SAMBOR PROJECT REPORT

Lower Mekong River Basin

Volume IV

Irrigation and Agriculture

Supplementary Material to Volume I

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

JUNE 1969

SAMBOR PROJECT REPORT

The Sambor Project Report consists of the following eight volumes:

Volume I	General Report (1)
Volume II	General Report (2) — Sambor with Nam Ngum and Pa Mong
Volume III	Dam and Hydroelectric Power — Supplementary Material to Volume I
Volume IV	Irrigation and Agriculture — Supplementary Material to Volume I
Volume V	Navigation — Supplementary Material to Volume I
Volume VI	Fishery — Supplementary Material to Volume I
Volume VII	Basic Data — Appendix (1) to Volume III
Volume VIII	Drill Hole Logs — Appendix (2) to Volumes III and V

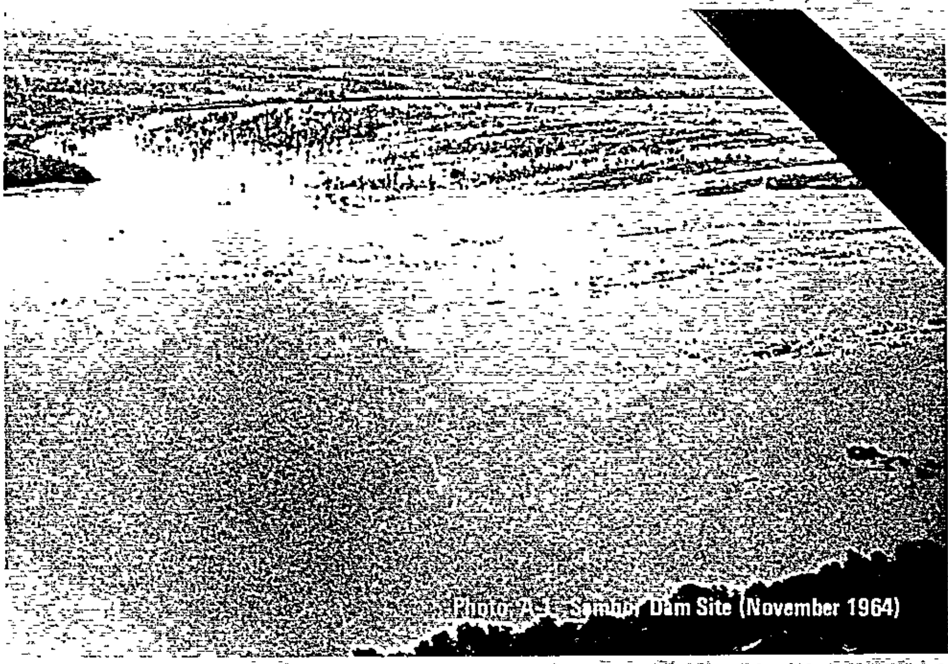


Photo. A-1 Sambor Dam Site (November 1964)

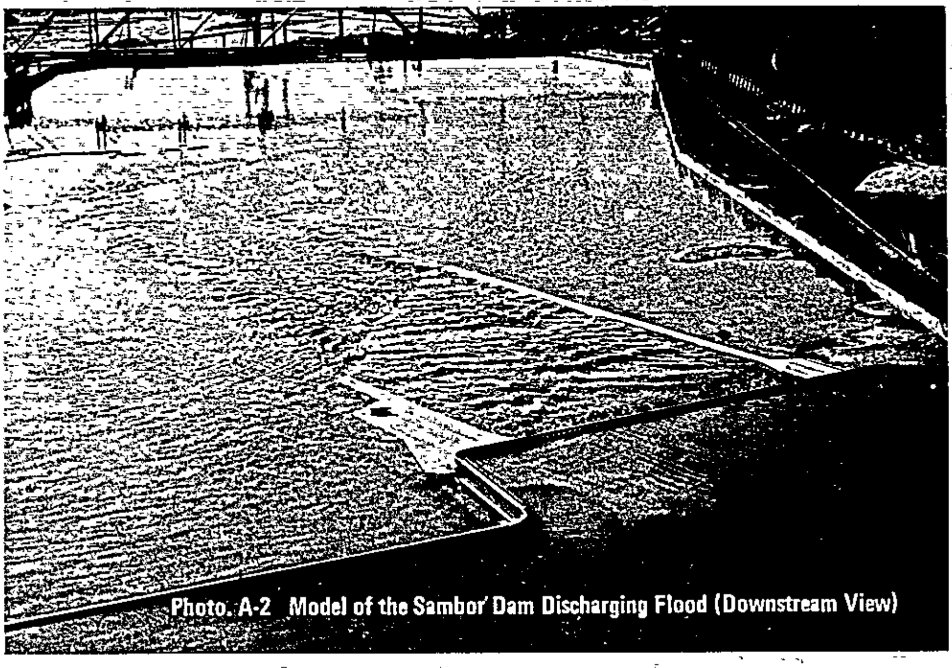
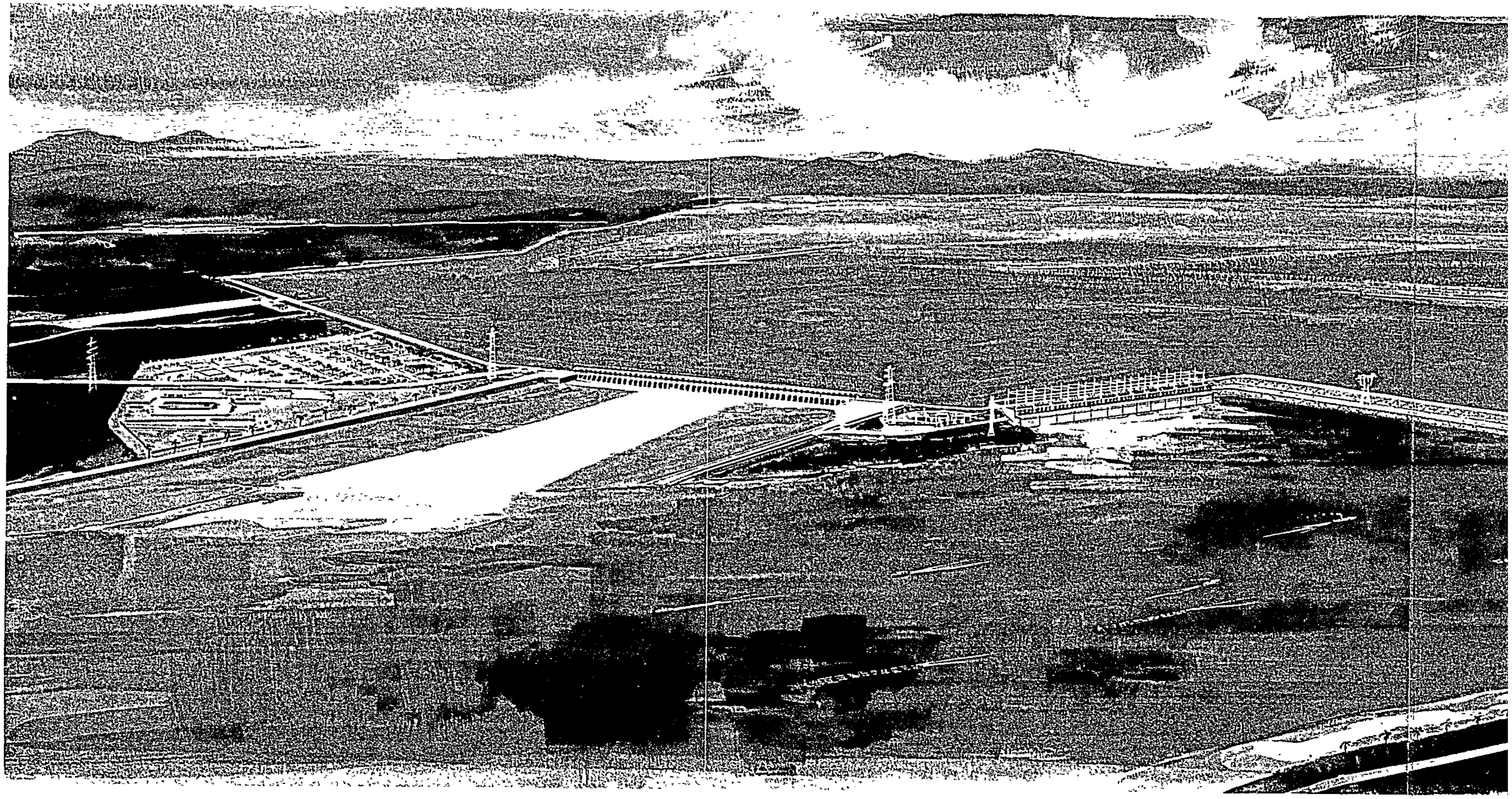
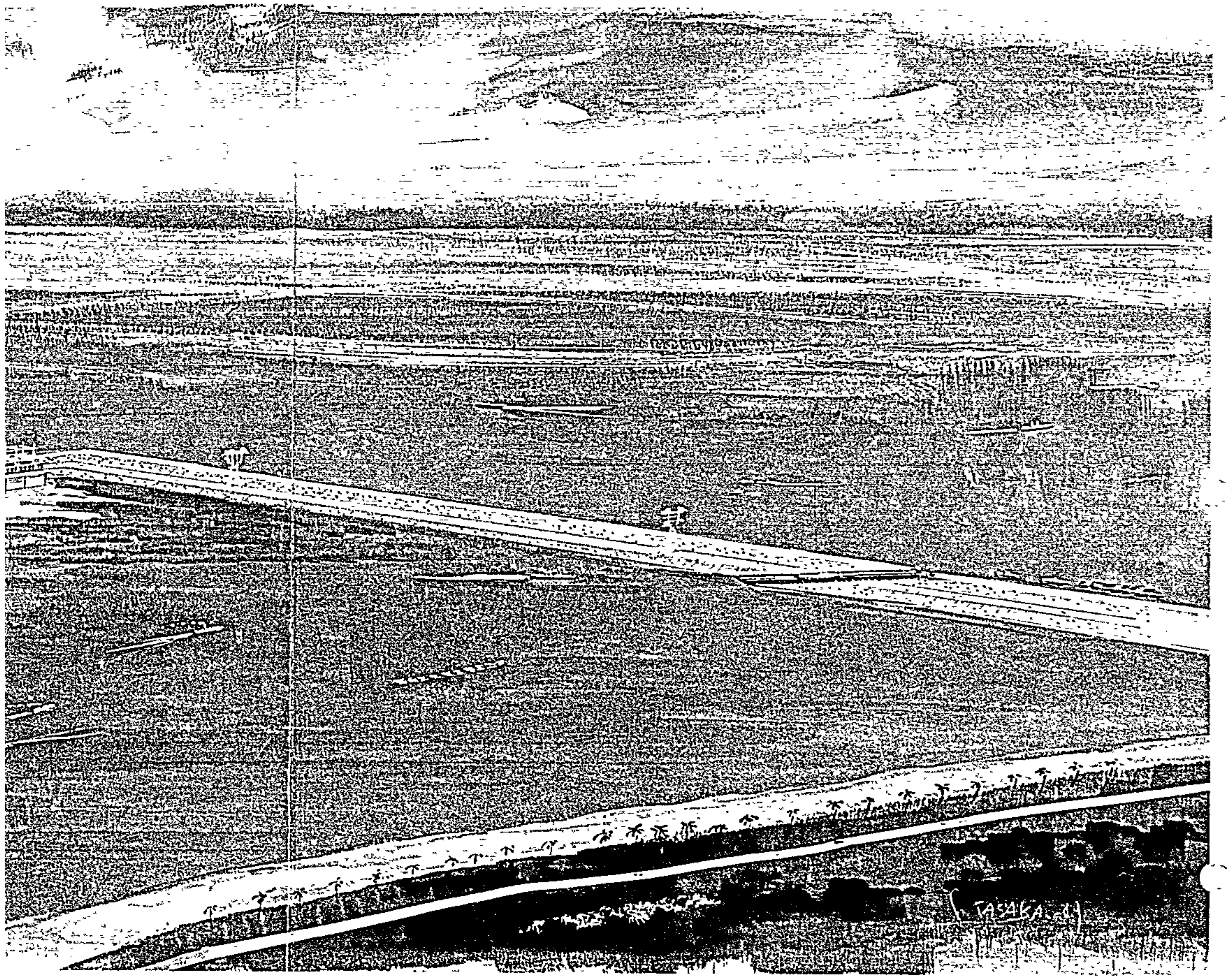


Photo. A-2 Model of the Sambor Dam Discharging Flood (Downstream View)



Aerial



Aerial View of the Projected Sambor Dam

SAMBOR PROJECT REPORT

Lower Mekong River Basin

Volume IV

Irrigation and Agriculture

Supplementary Material to Volume I

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

JUNE 1969

CONTENTS

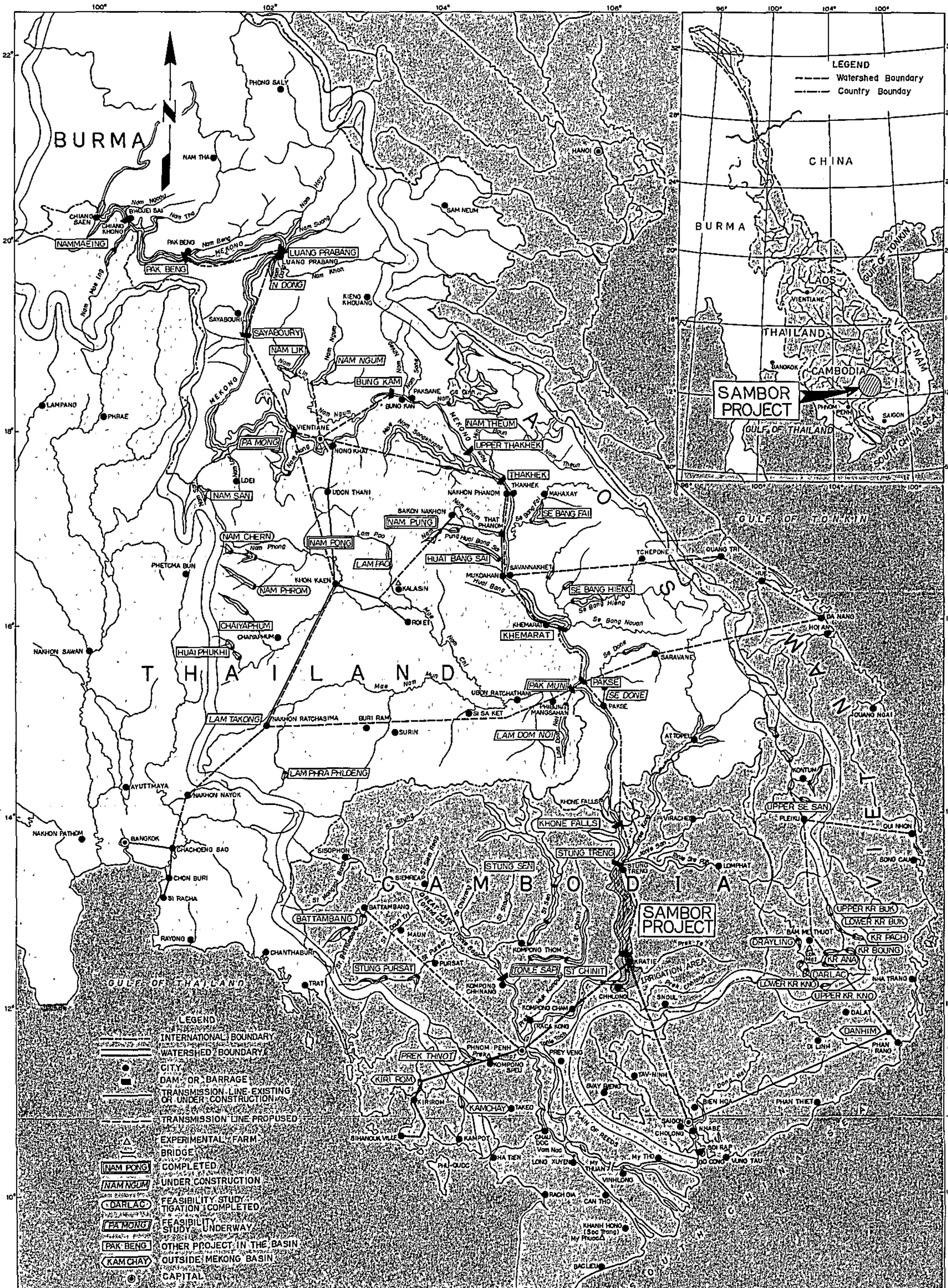
LIST OF FIGURES

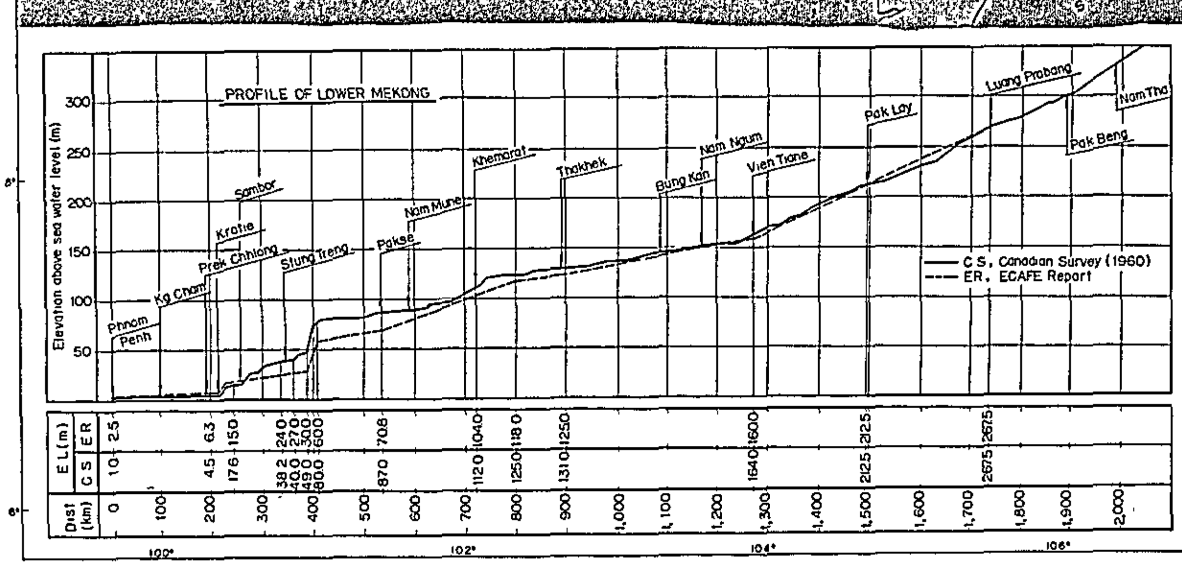
LIST OF TABLES

LIST OF DRAWINGS

ABBREVIATIONS

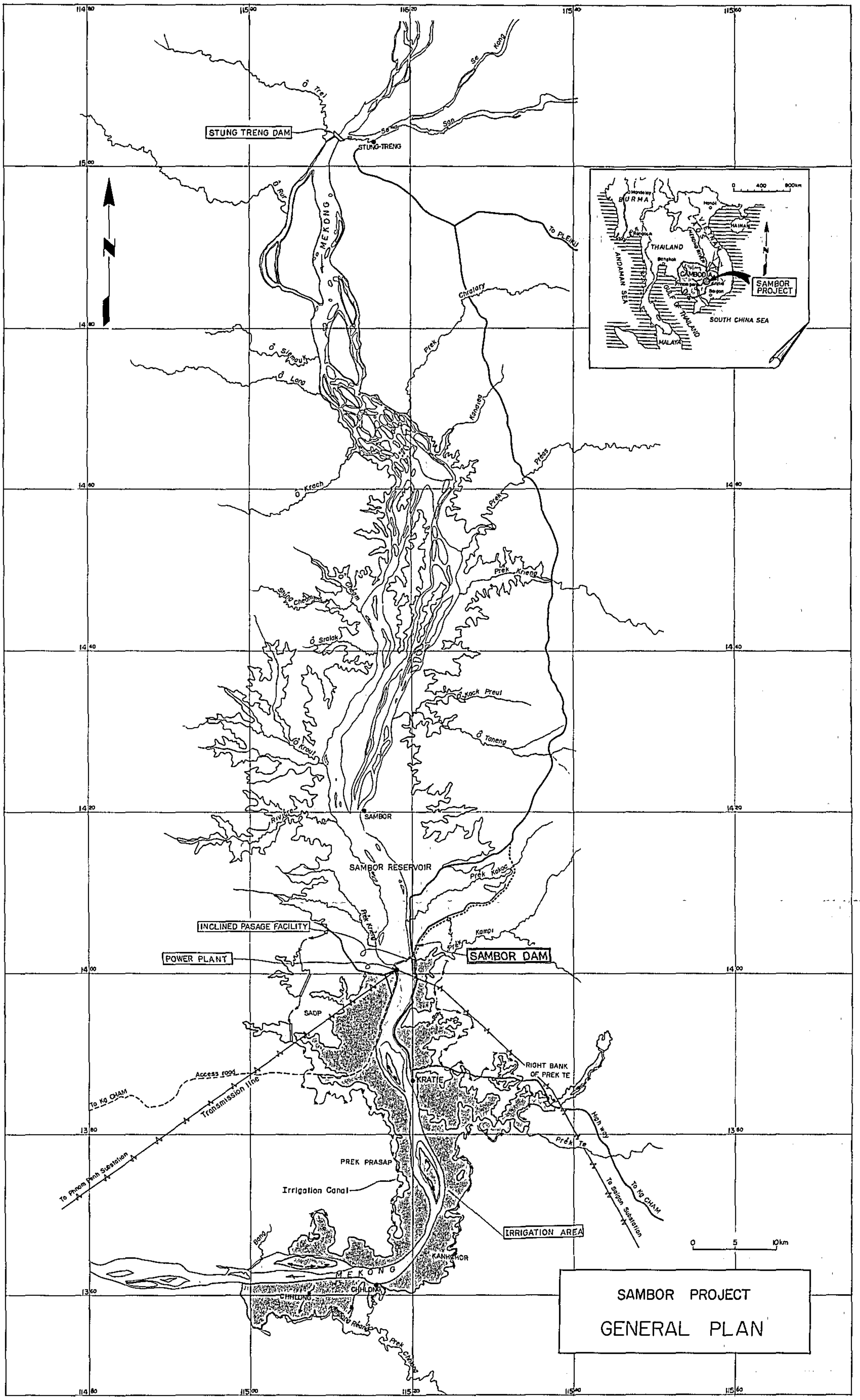
mm	millimeter
cm	centimeter
m	meter
km	kilometer
sq.mm	mm^2; square millimeter
sq.cm	cm^2; square centimeter
sq.m	m^2; square meter
sq.km	km^2; square kilometer
ha	hectare
cu.m	m^3; cubic meter
gr	gram
kg	kilogram
ton	metric ton
m/sec	meter per second
cu.m/sec	m^3/s; cubic meter per second
cu.m/sec-day	m^3/s-day; cubic meter per second per day
kW	kilowatt
MW	megawatt
kWh	kilowatt-hour
$	U.S. dollar
p.p.m.	parts per million
EL	the height above mean sea level
^oC	centigrade
hr	hour
R	Riel
kg.	Kompong
kh.	Khum
Ph.	Phum
S	sand
S.L	sandy loam
L	loam
SiL	silty loam
SiCL	silty clay loam
SiC	silty clay
C.L	clay loam
C	clay





This map was prepared with reference to the basin map of the Mekong Committee's Annual Report 1967 and the boundaries shown hereon do not imply official endorsement or acceptance by the United Nations.

Key and Location Map


SAMBOR PROJECT
GENERAL PLAN
STUNG TRENG DAM
STUNG-TRENG
MEKONG
To PLEIKU
SAMBOR
SAMBOR RESERVOIR
INCLINED PASAGE FACILITY
POWER PLANT
SAMBOR DAM
SADP
KRATIE
RIGHT BANK OF PREK TE
Access road
Transmission line
To Kg CHAM
To Phnom Penh Substation
To Saigon Substation
High way
PREK PRASAP
Irrigation Canal
IRRIGATION AREA
KANHCHOR
CHHLONG
0 5 10km
SAMBOR PROJECT
BURMA
THAILAND
CAMBODIA
ANDAMAN SEA
GULF OF THAILAND
SOUTH CHINA SEA
MALAYA
HAINAN
Hanoi
Bangkok
Saigon
0 400 800km

The Mekong in Cambodia

Photo. B-1 Inundation of Mekong Delta (March 1962)

Photo. B-2 Inundation in the Downstream Area of the Dam Site (March 1962)

Photo. B-3 Quatre Bras (Downstream View)

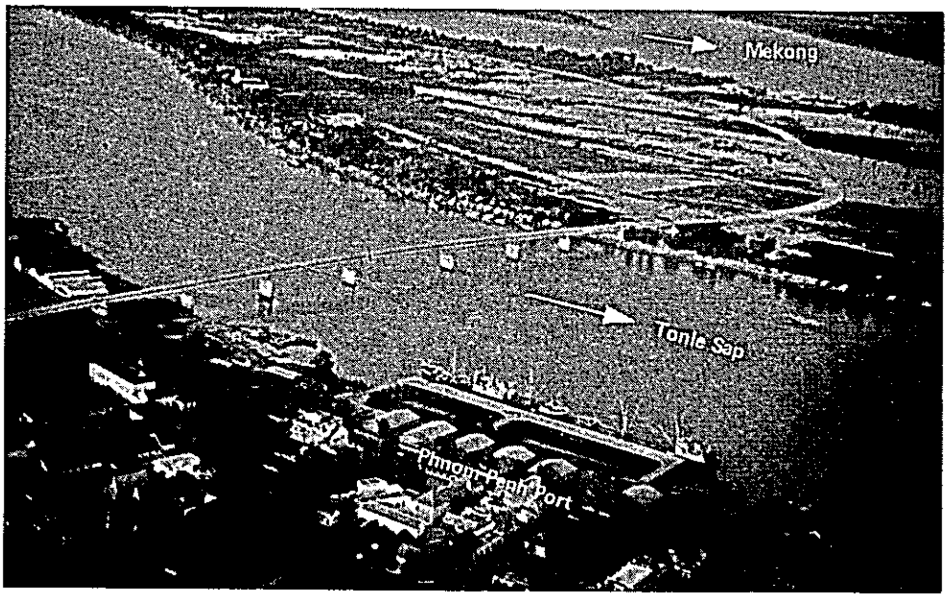


Photo. B-4 Mekong and Tonle Sap (Upstream View)

Photo. B-5 Island in front of Kratie (December 1964)

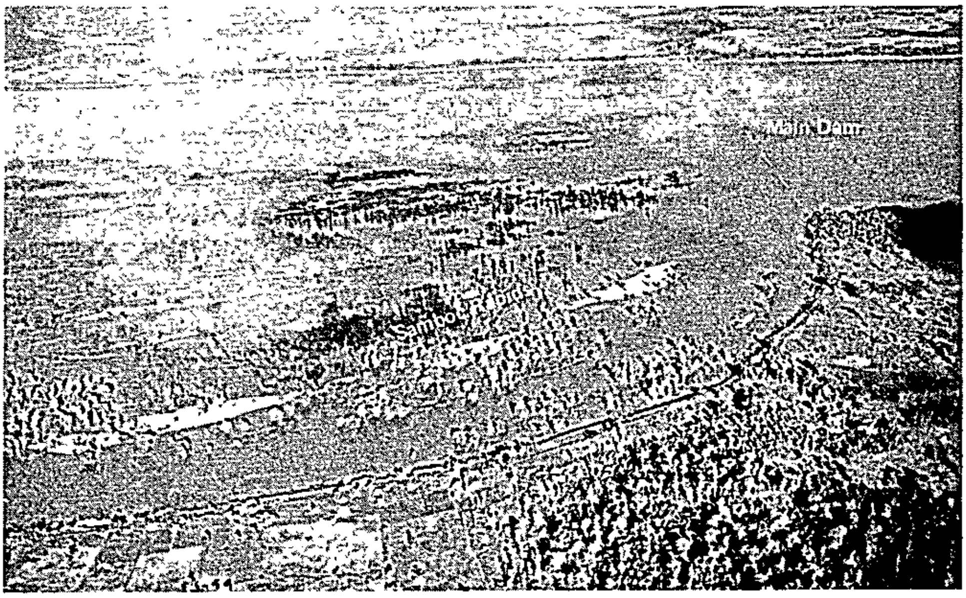


Photo. B-6 Sambor Dam Site (December 1964)

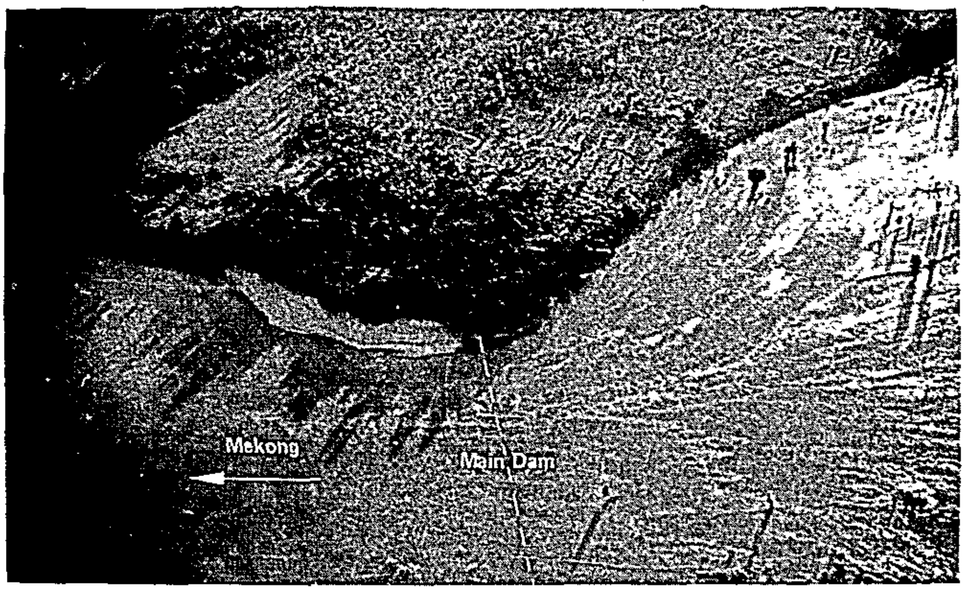


Photo. B-7 Right Bank of Sambor Dam Site (December 1964)

Photo. B-8 Samboc Rapids (December 1964)

Photo. B-9 Mekong between Sambor and Stung Treng

Photo. B-10 Mekong between Sambor and Stung Treng

Photo. B-9 Mekong between Sambor and Stung Treng

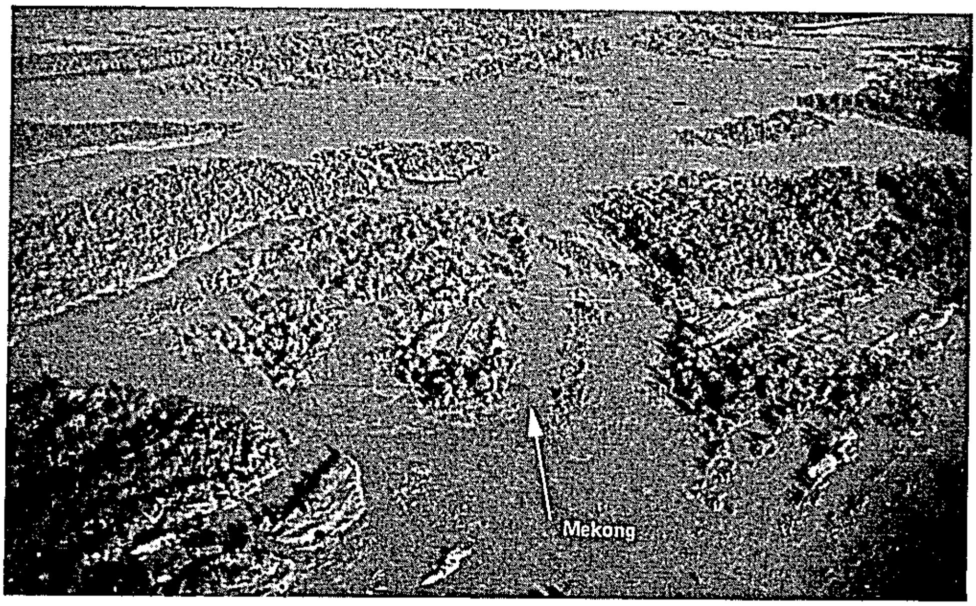


Photo. B-10 Mekong between Sambor and Stung Treng

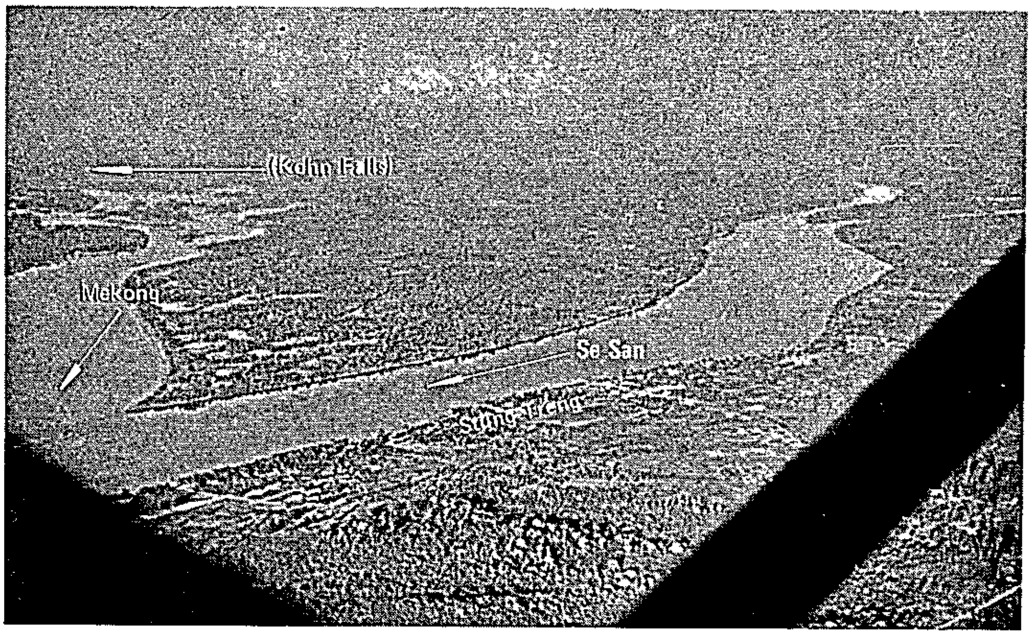


Photo. B-11 Confluence of Mekong and Se San at Stung Treng

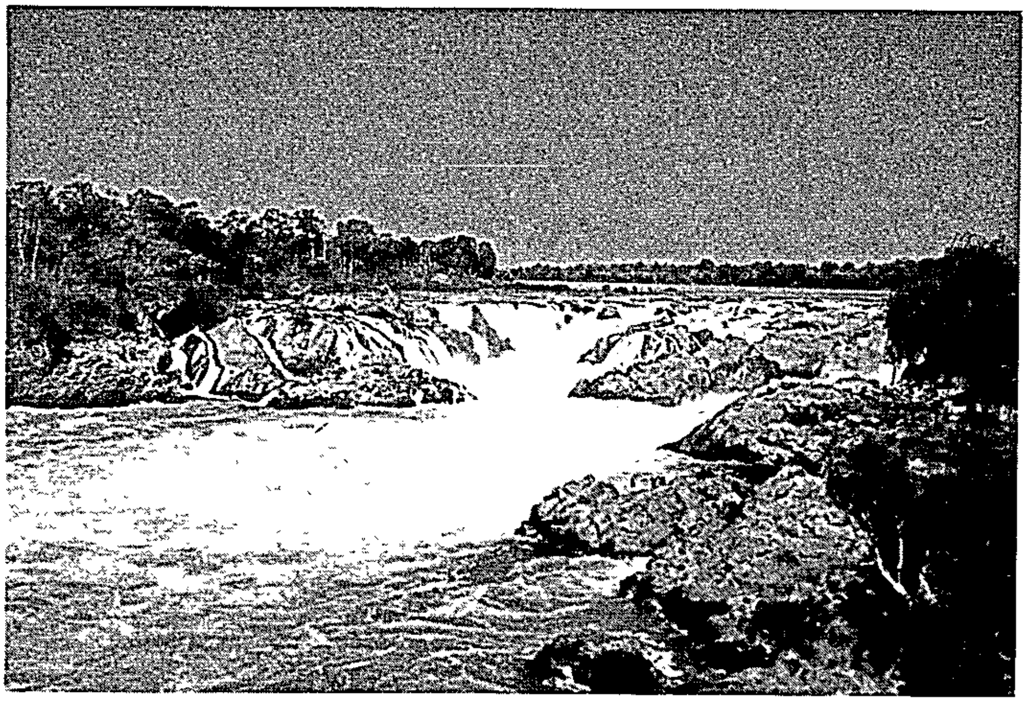
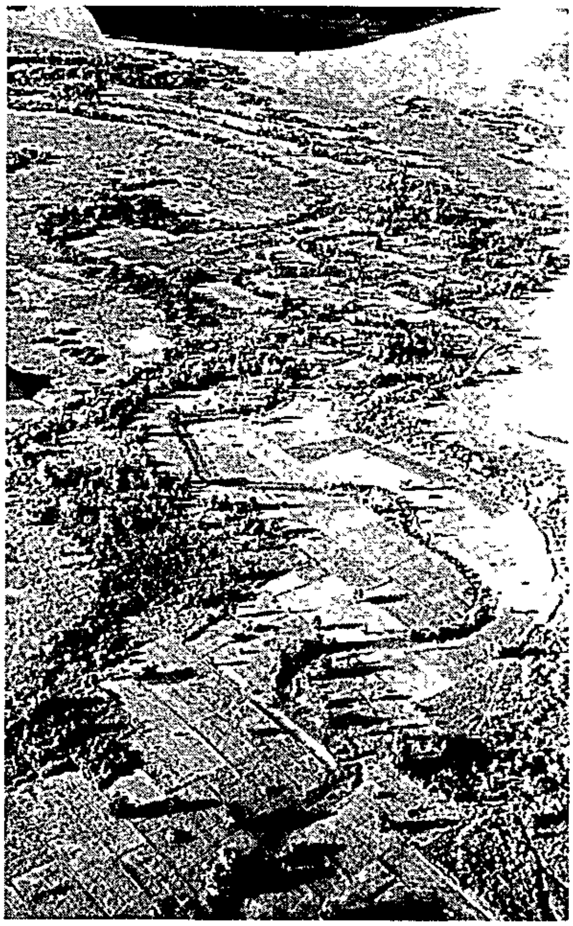


Photo. B-12 Part of the Kohn Falls (December 1964)

Agriculture



Typical Cultivated Land

Paddy Field in the Dry Season

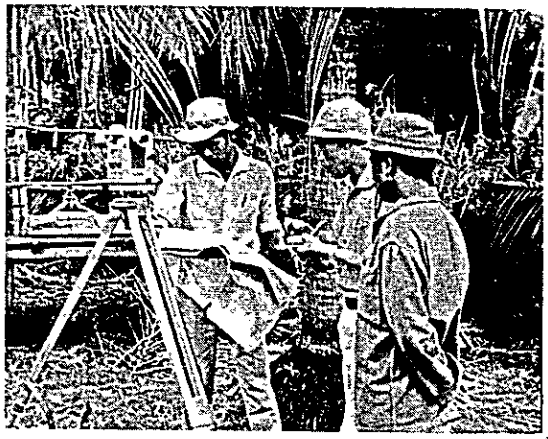
Photo. E-1 Project Area (1)

Experimental Paddy Field

Inundated Marshy Land

Photo. E-2 Project Area (2)

at Prek Chhlong



at Kratie

Photo. E-3 Field Work

Plowing Work

Rice Polishing for Family Use

Paddy Rice Seedlings

Paddy Rice Storage

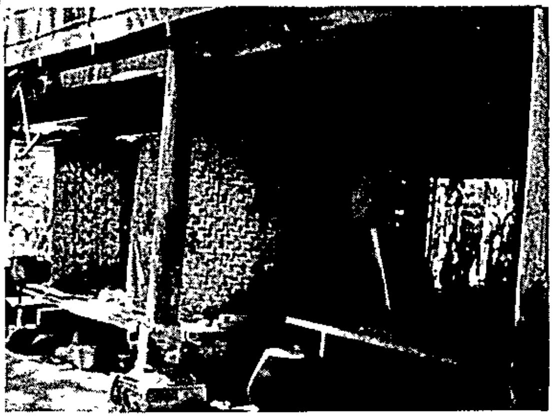
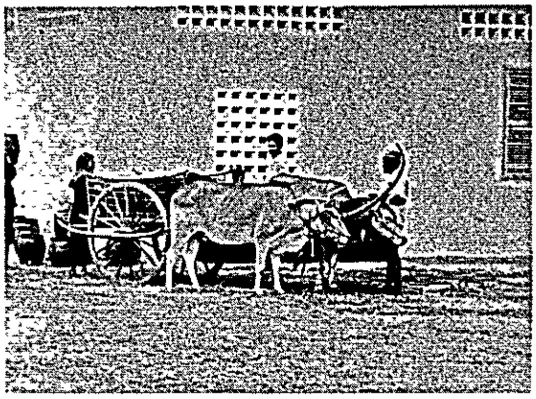


Photo. E-4 Present Farming (1)



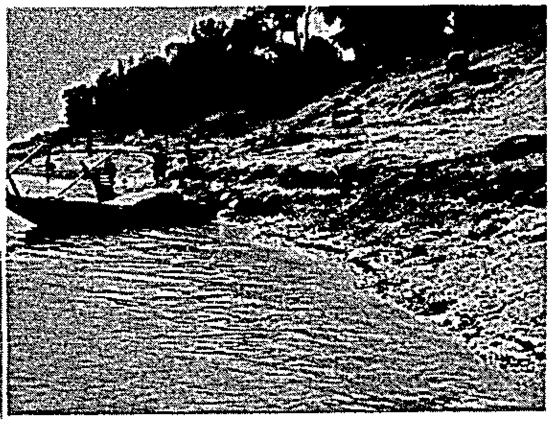
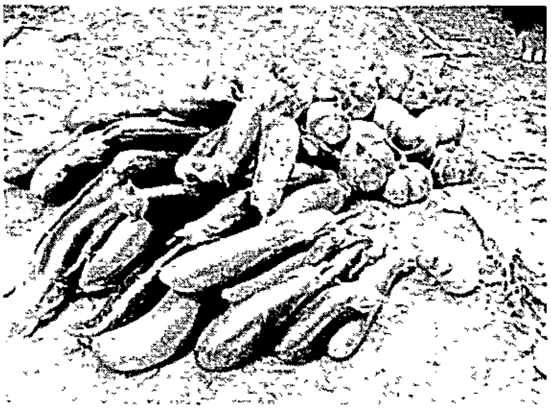


Photo. E-5 Present Farming (2): Transportation of Agricultural Products

Tomatoes

Cauliflower

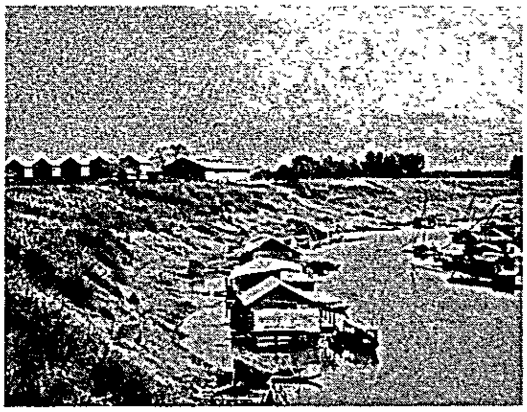


Eggplant and Tomatoes

Cabbage

Field of Cabbages

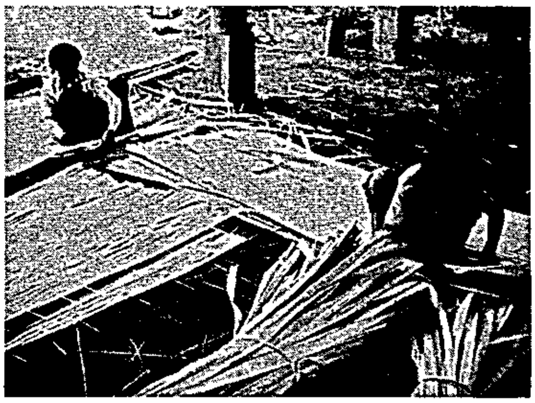
Photo. E-6 Present Farming (3): Upland Crops



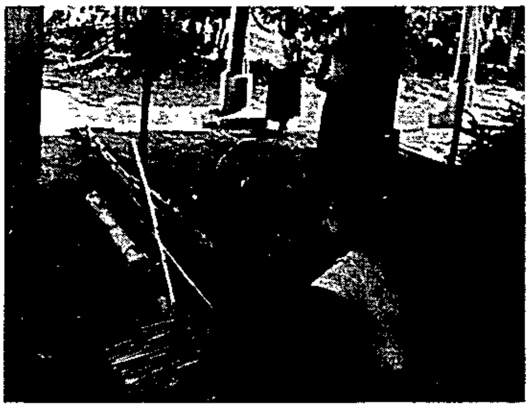
Fishing

Rushes

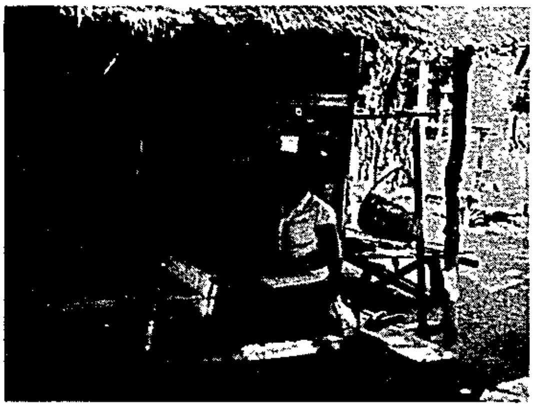
Carrying Palm Sugar



Cottage Industry



Cottage Industry



Cottage Industry

Photo. E-7 Present Farming (4): Works other than Farming

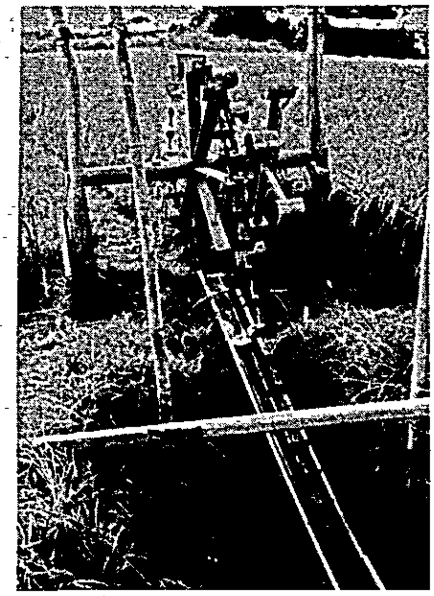
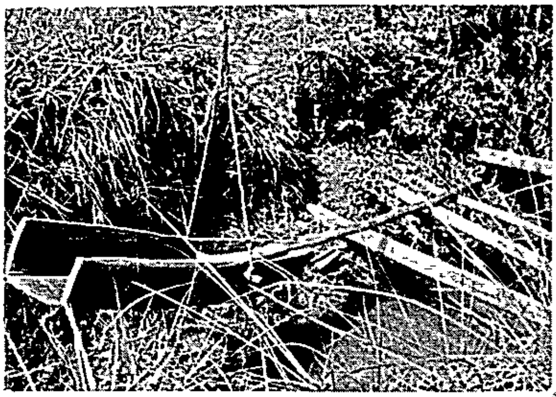
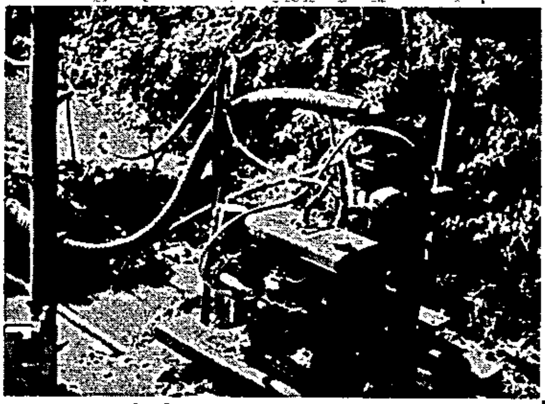
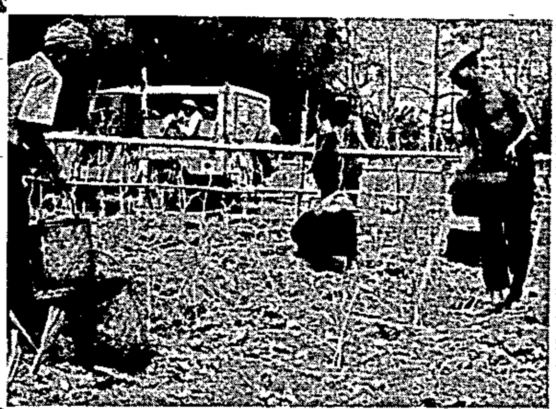
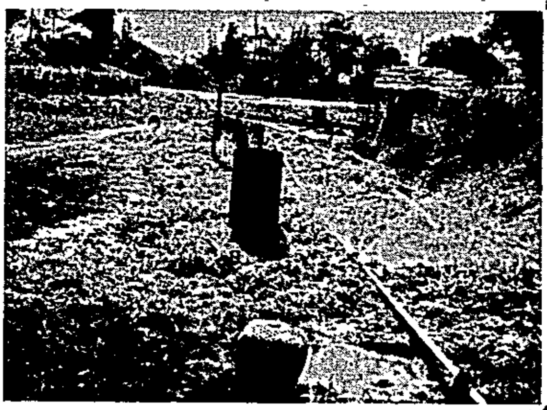



Photo. E-8 Present Irrigation Methods (1): Traditional Irrigation Implements in the Paddy Fields







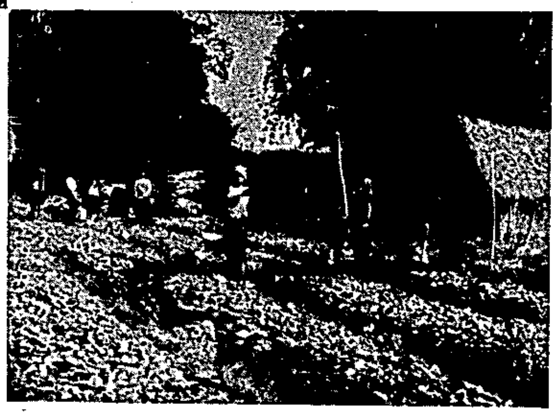
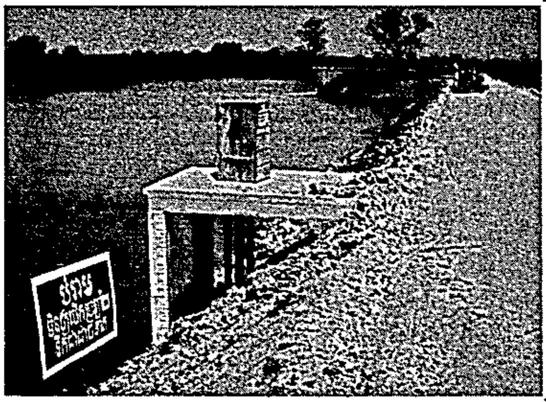


Photo. E-9 Present Irrigation Methods (2): Field Irrigation by Pumping or Watering Pot on the Rear Slope of the Natural Levee of the Mekong

Upland Field (Prek Te)

Irrigation Canal (Kratie)



Tank Reservoir (Kratie)

Irrigated Paddy Field in the Dry Season

Photo. E-10 Present Irrigation Methods (3)

MAIN FEATURES OF THE PROJECT

TOTAL CONSTRUCTION COST of the PROJECT	$358.0 million
in which FOREIGN CURRENCY	$256.5 million
DOMESTIC CURRENCY	$101.5 million

B. **Agricultural Sector**

1. Scale of Development

Irrigation Area	34,000 ha (Paddy Field – 58%, Upland Field – 42%)
Drainage Improvement Area	2,845 ha
Total Planting Area	60,739 ha (including 1,957 ha for Cultivation of Feed)
Number of Farming Households	8,500 (including 2,000 Households expected to settle from Farmland to be submerged under the reservoir)

2. Water Requirement and Facilities

Water Requirement	468 million cu.m
	Sambor Reservoir – 238 million cu.m Other Sources – 230 million cu.m
Division of Area	12 Districts
Length of Irrigation Canal	557 km
Length of Drainage Canal	31 km
Pumping Station	27 Stations
Irrigation Pumping Stations	23 (6,900 kW)
Drainage Pumping Stations	4 (1,900 kW)
Total Power Required	8,800 kW
Reservoir	3 Reservoirs
Effective Storage Capacity	35 million cu.m
Dam Embankment Volume	783 million cu.m
Lakes and Ponds with Gates	8 provided with 10 Gates
Colmatage Method	To be practised at 8 Places
	Canal length – 8.6 km

	Experimental Farm	To be established at 2 Places
3.	Construction Cost	
	Foreign Currency	$17.04 million
	Domestic Currency	$17.86 million
	Total	$34.90 million
4.	Construction Period	1970 - 1979
5.	Economic Evaluation and Financial Analysis	
	Averaged Internal Rate of Return	7.9%

Financial analysis are made by changing the rate of interest corresponding to the objects, where the interest during construction is also included in the cost.

CHAPTER A. INTRODUCTION

CHAPTER A. INTRODUCTION

The Mekong Committee has been working on the Mekong Mainstream Project bearing multipurpose nature in improving the navigation to Vientiane, capital of Laos, the flood control, the irrigation and the hydropower generation in the lower basin, and it has incorporated the Sambor Project for the development of the extreme lower stream area. At the 14th meeting of the Committee held in Bangkok in May 1961, the Government of Japan proposed to undertake the survey of the Sambor Project. In October 1961, the reconnaissance survey was conducted. A further investigation was requested, and subsequently, feasibility surveys were started in 1963 in various fields such as hydropower generation, power marketing, navigation and agriculture. All the field investigations were completed in 1966 through 1967.

The history of the agricultural surveys is briefly noted hereinafter. The first survey made in 1963 resulted in only studying the schedule of further surveys and the development plans. The second survey team was dispatched in 1964, but experts of agricultural field were not included in this team. However, the importance of agricultural development in the Sambor area was reconfirmed through the survey made by the Irrigation and Forest Development Survey Team for Cambodia dispatched by the Government of Japan in April and May 1964. Accordingly, investigation for agricultural development was initiated with full swing by the third survey for the Sambor area in 1964 through 1965, and the present conditions of agriculture, soil and hydrology were surveyed for the area of 69,000 ha immediate downstream of the proposed dam site. The fourth survey became necessary to finalize the preceding survey, during the rainy season in 1965 and the dry season in 1965 through 1966. The fifth survey made during the dry season in 1966 through 1967 was devoted to check the proposed scheme at the field, and studies were made to locate the irrigation facilities and to perform supplemental topographic and hydrologic surveys. Moreover, a reconnaissance survey was made as to the possibility of the future pumping irrigation in the downstream area of the Mekong.

During the period of these surveys, the Government of Cambodia prepared a topographical map at a scale of 1:20,000 with contour intervals of 1 m, which was made available for the project study. The map covered an area of 780 km^2

The Pa Mong-Sambor joint meetings were held by the Mekong Committee in May and December 1966, in April 1967, and in March 1968. The purpose of the meetings was to discuss and coordinate the joint technical problems of both projects between the Sambor Team of the Overseas Technical Cooperation Agency of Japan and the Pa Mong Team of the United States Bureau of Reclamation. In compiling the feasibility report of the Sambor Project, various useful references were obtained from the result of the meetings.

Finally, an irrigable area of 34,000 ha was selected, and a development plan was formulated and proved feasible. Further, development scheme of the downstream area was worked out.

CHAPTER B. SUMMARY

CHAPTER B. SUMMARY

B-1 Problems and Needs

Most of the problems encountered in agricultural development area of 34,000 ha selected for the Sambor Project area are typical to the entire Cambodia and other Southeast Asian countries as well. One of the major problems lies in the conventional means of production that the farmers were simply followed by adapting themselves to the natural conditions of the monsoon region.

People have developed a type of farming and crops which can be observed in various parts of Southeast Asia. The type of farming is deemed feasible to overcome both flood in the rainy season and drought in the dry season. Most of the crops are capable to withstand the flood and drought, but unfortunately, their yields are generally very small and their response to fertilizer is poor.

In order to solve the above problems, varieties bearing high yield instead of the conventional ones are to be introduced and the type of farming is to be improved to a great extent. To propagate the cropping of the varieties, it is always necessary to provide irrigation and drainage facilities, and flood control where necessary. At present, as the flood control project for the Mekong is not expected to materialize in the near future, the efforts for increasing agricultural production in the area along the Mekong would basically require development of local water resources, and expansion of irrigation utilizing the water from the mainstream of the Mekong (mainly in the dry season).

Now to deal with the area covered by the Sambor Project, this area includes the Kratie Province whose capital is Kratie which has been developed sinch early days as one of the centers for water and land transportations. In this province, where there are only a few upland fields along the Mekong and small paddy fields along its tributaries, people are sufferring from their own food self-sufficiency. Therefore, there are in need of an increase of food production and a raising of farmers living standard. For that purpose, an agricultural development should be undertaken. This purpose meets with the national policy of Cambodia whose main industry is agriculture and whose most important export item is agricultural products. This necessity of agricultural development in this area is believed to be so urgent that people can hardly wait until the Sambor dam, which is to be a very important water resources for irrigation, is completed.

B-2 Objective and Scope

It is obvious from the foregoing clause that the objective of this project is to increase agricultural production to a great extent by constructing irrigation facilities. Even though Sambor reservoir and the Mekong Mainstream could provide a sufficient amount of water for irrigation in the limited project area immediate downstream of the dam not only in the rainy season but also in the dry season, there might be hardly any instances where the Mekong Mainstream is used for irrigation purposes. The Sambor Project is the first one that depends primarily upon the mainstream for water resources and, as such, may be considered as the first demonstration project. In this sense, it has also an objective to motivate similar development projects in other areas.

The project is also considered to have an important effect on the overall development of the area. General increase in income from agriculture based upon improved productivity will probably make it possible to use capital and labor for industry, thus various industries will be developed. The increase income from industries to be developed will produce a further demand for agricultural products. Then, it will become possible to use a larger amount of capital for agricultural purpose, thus increasing the agricultural production to a further extent. It would be reasonable to assume that these things will happen recurrently.

Here, it is necessary to review the conditions under which an area of 34,000 ha immediate downstream of the dam has been chosen as an irrigable area for this project. The proposed site for the Sambor dam is located in an area between the plains and the hills, and the area immediate downstream of the dam has no large open field except those extending along the two tributaries, the Prek Saop and the Prek Te. At first, an area of 69,000 ha extending along the Mekong, as far as the boundary of the Kratie Province was chosen for survey as a possible area for gravity irrigation from the Sambor reservoir. But the results of soil survey indicated that a limited area of approximately 40,000 ha was classified as having higher land-productivity in the area. And finally, due to the complex topographical features, the irrigable area was selected to be 34,000 ha which is located from the immediate downstream of the dam to the boundary of Kratie Province. A survey was also made on local water resources (tributaries, ponds or lakes) and the Mekong which could be an alternative for the

Sambor reservoir, and it was concluded from an economical stand-point that majority of the areas should be irrigated by pumping from local water resources and the Mekong.

It is expected that in the remote future when the Sambor dam and other dams are completed along the mainstream of the Mekong, the river water in the dry season will be immensely increased in the area along the lowerstream of the river. Utilizing this abundant water, it will become possible to develop a part of the Mekong Delta in the lowerstream basin, and on area of 587,000 ha was tentatively selected for future irrigation projects as shown in Fig. IV-2, of which water resources mainly depends upon a pumping irrigation from the Mekong. The selection was principally based upon the availability of local water resources, topographical and soil conditions.

B-3 Findings

B-3-1 Climate and Hydrology

a. Climate

Precipitation: Conditions of the project area located in the Asian monsoon zone are summarized as follows:

i) Climate has a distinct division of two seasons, the dry season and the rainy season. Generally, the rainy season starts mid-April and ends in October, and it seldom rains in the dry season.

ii) The shower-type rainfall is frequent, the monthly, daily and hourly rainfalls are extremely different by each district in the project area of 34,000 ha.

Three months of 1965 in the survey period lasted droughly, but the annual rainfall recorded 1,498 mm in Kratie. This is equivalent to a probability of non-excess of 10% and is assumed to be the designed basic rainfall in calculating the water balance.

Temperature, Evaporation: The average temperature in Kratie is about 27°C, and seasonal variations of the temperature are hardly observed throughout the year. The maximum evaporation occurs around April, while the minimum occurs around August, and an average evaporation throughout a year is a little less than 6 mm/day.

b. Hydrology

The Mekong and Its Tributaries: Generally, the water level of the Mekong in Kratie rises rapidly in the later half of July, and reaches to the maximum between the latter half of August and the earlier half of September. The maximum range of the water level between the rainy and the dry season is around 14 m.

The water level of the tributaries follows after that of the Mekong owing to the back-water influence, but when there is a sudden rise in the Mekong water level, it often creates an adverse flow in the tributaries.

When the water level of the Mekong is almost at about peak, the inundation occurs at various places through the tributaries.

In the dry season, all of the tributaries except the Prek Te and the Chhlong will be dried up.

Inundation: One of the most characteristic features in this project area is inundation, which usually occurs during July through October every year by the influence of the Mekong flood. It is not only the flood of the Mekong, but the flood of the tributaries that causes the inundation, since the runoff of the tributaries can not be drained away into the Mekong owing to high water level of the Mekong.

Out of 34,000 ha of the project area, the inundated area covers about 19,000 ha. The duration and depth of inundation are different by locations, and generally the duration ranges from 60 days to 150 days with the depth of 1.5 m to 4.3 m.

Land utilization, crops, and a cropping pattern and calendar are affected by the beginning time, duration and area of inundation.

Colmatage: The *colmatage*, a method to create the arable land by intaking muddy water from the river, has been conducted since the ancient time at the area along the Mekong in this project area and other places of Cambodia as well.

As a result of a soil study, it is grasped that the productivity of the land created by alluviation is rich. The sediment in the Mekong seems to be accumulated by scouring the soil particle of the river bed by the tractive force of the flood. Consequently, it might be presumed that after implementation of the Sambor dam, the density of muddy water will not change from the present conditions.

Precolation: The average percolation of the paddy field is estimated at about 3 mm/day by the actual observation.

Infiltration: The infiltration, as the basic intake rate, of the upland field is mostly 10 mm/hr - 20 mm/hr, and most of the field capacity is around 30%.

Water requirement: The water requirement is determined by using the measured values and Blaney-Criddle formula.

B-3-2 Soil and Land Use

a. Soil

The soil analysis of the project area indicates that the soil can be classified into 15 soil series. A vast portion of the 69,000 ha area surveyed is composed of the alluvial soil existing in the inundated plain of the Mekong and its tributaries, and with the low humic gley soil it covers an area of 47,100 ha.

The alluvial soil in this area is most fertile and has been utilized as the upland fœlds of the silty loam as well as the paddy fields of the clayey soil. The red yellow podzolic soil spreads on highlands and the low humic gley soil in the bottom valley of the highlands.

b. Land classification

The productivity probability, as a paddy field and upland field, of each soil series id classified by the same way being employed in Japan for the classification of the productivity potentials of soil. This classification is found on the following criteria, that is, the factors of limitation and impediment which the soil ordinary have in their textures, or the kind and degree of danger to turn the soil for the worse.

The soil is classified into four classes, I, II, III and IV, from richness to poorness in order of productivity, and it was found from the results of the classification that in this area the class I does not exist and all of the area is graded from the II to IV.

It is of great interest that the majority of the inundated area belongs the class II, and this fact might show inundation to be effective for soil fertility though it limits land utilization. Presently, hardly any fertilization has been employed in this area but the yearly supplement of sediment has played an important role in soil fertility.

c. Land Use

A rate of arable land to the whole area of Kratie Province is 3%, which is about 1/4 of the average percentage in the country. Out of the arable lands of the province a rate of the paddy fields is 70% and the upland fields 30%. With regard to the existing farm lands in the project area of 34,000 ha there are paddy fields of 5,017 ha and upland fields of 7,452 ha, and the remaining 21,523 ha area is to be reclaimed in future.

Cropping intensity of the existing fields is as follows: about 100% a year for paddy, of which 80% is for the rainy season, and 150% a year for upland, of which a half for the rainy season, with an average of 130% a year for the total fields.

Factors to limit land utilization, under the present technique level of agriculture, are the inundation of the Mekong and its tributaries. The arable lands have existed even in the inundated area, and inundation leaves muddy soil in the area at its retreat, that is very effective for maintenance of the soil fertility under the situation of non-fertilization. But unless the inundation occurs adequately in depth, duration and timely beginning, of course, it will bring an adverse effect on agricultural farming.

Paddy fields: Present land utilization of the paddy fields has been compelled to be single cropping farming since the paddy fields were controlled by flood and rainfall, without any facilities for water resources. The paddy fields in this area could be divided into two types according to the cropping time, that is, the rainy and dry seasonal paddy fields.

The dry seasonal paddy fields exists in the lowland, which extends between the back slope in the natural levee of the Mekong and the hilly-lands, and utilizes the water being left in the depressed land after retreating of the flood as irrigation water resources.

The rainy seasonal paddy fields exist in the bottom valley in the hilly-lands where the flooding water will not reach at, and utilize the rainfall as the irrigation water resources.

The floating rice has become known as a characteristic crop in the flood area, however, has not been cultivated generally in this area because of severe fluctuation of the water level and complicated land formation which develop a deep water level.

Upland fields: The upland fields in this area could be divided into two, that is, upland fields located in the natural levee of the Mekong and its tributaries, and in the back slope of the natural levee of the Mekong and its tributaries.

Plantations of perennial crops such as banana, tea, kapok and so on, are located in the natural levee, and maize, peanut and mung bean have been mainly cultivated in the uplands located in the back slope in the natural levee, which are submerged with floods during August to October.

B-3-3 Present Conditions of Agriculture

The agriculture in Cambodia has had a most important position as the main industry, and it is also the same in Kratie Province.

The present agricultural conditions in the Sambor Project area can be focused on three districts, that is, Srok Kratie which is a densely populated district with many paddy fields, Srok Chhlong where upland farming has been mainly managed with comparatively large farm size, and Srok Prek Prasap where it is not easily accessible but has a great potentiality for development.

Farm size: More than 90% of the population are living in the rural communities, and more than 80% of them are engaged in farming. Population density of this area is 11 persons/km^2, which is about 1/3 of the country average.

An average cultivated area per household is about 2 ha, which is comparatively less than the country average of 3.5 ha, but the majority of the cultivated lands are owned by the farmers themselves. And about 2 ha is most common by the classification of land belonging to one household.

The average number of a family is 5.8 persons and the average number of working labor of a family is about 2.7 persons.

Livestocks: As for the average number of the livestocks bred per household, 2 heads of cows of 1.6 of buffalos, 0.8 head of pigs and 7.4 of domestic fowls are observed. The cow and buffalo are used mainly as animal power in plowing and harrowing, and the pig and domestic fowl are bred for meat. The livestocks are maintained on the grazed land without any enclosures, but no particular grass or fodder crops are planted.

Farm implements and fertilizer use: Most farm implements are composed of the manual type and the animal power type, and most of them are home-made. A small pump with engine for lift irrigation is the only power tool.

Fertilizer and agricultural chemical items are not used, except for a small amount used for some of the upland field irrigation.

Agricultural products: Main agricultural products are rice, maize, mung bean, tobacco and so forth, in which, needless to say, rice and maize occupy the greater part of them in quantity.

A trend of increasing in agricultural products can be seen in the agricultural statistics during 1963 to 1965. Except for the maize, this was made possible by increasing the cultivated area.

According to the data of 1963 to 1964, the unit yield of rice is 1.25 ton, which is a little more than the average of the national yield of 1.12 ton. As for the yield of the upland crops, it varies considerably, which is affected by the various conditions of soil and inundation. It is from the result of the survey that the soil fertility of the upland fields in the inundation area is richer than the non-inundation area.

B-4 Outline of the Project

The project area of 34,000 ha can be divided into three districts, as stated on B-3-3., according to farm management conditions. A further classification is made by studying topographic conditions, designed irrigation and drainage systems, and the following twelve districts are designated as appropriate districts for the plan of development, namely, six districts in the left bank, three districts in the right bank and the rest of three of island districts.

The procedure from an execution of this project to an accomplishment of the objective is determined as follows:

The benefit by production increase will reveal itself immediately after the completion of the construction, then it will gradually increase its benefit, and finally this will attain the full-benefit in 10th year after the completion of the construction. Periods of analysis for economic evaluation is considered at 50 years.

In reference to agricultural technique, local varieties of crops will be employed at the outset, but when the irrigation facilities and land reclamation works are in advance, it should contribute to the increase in farm products. The extension of using the improved or new varieties under experimentation will realize the objective of the project in ten years after the completion of construction, together with the advance farming techniques and demonstration farms to be constructed simultaneously with the project implementation.

For the time being the improved farm implements by animal power will be used, but farming work will be mechanized in the near future.

Irrigation: As for the water resources in the designed basic year, a total water requirement of 685 x $10^6 m^3$ depends upon an available rainfall of 217 x $10^6 m^3$ and a supplemental water from the Sambor reservoir of 238 x $10^6 m^3$ and the rest of 230 x $10^6 m^3$ is depended on a pumping water from the Mekong, its tributaries and natural ponds.

Drainage: In order to protect the arable land from the flood, polder dike and drainage pumps will be installed at the districts of Kratie and Chhlong covering 4,520 ha. These works will enable the perennial use of the arable land. The other present inundation area will remain flooded even after the completion of the construction.

Land development: Of 34,000 ha of the project area, 37% is the existing cultivated lands of which 40% is paddy fields and 60% is upland fields, and 63% is the lands to be reclaimed. After the completion of the construction, the area of the arable land will be tripled, of which 58% will be the paddy fields and 42% the upland fields.

About 2,000 farm households who are living in the proposed reservoir area to be submerged could be resettled in the project area. And, 8,500 household of farmers, adding 2,000 to 6,500 of the existing farm households, will be able to manage the farm size of 4 ha each, which is twice the present farm size on the average.

Construction plan: In order to carry out this project, the following construction works are necessary:

Reclamation works on 21,531 ha, canal works on 588 km, reservoir works at 16 locations, pumping station works at 27 places, *colmatage* works at 8 places and demonstration farms at 2 locations

The total construction cost is $34,900 x 10^3, and as to the construction cost per ha of twelve districts, the maximum is $1,208, the minimum is $797 and the average is $1,026.

This agricultural development project will renovate the farm management in the area as described hereinafter.

Agricultural products: By expansion of a cropping area, a crop ratio, and unit yield which will be trippled for the paddy and maize and doubled for the other upland crops, the present paddy rice production of 5,673 ton will increase to 86,169 ton in the future, maize from 10,299 ton to 72,590 ton and the other upland crops from 2,270 ton to 16,096 ton.

Standard farmer: A standard farmer's arable land will be of 4 ha, which can be managed by three persons with the aid of livestocks.

When the full benefit is reached, the annual net benefit will be approximately $727, and $1,246 when labor cost is included.

Internal rate of return: The internal rate of return of this project, being divided into twelve districts, is in the range of maximum 11.7% to minimum 6.0% with an average of 7.9%.

Future development in the downstream area: The development programs of the lower Mekong basin in the future covers 587,000 ha which expands over the following provinces, i.e., Kompong Cham, Prey Veng, Kandal and Takeo. And this development involves lift irrigation from the mainstream in the dry season, and the supplemental irrigation in the rainy season. Although the benefit will be almost the same as the Sambor Project, and the construction cost will abate about 10%, since the project area is situated in a plain topographical regios consequently, the average internal rate of return will gain 7.8%. Annual required consumptive power for pumping the irrigation water are estimated to be approximately 211,600 kw.

B-5 Conclusion and Recommendation

As the result of the surveys and studies for this area, the feasibility of such project plans as outlined under B-4 is clarified.

In order to carry out this project effectively and to materialize the benefit at an early stage, the following items should be recommended.

1. Early commencement of the project: The construction works shall be started by each district and shall be arranged to be completed simultaneously with the completion of the Sambor dam;

2. Installation of the pilot demonstration farms;

3. Study of excellent varieties and farming techniques, and strengthening of the extension work;

4. Establishment of an organization to manage the construction works and to operate the project after the completion: Enactment of the law for the organization, if required;

5. Continuation of hydrologic, meteorologic survey, and experimental inquiry of the canal management problems during the rainy season;

6. Necessary soil survey to be made to ensure proper water management and fertilization for each field.

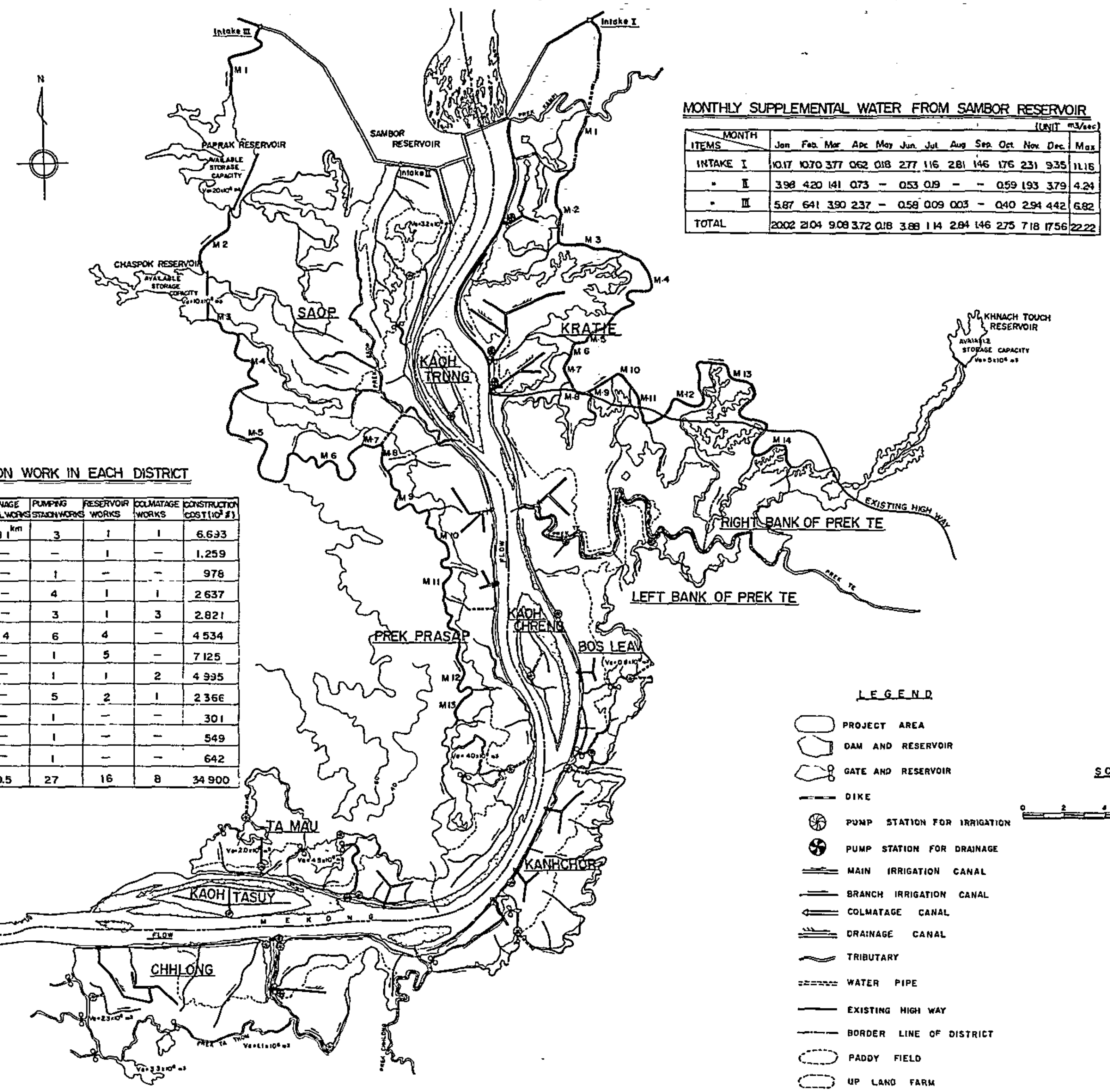
Fig IV-1 GENERAL PLAN OF AGRICULTURAL DEVELOPMENT IN SAMBOR PROJECT

ELEMENT OF MAIN IRRIGATION CANAL

MAIN CANAL	DISCHARGE	CANAL LENGTH	MAIN CANAL	DISCHARGE	CANAL LENGTH
Intake I M-1	m3/s 11.16	9.2 km	Intake III M-1	6.82	5.0
M 2	10.19	4.2	M-2	7.58	3.8
M-3	8.61	4.6	M 3	6.54	2.4
M 4	8.25	4.8	M 4	5.61	5.0
M-5	8.25	2.8	M 5	5.31	7.8
M-6	7.09	0.6	M 6	4.99	8.0
M 7	5.97	2.8	M-7	4.87	0.8
M-8	5.28	1.4	M 8	3.70	3.1
M 9	5.11	1.0	M-9	3.30	4.4
M-10	4.93	1.0	M 10	3.07	4.6
M 11	3.19	3.2	M 11	2.94	2.4
M 12	2.95	6.6	M-12	2.08	6.4
M 13	2.05	6.5	M-13	1.91	2.2
M 14	1.20	1.4			
TOTAL		50.1	TOTAL		55.9

RECAPITULATION OF MAIN CONSTRUCTION WORK IN EACH DISTRICT

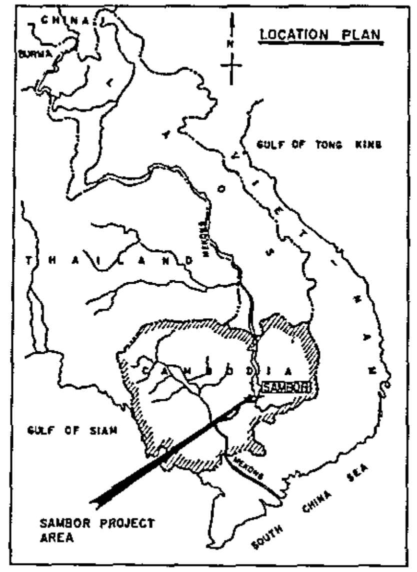
NAME OF DISTRICT	IRRIGABLE AREA PADDY FIELD	IRRIGABLE AREA UPLAND FIELD	RECLAMATION WORKS	IRRIGATION CANAL WORKS	DRAINAGE CANAL WORKS	PUMPING STATION WORKS	RESERVOIR WORKS	COLMATAGE WORKS	CONSTRUCTION COST (10³ $)
KRATIE	5.508 ha	873 ha	5.124 ha	128.6 km	18.1 km	3	1	1	6.693
PREK TE(R)	1.341	4	895	27.9	—	—	1	—	1.259
PREK TE(L)	780	175	951	22.5	—	1	—	—	978
BOS LEAV	815	1.881	2.573	40.7	—	4	1	1	2.637
KANHCHOR	1.191	1.287	2.120	40.9	—	3	1	3	2.821
CHHLONG	3.421	1.693	3.737	49.6	12.4	6	4	—	4.534
SAOP	4.308	2.868	6.288	122.0	—	1	5	—	7.125
PREK PRASAP	1.061	3.074	4.006	65.7	—	1	1	2	4.995
TA MAU	1.395	634	1.598	29.4	—	5	2	1	2.366
KAOH TRUNG	—	247	247	8.8	—	1	—	—	301
KAOH CHRENG	—	638	638	9.2	—	1	—	—	549
KAOH TASUY	—	806	806	12.1	—	1	—	—	642
TOTAL	19.820	14.180	28.983	557.4	30.5	27	16	8	34.900



MONTHLY SUPPLEMENTAL WATER FROM SAMBOR RESERVOIR

(UNIT m3/sec)

ITEMS \ MONTH	Jan	Feb.	Mar	Apr	May	Jun.	Jul	Aug	Sep.	Oct	Nov.	Dec.	Max
INTAKE I	10.17	10.70	3.77	0.62	0.18	2.77	1.16	2.81	1.46	1.76	2.31	9.35	11.16
" II	3.98	4.20	1.41	0.73	—	0.53	0.19	—	—	0.59	1.93	3.79	4.24
" III	5.87	6.41	3.90	2.37	—	0.58	0.09	0.03	—	0.40	2.94	4.42	6.82
TOTAL	20.02	21.04	9.08	3.72	0.18	3.88	1.14	2.84	1.46	2.75	7.18	17.56	22.22



OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO, JAPAN

SAMBOR PROJECT (AGRICULTURE)

GENERAL PLAN OF AGRICULTURAL DEVELOPMENT IN SAMBOR PROJECT

SANYU CONSULTANTS INTERNATIONAL. NAGOYA, JAPAN

SUBMITTED	DATE 1968
APPROVED	DWG NO

Fig IV-2 DOWNSTREAM DEVELOPMENT AREA OF THE MEKONG

CHAPTER C. DESCRIPTION OF THE PROJECT AREA

CHAPTER C. DESCRIPTION OF THE PROJECT AREA

C-1 Topography of the Area and Description of the Physical Features

C-1-1 Topography

The area selected for the agricultural development in connection with the Sambor Dam Project is situated at both the banks along the Mekong, from the immediate downstream of the dam site and extends as far as approximately 60 km downstream, and also belongs to Kratie Province.

This area lies from latitude 12°12' N to 12°37' N and east longitude 105°50' E to 106°15' E or within a 2,025 km^2 range. The surveyed area within these ranges was 69,000 ha below 40 m at elevation, surveyed area within these ranges was 69,000 ha below 40 m at elevation, but 40% of this area is unfertile mountain area, therefore 34,000 ha of arable land is selected as the project area.

From the 1:40,000 scale aerial photographic map, a topographic classification is made into eight categories. (See Drawing No. L enclosed in the envelope attached to the back of this volume).

a. Hilly-land Slope of Tertiary Rocks

This type of area is situated at the highest land in the region, layer from surface to bedrock is shallow. Most areas are of clear forest, but a few are of dense forest.

b. Valley Bottom Plain Inside Hilly-lands

This type of area having no inundation from the Mekong during the rainy season is being cultivated as the rainy seasonal paddy fields, and these areas are formed by the tributaries of the Mekong.

c. Gentle Slope in Mountain Foot

This is the transition area which stretches from the hilly-lands to the lowlands and principal soil texture is composed of colluvial soil with talus caused by degradation of the mountain foot.

d. Ridge in Natural Levee

The ridge of the natural levee formed by the Mekong gently curves along the banks and is being served as a traffic road.

e. Back Slope in Natural Levee

This type of area formed by sedimentation of the Mekong is situated at the place between the ridge of the natural levee and the low marshy land of the hinterland, and is being inundated during the rainy season. The soil fertility is rich and the land is utilized for upland fields.

f. Sedimentation Area by the Small River in Marshy Land

This is the delta area and the natural levee is formed by the small tributaries and is frequently inundated.

g. Low Area

This is the lowest land in the survey area with an elevation of 20 m to 14 m and is completely inundated during the rainy seasons, causing unsuitableness for farming.

h. Lake Pond or Shallow Concaved Area in Back Marshy Land

This is the old river bed, old meandering route and residual pond and is inundated even in the dry season.

C-1-2 Description of the Physical Features and Its Influences

One of the specific physical features of this area is the climate. This area as well as the entire Cambodia belongs to the tropical zone and is subject to the Asian monsoon, and the annual average temperature is very high. The peculiarity of the climate is the distribution pattern of precipitation and the north-easterly wind and south-westerly wind which blow regularly at alternative periods, so the dry and rainy seasons can be distinctly classified. This is the most important factor in regulating agricultural farming, especially in the rice farming.

As for the next physical features, topography, soil characteristic and the Mekong flood must be mentioned. Cambodia is a flat plain country with no steep mountainous area, but most of the soil texture in the hilly-lands of a gentle slope is unfertile sand or sandy loam soil originated from the sandstone of the Mesozoic. Most of the arable land is limited to the alluvial land along the Mekong and its tributaries, but the soil could hardly be called fertile.

A few sedimentation area affected by the inundation of the Mekong during the rainy season, of which soil texture is silty soil, is most fertile land in this area. The Mekong, flowing through this area, has been used as an important route for transportation of the agricultural products. Even with the completion of national highway, navigation is indispensable. However, sedimentation from the repeated floods during the rainy season, has a great influence on the inhabitants and agriculture.

Natural environment influences the production methods and in accordance with the development phases at the different region, an organized farming was adopted to meet this situation.

For instance, a variety of long stemmed rice having power of resistance to floods caused by the Mekong and its tributaries has been selected and brought up by farmers for a long time. The farmer's efforts to cope with the environment are to be admired. The production fluctuation influenced by the timeliness of rainfall in the rainy season is great, but comparing with the growth of other varieties of rice the cultivating of this variety should stabilize the rice production.

On the other hand, as the floods washing away the manure, makes it ineffective, artificial fertilization is impracticable. Local varieties of rice selected as anti-flood type was the low manure response type. For a rapid yield increment, it is necessary to cope with the natural environment by consolidating the infrastructure such as installation of irrigation system and flood protection. The high fertility effect, high-yield variety should be introduced only by those installations.

These basic equipments require immense investment, but Cambodia is making every possible effort towards modernization of production methods by supplemental irrigation for the swamp during the rainy season, the dry season irrigation and the *colmatage*, which is the method of utilizing the Mekong's sedimentation.

The physical feature is a problem closely related to the life of inhabitants and the rural communities, and to defeat these hazards is a natural scientific problem as well as a social organizational problem.

C-2 Climate

C-2-1 Precipitation

A few features of the precipitation in this area being under the Asian monsoons will be summarized as follows:

a. Dry and Rainy Season Classification

During summer, when the heated earth is under the atmosphere of the low pressure, warm and humid southwest monsoon blows from the sea to the continent and this is so called the rainy season that continues from mid-April to October. A completely reversed case is noticed in the winter. The continental high pressure surpasses and dry northeast monsoon covers all of downstream areas of the Mekong, and these areas have no precipitation during the period from the winter to the summer, and this is so called the dry season.

b. Locality of Precipitation

During the monsoon period, shower type precipitation is most common and the regional precipitation and the hourly precipitation varies considerably.

c. Rainstorm

The Mekong downstream area also is in the Pacific typhoon area, but most of the typhoon is weakened by the Indo-China Peninsula, and by the time it reaches the Mekong downstream area it has lost its strength. However the typhoon in the later stage of the southwest monsoon, sometimes brings much precipitation and causes a great flood.

d. Frequency of the Precipitation

Not only Cambodia but the entire Mekong Basin depend on the precipitation as main resources of irrigation water, therefore, coming and retiring time of the monsoon has a great influence on agriculture. But there is a great fluctuation on the rainy season and rainfall every year.

Fig. IV-3. Rainfall at Phnom Penh

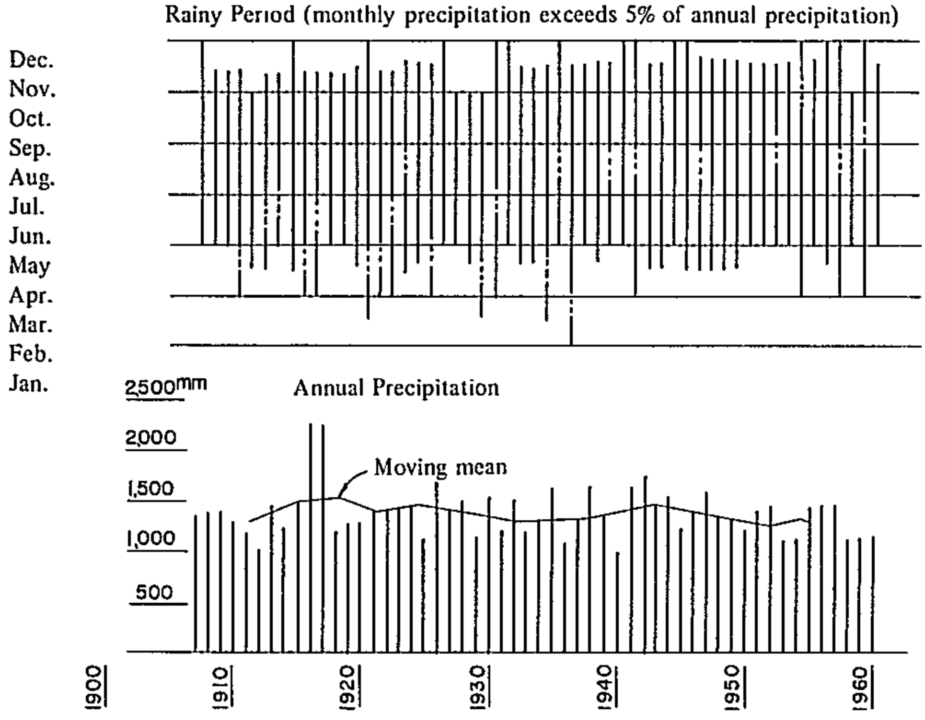


Fig. IV-3 shows the precipitation conditions at Phnom Penh. For convenience, the criterion of the rainy season is defined as follows: Some periods of rainy season have the amount of monthly rainfall more than 5% of the amount of the annual rainfall.

From the precipitation data of 54 years, 70% of these data indicate that the beginning month of the rainy season is in April or May, but widely scattered.

And even during the rainy season, there are months, which have less than 5% of the annual precipitation, and the records indicate nearly 50% during the 54 years (refer to Table IV-1).

Fig. IV-4 gives the annual precipitation over a long period at Phnom Penh. Since short periodicity of the trend is not specially noticed on the correlogram of Fig. IV-5, the original data is averaged by the arithmetical moving mean method by taking seven and four-year units in turn. The long-term trend appears to be a period of a decade or more.

Table IV-1 Frequency pertaining to the rainy season at Phnom Penh (1906 - 1960)

No. of months starting rainy season		No. of months including dry month among the left	No. of months finishing rainy season		Length of rainy season		
					months	Overall length	Actual period above average rains
Jan.	1	1	Oct.	5	6	2	6
Feb.	3	3	Nov.	35	7	15	23
Mar.	11	10	Dec.	14	8	19	17
Apr.	18	5			9	11	7
May	21	6			10	5	1
					11	2	
Total	54	25		54		54	54

Fig. IV-4. Annual precipitation over a long period at Phnom Penh

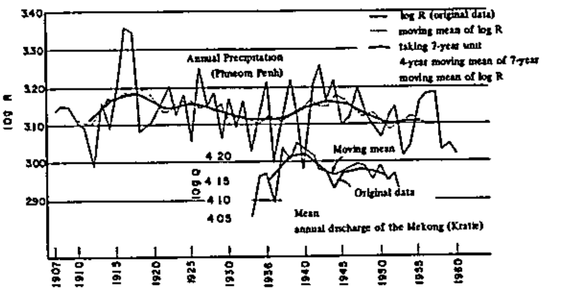


Fig. IV-5. A correlogram of annual precipitation at Phnom Penh

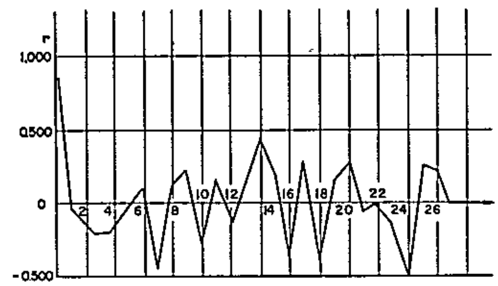


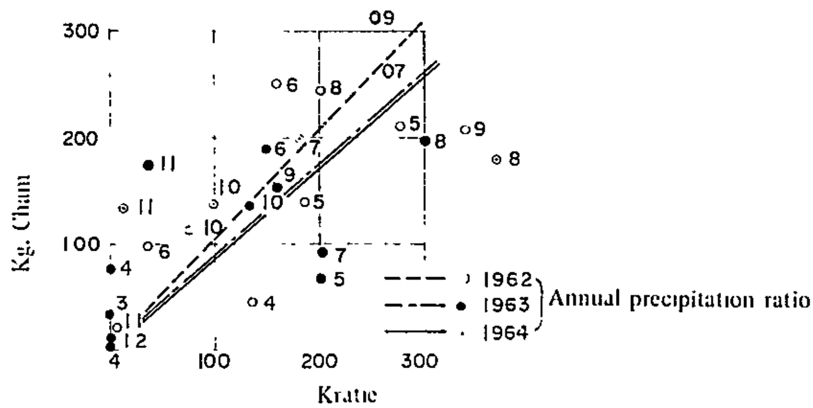
Fig. IV-4 also indicates data of the Mekong River's mean annual discharge.

From this Fig IV-4, it is not absurd even if the above-stated tendency does not interrelate with the precipitation at Kratie. To obtain the precipitation to cope with the discharge of the Mekong is a complicated and difficult problem.

Considering the precipitation data of Phnom Penh, the distribution pattern of annual precipitation seems to be a logarithmic normal distribution. The annual average precipitation is 1,340 mm, and when the probability of excess is 5% and 95%, they will be 1,820 mm and 990 mm respectively.

Fig. IV-6 is a comparison of monthly precipitation of Kratie along the Mekong and its downstream Kg. Cham Correlation between the two places was not discovered.

Fig. IV-6. Regional differences of monthly precipitation



Intensity of the rainfall is one of the important factors in planning soil conservation and canal. The following is being indicated as the result of analysis for the intensity of rainfall by using 1 hr., ½ hr. and ¼ hr. intensity of rainfall recorded during the rainy season in 1964.

As for the rainfall less than 1 hr. intensity of rainfall, following formula may be applied. (refer to Fig. IV-7)

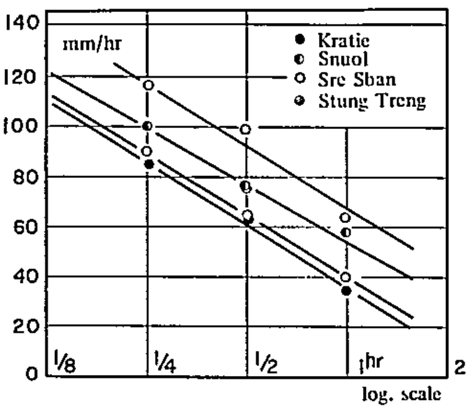
$$\gamma_r = d - 84 \log_{10} T$$

where;

γ_r is rainfall intensity, R_r being total rainfall in mm, in T hr, that is $\gamma_r = R_r/T$ (mm/hr).

C is constant, namely, rainfall intensity when T is T hr. According to the observation made in 1964, C is within 30 mm/hr. - 70 mm/hr. range.

Fig. IV-7. Intensity of squalls



Precipitation data indicate that the daily precipitation is very seldom twice that of the hourly precipitation. The daily shower-type precipitation lasts for more than two hours at times.

The aforementioned is the outline of the general characteristic of the precipitation. For further information, refer to hydrology section of C-4.

C-2-2 Temperature

Annual average temperature of Kratie is about 27°C and as shown in table IV-2, variation range of the average temperature of 12 months period is small and seasonal fluctuation is almost neglible.

Table IV-2. Mean monthly temperature in °C at Kratie (until 1963)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
25.3	27.3	28.9	29.7	28.1	27.5	26.8	27.0	26.5	26.4	25.7	24.7	27.0

Aforementioned tendency can also be seen at other area in Cambodia. For instance at Stung Treng the extent of monthly average temperature is from the high average temperature of 29.6°C in April to the low average temperature of 23.9°C in December. In Kompong Cham, the range is from 29.1°C in April to 25.1°C in December.

Daily range of temperature is rather great, and the daily range during the dry season is sometimes over 10°C.

A comparatively cold and extremely hot weather is sometimes experienced. In Phnom Penh, a high of 40.5°C (April 1926) and a low of 13.3°C (January 1955) is recorded.

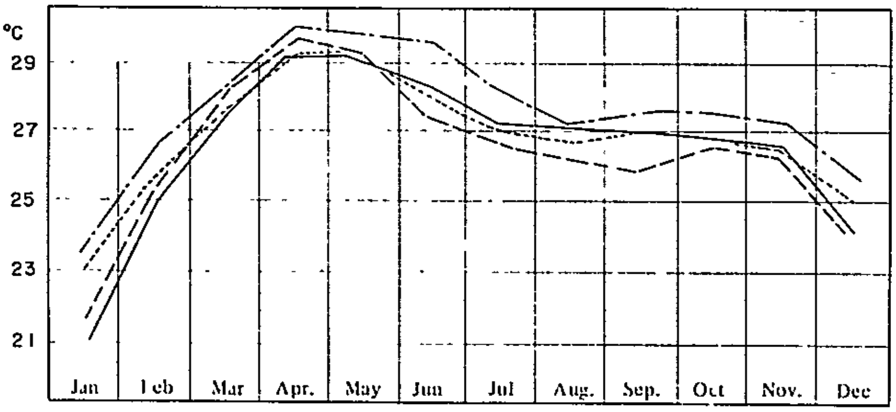


Fig. IV-8.
Temperature (°C) in 1963

C-2-3 Humidity

Relative humidity is high throughout a year, about 60% - 90% range and the highest month of the relative humidity is in September and this month has the peak precipitation. Lowest is when northeast seasonal wind ,onal wind is replaced by the southwest seasonal wind in March. During the rainy season the humidity is over 100% in the Mekong Delta.

C-2-4 Evaporation

Evaporation is the greatest in April, just before the rainy season, and the lowest in August. No great difference is noticed by the area and the annual average is less than 6 mm/day.

As shown in Fig. IV-9, fluctuation of the evaporation during twelve months is likely to have something to do with sunshine hour and temprature.

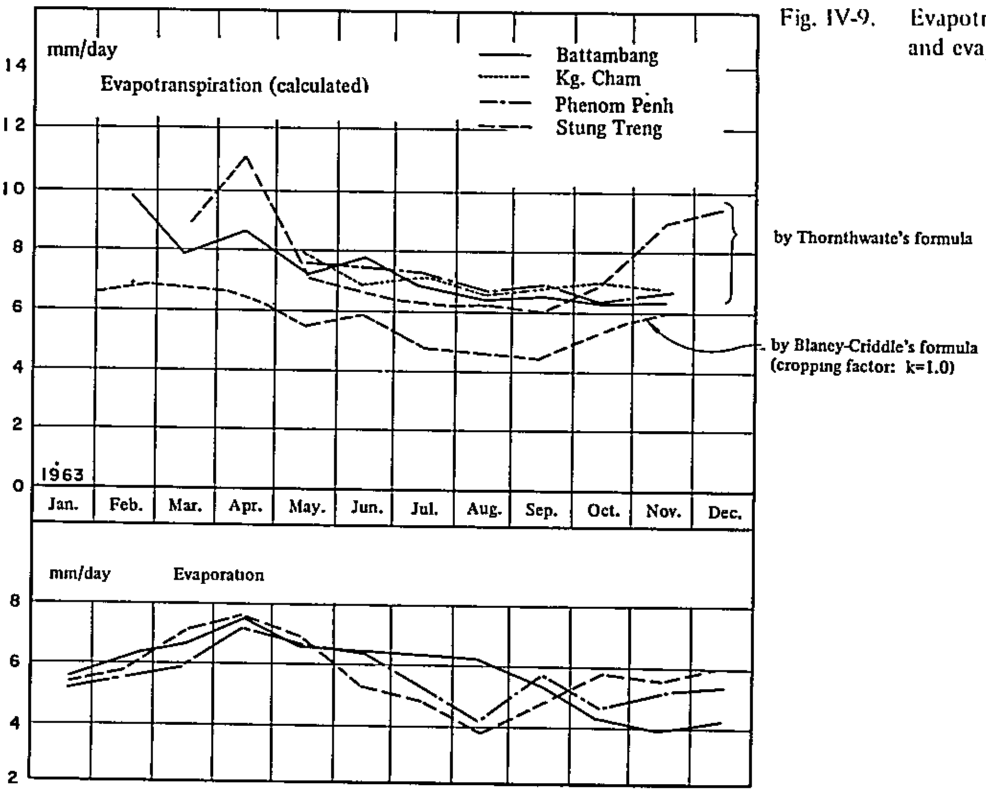
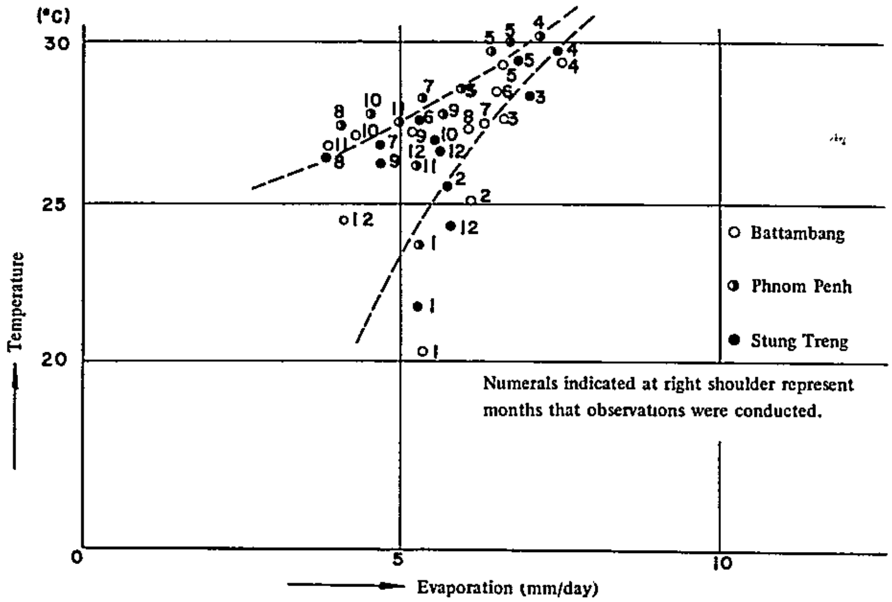


Fig. IV-9. Evapotranspiration and evaporation in 1963

Fig. IV-10 shows the relation between the evaporation and temperature at Battambang, Phnom Penh and Stung-Treng. From this chart, interesting tendency can be seen, that is, the relation between the evaporation and temperature of the rainy season of April to November is quite different from that of the dry season of December to May.

Mr. Hing Vn, Director of Agricultural Direction, Ministry of Agriculture, has experimented for the application of Penman formula on the potential of evapotranspiration and stated that it was not applicable during the dry season, but might be favorably applied during the rainy season. This is understandable considering the nature of potential of evapotranspiration.

Fig. IV-10. Relation between evaporation and temperature



C-2-5 Wind

About seven months from March to September, monsoon brings in moisture from south seas. Contrary to this, about five months from November to February, northeast monsoon causes a dry spell.

Wind velocity average 1.5 m/sec - 2.5 m/sec, with not much fluctuation during the whole year except for the high wind velocity from January to April.

C-2-6 Sunshine

The peculiar annual sunshine hour pattern is due to the dry and rainy seasons of this country's climate. Compared to the sunshine of 9 hrs during the dry season, there is only about 5 hrs of sunshine during the rainy season.

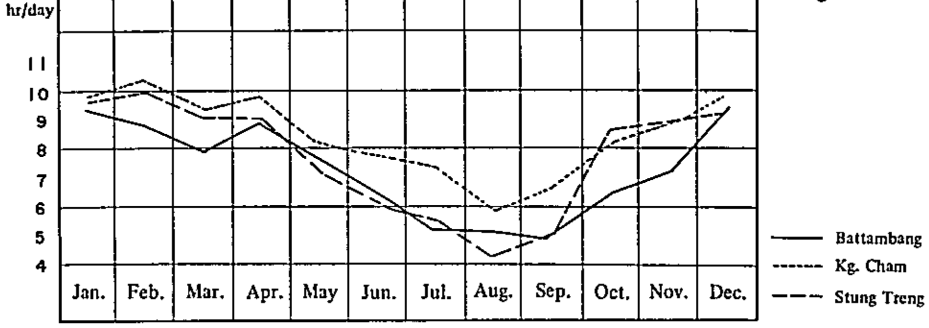


Fig. IV-11. Sunshine hours in 1963

C-3 Soils

C-3-1 Soil Classification

The parent material of the project area is mainly composed of alluvium, old alluvium, the Tertiary beds such as sandstone and shale, and basalt. The soils are developed mainly on alluvial plains, back marshy lands, natural levees of the Mekong and its tributaries, and on hill lands..

A reconnaisance soil survey of this area was made in 1964 and the soils were classified into five soil groups as follows: (See Drawing No. S enclosed in the envelope attached to the back of this volume).

1. Silty alluvial soils
2. Clayey alluvial soils
3. Podzolic residual soils
4. Clayey fan soils
5 Podzolic sandy soils

Furthermore the basic soil survey was conducted in 1965 for the area of 66,000 ha, and the soils were classified into six great soil groups. They were subdivided into 15 soil series. The soil groups and soil series are indicated in Table IV-3.

Most soils of this area are of fine texture and the whole areas are attributed to the base-enriched sedimentation from the Mekong and its tributaries. The soils on natural levees and on some parts directly influenced by inundation of the Mekong, are usually of medium or coarse texture. The lower the land to back marsh, the finer the soil texture. Consequently drainage conditions of the lowland area are poor to very poor, and swamps and marshy lands are found in some parts even in the dry season.

Of the total the Alluvial soils occupy 16 per cent (10,900 ha) of the area and the Low-Humic Gley soils 53 per cent (36,800 ha) of it. The Red-Yellow Podzolic soils are distributed on the hill lands, of which red member soils in the higher hill lands. The yellow member soils are found in the lower hill lands associated with the alluvial plains. The Low-Humic Gley soils are distributed mostly on alluvial plain and valley plain dissected in the hill lands. Some of Bos Leav and Kanhchor Districts there occur weakly developed Vertisols derived from basaltic parent material. The soils are classified into soil series based on mainly soil texture and drainage condition, presence or absence of mottlings and so on.

The profile descriptions and characteristics of the soils are shown as follows:

1. Chong Kaoh Series

The soils of this series are well drained, of coarse textured immature soils. They were classified as Alluvial soils and included in Aquic Ustipsamments of the 7th Approximation. The soils are distributed in the outside of natural levee of the Mekong, whereas in the inundation areas are not cultivated because of comparative long period of inundation.

2. Pongro Series

The soils of this series are well drained, of medium texture, were classified as Alluvial soils, and included in Typic Ustifluvents of the 7th Approximation. They occur in the gentle slope of natural levee, are distributed in Tamau and Chhlong Districts, and amount to 3.8 per cent (2,500 ha) of the surveyed area. The presence of one to two buried horizons within 1 m formed by flooding is one of the characteristics of the soils.

3. Bos Leav Series

The soils of this series are well drained, of fine texture from silty clay loam to clay loam, developed on natural levee of the Mekong and its back slope, and on those of the tributaries. They were classified as Alluvial soils, and belong to Aquic Ustifluvents according to the 7th Approximation. The soils are characterized by gleization throughout the profile, presence of iron and manganese mottles, and well developed granular structure formed

Table IV-3 Classification of Soils into Great Soil Groups and Soil Series

Great Soil Groups	Soil Series	Parent Material	Soil Texture	Drainage Class	Profile Development	Area (ha)	Capability Classification	
							Upland	Paddy
Alluvial Soils	1 Chong Kaoh	Alluvium	S	Good	None to Weak	400	III	
	2 Pongro	”	SiL	Good	None to Weak	2,500	II	
	3 Bos Leav	”	SiCL	Good	Weak	5,300	II	
	4 Moreum	”	HC	Very pooe	Weak	1,000		II
Lithosols	5 Pou	Basaltic/Tertiary		Good	None	300	IV	
Vertisols	6 Prek Chamlak	Basaltic	HC	Moderately good	Weak	900	II	II
	7 Sre Prang	Basaltic/Tertiary	HC	Moderately good	Weak	1,100	IV	
Low-Humic Gley Soils	8 Stung Preah	Alluvium	SL	Good	Strong	300		III
	9 Kampi	Alluvium/Teritary	CL	Moderately good	Medium	2,500	{III IV	
	10 Roha	Alluvium	LiC	Good	Medium	4,600		III
	11 Sambok	Alluvium	HC	Moderately good	Medium	24,000	III	II
	12 Russei Char	”	HC	Poor	Medium	6,500		II
Red-Yellow podzolic Soils	13 Krabor	Old alluvium	LS	Good	Medium	6,300	{III IV	
	14 Keng	”	LS	Good	Medium	1,500	III	
	15 Tuol	Old alluvium/ Tertiary	LS/CL	Moderately good	Medium to strong	8,800	III	

by earthworms.

The natural vegetation consists dominantly of Cha, Song Keam, Khtom, kapock and banana, whereas in the arable land peanuts, maize and tobacco, etc. are cultivated during the dry season.

4. Moreum Series

The soils of this series are very poorly drained, of very fine texture and were classified as Alluvial soils They belong to Aquic Ustifluvents according to the 7th Approximation. The soils are distributed in the back marshy lowlands of Kratie, Bos Leav, Kanhchor, Prek Prasap, Tamau and Chhlong, and amount to 1.5 per cent (1,000 ha) of the surveyed area.

Most of the soils is flooded even in the dry season, but is not strongly effected by ground water, thereby a considerable amount of thread rootlike and cloudlike mottles are found only within a depth of 50 cm to 60 cm from the surface.

The natural vegetation consists mainly of shrubs such as Roten and Snay and swamp vegetation such as Samour, Proandat, and Treng.

5. Pou Series

The soils of this series are well drained Lithosols, and included in Lithic Ustorthents according to the 7th Approximation. The soils are distributed in the hill lands of Bos Leav and Kanhchor, and developed from basaltic parent material over the Tertiary beds such as shale and sandstone beneath 20 cm.

It is one of the characteristics of the soils that the high basaltic gravel content and half-weathered basaltic boulder on the surface.

The natural vegetation is mainly shrubby clear forest such as Sankar, Chenko, Chlek and so on.

6. Prek Chamlak Series

The soils of this series are moderately well drained and characterized by the A horizon of grayish (10YR 4/1) very fine textured and the presence of whitish concretions likely coming from arbonate in the upper part of A horizon.

They were classified as Vertisols and belong to Typic Pellusterts according to the 7th Approximation. The soils derived from basaltic over the Tertiary beds, distributed in Bos Leav, Kanhchor, in the hill lands and valley plain of Prek Prasap, and amounted totally to 1.4 per cent (900 ha) of the surveyed area.

The natural vegetation is mainly of clear forest such as Sankar, Cha, Rovear, and mixed with grasses as Sabou and Treng.

7. Sre Prang Series

The soils of this series are moderately well drained, of very fine textured grayish in color, and were classified as Vertisols. They are included in Lithic Chromusterts according to the 7th Approximation. The parent material is basaltic underlying the Tertiary origin such as shale or sandstone.

They are distributed in rather low alluvial plains associated with the the hill lands, and amounted to 1,100 ha, 1.7 per cent of the surveyed area. The natural vegetation is mainly grasses such as Sabou and Treng, and deciduous such as Cha and Sankar.

8. Stung Preah Series

The soils of this series are well drained, of medium texture, and were classified as Low-Humic Gley soils. They are included in Anthropic Haplaquepts of the 7th Approximation. They are found in the valley plain of hill lands in Tamau, Chhlong and Prek Prasap.

The parent material of the horizon below 70 cm to 80 cm is composed of mixed alluvium with old alluvium.

No irrigation facilities have been prepared, but rice is cultivated during the rainy season.

9. Kampi Series

The soils of this series were classified as Low-Humic Gley soils and included in Lithic Ustropepts according to the 7th Approximation. They are distributed on the adjoining area to hill lands in a state of belt in alluvial plain, most of which are parallel to the Tuol series.

The parent material is alluvial deposits underlying gravel layers sometimes found immediately above the bedrocks. The depth to bedrock varies from 28 cm to 50 cm, and the soils are fine textured, and in the medium development of the profile. They have also threadlike iron mottles, mangnese mottles and concretions throughout the profile.

The soils were subdivided into two soil types (Kampi 1 and Kampi 2) on the basis of thickness of top soil. The soils are mainly distributed in Kratie, Saop, Prek Prasap and on the right bank of the Prek Te and occupy 3.8 per cent of the surveyed area.

The natural vegetation consists of mainly shrubs such as Pring, Klong, Chreak, Cha and somewhere can be found mixed with turf and Sabou.

10. Roha Series

The soils of this series are poorly drained, of coarse texture, and were classified as Low-Humic Gley soils. They are included in Anthropic Haplaquepts according to the 7th Approximation. The soil profile is well developed so that iron and manganese mottles are separately accumulated in the B horizon.

They occur mainly on the valley plain dissected in the hill lands and are distributed in Kratie, Saop, both banks of the prek Te, Bos Leav and Prek Prasap. They occupy 7.0 per cent (4,600 ha) of the surveyed area. No facilities for irrigation have been prepared, whereas rice is cultivated during the rainy season.

11. Sambok Series

The soils of this series are moderately well drained, of very fine texture and were classified as Low-Humic Gley soils. They are included in Aquic Ustropepts according to the 7th Approximation. The soils are widely distributed in the project area and mainly in alluvial plains between natural levee and back slope marshy land, and occupy 36 per cent (24,000 ha) of the surveyed area. The ground water table is rather fluctuating and mottles are found within 20 cm from the surface.

The natural vegetation is mainly Tumon, Kantock, Ran, Tasek, Bamboo, Cha, Ktom, Sabou and Treng. A portion of this land is utilized during the dry season for upland fields.

12. Russei Char Series

The soils of this series are similar to the Sambok series, having a particle size distribution of very fine texture and the only difference of poor to very poor drainage. They were classified as Low-Humic Gley soils and included in Aquic Ustropepts of the 7th Approximation. The soils are found in back marshy lands and amount to 9.9 per cent (6,500 ha) of the surveyed area.

The first horizon has weakly developed blocky structure and some mottles are found within 50 cm from the surface, but the profile differentiation is weak to very weak. The natural vegetation is mainly Taor, Tamonpakoi, and grasses such as Treng.

13. Krakor Series

The soils of this series are well drained, of coarse texture, have been classified as one of red members of Red-Yellow Podzolic soils, and fall into Typic Rhodustalfs of the 7th Approximation. They are developed from old alluvium of the Mekong over the Tertiary beds. The soils are distributed mainly in the hill lands higher than 35 m to 40 m above sea level; on the right banks of the Mekong and of the Prek Te, Saop, Prek Prasap, Kanhchor, and Chhlong.

The A 1 horizon is 12 cm thick, of coarse texture with low humus content. The A 2 horizon is weakly

No irrigation facilities have been prepared, but rice is cultivated during the rainy season.

9. Kampi Series

The soils of this series were classified as Low-Humic Gley soils and included in Lithic Ustropepts according to the 7th Approximation. They are distributed on the adjoining area to hill lands in a state of belt in alluvial plain, most of which are parallel to the Tuol series.

The parent material is alluvial deposits underlying gravel layers sometimes found immediately above the bedrocks. The depth to bedrock varies from 28 cm to 50 cm, and the soils are fine textured, and in the medium development of the profile. They have also threadlike iron mottles, mangnese mottles and concretions throughout the profile.

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The natural vegetation consists of mainly shrubs such as Pring, Klong, Chreak, Cha and somewhere can be found mixed with turf and Sabou.

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The A 1 horizon is 12 cm thick, of coarse texture with low humus content. The A 2 horizon is weakly developed underlying the B2 horizon of 5YR to 2.5YR 4/4, and unweathered fine gravels increase with depth.

The soils were subdivided into two soil types (Krakor 1 and Krakor 2) on the basis of the thickness of top soil and gravel content. The natural vegetation is shrubs such as Kron Chreak, Beng, Chlek, Mean and so on. The land has never been cultivated for agriculture.

14. Keng Series

The soils of this series are well drained, of coarse texture, and were classified as one of yellow members of Red-Yellow Podzolic soils. They occur mainly in Saop, in the dense forest stretching to south in a state of belt, and amounted to 1,500 ha, 2.3 per cent of the surveyed area.

The A2 horizon, about 20 cm thick, underlies the extremely thin A1 horizon. The B1 horizon is 10YR 5/4 to 5/7 and of coarse texture, whereas the B2 horizon has relatively high clay content and prominent clay skins on ped surfaces.

The natural vegetation consists mainly of shrubs such as Prou, Proprear, Propal, and sometimes mixed with Sabou. The Keng series is included in Typic Haplustalfs of the 7th Approximation.

15. Tuol Series

The soils of this series were classified as one of yellow members of Red-Yellow Podzolic soils, and the lower parts of the soil have a lithic contact with sandstone or half-weathered shale of the Tertiary beds. These are distributed in the transitional belt between alluvial plain and lower terrace, and both banks of the Mekong in Kratie and Saop. They occupy 13 per cent (8,800 ha) of the surveyed area.

The parent material of the soils consists of coarse textured old alluvium over the Tertiary beds such as shale and sandstone. The natural vegetation is shrubs such as Kalong, Chlek, Bamtomlerm and sometimes mixed with Sabou. The soils are included in Lithic Haplustalfs of the 7th Approximation.

The columnar sections of representative profile of the soil series recognized in the Sambor area are indicated in Fig. IV-12.

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The parent material of the soils consists of coarse textured old alluvium over the Tertiary beds such as shale and sandstone. The natural vegetation is shrubs such as Kalong, Chlek, Bamtomlerm and sometimes mixed with Sabou. The soils are included in Lithic Haplustalfs of the 7th Approximation.

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Fig. IV-12 Exemplar columnar section of each soil series

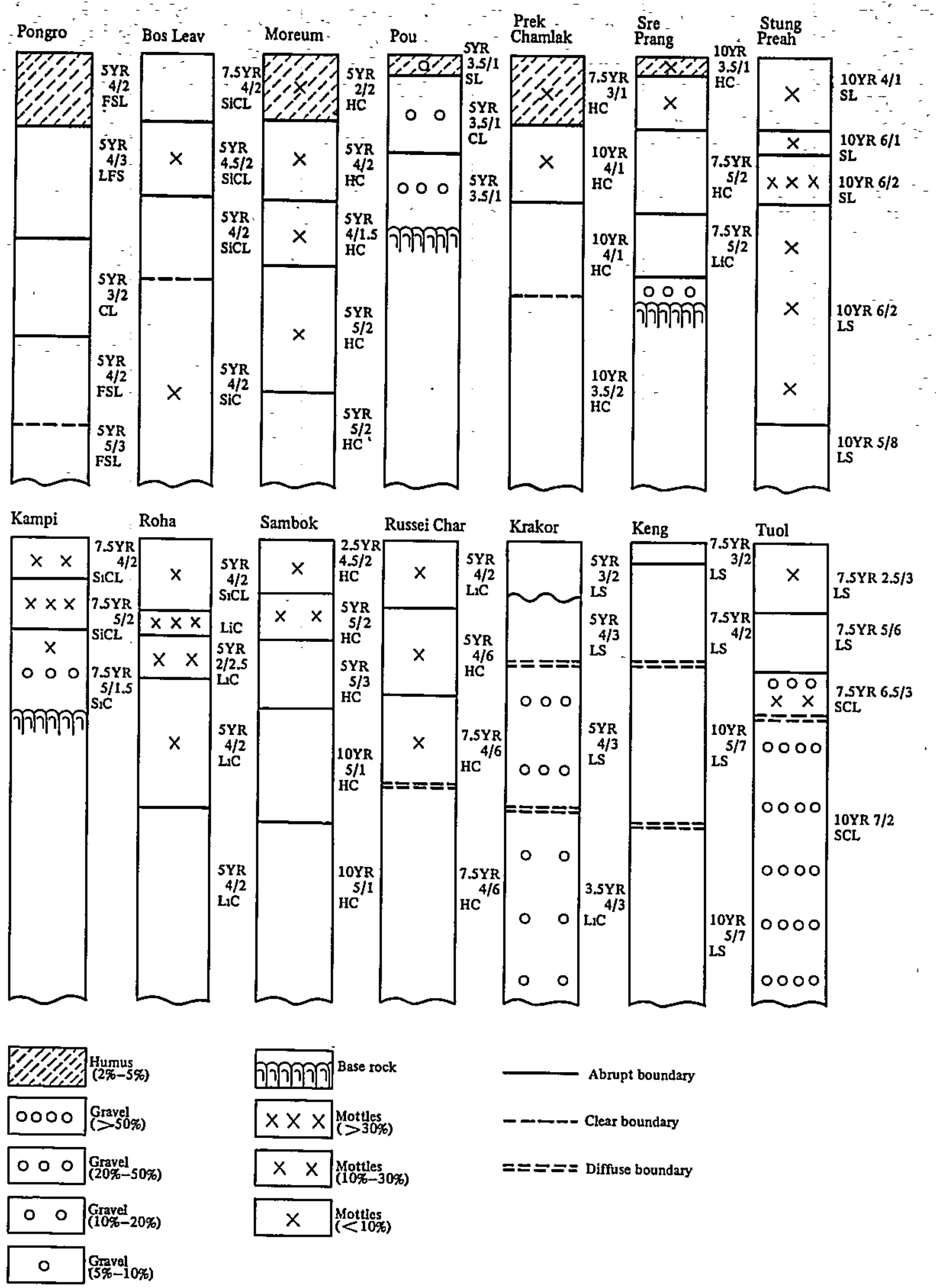


Fig. IV–12 Exemplar Columnar Section of Each Soil Series

C-3-2 Productive Capability Classification

The capability classification of the soils for upland and paddy fields was made based on physical and chemical properties of soils, the needs and limitations of the soils, on the risks of damage to them, and also on their response to management.

The land is classified into class I, II, III and IV by its productive capability for rice and upland crops on the basis of the suitability items and suitability decisive factors which show the restrictive and impeding factors as the following items inhering in the soil.

Upland crops	Paddy rice
Thickness of top soil (t)	Thickness of top soil (t)
Effective depth of soil (d)	Effective depth of soil (d)
Gravel content in top soil (g)	Gravel content in top soil (g)
Facility of plowing (p)	Permeability (i)
Wetness of land (w)	State of redox potentiality (r)
Inherent fertility (f)	Wetness of land (w)
Contents of available nutrients (n)	Inherent fertility (f)
Hazards (j)	Contents of available nutrients (n)
Slope of land (s)	Presence of harmful substances (h)
Erosion (e)	Frequency of accidents (a)

In other words, land is graded into four groups on the basis of the existence or absence of restrictive or impeding factors against production of a reasonable amount of crops or a reasonable control of the soil and the extent of possibility of the degradation of the soil.

Class I: Soils are those that have the widest range of use and the least risk of damage because of having no or virtually no restrictive or impeding factors and having no possibility of soil degradation. They can be cultivated with almost no risk of erosion and will remain productive if manage with normal care.

Class II: Soils can be cultivated regularly, but they do not have quite so wide a range of suitability as class I soils. Some soils need moderate care to prevent erosion, may be slightly droughty, slightly wet or somewhat limited in depth.

Class III: Soils can be cropped regularly but have a narrower range of use than the soils in class II. They need even more careful management.

Class IV: Soils have greater natural limitations than those in class III but can be cultivated for some crops under very careful management.

The soils of the projected area have been placed in the following capability classes. (see Tables IV-4 & 5)

Pongro soil type

a) Features of this soil type

The thickness of top soil is less than 15 cm, and the effective depth of soil is more than 1 m. Coarse alluvial materials which are different place to place, exist up to a depth of 1 m. The surface horizon becomes excessively dry in the dry season, but the subsoils are semi-moist and with granular structure well developed from excrement of earthworms. The soils are almost neutral, have a high value of calcium saturation, contain a large amount of exchangeable magnesium and available phosphorous throughout the profile. Some areas are flooded in the rainy season, but substantially flat and have little possibility of erosion. The land is classified as class II.

b) Vegetation and status of land utilization

The natural vegetation consists of shrubs such as kapock, Knor and Kwatt. There are many small parts being utilized as upland fields where banana, tomato, maize, upland rice and other crops are cultivated.

c) Problems relative to efficient land utilization and soil productivity improvement

As this soils are suitable for common upland crops, irrigation and drainage facilities must be constructed to enable upland crops to cultivate through the year. The soil fertility in some parts is improved when flooded with muddy water, thereby more fertile land may be obtained if *colmatage* is carried out in a larger scale. But when cultivating techniques are advanced to a high standard upland cropping systems, it would not be sufficient to rely on *colmatage* only for improving the soil fertility, but it would be necessary to consider the fertilization suitable for each crop.

Bos Leav soil type

a) Features of this soil type

The surface horizon is approximately 20 cm thick, and the effective depth of soil is as thick as 1 m or more. The soils are fine textured and sticky so that farming machine receive great resistance not only in the dry season, but also in the rainy season. The subsoils are semi-moist even in the dry season and with granular structure well developed from earthworm activities. The soils contain a large amount of exchangeable calcium and magnesium and available phosphorous, but not contain much organic matter. Being nearly flat, the land has little possibility of erosion. It is classified as class II.

b) Vegetation and status of land utilization

The natural vegetation consists of Cha, Song, Kean, Khtom, bamboo, kapock and banana, peanuts, maize, tobacco and melon are cultivated during the dry season.

c) Problems relative to efficient land utilization and soil productivity improvement

The same problems exist in this soil type as those in the Pongro soils, and of particular importance is the construction of irrigation and drainage facilities for annual rice cultivation. At present, it is satisfactory to rely upon *colmatage* for fertility, but high intensive cultivation would require improved fertilizations.

Moreum soil type

a) Features of this soil type

The surface horizon is 15 cm thick, and the effective depth of soil as thick as 1 m. The soils are very fine textured and low in permeability. Although the area is flooded for months of the year, the soils have little effect of underground water, and no gley horizon throughout the profile. It is classified as class II when used as paddy field. It would be difficult to use the land as upland field because of very poor drainage.

b) Vegetation and status of land utilization

The natural vegetation consists of such as Roten, Snag, Treng, and such marsh plants as Sarmour, and Proandat. Nearly the entire area has not been used for agricultural purposes.

c) Problems relative to efficient land utilization and soil productivity improvement

It is difficult to drain the soils perfectly since it is situated in lowland, therefore stress may have to be placed on dry seasonal rice cultivation. It is necessary to supply some potassium and nitrogen fertilizers to increase their yield.

Pou soil type

a) Features of this soil type

The surface soil is only 3 cm thick, and contains half-weathered gravels. The layer immediately below the surface is abundant in unweathered gravels originated from shale of the Tertiary. The effective depth of soil is so thin that the land is not suitable for cultivation. They have a large cation exchange capacity and are abundant in exchangeable calcium and magnesium, and available phosphorous.

b) Vegetation and status of land utilization

The natural vegetation is mostly thin woods of shrubs such as Sonkar, Chenko and Slolou.

Prek Chamlak soil type

a) Features of this soil type

The surface horizon is 15 cm thick and the effective depth of soil is 1 m or more. The soils are very fine textured and extremely sticky. Containing much clay the soils have a fairly large capacity of retaining water. They have a large exchange capacity and are well nourished except that it is slightly deficient in phosphorous. Situated on a flat plain the land has little risk of erosion. The soils are classified as class II.

b) Vegetation and status of land utilization

The natural vegetation consists of thin woods such trees as Sonkar, Cha, Rovear, and of grasses such as Sabou and Treng. The land is not utilized for agricultural purposes.

c) Problems relative to efficient land utilization and soil productivity improvement

Irrigation facilities would be required to increase crop yields in upland field during the dry season. The land, however, is fertile and can be cultivated for good upland crops.

Sre Prang soil type

a) Features of this soil type

The thickness of surface horizon is only 15 cm, and a half-weathered gravel layer is present immediately below the surface, and thereby the effective depth of soil is very shallow. The soils have a large cation exchange capacity and very well nourished, but it would be difficult to utilize the land as upland field, because the effective depth of soil is extremely shallow.

b) Vegetation and status of land utilization

The natural vegetation consists of grasses such as Sabou and Treng, and the land has never been used for agricultural purposes.

Stung Preah soil type

a) Features of this soil type

The surface horizon is 15 cm thick, medium textured, and the effective depth of soil is 1 m or more. The horizon immediately below the plow layer is very fine textured and compacted which prevent draining. Although the land has been cultivated as paddy fields, no gley horizons have developed noticeably. As the soil contains a small amount of organic matter its reduction does not seem to make much progress. Being low in inherent fertility and in available nutrients, the land is classified as class III.

b) Vegetation and status of land utilization

Almost the whole area is cultivated for rainy season rice.

c) Problems relative to efficient land utilization and soil productivity improvement

Although the land is flooded every year, the soils are less fertile than that of other soils. This land is not important from agricultural standpoint, since it covers an area of only 700 ha and the paddy fields are scatteringly distributed in valley plain of the hill lands. The land must be supplied with all kinds of fertilizers.

Kampi soils

The soils are subdivided into two soil types on the basis of the thickness of top soil and effective depth of soil.

Kampi 1 soil type

a) Features of this soil type

Both thickness of top soil and effective depth of soil are relatively small; the former is approximately 15 cm, and the latter not greater than 50 cm. The surface soil is fine textured and sticky. In the dry season, the soil immediately below the surface layer becomes so hard as to make cultivation difficult and prevents the growth of roots to a great extent.

The permeability of the soil is moderately good, and its water holding capacity relatively large, and the soil at a depth of approximately 30 cm is semi-moist even in the dry season. The land has a relatively high degree of calcium saturation, but is deficient in exchangeable magnesium and phosphorous, and is not very fertile. The land is nearly flat, situated around the hill, thereby erosion is not likely to happen. The soils are classified as class III.

b) Vegetation and status of land utilization

Shrubs such as Pring, Klong, Chreak, Cha and Sabou, etc. grow in this land.

c) Problems relative to efficient land utilization and soil productivity improvement

The gravel pan layer must, first of all, be destroyed or removed for normal agricultural utilization. Then it is necessary to apply organic matter as well as base-enriched material and phosphorous to improve the productivity.

Kampi 2 soil type

a) Features of this soil type

The surface horizon is approximately 15 cm thick. However the effective depth of soil is very thin because of the bed rock of unweathered shale below 30 cm from the surface. The land is extremely deficient in calcium magnesium and phosphorous. Situated on a gentle slope, the land is greatly subject to erosion and classified as class IV.

b) Vegetation and status of land utilization

The same kinds of vegetation as in the Kampi 1 soils is found, and no area is utilized for agricultural purposes.

Roha soil type

a) Features of this soil type

The surface horizon is 15 cm thick, and the effective depth of soil is 1 m. The soils, of very fine texture, are not permeable since there is a compacted layer immediately below the plowed layer. As the soils contain low organic matter, they are not reduced prominently. Both the inherent fertility and the contents of available nutrients are low as those in the Stung Preah soils. The land is classified as class III when used as paddy fields.

b) Vegetation and status of land utilization

In most area of cultivated land, rice is cultivated during the rainy season.

c) Problems relative to efficient land utilization and soil productivity improvement

It will be possible to grow rice in the dry season if irrigation facilities are constructed. As the soils are not fertile, however, it will be necessary to supply organic matter and fertilizers as much as possible to improve the soil fertility.

Sambok soil type

a) Features of this soil type

The surface horizon is 15 cm thick, and the effective depth of soil is as thick as 1 m or more. The soils are very fine textured and very sticky, thereby it would involve much difficulties to cultivate the land for upland crops. They do not contain much organic matter, and are not strongly reduced. The fertility of the soils is not so good as in the Russei Char soils. The land is flooded for a few months during the rainy season, but not so heavy as in the Russei Char soils. The land is classified as class II when used as paddy fields and class III as upland fields. It would be more advantageous to utilize the land for paddy field.

b) Vegetation and status of land utilization

Natural vegetation includes Rang, Tasek, Tumon-Kantock, Bamboo, Cha, Ktom, Sabou and Treng. A part of the land is utilized as upland or paddy fields.

c) Problems relative to efficient land utilization and soil productivity improvement

It would become possible to harvest paddy rice through the year in a flooded area if drainage and irrigation facilities are constructed. Since this area is situated substantially higher above sea level, the drainage for this district would be easier than the Russei Char soils. Rice cultivation through the year would require not only supply of phosphorous and potassium but also nitrogen as well. In case of the land is used as upland fields, a problem would be how to prevent the cementation of the soil in the dry season. One of the possible measures which are relatively easy to practice would be to place raw rice straw into soil with a spade year by year.

Russei Char soil type

a) Features of this soil type

The effective depth of soil is thick, and no gley horizons are strongly developed throughout the profile. The soils are very fine textured sticky, but with low organic matter and may not be strongly reduced. Except that slightly deficient in potassium and available phosphorous, the soils are well nourished and fertile. Many parts of the land are covered with water in the rainy season from June to November. The land as it is used for paddy fields, is classified as class II.

b) Vegetation and status of land utilization

The natural vegetation includes shrubs such as Taor and Tamompakoi and grasses such as Treng. Upland rice is cultivated in a limited area.

c) Problems relative to efficient land utilization and soil productivity

Some parts of the district heavily flooded during the rainy season, require drainage facilities. If stress is placed on the production of upland rice, it would require irrigation facilities. Upland field farming would also be possible if drainage could be performed completely in the dry season, but it would be difficult to carry out perfect drainage. Consequently it is more advantageous to utilize the land as paddy fields. Potassium and phosphorous must, first of all, be supplied to improve the soil fertility.

Krakor soils

The soils are subdivided into two soil types on the basis of the gravel content of surface soil and thickness of effective depth of soil.

Krakor 1 soil type

a) Features of this soil type

The thickness of top soil and effective depth of soil are approximately 15 cm and 50 cm respectively, and are both relatively small. The first horizon is coarse textured, slightly sticky and shows some resistance to farming tools. The soils have a good permeability, but is not capable of holding much water. It is possible that in the dry season the land will dry up considerably, probably to a depth of 60 cm. The soils contain little exchangeable magnesium and available phosphorous, thereby are not fertile. Although the land is nearly level, it is not flooded even in the rainy season because distributing on terrace. As shown in Table IV-4, the productive capability of the soils is classified as class III.

b) Vegetation and status of land utilization

Being excessively dry in the dry season, the natural vegetation is mostly clear forest such trees as Kron Chreak, Beng, Chlek and Mean and the land is little cultivated.

c) Problems relative to efficient land utilization and soil productivity

As there is a rounded gravel layer at a depth of 30 cm to 50 cm, the gravel layer must be removed for good agricultural land. Introduction of upland crops into this district would require use of soil improving materials containing such as magnesium and phosphorous, and construction ir irrigation facilities. But this would not be economically justified as the land is situated on terrace and far from any river.

Krakor 2 soil type

a) Features of this soil type

The thickness of top soil, overlying a very hard gravel pan, is relatively small, 15 cm, and the effective depth of soil is nothing more than the surface soil. The surface horizon is of coarse texture and slightly sticky. The soils have slightly poor permeability than the Krakor 1 soils and are susceptible to become too dry in the dry season. Therefore the growth of plant roots is heavily impeded. Lacking in lime and phosphorous, this land is classified as class IV in view of the existence of the gravel pan layer.

b) Vegetation and status of land utilization

Most of the land consists of thin woods as in the Krakor 1 soils, and is not suitable for agriculture.

Keng soil type

a) Features of this soil type

The surface horizon is approximately 20 cm, and the effective depth of soil is more than 1 m deep. The soils are of coarse texture, slightly sticky and show some resistance to farming tools. The soils have a good permeability, but are unable to hold much water and apt to have its surface horizon too dry. The subsoil, however, is semi-moist. Being deficient in exchangeable calcium, magnesium and available phosphorous, the land is not fertile. In high temperatures in summer, the organic matter is easily decomposed to remarkably low content. The subsoil becomes very hard in the dry season as its compactness 32 mm (reading of cone-penetrometer), but gets swollen and soft as its moisture increases. This district, mostly located on flat terrace, is hardly flooded or eroded even in the rainy season. The land is classified as class II.

b) Vegetation and status of land utilization

The soils are in a dense forest consisting such trees as Prou, Protrear and Propal, and grass such as Sabou.

c) Problems relative to efficient land utilization and soil productivity

Due attention should be paid to the soil moisture content so that the soil layer will not be compressed when the land is cultivated by a bulldozer. Attention should also be paid to the construction of irrigation facilities, augmentation of organic matter content by the introduction of grasses, and the dressing of soil improving materials containing such as calcium, magnesium and phosphorous

Tuol soil type

a) Features of this soil type

The thickness of top soil is 10 cm to 20 cm. At a depth of 15 cm to 25 cm, there is a gravel layer, and the effective depth of soil is small. The surface soil is coarse textured, slightly sticky and slightly acidic, and the subsoil is neutral or slightly alkaline. The land has a relatively good permeability, but has only a small capacity of holding water and is liable to become excessively dry as deep as 60 cm in the dry season. The soils are greatly deficient in exchangeable calcium, available phosphorous and organic matter. The land was classified as class IV, because of its poor fertility and the existence of gravel pan layer.

b) Vegetation and status of land utilization

Shrubs such as Klong, Chlek, Bamtomlern and Pjek, and Sabou grow in this area, and no land has been utilized for agricultural purposes.

C-3-3 Microbial activities and microflora

The microbial activities such as the mineralization degree of soil organic nitrogen, urease activities and oxygen uptake for the air-dried soils were examined. The microflora was studied by culture methods.

1) Microbial activities

a) The mineralization degree of soil organic nitrogen for poorly drained Alluvial soils flooded every rainy season was most significant. It is supposed that the nitrogen sources are supplied soils from muddy water. The mineralization degree of soil organic nitrogen for Alluvial soils flooded every rainy season was most significant irrespective of upland and paddy soils. In the uncultivated land, the mineralization degree for Lithosols was most noticeable, but the lowest for Vertisols.

b) Urease activities for Alluvial soils were more noticeable than those for Low-Humic Gley soils. For upland fields as well as paddy fields, the activities for Alluvial soils rarely flooded are more significant than those for other soils flooded every rainy season. Therefore, attention should be paid to those facts that it would take fairly long time until urea is changed into ammonia in the paddy or upland fields with weak urease activity. For uncultivated land, the urease activity for Lithosols and Vertisols was strong but weak for Red-Yellow Podzolic soils.

c) Oxygen uptake which indicates potential microbial activities was not high in any type of soils especially very low for Red-Yellow Podzolic soils. This explains that Red-Yellow Podzolic soils are extremely low in organic matter to be attacked by microbes. The paddy field soils getting organic matter from flooding every rainy season, did not have a high oxygen uptake. This may come from the fact that the organic matter of paddy fields which are not in wet condition in the dry season, is easily decomposed. As in the case of Red-Yellow Podzolic soils, paddy field soils must be supplied with organic matter in order to increase their fertility. It is especially important for paddy fields as well as upland fields to supply with organic matter in order to keep them easy to cultivate, since they become very hard in the dry season.

2) Microflora

The azotobactors which are not symbiotic but independently fix atmospheric nitrogen, were not recognized for any type of soils. It can be suggested that the soils except Lithosol are acidic, but it is not understood that the reason why no azotobactor was found for Lithosols. The microflora of paddy fields, was characterized by the fact that a large number of bacteria and anaerobic bacteria and a small number of fungi were recognized, and fairly large number of sulphuric reducing bacteria was found.

If the sulphate reducing bacteria which reduce sulphate into hydrogen sulphide, is active under the presence of sulphate in soils, hydrogen sulphide is much produced with reduction proceeds. The hydrogen sulphides cause root damage of rice plant when the fields are inundated. Therefore, much care should be taken in how to irrigate so that roots of rice plant grow healthy.

It was found that the soils have a large amount of nitrifying and denitrifying bacteria. In this connection, it is assumed that nitrogen fertilizers loose much their effect on those soils, since nitrifying bacteria change ammonium into nitrate nitrogen, and denitrifying bacteria change the nitrate into nitrogen gas which easily volatilize in the atmosphere. As it is impossible to supply a sufficient amount of fertilizer at present, it is very important to minimize the loss of nitrogen.

Table IV-4 Productive Capability Classification (upland field)

Item \ Soil series	Krakor-1	Krakor-2	Keng	Tuol	Kampi-1	Kampi-2	Pongro	Bos Leav	Sambok	Prek Chamlak	Sre Prang	Pou
Land Productivity classification	III	IV	III	IV	III	IV	II	II	III	II	IV	IV
Thickness of top soil (t)	III	IV	II	III	III	IV	II	III	III	III	III	III
Effective depth of soil (d)	II	IV	I	III	III	IV	I	I	I	I	IV	IV
Gravel content in top soil (g)	I	II	I	I	I	I	I	I	I	I	II	II
Facility of plowing (p)	I	I	I	II	III	III	I	III	IV	IV	IV	IV
(Texture of top soil)	1	2	1	1	2	2	1	3	3	3	3	2
(Stickness of top soil)	1	1	1	1	2	2	1	2	3	3	3	1
(Consistence of top soil when dry)	1	1	1	2	3	3	1	3	3	3	3	2
Wetness of land (w)	(IV)	(IV)	(III)	(IV)	(IV)	(IV)	(II)	(II)	(II)	(II)	(IV)	(IV)
(Permeability)	1	1	1	1	1	1	1	1	3	3	1	2
(Moisture holding capacity)	3	3	3	3	3	3	3	2	1	1	3	2
(Humidity)	(2)	(2)	(2)	(2)	(2)	(2)	2	2	1	(2)	(2)	(2)
Inherent fertility (f)	III	III	III	III	III	III	I	I	I	I	II	I
(Nurtrient holding capacity)	3	3	3	3	3	3	2	2	1	1	1	1
(Fixing capacity)	1	1	1	1	1	1	1	1	2	2	2	2
(Base status in soil)	1	1	1	2	1	1	1	1	2	1	2	1
Contents of available nutrients (n)	III	III	III	III	III	III	I	I	II	I	I	I
(Exchangeable Ca)	3	3	3	3	3	3	1	1	2	1	2	1
(Exchangeable Mg)	3	3	3	2	3	3	2	2	2	1	1	1
(Available P)	3	3	3	3	2	2	1	2	2	2	1	1
(Minor elements)	2	2	2	2	2	2	1	1	1	1	1	1
(Acidity)	2	2	2	2	2	2	1	1	2	2	2	1
Hazards (i)	III	III	I	III	III	III	I	I	III	III	III	III
(Chemical hazard)	1	1	1	1	1	1	1	1	1	1	1	1
(Physical hazard)	3	3	3	3	3	3	1	1	3	3	3	3
Slope of land (s)	I	II	I	II	I	II	I	I	I	I	I	I
(Natural slope)	1	2	1	2	1	1	1	1	1	1	1	1
(Aspect)	-	-	-	-	-	-	-	-	-	-	-	-
(Artificial slope)	-	-	-	-	-	-	-	-	-	-	-	-
Erosion (e)	I	III	I	II	I	III	I	I	I	I	I	I
(Degree of erosion)	1	3	1	2	1	3	1	1	1	1	1	1
(Water erodibility)	2	2	2	2	2	2	2	2	2	2	2	2
(Wind erodibility)	1	1	1	1	1	1	1	1	1	1	1	1

Table IV-5 Productive Capability Classification (paddy field)

Item \ Soil series	Russei Char	Sambok	Moreum	Stung Preah	Roha
Land productivity classification	II	II	II	III	III
Thickness of top soil (t)	I	I	I	I	I
Effective depth of soil (d)	I	I	I	I	I
Gravel content in top soil (g)	I	I	I	I	I
Permeability (i)	I	I	I	II	I
(Texture in 50 cm below plowing layer)	1	1	1	3	1
(Maximum compactness in 50 cm below plowing layer)	1	1	2	2	1
State of redox potentiality (r)	I	I	I	I	I
(Easily decomposing organic matter content)	1	1	1	1	1
(Degree of gleization)	1	1	1	1	1
Wetness of land (w)	IV	IV	IV	IV	IV
(Permeability)	3	3	3	1	3
(Moisture holding capacity)	1	1	1	3	1
(Humidity)	2	2	2	2	2
Inherent fertility (f)	I	I	I	III	I
(Nutrient holding capacity)	1	1	1	3	2
(Fixing capacity)	2	2	2	1	1
(Base status in soil)	2	2	2	3	1
Contents of available nutrients (n)	III	III	II	III	III
(Available N)	3	3	3	3	3
(Available P)	2	2	1	3	3
(Exchangeable K)	3	3	3	3	3
(Exchangeable Mg)	2	2	1	3	3
(Available Si)					
(Minor elements)	1	1	1	1	1
(Acidity)	2	2	2	2	2
Presence of harmful substances (h)	I	I	I	I	I
(Sulphur compounds)	1	1	1	1	1
(Content of salts)	1	1	1	1	1
(Content of heavy metals)	1	1	1	1	1
(Irrigation water)	1	1	1	1	1
Frequency of accidents (a)	III	III	III	III	III
(Risk of flooding)	3	3	3	3	3
(Risk of land slide)	1	1	1	1	1

It can be supposed that the number of blue green algae abundant in the surface layer of well drained Alluvial soils, will more multiply during a time of flooding than the dry season. This will help towards the improvement of soil fertility from the point of nitrogen content.

The upland field soils are characterized by the presence of greater numbers of actinomyces than those for the paddy field soils. All types of soil have a large number of nitrifying and denitrifying bacteria. Consequently it should be taken account of the way to use nitrogenous fertilizer for upland fields, since nitrate nitrogen oxidized by nitrifying bacteria, easily move down especially in the rainy season.

The soils of uncultivated land also have as much actinomyces as in upland soils, and have special microbial features different from those of paddy field soils. The nitrifying and denitrifying bacteria in the soils of uncultivated land were very active as in the upland field soils. Therefore it should be considered that ammonium produced by mineralization of organic nitrogen is changed instantly into nitrate nitrogen which easily move down to the lower layer.

When the microbial characteristics of paddy field, upland field and uncultivated land in the Sambor area are compared with those respective average numbers of Japanese soils, it is noticed that the paddy field soils of the Sambor have more sulphate reducing bacteria than those of Japan. This indicates that paddy field soils of the Sambor will be more likely cause root damage of rice plant under a condition of water logging in high temperatures than in temperate regions such as in Japan.

The fact that a large number of nitrifying and denitrifying bacteria is present in the soils of Cambodia, whatever it may be used as paddy or upland field or not cultivated, explains that the loss of nitrogen as nitrate nitrogen or elementary nitrogen gas in the soils of Cambodia, is more probable than those of Japan, and that much attention must be focused upon the beneficial effect of nitrogenous fertilizers in the future.

C-4 Hydrology

C-4-1 Rainfall

General descriptions of the rainfall characteristics are stated on preceding para. C-2-1.

In order to survey the regional feature of the rainfall in this project area, rain gauges were installed at ten places in this area as shown in Fig. IV-14 and the observation of daily rainfall was carried out during the rainy season of 1965 and 1966.

Beside the abovementioned rain gauges, an automatic rainfall gauge was installed in Kratie City.

Observation records of total rainfall, number of rainfall days and maximum rainfall per month at each observation point are shown in the Tables IV-6 & 7. Judging from these tables, large fluctuation can be seen on the monthly rainfall, monthly rainfall days, yearly rainfall, and yearly rainfall days.

Fig. IV-13 shows the relation between the yearly rainfall and yearly rainfall days, but it is hard to observe the correlation. Tables IV-8 & 9 show the records of maximum hourly rainfall.

C-4-2 Drought Days

The record of droughty days in 1965 is shown in the Table IV-11. As stated under para. C-2-1, the beginning and ending of the rainy season differs quite a bit by year, and the several droughty days are recorded even during the rainy season. The maximum consecutive droughty days are observed at about one month.

C-4-3 Infiltration and Water Holding Capacity

Infiltration of surface soil and soil layer near the surface soil were surveyed by several methods. The measured values are different depending on the measuring spot and plowing conditions of the soil. Table IV-13 gives the infiltration values under saturation conditions. This was measured for upland field irrigation and soil moisture indicates the basic intake rate approximately under the field capacity conditions.

In the previous Table, infiltration at the clayey soil is less than 5 mm/hr (120 mm/day) and at the loam or sandy soil, it is less than 20 mm/hr - 40 mm/hr (500 mm/day - 1,000 mm/day).

On the other hand, the percolation of the rainy seasonal paddy fields, of which soil texture is loamy soil, is an average of 4.8 mm/day, and of the dry seasonal paddy fields, it is approximately 1.8 mm/day.

According to the pumping tests of the well of the silty soil in the vicinity of Kratie City, permeability coefficient is in the range of 10^{-3} cam/sec -10^{-4} cm/sec, which is treated under the subsequent Chapter C-4-6.

This indicates that, when the hydraulic gradient is about 1, percolation is 86 mm/day - 860 mm/day, and it is interesting to note that these values are in correspondence with the basic intake rate in upland fields.

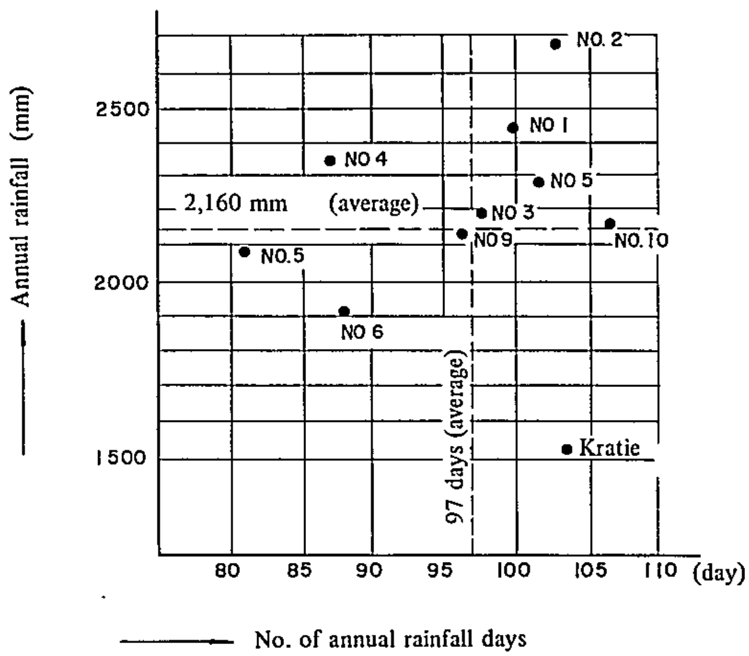
A small percolation in the paddy field is due to the existence of plow sole by rice cropping for a long period, and the small hydraulic gradient by high ground water and continuous innundation flood.

The laboratory test is performed for soil moisture constant and soil grading for 10 cc each of the typical soil samples of clear forest, paddy field, upland field and inundation area in the project area. The result is shown in Table IV-14, from which a water holding condition can be judged.

Maximum water holding capacity is 50% - 60% at the point of PF 0, and in case of remaining water after the excessive gravitational water had been eliminated, water holding capacity is less than 30% at the point of PF 1.5. Beside water holding capacity of wilting point at PF 4.2 is 6% - 7%. From the above, the available soil moisture for vegetation is assumed to be about 20% - 25%.

Water holding capacity after 24 hours of soil saturation was observed at 35 places for the purpose of upland fields irrigation plan, and the results were arranged by soil textures and given in Table IV-15. The wilting point on this table was obtained by calculation 1/. The value thus obtained will give a slightly higher value than that obtained at the laboratory which is shown on Table IV-14, but at the available moisture 2/ is considered to be approximately 21%.

Fig. IV-13 Relation between annual rainfall and its duration



1/ Laboratory formula in Japan, Aichi Irrigation Area $Wp = 0.238\ Fc^{1.102}$

2/ Water holding capacity from field capacity to wilting point.

Fig IV-14 LOCATION MAP OF THE GAUGING STATIONS

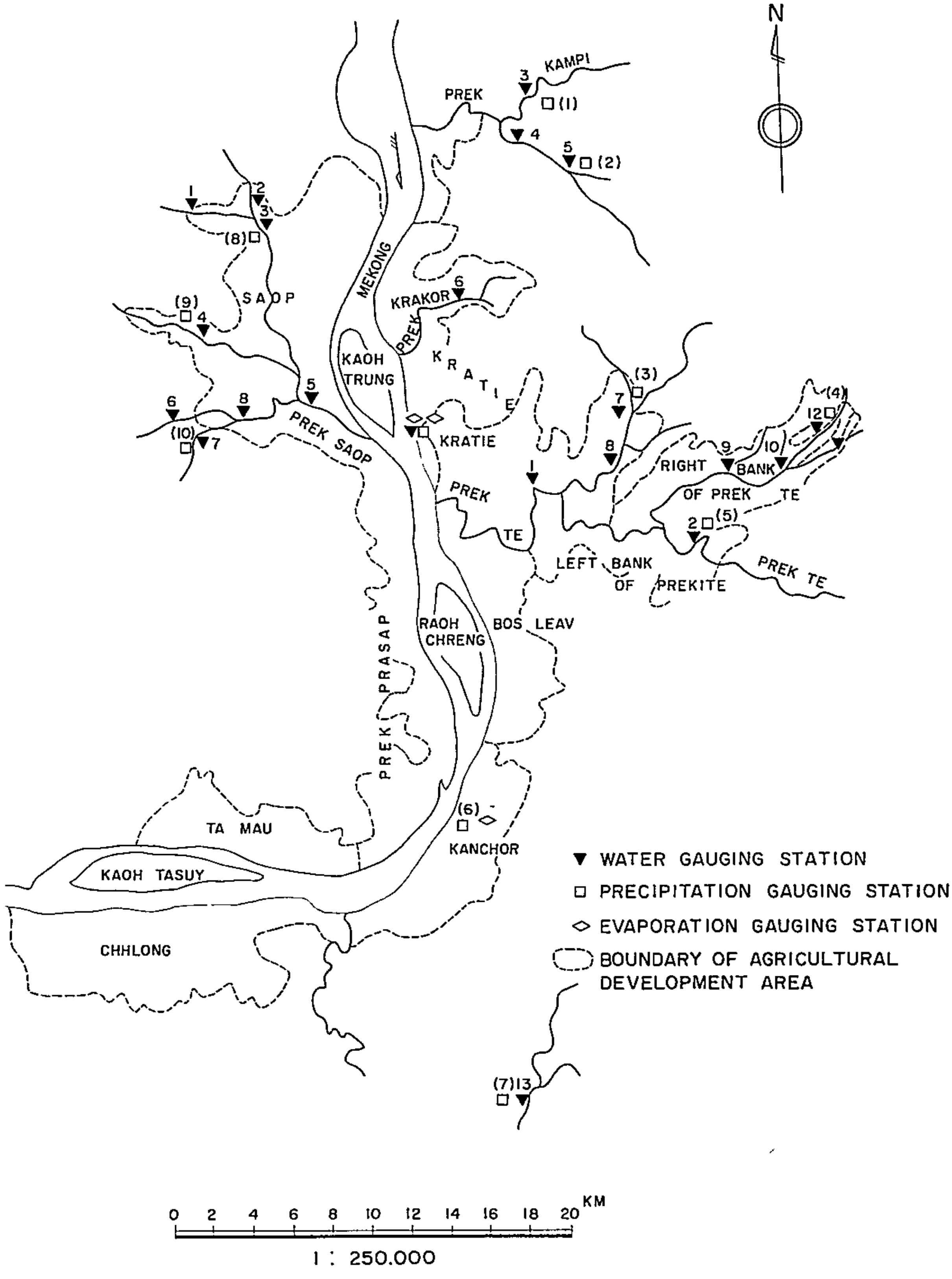


Table IV-6 Regional rainfall in 1965 (unit: mm)

Location	Apr.		May		Jun.		Jul.		Aug.		Sept.		Oct.		Nov.		Total	
	Σ Ri/n	R max	Σ Ri/n	R max	Σ Ri/n	R max	Σ Ri/n	R max	Σ Ri/n	R max	Σ Ri/n	R max	Σ Ri/n	R max	Σ Ri/n	R max	Σ Ri/n	R max
No. 1	156/5	50	161/10	46	583/21	85	607/18	110	486/18	60	274/14	43	148/11	43	22/3	20	2,437/100	110
2	176/5	65	238/10	121	561/21	48	617/19	80	550/18	87	322/15	52	201/12	61	11/3	6	2,676/103	121
3	44/7	14	562/14	116	403/18	76	358/14	67	143/6	62	428/24	61	229/12	56	17/3	6	2,184/98	116
4	90/6	27	522/16	65	520/14	68	298/8	66	157/8	41	545/23	69	156/7	71	63/5	20	2,351/87	71
5	83/5	21	567/19	59	346/12	48	214/8	41	155/6	52	465/17	55	183/8	66	74/6	18	2,087/81	66
6	29/3	15	333/16	55	249/15	40	420/16	100	252/11	36	346/16	45	241/9	88	28/2	15	1,898/88	100
7	77/6	43	210/13	50	235/15	63	454/16	94	153/12	33	122/8	34	-	-		-		
8	40/5	28	272/13	83	375/20	40	343/16	110	527/17	68	533/19	101	177/9	55	20/3	12	2,287/102	110
9	110/8	23	346/13	80	272/17	55	299/10	75	408/14	78	441/18	50	139/13	30	23/4	8	2,038/97	80
10	139/4	100	288/16	75	354/17	57	429/15	102	283/16	40	514/20	100	129/14	27	12/5	6	2,140/117	102
Kratie	43/6	25	332/16	102	227/20	54	324/18	97	196/11	68	260/22	46	114/10	25	2/1	2	1,498/104	102
Mean																	2,160/97	

Remarks: 1) R max = Maximum daily rainfall

2) Σ Ri = Total amount of rainfall

3) n = No. of rainfall days.

Table IV-7 Regional rainfall in 1966 (unit: mm)

Loca-tion	May		Jun.		Jul.		Aug.		Sept.		Oct.		Total	
	Σ Ri/n	R max	Σ Ri/n	R max	Σ Ri/n	R max	Σ Ri/n	R max	Σ Ri/n	R max	Σ Ri/n	R max	Σ Ri/n	R max
No. 1	'180/10	40	126.5/6	42	476/19	69	229.7/18	37.5	192/16	21.5	74/11	35	1,278/80	69
2	158.5/9	32.5	72.0/5	27.5	534.5/20	82	259.5/18	32	113.5/14	15	30/11	6	1,168/77	82
3	154/9	42.5	87.5/6	41.5	198.5/16	42.5	236.0/18	44.5	255.5/14	54.5	58/10	12.5	989/73	54.5
4	236.5/12	37	82.5/8	19	434.5/18	44	176/11	26	191.5/13	54	45.0/4	16.5	1,166/66	54
5														
6	105.5/9	30	184/12	52	417.5/15	95	272.5/14	68.5	124.5/13	23	134.5/6	51	1,238/69	95
7	218.5/15	77.5	356.5/11	68	373.5/14	57.5	330.5/15	64	352.0/12	73.5	107.5/4	43	1,738/71	77.5
8	292.0/15	55	292.5/10	70	510/24	65	253.5/18	30	376.5/16	80	16.5/12	30	1,741/95	80
9	247/16	43	216/9	43	499/14	82	224/15	48	227/16	35	146/10	28	1,559/83	·82
10	381/17	85	363/15	60.5	577/23	102.5	258.5/20	37	325.5/15	66	165.5/15	36	2,070/105	102.5
Mean													1,438/80	

Remarks:
1) R max = Maximum daily rainfall
2) Σ Ri = Total amount of rainfall
3) n = No. of rainfall days

Table IV-8 Maximum daily rainfall in 1965 (unit: mm)

Observed point	First mm	Day	Mon.	Year	Second mm	Day	Mon.	Year	Third mm	Day	Mon.	Year
No. 1	110	(13	7	65)	85	(15	6	66)	85	(17	7	66)
2	121	(3	5	")	27	(9	8	")	80	(13	7	")
3	116	(4	5	")	112	(6	5	")	103	(5	5	")
4	71	(10	10	")	69	(5	9	")	68	(4	9	")
5	66	(9	10	")	59	(3	5	")	55	(2	9	")
6	100	(10	7	")	82	(12	10	")	55	(21	5	")
7	94	(15	7	")	89	(17	7	")	68	(10	7	")
8	110	(10	7	")	101	(23	9	")	93	(9	9	")
9	80	(3	5	")	75	(12	7	")	75	(6	8	")
10	100	(2	4	")	100	(14	9	")	87	(1	6	")
Kratie	114	(7	7	")	102.	(2	5	")	97	(9	7	")

Table IV-9 Maximum daily rainfall in 1966 (unit: mm)

Observed point	First mm	Day	Mon.	Year	Second mm	Day	Mon.	Year	Third mm	Day	Mon.	Year
No. 1	69	(25	7	66)	43.5	(19	7	66)	40	(28	5	66)
2	82	(28	6	")	62.5	(30	6	")	43	(29	6	")
3	54.5	(22	9	")	44.5	(2	8	")	43.5	(5	8	")
4	54	(19	9	")	51	(16	7	")	44	(25	7	")
6	95	(25	7	")	94.5	(21	7	")	68.5	(17	8	")
7	77.5	(24	5	")	73.5	(1	9	")	68	(28	6	")
8	80	(22	9	")	70	(24	6	")	65	(31	7	")
9	82	(30	7	")	70	(31	7	")	69	(25	7	")
10	102.5	(15	7	")	100.5	(25	7	")	85	(15	5	")

Table IV-10 Maximum hourly rainfall (Apr.- Dec. in 1965) (unit: mm)

Items	First	Second	Third	Forth	Fifth
	mm	mm	mm	mm	mm
Hourly rainfall	62	44	42	38	32
Number of rainfall days	102	54	65	97	68
Starting day	2 May	11 Jun.	30 May	9 Jun.	30 Aug.

Table IV-11 Droughty days (May-Sept. in 1965)

Observed point	First No. of days	Date Day	Mon.	Day	Mon.	Second No. of days	Date Day	Mon.	Day	Mon.	Third No. of days	Date Day	Mon.	Day	Mon
No. 1	14:	19	9	2	10	12:	8	5	19	5	6:	22	5	27	5
2	12:	8	5	19	5.	11:	22	9	2	10	6:	22	5	27	5
3	20:	7	8	26	8	7:	18	7	24	7	7:	28	7	3	8
4	12:	8	8	25	8	12:	16	7	27	7	12:	27	9	8	10
5	19:	8	8	26	8	13:	25	9	7	10	12:	16	7	27	7
6	12:	15	8	26	8	5:	8	5	12	5	4:	11	6	14	6
8	12:	2	5	19	5	7:	25	9	1	10	6:	2	7	7	7
9	12:	28	6	9	7	9:	17	7	25	7	6:	29	8	3	7
10	11:	27	6	7	7	6:	19	1	24	7	6:	29	7	3	7
Kratie	9:	16	8	24	8	7:	7	8	13	8	7:	30	6	6	7

Table IV-12 Droughty days (May-Oct. in 1966)

Observed point	First No. of days	Date Day	Mon.	Day	Mon.	Second No. of days	Date Day	Mon.	Day	Mon.	Third No. of days	Date Day	Mon	Day	Mon.
No. 1	14.	5	6	18	6	10:	6	7	15	6	8:	10	5	17	5
2	20:	5	6	24	6	10:	6	7	15	6	8:	10	5	17	5
3	20:	5	6	24	6	13.	30	6	12	7	13:	23	9	5	10
4	28:	24	9	21	10	21:	4	6	24	6	12:	13	5	24	5
5	25:	25	9	19	10	10:	12	6	21	6	6:	20	8	25	8
6	17:	23	9	9	10	13:	27	5	8	6	7:	19	8	25	8
7	17.	21	9	7	10	14:	12	10	25	10	10:	7	6	16	6
8	12:	5	6	16	6	9:	27	9	5	10	7:	18	8	24	8
9	13:	23	9	6	10	12:	5	6	16	6	9:	17	8	25	8
10	7:	27	9	3	10	6:	8	7	13	7	5:	1	5	5	5

Table IV-13 Infiltration at upland fields

Observation place	Soil texture	Sa	Fc	Wp	Am	Am/Fc	Am/Wp	iB
Ph. Chaspok	C	1.627	27.6	9 0	18 6	0 67	2 1	1 4
Ph Sre Prang	"	1.397	37.5	13 0	24 5	0 65	1 9	0.5
Chong O Kapo	"	0.964	34 5	11 8	22.7	0 66	1 9	50
Ph Krakor	L.C.	1.451	34 7	11.9	22.8	0 66	1.9	11
Ph Kompong Kor	L	1.34	44.5	15.5	29.0	0 65	1 9	26 8
Ph. Khoan Khvien	"	1.213	36.5	12.6	23 9	0.65	1.9	2.5
Ph Prek Chik	S L.	1.317	41 2	14.3	26 9	0.65	1.9	1 7
Ph Kanhchor	"	1.178	48 4	17.1	31.3	0.65	1.8	8 1
Ph Dar	"	1.573	19.9	6 4	13.5	0.68	2.1	30.3
Ph Roha	"	1.542	22.3	7.3	15 0	0 67	2.1	0 9
Ph Sre Pring	S	1 682	19 6	6.3	13.3	0 68	2.1	78
Ph. Veal Vong	"	1 771	20.5	6 6	13.9	0 68	2.1	50
Ph Roka Thom (1)	"	1 641	22.2	7 1	15 1	0 68	2 1	16 9
" " (2)	"	1.647	23.9	7 8	16 1	0 67	2.1	23 4
Ph Roka Kandal	S L.	1.274	45.7	11.3	34 4	0 75	3 0	12 9
"	"	1.528	47 8	22.5	25.3	0 53	1.1	-
Ph Baug Thom	C	1 08	37.5	12 9	24 6	0 66	1.9	58 4
Ph Daidoh Beig	C	0.93	34 9	12.8	22.1	0 63	1.7	62 6
Ph. Prek Prang	C	1.38	38.0	13 1	24 9	0 66	1.9	4 1
Ph Saop Kraom	C	1 42	35 8	12.3	23.5	0.66	1.9	3 7
Ph Prek Chamlac	C	1.35	21 6	7.0	14.6	0.68	2 1	3 6
Ph Roka Kandal Bang Pdaev	C	1 20	20.8	6.8	14 0	0.67	2 1	1 9
Ph Russei Char	C.L.	1 24	33 4	12 8	20 6	0 62	1.6	2 6
Ph. Prek Te, Kh Bos Leav	"	1.32	2.95	9.9	19 6	0 66	2 0	55 1
Ph Prek Ta Am	"	1.34	38 8	13 4	25.4	0 65	1.9	12.5
Ph Pomgrow	"	1.31	37.7	13 0	24 7	0 64	1.9	4.5
Ph. Prek Chuk	L	1 23	22 7	7 4	15.3	0 67	2.1	24.0
Ph. Talons Chhamka	"	1.32	25.3	8.4	16 9	0 64	2.0	2.1
Ph Pomgrow Chamarow	"	1.33	20 6	6 7	13.9	0 68	2.1	20 0
Ph Prek Ku	S L.	1 27	33.0	12.8	20 2	0 61	1 6	3 9
Ph Prek Chuk	"	1.36	24 2	8 0	16 2	0 67	2 0	26.0
Ph. Kaoh Tasuy	S	1.37	29.5	9.9	19 6	0 66	2 0	33.6
Ph Ta Mau	"	1 41	42 0	14 6	27.4	0 65	1.9	9 8
Ph Daidoh Kraom	"	1.33	23 4	7 7	15 7	0 67	2.0	105 0
Ph Kbal Crach, Srok Snoul	L	0 95	26.1	6 8	19.3	0 74	2.8	89.7
"	"	0.95	30.2	8.0	22.2	0 74	2.8	89 7
Ph Prek Chik								*32 4

Remarks.
Sa Apparent specific gravity
Wp Permanent wilting point (%)
iB Basic intake rate (mm/hr)
Fc Field capacity (%)
Am Available moisture content (%)
* Dry condition

Table IV-14 Soil moisture constant

Soil group	Sample No.	Apparent Specific gravity	Real Specific gravity	Soil tex-ture	Composition of grain size (%)				Soil moisture constant (%)					
					Coarse sand	Fine sand	Silt	Clay	PF_0	$PF_{1.5}$	$PF_{2.7}$	$PF_{3.0}$	$PF_{3.8}$	$PF_{4.2}$
Aqueous Soil (Clear forest)	6-I	1.19	2.78	L	39.1	21.0	27.1	12.8	56.2	27.6	21.8	17.9	8.9	6.2
low humic gley soil	6-II	1.18	2.73	Lic	10.4	16.6	31.2	41.8	59.8	33.4	24.1	19.3	9.6	7.2
"	6-III	1.22	2.79	Lic	3.0	35.7	28.5	32.8	58.5	31.2	22.8	18.8	9.0	7.4
"	13-I	1.26	2.65	LFS	18.1	67.5	6.7	7.7	51.3	26.5	18.6	16.4	7.9	4.8
Alluvial Soil (Paddy)	9-I	1.18	2.66	SiCL	2.8	34.4	45.9	16.9	54.8	24.0	18.9	16.7	8.7	5.5
low humic gley soil	9-II	1.27	2.69	LiC	6.9	27.5	40.2	25.4	57.8	27.3	17.5	17.5	8.5	6.7
"	9-III	1.28	2.73	LiC	11.1	25.4	24.9	38.6	58.2	31.8	18.9	18.9	9.2	7.4
"	32-I	0.94	2.57	HC	5.0	16.6	25.3	53.1	59.5	32.2	18.7	18.7	7.9	6.5
low land in back marsh	32-II	1.30	2.64	LiC	12.0	29.2	26.3	32.5	52.4	25.3	16.7	16.7	8.5	6.0
"	32-III	1.40	2.72	CL	18.0	32.0	29.7	20.3	53.0	25.4	17.8	17.8	9.2	6.6
"	38-I	1.25	2.66	LiC	7.9	33.5	26.2	32.4	59.2	27.6	17.0	17.0	9.0	6.8
Mekong alluvial soil	18-I	1.03	2.73	SiC	0.1	21.0	47.0	31.9	58.2	27.2	21.4	17.5	8.6	6.5
Alluvial soil	18-II	1.16	2.75	SiC	0.1	22.3	45.9	31.7	57.1	26.9	20.4	16.5	8.2	6.0
"	18-III	1.13	2.73	SiC	0.1	25.9	46.3	27.7	57.8	28.0	21.6	17.1	8.5	6.4
Back slope in natural levee	31-I	1.06	2.70	LiC	0.5	28.6	43.8	27.1	55.2	26.1	20.0	17.2	7.9	5.8
"	39-I	0.96	2.72	HC	0.2	1.7	42.7	55.4	56.4	26.5	20.5	17.6	7.4	6.0
Old Mekong river bed	33'-I	1.22	2.63	FSL	4.2	77.5	8.9	9.3	50.4	25.0	19.7	15.1	8.5	5.6
Red yellow podozolic soil	33'-II	1.26	2.64	FSCL	4.1	70.8	10.0	15.1	53.2	28.9	20.8	14.0	9.3	6.4
"	33'-III	1.14	2.65	FSCL	3.5	63.0	9.3	24.2	52.9	27.7	20.4	16.5	8.9	5.3
Sandy soil	44-I	1.48	2.64	LFS	32.1	57.9	3.0	7.0	49.3	24.4	18.5	15.1	7.8	4.6

Table IV-15 Field capacity (Fc), Wilting point (Wp), Available moisture (Am), Basic intake rate (iB)

Items / Soil texture	Fc	Wp	Am	Am/Fc	Am/Wp	iB
Clay	30.2%	10.2%	20.0%	0.66	1.96	2.5 mm/hr
Clay Loam, Loam	31.9	10.8	21.1	0.66	1.95	10.5
Sandy Loam	34.3	11.7	22.6	0.66	1.93	16.2
Sand	27.9	8.4	19.5	0.70	2.32	23.6

Fc; Field capacity
Wp; $0.238\_Fc^{1.102}$
Am; Fc – Wp
iB; $60\ c.n\ [600\ (1-n)]^{n-1}$
C.n; Coefficient

During the rainy season, most of the soil retains the moisture of more than Fc and becomes close to the saturation condition, but at the end of the dry season, most of the soil close to the surface holds only a little moisture.

C-4-4 Porosity

Soil porosity in this area is almost equivalent to the soil moisture constant at PF 0, and can easily be calculated with the apparent specific gravity and real specific gravity shown on Table IV-14.

Effective porosity is some 20% and is equivalent to the available moisture on Table IV-15.

This table shows a unproportional relation between the field capacity (or water holding capacity after 24 hr of soil saturation) and apparent specific gravity of soil, and also the relation between SA (apparent specific gravity of soil item) and Fc. The characteristic of effective porosity distinguished in soil category can be seen from the above.

a) Upland fields are of alluvial soil consisting of the mica silt of the Mekong River as a parent materials and since the aggregated structure is expanded well in these area, the apparent specific gravity (Sa) is small and the field capacity (Fc) is high.

b) Clear forest in general is of the thin aqueous soil, of the upland region, including gravels or the weathered residual soil of sandstone and shale, and iron mottles and concretion have dried and solidified.

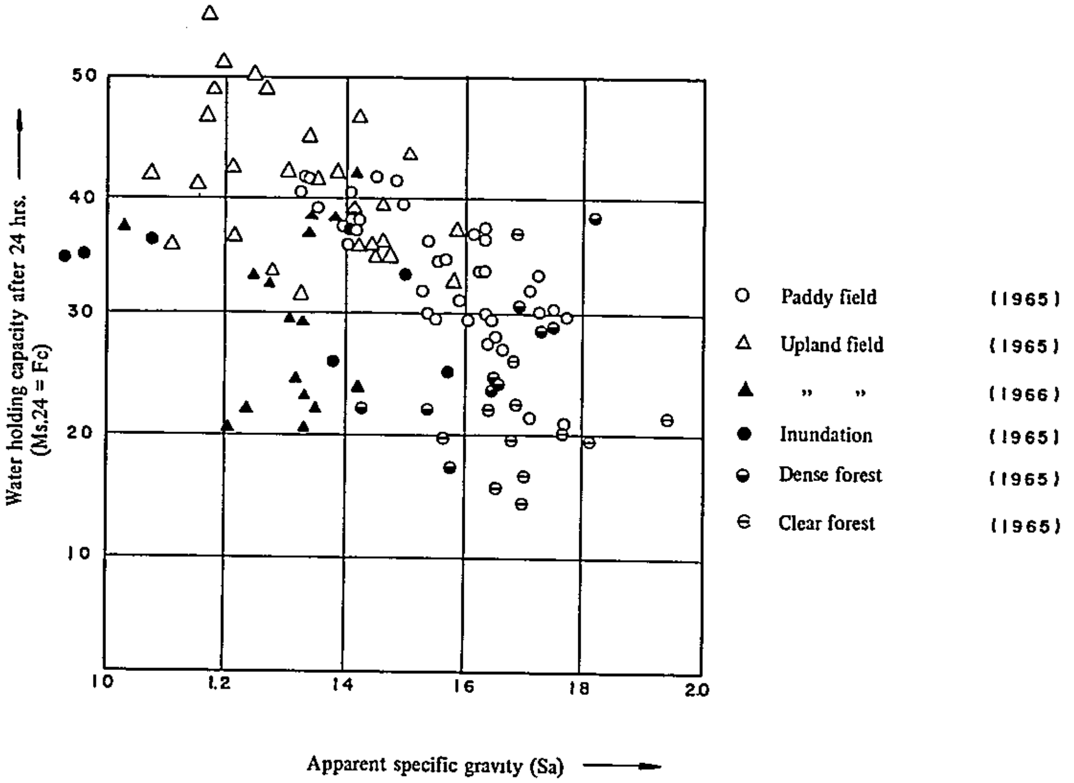
In these area, low permeability, small field capacity and large apparent specific gravity are observed. The arable land could only be utilized for paddy fields in which Fc will increase by crop rotation.

c) The present paddy fields are of the aqueous soil and silty or clayey alluvial soil of the sedimentation of the Mekong. Fig. III-15 shows that this soil is spread widely between the upland field and clear forest.

d) Dense forest is of alluvial soil developed in the old river route of the Mekong. Water retention capacity is comparatively good, and Fc is almost equal to the average value of paddy field and clear forest.

e) Most of the plains and marshy lands of the inundated area are composed of alluvial soil, and Fc is almost equal to the value in the paddy field. It is considered easy in this area to cultivate the clayey soil area and silty soil area into paddy fields and upland fields respectively.

Fig. IV-15 Relation between field capacity, apparent specific gravity and land category



C-4-5 Runoff of the Tributaries

River conditions and water level of the Mekong have been observed by the Ministry of Public Works, however, up to date no observations were made concerning the tributaries, accordingly no records were available.

To check the water level, its fluctuation and flooding capacity of the tributaries, the staff gauges were installed at a principal place in the project area in January of 1965, and water level was recorded at the fixed time every day. From the result of this observation, it was noted that water level of the tributaries suddenly rises with the rainfall within the watershed, but the flood does not continue so long.

To measure the maximum water level, which can not be measured by the fixed time observation, maximum water level gauge having the photosensitive tape was intalled at the same place of the water gauge. These water gauges were installed at eight places on the right bank of the Mekong and thirteen places on the left bank (see Fig. IV-14). Records are available from April 1965 to November 1965 and from May 1966 to October 1966. From these records, general runoff conditions of the tributaries in this area may be summarized as follows;

a) Influence by the water level of the Mekong

The observation points affected by the backwater of the Mekong are following five points; No. 5 (Prek Saop) on the right bank, No. 1, No. 2 (Prek Te) and No. 4 (Prek Kampi) on the left bank. Flows of these tributaries toward the Mekong are caused by the water level rise due to the rainfall in the basin, but when the water level of the Mekong rises suddenly, a reverse flow to the tributaries will dominate.

This fact is testified by the observation records. The water level of the tributaries is usually recorded to be higher than that of the Mekong, but at the flooding time of the Mekong, the water level of the tributaries is recorded to be lower than that of the Mekong.

Such reverse flow from the Mekong to the tributaries will have a good effect to the *colmatage*, as described hereinafter.

b) Maximum water level

In case of the observation by the photosensitive tape the maximum water level is in many times 0.2 m - 0.4 m higher than daily average water level. Table IV-16 shows the maximum height of the water level and the date recorded.

Table IV-16 Maximum rise of the water level

No. of observed point		Maximum water level height	Date occurred		No. of observed point		Average water level height
			1965 Mon.	day			
Left bank	12	2.34 m	9	25	Left bank	4	1.53 m
"	10	2.28	9	26	"	2	1.19
"	2	2.04	9	25	"	12	1.18
"	11	2 00	9	23	Right bank	2	0.93
"	1	1 81	9	19	"	5	0.85
"	5	1.56	9	17	"	10	0.82

The water level of the tributaries follows the mainstream of the Mekong owing to the influence of backwater, however, since the variation of water level in the tributaries is caused by the runoff from its watershed, the annual pattern of water level in the tributaries is complicated.

At the peak of the Mekong River's flood almost all of the area developed along the tributaries are inundated for relatively long period (1 - 3 months), and sometimes the water level at some place in the tributaries is suddenly risen by the squall within its watershed, and the river overflows certain area hence causing the flood. But this flood having depth as much as 2 m at certain spots, will decline in a few days.

c) Runoff coefficient

Generally the rainy season starts in April but since watershed is covered with dense and clear forest, and the rainfall during April and May is practically absorbed as soil moisture, for which the runoff coefficient is small.

Runoff coefficient of Prek Prasap (right bank No. 1) and O Krasang (right bank No. 2), of which watershed are comparatively clear and of which tributaries are not affected by the backwater of the Mekong, are shown as follows from the rainfall data of 1965.

Peak (August, September)

Catchment area	= 12,450 ha
Rainfall (ΣR)	= 755 mm
Rainfall (V_i)	= $93 \times 10^6 m^3$
Runoff (ΣQ)	= 952 m^3/sec-day
Runoff ($V_o = \Sigma Q \times 86,400$)	= $82 \times 10^6 m^3$
Runoff coefficient (f) (V_o/V_i)	= 0.88

First period (May)

Rainfall (ΣR) = 162 mm

Rainfall (ΣV_i) = $20 \times 10^6 m^3$

Runoff (ΣQ) = $52.4\ m^3/sec\text{-}day$

Runoff ($V_0 = \Sigma Q \times 86{,}400$) = $5 \times 10^6 m^3$

Runoff coefficient = 0.25

C-4-6 Subsurface Water

In the area along the Mekong River and its tributaries, many wells are dug mainly for drinking purpose. Each Phum has one or two public wells, and most of which are 6 m - 10m deep, and around Kratie City the subsurface water level was 1.5 m - 4.0 m below ground surface during the period of December to January.

Water level of these wells will begin to rise from around May, reach the peak during July to September, and become the lowest during March to April. Some of them will even dry up.

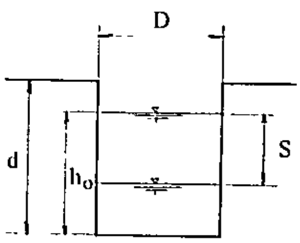
Difference between high and low water level is about 3.0 m - 5.5 m. As mentioned above, it is clear that the subsurface water level is being affected by the rainfall and the water level of the Mekong. The quality of subsurface water is not explored, but it is relatively clear.

During early part of February in 1966, pumping test was conducted at the ten wells which are located near Kratie City. Coefficient of permeability analyzed by the results of the test is shown on Table IV-17.

Table IV-17 Coefficient of permeability

Location		D	d	d-ho	ho	S	t (hour)	k (cm/sec)
Kbal Chur		1.30^m	5.25^m	3.53^m	2.32^m	0.76^m	19.5	1.9×10^{-3}
Sambok		1 35	3.13	2.26	0.87	0.30	26.1	8.0×10^{-5}
Kratie (1)		0.86	6.42	2.38	4.04	2.05	16.5	1.8×10^{-3}
" (2)		1.00	3.92	2.41	1.51	1.38	18.2	1.5×10^{-3}
Kou Leap	(1)	1.10	4.30	3.80	0.50	0.40	25.4	3.3×10^{-4}
"	(2)	1.40	6.15	3.87	2.28	0.68	7 0	4.5×10^{-3}
Russei Char	(1)	1.30	6.80	4.90	1.90	1.07	25.4	1.4×10^{-4}
"	(2)	1.20	6.85	3.60	3.25	0.85	14.1	2.5×10^{-3}
"	(3)	0.88	8 80	3.50	5.30	3.12	17.7	1.6×10^{-3}
Kapo		1.00	2.90	2.02	0.88	0.65	5.4	6.0×10^{-3}

Remarks:



s: Water level down by pumping up

t: Time required to recover the water level until first level since pumping is stopped.

k: Coefficient of permeability

Usually in the Mekong there is about 14 m difference of the water level between the dry season and the rainy season. Annual variation of the subsurface water level relates to the water level of the Mekong, but between the both variations some phase difference is seen and its range is smaller than one of the Mekong River.

At present subsurface water is utilized for only drinking water. As for the irrigation water resources the tributaries, ponds and the mainstream of the Mekong are considered more favorable than underground water, except in the case of small scale irrigation.

C-4-7 Inundation

The Mekong River water level rise during the rainy season and through its tributaries causes flood inundation at a wide area.

Hydrologic analysis on inundation is as described under para. C-4-5. Of the 34,000 ha of this project area, about 19,000 ha are inundated areas, but these inundation areas, depending on the location, differ in inundation period and inundation depth, because of the complex topography and the comparatively wide water level fluctuation.

These conditions strongly control the present agricultural farming, and also are very important factors in agricultural planning, cultivating period of products, cropping system and *colmatage* plan.

Fig. IV-16 gives the average water level of the Mekong for the recent four years (1962-65), which was adopted as an average water stage of the Mekong, and furthermore the average elevation of the arable land of a typical inundation area is recorded.

From this, as listed in Table IV-18, the average inundation period and inundation depth of each inundation area can be figured.

Informations gathered from the farmers concerning the inundation condition are shown on Table IV-19.

Table IV-18 Inundation (1)

	Location	Inundation period			Area	Depth
		Beginning	end	days	(km^2)	(m)
1.	Prek Krakor	Ear. Aug.	Ear. Oct.	75	11.5	3.5
2.	Prek Te	" Jul.	Mid. "	90	36.5	3.5
3.	Ph. Prek Ta Am	" Aug.	Ear. "	70	9.5	1.5
4.	Prek Chik	" Jul.	Mid. "	100	25	4.3
5.	Ph. Lovea Thom	Mid. "	" "	95		3.0
6.	Prek Chney	" "	" "	95		3.0
7.	Prek Saop	Ear. Aug.	Ear. "	60	11	2.0
8.	Prek Pralung	" "	" "	70	14.5	3.0
9.	Ph. Thoma Reap	Mid. Jul.	Mid. "	80		3.3
10.	Prek Prang	Ear. Aug.	Ear. "	70		2.0
11.	Bang Mokoy	Mid. Jul.	Mid. "	105	39	3.5
12.	Prek Kraham Kor	" "	Ear. "	100		3.0

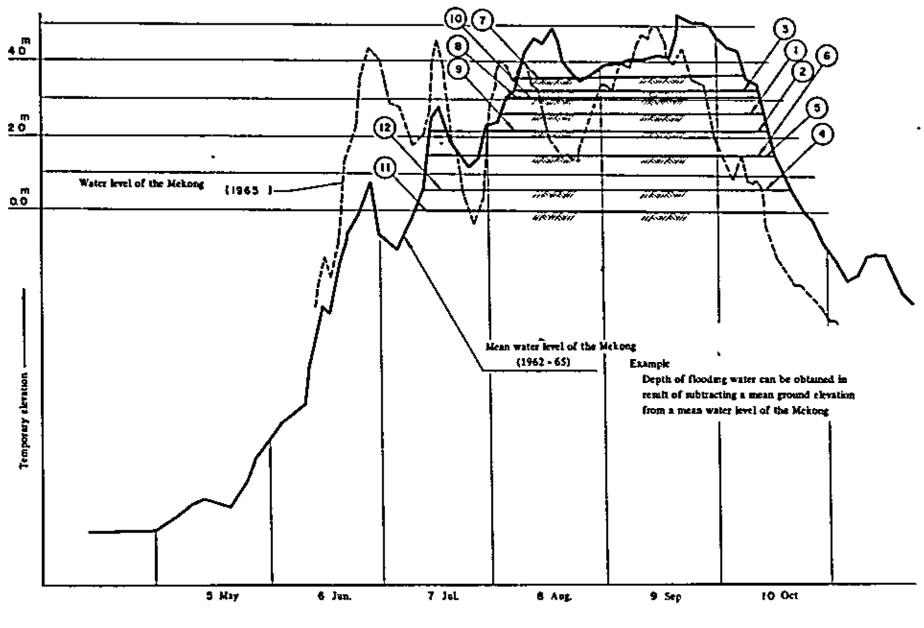
Table IV-19 Inundation (2) (information from farmers)

	Location	Inundation condition
1.	Ph. Roka Kandal	non inundation
2.	Kaoh Chreng	inundation, Aug. - mid. Oct., upland
3.	Prek Samann	" mid. Jul. - Sept., upland, paddy
4.	Ph. Kanhchor	" " " " " "
5.	Ph. Damrei Phong	non inundation
6.	Ph. Pongro	inundation, Aug. - Sept.
7.	Ph. Chrouy Banteay	non inundation, upland, paddy
8.	Prek Pralung	" upland
9.	Ph. Keng	" "
10.	Ph. Prey Ku	inundation Aug. - Sept., upland
11.	Ph. Ta Mau	" Jun. - Sept., upland
12.	Kaoh Tasuy	" Aug. - Sept.
13.	Ph. Kampong Kor	non inundation
14.	Ph. Deidoh Leu	inundation, 18th Jul. - 10th Oct.

As shown on Table IV-18, the inundation period of 60 days at Prek Saop is the shortest, 105 days at Bang Mokoy is the longest and the average is about 90 days. A good example of the well advanced *colmatage* by inundation is seen at the Prek Chik* at Kh. Kanhchor, where the inundation period is about 100 days

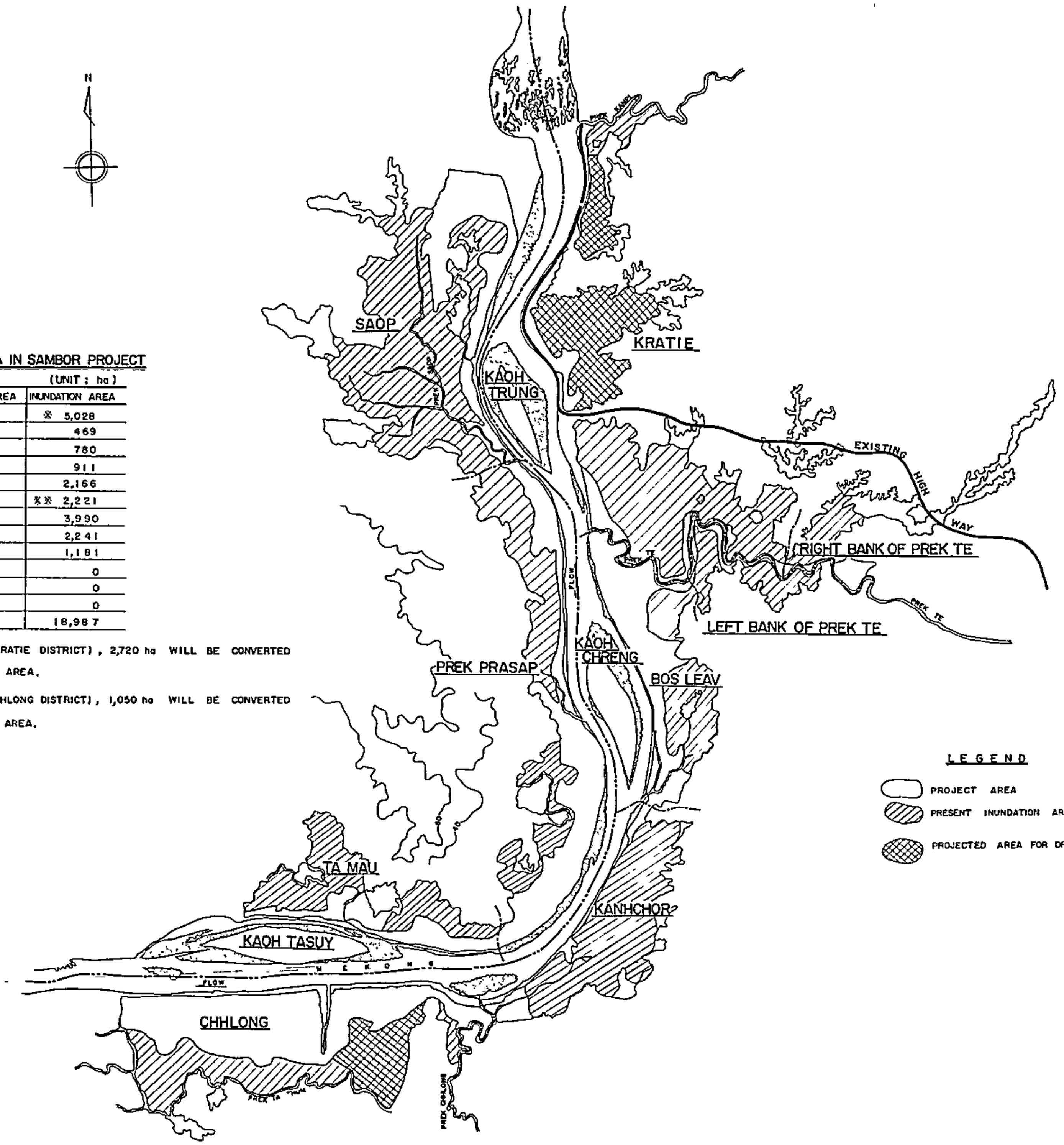
Information was collected at several places regarding the actual inundation condition (in the year of 1965) These data are shown in the following Table in comparison with the average hydrograph of the Mekong.

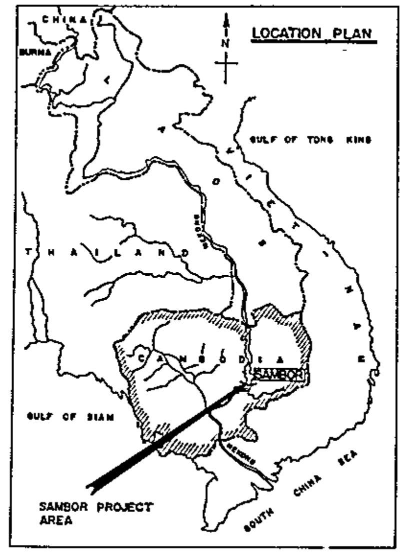
Fig. IV-16 Mean water level of the Mekong and inundation period

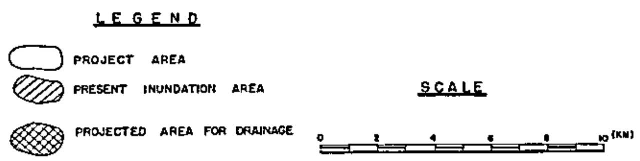


* Prek Chik is a Cambodian term for artificial excavated river.

Fig Ⅳ-17 PRESENT INUNDATION MAP IN SAMBOR PROJECT







PRESENT INUNDATION AREA IN SAMBOR PROJECT

(UNIT ; ha)

NAME OF DISTRICT	PROJECT AREA	INUNDATION AREA
KRATIE	6,381	※ 5,028
PREK TE (R)	1,345	469
PREK TE (L)	955	780
BOS LEAV	2,696	911
KANHCHOR	2,478	2,166
CHHLONG	5,114	※※ 2,221
SAOP	7,176	3,990
PREK PRASAP	4,135	2,241
TA MAU	2,029	1,181
KAOH TRUNG	247	0
KAOH CHRENG	638	0
KAOH TASUY	806	0
	34,000	18,987

※ OUT OF 5,028 ha (KRATIE DISTRICT), 2,720 ha WILL BE CONVERTED INTO NON-INUNDATED AREA.

※※ OUT OF 2,221 ha (CHHLONG DISTRICT), 1,050 ha WILL BE CONVERTED INTO NON-INUNDATED AREA.

Fig. IV-18 Location surveyed for inundation

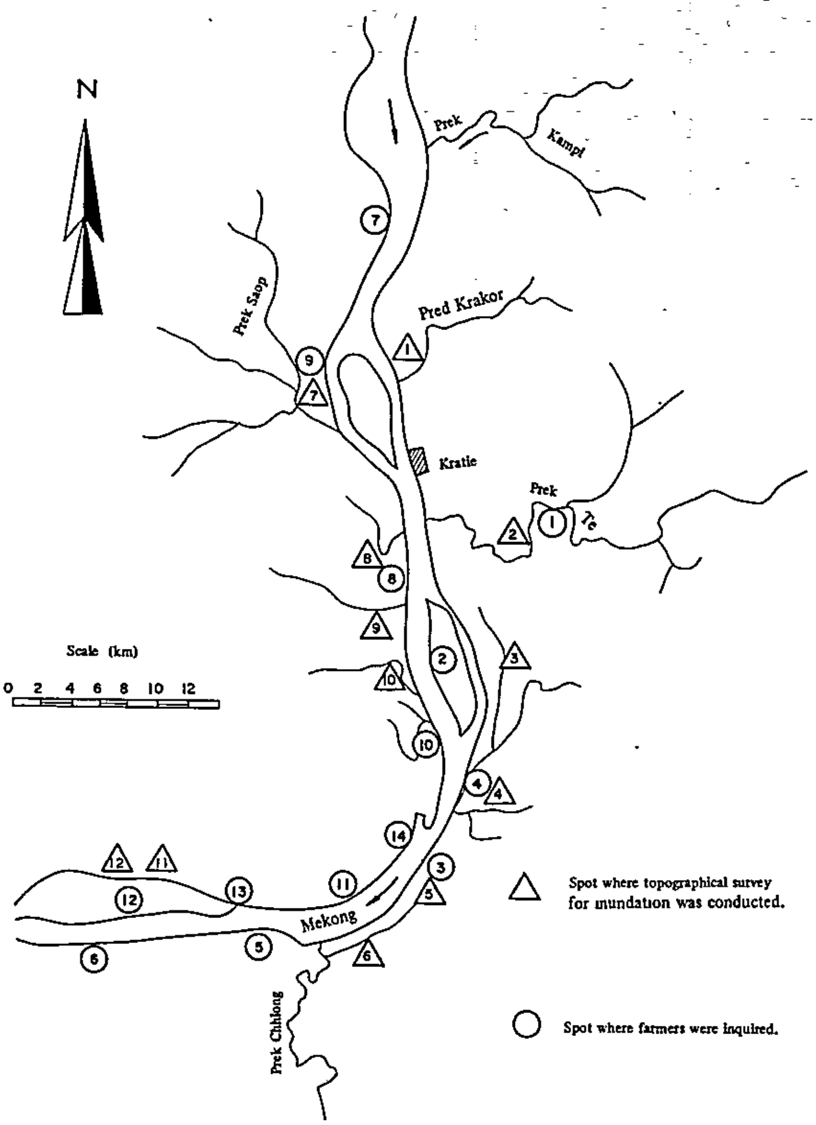


Table IV-20 Inundation (3)

Location	Period		Difference (2) - (1)
	(1) hearing	(2) calculation	
Prek Samann	85day	95day	10day
Ph. Kanhchor	85	100	15
Ph. Prey Ku	60	70	10
Ph. Chrouy Sneng	105	100	-5
Ph. Deidoh Leu	110	105	-5

There is a little difference in period between the calculation and the information collected, but this is due to the yearly variation of water level of the Mekong and average of the arable land elevation.

C-4-8 Drainage

As for drainage conditions of the project area of 34,000 ha, there is a complete change in the conditions between the rainy and dry season. In the rainy season, the water level of the Mekong rises and the reverse flow to most of the tributaries causes the inundation, consequently about 19,000 ha of the area remains in a submerged condition, for several months together with runoff from catchment area of the tributaries. At that time there are no means of drainage. In the dry season, the Mekong water level decreases gradually and the inundation water drains itself into the Mekong through the tributaries. Around March and April, the end of the dry season, some of the tributaries are dried up.

Generally, drainage is regulated by the conditions of topography, soil surface water and ground water. This area lies at the elevation between 30 m and 9 m, but greater part of the area is less than 20 m.

The maximum water level of the Mekong is 20 m in the rainy season and the minimum is 6 m in the dry season.

Flood water have hardly overtopped the natural levee. Most of the tributaries does not have dikes and the elevation of both banks are lower than the natural levee of the Mekong.

This area is surrounded by the high elevation natural levee formed by the Mekong, and the lowest part is marshy shallow concave, lake or pond and is inundated even in the dry season.

This low area is a long narrow strip that stretches along the Mekong or its tributaries, and there are natural small drainage canals that run into the tributaries.

Soil porosity, soil texture, water holding capacity and ground water level, are very important factor that controls the drainage efficiency.

In view of the above items, drainage is good in the silty loam area at the back slope in natural levee of the Mekong, but since the low area and valley bottom are of clayey soil, drainage is poor. Presuming the ground water level from the water level of many wells for drinking in this area, the ground water level affected by the precipitation and the Mekong is highest in July to September and lowest in March and April.

The only possible means of drainage in the low area during the rainy season is pumping drainage. With the exception of well drained upland fields, at present in the paddy field whose inundation period is comparatively short and water depth being shallow, and the rain fed paddy field of the bottom valley plain, there are almost no drainage canals provided and the drainage depends on only the natural gravityflow according to the topography

In the future, if irrigation in the dry season will be introduced, subsoil will be saturated, ground water level will probably rise within a limit of several meters. This area is not a flat plain, and topographically it is sloped, thus the water drains off to the depressed areas.

When a complete irrigation is introduced in the future and as a result, drainage deficiencies may occur in certain area, then an adequate drainage facilities should be replanned.

C-4-9 *Colmatage*

In the Sambor survey area, especially in Prek Chik of Khum Kanhchor, Srok Chhlong and Prek Chik of Khum Saop, Srok Prek Prasap, what is called *"colmatage"* to dress the soil sediments from the Mekong has been practiced for a long time. The land of the highest productivity at present in the district is the back slope area of the natural levee of Mekong, and is utilized as upland fields. This is the alluvial soil formed as a result of direct alluviation of the Mekong or the inundation into the back land from the tributaries.

As in this area the arable land reclaimed by *colmatage* has the highest productivity, *colmatage* method should be considered in this agricultural development project. It will be the present problem to know how the sediment concentration of the Mekong downstream will change and what degree of effective sedimentation can be expected by the artificial canal for *colmatage* after completion of Sambor Dam.

Colmatage phenomenon was analyzed hydraulically as shown in the followings:

a) Soil particle composing watershed and critical tractive force

The critical friction velocity ($V_{*}c$) and critical tractive force (τc) can be obtained from the soil material collected and analyzed in 1964 - 65.

τc is extremely small and $V_{*}c$ is also less than 2.0 cm/sec.

b) Sediment load in Sambor reservoir

Present situation: In case of the mean discharge of 40,500 m^3/sec in the rainy season of the August and September, concentration of sediment load is 315 PPM. Beside, actual sediment concentration of the Mekong which is observed in August and September shows 100 PPM - 1,500 PPM. This is considered due to wash load added to sediment load of 315 PPM.

Upstream situation of proposed dam when completed: At 19 km upstream of the dam, sediment load will be zero in case of the mean discharge of 40,500 m^3/sec, from which it is thought that after completion of the dam, sediment load from quite a ways upstream will decrease and water in the reservoir will become clear. However, further study for the matter should be required for the existing dam.

Downstream situation of the proposed dam when completed: It can be presumed from the study of the present situation that the flow of the Mekong discharged from the dam will cause sediment load again by tractive force. By studying the sediment load of the Mekong in the case of proposed minimum discharge of 1,470 m^3/sec, annual mean discharge of 15,000 m^3/sec, and mean discharge of August and September of 40,500 m^3/sec, it was proved that in each case friction velocity is larger than critical friction velocity and the sediment load will take place.

From the above, it was cleared that the muddy Mekong River was due to the soil grading property of the river bed soil formation. Since there is no great difference in the soil formation of the area from upstream to downstream, sedimentation is almost alike over the entire watersheds. Accordingly, even if water was held for a while in the dam, sediment ought to take place from the direct downstream of the dam.

c) *Colmatage* canal

Longitudinal slopes of the *colmatage* canal is shown in Fig. IV-19 in contrast to the Mekong water level at Prek Chik (Ph. Kannchor).

The water driving period from the Mekong is considered to be about 100 days, and maximum depth of inflow is about 8 m. It is noted from the hydrograph that during the period of 100 days, the Mekong has a flood peak of more than several times, and each time the new mud water flows into the area. This fact is obvious from the observation of the present profile of sediment.

When the variation of the Mekong water level is gradual, the water flowing into the project area through the *colmatage* canal will suddenly lose its velocity and will cause a silt sedimentation. Every inundation in its peak carries new silt into the project area, and as the water level of the Mekong decreases at the end of the flood, the silt in the area will settle slowly and cleared water will drained off.

C-4-10 Losses Due to Evapotranspiration

The potential evapotranspiration of the crop from the soil of saturated condition is shown in Fig. IV-19 under para. C-2-4.

Since evapotranspiration (ET) of the survey area was not observed, the necessary ET value for design water requirement of crop was obtained from Blaney-Criddle formula.

In case the cropping factor is 1.0, the ET value is 6.6 mm/day for the dry season and 4.8 mm/day for the rainy season in an average.

Water requirement for paddy field is equivalent to this ET plus percolation as described under para. C-4-3. In case of upland crop, only the amount of evapotranspiration is supplemented as consumptive use.

If corn having the cropping factor of 0.75 is taken up as a principal crop of the upland field the average ET value of the dry season is 4.9 mm/day.

Monthly ET values are shown in Table IV-21.

For reference, a result of actual survey* on water requirement of paddy at the Cambodian-Japanese Experimental Farm is shown as follows: The mean evapotranspiration of paddy (Variety: Tainam No. 3) is observed as 6.7 mm/day from December of 1965 to April of 1966, and this value is almost equal to the value calculated by Blaney-Criddle formula.

Fig. IV-19 Longitudinal section of the Prek Chik and water level of the Mekong at Kh. Kanhchor

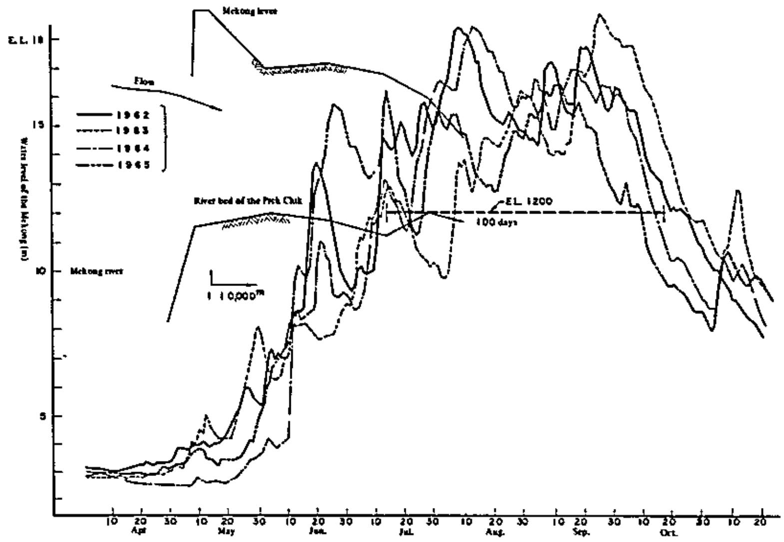


Table IV-21 Calculation of E.T. by Blaney-Criddle formula

Month	Mean sunshine hours	Ratio of the left column to the annual daily sunshine hours	Mean temperature	Mean consumptive use K = 1.0	
1	9.1 hr/day	9.35	77.5 F	6.14	mm/day
2	9.6	9.87	81.1	6.78	6.6
3	9.3	9.55	84.0	6.80	
4	8.8	9.04	85.5	6.55	
5	7.5	7.71	82.6	5.40	
6	8.1	8.33	81.5	5.75	
7	6.8	6.99	80.2	4.75	
8	6.5	6.68	80.5	4.57	4.8
9	6.4	6.58	79.7	4.45	
10	7.7	7.94	79.5	5.33	
11	8.5	8.84	78.3	5.87	
12	8.9	9.15	76.5	5.93	
Mean	8.1		80.6	5.69	

* Sadao HATTA, OTCA, 1966

Blaney-Criddle formula

$V = K \times Tm \times Pm$

V:	Amount of consumed water in certain period (inch)
K:	Crop coefficient (1 stands for rice)
T:	Daily mean temperature (^{o}F)
Tm:	Monthly mean temperature (^{o}F)
P:	Ratio of daily sunshine hours to annual sunshine hours
Pm:	Ratio of monthly sunshine hours to annual sunshine hours

C-5 Water Usage

As for the artificial irrigation in this area during the dry season, there are upland field irrigation by means of pumping-up on a small scale and paddy field irrigation that depends water resources on the water remained in lowland. These irrigated areas are only a few percent of the existing arable areas of 13,000 ha. The upland field is irrigated by using watering pots or drum cans after pumping-up. At the lowland there are some cases that small-scale canals convey waters to irrigate the paddy fields.

a) Upland field irrigation

Generally the upland fields are located in the natural levee and the back slope of the natural levee of the Mekong and its tributaries. These land are formed by the sedimentation of the Mekong flood, and the water holding capacity is extremely high in this area.

For this reason the crops will survive without irrigation in the normal year.

b) Paddy field irrigation

The dry season paddy fields are located in the lowland and depend on the remained water in the depressed land as the water resources. Marshy land is the area sedimented by the small river and percolation in the area is 2 mm/day - 5 mm/day, which is very low. For this reason even by the small-scaled, inefficient present irrigation system, some effect for irrigation has appeared.

The rainy seasonal paddy fields are located at the upland bottom valley plain beyond the reach of Mekong flood, and depend on rain water and the muddy water from the tributaries as the water resources. The percolation is comparatively high in the bottom valley plains inside the hilly-lands, but no special artificial irrigation is carried out.

As a peculiar example of water utilization in this area, there is *colmatage* that utilize the muddy water of the Mekong. *Colmatage* does not aim to take in the irrigation water, but utilizes the sedimentation of the Mekong to form a fertile arable land. This is explained under para. C-4-9.

c) Irrigation water quality

Irrigation water fertility is shown in Table IV-22, in case 13 mm/day is irrigated for 100 days.

Generally, the water quality is good for irrigation, and effect for realization of the potential land productivity such as nitrogen and phosphoric acid could be expected by the propagation of alga and activity of bacteria, and the sedimentation of the muddy soil of the floods. For this reason, *colmatage* has been initiatively planned at several districts to take in flood water, and has been thought most appropriate to cope with the present situation.

d) Water right and customs

There seems to be no law or regulations binding the water rights for the water usage of the Mekong and its tributaries. There are people who make their living by fishing in these rivers, and who live in the houses built on the river.

There are no water conflicts between the farmers and fishermen, and as far as water rights are concerned the custom of public order is prevailing and the water usage is completely controlled by the village chief rather than laws and regulations.

Table IV-22 Water quality analysis value

	Ph	K_2O	SiO_2	Alkali Degree	Date Collection
Average at 13 places	6.4	1.3	17	35	Jul. - Oct.
Average of 203 examples in Japan	6.9	1.8	18	35	
Mekong main stream Kompong Cham	7.3	1.2	24	62	Nov.
Mekong main stream Sam Rong Thom	7.0	1.2	14	46	Nov.
Barai Occidental	6.0	0.8	10	10	Nov.

Resources; *Centre Technique Agricole de l'Amitié Khméro – Japonaise*

C-6 Local Communities and Total Rural Population

Local administrative system of Cambodia consists of Khet (Province) Srok, Khum, and Phum.

This project area exists in Kratie Province (Khet) and consists of the administrative system as shown below:

Srok	Khum
Kratie	Sambok, Kratie, Bos Leav,
Chhlong	Kanhchor, Chhlong, Pongro,
Prek Prasap	Chroy Bantedy, Saop, Prek Prasap, Ta Mau, Chamlak.

Khet Governor is appointed by the Government and Srok Chief is appointed by the Khet Governor. Chief of each Khum and Phum is elected by the inhabitants, and by the help of their secretaries mainly control the works such as, taxation, census registration, and community security.

In the seat of the Khet Government office, the offices of agriculture, construction, forestry, veterinarian, education, OROC *(Office Royal de Cooperation)*, and polices of each state and district are also established. These offices receive direct orders from the state and carry out specialized administration. All personnel are nominated by the state.

Khet Governor control other administrative works except taxation census registration, public welfare stabilization, and has a role to adjust the problems intervening among specialized organizations for making all administration more effective.

Total rural population: The population of Kratie Province in this project area was 126,231 according to the census* of 1962, and the population density was 11.4 person/km^2, which was equivalent to only about one-third of that of the entire Cambodia. Comparative figures of each Srok are shown in Table IV-23.

Table IV-23 Population density in Kratie Province

Item	Cambodia	Kratie	Name of Srok				
			Chhlong	Kratie	Sambor**	Snoul	Center Urban
Population	574×10^4	126,231	46,114	38,398	11,269	18,542	11,908
Density	31.7 (man/m^2)	11.4	27.3	15.8	2.8	6.3	6.0

C-7 Agricultural Research and Extension Service

The majority of provinces have agricultural experimental stations and seeding farms, and test, experiments and extension of superior varieties have been promoted. Each province has a sectional agricultural office – *secteur agricole* – under direct control of the Ministry of Agriculture, and there are eleven officers at the sectional agricultural office of Kratie, and their duties are extension service of agricultural techniques and compiling of statistics. In the town where the sectional agricultural office is located, demonstration farms are set up and all important agricultural information are exhibited for the benefit of the farmers A program to train the farmers in farming techniques has been carried out since 1967.

Recently, radio has spread, and such programs as farming technique, agricultural office news, and farming news are broadcasted, and also pamphlets and posters are distributed to spread the farming activities.

The different schools and grades are also conducting agricultural education and even at elementary school – *Ecole primaire elementaire* – agricultural education is given 30 minutes a week.

Cambodia is placing a great emphasis on education, which can be observed from the fact that, in 1966, 19.2% of the entire national budget was appropriated for education. As explained above special effort has been made for training technicians and extending general education to supplement shortage of technicians, for which the future is very promising.

C-8 Willingness of People to Accept Irrigation

Certain parts of the project area utilize the natural reservoirs for the irrigation of upland fields. These are mainly for vegetable growing, and its growing area is increasing year by year. Some of these farmers use small pumps, and have taken in high grade crop varieties and developed a new farming techniques by using manure and fertilizer in enriching their lands.

In the Khum Sambok area, a reservoir construction works are in progress, and at the same time, paddy field demonstration farm is being built. The agricultural office is managing and operating this project. The surrounding farmers are taking this as an example and clearing marshy lands and are cultivating dry seasonal rice, this porject is worthy of notice.

The contract between the tobacco company and farmers are spreading and new modernized tobacco drying plants are being built.

The farmers' willingness towards cooperative is increasing and the number of farmers seeking technical training is also increasing. As stated previously, with the agricultural training pervasion, scientific methods for agricultural management should be promoted.

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* *Royaume de Cambodge Ministre du Plan "Résultates Préliminaires du recensment général de la population".*

** At the time when survey was conducted in 1962, Prek Prasap was assigned to Srok Sambor.

C-9 Marketing

Market in Kratie Province is located in the heavy populated place of each Srok, and farm products, seasoning spices and clothing are sold there. The farmers themselves sell their products and also merchants are doing business at the market. Kratie Province is the temporary central market for receiving and distributing farm products and circulating daily necessities. These products are transported by river and land from Kratie City to distant markets, such as Kg. Cham and the capital Phnom Penh.

The average prices of farm products at Kratie Khet area are as follows:

Table IV-24 Farm products average price ($/ton)

	Unhulled rice	Maize	Mung Bean	Sesame	Tobacco
Producer price	71.6	60.8	189.1	228.5	582.9
Market price	76.8	78.0	255.4	321.9	908.1

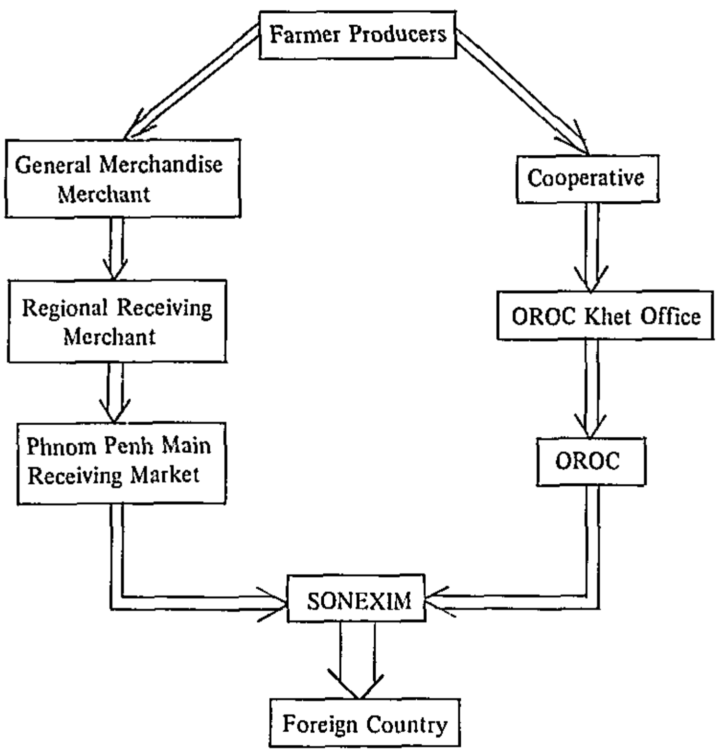
Remarks; *Releve mensuel des prix des productions agricole (1965) de Secteur Agricole de Kratie.*

The collection of rice and corn, principal export products of Cambodia, has been recently handled by OROC – *Office Royal de Cooperation* –, and the collection service handled during 1966 - 67 was about two-thirds of gross rice export of 270,000 ton.

The cooperative is subordinate organization of the OROC and have a direct contact with the farmers, and consists of the credit cooperative and the cooperative for corn, cotton or other products. And they help the farmers in financing and in getting materials for agricultural farming, and also aim to lead the farmer to organize the cooperative.

SONEXIM – *Société Nationale d'Exportation et d'Importation* – is organized by the government with an intent to promote export, and its activity is highly expected.

Circulation in Cambodia of the unhulled rice and maize are shown in following chart.



CHAPTER D. PRESENT AGRICULTURE

CHAPTER D. PRESENT AGRICULTURE

D-1 Landownership and Farm Size

According to the national census of 1962 in Cambodia, the population recorded 5,740,000, and her population density was 32 persons/km^2. Furthermore, Cambodia is an agricultural country holding farmer's population equal to 85% of whole national population.

The scale of the land has a great deal to do with the natural resources and dominates the growth of the economy. Cambodia has an area of 181,035 km^2, of which Kratie Province occupies 11,152 km^2 or equal to 6% of the total area. The outline of the land utilization for these areas is as follows:

Table IV-25 Outline of the land utilization (unit: ha)

Item	Total area	Potential arable land	Cultivated land			Forest
			Total	Paddy field	Others	
Cambodia	18,103,500 (100%)	6,698,300 (37 0%)	2,050,000 (11.4%)	1,750,000	300,800	9,051,700 (51.6%)
Kratie	1,115,187 (100%)	[40,000*]	28,806 (2.7%)	21,216	7,590	1,046,381 (97.3%)

Notes: Source of data

1) Figures for Cambodia — *Bulletin de la Statistique et des Etudes Agricoles, No. 3,* 1963 issue

2) Figures for Kratie — *La superficies de Riziers, Chamcar & Forets de la Province de Kratie* as provided by the Governor

* Since the above data did not contain any information in regards to the potential arable land, the figure given in the table indicates the potential paddy field cropping area, as shown in "Superficies des rizieres cultivees (Saisan des pluies)" compiled by Agriculture Office of the Kratie Province.

The total number of farm households in Cambodia is about 835,900 or 85% of the entire householders in the country. And in Kratie Province, there are about 14,900 farm households or 76% of the total householders in the province. These figures clearly indicate that farm households carry a big weight in this country.

Table IV-26 Number of families in the farm villages

Item	Population in villages (A)	Number of family in villages			Number of person per family (A/B)
		Total (B)	Farm households	Rice cropping households	
Cambodia	5,139,461	985,180	835,900	723,800	5.2
Kratie	114,323	19,500	14,900	11,300	5.8

Note: Data obtained from "*Bulletin de la Statistique et des Etudes Agricoles*, No. 3, 1963" under production of paddy of p.51.

Size of the family per household is 5.2 for Cambodia as a whole, and 5.8 for Kratie Province, therefore, Kratie has slightly more than that of the national average. Furthermore, in Cambodia, there are 723,800 families engaged in rice cultivation, which is about 87% of the entire farm families.

Rice cropping is predominant in Cambodia, and in Kratie Province, there are 11,300 households or 58% of its entire farm families. As compared with that of entire Cambodia, the number of the farm households engaged in the rice cropping is lower.

The working member per household is given in Table IV-27.

Table IV-27 Number of working members per household

	Family size per household (A)	Working population ratio (B)	Working members per household (A) x (B)
Cambodia	5.2	46.1%	2.4
Kratie	5.8	46.1%	2.7

Note: The working population ratio, 46.1% was adopted from p.51 of "*Annuaire Statistique du Cambodge 1963 - 64.*"

The average of working members per household in Cambodia is estimated 2.4 persons, and 2.7 persons in Kratie.

According to the data of 1962, average area of cultivated land per household was 2.93 ha. Suitable data to represent the land ownership and farm size for Kratie Province were not available, however, from other various reference material and data, the average cultivated area may be assumed at 2.0 ha which is lower than the national average. And moreover, from the verbal information made at the office in Khum, the size of the farm within the project area is considered at 1.4 ha of cultivated land per household. This cultivated land area is equivalent to the taxable area. Whereas, in computing the taxable area, approximately 70% of the actual area is usually taken into account. Therefore, the actual cultivated area may be recognized at about 2.0 ha. Furthermore, the information obtained from Khum also indicated that the majority of the farmers had about 2.0 ha of cultivated land. This means that most of the farmers fall in the category of average mid-class. This fact is likely to benefit the future extension works.

Since Kratie District is situated in the vicinity of the urban district and arable land being limited, even though there are many farmers, the majority of them are relatively small. Farmers in Saop, Prek Prasap districts and Chamlak Region are engaged in larger scale farming. About 40% of the farmers own more than 3.0 ha of arable land.

Official data to find out the picture of owner and tenant farmers are not available, however, the number of owner farmers are predominantly more than that of the tenant farmers.

It has been observed that the number of tenant farmers is extremely small. And even among the tenant farmers, there are only a very few farmers who rent the entire farm land from the landowners. In most cases, the big landowners let part of their land to the smaller ones. For instance, the Phum Chief of Roha owns 12 ha of farm land, and rents 9 ha of that to the small farmers. Depending upon the degree of land productivity, there are some differences as to the conditions of tenancy, however, by and large, in case of a paddy field it is about 360 kg of paddy per hectare, and in case of an upland field it is about 1,000 Riels to 2,000 Riels per year. But in case of Phum Kanhchor for upland field, they are turning in 1/2 of their products to their landowners. However, in either case, the landowner pays the land tax.

D-2 Land Use

D-2-1 Cultivated Land Use

Reference is made to Table IV-25, which gives the picture of the land utilization for Kratie Province in relation to Cambodia as a whole. From this table, the following could be said for Kratie; it has relatively large area of forestry land which is almost double the national average, and the remainder may be considered as potential arable land which is about 4% of the total area. This 4% is only 1/10 of the national average. However, when we consider the fact that the land utilized other than forestry and agriculture are merely for the Kratie City and villages, we should say that this province also bears a heavy weight in agricultural land utilization.

The forest region in Saop District is located in a highland and flat. The soil belongs to the category of Laterite series, therefore, there is a great possibility to cultivate the land by reclamation.

The existing arable area is about 2.7% of the total area, which is about 1/4 of the national average. And about 70% of the arable land are paddy fields.

The land utilization in Kratie Province by district is given in Table IV-28.

Table IV-28 Land utilization in Kratie Province

Srok	Cultivated area + Forest (Total)	Cultivated area (Cultivated land ratio)	Paddy area (Paddy field ratio)	Upland area (Upland field ratio)	Forest area (Forest ratio)
Right bank of the Mekong	ha	ha	ha	ha	ha
Srok Kratie	163,431	8,776 (5.4%)	6,126 (69.8%)	2,650 (30.2%)	154,655 (94.6%)
Srok Chhlong	90,072	7,450 (8.3)	4,450 (59.7)	3,000 (40.3)	82,622 (91.7)
Srok Snoul	286,274	4,048 (1.4)	4,038 (100.0)	10 (-)	282,226 (98.6)
Srok Sambor	187,270	3,330 (1.8)	3,320 (100.0)	10 (-)	183,940 (98.2)
Left bank of the Mekong					
Srok Prek Prasap	348,140	5,202 (1.5)	3,282 (63.1)	1,920 (36.9)	342,938 (98.5)
Total	1,075,187 (100)	28,806 (2.7)	21,216 (73.4)	7,590 (26.6)	1,046,381 (97.3)

Note: 1) The table was prepared from the data provided by the Provincial Government — "*La Superficies Riziers, Chamcar & Forets dans la Province de Kratie*"

2) The paddy field ratio and upland field ratio are in relation to the cultivated area.

In regards to the cultivated land ratio of Kratie Province, it is somewhat larger than the provincial average for the area which lies on the left bank of the Mekong, and smaller on the right bank. 55% of the cultivated lands are distributed in Srok Kratie and Chhlong areas, which also have a cultivated land ratio of approximately two to three times that of the provincial average.

In general, the cultivated land distributions are as follows:

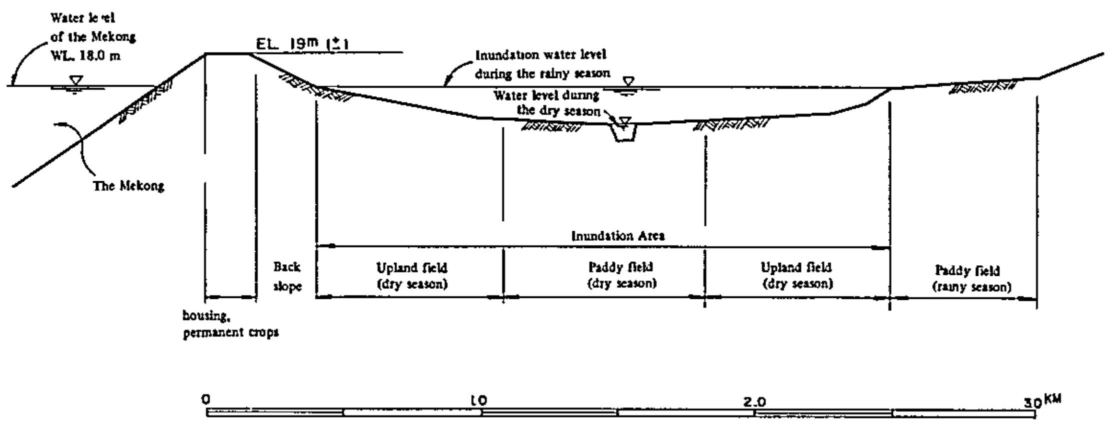
There are residence and upland field on the natural levee of the Mekong, and upland fields having a width of 1 km to 3 km lying on the back slope of the natural levee. These upland fields are situated in the inundated area of the Mekong or its tributaries, thereby the cropping is done only during the dry season. And the paddy fields are distributed in the lower portion of these inundated areas, and in the dry season, dry seasonal rice cropping is made available by using the water at the lower portion, which were stored during the rainy season. And at the valley bottom plain inside hilly-lands, there are some rainy seasonal paddy fields using the rainfall as irrigation water resources.

D-2-2 Land Use and Inundation

In regards to the inundation which is the principal feature of natural condition of this region, the water utilization is studied under para. C-4-7, and soil structure study and analysis are made under para. C-3. From these studies, it is made clear that inundation has a great factor in determining the land utilization. The agricultural development area by the Sambor Project elongates on both sides of the Mekong. Fig. D-20 showss the cross section of the area which is developed along the Mekong as a standard land utilization.

Now, the attention should be drawn to the fact that there are arable lands within the inundation area of the Mekong. These arable lands are being benefited in the following ways: by the fertile soil carried in by the flood, the soil moisture provided, and the flood water retained in the lowland, which are utilized for fertilizer and for irrigation waters. Therefore, for the existing agricultural farming, the inundation is a desirable phenomenoı However, this inundation should take place at the right period and in adequate scale.

Fig. IV-20 Illustration of standard land utilization



D-2-3 Land Use Viewed from the Point of Soil Classification

Table IV-29 gives the relationship between existing land category and soil classification along with the degree of inundation. From this table, it may be understood that the existing arable land in its entirety, falls under class II and partially under class III of the soil productivity classification, making the most advantageous utilization. For the paddy field, the majority are rain-fed paddy field in Roha series (III), but considering the land productivity the dry seasonal paddy field in Sambok series (II) is relatively high. However, owing to the limitation of the variety and irrigation facilities, the existing rice productivity does not always follow the above statement.

Table IV-29 Relationship between the existing land category and the soil productivity classification

Item / Land category	Area (10^3ha)	Soil texture	Soil series and land productivity	Existence of inundation
Paddy field	5.1	C, SiC, SL	Russei Char (II) Sambok (II) Stung Preah (III) Roha (III)	inundation of all II, a portion of III
Upland field	7.7	SiL, SiCL, C	Pongro (II) Bos Leav (II) Sambok (III)	Over 50% inundation
Marshy land	28.8	C – S	Russei Char (II) Sambok (II) Moreum (II) Chong Kaoh (III) Pongro (II) Bos Leav (II)	all inundation
Clear forest	22.6	LS, Cl, C	Krakor (III-IV) Toul (IV) Kampi (III-IV) Prek Chamlak (II) Sre Prang (IV) Pou (IV)	hardly inundation
Dense forest	4.8	LS	Keng (III) Krakor (III-IV)	no inundation
Total	69.0			

a. Clear forest and dense forest

The lands which are not considered as arable land at present, all fall in the class III or IV of the land productivity classification.

b. Marshy land

It is to be noted that the soil of the marshy lands which are inundated during the rainy season, all fall in the class II. The soil of these marshy lands may be classified into the following categories; Pongro, Bos Leav soil series bearing a soil texture of SiCl to SiL and are suitable for upland field, and Russei Cha, Sambok, Moreum series bearing a soil texture of C are suitable for paddy field.

c. Upland field

The soil series of the upland field are the sedimented silt of the Mekong, and are distributed at the natural levee and its back slope. These areas are used as upland field. This soil has a good drainage capability and on the other hand, it has a great available moisture (refer to C-4-3., "The field capacity is greater than that of the paddy field . . . .") Even during the dry season, the roots grow deep into the ground enabling them to absorb the moisture. Therefore, it is understandable that the *colmatage* is being experimented in various parts of the country.

d. Paddy field

The existing stabilized paddy fields are limited to dry seasonal paddy fields having irrigation facilities from the marsh. An experiment is being made partially for the rain-fed rice cropping in the area with relatively shallow inundation, however, it is being an unstabilized cultivation because the following factor varies each year; the start of the flood, the maximum flooded water level and its period, and the rising speed of the water table. This is worse and less stabilized than the rainy seasonal paddy field in the bottom valley of the hilly-lands.

Table IV-30 indicates the relation between the existence of inundation each year and the soil productivity. It is an interesting fact that the inundation has a lot to do with the degree of fertility.

Table IV-30 Recapitulation of the soil classification

Soil series		Area (ha)	Drainage class	Soil texture	Capability classification: Upland	Capability classification: Paddy	Existence of inundation
1.	Chong Kaoh	400	Good	S	III		Inundation
2	Pongro	2,500	Good	SiL	II		50% inundation
3.	Bos Leav	5,300	Good	SiCL	II		50% inundation
4	Moreum	1,000	Very poor	HC		II	Inundation
5.	Pou	300	Good		IV		No
6	Prek Chamlak	900	Moderately good	HC	II	II	No
7.	Sre Prang	1,100	Moderately good	HC	IV		No
8	Stung Preak	300	Good	SL		III	40% inundation
9	Kampi	2,500	Moderately good	CL	{III, IV		No
10	Roha	4,600	Good	LiC		III	40% inundation
11	Sambok	24,000	Moderately good	HC	III	II	70% inundation
12.	Russei Char	6,500	Poor	HC		II	Inundation
13	Krakor	6,300	Good	LS	{III, IV		No
14	Keng	1,500	Good	LS	III		No
15	Tuol	8,800	Moderately good	LS/CL	III		No
Lakes and ponds		3,000					
Total		69,000					

Table IV-31 Existing cropping area and its intensity

Name of district \ Item	Cropping area: Paddy field, Rainy season: Paddy	Paddy field, Dry season: Paddy	Upland field, Rainy season: Maize	Upland field, Rainy season: Mung bean*	Upland field, Rainy season: Sesame	Upland field, Dry season: Maize	Upland field, Dry season: Mung bean*	Upland field, Dry season: Peanut	Upland field, Dry season: Sesame	Upland field, Dry season: Tobacco	Total
Kratie	880	370	380	-	-	120	260	30	-	90	2,130
Prek Te (R)	740	-	-	-	-	-	-	-	-	-	740
Prek Te (L)	-	-	150	-	-	40	30	30	-	30	280
Bos Leav	70	50	870	-	-	330	290	40	-	110	1,760
Kanhchor	120	210	30	-	-	60	10	10	-	20	460
Chhlong	1,300	70	1,030	20	-	790	-	130	0	270	3,610
Saop	840	40	430	-	100	200	120	40	0	0	1,840
Prek Prasap	30	100	1,020	-	240	510	240	90	170	160	2,560
Ta Mau	350	70	170	-	20	170	10	10	10	30	840
Kaoh Trung	-	-	200	-	-	100	30	20	0	30	380
Kaoh Chreng	-	-	510	-	0	300	40	40	0	90	980
Kaoh Tasuy	-	-	560	0	120	420	120	50	90	40	1,400
Total	4,330	910	5,350	20	480	3,040	1,150	490	270	940	16,980
Cropping intensity (%)	82	17	67	-	6	39	15	6	3	12	129

Note The cropping intensity has been computed against the existing arable area (paddy field 5,280 ha), upland field (7,850 ha) in the project area (refer to Table IV-72)

The existing cropping area has been taken from *"Secteur Agricole de Kratie – (1963-65)"*

* *Phaseolus Radiatus L. Var Typicus* PRAIN

D-2-4 Cropping

The cropping in this area is dominated by the inundation, and the pattern is not consistent. Table IV-31 indicates cropping area by crop and cropping intensity.

a. Paddy field rice

Hatif (Early maturing rice): Growth period is about three to four months. There are cases when they are direct casted after the land contains enough moisture by the rainfall, but in most cases, they are sowed in the nursery bed and then transplanted in about 25 days to the paddy field. Where the land is low, the cropping is done during the dry season. Sow in May, transplant in June, flowering in August - September, and harvest in September - October.

Mi-Saison (Semi-Seasonal rice): Growth period is about for-five months. Sow in May - June, nursery, period about 40 - 50 days, transplant in July - August, flowering in November, and harvest in December. This variety is usually harvested earlier than the Saison which is described hereinafter, and as a whole, the cropping area is smaller than the Saison.

Saison (Seasonal rice): Growth period is about six months. This variety has the typical and fundamental cropping pattern for rice. The cropping area is the largest. Sow in May - June, nursery period about 40-50 days, transplant in July - August, flowering in December, and harvest in January.

Tardif (Late maturing rice): Growth period is about seven - eight months. Sow in May - June, transplant plant in July-August, flowering in December, and harvest in January. Among the rainy seasonal single cropping above stated rice, the semi-seasonal variety are planted in the paddy field at relatively high altitude, the seasonal variety is planted in the lower land than the former, and the late maturing variety is planted even lower than the seasonal variety.

Flottant (Floating rice): This variety grows in the flood area of low altitude where the flood water covers the ground 2 m deep or more, sometimes 4 m-5 m deep and is harvested when the flood water retreats. Also this variety is sown in the late April to early May, and cultivated without transplanting. After it is sown, it only requires the surface soil to be puddled once, and then it requires no care until harvesting. If the water rise is up to within 10 cm a day, the rice plant will grow without any harm. Unit yield is generally large but the quality of the rice is bad. This variety is not planted in Kratie Province.

Saison Seche (Flood retreating rice) (Dry seasonal rice): Preliminary sowing in the nursery bed is made in November, when the flood water retreats. Duration in the nursery bed will be about one month, and transplanting takes place in December and it will be ready for harvesting in three months. This is an early maturing variety. Since this rice is grown during the flood retreating period, it is called Flood retreating rice. The harvesting is done in April or May.

b. Upland field crop

The principal crops of the upland field are maize, mung bean, peanut and tobacco, etc.

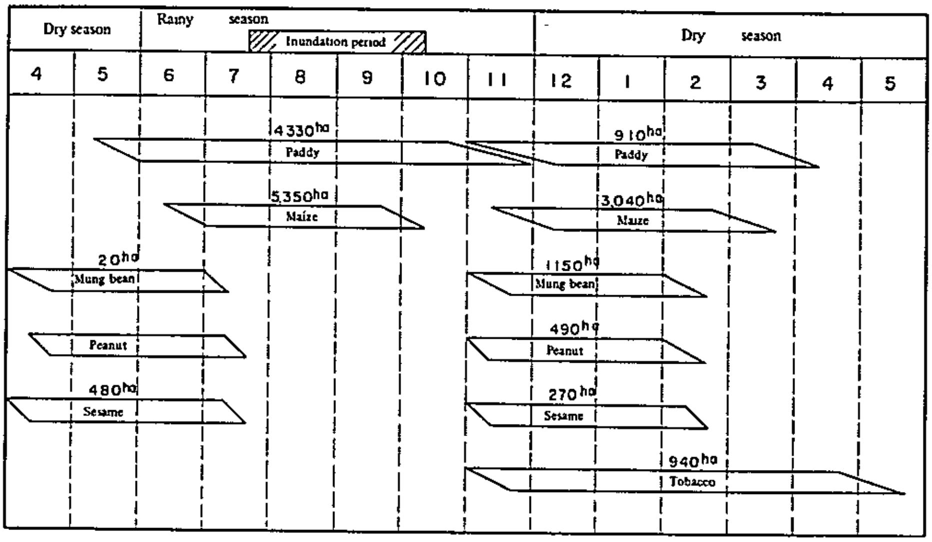
Maize: Growth period is about three to four months, and may be classified into rainy seasonal maize and dry seasonal maize. The former is sown in June to July, when the soil contains the moisture by the rainfall, and harvested in September to October. The latter is sown after the water from the Mekong retreat, therefore, it will be sown in November through December and harvested in February or March of the following year.

Mung bean, Peanut and Sesame: Growth period is about three months, and is cropped both in the rainy and dry season. The cropping during the rainy season is sown in April, taking the advantage of the rainfall, and harvested around July. And for the cropping in the dry season, it is sown in November to December when the water from the Mekong retreats and is harvested around February of the next year.

Tobacco: Planted only in the dry season. Cropping period is from November to around May of the following year. This has a relatively long cropping cycle.

Fig. IV-21 indicates the cropping pattern of paddy field rice and upland field crops.

Fig. IV-21 Present cultivation period for main crops



D-3 Agricultural Products

D-3-1 Total Products

The principal agricultural products are rice, maize, mung bean, tobacco, sesame and peanut etc. Among these, the production of rice and maize are the greatest. The following table gives the average quantity of production (1963 - 65) for the main crops in Kratie Province.

Table IV-32 Quantity of production for main crops

(unit: ton)

Name of srok	Rainy season			Dry season					
	Paddy	Maize	Sesame	Paddy	Corn	Mung bean	Peanut	Sesame	Tobacco
Srok Kratie	6,079	2,373	28	150	247	960	89	18	231
Srok Chhlong	3,507	4,243	33	640	2,404	19	7	15	369
Srok Sambor	4,423	-	2	-	2	28	3	1	1
Srok Prek Prasap	4,800	2,600	150	437	1,073	300	47	149	471
Srok Snoul	3,538	2	-	-	-	-	-	-	-
Total	22,347	9,218	213	1,227	3,726	1,307	146	183	1,072

Note. This data is obtained at *Secteur Agricole de Kratie, "Liste des superficies et production prévues des cultures sainon hieres et saison sèche dans compagne 1963 - 65".*

The paddy field rice in Cambodia is mainly rainy seasonal rice taking advantage of the rainfall, and covers 90% of the total rice production. Majority of the produced paddy are provided for subsistence, and then for export and conserved for seeds, and the remainder for industry and livestocks For subsistence, the computation is made on the basis of 228 kg per capita per year, and in 1963 - 64, it runs about 50% of the total production. And for the export, in 1962 - 63, it runs about 28% of the total production. In the Kratie Province, according to the survey of *Secteur Agricole de Kratie,* it is yet insufficient to be self-sustained in the province, and has to depend upon the importation from Kompong Cham Province.

That is, the consumption for subsistence is 31,000 ton, for seeds 2,000 ton, and process loss 2,000 ton, which total being 35,000 ton, against 25,000 ton of the total production in the province. As it is clear, 10,000 ton shortage exists. In the above computation, the paddy for seeds are estimated at 80 kg/ha of cultivated land, and above 10% of the total production is considered for the loss.

Maize is one of the important export goods in Cambodia, along with rice and rubber. And also in Kratie, corn is given a special attention for the training of the farming technique. A cooperative for the corn is also underway, and is benefiting the farmers in training on production methods and marketing.

Cropping area of the tobacco is also expanding, and the dry plant is constructed to improve the quality.

D-3-2 Per Unit Yield

In this district yield per hectare has been determined as follows:

Paddy field rice	(rainy season)	1.1 ton
" " "	(dry season)	1.0 "
Maize	(rainy season)	1.3 "
"	(dry season)	1.1 "
Mung bean	(rainy season)	0.7 "
" "	(dry season)	0.7 "
Peanut	(rainy season)	0.7 "
"	(dry season)	0.7 "
Sesame	(rainy season)	0.6 "
"	(dry season)	0.6 "
Tobacco	(dry season)	0.7 "

To determine the per unit yield, the following fundamental material and data are used.

"Liste des superficies et production prévues des cultures saison hieres et saison sèche dans compagne 1963-65" compiled by *Secteur Agricole de Kratie.*

From the above data, the mean value of valid data for a period of three years (pertaining to the beneficial-area), has been adopted as existing per unit yield. The procedures for determining the unit yield are as follows;

Table IV-33 Paddy (unit: t/ha)

Srok	Rainy season				Dry season			
	1963	1964	1965	Average	1963	1964	1965	Average
Kratie	1.20	1.18	1.18	1.18	1.29	1.00	1.00	1.09
Chhlong	1.00	0.95	0.95	0.96	1.00	1.00	1.00	1.00
Average				1.07				1.04

The mean per unit yield for entire Cambodia is 1.07 t/ha for the year of 1964 through 1966.

Table IV-34 Maize (unit: t/ha)

Srok	Rainy season				Dry season			
	1963	1964	1965	Average	1963	1964	1965	Average
Kratie	0.75	1.20	2.00	1.31	1.20	1.00	1.50	1.23
Chhlong	1.10	1.00	2.00	1.37	1.00	1.00	1.20	1.07
Average				1.34				1.15

The mean per unit yield for entire Cambodia is 1.17 t/ha for the year of 1964 through 1966.

Table IV-35 Mung bean (unit: t/ha)

Srok	Dry season			
	1963	1964	1965	Average
Chhlong	1.00	0.65	0 52	0.72

Table IV-36 Peanut (unit: t/ha)

Srok	Dry season			
	1963	1964	1965	Average
Kratie	1.00	0.80	0 80	0.83
Prek Prasap	0.31	0.75	0.75	0.60
Average				0.71

Table IV-37 Sesame (unit: t/ha)

Srok	Rainy season				Dry season			
	1963	1964	1965	Average	1963	1964	1965	Average
Kratie	0.50	0.35	0.60	0.48	0.34	-	0.60	0.47
Prek Prasap	-	0.50	0.75	0.63	0.40	0.74	0.74	0.62
Average				0.56				0.55

The mean per unit yield for entire Cambodia is 0 66 t/ha for the year of 1964 through 1966.

Table IV-38 Tobacco (unit: t/ha)

Srok	Dry season			
	1963	1964	1965	Average
Kratie	0.50	0 40	0.60	0.50
Chhlong	0 60	0.76	0 65	0 67
Prek Prasap	0.70	0.91	0.90	0.83
Average				0 66

The mean per unit yield for entire Cambodia is 0 61 t/ha

D-3-3 Price for Agricultural Products

The price for agricultural products in the project area is determined as follows;

Table IV-39 Price for agricultural products (unit: $/t)

Srok	Paddy	Maize	Mung bean	Peanut	Sesame	Tobacco
Kratie	72.2	57.1	185.7	-	252.9	654.3
Chhlong	71.3	68.6	200.1	-	-	645.1
Prek Prasap	71.3	56.7	181.4	-	204.0	448.6
Average	71.6	60 8	189.1	200.1	228.5	582.9

Note:
1) Extracted the producer price from the data of *Secteur Agricole de Kratie.*
2) For the peanuts, it represents the average for Kratie Province which were picked out from *"Bulletin de la Statistique et des Etudes Agricoles (1964 - 65)".*
3) Used the conversion rate of $1 00 = 35 Riels.

D-4 Livestocks

Among the livestocks, cattle and buffalo are employed for plowing, harrowing and transportation, using them as an animal power, and pig and other poultries are used for meat, egg, etc. According to the survey of *"Service Vétérinaire et des Epizooties de Kratie – 1964,"* livestocks per family in Kratie Province, are as follows; 1.9 head of cows or 1.6 of buffalos, 0.8 of pigs and 7.3 of poultries There are many livestocks in the area lying on the right bank of the Mekong, and in Kratie and its surrounding area, the number of livestocks are relatively small.

For animal power, it is mainly used for cultivation works. According to the data obtained by verbal information from farmers on site and also from the data compiled in *"Centre d'elevage de la fraternité Khméro – Japonaise,"* the efficiency of the work by two cattles is shown as the following table.

Table IV-40 Efficiency of the work by two cattles

Work	Efficiency of the work per day	Required days per ha	Required days for 2 times work
Plow	0.2 ha	5 days	10 days
Harrow	0 6	2	4
Total		7	14

Livestocks are breeded and grazed without any enclosure. No particular grass or fodder crops is planted for the livestock

In regard to the technical advice and instructions for the livestocks, the veterinarian office under direct supervision of the Department of Agriculture handles the case, and in Kratie, there are eight officers. The major duties are to prevent the cattle disease and to breed superior brand. The expense for the vaccinations are covered by the government. Also these staffs take care of extention service of the technical know-how, and they visit each village to hold a lecture class.

D-5 Farm Implement

There are power operated machine and manually operated equipment in Cambodia. In general, animal power implements and manually operated implements are used in agricultural farming.

The main implement used is the Furgason 60 HP tractor, which in 1963 - 64, there were 618 tractors in Cambodia. Tractors are mainly used for the major paddy field districts, 375 in Battambang, 111 in Kompong Thom, followed by Kompong Cham, Siemreap and Pursat. Now, according to the survey made in 1962 through 1964 in Kratie Province, there were only 10 tractors and few small pumps.

As to animal power implements, plow, harrow, roller and cart are used, and as to manually operated *implements, hoe, sickle, mortar, winnowing fan and handmill are also utilized.*

Table IV-41 Possessive conditions of farm implement per household

	Farm implements											Numbers of household surveyed
	Plow	Harrow	Roller	Win-nowing fan	Mortar	Lift machin-ery	Cart	Fabric machine	Hoe	Sickle	Others	
Cambodia	0.302	0.278	0.000	0.009	0.162	0.013	0 212	0.021	0.149	0.781	0.701	3,683
Kratie	1.083	0 083	-	-	-	-	1.000	-	-	0.000	-	24

Note: Source of data

1) *Résultat du recensement par sondage des Manages Agricoles dans le Royaume* 1963 - 64.

2) *Bulletin de la Statistique et des Etudes Agricoles No. 4 1964, page 62*

3) Data compiled from the survey in *1963 - 64*

According to the verbal information, the farmers have 1.4 plows, 1.4 harrows and 0.9 rollers, and also 1 cart, 4 sickles and 3 hoes per household as an average, which number are little more than that of the above table.

Although price of those implements is uncertain owing to homemade, they are approximated to as follows; 150 Riels each for plow and harrow, 100 Riels for roller, 2,300 Riels for cart, 68 Riels for hoe and 18 Riels for sickle.

Recently, shoulder sprayers for pest controls are being provided in the Srok Office, and pest control is being undertaken under the leadership of the officers. There are farmers conducting insect control for peanuts using Endrin at Phum Bos Leav on the left bank of the Mekong.

The majority of farmers have storage facility of paddy in their houses.

D-6 Fertilizer and Insecticide

Consumption of fertilizer and insecticide seems to be little in Cambodia though it is not certain quantitatively, and these floating assets are not so generalized in agricultural technique system.

Table IV-42 Ratio of household using the fertilizer in the paddy field

	Number of households surveyed		Number of household Fertilization		No fertilization	
Cambodia	3,683	(100%)	1,077	(29.2%)	2,606	(70.8%)
Kratie	24	(100%)			24	(100%)

Note: Sources of data

1) *Résultat du recensement par sondage des Manages Agricoles dans le Royaume (1963 - 64)*
2) *Bulletin de la Statistique et des Etudes Agricoles No. 4 1964, page 62.*
3) Data compiled from the survey in 1963-64.

In Kratie Province, poultry excrements and manure are utilized for tobacco nursery on the right bank of the Prek Te, and some farmers at Kaoh Trung who specialized upland farming utilize bean-cake and ammonium sulphate as fertilizer.

The Government of Cambodia has attached importance to fertilizer for rice cultivation development and has made the following plans, that is by the end of the second five-year program (1967) 10,860 ton of ammonium and 21,720 ton of hyperphosphate to 181,000 ha of cultivated land (equivalent to 10% of whole Cambodian cultivated land), by the end of the third five-year program (1975) 32,500 ton of ammonium and 65,160 ton of hyperphosphate.

There are one (1) fertilizer plant constructed in 1966 at Kampot and produces 12,000 ton of fertilizer a year. Furthermore, a program to construct an ammonium fertilizer plant will be promoted.

D-7 Basic Data for Farm Budget Analysis

The survey data pertaining to the production cost for the agricultural products may be obtained from *"Bulletin de la Statistique et des Etudes Agricoles No. 4, 1964."* This bulletin was compiled from the reports submitted by the Secteur Agricole of each province to Agricultural Statistic Department at the Central Government. Furthermore, direct hearing survey from individual farmers was made to compute the required working days by each crop (Table IV-43), and then the production cost was calculated as indicated in Table IV-44.

As under described para. C-4 and C-5 it may be considered that no measure has been taken against fertilization and pest control.

The farm works are conducted by animal power and human power. Heavy duty required in farming is the plowing work. For this reason, each farmer has an ox or a buffalo to do this work along with the hauling of the products. And for planting and harvesting which require concentrated manpower simultaneously, there are some cases where they make a cooperative work.

The annual net income for an average farmer (farm-size of 2 ha) is $90, and annual income including the labor cost is $231. As to the detail, it is described in Chapter H. Economic Analysis.

Table IV-43 Required working days by each crop (present) (unit: day/ha)

Name of crops \ Name of works	Plow 1 time	Plow 2 times	Harrow 1 time	Harrow 2 times	Sow, Trans-plantation	Fertili-zation	Manage-ment	Harvest	Thresh-ing	Hauling	Total
Paddy	7	5	4	3	1	-	9	6	7	3	45
Maize	7	5	4	3	8	-	9	7	6	5	54
Mung bean	7	5	4	3	8	-	12	10	8	6	63
Peanut	7	5	4	3	12	-	10	7	6	2	56
Sesame	7	5	4	3	8	-	12	10	8	6	63
Tobacco	10	5	6	4	20	-	40	50	120	20	275
Fodder	-	-	-	-	-	-	-	-	-	-	-

D-18

Note: By the data furnished by *Secteur Agricole de Kratie.*

Table IV-44 Production cost by each crop (unit $/ha)

Name of crops \ Expense	Labor force	Fertilizer	Pest control	Seed	Tax	Depreci-ation	Total Rainy season	Total Dry season	Remarks
Paddy	38.6	-	-	5.7	1.0 (0.2)	4.3	49.6	48.8	( ) shows the figures of the dry season
Maize	46.3	-	-	1.9	1.2 (0.5)	1.7	51.1	50.4	
Mung bean	54.0	-	-	7.5	0.2 (0.3)	4.3	66.0	66.1	
Peanut	48.0	-	-	8.6	- (0.2)	4.3	60.9	61.1	
Sesame	54.0	-	-	9.1	0.2 (0.2)	4.3	67.6	61.1	
Tobacco	235.7	-	-	85.7	0.2 (0.2)	4.3	325.9	67.6	
Fodder	-	-	-	-	-	-	-	325.9	

Note 1) By the data furnished by *Secteur Agricole de Kratie*

2) Figures in the original data were shown in Riels, but they were converted into dollars, at the rate of $1.00 = 35 Riels

CHAPTER E. PROJECT PLAN

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E-1 Introduction

Although the agricultural development is needed and a vital importance to any region of Cambodia, the priority of the agricultural development of this area may not always be high compared with other regions. The main purpose of this project is not for the agricultural development, which has been supplemented to the navigation and the hydropower generation by the construction of the Sambor dam.

The Sambor Project area does not belong to the plains, but to the area between the plains and hills. Rain-fed irrigation has been the main water resources for the farmlands, and the farming has been unstabilized, because the beginning of the rainy season fluctuates.

Irrigation water for the dry seasonal cropping, and supplemental irrigation for the rainy seasonal cropping are necessary, and the means to enable the above are either to provide a gravity irrigation system from the reservoir or lift irrigation. However, the necessity of constructing irrigation facilities are common for most of the farmland in Cambodia. Thereby, this project area is fortunate to have the Sambor Dam Project nearby, which will make the artificial irrigation possible.

69,000 ha situated in the immediate downstream of the dam site was designated as an area to be investigated for the development. Considering the natural and social characteristics of the area, approximately 38,410 ha of an area downstream of the dam is selected (Irrigable area is 34,000 ha), and this area is divided twelve districts to plan the agricultural development.

First, the irrigation area by gravity water from the huge Sambor dam, it was physically going to be extremely large, covering the area downstream from the dam site with an elevation of below 40 m.

However, as it is obvious from the topographic map, the elongated plains with the elevation of below 40 m develop on both banks of the Mekong, especially on the downstream of two main tributaries, the Prek Te and the Prek Prasap. The gravity irrigation for these plains would be veryuneconomical because it would necessitate a long canal. Therefore, at this stage, the project area is limited to the area within Kratie Province, and the survey area is determined to be 69,000 ha with an elevation below 40 m. Moreover, the result of the soil study indicated that there are only 40,200 ha of class II land (by productivity classification) which consist of 31,500 ha for paddy fields, and 8,700 ha for upland fields, and all the remainder fall under class III or IV. There is no class I area. Therefore, from the result of the soil investigation and analysis and from the topographical disadvantage for irrigation, 38,410 ha with priority given to the class II land is selected for this project study.

As for the water resources, the local tributaries and ponds shall be used at first, and from the cost analysis, the project area of 38,410 ha will not be irrigated with direct gravity flow through the irrigation canal from the dam, but in some cases, water will be lifted from the Mekong. It is needless to say that this type of agricultural development will contribute greatly to the development of Kratie Province, and moreover, it will serve to demonstrate various types of agricultural water resources development as a model case, which plays an important role in leading the agriculture development in Cambodia.

E-2 Survey and Mapping

E-2-1 Survey

The agricultural survey consisted of four technical fields, which are farm management, land use, soil and water utilization, and the experts of the respective fields performed their surveys during the period of 1963 to 1967. The outline of the survey by the various fields is as follows:

a. Farm management

In order to find out the existing agricultural conditions, an investigation for actual circumstances was conducted as follows; to collect data from the organizations concerning agriculture, to make survey and analysis on the administrative functions and marketing system, and to gather verbal information directly from the farmers. Furthermore, data were collected and hearing was made, to make an assumption for the production increase as a consequence to the improvement of land and water utilization.

b. Land use

The survey was made in relation to the soil fertility, topography and especially to the condition of inundation, which all have binding elements for the planning of land use, after finding out the current land use condition from the statistics and reconnaissance.

c. Soil

Topographical classifications are made from a map drawn at a scale of 1:50,000 and an aerial photograph of 1:40,000. At a typical spot of each type of topographical plain, soil samples were taken and their physical and chemical characteristics were analyzed at the laboratory. And then, in accordance with these results, the soil in the Sambor area is classified into twelve soil series. These soil series are used to judge the possibility for agriculture development.

d. Water utilization

Following survey and analysis were conducted; (1) collect and analyze the meteorological and hydrological data observed and recorded by the Government of Cambodia, (2) study and analyze the water requirements, (3) meteorology–rainfall evaporation–hydrology by the newly established instruments in the Sambor area. By the reconnaissance and verbal information in the project area, current practice of water utilization was found out and especially, thorough investigation was performed on the inundation and the *colmatage* which is the salient feature of water utilization in Cambodia.

E-2-2 Mapping

The maps available for this survey were those prepared by the Government of Cambodia at a scale of 1:100,000 and 1:250,000, and 1:50,000. As for the study on the feasibility stage, a map with at least 1:20,000 with 1 m contour intervals will be necessary. Therefore, the Government of Cambodia had completed the necessary portion of the map to the required scale and contour intervals in 1967, based on the aerial photograph taken in 1958. The rough preliminary investigation was made with the 1:50,000 scale map, and in the final stage project was formulated with a map of 1:20,000 scale.

E-3 Plan of Land Utilization

E-3-1 Determination of Area to be Developed

For the determination of this development project area, survey in regards to the conditions of land and water utilization, etc. were performed for the area from proposed Sambor dam site to the left bank region of the Prek Chhlong for the left bank of the Mekong, and down as far as Kaoh Tasuy for the right bank region of the Mekong, which river basin extends approximately 40 km with an elevation below 38 m, having an area of 69,000 ha.

First of all, as a result of the soil survey, some 45,000 ha is selected suitable for cultivation which mainly falls in the class II by the soil productivity classification. Furthermore, from the study made on the water utilization scheme, the irrigation facilities become great from the topography, thus eliminating the uneconomical area, 38,410 ha (net arable area: 34,000 ha) is selected for the development under this project.

E-3-2 Plan of Land Utilization

a. Objective for development

i) Stabilization of the production of the rainy seasonal rice: The rainy seasonal paddy fields in this project area are mostly rain-fed fields situated at the bottom plain of the hilly-lands, and they are greatly influenced by the rainfall conditions, thus making the production unstabilized.

Therefore, this project aims to stabilize the water resources for the rainy seasonal paddy fields of 4,330 ha, and to stabilize the production increase by adequate fertilization, pest control and also by introducing new varieties of crops.

ii) Reclamation of the paddy field: To reclaim 14,803 ha of land in the project area, which are now left as a marshy land and clear forest region, non-flooded area will have rainy and dry seasonal cropping (double cropping), and flooded area will have only the dry seasonal cropping (single cropping).

iii) Adopting double cropping: In order to improve the land utilization ratio, it is necessary to provide the irrigation water for the existing rainy seasonal paddy fields of 4,330 ha, and to enable the dry seasonal cropping.

iv) Stabilization of the water resources for dry seasonal rice: To stabilize the production, abundant irrigation water should be provided for the present dry seasonal paddy fields of 910 ha.

v) Stabilization of the upland products by the irrigation and increase of the land utilization ratio: Increase and stabilization of the products will be expected by the irrigation for existing upland fields. Present land utilization ratio of 129% will be change to 179%. (refer to Table IV-31, IV-47)

vi) Land reclamation for upland field: Along with the *colmatage* to increase the soil fertility, 6,728 ha of land will be reclaimed for the upland fields in order to expand the cultivated area.

b. Determination of crops to be introduced in the area

i) Rice and maize: The rice production in Kratie Province is extremely low compared with the required quantity. Only about 60% of the required staple food for the present population is produced, hence depending upon that from Kg. Cham Province and others. It is necessary to establish a self-sufficient base for the province, and moreover it is necessary to expand the paddy field area to increase the rice production to cope with the anticipated growth of population.

And also from the standpoint of assuring or increasing the export of rice which is one of the principal farm products in Cambodia, progressive attitude should be taken toward the increase of the rice production.

Furthermore, the production of maize should also be increased, as this is another important export item next to the rice and is well stabilized and bears a tendency to expand. From the above points of view, the crops to be introduced in this project area should be focused on the rice and corn.

ii) Tobacco: In Kratie, Bos Leav, and Chhlong, a contract has been signed with the tobacco factories, and the plantation and cropping are in an increasing trend, and moreover a drying plant has been constructed. Therefore, the assumption was made to the effect that the tobacco cropping is going to increase.

iii) Other crops: At present, the major crops introduced to this project area beside the above stated crops, are mung beans, peanuts, and sesame etc.

Sesame is harvested mainly in the area lying on the right bank of the Mekong, and existing cropping area will also be maintained in this project planning.

And for relatively highland in the flood area, mung beans and peanuts, which are to be harvested before the rainy season, (by mid-July) are scheduled to be planted, in order to maintain the soil fertility and to promote the agricultural income.

Furthermore, livestocks, such as oxen and buffalos, are to be increased to serve as an animal power for the farming and to produce manure for raising the soil fertility. And study is made to bring in some crops to fit manure fertilizing (fooder crops).

c. The basis to determine the classification of land use

The land use classification for cultivation of upland fields and reclamation of paddy fields, is determined by considering the soil productivity classifications and flood conditions.

The soils of the marshy land, which are flooded in the rainy season, generally have a high productivity, since flood water carries fertile soils and these fertile soils are sedimented in the area. Among these soils, clay is suited for paddy fields, Sil-SiCl, for upland fields. Even if the soil is unsuitable for upland fields, it could be reclaimed to suit upland fields by applying the *colmatage.*

From the above points of view, the area is divided into twelve districts in this project, and each district is checked against the suitability for either paddy fields or upland fields, hence formulating the land use classification.

Present and proposed land use for the project area are given in Table IV-45.

Table IV-45 Project area compared with present and proposed (unit: ha)

Present \ Future		Paddy field			Upland field			Total		Remarks
		Net arable paddy field	Canals and road, etc. 1/	Sub-total	Net arable upland field	Canals and road, etc.	Sub-total	Net arable paddy field	Canals and road, etc.	
Paddy field	5,280	5,017	263	5,280						Existing arable land
Upland field	7,850				7,452	398	7,850			
Subtotal	13,130							12,469	661	
Clear forest	3,070	1,508			1,006					Non-cultivated land at present (to be reclaimed in future)
Dense forest	1,500	75			1,040					
Bushwood	6,520	3,577			2,166					
Grassland	14,190	9,643			2,516					
Subtotal	25,280	14,803	2,580	17,383	6,728	1,169	7,897	21,531	3,749	
Total	38,410	19,820	2,843	22,663	14,180	1,567	15,747	34,000	4,410 2/	

1/ Non cultivated area used for canals and road, etc.

2/ Out of 38,410 ha, which is selected for the project study, 4,410 ha is eliminated as the site of canals and roads, or the land required for pasture of cattles, and is equivalent to about 5% of the existing arable land and about 15% of the reclaimed land.

E-3-3 Cropping Plan

a. Planned cropping area and cropping intensity

The cropping plan is determined in accordance with E-3-2.

Table IV-46 Cropping plan (Present, future) (unit: ha)

	Paddy field				Upland field			
	Rainy season		Dry season		Fodder	Rainy season		
	Paddy rice	Mung bean	Paddy rice	Maize		Maize	Mung bean	Sesame
Present	4,330	-	910	-	-	5,350	20	480
Future	9,196	5,320	19,530	290	1,957	7,351	1,916	483

	Upland field						Total
	Rainy season	Dry season					
	Peanut	Maize	Mung bean	Sesame	Peanut	Tobacco	
Present		3,040	1,150	270	490	940	16,980
Future	2,473	10,188	198	270	192	1,375	60,739

Table IV-46 indicates the entire cropping area of the this project, and furthermore, the figures for the twelve districts of the project area are given in Table IV-47. The cropping intensity of this project becomes 179%. And dividing by the season, the cropping intensity for the paddy fields during the rainy season is 73%, and 100% in the dry season. As for the upland field, it is 100% for both the rainy and dry season, which will be 200% per year.

b. Cropping patterns

The proposed cropping pattern is indicated in Fig. IV-22.

Fig. IV-22 Planned cultivation period for main crops

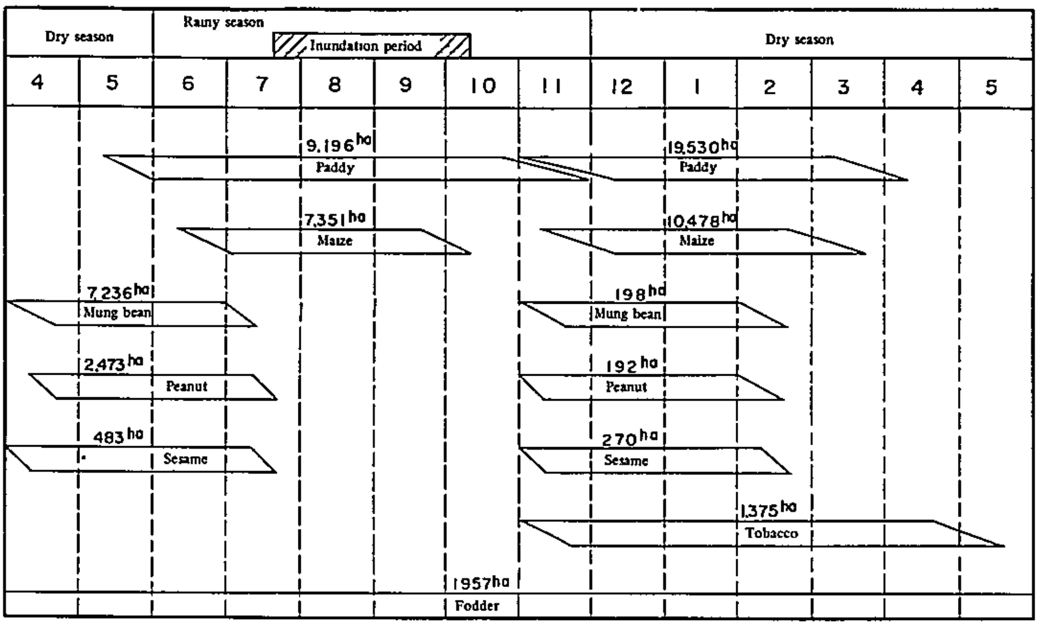


Table IV-47 Cropping area and cropping intensity (unit: ha)

Item / Name of district	Upland field														Total
	Paddy field				Upland field										
	Rainy season		Dry season			Rainy season				Dry season					
	Paddy	Mung bean	Paddy	Maize	Fodder	Maize	Mung bean	Sesame	Peanut	Maize	Mung bean	Sesame	Peanut	Tobacco	
Kratie	3,600	960	5,508		110	364	194		205	604	10		10	139	11,704
Prek Te (R)	872	240	1,051	290			4						4		2,461
Prek Te (L)		380	780		88	87				53				34	1,422
Bos Leav	206	300	815		210	1,369	100		202	1,455				216	4,873
Kanhchor	141	540	1,191		91	80	513		603	1,176				20	4,355
Chhlong	2,477	470	3,421		430	1,243	20			703			60	500	9,324
Saop	1,171	1,570	4,308		500	1,415	350	100	503	2,298				70	12,285
Prek Prasap	156	460	1,061		280	1,218	576	240	760	2,458		170		166	7,545
Ta Mau	573	400	1,395		70	188	159	17	200	514		10	10	30	3,566
Kaoh Trung					20	227				147	30		20	30	474
Kaoh Chreng					38	600				434	38		38	90	1,238
Kaoh Tasuy					120	560		126		346	120	90	50	80	1,492
Total	9,196	5,320	19,530	290	1,957	7,351	1,916	483	2,473	10,188	198	270	192	1,357	60,739
Cropping intensity (%)	46	27	99	1	14	52	14	3	17	72	1	2	1	10	179

Note: Cropping intensity is calculated by using the designed area of paddy field of 19,820 ha and designed area of upland field of 14,180 ha.

E-3-4 Livestocks

At present, in this project area, there are about 13,000 cattle mobilized for cultivation and conveyance in relation to the farming. Therefore, in this project planning, cattle will be used as they have been, and in the future, the plan intends to shift gradually towards mechanization. Based on one cattle per ha, the required number of cattles will be 34,000, as the farmland in the project area is 34,000 ha. This means, additional 21,000 cattle should be brought in. And the fodder crops will be wild grass, straw, and stems and leaves of the corn as done at present, but to serve the anticipated increase of the cattles, an upland field for fodder crops occupying an area of 1,957 ha (which is about 30% of the required quantity) is reserved, and tropical kudzu, para grass, etc. will be grown as fodder crops. By bringing in these cattle, the manure at one cattle per ha will be made available, and this provides supplemental organic matter to the soil, hence an increase in the yield is expected.

E-3-5 Farming Technique

It will become necessary to acquire an up-to-date technique for cropping, such as to change over to enjoy the benefit of irrigation rather than to depend solely upon the natural cause, and also to convert to fertilized agriculture from the non-fertilized practice which prevails in the area.

It is of vital importance to select suitable varieties, to apply fertilizers as required, to control the pest, and to perform and adopt other necessary measures, in order to ensure the field benefit of this project. To meet all these requirements, the training, guidance, and extension service should be performed through a demonstration farm.

a. Fertilization plan

According to the test results of the Agricultural Center of Battambang Province, when 60 kg/ha each of N, P_2O_5 and K_2O were applied, the production of paddy rice and corn have the highest yield, and 30 kg/ha comes next. Therefore, for this project, the following figures are derived;

For paddy rice, maize and tobacco:	60 kg/ha each of N, N_2P_5 and K_2O
For other crops:	30 kg/ha of N, P_2O_5 and K_2O

b. Pest and insect control plan

At present, almost no measures is taken for the pest and insect control. The Endrin, and DDT are being applied to only a portion of the upland fields, but since the rice borer and rice-blight are likely to damage the paddy rice in the future, BHC, DDT, and Endrin should also be applied to these fields.

c. Others

For the time being, the cropping varieties for each crop will be those used at present, but they are to be renewed gradually by superior varieties. The sowing rate will be the same as those at present, that is 80 kg/ha for paddy rice, 30 kg/ha for corn, and 40 kg/ha for other crops.

E-3-6 Computation of Production Cost

The production cost for each crop is estimated for the current stage and for the stage after the implementation of the project.

a. Current labor cost is determined, based on farming labor force (man-day/ha) which was obtained from the result of the survey by the Agricultural Office of Kratie Province and the "*Bulletin de la statistique et des Etudes Agricole.*" For the seed, tax, and depreciation, verbal information from the farmers is put into consideration in addition to the data submitted by the Agricultural Office of Kratie Province.

Table IV-48 Result of fertilizer experiment on typical rice variety

Variety	Fertilizer N, N_2O_5, K_2O			Production of paddy per ha	Index*
Sary-Kâun-Kath	0	0	0[kg]	2,559 kg	100
	30	30	30	2,079	81.2
	60	60	60	3,239	126.1
Néarrg-Stong	0	0	0	2,039	100
	30	30	30	2,706	132.7
	60	60	60	3,639	178.5
Néang-Rei	0	0	0	2,799	100
	30	30	30	3,093	110.5
	60	60	60	3,373	120.5
Néang-Champo	0	0	0	3,133	100
	30	30	30	3,413	108.9
	60	60	60	4,199	134.0
Pdouh	0	0	0	3,133	100
	30	30	30	3,786	120.8
	60	60	60	3,999	127.6
Khao-Long	0	0	0	3,106	100
	30	30	30	3,373	108.6
	60	60	60	4,159	133.9
Léas	0	0	0	3,426	100
	30	30	30	4,186	122.2
	60	60	60	4,853	141.7
Kâum-Trei	0	0	0	3,253	100
	30	30	30	3,399	104.5
	60	60	60	3,746	115.2
Phcar-Lom-En	0	0	0	2,666	100
	30	30	30	4,413	165.5
	60	60	60	5,199	195.0
Chhmar-Sar	0	0	0	3,479	100
	30	30	30	3,519	101.1
	60	60	60	4,346	124.9
Banteas-Phlouk	0	0	0	3,773	100
	30	30	30	3,213	85.2
	60	60	60	3,639	96.4
Tonle-Sap	0	0	0	4,199	100
	30	30	30	3,653	87.0
	60	60	60	4,546	108.3
Phear-Tien	0	0	0	2,986	100
	30	30	30	3,999	133.9
	60	60	60	4,253	142.4
Tjina	0	0	0	5,453	100
	30	30	30	6,053	111.0
	60	60	60	6,546	120.0

Note:

1) This data is compiled from the result of fertilizer experiment in Battambang Province.

2) Index is calculated by dividing the product which is harvested in the fertilized paddy fields by that of no fertilized paddy fields.

b. Proposed production cost

i) Farming labor force (man-day/ha)

(a) Cultivation: For sowing and planting, it will be the same as that for the present, the paddy cultivation will be performed by transplant-cropping system in its entirety, thus, the labor force will be inevitably increased for this cultivation.

(b) For fertilization and pest control, an addition 2 man-day/ha per crop will be incorporated.

(c) The operational labor force for irrigation of the upland field (one to two times in the rainy season, and about ten times in the dry season) is included.

(d) Harvesting, threshing, and hauling labor force: The labor force will be increased in proportion to the anticipated increase per unit yield.

ii) Fertilizer, pest control, and seed: Computation is based on the respective planned standards as described under para. E-3-5.

iii) Tax: The land tax is used as the current standard, however, this will result in reduction of the tax per unit yield, as the land utilization ratio increase by the implementation of the project.

iv) Depreciation: In order to cover the anticipated necessity of improving the various facilities and implements in proportion to the increase per unit yield, an additional amounts of the depreciation are included in the proposed one.

From the above fundamental data, the required working days and production cost are estimated as given in Table IV-51 & 52.

Table IV-49 Result of experiment on the effect of fertilizer, three essential elements for rice

Fertilizer N, N_2O_5, K_2O	Stem-length	Head-length	Number of head	Paddy product per ha	Index
0 - 0 - 0	105 cm	22.9 cm	7.3	2,566 kg	100%
30 - 0 - 0	116	23.1	10.0	3,728	145
0 - 30 - 0	108	23.0	7.8	2,948	115
30 - 30 - 0	124	23.2	9.3	3,873	151
30 - 30 - 30	124	23.4	9.3	4,103	160
(10 ton/ha)	123	23.8	9.9	3,973	155

Table IV-50 Result of experiment on the effect of fertilizer for maize

		Mekong alluvial soil	Inundated soil	Hydromorphic soil	Clear forest soil	Sand
Non-fertilizer	Product	65.88	51.0	40.0	26.0	59.0
	Percentage (%)	100	100	100	100	100
Three essential elements	Product	215.0	259.0	212.1	145.0	217.5
	Percentage (%)	327	509	530	558	368

Note: Both data in Table IV-49, 50 are compiled from the result of experiment in Battambang Province.

Table IV-51 Number of work days required (unit: day/ha)

		Plowing harrowing	Sowing Transplanting	Fertilizer	Operation	Harvesting	Threshing	Hauling	Total
(Rainy season)	Present	19	1	-	9	6	7	3	45
Paddy rice	Future	19	6	2	9	8	9	5	58
(Dry season)	Present	19	1	-	9	6	7	3	45
Paddy rice	Future	19	6	2	9	8	9	5	58
(Rainy season)	Present	19	8	-	9	7	6	5	54
Maize	Future	19	8	2	11	9	8	8	65
(Dry season)	Present	19	8	-	9	7	6	5	54
Maize	Future	19	8	2	14	9	8	8	68
(Rainy season)	Present	19	8	-	12	10	8	6	63
Mung bean	Future	19	8	2	14	12	10	8	73
(Dry season)	Present	19	8	-	12	10	8	6	63
Mung bean	Future	19	8	2	17	12	10	8	76
(Rainy season)	Present	19	12	-	10	7	6	2	56
Peanut	Future	19	12	2	12	8	7	3	63
(Dry season)	Present	19	12	-	10	7	6	2	56
Peanut	Future	19	12	2	15	8	7	3	66
(Rainy season)	Present	19	8	-	12	10	8	6	63
Sesame	Future	19	8	2	14	12	10	8	73
(Dry season)	Present	19	8	-	12	10	8	6	63
Sesame	Future	19	8	2	17	12	10	8	76
(Dry season)	Present	25	20	-	40	50	120	20	275
Tobacco	Future	25	20	2	45	60	144	26	322

Table IV-52 Production cost by crops (unit: $/ha)

		Labor force	Fertilizer	Pest control	Seed	Tax	Depreciation	Total
Paddy rice	Present	38.6	-	-	5.7	1.0	4.3	49.6
(Rainy season)	Future	49.7	58.6	25.7	5.7	0.3	5.1	145.1
Paddy rice	Present	38.6	-	-	5.7	0.2	4.3	48.8
(Dry season)	Future	49.7	58.6	25.7	5.7	0.9	5.1	145.7
Maize	Present	46.3	-	-	1.9	1.2	1.7	51.1
(Rainy season)	Future	55.7	58.6	12.0	1.9	0.7	2.1	131.0
Maize	Present	46.3	-	-	1.9	0.5	1.7	50.4
(Dry season)	Future	58.3	58.6	12.0	1.9	0.9	2.1	133.8
Mung bean	Present	54.0	-	-	7.5	0.2	4.3	66.0
(Rainy season)	Future	62.6	29.5	12.0	7.5	0.2	5.1	116.9
Mung bean	Present	54.0	-	-	7.5	0.3	4.3	66.1
(Dry season)	Future	65.1	29.5	12.0	7.5	0.2	5.1	119.4
Peanut	Present	48.0	-	-	8.6	-	4.3	60.9
(Rainy season)	Future	54.0	29.5	12.0	8.6	0.3	5.1	109.5
Peanut	Present	48.0	-	-	8.6	0.2	4.3	61.1
(Dry season)	Future	56.6	29.5	12.0	8.6	0.2	5.1	112.0
Sesame	Present	54.0	-	-	9.1	0.2	4.3	67.6
(Rainy season)	Future	62.6	29.5	12.0	9.1	0.2	5.1	118.5
Sesame	Present	54.0	-	-	9.1	0.2	4.3	67.6
(Dry season)	Future	65.1	29.5	12.0	9.1	0.2	5.1	121.0
Tobacco	Present	235.7	-	-	85.7	0.2	4.3	325.9
(Dry season)	Future	276.0	58.6	12.0	85.7	0.2	5.1	437.6

E-3-7 Determination of Unit Yield

Proposed unit yield is determined depending on such factors as the land productivity classification (refer to C-3-2 and D-2-3), *colmatage* and the test result for the respective crops. And the entire project area is classified into category I - II taking into consideration that all *colmatage* areas fall into category I as the soil fertility will be improved by it.

Table IV-53 Present and proposed unit yield (unit: t/ha)

		Present	Future		
			I	II	III
Paddy rice	Rainy season	1.1	3.2	3.0	2.9
	Dry season	1.0	3.2	3.0	2.9
Maize	Rainy season	1.3	4.2	4.0	3.8
	Dry season	1.1	4.2	4.0	3.8
Mung bean	Rainy season	0.7	1.4	1.3	1.2
	Dry season	0.7	1.4	1.3	1.2
Peanut	Rainy season	0.7	1.4	1.3	1.2
	Dry season	0.7	1.4	1.3	1.2
Sesame	Rainy season	0.6	1.1	1.0	0.9
	Dry season	0.6	1.1	1.0	0.9
Tobacco	Dry season	0.7	1.6	1.5	1.4

Mainly, the test results of *"Centre Technique Agricole de L'Amitie Khmero-Japonaise* (Agricultural Center)" are used as the basic data to assume the unit yield, but since there is a difference in the conditions of the land operation and custody between the laboratory and the farmers, about 80% of the above assumed unit yield is adopted for the farmers. However, these proposed figures may be acheived, only when the superior varieties are adopted, and the fertilization and pest control is performed.

The test examples are as follows:

a. Paddy rice

Table IV-54 Unit yield data of paddy rice in Cambodia (unit: t/ha)

Place experimented	Unit yield	Year experi-mented	Number of growth day	Fertilizer	Variety
Agricultural Center	4.10	1961	165 days	30 - 30 - 30 kg	Improvement variety
" "	3.78	1965	118	50 - 50 - 50	Kong Khsach

80% of the above result should be taken for the farmers, and 3.0 t/ha yield is assumed. However, according to the test results for five consecutive years as performed by Dr. Ho Tong Lip, the result indicated 2.7 t/ha. Therefore, by adopting the new superior varieties, about 20% increase in unit yield may be expected.

Table IV-55 Unit yield data of paddy rice in Cambodia (unit: t/ha)

Experimenter	Unit yield						Fertilizer	Variety
	1961	1962	1963	1964	1965	Average		
Dr. Ho Tong Lip	2.647	2.504	2.277	2.160	2.064	2.330	30 - 30 - 30	Cambodia variety
	2.868	2.783	2.739	2.503	2.358	2.650	60 - 60 - 60	

b. Maize

Table IV-56 Unit yield data of maize in Cambodia (unit: t/ha)

Place experimented	Condition	Unit yield	Year experimented	Fertilizer	Variety
Agricultural Center	Irrigated	4.83	1966	100 - 100 - 100	Average of new 7 varieties

At the farmers' level, 80% of the above result should be adopted and the estimated yield will be 4.0 t/ha.

c. Others

There are few test data pertaining to the other crops, therefore, an assumption is made from only available actual figures collected from various areas.

E-3-8 Present and Proposed Production

The net benefits per unit area for the principal crops are computed from the data indicated under the para. D-3, E-3-6, and E-3-7. Table IV-57 to 67 give the computed table for each crop, and I, II and III indicated in the table represent the category indexes as determined by the soil productivity classification.

Table IV-57 Rice (rainy season)

Item		Present	Future		
			I	II	III
Unit yield	(t/ha)	1.1	3.2	3.0	2.9
Whole sale cost	($/t)	71.6	71.6	71.6	71.6
Products	($/ha)	78.8	229.1	214.8	207.6
Farm input cost	(")	49.6	145.1	145.1	145.1
Net product	(")	29.2	84.0	69.7	62.5

Table IV-58 Rice (dry season)

Item		Present	Future		
			I	II	III
Unit yield	(t/ha)	1.0	3.2	3.0	2.9
Whole sale cost	($/t)	71.6	71.6	71.6	71.6
Products	($/ha)	71.6	229.1	214.8	207.6
Farm input cost	(")	48.8	145.7	145.7	145.7
Net product	(")	22.8	83.4	69.1	61.9

Table IV-59 Maize (rainy season)

Item		Present	Future		
			I	II	III
Unit yield	(t/ha)	1.3	4.2	4.0	3.8
Whole sale cost	($/t)	60.8	60.8	60.8	60.8
Products	($/ha)	79.0	255.4	243.2	231.0
Farm input cost	(")	51.1	131.0	131.0	131.0
Net product	(")	27.9	124.4	112.2	100.0

Table IV-60 Maize (dry season)

Item		Present	Future		
			I	II	III
Unit yield	(t/ha)	1.1	4.2	4.0	3.8
Whole sale cost	($/t)	60.8	60.8	60.8	60.8
Products	($/ha)	66.9	255.4	243.2	231.0
Farm input cost	(")	50.4	133.8	133.8	133.8
Net product	(")	16.5	121.6	109.4	97.2

Table IV-61 Mung bean (rainy season)

Item		Present	Future		
			I	II	III
Unit yield	(t/ha)	0.7	1.4	1.3	1.2
Whole sale cost	($/t)	189.1	189.1	189.1	189.1
Products	($/ha)	132.4	264.7	245.8	226.9
Farm input cost	(")	66.0	116.9	116.9	116.9
Net product	(")	66.4	147.8	128.9	110.0

Table IV-62 Mung bean (dry season)

Item		Present	Future I	Future II	Future III
Unit yield	(t/ha)	0.7	1.4	1.3	1.2
Whole sale cost	($/t)	189.1	189.1	189.1	189.1
Products	($/ha)	132.4	264.7	245.8	226.9
Farm input cost	(")	66.1	119.4	119.4	119.4
Net product	(")	66.3	145.3	126.4	107.5

Table IV-63 Peanut (rainy season)

Item		Present	Future I	Future II	Future III
Unit yield	(t/ha)	0.7	1.4	1.3	1.2
Whole sale cost	($/t)	200.1	200.1	200.1	200.1
Products	($/ha)	140.1	280.1	260.1	240.1
Farm input cost	(")	60.9	109.5	109.5	109.5
Net product	(")	79.2	170.6	150.6	130.6

Table IV-64 Peanut (dry season)

Item		Present	Future I	Future II	Future III
Unit yield	(t/ha)	0.7	1.4	1.3	1.2
Whole sale cost	($/t)	200.1	200.1	200.1	200.1
Products	($/ha)	140.1	280.1	260.1	240.1
Farm input cost	(")	61.1	112.0	112.0	112.0
Net product	(")	79.0	168.1	148.1	128.1

Table IV-65 Sesame (rainy season)

Item		Present	Future I	Future II	Future III
Unit yield	(t/ha)	0.6	1.1	1.0	0.9
Whole sale cost	($/t)	228.5	228.5	228.5	228.5
Products	($/ha)	137.1	251.4	228.5	205.7
Farm input cost	(")	67.6	118.5	118.5	118.5
Net product	(")	69.5	132.9	110.0	87.2

Table IV-66 Sesame (dry season)

Item		Present	Future I	Future II	Future III
Unit yield	(t/ha)	0.6	1.1	1.0	0.9
Whole sale cost	($/t)	228.5	228.5	228.5	228.5
Products	($/ha)	137.1	251.4	228.5	205.7
Farm input cost	(")	67.6	121.0	121.0	121.0
Net product	(")	69.5	130.4	107.5	84.7

Table IV-67 Tobacco

Item		Present	Future I	Future II	Future III
Unit yield	(t/ha)	0.7	1.6	1.5	1.3
Whole sale cost	($/t)	582.9	582.9	582.9	582.9
Products	($/ha)	408.0	932.6	874.4	757.8
Farm input cost	(")	325.9	437.6	437.6	437.6
Net product	(")	82.1	495.0	436.8	320.2

Table IV-68 Increased product, increased benefit

Land category	Season		Cropping area		Product and benefit				Increased product, benefit	
			Present (ha)	Future (ha)	Present		Future			
					Product (t)	Benefit ($)	Product (t)	Benefit ($)	Product (t)	Benefit ($)
Paddy field	Rainy season	Paddy rice	4,330	9,196	4,763	126,436	27,477	632,847	22,714	506,411
"	"	Mung bean	-	5,320	-		6,947	691,607	6,947	691,607
"	Dry season	Paddy rice	910	19,530	910	20,748	58,692	1,356,643	57,782	1,335,895
Upland field	"	Fodder	-	1,957	-		-		-	
"	Rainy season	Maize	5,350	7,351	6,955	149,265	30,070	865,396	23,115	716,131
"	"	Sesame	480	483	288	33,360	436	42,505	148	9,145
"	"	Mung bean	20	1,912	14	1,328	2,558	257,040	2,544	255,712
"	"	Peanut	-	2,473	-		3,249	389,412	3,249	389,412
"	Dry season	Maize	3,040	10,478	3,344	50,160	41,418	1,183,270	38,074	1,133,110
"	"	Mung bean	1,150	202	805	76,245	209	21,904	-	(-) 54,341
"	"	Peanut	490	192	343	38,710	255	29,595	-	(-) 9,115
"	"	Sesame	270	270	162	18,765	263	27,439	101	8,674
"	"	Tobacco	940	1,375	658	77,174	2,179	668,389	1,521	591,215
Total			16,980	60,739		592,191		1,166,047		5,573,856

E-4 Description of the Development Plan

E-4-1 Overall Plan

The production of paddy rice in Kratie Province is only 60% of what is actually needed in the province. And also from the standpoint of increasing the rice export for Cambodia herself, a progressive attitude toward increasing the rice production is an urgent task.

Although, there is a slight variation of each year, approximately 56% of the project area is inundated in the rainy season. In order to prevent the area from inundation during the rainy season, a great sum of project cost will be required. Therefore, the target has been set for the production increase, by securing sufficient irrigation water to the paddy field for the dry seasonal rice, and by reclaiming the areas which are not affected by inundation to paddy fields.

As for the upland farming, it should be noted that the production of the maize which is an important export product, should be increased Hence, an irrigation system should be introduced to the upland field, to increase the yield per unit area. Furthermore, it is considered to be effective to expand the arable area by applying the *colmatage.*

Now to summarize the above, the first and the most important target is to achieve the self-sufficiency for the staple food which is also the most urgent task in the area, and then, to improve the irrigation conditions, and to enlarge the arable area to increase the production of the crops to be exported. These are the main objectives of this project.

In order to cope with the above objectives, following measures for the agricultural development should be taken; (1) to increase and stabilize the production for the cultivated land during the rainy season (2) to propagate the up-to-date technique. (3) to expand the cultivation area by reclamation.

Out of 69,000 ha, which is located from the immediate downstream of the proposed Sambor reservoir to the border line of Kratie Province, 38,410 ha is selected as the agricultural development area considering the result of topographic and soil survey, and from the economical standpoints. Also in the uncultivated area, the dense forest where construction of irrigation system seems to be difficult, the clear forest with poor fertile soil layer, and the marshy land in Chhlong District are excluded from the project area. But the dense forest covering the mid portion of the northern district of Saop is included in this project area.

The existing cultivated lands excluded from the project are the rainy seasonal paddy fields at the foot of the mountains and at the hilly-lands where the construction of the irrigation facilities are considered to be uneconomical, and the upland fields of the riverside of levee

For the irrigation planning, the cropping by irrigation will be performed throughout a year, hence enabling the dry seasonal cropping, however, the supplemental irrigation during the rainy season will also pay an important role, since there are periods having at the most 20 consecutive days of a drought spell and also irregularity of the beginning of rainfall.

In regards to the drainage planning, except for a portion of Kratie and Chhlong Districts the drainage plans are not established, since the flood control for the Mekong is not likely to be regulated by the construction of the Sambor Dam, and moreover, every year's inundation brings about the effects of soil moisture retention and fertile soil dressing.

The areas where year-round cropping will be made possible by this project, are (1) the projected drainage areas in Kratie and Chhlong Districts, (2) the reclaimed upland fields from dense forest in Saop District, (3) rainy seasonal paddy fields in the hills, and (4) the upland fields in Kaoh Trung and Kaoh Chreng.

As to the reclamation plan, the *colmatage* works, which is the traditional ways of farming and also is the effective reclamation method, is adopted to the fullest extent by considering the topographical conditions.

And as for the farming in the project area, except the areas reclaimed by the *colmatage*, it is desirous to use the fertilizer. The reason is because even in the dense forest, the soil fertility is insufficient, therefore, it has to be considered that the soil fertility will soon diminish by the cultivation.

E-4-2 Plan for Each District

From the administrative district, the development area comes under the following three Sroks, namely, Kratie, Chhlong, and Prek Prasap. The development schemes by each Srok are as follows:

Kratie: This area is planned to expand the area by depending mainly upon the reclamation of paddy fields and also to introduce the year-round cropping by the drainage scheme. For the upland fields of Bos Leav District, perennial crops may be common, but for the upland fields in the surrounding area of the urban district, the crops having a great demand should be considered.

Chhlong: This area is the typical upland-field zone. The contracted cropping with the tobacco manufacturer in Kompong Cham is being expanded, therefore, this trend should be followed up with a progressive attitude.

Prek Prasap: Since there are many areas suitable for the reclamation of paddy fields in the upstream district, the development should be advanced by considering the rice cropping as main crops. And in the downstream area, the development is being relatively advanced and has a high soil fertility, therefore, the improvement of the upland field cropping in an intensive way may very well be expected

By considering the farm management and the condition of the water utilization, the development project area is divided into twelve districts, and development plans for each district is established. From 38,410 ha, which is selected as project area, 4,410 ha of the areas for road, water channel, and pasture pastune land and is deducted, hence 34,000 ha is selected as irrigable area of this project. The development schemes for each district are described hereinafter.

The cultivated area at present and after the implementation of the project is shown pasture on the Table IV-72 under Chapter E-5-1-1.

a. Kratie

This district includes Kratie City which is the capital of the province and also is situated in the central part of the Sambor Project, having a tremendous manpower resources and a fairly well organized marketing system. Moreover, the national highways intersect at this area and this district has a port where boats may be docked at the Mekong (during the dry season, this port is situated at the farthest upstream of the Mekong and is possible for the navigation of 100 ton to 200 ton vessels). Since this area occupies the central part for both the land transportation and navigation, if the other conditions, such as the soil and economy, are good, the development scheme will be feasible in a big scale.

The cultivated area of 1,731 ha involves the rainy seasonal paddy fields at the plain which are not inundated, and the upland fields developed at the river mouth of the Prek Te. Most of the areas except the above area is marshy land.

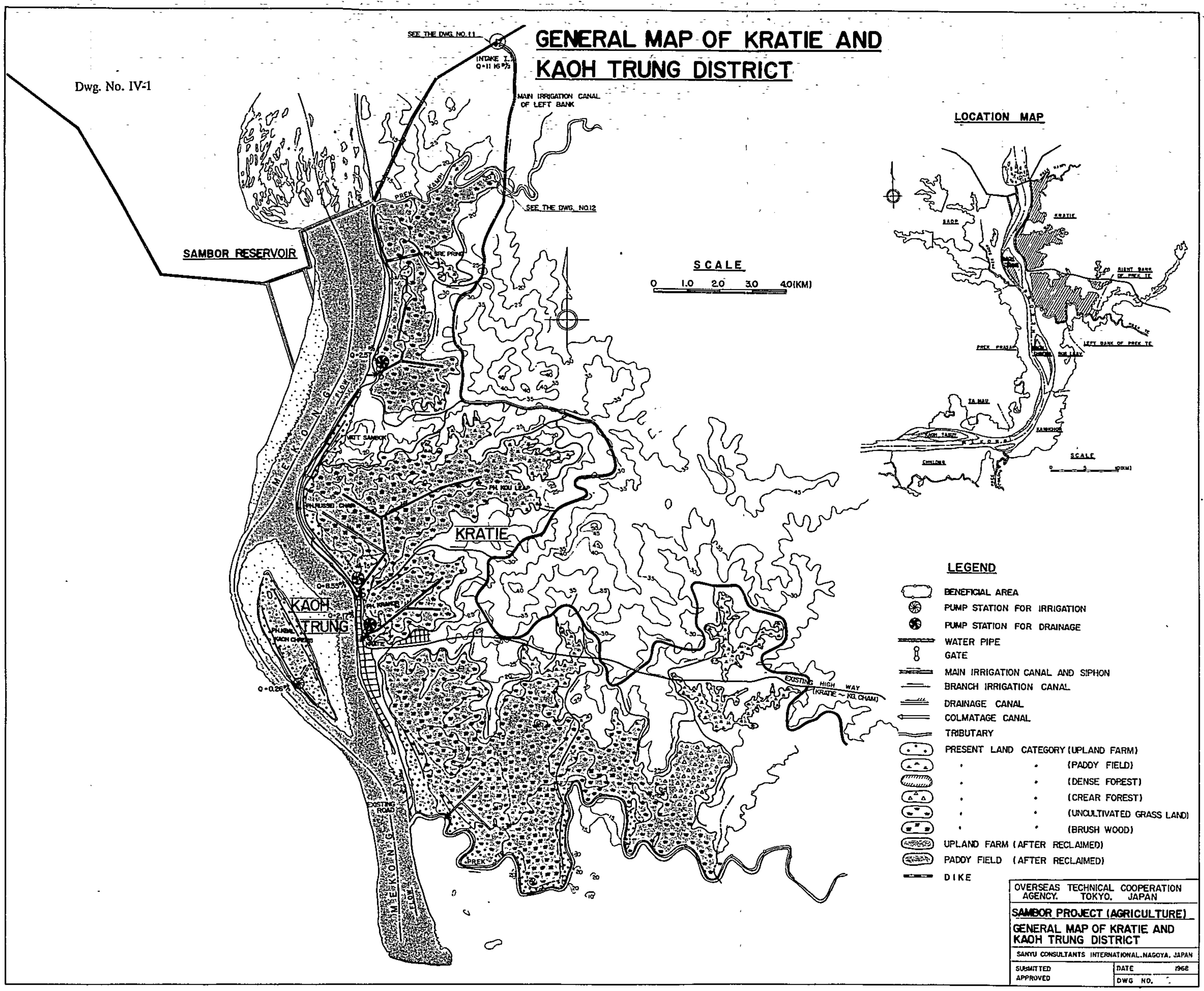
According to the classifications of the soil and land utilization, most of the marshy lands fall under the Sambok or the Russei Char soil series, and the former is suitable for paddy fields, and the latter for upland fields And they both come under class II of the soil productivity classification. Most of the clear forests which fall under the Kratie and Tuol soil series are excluded from the project area, as these type of soils are not suited for the cultivation.

The entire water resources for irrigation are from the Sambor reservoir, and the gravity irrigation is made possible by the construction of the main irrigation canal.

The drainage plan for Prek Krakor Basin during the rainy season is relatively economical. That is, this area has a natural polder, and the inundation during the rainy season is caused mainly by the flood from the Prek Krakor, therefore, if the sluiceways and pumps are provided to prevent the inundation, the year-round utilization of cultivated area will be made possible.

The areas projected by land categories are 5,508 ha of paddy fields, 873 ha of upland fields, and a total of 6,381 ha. The project involves 5,124 ha of reclamation works, 128.6 km of irrigation canal works, 18.1 km of drainage canal works, construction of three pumping stations, and one tank reservoir, and one *colmatage* works. Total construction cost for the above works is estimated at \$6,693 x 10^3.

Dwg. No. IV-1


GENERAL MAP OF KRATIE AND
KAOH TRUNG DISTRICT
SEE THE DWG. NO.11
MAIN IRRIGATION CANAL OF LEFT BANK
SEE THE DWG. NO.12
SAMBOR RESERVOIR
SCALE
0 1.0 2.0 3.0 4.0(KM)
KRATIE
KAOH TRUNG
MEKONG
EXISTING HIGH WAY (KRATIE ~ KG. CHAM)
EXISTING ROAD
LOCATION MAP
LEGEND
BENEFICIAL AREA
PUMP STATION FOR IRRIGATION
PUMP STATION FOR DRAINAGE
WATER PIPE
GATE
MAIN IRRIGATION CANAL AND SIPHON
BRANCH IRRIGATION CANAL
DRAINAGE CANAL
COLMATAGE CANAL
TRIBUTARY
PRESENT LAND CATEGORY (UPLAND FARM)
(PADDY FIELD)
(DENSE FOREST)
(CREAR FOREST)
(UNCULTIVATED GRASS LAND)
(BRUSH WOOD)
UPLAND FARM (AFTER RECLAIMED)
PADDY FIELD (AFTER RECLAIMED)
DIKE
OVERSEAS TECHNICAL COOPERATION AGENCY. TOKYO. JAPAN
SAMBOR PROJECT (AGRICULTURE)
GENERAL MAP OF KRATIE AND KAOH TRUNG DISTRICT
SANYU CONSULTANTS INTERNATIONAL.NAGOYA. JAPAN
SUBMITTED
APPROVED
DATE 1968
DWG NO.

Furthermore, the Kratie District is divided into two areas, namely, the Kratie (2) area having beneficial area of 2,842 ha by the drainage plan, and the Kratie (1) area having an area of 3,539 ha by the irrigation plan. Construction periods of Kratie (1) are three years, and that of Kratie (2) is two years.

b. Right bank of Prek Te District

This district mainly occupies the rainy seasonal paddy fields developed at the elongated plain along the Prek Chhung River and its tributaries which flow into Prek Te River on the right bank. These rainfed paddy fields are being the grain production area of Sambor Region, but the yield is being unstable, since it is affected by the rainfall and the flood of the tributaries.

This project is to reclaim the clear forest and marshy land in the vicinity of Chuor Kroich and the marshy land downstream of Prek Chhung. The former falls under Roha soil series and the latter falls under Sambok soil series, and they are both suitable for paddy fields.

As to the irrigation, for the 290 ha of paddy fields in Prek Khnach, where gravity irrigation is impossible from the Sambor reservoir having diversion water level of EL 38 m, the Khnach Touch dam at Prek Khnach is to be constructed, and the area will be irrigated by the gravity method.

Since this district has the largest paddy fields in the Sambor Region, the increase of self-sufficiency ratio for rice and the benefit by agricultural products will be expected in the future.

The areas projected by land categories are 1,341 ha of paddy fields, 4 ha of upland fields, and a total of 1,345 ha.

The project involves 895 ha of reclamation works, 27.9 km of irrigation canal works, and one tank reservoir works. The total construction cost is estimated at $1,239 x 10^3. Construction periods of this district are two years.

c. Left Bank of Prek Te District

The projected area covers 955 ha of land on the left bank of Prek Te. The back-slope area of Prek Te falls under the Bos Leav soil series, and the soil fertility is high, and is suitable for upland fields. The marshy land and the lowland of the clear forest are to be reclaimed as the paddy fields. These soil series are the same as that in the right bank.

Irrigation water will be lifted from the Prek Te River. The reclaimed lands are to be paddy fields and rice production increase will be the objective, and for the back-slope area of the levee on the fertile upland field, the corn will mainly be planted.

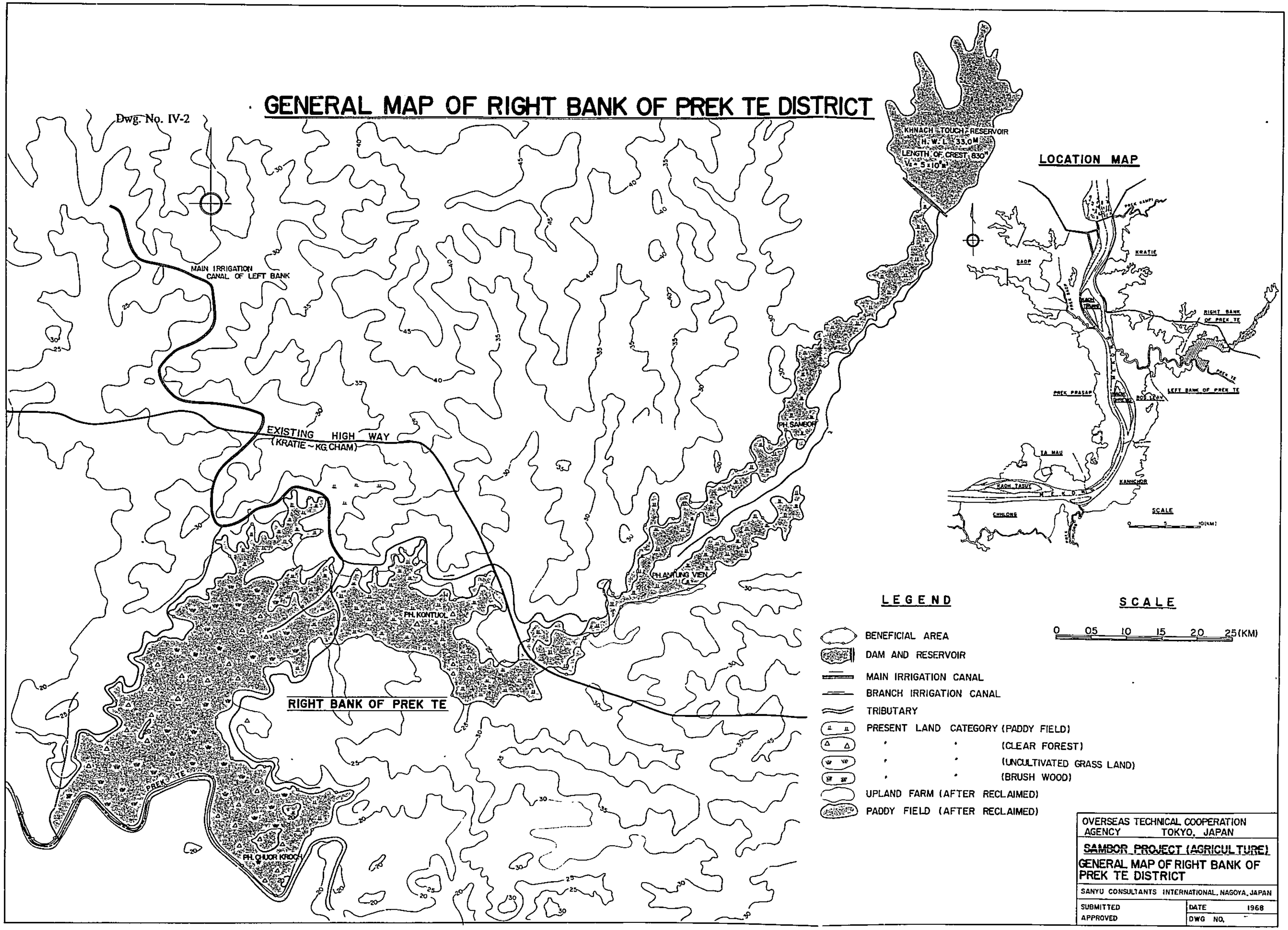
The areas projected by land categories are 780 ha of paddy fields, 175 ha of upland fields, and a total of 955 ha. The project involves 957 ha of reclamation works, 22.5 km of irrigation canal works, and a construction of one pumping station. The total construction cost is estimated at $977 x 10^3. Construction periods of this district are two years

d. Bos Leav District

Except for the thin layer of effective soil in the hilly region in the northern part, there is a fairly large distribution of fertile upland fields of Bos Leav soil series along the levee of the Prek Te and the Mekong. And the remainder of the area is mostly of Sambok soil series. There are many swamps in the valley between the Mekong and the hills, and its surrounding areas fall under the Russei Char soil series which are suitable for paddy fields.

The rainy seasonal paddy fields scattered around the foot and that in the hills of the eastern region are not included in the beneficial area, as it is foreseen that the construction of irrigation facilities will be uneconomical from the topographical standpoint.

The areas projected by land categories, are 815 ha of paddy fields, 1,881 ha of upland fields, and a total of 2,696 ha. The project involves 2,573 ha of reclamation works, 40.7 km of irrigation canal works, construction of four pumping stations, one tank reservoir, and one *colmatage*. The total construction cost is estimated at $2,637 x 10^3. Construction period of this district are two years.


GENERAL MAP OF RIGHT BANK OF PREK TE DISTRICT
Dwg. No. IV-2
KHNACH TOUCH RESERVOIR
H. W. L. 33.0M
LENGTH OF CREST 830M
LOCATION MAP
KRATIE
SAOP
RIGHT BANK OF PREK TE
PREK TE
LEFT BANK OF PREK TE
PREK PRASAP
TA MAU
KAMCHOR
CHHLONG
SCALE
MAIN IRRIGATION CANAL OF LEFT BANK
EXISTING HIGH WAY
(KRATIE ~ KG.CHAM)
PH. SAMBOR
PH. ANTUNG VIEN
PH. KONTUOL
RIGHT BANK OF PREK TE
PREK TE
PH. CHUOR KROCH
LEGEND
BENEFICIAL AREA
DAM AND RESERVOIR
MAIN IRRIGATION CANAL
BRANCH IRRIGATION CANAL
TRIBUTARY
PRESENT LAND CATEGORY (PADDY FIELD)
(CLEAR FOREST)
(UNCULTIVATED GRASS LAND)
(BRUSH WOOD)
UPLAND FARM (AFTER RECLAIMED)
PADDY FIELD (AFTER RECLAIMED)
SCALE
0 05 10 15 20 25(KM)
OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO, JAPAN
SAMBOR PROJECT (AGRICULTURE)
GENERAL MAP OF RIGHT BANK OF PREK TE DISTRICT
SANYU CONSULTANTS INTERNATIONAL, NAGOYA, JAPAN
SUBMITTED
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DATE 1968
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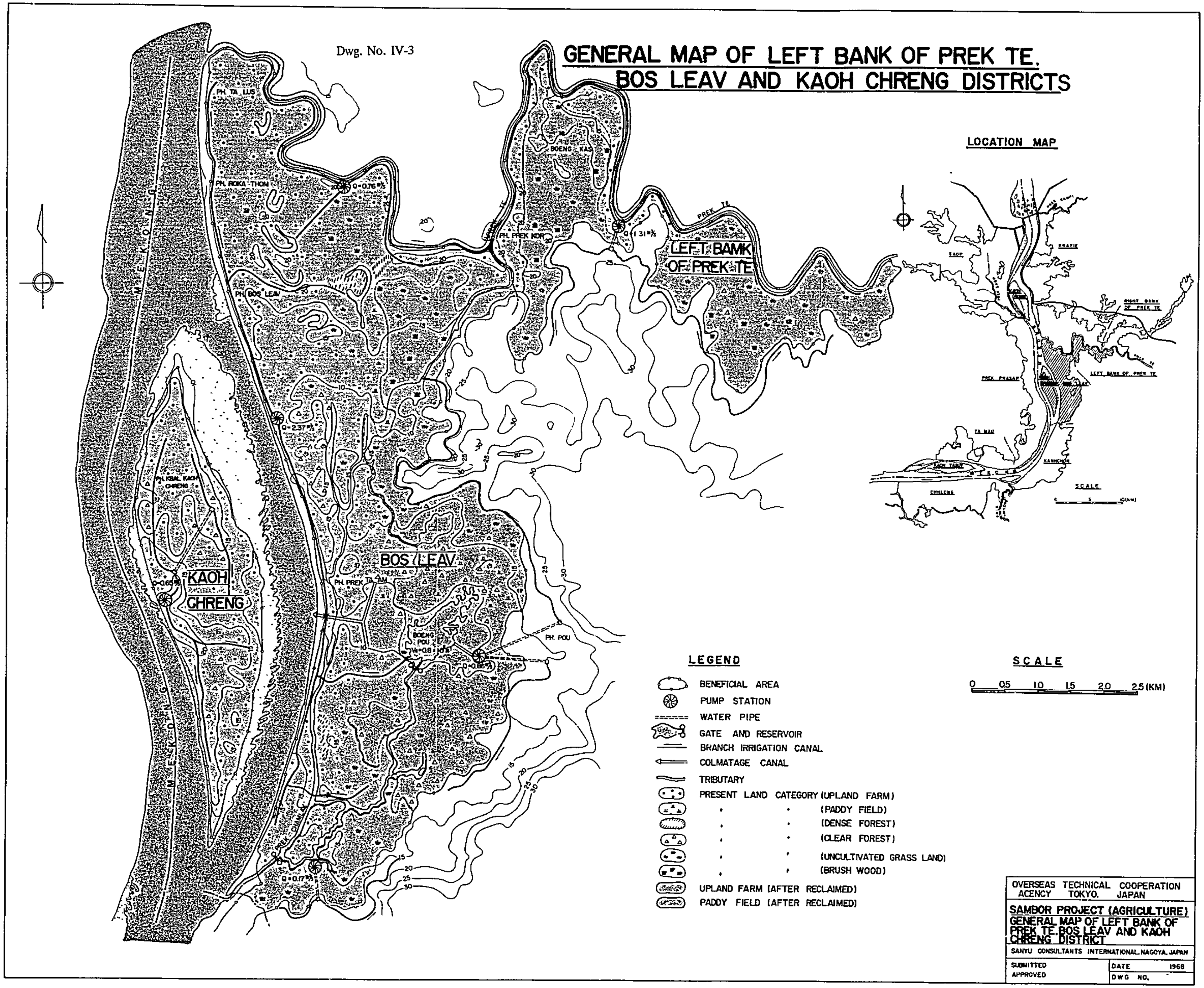
Dwg. No. IV-3



GENERAL MAP OF LEFT BANK OF PREK TE, BOS LEAV AND KAOH CHRENG DISTRICTS
LOCATION MAP
LEFT BANK OF PREK TE
BOS LEAV
KAOH CHRENG
MEKONG
PH. TA LUS
PH. ROKA THOM
PH. BOS LEAV
PH. PREK KOR
PH. PREK TA MAI
PH. KBAL KAOH CHRENG
PH. POU
BOENG POU
PREK TE
LEGEND
BENEFICIAL AREA
PUMP STATION
WATER PIPE
GATE AND RESERVOIR
BRANCH IRRIGATION CANAL
COLMATAGE CANAL
TRIBUTARY
PRESENT LAND CATEGORY (UPLAND FARM)
(PADDY FIELD)
(DENSE FOREST)
(CLEAR FOREST)
(UNCULTIVATED GRASS LAND)
(BRUSH WOOD)
UPLAND FARM (AFTER RECLAIMED)
PADDY FIELD (AFTER RECLAIMED)
SCALE
0 0.5 1.0 1.5 2.0 2.5 (KM)
OVERSEAS TECHNICAL COOPERATION ACENCY TOKYO. JAPAN
SAMBOR PROJECT (AGRICULTURE)
GENERAL MAP OF LEFT BANK OF PREK TE, BOS LEAV AND KAOH CHRENG DISTRICT
SANYU CONSULTANTS INTERNATIONAL, NAGOYA, JAPAN
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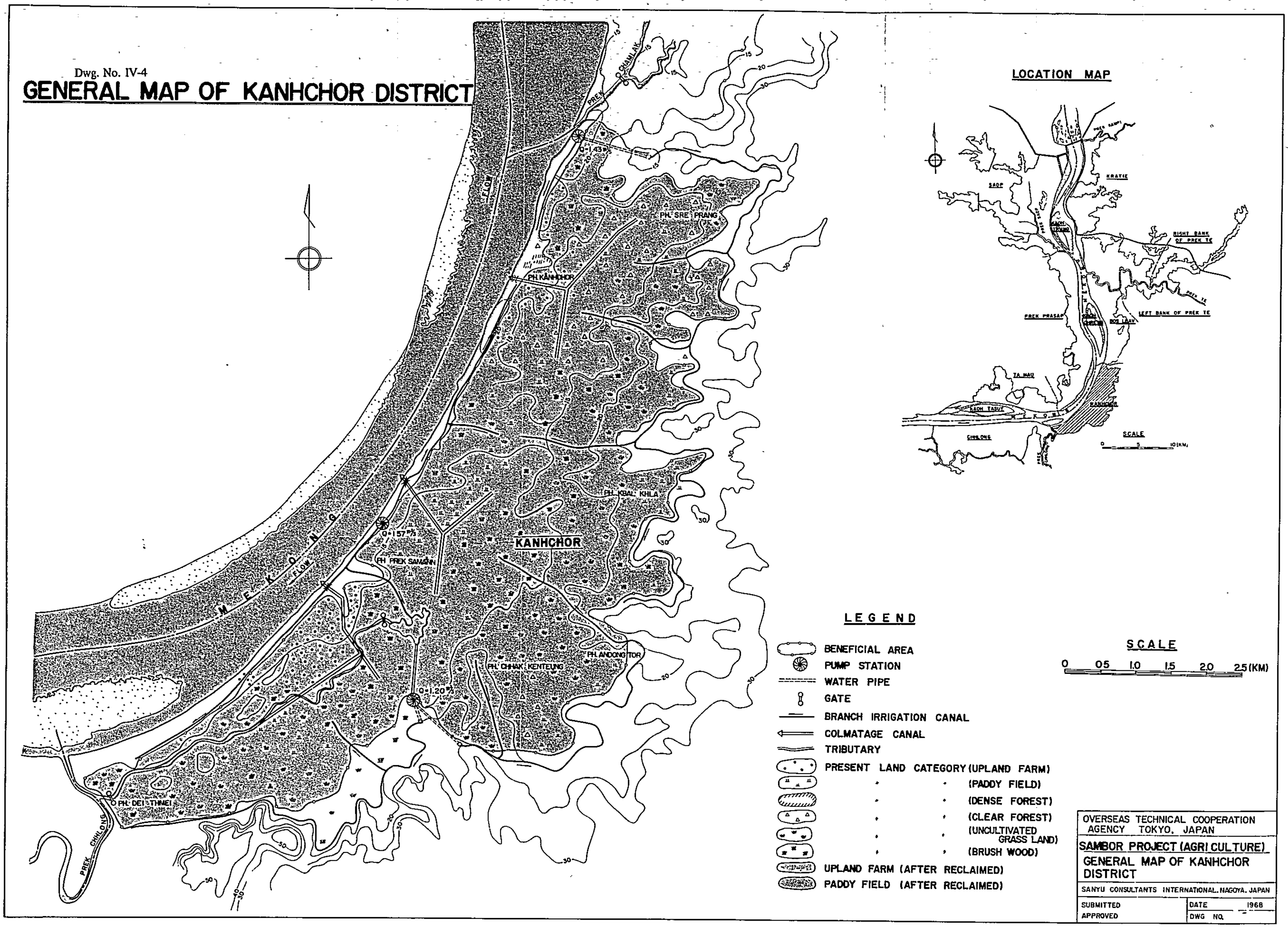
Dwg. No. IV-4

GENERAL MAP OF KANHCHOR DISTRICT



e. Kanhchor District

This district covers the surrounding area of Prek Chik of which the *colmatage* is being in success, 108 ha of upland fields and 359 ha of rainy seasonal paddy fields scattered at the foot of the hills and the dry seasonal paddy fields around the pond. Along the levee of the Mekong, the soil falls under the rich, fertile Bos Leav soil series, and in the southern portion of the district the soil falls under Pongro soil series which has a fairly good water holding capacity.

The marshy lands in the district are to be reclaimed into upland field by newly adopting the *colmatage* at three places.

This district has only a few paddy fields and has been suffering from shortage of rice, however, the side business is gaining. In order to establish the self-sufficiency for rice, the reclamation of paddy fields is taken into consideration for this project, however, the farmers' training will be required for the rice cropping. The upland field will mainly be used for the corn.

The areas projected by land categories, are 1,191 ha of paddy fields, and 1,287 ha of upland fields. The project involves 2,120 ha of reclamation works, 40.9 km of irrigation canal works, construction of three pumping stations and one tank reservoir, and three *colmatage*. The total construction cost estimated at $2,821 x 10^3$. Construction periods of this district are two years.

f. Chhlong District

This district has the largest upland crops of the entire project area. Pongro soil series are found along the levee of the Mekong and the Prek Kompong Kor, Sambok soil series are found in most of the inundated areas, but in the lower area of the above are formed of Russei Char soil series. Among the upland fields, along the levee of the Mekong, in the vicinity of Pongro, there is a vast formation of fertilie Bos Leav soil series by the *colmatage* from the old days. Upland fields have a rich fertility, and the crop that occupies the largest cropping area is the corn. However, as it is close to Kompong Cham, tobacco plantation is done under a contract with the tobacco manufacturer in the above town. And it is believed that the demand will have an upward trend.

As for the irrigation water resources, the water from the lakes and ponds of Kompong Kor and Ta Thom, and from the reservoir of Prek Kor will be utilized by providing a gate, but majority of the water are to be lifted from the Mekong.

For the inundated area lying between Prek Pongro and Chhlong City east of the district, the inundation is relatively easy to be prevented by the construction of the polder dike, therefore, the drainage plan is established by installing a drainage pump. Furthermore, since the area along the Prek Ta Thom has a poor drainage, the drainage canal will be provided to improve the drainage condition during the later part of the rainy season.

The area projected by land categories, are 3,421 ha of paddy fields, 1,693 ha of upland fields, and a total of 5,114 ha. The project involves 3,737 ha of reclamation works, 49.6 km of irrigation canal works, 12.4 km of drainage canal works, and construction of six pumping stations and four tank reservoirs. The total construction cost is estimated at $4,534 x 10^3$. Furthermore, the district will be divided into two districts by the polder dike, the drainage beneficial area of 1,913 ha as Chhlong (2) area, and the remainder as Chhlong (1) area. Construction periods of the both districts are two years

g. Saop District

This district is the largest as a unit district in the Sambor Region, covering the Prek Saop of the right bank of the Mekong and the watershed of its tributaries, Prek Paprak and Prek Roha, which sum up to 7,176 ha.

Most of the marshy lands are formed of Sambok and Russei Char soil series, and a portion formed of Bos Leav and Roha soil series. All of these are suitable for paddy fields. As for the dense forest area in the north, it is planned to be reclaimed as the upland fields, but this land belongs to Keng soil series and has the sand layer of 1 m over, and moreover the soil fertility is not so rich, therefore the irrigation as well as the fertilization is absolutely necessary. The downstream area of Prek Saop has a relatively vast area of Bos Leav soil series, and is suitable for upland fields.

Since the diversion water level from the Sambor reservoir is EL 38 m, it would be possible to irrigate the entire area of this district by gravity except for the upland fields along the levee of the Mekong which will have to pass through a pressure pipe canal. This will be rather costly. Therefore, by comparing the above scheme with the lift irrigation, it is determined to adopt the pumping system which would result in being more economical. As to the water resources except for a portion irrigated by utilizing the local water of Boeng Romeas, all of the areas rely on the Sambor reservoir as the water resources.

The crops will be mainly paddy and corn, and aim to achieve the production increase of ordinary crops.

The areas projected by land categories are 4,308 ha of paddy fields, 2,868 ha of upland fields, and a total of 7,176 ha. The areas of reclamation for paddy fields and for upland fields are the maximum among the districts in the project area.

The project involves 6,288 ha of reclamation works, 122.0 km of irrigation canal works, and construction of one pumping station and five tank reservoirs. The total construction cost is estimated at $7,125 x 10^3.

The district is divided into two areas, the reclaimed upland fields around the dense forest in the northern portion of the district occupying 3,144 ha, as Saop (2) area, and the remainder of 4,032 ha as Saop (1) area.

Construction periods of Saop (1) project are six years, and that of Saop (2) are two years.

h. Prek Prasap District

This district occupies 4,135 ha, and differs greatly from the northern area to southern area. That is, the northern area is an elongated uncultivated marshy land along the Mekong, except for the cultivated land of the river mouth areas of Prek Saop Kraom and Prek Pralung, and belong to the soil series of Russei Char or Sambok soil series. In the southern area, there are big lakes and swamps, and their surrounding areas are formed either by Russei Char or Sambok soil series, and is suitable for paddy fields.

The resources of irrigation water in the northern area is possible for a gravity irrigation from the Sambor reservoir. And in the southern area, lift irrigation from Boeng Chrvea pond is made available, and if necessary, supplemental water is drawn into this pond from the Sambor reservoir.

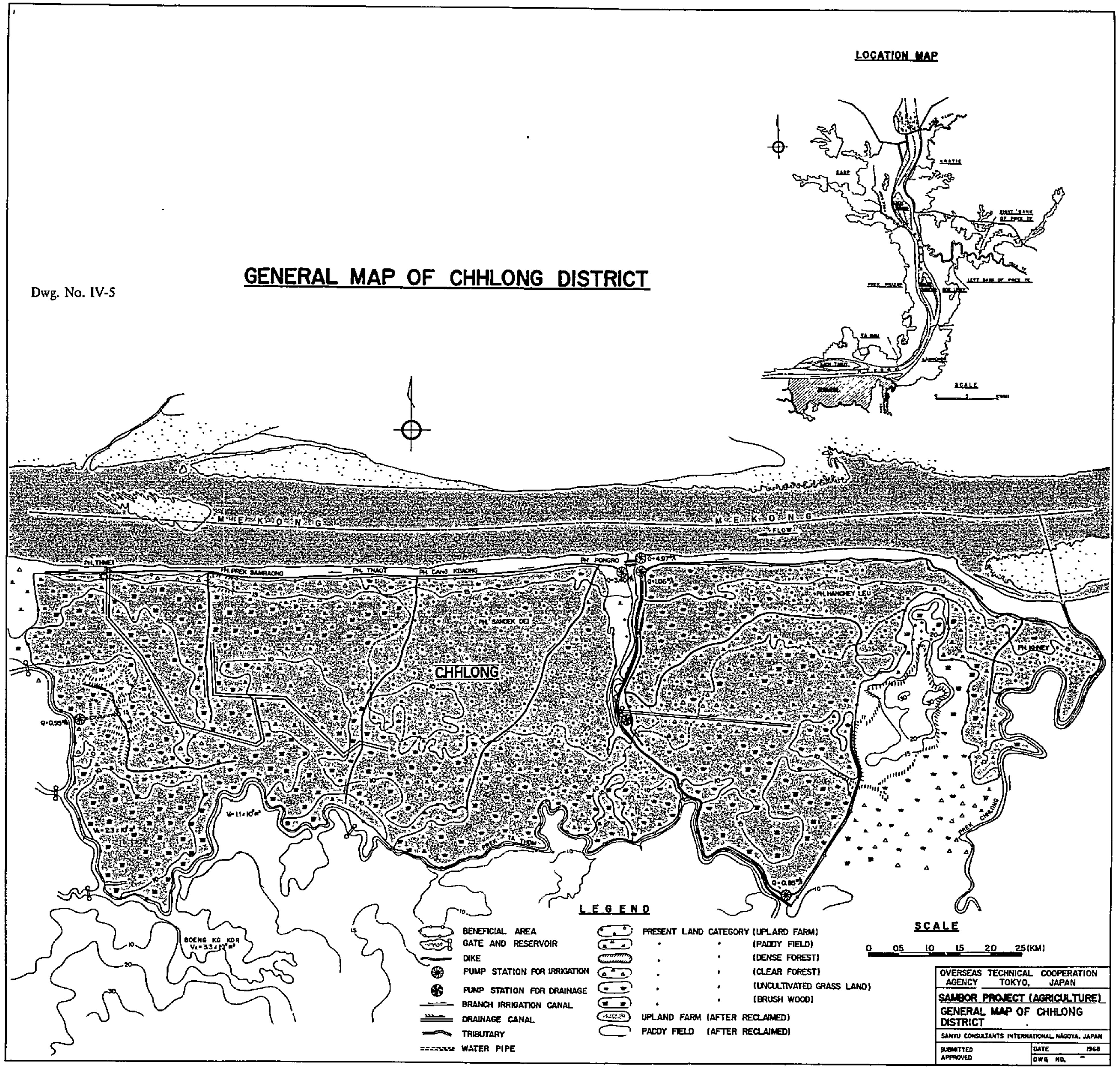
The areas projected by land categories, are 1,061 ha of paddy fields, 3,074 ha of upland fields, and a total of 4,135 ha.

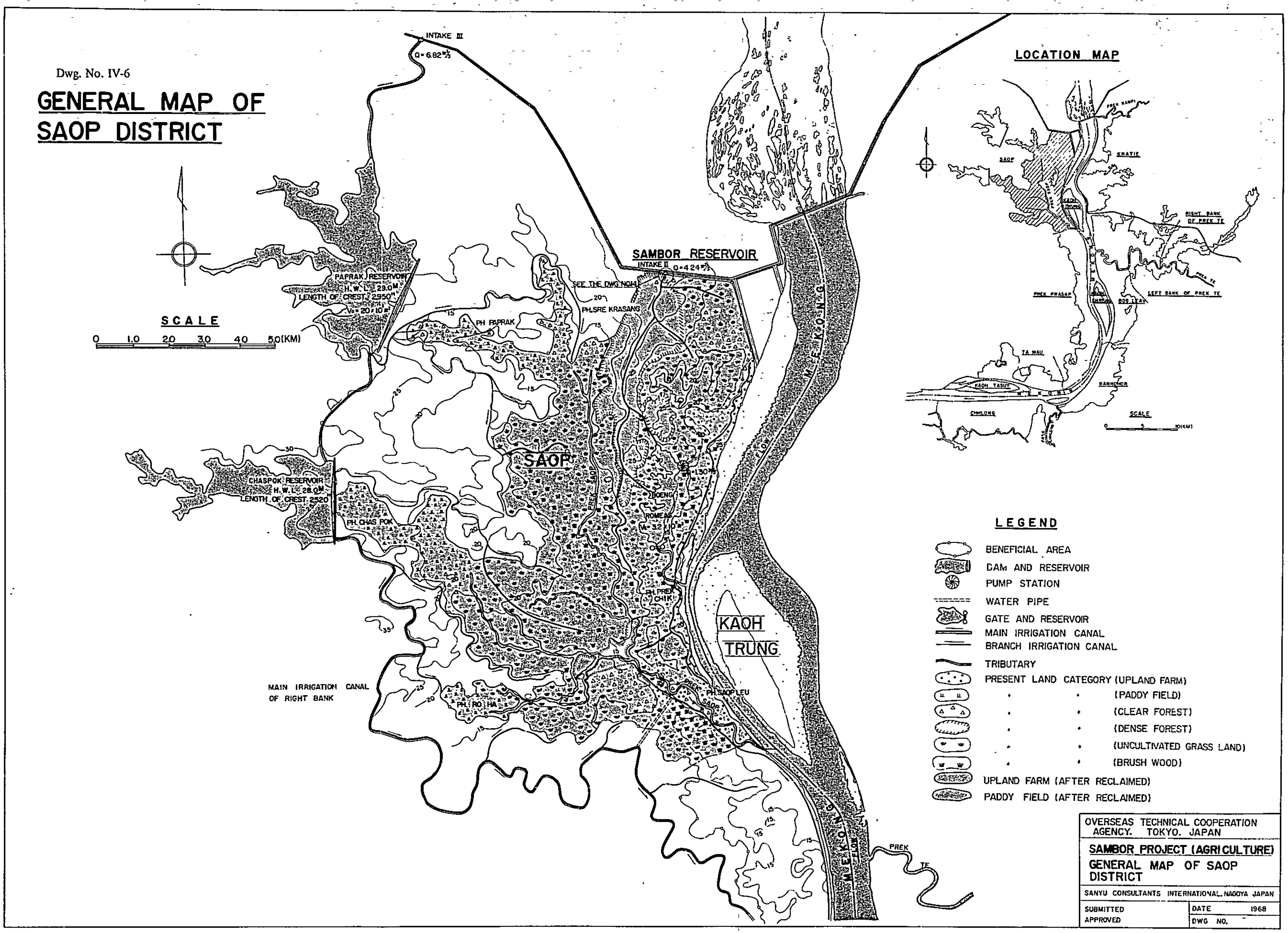
The project involves 4,006 ha of reclamation works, 65.7 km of irrigation canal works. The total construction cost is estimated at $4,995 x 10^3.

This district is divided into two by irrigation method, that is, Prek Prasap (1) of 2,395 ha which is situated north and irrigated directly from the Sambor reservoir, and Prek Prasap (2) of 1,740 ha in which lift irrigation is employed. Construction periods of the both districts are two years.

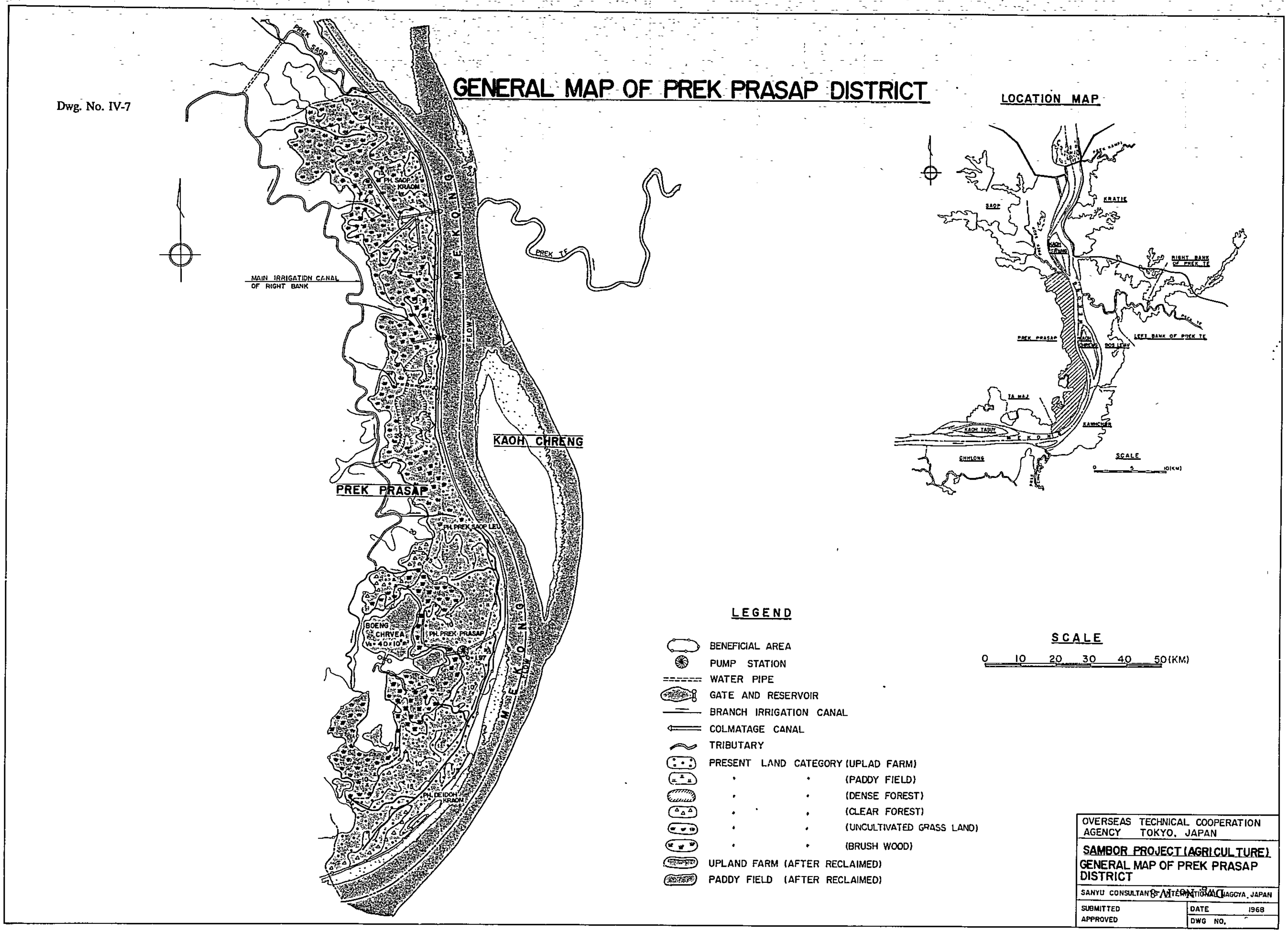
Dwg. No. IV-5

GENERAL MAP OF CHHLONG DISTRICT





Dwg. No. IV-6
GENERAL MAP OF SAOP DISTRICT
SCALE
0 1.0 2.0 3.0 4.0 5.0(KM)
INTAKE III
Q=6.82
SAMBOR RESERVOIR
INTAKE II
Q=4.24
SEE THE DWG NO.
PAPRAK RESERVOIR
H.W.L. 23.0M
LENGTH OF CREST 2950
PH PAPRAK
PH.SRE KRASANG
CHASPOK RESERVOIR
H.W.L. 28.0M
LENGTH OF CREST 2520
PH. CHAS POK
SAOP
PREK SAOP
BOENG
ROMEAS
PH.PREK CHIK
KAOH TRUNG
PH. RO HA
PH.SAOP LEU
MAIN IRRIGATION CANAL OF RIGHT BANK
MEKONG
FLOW
PREK TE
LOCATION MAP
SAOP
KRATIE
KAOH TRUNG
RIGHT BANK OF PREK TE
PREK PRASAP
LEFT BANK OF PREK TE
TA MAU
KAOH TASUY
KANHCHOR
CHHLONG
SCALE
LEGEND
BENEFICIAL AREA
DAM AND RESERVOIR
PUMP STATION
WATER PIPE
GATE AND RESERVOIR
MAIN IRRIGATION CANAL
BRANCH IRRIGATION CANAL
TRIBUTARY
PRESENT LAND CATEGORY (UPLAND FARM)
(PADDY FIELD)
(CLEAR FOREST)
(DENSE FOREST)
(UNCULTIVATED GRASS LAND)
(BRUSH WOOD)
UPLAND FARM (AFTER RECLAIMED)
PADDY FIELD (AFTER RECLAIMED)
OVERSEAS TECHNICAL COOPERATION AGENCY. TOKYO. JAPAN
SAMBOR PROJECT (AGRICULTURE)
GENERAL MAP OF SAOP DISTRICT
SANYU CONSULTANTS INTERNATIONAL. NAGOYA JAPAN
SUBMITTED
APPROVED
DATE 1968
DWG NO.


Dwg. No. IV-7
GENERAL MAP OF PREK PRASAP DISTRICT
PREK SAOP
PREK TE
MAIN IRRIGATION CANAL OF RIGHT BANK
PH. SAOP KRAOM
MEKONG
FLOW
KAOH CHRENG
PREK PRASAP
PH. PREK SAOP LEU
BOENG CHRVEA
PH. PREK PRASAP
PH. DEIDOH KRAOM
LOCATION MAP
SAOP
KRATIE
KAOH TRONG
RIGHT BANK OF PREK TE
PREK PRASAP
LEFT BANK OF PREK TE
TA MAU
KAOH TASUY
KANHCHAR
CHHLONG
SCALE
0 5 10(KM)
LEGEND
BENEFICIAL AREA
PUMP STATION
WATER PIPE
GATE AND RESERVOIR
BRANCH IRRIGATION CANAL
COLMATAGE CANAL
TRIBUTARY
PRESENT LAND CATEGORY (UPLAD FARM)
" " (PADDY FIELD)
" " (DENSE FOREST)
" " (CLEAR FOREST)
" " (UNCULTIVATED GRASS LAND)
" " (BRUSH WOOD)
UPLAND FARM (AFTER RECLAIMED)
PADDY FIELD (AFTER RECLAIMED)
SCALE
0 10 20 30 40 50(KM)
OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO, JAPAN
SAMBOR PROJECT (AGRICULTURE)
GENERAL MAP OF PREK PRASAP DISTRICT
SANYU CONSULTANTS INTERNATIONAL NAGOYA, JAPAN
SUBMITTED
APPROVED
DATE 1968
DWG NO.

i. Ta Mau District

This district is similar in many respects to the southern area of Prek Prasap. In the easterly portion around the Kompong Kor, the upland fields are developed in the Pongro and Bos Leav soil series, and the westerly portion around the several lakes and ponds, they are mainly marshy lands formed from Russei Char soil series. The plan of this district aims to expand the upland fields by the *colmatage* in the east, and paddy fields reclamation for the areas around the lakes and swamps in the west.

The resources for irrigation water are from Trapeang Thom and Boeng Mokoy, and an insufficiency is supplemented by pumping from the Mekong.

The areas projected by land categories are 1,395 ha of paddy fields, 634 ha of upland fields, and a total of 2,029 ha.

The project involves 1,598 ha of reclamation works, 29.4 km of irrigation canal works, and construction of five pumping stations, two tank reservoirs and one *colmatage.*

The total construction cost is estimated at $2,366 x 10^3. Construction periods are two years.

j. Kaoh Trung District

This district is an island in the Mekong and facing Kratie City. The cultivated area of 247 ha is all upland fields. This upland fields are formed of Bos Leav soil series, and is the most fertile land in Sambor Region. Since it is close to Kratie City, the leaf vegetables are mainly grown in the irrigated upland. Having the advantage of the rich soil fertility, it has a great possibility for profitable farming operation to the urban districts by adopting the upland field irrigation and the improvement of cropping techniques.

The water resources for irrigation solely depend upon the Mekong. The project involves 247 ha of reclamation works, 8.8 km of irrigation canal works, and construction of one pumping station.

The total construction cost is estimated at $301 x 10^3. Construction periods of this district are one year.

k. Kaoh Chreng District

This district is an island in the Mekong facing Bos Leav. The shape and topography are similar to that of Kaoh Trung. However, the population and the area of upland fields are greater than Kaoh Trung. The cultivated area is 648 ha, and its soil series fall under Bos Leav and has a high productivity.

The water resources for irrigation is solely from the Mekong. The project involves 638 ha of reclamation works, 9.2 km of irrigation canal works, and construction of one pumping station.

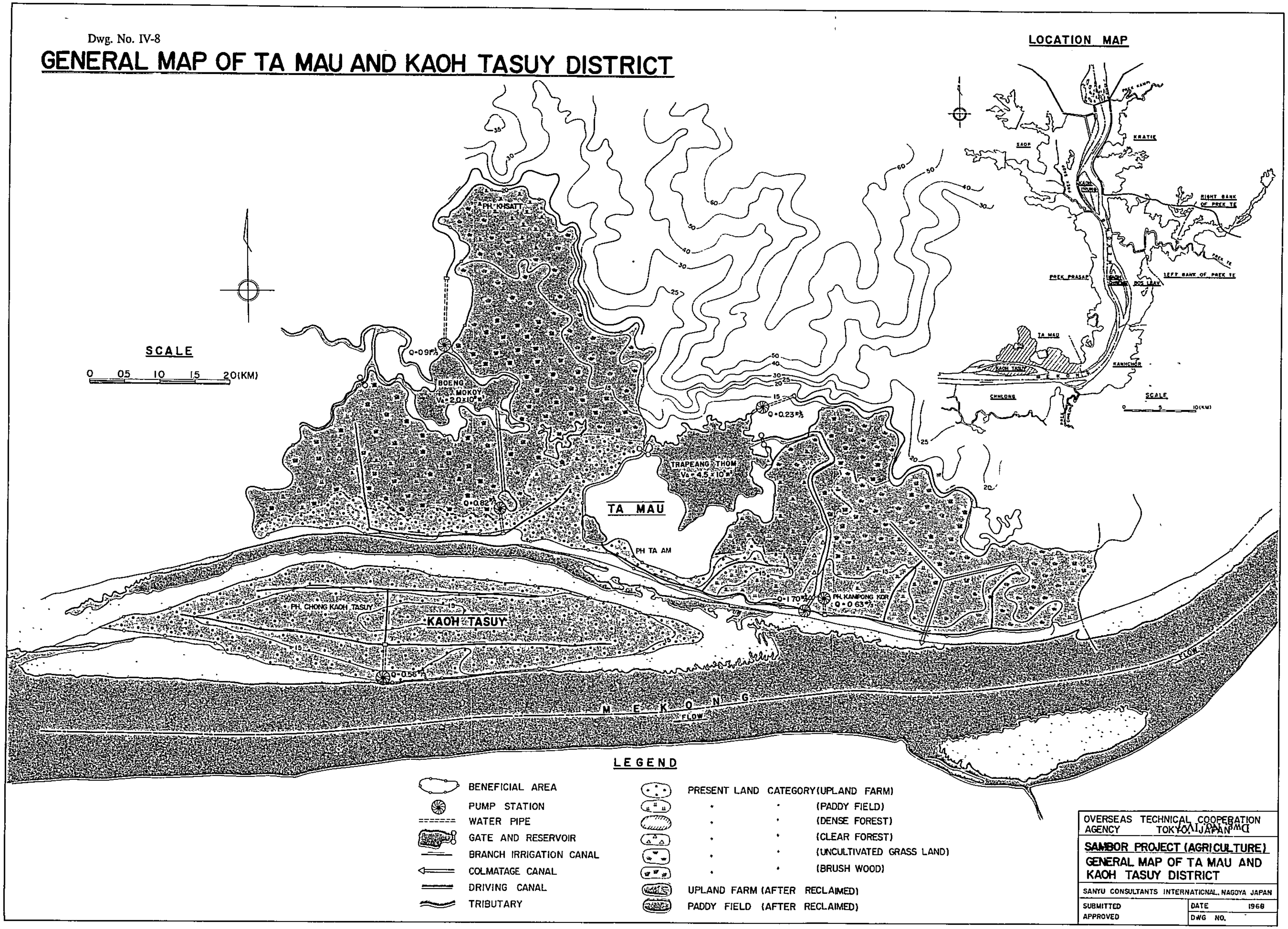
The total construction cost is estimated at $549 x 10^3. Construction periods of this project are two years.

l. Kaoh Tasuy District

Among the project area of 806 ha, 500 ha is occupied by the rich, fertile upland fields. The yield for corn ranks on the top in Khum Ta Mau. The soil is mainly formed of Pongro soil series, and possess a better water holding capacity than the other two islands. The present main crop is corn, but in the future, this district is expected to adopt a cropping pattern to meet the demand of Chhlong City.

The project involves 806 ha of reclamation works, 12.1 km of irrigation canal works, and one pumping station.

The total construction cost is estimated at $642 x 10^3. Construction periods of this district are two years.


Dwg. No. IV-8
GENERAL MAP OF TA MAU AND KAOH TASUY DISTRICT
LOCATION MAP
KRATIE
RIGHT BANK OF PREK TE
LEFT BANK OF PREK TE
PREK PRASAP
TA MAU
KAOH TASUY
CHHLONG
KANHCHOR
SCALE
0 5 10(KM)
SCALE
0 05 10 15 20(KM)
PH. KHSATT
Q=0.9m³/s
BOENG MOKOY
Va=2.0×10⁶m³
Q=0.82m³/s
TRAPEANG THOM
Va=4.5×10⁶m³
Q=0.23m³/s
TA MAU
PH TA AM
Q=1.70m³/s
PH. KAMPONG KOR
Q=0.63m³/s
PH. CHONG KAOH TASUY
KAOH TASUY
Q=0.56m³/s
M E K O N G
FLOW
LEGEND
BENEFICIAL AREA
PUMP STATION
WATER PIPE
GATE AND RESERVOIR
BRANCH IRRIGATION CANAL
COLMATAGE CANAL
DRIVING CANAL
TRIBUTARY
PRESENT LAND CATEGORY(UPLAND FARM)
" " (PADDY FIELD)
" " (DENSE FOREST)
" " (CLEAR FOREST)
" " (UNCULTIVATED GRASS LAND)
" " (BRUSH WOOD)
UPLAND FARM (AFTER RECLAIMED)
PADDY FIELD (AFTER RECLAIMED)
OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO, JAPAN
SAMBOR PROJECT (AGRICULTURE)
GENERAL MAP OF TA MAU AND KAOH TASUY DISTRICT
SANYU CONSULTANTS INTERNATIONAL, NAGOYA JAPAN
SUBMITTED
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DATE 1968
DWG NO.

Table IV-69 Main construction works by district

Name of district	Project area (ha)	Construction cost (10^3)	Main construction works
Kratie	6,381	6,693	Reclamation works 5,124 ha Irrigation canal works 128.6 km Drainage canal works 18.1 km Pumping works at 3 sites Tank reservoir works at 1 site *Colmatage* works at 1 site
Prek Te (R)	1,345	1,259	Reclamation works 895 ha Irrigation canal works 27.9 km Tank reservoir works at 1 site
Prek Te (L)	955	978	Reclamation works 951 ha Irrigation canal works 22.5 km Pumping works at 1 site
Bos Leav	2,696	2,637	Reclamation works 2,573 ha Irrigation canal works 40.9 km Pumping works at 4 sites Tank reservoir works at 1 site *Colmatage* works at 1 site
Kanhchor	2,478	2,821	Reclamation works 2,120 ha Irrigation canal works 47.9 km Pumping works at 3 sites Tank reservoir works at 1 site *Colmatage* works at 3 sites
Chhlong	5,114	4,534	Reclamation works 3,737 ha Irrigation canal works 49.6 km Drainage canal works 12.4 km Pumping works at 6 sites Tank reservoir works at 4 sites
Saop	7,176	7,125	Reclamation works 6,288 ha Irrigation canal works 122.0 ha Pumping works at 1 site Tank reservoir works at 5 sites
Prek Prasap	4,135	4,995	Reclamation works 4,006 ha Irrigation canal works 65.7 km Pumping works at 1 site Tank reservoir works at 1 site *Colmatage* works at 2 sites
Ta Mau	2,029	2,366	Reclamation works 1,598 ha Irrigation canal works 29.4 Pumping works at 5 sites Tank reservoir works at 2 sites *Colmatage* works at 1 site

(to be cont'd)

Name of district	Project area (ha)	Construction cost (\$10³)	Main construction works
Kaoh Trung	247	301	Reclamation works 247 ha Irrigation canal works 8.8 km Pumping works at 5 sites Tank reservoir works at 2 sites *Colmatage* works at 1 site
Kaoh Chreng	638	549	Reclamation works 638 ha Irrigation canal works 9.2 km Pumping works at 1 site
Kaoh Tasuy	806	642	Reclamation works 806 ha Irrigation canal works 12.1 km Pumping works at 1 site
Total	34,000	34,900	Reclamation works 28,983 ha Irrigation canal works 557.4 km Drainage canal works 30.5 km Pumping works at 27 sites Tank reservoir works at 16 sites *Colmatage* works at 8 sites

E-5 Engineering

E-5-1 Land Development

E-5-1-1 Irrigable Area

The restricting factors of land utilization and the possibility of land productivity were made clear by the surveys of land utilization conditions and of soils. For the planning of agricultural development, the soil productivity classification as described under D-6 is adopted, and its selection is made in the order of high productivity, but class IV area is excluded. As there was no area to qualify for class I, II and III are taken up for this project. The result of the soil survey reflects the overall analysis and judgement by considering the soil fertility, soil limitation of soil control (i.e., topographical conditions, and the physical characteristics of the soil pertaining to the degree of difficulties for irrigation and drainage), and possibilities of soil deterioration for the soil productivity classifications.

Considering the crop yield standpoint, the productivity is the highest in the upland fields at the back-slope of the Mekong levee where the soils are formed with Pongro and Bos Leav soil series, and there is quite a difference in the yield compared with other soil series. Therefore, from the yield computation standpoint, these two soil series are classified as category I instead of category II for its convenience sake. These two soil series for the paddy fields will also be treated likewise.

The area of 69,000 ha having an elevation below 38 m, where gravity irrigation is made possible by the Sambor resorvoir, is considered as an area to be studied. The soil and water utilization survey was made for the above area, and first of all class II - III lands suitable for cultivation were selected by soil productivity classification. Furthermore, the areas in the vicinity of the investigation areas, which were estimated to be uneconomical to provide irrigation system, are excluded from the development plan.

By following the above steps, the area of 38,410 ha is selected finally as the area to be developed. In this area, there are 66% of uncultivated lands.

Table IV-70 Present land category (unit: ha)

Item	Existing cultivated area			Uncultivated area					Total
	Paddy field	Upland field	Sub-total	Clear forest	Dense forest	Bush-wood	Grass-land	Sub-total	
Project area	5,280	7,850	13,130	3,070	1,500	6,520	14,190	25,280	38,410
Ratio (%)	14	20	34	8	4	17	37	66	100

From the 38,410 ha of the area to be developed, 5% of the cultivated land and approximately 15% of the uncultivated land are deducted for road, canal lot and grassland, which will leave 34,000 ha as an arable land.

Table IV-71 Future land category (unit: ha)

Item	Paddy field			Upland field			Total
	Existing Paddy field	Reclaimed Paddy field	Sub-total	Existing Upland field	Reclaimed Paddy field	Sub-total	
Project area	5,017	14,803	19,820	7,452	6,728	14,180	34,000
Ratio (%)	15	43	58	22	20	42	100

Table IV-72 Project area by land category and each district

(unit: ha)

Name of District	Present area			Reclaimed area										Total	
				Paddy					Upland						
	Paddy	Upland	Total	Clear forest	Dense forest	Bush-wood	Grass-land	Sub-total	Clear forest	Dense forest	Bush-wood	Grass-land	Sub-total		
Kratie	378	60	438	15	0	478	3,758	4,251	0	0	339	0	339	5,028	6,381
	879	474	1,353	0	0	0	0	0	0	0	0	0	0	1,353	
Right bank of Prek Te	0	0	0	52	0	0	417	469	0	0	0	0	0	469	1,345
	450	4	454	382	0	0	40	422	0	0	0	0	0	876	
Left bank of Prek Te	4	0	4	22	0	111	643	776	0	0	0	0	0	780	955
	0	175	175	0	0	0	0	0	0	0	0	0	0	175	
Bos Leav	51	0	51	304	0	82	172	558	185	0	0	117	302	911	2,696
	72	1,092	1,164	0	0	0	134	134	79	25	55	328	487	1,785	
Kanhchor	236	78	314	172	0	61	581	814	196	0	731	111	1,038	2,166	2,478
	122	30	152	19	0	0	0	19	0	8	0	133	141	312	
Chhlong	75	0	75	48	46	1,182	768	2,044	0	0	0	102	102	2,221	5,114
	1,302	1,319	2,621	0	0	0	0	0	32	0	0	240	272	2,893	
Saop	24	0	24	39	16	518	2,540	3,113	0	0	535	318	853	3,990	7,176
	864	639	1,503	307	0	0	0	307	420	844	112	0	1,376	3,186	
Prek Prasap	100	0	100	0	9	496	300	805	41	139	184	972	1,336	2,241	4,135
	29	1,615	1,644	111	0	16	0	127	32	24	67	0	123	1,894	
Ta Mau	77	0	77	37	4	633	71	745	21	0	143	195	359	1,181	2,029
	354	275	629	0	0	0	219	219	0	0	0	0	0	848	
Kaoh Trung	0	0	0	0	0	0	0	0	0	0	0	0	0	0	247
	0	247	247	0	0	0	0	0	0	0	0	0	0	247	
Kaoh Chreng	0	0	0	0	0	0	0	0	0	0	0	0	0	0	638
	0	638	638	0	0	0	0	0	0	0	0	0	0	638	
Kaoh Tasuy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	806
	0	806	806	0	0	0	0	0	0	0	0	0	0	806	
Sub total	945	138	1,083	689	75	3,561	9,250	13,575	443	139	1,932	1,815	4,329	18,987	34,000
	4,072	7,314	11,386	819	0	16	393	1,228	563	901	234	701	2,399	15,013	
Total	5,017	7,452	12,469	1,508	75	3,577	9,643	14,803	1,006	1,040	2,166	2,516	6,728	34,000	

Note. The upper figures show inundated area and the lower non-inundated area

E-5-1-2 Land Leveling

The beneficial area of 34,000 ha is composed of 12,469 ha of cultivated lands and 21,531 ha of uncultivated lands. In regards to the land leveling, the paddy fields should be reclaimed to bench terrace condition to enable flood irrigation, and the upland fields should be reclaimed in natural slope to allow the furrow irrigation. In either case, the longitudinal slope should be parallel to the contour line to minimize the earth removal.

Existing upland fields are mostly developed along the bank of the Mekong, and in order to perform the effective irrigation in these area, the land-leveling will be required. However, for the existing paddy fields there will be no land leveling involved. Hence, this being the case, reclamation works include 21,531 ha of uncultivated lands and 7,452 ha of cultivated upland fields, totaling 28,983 ha.

For all the cultivated lands, the terminal irrigation and drainage facilities from the branch irrigation canal will be provided.

The road with 4 m width will be provided along the designed main and branch irrigation canal in order to serve for the operation and maintenance of the canal, and also to haul the construction equipments and materials as well as transport the crops.

E-5-1-3 Type of Irrigation

The surface irrigation and sprinkler irrigation methods may be adopted for the upland fields in this project area. For the determination of the method, an overall study should be made by considering the problems as listed below:

Location:	Type of soil and slope of the land, etc.
Management conditions:	Crops varieties, labor cost for supplemental water and the degree of difficulty of irrigation technique
Economical conditions:	Cost of irrigation facilities and their running cost

Upon studying the upland fields cropping in this area, the surface irrigation seems to be favorable for the following reason.

(1) The land slope is comparatively gentle; (2) the sprinkler irrigation is said to be disadvantageous for the corn which is the major upland crops in this area; and (3) the construction cost required for irrigation should be kept to the minimum.

Furthermore, from the results of the intake rate tests at the field, even at the upland fields with sandy soil texture, the basic intake rate is an average of 23.6 mm/hr, and this value is suited for the furrow irrigation. In general, it is considered that the sprinkler irrigation is suitable when the basic intake rate is over 75 mm/hr. The observed basic intake rates are indicated in the following table.

Table IV-73 Basic intake rate

Soil texture	Area (ha)	Basic intake rate
Clay	14,830	2.5 (mm/hr)
Clay loam & sand Sandy loam	11,133	10.5 - 16.2
Sand	8,037	23.6

E-5-1-4 Housing

21,531 ha will be reclaimed, and 34,000 ha of irrigable area will be used for the cultivation after the implementation of the project. The current number of farm household runs up to 6,500, and adding the 2,000 farm households that are anticipated to resettle when their land will be submerged by the construction of the Sambor dam, then the total will be 8,500 families. The farm management will be planned depending on the following basis; an average cultivated land per household will be 4 ha and their main cropping will be paddy and corn.

Now, as for the settlers' village planning, taking into account not only the current conditions of the farmers' community, but the standard of living and the production activities, such as the convenience of collection, distribution and cooperation, then, it would probably be either concentrated village or half concentrated village. And as to the private lands, they will probably have vegetable planted area around their residence, and the 4 ha of cultivated land will be situated at a distance from their respective residences. The dwelling houses will probably be built along the Mekong or its tributaries where is the fundamental requirements for the living, production, and transportation.

At any rate, the settlers' program and concentration of the farmers' community should be planned by foreseeing the future farmer's activities and farm village plan by taking into account the network of the roads, farmlands, dwelling houses, and schools, etc.

E-5-2 Water Requirement

E-5-2-1 Unit Water Requirement

a. Water requirement for paddy field

Percolation: From the results of the surveys made in the project area, the percolation by soil texture is determined as follows:

Sandy soil	4.8 mm/day
Loam	2.8 mm/day
Clay	1.8 mm/day

Evapotranspiration (E.T.): By Blaney-Criddle formula, the average daily evapotranspiration is obtained from the meteorological data at Kratie and Kompong Cham. (Refer also to Chapter C-2-4)

Table IV-74 Daily Evapotranspiration (E.T.)

Month	E.T. (mm/day)	Remarks
Jan.	6.14	
Feb.	6.78	Average value of dry season 6.6 (Jan.–Mar.)
Mar.	6.80	
Apr.	6.55	
May	5.40	
Jun.	5.75	
Jul.	4.75	
Aug.	4.57	
Sept.	4.45	Average value of rainy season 4.8 (Jul.–Oct.)
Oct.	5.33	
Nov.	5.87	
Dec.	5.93	
Mean	5.69	

Unit water requirement in depth: The design net water requirement is obtained by adding E.T. to the percolation by soil textures. The average value is shown as follows.

Table IV-75 Design net water requirement (unit: mm/day)

Item	Sand	Loam	Clay
Mean	10.49	8.49	7.49

Unit water requirement including losses: The gross water requirement per 100 ha of paddy fields is obtained from the following equation by considering the water losses.

$$q_p = \frac{d \times 10^{-3}}{(1 - f)} \times \frac{100 \times 10^4}{86,400} \quad \ldots\ldots\ldots\ldots\ldots \quad (m^3/sec/100\ ha)$$

Where, d : unit water requirement in depth (mm)

f : 0.25 = conveyance and operation losses

Table IV-76 Design gross water requirement (unit: m^3/sec/100 ha)

Month	Sand	Loam	Clay
Jan	0 169	0.138	0.123
Feb.	0.179	0.148	0.133
Mar.	0.179	0.148	0.133
Apr.	0.175	0.144	0.129
May	0.158	0.127	0.111
Jun	0 163	0.132	0.117
Jul.	0.148	0.117	0.101
Aug.	0.145	0.114	0.098
Sept.	0.143	0.112	0.096
Oct.	0.156	0.126	0.110
Nov.	0.165	0.134	0.118
Dec.	0.166	0.135	0.119
Mean	0.162	0.131	0.116

b. Water requirements of the upland field

Consumptive use: For the upland field irrigation, it is only necessary to supplement irrigation water for the quantity equal to the evapotranspiration of the crop concerned. The evapotranspiration for each upland field crop is obtained by the Blaney-Criddle Formula. And for the cropping factor K of the above formula is assumed as below:

For the fodder crops	0.75
For beans, tobacco and sesame	0.65
For leaf vegetables	0.55

Unit water requirements including losses: The gross water requirement per 100 ha of upland field is obtained from the following equation by considering the conveyance losses and irrigation efficiency.

$$q_u = \frac{d \times 10^{-3}}{(1-f)E} \times \frac{100 \times 10^4}{86,400} \quad (m^3/sec/100\ ha)$$

Where, d = Consumptive use (mm/day)

f = Conveyance losses = 0.2

E = Irrigation efficiency

Sand:	0.5
Loam:	0.7
Clay:	0.8

Table IV-77 Design gross water requirement (unit: m^3/sec/100 ha)

Month	Sand			Loam			Clay		
	0.55	0.65	0.75	0.55	0.65	0.75	0.55	0.65	0.75
Jan.	0.098	0.116	0.133	0.070	0.083	0.095	0.061	0.072	0.083
Feb.	0.107	0.127	0.148	0.077	0.091	0.105	0.067	0.080	0.092
Mar.	0.107	0.127	0.148	0.077	0.091	0.105	0.067	0.080	0.092
Apr.	0.104	0.124	0.142	0.074	0.089	0.101	0.065	0.078	0.089
May	0.087	0.101	0.119	0.062	0.072	0.085	0.054	0.063	0.074
Jun.	0.093	0.107	0.124	0.066	0.077	0.089	0.058	0.070	0.078
Jul.	0.075	0.090	0.104	0.054	0.064	0.074	0.047	0.056	0.065
Aug.	0.072	0.087	0.098	0.052	0.062	0.070	0.045	0.054	0.062
Sept.	0.072	0.084	0.096	0.052	0.060	0.068	0.045	0.052	0.060
Oct.	0.084	0.010	0.116	0.060	0.072	0.083	0.052	0.063	0.072
Nov.	0.093	0.110	0.127	0.066	0.079	0.091	0.052	0.069	0.080
Dec.	0.096	0.113	0.130	0.068	0.081	0.093	0.060	0.071	0.081

Quantity of irrigation water per operation: The quantity of irrigation water per operation for the upland fields is obtained from the following equation.

$$D = \frac{1}{100} \times \frac{1}{2} \times \overline{AM} \times t \quad .... \quad (mm)$$

Where,

$\overline{AM}$ = available moisture .... (%)

t = effective root zone ...... (mm)

The effective root zone (t) in this area is of 400 mm, and the available moisture is observed to be 21%, thereby the quantity of irrigation water per operation is calculated to be 42 mm. And since the water consumption per day is 6 mm - 8 mm, the frequency of irrigation will be 5 days - 7 days.

c. Water for miscellaneous uses

The water for this purpose is estimated at 0.1 mm/day. This is derived on the basis of a farmer with six persons to a family, four oxen, and 4 ha of arable land, whose water consumption is estimated to be about 4,000 liter for living and for livestocks.

$$d = 4{,}000\ l/40{,}000\ m^2/day = 0.01\ mm/day$$

When figuring the loss rate at 0.25, the required water for miscellaneous uses per 100 ha will be calculated as follows:

$$q_m = \frac{0.1 \times 10^{-3}}{1 - 0.25} \times \frac{100 \times 10^4}{86{,}400} = 0.002\ (m^3/sec/100\ ha)$$

This water will be conveyed through an irrigation canal.

E-5-2-2 Seasonal and Total Water Requirements

The seasonal and total water requirements may be computed from the unit water requirement which varies by the month and by the soil texture, and from the cropping pattern. The amount of water to be supplied for irrigation is obtained by deducting the effective rainfall from the total water requirements. And for the available rainfall, 75% of the monthly rainfall over 50 mm is considered to be effective for irrigation. The available rainfall was computed by taking the rainfall in Kratie in 1965 as design basic rainfall. The annual rainfall in Kratie in 1965 was 1,498 mm, and this corresponds to the probable rainfall of once in every ten years, when assuming from the rainfall data of the seven years from 1938 to 1944.

a. Maximum water requirement

The water consumption for crops will be at the peak in February and March. Since the cropping area in this area will be the most in February, the maximum water requirement will occur in this month and its volume will be 43.90 m^3/sec.

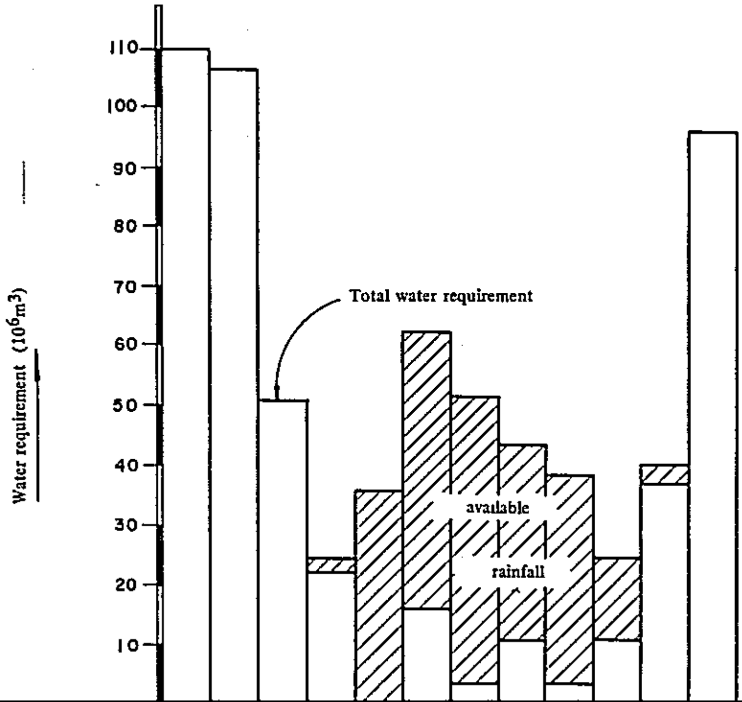
Table IV-78 Design maximum water requirement

Cultivated area (ha)			Maximum water requirement (m^3/sec)		
Paddy field	Upland field	Total	Paddy field	Upland field	Total
19,820	14,180	34,000	29.83	14.07	43.90

b. Monthly water requirements

The total water requirements for this project area are 685 x $10^6 m^3$, and out of this 32% which is equivalent to 217 x $10^6 m^3$ will be supplied by the available rainfall. Therefore, the amount of irrigation water to be provided will be 468 x $10^6 m^3$. Fig. IV-23 indicates the monthly water requirements. As it may be observed from the following figure, the maximum water consumption per month occurs in January, which is approximately 110 x $10^3 m^3$, whereas the maximum water requirement occurs in February (43.9 m^3/sec) as stated above.

Fig. IV-23 Monthly water requirement



Month	Jan.	Feb	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Water requirement	110	106	51	24	36	62	52	44	39	25	40	96	685 x 10^6m^3
Available rainfall	—	—	—	2	36	46	48	33	35	14	3	—	217 x 10^6m^3
Supplemental water	110	106	51	22	—	16	4	11	4	11	37	96	468 x 10^6m^3

E-5-2-3 Planning for Water Resources

a. Water resources

There are Sambor reservoir, lakes, ponds, swamps, and the Mekong and its tributaries. The advantages and disadvantages of these water source utilizations are as follows:

Sambor reservoir: If the cost allocation of the Sambor dam to agriculture is neglected, only the construction cost for outlet work is required for the water resources works, and moreover there will be an abundant water available, and having a hydraulic advantages deriving from the high water level or the operation and maintenance cost will be small. Therefore, it is considered that use of Sambor reservoir as the water resources will be most advantageous. Consequently, in this project, the water resources for the cultivated area, where gravity irrigation is made possible by the water head of 38 m at the Sambor reservoir, is planned to rely on the Sambor reservoir as the water resources. The areas fallen under this category are the entire areas of Kratie and Saop, and the right banks of the Prek Te and the Prek Prasap, which total comes 17,007 ha.

Lakes and ponds: To the existing lakes and ponds having comparatively large amount of water storage, gates installation will be made it possible to increase the storage capacity of the water and utilize them as water resources. In this case, it would be necessary to lift the water by pump, but it would be yet much lower than that of pumping from the Mekong.

Tributary: The gravity irrigation will be made possible by the construction of a dam, but there are only a few or almost no suitable dam site in the area, and furthermore, except the Prek Te and the Prek Chhlong, the other areas practically dries up in the dry season. Therefore, the construction of the dam to reserve the water is considered in general to be uneconomical.

Mekong mainstream: It has the advantages of abundant and stabilized water, and moreover it is close to the beneficial areas, however, it bears a disadvantage of requiring a high head, since the water level varies considerably, between the rainy and the dry season.

b. Water requirements by water resources

The water resources for each district are determined by utilizing the advantages of the respective resources. (Refer to E-4-2 plan for each district)

The following tables give the breakdown of the total water requirements for irrigation (685 x $10^6 m^3$) by the water resources. The irrigation water from Sambor reservoir is the greatest, and occupies 35% of the total water requirement.

Table IV-79 Water requirement by the water resources

	Available rainfall	Lakes & Ponds	Tributaries	Mekong	Sambor reservoir	Total
$10^6 m^3$	217	21	53	156	238	685
(%)	31.6	3.1	7.8	22.8	34.7	100

As to the irrigation method, the gravity irrigation was studied first as the operation and maintenance cost is much more inexpensive. However, the irrigation water by irrigation method is as shown in Table IV-80.

Table IV-80 Irrigation water by irrigation method

Item	Gravity	Pump	Total
$10^6 m^3$	257	210	468
(%)	55	45	100

Fig. IV-24 shows the irrigation supply system in Sambor Project.

E-5-3 Drainage

E-5-3-1 Overall Plan

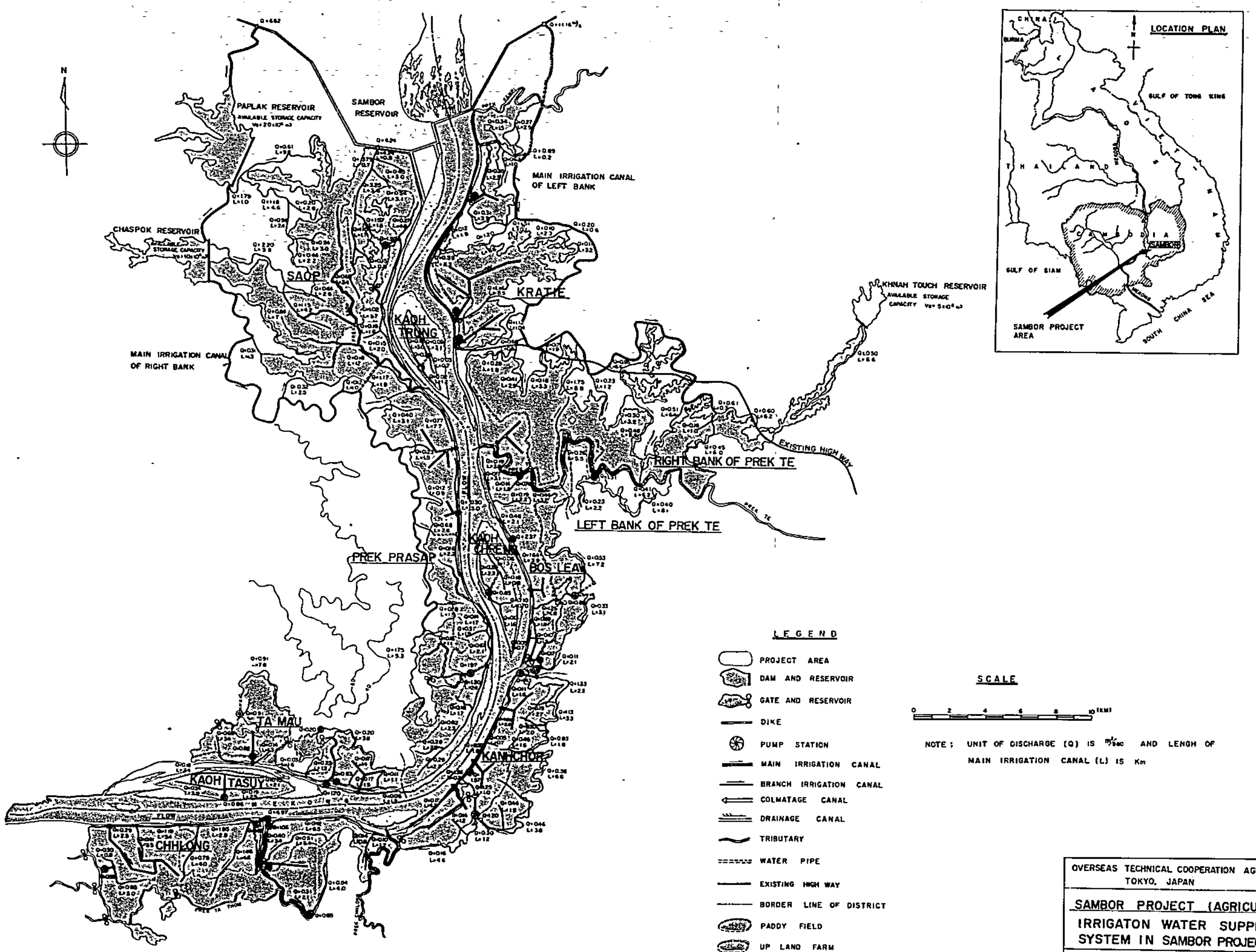
Of the 34,000 ha of beneficial area of agricultural development in the Sambor Project, 19,000 ha of the area is currently being inundated in the rainy season, and this is equivalent to 55% of the total project beneficial area. As studied by the hydrological survey, this fact is due to the inundation by the rainfall in relation to the increase of water level at the Mekong, and also the inundation caused by the backwater into the project area from the Mekong.

As to the drainage methods of the inundation area, there are two ways, which are (1) to drain the water by pump or (2) to prevent the intrusion of the water by constructing a polder dike.

This area is situated at the upstream of the Mekong Delta area, and there are great variations in water levels at the Mekong, and moreover, the catchment area is being large, therefore, there are only a few sites for drainage plan where are at present considered to be economical.

The effective drainage plan will have to await until the completion of the dams at the mainstream of the Mekong. However, in portions of Kratie and Chhlong area, there is a possibility to establish a relatively economical drainage system, so the drainage scheme is adopted in the both district. 3,770 ha out of 19,000 ha of the inundation area will receive the benefit of this scheme and 2,845 ha (75% of 3,770 ha) will be reclaimed as cultivated land suitable fo suitable for the perem.i

Fig IV -24 IRRIGATON WATER SUPPLY SYSTEM IN SAMBOR PROJECT



OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO, JAPAN

SAMBOR PROJECT (AGRICULTURE)

IRRIGATON WATER SUPPLY SYSTEM IN SAMBOR PROJECT

SANYU CONSULTANTS INTERNATIONAL, NAGOYA, JAPAN

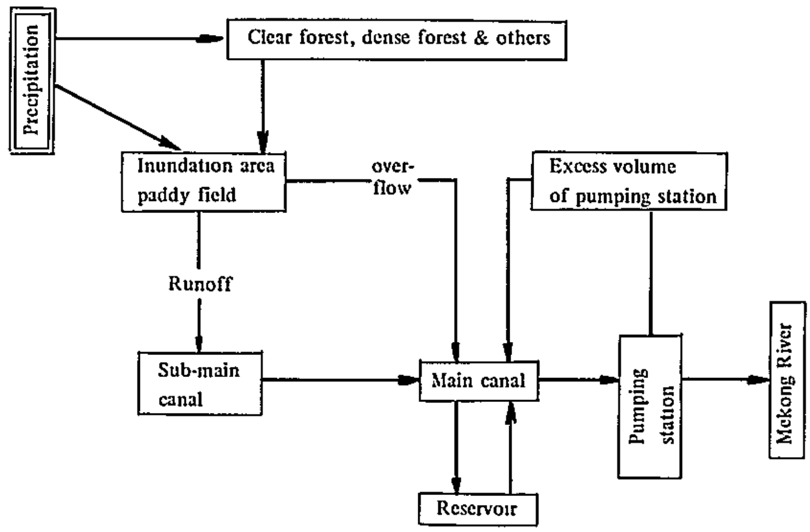
SUBMITTED	DATE 1968
APPROVED	DWG NO

E-5-3-2 Runoff Analysis and Unit Drainage Discharge

a. Function of runoff

The drainage for the cultivated land does not necessarily aim to completely drain the rainfall water. Specially in the paddy field, the allowable flooding depth is large, and the allowable flooding period is long. And in the area of paddy fields, they are considered as collective body of small reservoirs, and the storage effect of rainfall water is considered to be great by the notch, ridge and/or the drainage canal. The drainage system for this area is illustrated in Fig. IV-25.

Fig. IV-25 Illustration of drainage system



b. Unit discharge

The designed drainage discharge will be capable to drain 30 days rainfall in 30 days by considering the flood control capacity of the paddy field and the economical aspects of the facilities. For the design basic rainfall, 30 days rainfall of 497 mm as observed in Kratie Province in 1965 will be adopted. Therefore, the mean unit discharge for the entire river basin will be,

$$q = 497/30 = 18.5 \text{ mm/day}$$

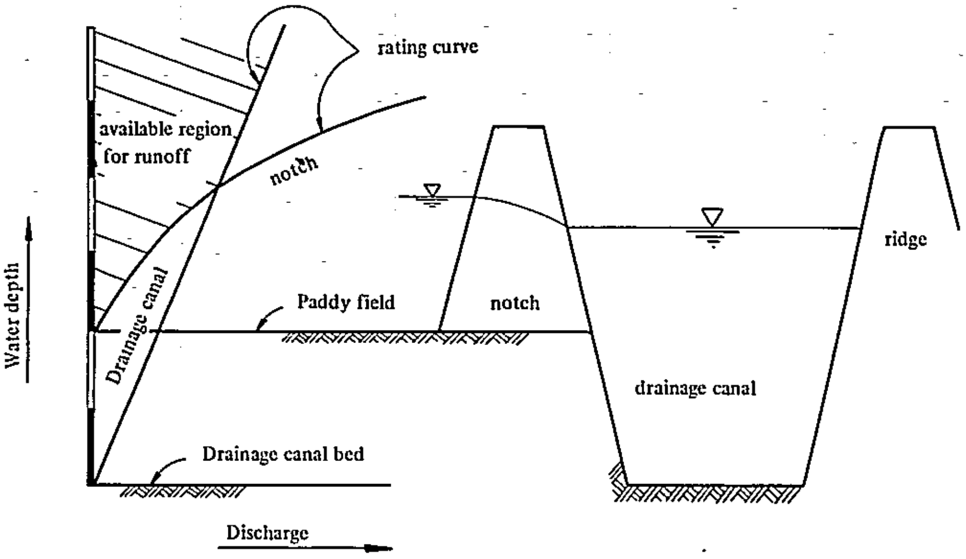
c. Drainage facilities

The notch to drain from each field to the terminal drainage canal will require a length of 15 m per 100 ha of paddy field when draining 18.5 mm/day, as the ridge height and the allowable flooding depth is assumed at 0.4 m. For the purpose of lowering the ground water level, the lateral canal bed should be 1 m below the surface of the paddy field.

d. Effective discharge region

Discharge from the notch of the ridge is determined by the difference in water level for inside and outside of the ridge. That is, the discharge is controlled by water level of the lateral canal. Therefore, the effective discharge region from the notch is generally controlled as shown in Fig. IV-26.

Fig. IV-26 Illustration of available region for runoff in paddy field



E-5-3-3 Discharge Plan for Each District

a. Kratie District

Area: The river basins of the three tributatries north of Kratie City, namely, the Prek Krakor, Prek Sambok, and Prek Andong Pring, have the catchment area of 4,380 ha which is comparatively small against the 2,720 ha of flooding area. Furthermore, since the bank of the Mekong is high, there is no fear for the intrusion of overflooding water. Therefore, it is possible to prevent the flood by installing gates and pumps.

Table IV-81 Area of present land category (unit: ha)

Name of tributaries	Project area	Catchment area			Total
	(1) Inundation area	(2) Paddy field	(3) Others	Subtotal	
Sambok	650	40	810	850	1,500
Krakor	1,490	420	2,500	2,920	4,410
Andong Pring	580	-	610	610	1,190
Total	2,720	460	3,920	4,380	7,100

Remarks: (1) Inundation area, and (2) Paddy field are the land that could storage the flood, which are shown as Af.
(3) Others are upland field, residential area and clear forest that could not storage the flood, which is shown as Ac.

Designed discharge: The rainfall (r) at the river basin will be equivalent to a catchment volume of r x (1 + Ac/Af) at the projected area. Furthermore, this catchment volume is divided into field surface storage water, by receiving the restrictions of the lateral canals and notches, and drainage water, flowing into the drainage pumping station through the drainage canal. The capacity of the drainage pump will be sufficient, if it could drain the accumulated water of 30 days at the pump station in 30 days. Following this procedure, when the discharge (q) for each tributary is obtained, they will be as follows for their respective project areas.

Prek Sambok : q = 34.2 (mm/day) = 2.57 m^3/sec

Prek Krakor . q = 51.6 (mm/day) = 8.90 m^3/sec

Prek Andong Pring: q = 32.2 (mm/day) = 2.17 m^3/sec

Land utilization: By the installation of pump and the prevention of the back water from the Mekong, 70% of the inundation area (2,720 ha) or 1,960 ha of lands may be cultivated and will be feasible for perennial cropping. 760 ha of a low elevation land in the inundated area has a function as flood control, during the rainfall exceeding the capacity of the pump. The above lowland will be cultivated for cropping during the dry season.

Table IV-82 Area of designed land category (unit: ha)

Item	Project area		Catchment area		Total
	Inundation area	Paddy field	Paddy field	Others	
Present	2,720	-	460	3,920	7,100
Project	760	1,960	460	3,920	7,100

b. Chhlong District

Area: The inundation of the Chhlong District is caused by the backwater of the Mekong from the Prek Pongro, and the over flooding from the tributaries, the Prek Kompong Reang and the Prek Ta Thon. And the retiring of the inundated water is very slow because the upland fields developed along the Mekong and the Prek Pongro prevent from retreating flood water. The backwater from the Mekong is easily prevented by closing the Prek Pongro by means of gates and dikes.

And the overflooding from the tributaries may also be prevented by constructing polder dike along the tributaries. And the area situated in the eastern portion of the district near the Chhlong City is also easily closed by polder dikes, as the area is almost a triangular shape with two sides being the Mekong bank and highway.

And this area does not have an external catchment area, therefore, it is possible to prevent flood by a relatively small pump.

The 1,050 ha of the inundated area will have the drainage improved by the construction of polder dike and the installation of the pump.

Design discharge: Following the pattern and method used for Kratie District, the designed discharge of the area will be 27.3 mm/day for the projected area.

Land utilization: By the implementation of the drainage scheme, 885 ha of lands out of 1,050 of inundated area may be reclaimed for perennial cropping.

Table IV-83 Area of land category (unit: ha)

Item		Project area			Total
		Inundation area	Paddy field	* Others	
Chhlong	Present	800	250	750	1,800
	Project	165	885	750	1,800

Remarks: * Others are upland field, residential lots, clear forest, where the areas are unable to store the flood.

E-5-4 Tank Reservoir

This project involves construction of a total of 16 reservoirs to utilize the water resources in the project area, and the breakdown of the reservoirs are 3 by the construction of tank reservoirs, 10 by installing a gate, and 3 intakes from Sambor reservoir. The total amount of irrigation water available from these reservoirs as water resources is estimated to be 59 x $10^6 m^3$, which is 9% of the required total irrigation water for 34,000 ha (685 x $10^6 m^3$).

E-5-4-1 Dam and Tank Reservoir

In the project area, the following three tributaries have the suitable dam sites, namely, Prek Saop, Prek Paprak and Prek Khnach. These tributaries are dried up during the dry season, but have abundant flow during the rainy season. However, this rainy season discharge is merely being drained downstream without making any use for the river basin area. Therefore, it is projected to construct small earth-fill dams at the three tributaries and reserve the water to be used mainly during the dry season for irrigation. The annual discharge of the three tributaries is 589 x $10^6 m^3$, of which 6% or 38 x $10^6 m^3$ of water may be used for irrigation.

Table IV-84 Water utilization capacity from tank reservoir (unit: $10^6 m^3$)

Name of dam	Total runoff	Utilization capacity	Utilization rate	Available storage capacity	Catchment area (KM^2)
Paprak	177	18	10 %	20	110
Saop	371	14	4	10	230
Khnach Touch	41	6	15	5	35
Total	589	38	6	35	375

The dam construction is advantageous not only to utilize the water resources in the project area, but to be an economical irrigation method on the irrigation facilities plan. By constructing the Paprak and Chaspok dams, the length of the main canal from Sambor reservoir to Saop and Prek Prasap areas will be curtailed, and moreover the sectional area of the canal may be reduced. And also the river-pass works at the tributaries, Prek Saop and Prek Prasap, will be unnecessary.

The gravity irrigation from Sambor reservoir will be impossible for 290 ha of the upstream paddy fields of Prek Khnach River Basin, as for the lack of water head. To lift the water from the Prek Te or from the main irrigation canal will be more expensive than the dam construction, as it will require a long distance of pipe work due to the topographical conditions. The following table gives the design elements of dam.

Table IV-85 Designed dam elements

Name of district	Name of dam	Irrigable area	Dam: Dam length	Dam: Dam height	Dam: Structure	Embankment volume
Saop	Paprak	1,132 ha	2,950 m	8 m	Earth-fill	222 x $10^3 m^3$
"	Chaspok	1,368	2,520	12	"	537 "
Prek Te (R)	Khnach Touch	290	830	4	"	24 "
Total		2,790				783 "

E-5-4-2 Gate and Tank Reservoir

The lakes and ponds in the project area reserve the water from the Mekong and the rainfall runoff from the mountains during the rainy season, and in the dry season when the water level of the Mekong gets low, the reserved water flows into the Mekong.

Therefore, by providing gates for each of these lakes and ponds, the reserved water capacity could be increased and the water could be used as the irrigation water during the dry season. The gate to be installed will be at ten places, and the lakes and ponds utilized as water resources for irrigation will be eight, and their water capacities to be utilized will be as shown in Table IV-86.

Table IV-86 Lakes utilized for water resources

Name of district	Name of lake	Utilized water capacity (10^3 m^3)		
		Area	Water depth	Water capacity
Bos Leav	Boeng Pou	50 ha	1.5 m	750
Chhlong	Boeng Kg. Kor	110	3	3,300
"	Ta Thom	35	3	1,050
"	Prek Kor	200 m^2 x 11,000 m		2,270
Saop	Boeng Romea	160	2	3,200
Prek Prasap	Boeng Chrvea	200	2	4,000
Ta Mau	Trapeang Thom	150	3	4,500
"	Boeng Mokoy	100	2	2,000
Total	8 places			21,070

E-5-5 Pumping Station

This project consists of 23 irrigation pumping stations and four drainage pumping stations. The power resources are the power generated at the Sambor dam. In case of introducing the water from the Mekong and the Prek Te, the suction water level varies greatly, the maximum difference between the water level in the dry season and that in the rainy season is as much as 15 m. Therefore, it has to be considered not to reduce the pump efficiency by using an axial flow pump or by separating the low lifting pump and high lifting pump.

E-5-6 Canals

The lining for the water canals is eliminated and earth canal is used for both irrigation and drainage, as the construction cost will be large and uneconomical. The section of canal is determined as such that the flow velocity will not exceed 0.5 m/sec., to prevent erosion of the canal. The typical section of the canal will be trapezoid and will be designed to have a side slope of 1:2. And on one side of the canal, an inspection path having a width of 4 m will be provided.

E-5-6-1 Irrigation Canal

For the determination of the cross section of main canal, the water requirement per month is computed by considering the seasonal water requirements and the cropping area, of which the maximum water requirement occurs in February. The flow section of the lateral canal is determined by taking 100% for the cropping rate, as the area to be irrigated is small. Each canal is laid out at high elevation in order to maintain a high diversion water level. For the sake of its operation and maintenance, the earth fill and embankment are avoided for the canals. The total length of the canal will be 557.4 km and its breakdown is given in Table IV-88.

Table IV-87 Pumping stations

Name of district	Number of stations	Required energy	Remarks
Kratie	3 (3)	1,541 kW	( ) shows the drainage pumping stations
Prek Te (L)	1	376	
Bos Leav	4	1,277	
Kanhchor	3	1,408	
Chhlong	6 (1)	1,971	
Saop	1	278	
Prek Prasap	1	586	
Ta Mau	5	840	
Kaoh Trung	1	73	
Kaoh Chreng	1	199	
Kaoh Tasuy	1	247	
Total	27 (4)	8,796	

The total length of the canal will be 557.4 km and its breakdown is given as a following table.

Table IV-88 Table of irrigation canal (unit: km)

Name of district	main	lateral	Total
Kratie	49.3	79.3	128.6
Prek Te (R)	1.4	26.5	27.9
Prek Te (L)	-	22.5	22.5
Bos Leav	-	40.7	40.7
Kanhchor	-	40.9	40.9
Chhlong	-	49.6	49.6
Saop	32.8	89.2	122.0
Prek Prasap	23.1	42.6	65.7
Ta Mau	-	29.4	29.4
Kaoh Trung	-	8.8	8.8
Kaoh Chreng	-	9.2	9.2
Kaoh Tasuy	-	12.1	12.1
Total	106.6	450.8	557.4

Remarks: (R) and (L) represent right bank and left bank respectively.

E-5-6-2 Drainage Canal

The typical section of the drainage canal is the same as for the irrigation canal. The water level in the drainage canal is designed at 50 cm below the paddy field surface, to lower the ground water table and also to drain the surface water during the rainy season.

Table IV-89 Table of drainage canal

Name of district	Length of drainage canal
Kratie	18.1 km
Chhlong	12.4
Total	30.5

E-5-6-3 *Colmatage* Canal

The *colmatage* is a typical and traditional water utilization method in the lower basin of the Mekong, and in the Sambor Project, this method is being adopted in the following area; Prek Pongro in Chhlong District, Prek Chik in Kanhchor, and Prek Chik in Saop Districts, etc.

The study on the sedimentation is made for the Prek Chik in Kanhchor District, which is a successful case. According to the result of the above study, it is found that the following conditions have to be fulfilled.

1) To be able to lead water from the Mekong for about 100 days.

2) The cross section of the *colmatage* canal should have a sufficient flow capability, so that the internal water level will assimilate without delay with the water level variations of the Mekong.

3) In order to prevent the siltation in the canals, especially during the inflow season (when water level rises in the Mekong) the friction velocity should be fairly big compared with the critical friction velocity.

It is necessary to fulfill the following three conditions to make a detail design of the *colmatage* canal.

1) The silt of the canal for each proposed site should be determined on its elevation as indicated in Fig. IV-27.

2) The maximum daily rise of the water level is 1.8 m, according to the past record. Now, if an assumption is made that this water volume is the maximum water level difference in the inundation areas which are governed by the canals, the canal cross section should be capable to convey this amount of water in one day.

3) The friction velocity of the canals should be designed to be larger than the mean friction velocity of the Mekong, which is 0.11 m/sec.

The marshy lands with poor fertility may be converted and reclaimed into rich, fertile upland fields, by introducing the dirty water from the Mekong to these areas. The application of the *colmatage* to the greatest extent should be exercised for the reclamation of the marshy lands.

It will be necessary to have flow velocity of 2 m/sec in the canals to prevent the sedimentation in the canals. With this velocity of flow, it is likely to cause an erosion to the canal surface, therefore, for the canal requiring this velocity, the side slopes of the canal will be lined by concrete.

Table IV-90 Table of *colmatage* canal

Name of district	Name of canal	Sill elevation	Mekong levee elevation	Length
Kratie	Prek Kandal	12.95 m	17.0 m	700 m
Bos Leav	Prek Ta Am	12.40	19.0	650
Kanhchor	Prek Kanhchor	12.15	18.0	800
"	Prek Samann	11.80	19.0	700
"	Lovea Thom	11.70	19.0	800
Prek Prasap	Saop Kraom	12.95	17.0	3,600
"	Thoma Reap	12.75	17.0	450
Ta Mau	Kampong Kor	11.30	17.0	900

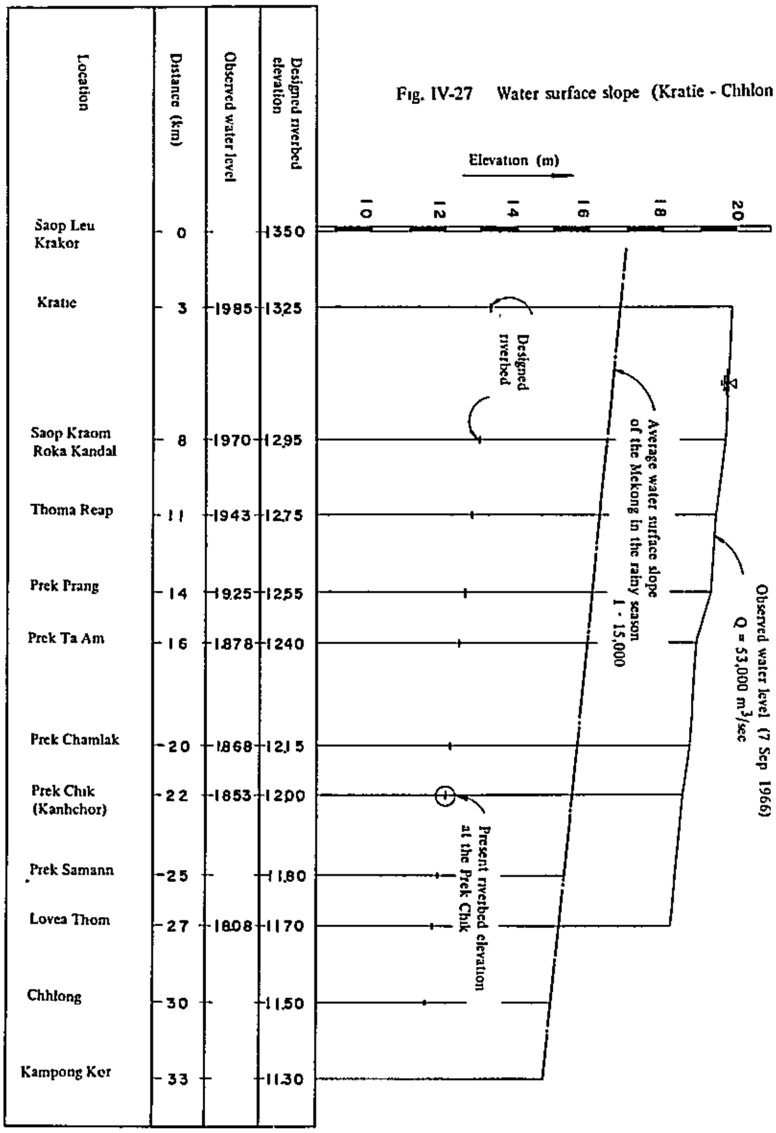
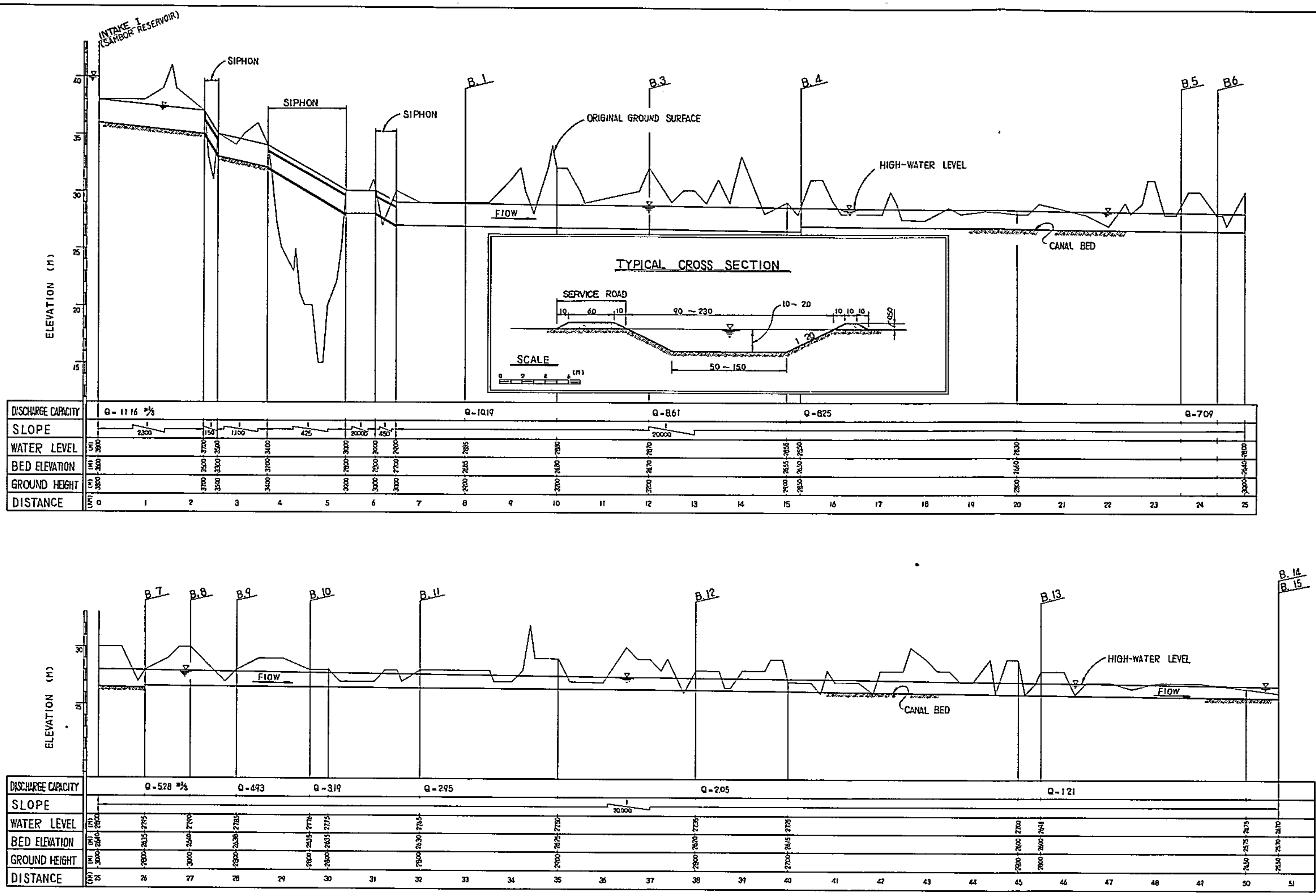
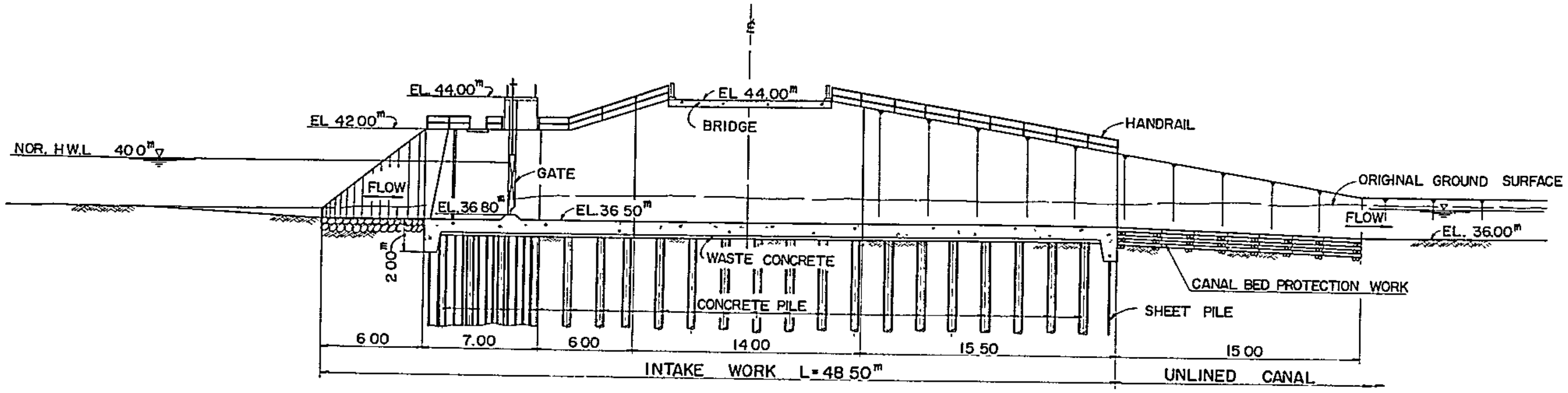


Fig. IV-27 Water surface slope (Kratie - Chhlon



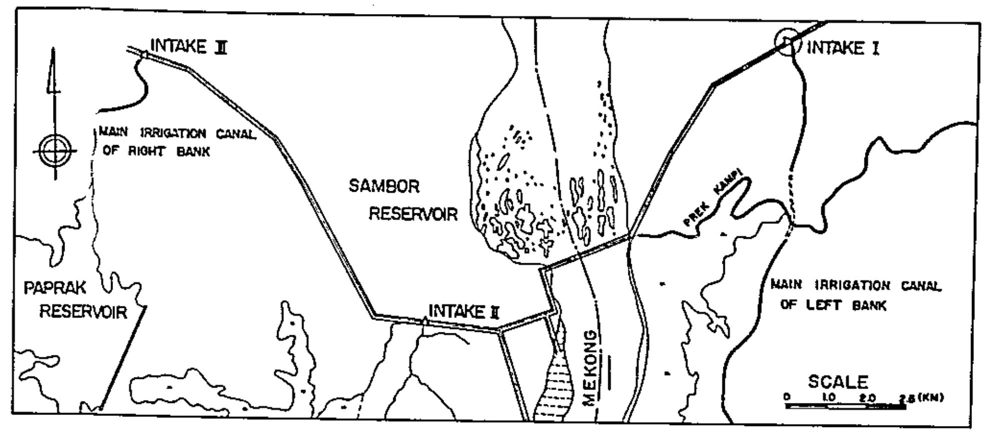
NOTE: SIPHON REFER TO DWG NO. 2

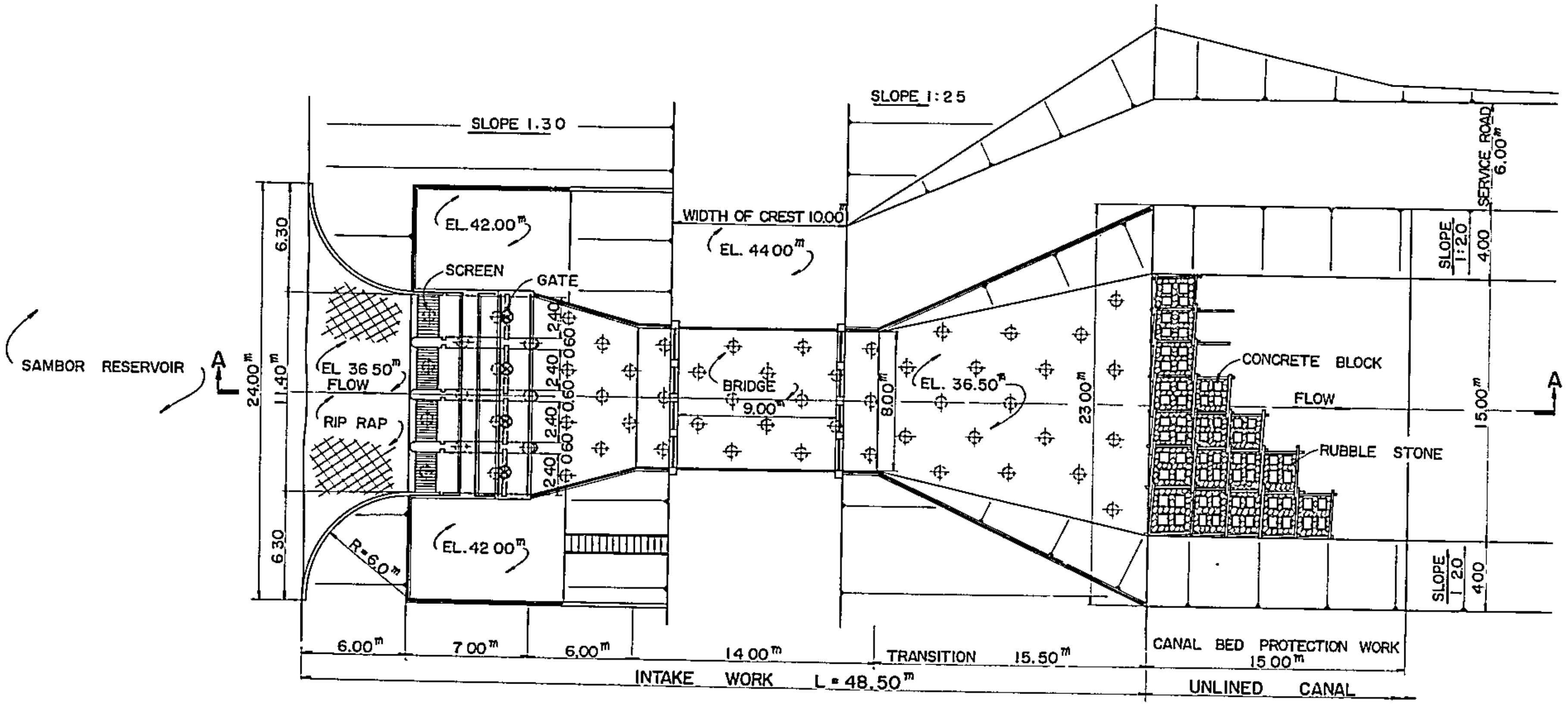
OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO, JAPAN	
SAMBOR PROJECT (AGRICULTURE) PROFILE OF MAIN IRRIGATION CANAL OF LEFT BANK	
SANYU CONSULTANTS INTERNATIONAL, NAGOYA, JAPAN	
SUBMITTED APPROVED.	DATE 1968 DWG. NO. IV-9



PROFILE OF INTAKE WORK I (SEC. A~A)

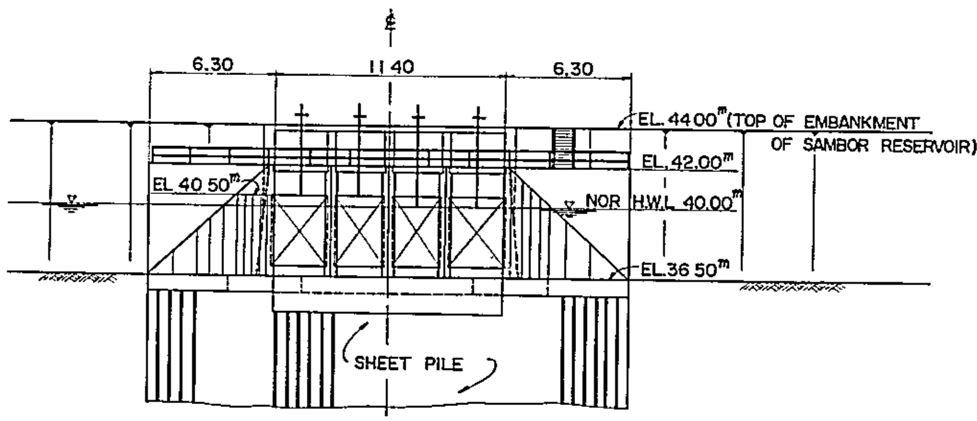
LOCATION PLAN





PLAN OF INTAKE WORK I

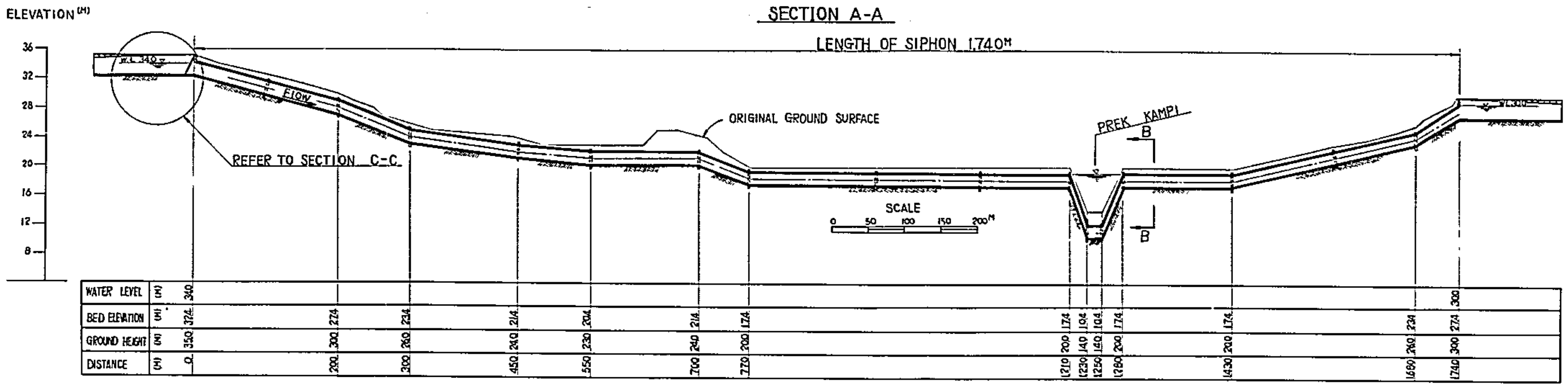
SCALE 0 2 4 6 8 10 12 14 (M)

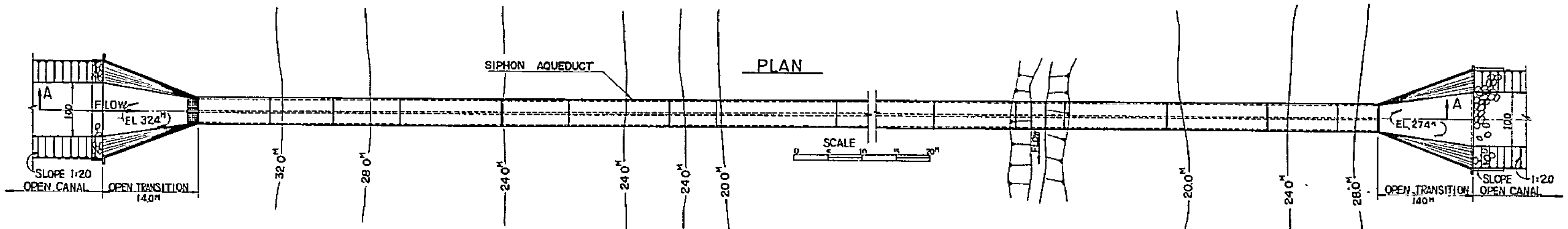


FRONT VIEW OF INTAKE WORK I

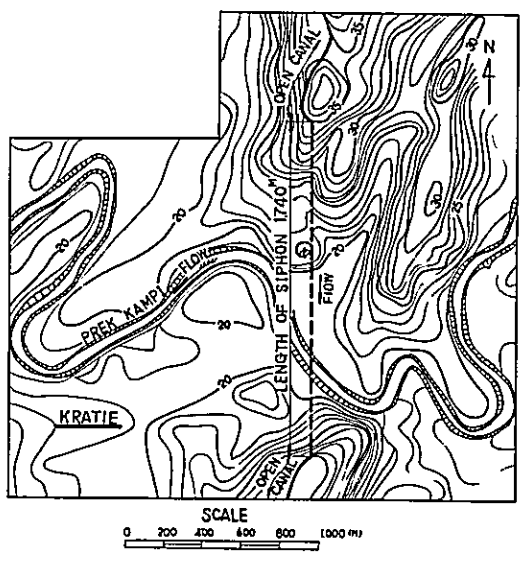
SCALE 0 2 4 6 8 10 12 (M)

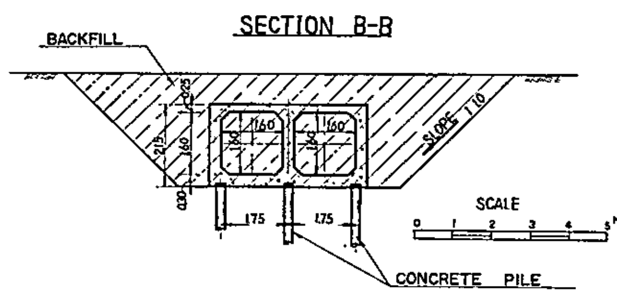
OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO, JAPAN	
SAMBOR PROJECT (AGRICULTURE)	
PLAN OF INTAKE I FROM SAMBOR RESERVOIR $Q_{MAX} = 11.16\ M^3/SEC$	
SANYU CONSULTANTS INTERNATIONAL. NAGOYA. JAPAN	
SUBMITTED	DATE 1968
APPROVED	DWG NO. IV-10

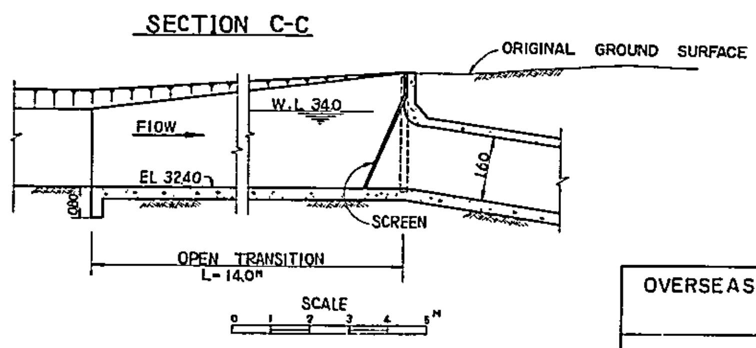




LOCATION PLAN

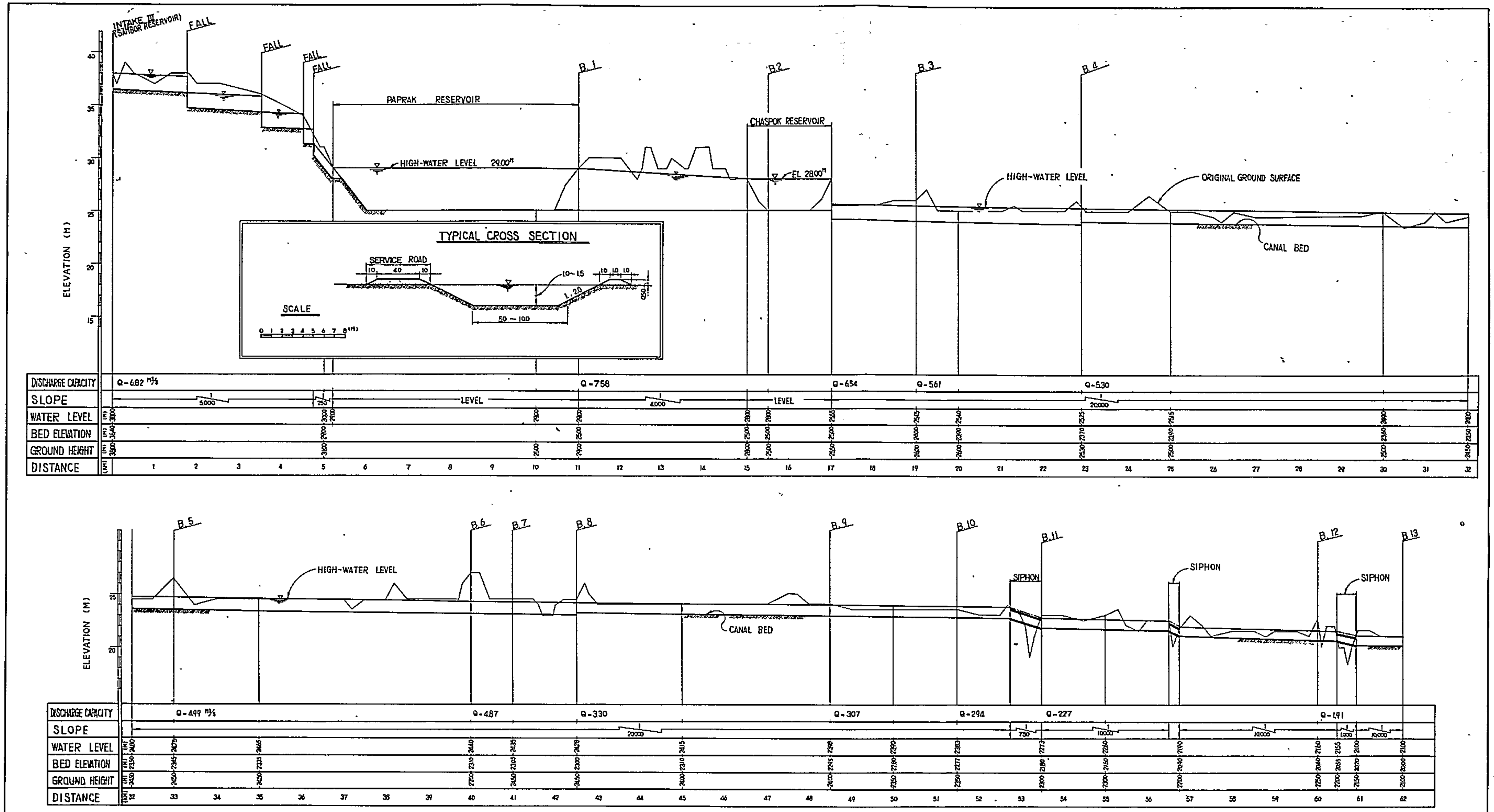






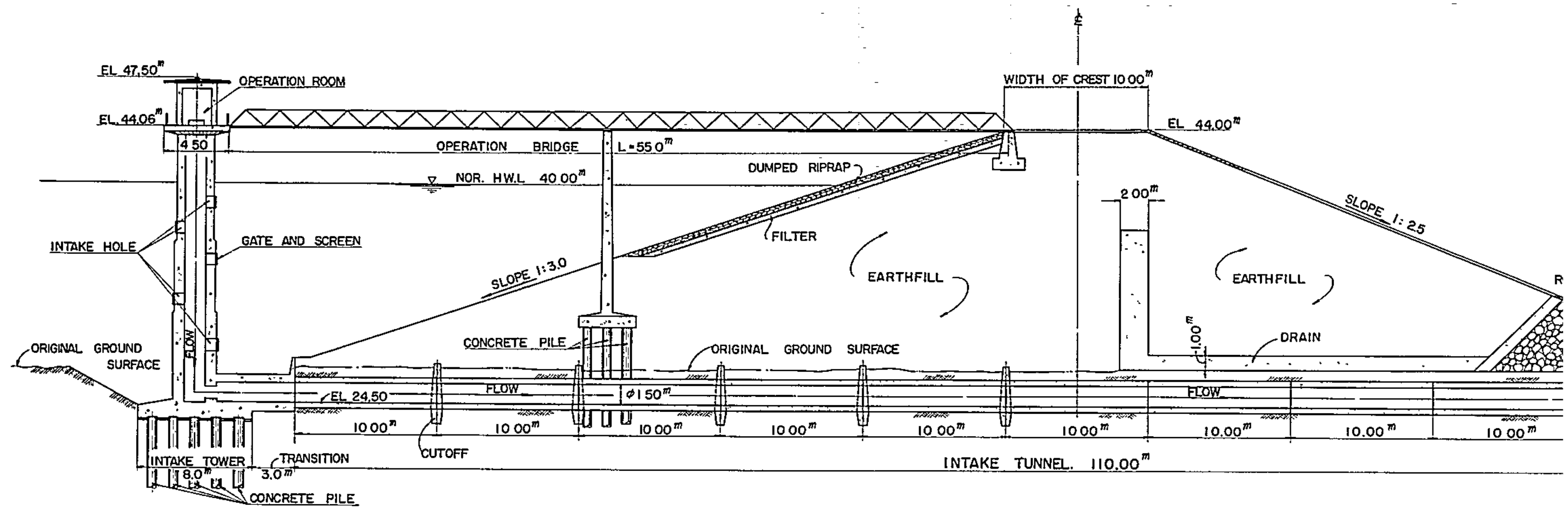
NOTE SIPHON TO CROSS PREK KAMPI

OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO, JAPAN	
SAMBOR PROJECT (AGRICULTURE) SIPHON AT KRATIE $Q_{Max} = 11.2\ M^3/SEC$	
SANYU CONSULTANTS INTERNATIONAL, NAGOYA, JAPAN	
SUBMITTED APPROVED	DATE 1968 DWG. NO. IV-11

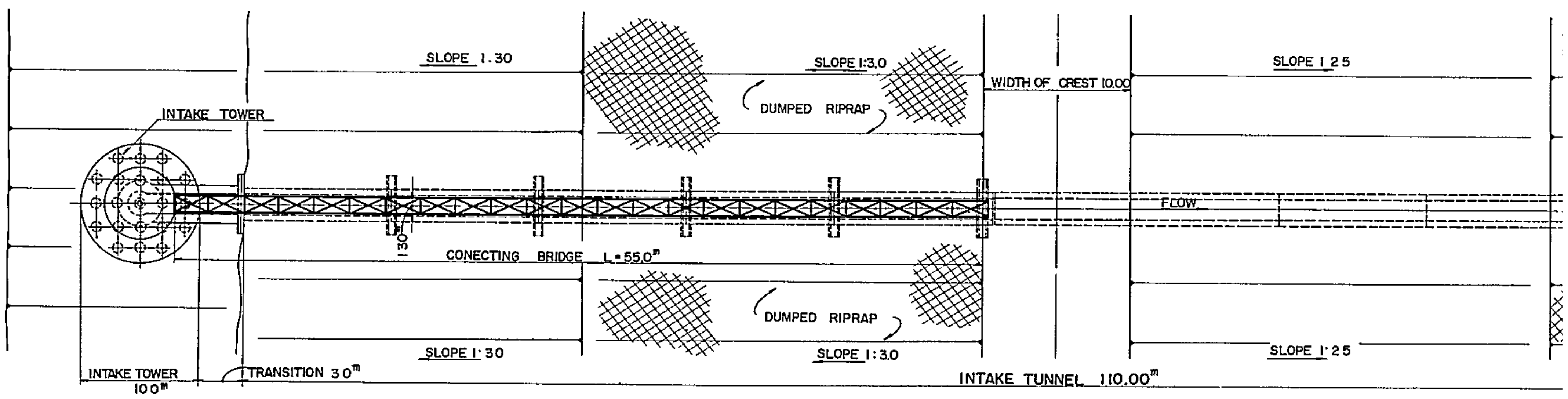


NOTE: PAPRAK RESERVOIR REFER TO DWG NO 4

OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO, JAPAN	
SAMBOR PROJECT (AGRICULTURE)	
PROFILE OF MAIN IRRIGATION CANAL OF RIGHT BANK	
SANYU CONSULTANTS INTERNATIONAL, NAGOYA, JAPAN	
SUBMITTED	DATE 1968
APPROVED.	DWG. NO. IV-12



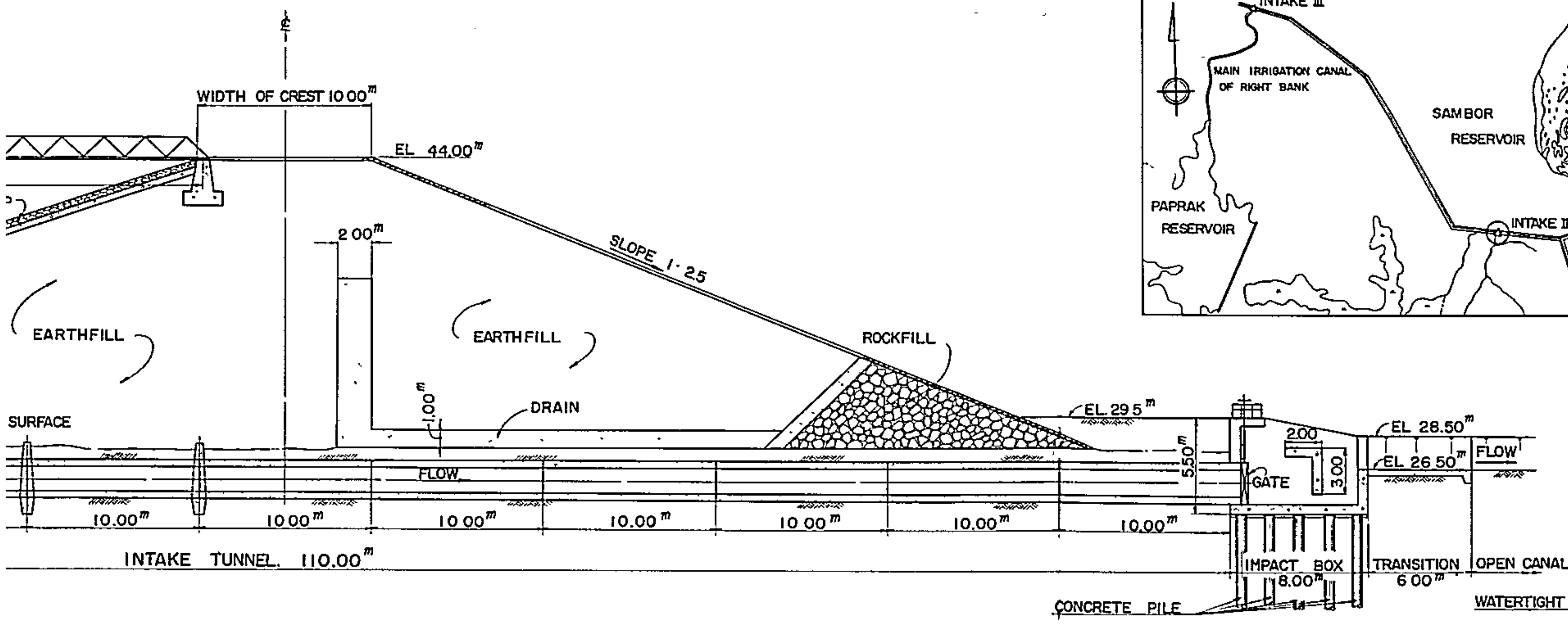
PROFILE OF INTAKE WORK II



PLAN OF INTAKE WORK II

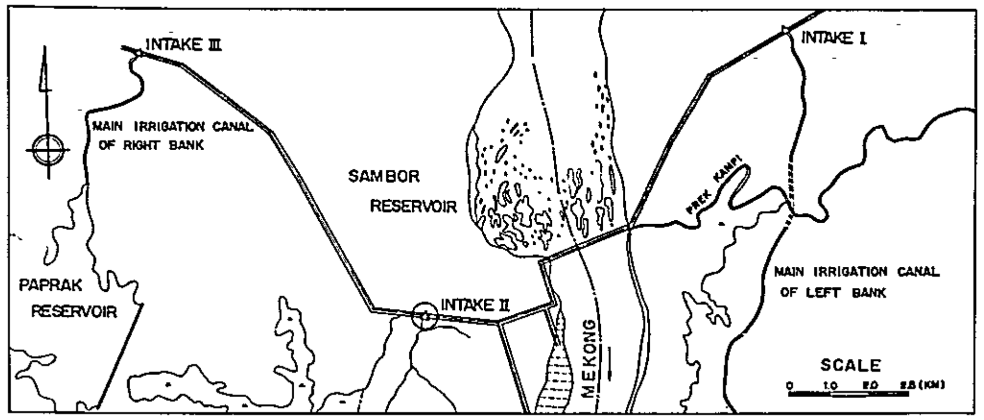
SCALE

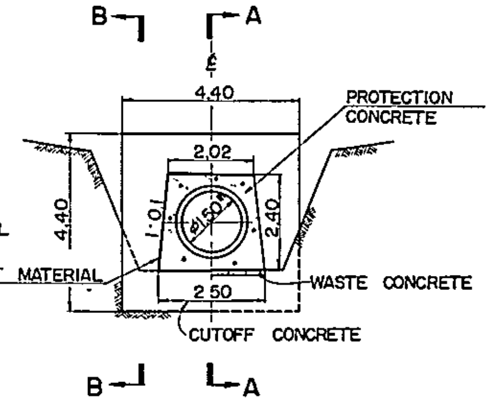
0 2 4 6 8 10 12(M)



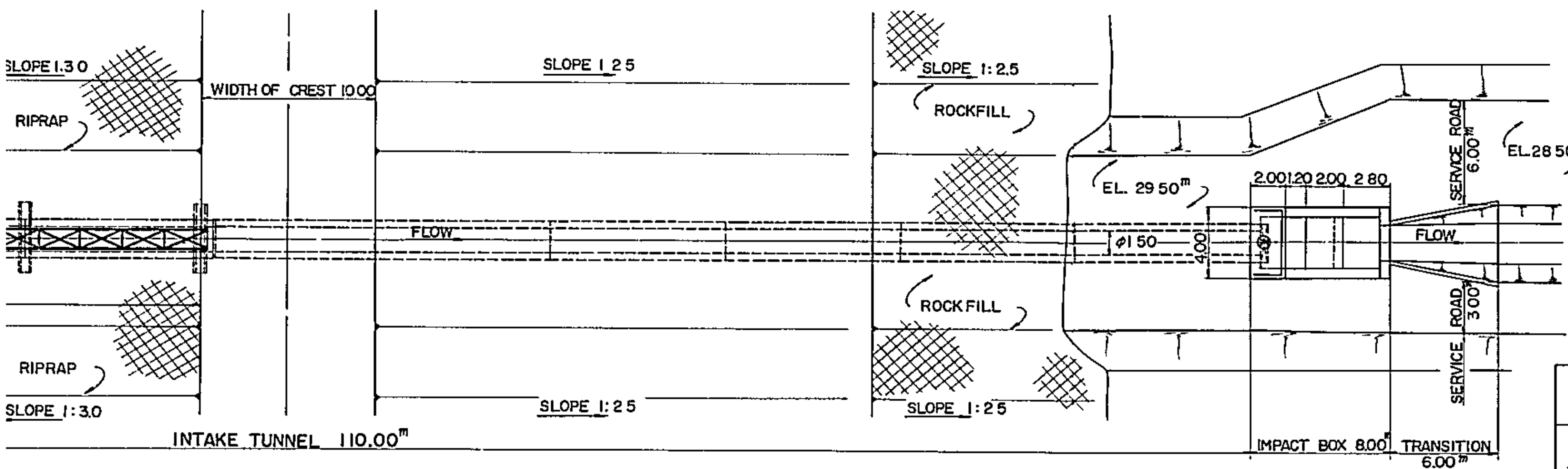
PROFILE OF INTAKE WORK II

LOCATION PLAN



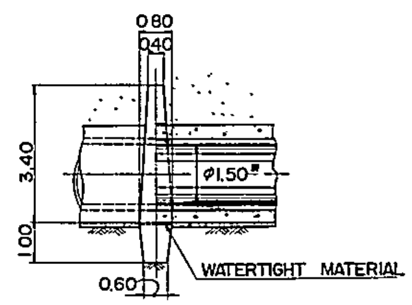


DETAIL OF CUTOFF



PLAN OF INTAKE WORK II

SCALE 0 2 4 6 8 10 12(M)

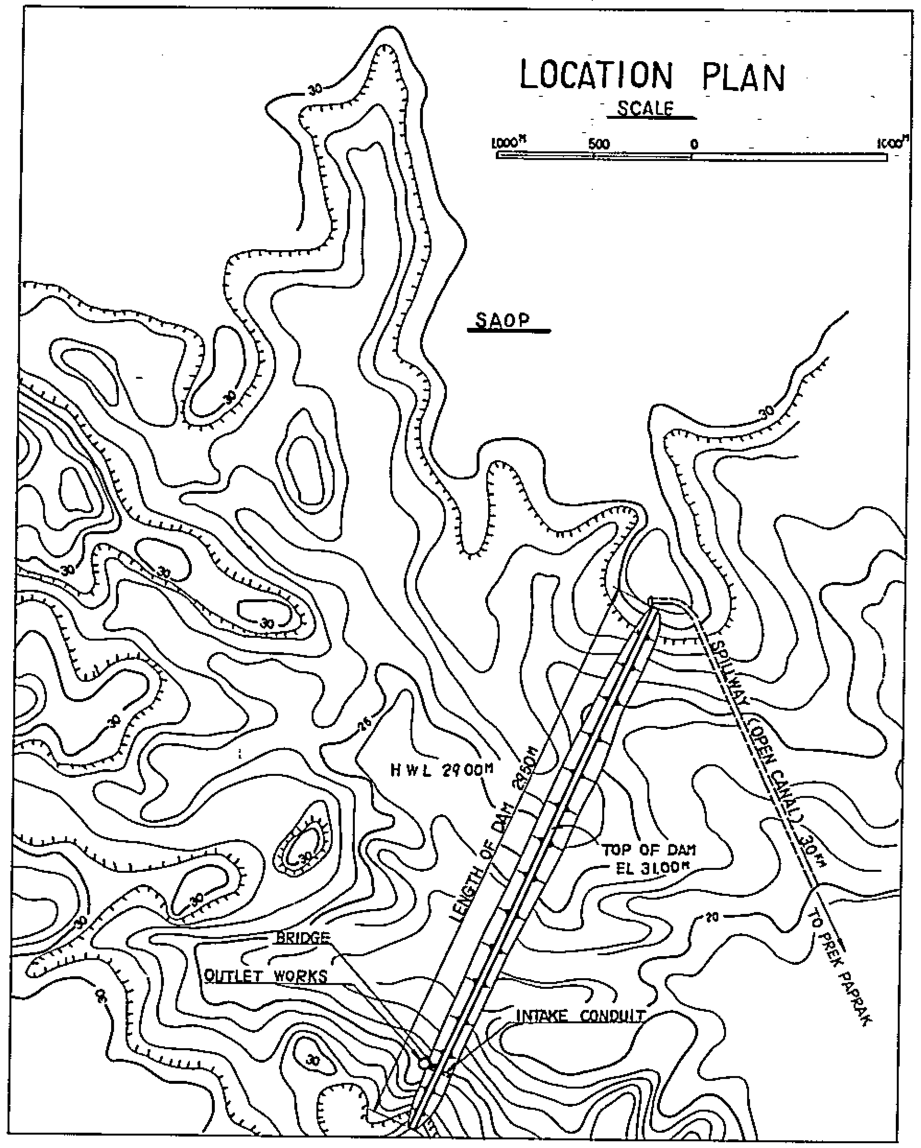


SEC.B~B SEC.A~A

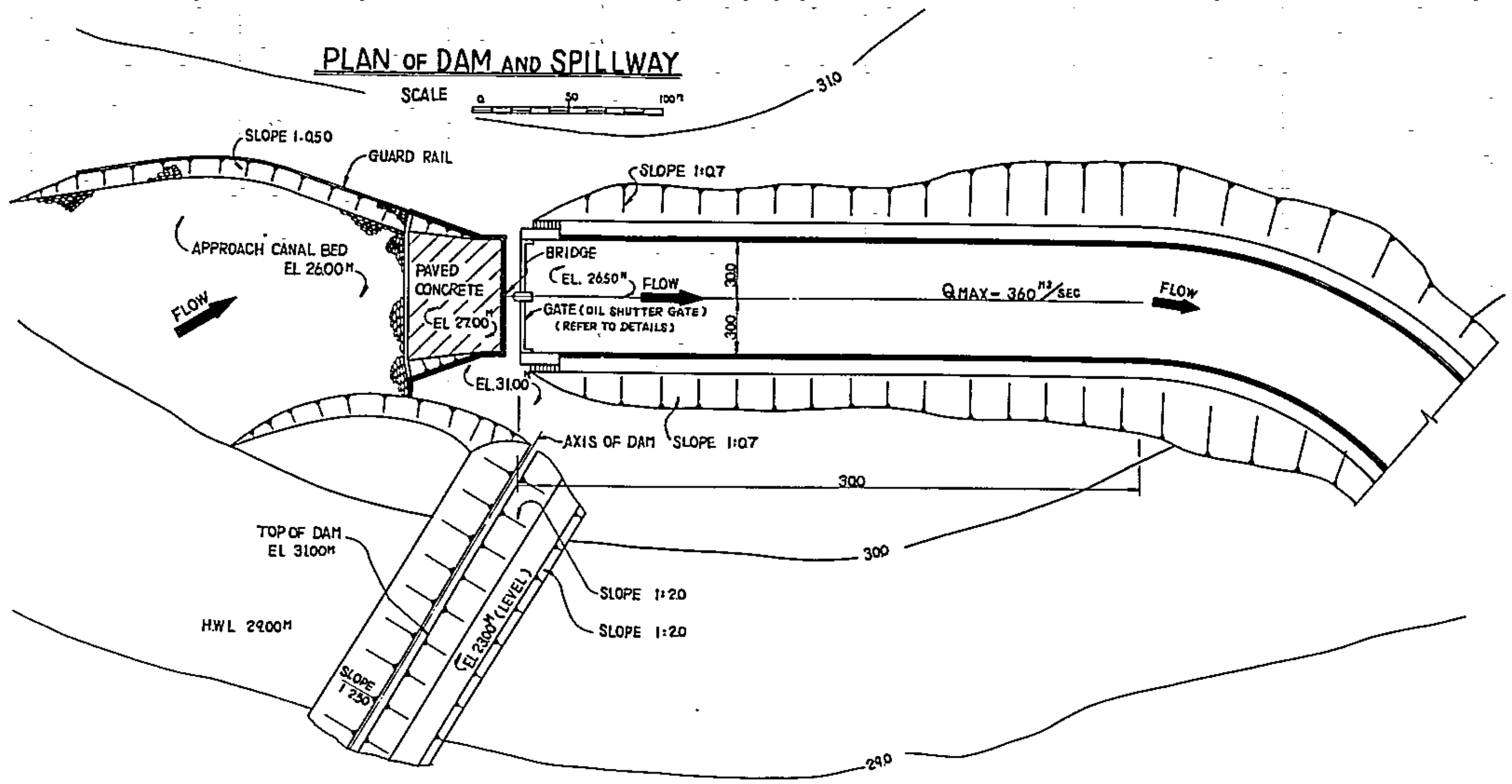
SCALE 0 1 2 3 4(M)

OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO, JAPAN	
SAMBOR PROJECT (AGRICULTURE)	
PLAN OF INTAKE II FROM SAMBOR RESERVOIR Q_{MAX} = 4.24 M^3/SEC	
SANYU CONSULTANTS INTERNATIONAL. NAGOYA. JAPAN	
SUBMITTED	DATE 1968
APPROVED	DWG NO. IV-13

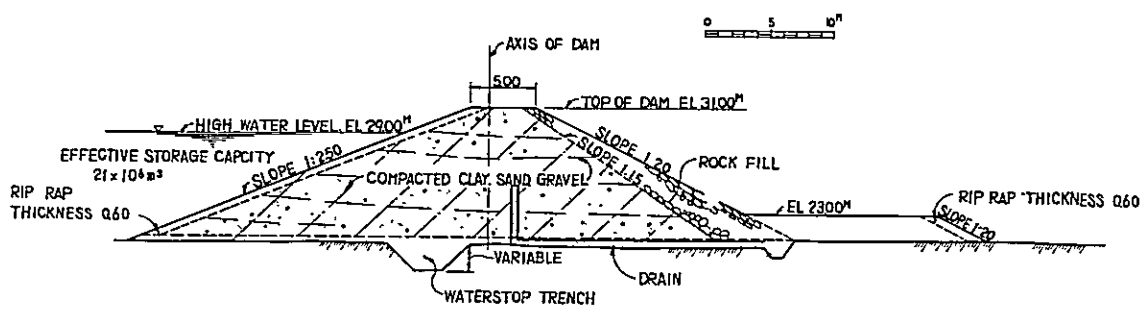
LOCATION PLAN



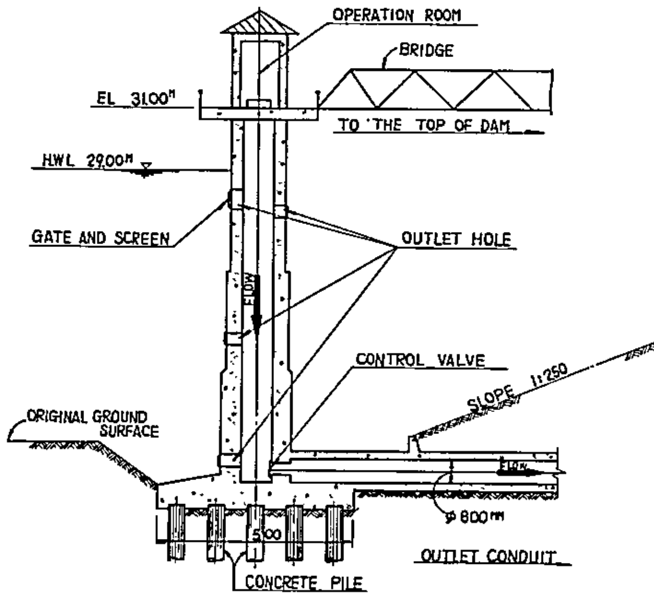
PLAN OF DAM AND SPILLWAY



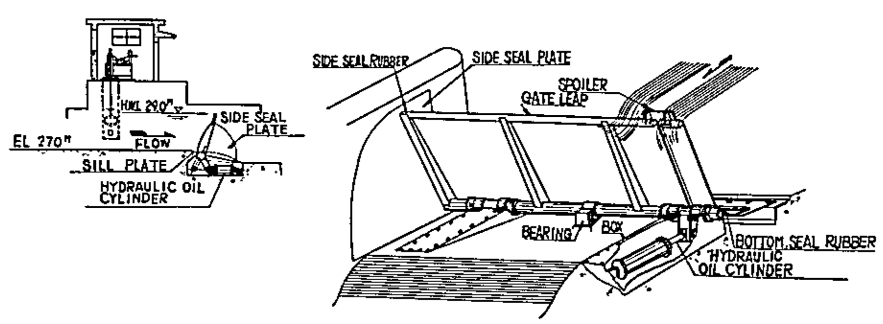
TYPICAL CROSS SECTION OF PAPRAK DAM



INTAKE WORKS



HYDRAULIC OIL SHUTTER GATE



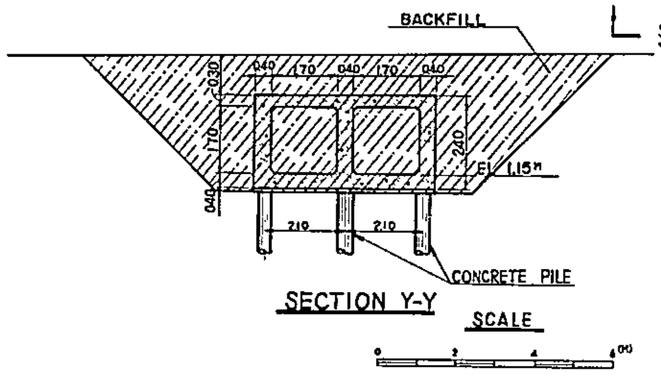
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO, JAPAN

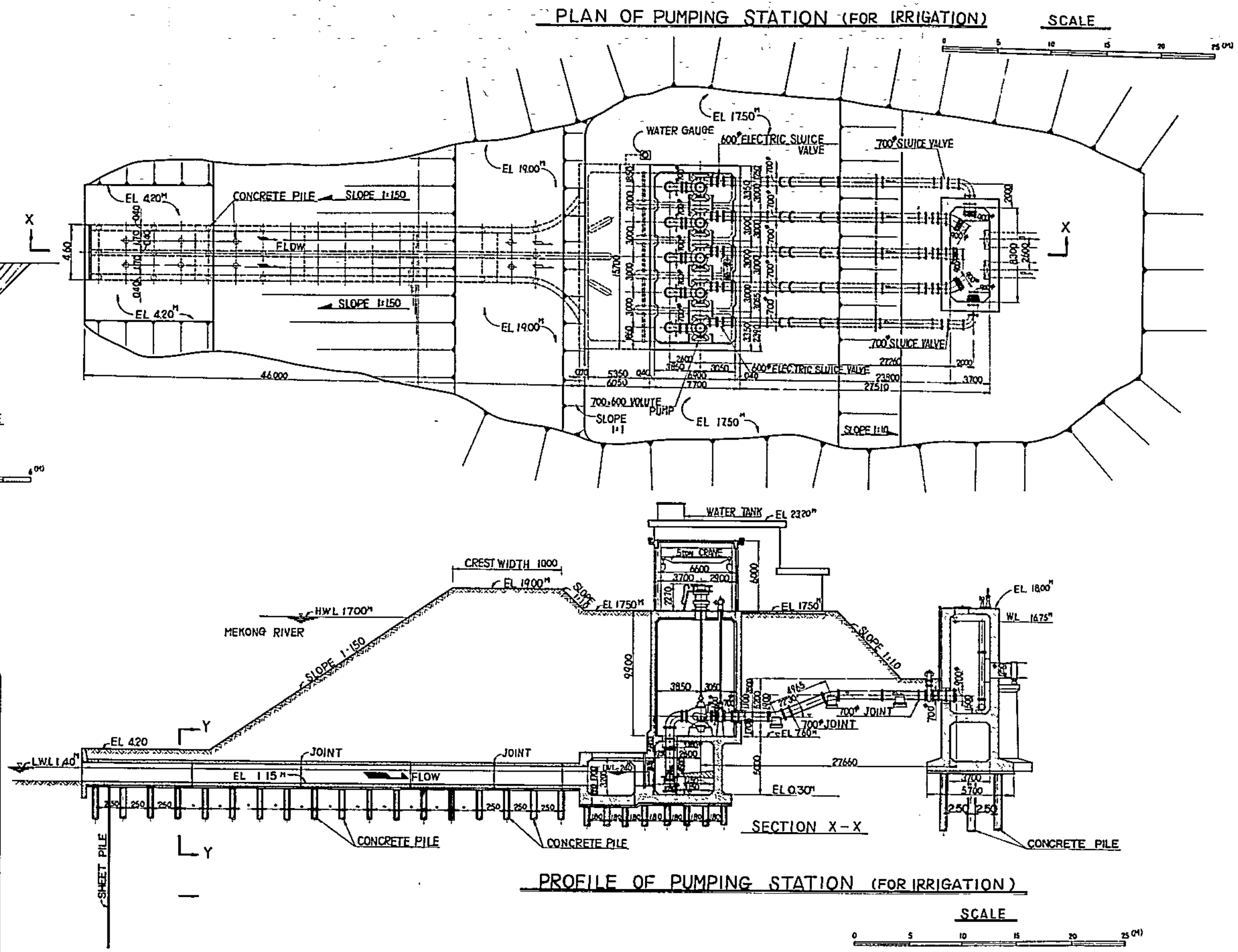
SAMBOR PROJECT (AGRICULTURE)

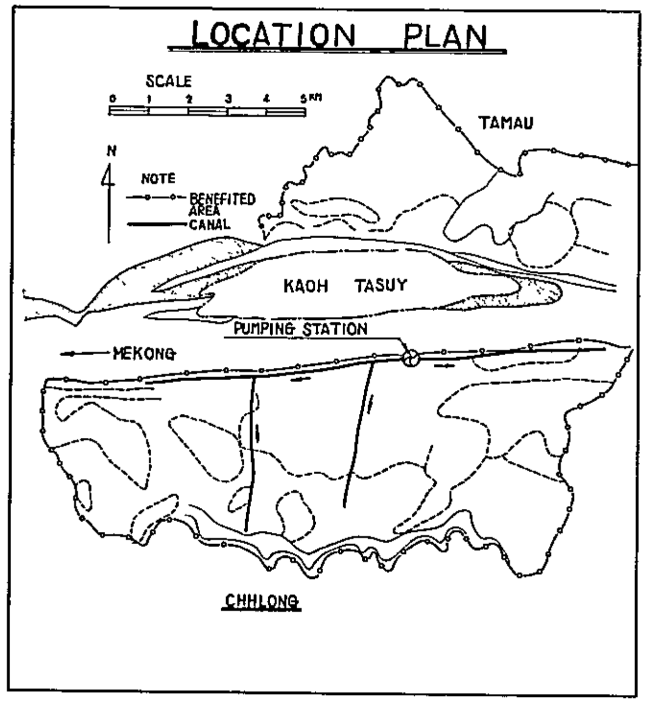
RESERVOIR AT SAOP

SANYU CONSULTANTS INTERNATIONAL, NAGOYA, JAPAN

SUBMITTED APPROVED.	DATE 1968 DWG NO. IV-14







DEMENSIONS OF IRRIGATION PUMP

TYPE	VERTICAL DOUBLE SUCTION VOLUTE PUMP				
CALIBER (mm)	DISCHARGE (m³/min)	TOTAL HEAD (m)	R. P. M	MOTOR POWER (kw)	
700 × 600	60	15	720	200	

OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO, JAPAN

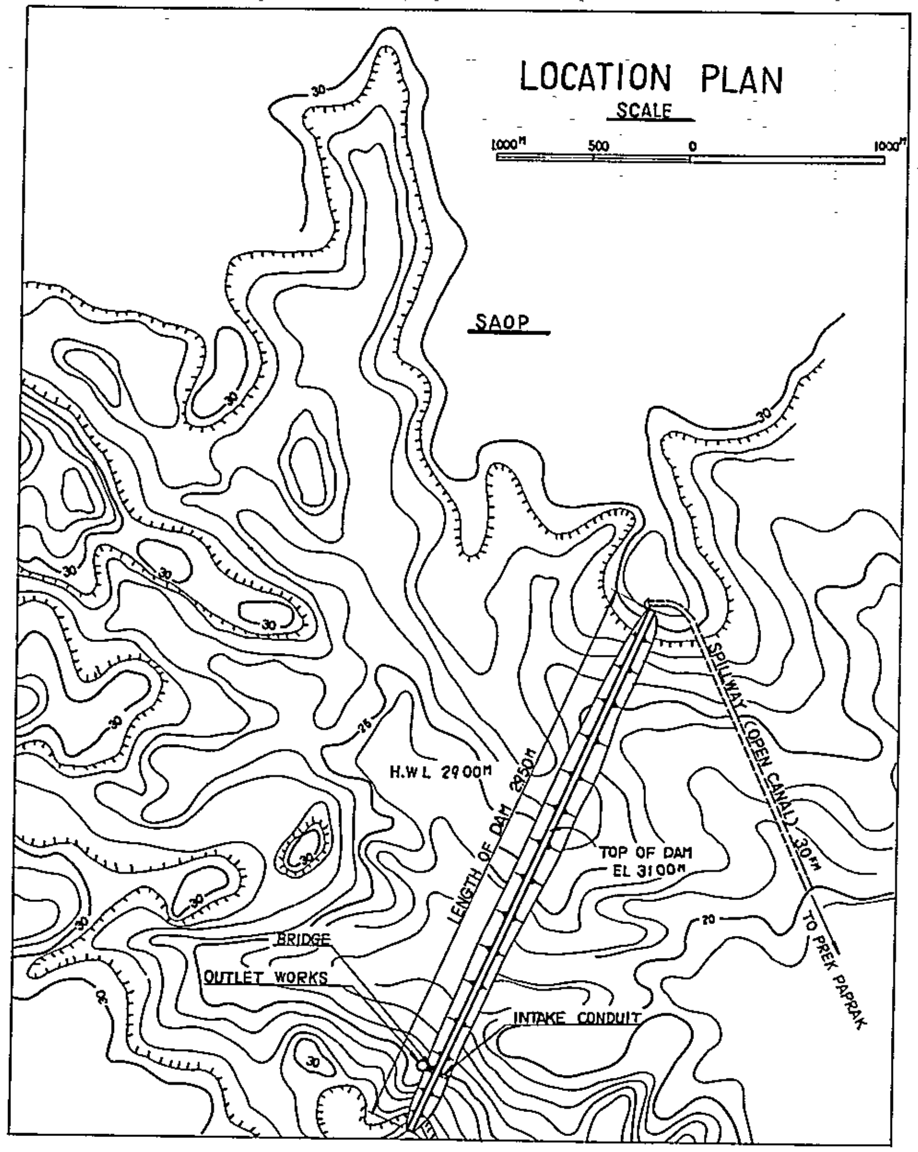
SAMBOR PROJECT (AGRICULTURE)

PUMPING STATION AT CHHLONG
(FOR IRRIGATION)

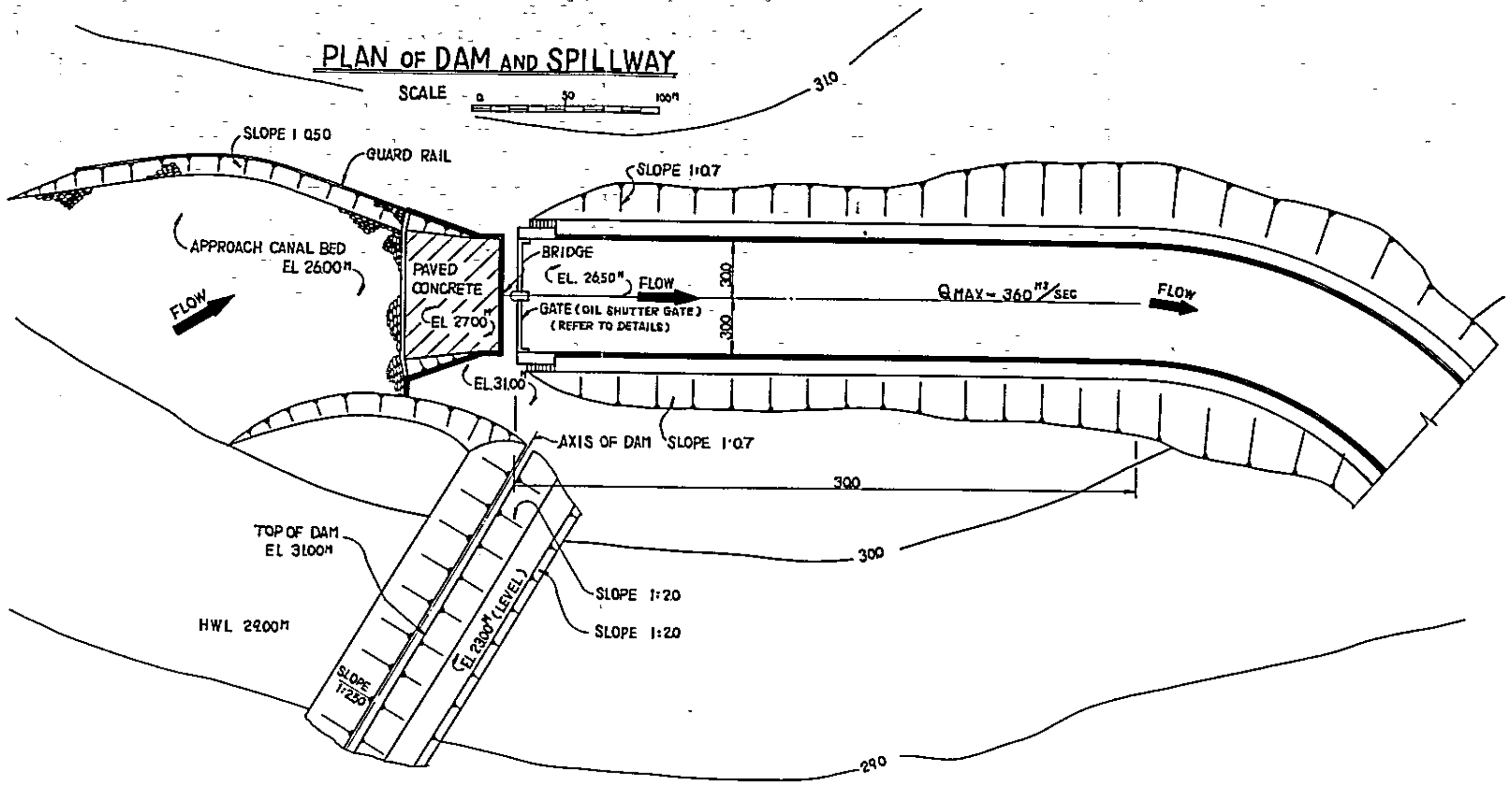
SANYU CONSULTANTS INTERNATIONAL, NAGOYA, JAPAN

SUBMITTED	DATE 1968
APPROVED	DWG. NO 15

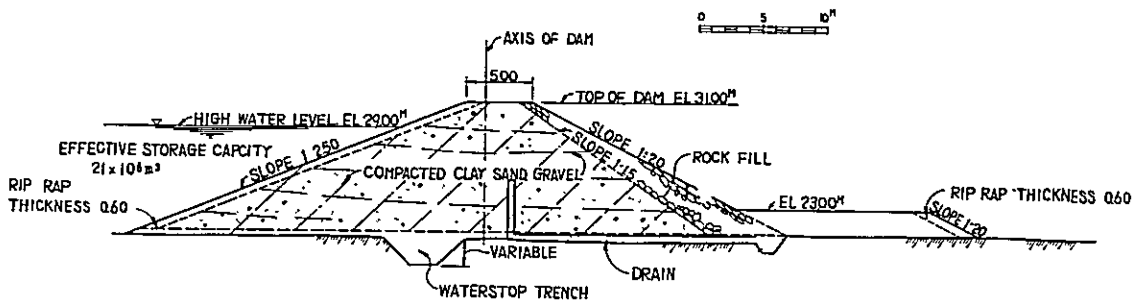
LOCATION PLAN



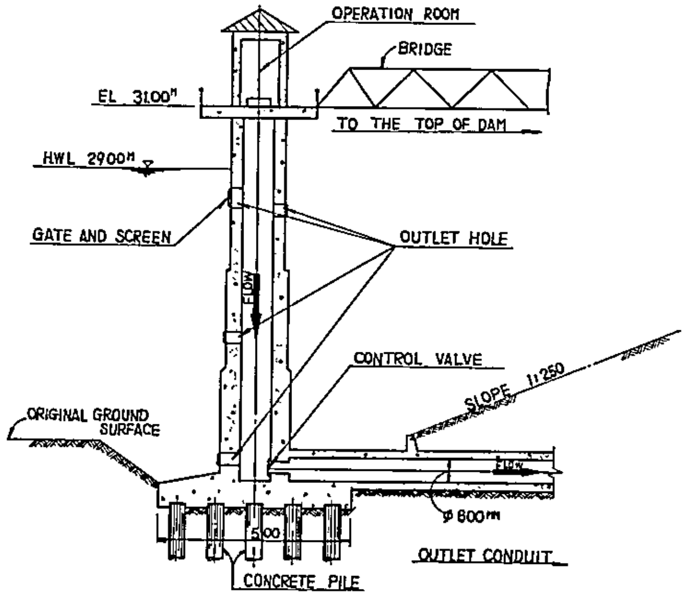
PLAN OF DAM AND SPILLWAY



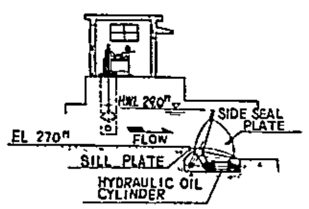
TYPICAL CROSS SECTION OF PAPRAK DAM

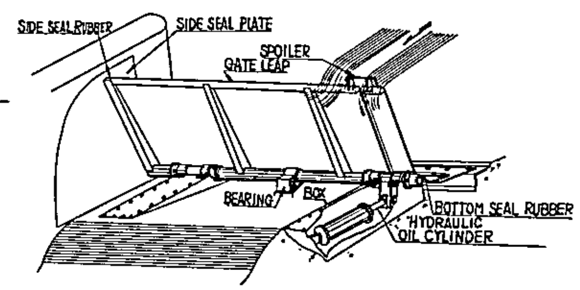


INTAKE WORKS

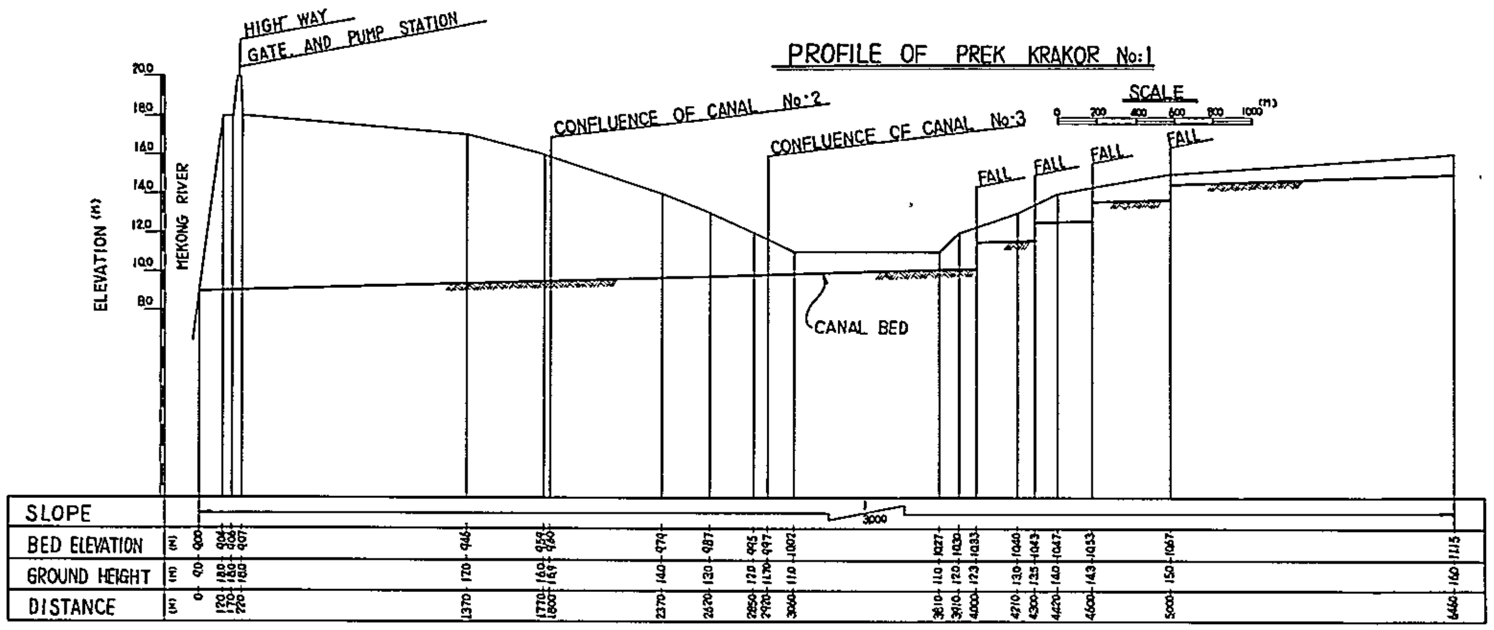


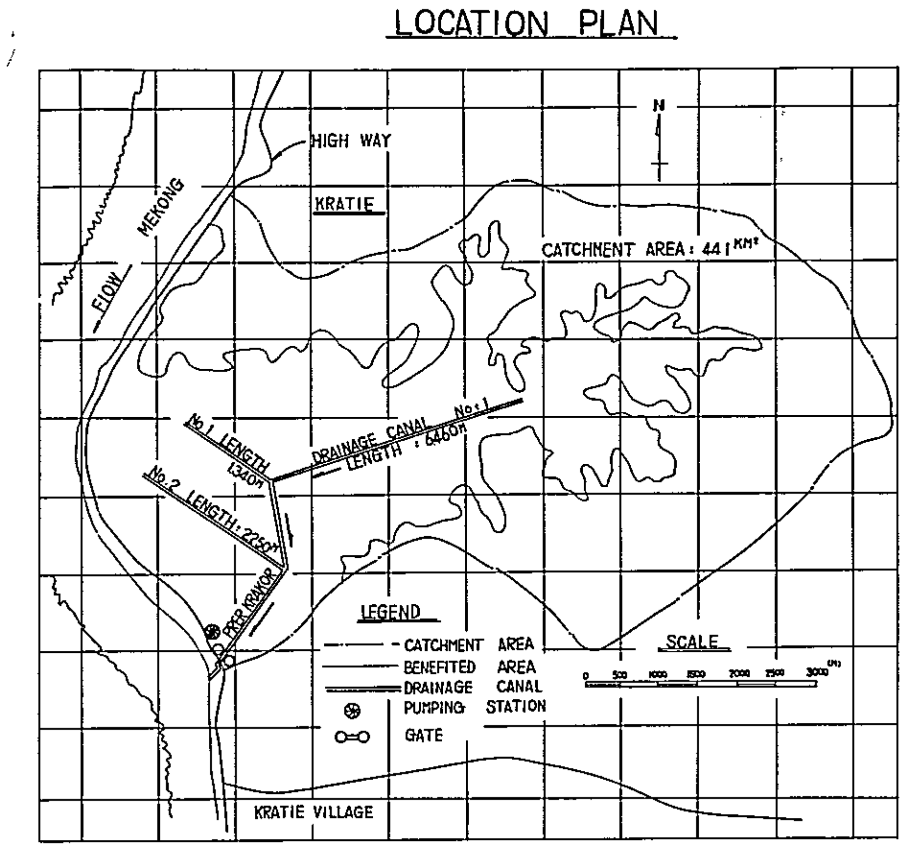
HYDRAULIC OIL SHUTTER GATE

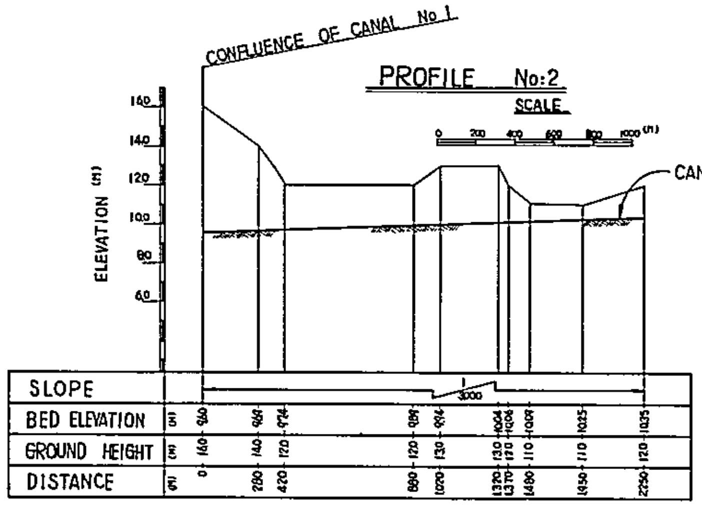


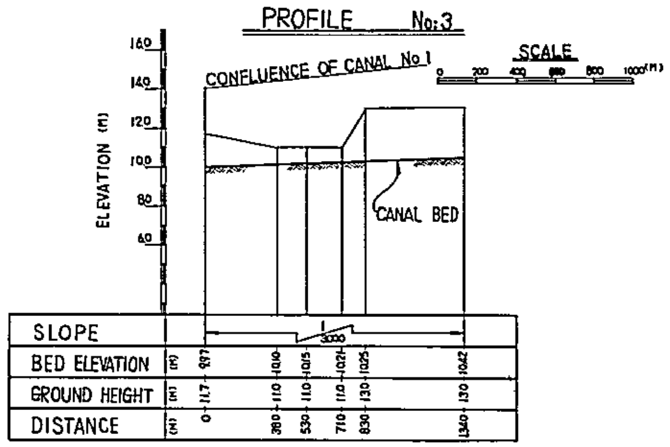


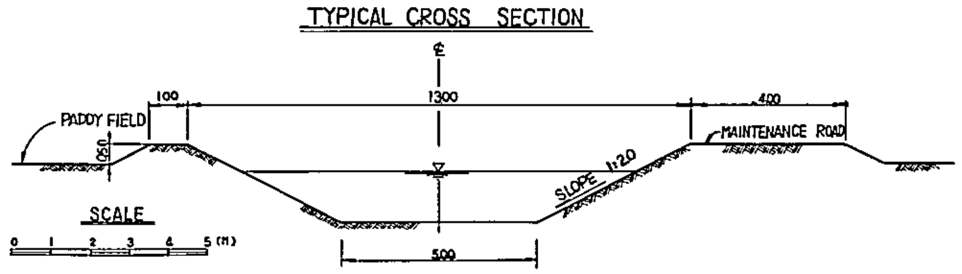
OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO, JAPAN	
SAMBOR PROJECT (AGRICULTURE)	
RESERVOIR AT SAOP	
SANYU CONSULTANTS INTERNATIONAL, NAGOYA, JAPAN	
SUBMITTED	DATE 1968
APPROVED.	DWG NO. IV-14





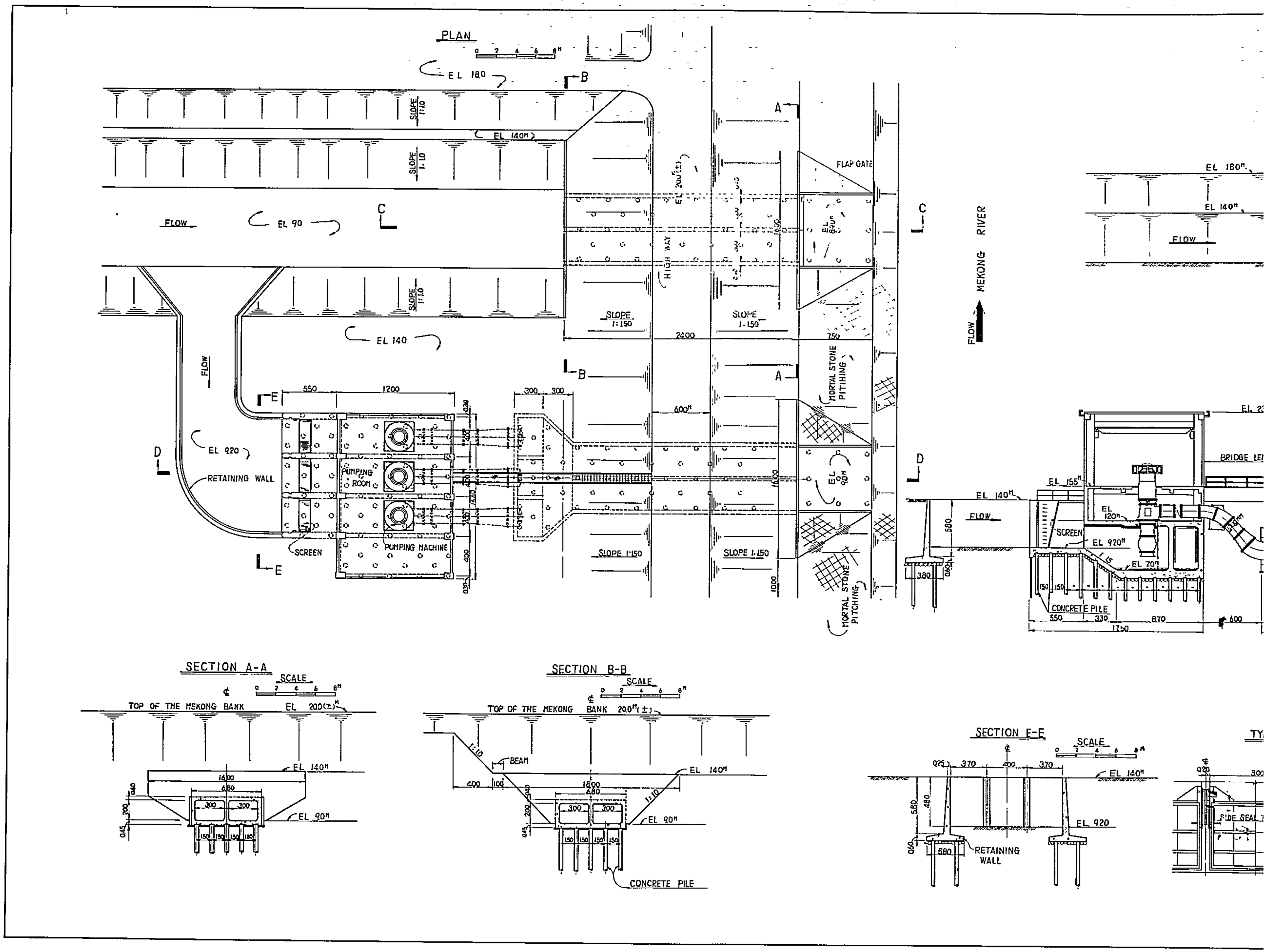




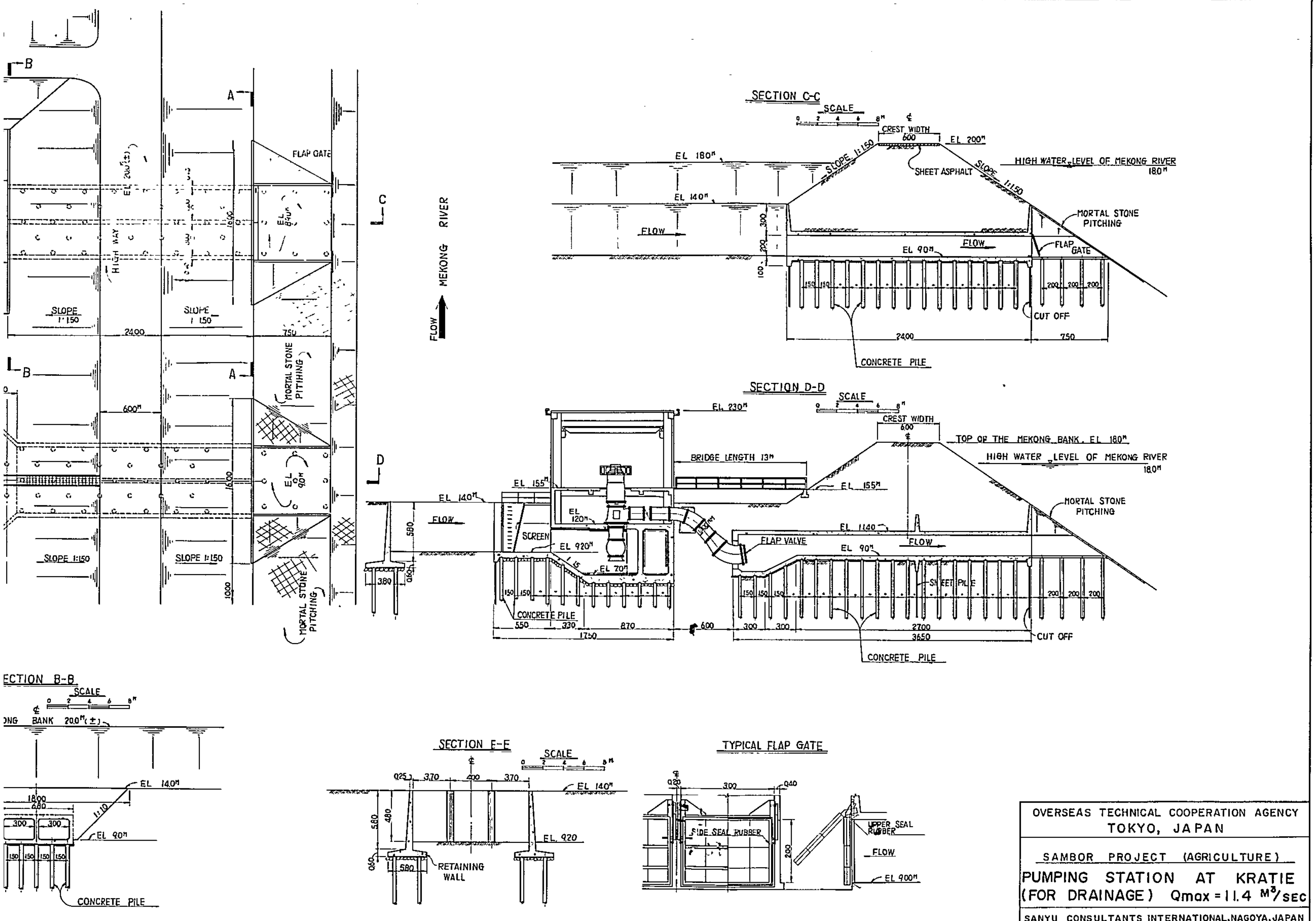


NOTE : GATE AND PUMP STATION REFER TO DW.G NO 7

OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO, JAPAN	
SAMBOR PROJECT (AGRICULTURE)	
PROFILE OF DRAINAGE CANAL AT KRATIE	
SANYU CONSULTANTS INTERNATIONAL, NAGOYA, JAPAN	
SUBMITTED APPROVED.	DATE 1968 DWG NO. IV-16



PLAN
EL 180
EL 140
FLOW
EL 90
SLOPE 1:10
HIGH WAY
FLAP GATE
SLOPE 1:150
2400
750
MEKONG RIVER
FLOW
MORTAL STONE PITIHING
600
550
1200
300
EL 920
RETAINING WALL
PUMPING ROOM
PUMPING MACHINE
SCREEN
MORTAL STONE PITCHING
EL 155
EL 120
EL 70
CONCRETE PILE
1750
BRIDGE
SECTION A-A
SCALE
TOP OF THE MEKONG BANK
EL 200(±)
EL 140
EL 90
1600
SECTION B-B
BEAM
CONCRETE PILE
SECTION E-E
RETAINING WALL
EL 920
SIDE SEAL



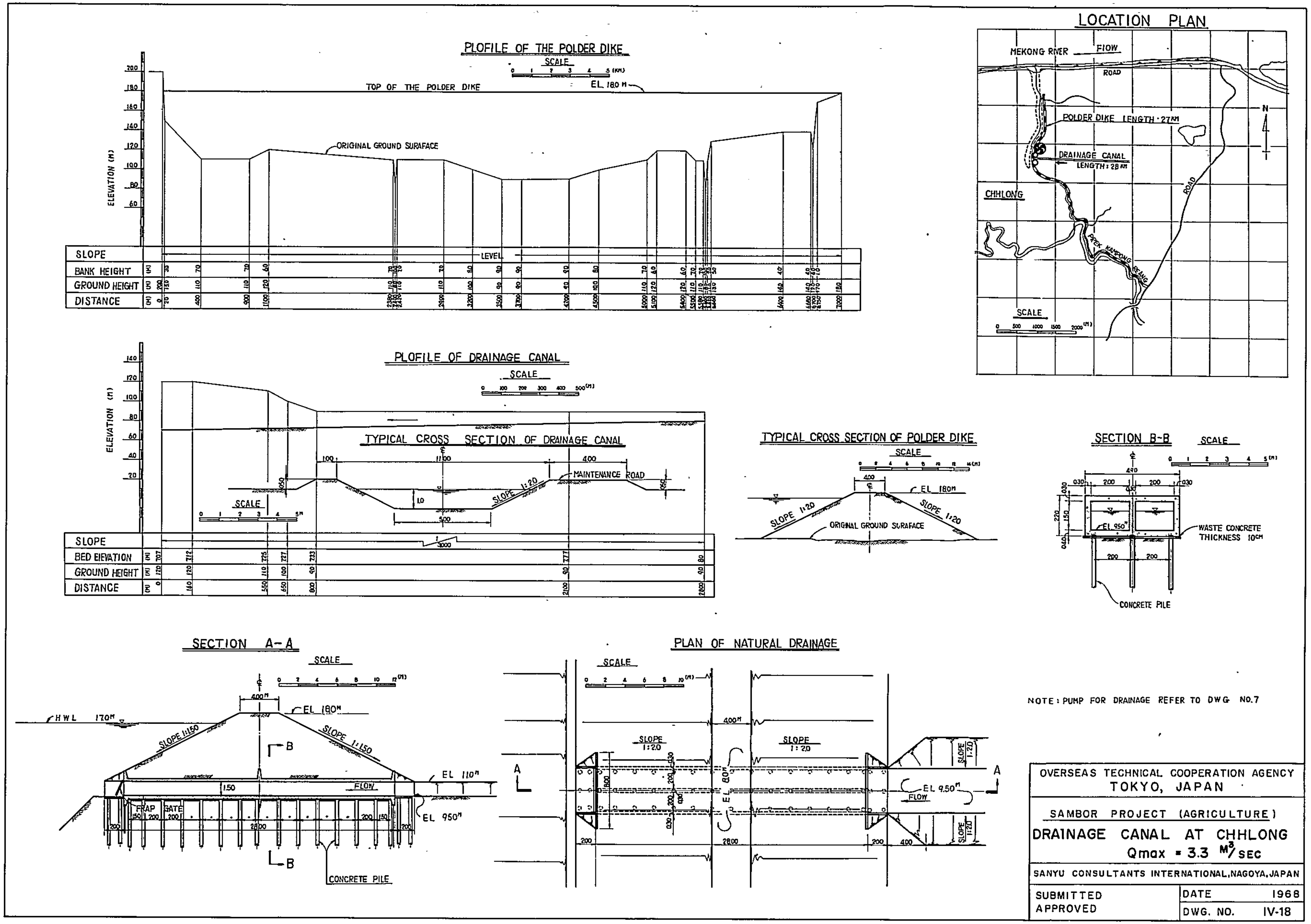
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO, JAPAN

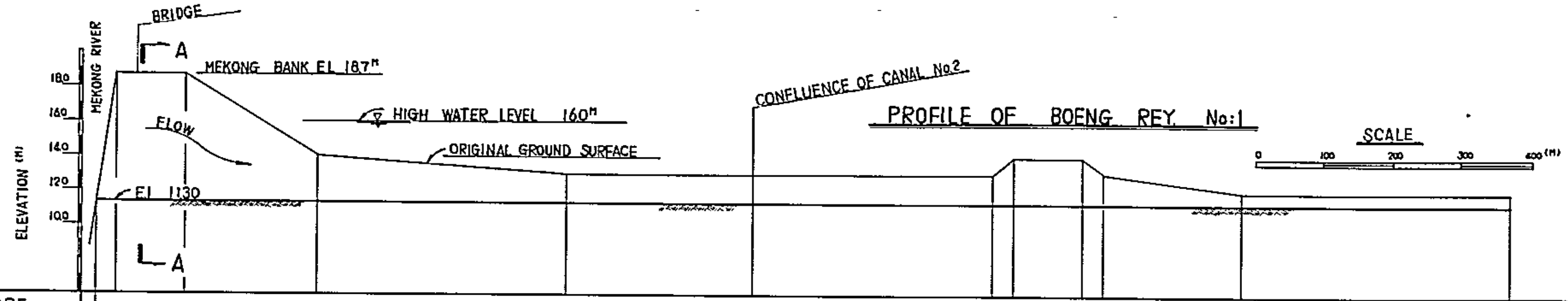
SAMBOR PROJECT (AGRICULTURE)

PUMPING STATION AT KRATIE (FOR DRAINAGE) Qmax = 11.4 M^3/SEC

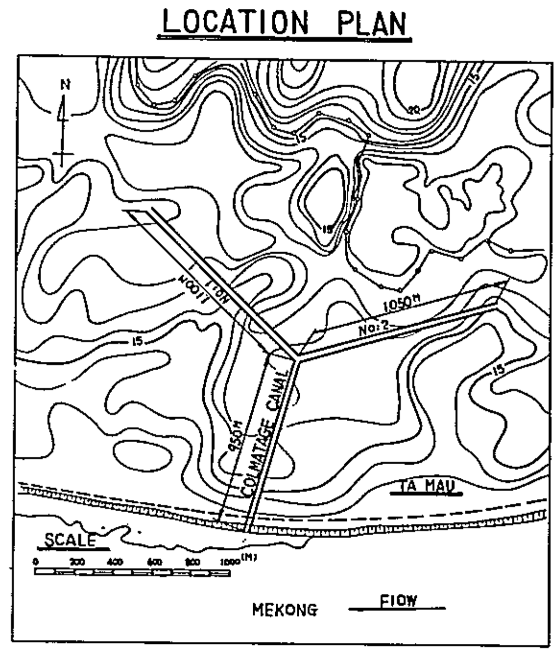
SANYU CONSULTANTS INTERNATIONAL, NAGOYA, JAPAN

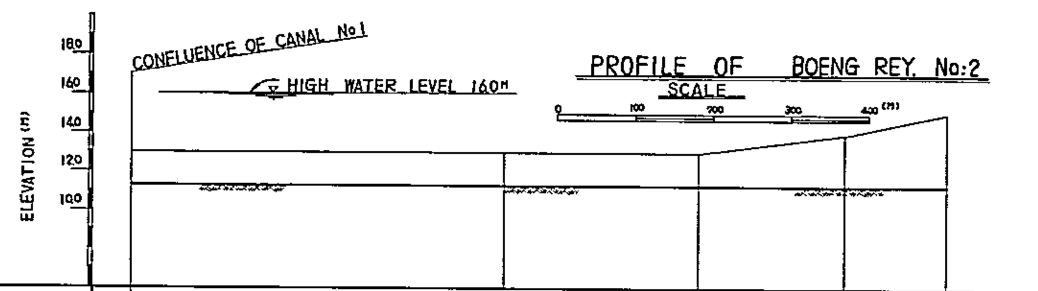
SUBMITTED		DATE	1968
APPROVED		DWG NO.	E-17


PLOFILE OF THE POLDER DIKE
SCALE
TOP OF THE POLDER DIKE
EL 180 M
ORIGINAL GROUND SURAFACE
ELEVATION (M)
SLOPE
LEVEL
BANK HEIGHT
GROUND HEIGHT
DISTANCE
LOCATION PLAN
MEKONG RIVER
FLOW
ROAD
POLDER DIKE LENGTH 27KM
DRAINAGE CANAL LENGTH 28KM
CHHLONG
PREK KAMPONG
SCALE
PLOFILE OF DRAINAGE CANAL
SCALE
TYPICAL CROSS SECTION OF DRAINAGE CANAL
MAINTENANCE ROAD
SLOPE 1:20
SCALE
SLOPE
BED ELEVATION
GROUND HEIGHT
DISTANCE
TYPICAL CROSS SECTION OF POLDER DIKE
SCALE
EL 180M
SLOPE 1:20
ORIGINAL GROUND SURFACE
SECTION B-B
SCALE
WASTE CONCRETE THICKNESS 10CM
CONCRETE PILE
SECTION A-A
SCALE
HWL 170M
EL 180M
SLOPE 1:150
FLOW
EL 110M
FRAP GATE
EL 950M
CONCRETE PILE
PLAN OF NATURAL DRAINAGE
SCALE
SLOPE 1:20
EL 9.50M
FLOW
NOTE: PUMP FOR DRAINAGE REFER TO DWG NO.7
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO, JAPAN
SAMBOR PROJECT (AGRICULTURE)
DRAINAGE CANAL AT CHHLONG
Qmax = 3.3 M3/SEC
SANYU CONSULTANTS INTERNATIONAL, NAGOYA, JAPAN
SUBMITTED
APPROVED
DATE 1968
DWG. NO. IV-18

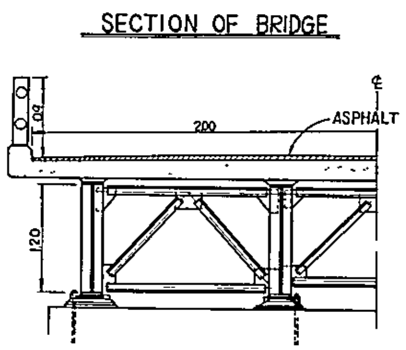


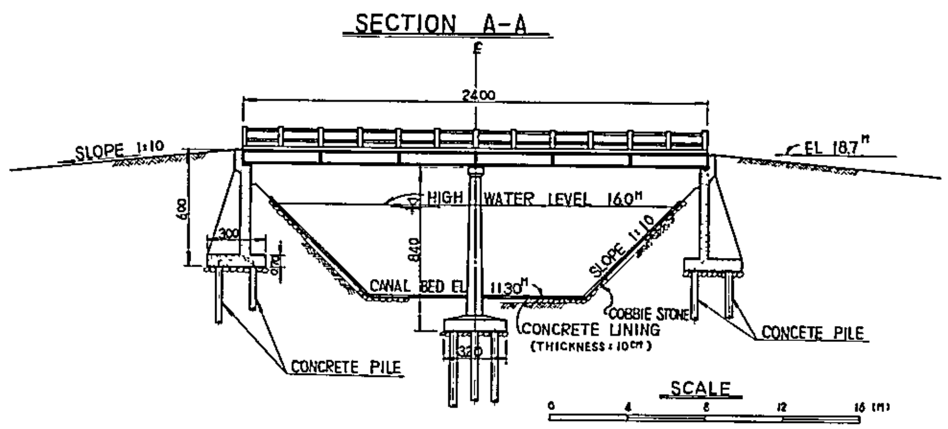
SLOPE	LEVEL											
BED ELEVATION (m)	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3
GROUND HEIGHT (m)	11.3	18.7	18.7	14.0	13.0	13.0	12.0	14.0	14.0	13.0	12.0	12.0
DISTANCE (m)	0	30	130	330	680	950	1300	1330	1430	1460	1660	2050





SLOPE	LEVEL				
BED ELEVATION (m)	11.3	11.3	11.3	11.3	11.3
GROUND HEIGHT (m)	13.0	13.0	13.0	14.0	15.0
DISTANCE (m)	0	480	780	970	1050





OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO, JAPAN

SAMBOR PROJECT (AGRICULTURE)

COLMATAGE PLAN
AT TA MAU

SANYU CONSULTANTS INTERNATIONAL, NAGOYA, JAPAN

SUBMITTED APPROVED	DATE 1968
	DWG NO. IV-19

CHAPTER F. PROJECT CONSTRUCTION