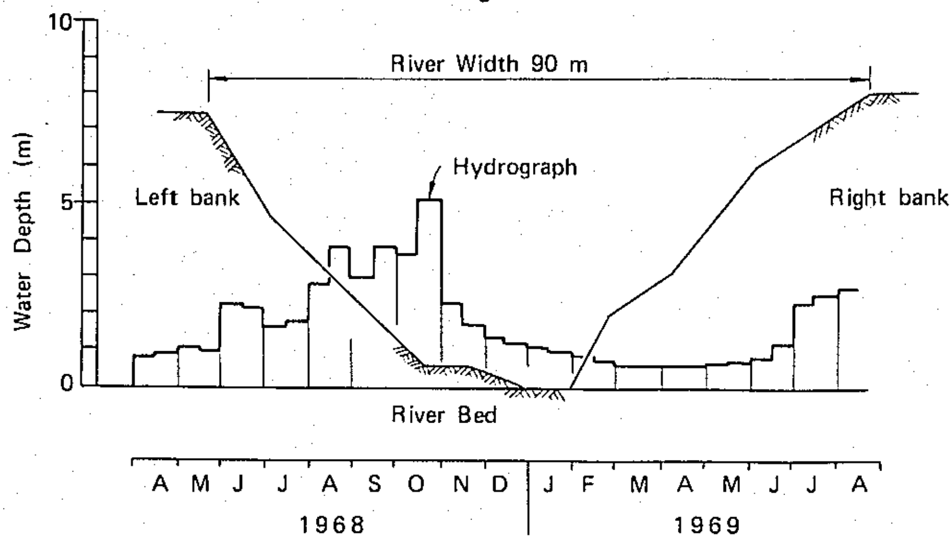
1-14-2. Present Situations of Stung Chinit - From Navigation View Point -

Evaluation of the Stung Chinit from the navigation view point is outlined as follows:

(a) The fluctuation of water level between the dry and rainy season is large and the water depth becomes remarkably shallow in the dry season.

The water level fluctuation during 1968 through 1969 at Phum Kg. Krabei is charted with the cross section of the river in Fig. I-16. It was a dry year from 1968 to 1969 and even during the rainy season the water level was at least one meter lower than that in the case of ordinary years. But the water depth during the dry season is less than 1 meter. As shown in Fig. I-16, the period for the boat services is restricted to only the rainy season. In fact, the present lumber transportation by rafts is, in general, useful during only 3 months of the rainy season.

Fig. I-16 Hydrograph of the Stung Chinit at Kg. Krabei



(b) Alignment is a meandering type, with excessively sharp bends.

The Stung Chinit is of a meandering type. The comparison of the distance along the river with the straight line distance between Phum Kg. Thma and Phum Bangki Tangren is shown in Table I-29, and it can be concluded that the stretched distance along the river is twice of the straight line distance.

Table I-29 Distance from Kg. Thma (in km)

Location	Distance along River		Straight Distance	
	Distance	Accumulative	Distance	Accumulative
Kg. Thma Bridge	0	0	0	0
Andaot	39	39	21	21
Dam site	20	59	9.5	30.5
Bangki Tangren	29	88	13	43.5

The forest road route No.402 is 55 km long from Kg. Thma to Bangki Tangren.

(c) The maximum velocity of flow is around 1.0 m/s, which is adequate to raft transportation.

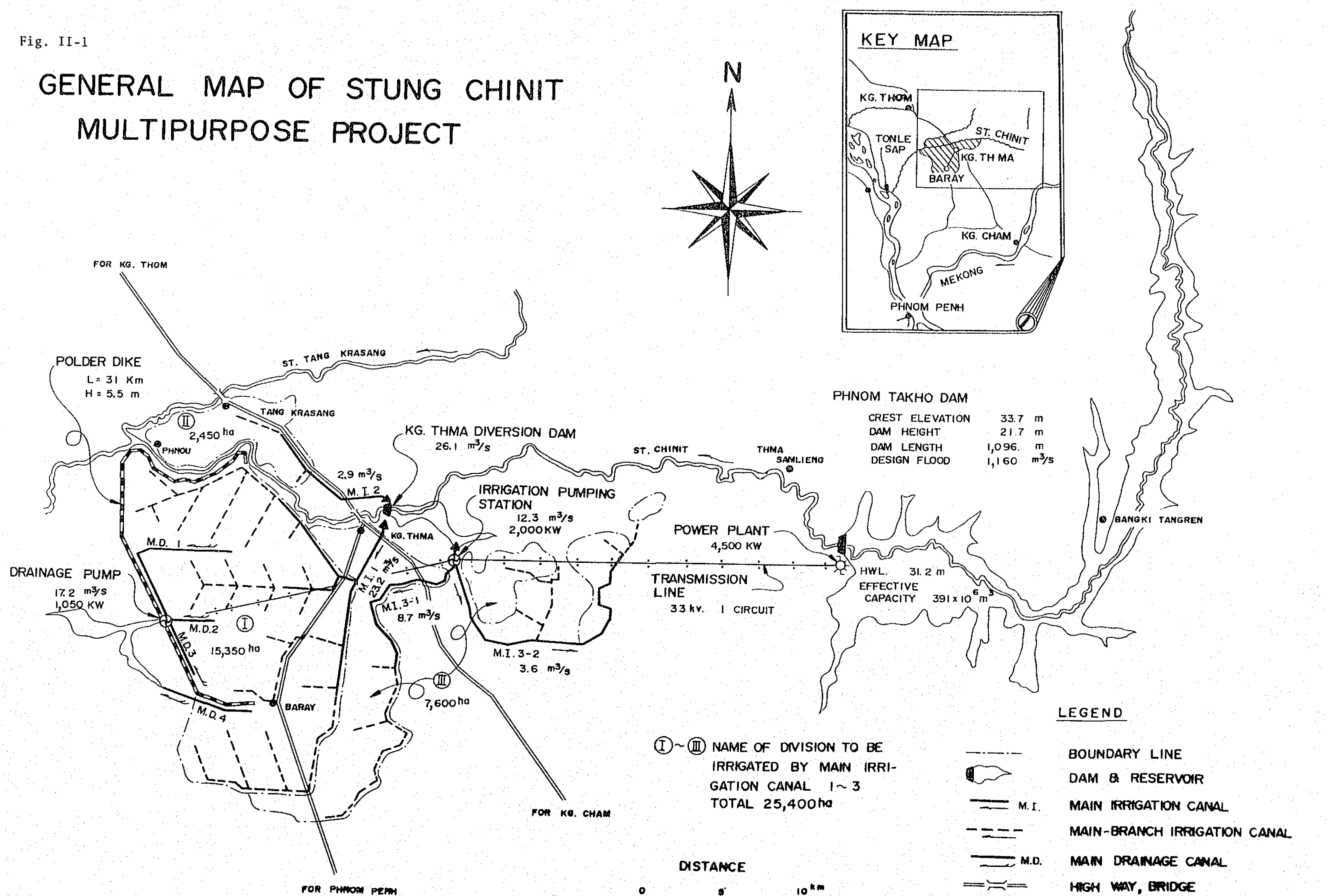
The maximum velocity of flow may be 0.8 - 1.2 m/s at the highest water level, which is adequate velocity for riding the rafts in the Stung Chinit in sharp meandering. The minimum velocity of flow in the dry season is reduced to 0.4 m/s at the lowest water level. As a result it become impossible to utilize the navigation during the dry season due to insufficient water depth for the navigation.

PART II

PROJECT PLAN

Fig. II-1

GENERAL MAP OF STUNG CHINIT MULTIPURPOSE PROJECT



PART II PROJECT PLAN

2-1. Problems and Needs of the Project

The Stung Chinit multipurpose development project is regarded as one of the regional development projects in the Khmer Republic. However, a regional development plan should have a close relation to the nation-wide development. In this sense, a position of the Stung Chinit Basin Development Plan in the Second Five Years Economic Development Program in the Khmer Republic shall be envisaged, and the needs and problems as well as the special features of this Project shall be clarified in view of each special field as described hereinafter under paragraph 2-1-2.

2-1-1. Economic Development of the Khmer Republic and the Stung Chinit Basin Development

In the Economic Development Plan, the Government of the Khmer Republic gives the first priority to an increase of agricultural products and next to various industrial products necessary for its increase, such as fertilizer, agricultural chemicals and machinery.

In this connection, the government employs the following policy for the increase of agricultural products: (a) to raise the efficiency of the existing irrigation facilities as well as expansion of a small scale irrigation networks: (b) to develop agricultural techniques such as fertilization, introduction of proper seed varieties, extermination of disease and insect damage, agricultural mechanization, and land improvement, and (c) to increase farmer's income by setting up reasonable prices for agricultural products and by strengthening the credit system functioned by OROC.

As one of development projects corresponding to such a government policy, the Stung Chinit Project is fairly prospective. Because, in comparison with the Mekong mainstream development plans involving large construction works, the area and investment funds required for the project are considerably easy to be implemented from the financial viewpoints.

2-1-2. Well-balanced Regional Developments and Technical Considerations

There are three river systems in Cambodia; the Mekong, the Tonle Sap, and rivers flowing into the Gulf of Thailand. The Mekong basin is divided into two parts; the northeast area of Cambodia and the delta area in the southwest. The former is predominant with wood and less populated, and its area of arable lands is small. However, the delta area has been cultivated to be a vast paddy field, while all-around natural levee along the Mekong have been utilized as a center of upland farming of Cambodia.

The west side of the Great Lake, where agriculture has been considerably developed, is regarded as a granary of Cambodia. The east side is less developed comparing with the west side but will become a promising area by a future development.

The basin of the river system along the Gulf of Thailand is so mountainous and soil fertility is so poor that potentiality for the agricultural development is not enormous.

Accordingly, the development of the Stung Chinit basin located at the east-side of the Great Lake might be emphasized in the sense that the respective development in the above areas shall be well-balanced on the nation-wide bases.

(a) Soil and Weather Condition

The surrounding area of the Great Lake has two seasons; the dry and the rainy season, under the semi-wet tropical climate. And the soil is not of the extreme dry-type, such as alkaline soil and desert soil, and not of the extreme wet-type such as reduction type of the delta district. Under such a soil and weather condition, the increase of the agricultural products is anticipated to be realized by the advanced water utilization on the paddy cultivation during the dry season as well as the rainy season.

(b) Farming Technique Problem

In the Stung Chinit basin, especially in the project area, the paddy fields predominate in the agriculture lands. The farmers are taking a positive attitude to cooperate with the OROC, wishing to acquire the technical extension services and so forth. Since a rather large size of paddy field extends collectively in this area, the farm mechanization will be introduced in a favorable condition in the future.

The administrative efforts to intensify the infrastructure in developing the irrigation and drainage system are being made, and there is an effective drainage system already in operation in the project area. The farm size per household of approximately 2 - 3 ha is adequate for performing the extension service of agriculture effectively in order to raise the productivity of existing farming lands rather than to expand farm lands.

(c) Fishery

One of the major targets of the multipurpose development projects is to increase the quantity of fish, which is most important protein sources in the project area.

A wide survey for species and ecology of fish will be almost difficult in the Mekong area, whereas the fish survey in the Stung Chinit will be possible, and it may be an ideal case for examining a relation between ecology of fish originated from the Great Lake and the environmental conditions of water level and water quantity. Also, there are suitable places for fresh water pisciculture along the main canals in the project area.

A reservoir to be built at hilly basin, where fish meat is particularly wanted by inhabitants, will be utilized as a source of fish meat if the reservoir is properly controlled.

(d) Hydro-power Generation

The central power networks of this country will not cover the whole project areas in the immediate future. Therefore, the power provided with the main dam of this project will mainly function as a power source of the area. Inhabitants recognize convenience of the power so well, that they are found enthusiastic to adopt power energy in their daily life, if it turns out to be profitable. A current rate of diesel power is very high, 6 Riel/kWh, so that future hydro-power supply at the low rate would release the users from the economic burden.

2-1-3. Staged Economic Development

It is assumed that agricultural development and stabilization of agricultural production are now most important for the future national and regional development of Cambodia.

Thus, as a desirable process the following three stages could be assumed:

1st stage: low productivity of labor and land

2nd stage: low productivity of labor and high productivity of land

3rd stage: high productivity of labor and land

To increase agricultural production, much investment should be concentrated to the fixed capital, such as facilities for irrigation and drainage, and flood control, and at the same time to the working capital, such as agricultural credit, fertilizer, chemicals and so forth. In the course of this investment, examination, training and extension services for farmers to meet with agricultural techniques, and improvement of marketing systems will help to increase the agricultural production as influential matters.

2-2. Agricultural Development

2-2-1. Land Development

(a) Determination of the Project Area

On the basis of the reconnaissance survey of the northern area of the Great Lake, a feasibility survey was requested for an area totalling 40,000 ha, of which 28,000 ha is at the left bank of the river and 12,000 ha at the right, and both below an elevation of 20 meters.

The latest feasibility investigation was made on a 48,000 ha area, on its topography, soil, land use, etc., including the area mentioned above, of which 12,000 ha is at the right bank as far as the Tang Krasang, and 36,000 ha at the left bank, at the elevation below 25 meters. Among these areas, a 28,547 ha area below EL 25 m is finally selected as an area to be developed, from the technical viewpoint, limitation of the water resources and economic evaluation, excluding uncultivated hilly lands at the left bank of the river and poor fertility areas of coarse-textured alluvial soil at the right bank.

(b) Objective for Development

Present paddy cultivation is one crop a year, and is mostly in the rainy season. Furthermore, it is seriously affected by rainfall every year, and the efficiency of land use is low. In order to increase the productivity of land, the following countermeasures are planned.

1. To stabilize the production of the rainy seasonal rice
The present paddy fields are supplied with water from rainfall or the natural flow of the river without irrigation facilities, and therefore the yield is always unstable. Accordingly, the main objective of the project is to stabilize the yield of the rainy seasonal rice.

2. To reclaim uncultivated lands
In the project area, especially around the Great Lake, there is much land

left uncultivated due to the inundation in the rainy season and lack of water in the dry season. Among them a 4,700 ha area composed of swamp and grass land which is fertile and comparatively easy to be reclaimed, is selected for the purpose of expanding a paddy field.

3. To introduce the second crop of paddy rice in the dry season Irrigation in the dry season become possible by securing water sources, and thus, it is planned to introduce second crop of paddy rice over the area, and vegetables and fruits in the future.

According to the development policy mentioned above, the whole area of 28,547 ha (25,400 ha of net benefited area) is classified as Table II-1.

Table II-1 Comparison of the Area without and with Project

(ha)

Present \ Project		Cultivated Land			Road, Canal & etc.
		Paddy	Upland	Total	
Paddy field	23,020	20,700	-	20,700	2,320
Upland field	-	-	-	-	-
Sub-total	23,020	20,700	-	20,700	2,320
Grass land	5,527	4,700	-	4,700	827
Others	-	-	-	-	-
Sub-total	5,527	4,700	-	4,700	827
Total	28,547	25,400		25,400	3,147

2-2-2. Water Resources Development

(a) Water Sources

The project area has three kinds of water sources as the development objectives such as rainfall, natural flow of the rivers, and ground water.

Rainfall The rainfall in the area shall be represented by that in Baray. The effective rainfalls in the paddy fields shall be computed on the following basis; daily rainfall below 5 mm is considered ineffective, and in case of that over 5 mm upto 80 mm per day, 80 percent of rainfall is taken effective. The annual variation of the monthly rainfall for the last 7 years is shown separately in the figure, and the total rainfall in a year and its effective rainfall are tabulated and shown in Table II-2.

Table II-2 Total Rainfall & Effective Rainfall (mm)

Year	Total Rainfall	Effective Rainfall	Year	Total Rainfall	Effective Rainfall
1962	1,773.6	1,182.2	1966	1,648.0	1,304.5
1963	1,548.2	1,154.0	1967	1,246.9	979.0
1964	1,515.0	1,082.3	1968	1,252.9	924.3
1965	1,602.8	1,259.2	1969	1,163.0	850.3

According to the probability computation by the *Service Meteorologique du Cambodge* on rainfall at Baray for 24 years (1962 - 1942, 1952, 1961 - 1966), the probable rainfall of 50% is 1,490 mm (Ref. Fig. II-3).

Natural Flow of River The runoff at the proposed damsite1/ of the Stung Chinit is estimated by the conversion multiplying 0.91, the ratio of the catchment areas, by the value observed at Kg. Thma, because no observation data are available at the said damsite for a long period. (Catchment areas are Kg. Thma 4,130 km^2 and damsite 3,770 km^2). The mean value of the discharge ratio of the damsite to Kg. Thma, observed in 1968, is 0.905, and it proves that the ratio of the catchment area of 0.91 is reasonable.

1/ At first, two sites, Bangki Tangren and Phnom Takho were selected as the proposed damsites, but finally Phnom Takho was decided as the damsite, after comparative studies with each other in topography, construction cost, storage capacity.

The annual total discharges of the last 7 years at the both points, Kg. Thma and damsite, are shown in Table II-3.

Table II-3 Annual Runoff ($10^6 m^3$)

Year	Kg. Thma	Damsite	Year	Kg. Thma	Damsite
1962	2,267	2,063	1966	1,583	1,441
1963	956	870	1967	1,637	1,490
1964	972	885	1968	930	846
1965	1,407	1,280			

Ground Water In the hilly lands at the left side of the Stung Chinit, the laterite layers are developing and yielding fair amount of ground water for domestic use and cattles. The survey was conducted for the availability of the ground water as water sources for irrigation, (Ref. 1-4-3 Ground Water), and the survey made it clear that the available amount of water will be approximately 380 m^3/day/km^2, which is equivalent to only 0.38 mm per day in water depth. This amount is too small to be utilized for paddy rice, because the minimum water requirement for paddy rice is about 10 mm per day in this area. Consequently, the ground water utilization for irrigation is judged uneconomical in this project.

(b) Water requirements

(i) Irrigation water

The water requirements of paddy rice are classified into the net irrigation water to be consumed in the fields, and gross irrigation water consisting of the net irrigation water and several losses. And the net irrigation water is computed by deducting the evapo-transpiration and percolation losses from the effective rainfall.

Net Irrigation Water Evapo-transpiration is computed on the monthly basis by using the method of Blaney-Criddle and percolation losses are fixed respectively on the features of soils such as sand, loam, clay. (Ref. 1-4-2 Soil and Water). Thus, daily decrease of water depth on paddy field is shown in Table II-4.

Table II-4 Daily Decrease of Water Depth (mm/day)

Soils	Percolation	Decrease of Water Depth		
		Max.	Min.	Mean
Sand	7.0	14.1	11.4	12.7
Loam	5.0	12.1	9.4	10.7
Clay	2.0	9.1	6.4	7.7

The maximum water requirement arises in February, and the minimum in September.

Gross Irrigation Water The irrigation efficiency in the project is estimated at 75%. At the early stage of the operation of the project, the efficiency is presumed to be low, but it will be raised gradually by rational water control which will be operated by an organization to be established in future, together with the effect of demonstration and extension base farms, and thus efficiency will reach 75% on an average during the project life.

The loss of 25%[1/] includes conveyance loss of 5% in main canals, 12% in laterals and 10% on operation.

On the basis of the land development and cropping plan, irrigation water requirement is computed and given in Table II-5, taking the data of rainfall and runoff from 1962 to 1968 as designed basic years. Net

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1/ Efficiency of irrigation $= \frac{1}{(1-0.05)} \times \frac{1}{(1-0.12)} \times \frac{1}{(1-0.10)} = \frac{1}{0.75}$

water requirement is obtained by multiplying the monthly water requirement[1/] in depth in ha by the area of 25,400 ha in the rainy season and 20,300 ha in the dry season, and an amount of water to be supplied from other than rainfall is equivalent to an amount subtracted the effective rainfall mentioned in 2-2-2 (a), from the net water requirement.

Table II-5 Total Water Requirements ($10^6 m^3$)

Year	Water Requirement	Effective Rainfall	Amount of Water Supply
1962	1,015	285	730
1963	1,015	276	739
1964	1,015	256	759
1965	1,015	310	705
1966	1,015	311	704
1967	1,015	244	771
1968	1,015	223	792

Irrigation area: 25,400 ha

Cropping: Paddy rice

Cropping intensity: 100% (rainy season), 80% (dry season)

Including various losses.

(ii) Others

The river maintaining flow for fishery and navigation is not planned particularly in this scheme, and it is supposed that irrigation in the dry season and hydraulic power generation will produce a larger water discharge than before the project in dry season.

(c) Plan of Water Supply

Based on the rainfall data of 1962 to 1968, irrigation water to be

1/ Refer to Appendix A-1

Fig. II-2 Rainfall at Baray

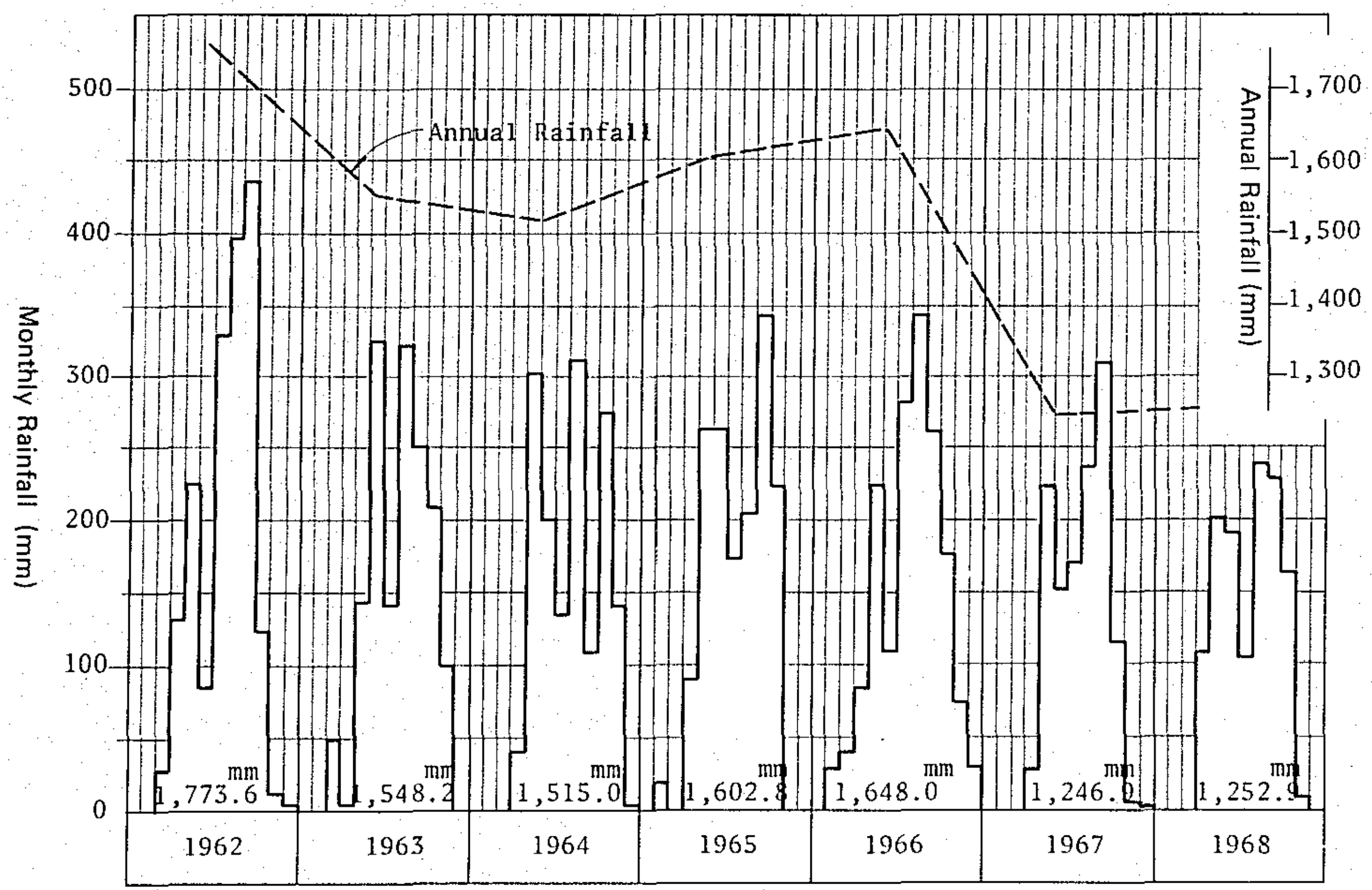
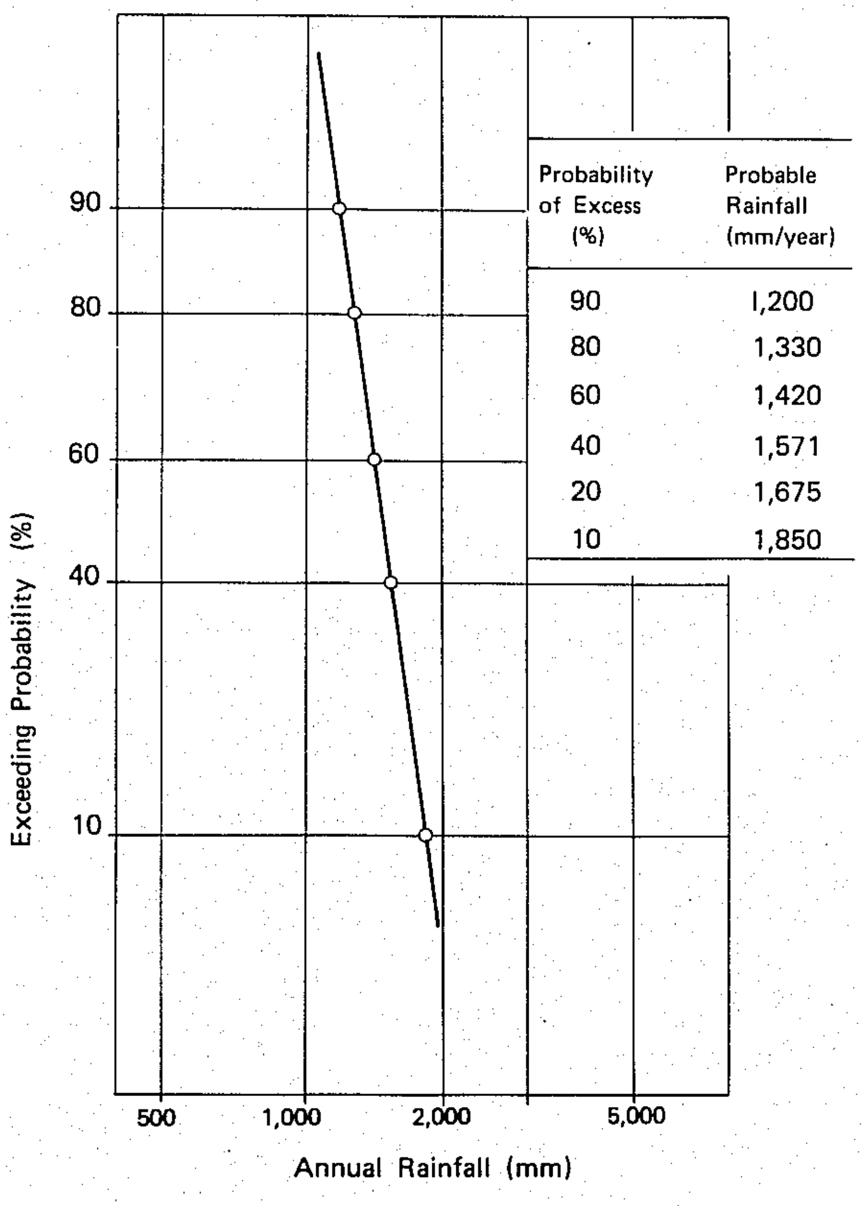
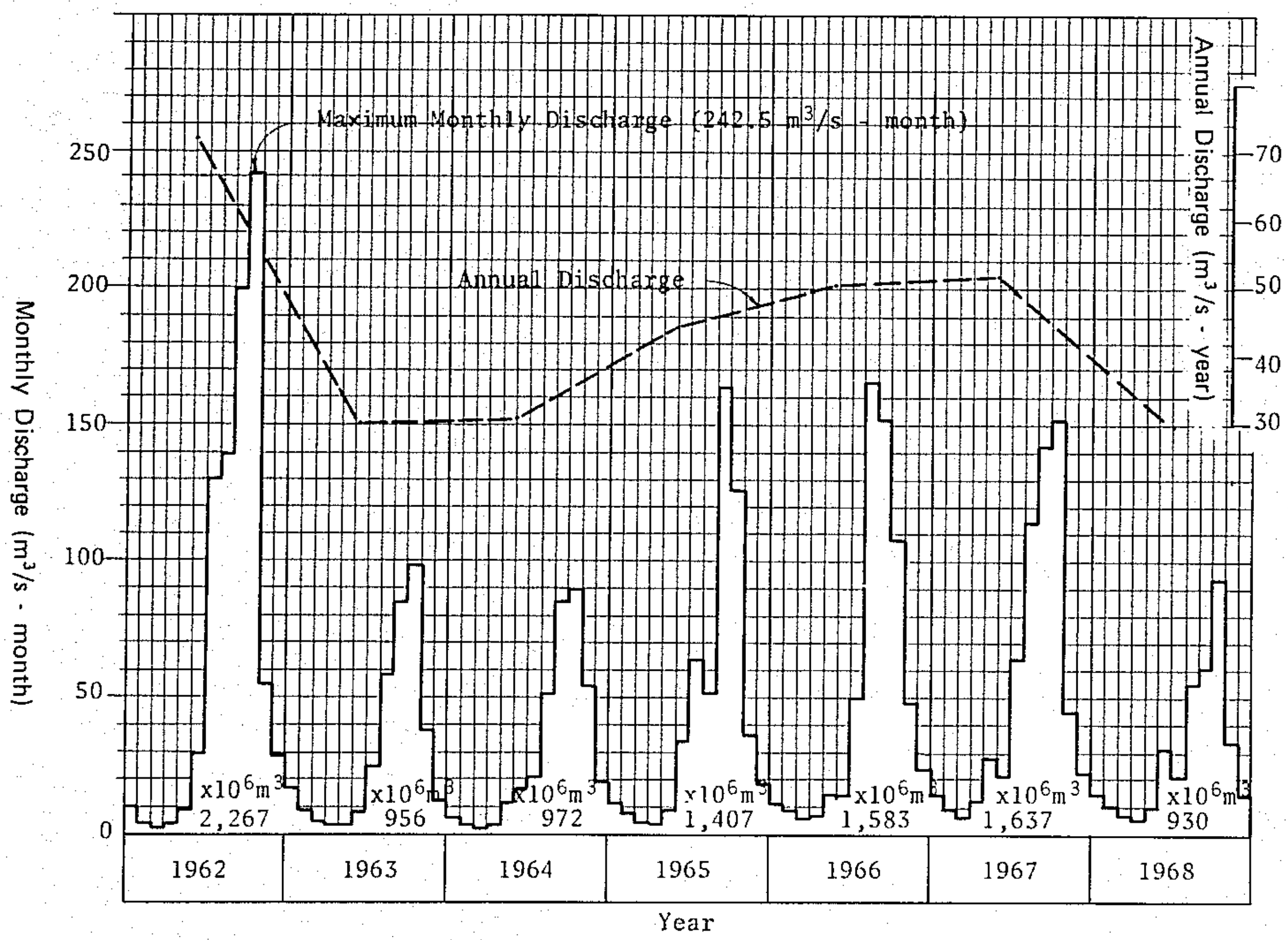


Fig. II-3 Probable Rainfall at Kg. Thom Calculated by TP



Probability of Excess (%)	Probable Rainfall (mm/year)
90	1,200
80	1,330
60	1,420
40	1,571
20	1,675
10	1,850

Fig. II-4 Discharge of the Stung Chinit at Kg. Thma (4,130 km^2)



supplied from other sources than rainfall is obtained in 2-2-2, (b), and the runoff of the Stung Chinit is also known in 2-2-2, (a). When the monthly variation of both data, supplementary water and runoff, are illustrated for 8 years by means of the mass curve method, the maximum shortage water shall amount to 391[1/] x $10^6 m^3$ to irrigate 25,400 ha, of which 20 x $10^6 m^3$ is a regulating discharge for hydro-power generation.

The amount of 391 x $10^6 m^3$ is planned to be stored by constructing a dam.

2-2-3. Development Plan

(a) Staged Development

With expectation that the pilot farm (extension base farms) in the irrigation area will be efficiently managed, the project shall be realized in the following two stages.

First stage The head works at Kg. Thma and the canal systems shall be constructed at first. The discharge of the Stung Chinit and the stored water by the diversion dam make it possible to irrigate the paddy fields in the rainy season (the farm lands below EL 12.0 m, expanding to 14,800 ha as shown in most part of I, and II in Fig. II-1), and in the dry season (the paddy fields about 5,000 ha below EL 12.0 m).

Second stage The construction of a reservoir and pumping facilities to be built near the diversion dam. With the dam facilities and poldering works completed, the amount of intake water at the diversion dam can keep it constant and necessary level, through the rainy and dry season, stabilizing the cultivation for the total area of 25,400 ha. (7,600 ha in III and 3,000 ha in I of Fig. II-1 to be added to 14,800 ha in the first stage).

1/ Refer to Appendix B-1

(b) Farming Program

The area is divided into 5, A, B, C, D and E, as mentioned in 1-6-3. The plan of farming program by each area is as follows,

Area A

Scope: The area extends on the right bank of the downstream of the Stung Chinit, and between the Stung Chinit and the St. Tang Krasang. The area is at about EL 10 m, and of grayish brown soil (fine) zone. The area is frequently inundated at present and has floating paddy cultivation besides parts of seasonal or semi-seasonal paddy.

Farming Program: A double-cropping system is adopted by introducing the dry-seasonal paddy into the seasonal and semi-seasonal paddy zones. Also in the area of the floating paddy zones, which is prevented from the inundation by controlling the discharge from the dam, the double-cropping system is adopted. In the areas which are not prevented from inundation, the floating paddy is left intact.

In the dry season, lands along the canal and fallow farms are mainly utilized as pasture. In addition, it is possible to feed small livestock such as pigs, and poultry, in the future.

Area B (This is located outside of the project area at present, but an explanation is given for the future convenience.)

Scope: The area is at about EL 12 - 15 m and flat on the right bank of the Stung Chinit. The soils are grayish brown (Medium, Coarse), very permeable and unfit for irrigation. The area will be cultivated for the seasonal paddy.

Farming Program: Principally, the double-cropping system is adopted by introducing the dry seasonal paddy. Some parts of the area can be converted to upland crop fields. Pulse crops are desirable to be cultivated.

Area C

Scope: The area ranges between EL 10 m and EL 15 m on the left bank of the Stung Chinit. The national road passes through the central part of this area, and the traffic in this area is generally convenient but the southernwest part of the area. The soils are grayish brown (Medium), and partly vertisols (Hydromorphic) by blending. Generally the seasonal paddy and partly the floating paddy are cultivated.

Farming Program: The double cropping system is expected to be adopted in the floating paddy areas because drainage conditions are to be improved and, further, roads conditions also consolidated. In some parts of vertisols at the high elevation in the seasonal paddy zone, a rotation system of paddy rice and upland crop such as maize in the dry season can be introduced to increase the farmers' income. Vegetable farming is also promising in some areas near Kg. Thma.

Area D

Scope: The area is a hilly land on the left bank of the Stung Chinit with EL 15 to 20 m, suffering from shortage of water even in the rainy season. There are many vertisols (Hydromorphic), with considerably high potential productivity. The seasonal paddy is under cultivation.

Farming Program: The double-cropping system is also adopted by positive introduction of the dry-seasonal paddy. The pulse crop is expected to increase the land productivity.
The livestock at present is bred with considerable deliveration, but it will be possible to multiplicate the product by utilizing and improving the wild plants for feed stuff, and also the introduction of upland crops and advantageous breeding of the beef cattle are greatly expected.

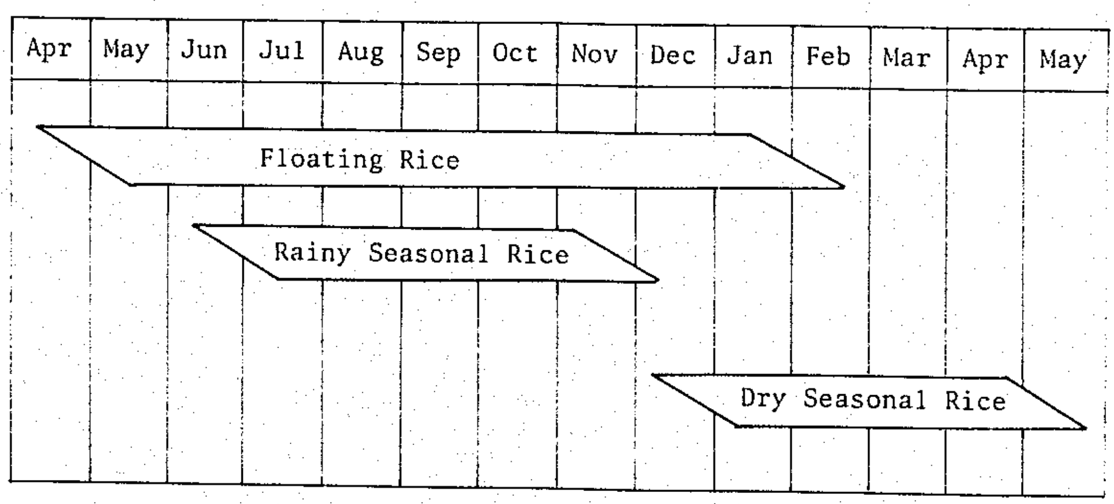
Area E

Scope: This is the low land less than EL 10 m, and usually inundated from the Tonle Sap. Soils are grayish brown (Medium fine). There are few roads, and most part of the area is left uncultivated.

Farming Program: The land is to be prevented from inundation by setting up polder dikes and a pumping station, in order to cultivate crops in the rainy seasons. The irrigation system is expected to facilitate the cultivation of crops in the dry season.

Cropping System The growing periods of the main crops to be proposed are shown in Fig. II-5.

Fig. II-5 Growth Period of Paddy Rice



On the occasion of shifting to the double cropping of paddy rice, IR 5 and Masuri, for the rainy season, and IR 8 and others for the dry season will be adopted. The study of this problem should be finished before construction works are over, and therefore, special considerations will be required for the selection of the seeds.

(c) Plan of Land Improvement

On the foundation of the farming program, the following plan of land improvement shall be established to reasonably utilize the land and water resources. (Fig. II-1. General Plan)

(i) Irrigation facilities

Reservoir To irrigate the paddy fields of 25,400 ha at 180 per cent in crop intensity, the amount of water of 391 x $10^6 m^3$ together with hydro-power purpose shall be stored. (Refer to 2-2-2) A reservoir shall be constructed at the site of Phnom Takho with a storage capacity 500 x $10^6 m^3$, in taking best consideration into hydropower generation, flood control, and dead water.

As the result of tests and investigations of soils at the site, the dam shall be constructed in the earthfill type, which is low in construction cost, and only the spillway facilities in the gravity concrete type. A designed flood is at 1,160 m^3/s on an exceeding probability of 0.1 per cent. The spillway facilities shall be provided with the conduits, at the downstream of the dam, with a discharge capacity of 80 m^3/s, and with three gates spillways with a maximum discharge capacity of 710 m^3/s. (Width 7 m x height 5.7 m x 3 gates) Furthermore, an emergency spillway of 200 m wide at the right abutment of the earthfill dam shall also be provided.

The main dimensions of the dam are as the Table II-6.

Table II-6 The Dimensions of the Dam

Catchment Area: 3,770 km^2						
Embankment	Type	Crest Height	Crest Length	Capacity	Total reservoir capacity	Effective reservoir capacity
	Earth-fill type	21.7m	1,040m	540 x $10^3 m^3$	500 x $10^6 m^3$	391 x $10^6 m^3$
	Type					Designed Flood
Spillway	Roller gate type 3 gates, 2 culverts and an emergency spillway					1,160 m^3/s

Diversion Dam As the result of the comparative studies about various methods to utilize the stored water, two divisions in the total irrigable area are fixed at the elevation above and below 12 m. For the cultivated area, 17,800 ha (Fig. II-1, I and II), the intake method from a diversion dam at Kg. Thma is more economical than direct intake from the reservoir, and therefore, a diversion dam shall be constructed at the point with intake water level of 12.25 m. The diversion dam shall be open type with two roller gates with a length of 20 m, and height of 6.5 m. The amount of intake water shall be 26.1 m^3/s, of which 23.2 m^3/s is for the main irrigation canal No.1 of the left bank, and 2.9 m^3/s for the No.2 on the right bank.

Irrigation Pumping Station In regards to the intake of water for the area above EL 12 m in the entire cultivated area, three methods are available, namely direct intake from the dam, intake from a diversion dam to be constructed newly at intake water level of EL 25 m, and pumping-up water at Kg. Thma. In comparison with one another, the pumping method was found to be preferably economical[1/]. The amount of water of 12.3 m^3/s shall be pumped up at the pumping water level of 12 m, on the stored water surface in the diversion dam at Kg. Thma. The pumping station shall be provided with two mixed flow pumps with a diameter of 1,700 mm. Requested motor power is 2,000 kW, and the said power shall be supplied from a power station to be constructed at Phnom Takho.

Irrigation Canal The canal shall be of earth type for the curtailment of the construction cost, but earth lining shall be applied only to the canals running along the hilly left bank of laterite soil, which is highly permeable. To raise up the efficiency of irrigation, the best maintenance

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1/ At the present feasibility stage, three alternative studies have been made, (1) Installation of a pump station at the diversion dam site, (2) Gravity irrigation from the main dam, and (3) Construction of a new diversion dam. According to the result of economic studies (refer to Appendix A-3), (1) Plan, which is adopted in this report, has some advantages. However, detail studies on the two alternatives shall be advised at the design stage.

of the facilities including terminal irrigation facilities is indispensable. In the project, a canal system is designed to irrigate 10 ha at its terminal.

(ii) Drainage Facilities

The effect of drainage appears clearly in the increase of labor productivity with the improvement of cultivating and soil characteristics, and bearing power of the ground. Especially, to strengthen the function of drainage at the end of the rainy season is very important for this district where the cropping in the dry season is planned to be introduced. The ridges of paddy fields have some capacity to control flood and paddy rice being bearable against the flooding to some extent. In making a plan for draining farm lands, therefore, the data of continuous rainfalls shall be essential. The rainfall of 1,773.6 mm in 1962, a heavy rainfall year, is taken as the designed basic rainfall, and the drainage facilities are economically planned to provide a capacity of 12 mm/day. In this case, the maximum amount of water ($18.6 \times 10^6 m^3$) cannot be drained and an area of 3,700 ha will be inundated. But average depth in this inundation is under 0.50 m[1/] and its duration is expected to be only some 5 days or so, and the damage to the paddy rice will be very small.

Drainage Canal In the terminal facilities, the canals will function for the dual-purpose, irrigation and drainage, but the canals dominating over 10 ha of the cultivated area shall be constructed exclusively for drainage. To lower the level of the ground water, the minimum depth of a canal shall be 1.0 m.

Polder Dike A polder dike shall be constructed at the inundated area between the Stung Chinit and Baray to prevent the inundation from the Great Lake, and grass lands of 3,470 ha there shall be converted to farm lands for perennial cropping. The increase of paddy production can be

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1/ Ref. 2-10-1 (d) Flood Control.

expected due to the comparatively high fertility of soil in this district, and yet the embankment of the polder dike can be utilized as a road running through the southern border of the project area, and the road will contribute to a regional development of the district.

The polder dike shall be 5.5 m in height, 31 km in length and the amount of earth for the embankment 2,231 x $10^3 m^3$.

<u>Pumping Station for Drainage</u> Pumping facilities to drain water within the polder dike are requested inevitably.

At present, the said area has a catchment area of 37,800 ha, and an intercepting drain designed along the national road can make a mountainous catchment area of 25,400 ha separated and them a designed catchment area can be reduced to 12,400 ha. A pumping station for drainage shall be provided with 4 propeller pumps with a 1,600 mm diameter, and its drainage capacity shall be 17.2 m^3/s with motor power of 1,050 kW.

In connection with the various structures mentioned above, on the basis of the plan of land improvement, the entire project area is divided into the following three divisions; they are an area of 15,350 ha (I division) on the left bank, shown in the Fig. II-1, and an area of 2,450 ha (II division) on the right bank, and both of the areas are irrigable by the diversion dam at Kg. Thma, and the other area of 7,600 ha (III division) by pumping at Kg. Thma.

Table II-7 General Standing on Each Division

King of Project	Unit	Division I	Division II	Division III	Total
Project Area	ha	15,350	2,450	7,600	25,400
Highest elevation	m	12.0	11.5	22.0	22.0
Water requirement	m^3/s	23.2	2.9	12.3	38.4
Water level of intake	m	12.25	12.25	23.8	
Diversion dam	set	1 (I & II)		-	1
Pumping station for irrigation	set	-	-	1	1
Canal for irrigation	km	136.80	26.95	124.95	288.70
Pumping station for drainage	set	1	-	-	1
Canal for drainage	km	78.5	-	81.6	160.1
Reclamation	ha	4,200	450	50	4,700

2-2-4. Construction Scheme

The construction shall be completed according to the staged development plan of the project. In the first stage, the diversion dam at Kg. Thma shall be completed and also the irrigation facilities (main canal 35.25 km, lateral canal 128.50 km, and 145 appurtenant structures) and the land consolidation for 17,800 ha shall be completed. These structures can make the rice production stabilized in division I & II by irrigation in the rainy season. In the dry season, the natural flow of the Stung Chinit and the stored water at the diversion dam can irrigate paddy fields for about 5,000 ha. In the second stage of the development, the main dam shall be constructed and the flood shall be controlled. And even in the dry season, the necessary irrigation water for the whole project area can be stored with those facilities.

In the second stage, the division (III) shall be provided with the pumping facilities (1,000 kw x 2, Q max. 12.3 m^3/s) and the irrigation facilities (main canal 31.05 km, lateral canal 93,90 km, 104 appurtenant structures) and the land consolidation for 7,600 ha shall be completed. And together with them, the drainage facilities (main canal for drainage 49.8 km, lateral canal for drainage 110.3 km, 120 appurtenant structures and a pumping station for drainage (Q = 17.2 m^3/s, 1,050 kw) and polder dike 31 km) shall be provided. With those constructions completed, the double cropping for the whole project area shall be available.

Regarding with the construction works, an annual working efficiency is supposed to become low by the meteorological conditions (during the rainy season, the main construction works can not be proceeded). To complete the construction within a designed period, the mechanization of the civil works is inevitable, requiring the earth-moving machinery such as bulldozers, tractor-shovels, dumptracks and mixers.

And also, the number of the skilled operators of those machinery can control the progress of the heavily equipped earth-moving works. The training of the operators of those machinery, therefore, is urgently required in Cambodia.

The construction materials are mainly cement, fine aggregate, coarse aggregate, iron bars, earth for embankments and the material for earth lining and so forth. The annual production of cement is Cambodia is approximately 50,000 ton, which will be totally home use. But a large quantity of the foreign-made cement shall be consumed in the works.

As for the coarse aggregate, Mt. Santok near the project area produces the good quality sandy rock, which can be used as the coarse aggregate. The fine aggregate must be carried from Kg. Cham as there is no suitable place to produce the material in the project area. Iron bars shall be imported from the foreign countries.

As a result of the soil test, the earth in the job site can be judged to have good quality for embankments and earth lining.

2-3. Power Development

2-3-1. Scope of Project

The project includes a hydro-power station with an installed capacity of 4,500 kW to be built together with the Stung Chinit main dam, a related transmission network and distribution lines, and substations. The power is distributed to the pumping stations for irrigation and drainage in the agricultural project, and for an individual domestic load at Kg. Thma, Baray, Tang Krasang and so forth.

2-3-2. Assumption on Power Demand

The number of households to be electrified becomes approximately 7,500 households of 10,000 in the project area. At an early stage of power generation at the end of June 1977, the classification of loads and the trend of power increase will be given as follows: (Table II-8)

The power station is to have two main generators, and its maximum power output should be 2,350 kW by one unit, 4,500 kW by two units.

The average annual power consumption for 50 years will be 21.7 GWh at generating end. The rate of transmission loss will be about 5% and the rate of distribution loss will amount to about 7%.

2-3-3. The Plan of Hydro-power Station

The reservoir has the effective capacity of 391 x $10^6 m^3$. The stored water will repeat itself in water level fluctuation every year in a cycle. The highest water level will be EL 31.2 m and the lowest EL 24.7 m.

Table II-8 Power Demand and Its Trend in kW

Item	Demand	1977 1st	1978 2nd	1979 3rd	1980 4th	1981 5th	1982 6th	Remarks
Agricultural Use	Irrigation Pump	500	800	1,100	1,400	1,700	2,000	Including a peak load of the drainage pumps
	Demand at Generating End	530	850	1,170	1,490	1,810	2,130	kW Loss: 6%
General Use	Domestic use	800	1,000	1,200	1,300	1,400	1,500	Lighting, etc.
	Public use	30	30	35	40	45	50	
	General Industrial use	150	180	210	250	300	350	Rice Mill, etc.
	Total	980	1,210	1,445	1,590	1,745	1,900	
	Demand at Generating End	1,140	1,400	1,680	1,850	2,020	2,210	kW Loss: 14%
Total Demand at Generating End		1,670	2,250	2,850	3,340	3,830	4,340	
Maximum Power Output		4,500	4,500	4,500	4,500	4,500	4,500	At Maximum Energy Head

Note: The adjustment of power demand and its supply in fluctuation of the available head shall be made with the ristriction for irrigation load at its peak and arrangement of the operation hours of the pumps.

If unexpected power demand would rise after the Stung Chinit power station starts its operation, it is recommendable for a diesel power station to be constructed for combined operation with hydro-power.

The maximum discharge for the hydro-power generation will be 17.75 m^3/s, and the maximum water discharge of the power station will be 35.5 m^3/s with 50% of the lowest daily load factor. The daily adjustment of discharge fluctuation by 50% of the load factor can be adversely controlled by the diversion dam for irrigation at Kg. Thma.

In case of the water discharge of 17.75 m^3/s and 35.5 m^3/s, the tailrace level at the power station is EL 14.1 m and 15.0 m respectively, and furthermore, the tailrace level for the 200 m^3/s1/ flood discharge will be about EL 19.3 m.

The hydro-power station shall be of an indoor type and a power house will be constructed at the downstream side of the main dam. An attached switch yard is to be of an outdoor type. An intake will be installed at the side of the spill-way gates, and an outlet will be connected with the downstream parts of the spill-way.

The maximum net head is computed from the highest water level of EL 31.2 m in the reservoir and the tailrace level of EL 14.1 m at one unit operation, and 16.3 m is obtained by the deduction of the loss head of 0.8 m in the water way from the maximum static head of 17.1 m. The maximum net head at two units operation is 15.4 m for the above mentioned conditions. Hydraulic turbines and generators are to be installed in two pairs each. The turbines are to have 2,500 kW of the maximum output and be of the horizontal shaft Kaplan type. The generators are to have 3,000 kVA of the rated output and be of the three phase A.C. horizontal shaft synchronous type. Both the turbines and generators shall be in the tubular type.

The maximum output of the hydro-power station shall be 4,500 kW, and 2,350 kW at the one unit operation.

1/ Flood discharge at 1% of exceeding probability, after flood control by the dam.

2-3-4. Transmission, Distribution line and Substation

Transmission and distribution lines shall be all in the aerial wiring system with three phases and three wires. The transmission lines between the power station and the drainage pump station shall be of 33 kV in 1 - circuit on concrete poles, and the distribution lines between the substations and each village be 15 kV on concrete poles. These lines shall be laid along the roads in the plains. Insulators shall be mainly used with the suspension type and partly supporting type.

The neutral point of the transmission lines of 33 kV is installed in the method of the Petersen coil grounding system and the 15 kV distribution lines in the non-grounding system. For thunder protection, the grounding wires shall be attached to the transmission and distribution lines.

As to distribution voltage for each load, the voltage to the motors of pumping for irrigation and drainage shall be in three phases of 6.3 kV and to the other loads shall be three phase of 380 V or single phase of 220 V. The low tension distribution line is to take the three phases four-wire system with 380/220 V and the neutral grounding point shall be in the direct grounding system.

Three receiving substations with 33 kV/15 kV for general distribution except for pumping shall be constructed, and two of them shall have an installed output of 1,500 kVA each and the other 500 kVA. The transformer with a capacity of 15 kV/$\frac{380\ V}{220\ V}$ for distribution shall be principally in a pole-mounted type. The substations for two pump stations shall have capacities of 3,000 kVA and 1,500 kVA respectively and those shall belong to their pumping stations. A communication system between the stations or plants relating to the power system takes use of a wireless telephone and a telephone with wire jointly.

2-3-5. Main Structures

As to the hydro-power station, a main house shall be constructed at the downstream side of the dam, and the intake shall be installed at the side of the spill-way of the dam and one main penstock shall lay from the intake and it shall be divided into two branches at the downstream point.

The main building is constructed with concrete structure, and at the bottom part of the building, there shall be installed the tubular type Kaplan turbines and the generators at the level. The gates shall be placed at the front and rear of the installations.

For installation of the main generators and other equipments, the movable overhead crane shall be equipped. EL 22.0 m shall be the level for carrying the machines and equipment into the power plant, and the open part of the structure shall not be set up below this level. The switch yard shall be of outdoor type, and main transformer, circuit breaker, other equipment and instruments shall be placed at the level 22.0 m.

The installation of power equipment shall be proceeded in keeping pace with construction of the main dam and installation of other structure and equipment.

2-4. Fishery Development

2-4-1. Plan of Fishery Development

Around the Stung Chinit basin, fishery becomes relatively active during the rainy season, so that protein source is secured for the people, whereas during the dry season they have to get fish protein from outsides.

In case of the inundation, the following measures are planned for meeting with the people's food demand.

There will be generally found a change of fishery at the upstream and the downstream of the dam after the dam construction. Namely, at the upstream, there will be a decrease of cat fish, snake head fish and the family with which the natives have been acquainted and on the contrary there will be an increase of carp, wild carp and the family which have been strange for the people around there at the downstream of the dam. Also at the downstream of the dam there will be found many fish migrating from the far downstream, but they are liable to be caught.

Thereby the counterplan of fishery development is stated below on each of the downstream and upstream divisions.

Counterplan in the Downstream Division

(1) Fish migrating up to the downstream are matured and they may spawn. Therefore, the catch of matured fish should be strictly forbidden, and it would be done by enforcing the existing laws.

(2) As for the tributaries joining the Stung Chinit at the downstream division, matured fish migrate up into them, in where the catch of fish is to be strictly prohibited.

(3) As the compensations for these prohibition, water canals shall be utilized for fishery (2-4-2).

Measure in the Upstream Division

Fish propagation in the stored water areas of the upstream is greatly subject to the condition of the areas.

That is to say, an artificial shallow lake with depth of average several meters will be a promising facility for fish propagation. However, an artificial lake of "V" type valley is not so much expected for fishery. Nevertheless, fishermen's life with the new lake will be richer than the before. Therefore, the following counterplan will be necessary at the upstream basin.

(1) All branches of trees in the prospected areas for fishing in the inundated lake shall be cut down. Boughs have to be left intact, so that they may be disassimilated by insects beforehand to be a source of the nutrition supply for fishes.

(2) Prospected species (Tilapia, common carp, etc.) shall be stocked and propagated in the river at first.

(3) Since there will be the most productivity for fishing in the reservoir for several years after the dam construction, much endevour for fishing shall be concentrated during the period.

(4) A preparation such as gill nets, fishing boats and other fishing tools shall be made for effective catching fishes.

(5) A consideration shall be paid to the effective collection of catches. For this, some roads shall be developed and carriers shall be prepared.

(6) Cold storage facilities, and salting facilities shall be set up in the catch collection center.

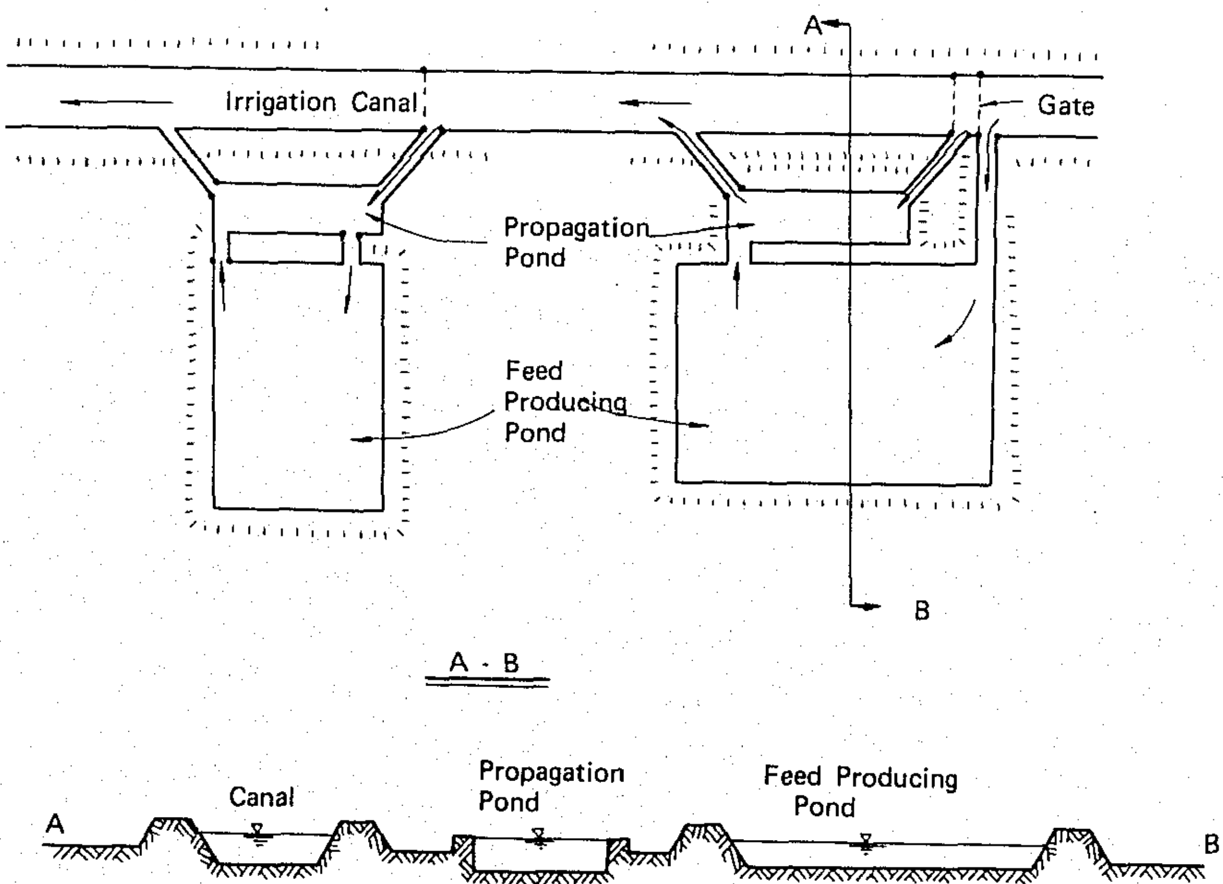
2-4-2. Counterplan for propagation

By the dam construction, catches of fishes as food will become lessen at least in the downstream division, and it is considered that this affects the village people's life. Following counterplans for this shall be made. It is hopeful that fish farm ponds shall be set up as shown in Fig. II-6 in optional parts of the canals, and that small species of fishes which are caught during the rainy season shall be propagated in those fish farm ponds.

A unit fish farm pond consists of 2 fields; the one is to breed the young esculent fishes which are caught in the river in the rainy season, and the other is to propagate small type fishes and micro-animals which are available as a bait for the young. Therefore, the people can supply fish protein for themselves all-around year.

The detail is shown in Fig. II-6 as a standard type, but it may well be deformed according to topography. Also ten fields are necessary at least according to a feeding method, water quantity, fish species and a fertilizing method. If possible, furthermore, these ponds with two divisions, are desirable to be set up in the upstream area and polder area as well.

Fig. II-6 Standard Fish Pond



Description

Structure:

Feed producing pond

It shall be as wide as possible.
Water level shall be the same as that of the canal.
Its depth shall be 1 m.

Propagation pond

Water level shall be at the middle point between the ground level and flooding water level of the canal.
The area shall be 25 m by 40 m. Its depth shall be 2 m.

Flooding Mouth

No.1; each flooding mouth shall be for propagation pond
No.2; one flooding mouth shall be for both ponds.

Overflow

A one way system from the feed producing pond to the propagation pond shall be taken essentially to prevent fishes from migrating.

Management:

Fish Seed

Esculent fish which is easily obtainable, such as snake head fish, cat fish and so forth.

Fertilization

The feed producing pond should be fertilized if necessary.
The days, and quantity are optional.

Management

The fish farm pond shall be managed by irrigation association.

2-5. Proposed Works - Others

2-5-1. Flood Control

It has been stated in Paragraph 1-4-5 that the Stung Chinit overflows sometimes into the rather wide areas. It is possible that these submerged areas are reduced by a flood regulation of the reservoir which is to be constructed at the upstream of the Stung Chinit. The areas which can be prevented from flood by the dam are shown in Table II-9.

Table II-9 Flood Prevention Area

Flood Level at Kg. Thma		Max. Discharge at Kg. Thma		Flooded area (Right Bank)					
				Downstream		Upstream		Total	
11.0^m	(10.25^m)	160 m³/sec	(105)	420 ha	(255)	-	(-)	420 ha	(255)
12.0	(10.9)	253	(150)	1,190	(390)	-	(-)	1,190	(390)
13.0	(11.95)	385	(245)	3,500	(1,050)	4,100 ha	(-)	7,600	(1,050)

The parentheses stand for the value after regulation of the water level.

In the above table the flooded areas are limited to the cultivated land of the right bank, and the areas divide into two parts, the upstream and the downstream of Kg. Thma. The flood to the left bank area covers over 10,000 ha, together with the inundation from the Great Lake and the flood is not prevented without poldering works. Therefore this area is excluded from the plan of the flood prevention by the dam.

As shown in the flood control study of Appendixes, the dam requires the flood regulation capacity of about 270 million m^3. As for this capacity the reservoir is, however, almost empty every June and July because of the discharge of the water mainly for irrigation. Therefore it is to ensure the capacity about 270 million m^3, so that it may not necessary to on purpose provide the excess regulating capacity over the high water level.

A peak flood of 590 m^3/s in return period of 10 years at Kg. Thma will be resulted in a discharge of 473 m^3/s at Kg. Thma by reducing 117 m^3/s at the main damsite of which catchment area is 91% of Kg. Thma.

Fig. II-7 shows the flood water level and flooded area before and after the flood regulation. A flood frequency is taken out of Fig. II-8 (showing the probability of all the peak level of the flood for the last 8 years), and the flood frequency multiplied by the flooded area (Fig. II-7) gives probable flooded area (Fig. II-8). Namely, under the present conditions, there are about 700 ha of the annually inundated farm lands, of which about 410 ha is found preventable from the inundation by means of flood regulation.

2-5-2. Navigation

(a) Navigation Use in Future

The Stung Chinit does not serve so much for navigation except lumber transportation, as stated in the Part I, 1-14. Most villages in the upperstream of the proposed damsite is to be submerged when the dam is constructed, and, therefore, it is presumed that the necessity of groceries and passenger transportation will decrease after the completion of the dam.

The lumber production shows a yearly increase, and it was 16,304 m^3 in 1968, which was 1.6 times as much as that of 1967. Though not yet decided in quantity, the plan of lumber product after 1970 has been made by the authorities.

The proposed lumbering sites under the control of Kg. Thma forest agency have shifted far and far yearly toward the interior, that is, they are moving into the Stung Sen and Mekong basin from the Stung Chinit basin. In 1968 the first transportation of lumber by means of a raft through the Stung Sen was made, and the quantity of the transported lumber amounted to 77% of the whole quantity transported during that year. In 1969,

Fig. II-7 Flooded Area, Before and After Flood Control

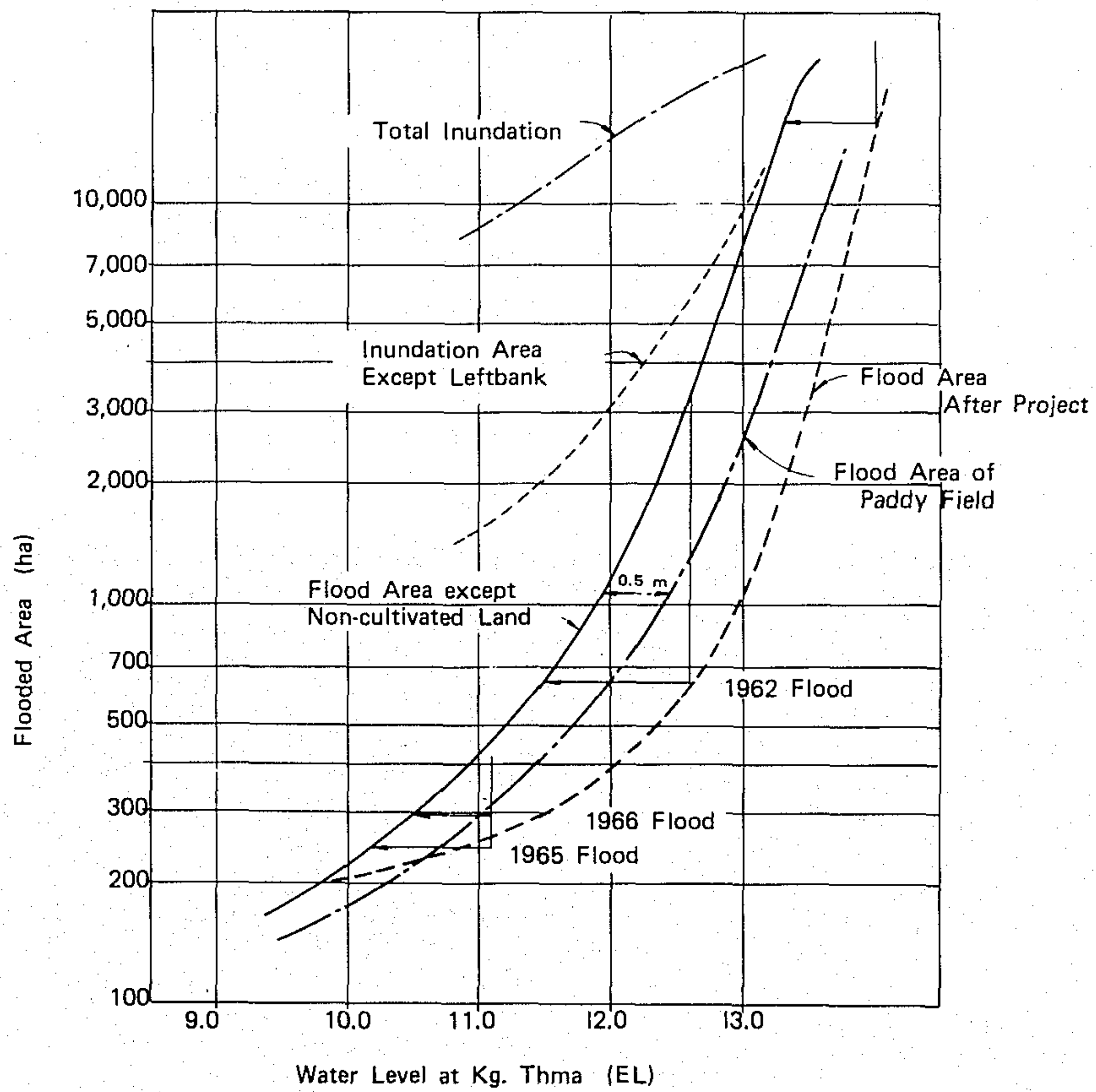
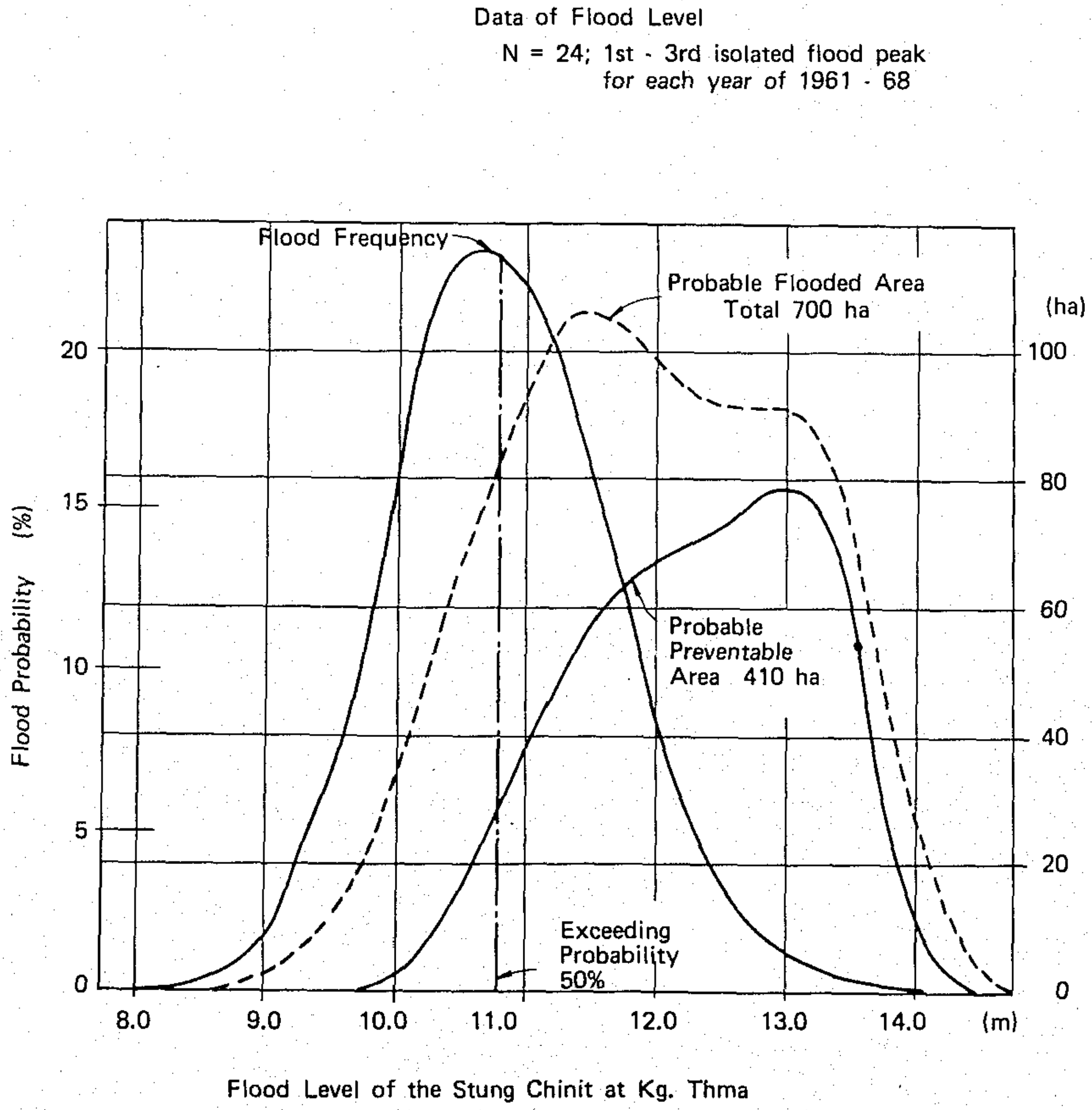


Fig. II-8 Flood Frequency and Probable Flood Area



besides the Stung Sen, the Mekong was used for lumber transportation.

The lumber product in the Stung Chinit basin no doubt will decrease sharply when the dam is completed.

(b) Navigation Facilities

Specific facilities for navigation are not planned in this project, since service for navigation of the Stung Chinit is not much as described in 2-5-2. (a).

2-6. Construction Cost

2-6-1. Assumption on Cost Estimate

Construction cost is described in U.S. dollars at the exchange rate of 55.5 Riel a dollar. The unit price and efficiency per unit work are fixed on the basis of those used by the Ministry of Public Works and Communications of Cambodia.

The project cost consists of an engineering cost, a net construction cost, and contingency. The engineering fee is reserved for definite design, supervision and so forth, and is estimated at the following rate to the net construction cost.

Agriculture	10%	Power	4%
Fishery	3%	Dam	12%

The contingency is also fixed at 10% of the net construction cost.

2-6-2. Cost Estimate

<u>Total Project Cost</u>

Total Cost of the Project; $\$26,220 \times 10^3$

Table II-10 Construction Cost

Unit: 10^3

Development purpose	Specific Cost	Cost of main dam 1/	Total Cost	Remarks
Agriculture	17,680	3,810	21,490	25,400 ha, $846/ha
Power generation	2,660	1,580	4,240	4,500 kW, ¢2.75/kWh 2/
Fishery	100 3/	120	220	
Flood control	-	270	270	
Total	20,440	5,780	26,220	F.E. 14,735 L.C. 11,485 equivalent 4/

Note: 1/ Cost allocation of main dam is conducted by the method of separable costs-remaining benefits for each purpose.

2/ Including distribution cost.

3/ Facilities for 3 nursery ponds and landing place in the reservoir.

4/ F.E.; Foreign Exchange
L.C.; Local Currency, $1 = 55.5 Riel

Construction Cost by Each Field

Agricultural Development; $17,680 x 10^3$

Table II-11 Agricultural Development Cost

Construction Works	Cost ($ 10^3)
Land Development	4,010
Irrigation Canal	3,450
Irrigation Pumping Station	1,170
Drainage Canal	1,940
Polder Dike	1,750
Drainage Pumping Station	1,140
Diversion Dam	1,155
Sub-total	14,615
Engineering Fee	1,460
Contingency	1,605
Sub-total	3,065
Total	17,680

Power Development Cost; $2,660 x 10^3

Table II-12 Power Development Cost

Construction Works	Cost ($ 10^3)
Installation Cost at Load Center	
Power House	185
Foundation Works	85
Penstock and Intake	100
Turbines & Generators	700 1/
Transmission Line (45 km)	290
Substation	150
Communication Facilities, etc.	45
Contingency (10%)	155
Sub-total	1,710
Distribution Cost	
Distribution Line, Concrete Poles, Wire, Foundation, etc.	590
Equipment, Poles, CB, etc.	245
Communication Facilities	30
Contingency (10%)	85
Sub-total	950
Total	2,660

1/ Including $50,000 for 700 kW diesel generator.

Fishery Development; $100 x 10^3

Table II-13 Fishery Development Cost

Construction Works	Cost ($ 10^3)
Fish Pond 1/	54
Fishery Facilities	34
Sub-total	88
Engineering Fee	3
Contingency	9
Sub-total	12
Total	100

1/ Total construction of the fish pond has a compensatory character, and total cost of $60 x 10^3 required for the construction, including the engineering fee and contingency, is eliminated from cost allocation.

Dam Construction; $\$5,780 \times 10^3$

Table II-14 Dam Construction Cost

Construction Works	Cost ($ 10^3)
Gravity Dam	
Concrete Dam Body	1,200
Foundation Works	990
Conduit	40
Gate	280 1/
Fill Dam	1,570
Sub-total	4,080
Access Road	330
Compensation	350
Sub-total	680
Engineering Fee	490
Contingency	530
Sub-total	1,020
Total	5,780

1/ Including $25,000 for 300 kW diesel generator.

2-7. Construction Schedule

Large-sized construction machinery is introduced into the project site with a view to shortening a construction period and having a successful result from the early completion. The adequate construction period will be 5 years until the 2nd stage completion of the project in consideration of an increase in working efficiency of introduced machinery and facilities. As mentioned in 2-2-3, agricultural development will be partially accomplished before the completion of the whole construction works. There are some instances that the farmland is increased by land reclamation, and intaking water at the diversion dam and so forth.

Prior to the execution of the planned construction works, design and preparation for the works will take 2 years in all. The emphasis are placed on the diversion dam construction, land reclamation of the proposed benefited area and improvement of irrigation-drainage system in the first 2 years of a 5-year construction period. Main dam will be completed in 3 years after the first 2 years. The construction of the power station is to be started at the forth year on the consideration of the construction progress of the main dam. Irrigation and drainage pumping station are to be executed in the forth or fifth year considering the completion time of the power station.

2-8. Organization and Management

2-8-1. Organization for Construction of Project

At present, Cambodia has a large scale organization of SNGB *(Société nationale des Grands Barrages)* for the development of water resources. The organization entrusted by the government will collect the construction funds offered by the various sources and take a supervisory role of the whole Stung Chinit multipurpose project, asking for assist of manpower from Ministry of Finance, Ministry of Plan, Ministry of Agriculture and Public Works, and *Banque Nationale du Cambodge*, to be an organization for the execution of the project.

2-8-2. Organization for Operation and Maintenance

After the completion of the project, it is inevitably required to form an organization for operation and maintenance of the main equipment and facilities in the project. The expected organization shall be a corporation headed by two superintendents; the one taking charge of irrigation and fisheries, and the other of hydro-power generation and flood control. The corporation shall consist of members for various purposes such as the dam operation and maintenance in the water supply to each field, the power station, the diversion dam, the pumping station, and the main canal.

The management of the corporation will have to be supported with the government subsidy in the beginning, but principally it must be done with the operation and maintenance cost of each section. The corporation shall be provided with the activity for collection of the water charge, electric charge and fisheries tax. Furthermore, the corporation shall have a committee joined by the representatives from the water and the power users as well, and all policies according to the decision at the committee shall aim at increasing the development benefits in this area.

On the other hand, a water user's association shall be organized by the beneficiaries farmers for their full development of irrigated agriculture. Another relative association shall control and maintain the lateral canals and further branches with the reasonable water charge to be collected from users.

2-9. Extension Base Farms and Agricultural Community Development Plan

2-9-1. Extension Base Farms

It is indispensable for a reliable increase of the project effect to extend new agricultural techniques to the farmers, prior to the implementation and completion of the Stung Chinit Project.

For this purpose, some farm-households' groups are to be designated to take part in the extension on their farms, where irrigation and drainage facilities are also built before the completion of the project. To utilize these irrigation facilities with careful guidance and to introduce new agricultural techniques will be naturally required, and the effects by realization of these plans will come out soon after the completion of the project.

Three or four farms are to be established, with areas totaling to approximately 250 ha. In order to make an effective direction, one farm will be worked together with about 30 farm-households. The extension farms operation will last for 7 years after the farm management starts.

Table II-15 Schedule of the Extension Base Farms

	Construction Works	Maintenance and operation
1st year	Detailed design for the extension base farms	
2nd year	Construction Works (1 spot)	
3rd year	Construction Works (2 spots)	Beginning of the operation of the extension farm (1 spot)
4th year	Construction works (1 spot)	Beginning of the operation of the extension farm (2 spots)
5th year		Beginning of the operation of the extension farm (1 spot)
6th year		Introduction of new technique
7th year		
8th year		
9th year		

It is necessary to introduce new agricultural techniques in conformity with the present agriculture in Cambodia so as to be accepted easily by the farmers. In this respect, it is desired to manage the farms by themselves, so that they may let the lay-farmers familiar with the farms.

Some problems on the extension of agricultural techniques are now studied in some development farms, and the results of those studies will be used for actual management of the farms. It will be effective in producing the successful fruits of the work to establish a small scaled experimental farm in the extension base farm, and settle some of agricultural machinery and equipments.

2-9-2. Agricultural Community Development Plan

There are many problems to be solved when the project is completed and the irrigation farms are implemented. Among them, the provision of finance for agricultural improvement will be urgently required.

For the solution of these problems, villages (khum) which set up the extension base farms will be appointed specially as model villages and expand an extension effect information up to the village-wide knowledge. At the same time, a special fund for high-quality seeds, fertilizer, agricultural chemicals, improved equipments and livestocks must be provided for the farmers. Further, a terminal irrigation facility and farm products facilities will be newly built.

A committee by representatives of the villages will be organized, and will engage in making a good operation of the farm with the help of the administrative and educational bodies.

This will surely give good effects on the local development in realization of the plan. Though much fund will be required for this, it is expected to extend this plan to the whole project area, as far as circumstances permit.

2-10. Estimated Benefit

2-10-1. Assumption on Benefit Estimate

(a) Agriculture

The farming program in each division has been already mentioned in 2-2-3 (b). The estimated benefit is, however, calculated on the basis of a double cropping system of paddy rice. In consideration of the breakdown of current unhulled rice price, the fact is that the benefit ratio of paddy rice production is, at present, lower than that of upland crops production. In the light of current field farming status unprevailing in this area, upland crops farming is not included in the farming program, which will be taken into consideration for forth-increasing demand of vegetables and fruits together with the progress of farmers' agricultural techniques in the near future. The species of paddy rice and the planting technique are based on current technical level of the farmers in the area. For the calculation of the estimated benefit, it is classified into 11 districts as well as in Table I-9.

The production of unhulled rice per ha is expected to change as Table II-16 after completion of the project, and the production cost of unhulled rice is estimated in Table II-17.

Table II-16 Estimated Increased Production

(t/ha)

Item / District		Present status		After completion of project		
		Seasonal rice	Floating rice	Rainy Seasonal rice	Dry Seasonal rice	Floating rice
A		0.9	1.0	2.7	3.1	1.9
B	B-1	1.0		3.0	3.3	
B	B-2	0.9		2.6	2.8	
C	C-1	0.9		2.7	3.0	
C	C-2	1.2		3.0	3.4	
C	C-3	1.1	1.1	2.8	3.3	
D	D-1	1.1		2.7	3.0	
D	D-2	1.0		2.8	3.1	
D	D-3	0.9		3.0	3.2	
E	E-1	-		3.0	3.2	
E	E-2	-		3.1	3.3	

Table II-17 Production Cost of Unhulled Rice

(Riel/ha)

	Present status		After completion of project		
	Seasonal rice	Floating rice	Rainy Seasonal rice	Dry Seasonal rice	Floating rice
Labors					
Cultivation	950	950	700	700	700
Operation	250	125	300	300	275
Harvest	375	375	700	800	525
Materials					
Seed	198	198	198	198	198
Fertilizer	-	-	1,650	2,355	700
Agricultural Chemicals	-	-	760	1,180	-
Others					
Transportation	100	100	250	300	150
Management	150	150	150	150	150
Tax	24	20	60	60	30
Total	2,047	1,918	4,768	6,043	2,728

Fertilizer and agricultural chemicals are indispensable for keeping the rice production stable. Table II-18 shows standard consumption of those materials.

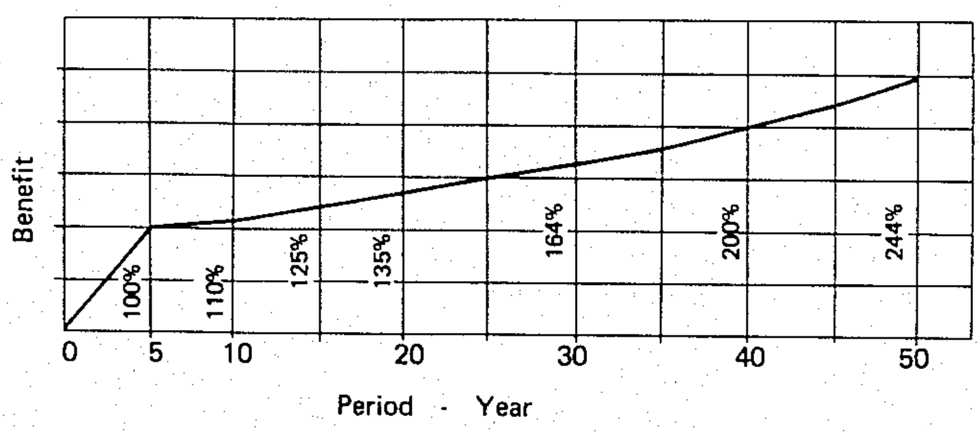
Table II-18 Standard Consumption of Fertilizer and Agricultural Chemicals

(kg/ha)

Kind of rice	Fertilizer Quantity			Agricultural Chemicals Quantity	
	N	P2O5	K2O	Gamardol	P.C.P.
Rainy Seasonal rice	60	60	30	40	20
Dry seasonal rice	90	90	30	70	20
Floating rice	30	30	-	-	-

With the actual function of the extension base farms in introducing new techniques to the farmers, full benefit will be received in 5 years after completion of the construction works. The farmers in the project area are found to have a desire to increase the income from their farm management, so that they may pave a way for a higher standard of life by the survey of farm-household. A consideration will be taken for further improvement of agricultural techniques, introduction of maize and other profitable upland crops and promotion of livestock-raising, which will lead to an increased income of the farmers. If the system of cooperatives is reorganized to rationalize the distribution function, the farmers will be able to enjoy further benefit from the cooperatives. Benefit from the completed project will be produced for the farmers in an unbelievable size. We estimate that the benefit will increase at an annual rate of 2 per cent at least.[1/] Fig. II-9 shows the increase of benefit.

Fig. II-9 Proposed Development of Benefit



1/ The input of fertilizer and high-quality seeds is supposed to increase at an annual rate of 2 per cent together with total output of crops. Rice production and its equivalent to other crops will amount to 3.1 t/ha x 2.44 = 7.6 t/ha after 50 years from trial result of Battambang. FAO reports the annual rate of 2.9 per cent increase according to "Indicative World Plan for Agricultural Development Asia and Far East", issued by FAO.

(b) Hydro-power

The benefit of hydro-power will be calculated in terms of a diesel-electric power by the same capacity of the expected diesel power plant as the hydro-power plant. In this respect, the following installation is assumed as equivalent to the hydro-power plant of 4,500 kW and 21,470 MWh of annual power delivery at the load center.

The diesel-electric plant consists of five sets of each 1,250 kW including one spare set, totaling 6,250 kW installation. In addition, the cost of substation, distribution networks, fuel and operation and management cost should be considered as well as the installation cost and its replacement cost.

The assumption of the useful lives of the facilities and present worth factors are as follows:

Power house	Useful life	50 years
Diesel-electric equipment	"	15 years
Substation and distribution equipment	"	25 years
Distribution line	"	35 years
Period of capitalization of fuel and O&M costs	"	50 years
Interest rate for present worth factors		6%

(c) Fishery

In order to make an assumption of fishery benefit after completion of the Stung Chinit Reservoir, two reservoirs have been chosen from representative reservoirs in Thailand; Ubolratana Reservoir and Phumipol Reservoir.

(i) Estimate of Fish Catches

According to the available data, procedure of an estimate for the fish catches is stated below.

Ubolratana Reservoir

Rable II-19 Annual Total and Monthly Average Fish Catches, 1966 - 1968

(Unit: Metric tons)

	1966	1967	1968	Average
Annual Total	479.7 1/	942.5	1,292.6	1,035.4
Monthly Average	80.8 1/	78.5	107.7	86.3

Inhabit depth of fishes is assumed to range from the water-surface to five meters below in the reservoir with the water surface area of 153 square kilometers of effective inhabit capacity.

Table II-20 Fish Catches per square kilometer

(Unit: ton/km^2)

	1966	1967	1968	Average
Annual Total	3.135	6.160	8.448	6.768
Monthly Average	0.523	0.513	0.704	0.564

(Area of effective inhabit capacity: 153 km^2)

Phumipol Reservoir

Table II-21 Annual Total and Monthly Average Fish Catches, 1963 - 1968

(Unit: Metric tons)

	1963	1964	1965	1966	1967	1968	Average
Annual Total	82.0 2/	546.2	998.4	753.5	614.0	742.9	713.4
Monthly Average	27.3 2/	45.5	83.2	61.3	51.2	61.9	59.5

1/ Data are not available from January to June in 1966. Therefore the average is calculated by using data from July to December.

2/ Data are not available from January to September. Therefore the average is computed by using data from October to December.

Table II-22 Fish Catches per square kilometer

(Unit: ton/km^2)

	1963	1964	1965	1966	1967	1968	Average
Annual Total	0.456	3.034	5.547	4.186	3.411	4.127	3.963
Monthly Average	0.152	0.253	0.462	0.341	0.284	0.344	0.330

(Area of effective inhabit capacity 1/: 180 km^2)

The area of inhabit capacity of the Stung Chinit Reservoir is assumed to be 40 km^2 in W.L. 26 m when this dam is designed as H.W.L. 31.2 m (Refer to 2-10-2 (c))

Thus, average fish catches of the Stung Chinit Reservoir per km^2 can be presumed to be 0.45 ton from the above 2 tables, Table II-20 and II-22.

(d) Flood Control

The effects of flood control are expressed in the prevention cost of damage to cropping, and to civil works such as roads, facilities in the rivers and houses. Since the flow velocity in the area is rather low, there is not found such damage that the flow washes facilities away. Also since the present local paddy is so tall that it is safe from the inundation in 50 cm depth even during August to September, the flooding season.

Then, the suffered areas are explained as an area flooded with water in excess of 50 cm in depth. (Fig. II-7 shows real suffered areas in the dot-and-dash line)

(i) Loss per hectare of paddy rice

The yield of paddy rice on the right bank of the Stung Chinit sometimes falls under 1 ton/ha on an average owing to flood damage as well as drought damage. The overflood lasting for several days will cause damages to the paddy rice in foot-stage or heading-sprout period and flowering by

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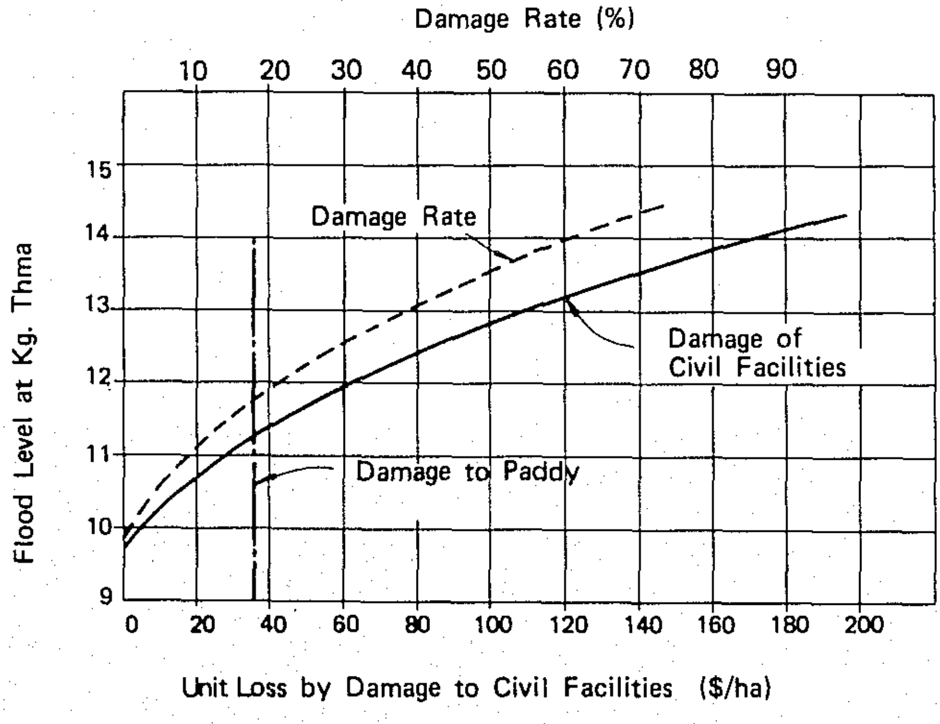
1/ The area of effective inhabit capacity is assumed as well as the previous case.

Fig. II-10 Loss by Damage to Civil Facilities



muddy water inundation, and yield of paddy rice decrease to 20% of the average year production. That is, 1.0 t/ha x 80% x 2,480 Riel/t = $35.7/ha is considered as the loss per hectare when flooding depth at paddy field is over 50 centimeters.

(ii) Loss per hectare of civil facilities

Each farmer along the Stung Chinit, where the land is annually inundated, has average 3 ha of paddy field, and owns his house of $540 worth ($180/ha). The farmers also have civil facilities,[1/] such as water control systems of river, and roads. They have to repair the damages of those facilities in a cooperative group works for about two weeks during the dry season.

The loss by damage to these facilities is estimated at about $280/ha. Also the damage rates of the civil facilities is estimated according to the flood level as shown in Fig. II-10.

2-10-2. Benefit Estimate

(a) Agriculture

(i) Price of Rice

One of the most important factors to assume benefit assumption in the Stung Chinit Project is to settle the price of rice. The present price of rice should be based on the "normal" export price or world marked one[2/], as Cambodia has been exportable country in rice.

The project area, however, does not fully attain self-sufficiency in rice, so the unit price is amended from $44.68 per metric ton to $50.00[3/] per metric ton considering the above circumstances.

The comparison between net revenues in two prices in the Stung Chinit Project and also the comparison of each net revenue (per hectare per annum) among other projects in Cambodia, are calculated in (ii) and (iii).

1/ Repair cost for these is equivalent to about 700 Riel/3 ha or about \$4/ha. It is estimated to be a facility of about \$100/ha worth when capitalized with an interest rate of 3% over 50 years of facilities' life.

2/ Price of Rice in Cambodia (1965) and Thailand (1967 - 68)

Table II-23 Rice Price of Cambodia (1965)

(Unit: Riel/100 kg)

1965	479 (86.31 \$/1,000 kg)
1966	...
1967	...
1968	...

Source: FAO, "Monthly Bulletin of Agricultural Economics and Statistics" September 1968

Table II-24 Rice Price of Thailand (1967 - 68)

(Unit: \$/1,000 kg)

White, 5-7% broken, government standard f.o.b. Bangkok

1967						1968						
July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July
86.0	84.0	90.0	90.0	86.0	92.0	94.5	101.0	98.0	90.0	86.0	83.2	...

Source: FAO, "Monthly Bulletin of Agricultural Economics and Statistics" September 1968

3/ As the price of paddy received farmers is \$44.68/ton and the export price of paddy is Riel 4,790/ton x 0.65 or \$56.10/ton, this price is taken as an intermediate one.

(ii) Present situation

Unit: US Dollars/ha
($1 = Riels 55.5)

Gross income	St. Chinit		Sambor	Prek Thnot	Battambang
Unit yield (t/ha)	0.99		1.08	0.75	1.50
Unit price ($/ton)	44.68	50.00	45.15	50.00	36.04
Total value ($)	44.23	49.50	48.76	37.50	54.06
Total outgo per ha					
Seed of paddy	3.57 (198)		3.59	1.80 (100)	3.60 (200)
Fertilizer				9.01 (500)	
Agricultural Chemicals					
Depreciation of farm implements	2.70		2.71	5.41	Neglected
Land Tax	0.43 (24)		0.63		
Labor expenses	30.18 (1,675)		24.34	21.62 (1,200)	Neglected
Sub-total	36.88 (2,047)		31.27	37.84 (2,100)	3.60 (200)
Net farm profit (or Capacity to pay) per ha	7.35	17.62	17.49	Δ0.34	50.46

Note: 1) Figures in the parentheses show the local currency of Riels.

2) All figures in Riels are converted to US$1 = Riels 55.5 in order to compare each values.

(iii) Situation with the project

Unit: US Dollars/ha
($1 = Riels 55.5)

Gross income (with 2nd crops)	St. Chinit		Sambor	Prek Thnot	Battambang
Unit yield (t/ha)	3.13		3.00	2.25	4.00
Unit price ($/ton)	44.68	50.00	45.15	50.00	36.04
Total value ($)	279.70	313.00	270.90	225.00	288.32
Total outgo per ha					
Seed of paddy	7.14 (396)		7.18	7.21 (400)	7.21 (400)
Fertilizer	72.16 (4,005)		73.84	19.82 (1,100)	
Agricultural chemicals	34.95 (1,940)		32.38	10.81 (600)	
Depreciation of farm implements	5.41 (300)		6.43	9.01 (500)	Neglected
Land tax	2.16 (120)		0.76		
Labor expenses	72.97 (4,050)		62.62	36.04 (2,000)	Neglected
Sub-total	194.79 (10,811)		183.21	82.88 (4,600)	7.21 (400)
Net farm profit (or Capacity to pay) per ha	84.91	118.21	87.69	142.12	281.11

Note: If labor expenses are estimated at $72.97 x 1/4 or $18.24 from a viewpoint of the opportunity cost on the condition that the other production costs are the same and unit price is $50.00/ton, net farm profit or capacity to pay per hectare will be $172.9. While, $118.21 is adopted for net farm profit in the project on the ground that Cambodia will be eventually placed in a developed situation within 50 years.

(iv) Benefits

Benefit assumption is made in this study for the price of unhulled rice, $50 per metric ton.

Present situation (without project)

Divisions	Cultivated area (ha)	Yields (ton)	Total prices (10^3 Riels)	Production costs (10^3 Riels)	Net farm benefits (10^3 Riels)
I	12,450	12,860	35,687	25,297	10,390
II	2,230	2,007	5,569	4,307	1,262
III	8,400	7,957	22,081	17,195	4,886
Total	23,080	22,824	63,337	46,799	16,538

Future situation (with project)

Divisions	Cultivated area (ha)	Yields (ton)	Total Prices (10^3 Riels)	Production costs (10^3 Riels)	Net farm benefits (10^3 Riels)
I	15,350	88,112	244,511	147,384	97,127
II	2,450	9,917	27,520	16,652	10,868
III	7,600	42,751	118,634	72,978	45,656
Total	25,400	140,780	390,665	237,014	153,651

(v) Benefits Estimate from Agriculture

Division	Area (ha)	Total increased net benefits (10^3 Riels)	Net increased benefit per ha (Riels)	($)
I	15,350	86,737	5,651	102
II	2,450	9,606	3,921	71
III	7,600	40,770	5,364	97
Total	25,400	137,113	Mean 5,400	97.3

(b) Hydro-electric power

The benefit of hydro-electric power, in terms of the diesel-electric power, is estimated according to the assumption stated in 2-10-1 (b). The results are shown in Table II-25.

Table II-25 Cost of Diesel-electric Power (Equivalent Benefit of Hydro-power)

Items	Cost Capitalized	Annual Cost	Cost/kWh
Installation	$1,310,000	$ 83,000	for 21,470 MWh per year at load center
Replacement	680,000	43,100	
O & M	1,030,000	65,500	
Fuel	2,430,000	154,600	
Total	$5,450,000	$346,200	¢1.61/kWh
Distribution	950,000	60,200	for 8,050 MWh per year at distributed side
Replacement	140,000	9,000	
O & M	670,000	42,800	
Total	$1,760,000	$112,000	¢1.39/kWh
Grand Total	$7,210,000	$458,200	¢3.00/kWh

(c) Fishery

The area of effective inhabit capacity is assumed to be 40 km^2 at a mean water level of EL 26 m, while the dam is designed at a high water level of EL 31.2 m.

From the study in 2-10-1, (c), the fish catches per km^2 is appropriated to be 0.45 ton per month as a conservative estimate. Benefit is assumed to be 3 Riel/kg,[1/] thus total net profit will be,

0.45 t/km^2 x 40 km^2 x 12 months = 216 t/annum

216 t x 3,000 Riel = 648,000 Riel/annum

= $11,676

1/ Reference is made to Dr. John. E. Bardach, "Report on Fisheries in Cambodia", P.42.

(d) Flood Control

Annual probable damage to farm land covers 700 ha, of which 410 ha is prevented from flood (2-5-1). Also, annual probable damage to civil facilities is equivalent to 396 ha of farm lands, of which 188 ha is prevented in the same way as stated in 2-5-1.

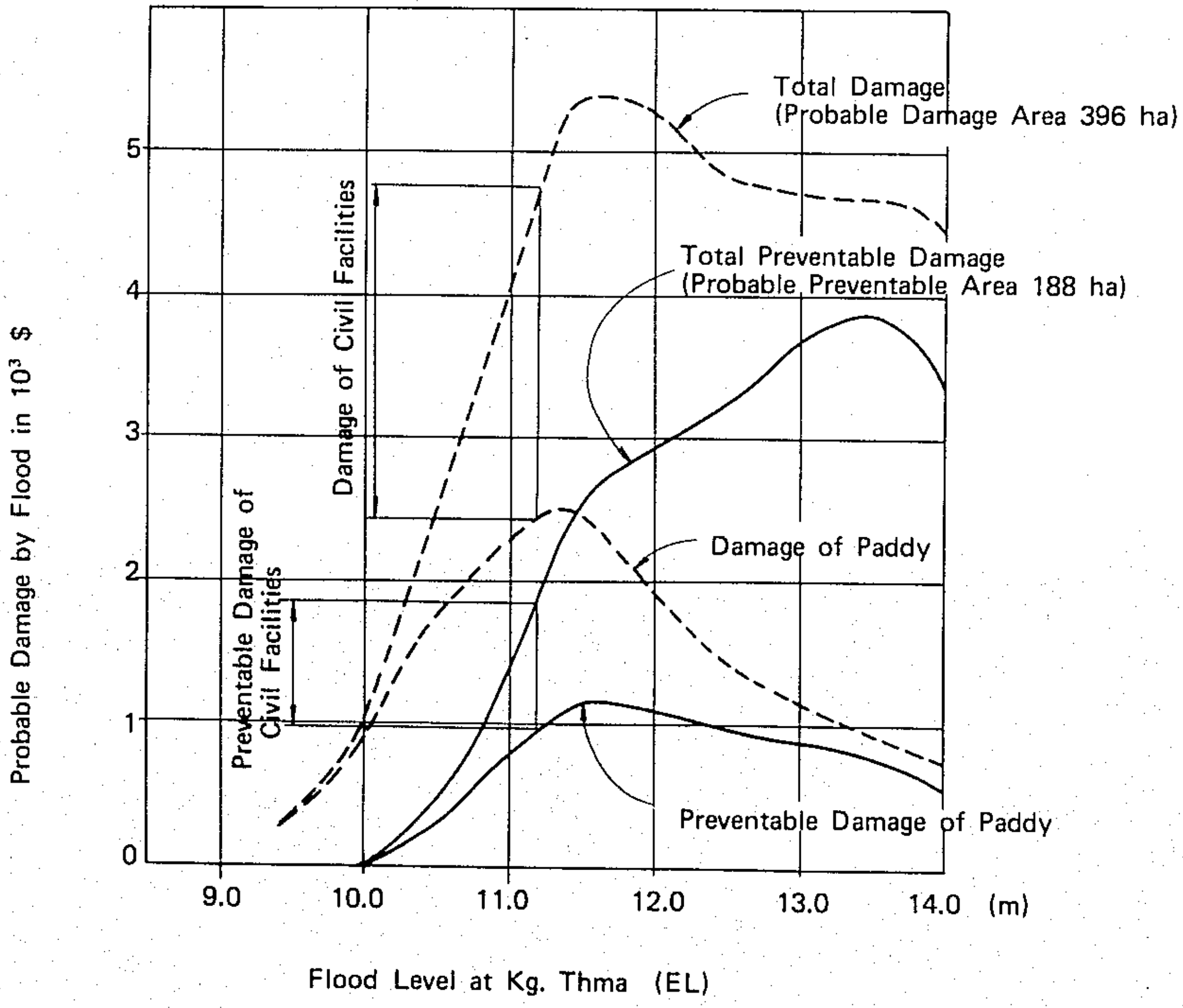
Thus, probable loss by damage is obtained in Fig. II-11 by multiplying the damaged area by the unit loss. Annual loss by damage is also obtained in Table II-26 by summing up the loss of Fig. II-11.

Table II-26 Annual Damaged and Preventive Loss

	Paddy	Civil facilities	Total
Before flood regulation (Damaged cost)	$13,730	$23,590	$37,320
After flood regulation (Prevented damaged cost)	$ 6,700	$14,930	$21,630

Approximate 58% of loss by flood damage is prevented by the proposed works. Moreover, the annual prevented cost is capitalized with the period of 50 years and at 6% interest rate. The total is computed to $560,000.

Fig. II-11 Probable Damage, Before and After Flood Control



PART III

ECONOMIC JUSTIFICATION AND FINANCIAL PROGRAM

PART III ECONOMIC JUSTIFICATION AND FINANCIAL PROGRAM

3-1. Economic Justification

3-1-1. Introduction

This part deals with the economic justification and financial program of the project.

To make economic evaluation of the project, benefit-cost analysis and internal rate of return are used. In evaluating the project from the economic viewpoint, indirect benefits are not taken into account, because the project feasibility has been estimated on a conservative basis.

3-1-2. Assumption and Methods of Economic Evaluations

The method of economic evaluations is based on the publication of 'Benefit-cost evaluations as applied to AID financed water or related land use projects' issued by U.S.A.I.D., dated May 31, 1963. The method is summarized by a calculation formula shown below:

$$C + O \& M \times \sum_{1}^{n} \frac{1}{(1+i)^n} \leqq B \times \sum_{k}^{n} \frac{1}{(1+i)^n} \quad \text{----------} \quad (1)$$

Where,

C	:	Installation cost including interest during construction
O & M	:	Annual operation and maintenance cost assumed as a constant value
B	:	Annual target benefit
i	:	Interest rate
n	:	Period for economic analysis
k	:	Complete lag years in accrual of benefit

On the basis of the formula (1), assumption of the factors, and definition of the terms necessary for economic justification are explained.

(a) Period of Analysis

The period of analysis shall encompass that period of time over which the project will usefully serve its intended purpose. In any case, this period should not exceed 50 years[1/] considering the next item: useful lives.

(b) Useful Lives (in years)

The typical (example of) useful lives are shown as follows:

Dam earth or concrete	50 Yrs
Dike and road	50
Canal and ditch	50
Pumps (large)	25
Pipe, reinforced concrete	50
Diesel generators	15
Hydraulic turbines and generators	35
Power plant structures	50
Transmission line	50
Substation	25

1/ Seeing from the standpoint of actual calculation of amortization, there is no actual difference between the capital recovery factors in case of $n = 50$ years and 100 years (difference is about 5% when $i = 6\%$), so it is meaningless even if the period were set over 50 years.

(c) Interest Rate

Interest rates to amortize the installation costs and to discount the benefits are adopted as appropriate for each section as follows:

Irrigation	i = 3%
Power	i = 6%
Flood prevention	i = 3%
Fishery	i = 3%

Benefit-cost ratio and Internal rate of return are calculated in the ratio of the right side to the left of the formula (1) and in the division of the value 'i' in the form of an equality of the formula (1), respectively.

(d) Discounting

The right side of the formula (1) expresses a general form of visible benefits, which should be devaluated according to the target diagram of prospective benefit (2-10).

As to elements whose useful lives are less than 50 years, such as pumps, generators and so forth, the estimated replacement cost must be discounted to the present time by adding the following calculation value to the left side of the formula (1).

$$C' \times \left[\frac{1}{(1+i)^m} + \frac{1}{(i+i)^{2m}} + \cdots\cdots\cdots \right]$$

Where, C' : Replacement cost

m : Useful life in years

$m, 2m \ldots < n = 50$ years

(e) Annual Benefit and Annual Cost

Each value of annual benefit and annual cost is calculated in the division of the both sides of the formula (1) by a uniform series-present worth factor $[\sum_{1}^{n} \frac{1}{(1+i)^n}]$. 1/ In comparison of annual benefit with annual cost, an indication of Annual Values per hectare is used for convenience.

(f) Cost Allocation

The multipurpose dam construction of Phnom Takho will produce benefit in each field of irrigation, power, flood control and fishery. Therefore, the joint costs for the dam construction should be allocated to each field, the allocation method of which is based upon the separable costs-remaining benefits method as explained below.

Take the benefit or alternate cost to the right side of the formula (1) and add the separable cost to the left of the formula, and distribute the joint costs to each field in proportion as the remaining benefits.

For this computation, the interest rates of 3-1-2(c) are adopted. After the computation, the allocated dam cost added to the specific cost gives the total cost - including capitalized O & M costs, so that the rate of the benefit with the total cost is regarded as the benefit-cost ratio.

(g) Internal Rate of Return

The annual values are calculated for every 1% increment of the interest plotted on a graph for the I.R.R. as the cross point of two curves showing annual benefit and cost.

1/ These are equal to what is obtained by multiplying the capital recovery factor.

3-1-3. Cost Allocation

The Separable Cost-Remaining Benefit Method of cost allocation is adopted for the case of the Stung Chinit multipurpose project. The Phnom Takho main dam serves Irrigation, Power, Flood control and Fishery with water supply or control in order to produce the benefits[1/] for each purpose. In this way, the cost of multipurpose dam is equitably distributed among the purposes served.

Briefly, the procedure provides for assigning to each purpose (1) its separable cost, i.e., the added cost including the purpose in the project, and (2) a share of the remaining or residual joint cost in proportion to the remaining benefits, i.e., the benefits (as limited by alternate cost) less the separable cost.

The followings are a definition of terms and their use in the computation sheet of cost allocation.

a. Benefit: Total benefit for 50 yrs. in present worth discounted by interest rate of 3% for Irrigation, Flood control and Fishery, and 6% for Power.

b. Alternate Cost: The lowest cost for achieving the same benefit or equivalent in exclusive purpose structures, and that consists of specific cost and alternate dam cost.

c. Specific Cost: The cost of facilities that exclusively serve one project purpose.

e. Separable Cost: The difference between the multipurpose dam cost and the dam cost with that purpose omitted. The cost to be allotted for each purpose out of the total multipurpose dam cost.

1/ As for the benefits and specific costs for each purpose, refer to 2-7, 2-8 and 2-10.

f. Remaining Benefit: Benefit limited by alternate cost (lesser of a and b) less c and d.

g. Joint Cost: Multipurpose dam cost less Σe. The joint cost is allocated to each purpose in proportion to each f.

h. Total Allocated Dam Costs: e plus allocated joint cost.

i. Total Project Cost: c plus h.

The next equation will show the foundation of the allocation method for each purpose project.

$$\begin{bmatrix}\text{Specific Cost} \\ \text{and Its} \\ \text{O\&M Costs}^{1/}\end{bmatrix} + \begin{bmatrix}\text{Separable Cost} \\ \text{and Its} \\ \text{O\&M Costs}^{1/}\end{bmatrix} + \begin{bmatrix}\text{Allocated Joint} \\ \text{Cost and Its} \\ \text{O\&M Costs}^{1/}\end{bmatrix} \leq \begin{bmatrix}\text{Benefit} \\ \text{or Alter-} \\ \text{nate Cost}\end{bmatrix}$$

The allocation of $5.78 millions of the dam construction cost results in Table III-1.

The result of the cost allocation shows that the total cost including O & M costs does not exceed each of capitalized benefits, so that the share of such dam costs would be feasible.

3-1-4. Annual Cost and Annual Benefit

(a) Annual Cost

Annual costs for each sector are calculated on the methods stated in 3-1-2 (e) and shown below in Table III-2. Namely, operation and maintenance costs, replacement to be required during the periods of analysis, and amortization of investment costs are discounted at the present worth over 50 years of the project life at the interest rates described under 3-1-2 (c).

1/ Capitalized for 50 yrs. with an interest.

Table III-1 Cost Allocation of Multipurpose Dam

in million US$

		Irrigation (i=3%)	Power (i=6%)	Flood control (i=3%)	Fishery (i=3%)	Total
a.	Benefits	91.40	7.21	0.56	0.30	99.47
b.	Alternate Costs	35.75	10.38	6.69	5.22	58.04
	Installation	22.94	7.49	4.83	3.77	39.03
	O & M	12.81	2.89	1.86	1.45	19.01
c.	Specific Costs	28.46	4.41	-	0.05	32.92
	Installation	17.68	2.66	-	0.04	20.38
	O & M	10.78	1.75	-	0.01	12.54
d.	Lesser of a and b	35.75	7.21	0.56	0.30	43.82
e.	Separable Costs	0.59	0.64	0	0	1.23
	Installation	0.48	0.52	0	0	1.00
	O & M	0.11	0.12	0	0	0.23
f.	Remaining Benefit (d - c - e)	6.81 (69.6%)	2.16 (22.1%)	0.56 (5.7%)	0.25 (2.6%)	9.78 (100%)
g.	Allocated Joint Costs	4.12	1.31	0.33	0.15	5.91
	Installation	3.33	1.06	0.27	0.12	4.78
	O & M	0.79	0.25	0.06	0.03	1.13
h.	Total Allocated Dam Cost	4.71 (66.0%)	1.95 (27.3%)	0.33 (4.6%)	0.15 (2.1%)	7.14 (100%)
	Installation	3.81	1.58	0.27	0.12	5.78
	O & M	0.90	0.37	0.06	0.03	1.36
i.	Total Project Cost	33.17	6.36	0.33	0.20	40.06
	Installation	21.49	4.24	0.27	0.16	26.16
	O & M	11.68	2.12	0.06	0.04	13.90
j.	Benefit-Cost Ratio a/i	2.76	1.13	1.70	1.50	2.48

Note: (1) Besides, there is found the cost $60,000 for three pilot fish farm ponds as the fishery compensation in the downstream of the river. But it is not for the allocation.

(2) The capitalized benefit of power genration is regarded as the cost of alternative diesel power, which is ¢3.00/kWh including distribution cost.

Table III-2 Annual Costs

(Unit $ 10^3)

	Irrigation 25.400 ha	Power 21,470 MWh 2/	Fishery	Flood control	Total
O & M Costs					
Specific Facilities	398.80	94.10	1.50 3/	-	494.40
Dam 1/	57.20	23.50	1.80	4.05	86.55
Amortization Costs	(i=3%)	(i=6%)	(i=3%)	(i=3%)	
Specific Facilities	738.80	168.60	3.89	-	911.29
Dam	159.20	100.20	4.66	10.50	274.56
Replacement	20.40	17.70	-	-	38.10
Total	1,374.40	404.10 4/	11.85	14.55	1,804.9
	54.1 $/ha	¢2.75/kWh 4/			

1/ 1.5 % x Allocated dam cost

2/ At load center

3/ Total cost $100,000 x 1.5%

4/ Consisted of ¢1.36/kWh of power cost at load center and ¢1.39/kWh of distribution cost.

(b) Annual Benefits

(i) Irrigation

Annual mean benefit of the irrigation sector, treated for analysis period of 50 yrs. with various interest rate, is shown in Table III-3.

Table III-3 Annual Benefit (present worth) of Irrigation

in US$/ha

Interest rate \ Divisions	I	II	III	Total	Capitalized benefit 1/
i=0%					
at 5th year	102	71	97	97.3	
at 50th year	249	173	236	237	
i=3%	146.7	102.1	139.5	140	$91.4 million
i=4%	139.1	96.8	132.3	133	$72.4 million
i=5%	132.1	92.0	125.7	126	$58.5 million
i=6%	125.9	87.6	119.7	120	$48.0 million
i=7%	120.3	83.7	114.4	115	$40.2 million
i=8%	115.3	80.2	109.6	110	$34.2 million
i=10%	106.8	74.3	101.6	102	$25.6 million

1/ Capitalized annual benefit for 50 yrs. with an interest rate, after multiplying the total irrigation area 25,400 ha.

(ii) Hydro-electric Power

As mentioned in Table II-25, the annual benefit of hydro-power (equivalent cost of the alternate diesel-electric power) is;

$346,200 or ¢1.61/kWh at load center,

$112,000 or ¢1.39/kWh at distributed side

$458,200 or ¢3.00/kWh in total

Whereas analysis period of 50 yrs. with 6% interest rate is assumed.

(iii) Flood Control

As described in 2-10-2 (d), the annual benefit gained from the flood control is $21,630, and capitalized it for 50 yrs at 3% interest rate is $560,000.

(iv) Fishery

As described in 2-10-2(c), the annual benefit expected from the fishery section is $11,676, and capitalized it for 50 yrs at 3% interest rate is $300,000.

3-1-5. Economic Evaluation for Each Sector

(a) Agriculture

The economic evaluation for each sector is made by the internal rate of return method as an index, and the result is graphed in Fig. III-1.

i) I.R.R. = 8.6% for the whole area of 25,400 ha.

ii) I.R.R. = 10.8% for the area of 2,450 ha at the downstream of the right bank of the St. Chinit. (Division II)

iii) I.R.R. = 8.5% for the area of 22,950 ha at the left bank of the St. Chinit. (Division I and III)

Though both the investment and benefit per hectare of Division II are lower than those of the other divisions, the comparatively high I.R.R. is obtained, being blessed with topography and soil conditions. The floating rice can not entirely be cultivated in this area, because the inundation is still inevitable. However, the low investment but comparatively high benefit may be one of the promising methods for the agricultural development of this kind.

As Division I and III are included rather high investment costs such as polder dike with drainage pumps and an introduction of irrigation pumps, their O&M costs are also high. In this respect, the I.R.R. 8.5% can not be regarded as high value, but such investment cost is necessary yet in order to raise significantly the agricultural productivity. On the other hand, the investment of poldering, pumping and so forth may strengthen the infrastructure with a far reaching influence. Such being the case, the I.R.R. of Division I & III could reasonably be understood.

Furthermore, the benefit estimate of irrigation was conservatively made merely upon the paddy farming under the current rice price. In future, when the introduction of some of upland crops, the development of the market and raise of the market price of crop would be prospected, it may be safely said that the I.R.R. would raise up and the project be more feasible.

(b) Effect of Stage Development of Agriculture

It is possible to get an earlier benefit by means of completing the diversion dam and irrigation canals from Kg. Thma prior to completion of the main dam in the first two years of the total five years of the construction period as stated in 2-2-3(a).

Namely, 2,450 ha in the right bank (Division II) and 12,350 ha on the left Bank (excluding the current inundated area to occupy a half of Division I), 14,800 ha in all are possible to be irrigated during the rainy season from the 3rd year according to Table III-4.

As to the dry seasonal irrigation, the irrigable area, judging from the droughty water discharge of the Stung Chinit, is limited to about 5,000 ha until the 2nd stage construction is accomplished. At the beginning of the 1st year of the 2nd stage, irrigation is to be started covering 80 percent of 5,000 ha as many as the other areas.

The portion A in Table III-4, as stated in 2-10-1(a), represents a form of the benefit increase which has been used in the economic evaluation of this part, and the portion B is the benefit of the first stage which will be added by adopting the stage development. This kind of development policy will be considered reasonable from the extension effects that the agricultural extension farms are to be set up in two years before the first stage starts i.e., 7th year. Namely the benefit attainment in the extension farms is prospected 50 percent in the 4th year and 100 percent in the 1st year.

The benefit in Table III-4 was computed on the basis of the target benefit in 5th year, as stated in 2-10-2, using a parameter of "Irrigation area x Rate of attaining benefit".

The additional benefit of the first stage (Portion B) is about $2.9 millions, i.e., $2.8 millions at the present worth of 0 point, with 3% interest rate. Judging from the whole, this is 4.1% of the benefit of portion A which is equivalent to $91.4 millions at the present worth, with 3% of interest and 50 years.

Namely the schedule of the execution of the first stage will be realized for a rather large merit because it will raise the benefit-cost ratio by 4%.

From the financial point of view, the first stage would only be provided with the finance and the following stage would not be supplied. Then, can the first stage be feasible as an independent project? The study of this problem was resulted in the following. If the benefit would trace the same form[1/] stated in Fig. II-9, the target benefit attained at the 5th year will be $798,000 or $53.9 per hectare and the cost be $8.1 millions[2/] or $547 per hectare. Benefit-cost ratio 2.63 is obtained by the factors of 3% interest rate and 50 years periods of analysis. This ratio is somewhat higher than that (2.06) of the whole irrigation project. Therefore, it may be safely said that this first stage of the development will be independently feasible too.

1/ The target benefit will be attained at the 5th year and raised at the compound rate of 2% per annum after the 5th year.

2/ The costs of the component of the land development, irrigation canal and drainage canal in this district, 14,800 ha was extracted from the costs breakdown presented in Table 4 construction schedule.

Fig. III-1 Internal Rate of Return

I:	Leftbank of the Stung Chinit	(15,350 ha)
II:	Rightbank of the Stung Chinit	(2,450 ha)
III:	Pumping Irrigation Area	(7,600 ha)
	Total	25,400 ha

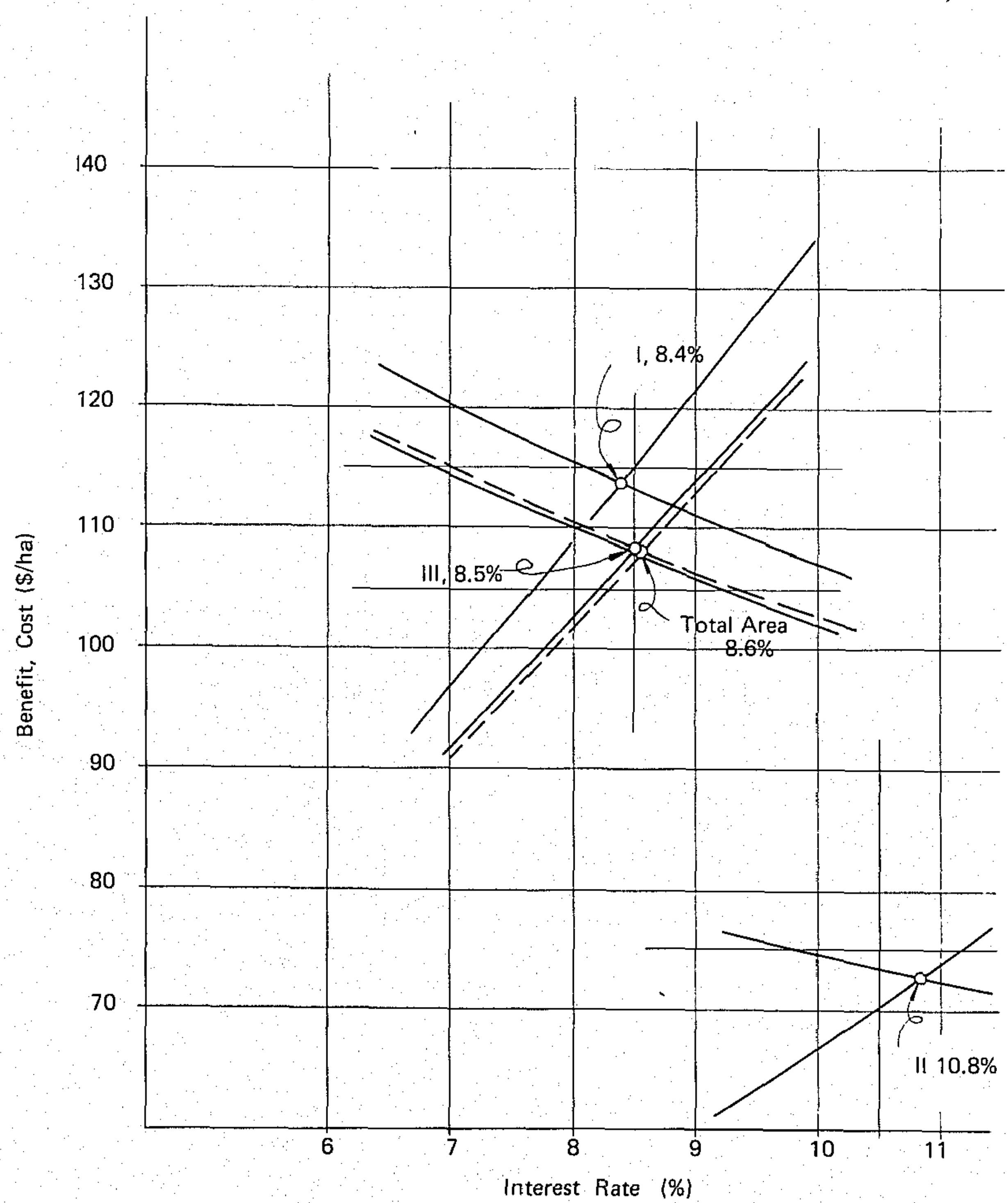
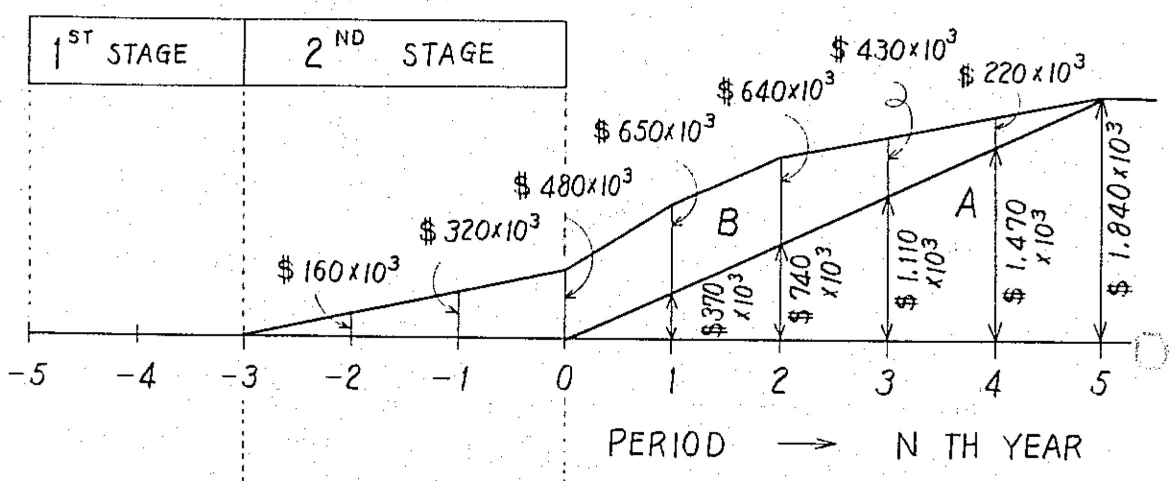


Table III-4 Benefit from the First Stage Development



1st Stage								
Irrigation Area	(10³ ha)							
Rainy Season	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8
Dry Season	5.0	5.0	5.0	11.8	11.8	11.8	11.8	11.8
Rate of Benefit	0.2	0.4	0.6	0.8	1.0	1.0	1.0	1.0
2nd Stage								
Irrigation Area	(10³ ha)							
Rainy Season	-	-	-	10.6	10.6	10.6	10.6	10.6
Dry Season	-	-	-	8.5	8.5	8.5	8.5	8.5
Rate of Benefit	-	-	-	0.2	0.4	0.6	0.8	1.0

(c) Hydro-power

As stated in Table III-2 Annual Costs, the actual power cost becomes ¢1.36/kWh in case of being computed at 6% interest rate and the period of 50 years. This is about a half of the present power cost[1/], and cheaper than the best alternate cost of ¢1.61/kWh which is computed on the utilization of an up-to-date diesel power plant. Therefore the hydro-electric power is considered feasible enough for the general demand.

(d) Flood Control

As stated in 2-6 other Proposed works that the dam cost allocated to flood control and its O&M costs are $330,000 in total against the capitalized benefit cost, $560,000, it is considered feasible.

The dam for irrigation is almost empty around the beginning of the rainy season, so that it functions favorably in controlling the flood.

Such proper dam operation should be evaluated meaningfully in view of economy of the project.

(e) Fishery

As stated hereinbefore, it is expected to breed fish fauna by means of constructing reservoirs. The benefit is to be $300,000 and the dam cost allocated to the fishery is $200,000, so that it is considered feasible. However, for the due period, the Fishery Agency should aid in financing the allocated cost, although this cost shall be collected as a tax in the future.

3/ The cost of the existing Phnom Penh Thermal Power Plant is 1.531 Riels/kWh. (See the preceding page.)

3-2. Financial Program

3-2-1. Required Fund

The capital investment cost for construction works of the Stung Chinit Project is estimated at \$26,220 thousand excluding interest during construction period. The breakdown of the capital investment cost is \$21,490 thousand for agriculture, \$4,240 thousand for power, \$270 thousand for flood control and \$220 thousand for fishery. (Refer to 3-1-3 Cost Allocation and Table III-5).

Table III-5 Project Cost

Unit: \$$10^3$

	Foreign Exchange		Local Currency		Total
Agriculture	11,170		10,320		21,490
Power	3,240		1,000		4,240
Fishery	140	3,565	80	1,165	220
Flood Control	185		85		270
Total	14,735		11,485		26,220

3-2-2. Sources of Fund

The fund is divided into two components, one of which is a soft-terms loan of foreign exchange, the other is the Khmer Republic Government-financed local currency. The foreign exchange and the local currency will amount to \$15,786 thousand and \$12,790 thousand respectively, totalling \$28,576 thousand for the capital investment cost. In each amount the interest during construction period of the project is included.

Table III-6 Interest During Construction[1]

Unit: $\$10^3$

I. Foreign Exchange	Agriculture	I/C[2]	0.5 x 5 x 8,510 x 0.03 =	638	
		A/C/D[3]	0.5 x 3 x 2,660 x 0.05 =	200	
	Power	I/C	0.5 x 2 x 2,130 x 0.05 =	107	213
		A/C/D	0.5 x 3 x 1,110 x 0.05 =	83	
	Fishery	I/C	0.5 x 2 x 55 x 0.05 =	3	
		A/C/D	0.5 x 3 x 85 x 0.05 =	6	
	Flood Control	A/C/D	0.5 x 3 x 185 x 0.05 =	14	
			Subtotal 14,735	1,051	
II. Local Currency	Agriculture	I/C	0.5 x 5 x 9,170 x 0.05 =	1,146	
		A/C/D	0.5 x 3 x 1,150 x 0.05 =	86	
	Power	I/C	0.5 x 2 x 530 x 0.05 =	27	73
		A/C/D	0.5 x 3 x 470 x 0.05 =	35	
	Fishery	I/C	0.5 x 2 x 45 x 0.05 =	2	
		A/C/D	0.5 x 3 x 35 x 0.05 =	3	
	Flood Control	A/C/D	0.5 x 3 x 85 x 0.05 =	6	
			Subtotal 11,485	1,305	
III. Total Interest During Construction				2,356	

1/ An acceptable method of computing interest during construction is as follows;

0.5 x (construction periods in years) x (interest rate)

2/ Installation Cost

3/ Allocated Cost for Dam

3-2-3. Interest and Repayment Term

The agricultural yield will increase in parallel with the introduction and promotion of agricultural knowledge and techniques in the agricultural development, but fairly long period is required until the anticipated yield will be realized. Accordingly, the fund of the Stung Chinit Project should be provided with a long-term finance at low interest.

Table III-7 Interest Rate and Repayment Term

	Repayment Term	Interest rate per annum	Grace periods
I. Foreign Exchange (No interest will be assessed during the grace periods).			
Agriculture	30 yrs	3 %	5 yrs
Power, Dam Fishery & Flood Control	30 yrs	5 %	3 yrs
II. Local Currency (No interest will be assessed during the grace periods).			
Agriculture	30 yrs	5 %	5 yrs
Power, Dam, Fishery & Flood Control	30 yrs	5 %	3 yrs

3-2-4. Payment Policy

Principally, the operation and maintenance cost should be borne by the benefited farmers in terms of water charge. As there is no customs and regulations about this matter, a water charge would be instituted on an experimental basis which would permit the full recovery of the cost of the operation and maintenance of the project.

Therefore, it is decided that the repayment of specific cost ($525,000) would be borne by the Khmer Republic Government for 25 years and the benefited farmers should bear the payment of the O & M costs of specific facilities and O & M costs of allocated share of dam, totalling $456,000 (or \$456,000/25,400 ha = \$17.95/ha) for 50 years. As net farm profit or capacity to pay is \$118.21/ha (see 2-10-2), it is considered that the water charge (\$17.95 per hectare per annum) will be able to be paid by the farmers.

3-2-5. Repayment

(a) Total Project Cost

Reference is made to Tables III-5 and III-6.

Agriculture		
Foreign Currency Component		\$12,008 x 10^3
Local Currency Cost		11,552 x 10^3
	Subtotal	\$23,560 x 10^3
Power, Fishery & Flood Control		
Foreign Currency Component		\$ 3,778 x 10^3
Local Currency Cost		1,238 x 10^3
	Subtotal	\$ 5,016 x 10^3
	Total	\$28,576 x 10^3

(b) Repayment for Loan

The total project cost is converted into an equivalent uniform annual repayment over the period of analysis by applying the Capital Recovery Factor. This computation provides the amount required to repay a debt at interest by a series of equal end of year payments. This process is called amortization.

Formula: $$A = p \frac{i(1 + i)^n}{(1 + i)^n - 1}$$

Where,
A is amortization
p is present value
i is interest rate
n is repayment period

(i) Annual and Total Repayment for <u>Agriculture</u> (Refer to Table III-7 and 3-2-5(a) & Cost Allocation)

Annual Repayment (X 10^3)

F.C.	\$2,860 x 0.06829 =	\$ 195	(A/C/D, i=0.05, n=27)
	\$9,148 x 0.05743 =	\$ 525	(I/C, i=0.03, n=25)
	Subtotal	\$ 720	
L.C.	\$1,236 x 0.06829 =	\$ 84	(A/C/D, i=0.05,,n=27)
	\$10,316x 0.07095 =	\$ 732	(I/C, i=0.05, n=25)
	Subtotal	\$ 816	

Total Repayment (X 10^3)

F.E.	\$ 195 x 27 yrs =	\$ 5,265
	\$ 525 x 25 yrs =	\$13,125
	Subtotal	\$18,390
L.C.	\$ 84 x 27 yrs =	\$ 2,268
	\$ 732 x 25 yrs =	\$18,300
	Subtotal	\$20,568

(ii) Annual and Total Repayment for <u>Power, Fishery and Flood Control</u>

Annual Repayment (X 10^3)

\$3,778 x 0.06829 =	\$ 258	(F.E., i=0.05, n=27)
\$1,238 x 0.06829 =	\$ 85	(L.C., i=0.05, n=27)
	\$ 343	

Total Repayment (X 10^3)

\$ 258 x 27 yrs =	\$ 6,966	(F.E.)
\$ 85 x 27 yrs =	\$ 2,295	(L.C.)
	\$ 9,261	

(iii) Generalization (X 10^3)

	Annual Repayment (for 27 years)		Annual Benefit (for 50 years)	Total Repayment (for 27 years)		Total Benefit (for 50 years)
Agriculture	(F.E.)	720	3,746	(F.E.)	18,390	187,334 1/
	(L.C.)	816		(L.C.)	20,568	
		1,536			38,958	
Power	(F.E.)	234	404	(F.E.)	6,318	20,205 2/
	(L.C.)	73		(L.C.)	1,971	
		307			8,289	
Fishery	(F.E.)	10	12	(F.E.)	270	584 3/
	(L.C.)	6		(L.C.)	162	
		16			432	
Flood control	(F.E.)	14	22	(F.E.)	378	1,082 4/
	(L.C.)	6		(L.C.)	162	
		20			540	

1/ $97.3/ha (at fifth year, interest rate at 0%) x 25,400 ha x 1.516 (rate of average benefit for 50 years to the target benefit)x 50 years.

2/ $404,100 (reference is made Project Report appearing on Annual cost of hydro-power) x 50 yers

3/ $11,676 (Annual benefit to be expected) x 50 years

4/ $21,630 (Annual benefit to be protected) x 50 years

PART IV

CONCLUSIONS AND RECOMMENDATIONS

PART IV CONCLUSIONS AND RECOMMENDATIONS

4-1. Conclusions

4-1-1. Significance of the Project

(a) The development of the Stung Chinit basin is one of the many regional development Project in the Khmer Republic. Since the project is not a large scale one, it is comparatively easy to be carried out from the financial viewpoint. The implementation of the project bears a great deal of significance in balancing the development of the rural areas of the Khmer Republic, situated at the east of the Great Lake which has been overlooked until today.

(b) The Stung Chinit Project has common natural and social conditions with those of the mainstream big projects as the Sambor and Pa Mong. The project is of the medium scaled but multipurpose one, therefore it will serve as a forerunner to carry out such big projects.

(c) Some characteristics of each sector

Irrigation: Supplemental irrigation is, of course, practiced to paddy fields in the rainy season, and at the same time irrigation for an area of 80 per cent of the paddy field is introduced in the dry season. This is a first trial in Cambodia to introduce the double cropping of paddy to such a vast area.

To realize an early implementation of the project, the project plan is divided into two stages. Further, agricultural extension base farms are proposed to be established, and upland crops and fruit trees will be cultivated in the project area in the future, Hydro-power: The development of hydro-power has so far been emphasized for supplying power to the urban areas in Cambodia, while the project aims at rural electrification, since this hydro-power is generated along with the supply of irrigation water, and the power cost is more reasonable than that of transmitting the power to the urban areas.

The hydro-power will be used for general use as well as irrigation and drainage pumps. The distribution net-works of the power will set up in the project area.

Fishery: Although this river is not blessed with a lot of fishes, providing facilities for their breeding will be effective to increase fish catches.

Flood control: In the Stung Chinit reservoir there is no plentiful water around the flood season, since all the water are used out during the dry season. Therefore, a peak of flooding can be controlled by storing the water with a deliberate operation of the gates. From the above, the construction cost of the dam could be allocated to the flood control sector.[1/]

Navigation: At present the frequency of the inland navigation through the Stung Chinit is very small except that of floating rafts, which will no longer be used so much in the future. Therefore, particular measures for deterioration of navigation as well as its benefit will not be necessary to take up in this project.

1/ The construction cost of the multipurpose dam is allocated to the sectors of irrigation, power, fishery and flood control. See page III-6, Table III-1.

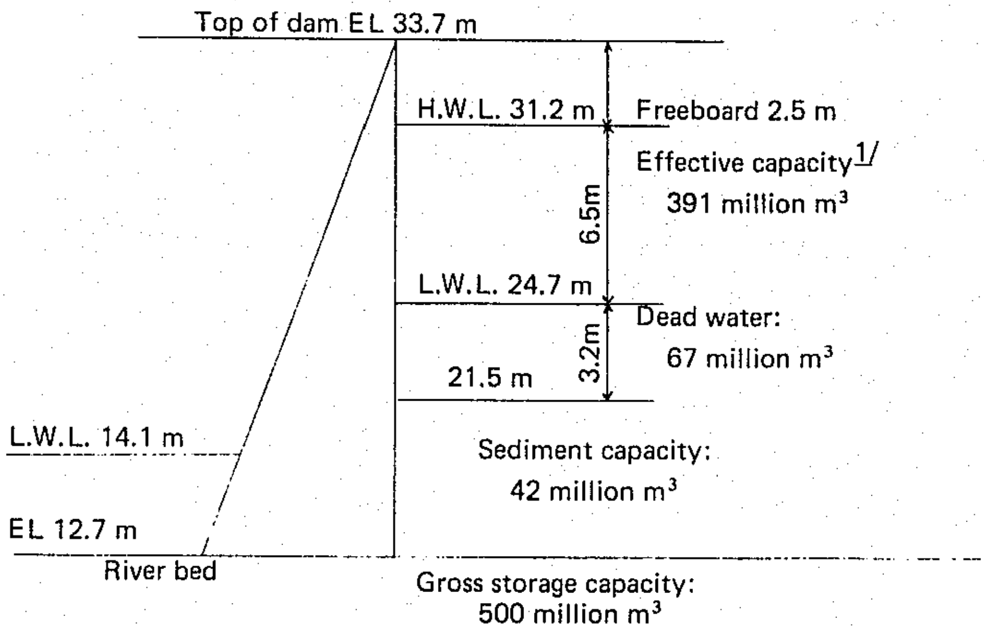
4-1-2. Feasibility of the Project

(a) The result of this feasibility study leads to the following conclusions.

Irrigation: Consideration of soil condition and limitation of water resources of the Stung Chinit, the irrigable area of 2,450 ha is selected on the right bank and 22,950 ha on the left bank, totaling 25,400 ha. Double cropping of paddy rice is possible by supplemental water supply of 550 - 850 million m^3 per annum. The provision project facilities at suitable sites, such as the main concrete and fill-type dam, concrete diversion dam, earth lining canal, irrigation and drainage pumps, polder dike and so forth could be completed within five years. In the first two years, the construction of the diversion dam and canal for intaking water will be completed as a first stage, and then the paddy irrigation for the area of 14,800 ha in the rainy season and 5,000 ha in the dry season could be in operation from the third year after commencement of the construction.

Main dam: The capacity of the dam to be built at the site of Phnom Takho is designed as indicated in Fig. IV-1. After studying the water level fluctuation for periods of eight years (1962 - 1969), the storage capacity should be justified.

Fig. IV-1 Distribution Plan of Reservoir Capacity



1/ This capacity is satisfied with each objective required water quantity, while overlapping each required water quantity.

Irrigation:	370 million m^3
Power:	300 "
Flood control:	270 "

Hydro-power: It is advantageous to get irrigation water at the diversion dam site in the downstream of the river, and to set up a power generation there by utilizing water (sometimes the discharge water for power generation exceeds that for the supplemental irrigation). In view of power supply and demand, the maximum capacity of 4,500 kW generator is most adequate for the consumption of power in the project area.

Fishery: In the lower stream of Kg. Thma diversion dam, fish catches are threatened to be decreased in the future.

For the countermeasures, it is required to provide some fish breeding ponds by taking water from the irrigation canal. On the other hand, fishes in the reservoir are expected to be propagated producing about 4.5 ton/km^2 per annum. This benefit is sufficient to allocate the multipurpose dam cost to the fishery sector.

Flood control: It is practicable to make a flood control by operating an emergency conduit and spillway gates at the main dam without any surcharge capacity on the high water level. By this operation, it is possible to lower the flood stage of Kg. Thma lower about 1 m. The benefit by preventing the damages and disasters caused by inundation could be estimated upon the analysis of flood frequency.

Navigation: Installation of any special facility is not required for the navigation in the project. Most of the lumbering sites will be transferred to basins of the Mekong and the Stung Sen. The existence of the main reservoir will be favorable to the navigation in the upper reaches of the river, and since the access road is to be constructed at the main dam, there will be no problem for transportation in the downstream area.

(b) Economic feasibility

As shown in Table IV-1, the result of the economic evaluation proves the project feasible.

Table IV-1 Economic Evaluations

	B/C ratio (interest rate)	Remarks
Irrigation	2.76 (i=3%)	I.R.R. 8.6%
Power	1.13 (i=6%)	Power cost: 1.36/kWh at load center
Fishery	1.50 (i=3%)	
Flood Control	1.70 (i=3%)	
Total	2.48	

(c) Financial feasibility

The total project cost is estimated at $28.6 millions including interest during construction periods, foreign exchange for $15.8 millions and local currency for $12.8 millions.

It is considered that the financing for the foreign exchange will be made by the loan from an international financial institution, and for the local currency will be provided by the Government of Cambodia.

The financial feasibility of the project is made on the basis of the following anticipated terms of loan and its summary is seen in Table IV-2.

Table IV-2 Repayment Terms

	Repayment Term	Interest per annum	Grace
I. Foreign Exchange (No interest during grace)			
Agriculture ($12.0 millions)	30 years	3%	5 years
Power, Dam, Fishery & Flood control ($3.8 millions)	30 years	5%	3 years
II. Local Currency (No interest during grace)			
Agriculture ($11.6 millions)	30 years	5%	5 years
Power, Dam, Fishery & Flood control ($1.2 millions)	30 years	5%	3 years

Development effect of the Stung Chinit Project is confined to the domestic regions in Cambodia and has nothing to do with the other riparian countries, where a development on the mainstream involves various complicated problems to be internationally solved. Hence, the project can be implemented without any difficulty so far as the finance arrangement is favorably made.

4-2. Recommendations

(a) Extension Services

It is well understood that an extension of farming techniques based on pilot extension farms is the best way to increase agricultural products. The extension base farms should be established at appropriate places prior to implementation of the project construction.

In the extension farms, especially by using facilities of the base farms the intensive training should be given to extension workers in quality and quantity for the purpose of leading the farmers to the improvements of their irrigation techniques as well as farming methods.

(b) Farmers' Organization

The main water supply facilities as described in Part II, will be provided by the SNGB, and the remaining terminal irrigation system covering less than 10 ha will be completed by farmers themselves. Further, the farmers will be responsible for operation and maintenance of facilities from the distribution of the lateral canals to the turnouts and all the terminal facilities.

In this respect, in order to concentrate the water utilization activities and to collect the water charge reasonably, the farmers' organization should be established.

The organization will undertake the land arrangement in order to perform the most effective distribution of irrigation water and to raise the labor productivity.

(c) Improvement of Marketing

Marketing system including wholesale prices of crops and cooperative's activities has a considerable influence on the farmers enthusiasm for modernized agriculture, while further improvement will be required in this system.

The Project provides the irrigation system, the power supply system, the fish nursery, and even the access and feeder roads along the canals. The farm input in the benefits estimate involves the necessary amount of fertilizer and crop protection chemicals and so forth. However, the intangible but important factors assuring effectiveness of these project facilities, depend upon the circumstances of the project.

(d) Administrative Treatment

As mentioned in 2-8 of the report, an administrative consideration of organization in SNGB, Ministry of Agriculture and so forth will be necessary for implementation, operation, and maintenance of the project. For the above, a legal treatment will be also required. All these activities administrative treatment should be oriented to assure the benefits of the water and power users with their cooperation.

(e) Finance

An example of the financing plans for the project execution has been described in Part III. There will be practically no difficulty for financing because the project scale is not particularly large. Further, the project will produce various benefits from irrigation, power, fishery and flood control, and the procedures to attain benefits could be a pilot example for other developments in future.

Such being the case, it is strongly expected that the financing to the project be made at the earliest possible date.

APPENDICES

APPENDIX A AGRICULTURE

A-1. Computation of Irrigation Water Requirement (1962 - 1968)

Table A-1 Net and Gross Water Requirement

Month	Net water requirement (mm/day) 1/						Gross water requirement 3/ (mm/month)			Cropping area (ha)			
	Soil texture			Weighted mean 2/									
	Sand	Loam	Clay	I	II	III	I	II	III	I	II	III	Total
Jan	12.9	10.9	7.9	10.2	7.9	10.9	421.6	326.5	450.5	12,280	1,960	6,080	20,320
Feb	14.1	12.1	9.1	11.4	9.1	12.1	425.6	339.7	451.7	12,280	1,960	6,080	20,320
Mar	13.4	11.4	8.4	10.7	8.4	11.4	442.3	347.2	471.2	12,280	1,960	6,080	20,320
Apr	13.4	11.4	8.4	10.7	8.4	11.4	428.0	336.0	456.0	6,140	980	3,040	10,160
May	12.2	10.2	7.2	9.5	7.2	10.2	392.7	297.6	421.6	15,350	2,450	7,600	25,400
Jun	12.7	10.7	7.7	10.0	7.7	10.7	400.0	308.0	428.0	15,350	2,450	7,600	25,400
Jul	11.6	9.6	6.6	8.9	6.6	9.6	367.9	272.8	396.8	15,350	2,450	7,600	25,400
Aug	11.4	9.4	6.4	8.7	6.4	9.4	359.6	264.5	388.5	15,350	2,450	7,600	25,400
Sep	11.4	9.4	6.4	8.7	6.4	9.4	348.0	256.0	376.0	15,350	2,450	7,600	25,400
Oct	12.2	10.2	7.2	9.5	7.2	10.2	392.7	297.6	421.6	15,350	2,450	7,600	25,400
Nov	12.9	10.9	7.9	10.2	7.9	10.9	408.0	316.0	436.0	7,675	1,225	6,080	14,980
Dec	12.7	10.7	7.7	10.0	7.7	10.7	413.3	318.3	442.3	12,280	1,960	6,080	20,320

1/ Percolation measured + evapotranspiration computed by Blaney-Criddle formula

2/ By soil texture

3/ Including conveyance and operation loss water (25%)

Table A-2 Monthly Irrigation Water to be Supplied

Year	Month	Effective rainfall		Water to be supplied 1/	
		(mm)	($10^6 m^3$)	($10^6 m^3$)	(m^3/sec)
1962	Jan	-	-	°85.6	32.0
	Feb	-	-	86.4	35.7
	Mar	22.2	4.53	°85.3	31.8
	Apr	86.2	8.79	34.7	13.4
	May	171.7	43.61	°56.0	20.9
	Jun	56.3	14.30	87.2	33.6
	Jul	248.0	62.99	°30.3	11.3
	Aug	274.6	69.75	°21.7	8.1
	Sep	220.3	55.96	32.3	12.5
	Oct	94.6	24.03	°75.6	28.2
	Nov	8.3	1.25	50.7	19.6
	Dec	-	-	°83.9	31.3
1963	Jan	-	-	°85.6	32.0
	Feb	-	-	86.4	35.7
	Mar	40.0	8.12	81.6	30.5
	Apr	4.2	0.43	43.0	16.6
	May	113.0	28.70	70.9	26.5
	Jun	270.2	68.63	32.8	12.7
	Jul	101.9	25.88	67.4	25.2
	Aug	213.0	54.10	37.1	13.9
	Sep	185.8	47.19	41.1	15.9
	Oct	146.1	37.11	62.5	23.3
	Nov	79.8	11.97	41.6	16.1
	Dec	-	-	83.9	31.3
1964	Jan	-	-	85.6	32.0
	Feb	-	-	86.4	35.7
	Mar	-	-	89.8	33.5
	Apr	32.0	3.26	40.2	15.5
	May	240.0	60.96	38.6	14.4
	Jun	111.8	28.40	73.1	28.2
	Jul	101.9	25.88	67.4	25.2
	Aug	234.4	59.54	31.7	11.8
	Sep	78.9	20.04	68.2	26.3
	Oct	170.2	43.23	56.4	21.1
	Nov	113.1	16.97	37.4	14.4
	Dec	-	-	83.9	31.3

1/ Gross water requirement-effective rainfall

Year	Month	Effective rainfall (mm)	Effective rainfall (10^6m^3)	Water to be supplied (10^6m^3)	Water to be supplied (m^3/sec)
1965	Jan	-	-	85.6	32.0
	Feb	15.8	3.21	83.2	34.4
	Mar	-	-	89.8	33.5
	Apr	60.6	6.16	37.3	14.4
	May	207.6	52.7	46.9	17.5
	Jun	210.7	53.5	48.0	18.5
	Jul	128.4	32.6	60.7	22.7
	Aug	183.1	46.5	44.7	16.7
	Sep	274.3	69.7	19.0	7.3
	Oct	178.7	45.4	54.2	20.3
	Nov	-	-	51.8	20.0
	Dec	-	-	83.9	31.3
1966	Jan	-	-	85.6	31.9
	Feb	23.2	4.7	81.7	33.8
	Mar	32.2	6.5	83.2	31.1
	Apr	64.6	6.6	36.9	14.2
	May	177.9	45.2	54.4	20.3
	Jun	88.1	22.7	79.0	30.5
	Jul	220.8	56.1	37.2	13.9
	Aug	273.5	69.5	22.0	8.2
	Sep	204.0	51.8	36.4	14.1
	Oct	136.7	34.7	64.9	24.2
	Nov	58.5	8.8	44.3	17.1
	Dec	25.0	5.1	78.8	29.4
1967	Jan	-	-	85.6	31.9
	Feb	-	-	86.4	35.7
	Mar	-	-	89.8	33.5
	Apr	13.9	1.4	42.0	16.2
	May	173.0	43.9	55.6	20.8
	Jun	115.9	29.4	72.0	27.8
	Jul	152.5	38.7	54.6	20.4
	Aug	181.3	46.1	45.2	16.9
	Sep	239.6	60.9	27.4	10.6
	Oct	87.7	22.3	77.3	28.9
	Nov	5.1	0.8	51.1	19.7
	Dec	-	-	83.9	31.3

Year	Month	Effective rainfall (mm)	Effective rainfall ($10^6 m^3$)	Water to be supplied ($10^6 m^3$)	Water to be supplied (m^3/sec)
1968	Jan	-	-	85.6	32.6
	Feb	-	-	86.4	35.7
	Mar	-	-	89.8	33.5
	Apr	82.4	8.4	35.1	13.5
	May	161.0	40.9	58.7	21.9
	Jun	139.7	35.5	66.0	25.5
	Jul	76.7	19.5	73.1	27.6
	Aug	182.4	46.3	44.9	16.8
	Sep	144.3	36.7	51.6	19.9
	Oct	131.6	33.4	66.2	24.7
	Nov	6.2	0.9	50.9	19.7
	Dec	-	-	83.9	31.3
1969	Jan	-	-	85.6	32.0
	Feb	-	-	86.4	35.7
	Mar	-	-	89.8	33.5
	Apr	-	-	43.5	16.8
	May	89.6	22.8	76.9	28.7
	Jun	119.2	30.3	71.2	27.5
	Jul	157.6	40.0	53.3	19.9
	Aug	156.8	39.8	51.4	19.2
	Sep	236.4	60.0	28.2	10.9
	Oct	85.1	21.6	78.0	29.1
	Nov	5.6	0.8	51.0	19.7
	Dec	-	-	83.9	31.3

A-2. Estimation of Agricultural Development Cost

Table A-3 Agricultural Development Cost (in $\$10^3$)

Item of Works	Quantity	Local Currency	Foreign Currency	Total
Land Development				
Reclamation	4,700 ha	829	591	1,420
Consolidation	25,400 ha	2,311	279	2,590
Sub-total		3,140	870	4,010
Irrigation Canal				
Main canal	66.30 km	1,118	846	1,964
Branch canal	222.4 km	316	193	509
Collateral works	249	446	531	977
Sub-total	288.70 km	1,880	1,570	3,450
Irrigation Pumping Station				
Machinery	2x1,000 kW	-	410	410
House & foundation	LS	190	200	390
Pipe & canal	3,150 m	115	210	325
Collateral works	LS	15	30	45
Sub-total		320	850	1,170
Drainage Canal				
Main canal	49.80 km	638	577	1,215
Branch canal	110.30 km	279	104	383
Collateral works	120	183	159	342
Sub-total	160.10 km	1,100	840	1,940
Polder Dike				
Excavation	51.63 $10^3 m^3$	126	124	250
Embankment	2,231.00 $10^3 m^3$	258	255	513
Earth moving	1,761.00 $10^3 m^3$	496	491	987
Sub-total	31.00 km	880	870	1,750
Drainage Pumping Station				
Machinery	3x350 kW	-	690	690
House & foundation	LS	205	205	410
Collateral works	LS	15	25	40
Sub-total		220	920	1,140
Diversion Dam				
Foundation	LS	45	160	205
Earth works	28.34 $10^3 m^3$	9	8	17
Concrete works	9,65 $10^3 m^3$	173	170	343
Collateral works	LS	22	42	64
Temporary works	LS	96	34	130
Gate & bridge	290 m^2	-	396	396
Sub-total		345	810	1,155
Engineering Fee		480	980	1,460
Sub-total		480	980	1,460
Contingency		805	800	1,605
Sub-total		805	800	1,605
Total		9,170	8,510	17,680
Main Dam Cost Allocated		1,150	2,660	3,810
Grand total		10,320	11,170	21,490

Table A-4 Agricultural Development Cost by Division

(in $\$10^3$)

Name of Division	I	II	III	Total
Area in ha	15,350	2,450	7,600	25,400
Land Development	2,820	400	790	4,010
Irrigation Canal	2,050	220	1,180	3,450
Irrigation Pumping Station	-	-	1,170	1,170
Drainage Canal	1,170	-	770	1,940
Polder Dike	1,750	-	-	1,750
Drainage Pumping Station	1,140	-	-	1,140
Diversion Dam	860	105	190	1,155
Engineering Fee	980	70	410	1,460
Contingency	1,075	80	450	1,605
Total	11,845	875	4,960	17,680
Main Dam Cost Allocated	2,305	286	1,219	3,810
Total	2,305	286	1,219	3,810
Grand Total	14,150	1,161	6,179	21,490
Cost per ha ($)	922	474	813	846

A-3. Evaluation of Alternate Project Plans

A-3-1. Comparison of irrigating Division III by pumping or gravity related to the hydropower generation

In this case, the irrigation water for the area division III shall be diverted directly from the main reservoir. Simultaneously, a main irrigation canal shall be provided at the place between the dam and the service area (division III). The canal is to be a 13.7 m^3/sec capacity in the head and about 50 km in the length, which is about 19 km longer than that of the original irrigation plan by pumping from the diversion dam site.

The hydro-electric power to be generated at the main dam site shall be decreased from 4,500 kW in the original plan to 3,400 kW in this gravity irrigation case, since the irrigation water for the division III is not released through turbines.

The construction cost of the gravity irrigation plan is tabulated in Table A-5, and its annual cost is shown as Table A-6 in comparison with that of the lift irrigation plan. Cost allocation of multipurpose dam is also made in the case of gravity irrigation and the result is figured in Table A-7. From these tables, the following matters are clarified.

(1) The initial investment cost of the case of pumping is cheaper than that of gravity, but there is opposed in their operation and maintenance costs. Despite these differences, there is no remarkable change in the total annual costs of the both cases.

On the other hand, the share of allocated dam cost to each division (I, II and III) in the case of gravity is higher than that of the case of pumping.

(2) In evaluation of the multipurpose project in the both cases, the benefit cost ratios for the whole projects are quite similar. However, it turned out that the original case, pumping irrigation, has a high ratio, therefore, the original plan is selected preferably, Further discussion is described later.

Table A-5 Construction Cost of Agricultural Development (Alternate plan)

in $ 1,000

Works Item	Division Area (ha)	I 15,350	II 2,450	III 7,600	Total 25,400
Land Development		2,820	400	790	4,010
Irrigation Canal		2,050	220	2,970	5,240
Drainage Canal		1,170	-	770	1,940
Polder Dike		1,750	-	-	1,750
Drainage Pumping Station		1,140	-	-	1,140
Diversion Dam		1,025	130	-	1,155
Engineering		995	75	450	1,520
Contingency		1,100	80	500	1,680
Sub-total		12,050	905	5,480	18,435
Dam Cost allocated to Irrigation		2,640	330	1,400	4,370
Total		14,690	1,235	6,880	22,805
$/ha		957	504	905	899

Table A-6 Comparison of Annual Costs for the Area of Division III irrigated by Pumping or Gravity

	Item	Pumping irrigation (original plan)	Gravity irrigation (alternate plan)
a.	Service Area	7,600 ha	7,600 ha
b.	Initial Investment Cost	$6,179,000	$6,880,000
c.	b/a	$813/ha	$905/ha
d.	Amortization of Investment 1/ (i = 6%)	$451,000	$502,000
e.	Replacement Cost	6,000	-
f.	O & M Cost 2/	167,000	103,000
g.	Total of d to f	624,000	605,000
h.	Annual Cost per ha	$82.1/ha	$79.6/ha

1/ Interest during construction is included. Interest rate of 6% is adopted as an approximate value of the internal rate of return.

2/ 3% of investment cost for the case of pumping irrigation, 1.5% of costs for the main dam and gravity irrigation.

A further comparative study is made among the following three cases.

(1) Original plan

gravity irrigation for Division I and II: 17,800 ha
pumping irrigation for Division III: 7,600 ha
hydropower generation: 4,500 kW max. output
by 35.5 m^3/sec max. discharge
supplementary diesel generator: 1,000 kW

(2) Alternate plan (with diesel generator)

gravity irrigation for Division I - III: 25,400 ha
hydropower generation: 3,400 kW max. output
by 27.0 m^3/sec max. discharge
supplementary diesel generator: 1,000 kW

(3) Alternate plan (without diesel generator)

gravity irrigation and hydropower generation: same as the case (2)

With regard to hydropower generation in the cases (1) and (2), a 1,000 kW diesel plant is planned to install in order to supplement hydropower when the water level of reservoir draws down. In the case (1), the annual generated energy of 12,770 MWh for irrigation and drainage pump load and 8,700 MWh for general load will be used in the entire project area. In the case (2), 1,770 MWh for drainage pump load and 11,200 MWh for general load in the project area and also nearby Speu, Srok Chamkar Leu. However, in the case (3) without diesel facilities, 1,770 MWh for drainage pump load and 8,700 MWh for general load in the project area will be used.

The results of studies are tabulated as follows showing the benefit-cost ratio for each case.

Table A-7 B/C ratio in various cases

		Irrigation (i=3%)	Power (i=6%)	Flood Control (i=3%)	Fishery (i=3%)	Total
(1)	Original plan (pumping irrigation)	2.76	1.13	1.70	1.50	2.48
(2)	Alternate plan (gravity irrigation)	2.75	1.00	1.27	1.25	2.46
(3)	Alternate plan (gravity irrigation and without diesel generator)	2.75	1.02	1.27	1.25	2.50
		(i=6%)	(i=6%)	(i=6%)	(i=6%)	
(4)	Original plan (1)	1.65	1.10	1.42	1.29	1.55
(5)	Alternate plan(3)	1.60	1.00	1.00	1.06	1.51

In case II), (2) and (3), the interest rate of 3% is taken for irrigation, Flood control and Fishery, and 6% for Power. Since the B/C ratio in total for each case seems to be influenced greatly by the irrigation project having the biggest values of benefit and cost, an examination is made in (4) and (5), taking the same interest rate of 6% for the all purposes. Then, it is seen that the B/C ratio for the cases (1) and (3) changes their order in the cases (4) and (5) according to the different interest rate and consequently, changing weighted values of benefits and costs.

In case the comprehensive B/C ratio for various alternate plans are almost similar as described above, an attention should be put on the B/C ratio of each purpose. Then priority could be decided by the order of the ratio for each portion. In this viewpoint, the original plan is considered reasonable.

Table A-8 Power cost in various cases

in ¢/kWh

Item \ Case*	(1)	(2)	(3)	(4)	(5)
i. Load center	1.36	1.79	1.87	1.41	1.88
(for allocated dam cost, included into the above)	(0.58)	(0.32)	(0.42)	(0.63)	(0.43)
ii. Distribution	1.39	1.44	1.39	1.39	1.39
i + ii	2.75	3.23	3.26	2.80	3.27
iii Alternate diesel power cost including distribution cost	3.00	3.23	3.27	3.00	3.27

* Case number corresponds to that of Table "B/C ratio in various cases" in previous page.

Table A-9 Cost Allocation of Original Project Plan (1)

in million US$

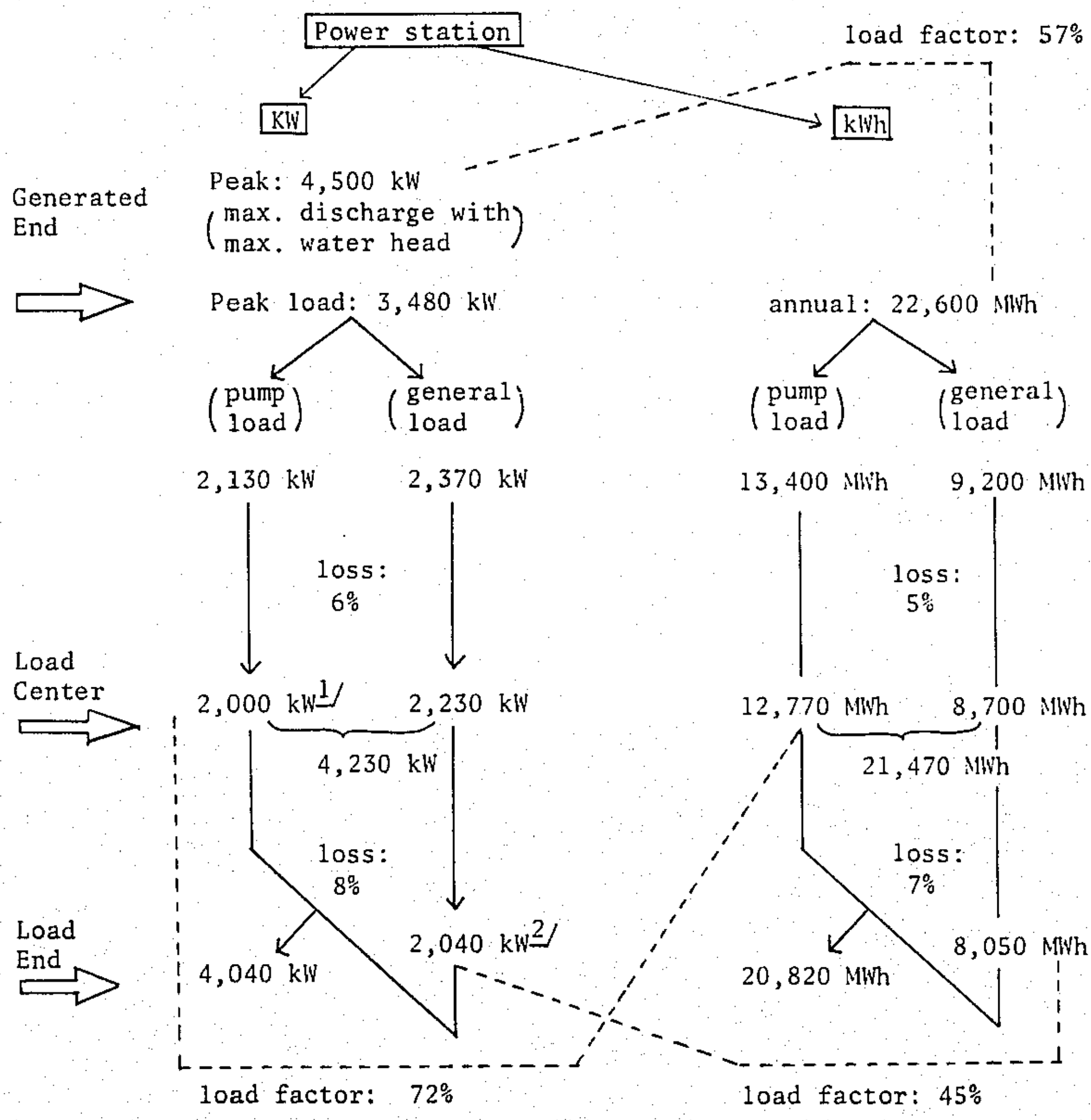
Item	Irrigation (i=3%)	Power (i=6%)	Flood control (i=3%)	Fishery (i=3%)	Total
a. Benefits	91.40	7.21	0.56	0.30	99.47
b. Alternate Costs	35.75	10.38	6.69	5.22	58.04
Installation	22.94	7.49	4.83	3.77	39.03
O & M	12.81	2.89	1.86	1.45	19.01
c. Specific Costs	28.46	4.41	-	0.05	32.92
Installation	17.68	2.66	-	0.04	20.38
O & M	10.78	1.75	-	0.01	12.54
d. Lesser of a and b	37.75	7.21	0.56	0.30	43.82
e. Separable Costs	0.59	0.64	0	0	1.23
Installation	0.48	0.52	0	0	1.00
O & M	0.11	0.12	0	0	0.23
f. Remaining Benefit (d - c - e)	6.81 (69.6%)	2.16 (22.1%)	0.56 (5.7%)	0.25 (2.6%)	9.78 (100%)
g. Allocated Joint Costs	4.12	1.31	0.33	0.15	5.91
Installation	3.33	1.06	0.27	0.12	4.78
O & M	0.79	0.25	0.06	0.03	1.13
h. Total Allocated Dam Cost	4.71 (66.0%)	1.95 (27.3%)	0.33 (4.6%)	0.15 (2.1%)	7.14 (100%)
Installation	3.81	1.58	0.27	0.12	5.78
O & M	0.90	0.37	0.06	0.03	1.36
i. Total Project Cost	33.17	6.36	0.33	0.20	40.06
Installation	21.49	4.24	0.27	0.16	26.16
O & M	11.68	2.12	0.06	0.04	13.90
j. Benefit-Cost Ratio a/i	2.76	1.13	1.70	1.50	2.48

Note: (1) Besides, there is found the cost $60,000 for three pilot fish farm ponds as the fishery compensation in the down-stream fo the river. But it is not for the allocation.

(2) The capitalized benefit of power generation is regarded as the cost of alternative diesel power, which is ¢3.00/kWh including distribution cost.

Estimation of power energy balance (1)

- Original plan including pumping irrigation -



1/ Irrigation pumps: 2,000 kW or Drainage pumps: 1,050 kW

2/ Domestic use: 1,600 kW (7,500 houses), Public use: 60 kW, General industrial use: 380 kW.

A-3-2. Estimation of Annual Cost and Benefit of Hydro-power

1. Cost Estimation of Hydro-power

1-1. Basic Items:

Installation power	4,500 kW
Annual power delivery	22,600 MWh (generated end)
	21,470 MWh (load center)
	20,820 MWh (sellable)
	8,050 MWh (distributed, for general use)
Load factor	average 57% (generated end)

1-2. Installation cost at load center, in US$ 1,000 excluding dam cost allocated to power

		(cost)	(useful lives)
a.	Power house	185	50 yrs
b.	Foundation treatment for power house	85	50 yrs
c.	Penstocks and intake	100	50 yrs
d.	Turbines & generators	700	35 yrs
e.	Transmission line (45 km)	290	50 yrs
f.	Substation	150	25 yrs
g.	Communication facilities etc.	45	25 yrs
h.	Contingency (10%)	155	
	Total	1,710	

1-3. Distribution Cost in US$ 1,000

		(cost)	(useful lives)
a.	Distribution line concrete pole, wire, foundation, etc.	590	35 yrs
b.	Equipment pole trans, CB, etc.	245	25 yrs

		(cost)	(useful lives)
c.	Communication facilities	30	25 yrs
d.	Contingency (10%)	85	
	Total	950	

1-4. Annual cost of hydro-power

i) At load center, excluding dam cost allocated to power

a. Amortization of installation cost,
for 50 yrs. @ 6% interest rate
$ 1,710,000 x 0.0634 = $108,400

b. Replacement:
Turbines and generators,
at 35th yr. @ 6%
$ 700,000 x 0.130 x 0.0634 = $ 5,800
Substation and communication facilities,
at 25th yr. @ 6%
$ 195,000 x 0.233 x 0.0634 = $ 2,900

c. O&M cost
3% of total installation cost $ 51,300

Total $168,400

Cost/kWh
$168,400/21,470 MWh = ¢0.78/kWh

Capitalized the above, for 50 yrs. @ 6%
$168,400 x 15.76 = $2.65 million

ii) Distribution cost

a. Amortization of distribution system,
for 50 yrs. @ 6%
$ 950,000 x 0.0634 = $ 60,200

b. Replacement:

Concrete pole, wire, foundation and soforth, at 35th yr. in 50 yrs. @ 6%

$590,000 x 0.130 x 0.0634 =	$ 4,900

Pole trans, CB and other equipments, at 25th yr. in 50 yrs.

@ 6%

$275,000 x 0.233 x 0.0634 =	$ 4,100

c. O&M costs

4.5% of total installation cost	$ 42,800
Total	$112,000

Cost/kWh	$112,000/8,050 MWh =	¢1.39/kWh
Capitalized the above, for 50 yrs.	@ 6%	
	$112,000 x 15.76 =	$1.76 million

iii) Annual cost of multipurpose dam allocated to power

a. Amortization of allocated dam cost[1/],

for 50 yrs. @ 6% interest rate

$ 1.58 million x 0.0634 =	$100,200

b. O&M costs

$ 0.37 million x 0.0634 =	$ 23,500[2/]
Total	$123,700

Cost/kWh	$123,700/21,470 MWh =	¢ 0.58/kWh

1/ See the Cost Allocation of Multipurpose Dam

2/ Equivalent to 1.5% of allocated dam cost

iv) Total power cost/kWh

At load center :	excluding dam cost	¢ 0.78/kWh
	including dam cost	¢ 1.36/kWh
Distributed, for general use		¢ 2.75/kWh

2. Benefit of Hydro-power, equivalent to the cost of same amount of the power from the alternate Diesel-electric plant

The best possible alternate source of the power would be a Diesel-electric plant built in Kg. Thma-ville. Total installation of 6,250 kW, which consists of five sets of each 1,250 kW including one spare set, is assumed as equivalent hydro-power station of 4,500 kW. Annual power delivery at load center is 21,470 MWh for pumps and general use, and 8,050 MWh distributed for general use.

2-1. Installation cost of Diesel-electric plant

a.	Diesel-electric equipment	
	6,250 kW x @ $153 =	$ 970,000
b.	Power house	$ 70,000
c.	Substation	$ 150,000
d.	Contingency (10%)	$ 120,000
	Total cost at load center	$1,310,000
f.	Distribution system[1/] including contingency	$ 950,000
	Total installation cost	$2,260,000

2-2. Annual cost of Diesel-electric plant

i) At load center

a. Amortization of installation cost, for 50 yrs. @ 6% interest rate

$1,310,000 x 0.0634 = $ 83,000

1/ Same as the case of hydro-power, refer to A-3-2, 1-3.

b. Replacement:

Diesel-electric equipment,

for each 15 yrs. in 50 yrs. @ 6%

$970,000 x (0.417 + 0.174 + 0.073) x 0.0634 = $ 40,900

Substation, at 25th yr.

in 50 yrs. @ 6%

$150,000 x 0.233 x 0.0634 = $ 2,200

c. O & M costs

5% of total installation cost $ 65,500

d. Fuel cost

consuming 0.23 kg/kWh of

fuel, costing ¢ 3.15/kg

21,470 MWh x @ $ 7.2/MWh = $154,600

Total $346,200

Cost/kWh 346,200/21,470 MWh = ¢ 1.61/kWh

Capitalized the above, for 50 yrs. @ 6%

(equivalent benefit of hydroelectric power)

$ 346,200 x 15.76 = $ 5.45 million

ii) Distribution cost[1/]

Total $112,000

Cost/kWh $112,000/8,050 kWh = ¢ 1.39/kWh

Capitalized the above, 50 yrs. @ 6%

$112,000 x 15.76 = $ 1.76 million

iii) Total Diesel-electric power cost per kWh

¢ 1.61/kWh + ¢ 1.39/kWh = ¢ 3.00/kWh

1/ Same as the case of hydro-power, refer to A-3-2, 1-4.

3. Basic data of Power for Cost Allocation

in million US$

Item	At load center	Distribution	Total
a. Benefits	5.45	1.76	7.21
b. Specific costs 1/	2.65	1.76	4.41
b-1 Installation	1.71	0.95	2.66
b-2 O&M 2/	0.94	0.81	1.75
c. Alternate dam cost			4.83 5/
c' O&M costs for c 3/			1.14
d. Alternate costs (b-1) + (c)			7.49
d' O&M costs for d (b-2) + (c')			2.89
e. Dam costs with that purpose (power) omitted			5.26 6/
e' O&M costs for e 4/			1.24

1/ Capitalized annual costs, refer to A-3-2, 1

2/ Capitalized O&M costs including replacements costs

3/ Capitalized O&M costs, taken 1.5% of dam cost per annum, for 50 yrs. @ 6% interest rate.

4/ Taken same procedure of 3/

5/ 180 x $10^6 m^3$ for required storage capacity and 310 x $10^6 m^3$ for gross capacity.

6/ 350 x $10^6 m^3$ for required capacity and 480 x $10^6 m^3$ for gross capacity.

Table A-10 Basic Data for Cost Allocation of Main Dam

in million US$

Item	Irrigation	Power	Flood control	Fishery
a. Benefits	91.40	7.21 1/	0.56	0.30
b. Specific Costs	17.68	2.66 2/	-	0.04
b' O & M Costs for b 3/	10.78	1.75	-	0.01
c. Alternate Dam Costs	5.26 4/	4.83	4.83 5/	3.73 6/
c' O & M Costs for c 7/	2.03	1.14	1.86	1.44
d. Alternate Costs (b + c)	22.94	7.49	4.83	3.77
d' O & M Costs for d (b' + c')	12.81	2.89	1.86	1.45
e. Dam Costs with that Purpose Omitted	5.30 8/	5.26	5.78	5.78
e' O & M Costs for e 9/	1.25	1.24	1.36	1.36
f. Multipurpose Dam Cost	5.78			
f' O & M Costs for f 10/	1.36			

Note: 1/ , 2/ The distribution cost is included in the benefit or cost at the load center.

3/ Including the replacement costs. O & M costs taken 1.5 - 3.0 % of specific costs per annum for each purpose practically, and capitalized for 50 yrs. @ 6% interest rate for power and @ 3% for other purpose.

4/ 350 x $10^6 m^3$ for required capacity and 480 x $10^6 m^3$ for gross capacity.

5/ 270 x $10^6 m^3$ for required capacity and 312 x $10^6 m^3$ for gross capacity.

6/ Reservoir area of 40 km^2 at water level 26.2 m.

7/ Capitalized O&M costs taken 1.5% of dam costs per annum for 50 yrs. @ 3% for irrigation and @ 6% for power in interest rate.

8/ 270 x $10^6 m^3$ for required capacity and 400 x $10^6 m^3$ for gross capacity.

9/, 10/ Capitalized O&M costs taken 1.5% of dam costs for 50 yrs. @ 6% interest rate.

Table A-11 Cost Allocation of Alternate Project Plan (2)

in million US$

Item	Irrigation (i=3%)	Power (i=6%)	Flood control (i=3%)	Fishery (i=3%)	Total
a. Benefits	91.40	6.02	0.56	0.30	98.28
b. Alternate Costs	34.73	10.88	6.69	5.22	57.52
Installation	23.70	7.66	4.83	3.77	39.96
O & M	11.03	3.22	1.86	1.45	17.56
c. Specific Costs	27.44	5.36	-	0.05	32.85
Installation	18.44	3.19	-	0.04	21.67
O & M	9.00	2.17	-	0.01	11.18
d. Lesser of a or b	34.73	6.02	0.56	0.30	41.61
e. Separable Costs	0.59	0.64	0	0	1.23
Installation	0.48	0.52	0	0	1.00
O & M	0.11	0.12	0	0	0.23
f. Remaining Benefit (d - c - e)	6.70 (89.0%)	0.02 (0.3%)	0.56 (7.4%)	0.25 (3.3%)	7.53 (100%)
g. Allocated Joint Costs	5.26	0.02	0.44	0.19	5.91
Installation	4.26	0.01	0.35	0.16	4.78
O & M	1.00	0.01	0.09	0.03	1.13
h. Total Allocated Dam Costs	5.85 (81.9%)	0.66 (9.2%)	0.44 (6.2%)	0.19 (2.7%)	7.14 (100%)
Installation	4.74	0.53	0.35	0.16	5.78
O & M	1.11	0.13	0.09	0.03	1.36
i Total Project Costs	33.29	6.02	0.44	0.24	39.99
Installation	23.18	3.72	0.35	0.20	27.45
O & M	10.11	2.30	0.09	0.04	12.54
j Benefit Cost Ratio a/i	2.75	1.00	1.27	1.25	2.46

Table A-12 Basic Data for Cost Allocation (2)

in million US$

Item	Power[1/] at load center	Power[1/] distribution	sub total	Irrigation	Flood control	Fishery
a. Benefit	3.66	2.36	6.02	91.40	0.56	0.30
b. Specific cost	3.00	2.36	5.36	27.44	-	0.05
b-1 Installation	1.92	1.27	3.19	18.44[2/]	-	0.04
b-2 O & M costs	1.08	1.09	2.17	9.00[3/]	-	0.01
c. Alternate dam cost			4.47	5.26	4.83	3.73
c'. O & M costs for c			1.05	2.03	1.86	1.44
d. Alternate costs (b-1) + (c)			7.66	23.70	4.83	3.77
d'. O & M costs for d (b-2) + (c')			3.22	11.03	1.86	1.45
e. Dam costs with that purpose omitted			5.26	5.30	5.78	5.78
e'. O & M costs for e			1.24	1.25	1.36	1.36
f. Multipurpose dam cost			5.78			
f'. O & M costs for f			1.36			

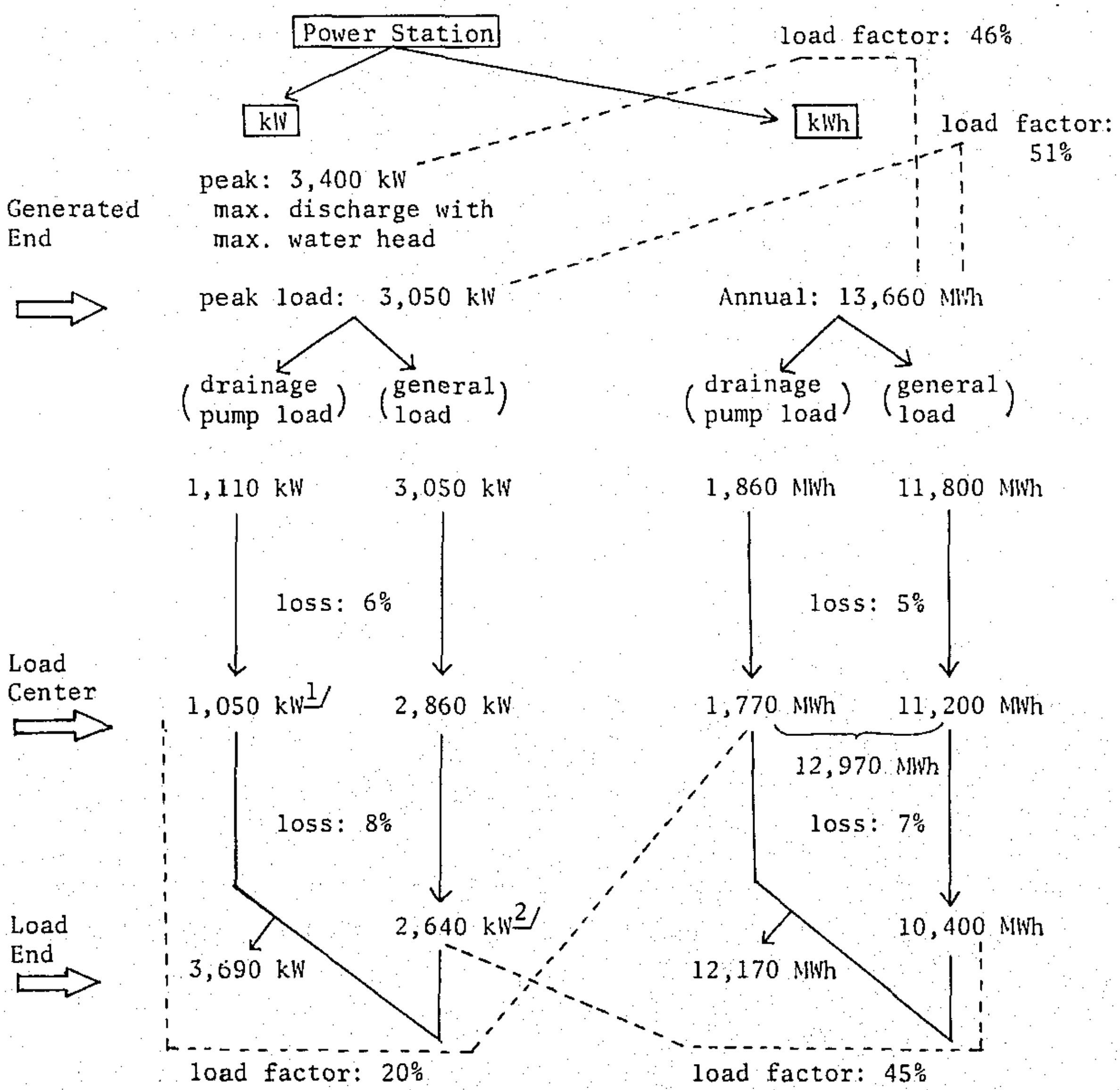
1/ See next page and thereafter,''estimation of power energy balance and power cost."

2/ See Table A-5.

3/ 2% of construction cost for division I and 1.5% for division II and III. Capitalized by 3% interest rate for 50 yrs.

Estimation of power energy balance (2)

- alternate plan, gravity irrigation case -



1/ Drainage pump: 1,050 kW

2/ Domestic use: 2,040 kW (7,500 houses in the project area and 2,200 houses in speu and nearby)
Public use: 100 kW, Rubber and other industrial use: 500 kW

Estimation of Annual Cost and Benefit of Hydro-power

- alternate plan, gravity irrigation case (2) -

1. Basic items:

Maximum output	3,400 kW	
Peak load	3,050 kW	
Annual power delivery	13,660 MWh	(generated end)
	12,970 MWh	(load center)
	12,170 MWh	(sellable)
	10,400 MWh	(distributed, for general use)
Load factor to max. output	46%	(generated end)
Load factor to peak load	51%	(generated end)

2. Cost at load center

2-1. Initial installation[1/]

		(cost)	(useful lives)
a.	Power house	170	50 yrs
b.	Foundation treatment	80	50
c.	Penstocks and intake	80	50
d.	Turbines & generators	600	35
e.	Diesel generator	50	15
f.	Transmission line (80km)	520	50
g.	Substation	195	25
h.	Communication facilities etc.	55	25
i	Contingency (10%)	170	
	Total	1,920	

1/ excluding dam cost allocated to power.

2-2. Annual cost (excluding dam cost allocated to power) for 50 yrs with 6% of interest rate

a. Amortization of installation cost

$1,920,000 x 0.0634 =	$121,700

b. Replacement

Turbine and generators:

$600,000 x 0.130 x 0.0634 =	$ 4,900

Diesel generator:

$50,000 x (0.417 + 0.174 + 0.073) x 0.0634 =	$ 2,100

Substation and communication facilities:

$250,000 x 0.233 x 0.0634 =	$ 3,700

c. O & M costs

3% of total installation cost:	$ 57,600
Total	$190,000

Cost/kWh

$190,000/12,970 MWh = <u>¢1.47/kWh</u>

Capitalized the above for 50 yrs.

$190,000/0.0634 = <u>$3.00 million</u>

3. Cost at distributed end

3-1. Distribution cost in US$1,000

	(cost)	(useful lives)
a. Distribution line concrete pole, wire, foundation, etc.	780	35 yrs
b. Equipment pole trans, CB, etc.	330	25
c. Communication facilities	45	25
d. Contingency (10%)	115	
Total	1,270	

3-2. Annual cost of distribution for 50 yrs with 6% of interest rate

a. Amortization

$1,270,000 x 0.0634 =	$ 80,600

b. Replacement

Distribution line:

$780,000 x 0.130 x 0.0634 =	$ 6,400

Equipment and facilities:

$375,000 x 0.233 x 0.0634 =	$ 5,500

c. O & M costs

4.5% of total distribution cost:	$ 57,200
Total	$149,700

Cost/kWh $149,700/10,400 MWh =	¢1.44/kWh
Capitalized the above for 50 yrs $149,700/0.0634 =	$2.36 million

4. Cost of alternate Diesel-electric plant

4-1. Installation cost

		(cost)	(useful lives)
a.	Diesel-electric equipment 4,000 kW x @$153 =	$615,000	15 yrs
b.	Power house	$ 60,000	50
c.	Substation	$150,000	25
d.	Communication facilities, etc.	$ 55,000	25
e.	Contingency (10%)	$ 90,000	
	Total cost at load center	$970,000	
f.	Distribution system[1/]	$1,270,000	
	Total installation cost	$2,240,000	

1/ See 3-1. Distribution cost (same as the case of hydro-power)

4-2. Annual cost for 50 yrs with 6% of interest rate (at load center)

a. Amortization	
$970,000 x 0.0634 =	$ 61,500
b. Replacement	
Diesel-electric equipment:	
$615,000 x (0.417 + 0.174 + 0.073) x 0.0634 =	$ 25,700
Substation and communication facilities:	
$205,000 x 0.233 x 0.0634 =	$ 3,100
c. O & M costs	
5% of total installation cost:	$ 48,500
d. Fuel cost	
consuming 0.23 kg/kWh of fuel, consting ¢3.15/kg:	
12,970 MWh x @$7.2/MWh =	$ 93,400
Total	$232,200

Cost/kWh $232,200/12,970 MWh = ¢1.79/kWh

Capitalized the above for 50 yrs
$232,200/0.0634 = $3.66 million

(At distributed end)1/

Total: $149,700

Cost/kWh: $149,700/10,400 MWh = ¢1.44/kWh

Capitalized the above for 5p yrs
$149,700/0.0634 = $2.36 million

1/ See 3-2. Annual cost of distribution for 50 yrs with 6% of interest rate. (same as the case of hydro-power)

4-3. Total Diesel-electric power cost per kWh

¢1.79/kWh + ¢1.44/kWh = <u>¢3.23/kWh</u>

Table A-13 Cost Allocation of Alternate Project Plan (3)

in million US$

Item	Irrigation (i=3%)	Power (i=6%)	Flood control (i=3%)	Fishery (i=3%)	Total
a. Benefits	91.40	4.86	0.56	0.30	97.12
b. Alternate Costs	34.73	9.67	6.69	5.22	56.31
Installation	23.70	6.96	4.83	3.77	39.26
O & M	11.03	2.71	1.86	1.45	17.05
c. Specific Costs	27.44	4.15	-	0.05	31.64
Installation	18.44	2.49	-	0.04	20.97
O & M	9.00	1.66	-	0.01	10.67
d. Lesser of a or b	34.73	4.86	0.56	0.30	40.45
e. Separable Costs	0.59	0.64	0	0	1.23
Installation	0.48	0.52	0	0	1.00
O & M	0.11	0.12	0	0	0.23
f. Remaining Benefit (d - c - e)	6.70 (88.4%)	0.07 (0.9%)	0.56 (7.4%)	0.25 (3.3%)	7.58 (100%)
g. Allocated Joint Costs	5.28	0.05	0.44	0.19	5.91
Installation	4.23	0.04	0.35	0.16	4.78
O & M	1.00	0.01	0.09	0.03	1.13
h. Total Allocated Dam Costs	5.82 (81.5%)	0.69 (9.6%)	0.44 (6.2%)	0.19 (2.7%)	7.14 (100%)
Installation	4.71	0.56	0.35	0.16	5.78
O & M	1.11	0.13	0.09	0.03	1.36
i. Total Project Costs	33.26	4.84	0.44	0.24	38.78
Installation	23.15	3.05	0.35	0.20	26.75
O & M	10.11	1.79	0.09	0.04	12.03
j. Benefit Cost Ratio a/i	2.75	1.02	1.27	1.25	2.50

Table A-14 Basic Data for Cost Allocation (3)

in million US$

Item	Power[1] at load center	Power[1] distribution	sub total	Irrigation	Flood control	Fishery
a. Benefits	3.10	1.76	4.86	91.40	0.56	0.36
b. Specific cost	2.39	1.76	4.15	27.44	-	0.05
b-1 Installation	1.54	0.95	2.49	18.44[2]	-	0.04
b-2 O & M Costs	0.85	0.81	1.66	9.00[3]	-	0.01
c. Alternate dam cost			4.47	5.26	4.83	3.73
c'. O & M costs for c			1.05	2.03	1.86	1.44
d. Alternate costs (b-1) + (c)			6.96	23.70	4.83	3.77
d'. O & M costs for d (b-2) + (c')			2.71	11.03	1.86	1.45
e. Dam costs with that purpose omitted			5.26	5.30	5.78	5.78
e'. O & M costs for e			1.24	1.25	1.36	1.36
f. Multipurpose dam cost			5.78			
f'. O & M costs for f			1.36			

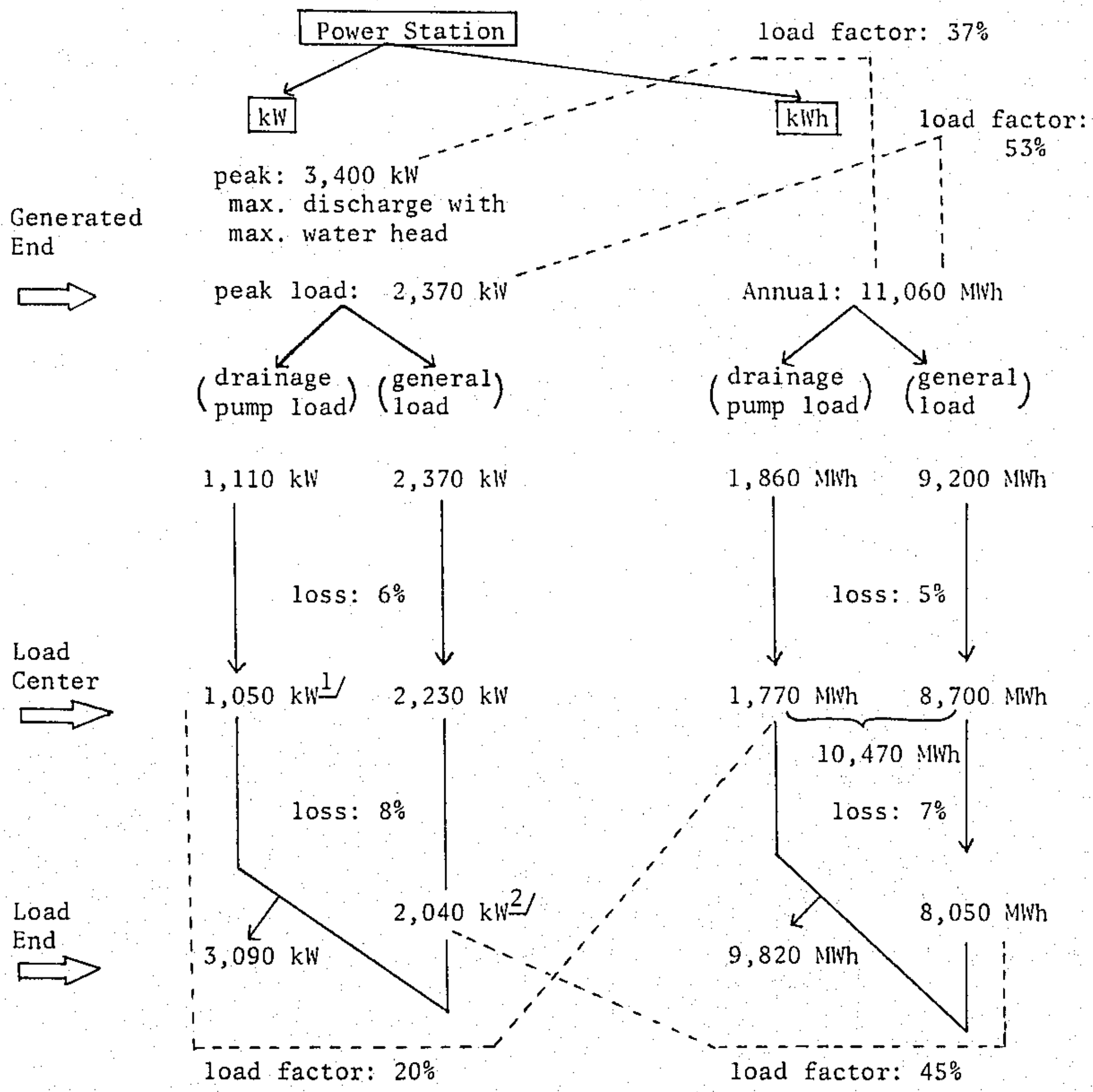
1/ See next page and thereafter, "estimation of power energy balance and power cost".

2/ See Table A-5

3/ 2% of construction cost for division I and 1.5% for division II and III. Capitalized by 3% interest rate for 50 yrs.

Estimation of power energy balance (3)

- Alternate plan, gravity irrigation case -



1/ Drainage pumps: 1,050 kW

2/ Domestic use: 1,600 kW (7,500 houses), public use: 60 kW, General industrial use: 380 kW

Estimation of Annual Cost and Benefit of Hydro-power

- Alternate plan, gravity irrigation case (3) -

1. Basic items:

Maximum output	3,400 kW	
Peak load	2,370 kW	
Annual power delivery	11,060 MWh	(generated end)
	10,470 MWh	(load center)
	9,820 MWh	(distributed, for general use)
Load factor to max. output	37%	(generated end)
Load factor to peak load	53%	(generated end)

2. Cost at load center

2-1. Initial installation1/ in US$1,000

		(cost)	(useful lives)
a.	Power house	160	50 yrs
b.	Foundation treatment	75	50
c.	Penstocks and intake	80	50
d.	Turbines & generators	600	35
e.	Transmission line (45 km)	290	50
f.	Substation	150	25
g.	Communication facilities, etc.	45	25
h.	Contingency (10%)	140	
	Total	1,540	

1/ excluding dam cost allocated to power

2-2. Annual cost (excluding dam cost allocated to power) for 50 yrs with 6% of interest rate

a. Amortizarion of installation cost

$1,540,000 x 0.0634 =	$ 97,600

b. Replacement

Turbine and generators:

$600,000 x 0.130 x 0.0634 =	$ 4,900

Substation and communication facilities:

$195,000 x 0.233 x 0.0634 =	$ 2,900

c. O & M costs

3% of total installation cost:	$ 46,200
Total	$151,600

Cost/kWh

$151,600/10,470 MWh = <u>¢1.45/kWh</u>

Capitalized the above for 50 yrs

$151,600/0.0634 = <u>$2.39 million</u>

3. Cost at distributed end

3-1. Distribution cost in US$1,000

		(cost)	(useful lives)
a.	Distribution line Concrete pole, wire, foundation, etc.	590	35 yrs
b.	Equipment pole trans, CB, etc.	245	25
c.	Communication facilities	30	25
d.	Contingency (10%)	85	
	Total	950	

3-2. Annual cost of distribution for 50 yrs with 6% of interest rate

a. Amortization

$950,000 x 0.0634 =	$ 60,200

b. Replacement

Distribution line:

$590,000 x 0.130 x 0.0634 =	$ 4,900

Equipment and facilities:

$275,000 x 0.233 x 0.0634 =	$ 4,100

c. O & M costs

4.5% of total distribution cost:	$ 42,800
Total	$112,000

Cost/kWh $112,000/8,050 MWh =	¢1.39/kWh

Capitalized the above for 50 yrs

$112,000/0.0634 =	$1.76 million

4. Cost of alternate Diesel-electric plant

4-1. Installation cost

		(cost)	(useful lives)
a.	Diesel-electric equipment 3,400 kW x @$153 =	$520,000	15 yrs
b.	Power house	$ 50,000	50
c.	Substation	$150,000	25
d.	Communication facilities, etc.	$ 55,000	25
e.	Contingency (10%)	$ 75,000	
	Total cost at load center	$850,000	
f.	Distribution system[1/]	$950,000	
	Total installation cost	$1,800,000	

1/ See 3-1. Distribution cost (Same as the case of hydro-power)

4-2. Annual cost for 50 yrs with 6% of interest rate (at load center)

a. Amortization

$850,000 x 0.0634 =	$ 53,900

b. Replacement

Diesel-electric equipment:

$520,000 x (0.417 + 0.179 + 0.073) x 0.0634 =	$ 21,900

Substation and communication facilities:

$205,000 x 0.233 x 0.0634 =	$ 3,100

c. O & M costs

5% of total installation cost:	$ 42,500

d. Fuel cost

consuming 0.23 kg/kWh of fuel,

costing ¢3.15/kg:

10,470 MWh x @$7.2/MWh =	$ 75,400
Total	$196,800

Cost/kWh $196,800/10,470 MWh =	¢1.88/kWh
Capitalized the above for 50 yrs $196,800/0.0634 =	$3.10 million

(At distributed end)1/

Total:	$112,000
Cost/kWh: $112,000/8,050 MWh =	¢1.39/kWh
Capitalized the above for 50 yrs $112,000/0.0634 =	$1.76 million

1/ See 3-2. Annual cost of distribution for 50 yrs with 6% of interest rate (Same as the case of hydro-power)

4-3. Total Diesel-electric power cost per kWh

¢1.88/kWh + ¢1.39/kWh = ¢3.27/kWh

Table A-15 Cost Allocation in Original Project Plan (1)

- taking 6% of interest rate for each purpose -

(US\$ 10^6)

Item	Irrigation	Power	Flood Control	Fishery	Total
a. Benefits	48.00	7.21	0.34	0.18	55.73
b. Alternate Costs	30.78	10.38	5.97	4.66	
c. Specific Costs	24.28	4.41	-	0.05	
d. Lesser of a and b	30.78	7.21	0.34	0.18	
e. Separable Costs	0.59	0.64	-	-	1.23
f. Remaining Benefits	5.91 (69.3%)	2.16 (25.2%)	0.34 (4.0%)	0.13 (1.5%)	8.54 (100%)
g. Allocated Joint Costs	4.09	1.49	0.24	0.09	5.91
h. Total Allocated Dam Costs	4.68	2.13	0.24	0.09	7.14
i. Total Project Costs	28.96	6.54	0.24	0.14	35.88
j. Benefit-Cost Ratio	1.65	1.10	1.42	1.29	1.55

Table A-16 Basic Data for Cost Allocation in Original Plan (1)

- taking 6% of interest rate for each purpose -

(US$ 10^6)

Item	Power	Irrigation	Flood control	Fishery
a. Benefit	7.21	48.00	0.34	0.18
b. Specific cost	4.41	24.28	-	0.05
b-1 Installation	2.66	17.68	-	0.04
b-2 O & M costs	1.75	6.60	-	0.01
c. Alternate dam cost	4.83	5.26	4.83	3.73
c'. O & M costs for c	1.14	1.24	1.14	0.88
d. Alternate costs (b-1) + (c)	7.49	22.94	4.83	3.77
d'. O & M costs for d (b-2) + (c')	2.89	7.84	1.14	0.89
e. Dam cost with that purpose omitted	5.26	5.30	5.78	5.78
e'. O & M costs for e	1.24	1.25	1.36	1.36
f. Multipurpose dam cost		5.78		
f'. O & M costs for f		1.36		

Table A-17 Cost Allocation in Alternate Project Plan (3)

- taking 6% of interest rate for each purpose -

(US$ 10^6)

Item	Irrigation	Power	Flood Control	Fishery	Total
a. Benefit	48.00	4.86	0.34	0.18	53.38
b. Alternate Costs	30.46	9.67	5.97	4.66	
c. Specific Costs	23.96	4.15	-	0.05	
d. Lesser of a and b	30.46	4.86	0.34	0.78	
e. Separable Costs	0.59	0.64	-	-	1.23
f. Remaining Benefits	5.91 (91.6%)	0.07 (1.1%)	0.34 (5.3%)	0.13 (2.0%)	6.45
g. Allocated Joint Costs	5.41	0.07	0.31	0.12	5.91
h. Total Allocated Dam Costs	6.00	0.71	0.31	0.12	7.14
i. Total Project Costs	29.96	4.86	0.31	0.17	35.30
j. Benefit-Cost Ratio	1.60	1.00	1.10	1.06	1.51

Table A-18 Basic Data for Cost Allocation in Alternate Plan (3)

- taking 6% of interest rate for each purpose -

(US$ 10^6)

Item	Power (2)	Power (3)	Irriga-tion	Flood Control	Fishery
a. Benefit	6.02	4.86	48.00	0.34	0.18
b. Specific cost	5.36	4.15	23.96	-	0.05
b-1 Installation	3.19	2.49	18.44	-	0.04
b-2 O & M costs	2.17	1.66	5.52	-	0.01
c. Alternate dam cost	4.47	4.47	5.26	4.83	3.73
c'. O & M costs for c	1.05	1.05	1.24	1.14	0.88
d. Alternate costs (b-1) + (c)	7.66	6.96	23.70	4.83	3.77
d'. O & M costs for d (b-2) + (c')	3.22	2.71	6.76	1.14	0.89
e. Dam cost with that purpose omitted	5.26	5.26	5.30	5.78	5.78
e'. O & M costs for e	1.24	1.24	1.25	1.36	1.36
f. Multipurpose dam cost		5.78			
f'. O & M costs for f		1.36			

A-3-2. The case of providing diversion dam at Andaot

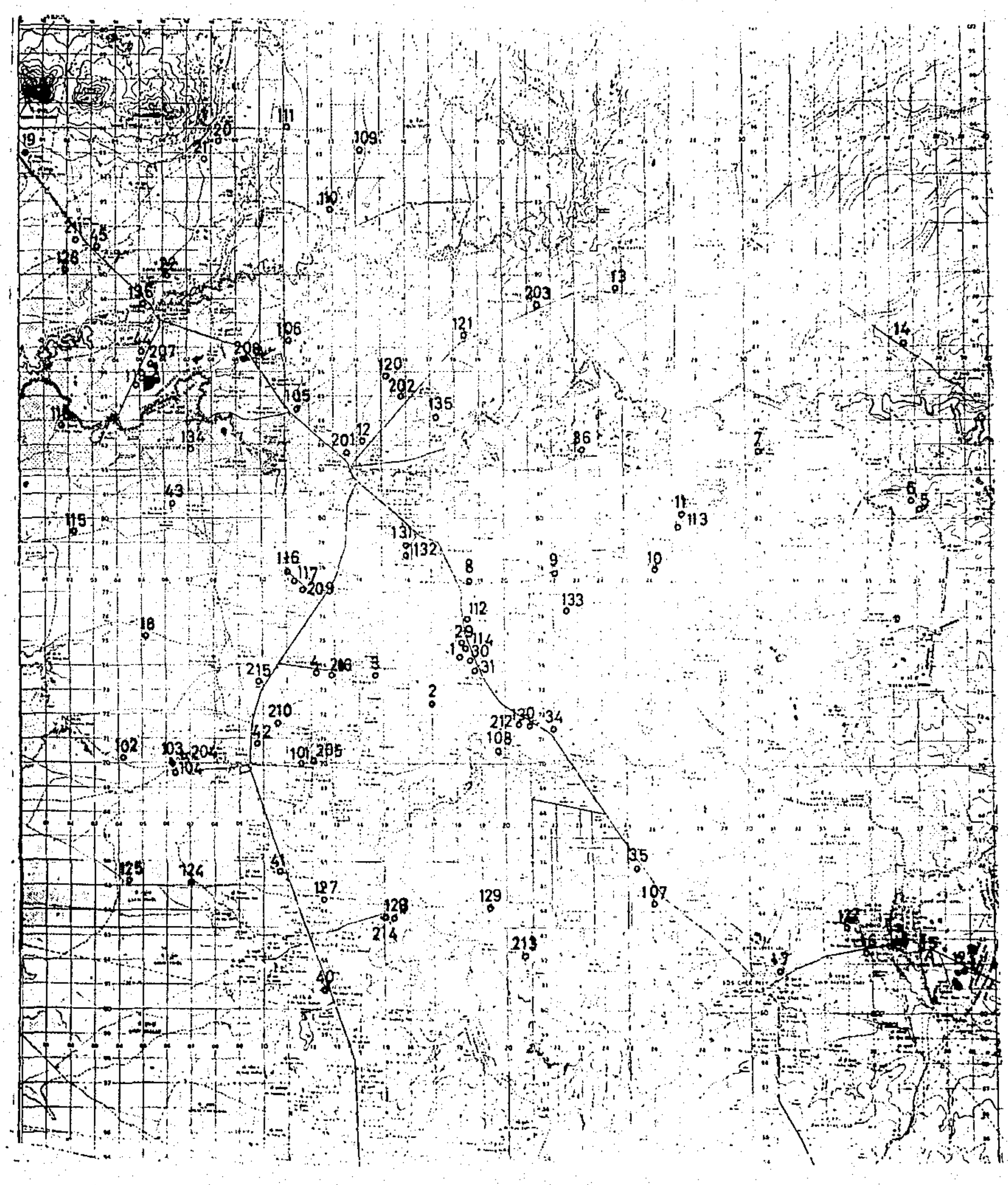
The possible diversion dam sites have been studied for the both cases of selecting the location at Kg. Thma or Andaot. The Andaot diversion dam is situated at about 20 km upstream of the Kg. Thma site, and the intake water level shall be EL 20 m.

The construction cost of the Andaot diversion dam shall be $1,440,000, while that of the Kg. Thma diversion dam shall be $1,155,000. In addition, in the case of Andaot, the hydro-electric power to be generated at the main dam site shall be decreased remarkably, since the available maximum water head is reduced to 11.2 m from 16.2 m in the case of Kg. Thma diversion dam.

Therefore, the plan of adopting the Kg. Thma diversion dam is more advantageous than the alternate plan.

A-4 Soil

(1) Fig. A-1 Map of Location and Number of Pit



(2) Description of Profile

Profile No. 21

Alluvial Soil, coarse-textured

Location; Ph. Chhuk, Kh. Tang Krasang, Sr. Santuk, Kg. THOM
Parent material; fluvial deposits of coarse texture
Topography; flood plain (natural levee), flat, 18m above sea level
Plant cover; bushy ground

Ap 0-20cm, dull reddish brown (5YR 5/4); S; massive; compact (22mm); dry; sharp smooth boundary.

C 20cm+, dull reddish borwn (5YR 5/4) (a little lighter than Ap); S.

Profile No. 12

Low Humic Gley Soil, Grayish Brown Soil, coarse-textured

Location; Ph. Khley, Kh. Kg. Thma, Sr. Santuk, Kg. THOM
Parent material; fluvial deposit of coarse texture
Topography; flood plain, flat, 15m above sea level
Land use; paddy field

Apg 0-12cm, dull reddish brown (5YR 5/4); FS; massive; common rusty mottlings; slightly compact(15mm); dry; gradual boundary.

B21g 12-40cm, grayish brown (7.5YR 5/2); LFS; massive; abundant bright brown (7.5YR 5/6) mottlings; compact(22mm); dry; gradual boundary.

B22g 40-70cm, brownish gray (7.5YR 6/1); LFS; massive; many bright brown (7.5YR 5/6) mottlings; compact (22mm) ; dry.

Cg 70cm+, brownish gray (7.5YR 6/1); LFS; common rusty mottlings; slightly compact (18mm); dry.

Profile No. 120

Low Humic Gley Soil, Grayish Brown Soil, medium textured

Location; Ph. Bek Chiem, Kh. Kg. Thma, Sr. Baray, KG. THOM
Parent material; fluvial deposit of medium texture
Topography; flood plain, flat, 17 m above sea level
Land use; Paddy field

Apg 0-13cm, yellowish gray (2.5Y 5/1); SL; massive; few thready mottlings; extremely compact (31mm); dry; sharp smooth boundary.

B1g 13-29cm, brownish gray (10YR 5.5/1); SL; massive; common thready mottlings; extremely compact (31mm); dry; gradual boundary.

B21g 29-65cm, yellowish gray (2.5Y 5.5/1); CL; massive; common cloudy mottlings (10YR 5/4) and few speckled mottlings (2.5YR 4/6); compact (24mm); semi-moist; gradual boundary.

B22g 65-86cm, gray (5Y 6/1); CL; massive; common cloudy mottlings (10YR 5/4) and common iron concretions (2/5YR 3/4); compact (24mm); semi-moist to moist; clear boundary.

B23g 86cm+, gray (5Y 6/1); CL; massive; common cloudy mottlings (7.5YR 4/4) and many speckled mottlings (2.5YR 3/6); very compact (25mm); moist.

Profile No. 115

Low Humic Gley Soil, Grayish Brown Soil, medium-textured

Location; 12 km west of Kg. Thma (inundation area of Tonle Sap)
Parent material; lacustrine deposits of medium texture
Topography; coastal plain of Tonle Sap , flat, 7 to 8m above sea level
Plant cover; grassland

Ag 0-12cm, brownish gray (10YR 3.5/1); SL; massive; few thready mottlings; compact (24mm); dry; sharp boundary.

B1g 12-21cm, grayish brown (7.5YR 5/2); SL; massive; common to many thready mottlings; compact (24mm), semi-moist to moist; clear boundary.

B21g 21-40cm, brownish gray (7.5YR 5/1); L; massive; common thready mottlings, abundant speckled (7.5YR 4/6) mottlings; compact (24mm); semi-moist to moist; clear boundary.

B22g 40-67cm, brownish gray (10YR 5/1); SCL; massive; many speckled mottlings (7.5YR 4/6) and many iron concretions (2.5YR 3/4); compact (22mm); moist; gradual boundary.

B23g 67cm+, yellowish gray (2.5Y 6.5/1); SCL; massive; many speckled mottlings (7.5YR 4/6) and many iron concretions (2.5YR 3/4); compact (22mm); moist.

Profile No. 124

Low Humic Gley Soil, Grayish Brown Soil, medium-textured

Location; Ph. Kamchang Meas, Kh. Triel, Sr. Baray, KG. THOM
Parent material; fluvial deposit of medium tecture
Topography; flood plain, flat, 12m above sea level
Land use; paddy field

Apg 0-16cm, yellowish gray (2.5Y 5/1); CL; massive; common thready mottlings and few filmy mottlings; compact (19mm); semi-moist to moist; clear boundary.

B21g 16-26cm, brownish gray (10YR 5/1); L; massive; common to many thready mottlings; extremely compact (29mm); semi-moist to moist; sharp wavy boundary.

B22g 26-43cm, yellowish gray (2.5Y 6/1); CL; massive; abundant cloudy mottlings (7.5YR 4/6) and few thready mottlings; extremely compact (29mm); semi-moist to moist; clear wavy boundary.

B23g 43-81cm, yellowish gray (2.5Y 6/1); L; massive; many cloudy mottlings (7.5YR 4/6) and few speckled mottlings (2.5YR 3/6); compact (24mm); moist; clear boundary.

Cg 81cm+, Laterite pan (iron and manganese stones are conneted each other to form a hard cemented layer).

Profile No. 42

Low Humic Gley Soil, Grayish Brown Soil, medium-textured

Location; Kh. Baray, Sr. Baray, KG. THOM
Parent material; recent lacustrine deposits of medium texture
Topography; coastal plain of Tonle Sap, flat, 10m above sea level
Land use; paddy field

Apg 0-15cm, grayish yellow brown (10YR 5/2); SL; massive; common rusty mottlings; compact; dry; sharp smooth boundary.

B21g 15-45cm, grayish yellow brown (10YR 5/2); SL; massive; abundant bright brown (7.5YR 5/8) mottlings; compact; dry; sharp smooth boundary.

B22g 45-90cm, dull yellowish orange (10YR 6/3); SCL; abundant reddish brown (5YR 4/8) mottlings; compact; dry.

Profile No. 18

Low Humic Gley Soil, Grayish Brown Soil, fine-textured

Location; Kh. Chong Dong, Sr. Baray, KG. THOM
Parent material; recent lacutrine deposits of fine texture
Topography; coastal plain of Tonle Sap, flat, 7m above sea level
Plant cover; grassland

A11g 0-4cm, brownish black (10YR 2/2); L; weak blocky structure; abundant roots; very compact (26mm); sharp smooth boundary.

A12g 4-8cm, brownish black (10YR 2/2); L, weak blocky structure; many roots; very compact (26mm); sharp wavy boundary.

A3g 8-14cm, grayish yellow brown (10YR 4/2); CL; weak blocky structure; many yellowish brown (10YR 5/8) mottlings; very compact (28mm); dry; sharp wavy boundary.

B1g 14-30cm, grayish yellow brown (10YR 6/2); HC; weak blocky structure; many yellowish brown (10YR 5/8) mottlings; very compact (28mm); dry; gradual boundary.

B21g 30-85cm, grayish yellow brown (10YR 6/2); HC; weak blocky structure; many reddish brown (2.5YR 4/8) mottlings; very compact (28mm); dry; sharp smooth boundary.

B22g 85cm+, yellowish gray (2.5Y 6/1); HC; massive; many dark reddish brown (2.5YR 3/6) mottlings; dry.

Profile No. 44

Low Humic Gley Soil, Grayish Brown Soil, fine-textured

Location; Ph. Chambak, Kh. Tang Krasang, Sr. Santuk, KG. THOM
Parent material; recent lacustrine deposits of fine texture
Topography; flood plain, flat, approximately 11m above sea level
Land use; paddy field

Apg 0-10cm, brownish black (10YR 3/1); SiCL; blocky structure; extremely compact (29mm); dry; gradual boundary.

A12g 10-20cm, brownish black (10YR 3/1); SiCL; blocky structure; common brown (7.5YR 4/6) mottlings; extremely compact (29mm); dry; gradula boundary.

B1g 20-30cm, brownish gray (7.5YR 4/1); SiCL; blocky structure; many brown (7.5YR 4/6) mottlings; very compact (27mm); dry; gradual boundary.

B21g 30-65cm, brownish gray (7.5YR 5/1); SiCL; massive; abundant reddish brown (5YR 4/8) mottlings; very compact (28mm); dry; gradual boundary.

B22g 65cm+, grayish brown (7.5YR 5/2); SiCL; massive; abundant yellowish brown (10YR 5/8) mottlings; extremely compact (36mm); dry.

Profile No. 118

Low Humic Gley Soil, Grayish Brown Soil, fine-textured

Location; Ph. Kang Meas, Kh. Tnaot Chum, Sr. Baray, KG. THOM
Parent material; lacustrine deposits of fine texture
Topography; coastal, plain of Tonle Sap, flat, approximately 9m above sea level
Land use; paddy field

Apg 0-16cm, gray (N 6/); LiC; massive; common thready and cloudy mottlings; extremely compact (31mm); dry; sharp smooth boundary.

B21g 16-40cm, brownish gray (10YR 5/1); HC; blocky structure; common thready and speckled mottlings, abundant cloudy mottlings; extremely compact (31mm); dry to semi-moist; gradual boundary.

B22g 40-66cm, brownish gray (10YR 5/1); HC; blocky structure; abundant cloudy mottlings, common speckled mottlings, few small specks and threads of manganese; very compact (28mm); dry to semi-moist; gradual boundary.

B23g 66cm+, brownish gray (7.5YR 5.5/1); LiC; massive; common cloudy mottlings (7.5YR 4/2), common small black specks of manganese, few speckled mottlings (7.5YR 5/6); very compact (25mm); semi-moist to moist.

Profile No. 122

Low Humic Gley Soils, Gray Soil

Location; Ph. Banteay Chey, Kh. Banteay Chey, Sr. Chamcaleu, KG. CHAM
Parent material; fluvial or colluvial deposits from the surrounding basalt plateau
Topography; valley plain, flat, approximately 37m above sea level
Land use; paddy field

Apg 0-17cm, gray (N 4/); LiC; massive; many thready and filmy mottlings; slightly compact (14mm); moist; clear boundary.

B21g 17-35cm, gray (N 4/); LiC; massive; many cloudy mottlings (7.5YR 4/4) and few thready mottlings, few small black specks of manganese; compact (20mm) moist; clear boundary.

B22g 35-72cm, gray (N 5/); HC; fine blocky structure, of which surfaces are lustrous; common cloudy mottlings (2.5Y 4/3), few small reddish brown and black specks; slightly compact (18mm); moist; gradual boundary.

Cg 72cm+, grayish olive (5Y 4/2); HC; fine blocky structure, of which the surfaces are lustrous; many cloudy mottlings (2.5Y 4/3), few speckled mottlings; slightly compact (15mm); moist.

Profile No.3

Vertisol, hydromorphic

Location; Ph. Beng, Kh. Beng, Sr. Baray, KG. THOM
Parent material; weathering product of basalt
Topography; basalt plateau, flat, 15m above sea level
Land use; paddy field

Apg 0-7cm, grayish yellow brown (10YR 4/2); CL; blocky structure; slightly compact (17mm); dry; sharp smooth boundary.

B2g 7-35cm, brownish black (10YR 2/3); CL: common manganese concretions many very fine subangular and rounded gravels; very compact (25mm); dry; sharp smooth boundary.

C 35cm+, gray (10Y 4/1), HC; common manganese concretions, many very fine rounded iron concretions ("buck-shot" concretion); slightly compact (17mm); dry.

Profile No. 112

Vertisol, hydromorphic

Location; Ph. Sralau Tong, Kh. Beng, Sr. Baray, KG. THOM
Parent material; weathered products of basalt
Topography; basalt plateau, undulating, approximately 33m above sea level
Land use; paddy field

Apg 0-14cm, yellowish gray (2.5Y 4/1); LiC; common thready and filmy mottlings, common to many very fine rounded iron concretions ("buck-shot" concretion); compact (24mm); semi-moist; sharp boundary.

Bg 14-32cm, gray (7.5Y 5/1); LiC; common cloudy mottlings, common manganese concretions, abundant very fine rounded iron concretions ("buck-shot" concretion); very compact (28mm); semi-moist; clear boundary.

C1 32-46cm, gray (N 5/); HC: massive; abundant very fine rounded iron concretions ("buck-shot" concretion); compact (24mm); moist; clear wavy boundary.

C2 46-56cm, gray (N 5/); HC; massive; few speckled mottlings; slightly compact (17mm); moist; clear wavy boundary.

C3 56-94cm, gray (7.5Y 5/1); LiC; massive; many cloudy mottlings, few small black specks of manganese, few very fine rounded iron concretion; compact (19mm); moist.

R 94cm+, decayed basalt.

Profile No. 113

Vertisol, hydromorphic

Location; Ph. Krava, Kh. Krava, Sr. Baray, KG. THOM
Parent material; fluvial or colluvial deposits from the surrounding basalt plateau
Topography; valley plain, flat, between 15-20m above sea level
Land use; paddy field

Apg 0-15cm, gray (7.5Y 4/1); LiC; many thready and cloudy mottlings, few very fine rounded iron concretions ("buck-shot" concretion); extremely compact (34mm); dry; sharp boundary.

B2g 15-35cm, gray (7.5Y 4/1); LiC many cloudy mottlings (7.5YR 3/3), common small black concretions of manganese, few very fine rounded iron concretions ("buck-shot" concretion); very compact (26mm); dry to semi-moist; clear boundary.

B3g 35-58cm, gray (10Y 4/1); LiC; weak blocky structure; common cloudy mottlings (7.5YR 3/3), few small black concretion of manganese, few very fine rounded iron concretions ("buck-shot" concretion); compact (24mm); semi-moist; gradual boundary.

C 58cm+, gray (N 4/): HC; moderate fine blocky structure, of which the surfaces are lustrous (slickenside); compact (19mm); moist.

Profile No.5

Vertisol, lithic

Location; Ph. Andaot, Kh. Krava, Sr. Baray, KG. THOM
Parent material; weathering products of basalt
Topography; basalt plateau, gently undulating, 20m above sea level
Plant cover; clear forest

A11 0-10m, brownish black (5YR 3/1); L; many fine subangular gravel; compact (19mm); many roots; dry; sharp smooth boundary.

A12 10-16cm, brownish black (10YR 3/2); CL; abundant fine to medium subangular gravels; compact (23mm); sharp smooth boundary.

C 16-25cm, yellowish gray (2.5Y 5/1); HC: abundant fine to medium subangular gravels; dry; clear smooth boundary.

R 25cm+, basement rock of basalt.

Profile No. 2

Vertisol, lithic

Location; Ph. Sralau Tong, Kh. Beng, Sr. Baray, KG. THOM

Parent material; weathering products of basalt

Topography; basalt plateau, undulating, approximately 25m above sea level

Plant cover; clear forest

A1 0-10cm, brownish black (7.5YR 3/2); CL; many very fine to fine angular gravels; slightly compact (11mm); dry; sharp smooth boundary.

C 10-27cm, yellowish gray (2.5Y 5/1); L; many very fine to fine angular gravels; slightly compact (18mm); dry; clear smooth boundary.

R 27cm+, olive gray (10Y 6/2) colored basement rock of decayed basalt.

Profile No. 29

Vertisol, cambic

Location; Ph. Sralau Tong, Kh. Beng, Sr. Baray, KG. THOM
Parent material; weathering products of basalt
Topography; basalt plateau, undulating, approximately 33m above sea level
Plant cover; clear forest

A11 0-15cm, brownish black (7.5YR 3/2); CL; fine blocky structure; common subangular gravels; compact (24mm); dry; sharp smooth boundary.

A12 15-30cm, brownish black (10YR 3/2); CL; granular structure; common subangular gravels; slightly compact (18mm); dry; sharp smooth boundary.

C1 30-43cm, dark brown (7.5YR 3/3); CL; abundant very fine subangular gravels; gradual boundary.

C2 43-60cm, dark brown (10YR 3/3); CL; abundant fine to medium subangular gravels; gradual boundary.

C3 60-80cm, grayish yellow brown (10YR 4/2); subangular gravel layer.

R 80cm+, basement rock of weathered basalt, gray (5Y 5/1)in color.

Profile No. 17

Vertisol, cambic

Location; Ph. Thnal Bek, Kh. Banteay Chey, Sr. Chamcaleu, KG. CHAM
Parent material; weathering products of basalt
Topography; basalt plateau, undulating, 40m above sea level
Plant cover; clear forest

A11 0-10cm, brownish black (7.5YR 3/2); L; fine blocky structure; very compact (28mm); dry; clear smooth boundary.

A12 10-20cm, dark brown (7.5YR 3/3); L; fine blocky structure; extremely compact (35mm); dry; clear smooth boundary.

A13 20-33cm, brown (7.5YR 4/4); L; fine blocky structure; very compact (25mm); dry; clear smooth boundary.

C1 33-65cm, reddish brown (5YR 4/6); CL; fine blocky structure; very fine subangular gravels; very compact (25mm); dry; sharp smooth boundary.

C2 65-90cm, brown (7.5YR 4/6); CL; abundant very fine subangular gravels; very compact (27mm); dry; clear smooth boundary.

R 90cm+, basement rock of basalt.

Profine No. 107

Latosol

Location; Ph. Caoutchouc, Kh. Chamkar Andong, Sr. Chamcaleu, KG. CHAM
Parent material; weathered products of basalt
Topography; basalt plateau, gently undulating, 90m above sea level
Land use; rubber plantation

A 0-20cm, dark reddish brown (10R 3/3.5); LiC; granular and blocky structure; few small black specks of manganese; extremely compact (31mm); dry; gradual boundary.

B21 20-69cm, dark red (10R 3/4); LiC; massive; extremely compact (29mm); dry to semi-moist; gradual boundary.

B22 69cm+, dark red (10R 3/4); LiC; massive, breaking into fine granular structure; compact (24mm), semi-moist.

Profile No. 1

Latosol

Location; Ph. Sralau Tong, Kh. Beng, Sr. Baray, KG. THOM
Parent material; weathering products of basalt
Topography; basalt plateau, undulating, 35m above sea level
Land use; banana field

A1 0-7cm, dark reddish brown (5YR 3/3); LiC; blocky structure; very compact (26mm); dry; sharp smooth boundary.

B11 7-23cm, dark reddish brown (2.5YR 3/4); CL; blocky structure; very compact (27mm); dry; clear smooth boundary.

B12 23-40cm, dark reddish brown (2.5YR 3/4); CL; abundant very fine to fine subangular gravels; very compact (27mm); dry; gradual boundary.

B2 40-85cm, dark reddish brown (2.5YR 3/6); CL; abundant very fine to fine subangular gravels; very compact (26mm); dry; gradual boundary.

B3 85-100cm, dark reddish brown (2.5YR 3/6); CL; many medium subangular gravels; sharp boundary.

R 100cm+, layer of semi-weathered gravels of basalt, dull yellow orange (10YR 7/3).

Profile No. 14

Red Yellow Podsolic Soil

Location; Ph. Thma Samlieng, Kh. Viel Thom, Sr. Santuk, KG. THOM
Parent material; old lacustrine deposits of coarse texture
Topography; tableland, flat, 40m above sea level
Plant cover; dense tropical forest

A1 0-3cm, dull brown (7.5YR 5/4); FSL; blocky structure; dry; sharp smooth boundary.

A2 3-20cm, bright brown (7.5YR 5/6); FSL; blocky structure; common roots; compact (19mm); dry; gradual boundary.

B21 20-45cm, bright brown (7.5YR 5/8); FSL; blocky structure; very compact (25mm); dry; gradual boundary.

B22 45-70cm, bright reddish brown (5YR 5/8); L; blocky structure; very compact (25mm); dry; sharp smooth boundary.

IIB23 70cm+, bright reddish brown (5YR 5/8); L; abundant unweathered angular gravels; compact (22mm); dry.

(3) Analytical result

Analytical data of Profile No.21

Alluvial Soil, coarse textured

on dry basis

	Depth	Gravel	Particle Size Distribution				Texture	Maximum water capacity	pH		Exch. acidity
			Co.S.	F.S.	Silt	Clay					
	cm	%	2-0.2mm	0.2-0.02mm	0.02-0.002mm	<0.002mm			H_2O	KCL	Y_1
1.	0 - 20	-	34.3	60.9	3.9	1.0	FS	-	4.45	4.25	1.0
2.	20 -	-	36.5	56.3	4.1	3.1	FS	-	5.00	4.50	0.8

	Organic Matter			Cation exch. cap. meg.	Exchangeable Bases meg.				Total	Base satur. %	P_2O_5 absorption coeff.
	Carbon %	Nitrogen %	C/N ratio		Ca	Mg	K	Na			
1.	0.21	0.03	7.0	1.32	0.83	tr.	0.06	0.25	1.14	86.4	-
2.	0.08	0.02	3.3	0.43	0.22	tr.	0.05	0.16	0.43	100.0	-

Analytical data of Profile No.12

Grayish Brown Soil, coarse-textured

on dry basis

	Depth	Gravel	Particle Size Distribution Co.S.	F.S.	Silt	Clay	Texture	Maximum water capacity	pH H_2O	pH KCL	Exch. acidity Y_1
	cm	%	2-0.2mm	0.2-0.02mm	0.02-0.002mm	<0.002mm					
1.	0 - 12	-	8.5	76.6	7.7	7.3	LS	-	4.52	4.38	2.50
2.	12 - 40	-	9.5	62.9	13.1	14.5	FSL	-	4.90	4.04	2.75
3.	40 - 70	-	10.0	61.5	16.1	12.3	FSL	-	5.10	4.10	2.65
4.	70 -	-	10.1	61.0	12.5	16.6	SCL	-	5.10	4.08	3.15

	Organic Matter Carbon %	Nitrogen %	C/N ratio	Cation exch. cap. meg.	Exchangeable Bases meg. Ca	Mg	K	Na	Total	Base satur. %	P_2O_5 absorption coeff.
1.	0.22	0.03	6.9	12.93	1.04	0.63	0.05	-	-	-	-
2.	0.14	0.03	4.1	1.76	0.85	0.21	0.05	-	-	-	-
3.	0.08	0.02	4.0	1.95	0.44	0.88	0.04	-	-	-	-
4.	0.05	0.02	2.6	1.86	0.41	0.70	0.06	-	-	-	-

Analytical data of Profile No.120

Grayish Brown Soil, medium-textured

on dry basis

	Depth	Gravel	Particle Size Distribution Co.S.	F.S.	Silt	Clay	Texture	Maximum water capacity	pH H_2O	pH KCL	Exch. acidity Y_1
	cm	%	2-0.2mm	0.2-0.02mm	0.02-0.002mm	<0.002mm					
1.	0 - 13	-	24.4	47.1	15.3	12.2	FSL	36.06	4.8	4.5	13.4
2.	13 - 29	-	24.7	44.4	16.0	14.9	FSL	34.15	4.8	4.0	15.0
3.	29 - 65	-	22.9	39.8	16.4	20.9	SCL	37.40	4.7	4.1	22.6
4.	65 - 86	-	21.9	32.0	15.0	31.1	SC	44.70	4.8	3.9	37.6
5.	86 -	-	17.5	30.6	14.7	37.2	LiC	48.77	4.6	3.9	41.6

	Organic Matter Carbon %	Nitrogen %	C/N ratio	Cation exch. cap. meg.	Exchangeable Bases meg. Ca	Mg	K	Na	Total	Base satur. %	P_2O_5 absorption coeff.
1.	0.77	0.06	12.7	3.48	0	0.17	0.07	0.06	0.30	8.6	158
2.	0.38	0.03	12.9	2.19	0.01	0.07	0.04	0.05	0.17	7.8	137
3.	0.20	0.06	3.1	2.50	0.11	0.21	0.03	0.20	0.55	22.0	137
4.	0.20	0.03	6.4	3.91	0	0.40	0.03	0.07	0.50	12.8	211
5.	0.20	0.03	6.7	4.58	0	0.27	0.02	0.05	0.34	7.4	295

Analytical data of Profile No.115

Red Yellow Podzolic Soil (RYP)

on dry basis

	Depth	Gravel	Particle Size Distribution Co.S.	F.S.	Silt	Clay	Texture	Maximum water	pH		Exch. acidity
	cm	%	2-0.2mm	0.2-0.02mm	0.02-0.002mm	<0.002mm		capacity	H_2O	KCL	Y_1
1.	0 - 12	-	26.2	44.7	16.8	12.3	FSL	56.70	5.0	4.3	9.5
2.	12 - 21	-	25.2	51.1	8.0	15.7	SCL	36.80	4.8	4.1	9.8
3.	21 - 40	-	24.1	47.5	8.5	19.9	SCL	37.01	4.9	4.1	13.1
4.	40 - 67	-	27.1	44.3	5.1	23.5	SCL	39.26	5.1	4.3	13.6
5.	67 -	-	20.9	38.7	6.8	33.6	SC	47.70	5.1	4.3	12.0

	Organic Matter Carbon %	Nitrogen %	C/N ratio	Cation exch. cap. meg.	Exchangeable Bases meg. Ca	Mg	K	Na	Total	Base satur. %	P_2O_5 absorption coeff.
1.	1.87	0.18	10.2	6.19	0	0	0.05	0.08	0.13	2.1	655
2.	0.55	0.07	7.9	2.38	0.15	0	0.02	0.06	0.23	9.7	233
3.	0.32	0.03	12.9	2.20	0.06	0	0.03	0.10	0.19	8.6	190
4.	0.19	0.03	6.9	2.61	0.33	0.02	0.02	0.04	0.41	15.7	211
5.	0.19	0.02	8.4	4.46	0.90	0.15	0.02	0.05	1.12	25.1	296

Analytical data of Profile No.124

Red Yellow Podzolic Soil (RYP)

on dry basis

	Depth	Gravel	Particle Size Distribution				Texture	Maximum water capacity	pH		Exch. acidity
			Co.S.	F.S.	Silt	Clay					
	cm	%	2-0.2mm	0.2-0.02mm	0.02-0.002mm	<0.002mm			H_2O	KCL	Y_1
1.	0 - 16	-	11.4	49.3	9.1	30.2	SC	55.29	5.0	3.9	16.1
2.	16 - 26	-	16.4	53.7	7.9	22.0	SCL	45.98	5.1	4.0	11.8
3.	26 - 43	-	13.7	42.6	14.0	29.7	SC	51.73	5.4	4.6	1.3
4.	43 - 81	-	15.0	41.2	12.2	31.6	SC	51.61	5.6	4.7	1.9
5.	81 -		(Laterite Pan)								

	Organic Matter			Cation exch. cap. meg.	Exchangeable Bases meg.				Total	Base satur. %	P_2O_5 absorption coeff.
	Carbon %	Nitrogen %	C/N ratio		Ca	Mg	K	Na			
1.	1.02	0.09	11.2	8.87	1.60	0.74	0.08	0.13	2.55	28.8	442
2.	0.54	0.05	10.1	5.81	1.23	0.37	0.04	0.12	1.76	30.3	338
3.	0.46	0.03	13.1	6.19	1.51	0.43	0.03	0.12	2.09	33.8	401
4.	0.38	0.04	8.6	6.54	1.81	0.65	0.04	0.12	2.62	40.1	444

Analytical data of Profile No.42

Red Yellow Podzolic Soil (RYP)

on dry basis

	Depth	Gravel	Particle Size Distribution				Texture	Maximum water capacity	pH		Exch. acidity
			Co.S.	F.S.	Silt	Clay			H_2O	KCL	Y_1
	cm	%	2-0.2mm	0.2-0.02mm	0.02-0.002mm	<0.002mm					
1.	0 - 15	-	21.3	50.4	15.7	12.6	FSL	-	4.78	3.93	4.0
2.	15 - 45	-	24.0	46.0	12.4	17.8	SCL	-	4.60	3.87	6.0
3.	45 -	-	23.5	47.1	8.8	21.6	SCL	-	4.80	3.85	5.8

	Organic Matter			Cation exch. cap. meg.	Exchangeable Bases meg.				Total	Base satur. %	P_2O_5 absorption coeff.
	carbon %	Nitrogen %	C/N ratio		Ca	Mg	K	Na			
1.	0.75	0.08	9.6	3.22	1.28	0.64	0.09	0.63	2.64	82.0	-
2.	0.16	0.03	5.5	2.62	0.62	0.21	0.05	0.29	1.17	44.7	-
3.	0.16	0.02	7.3	2.14	0.43	1.08	0.07	0.32	1.90	88.8	-

Analytical data of Profile No.18

Grayish Brown Soil, fine-textured

on dry basis

	Depth	Gravel	Particle Size Distribution Co.S.	F.S.	Silt	Clay	Texture	Maximum water capacity	pH		Exch. acidity
	cm	%	2-0.2mm	0.2-0.02mm	0.02-0.002mm	<0.002mm			H_2O	KCL	Y_1
1.	0 - 4	-	17.0	48.0	10.8	25.0	SCL	-	5.10	3.98	5.0
2.	4 - 8	-	19.0	52.1	11.0	18.0	SCL	-	5.05	3.92	7.0
3.	8 - 14	-	18.5	44.3	10.7	26.5	SC	-	4.92	3.90	9.3
4.	14 - 30	-	13.0	35.6	10.8	40.7	LiC	-	4.92	3.85	12.5
5.	30 - 85	-	12.7	32.7	19.7	34.9	LiC	-	5.20	3.90	15.3
6.	85 -	-	11.8	30.0	14.0	45.0	Lic	-	5.22	3.69	16.0

	Organic Matter carbon %	Nitrogen %	C/N ratio	Cation exch. cap. meg.	Exchangeable Bases meg. Ca	Mg	K	Na	Total	Base satur. %	P_2O_5 absorption coeff.
1.	4.01	0.35	11.6	13.71	2.58	0.43	0.35	0.28	3.64	26.5	-
2.	2.36	0.21	11.5	8.84	1.79	0.22	0.13	0.20	2.34	26.5	-
3.	1.06	0.10	11.2	5.36	1.08	0.43	0.09	0.21	1.81	33.8	-
4.	0.45	0.06	7.5	4.46	1.09	0.65	0.07	0.25	1.96	46.2	-
5.	0.20	0.04	5.6	5.06	1.29	0.64	0.05	0.15	2.13	42.1	-
6.	0.21	0.04	4.9	5.53	1.69	0.70	0.07	0.20	2.66	48.1	-

Analytical data of Profile No.44

Grayish Brown Soil, fine-textured

on dry basis

	Depth	Gravel	Particle Size Distribution				Texture	Maximum water capacity	pH		Exch. acidity
			Co.S.	F.S.	Silt	Clay			H_2O	KCL	Y_1
	cm	%	2-0.2mm	0.2-0.02mm	0.02-0.002mm	<0.002mm					
1.	0 - 10	-	1.4	34.1	22.2	42.2	LiC	-	4.73	3.62	16.0
2.	10 - 20	-	1.9	31.0	18.5	47.8	HC	-	4.70	3.65	12.0
3.	20 - 30	-	1.5	35.7	17.1	45.6	HC	-	5.20	3.72	12.8
4.	30 - 65	-	6.9	50.4	15.0	28.0	SC	-	5.15	4.02	4.3
5.	65 -	-	7.2	43.0	17.0	33.3	LiC	-	5.10	3.99	8.3

	Organic Matter			Cation exch. cap. meg.	Exchangeable Bases meg.				Total	Base satur. %	P_2O_5 absorption coeff.
	Carbon %	Nitrogen %	C/N ratio		Ca	Mg	K	Na			
1.	1.58	0.14	11.7	14.90	3.21	2.14	0.17	0.26	5.87	38.8	-
2.	1.56	0.13	12.4	14.93	2.82	1.74	0.10	0.31	4.97	33.3	-
3.	0.78	0.07	10.7	14.98	2.61	1.09	0.08	0.24	4.02	20.2	-
4.	0.17	0.03	5.3	5.76	1.53	0.44	0.06	1.07	3.10	53.8	-
5.	0.09	0.02	3.8	4.72	1.47	0.21	0.09	0.55	2.32	49.2	-

Analytical data of Profile No.118

Grayish Brown Soil, fine-textured

on dry basis

	Depth	Gravel	Particle Size Distribution				Texture	Maximum water capacity	pH		Exch. acidity
			Co.S.	F.S.	Silt	Clay					
	cm	%	2-0.2mm	0.2-0.02mm	0.02-0.002mm	<0.002mm			H_2O	KCL	Y_1
1.	0 - 16	-	0.1	5.1	44.2	50.6	HC	61.83	4.5	3.3	51.0
2.	16 - 40	-	0.6	6.3	41.5	51.6	HC	58.14	4.7	3.2	94.6
3.	40 - 66	-	2.7	9.1	37.9	50.3	HC	55.20	4.7	3.2	105.6
4.	66 -	-	3.4	11.6	33.6	51.4	HC	54.02	4.7	3.3	96.1

	Organic Matter			Cation exch. cap. meg.	Exchangeable Bases meg.				Total	Base satur. %	P_2O_5 absorption coeff.
	Carbon %	Nitrogen %	C/N ratio		Ca	Mg	K	Na			
1.	1.17	0.09	12.9	16.33	1.92	0.87	0.15	0.14	3.08	18.9	664
2.	0.54	0.05	10.7	15.28	1.95	0.87	0.07	0.14	3.03	19.8	601
3.	0.46	0.06	7.3	15.45	1.89	0.92	0.08	0.16	3.05	19.8	601
4.	0.42	0.04	9.9	14.62	1.86	1.49	0.09	0.18	3.62	24.8	559

Analytical data of Profile No.122

Gray Soils

on dry basis

	Depth	Gravel	Particle Size Distribution				Texture	Maximum water capacity	pH		Exch. acidity
			Co.S.	F.S.	Silt	Clay					
	cm	%	2-0.2mm	0.2-0.02mm	0.02-0.002mm	<0.002mm			H_2O	KCL	Y_1
1.	0 - 17	-	14.4	36.5	14.4	34.7	LiC	51.25	5.9	5.6	0.9
2.	17 - 35	-	20.5	37.4	4.6	37.5	SC	51.20	6.6	6.4	0.8
3.	35 - 72	-	12.9	32.6	8.7	45.8	HC	54.96	6.8	6.4	0.8
4.	72 -	-	12.5	28.2	7.8	51.5	HC	61.85	6.9	6.5	0.8

	Organic Matter			Cation exch. cap. meg.	Exchangeable Bases meg.				Total	Base satur. %	P_2O_5 absorption coeff.
	Carbon %	Nitrogen %	C/N ratio		Ca	Mg	K	Na			
1.	0.63	0.08	7.9	14.21	4.05	2.70	0.06	0.17	6.98	49.1	738
2.	0.31	0.04	6.8	15.03	4.34	2.73	0.03	0.17	7.27	48.4	707
3.	0.32	0.04	7.4	21.71	6.93	3.95	0.05	0.20	11.13	51.3	981
4.	0.28	0.03	7.6	24.00	7.78	4.12	0.05	0.20	12.15	50.6	897

Analytical data of Profile No.3

Vertisol, hydromorphic

on dry basis

	Depth	Gravel	Particle Size Distribution				Texture	Maximum water capacity	pH		Exch. acidity
			Co.S.	F.S.	Silt	Clay					
	cm	%	2-0.2mm	0.2-0.02mm	0.02-0.002mm	<0.002mm			H_2O	KCL	Y_1
1.	0 - 7	51.8	11.3	17.6	29.6	41.5	LiC	-	5.60	5.00	0.3
2.	7 - 35	37.7	16.0	16.5	21.0	46.5	HC	-	5.70	5.30	0.3

	Organic Matter			Cation exch. cap. meg.	Exchangeable Bases meg.				Total	Base satur. %	P_2O_5 absorption coeff.
	Carbon %	Nitrogen %	C/N ratio		Ca	Mg	K	Na			
1.	1.21	0.10	11.9	33.00	14.63	12.75	0.11	0.48	27.97	84.8	-
2.	0.86	0.08	11.5	31.47	17.06	9.21	0.08	0.32	26.67	84.7	-

Analytical data of Prcfile No.112

Vertisol, hydromorphic

on dry basis

	Depth	Gravel	Particle Size Distribution Co.S.	F.S.	Silt	Clay	Texture	Maximum water capacity	pH		Exch. acidity
	cm	%	2-0.2mm	0.2-0.02mm	0.02-0.002mm	<0.002mm			H_2O	KCL	Y_1
1.	0 - 14	-	13.0	26.6	22.4	38.0	Lic	58.17	5.4	4.4	4.2
2.	14 - 32	-	16.9	22.9	21.7	38.5	LiC	54.65	5.7	4.7	3.8
3.	32 - 46	-	48.4	14.4	8.8	28.4	SC	56.62	6.5	5.6	1.0
4.	46 - 56	-	16.4	12.9	10.5	60.2	HC	81.25	7.0	5.8	1.0
5.	56 -	-	34.7	23.8	15.4	26.1	SC	81.57	7.2	5.9	1.2

	Organic Matter Carbon %	Nitrogen %	C/N ratio	Cation exch. cap. meg.	Exchangeable Bases meg. Ca	Mg	K	Na	Total	Base satur. %	P_2O_5 absorption coeff.
1.	1.07	0.12	9.2	16.88	3.80	1.91	0.08	0.32	6.11	36.2	791
2.	0.67	0.07	9.7	16.62	4.30	2.34	0.06	0.25	6.95	41.8	875
3.	0.39	0.04	8.7	21.09	4.41	2.92	0.06	0.33	7.72	36.6	928
4.	0.44	0.06	8.6	38.76	12.85	5.88	0.09	0.48	19.30	49.8	1,477
5.	0.34	0.04	8.5	55.15	18.74	7.93	0.08	0.76	27.51	49.9	1,741

Analytical data of Profile No.113

Vertisol, hydromorphic

on dry basis

	Depth	Gravel	Particle Size Distribution				Texture	Maximum water capacity	pH		Exch. acidity
			Co.S.	F.S.	Silt	Clay					
	cm	%	2-0.2mm	0.2-0.02mm	0.02-0.002mm	<0.002mm			H_2O	KCL	Y_1
1.	0 - 15	-	5.0	19.9	19.9	55.2	HC	62.64	5.2	4.4	5.4
2.	15 - 35	-	5.8	17.5	19.8	56.9	HC	64.74	5.1	4.5	4.4
3.	35 - 58	-	7.5	18.2	17.6	56.7	HC	59.85	5.4	4.9	2.3
4.	58 -	-	7.7	15.1	20.0	57.2	HC	64.30	6.1	5.3	1.3

	Organic Matter			Cation exch. cap. meg.	Exchangeable Bases meg.				Total	Base satur. %	P_2O_5 absorption coeff.
	Carbon %	Nitrogen %	C/N ratio		Ca	Mg	K	Na			
1.	1.20	0.12	10.4	22.34	5.05	3.34	0.05	0.15	8.59	38.5	1,161
2.	0.68	0.04	14.9	22.05	5.56	3.50	0.05	0.13	9.24	41.9	1,055
3.	0.41	0.02	15.8	19.38	5.54	2.66	0.05	0.14	8.39	43.3	1,034
4,	0.32	0.02	14.0	17.79	5.43	4.65	0.05	0.16	10.29	57.8	971

Analytical data of Profile No.5

Vertisol, lithic

on dry basis

	Depth	Gravel	Particle Size Distribution				Texture	Maximum water capacity	pH		Exch. acidity
			Co.S.	F.S.	Silt	Clay					
	cm	%	2-0.2mm	0.2-0.02mm	0.02-0.002mm	<0.002mm			H_2O	KCL	Y_1
1.	0 - 10	30.0	21.3	23.3	20.0	35.4	LiC	-	5.60	5.05	0.5

	Organic Matter			Cation exch. cap. meg.	Exchangeable Bases meg.				Total	Base satur. %	P_2O_5 absorption coeff.
	Carbon %	Nitrogen %	C/N ratio		Ca	Mg	K	Na			
1.	2.43	-	-	24.05	13.69	6.31	0.26	0.19	20.45	85.0	-

Analytical data of Profile No.2

Vertisol, lithic

on dry basis

	Depth cm	Gravel %	Particle Size Distribution Co.S. 2-0.2mm	F.S. 0.2-0.02mm	Silt 0.02-0.002mm	Clay <0.002mm	Texture	Maximum water capacity	pH H_2O	pH KCL	Exch. acidity Y_1
1.	0 - 10	28.6	42.3	21.2	15.4	21.2	SCL	-	5.20	3.84	7.5
2.	10 - 27	50.3	45.3	15.6	15.1	24.0	SCL	-	5.70	4.92	0.8

	Organic Matter Carbon %	Nitrogen %	C/N ratio	Cation exch. cap. meg.	Exchangeable Bases meg. Ca	Mg	K	Na	Total	Base satur. %	P_2O_5 absorption coeff.
1.	1.23	0.09	14.3	30.89	12.64	9.89	0.34	0.26	23.13	40.9	-
2.	0.93	0.07	12.4	42.35	25.56	11.45	0.16	0.37	37.54	60.4	-

Analytical data of Profile No.29

Vertisol, cambic

on dry basis

	Depth	Gravel	Particle Size Distribution				Texture	Maximum water capacity	pH		Exch. acidity
			Co.S.	F.S.	Silt	Clay			H_2O	KCL	Y_1
	cm	%	2-0.2mm	0.2-0.02mm	0.02-0.002mm	<0.002mm					
1.	0 - 15	23.9	37.1	25.4	15.8	21.4	SCL	-	6.70	5.75	0.3
2.	15 - 30	43.9	47.3	20.0	11.8	20.9	SCL	-	6.40	5.60	0.3
3.	30 - 43	44.7	40.5	19.4	13.6	26.5	SC	-	6.40	5.60	0.3
4.	43 - 60	75.0	36.1	18.0	13.8	32.1	LiC	-	6.20	5.63	0.3

	Organic Matter			Cation exch. cap. meg.	Exchangeable Bases meg.				Total	Base satur. %	P_2O_5 absorption coeff.
	Carbon %	Nitrogen %	C/N ratio		Ca	Mg	K	Na			
1.	2.41	0.16	15.0	25.34	20.13	2.19	0.38	0.19	22.89	90.3	-
2.	2.10	0.08	14.3	20.28	10.51	3.75	0.32	0.29	14.87	73.2	-
3.	1.16	0.07	9.1	16.42	8.03	3.98	0.28	0.20	12.49	76.1	-
4.	1.09	0.07	9.7	17.35	10.09	3.66	0.36	0.28	13.75	82.9	-

Analytical data of Profile No.17

Vertisol, Cambic

on dry basis

	Depth	Gravel	Particle Size Distribution				Texture	Maximum water capacity	pH		Exch. acidity
			Co.S.	F.S.	Silt	Clay					
	cm	%	2-0.2mm	0.2-0.02mm	0.02-0.002mm	<0.002mm			H_2O	KCL	Y_1
1.	0 - 10	20.0	27.7	18.0	14.1	40.5	LiC	-	5.82	5.58	0.5
2.	10 - 20	25.5	21.0	17.4	25.3	26.3	LiC	-	5.46	4.82	0.7
3.	20 - 33	35.2	17.5	14.3	19.5	48.7	HC	-	5.54	4.20	1.9
4.	33 - 65	55.6	9.2	7.3	3.6	80.0	HC	-	5.01	3.74	10.8
5.	65 - 90	80.0	7.0	7.0	5.4	81.0	HC	-	4.85	3.75	10.3

	Organic Matter			Cation exch. cap. meg.	Exchangeable Bases meg.				Total	Base satur. %	P_2O_5 absorption coeff.
	Carbon %	Nitrogen %	C/N ratio		Ca	Mg	K	Na			
1.	2.86	0.19	14.7	20.10	12.56	5.20	1.32	1.02	20.10	100.0	-
2.	1.39	0.12	11.2	14.84	4.84	3.09	0.47	0.33	8.73	58.8	-
3.	0.95	0.11	9.0	12.63	3.03	3.78	0.26	0.24	7.31	57.9	-
4.	0.65	0.08	7.8	10.94	2.27	1.82	0.26	0.34	4.69	42.9	-
5.	0.57	0.08	6.9	10.80	1.31	2.17	0.28	0.31	4.07	37.7	-

Analytical data of Profile No.107

Latosol, rhodic

on dry basis

	Depth	Gravel	Particle Size Distribution Co.S.	F.S.	Silt	Clay	Texture	Maximum water capacity	pH		Exch. acidity Y_1
	cm	%	2-0.2mm	0.2-0.02mm	0.02-0.002mm	<0.002mm			H_2O	KCL	
1.	0 - 20	-	2.4	55.4	10.9	31.3	SC	65.14	5.6	4.7	1.9
2.	20 - 40	-	1.7	69.7	10.4	18.2	SCL	69.28	4.7	4.0	9.2
3.	40 - 69	-	2.1	60.3	3.1	34.5	SC	68.58	4.7	4.0	11.4
4.	69 -	-	2.9	54.5	4.4	38.2	SC	68.20	4.8	4.0	11.9

	Organic Matter Carbon %	Nitrogen %	C/N ratio	Cation exch. cap. meg.	Exchangeable Bases meg. Ca	Mg	K	Na	Total	Base satur. %	P_2O_5 absorption coeff.
1.	1.09	0.12	8.8	11.08	1.70	0.40	0.75	0.06	2.91	26.3	791
2.	0.69	0.10	6.8	10.34	1.02	0.05	0.26	0.05	1.38	13.4	781
3.	0.57	0.08	6.8	10.05	0.51	0.10	0.15	0.08	0.84	8.4	739
4.	0.47	0.06	7.3	8.86	0.46	0.03	0.07	0.07	0.63	7.1	728

Analytical data of Profile No.1

Latosol, rhodic

on dry basis

	Depth	Gravel	Particle Size Distribution Co.S.	F.S.	Silt	Clay	Texture	Maximum water capacity	pH		Exch. acidity
	cm	%	2-0.2mm	0.2-0.02mm	0.02-0.002mm	<0.002mm			H_2O	KCL	Y_1
1.	0 - 7	1.0	11.5	21.0	18.8	49.0	HC	-	5.20	4.20	17.0
2.	7 - 23	21.6	13.4	14.3	14.4	57.9	HC	-	5.30	3.77	19.5
3.	23 - 40	40.9	17.0	13.0	14.1	56.0	HC	-	5.20	3.77	19.0
4.	40 - 85	61.3	12.7	10.7	8.1	66.5	HC	-	5.20	3.74	16.8
5.	85 - 100	21.6	8.4	21.0	18.8	52.0	HC	-	5.15	3.67	25.0
6.	100 -	-	26.0	41.2	22.5	8.4	SL	-	4.90	3.45	60.2

	Organic Matter Carbon %	Nitrogen %	C/N ratio	Cation exch. cap. meg.	Exchangeable Bases meg. Ca	Mg	K	Na	Total	Base satur. %	P_2O_5 absorption coeff.
1.	2.63	0.15	18.0	15.26	4.79	3.92	0.65	-	-	-	-
2.	1.42	0.13	11.1	13.74	1.22	1.64	0.31	5.50	8.67	45.9	-
3.	0.97	0.09	10.7	13.55	0.90	1.59	0.25	5.65	8.39	45.7	-
4.	0.43	0.06	7.5	12.76	1.11	0.89	0.34	5.55	7.89	47.9	-
5.	0.43	0.06	7.3	17.95	1.32	2.43	0.18	5.20	9.13	50.8	-
6.	0.15	0.03	4.4	17.95	-	8.21	0.21	2.45	-	-	-

Analytical data of Profile No.14

Red Yellow podzolic soil

on dry basis

	Depth	Gravel	Particle Size Distribution				Texture	Maximum water capacity	pH		Exch. acidity
			Co.S.	F.S.	Silt	Clay					
	cm	%	2-0.2mm	0.2-0.02mm	0.02-0.002mm	<0.002mm			H_2O	KCL	Y_1
1.	0 - 3	3.8	24.9	58.3	5.0	11.5	FSL	-	5.10	4.02	0.5
2.	3 - 20	2.6	25.2	52.5	7.4	14.9	FSL	-	4.75	4.00	3.8
3.	20 - 45	10.2	23.4	50.3	6.7	19.7	SCL	-	5.08	3.99	4.3
4.	45 - 70	15.8	23.4	46.0	6.3	24.4	SCL	-	5.10	3.95	4.8
5.	70 - 100	38.0	23.8	38.5	5.7	32.1	SC	-	5.18	3.93	5.3

	Organic Matter			Cation exch.	Exchangeable Bases meg.				Total	Base satur.	P_2O_5 absorption
	Carbon %	Nitrogen %	C/N ratio	cap. meg.	Ca	Mg	K	Na		%	coeff.
1.	0.89	0.08	11.0	2.89	0.43	0.21	0.16	1.32	2.12	73.4	-
2.	0.43	0.05	9.1	2.52	0.21	0.21	0.05	0.74	1.21	48.0	-
3.	0.29	0.03	9.1	2.19	0.21	0.21	0.06	0.93	1.41	64.4	-
4.	0.27	0.03	8.7	2.07	tr	tr	0.06	0.79	0.85	41.1	-
5.	0.29	0.03	9.4	2.55	tr	tr	0.06	0.82	0.88	34.5	-

Table A-19 Synthetic Judgement of Soil Productivity

Soil No.	family Name	Land condition	Chemical property	Synthetic judgement
1	Alluvial coarse	III	III	III
2	Alluvial medium	II	II	II
3	Grayish Brown coarse	II	III	II-III
4	Grayish Brown medium	I-II	II-III	II
5	Grayish Brown fine	I	II	I-II
6	Gray	I	II	I-II
7	Vertisol Hydromorphic	I-II	I	I-II
8	Vertisol Lithic	III	I	II-III
9	Vertisol Cambic	II-III	I	II-III
10	Latosol	I	II	I-II
11	Red Yellow Podzolic	III	III	III

Table A-20 Mean values used for judgement of land condition

Soil family No.	Name	Depth of plowing layer (cm)	Depth of available soil (cm)	Soil texture (Index of intake)	Maximum water capacity (%)
1	Alluvial coarse	18	30	LS	27
2	Alluvial medium	18	40	L	-
3	Grayish Brown coarse	16	70	SL	-
4	Grayish Brown medium	15	45	SCL	50
5	Grayish Brown fine	16	76	HC	62
6	Gray	17	70	LiC	51
7	Vertisol Hydromorphic	12	51	HC	63
8	Vertisol Lithic	10	16	SCL	-
9	Vertisol Cambic	15 1/	30 1/	SCL	-
10	Latosol	20	70	SC	65

1/ It contains many gravels.

Table A-21 Mean values of analytical results used for the judgement of chemical property

Soil family		Cation exchange capacity	Saturated degree of calcium	Exchangeable cation (me)			Total Nitrogen	Available Phosphate	Soil acidity	
No.	Name	(me)	(%)	Ca	Mg	K	(%)	(mg/100g)	pH (H_2O)	Exchange acidity (y_1)
1	Alluvial coarse	1.5	27	0.4	tr	0.04	0.04	tr	4.5	5.0
3	Grayish Brown coarse	1.3	78	1.0	0.6	0.05	0.03	4	4.5	2.5
4	Grayish Brown medium	4.3	28	1.2	0.4	0.08	0.05	7	4.9	8.1
5	Grayish Brown fine	16.0	16	2.6	1.5	0.16	0.11	2	4.8	22.0
6	Gray	14.2	29	4.1	2.7	0.06	0.08	-	5.9	0.9
7	Vertisol Hydromorphic	32.0	31	10.0	7.5	0.06	0.11	3	5.4	2.6
8	Vertisol Lithic	30.9	41	12.6	9.9	0.34	0.08	5	5.2	7.5
9	Vertisol Cambic	23.2	71	16.4	3.2	0.70	0.17	-	6.3	0.4
10	Latosol	11.1	14	1.7	0.4	0.75	0.12	-	5.6	1.9

(4) Soils in wet season

The soils in wet season show the differences in chemical, physical and biological properties from the soils in dry season.

During wet season, the oxidation of soils is mostly depressed by flooding, and the most of the surface soil show a dipyridyl reaction which indicates the existence of active ferrous iron. But, in subsoils the reaction is not so clear as in surface soils, and in many soils the reaction is not so clear as in surface soils, and in many soils the reaction is negative.

However in few soils containing some organic matter, reduction has developed and symptoms of so-called "Negusare" (root rot) and "brown spot" like disease were observed in some places. But it is questionable that iron reduction in surface soils is caused only by the decomposition of the organic matter in soils (except in some soils having some organic matter contents).

The physical properties of soils, especially the compactness, have remarkably changed by flooding comparing with the soils in dry season. In wet season the soils become extremely soft and the compactness measured by cone-penetrometer was less than 20, while values of more than 25 are quite common in dry season. This is especially the true for surface soils.

The development of so-called "plow layer" which form widely in Japanese paddy soils was not clear in the soils of the Stung Chinit area. This reason seems to be the extensiveness of cultivation system of paddy soils and the lack of organic matter and iron minerals in surface soils.

In Vertisols which is the most fertile soil in this area, the characteristic physical properties i.e. deep cracks and slickensides have disappeared in wet season due to the soil swelling on wetting. Therefore the percolation of water will be hindered in the soils of this group in wet season.

By the aid of inundation the close correlation was observed in this area between the forms of microrelief and the soil distribution pattern, although this correlation is not distinct in dry season. It is thought therefore that this correlation will assist to improve the planning and guidance on the introduction of agricultural technics from now.

(5) Soils and Agriculture

There will be two types of double -cropping systems of rice; (a) both cropping in wet season, (b) the first cropping in wet and the second in dry season. In the former case, the beginning one month of nursery in the first crop and the last one month of ripening in the second crop might belong to dry season. Therefore, paddy should be irrigated in these months. The required amount of water, however, would be sufficiently smaller than in the case of cropping in dry season.

The variety to be used should be high either in yield or in quality. In double -cropping system possible cases are; (a) combination of native and improved varieties, (b) esclusive use of improved varieties. Although a available valuable non-photosensitive variety is grown in Thailand. Some experiments are necessary to decide the adoption of the said variety.

On the manuring, the combination of basal and top dressing appears to be effective in increasing yield even on soils of fine texture. It is desirable to divide the fertilizers to be applied into basal dressing and "Hogoe" on those soils. On grayish brown soil (medium to coarse texture), more finely divided application of fertilizer will be required. As nothing is known on it, it is necessary to make experiments to establish the method of fertilizer application including the determination of the most effective stage of "Hogoe". In general the effect of phosphate is considerably high. It is recommended to make extensive use of domestic apatite powder in Cambodia (Total -P_2O_5 32.5%, Citric acid soluble- P_2O_5 14.2%). As the double -cropping of rice will promote the decline of soil fertility, it is desirable to increase the production and the extensive application of barnyard manure. Since coarse soils are low in base contents, the supply of the elements other than nitrogen, phosphorus and potassium should also be taken into account. Studies on the techniques of plant protection is necessary because rice is suffered from the outbreaks of Rice borer in dry season. Especially, the plant protection by chemicals after the heading stage should be studied.

APPENDIX B DAM

B-1. Study on Required Capacity of Reservoir

A computation of required storage capacity of the Phnom Takho reservoir is shown in Table B-1, considering necessary requirements for irrigation, power and flood control. In this table, the following is assumed.

(1) In order to determine the effective storage capacity of the reservoir, river flow data of eight years (1962 - 69) are taken. As the flow data is closely related with rainfall data of the period, and similar to that of the longer period from the hydrologic and statistic points of view, the computation of required storage capacities for eight years is considered to be appropriate for any longer term computation. (Those arguments are described in Appendix E.)

(2) The inflow at the Phnom Takho damsite is estimated to be 91% out of that at the Kg. Thma gauge station taking the proportion of catchment areas at each site.

(3) As for calculating irrigation water, such factors as effective rainfall at Baray and 25% of required water for losses of conveyance and operation are taken into consideration. Monthly effective rainfall is obtained by cumulating daily, in which 80% of 5 - 80 mm/day is assumed available.

(4) Minimum discharge for the hydropower generation is considered to be 17.8 m^3/sec.

(5) Regarding the flood control, regulating capacity of 270 million m^3 at the end of every August is taken to be necessary.

The above computation is also shown in the Fig. B-1, 2 using the differential mass curve method.

As a result of the computation, required storage capacities for each year are as follows.

Year	Required capacity	H.W.L.	L.W.L.
		Water level of reservoir	
1962	300 x $10^6 m^3$	31.2 m	27.2 m
1963	326 "	"	26.6 m
1964	391 "	"	24.7 m
1965	297 "	"	27.2 m
1966	328 "	"	26.5 m
1967	311 "	"	27.0 m
1968	281 "	"	27.5 m
1969	413 "	"	23.9 m

The above values of capacity are evaluated by adopting the log-normal distribution shown in the Fig.B-4 Then, the year of 1964, in which the required capacity is 391 million m^3 with exceeding probability of 10%, is considered to be reasonable for a basic drought year in planning.

In the case of worse year of drought such as 1969, dead water of 67 million m^3 is available for irrigation use. A total storage capacity of 458 million m^3 is enough to guarantee the required water in droughty year of 3% in the probability.

Fig. B-1 Distribution Plan of Reservoir Capacity

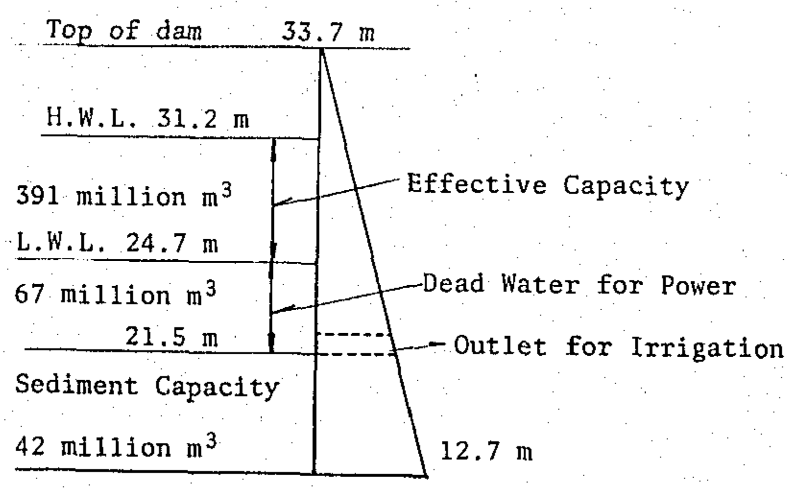


Table B-1 Water Balance Sheet of the Phnom Takho Reservoir

Year	Month	Inflow (1)	Discharge (m^3/sec) Irri-gation	Power	Flood	Total (2)	(3) =(1)-(2)	Cumulated discharge from reservoir Σ{(-)(3)}	
		m^3/sec						m^3/sec	10^6m^3
1962	Jan.	9.4	32.0	0	0	32.0	-22.6	22.6	59
	Feb.	4.3	35.7	0	0	35.7	-31.4	54.0	140
	Mar.	3.1	31.8	0	0	31.8	-28.7	82.7	214
	Apr.	3.7	13.4	4.4	0	17.8	-14.1	96.8	251
	May	8.4	20.9	0	0	20.9	-12.5	109.3	283
	Jun.	27.1	33.6	0	0	33.6	-6.5	115.8	300
	Jul.	118.4	11.3	6.5	98.0	116.7	1.7	114.1	296
	Aug.	126.7	8.1	9.7	98.9	116.7	10.0	104.1	270
	Sep.	181.5	12.5	5.3	131.2	149.0	32.5	71.6	187
	Oct.	220.7	28.2	0	120.9	149.1	71.6	0	0
	Nov.	50.4	19.6	0	30.8	50.4	0	0	0
	Dec.	25.5	31.3	0	0	31.3	-5.8	5.8	15
1963	Jan.	15.1	32.0	0	0	32.0	-16.9	22.7	59
	Feb.	8.4	35.7	0	0	35.7	-27.3	50.0	130
	Mar.	4.6	30.5	0	0	30.5	-25.9	75.9	197
	Apr.	3.3	16.6	1.2	0	17.8	-14.5	90.4	234
	May	3.4	26.6	0	0	26.6	-23.2	113.6	294
	Jun.	8.3	12.7	5.1	0	17.8	-9.5	123.1	319
	Jul.	22.6	25.2	0	0	25.2	-2.6	125.7	326
	Aug.	53.2	13.9	3.9	13.7	31.5	21.7	104.0	270
	Sep.	76.4	15.9	1.9	12.9	30.7	45.7	58.3	151
	Oct.	89.0	23.3	0	7.4	30.7	58.3	0	0
	Nov.	33.9	16.1	1.7	16.1	33.9	0	0	0
	Dec.	11.1	31.3	0	0	31.3	-20.2	20.2	52

Year	Month	Inflow (1)	Discharge (m^3/sec) Irri-gation	Power	Flood	Total (2)	(3) =(1)-(2)	Cumulated discharge from reservoir $\Sigma\{(-)(3)\}$	
		m^3/sec						m^3/sec	10^6m^3
1964	Jan.	5.2	32.0	0	0	32.0	-26.8	47.0	122
	Feb.	3.2	35.7	0	0	35.7	-32.5	79.5	206
	Mar.	2.5	33.5	0	0	33.5	-31.0	110.5	286
	Apr.	2.7	15.5	2.3	0	17.8	-15.1	125.6	326
	May	11.1	14.4	3.4	0	17.8	-6.7	132.3	343
	Jun.	15.4	28.2	0	0	28.2	-12.8	145.1	376
	Jul.	19.4	25.2	0	0	25.2	-5.8	150.9	391
	Aug.	47.0	11.8	6.0	0	17.8	29.2	121.7	315
	Sep.	77.9	26.3	0	0	26.3	51.6	70.1	181
	Oct.	83.8	21.1	0	0	21.1	62.7	7.4	19
	Nov.	50.0	14.4	3.4	24.8	42.6	7.4	0	0
	Dec.	17.1	31.3	0	0	31.3	-14.2	14.2	37

1965	Jan.	11.4	32.0	0	0	32.0	-20.6	34.8	90
	Feb.	7.3	34.4	0	0	34.4	-27.1	61.9	160
	Mar.	4.8	33.5	0	0	33.5	-28.7	90.6	235
	Apr.	4.1	14.4	3.4	0	17.8	-13.7	104.3	270
	May	7.6	17.5	0.3	0	17.8	-10.2	114.5	297
	Jun.	31.2	18.5	0	0	18.5	12.7	101.8	264
	Jul.	58.1	22.7	0	30.9	53.6	4.5	97.3	252
	Aug.	46.9	16.7	1.1	35.8	53.6	-6.7	104.0	270
	Sep.	149.6	7.3	10.5	62.3	80.1	69.5	34.5	89
	Oct.	114.6	20.3	0	59.8	80.1	34.5	0	0
	Nov.	33.3	20.0	0	13.3	33.3	0	0	0
	Dec.	16.7	31.3	0	0	31.3	-14.6	14.6	38

Year	Month	Inflow (1)	Discharge (m^3/sec) Irri-gation	Power	Flood	Total (2)	(3) =(1)-(2)	Cumulated discharge from reservoir Σ{(-)(3)}	
		m^3/sec						m^3/sec	10^6m^3
1966	Jan.	10.7	32.0	0	0	32.0	-21.3	35.9	93
	Feb.	8.0	33.8	0	0	33.8	-25.8	61.7	160
	Mar.	5.5	31.1	0	0	31.1	-25.6	87.3	226
	Apr.	6.1	14.2	3.6	0	17.8	-11.7	99.0	257
	May	14.0	20.3	0	0	20.3	-6.3	105.3	273
	Jun.	13.2	30.5	0	0	30.5	-17.3	122.6	318
	Jul.	46.2	13.9	3.9	32.2	50.0	-3.8	126.4	328
	Aug.	151.5	8.2	9.6	111.4	129.2	22.3	104.1	270
	Sep.	126.8	14.1	3.7	42.3	60.1	66.7	37.4	97
	Oct.	97.6	24.2	0	36.0	60.2	37.4	0	0
	Nov.	42.7	17.1	0.7	24.9	42.7	0	0	0
	Dec.	22.5	29.4	0	0	29.4	-6.9	6.9	18

1967	Jan.	13.4	32.0	0	0	32.0	-18.6	25.5	66
	Feb.	8.7	35.7	0	0	35.7	-27.0	52.5	136
	Mar.	6.3	33.5	0	0	33.5	-27.2	79.7	207
	Apr.	11.3	16.2	1.6	0	17.8	-6.5	86.2	223
	May	26.1	20.8	0	0	20.8	5.3	80.9	210
	Jun.	19.0	27.8	0	0	27.8	-8.8	89.7	233
	Jul.	58.2	20.4	0	69.0	88.4	-30.2	119.9	311
	Aug.	104.2	16.9	0.9	70.6	88.4	15.8	104.1	270
	Sep.	119.0	10.6	7.2	58.3	76.1	42.9	61.2	159
	Oct.	137.3	28.9	0	47.2	76.1	61.2	0	0
	Nov.	40.1	19.7	0	20.4	40.1	0	0	0
	Dec.	29.4	31.3	0	0	31.3	-1.9	1.9	5

Year	Month	Inflow (1)	Discharge (m^3/sec) Irri-gation	Power	Flood	Total (2)	(3) =(1)-(2)	Cumulated discharge from reservoir Σ{(-)(3)}	
		m^3/sec						m /sec	10^6m^3
1968	Jan.	13.2	32.0	0	0	32.0	-18.8	20.7	54
	Feb.	9.2	35.7	0	0	35.7	-26.5	47.2	122
	Mar.	6.1	33.5	0	0	33.5	-27.4	74.6	193
	Apr.	4.8	13.5	4.3	0	17.8	-13.0	87.6	227
	May	8.3	21.9	0	0	21.9	-13.6	101.2	262
	Jun.	27.8	25.5	0	0	25.5	2.3	98.9	256
	Jul.	18.2	27.6	0	0	27.6	-9.4	108.3	281
	Aug.	50.1	16.8	1.0	28.1	45.9	4.2	104.1	270
	Sep.	54.9	19.9	0	0	19.9	35.0	69.1	179
	Oct.	85.1	24.7	0	0	24.7	60.4	8.7	23
	Nov.	29.7	19.7	0	1.3	21.0	8.7	0	0
	Dec.	12.6	31.3	0	0	31.3	-18.7	18.7	48
1959	Jan.	8.2	32.0	0	0	32.0	-23.8	42.5	110
	Feb.	5.7	35.7	0	0	35.7	-30.0	72.5	188
	Mar.	3.7	33.5	0	0	33.5	-29.8	102.3	265
	Apr.	3.0	16.8	1.0	0	17.8	-14.8	117.1	304
	May	5.9	28.7	0	0	28.7	-22.8	139.9	363
	Jun.	11.0	27.5	0	0	27.5	-16.5	159.4	413
	Jul.	33.5	19.9	0	0	19.9	13.6	142.8	370
	Aug.	41.7	19.2	0	0	19.2	22.5	120.3	312
	Sep.	120.9	10.9	6.9	65.6	83.4	37.5	82.8	215
	Oct.	166.2	29.1	0	54.3	83.4	82.8	0	0
	Nov.	50.3	19.7	0	31.6	50.3	0	0	0
	Dec.	19.6	31.3	0	0	31.3	-11.7	11.7	30

Fig. B-2 DIFFERENTIAL MASS CURVE OF PHNOM TAKHO DAM

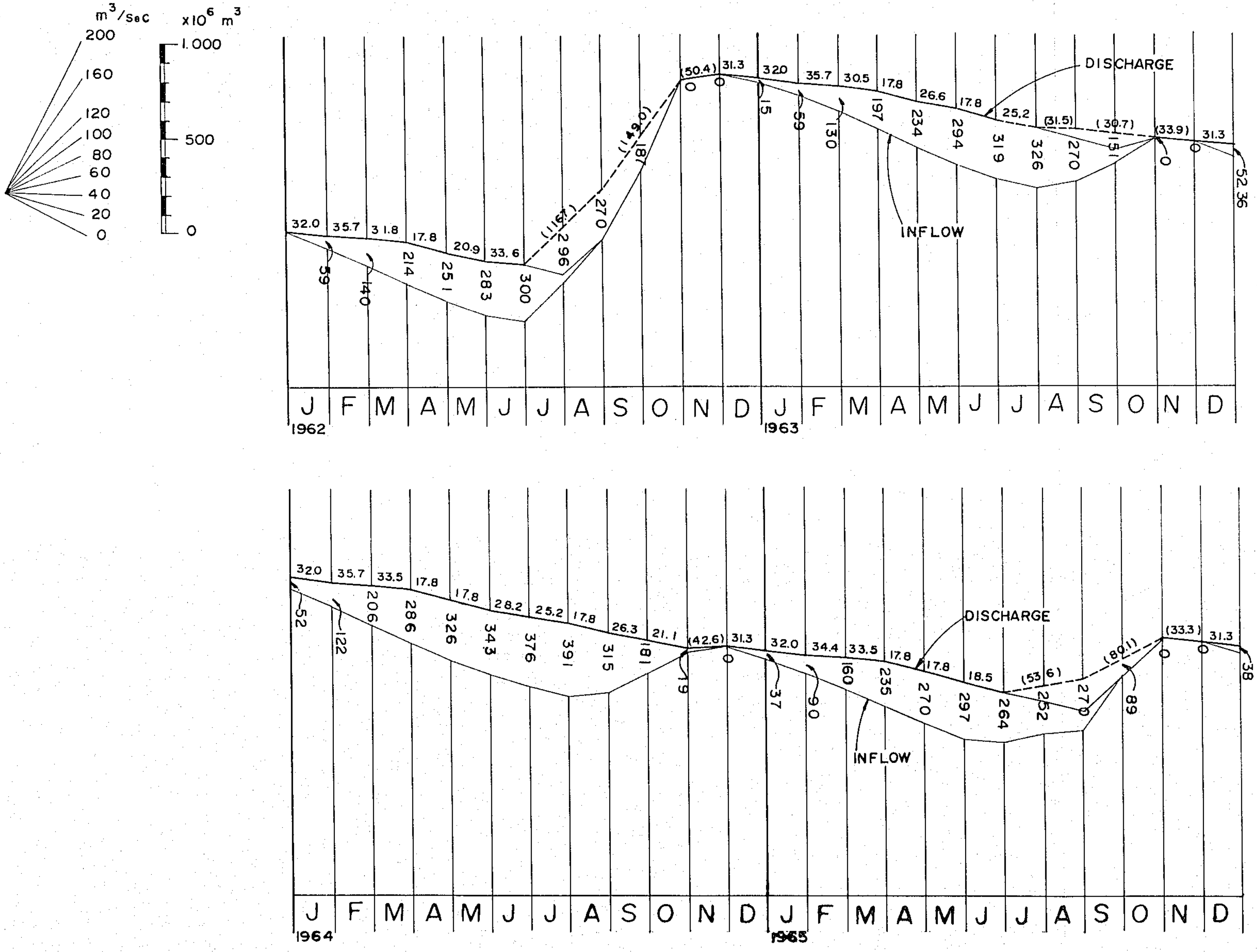
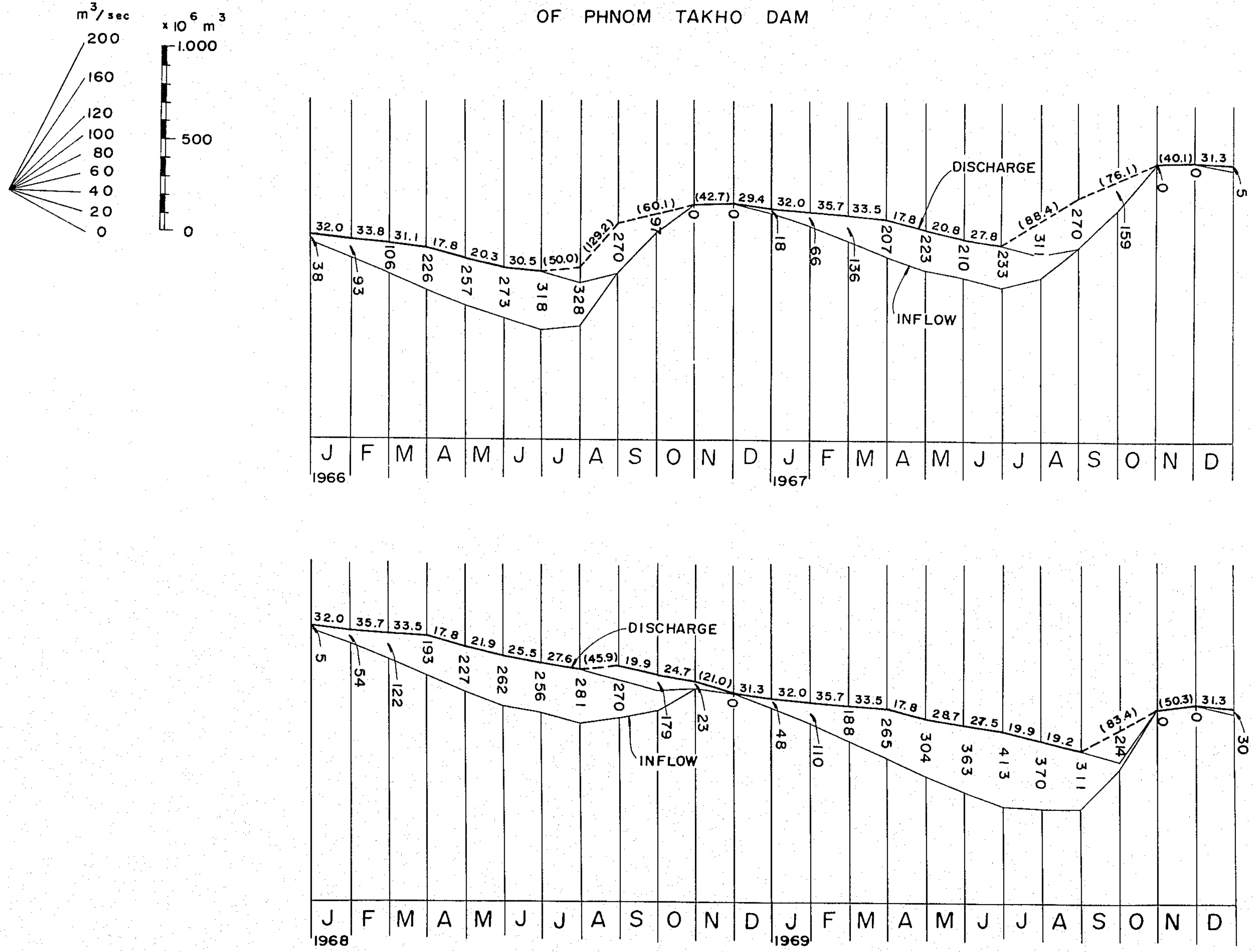
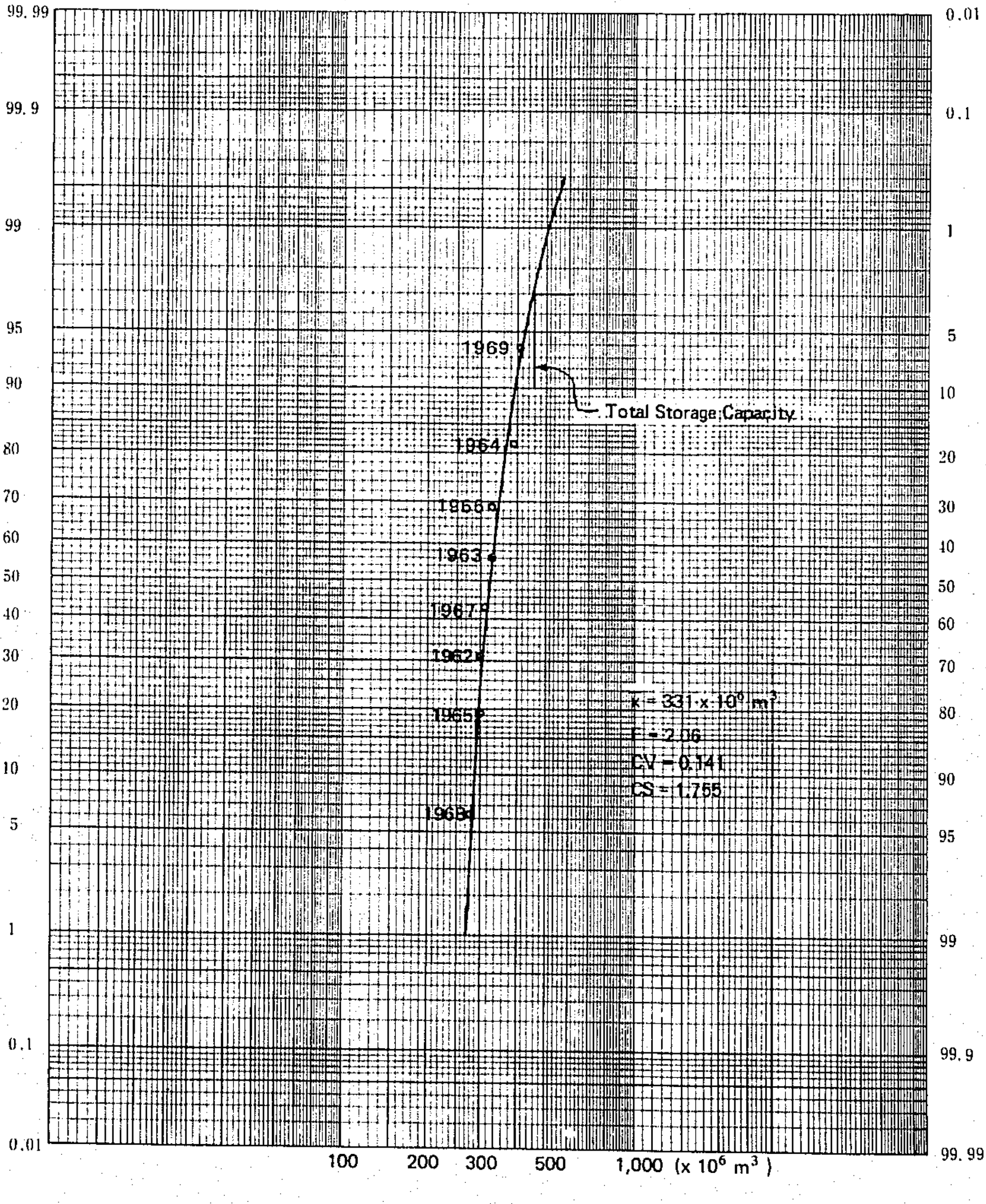


Fig. B-3 DIFFERENTIAL MASS CURVE OF PHNOM TAKHO DAM



対　数　正　規　確　率　紙

Fig. B-4 Log-Normal Distribution of Required Storage Capacity in Phnom Takho Reservoir



B-2. Selection of main damsite

A comparison of superiority of two proposed main damsites, Phnom Takho and Bangki Tangren, is summarized as follows from geological and topographical viewpoints;

At the left wing of the Bangki Tangren proposed damsite, a weathered bed rock rises up to shallow depth, and the elevation of its upper surface is about 15 m and the existing ground surface is 38 m in elevation.

In order to set the foundaton of heavy structures directly on the bed rock, therefore, the excavation depth shall be more than 20 m and the excavation amount may reach several hundred thousands cubic meters. Furthermore, some excavation amount for the spillway, from approach to tail-race chanel, shall be added to it, since the spillway requires the maximum bearing capacity for the foundation.

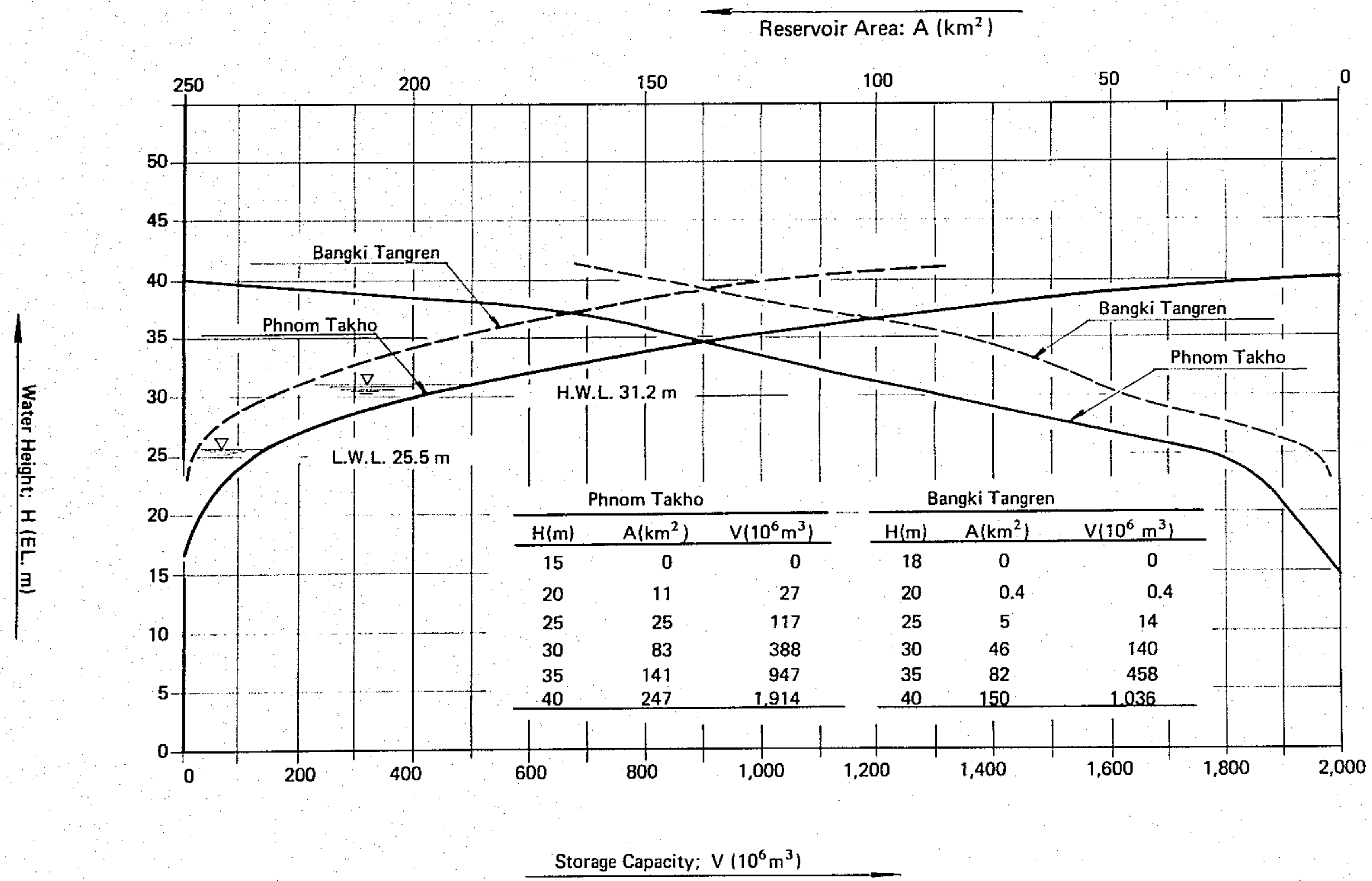
The depth to bed rock in the Bangki Tangren is shallower than that in the Phnom Takho, however, from the fact mentioned above, this matter does not become a superior condition.

In either sites, the foundation for the structures shall be set on the alluvial overburden and some foundation treatment shall be required.

On the other hand, as regards topographic conditions, the storage efficiency of both sites is illustrated in Fig. B-5. The Phnom Takho damsite, as is seen in the figure, is more profitable as to a required storage capacity of $500 \times 10^6 m^3$.

Judging from the above facts, the Phnom Takho damsite is assumed to be better than the Bangki Tangren damsite.

Fig. B-5 H-V & H-A Rating Curve for Phnom Takho and Bangki Tangren Dam



Phnom Takho			Bangki Tangren		
H(m)	A(km^2)	V($10^6 m^3$)	H(m)	A(km^2)	V($10^6 m^3$)
15	0	0	18	0	0
20	11	27	20	0.4	0.4
25	25	117	25	5	14
30	83	388	30	46	140
35	141	947	35	82	458
40	247	1,914	40	150	1,036

B-3. Foundation Treatment for Main Structures

The foundation layer in the area consists of deposit layer which is not well compacted. Though they have an enough bearing capacity, settlement of the foundation due to a surplus load should be considered in designing of the main structures.

Settlement, especially differential settlement, can be hardly allowed for such facilities as a gate, therefore the constructicn works of spillway with gates and outlet works of the main and diversion dams will require careful treatment of the foundation.

Spillways and outlet works shall be constructed on a gravity dam body of concrete. Under which, a cutoff walls of reinforced concrete are designed to construct by means of a slurry trenched wall method in order to control the seepage through foundation and to strengthen the shearing resistance of the foundation, together with a purpose to protect the structures from settlement. The elevation of the base of the cutoff walls shall be -20 m.

Foundation for the other comparatively heavy structures, such as a wing wall between the concrete dam and the fill-type dam, a stilling basin and so forth shall be treated with piles. Piling by a hammering or viblation method is impossible owing to hard ground, so the piling shall be done by a drilling method.

As to the foundation of the fill-type dam to be constructed on soft layer, the consolidation works of the layer shall be made during a construction period. For seepage control, relief wells shall be provided at the downstream side of comparatively high portion of the dam body. Drain holes shall be constructed to reduce up-lift pressure under the concrete body.

The diversion dam body shall be supported with a bearing layer which lies at EL-8 m through piles. Seepage control shall be made with cutoff walls to be constructed in front of the dam. As there exists an impermeable layer of the old alluvium, the cutoff walls do not need to be so deep. And the walls shall be constructed, considering creap length of percolation, with 20 m deep from the dam body.

A permeable layer with a thickness of 7 - 8 m can be partialy seen in the ground of the proposed polder dikesite, but the foundation layer seems to be mostly composed of clayey soils. The solidity of the layer is comparatively low so that its N-value is less than 20, but the settlement of the layer can not be estimated so large since the dike height is only several meters. Therefore, there is no necessity for making overall seepage control.

APPENDIX C. POWER

C-1. Power Supply in Cambodia

Table C-1 Power Supply in Cambodia *(non compris les autoproducteurs)*

Year	Installed capacity		Max. required capacity		Production		Consumption		Annual load factor(%)	Annual capacity use factor(%)
	kW	Rate of growth(%)	kW	Rate of growth(%)	MWh	Rate of growth(%)	MWh	Rate of growth(%)		
1956	11,026		9,036		34,402		31,117		43	36
1957	11,267	2	9,350	3	39,729	15	36,798	18	48	40
1958	17,419	54	10,916	17	45,378	14	35,724	3	47	30
1959	18,052	4	12,457	14	50,959	12	40,981	15	46	32
1960	20,400	13	14,611	17	59,816	17	45,245	10	47	33
1961	23,852	17	17,820	22	71,527	19	52,280	15	46	34
1962	23,223	-2	16,649	-7	78,445	10	59,045	13	54	39
1963	31,504	36	20,949	27	86,782	10	65,750	11	47	31
1964	33,299	6	16,776	-20	84,248	-3	63,686	-3	57	29
1965	56,065	69	18,690	12	80,753	-4	62,894	-1	49	16
1966	56,065	0	21,840	12	89,304	11	65,848	4	46	18
1967	56,065	0	25,040	11	94,224	11	72,698	11	43	19
1968	66,280	12	26,870	11	109,312	12	83,230	11	46	19
Average rate		16		9.5		10		8.5		

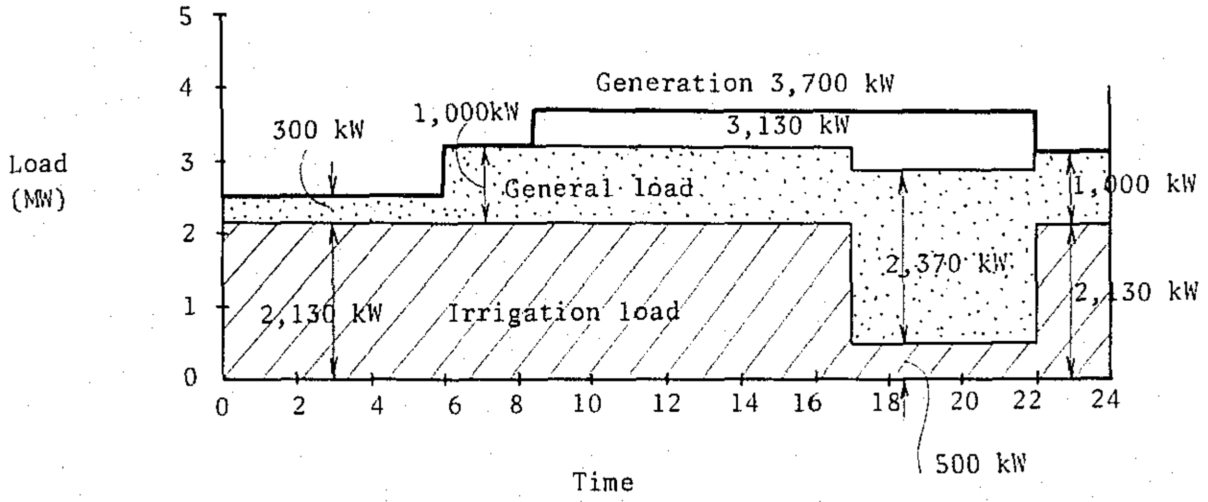
La puissance installée des autoproducteurs est d'environ 25 MW.

L'énergie produite est d'environ 35,000 MWh.

C-2 Estimated Daily Load* at the End of Each Month in The Droughty Year, 1964. (1)

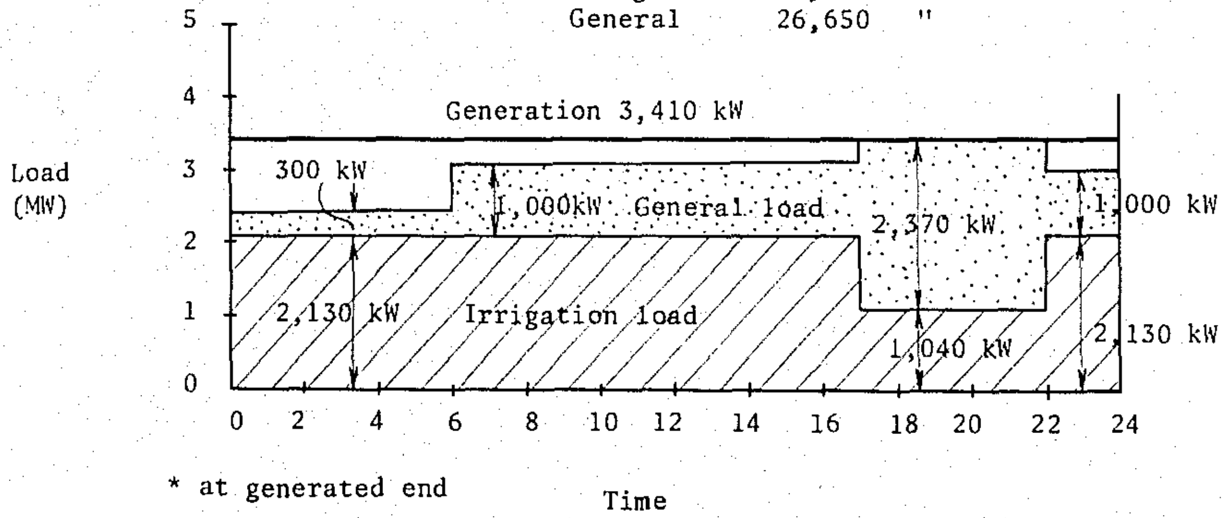
The end of Jan. 1964

Daily energy	
Generation	80,000 kWh
Load	68,650 kWh
Irrigation	42,000 kWh
General	26,650 kWh



The end of Feb. 1964

Daily energy		
Generation	82,000	kWh
Load	73,350	"
Irrigation	46,700	"
General	26,650	"

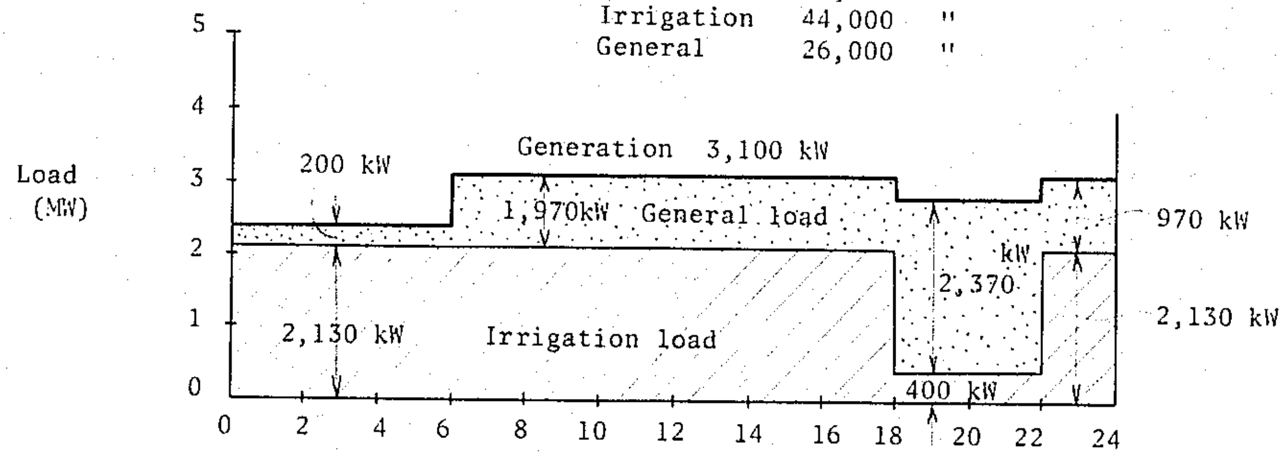


* at generated end

C-2 Estimated Daily Load* at the End of Each Month in The Droughty Year, 1964. (2)

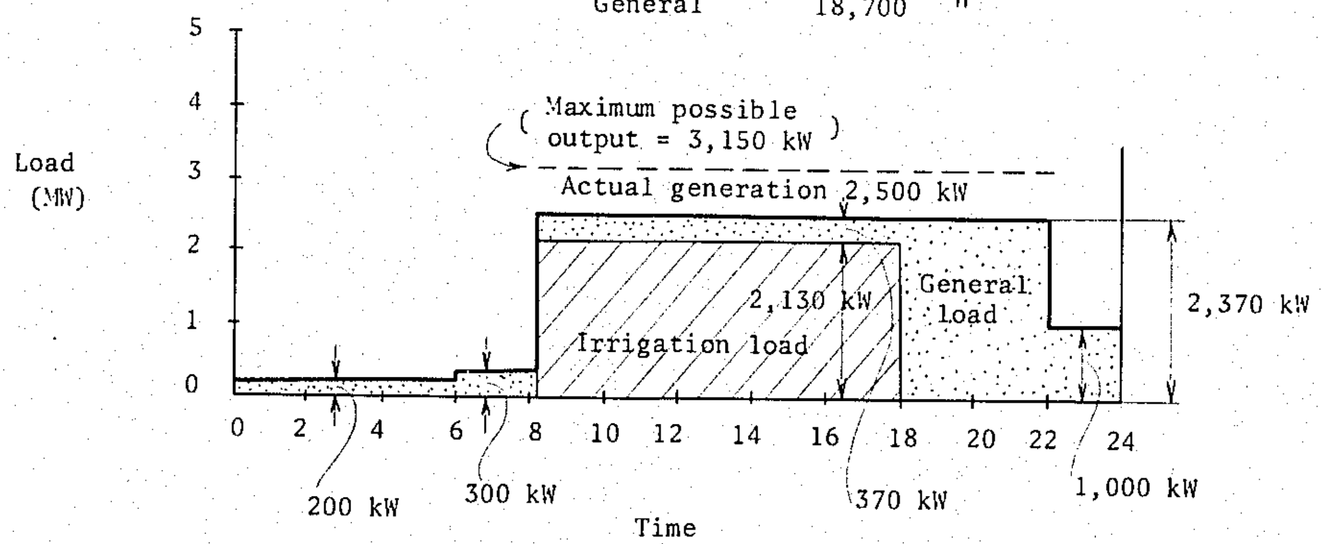
The end of Mar. 1964

Daily energy		
Generation	70,000	kWh
Load	70,000	"
Irrigation	44,000	"
General	26,000	"



The end of Apr. 1964

Daily energy		
Generation	39,300	kWh
Load	39,300	"
Irrigation	20,600	"
General	18,700	"

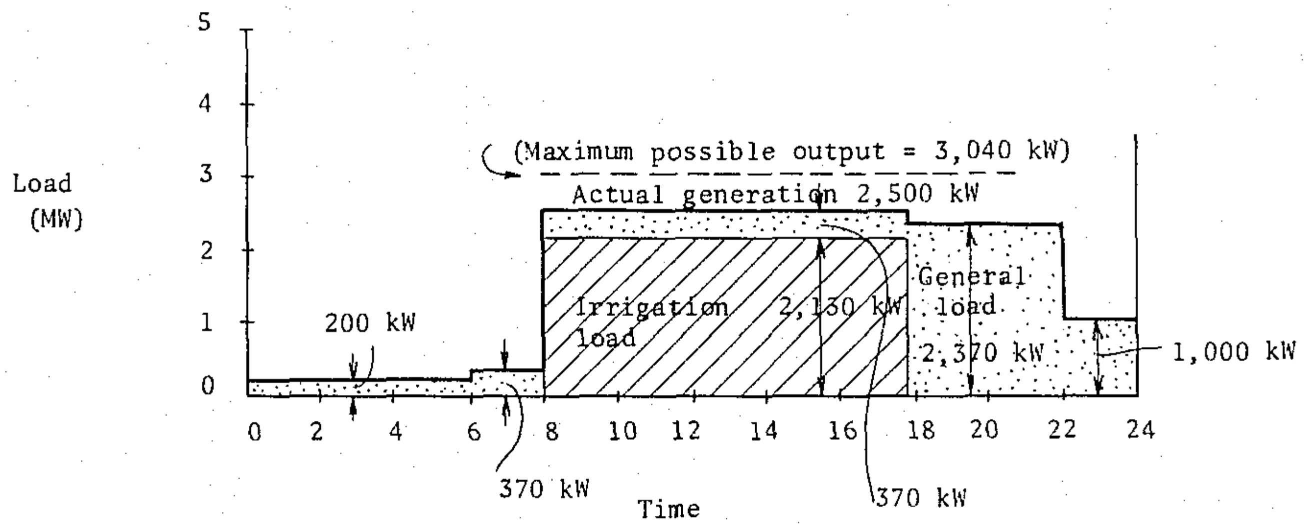


C-2 Estimated Daily Load* at the End of Each Month in The Droughty Year, 1964. (3)

The end of May, 1964

Daily energy

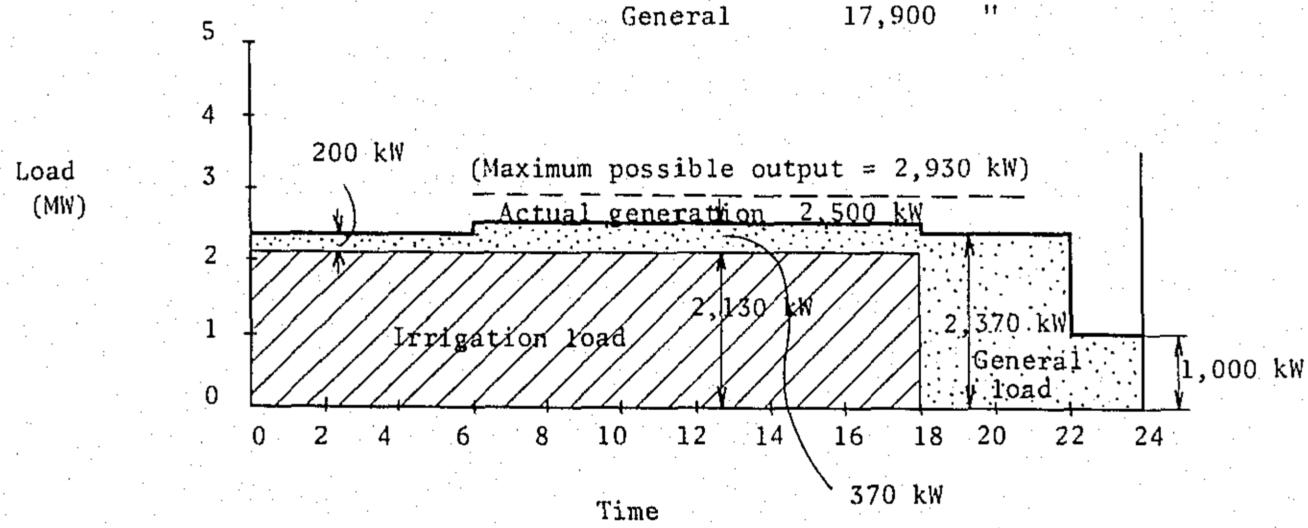
Generation	38,000	kWh
Load	38,000	"
Irrigation	21,000	"
General	17,000	"



The end of Jun. 1964

Daily energy

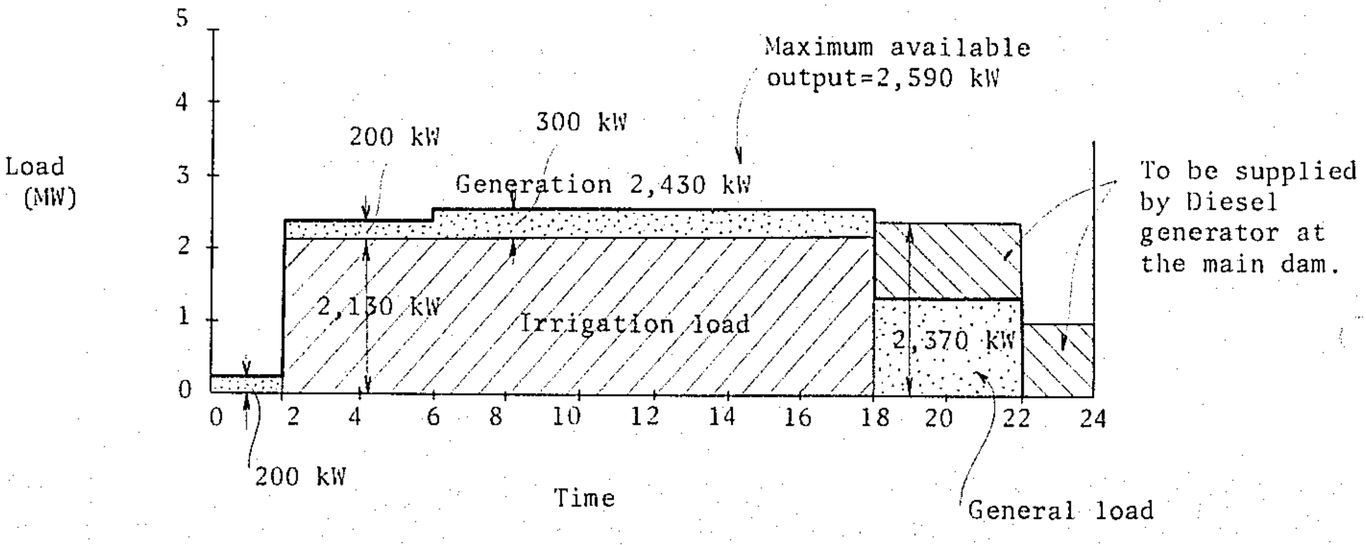
Generation	56,000	kWh
Load	56,000	"
Irrigation	38,100	"
General	17,900	"



C-2 Estimated Daily Load* at the End of Each Month in the Droughty Year, 1964. (4)

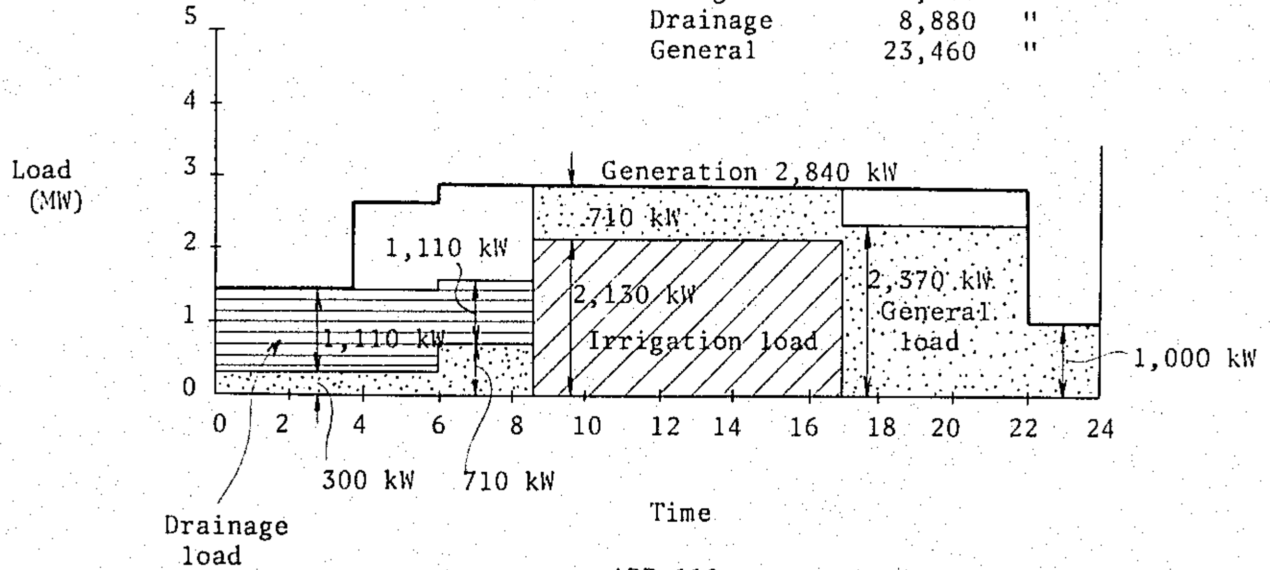
The end of Jul. 1964

Daily energy		
Generation	50,880	kWh
Hydro	44,000	"
Diesel	6,880	"
Load	50,880	"
Irrigation	34,600	"
General	16,280	"



The end of Aug. 1964

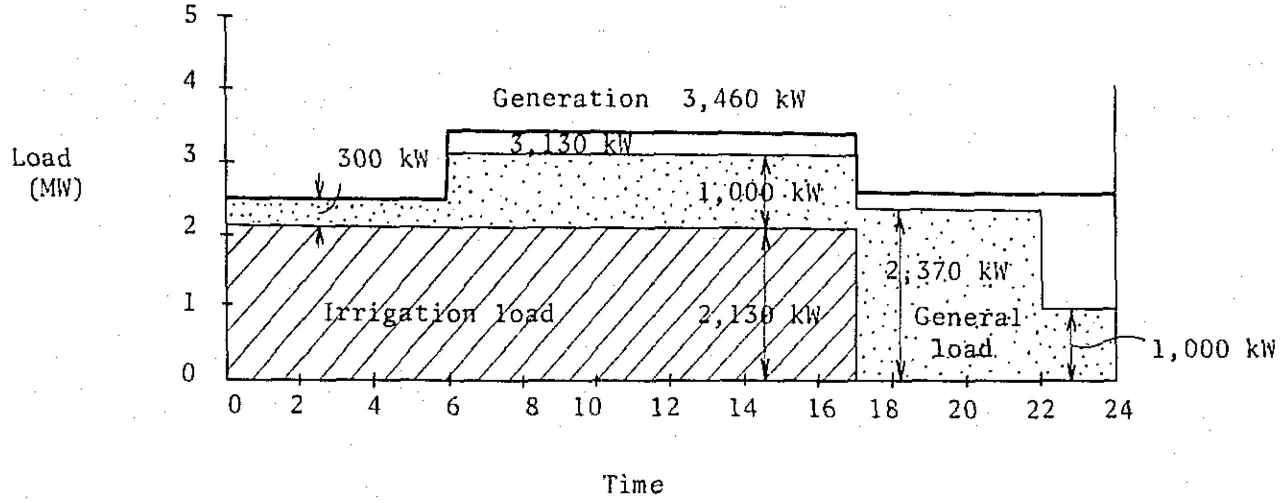
Daily energy		
Generation	56,000	kWh
Load	50,340	"
Irrigation	18,000	"
Drainage	8,880	"
General	23,460	"



C-2 Estimated Daily Load* at the End of Each Month in The Droughty Year, 1964. (5)

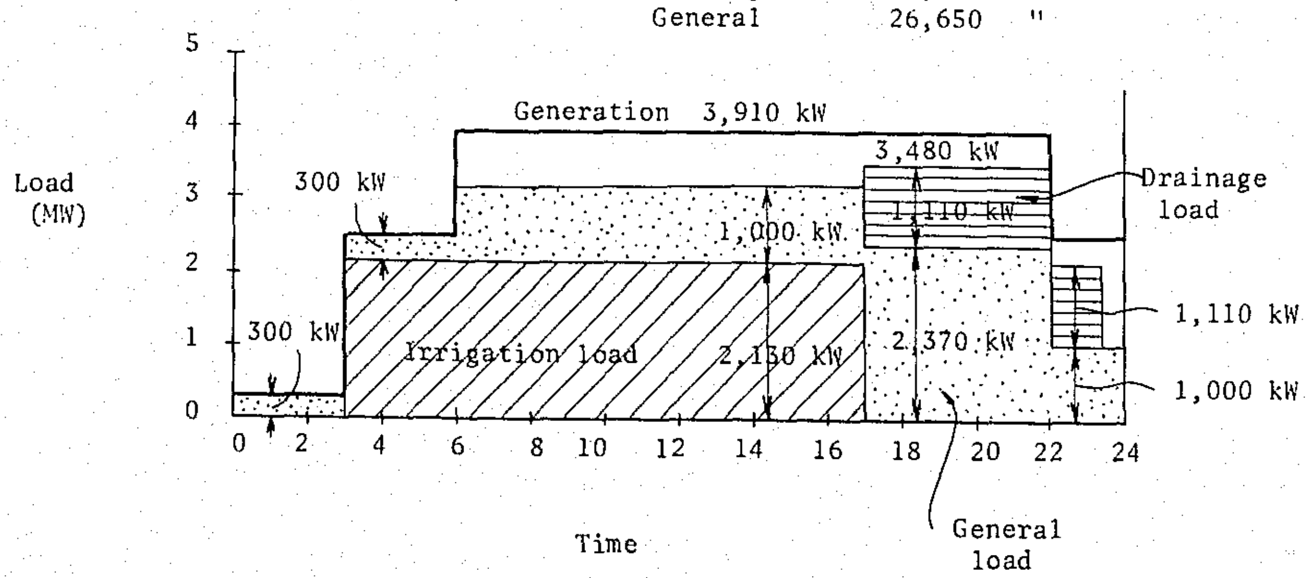
The end of Sep. 1964

Daily energy		
Generation	68,000	kWh
Load	62,650	"
Irrigation	36,000	"
General	26,650	"



The end of Oct. 1964

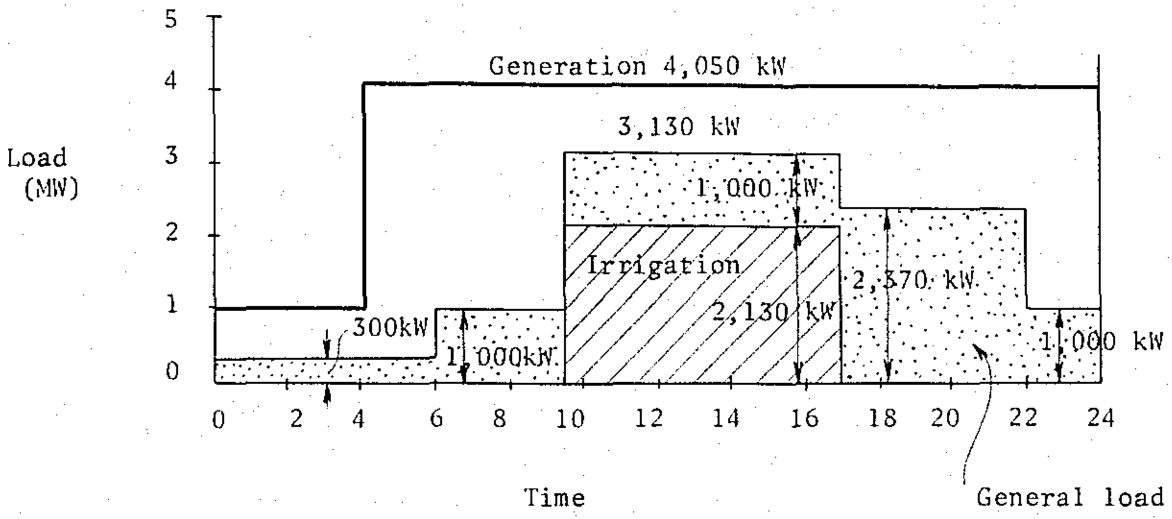
Daily energy		
Generation	77,000	kWh
Load	63,350	"
Irrigation	29,500	"
Drainage	7,200	"
General	26,650	"



C-2 Estimated Daily Load* at the End of Each Month in The Droughty Year, 1964. (6)

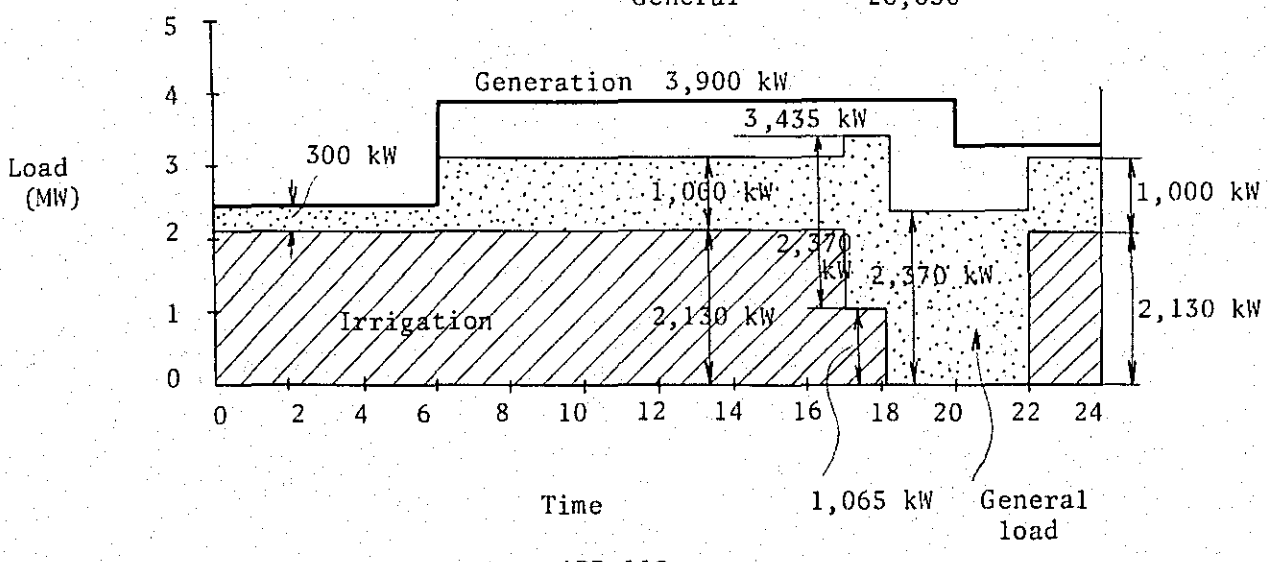
The end of Nov. 1964

Daily energy		
Generation	80,000	kWh
Load	42,750	"
Irrigation	16,100	"
General	26,650	"



The end of Dec. 1964

Daily energy		
Generation	82,500	kWh
Load	68,350	"
Irrigation	41,700	"
General	26,650	"



APPENDIX D. FISHERY

The number of species confirmed at the site is 48 and their names are shown in Table D-1. However, the number is considered less than that of actual living fish because fishing by pouring poison was made twice on a large scale just before the survey.

Table D-1 Name of Species

Scientific Name	Site Name
Oxyeleotris marmorata	T. Damray
Cryptopterus apogon	T. Kes
Wallagonia atta	T. Sanday
Ophycephalus striatus	T. Ros, T. Phtok
Ophycephalus micropeltes	T. Chhdor, T. Ros
Pristolepsis fasciatus	T. Kantrap
Macrones nemurus	T. Chlaing
Puntius altus	T. Chpin
Leptobarbus hoevenii	T. Pralong
Xenentoden canciloides	T. Ptong
Mystis vittatus	T. Kanchos
Trichogaster pectoralis	T. Kanthor
Mastacenbellus argus	T. Kcheung
Hampala macrolepidota	T. Khman
Osteochilus mellanopleura	T. Krom
Notopterus notopterus	T. Slat
Cosmochilus harmandi	T. Kampoul Bay
Cosmochilus schlegeli	T. Rolok Sor
Pangassius pangassius	T. Pra
Rasbora argyrotaenia	T. Changwar
Trichogaster trichopterus	T. Kamplenh
Notopterus chitala	T. Kray
Labeo crysophecadion	T. Khaeh

Scientific Name	Site Name
Cirrhinus jullieni	T. Riel
Clarias meladerma	T. Andeng
Datnioides micropeltis	T. Kla
Anabas testudineus	T. Kranh
Osphronemus goramy	T. Romeas
Gyrinocheilus pennocki	T. Smok
Ophicephalus gachua	-
Trichopsis vittatus	T. Kroem Kda
Macrognathus aculeata	T. Chhlaunh
Macrognathus armatus favus	T. Chhlaunh
Mastacembellus circumcinctus	T. Chhlaunh
Synaptura orientalis	T. Andat Chkke
Acanthopsis choirorhynchus	T. Rus Chek
Botia modesta	T. Kanchrut Kraham
Ompok bimaculatus	T. Kraman
Chanda wolffi	T. Kantrang preng
Mystis cavasius	-
Silurodes hypophthalmus	-
Ophicephalus melasomus	-
Oxygaster oxygastroides	T. Chanteas phluk
Aspidoparia siamensis	-
Mystacoleucus atridorsalis	-
Thynnichthys thynnoides	T. Link
Labiobarbus siamensis	-
Labiobarbus spilopleura	T. Khnong Veng
Botia hymenophysa	T. Kanchruk

Some Examples of Fish Catch by the Reservoirs

Example 1. Ubolratana Reservoir in Thailand, 1966 - 1968

Unit: Metric ton

Month	1966	1967	1968	Average
January	-	21.1	53.2	37.2
February	-	15.8	56.3	36.1
March	-	25.3	63.7	44.5
April	-	28.4	117.4	72.9
May	-	41.8	152.7	97.3
June	-	69.5	137.2	103.4
July	103.4	111.6	140.5	118.5
August	133.4	178.8	135.1	149.1
September	124.3	190.2	126.0	150.0
October	60.1	144.9	124.3	109.8
November	26.6	62.2	91.5	60.1
December	21.9	52.9	94.7	56.5
Annual Total	479.7	942.5	1,292.6	1,035.4
Monthly Average	80.0	78.5	107.7	86.3

Example 2. Phumipol Reservoir in Thailand, 1963 - 1968

Unit: Metric tons

Month	1963	1964	1965	1966	1967	1968	Average
January	-	12.4	96.7	47.0	43.2	30.2	45.9
February	-	14.7	67.6	68.8	39.4	7.8	39.7
March	-	17.5	84.2	62.8	15.1	89.4	53.8
April	-	12.2	66.8	66.6	69.1	118.2	66.5
May	-	13.0	77.8	100.0	70.3	66.0	65.4
June	-	12.2	64.4	67.9	80.7	69.8	59.0
July	-	21.5	90.0	47.1	93.4	77.2	65.8
August	-	60.2	109.4	67.4	43.3	90.0	74.0
September	-	95.2	100.9	70.8	40.1	61.8	73.8
October	36.1	74.6	87.7	53.0	49.8	65.4	61.1
November	21.2	91.9	89.7	51.7	35.8	33.3	53.9
December	24.7	120.8	63.2	50.6	33.8	33.8	54.5
Annual Total	82.0	546.2	998.4	753.5	614.0	742.9	713.4
Monthly Average	27.3	45.5	83.2	61.3	51.2	61.9	59.5

Reference: 1) Fish catches in Cambodia and Thailand are as follows:

(Unit: Thousand metric tons)

	1963	1964	1965	1966
Cambodia	157.5	164.6	165.8	163.3
Thailand	418.7	577.0	615.1	708.1

Source: United Nations "1967 Statistical Yearbook"

2) Fish catches at:

Tonle Sap 10 metric tons/km^2 per annum

The northern parts of the Pacific Ocean
The neighboring seas at the Aleutian Islands } 1 metric ton/km^2 per annum

APPENDIX E. STUDY ON FLOOD HYDROLOGY OF THE STUNG CHINIT

E-1. Runoff analysis

There are successive hydrologic data in the Stung Chinit basin as follows.

Rainfall at Baray: 26 years (1926 - 42, 52, '62 - 69), daily

Rainfall at Bangki Tangren, Thma Samlieng, Kg. Thma, Krava, Speu, etc; 1968 or 1969, daily

Water height and discharge at Kg. Thma (catchment area: 4,130 km^2); 8 years (1962 - 69)

Water height and discharge at Kg. Krabei (catchment area: 3,770 km^2); 2 years (1968 - 69)

Water height at Bangki Tangren (catchment area: 3,100 km^2); 2 years (1968 - 69)

Examples of typical flood of the St. Chinit are figured as Fig. E-1 & 2 in round year hydrograph of water level and discharge. Out of figures, the hydrograph of 1962 shows the biggest runoff in the latest eight years.

It is obviously observed from Fig. E-1 & 2 that a pattern of the river flow is a period of one year showing the maximum in Sept. - Oct. and the minimum in Mar. - Apr. Therefore, runoff analysis of the river should be done for a year round from April to March according to the rainfall in wet season which usually occurs in Apr. - Nov.

Cumulated monthly runoff and rainfall for each year are shown in Fig.E-3 and annual runoff coefficient for eight years is as Table E-1 below.

Table E-1 Annual Runoff Coefficient in mm

Year	1962	1963	1964	1965	1966	1967	1968	1969	Mean
Rainfall 1/	1,774	1,548	1,515	1,603	1,648	1,247	1,253	1,163	1,469
Total runoff	601	230	258	373	419	435	244	361	365
Coefficient(%)	33.8	14.9	17.0	23.3	25.5	35.0	19.5	31.0	24.9

1/ At Barai, argument on representative rainfall in catchment area is made in next item i)

From Fig. E-3, a common characteristic of runoff is abstracted as Fig. E-4 showing a similarity in relationship between cumulated rainfall and its loss for each year, and the above relation is expressed by means of monthly runoff coefficient in average as follows.

Table E-2 Average Monthly Runoff Coefficient in %

Month	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec. Jan.	Feb.	Mar.
									more than		
Coefficient	6.1	3.9	7.8	19.0	21.2	30.6	54.5	63.4	100	80.4	24.2

The biggest runoff in volume, however, occurs in Spetember to October, so that the runoff coefficient for these two months tabulated as Table E-3 below, will assist a design flood analysis.

Table E-3 Two-month Runoff Coefficient (Sep. and Oct.)

Year	1962	1963	1964	1965	1966	1967	1968	1969	Mean
Rainfall (mm)	559	459	381	566	433	427	400	428	
Runoff (mm)	309	127	124	202	172	197	106	221	
Coefficient (%)	55.3	27.7	32.6	35.7	39.7	46.1	26.4	51.6	39.4

E-2. Prior to flood analysis

Prior to flood analysis, there are some of problems to be solved as follows.

i) Representative rainfall in catchment area

Examples of cumulated rainfall of various stations in the St. Chinit basin are shown in Fig. E-5 & E-6. In the figures, rainfall at each station seems to have almost same pattern, therefore, it is admitted to assume that the rainfall at Baray represents for that of the catchment area. It is impossible to know the true rainfall of the catchment area in this stage, and the rainfall at Baray more or less differs from the true one. Nevertheless, the runoff analysis is possible by means of applying the long term record of rainfall at Baray, because the existing runoff analysed from the true rainfall must have a similality to that of Baray.

ii) Maximum and mean water level in daily flow record

Relation between daily mean water level and maximum one is shown in Fig. E-7 taking many flood peaks daily from automatic water gauge records in 1968 - 69. From the analysis, difference between the maximum and mean are negligibly small. Therefore, it is enough to calculate flood runoff daily instead of hourly.

iii) Correlation of river flow at Kg. Thma and damsite

The above item is reviewed in Fig. E-8, in which Kg. Krabei station is located at the damsite having a rate of 0.91 of the catchment area to that of Kg. Thma. However, the rate of 1.20 should be taken for safety in the flood peak discharge.

iv) Probability of rainfall and maximum discharge

As mentioned previously, the continuous river flow record is restricted to eight years. Relation between annual rainfall for the period and that for 26 years including the eight years is studied in their probability as showing in Fig. E-9. As a result of the study, it turned out that the both distribution curves were quite similar. Further, the same kind of study is made in annual rainfall of Phnom Penh by adopting longer records than that of Baray. The result is also the same as previous one as shown in Fig. E-10. Therefore, it is concluded that a period of eight years for data analysis is not necessarily short.

The above study is based on log-normal distribution. For the study on design flood, however, it is reasonable to apply the gunbel's extreme distribution to maximum rainfall and discharge for each year. Studies on the above are made and results are figured in Fig. E-11 - E-13. In Fig. E-13, maximum discharges at Kg. Krabei in 1962 - 69 are shown as 1.2 times of that at Kg. Thma as described in iii), and an estimated flood in 1953 is also plotted. Those values are in Table E-4.

Table E-4 Maximum Discharge at Kg. Krabei

Year	1953	1962	1963	1964	1965	1966	1967	1968	1969
Q Max. (m^3/sec)	740*	395	196	157	290	262	289	178	299

* Estimated by H-Q rating curve at water level 22.4 m based on habitant's information; since 1921 when the Kg. Thma bridge across the St. Chinit was built, three remarkable floods occurred in 1931, 1942 or 1944 and 1953, out of which the biggest was in 1953. Those floods were bigger than that in the latest eight years. As for plotting values of Fig. E-13, it is assumed that the flood in 1953 takes the first rank among 17 years (1953 - 69) and the rest of eight years (1962 - 69) for 10th to 17th in order.

E-3. Flood routing in return period of 1,000 years

As mentioned in (1) runoff analysis, the peak flood occurs in the latter term of rainy season when the river flow has already raised by rainfall for some months before the peak flood. And after the flood, decreasing runoff still remains for several months.

Therefore, a method of runoff synthesis from several days rainfall is not applicable for the flood routing. As for realistic analysis, following method will be rather practical: to increase real flood discharge for long period such as flood discharge series for one month in 1962, by means of analogy to statistic and hydrologic data in planning.

From the above viewpoint, procedure of designed flood analysis is as follows.

i) Total designed discharge in 0.1% probability is estimated from probable rainfall in Fig. E-11 and maximum runoff coefficient of 55.3% in Table E-3.

ii) Maximum designed discharge is obtainable from Fig. E-13.

iii) Designed flood hydrograph considered the above two items is drawn by modifying the real flood in 1962, of which maximum monthly discharge occurred in a duration of Sep. 19th to Oct. 18th. Before and after the duration, the hydrograph in 1962 is adopted to that of the designed flood.

iv) Various values in the designed flood such as max. monthly and 5 day rainfall, max. monthly and daily discharge are checked by analogic rates of those data in 1962.

Results of the above study are shown in Table E-5.

Table E-5 Analogy between Floods in 1962 and Designed

Item	Max. Monthly rainfall	Max. 5-day rainfall	Total discharge	Max. daily discharge
(1) Flood in 1962 Sep.19 - Oct.18	436^{mm}	150.2^{mm}	198.7^{mm}	395 m^3/sec=329x1.2
(2) Designed flood for a month	940^{mm}	390^{mm}	522^{mm}	1,160 m^3/sec
Rate of (2)/(1)	2.2	2.6	2.6	2.9

The designed flood assumed in Table E-5 seems to be reasonable from the viewpoint of various analogic rates.

Flood routing in the Phnom Takho reservoir is made utilizing three kinds of spillway facilities shown in Fig. E-14. As a result of the study, the highest water level is estimated at 32.15 m figured in Fig. E-15.

Some expert opinion is that the design flood is not as large as should be used for spillway design and the levels of the power house, so additional study and refinement of design criteria should be included in the preconstruction investigations of the final design phase of the project.

E-4. Freeboard in contingency

Freeboard of the reservoir is 2.5 m above F.W.L. of 31.2 m in usual, and it becomes 1.55 m in the time of maximum discharge of the designed flood by the surcharge of 0.95 m. The freeboard is still enough for wave height as follows.

Stevenson's formula: $h = \frac{1}{3}\sqrt{F}$

$= 0.88$ m

where, h: wave height (m), F: fetch (km) = 7

Freeboard in contingency: $D = 1.5\ h$

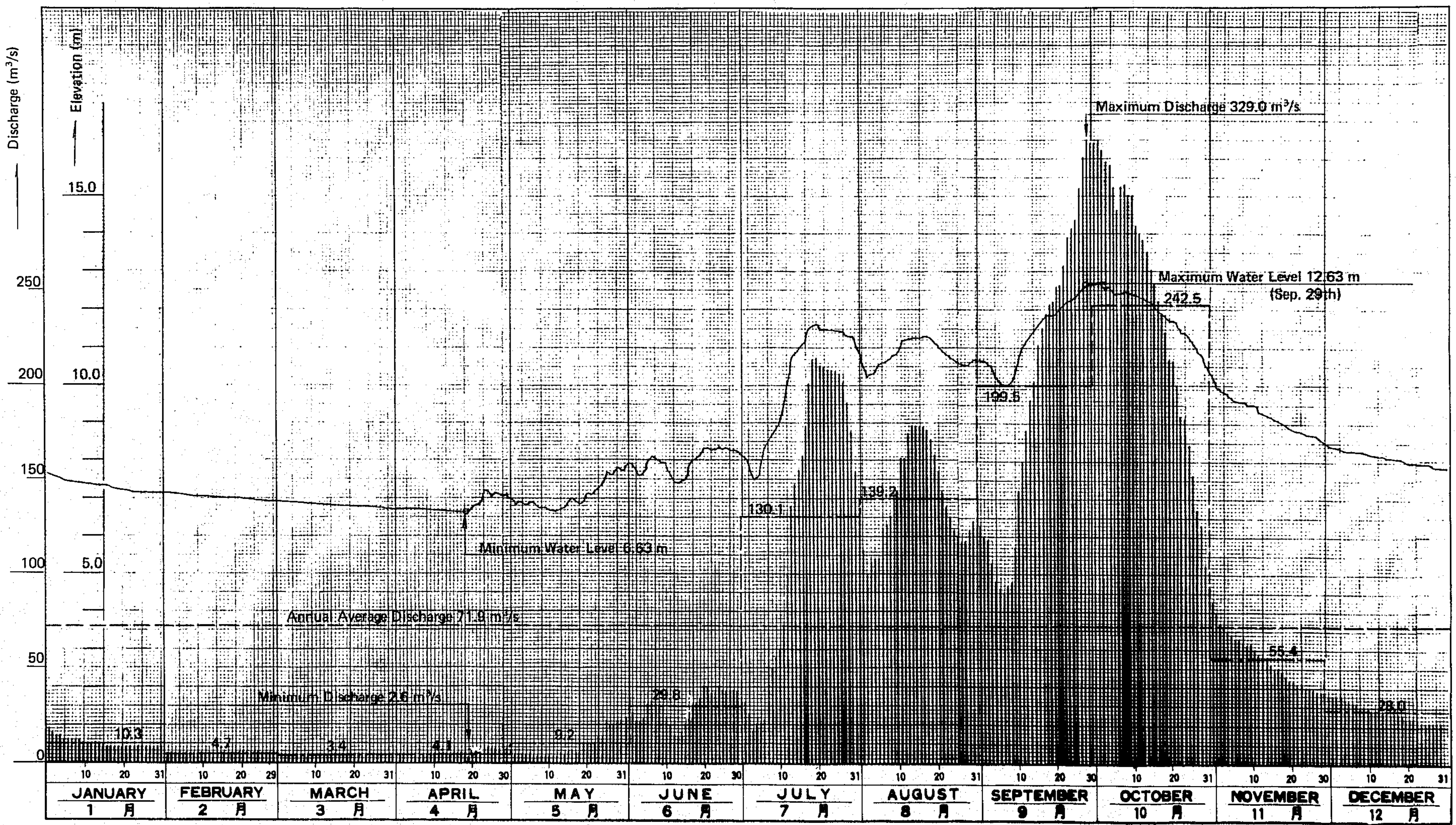
$= 1.32\ m < 1.55\ m$

O.K.

No. ....

Fig. E-1 Water Level and Discharge

STATION 観測所 Kg. Thma | Stung Chinit RIVER, IN THE BASIN OF 河川 水系 Tonle Sap | YEAR 年 1962



No.

Fig. E-2 Water Level and Discharge

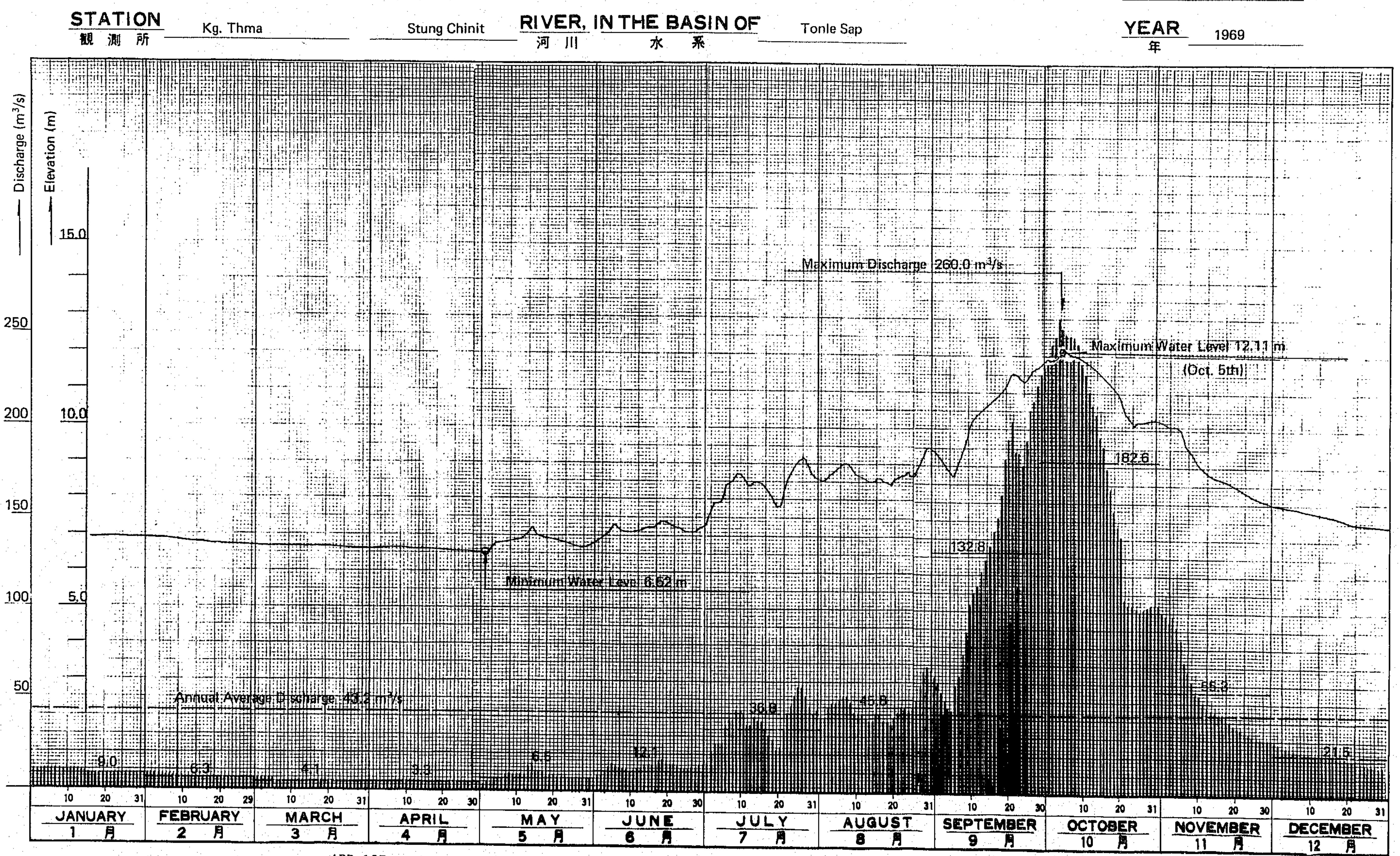


Fig. E-3 Cumulated Curves of Discharge and Rainfall

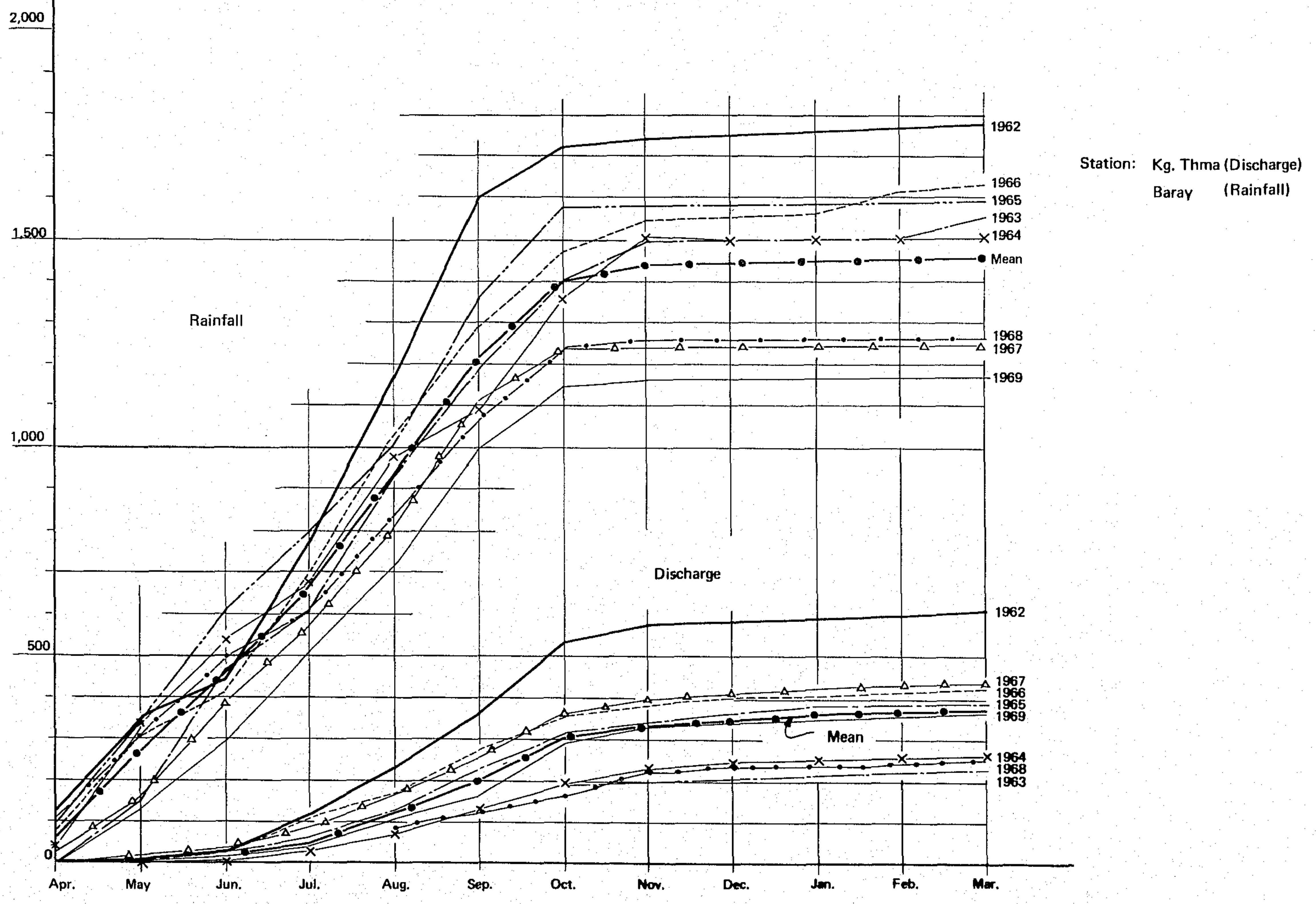


Fig. E-4 Relationship between Cumulated Rainfall and Loss

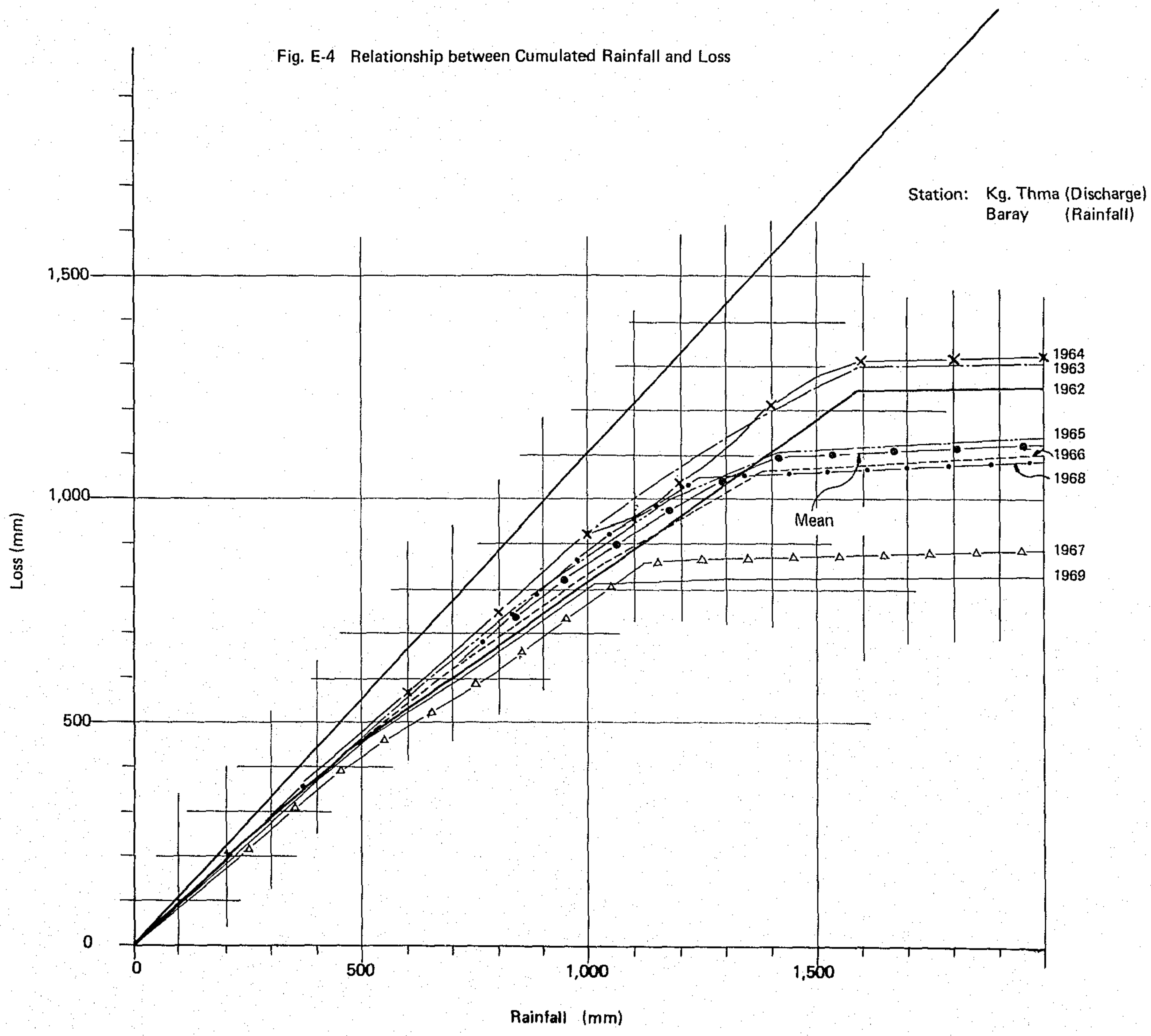


Fig. E-5 Cumulated Rainfall in 1968

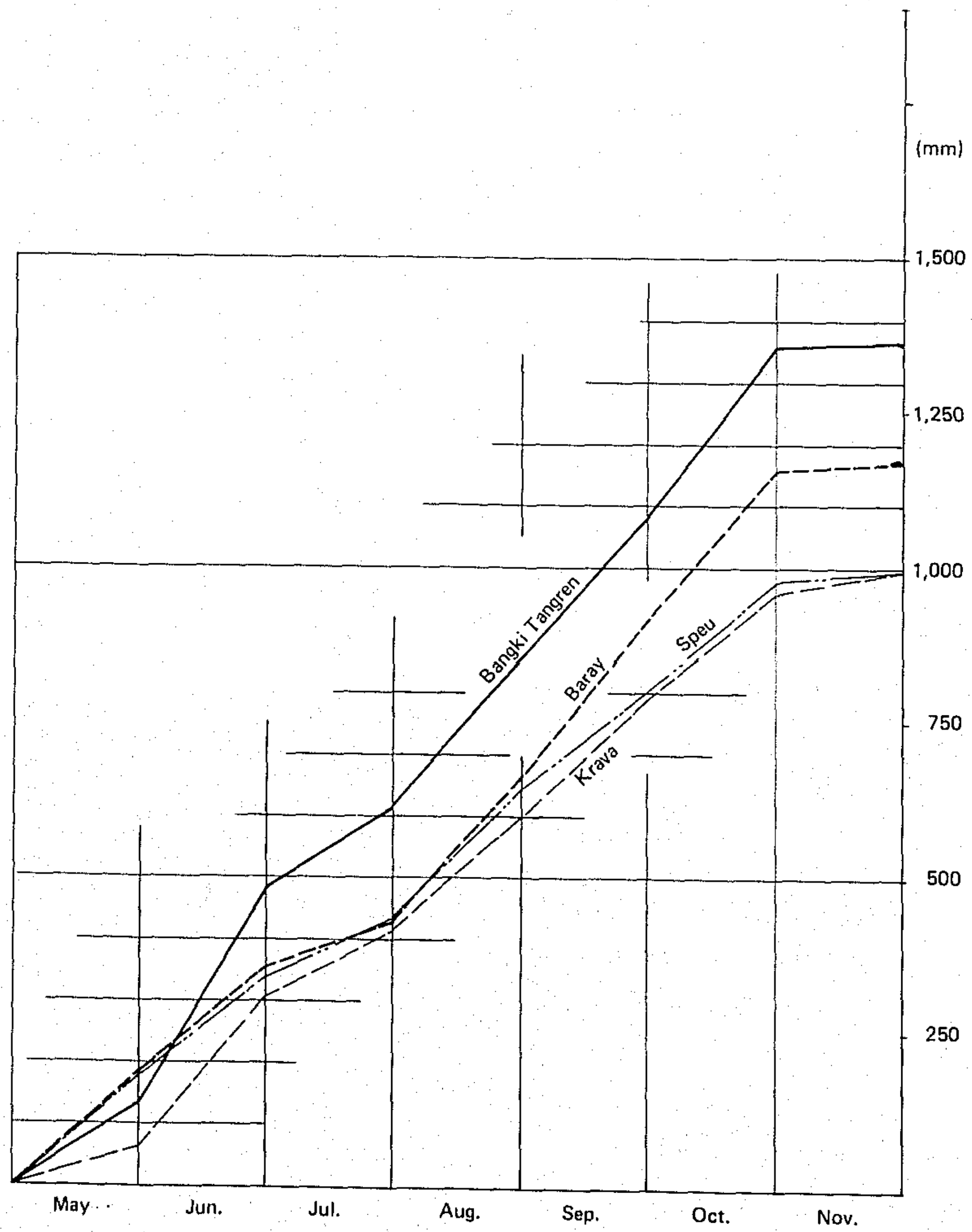
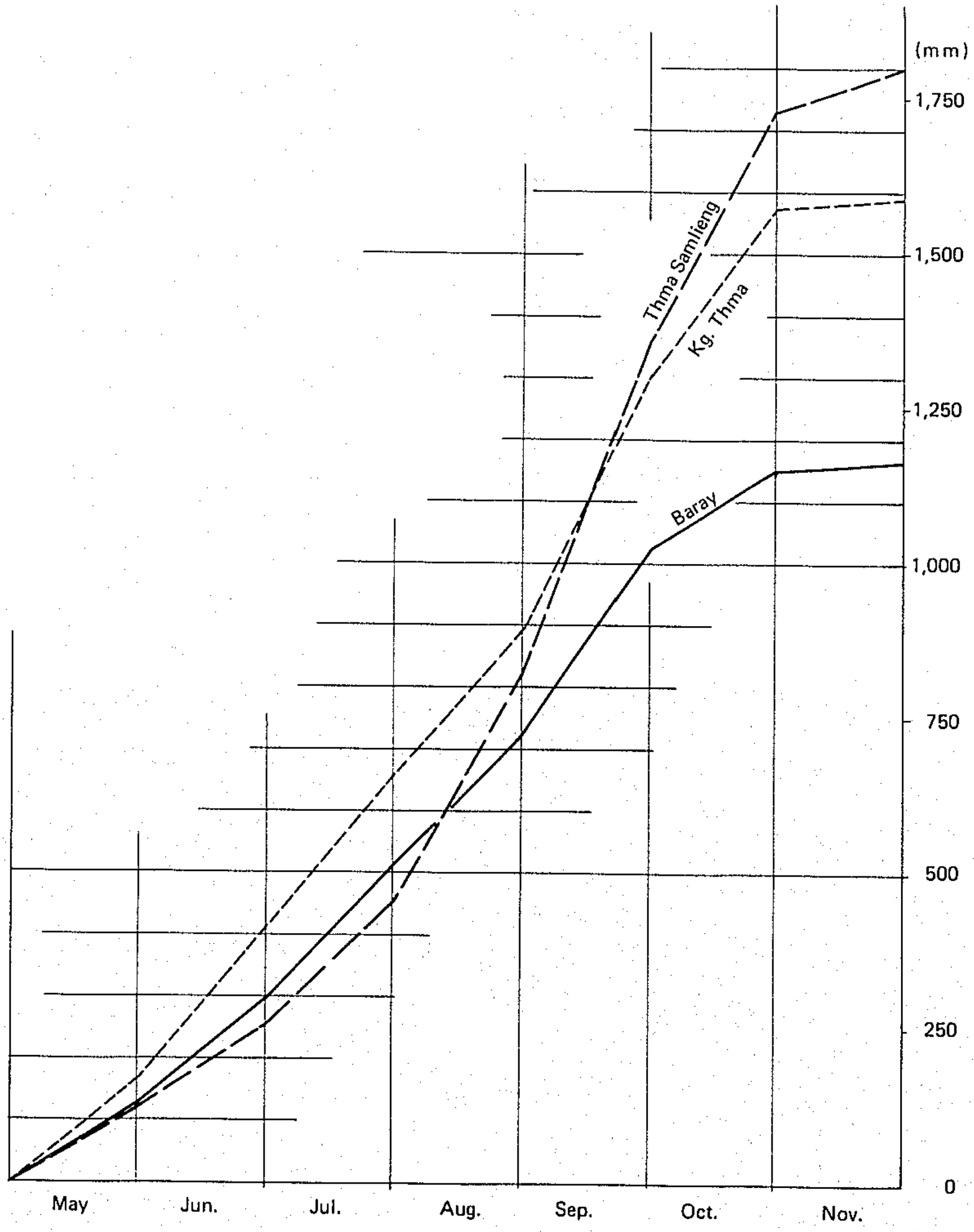


Fig. E-6 Cumulated Rainfall in 1969



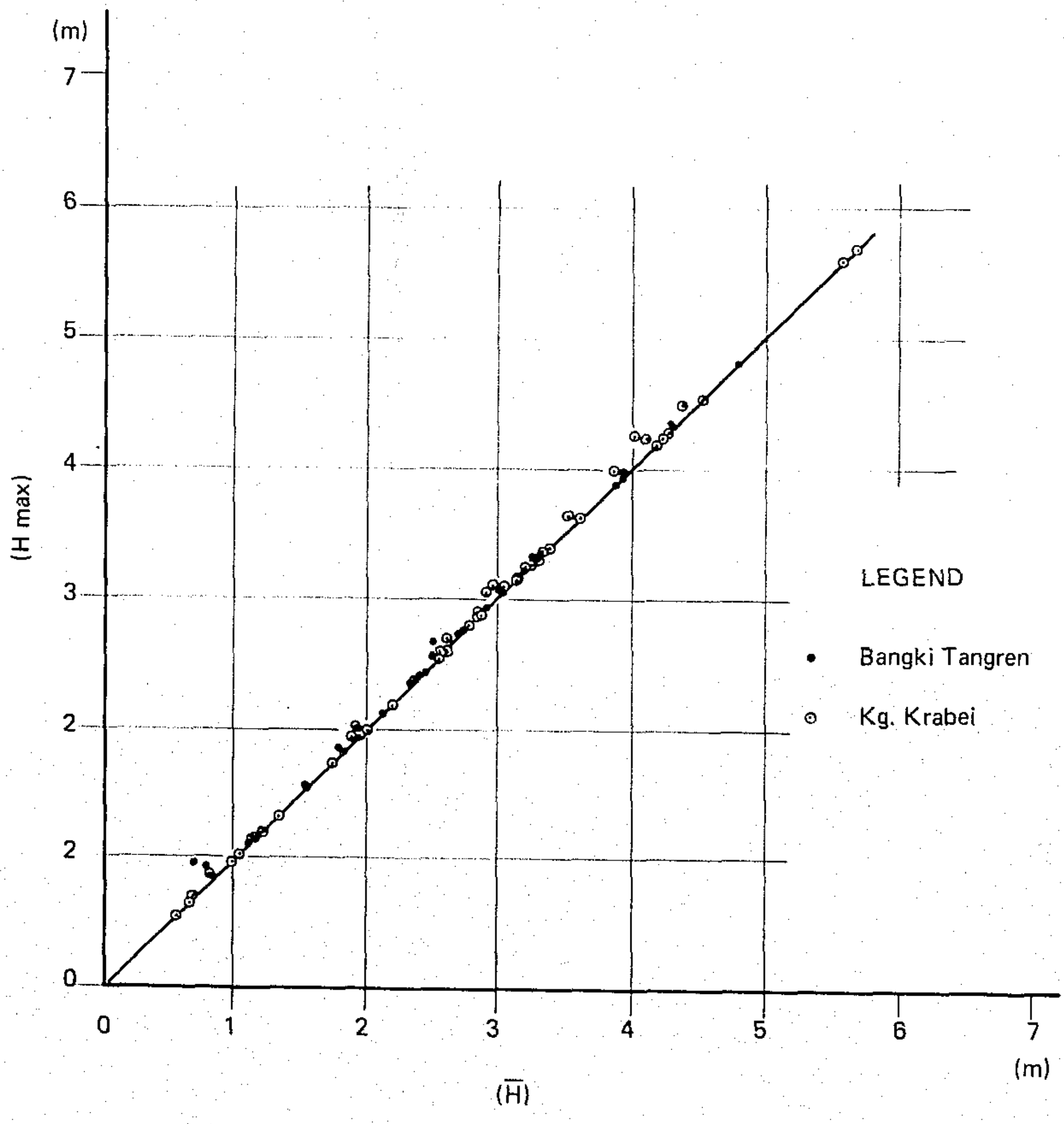
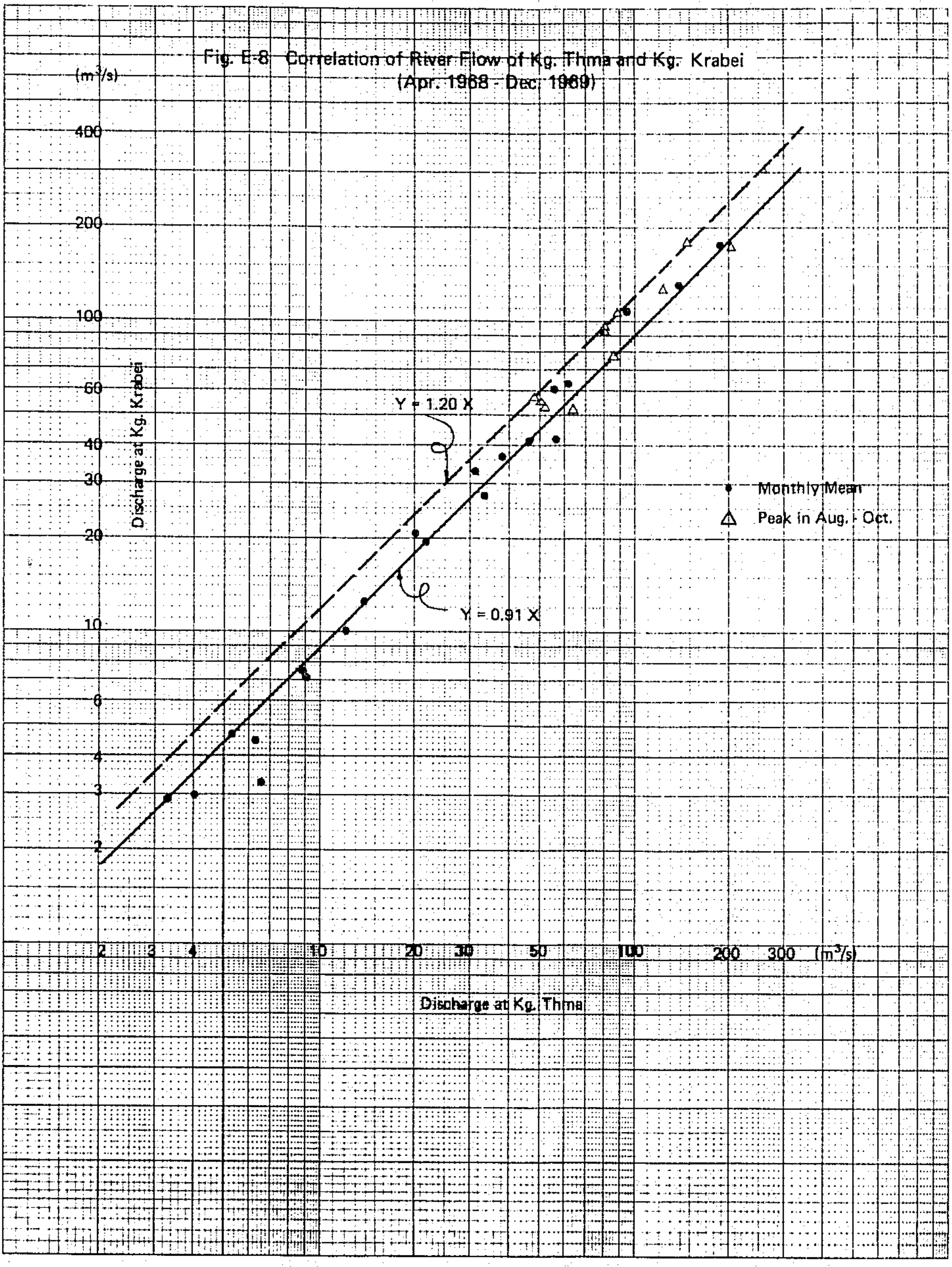


Fig. E-7 Relation between Daily Mean Water Height and Daily Maximum Water Height in Flood Peak, 1968 - 1969

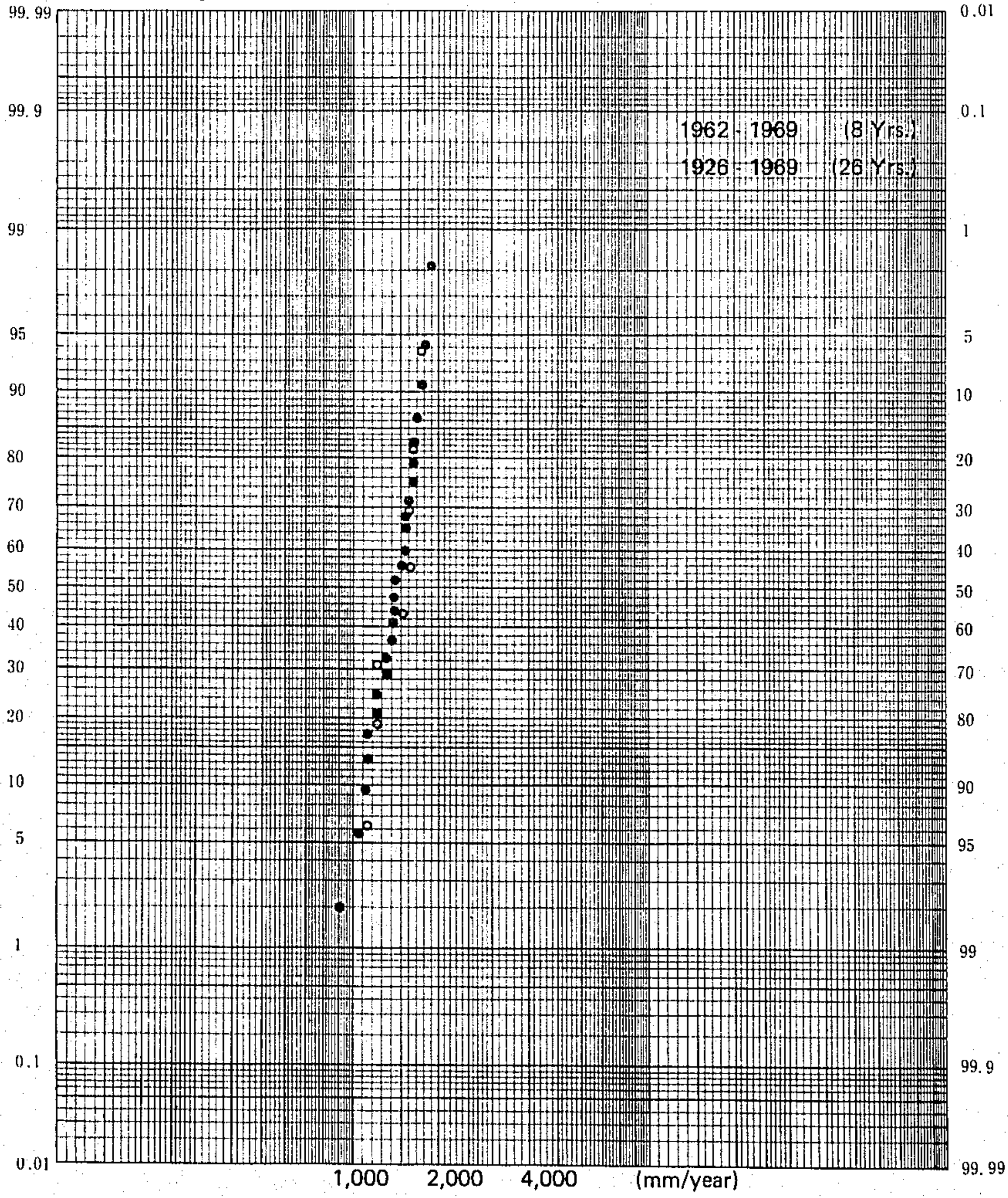
Fig. E-8 Correlation of River Flow of Kg. Thma and Kg. Krabei
(Apr. 1968 - Dec. 1969)



対 数 正 規 確 率 紙

(Log-Normal Distribution)

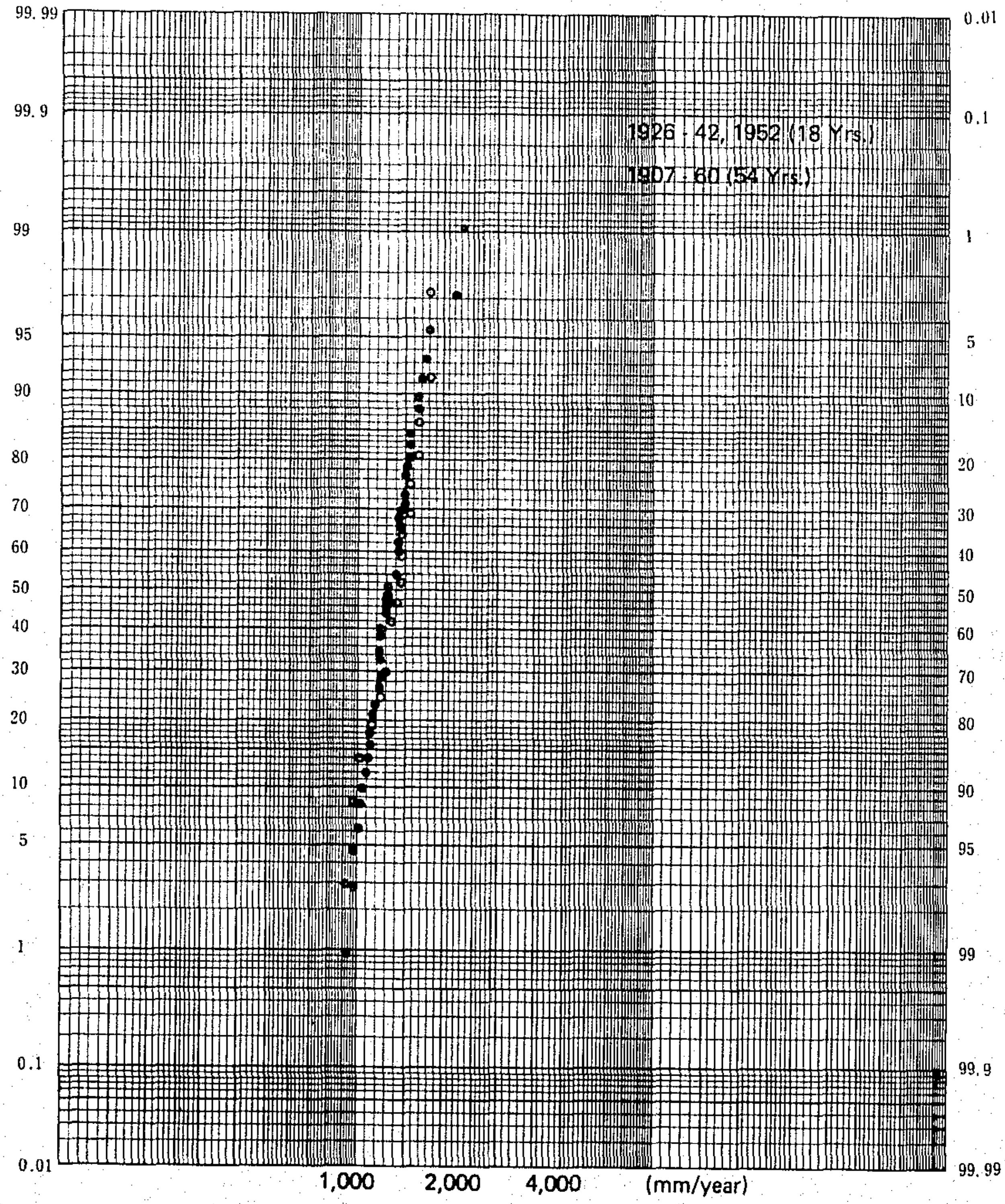
Fig. E-9 Cumulated Probability of Annual Rainfall at Baray



對 数 正 規 確 率 紙

(Log-Normal Distribution)

Fig. E-10 Cumulated Probability of Annual Rainfall in Phnom Penh



Gumbel's Extreme Limiting Distribution

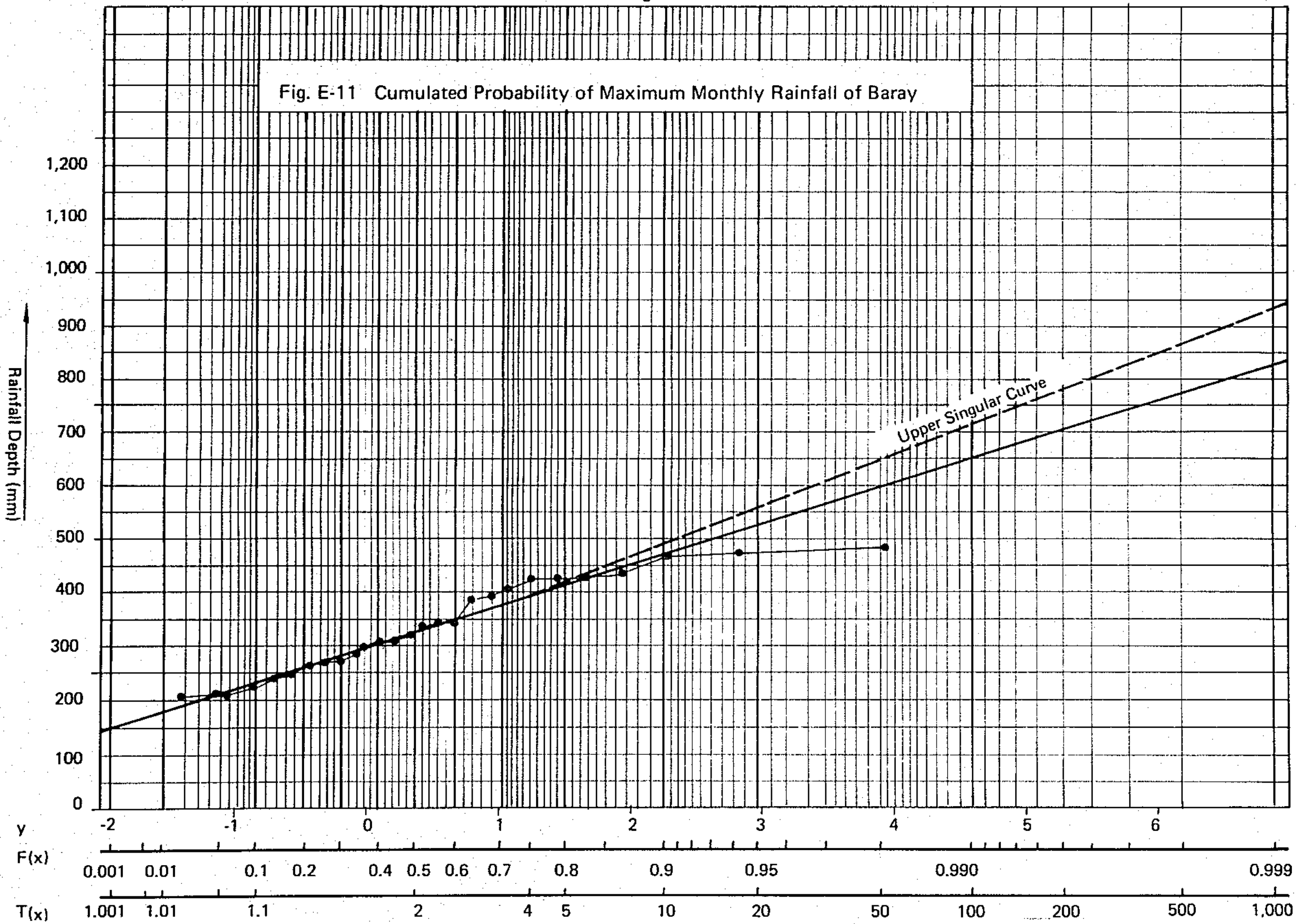


Fig. E-11 Cumulated Probability of Maximum Monthly Rainfall of Baray

Gumbel's Extreme Limiting Distribution

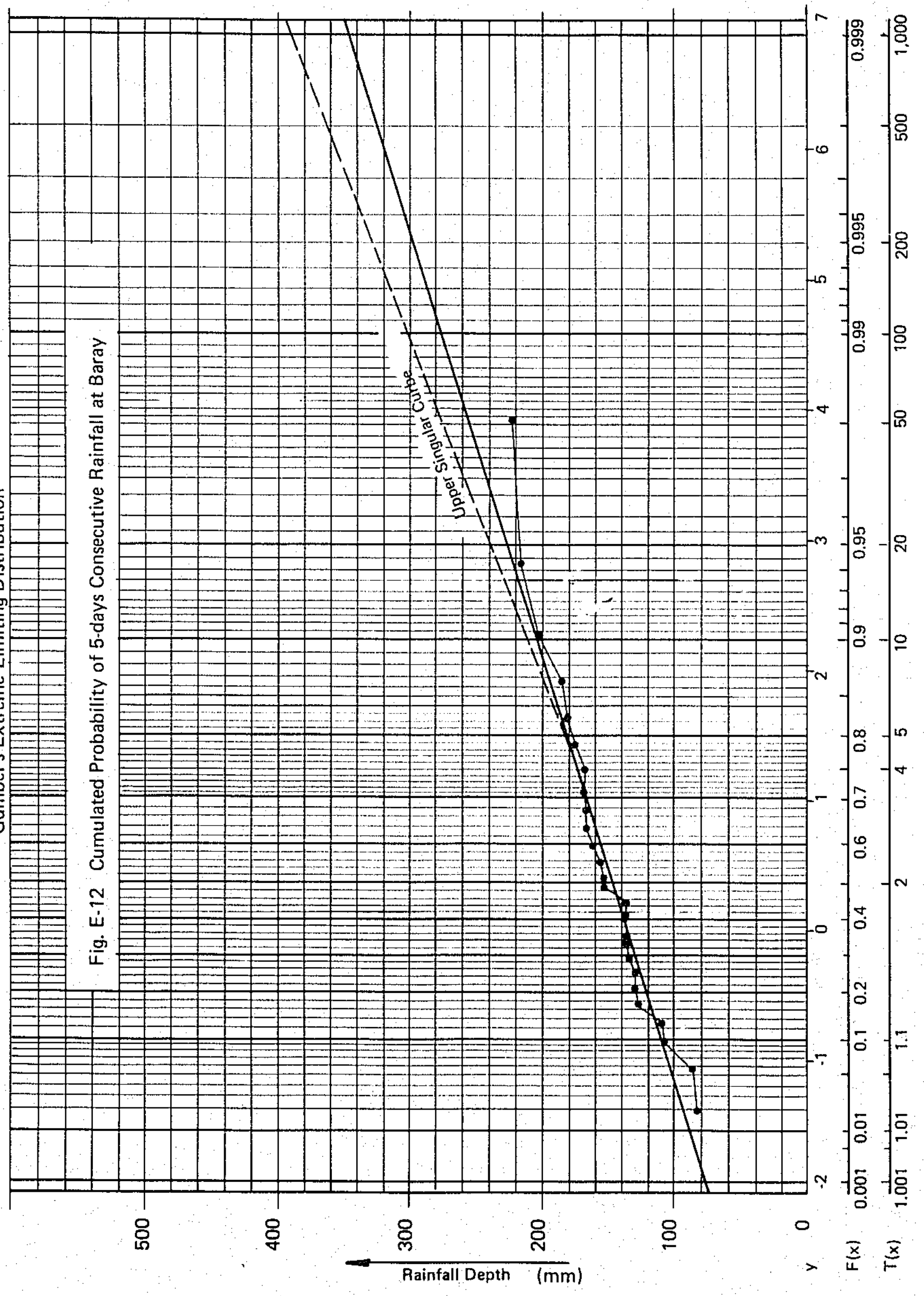


Fig. E-12 Cumulated Probability of 5-days Consecutive Rainfall at Baray

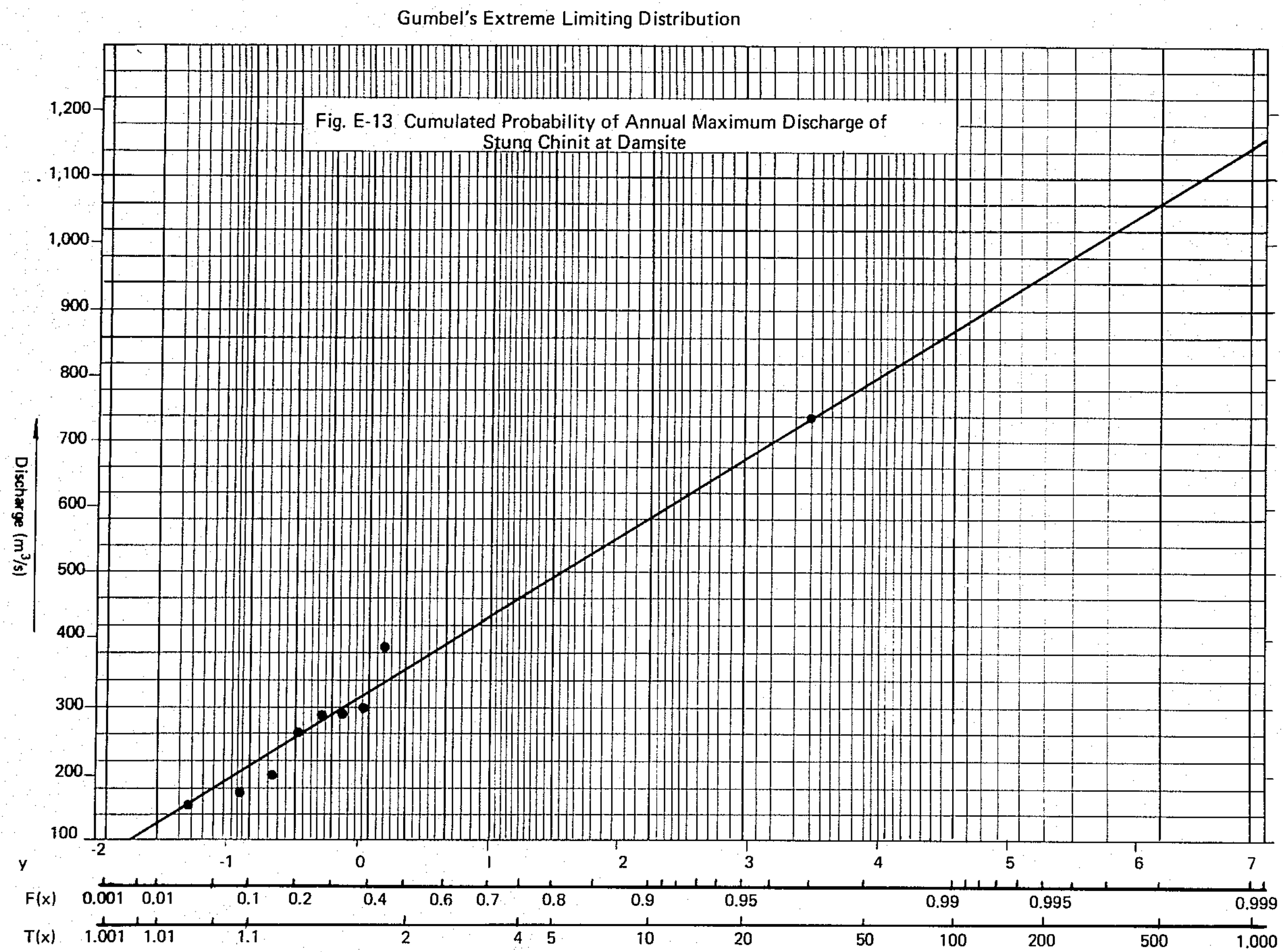

Gumbel's Extreme Limiting Distribution
Fig. E-13 Cumulated Probability of Annual Maximum Discharge of Stung Chinit at Damsite
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
Discharge (m^3/s)
y
-2
-1
0
1
2
3
4
5
6
7
F(x)
0.001
0.01
0.1
0.2
0.4
0.6
0.7
0.8
0.9
0.95
0.99
0.995
0.999
T(x)
1.001
1.01
1.1
2
4
5
10
20
50
100
200
500
1,000

Fig. E-14 Discharge Capacity of Spillway

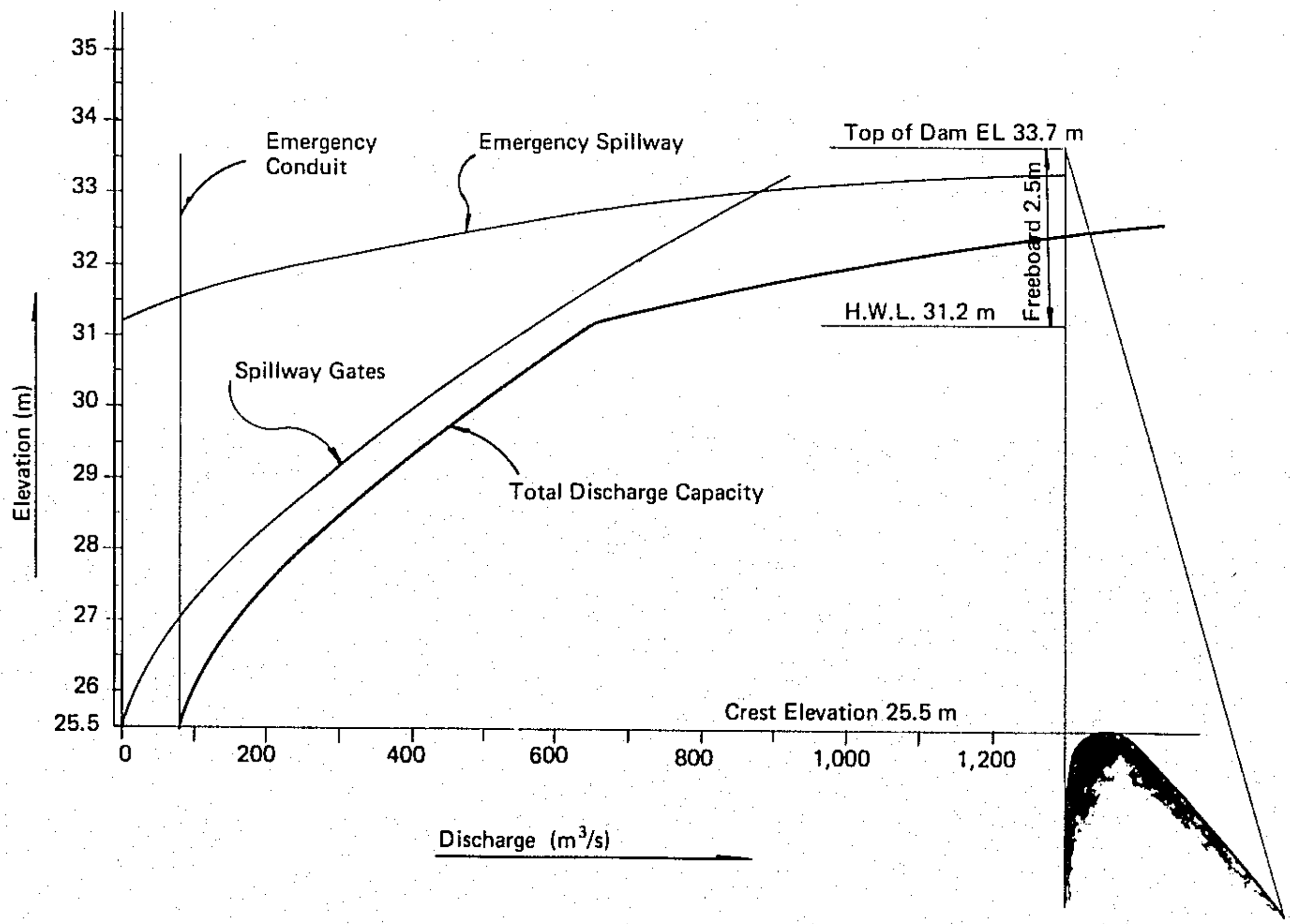
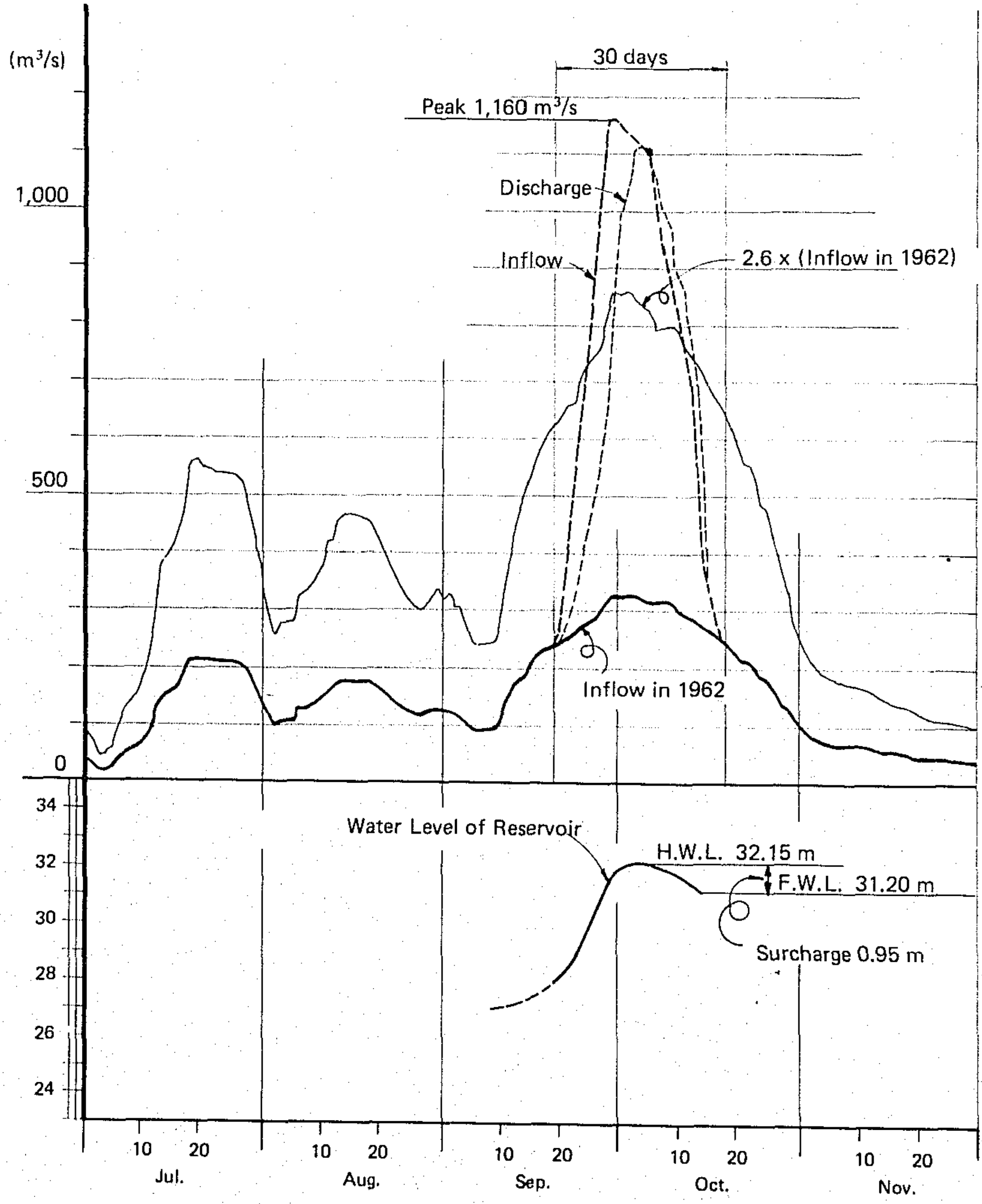
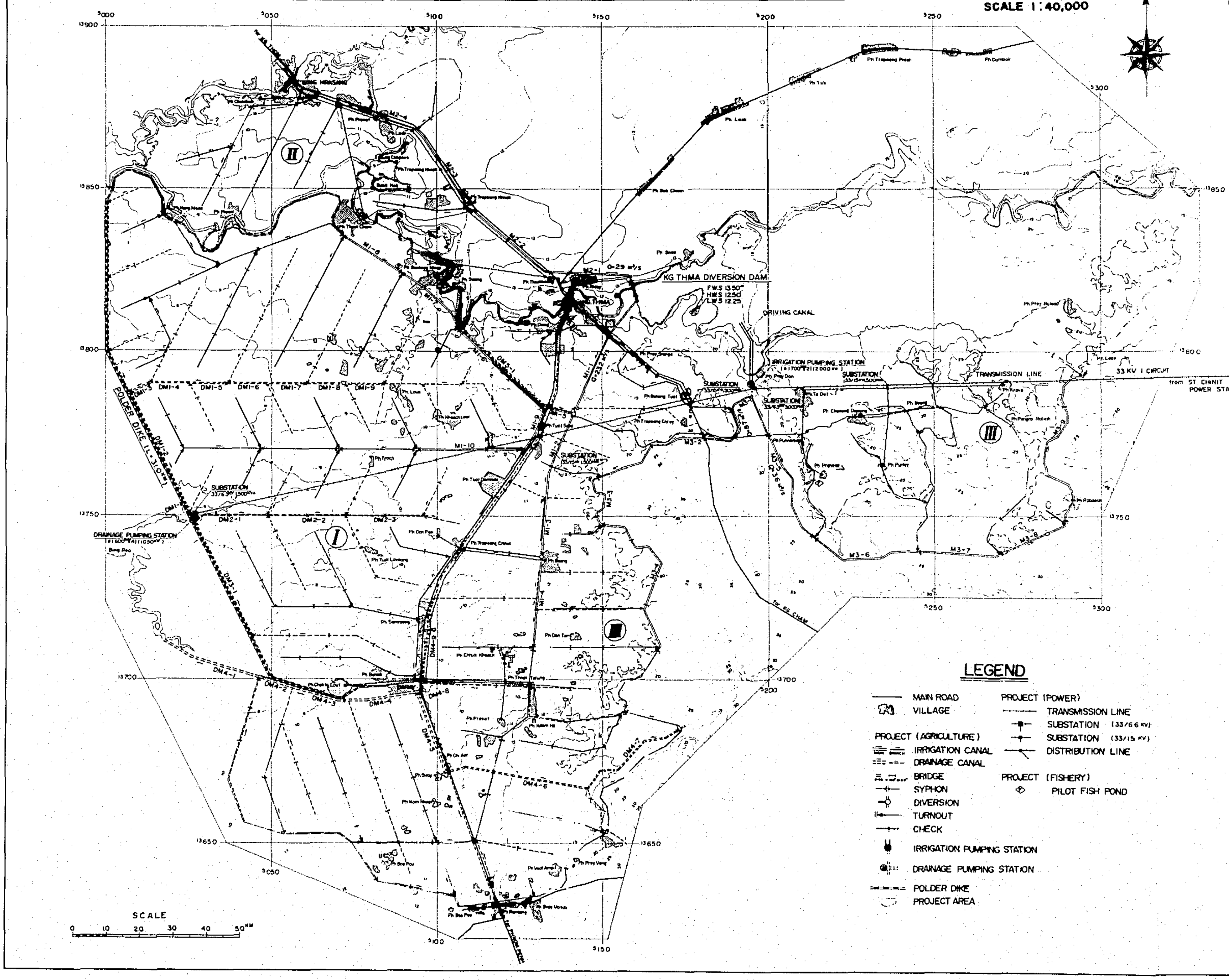


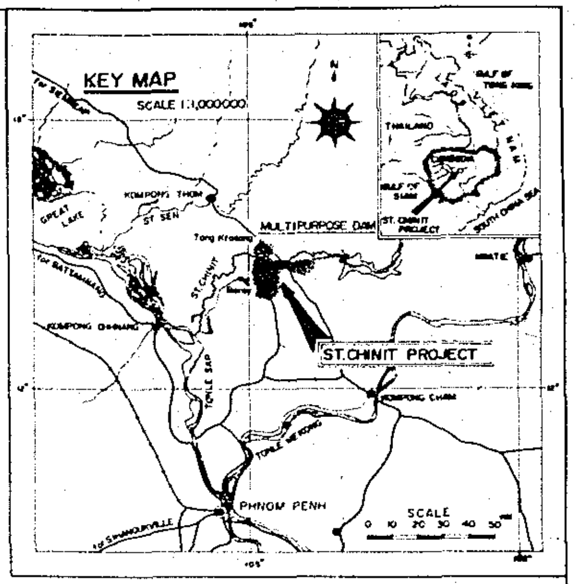
Fig. E-15 Hydrograph of Design Flood



LIST OF DRAWINGS

GENERAL PLAN OF THE STUNG CHINIT MULTIPURPOSE PROJECT





ITEM

MULTIPURPOSE DAM

- TYPE .... COMBINED TYPE
- DAM HEIGHT .... 21.7 M
- DAM LENGTH .... 1,096 M
- EFFECTIVE RESERVOIR CAPACITY 391 × 10^6 M^3
- TOP WATER LEVEL .... EL. 31.20 M
- LOW WATER LEVEL .... EL. 24.70 M
- DESIGNED FLOOD DISCHARGE .... 1,160 M^3/S

AGRICULTURE

- PROJECT AREA
  - Ⓘ .... 15,350 HA
  - Ⓘ .... 2,450 "
  - Ⓘ .... 7,600 "
  - TOTAL .... 25,400 HA
- IRRIGATION CANAL .... L = 268.70 KM
  - QMAX. = 38.4 M^3/S
- DRAINAGE CANAL .... L = 160.1 KM
- POLDER DIKE .... L = 31 KM
- DIVERSION DAM
  - TYPE .... ROLLER GATE TYPE
  - HEIGHT AND LENGTH .... 6.5 M × 20.0 M × 2
  - MAXIMUM INTAKE WATER .... 26.1 M^3/S
- IRRIGATION PUMPING STATION .... 1 SET
- DRAINAGE PUMPING STATION .... 1 SET
- LAND RECLAMATION .... 4,700 HA

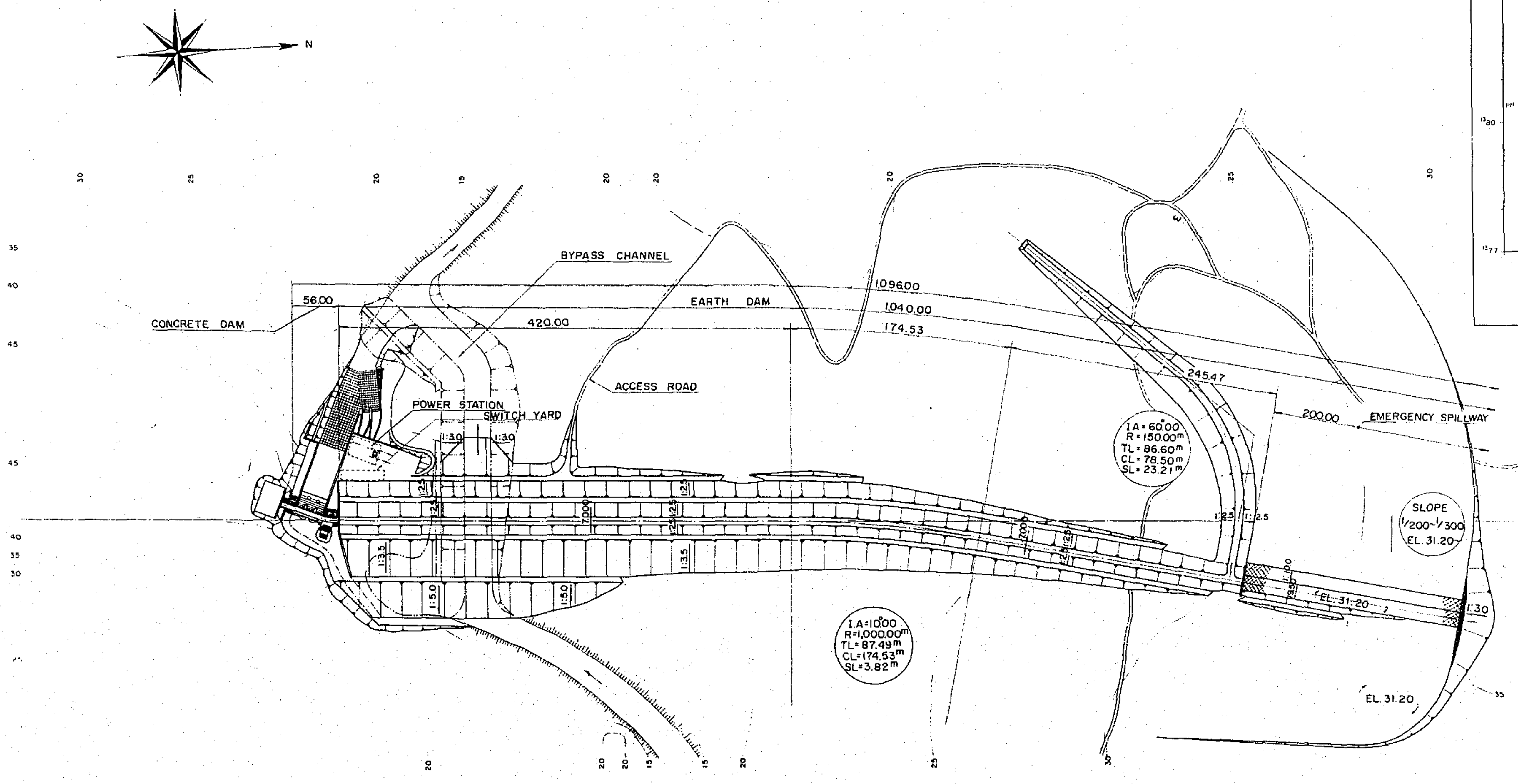
POWER

- HYDROELECTRIC POWER STATION .... 1 SET
  - MAXIMUM POWER OUTPUT .... 4,500 KW
  - ANNUAL POWER DELIVERY .... 22,600 MWH
  - AC GENERATOR HORIZONTAL SYNCRONOUS 2 UNITS
  - WATER TURBINE .... HORIZONTAL KAPLAN 2 UNITS
- TRANSMISSION LINE .... 33 KV L = 45 KM
- SUBSTATION .... 5 SET

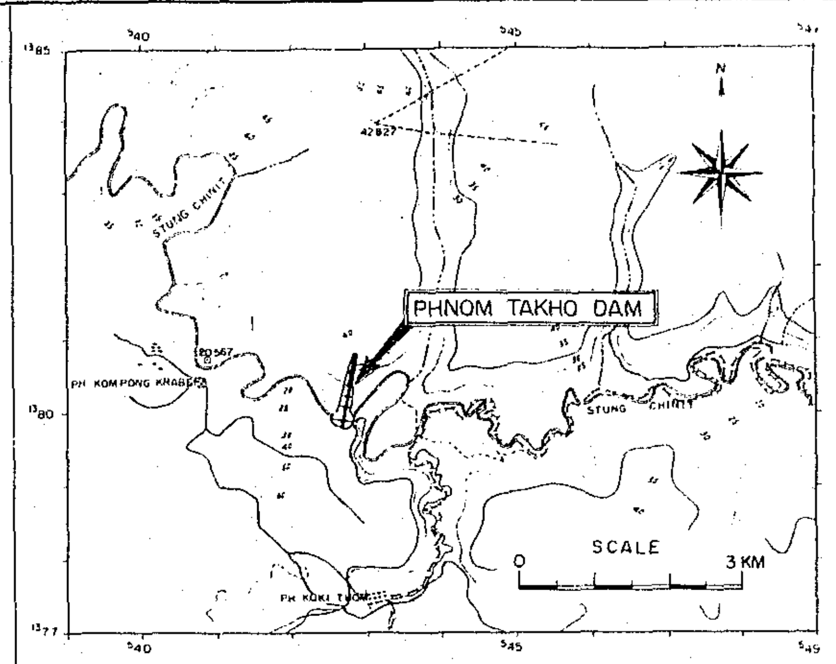
FISHERY

- PILOT FISH POND .... 3 SET

OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
STUNG CHINIT MULTIPURPOSE PROJECT	
GENERAL PLAN	
SANYU CONSULTANTS INTERNATIONAL INC.	
SUBMITTED	DATE
APPROVED	DRAWING NO. 1



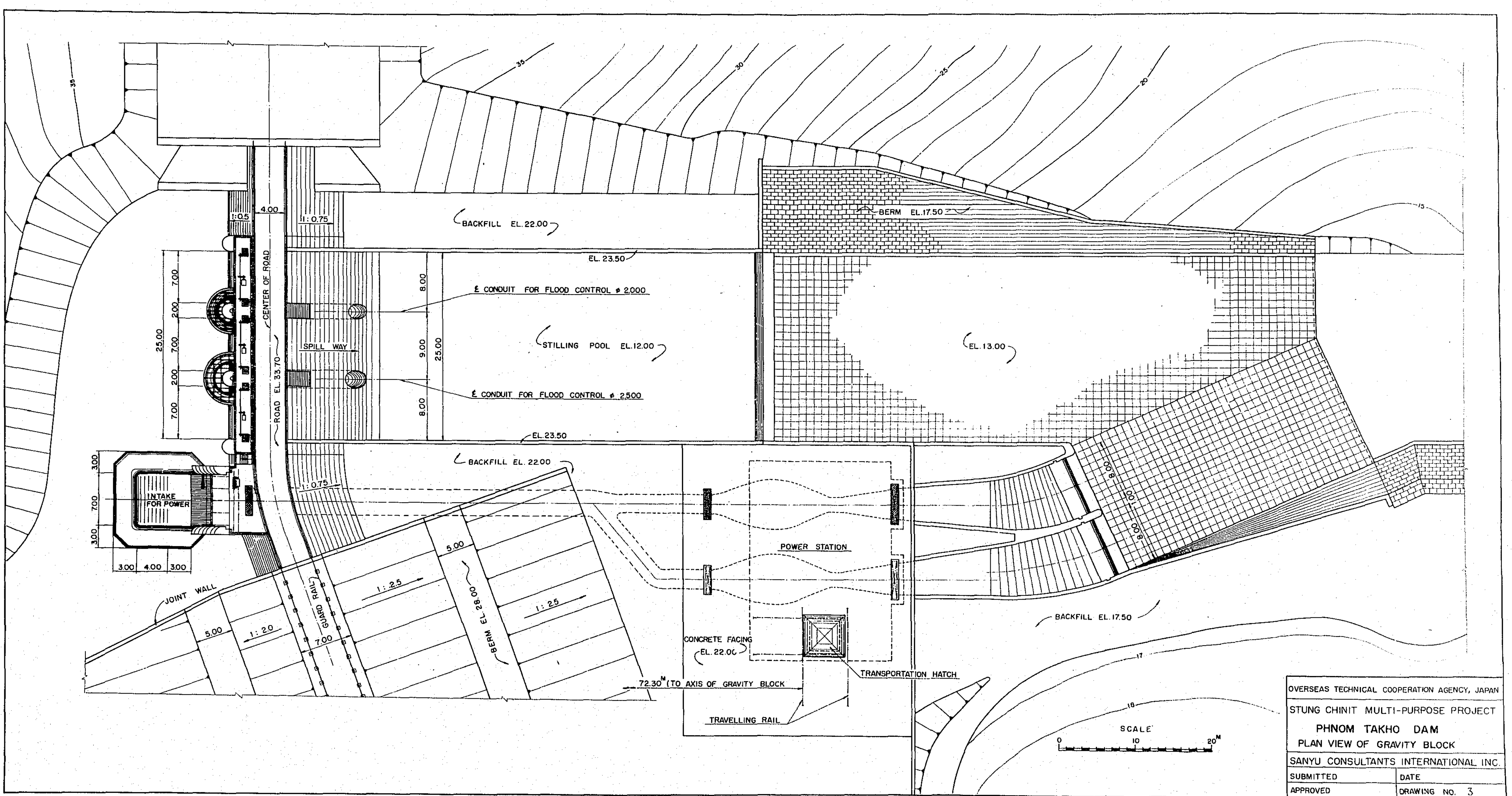
GENERAL PLAN



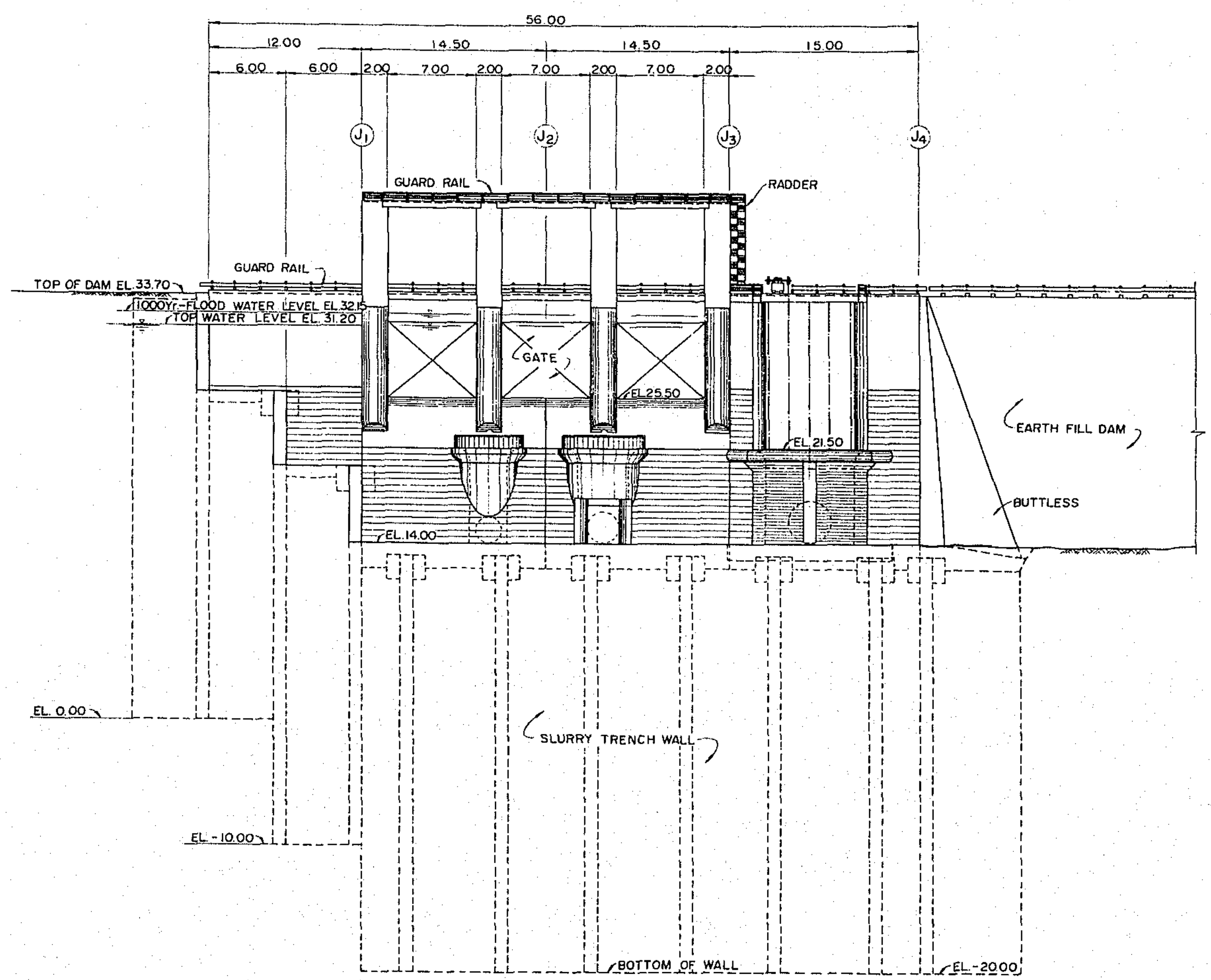
KEY MAP OF PHNOM TAKHO DAM

SCALE 0 — 200M

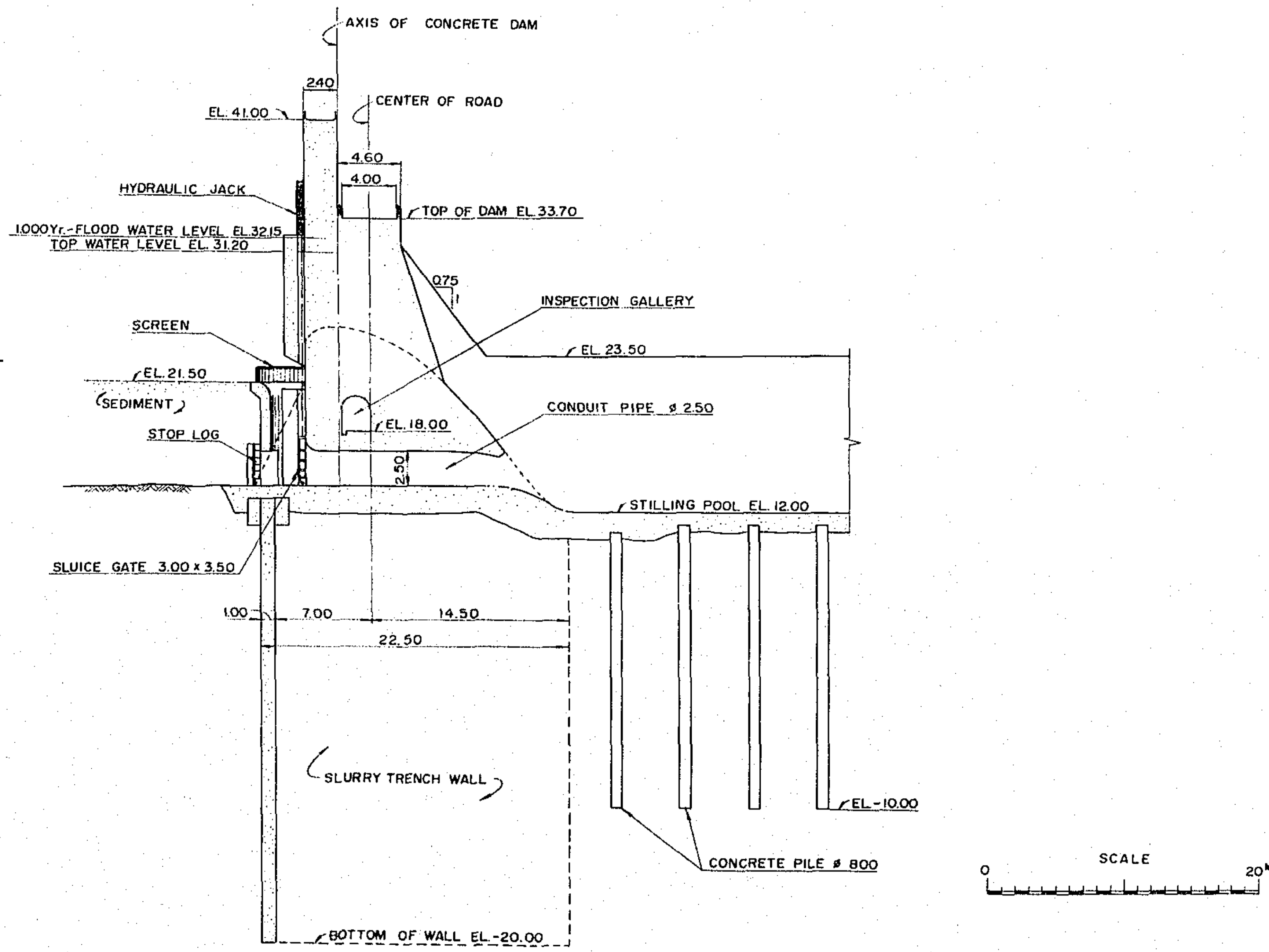
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
STUNG CHINIT MULTI-PURPOSE PROJECT	
PHNOM TAKHO DAM GENERAL PLAN	
SANYU CONSULTANTS INTERNATIONAL INC.	
SUBMITTED	DATE
APPROVED	DRAWING NO. 2



BACKFILL EL. 22.00
BERM EL. 17.50
EL. 23.50
℄ CONDUIT FOR FLOOD CONTROL ϕ 2,000
STILLING POOL EL. 12.00
EL. 13.00
SPILL WAY
CENTER OF ROAD
ROAD EL. 33.70
℄ CONDUIT FOR FLOOD CONTROL ϕ 2,500
EL. 23.50
BACKFILL EL. 22.00
INTAKE FOR POWER
POWER STATION
JOINT WALL
GUARD RAIL
BERM EL. 28.00
CONCRETE FACING EL. 22.00
TRANSPORTATION HATCH
72.30M (TO AXIS OF GRAVITY BLOCK
TRAVELLING RAIL
BACKFILL EL. 17.50
SCALE
0 10 20M
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN
STUNG CHINIT MULTI-PURPOSE PROJECT
PHNOM TAKHO DAM
PLAN VIEW OF GRAVITY BLOCK
SANYU CONSULTANTS INTERNATIONAL INC.
SUBMITTED
DATE
APPROVED
DRAWING NO. 3

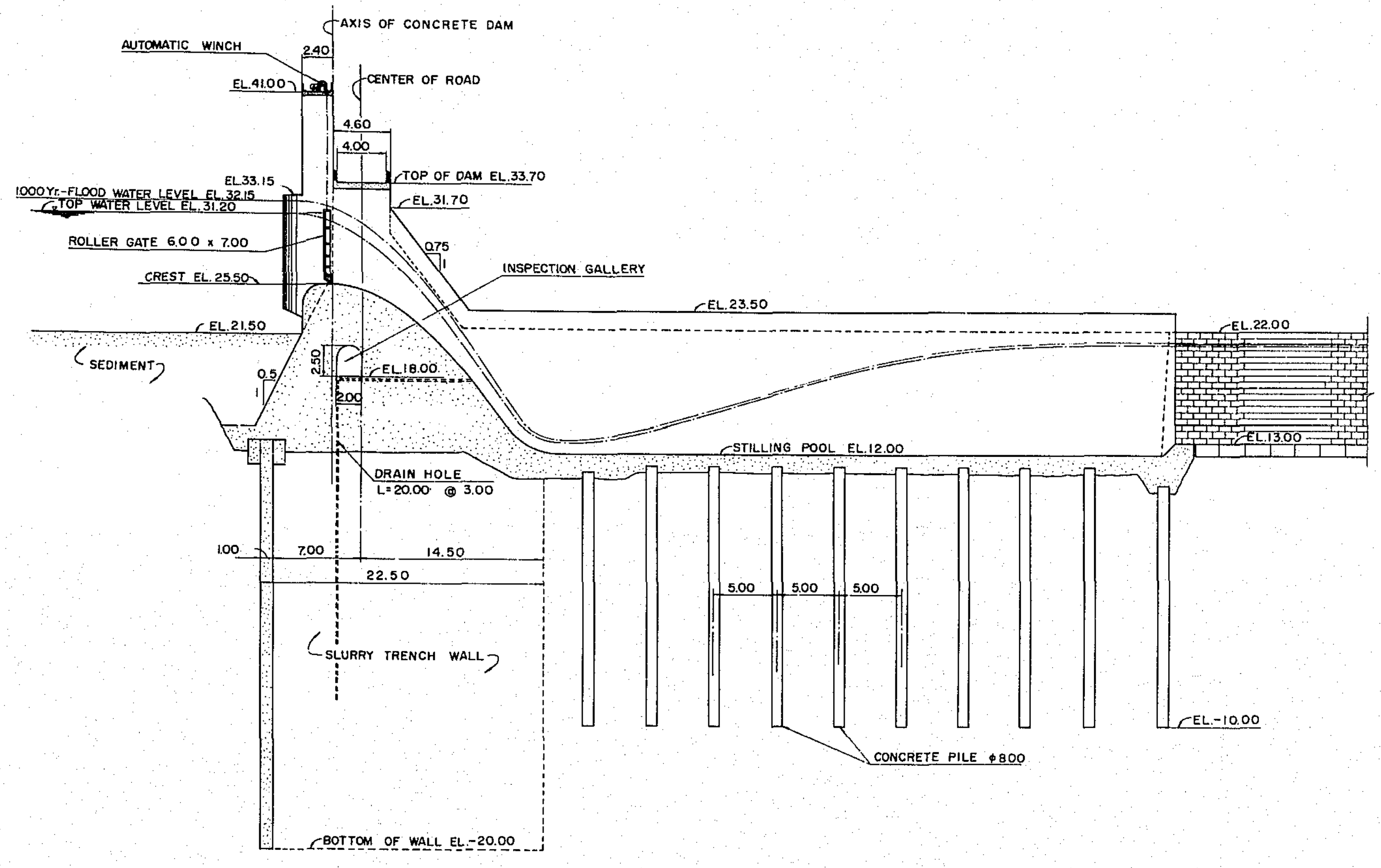


UPSTREAM VIEW

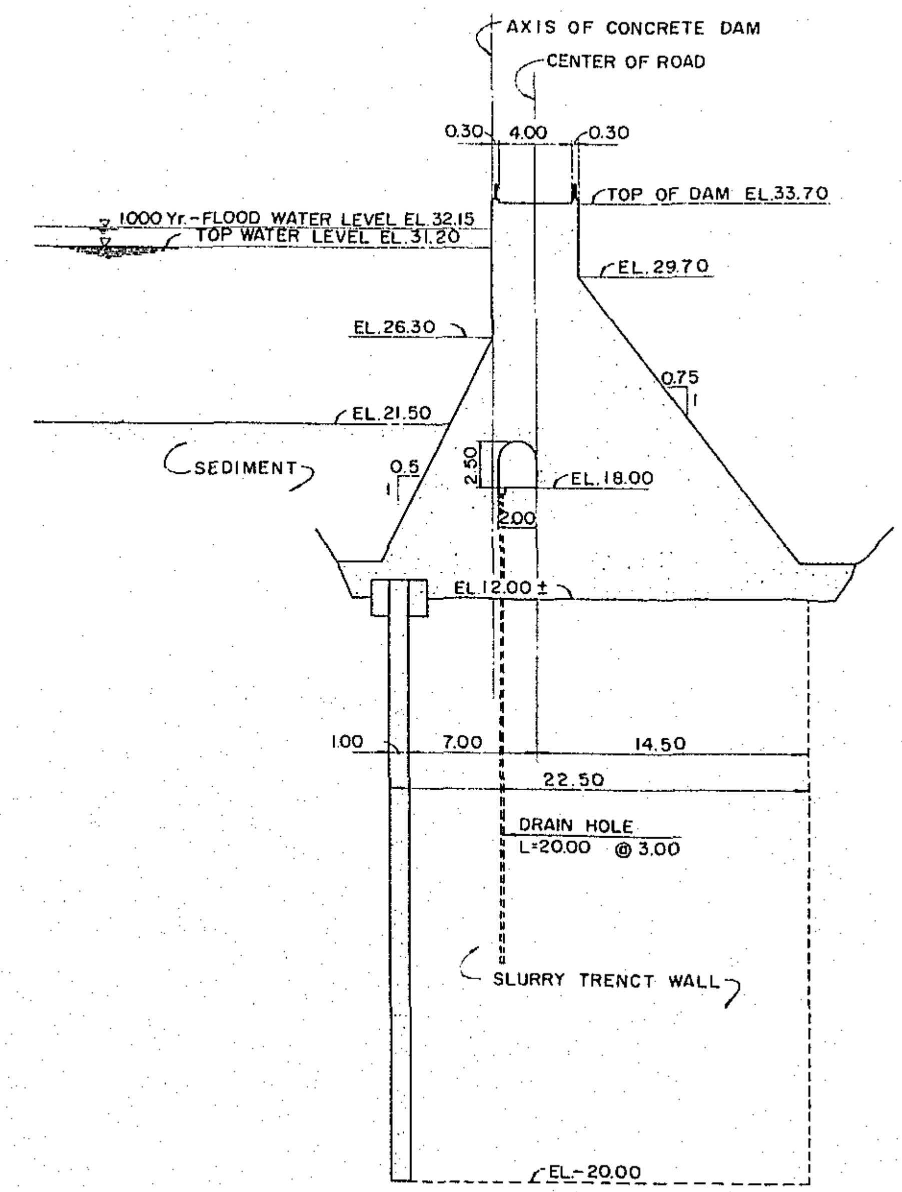


SECTION OF FLOOD CONTROL BLOCK

OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
STUNG CHINIT MULTI-PURPOSE PROJECT PHNOM TAKHO DAM UPSTREAM VIEW AND TYPICAL SECTION	
SANYU CONSULTANTS INTERNATIONAL INC.	
SUBMITTED	DATE
APPROVED	DRAWING NO. 4



SECTION OF FLOOD DISCHARGE BLOCK



SECTION OF GRAVITY BLOCK

SCALE 0 20M

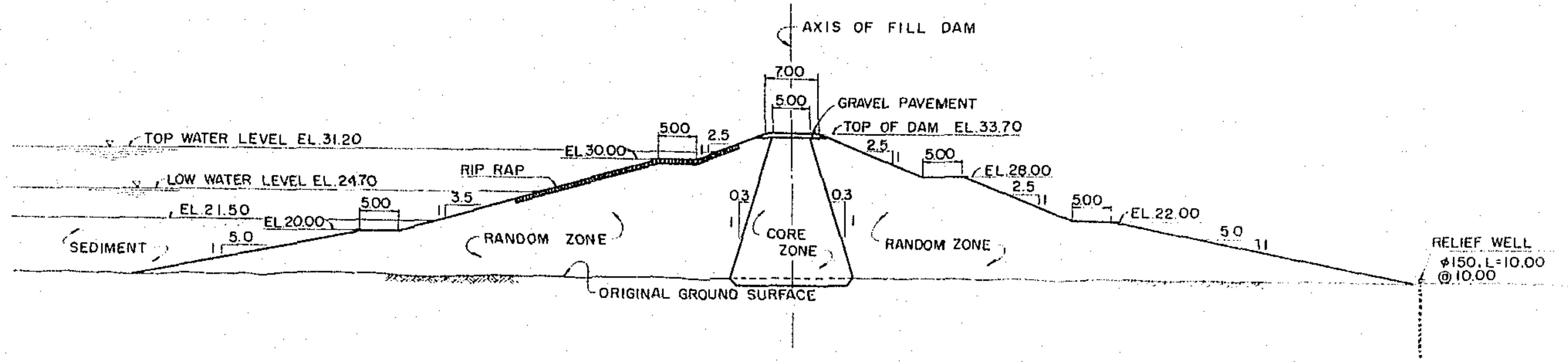
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN

STUNG CHINIT MULTI-PURPOSE PROJECT

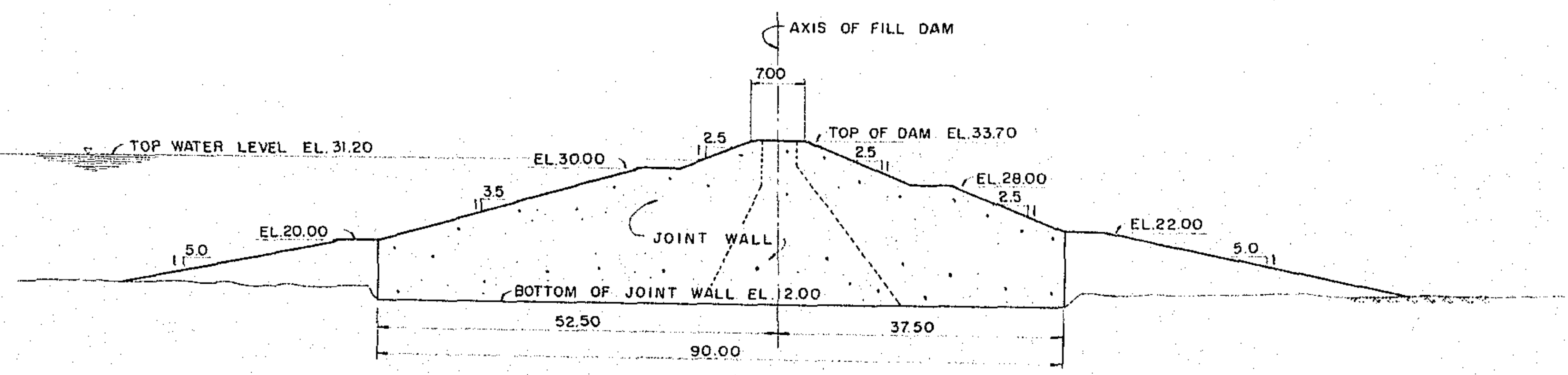
PHNOM TAKHO DAM
TYPICAL SECTIONS (1)

SANYU CONSULTANTS INTERNATIONAL INC.

SUBMITTED	DATE
APPROVED	DRAWING NO. 5



TYPICAL SECTION OF FILL DAM

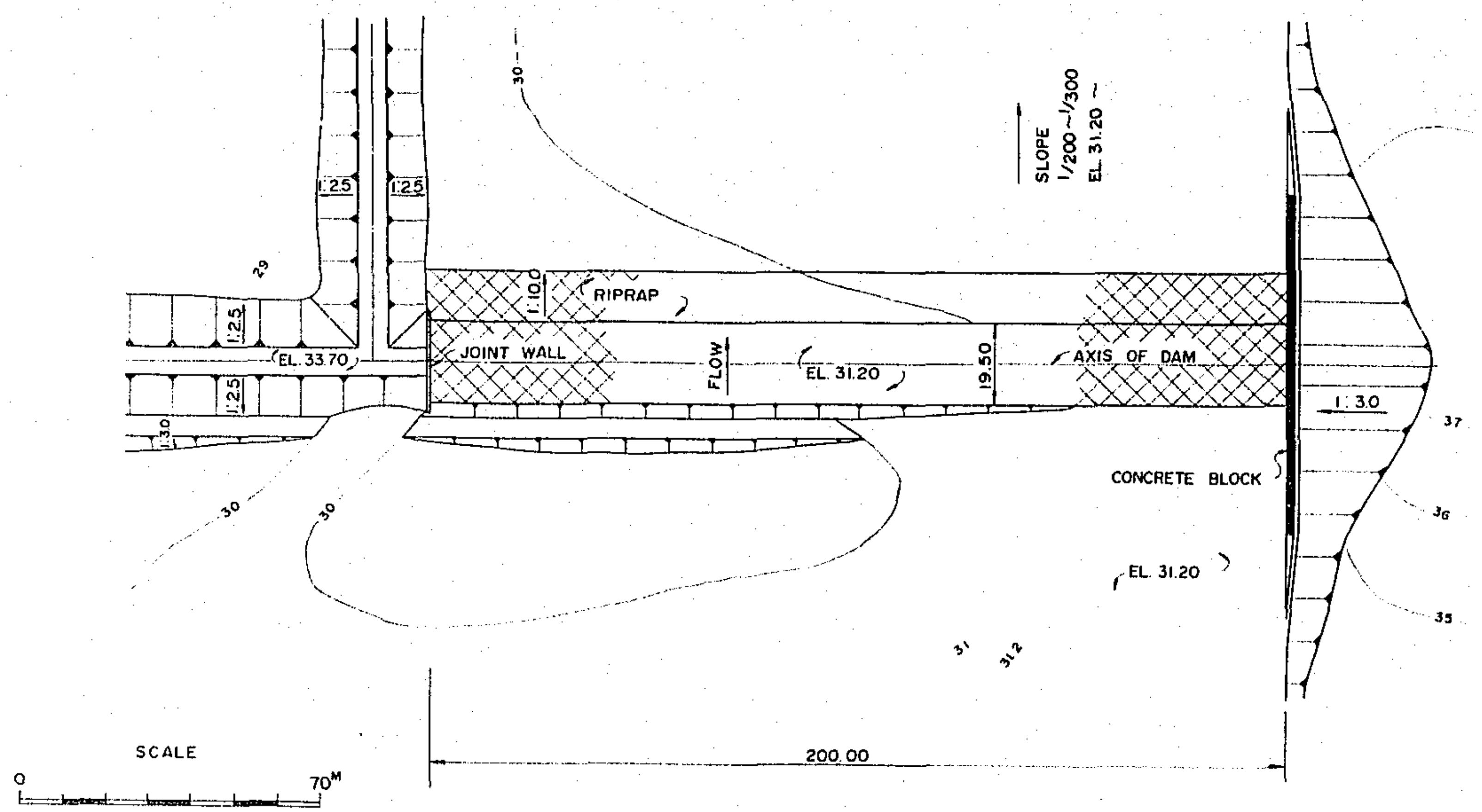


SECTION OF JOINT BLOCK WITH CONCRETE DAM

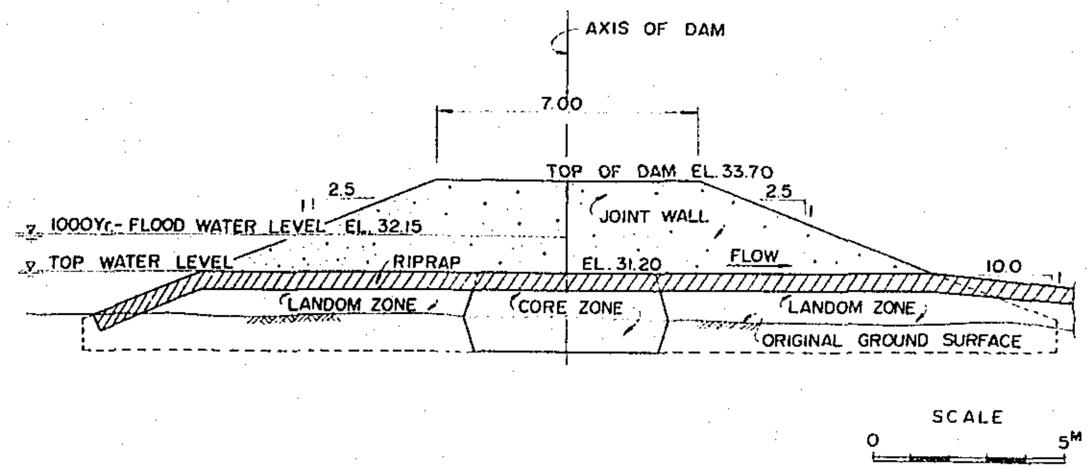
SCALE
0 40.00M

OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN
STUNG CHINIT MULTI-PURPOSE PROJECT PHNOM TAKHO DAM TYPICAL SECTIONS (2)
SANYU CONSULTANTS INTERNATIONAL INC.

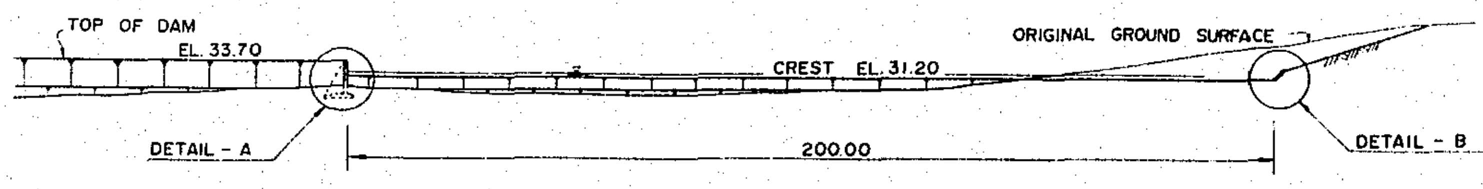
SUBMITTED	DATE
APPROVED	DRAWING NO. 6



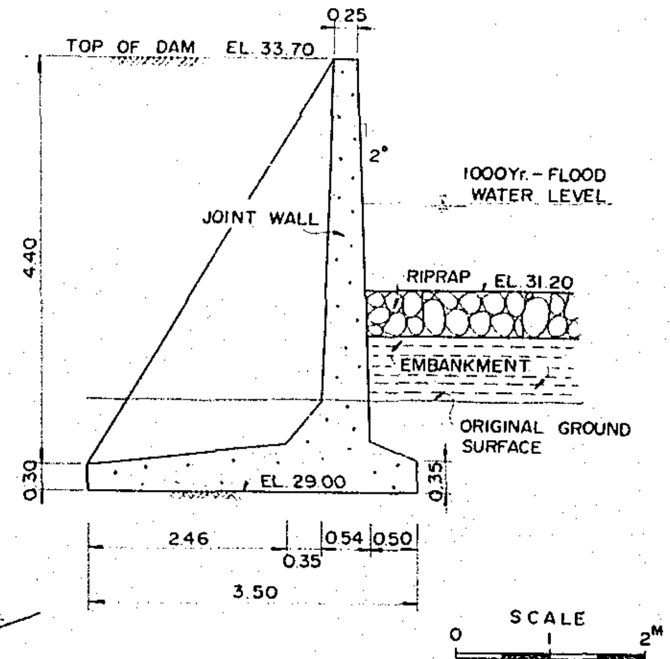
PLANE OF EMERGENCY SPILLWAY



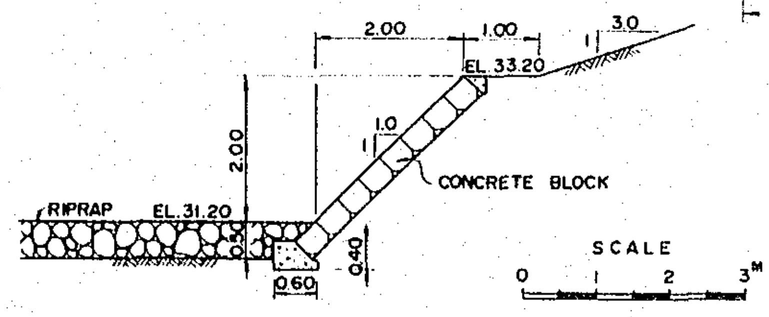
SECTION OF EMERGENCY SPILLWAY



UPSTREAM VIEW OF EMERGENCY SPILLWAY

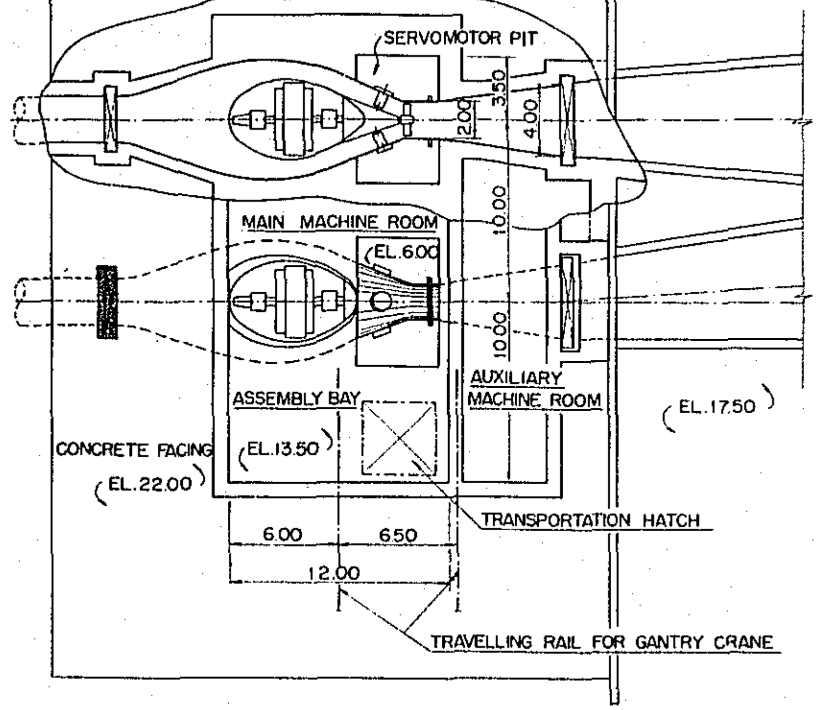


DETAIL - A



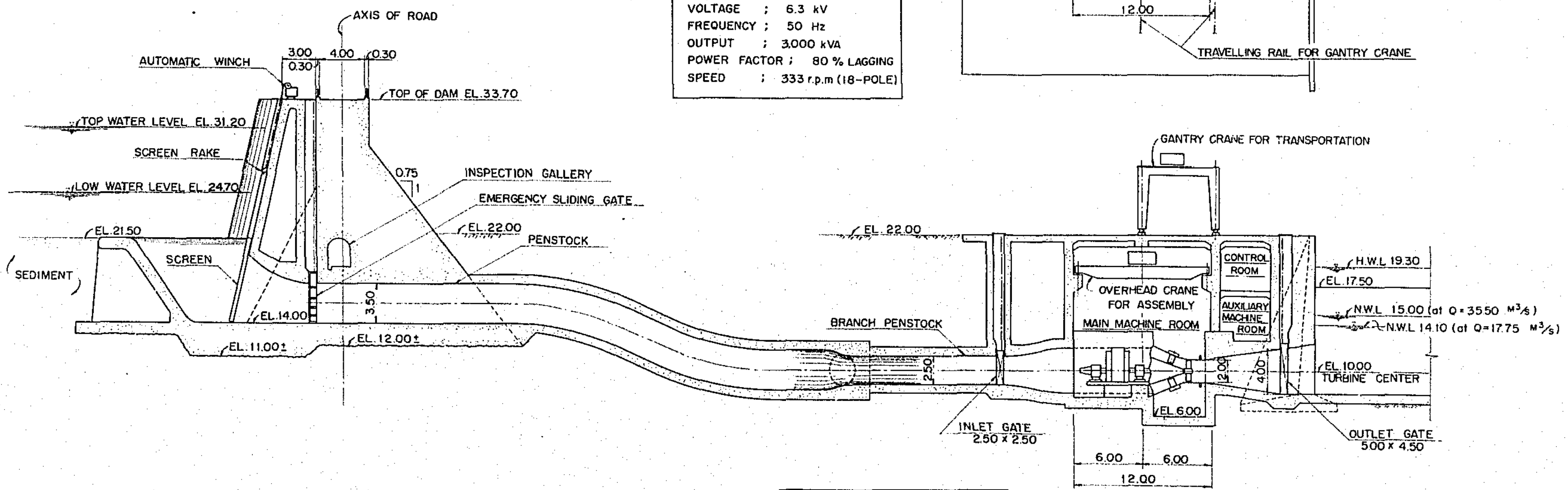
DETAIL - B

OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
STUNG CHINIT MULTI-PURPOSE PROJECT PHNOM TAKHO DAM EMERGENCY SPILLWAY	
SANYU CONSULTANTS INTERNATIONAL INC.	
SUBMITTED	DATE
APPROVED	DRAWING NO. 7



A.C. GENERATOR

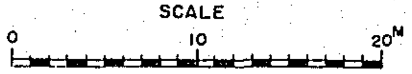
TYPE	; HORIZONTAL SYNCHRONOUS
PHASE	; 3 2 UNITS
VOLTAGE	; 6.3 kV
FREQUENCY	; 50 Hz
OUTPUT	; 3,000 kVA
POWER FACTOR	; 80 % LAGGING
SPEED	; 333 r.p.m (18-POLE)



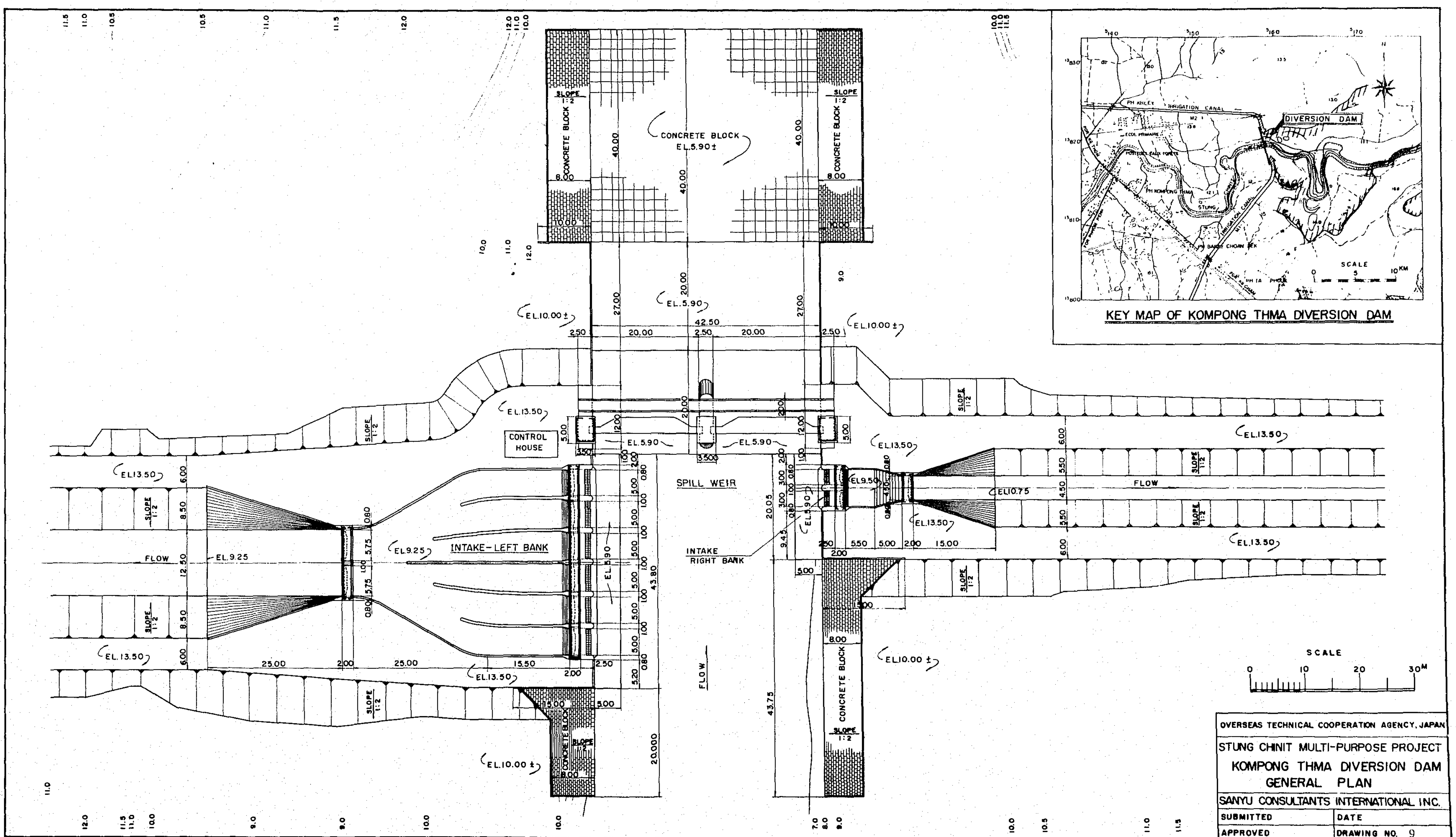
WATER TURBINE

TYPE	; HORIZONTAL KAPLAN
HEAD	; 16.30m 2 UNITS
DISCHARGE	; 17.75 M^3/s
OUTPUT	; 2,500 kW
SPEED	; 333 r.p.m

PLANT OUTPUT = 4,500 kW



OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
STUNG CHINIT MULTI-PURPOSE PROJECT PHNOM TAKHO DAM HYDROELECTRIC POWER STATION	
SANYU CONSULTANTS INTERNATIONAL INC.	
SUBMITTED	DATE
APPROVED	DRAWING NO. 8



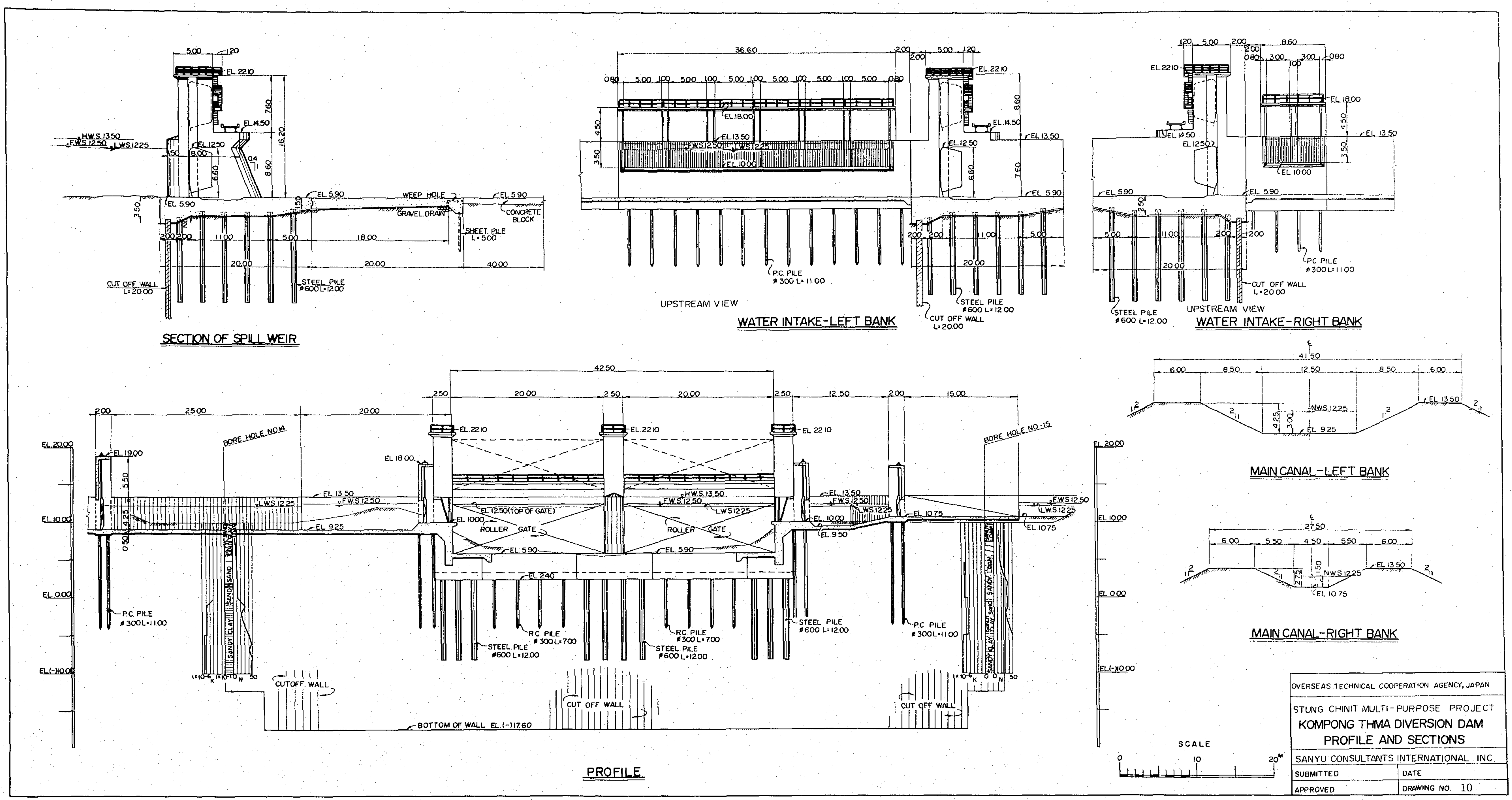
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN

STUNG CHINIT MULTI-PURPOSE PROJECT

KOMPONG THMA DIVERSION DAM
GENERAL PLAN

SANYU CONSULTANTS INTERNATIONAL INC.

SUBMITTED	DATE
APPROVED	DRAWING NO. 9



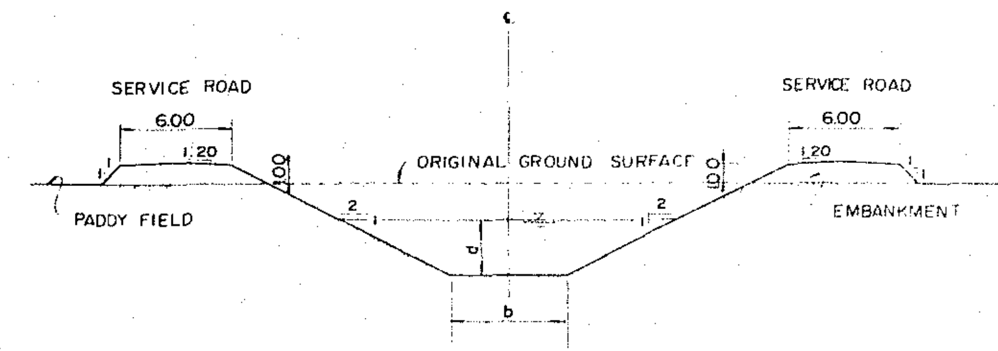
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN

STUNG CHINIT MULTI-PURPOSE PROJECT

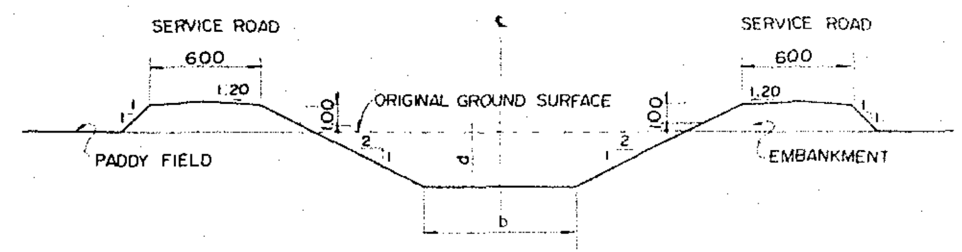
KOMPONG THMA DIVERSION DAM
PROFILE AND SECTIONS

SANYU CONSULTANTS INTERNATIONAL INC.

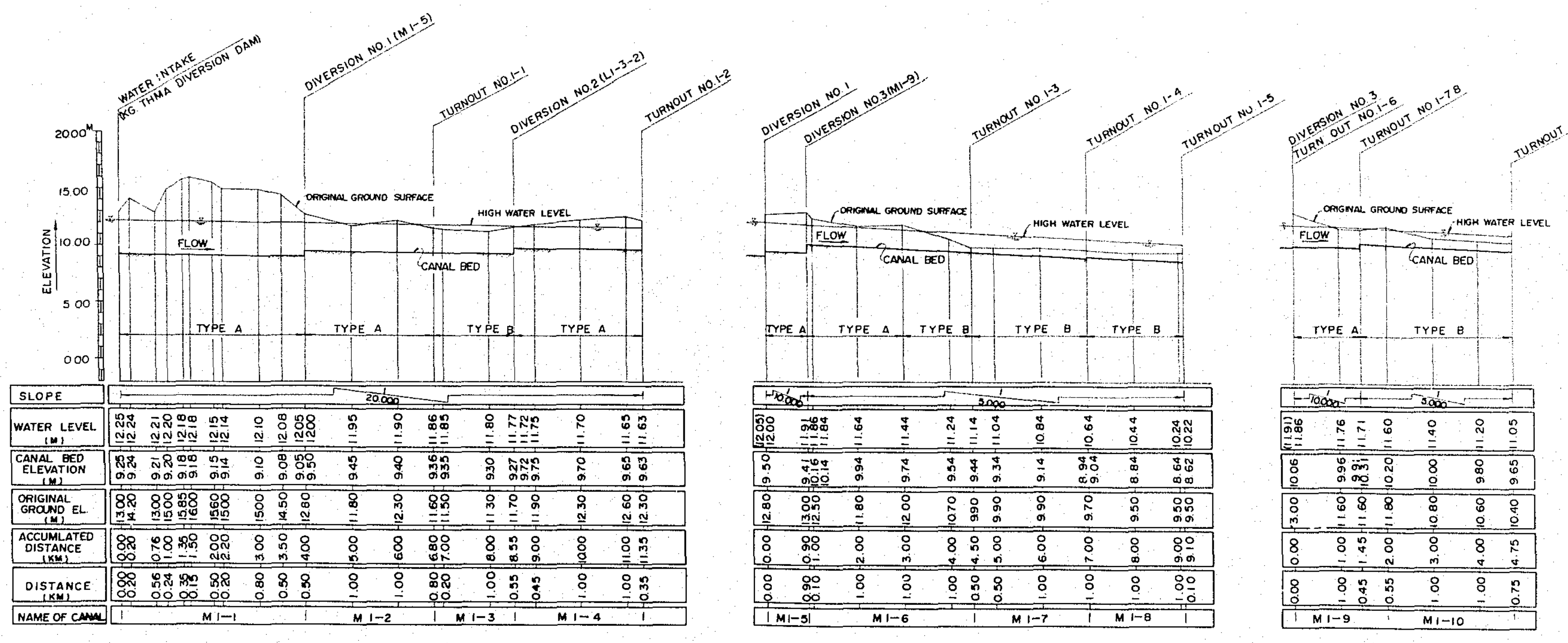
SUBMITTED	DATE
APPROVED	DRAWING NO. 10



TYPICAL CROSS SECTION (TYPE A)



TYPICAL CROSS SECTION (TYPE B)



CANAL TYPE

NAME OF CANAL	CANAL TYPE	DISCHARGE CAPACITY (M^3/S)	LENGTH (KM)	b (M)	d (M)	REMARK
M I-1	A	25.89	4.00	12.5	3.0	
M I-2	A	12.41	2.80	7.6	2.5	
M I-3	B	11.75	1.75	7.1	2.5	
M I-4	A	7.06	2.80	6.5	2.0	
M I-5	A	13.48	0.90	5.0	2.5	
M I-6	A B	6.67	3.60	3.5	1.7	
M I-7	B	6.20	2.50	3.0	1.7	
M I-8	B	5.29	2.10	3.0	1.6	
M I-9	A	6.36	1.45	4.5	1.8	
M I-10	B	4.93	3.30	4.0	1.4	

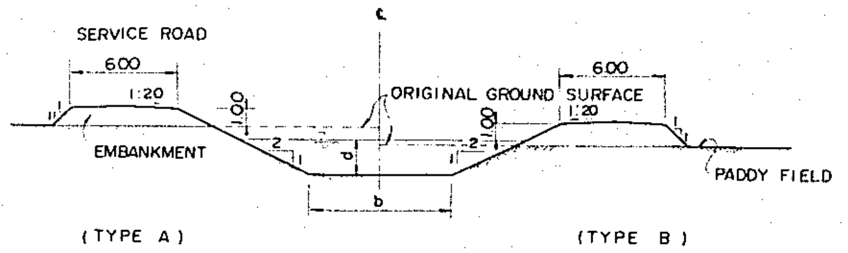
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN

STUNG CHINIT MULTIPURPOSE PROJECT

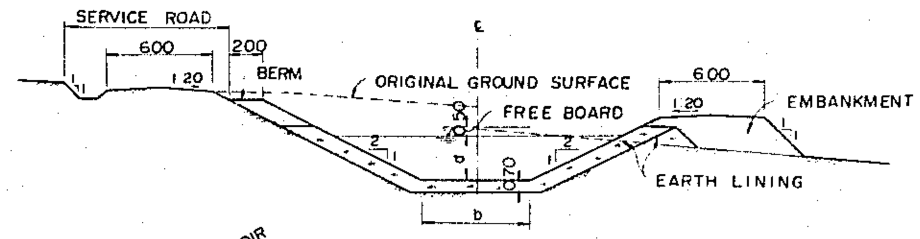
PLAN AND PROFILE (MAIN IRRIGATION CANAL M I)

SANYU CONSULTANTS INTERNATIONAL INC.

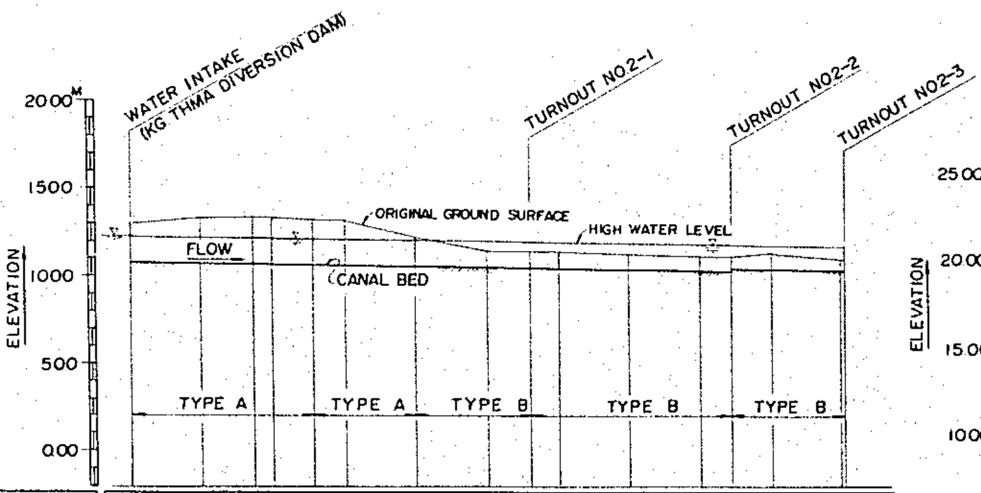
SUBMITTED	DATE
APPROVED	DRAWING NO. 11



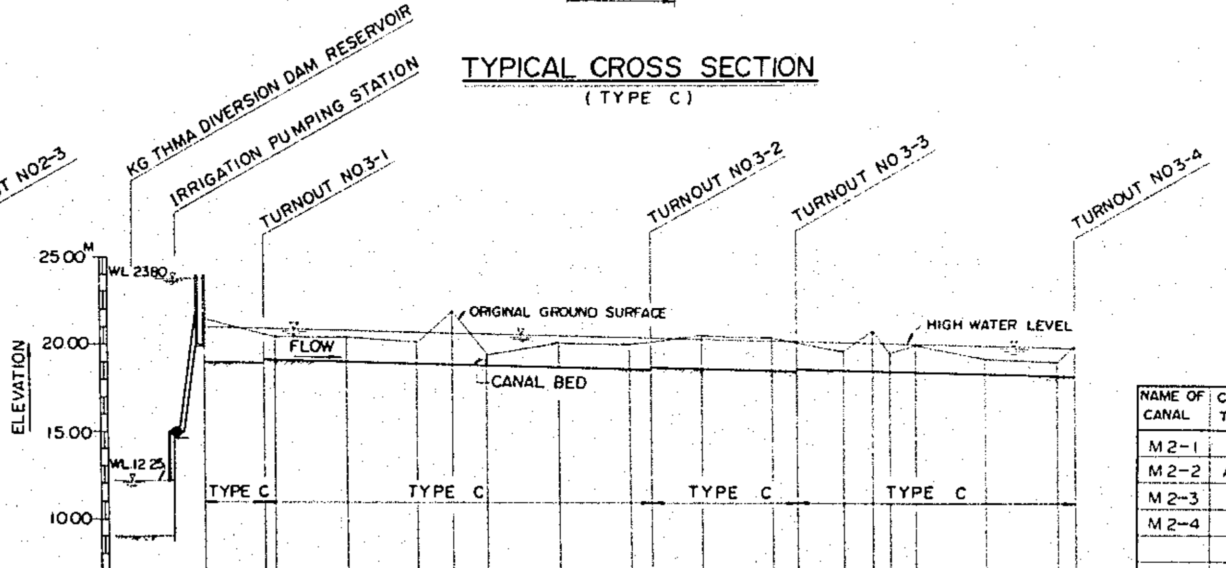
TYPICAL CROSS SECTION



TYPICAL CROSS SECTION
(TYPE C)



SLOPE	1/20,000															
WATER LEVEL (M)	12.25	12.20	12.16	12.15	12.12	12.10	12.05	12.00	11.97	11.95	11.90	11.85	11.83	11.80	11.75	11.75
CANAL BED ELEVATION (M)	10.75	10.70	10.66	10.65	10.62	10.60	10.55	10.50	10.47	10.45	10.40	10.35	10.33 / 10.43	10.40	10.35	10.35
ORIGINAL GROUND EL. (M)	13.00	13.40	13.40	13.40	13.28	13.20	12.20	11.50	11.50	11.50	11.30	11.20	11.20	11.40	11.00	11.00
ACCUMLATED DISTANCE (KM)	0.00	1.00	1.75	2.00	2.55	3.00	4.00	5.00	5.60	6.00	7.00	8.00	8.45	9.00	10.00	10.05
DISTANCE (KM)	0.00	1.00	0.75	0.25	0.55	0.45	1.00	1.00	0.60	0.40	1.00	1.00	0.45	0.55	1.00	0.05
NAME OF CANAL			M2-1				M2-2				M2-3			M2-4		



SLOPE	1/10,000																			
WATER LEVEL (M)	21.00	20.96	20.95	20.85	20.75	20.70	20.65	20.55	20.45	20.42	20.35	20.25	20.22	20.15	20.11	20.09	20.05	19.95	19.85	19.83
CANAL BED ELEVATION (M)	19.00	18.96 / 19.16	19.15	19.05	18.95	18.90	18.85	18.75	18.65 / 18.62	18.72	18.65	18.55	18.52 / 18.62	18.55	18.51	18.49	18.45	18.35	18.25	18.23
ORIGINAL GROUND EL. (M)	21.50	20.65	20.50	20.50	20.20	22.00	19.50	20.20	20.10	20.25	20.60	20.50	20.25	19.70	20.90	19.60	20.00	19.20	19.00	20.00
ACCUMLATED DISTANCE (KM)	0.00	0.85	1.00	2.00	3.00	3.50	4.00	5.00	6.00	6.30	7.00	8.00	8.35	9.00	9.40	9.65	10.00	11.00	12.00	12.25
DISTANCE (KM)	0.00	0.85	0.15	1.00	1.00	0.50	0.50	1.00	1.00	0.30	0.70	1.00	0.35	0.65	0.40	0.25	0.35	1.00	1.00	0.25
NAME OF CANAL		M3-1				M3-2					M3-3						M3-4			

CANAL TYPE

NAME OF CANAL	CANAL TYPE	DISCHARGE CAPACITY (M3/S)	LENGTH (KM)	b (M)	d (M)
M2-1	A	3.19	2.55	4.5	1.5
M2-2	A.B	3.19	3.05	4.5	1.5
M2-3	B	2.65	2.85	4.0	1.5
M2-4	B	2.32	1.60	4.0	1.4
M3-1	C	9.63	5.55	6.0	2.0
M3-2	C	6.96	5.45	6.0	1.8
M3-3	C	6.36	2.05	6.0	1.7
M3-4	C	5.69	3.90	6.0	1.6

OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN

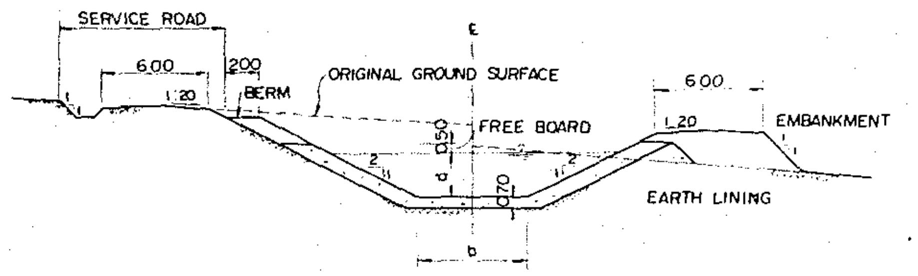
STUNG CHINIT MULTIPURPOSE PROJECT

PLAN AND PROFILE

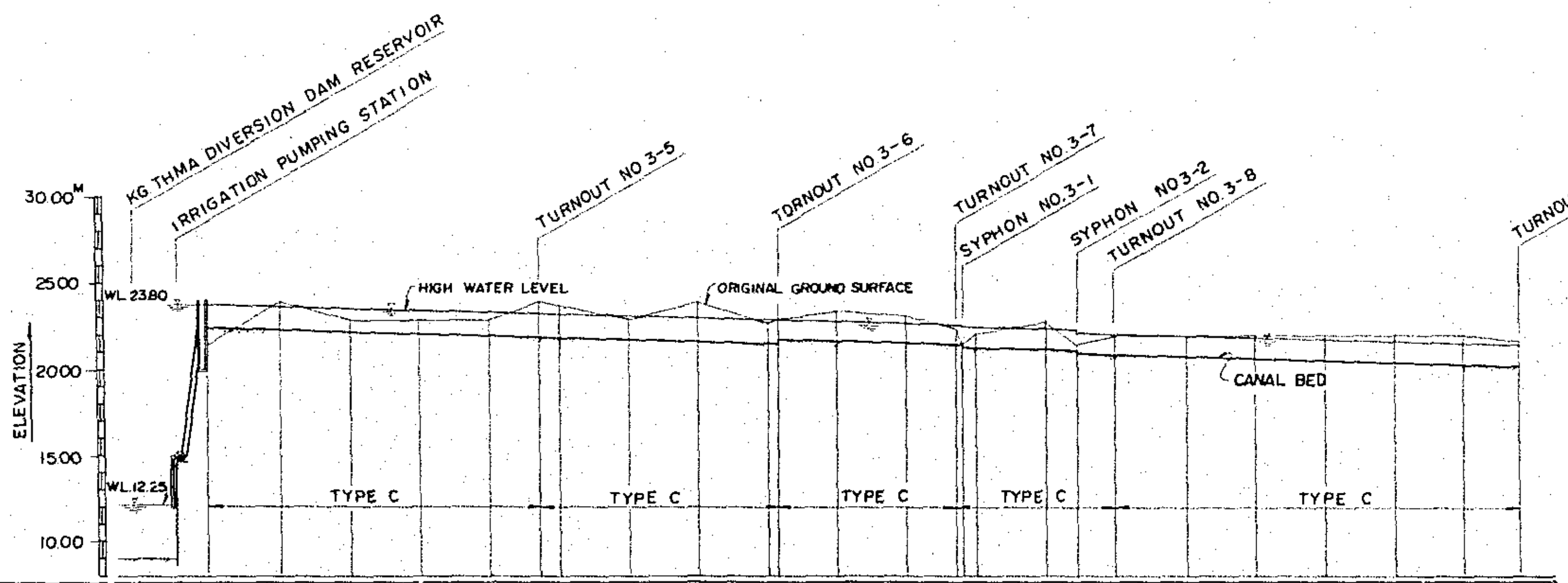
(MAIN IRRIGATION CANAL M2.M3)

SANYU CONSULTANTS INTERNATIONAL INC

SUBMITTED	DATE
APPROVED	DRAWING NO. 12



TYPICAL CROSS SECTION (TYPE C)



WATER LEVEL (M)	CANAL BED ELEVATION (M)	ORIGINAL GROUND EL (M)	ACCUMLATED DISTANCE (KM)	DISTANCE (KM)
23.80	2240	21 50	0.00	0.00
23.70	22.30	24.00	1.00	1.00
23.60	22.20	23.00	2.00	1.00
23.50	22.10	23.00	3.00	1.00
23.40	22.00	23.00	4.00	1.00
23.33	21.93	24.00	4.70	0.70
23.30	21.90	23.80	5.00	0.30
23.20	21.80	23.00	6.00	1.00
23.10	21.70	24.00	7.00	1.00
23.00	21.60	22.80	8.00	1.00
22.98	21.58 21.78	23.00	8.15	0.15
22.90	21.70	23.50	9.00	0.85
22.80	21.60	23.20	10.00	1.00
22.73	21.53	22.50	10.70	0.70
[illegible]	[illegible]	[illegible]	10.80	0.10
22.50	21.30	22.20	11.00	0.20
22.40	21.20	22.80	12.00	1.00
22.35	21.15	21.50	12.45	0.45
22.15	20.95			
22.10	20.90	22.00	13.00	0.55
22.00	20.80	22.00	14.00	1.00
21.90	20.70	22.00	15.00	1.00
21.80	20.60	22.00	16.00	1.00
21.70	20.50	22.00	17.00	1.00
21.60	20.40	22.00	18.00	1.00
21.52	20.32	21.80	18.80	0.80

SLOPE

NAME OF CANAL: M 3-5 | M 3-6 | M 3-7 | M 3-8 | M 3-9

CANAL TYPE

NAME OF CANAL	CANAL TYPE	DISCHARGE CAPACITY (M^3/S)	LENGTH (KM)	b (M)	d (M)	REMARK
M 3-5	C	4 06	4 70	5 0	1 4	
M 3-6	C	3 29	3 45	4 0	1 4	
M 3-7	C	2 14	2 55	3 0	1 2	
M 3-8	C	1 65	2 30	2 0	1 2	
M 3-9	C	1 47	5 80	2 0	1 2	

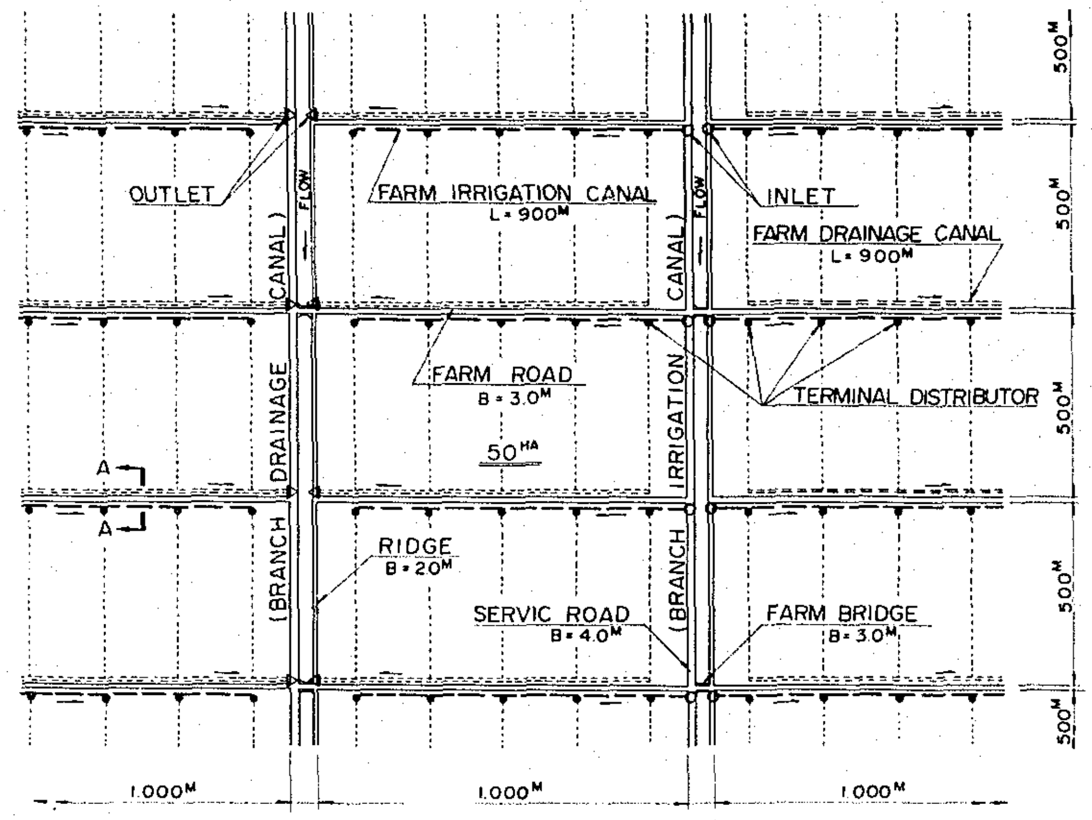
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN

STUNG CHINIT MULTIPURPOSE PROJECT

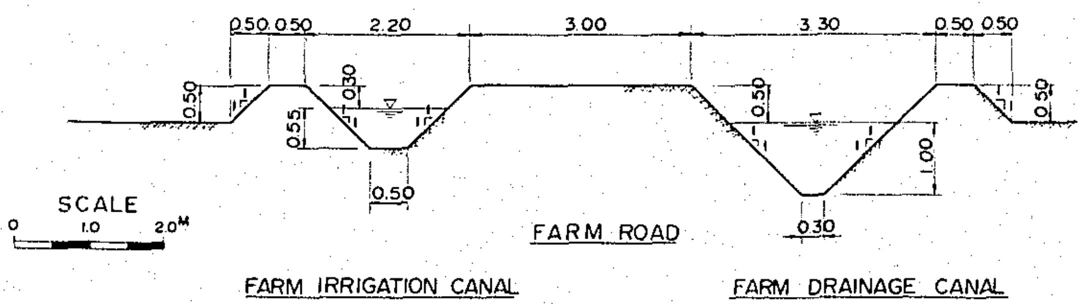
PLAN AND PROFILE (MAIN IRRIGATION CANAL M3)

SANYU CONSULTANTS INTERNATIONAL INC

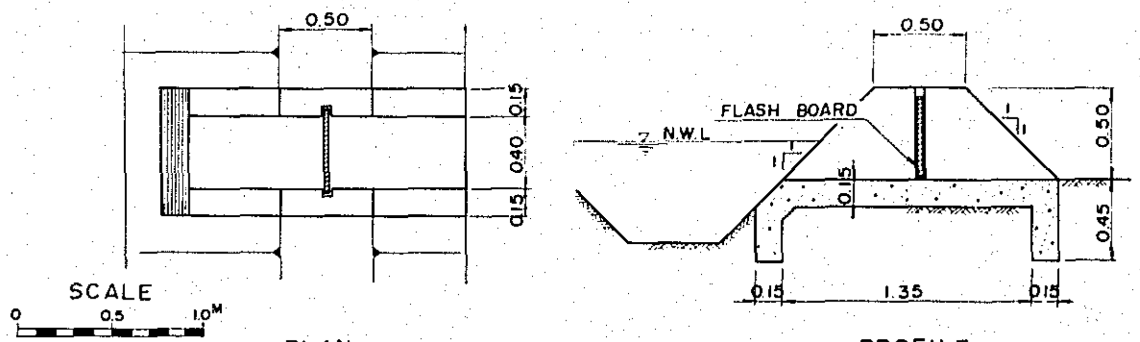
SUBMITTED	DATE
APPROVED	DRAWING NO. 13



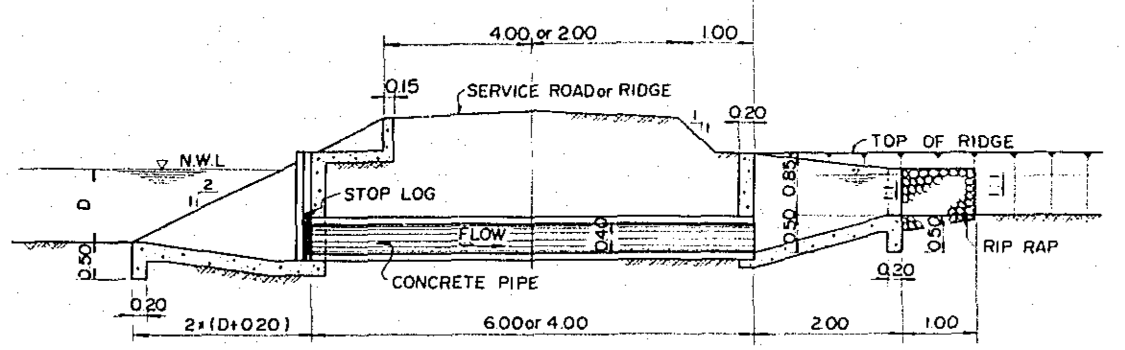
SYSTEM OF IRRIGATION AND DRAINAGE



TYPICAL CROSS SECTION A-A

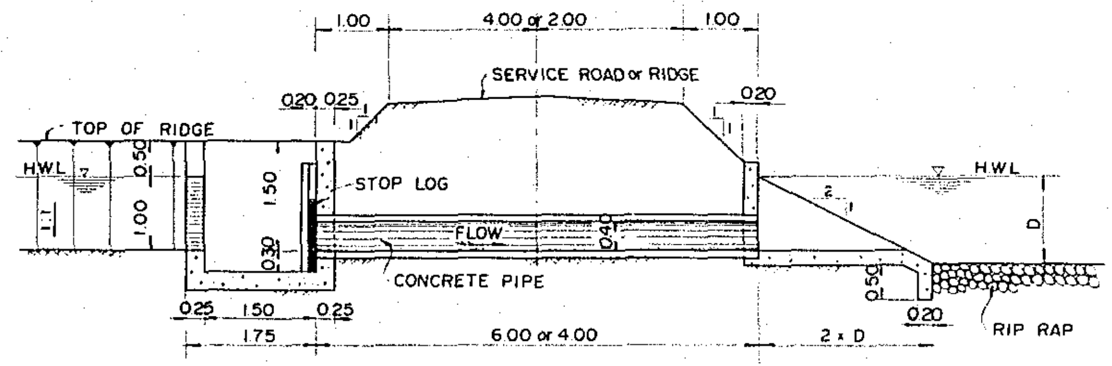


TERMINAL DISTRIBUTOR

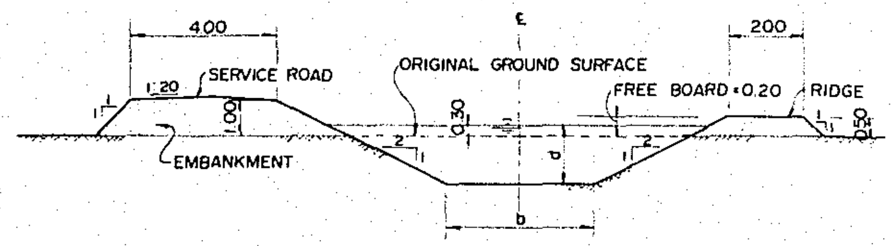


PROFILE OF INLET

SCALE
0 1 2 3M

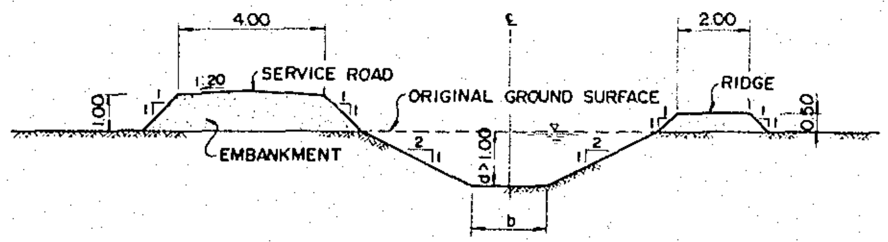


PROFILE OF OUTLET



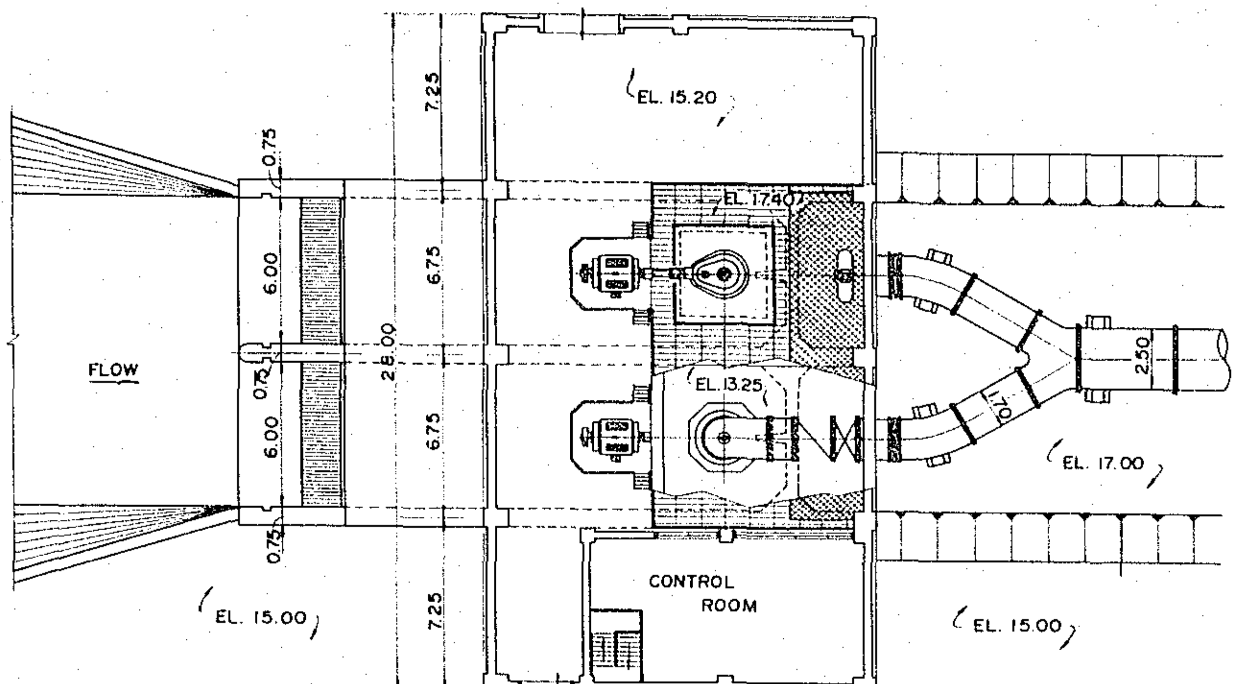
TYPICAL CROSS SECTION OF BRANCH IRRIGATION CANAL

SCALE
0 1 2 3 4 5

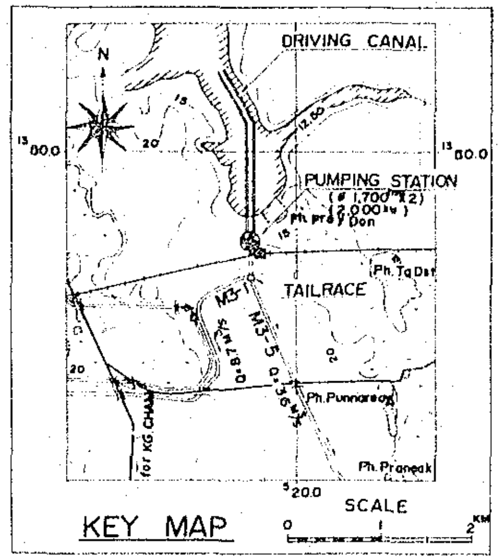


TYPICAL CROSS SECTION OF BRANCH DRAINAGE CANAL

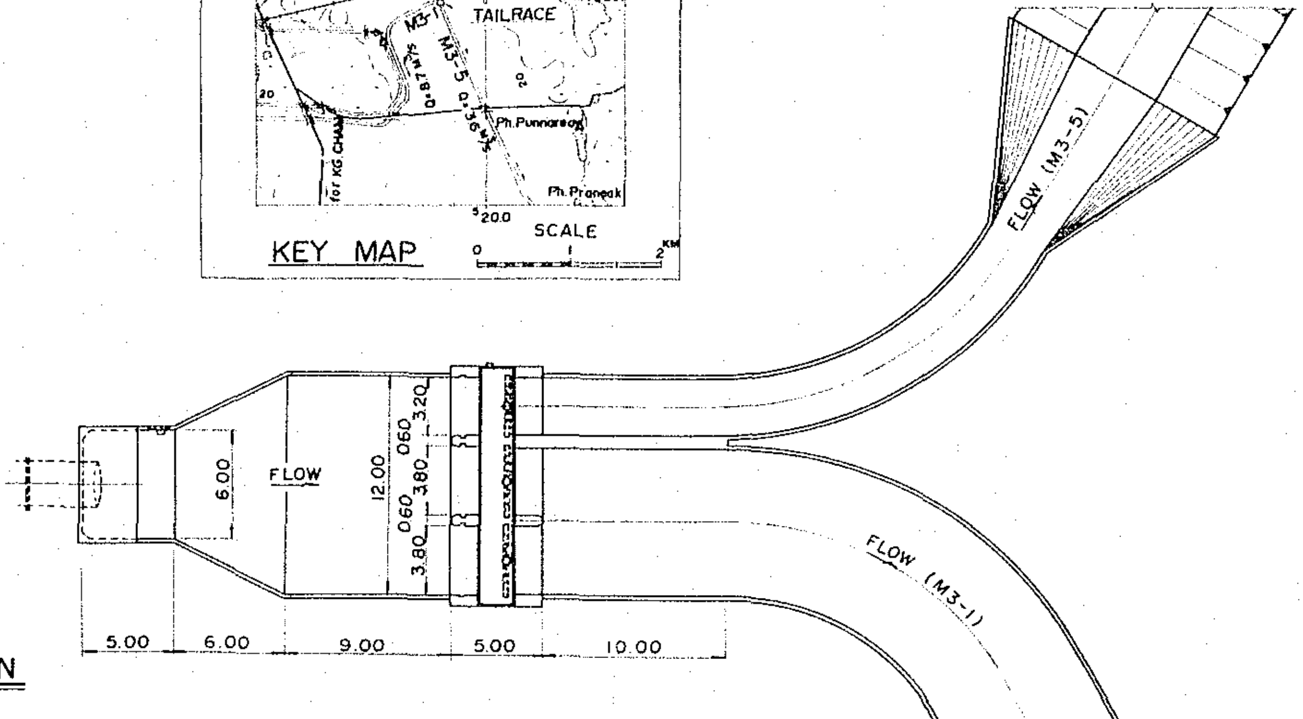
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
STUNG CHINIT MULTIPURPOSE PROJECT	
SYSTEM OF IRRIGATION AND DRAINAGE	
SANYU CONSULTANTS INTERNATIONAL INC.	
SUBMITTED	DATE
APPROVED	DRAWING NO. 14



PLAN OF PUMPING STATION

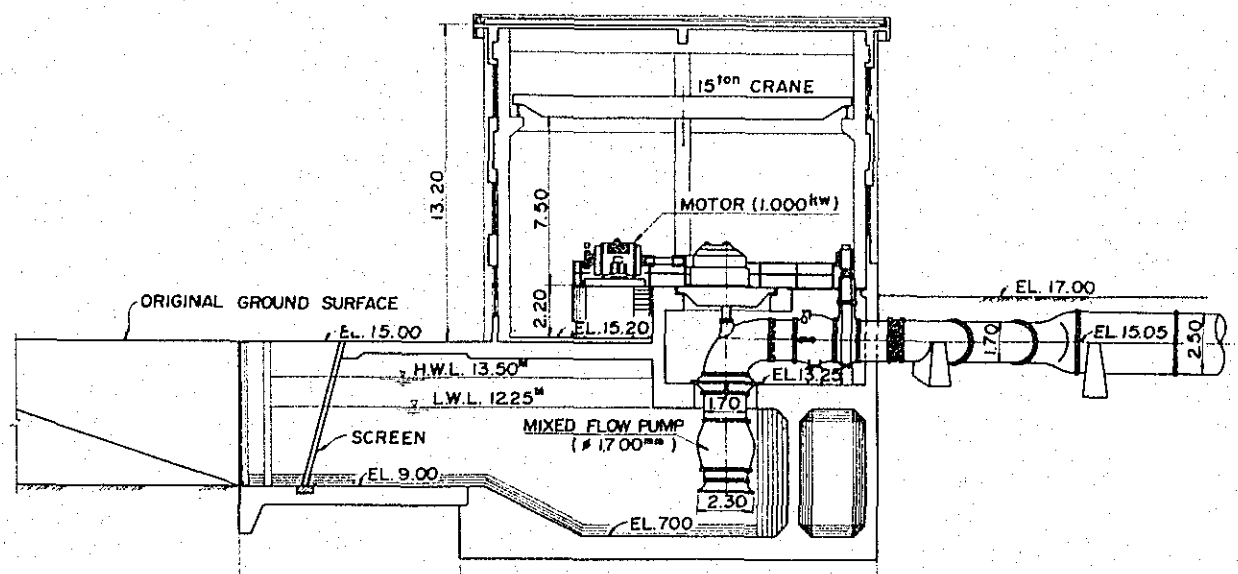


KEY MAP

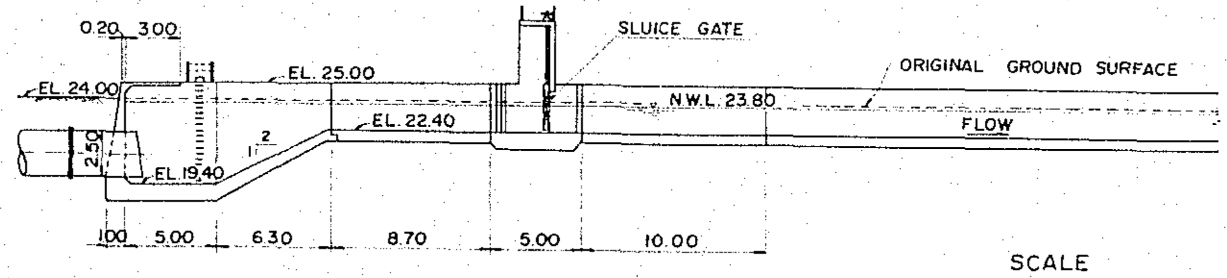


PLAN OF TAILRACE

SCALE
0 5 10M



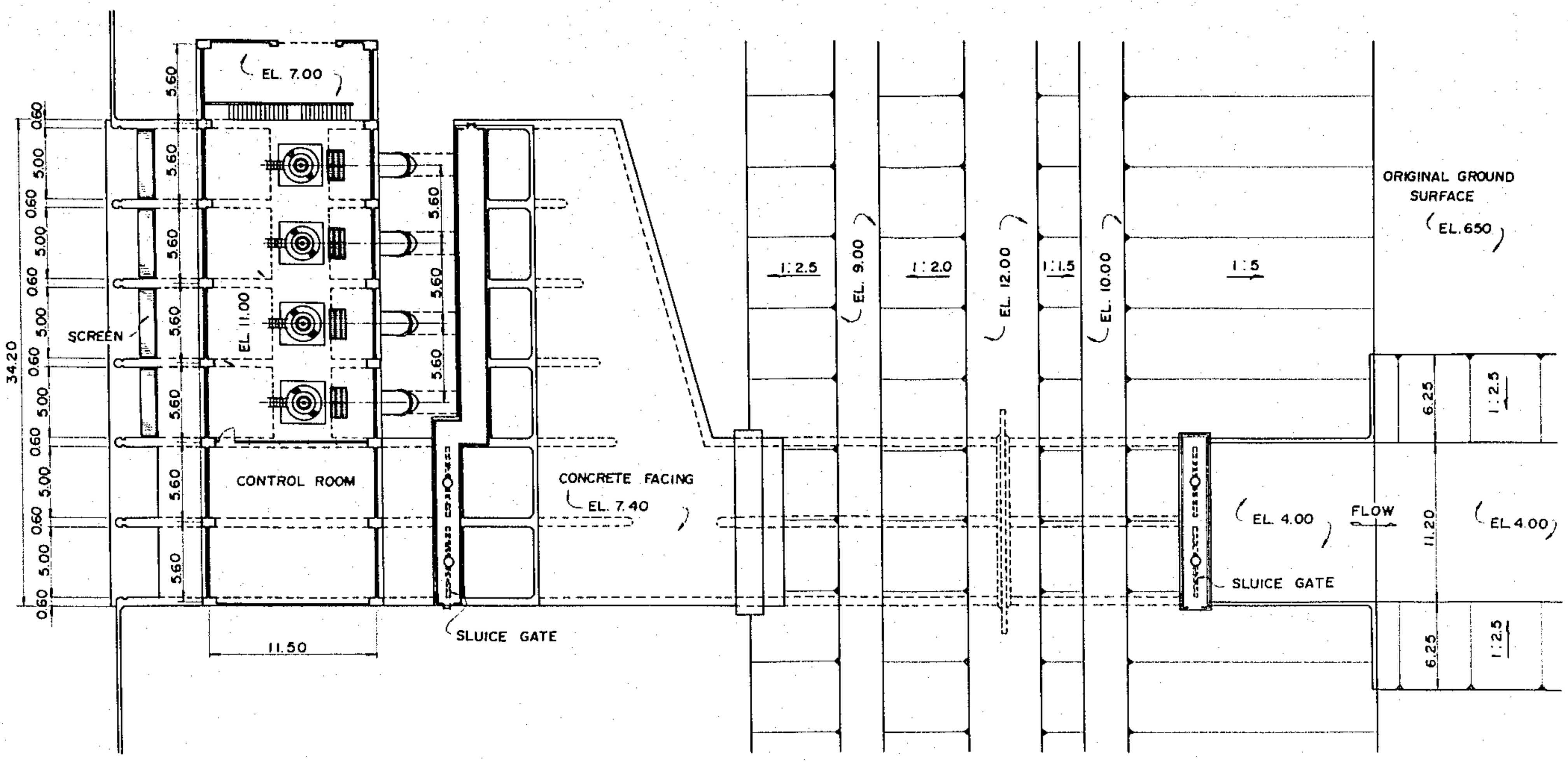
SECTION OF PUMPING STATION



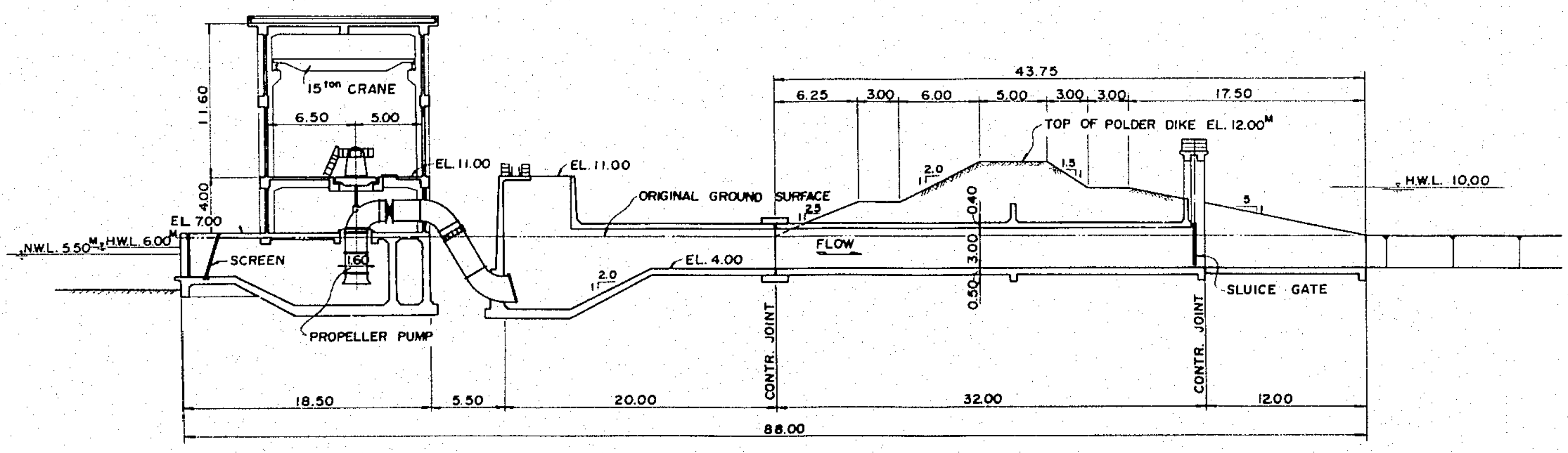
SECTION OF TAILRACE

SCALE
0 5 10 15M

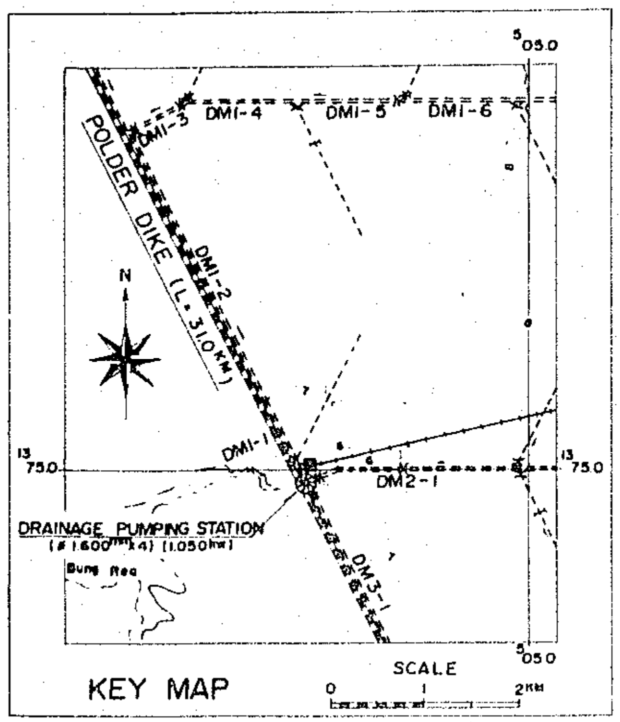
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
STUNG CHINIT MULTIPURPOSE PROJECT	
IRRIGATION PUMPING STATION	
SANYU CONSULTANTS INTERNATIONAL INC.	
SUBMITTED	DATE
APPROVED	DRAWING NO. 15

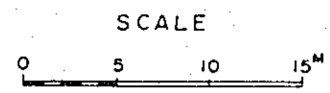


PLAN

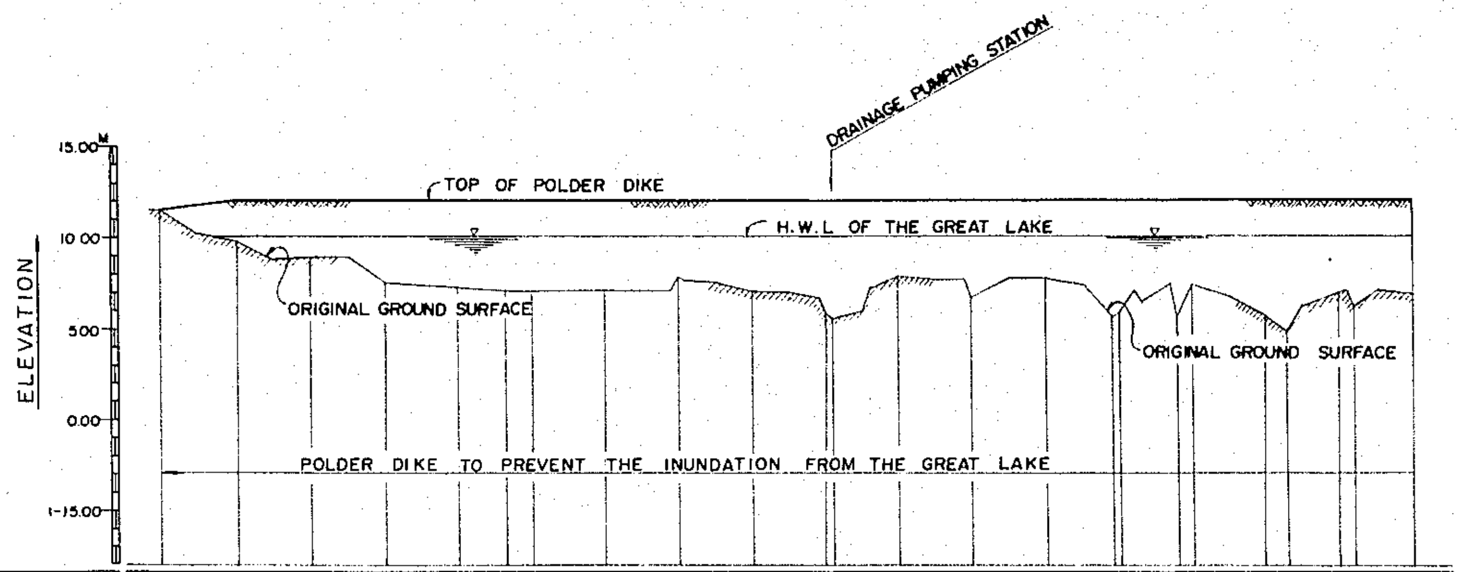


SECTION

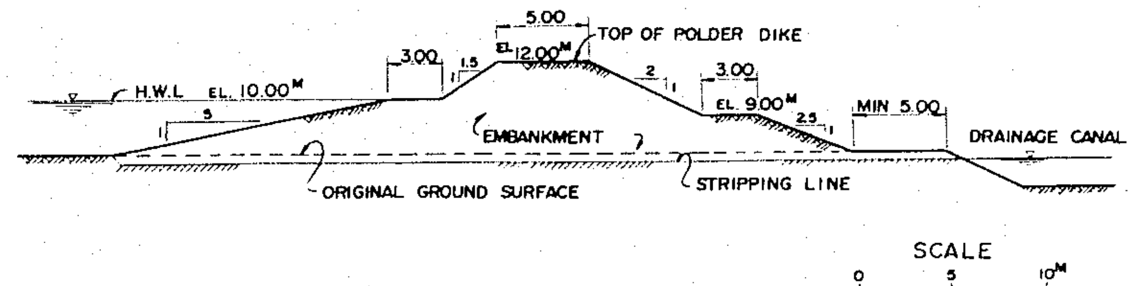




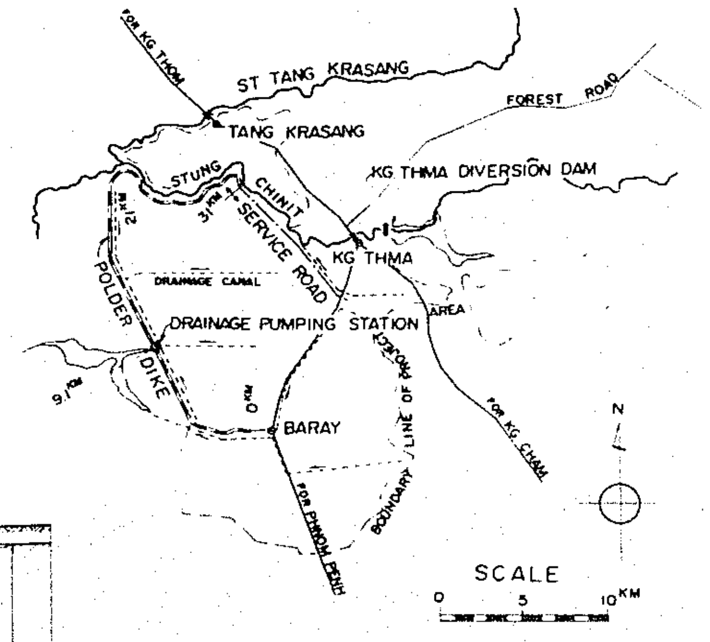
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
STUNG CHINIT MULTIPURPOSE PROJECT	
DRAINAGE PUMPING STATION	
SANYU CONSULTANTS INTERNATIONAL INC.	
SUBMITTED	DATE
APPROVED	DRAWING NO. 16



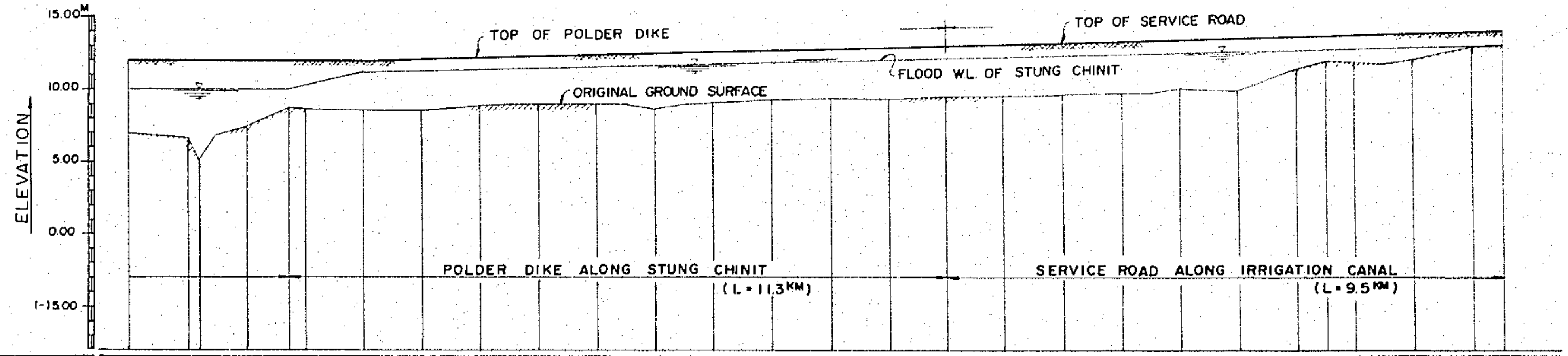
TOP ELEVATION OF DIKE (M)	11.50	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
FLOOD WATER LEVEL (M)	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
ORIGINAL GROUND ELEVATION (M)	11.50	9.80	8.90	7.55	7.24	7.12	7.05	7.10	7.83	7.08	5.91	5.51	7.88	6.71	7.76	5.69	5.88	5.65	7.35	5.72	4.82	6.98	6.15	6.92
ACCUMLATED DISTANCE (KM)	0.00	1.00	2.00	3.00	4.00	4.65	5.00	6.00	7.00	8.00	9.00	9.10	10.00	11.00	12.00	12.90	13.00	13.80	14.00	15.00	15.30	16.00	16.20	17.00
DISTANCE (KM)	0.00	1.00	1.00	1.00	1.00	0.65	0.35	1.00	1.00	1.00	1.00	0.10	0.90	1.00	1.00	0.90	0.10	0.80	0.20	1.00	0.30	0.70	0.20	0.80



TYPICAL SECTION OF POLDER DIKE



LOCATION OF POLDER DIKE



TOP ELEVATION OF DIKE (M)	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.05	12.16	12.27	12.38	12.49	12.60	12.70
FLOOD WATER LEVEL (M)	10.00	10.00	10.00	10.00	10.00	10.00	10.90	11.20	11.30	11.40	11.50	11.60	11.70	11.80
ORIGINAL GROUND ELEVATION (M)	6.92	6.64	5.18	7.47	8.75	8.65	8.60	8.56	8.90	9.00	9.00	8.66	9.10	9.30
ACCUMLATED DISTANCE (KM)	17.00	18.00	18.20	19.00	19.70	20.00	21.00	22.00	23.00	24.00	25.00	26.00	27.00	28.00
DISTANCE (KM)	0.80	1.00	0.20	0.80	0.70	0.30	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

TOP ELEVATION OF DIKE (M)	12.81	12.92	13.00	13.14	13.24	13.35	13.46	13.57	13.68	13.73	13.78	13.89	14.00	14.00
FLOOD WATER LEVEL (M)	11.90	12.00	12.10	12.20	12.30	12.40	12.50	12.60	12.70	12.75	12.80	12.90	13.00	13.05
ORIGINAL GROUND ELEVATION (M)	9.40	9.40	9.50	9.60	9.70	9.80	10.20	10.00	11.50	12.00	11.90	12.10	13.00	13.00
ACCUMLATED DISTANCE (KM)	29.00	30.00	31.00	3200	33.00	34.00	35.00	36.00	37.00	37.50	38.00	39.00	40.00	40.50
DISTANCE (KM)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.50	1.00	1.00	0.50

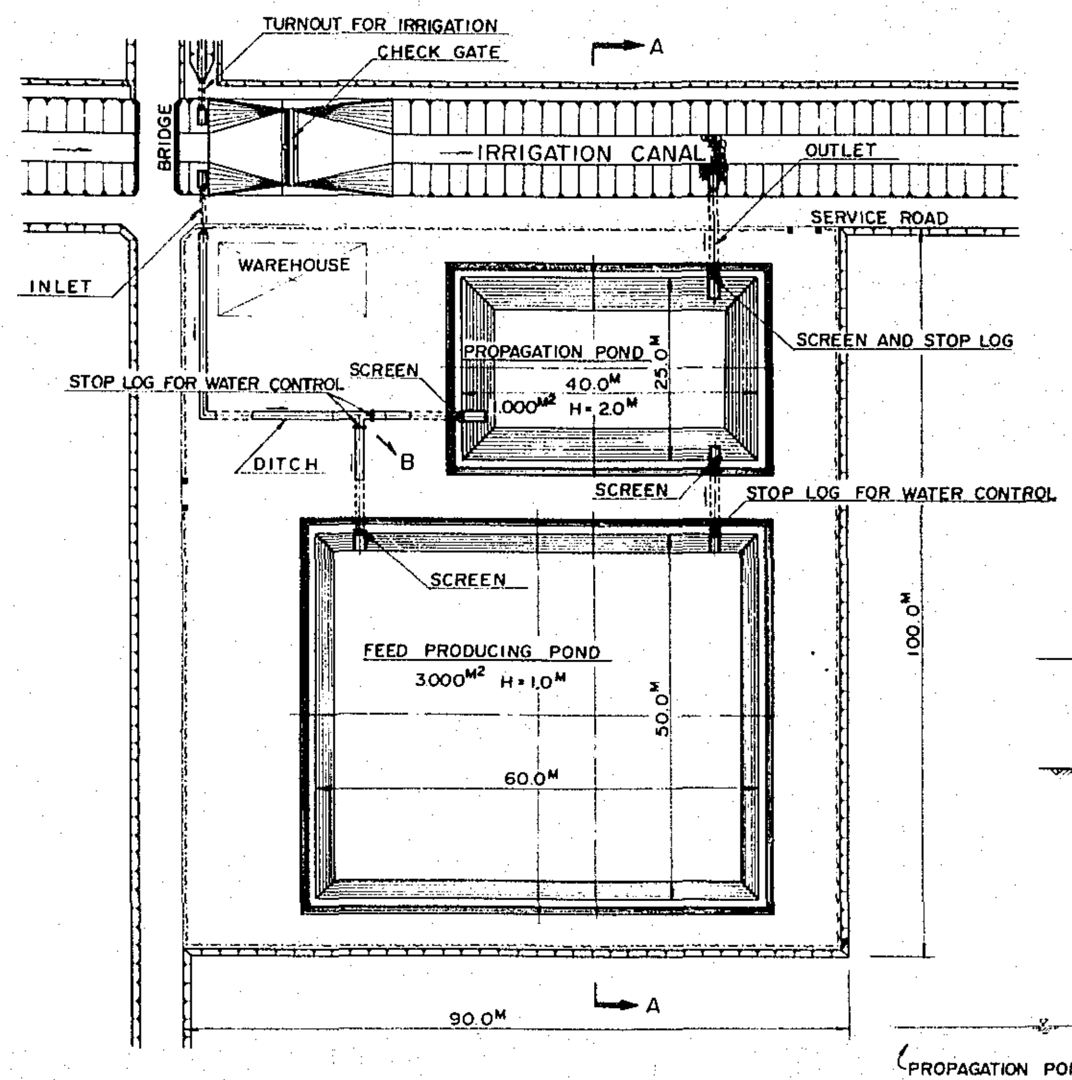
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN

STUNG CHINIT MULTIPURPOSE PROJECT

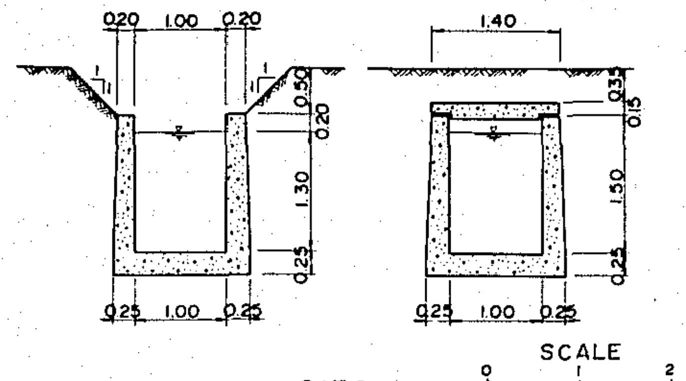
PROFILE OF POLDER DIKE

SANYU CONSULTANTS INTERNATIONAL INC.

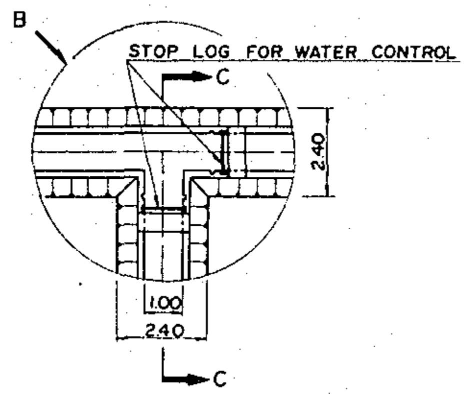
SUBMITTED	DATE
APPROVED	DRAWING NO. 17

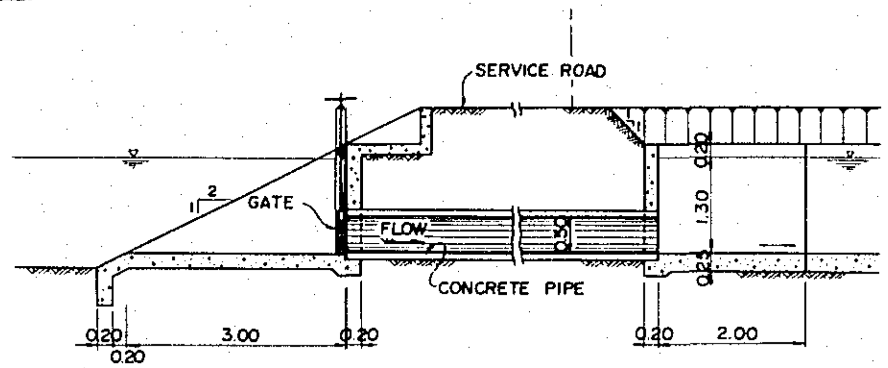


TYPICAL PLAN OF PILOT FISH POND



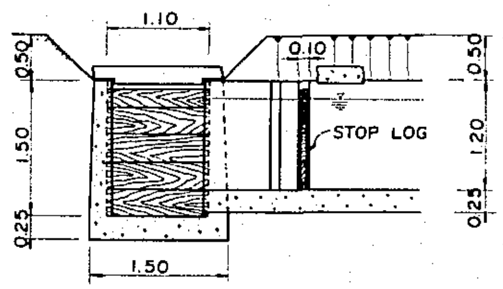
DITCH



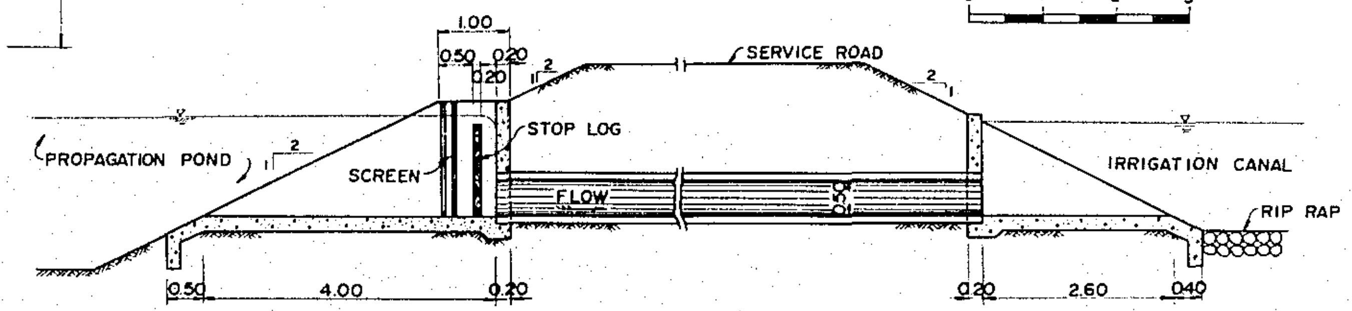


INLET

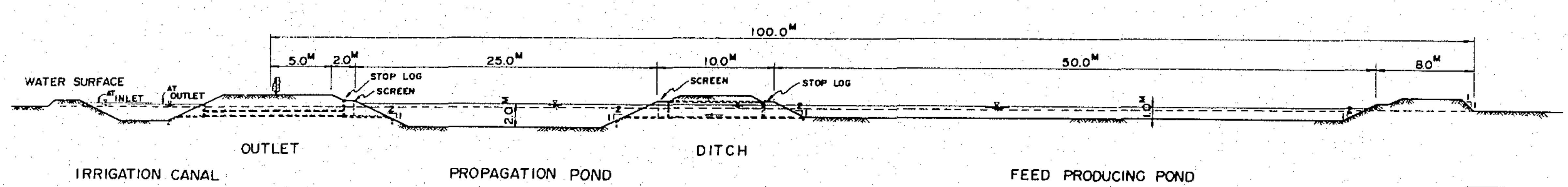
SCALE
0 1 2 3M



SECTION C-C



OUTLET



TYPICAL CROSS SECTION A-A

SCALE
0 10 20M

OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
STUNG CHINIT MULTIPURPOSE PROJECT	
PILOT FISH POND	
SANYU CONSULTANTS INTERNATIONAL INC.	
SUBMITTED	DATE
APPROVED	DRAWING NO. 18