FEASIBILITY REPORT
ON
THE DARLAC IRRIGATION PROJECT
IN
THE UPPER SREPOK BASIN

VIET NAM

DECEMBER 1963

THE OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO

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Preface

The Government of Japan, which had conducted a hydrologic investigation of the Upper Srepok in Viet Nam in the fiscal year 1961, was requested again at the 17th Session of the Committee for Coordination of the Investigations of the Lower Mekong Basin held in Tokyo in March 1962 to assist the preliminary investigation and planning on the comprehensive development of the Upper Srepok Basin. The Government of Viet Nam also expressed its earnest desire and asked the Government of Japan for the same investigation works as a part of the development project of the Central Plateau around of Ban Me Thuot on the basis of the "Reconnaissance Report of the Major Tributaries of the Lower Mekong Basin" already submitted by the Government of Japan. Under this circumstances, the Government of Japan entrusted the investigation work to the Overseas Technical Cooperation Agency, which is the executive agency of the Government, with the budget for the fiscal year 1962. Upon conclusion of the Service Agreement with Nippon Koei Co., Ltd. the Agency organized a Survey Team and carried out a field investigation during the period from December 1962 to March 1963.

The scope of work conducted by the Survey Team was based on the "Plan of Operation" and covered the Darlac Basin in the main.

As the result of this investigation, it is confirmed that the development of the Darlac Basin should not be projected exclusively for the basin itself, but as a part of the comprehensive development project of the whole Upper Srepok area including flood control, storage of water, and irrigation in the light of specific natural conditions

/especially

especially hydrologic features of the Darlac Basin.

This report is compiled, accordingly, from the viewpoint mentioned above.

On this opportunity, I wish to express my deep thanks to the Committee for Coordination of the Investigations of the Lower Mekong Basin and the authorities concerned of the Government of Viet Nam for their generous collaboration in the course of this investigation works.

December, 1963

Shinichi Shibusawa
Director General,
The Overseas Technical Cooperation Agency

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SUMMARY

The upper basin of the Srepok has a great possibility of development in terms of both power generation and irrigation, as stated in "Comprehensive Reconnaissance Report on the Major Tributaries of the Lower Mekong Basin", a result of three years' investigation. The Government of Viet Nam is now contemplating a large-scale development program for the vast highland area situated in the middle part of the country. In view of this situation, the development of the upper basin of the Srepok is considered to be significant worth to be realized.

Of the six development plans now contemplated for power generation and irrigation for this region, an excellent one is the irrigation and drainage scheme for the Darlac Basin. The irrigable area in this basin presumed to be about 8,000 hectares, of which about 5,000 hectares of land extending on both sides of the Ea Krong Ana, is the most fertile region and early in 1958 new settlements of about 500 farmsteads were established in this place. However, without irrigation and drainage facilities the region has been annually subjected to flood damage by the innudation of the Ea Krong Ana and the Ea Krong Kno between which the region is located, and development was limited to a small tract of land, while greater part of the region has been left devastated with luxuriant growth of rush and other grasses peculiar to low-lying damp places. Under the circumstances, a comprehensive plan to develop the whole area of the Darlac Basin by carrying out irrigation and drainage scheme was considered. In this plan, an intake weir was to be constructed across the Ea Krong Ana and irrigate the area of about 8,000 hectares on both banks of the river through the irrigation canals palnned for these area, and the drainage plan was to construct long dikes on both banks of each of the said two rivers to prevent innundation and

/straighten

straighten their river courses as far as possible. In addition, it was considered to blast off the rocks existing in the outlet of the river from this area to improve the passage of the flow, which results in lowering the ground water level of this marshy area.

However, as the result of our investigation, the following matters have been made clear.

1) To construct a intake weir and carry out irrigation undêr one system will give rise to some difficulty in that the water level of the Ea Krong Ana will have to be kept constantly at or above El. 422 meters, and in that it will be costlier technically, as there are depressions over a wide area in the region which must be remedied if irrigation is to be carried out in one irrigation system.

2) For the reason stated under (1) and for technical and geological reasons, it is considered to be economical to realize the plan by dividing the area into six irrigation sections. Consequently pumping irrigation is considered.

3) Since the drainage scheme in the Darlac Basin is closely related with the drainage schemes, especially the flood regulation schemes being considered for the upstream basin of the Ea Krong Ana, namely basins of the Krong Buk, Krong Pach, Krong Boung, the fundamental drainage schemes for this basin must be planned in conjunction with the development plans for the upstream basin and the development plan of the Krong Kno. Removal of the rocks in the rapids downstream of Ban Dray, considered in the original plan to ease the passage of flood discharge, was found to require enormous expenditure (about 3,000,000 U.S.Dollars) and for this reason the original plan must be modified to some extent.

/4)

4) Of the six sections mentioned above, C-section is already settled by about 500 farmstead of immigrants, but the farmers are suffering from unstable yield. Hence, it is planned, as the first stage development, to irrigate an area of about 1,000 hectares of comparatively high region (above El. 416 meters) in C-section, for the purpose of stabilizing farmers' lives. For this purpose an intake dam shall be constructed at the outlet of Lake Darlac and dam up the water surface level of the lake to El.420 meters to enable to irrigate the above-mentioned 1,000 hectares of arable land. After the realization of the comprehensive development plan for the whole of the upper basin, this scheme shall be integrated in a comprehensive plan, and the irrigation shall be converted to the system included in this comprehensive plan. Major work in the initial stage development shall include the followings.

(1)	Irrigable area		1,000 ha
(2)	Intake dam	crest El:	422 m
		H.W.L. El:	420 m
		volume :	50,000 m^3
		type:	earth dam
(3)	Irrigation canal	main canal:	10 km
		lateral canal:	20 km
	Drainage canal	main canal:	6 km
(4)	Reclamation area		500 ha

The construction cost of the above irrigation and drainage scheme is estimated at about 350,000 U.S.Dollars equivalent or 350 U.S.Dollars per

/hectare

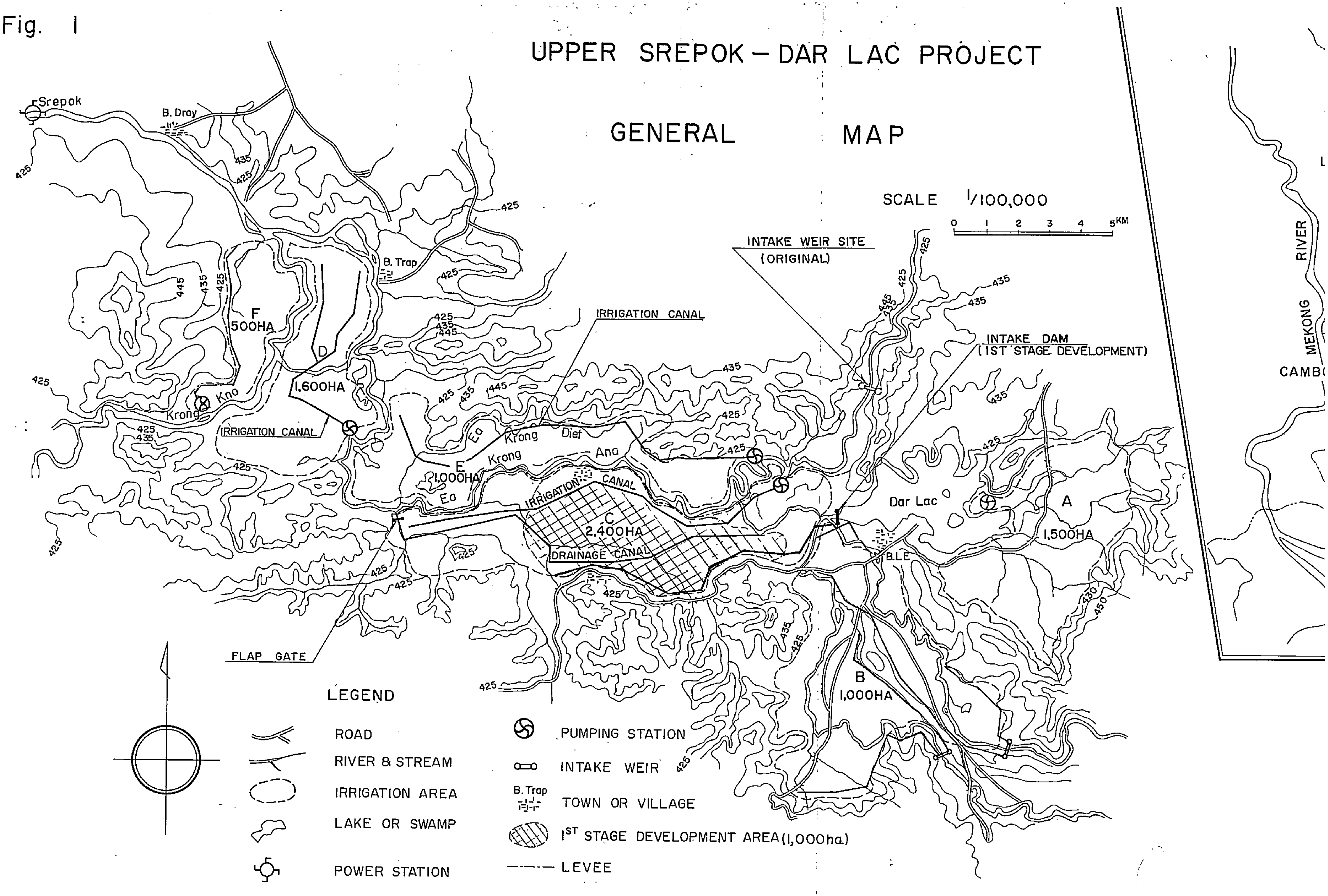
hectare. Under the present scheme, two crops a year would at least become possible on the land of about 1,000 hectares including the already cultivated about 500 hectares, and thereby an annual income of about 485, 000 U.S.Dollars equivalent could be expected. The ratio between the annual income and the necessary expenses (benefit-cost ratio) is calculated to be about 1.6. From theabove it is concluded that this plan, though temporary in nature, is sufficiently economical to be feasible. Futhermore, the immigrated farmers can expect, in ten years' time, a net annual income of about 100 U.S.Dollars. Also from this viewpoint, the investment on this scheme is considered to be quite reasonable.

(5) As for the agricultural development in the areas other than those included in the present scheme, it is considered to be the most economical to undertake after or in parallel with the development of the upper basins of the Ea Krong Ana and of the basin of the Ea Krong Kno, and it is the most uneconomical to attempt to carry out these development schemes independently and respectively.

Fig. 1

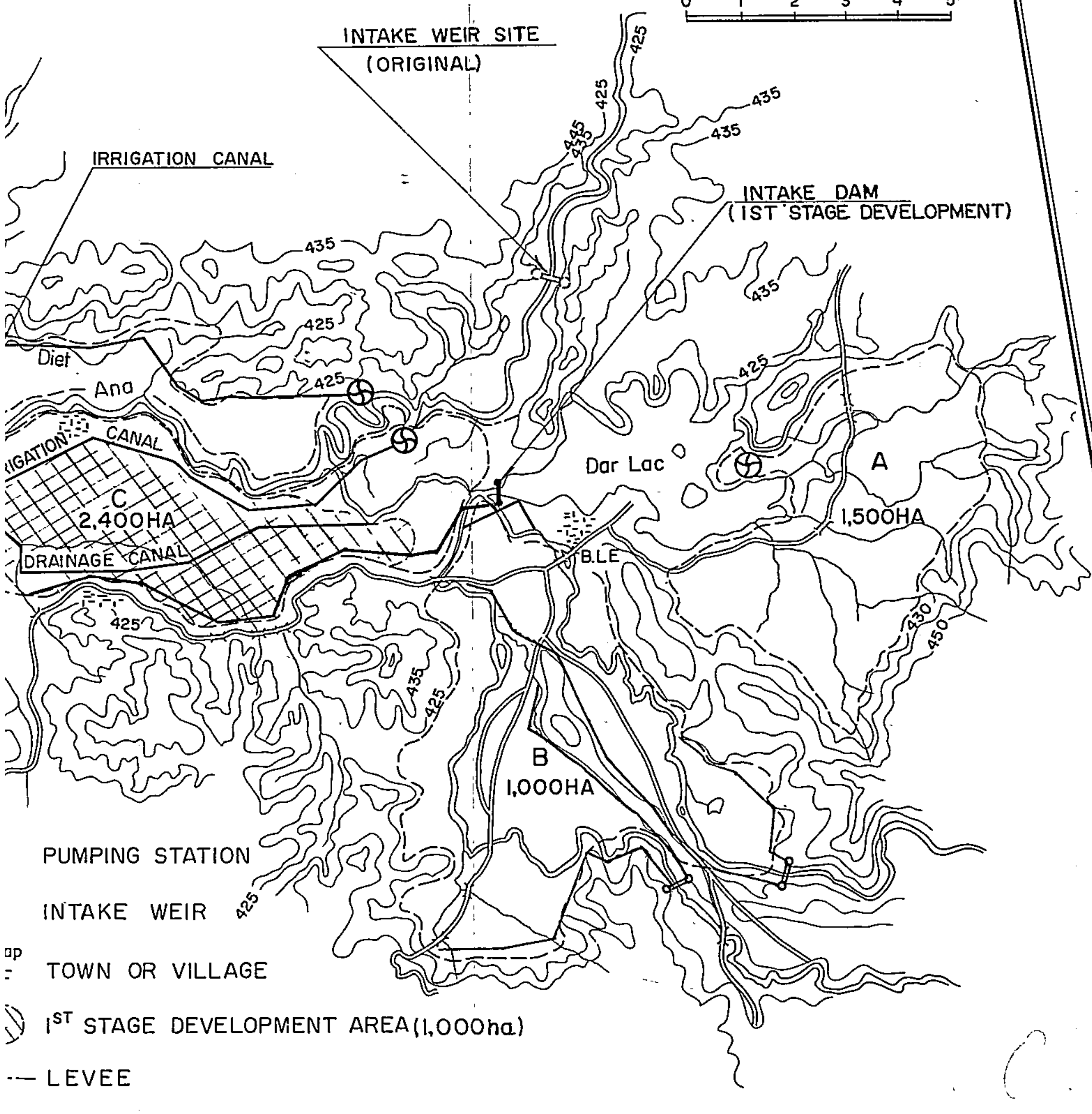
UPPER SREPOK – DAR LAC PROJECT

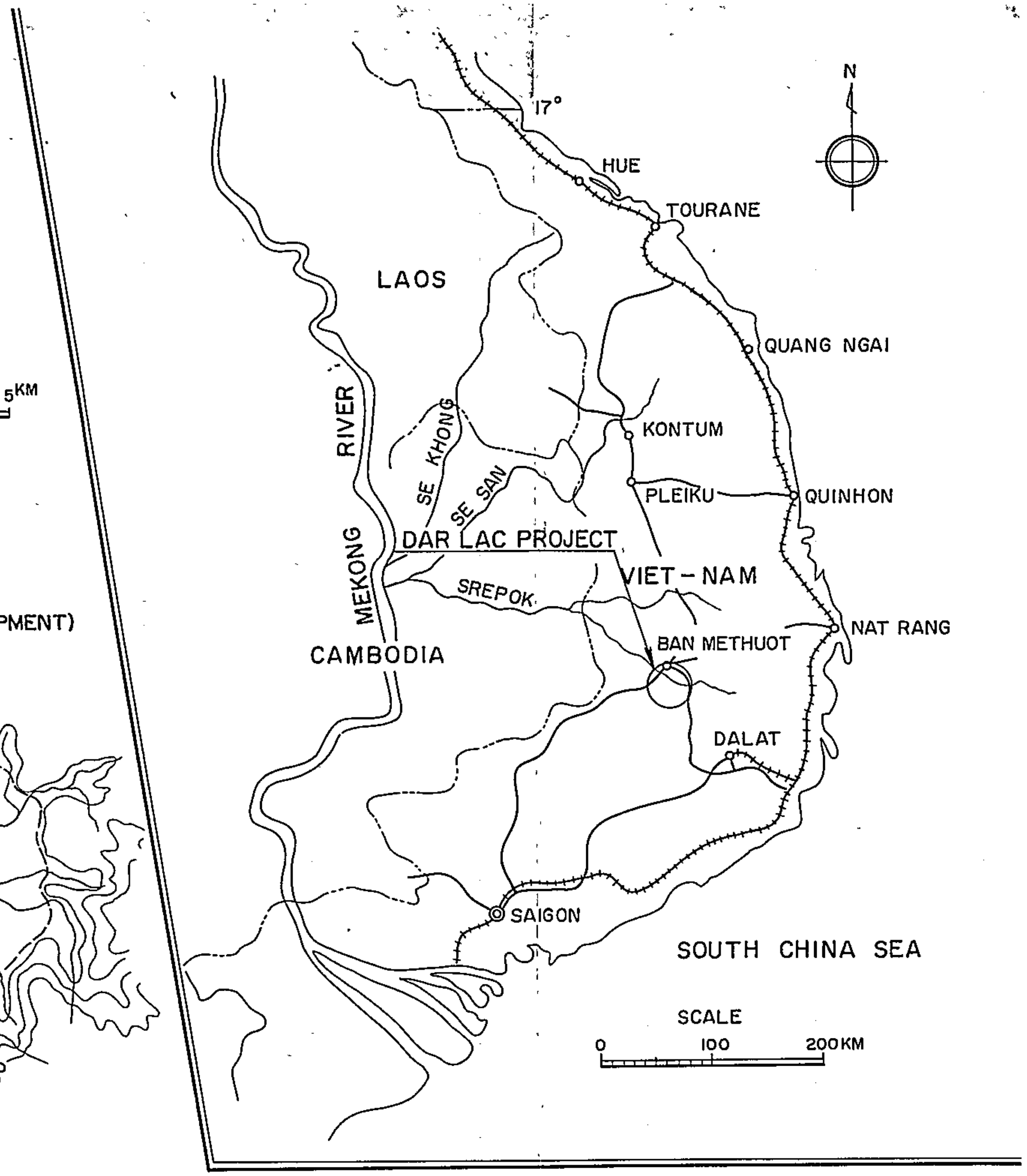
GENERAL MAP



PPER SREPOK – DAR LAC PROJECT

GENERAL MAP





CHAPTER I

INVESTIGATIONS

The investigation works on the Darlac low-lying area in the Upper Srepok Basin were set on and carried out in conformity with the "Plan of Operation" concluded between the Committee for Coordination of the Investigations of the Lower Mekong Basin and the Government of Japan.

The principal contents were as follows:

A. Project investigation

(1) Review of the results of reconnaissance survey undertaken under the Japanese contribution and confirmation of the feasibility of development.

(2) Survey

a) Levelling from the existing bench marks, for the purpose of determination of the required ground height in the project area.

b) Profile levelling along the river.

c) Topographic survey of the proposed intake weir sites and structure sites.

d) Ground control survey necessary for the mapping of aerial photograph.

(3) Hydrologic investigation

Observation of river stages and measurement of stream discharge during the survey period.

(4) Geological investigation

Geological surface exploration of the project area, and core

/boring

boring and test pitting of the proposed intake weir sites.

(5) Agricultural investigation

Detailed soil survey of the irrigable area and preparation of land use map giving broad outline of type and fertility of soils together with agricultural survey to arrive at a sound recommendation regarding the type and pattern of crops which will be best suited to the soil and climatic condition.

B. Aerial mapping of irrigable area

Aerial mapping of prospective irrigation area on a scale of 1 to 20,000 with contour intervals of 1 meter for plain area and 5 to 10 meters for steep area, on the basis of the results of ground control survey.

C. Project planning

(1) Collection and analysis of meteorological and hydrologic data.

(2) Study on irrigation and drainage method, and layout of main canals and distribution system.

D. Project design (not including detailed construction design)

(1) Design of intake weirs, appurtenant structures and pumping stations, if any.

(2) Design of irrigation structures and main canals, and preliminary design of distribution system.

(3) Selection of type and rating of pumps and accessories, if necessary.

(4) Preparation of construction schedule.

/E. Project

E. Project evaluation

(1) Estimated cost of construction of the project broken down into annual funds requirement (local as well as foreign currencies).

(2) Estimated amount of loan and interest rate (foreign currency only), period of loan and recommended repayment schedule.

(3) Assessment of benefits to be derived from the project.

(4) Economical justification

F. Preparation of comprehensive project feasibility report

Preparation of a comprehensive project feasibility report in a form acceptable to a financial institution as an application for development loan.

In accordance with the foregoing investigation program, the field works, such as surveys, geological studies, and agricultural researches were performed during the period of about three months from January to March in 1963. And the hydrologic investigation was conducted up to the end of March 1963, subsequently to the works by the contribution of the Government of Japan, which was the Hydrologic Investigation Project on the Upper Srepok commenced in 1961. These field works were successfully completed by the end of March 1963.

The staff engaged in this planning and investigation works are as follows:

No.	Name	Designation
1.	Y. Kubota	President
2.	M. Sugawara	Agronomist
3.	I. Arimoto	Civil engineer
4.	M. Sakaita	Geologist

/5.

5.	K. Shibata	Irrigation engineer
6.	R. Yoshida	Civil engineer
7.	T. Yoshimatsu	do.
8.	S. Yano	Irrigation engineer
9.	R. Yokota	do.
10.	H. Hoshino	Geologist
11.	K. Irie	Irrigation engineer
12.	S. Arisaka	Civil engineer
13.	H. Kamiyama	do.
14.	K. Tadano	do.
15.	I. Suzuki	do.
16.	S. Inagaki	Survey expert
17.	I. Ikejima	do.
18.	H. Kumagawa	do.
19.	M. Kuwabara	Office manager

1.1. Survey

For the determination of the required ground height in the project area, levelling for about 157 kilometers were done along the National Route No.21 and No.14 by taking advantage of the existing bench marks in this area. Newly constructed bench marks were made of durable concrete and their locations are shown with other detailed descriptions in the attached data book.

Profile levelling along the river was done for about 83 kilometers along the Ea Krong Ana, and detailed topographical surveys of the proposed intake weir sites and structure sites were accomplished at

/Ban Dray

Ban Dray fall and other location with area of about 0.3 square kilometers in all. By the use of these survey works, the detailed topographical maps were drawn on a scale of 1 to 2,000 for structure design.

Ground control survey for mapping aerial photographs was also completed during the survey period over all project area of about 200 square kilometers.

1.2. Hydrologic investigation

The hydrologic investigation on the Upper Srepok was conducted subsequently during a 12-month period from October 1961 to September 1962, and is still being continued at the two gauging stations of Kana and Ban Bur.

All the locations of gauging stations as well as the records of water stages and stream discharges are shown in the attached data book.

1.3. Geological investigation

During the survey period, geological investigation was conducted all over the project area, and the most suitable sites for intake weirs were selected on the basis of the results. Then, core borings were drilled to a total depth of 92 meters at the intake weir site with a pressure type rotary boring machine.

1.4. Agricultural investigations

The detailed soil survey on the irrigable land in the project area was carried out in the middle of and late in March in succession to the reconnaissance soil survey at the beginning of March. In the course of field work, several principal soil characteristics such as specific gravity,

/moisture

moisture contents, intake rates etc. were disclosed to determine the design criteria of irrigation system in this project area.

The current state of crop production and farm management were also investigated by means of door-to-door inspections of farmers during the soil survey period. Based upon these data, soil map and land use map giving broad outline of type and fertility of soils were prepared.

The most adapted farming unit was also illustrated for the type and pattern of crops suitable to the natural and economical conditions of the project area. They are shown in the appendix of this report.

1.5. Aerial mapping of irrigable area

By the use of the ground control survey results and the aerial photograph of U.S. Army Map Service, the maps of the project area on a scale of 1 to 20,000 with cotour intervals of 1 meter for plain area and 5 to 10 meters intervals for steep sloping area were prepared in Tokyo after April in 1963, and the maps covering about 200 square kilometers were completed in August 1963.

CHAPTER II

NATURAL CONDITIONS

2.1. Geology and topography

The Darlac area is situated on the highland in the west of the Annan Cordillera and is 30 kilometers to the south of the city of Ban Me Thuot. At the eastern end of this area there is a lake called Darlac and to the west of this lake extends a low-lying damp plain. Into this damp plain flows the Ea Krong Ana from the north-east and the Ea Krong Kno from the south-west.

These rivers join together into the Srepok in the west of this plain and leave this plain at the western end. There are some lowland paddy fields around the lake at the eastern end of this plain, but greater part of this plain is left devastated with luxuriant growths of wild rushes. This is due to the fact that the entire region is submerged in the rainy season, while in the dry season the entire region, with the exception of the tracts along these rivers, suffers from lack of water.

The high plain lying in the south of the Annan Cordillera is one of the areas where the earth movement had stabilized in the geological age, and the pattern of discharge of the Srepok is considered to have been completed at the beginning of the quaternary period. During the quaternary period many eruptions of baslt rocks took place on the crest and both sides of the Cordillera, and resulted relatively flat plateaus of basalt and lava at some ten locations.

/Also

Also in this area, there are numerous flows of basalt lavà along both sides of the Srepok. Some of these flows ran across the old course of the Srepok and interrupted the passage of the river water, but as they were so thick the flow broke them or ran over them and flew westward. At these places where the river broke through, there were formed, according to the degree of erosion, such falls as Dray Nor, Dray Sap, Dray Ling, etc. and the rapids that follow. The greatest example of this action is the low-lying Darlac plain. The lavà, erupted over the area extending for a few kilometers downstream of Ban Dray at the western end of this area, interrupted the flow of the Srepok and formed a shallow dammed lake and later the lavà which blocked the passage of the river water was broken and drained the water from the lake, giving birth to the low-lying dam plain that we find today and leaving the present Darlac Lake at the eastern end of the area.

Into this dammed lake, the sand and silt were discharged from upstream reaches as in the delta of a river, and fertile soil was accumulated. Consequently, if this area is improved by draining the water, a vast area of fertile farmland could be reclaimed in this area.

In view of this geological history, it is considered to be the best way to break up the lavà that is blocking the water. However, to break up the flow of lavà extending for so many kilometers, there will be needed a large amount of excavation and naturally such will be difficult economically.

2.2. Soil

The soil group in the low-lying damp area at elevations below El. 425 meters is the recent alluvial soil deposited after being

/carried

carried with the flow of the river. It is composed of the following groups.

(1) Recent alluvial medium textured gley soil

(2) Recent alluvial heavy textured gley soil

(3) Recent alluvial humic gley soil

(1) Recent alluvial medium textured gley soil:

This soil lies on the banks of the river as the natural levee, and has loamy or silty texture with pH of 5.5 to 5.8 and high natural fertility.

(2) Recent alluvial heavy textured gley soil:

This soil forms the low-lying marshy plain at the back of the natural levee, and has heavy clay or silty clay texture with pH of less than 6.0 and considerably high natural fertility.

(3) Recent alluvial humic gley soil:

This soil occurs in the old course of the river and forms depressions and the surface soil is very rich in humus with pH of 6 to 6.3. It has heavy clay texture with very high natural fertility.

The basaltic residual latosol soil group develops on the highland with elevations of more than El. 425 meters in the west part of the Darlac Valley. This soil has rather coarse texture such as fine sandy loam or coarse sandy loam with pH of around 4.5 and high natural fertility.

The ancient alluvial lateritic soil develops in the east of the Darlac Lake as well as on the banks of the Ea Lien and the Da P'Heui. The soil is loamy fine sandy loam or coarse sandy loam in texture

/with

with pH of 4 to 4.5. This soil has the lowest natural fertility of all soil groups in this project area.

2.3. Nature of river water

All the river waters in this project area have alkaline reaction without exception. Values of pH range between 8.2 to 8.3 in the waters of the Ea Krong Buk and the Ea Krong Pach, which are the upstream of the Ea Krong Ana, while the water in the downstream of the Ea Krong Ana has pH value of about 8.0 to 7.8.

All the river waters contain no significant quantity of injurious components and they are rated at excellent or good for irrigation. Moreover, they are fairly rich a large quantity of in calcium bicarbonate and serviceable for the improvement of soil acidity. /1

2.4. Climate

The Annan Cordillera lying in the east of the Srepok basin runs approximately from north to south and forms a barrier against the northeastern monsoon, and causes a large quantity of rainfall in front of the Cordillera, and few rainfall at the back of the Cordillera. In the case of the southwestern monsoon the reverse phenomenon takes place.

2.4.1. Precipitation

The monthly rainfall record at Ban-Me-Thuot, situated about 30 kilometers from the project site, is shown below.

/1 Provided that 10,000 m^3 of water are applied on farmland of 1 hectare annually, the amount of lime to be given to the land is estimated at about 300 to 500 kilograms per hectare that is equivalent to 3 to 5 U.S. Dollars in price.

/Table

Table 1. Monthly mean precipitation (unit: mm)

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1.09	3.55	30.2	91.0	208.9	243.9	289.2	292.0	269.0	225.7	74.0	8.0	1736.56

(Source : Engineers in charge of hydrologic investigation on the Upper Srepok, the Government of Japan.)

The highest record of monthly average precipitation is 450 millimeters in September, 1960.

The mean precipitation in the four months of the dry season (December to March next year) is 42.8 millimeters in total, or 10.7 millimeters per month, and thus water is not sufficient for cropping, unless water is supplied from other source.

2.4.2. Evaporation

According to the observation record, evaporation by month is as shown in the following table.

Table 2. Monthly mean evaporation (unit: mm/day)

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
3.3	4.4	4.6	4.1	2.4	1.7	1.5	1.5	1.2	1.5	2.1	3.6	2.66

The annual mean evaporation is about 970 millimeters, which is equivalent to about 2.7 millimeters per day. By the month, it is severe during the dry season from November to April and is 4 millimeters per day, and is 2.2 millimeters per day in the rainy season from May to October.

2.4.3. Temperature

The annually mean temperature is 24.5°C and the highest monthly mean temperature is 26.7°C in April while the lowest is 22.0°C in January.

/The

The maximum daily temperature is 39.4°C (March, 1937)

The minimum daily temperature is 7.4°C (December, 1955)

Table 3. Mean temperature by month (unit: degree in Centigrade)

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
22.0	23.9	25.6	26.7	26.5	25.4	24.9	25.0	24.7	24.0	23.2	22.1	24.5

(Source : Meteorogical Bureau's data 1937-44, 1954-57)

2.4.4. Mean monthly relative humidity

The monthly mean relative humidity in Ban-Me-Thuot is as shown in the following table.

Table 4. Monthly mean relative humidity (unit: %)

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
79.4	74.7	73.2	74.4	82.2	85.7	87.0	87.6	88.7	86.9	85.9	82.5

(Source : Meteorogical Bureau's data 1937-44, 1954-57)

2.5. Rivers

The Ea Krong Ana flows through the central part of this area heavily meandering on its 40 kilometers course over a bee-line distance of 30 kilometers.

The slope of the river bed is 1 : 7,000 on an average.

The mean monthly discharges for a year between October, 1961 and September, 1962 are shown in the following table.

Table 5. Mean monthly discharge at Kana (unit: m^3)

1961			1962									
Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Total
85.6	59.4	31.8	25.5	18.1	12.9	9.8	13.0	14.4	37.8	88.7	94.8	491.8

/The run-off

The run-off coefficient during the 6 months in the dry season (November - May) is about 32%, and the flow in the dry season is rather abundant. The observed annual discharge is about 1.3 x $10^9 m^3$ which is converted into the average depth of 405 millimeters to the total area. The precipitation during this period at Ban-Me-Thuot is 1,535 millimeters.

Annual run-off coefficient = 405/1,535 = 26.4%.

Assuming that the precipitation at Ban Me Thuot represents the mean precipitation of this area, the run-off coefficient of this area can be estimated at 26.4%. According to the observation at Ban Bur, the total annual run-off is about 4.6 x $10^9 m^3$ which can be converted into the mean depth of 530 millimeters to the area and is larger than that of Kana.

The minimum run-off at Kana during the same observation period occurs in May and is 8 cubic meters per second, while the maximum run-off occurs in September and is 185 cubic meters per second.

There were considerable precipitations in October and November, and the flood run-off was 400 cubic meters per second at Kana, and 1,040 cubic meters per second at Ban Bur.

2.6. Flood

On the basis of the rainfall record for 20 years at Ban Me Thuot, the probable daily maximum rainfall once in 200 years is presumed to be 190 millimeters. This value equals about 1.37 times the value of the probable daily maximum rainfall once in 8 years. In the light of the above computation along with the hydrograph and the maximum continuous rainfall for 5 days in the past, the flood discharge at Kana

/is presumed

is presumed at about 500 cubic meters per seccnd, but this value would be revised when the flood control plan for the upstream area becomes available.

(Refer to Hydrological Data in APPENDIX 2 of this report.)

CHAPTER III

CURRENT STATE OF AGRICULTURE

The Darlac Basin may be divided into the following three partial areas from agricultural point of view.

1) The highland surrounding the Darlac Lake, where paddy is cultivated as principal crop and common dry field crops are planted secondarily.
2) The lowland in the middle part of the basin, where new reclamation is required.
3) The highland in the western part of the basin, where perennial crops are planted principally and upland rice etc. are cultured secondarily.

The number of the existing villages, households and the area of cultivated land in each partial areas are as follows:

Area	No. of village	No. of household	Area of farmland ha.	Area of farmland per household ha.
No.1-area	46	2,000	2,500	1.25
No.2-area	11	500	600	1.20
No.3-area	25	1,000	1,300	1.30

No.1 area: The area around the Darlac Lake is situated at high elevation and therefore there is little damage from inundation. Principal crop is paddy with the average yield of about 3 ton per hectare in the lower farmland and 1 ton per hectare in the highly elevated farmland under rain-fed cropping conditions. Some fruits (about 100 ha. of banana, papaya etc.), various vegetables (about 100 ha., in total), common field crops (about 110 ha. in total) are cultivated secondarily.

/ No.2 area:

No.2 area: The development is disturbed by the periodic inundation with depth of 1 to 4 meters. Only small areas on fan-shape lands are used for the culture of paddy and common field crops. Recently in 1958, 2 hamlets with the name of Tham Trach and Quang Trach were newly established by the Government. In these hamlets, 2 hectares of land were given to each households, and the reclamation of land was carried out by the Government. In this areas, most farmers cultivate paddy rice as the principal crop together with the secondary crops such as tobacco, maize, beans, potatoes, and some vegetables by means of rain-fed culture in the rainy season. Besides, some fruits such as papaya and banana etc. are planted perennially on the adjacent sloping mountainous land. In the dry season, the farmers scarcely support their livings by fishing in the lakes and ponds as no farming can be done due to the shortage of water. The paddy cultivated by farmers is the late-maturing variety of Indica in general. The seed is sown directly on the field or on the nursery in May(the transplantation is done in June), and the harvesting period is December to next January. The growing period ranges from 250 to 280 days. In spite of its rather high natural fertility, the soil in this lowland area produces unsatisfactory results affected by periodic flood damage. So the farmers' livings are poor and unstable in general.

No.3 area: The greater part of this area lies waste except some arable land used for the plantation of rubber plant and

/ coffee

coffee etc. Several small communities of farmers are scattered along the rivers and streams. Most farmers pick up their scanty livelihoods by means of their rain-fed farming management.

CHAPTER IV

DEVELOPMENT PLAN FOR DARLAC BASIN

4.1. Examination of original plan

4.1.1. Irrigation scheme

The initial plan to irrigate the Darlac Basin was to built an intake weir across the Ea Krong Ana at the east end of the basin and to maintain the water level of the Ea Krong Ana at EL. 422 meters in order to irrigate about 7,000 hectares of land by gravity flow.

In the light of our examination, however, we confirmed the disadvantages of this plan as follows:

(1) The continuous maintenance of water level at EL. 422 meters or more will inundate a considerably wide area and hinder the drainage of reclaimable fertile land in the upstream basin above the intake weir.

(2) The completion of detailed topographic maps reveals that there are fairly large depressions within this area and that it is impossible to command them by one irrigation system.

(3) According to the results of core borings at the proposed intake weir site of the Ea Krong Ana, the fresh rock base is considered to be at the depth of about 26 meters to 40 meters under the river bed. Moreover, as described above, the proposed irrigable area has rather complicated rolling topography. In such circumstance, the total construction cost for gravity irrigation system is expensive as compared with that of pumping irrigation by about 600,000 U.S. Dollars.

/ In consequence

In consequence, it can be concluded that the lift irrigation is more profitable from the financial point of view because of its smaller initial investment, even taking into account that the operation and maintenance cost for it is somewhat higher than that for irrigation by gravity flow.

4.1.2. Drainage scheme

In the upstream area of Srepok, there are the water system composed of the Ea Krong Ana, and its tributaries such as the Ea Krong Pach, and the Ea Krong Buong, and the Ea Krong Ana is joined by the Ea Krong Kno in the western part of the Darlac Valley.

Besides the Darlac Valley, there is a vast development of lowland with area of 50 square kilometers along the Upper Ea Krong Ana above the Darlac Valley. This wide lowland used to be inundated with periodic flood in every rainy season in the same way as the Darlac Valley. The flooded water is withdrawn slowly through evaporation and lagging drainage by river with gentle gradient of 1 to 7,000, and stagnates for so long times as three months after the end of the rainy season. The amount of water to be stored in the Darlac Valley is estimated at about 200 million cubic meters with water level of El. 418 meters, and the water stored in the upper lowland is estimated at about 100 to 300 million cubic meters with water level of El. 420 meters to 430 meters.

Both of the Darlac Valley and the upper lowland extend over 140 square kilometers in area and serve as a natural flood control reseavoir for the Ea Krong Ana.

Providing that these lowland areas are tightly enclosed with surrounding embankment, the flood discharge of the Ea Krong Ana would be increased extraordinarily.

/ Therefore

Therefore, in order to develop these low-lying lands it is necessary not only to construct embankments but to control the flood in the upstream of the Ea Krong Ana. And our presupposed plan to protect the Darlac Basin against flood by constructing of surrounding embankment are revised, and we come to a conclusion that it is inevitable to construct flood control reservoirs at the upper reaches of the rivers above the Darlac Basion.

4.2. Irrigation scheme

4.2.1. Introduction

The irrigable area in the Darlac Basin is about 8,000 hectares in total. In due consideration of the topographical features including the locations of water sources etc., the area should be divided into six partial areas where could better be irrigated by six independent irrigation systems. (See Area A to F in Drawing)

Out of these six irrigable areas, five areas could be irrigated by pumping up system advantageously while one area is suitable to be irrigated by gravity flow system in the light of their topographical conditions.

For the performance of these pumping up irrigation systems, it is desired that possibly cheap electric power is available. At present, however, there is no such surplus power, and it is unprofitable to construct a hydroelectric power station solely for this purpose. Therefore, the generation of power by diesel engine is recommendable until cheap hydoroelectric power becomes available for this purpose with the advance of the development of the comprehensive Upper Srepok Project.

The development scheme for these six irrigable areas are as follows: (See Area A to F in Drawing)

/ A-area

A-area: 1,500 hectares including the existing paddy fields around the Darlac Lake. (pump up irrigation)

B-area: 1,000 hectares area of elevated flat land about the courses of the Da P' Heui and Ea Lien, the tributaries of the Ea Krong Ana. (Gravity flow irrigation)

C-area: 2,400 hectares area in the middle part of the Darlac Basin and situated on the upstream left bank. (pump up irrigation)

D-area: 1,600 hectares in the middle part of the Darlac Basin situated on the lower left bank. (pump up irrigation)

E-area: 1,000 hectares in the middle part of the Darlac Basin on the right bank. (pump up irrigation)

F-area: 500 hectares area on the left bank of the Ea Krong Kno. (pump up irrigation)

Total areas : 8,000 hectares.

Of the above six irrigation areas, C, D, and E-areas are located in the middle part of the Darlac Basin and are very flat and able to be reclaimed easily. Most soils have high natural fertility. In C-area, about 500 households of farmers have been settled recently and are mainly engaged in the rain-fed culture of paddy etc. However, all the fields are inundated in the rainy season and suffered by flood damage. Accordingly, the farmers are driven into scanty livelihoods. So the proper measures are urgently needed to stabilize the farm management and to improve the farmers' livings. However, as stated in the preceding chapter, the development of the Darlac Basin as a whole is technically infeasible and economically unjustifiable unless it would be undertaken in connection with the development of the integrated Upper Srepok Project.

/ Under

Under such circumstances, it is strongly recommended that the arable land of 1,000 hectares with rather high elevations more than El. 416 meters should be taken up as the object of the Darlac Irrigation Project at the first stage. In this case, the existing two hamlets can be serviceable as the center of the project.

As for the development of the lowland area other than the above-mentioned part, it should be carried out in coordination with the development of the integrated Upper Srepok Project.

A-area is situated on the highland around the Darlac Lake and the farmers are making rather stabilized lives as this area is free from flood although the soil is not so fertile as the lowland soils. For this reason, the development is not so urgently required for this area as for the aforementioned area.

B and F areas are located at high elevation where is no fear of flood and the development plan could be contemplated independently. But the priority of this area in the schedule of development is to be the lowest because this area is sparsely populated and densely covered with forests, and additionally, the initial investment is relatively high as compared with the other areas.

For the accomplishment of the irrigation project at the first stage in C-area, an earth dam should be constructed to stop the outflow from the Darlac Lake and to raise the water level to about El. 420 meters for irrigating the area with elevation of El. 419 to 416 meters by gravity flow.

When the comprehensive Upper Srepok Project should be completed in future, the water in the Darlac Lake should be used for irrigation on A-area, and the irrigation water on

/ C-area

C-area should be pumped up from the Ea Krong Ana.

4.2.2. Water requirement

The water requirement for irrigation is computed in consideration of the following conditions.

(1) Arable land allotted to farmers is 2 hectares per farm household. One-fourth of the land is used as a paddy field, and the remaining three-fourths for rotative cropping field of paddy and dry farm crops.

(2) The consumptive use of water for dry farm crops is estimated at 60 percent of that for paddy.

(3) The average consumptive use of water is 1.5 times the amount of evaporation from evaporation pan.

Thereupon, the net water requirement for irrigation is calculated as follows.

Table - 6 Net water requirement for irrigation

(Unit mm/day)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1. Evaporation	3.3	4.4	4.6	4.1	2.4	1.7	1.5	1.5	1.2	1.5	2.1	3.6
2. Average consumptive use of water for paddy	5.0	6.6	6.9	6.2	3.6	2.6	3.3	2.3	1.8	2.8	3.2	5.4
3. Maximum consumptive use of water for paddy	7.4	9.9	10.4	9.2	5.4	3.8	3.4	3.4	2.7	3.4	4.7	8.1
4. Mean consumptive use of water for paddy	6.2	8.3	8.7	7.7	4.5	3.2	2.9	2.9	2.3	2.9	4.0	6.8
5. Consumptive use of water for dry farm crops	3.7	5.0	5.2	4.6	2.7	1.9	1.7	1.7	1.4	1.7	2.4	4.1
6. Net water requirement	4.3	5.8	6.1	5.4	3.2	2.2	2.0	2.0	1.6	2.0	2.8	4.8

/ As seen

As seen in above table, the maximum net water requirement is 6.1 millimeters per day in March.

Adding 40 percent of net water requirement as application loss to the net, the gross water requirement for irrigation or the field irrigation application is determined at 8.54 millimeters per day at maximum.

4.2.3. Adapted irrigation method

In general, adapted irrigation method depends mainly upon the kind of crops, the nature of soil and the topographical condition. According to the results of our investigations and soil survey, the proposed irrigable area is mostly the flat lowland with the land gradient of less than 2 percent, and soil in this area have relatively high water holding capacity and rather low basic intake rate.

In due consideration of various basic factors regarding to irrigating water application in this area, the adapted irrigation methods are considred by crops as follows.

	Irrigation method	Adapted crops
1.	Strip border method	paddy
2.	Downhill small furrow method or contour small furrow method	green bean, soybean and vegetables etc.
3.	Downhill large furrow-method or contour large furrow-method	maize, kenaf, tobacco, sweet poteto etc.

4.3. Drainage plan

As stated before, the drainage plan for the Darlac Basin cannot be completed independently, because it is closely related with the development of the upstream area. Therefore, it should be carried out in connection with the development of the Upper Ea Krong Ana Project and the development of the Ea Krong Kno Project. For the development of C-area at the first

/ stage

stage, therefore, the adequate drainage system should be provided so as to minimize the stagnant water on the arable land in the project area. That is to say, a main drainage canal should be constructed so as to connect it with the river and streams in the area. The section of the drainage canal should be enough to drain the run-off from its own drain area.

By using such a draining system, the stagnating period of flood on the arable land would be shortened to about 2 months in every rainy saeson, and some crops such as vegetables etc. with rather short growing period could be cultivated without the suffering by flood. In such a case, floating-paddy should be cultivated throughout the rainy saeson.

4.4. Agricultural development

For the agricultural development in the Darlac Basin, it is considered to be a most appropriated measure to immigrate inhabitants from the densely populated regions such as the costal districts, and to manage a small-scale and stabilized farming.

For the purpose it is necessary to take such measures as will enable to lessen the flood damage in the rainy season and to permit the irrigation in the dry season as well.

In such a case, it is necessarily required to construct proper irrigation facilities for watering onto the arable land mainly in the dry season, and additionally to provide possible drainage system for sustaining the optimum soil moisture level of land during the rainy season to a great extent. As for the type of farm management, the paddy livestock farming should be taken up for the purpose of getting sufficient stable

/ manures

manures for the improvement of farmland as well as obtaining rich stock-raising products for the stabilization of irrigated farm management. Then, the standard acreage of a farming unit is determined at 2 hectares. Out of 2 hectares in total, 1.8 hectares are used for cropping, 0.1 hectare for homestead, and remaining 0.1 hectare for grassland with forest. The most principal crop should be paddy and some vegetables which are indispensable for farmers' livings. Besides, beans, maize.and pasture grass should be grown as the self-supplying feeds for livestocks.

In addition to these, kenaf, tobacco, peanut and green bean are cultivated for marketing.

It is noteworthy that special consideration should be paid for the selection of crop varieties in view of the climatic and local natural conditions. Especially, in the case of paddy culture, it is desirable to select a early-maturing variety which can be harvested within 120 to 150 days such as the special varieties bred in Japan and other advanced countries in the breeding of this crop.

Two milk cows, 2 swines and 11 fowls are raised, and stable manure of at least 20 tons can be obtained and applied on farm for supplying proper amount of humus and nutrients into soils annually.

For the paddy culture on lowland where excess water is stagnating for a long period during the rainy season, floating rice is recommended to be used. Also in this case, the most adapted variety should be taken up in the light of actual experimental results in this area.

CHAPTER V

CONSTRUCTION COST

The construction cost of the first stage development is estimated at about 350,000 U.S. Dollars or equivalent to 350 U.S. Dollars per hectare as broken down below. The cost does not include the amount of taxes and duties imposed on imported machinery and materials.

	Item	Foreign currency U.S.$	Local currency U.S.$	Total U.S.$
1.	Preparatory works	5,000	5,000	10,000
2.	Intake dam	60,000	80,000	140,000
3.	Irrigation canal	20,000	30,000	50,000
4.	Drainage canal	15,000	25,000	40,000
5.	Reclamation	10,000	20,000	30,000
6.	General expenses and engineering service	20,000	30,000	50,000
7.	Contingency and reserve	15,000	15,000	30,000
8.	Total	145,000	205,000	350,000

The construction will require a period of about two years including preparatory works and purchase of materials and others. Out of the above works, it is desirable that reclamation is executed by using the government-owned construction machineries.

All the construction works should be performed during the dry season. As shown on the following construction schedule, about 50 percent of all works is to be completed during the dry season of the first year. For this purpose, the preparatory works is required to be started at the beginning of the dry season, and all the construction should be completed by the end of the dry season of the second year.

/ The annual

The annual fund requirement for this construction will be broken down in accordance with the construction schedule as follows:

Year	Foreign currency U.S.$	Local currency U.S.$	Total U.S.$
1st year	80,000	70,000	150,000
2nd year	65,000	135,000	200,000

Fig. 2

CONSTRUCTION SCHEDULE FOR 1ST STAGE DEVELOPMENT OF DARLAC IRRIGATION PROJECT.

WORK	QUANTITY	1ST YEAR	2ND YEAR	3RD YEAR
1. Preparatory works				
2. Purchase of equipment				
3. Intake dam	50,000 M^3			
4. Irrigation canal works	40.000 M^3			
5. Drainage canal works	70.000 M^3			
6. Reclamation	1.000 ha.			
7. Priming test and adjustment				
for canals				

CHAPTER VI

BENFIT AND EVALUATION

6.1. Benefit

By the completion of the first stage development, the land improvement of about 500 hectares of the existing paddy field and the reclamation of about 500 hectares of newly paddy field could be expected. On both of these fields, it would be possible to harvest two crops a year. Moreover, the more the adapted varieties of crops and the improved irrigation farming techniques are introduced, the more the farm products would be increased year by year. Then, the total amount of annual crop products would be increased as shown in Table-1.

/ Table-1

Table-1 Prospective increase of farm products

Kind of crop	Before irrigation					After irrigation					
	Harvested area	Unit yield	Total products	Unit price	Total price	Harvested area	Unit yield	Total products	Unit price	Total price	Amount increased
	(ha)	(ton)	(ton)	(U.S.$)	(U.S.$)	(ha)	(ton)	(ton)	(U.S.$)	(U.S.$)	(U.S.$)
First paddy	400	2	800	50	40,000	400	3	1,200	50	60,000	20,000
Second paddy	-	-	-	-	-	400	4	1,600	50	90,000	90,000
Red bean	10	1	10	40	400	240	2	480	40	19,200	18,800
Green bean	10	1	10	40	400	160	2	320	40	12,800	12,400
Pasture grass	-	-	-	-	-	240	70	16,800	2	33,600	33,600
Soybean	20	1.2	24	40	960	160	3	480	40	19,200	18,240
Tobacco	10	1	10	400	4,000	160	1	160	400	64,000	60,000
Peanut	15	1	15	100	1,500	240	1.5	360	100	36,000	34,500
Kenaf	30	2	60	175	7,500	160	2	320	124	40,000	32,500
Sweet potato	10	18	180	5	900	160	20	3,200	5	16,000	15,100
Fruits	50	5	250	40	10,000	80	10	800	40	32,000	22,000
Vegetables	50	15	750	10	7,500	160	1.5	2,400	10	24,000	16,500
Total					73,160					446,800	373,640

/ In addition

In addition to above, the total price of livestock products such as milk, meat, egg and young animals can be estimated as floows.

Table 2. Livestock products

Kind of animal

Product	unit	product	unit price U.S.$	total price U.S.$
Milk	Kl	3,200	15	48,000
Calf	head	1,600	20	32,000
Shoat	haed	4,000	3	12,000
Egg	nos.	800,000	0.02	16,000
Poultry		4,000	1	4,000
Total				112,000

Consequently, the toatl amount of annual crop and livestock products is computed below.

373,640 + 112,000 = 485,640 = 485,000 U.S. Dollars

The annual net increase of agricultural products by irrigation farming is computed by deducting annual average farming expenditure of about 268 U.S. Dollars per hectare including fertilizers, agricultural chemicals, public impost etc. needed for improved irrigation farming from the annual increased amount of products as follows:

485,000 - (268 x 1,000) = 217,000 U.S.Dollars

(217 U.S.Dollars per hectare)

6.2. Evaluation

By using the result of the balance of the paddy livestock farming management which is shown in Table A-15 in appendix of this report, the benefit cost ratio of the first stage development can be calculated by the

/ method

method indicated in the ECAFE Flood Control Series No.7, Part 1, Chapter III as follows.

(1) Irrigation benefits

Direct benefit .... 485,000 U.S.Dollars

(Increased agricultural products)

Indirect benefits .... not included

Intangible benefits .... not included

(2) Municipal benefits .... not included

(3) Project costs

Capital cost 350,000 U.S.Dollars

Operation and maintenance of

irrigation system $10^{U.S.\$/ha} \times 1{,}000^{ha}$ = 10,000 U.S.Dollars

Farming expenses $268^{U.S.\$/ha} \times 1{,}000^{ha}$ = 268,000 U.S.Dollars

(4) Annual costs

Equivalent cost of project capital cost

$27^{U.S.\$/ha} \times 1{,}000^{ha}$ = 27,000 U.S.Dollars

Annual operation and maintenance cost 10,000 U.S.Dollars

Annual farming expenses 268,000 U.S.Dollars

Total annual costs= 305,000 U.S.Dollars

(5) Bnefit cost ratio

$$\text{Bnefit cost ratio} = \frac{\text{Annual benefits}}{\text{Annual costs}}$$

$$= \frac{485{,}000}{305{,}000} = 1.6$$

In addition to this, the justifiable investment and investment efficiency are computed as follows:

(1) Annual net increase of products ....217,000 U.S.Dollars

(2) Annual costs

Equivalent cost of project capital cost...... 27,000 U.S.Dollars

/ Annual operation

Annual operation and maintenance costs .... 10,000 U.S. Dollars

(3) Standard rate of interest 0.06

(4) Number of years for durable period 35 years

Justifiable investment

$$= \frac{\text{Annual net increase of products} - \text{Annual costs}}{\text{Standard rate of interest} + \dfrac{1}{\text{Number of years for durable period}}}$$

$$= \frac{217{,}000 - 37{,}000}{0.06 + \dfrac{1}{35}} \doteqdot 5.8$$

As shown in the above computation, the benefit cost ratio and investment efficiency of the first-stage development is estimated at 1.6 and 5.8 respectively, which are remarkably higher than 1.0.

On the other hand, as described in Appendix Chapter VI, the farmer will be able to get the annual net profit of about 100 U.S. Dollars after deducting the repayment of construction cost, operation and maintenance cost and farming expenditure from his annual gross income.

Therefore, this development project can be evaluated to be economically profitable and feasible.

6.3 Financial arrangement and repayment schedule

This first stage development calls for a long-term loan with a low interest rate. The source of repayment for such loan will be borne by the net income to be obtained from the irrigation farming./1

/1 The annual income, outgo and balance sheet of a unit farm are shown in order for 15 years on Table A-15 in Appendix.

/ Now, assuming

Now, assuming that the loan is repayable during the period of 35 years at an interest rate of 3.5 percent per annum without paying the interest and the capital for the first 7 years after the commencement of the construction, the repayment schedule is as shown in Table-7.

As shown is this table, the amount of repayment will keep on the same amount from the 8th to 33th, then will gradually be decreased towards the end of the 34th year. The amount for repayment due to farmers will be about 27 U.S. Dollars per hectare which corresponds to about 3.8 percent of gross income./1 After such amount is paid, the farmers will still reserve a surplus of about 55 U.S. Dollars per hectare.

The financial management will be practiced by a special organization to be established for this purpose. The balance sheet of this organization is estimated as illustrated in Table-7.

/1 Pre-estimation of gross income together with farm management expenditures at irrigation farming unit is explained on Table A-15. in Appendix.

Table 7 Balance schedule for expected incomings and outgoings of irrigation enterprise in charge of operation and maintenance of irrigation system

Year 1/	Construction cost (US $) 2/	Accumulated loan (US $) 3/	Irrigation area (ha)	Allotment of const. cost (US $/ha) 4/	Allotment of op cost (US $/ha) 5/	Total income (US $) 6/	Operating cost (US $) 7/	Repayment for loan (US $) 8/	Total outgo (US $)	Balance (US $) 9/
1	350.000	362.250	—	—	—	—	—	—	—	—
2		374.929	—	—	—	—	—	—	—	—
3	—	388.052	1.000	—	10	10.000	10.000	—	10.000	—
4	—	401.634	1.000	—	10	10.000	10.000	—	10.000	—
5	—	415.691	1.000	—	10	10.000	10.000	—	10.000	—
6	—	430.240	1 000	—	10	10.000	10.000	—	10.000	—
7	—	445.298	1 000	—	10	10 000	10.000	—	10 000	—
8	—	434.796	1.000	27	10	37.000	10.000	26.087	36.087	913
9	—	423 927	1 000	27	10	37.000	10.000	26.087	36.087	913
10	—	412.677	1.000	27	10	37.000	10.000	26.087	36.087	913
11	—	401.034	1.000	27	10	37.000	10.000	26.087	36.087	913
12	—	388.983	1.000	27	10	37.000	10.000	26 087	36.087	913
13	—	376.516	1.000	27	10	37.000	10.000	26.087	36.087	913
14	—	363.607	1.000	27	10	37.000	10.000	26.087	36.087	913
15	—	350 846	1.000	27	10	37.000	10.000	26.087	36 087	913
16	—	336 418	1.000	27	10	37.000	10.000	26.087	36.087	913
17	—	322 106	1.000	27	10	37 000	10 000	26.087	36.087	913
18	—	307.293	1.000	27	10	37.000	10 000	26.087	36.087	913
19	—	291.961	1.000	27	10	37.000	10 000	26.087	36.087	913
20	—	276.093	1.000	27	10	37.000	10.000	26.087	36 087	913
21	—	259.669	1.000	27	10	37.000	10.000	26.087	36 087	913
22	—	242 670	1 000	27	10	37 000	10.000	26 087	36 087	913
23	—	225.076	1.000	27	10	37.000	10.000	26 087	36.087	913
24	—	206.866	1.000	27	10	37.000	10.000	26.087	36.087	913
25	—	188 019	1 000	27	10	37.000	10.000	26 087	36 087	913
26	—	168.513	1.000	27	10	37.000	10 000	26 087	36 087	913
27	—	148.324	1.000	27	10	37.000	10.000	26.087	36 087	913
28	—	127.428	1.000	27	10	37.000	10.000	26 087	36 087	913
29	—	105.801	1.000	27	10	37.000	10000	26 087	36 087	913
30	—	83.417	1 000	27	10	37.000	10 000	26.087	36 087	913
31	—	60.249	1.000	27	10	37.000	10.000	26.087	36 087	913
32	—	36 271	1.000	27	10	37.000	10 000	26 087	36 087	913
33	—	11.453	1 000	27	10	37.000	10.000	26.087	36 087	913
34	—	—	1 000	12	10	22.000	10.000	11.854	21 854	146
35	—	—	1 000	—	10	10.000	10.000	—	10 000	–

1/ Figure illustrates the numerical order of year after the commencement of irrigation system construction
2/ Figure shows the construction cost of irrigation system.
3/ Figure shows the accumulated sum of loan and interest minus the repayment.
4/ Figure is estimated with unit of US $ per ha by using integral number.
5/ Figure shows working cost of irrigation administration of 10 U.S. $ per ha annually.
6/ Figure shows the total income collected by irrigation administration organization.
7/ Figure shows the total working cost of irrigation administration organization.
8/ Figure shows the redemption by yearly installment over 28 years at an interest rate of 3.5%, unredeemable for the first 5 years after the completion of construction works.
9/ Black figure shows the surplus to be used for contingency fund.

CHAPTER VII

CONCLUSION AND RECOMMENDATION

Since this project area is situated in the lower reaches of the Upper Srepok, it is inevitably required to consider it as a link in the chain of the comprehensive Upper Srepok Project covering the basins of the Ea Krong Buk, the Ea Krong Boung and other rivers. As the drainage of the Darlac Basin is vitally affected by the flood control works for the upstream reaches, the final drainage plan shall be completed jointly with the planning of the upstream basin projects. In this area, however, about 500 hectares of lowland have been cultivated, and 2 hamlets have been established already. In order to stabilize these farmers' agricultural managements as early as possible, it is imperative to perform the development works of this area so as to enable the farmers to maintain profitable irrigation farming during the dry season and to protect their lives against the sufferings from periodic floods. For this purpose, as an area for first stage development, about 1,000 hectares of central lowland along the Ea Krong Ana including about 500 hectares of existing arable land will be selected. On this land, it is possible to construct the irrigation system within the limits of an economically justifiable investment as previously mentioned.

As for the remained area of Darlac Basin, its development is desirable to be considered as a part of the comprehensive development project all over the Upper Srepok Basin in future.

A P P E N D I C E S

APPENDIX 1

GEOLOGICAL STUDIES OF THE PROPOSED INTAKE WEIR SITES AND STRUCTURE SITES

1.1. Intake weir site

The Ea Krong Ana flows into the Darlac marshy land through an isthmus of some 10 kilometers long between Kana and the north-eastern end of the Darlac Valley. This isthmus is, as a whole, a kind of corridor composed of the alternative bed of sandstone and shale.

Though there are a large number of sites suitable to a low intake weir through its length, a special point near the lower exit of the isthmus is taken up as the recommendable intake weir site in order to minimize the length of irrigation canal connected with the intake weir. It is a matter of course that the more the site approaches to the exit, the more the layer of gravel and sand increases its depth under the influence of the deposits sent back from the lower marsh. But in this case, it is not always necessary to fix the foundation of the weir to rock directly and the weir with such a small hight can be constructed so as to have a floating foundation. Then, the geological survey for the designing of the weir was conducted on the assumption that the weir should be floating type. This site, as mentioned above, is the place where river water flows into the marsh from the isthmus, forming a sort of drowned valley.

A strip of sand and silt buried in this drowned valley stretches with a width of about 300 meters in which the Ea Krong Ana of about 70 meters in width flows adjacent to the left bank of the valley. (See topographic map with scale 1: 2,000 in attached data book)

The results of core borings conducted at three points crossing the river are illustrated in the geological column and the geographical section of weir site is prepared by using the core boring results as shown in Fig. A-1.

The foundation rock is mainly composed of phyllite slate with partial intrusion of quartz veins. The rock crops out on the left bank of the river, while on the right bank it descends at the depth of about 40 meters under the river bed. This fact suggests the form of the valley due to the old river course. Such being the case, the intake weir (proposed crest of EL. 422 meters, the maximum height above the river bed of 7 meters.) cannont but be constructed upon the foundation of permeable layer composed of sand and gravel. Then, there is a fear that the river bed just below the weir may be heavily scoured by overflow from the weir, so it is necessary to provide a sufficiently long apron or to make the riprap work in order to prevent the excess scouring of the river bed.

1.2. Main irrigation canal

Most of the main irrigation canal are to be constructed on the layer which is mainly composed of sand and silt. So, the foundation of canal should be designed with due regard to the layer of silt.

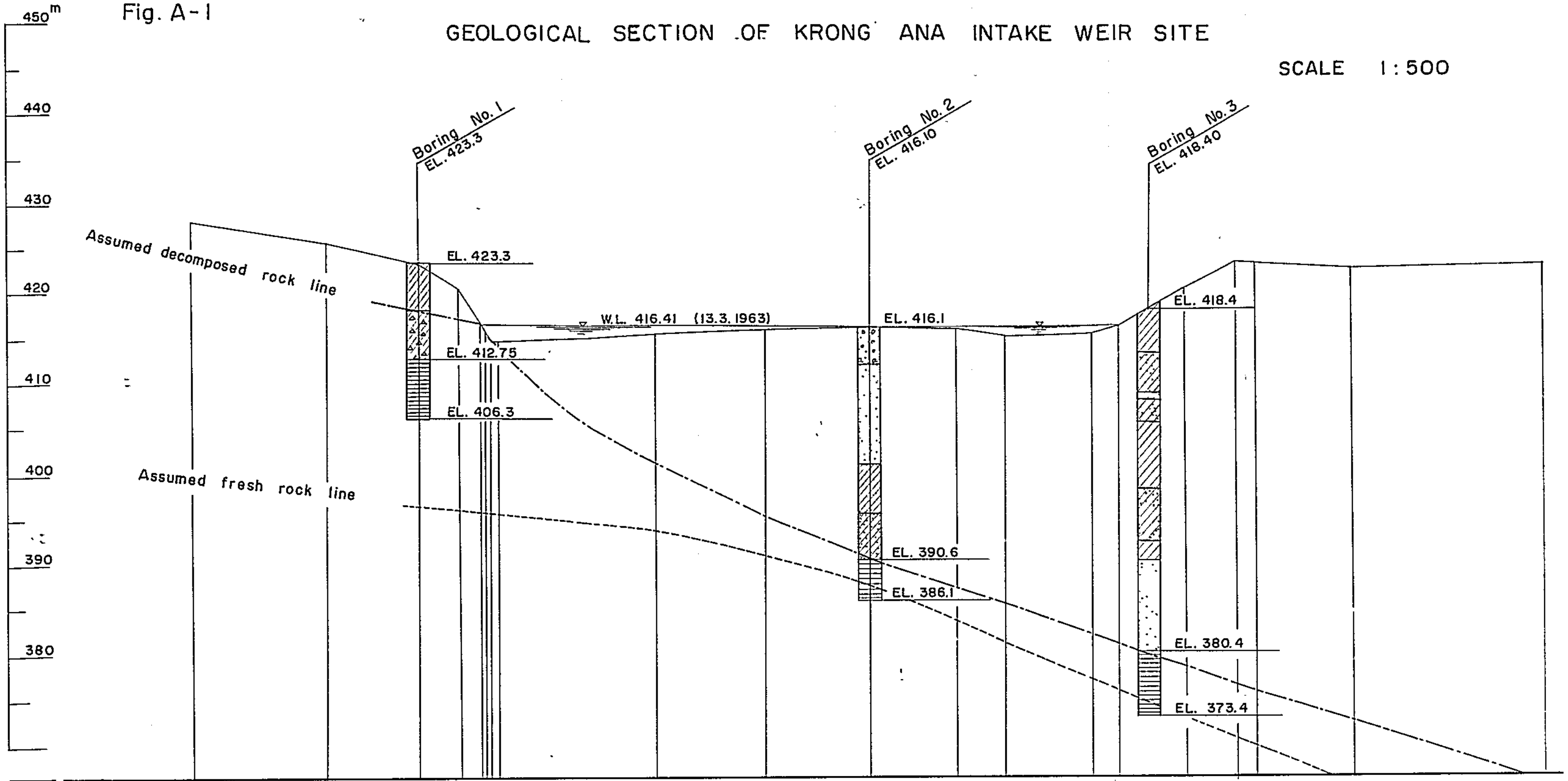
1.3. Pumping station

The thick layer of silt developing widely within the low marshy area is unfavorable for the foundation of pumping station. Therefore, the station should be constructed on the firm ground of coarse textured soil which can be found at the foot of a mountain or foot-hills in the project area.

Fig. A-1

GEOLOGICAL SECTION OF KRONG ANA INTAKE WEIR SITE

SCALE 1:500



St.	Dist.	Accu. dist.	G.H.
C 1			427.93
C 2	14.52	14.52	452.68
C 3	10.10	24.62	423.37
C 4	4.29	28.91	420.64
C 5	2.39	31.30	416.41
C 6	0.50	31.80	415.86
C 7	0.50	32.30	414.81
C 8	0.80	33.10	414.81
C 9	17.48	50.58	415.55
C 10	17.82	62.40	416.00
C 11	11.44	73.84	416.33
C 12	9.70	83.54	415.97
C 13	5.00	88.54	415.66
C 14	9.74	98.28	415.66
C 15	3.00	101.28	416.41
C 16	7.41	108.69	420.57
C 17	5.63	114.32	423.48
C 18	2.30	116.62	423.37
C 19	10.37	126.99	422.89
C 20	20.93	147.92	423.32

St.: Station Dist.: Distance Accu. dist.: Accumlative distance G.H.: Ground height

APPENDIX 2

ANALYSIS OF HYDROLOGIC DATA

2.1 Estimation of flood discharge

2.1.1. Annual run-off coefficient

The relation between the annual rainfall in Ban Me Thuot and the annual run-off (hereinafter referred to as "the average depth of water", which is the value calculated in terms of the average depth of water to a basin) of the Ea Krong Ana during the past year, October in 1961 to September in 1962 is as shown in the following table A-1.

Table A-1 Annual rainfall and annual runoff coefficient in Ban Me Thuot

1,535mm

	Basin	Area of basin	Annual runoff (Av.depth of water)	Annual runoff coefficient
A.	Upstream area of Ban Bur	8.650 Km^2	530 m.m.	35%
B.	Upstraem area of Kana water gauging station	3.210	404	26
C.	Area between Kana and Ban Bur	5.440	605	40

From above table, the annual runoff coefficient in the Upper Srepok Basin is estimated at about 30 to 40 percent.

2.1.2. Estimation of the probable maximum daily rainfall and the design continuous rainfall.

The maximum daily rainfall in Ban Me Thuot for the past 20 years is as follows.

/ TableA-2

Table A-2 Maximum daily rainfall in Ban Me Thuot

year	maximum daily rainfall m.m.	year	maximum daily rainfall m.m.	year	maximum daily rainfall m.m.	year	maximum daily rainfall m.m.
1928	96	1934	102	1941	112	1950	113
29	80	35	72	43	178	59	83
30	142	36	102	55	102	60	104
32	85	37	189	56	78.7	61	82
33	140	40	117	57	110	62	87.2

From the above table, the probable maximum daily rainfall is calculated as follows. (See Fig A-2)

Table A-3 Probable maximum daily rainfall

Occurrence Probability	Probable maximum daily rainfall m.m.
Once in 8 years	138
" 10 "	141
" 20 "	153
" 50 "	168
" 100 "	179
" 200 "	190
" 500 "	204

As shown in this table, the probable maximum daily rainfall once in 200 years is equivalent to about 1.37 times the value of once in 8 years. On the other hand, the maximum contiunuos rainfall for 5 days during the past 8 years, from 1955 to 1962, is 284.8 millimeters, recorded in 1960; therefore the probable maximum continuous rainfall for 5 days once in 200 years is estimated as follows;

/Table A-4

Fig A-2 PROBABLE MAXIMUM DAILY RAINFALL AT BAN ME THUOT

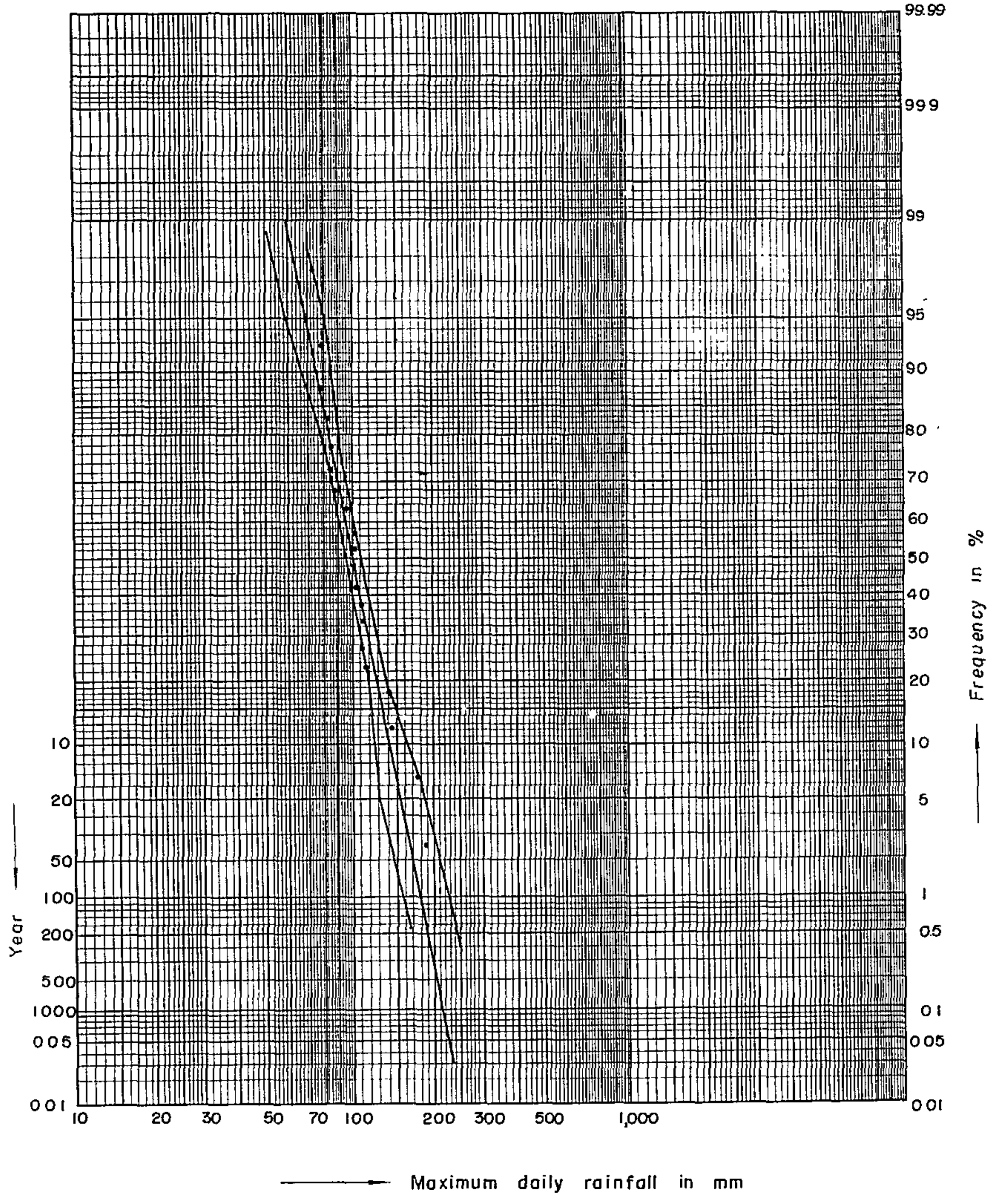


Table A-4 The maximum continuous rainfall for 5 days

	Maximum continuous rainfall for 5 days m.m.	Designed rainfall (A) x 1.37 m.m.
1st year	39.7	54.4
2nd year	22.0	30.1
3rd year	70.0	95.9
4th year	49.2	67.4
5th year	103.9	142.3
Total	284.8	390.1

Besides, according to the hydrograph observed at Kana gauging station, the type of run-off at Kana site could be expressed in triangular-shaped line as shown in the following Fig. A-3. As seen in this figure, the first stage run-off reaches to the maximum on the 5th day after rainfall, and then, it decreases rapidly and finishes by the end of the next 13 days. The second stage run-off shows a gradual decrease for about 40 days, and after that the third stage run-off (ground water outflow) is considered to start.

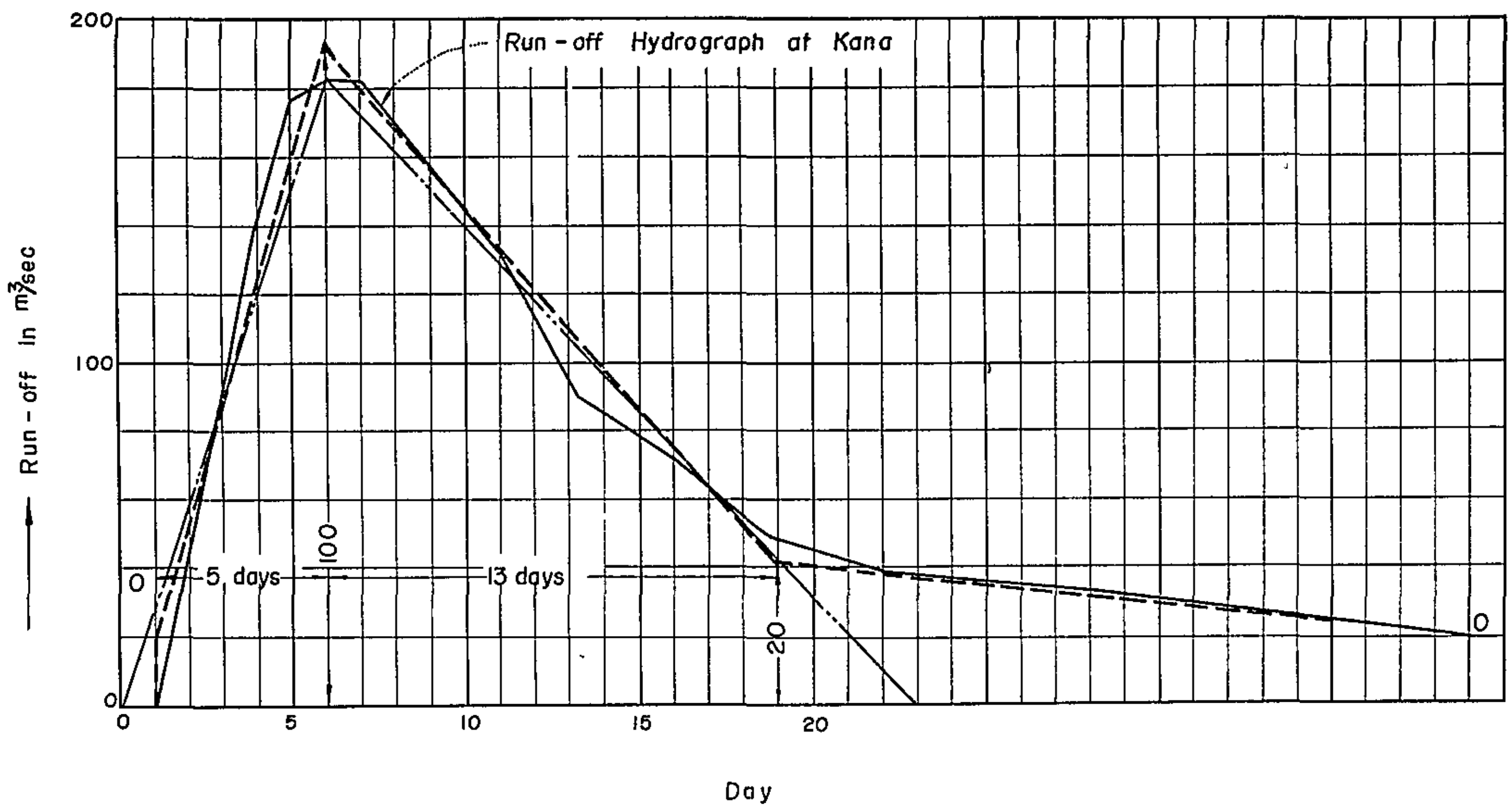
2.1.3. Estimation of flood run-off

1) The distribution of surface run-off

The amount of run-off at Kana gauging station during November 1961 to April 1962 is equivalent to 127.9 millimeters in the value of the depth of water to its catchment area. This amount is presumed to be the ground water outflow, which is equivalent to about 30 percent of 404 millimeters of annual run-off at this site. Therefore, the rest 70 percent may be

/ considered

Fig. A-3 SCHEMATIC RUN-OFF PATTERN



considered to be the surface run-off. On the other hand, the rate of the primary and the secondary run-off in the surface run-off by one rainfall can be calculated by using the schematic run-off pattern (shown in Fig. A-3) as follows.

		Rate
(1.00 - 0.2) x 18/2 + 0.2 x 18	= 10.8	73%
(0.2 + 0)/ 2 x 40	= 4.0	27
Total	14.8	100

Then, the surface run-off can be divided on the basis of the results of above computation as follows.

the primary run-off = 73 x (70/100) = 50% of annual run-off

the secondary run-off = 27 x (70/100) = 20% of annual run-off

2) Run-off coefficient at flood time

As described in foregoing section, the annual run-off coefficient in this basin is presumed at about 40 percent. But the run-off coefficient at flood time has a general tendency to be higher than the annual run-off coefficient, and it can be assumed at about 50 percent. Accordingly, the rates of primary and secondary run-off at flood time are computed respectively as follows.

Primary run-off	50 x (50/100) = 25%
Secondary run-off	20 x (50/100) = 10%

3) Estimation of design flood

The design value of flood can be estimated on the basis of the flood records covering the past long years, and it is almost impossible to decide the value of the Ea Krong Ana with the flood record for only one

/ year

year. Then we tried to estimate the design flood by means of the graphical method with the following procedures.

i) To assume 25 percent of the daily rainfall as the primary run-off.

ii) To distribute 80 percent of the above primary run-off into 18 days so as to make a triangular-form with 18 days as its base-line on the assumption that the peak runoff appears on the 5th day after the beginning of the rainfall, and the 20 percent of the primary runoff is divided into 18 equally, and then, each of them are added to the above distributed values for 18 days respectively.

4) The secondary runoff is presumed as 20 percent of the primary runoff, and it begins on the (13 + 5 =) 18th day after the beginning of the rainfall and is distributed so as to make zero on the 40th day after the beginning of the secondary runoff.

The culculation is as follows;

Table A-5 Computation process of schematic runoff distribution

I Day in order	II Design rainfall (Rs) (mm)	III 0.25Rs (mm)	IV 0.8(0.25Rs) (mm)	V Average runoff (cm s)	VI peak (cm s)	VII $\frac{1}{4}$(VI) (cm s)	VIII VI + VII (cm s)
1st day	54.4	13.6	10.9	22.5	45.0	11.3	56.3
2nd day	30.1	7.5	6.0	12.4	24.8	6.2	31.0
3rd day	95.9	24.0	19.2	39.6	79.2	19.8	99.0
4th day	67.4	16.9	13.5	27.8	55.6	13.9	69.5
5th day	142.3	35.6	28.5	58.8	117.6	29.4	147.0
Total	390.1	97.6	78.1	161.1	322.2	80.6	402.8

(Note: The catchment area in above computation is 3,210 square kilometers. Besides, in order to draw the estimated flood hydrograph

/ by using

by using the results of above computation, the base-flow is represented in (-) and is 135 cubic meters per second at the beginning of flood to be assumed. And it is distributed so as to make zero on 40 days after. In this way the estimated flood hydrograph is drawn as shown in Fig A-4, and the maximum flood runoff is presumed at about 500 cubic meters per second from this flood hydrograph. But this value would be somewhat modified in response to the integrated development planning inclusive of the upstream reaches of the Ea Krong Ana.)

2.2. Amount of the flooding in the Darlac Valley

2.2.1 Relation between elevation and inundation

Providing that the flood water flows and stagnates in the Darlac Valley is level, the relation between elevation and inundation in this valley are presumable as shown in Fig. A-5.

2.2.2 Fig. A-6. shows the result of the water-surface-tracing in the Ea Krong Ana, which is calculated by using the Escoffier method on the assumption that the river discharge of the Ea Krong Ana is 500, 375 or 250 cubic meters per second.

On the other hand, Fig. A-7 illustrates the discharge curves of the Ea Krong Ana at its confluence with the Ea Krong Diet and in the upstream above Ban Dray Falls. From these figures, it is presumed that the banked-up-backwater of the Ea Krong Ana does not appear while the river discharge is less than about 675 m^3/sec. at No.16 station and less than 420 m^3/sec. at its confluence with the Ea Krong Diet. The influence of backwater comes out in proportion to the increase of the river discharge and reaches to the confluence with the Ea Krong Diet at the most.

/ However

Fig. A-4 .SCHEMATIC HYDROGRAPH OF FLOOD

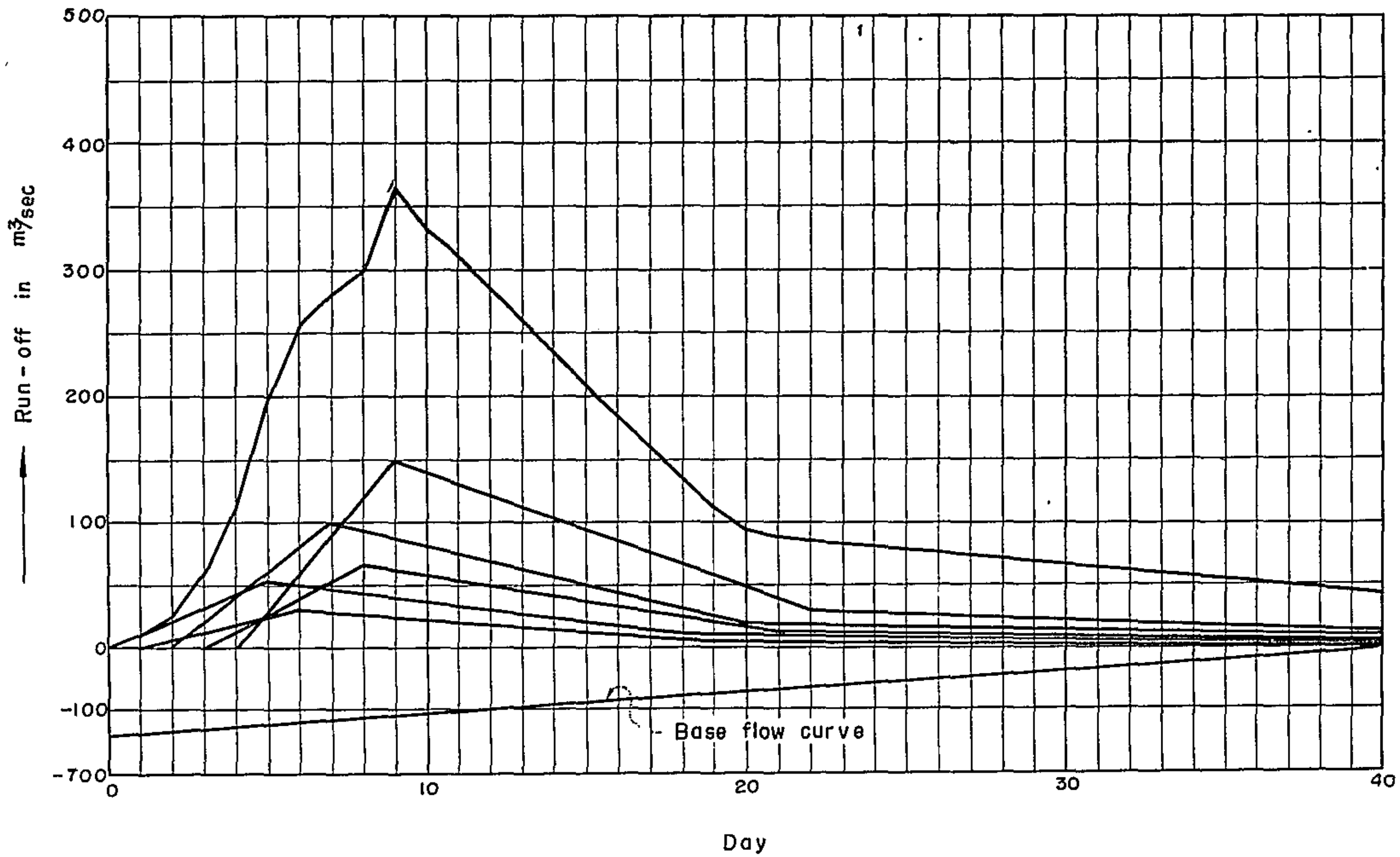


Fig. A-5 RELATION BETWEEN ELEVATION AND INUNDATION IN DAR LAC VALLEY

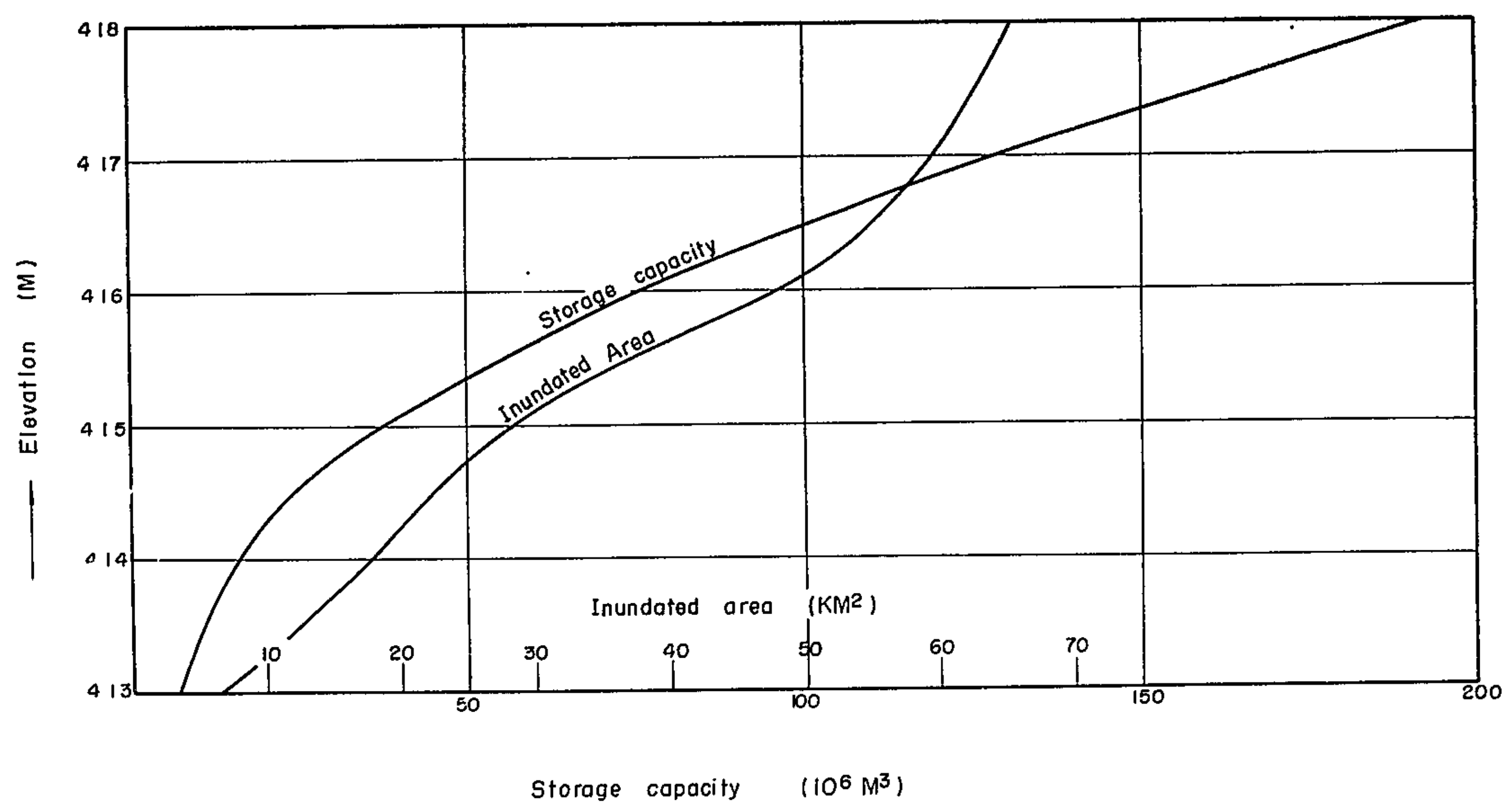
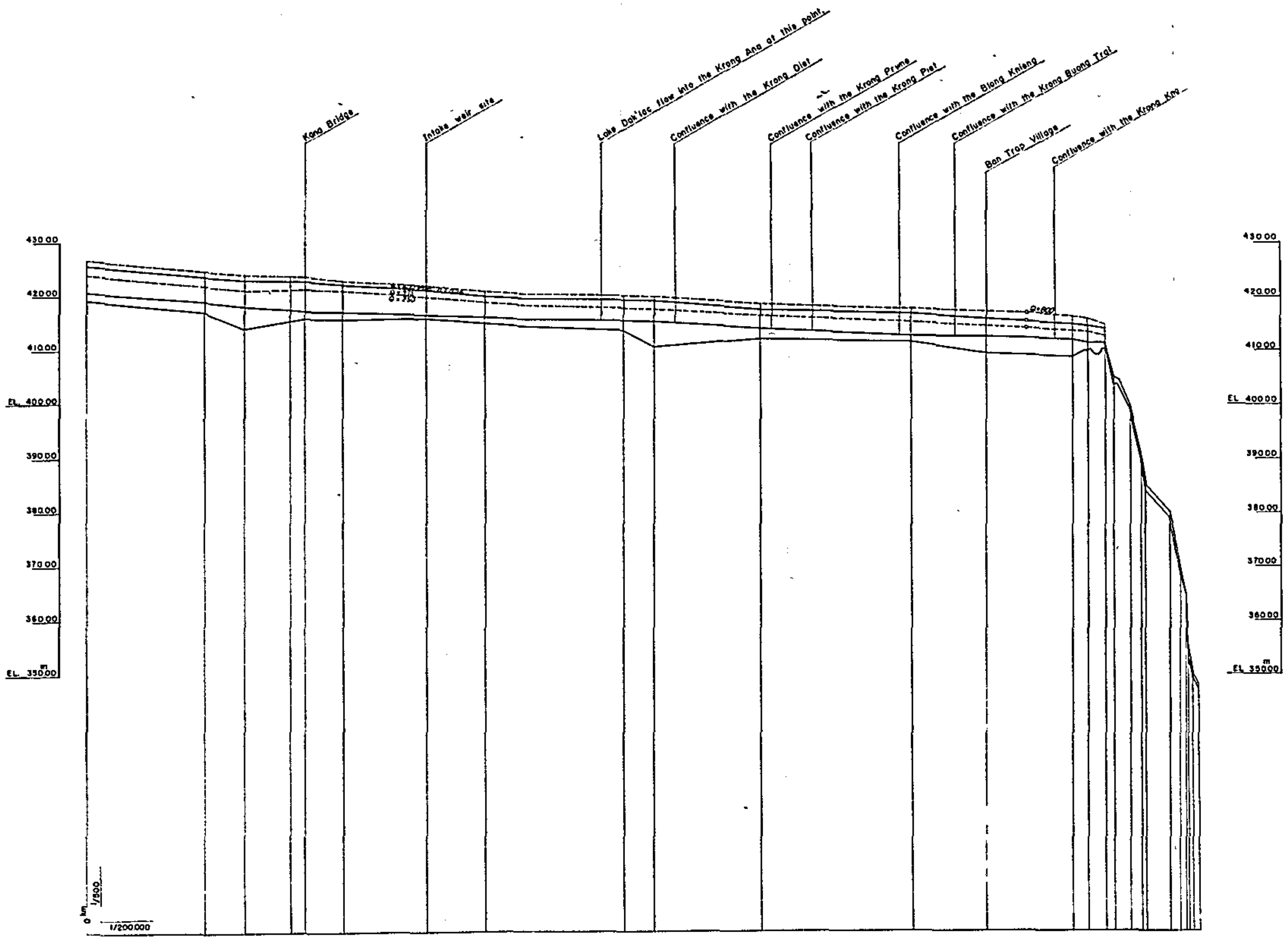


Fig. A-6 Longitudinal Section of Ea Krong Ana



SP	PD	A.D	RBH	WH	Date
NO. 1	0.000	0.000	419.22	420.63	3.16
NO. 2	8.930	8.930	416.91	418.71	3.8
NO. 3	2.940	11.870	413.96	418.11	3.8
NO. 4	3.510	15.380	415.25	417.45	3.7
NO. 5	1.080	16.460	415.59	417.19	3.18
NO. 5	2.840	19.300	415.65	417.00	3.19
NO. 6	6.300	25.600	415.86	416.41	
NO. 7	4.350	29.950	415.17	416.27	3.6
NO. 9	10.780	40.730	413.73	415.43	3.4
NO. 10	2.230	42.960	410.51	415.21	3.4
NO. 11	7.950	50.910	411.85	413.86	3.29
NO. 13	11.240	62.150	411.43	412.53	3.31
NO. 15	5.610	67.760	409.15	412.35	3.30
NO. 16	6.430	74.190	408.69	411.90	3.31
NO. 17	1.110	75.300	410.10	411.40	
NO. 18	1.390	76.690	410.50	411.30	
NO. 19	0.610	77.300	403.90	405.00	
NO. 20	1.170	78.470	399.10	400.00	
NO. 21	0.960	79.430	389.30	390.00	
NO. 22	0.530	79.960	383.80	385.00	
NO. 23	1.530	81.490	379.20	380.00	
NO. 24	[illegible]	[illegible]	[illegible]	[illegible]	
NO. 25	[illegible]	[illegible]	[illegible]	[illegible]	
NO. 26	[illegible]	[illegible]	[illegible]	[illegible]	
NO. 27	[illegible]	[illegible]	[illegible]	[illegible]	
NO. 28	[illegible]	[illegible]	[illegible]	[illegible]	

H.L. SCALE 1 : 200,000
V.L. SCALE 1 : 500

OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

UPPER SREPOK-DAR LAC PROJECT

LONGITUDINAL SECTION OF EA KRONG ANA

NIPPON KOEI CO., LTD. TOKYO
(CONSULTING ENGINEERS)

DRAWN	OFFICE TOKYO	DWG NO
CHECKED	DATE MAY 30 1963	
SUBMITTED	RECOMMENDED	SHEET NO
APPROVED		

However, the influence of backwater generally does not reach to the confluence with the Ea Krong Diet so far as the river discharge is nearly balanced to the annual flood run-off as usual.

2.2.3 Relation between the river stage and the amount of flooding of the Darlac Valley.

The following table shows the relation between the river stage and the discharge of the Ea Krong Ana at its confluence with the outflow of the Lake Darlac and that with the Ea Krong Diet. (See Fig. A-7)

Table A-6 Relation between the river stage and discharge of the Ea Krong Ana.

Table A-6. No. of case	River discharge of the Ea Krong Ana m^3/sec	River stage of the Ea Krong Ana: Confluence with the Darlac El.m.	River stage of the Ea Krong Ana: Confluence with the Krong Diet El.m.
A	500	419.8	417.7
B	375	419.0	416.7
C	250	417.9	415.5

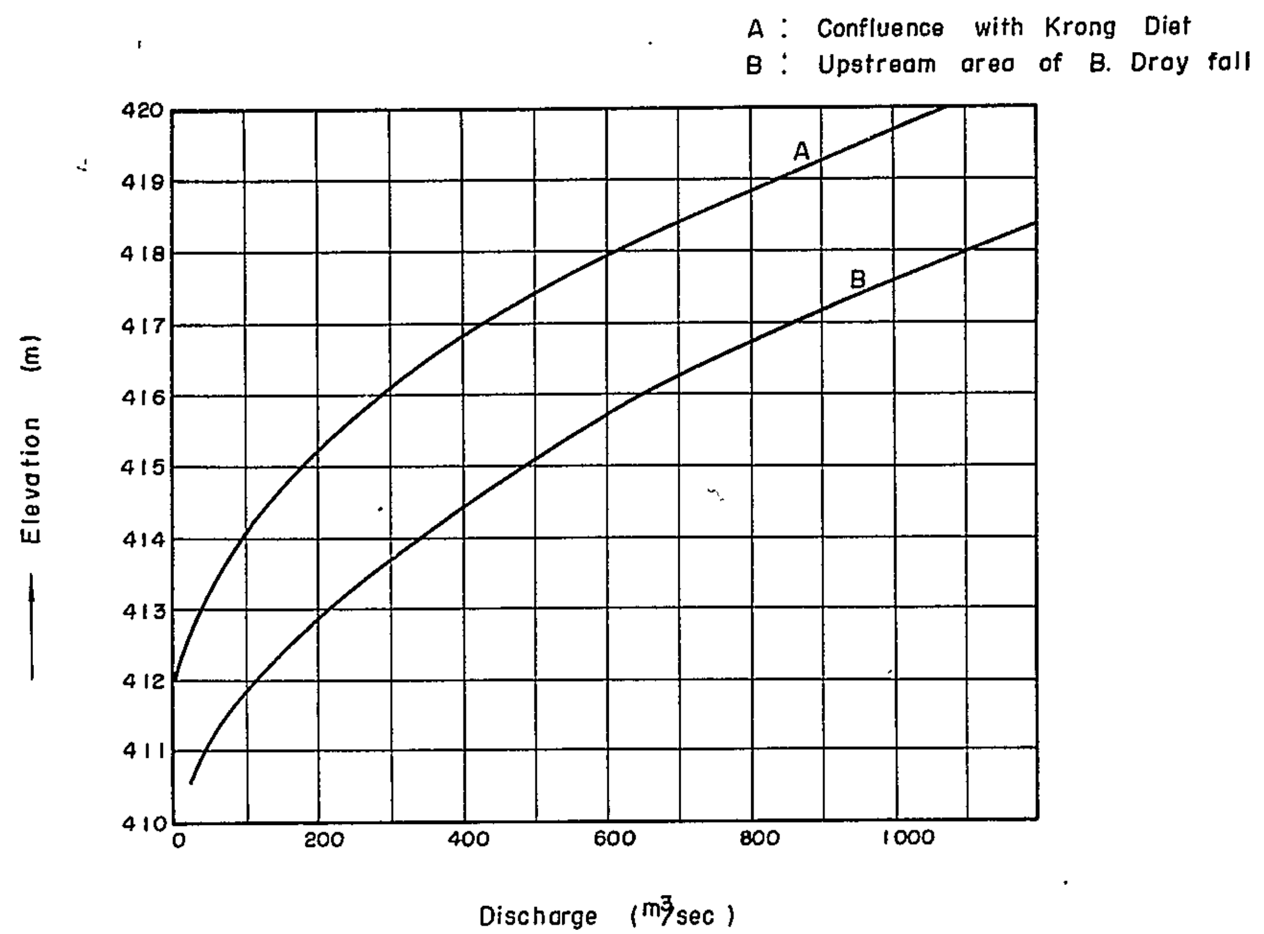
Providing that the water of the Ea Krong Ana flows into the lowland in the Darlac Valley over the natural levee along the river and the water holds its level similar to the river stage in the above table, the amount of flooding and the area of submerged land are as follows;

Table A-7. Amount of flooded water and submerged area corresponding to the river stage of the Ea Krong Ana.

Table A-7.	Confluence with The Lake Dorlac		Confluence with The Ea Krong Diet	
No.of case	Amount of flooding $10^6 m^3$	Submerged area ha	Amount of flooding $10^6 m^3$	Submerged area ha
A	300	7,000	174	6,400
B	240	6,800	113	5,700
C	185	6,500	51	3,750

/ Then

Fig. A-7 WATER LEVEL IN DAR LAC VALLEY & DISCHARGE



Then it may be advisable to take up the following measures tentatively in order to reduce the damage of the Darlac Valley caused by the flood of the Ea Krong Ana.

1) To construct the dyke along the river in order to protect the lowland area from the back-flowing of flood.

2) In case of need, the water should be flowed into the lowland over and it is advisable to let its water flow into the lowland at the dyke at the downstream site of the Ea Krong Ana instead of its upstream site so as to minimize the area of submerged land.

2.3. Amount of outflow within the project area

Besides the flood of the Ea Krong Ana, the amount of the outflow drained from the catchment area within the boundary of this Darlac Project is necessary to be considered for the control of soil moisture level in the project area.

From such a view point, the proposed project area can be divided into three, namely the area around the Darlac Lake, the highland area with two rivers flowing into the Darlac Lake and the lowland area behind the south bank of the Ea Krong Ana.

Hereinafter, these areas are referred to as "A", "B" and "C" area, and their catchment areas are about 118, 218 and 200 square kilometers respectively.

Out of these areas, the annual outflow from A-area is estimated at $118 \text{ Km}^2 \ (100 \text{ ha} \times 10{,}000) \ . \ \frac{2{,}400}{1000} \times 0.45 = 127{,}000{,}000 \text{ m}^3$ as the annual rainfall is 2.400 millimeters and the runoff coefficient is 45 percent in this basin. This amount could be steadily stored by [illegible]g in the Darlac Lake by elevating its water surface to EL. 418.7 m.

/As for

As for B-area, the total annual outflow of two rivers through this area is estimated at about 23,000,000 m^3 ($\frac{218}{118}$ x 127,000,000). Out of the amount, about a third of total or 7,000,000 m^3 can be stored in the Darlac Lake by elevating its water stage up to EL. 420 meters. Thus, the peak run-off in this area could be controlled perfectly and the submerged land in B-area will be restricted within very small boundaries. If total outflow of about 23 million cubic meters is uniformly drained into the Ea Krong Ana for 100 days through the drainage canal to be constructed, newly, its discharge will be about 2.7 cubic meters per second.

The annual outflow from C-area is estimated at about 21 million cubic meters. Out of this amount, about 6 million cubic meters are considered to be discharged during two months from September to October. Then, the submerged area could be limited to less than about 1,300 hectars even if the total amount would be stored in this lowland (See Fig. A-8)

As shown in the following table illustrating the average elevations of the river-stage of the Ea Krong Ana at the confluence with the Ea Krong Diet for 10 days at the heavy flood during August to December in 1962, the flooding water-level in this area is not more than EL.415.9 meters and rather low in comparision with the river-stage of the Ea Krong Ana even at the end of the rainy season.

/ Table A-8

Fig.A-8 RELATION BETWEEN ELEVATION AND AREA, STORAGE CAPACITY

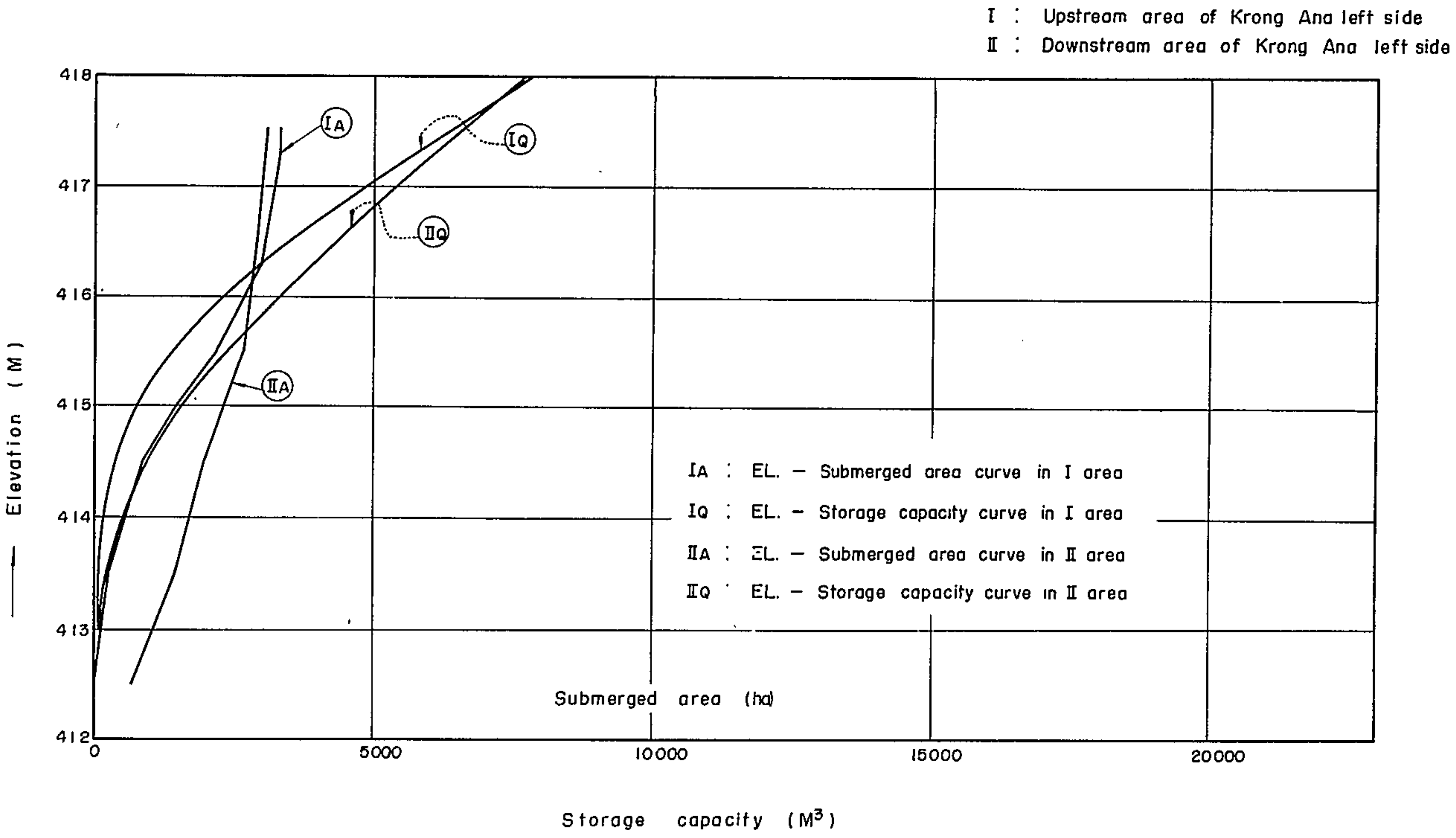


Table A-8 River-stage of the Ea Krong Ana at the confluence with the Ea Krong Diet.

Period	Aug.	Sept.	Oct.	Nov.	Dec.
Early	414.6	413.0	414.3	416.4	416.4
Middle	413.8	413.3	413.9	415.7	414.3
Late	413.1	414.8	415.6	415.3	413.6

In view of these facts, it is desirable to minimize the inundated land within the project area by surrounding the project area with dykes to be constructed newly along the river.

APPENDIX 3

AGRICULTURAL RESEARCHES

The lowland in the Darlac Valley can be divided into three regions from the viewpoint of the agricultural development and present conditions in this district.

a. The highland where the paddy is the primary crop and the field crops are the secondary.

b. The lowland in the middle part of the basin where is reclaimed recently.

c. The highland, downstream of the Darlac Valley where the field crops are the principal and the paddy is the subordinate.

The name of existing villages, number of households, the area of arable land, the cultivated area for main crops and crop productions in this basin are summarized as follows.

Table A-9 Agricultural researches of existing villages in the project area

	a) Region around the Lake Darlac	b) Region in the middle part of the basin	c) Region in the lower part of the basin
Name of Villages			
	B. Yuk, B. Dang,	B.M'Lieng, V.Kram,	B. Kedou, B. Kdioh,
	B. Quk, B. Dang,	B. Bune, B. Krongue,	B. Choah, K' Plang
	B. Mong, B. Eria,	Tham Trach, B. Knach,	B. Trap, B. Cham
	B. Tu, B. D'de,	B. Ya Tou, Quang Track,	B. Mong, B. Tur,
	B. Yan La, B. Dia,		B. M' Blat, B. Kbul,
	B. Dong, B. Dong Ma,		B. Ima, B. Dham,
	B. Nop, B. Don Krin,		B. Ko, B. Reang,

/B.Nam

B. Nam Bon, B. Yo Gdid,			B. Knul, B. Dray,
B. Ma, B. Dar Dion,			B. Blang, B. Tie,
B. Dioun, B. Dia,			B. Tlo, B. M' Pok,
B. Da, B. Treum,			B. Dray,
B. Drung, B. Chur Tar,			
B. Bokrang, B. K' nans,			
B. Chur Tien, B. Chur Teo,			
B. Haet, B, Laek,			
B. Targ. Yang,			
B. Phok, B. Chur Kuop,			
B. Yang Tao, B. Uang,			
B. Kla, B. Biep,			
B. Boung Lu,			
B. Dreng, B. Mao,			
Total number of households			
	About 2,000	About 500	About 1,000
Total area of arable land			
	About 2,500 ha.	About 600 ha.	About 1,300 ha.
Harvested area			
Paddy	2,000 ha.	400 ha.	300 ha.
Dry field crops; beans, maize peanut, sweet potato, etc.	300 ha.	100 ha.	200 ha.
Vegetables	100 ha.	50 ha.	150 ha.
Fruit	100 ha.	50 ha.	150 ha.
Rubber, Tea, Coffee	—	—	500 ha.

/Total

Total amount of paddy	3,000 ton	800 ton	700 ton
Unit yield of paddy (^{t}/ha)			
Highland	1 ton	—	1 ton
Lowland	3 ton	2 ton	2 ton

Out of the above, the region around Lake Darlac has a comparatively high elevation and is not suffered by floods as the rain water in the rainy season is well drained into the Darlac Lake. The region is widely developed already, and a large number of farmers are engaged in rather stabilized rain-fed farming. The principal crop is paddy rice of rain-fed culture without manuring in general. In the dry season, most fields are wasted in fallow because of no provision of irrigation facilities. It is generally told that the paddy fields in lowland have relatively high natural fertility and produce about 3 tons of unhulled rice per hectar at maximum without fertilizing. The ancient alluvial soil on highland in this region is not so fertile as the soil on lowland and produces about 1 ton of unhulled rice per hectare. Various kinds of fruits such as banana, papaya, etc., some vegetables, and common dry field crops are also planted, but their harvested areas are smaller than that of paddy rice.

In spite of such favourable natural conditions of farmland in this region, their annual crop products are rather poor in response to the primitive farm management conducted by farmers. Accordingly, the livelihoods of farmers are not so rich and scanty in common.

In the lower region of the Darlac Vally, farmers reclaimed the highland of the basaltic residual soil and are engaged in dry field farming in the rainy season. About 40 percent of the whole afarm land are used for plantations of rubber plant and coffee, while about 20 percent of the whole farm land are used for one-crop-a-year farming of paddy rice in the rainy season.

On the undulating highland covered with the basaltic residual soil there are no remarkable area of farmlands except some lands grown by special plants such as rubber plant and coffee etc.

In the low, flat lowland in the central part of the Darlac Valley, more than 90 percent of the land forms a depression lower than EL, 420 meters, and is inundated with flooded water of 1 to 4 meters in depth at the end of the rainy season from September to October every year. So, there are no remarkable farming development in this area except some rein-fed culture of paddy and dry field crops once a year in the past.

Recently, in 1958, the Government of Viet Nam established two hamlets, Tham Trach and Quang Trach as the center for the agricultural development of this lowland. Since then, the reclamation of land and the cultivation of crops are proceeded by newly settled farmers under the encouragement of the Government. In Tham Trach, the households of farmers are 237 in total in 1963.

At the beginning of the immigration, a considerable amount of the governmental subsidy was given to farmers, namely, 2,500 piastres per family as the subsidy for house building, 9 piastres per capita per diem for six months after immigration as the allowance for living expense in addition to the allowance including 500 grams of rice per diem to an adult and 250 grams per diem to a child. Besides, seeds and seedlings were provided by the Government. For the guidance of farming technics and agricultural management, a technician was assigned and despatched by

/the

the Land Development Center of the Government.

Two hectares of arable land were reclaimed by the governmental tractor and allocated to each family without compensation, moreover, the mountainous sloping lands were freely given to the farmer who reclaimed the lands for himself.

As to the crops, paddy rice was taken up as the most principal crop, and kenaf, tobacco, corn, sweet potato, and green peas were additionally cultivated. All of these crops were planted once a year in the rainy season so as to make a good use of rainfall. Besides, banana and papaya were planted on sloping lands perennially.

During the dry season, most crops could not be cultivated due to the shortage of water, and the farmers were engaged in the fishing of wild fishes in the lakes and ponds near the hamlet and supported their livings by selling the fishes at the markets in the towns of Ban Me Thuot or Lac Thien. According to the explanation by the residencial technician of the Land Development Center, the yield of paddy in his area was about 3 tons per hectare on an average and 4 tons per hectare at the maximum. Such a yield in this area was relatively higher than that in the other lowland area of this country. And it may be considered that the soil in this area has rather high natural fertility due to rich contents of plant nutrients supplied by periodic flooding of the rivers.

Kenaf is one of the important crops in this area, The Government purchase the products at the price of 12 piastres per kilogram. As its average yield is 2 tons per hectare, the farmers are able to make an income of 24,000 piastres per hectare by kenaf culture.

/As

As aforementioned, however, all the crops in this area were frequently damaged by the periodic flood in the late rainy season, and the farmers lives are extremely unstable still at present. In October of 1962, especially about 300 hectares of total cultivated land in this area were inundated with flood of 4 meters in depth, and consequently, all the crops were damaged. Then the farmers were driven to support their livings scarcely by fishing in the lakes and ponds around the village during 6 months from November 1962 to April 1963. According to our inspection, their total incomes earned by fishing during 6 months were presumed at about 100,000 piastres, that is equivalent to only 422 piastres per household.

In Quang Trach that was settled concurrently with Tham Trach village, all of 150 houses and total 200 hectares of cultivated land were completely suffered by flood damage because this village was located on the depressed land lower than Tham Trach. So the farmers livings in this village appeared far poorer than those in Tham Trach. Such being the case, the proper measures to stabilize the livings of the farmers in this area by protecting them against the periodic flood damage as fast as possible in advance of the completion of the integrated flood control project covering all over the Upper Srepok Basin.

As the urgent project of the Central Darlac Valley, it is recommended that the principal cropping period should be changed into the dry season from the rainy season by providing necessary irrigation and drainage facilities for such profitable irrigation farming and the advantageous rotativ cropping pattern should be framed up and carried out by selecting the adapted kinds and varieties of crops so as to be planted two or three crops a year in general.

APPENDIX 4

STUDIES ON SOIL AND RIVER WATER

4.1. Soils

According to our detailed soil survey results of the Darlac Valley, the distributions and demarcations of the main soil groups in this area are completed as they are illustrated in Fig. A-9 SOIL MAP OF DARLAC VALLEY. The principal natures and properties of these soil groups are interpreted in general hereunder.

The soils of the Darlac Valley can be broady divided into two soil groups. One is the lowland soil group distributed in the low flat area of about 400 to 425 meters in elevation and is mainly composed of the recent alluvial soil transported and deposited by the Ea Krong Ana, the Ea Krong Kno and their tributaries. The other is the upland soil group distributed in the gently undulating area with elevation of about 425 to 450 meters, and it includes two soils such as the basaltic residual latosol developing mostly on both sides of the lower Ea Krong Ana below its confluence with the Ea Krong Boung Troi, a distributary of the Ea Krong Kno, and the ancient alluvial lateritic soil developing remarkably in the east of the Darlac Lake as well as in the basins of the Ea Lieu and the Da P'Heui.

The Former, the lowland soil group, includs three soils, namely, the recent alluvial medium textured gley soil, the recent alluvial heavy textured gley soil and recent alluvial humic gley soil. The recent alluvial medium textured gley soil forms narrow natural levees elongated along the both banks of rivers and streams and has loam or silty loam texture with PH value of 5.5 to 5.8, a moderate cation exchange capacity and base saturation degree, and its natural fertility is relatively high. But the distribution

/of this

of this soil is not so remarkable except somewhat wide area near the confluence of the Ea Krong Ana and the Ea Krong Kno. Therefore, this soil has little significance from the viewpoint of the agricultural development of the Darlac Valley. The recent alluvial heavy textured gley soil forms low marshy land at the back of the said natural levee and has heavy clay or silty clay texture in general with PH value of 6.0 or so, that is, the lowest soil acidity in this project area, moderate cation exchange capacity and base saturation degree. The natural fertility of this soil is somewhat higher than that of the aforementioned recent alluvial medium textured gley soil. This soil has the widest distribution of all soils in this project area, and it has the greatest significance for the agricultural development of the area.

Up to the present, however, the soil used to fall into continuous overwet condition due to its topographical features unfavorable for draining during the rainy season. Especially in the late rainy season, from August to October, the land of this soil is periodically inundated with overflow of rivers and drains. This is why the land lies almost waste in despite of its rather high natural fertility.

The recent alluvial humic gley soil occurs in the lowest depressions of the Darlac Valley, and has narrow distributions limited to ruined course of rivers and surrounding of lakes and ponds.

The surface soil is very rich in humus, and it has peaty humic texture at some locations such as adjacnet to lakes and ponds. Its acidity is rather weak as shown by PH value of 6.0 to 6.3.. The subsoil has heavy texture in common. These soils have fairly high cation exchange capacity, high base saturation degree, and the highest natural supply of plant nutrients of all the soils in the project area. But the land of this soil could not be used for cropping unless the complete facilities for flood control and

/ drainage

drainage would be provided thoroughly. It is due to the fact that the depressed land is excessively wetted not only by inundation in the rainy saeson but also by excess soil moisture raised from high groundwater level even in thedry season. In addition to this, the distributed area of this soil is extremly small. Accordingly, the land of this soil has little significance and is almost negligible from the general viewpoint of the agricultural development of the Darlac Valley.

Out of upland soil groups, the basaltic residual latosol is the residual soil originated from the basaltic rocks developing in the western part of the Darlac Valley, especially on the undurating upland on both sides of the lower Ea Krong Ana below its confluence with the Ea Krong Boung Trai, a distributary of the Ea Krong Ano.

It has typical latosol profile where both of surface soil and subsoil have medium textures such as silty clay or silty clay loam, relatively strong acidity with PH value of 4.5 or so, rather small cation exchange capacity and low base saturation degree, and poor amounts of plant nutrients. To speak in general, the natural fertility of this soil is lower than those of the lowland soil groups aforementioned. The soils of this group have been used for the plantations of rubber plant, coffee, tea-tree and other perennial plants by French planters, and it is told that these soils are extremly fertile as compared with the other tropical soils.

According to the results of our physico-chemical examinations and agronomic researches on the spots, it is confirmed that the contents of available plant nutrients in these soils are not always so rich, and so, they canbe concludedto be infertile by nature for the culture of common crops. Though these soils are not so favored by chemical components, they are

/ blessed

blessed with excellent physical nature due to their deep layers with depths of 5 to 10 meters of residual soils with uniform texture.

The root development of plants especially coffee, tea, and rubber plants are flourlishing in response to such soil layer conditions, and the effective rootzone depths of these plants frequently attain to 2 meters or more. Then, these plants are able to have their layer extent of nutrients and moisture absorption in soils, and accordingly, they are highly resistant to drought disasters.

In view of these facts along with our experimental results on the farmland of similer soil groups, these upland soils of latosol group are considerd to be exactly within the bounds of possibility for profitable agricultural development providing necessary amount of water would be supplied by completed irrigation system.

The ancient alluvial lateritic soils develop on the gently sloping upland in the east of the Darlac Lake as well as both sides of the Ea Lieu and the Da P'Heui. These soils are presumable to be in the process of the weak lateritic weathering of ancient alluvial deposits. They have mostly rather coarse texture of fine sandy loam or coarse sandy loam, considerably strong acidity of PH 4.0 to 4.5, very small cation exchange capacities and extremly low saturation degrees. The contents of available nutritious components are so poor in these soils that their natural fertilities are the lowest of all soils in the Darlac Valley.

In case of agricultural use of these soils, therefore, it is necessary to practice adequate fertilization procedures by using compost and chemical fertilizers in addition to the regulation of soil moisture level by the proper operation of well installed irrigation system. In conclusion,

/ the object

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/ the object

the object area of the Darlac Valley Project should be concentrated on the land of the recent alluvial heavy textured gley soil among of several soil groups discriminated from pedological standpoint. This is because of the excellent availability of the former soil for profitable irrigation farming prefer to those of the other soils. In brief, the soil occupies the greater part or about 80 percent of the lowland area and can be irrigated readily, while the upland soils develop on elevated sloping land disadvantageous for the construction and operation of irrigation system.

At the practice of irrigation farming on this soil, it is necessary to carry out the adapted procedures for the maintenance of soil productivity, for the supply of plant nutrients, and for the regulation of soil moisture level. As the general standard of these procedures, it is recommended that about 10 tons per hectare of compost or stable manure, about 30 kilograms of nitrogen, 20 kilograms of phosphric acid, and about 10 kilograms of potash should be applied per hectare annually. In addition, about 100 kilograms of calcium in the form of lime or calcium silicate should be given every 10 years for the amendment of soil acidity and other soil conditions.

As for the practice of water application on farmland, the properly designed strip-border method fit to the soil with low intake rate and relatively large available water holding capacity as well as almost flat land surface with gradient less than 2 percent in general should be applied.

4.2. River water

The river water of the Ea Krong Ana, the Ea Krong Kno and their main tributaries and distributaries have alkaline reaction without exception.

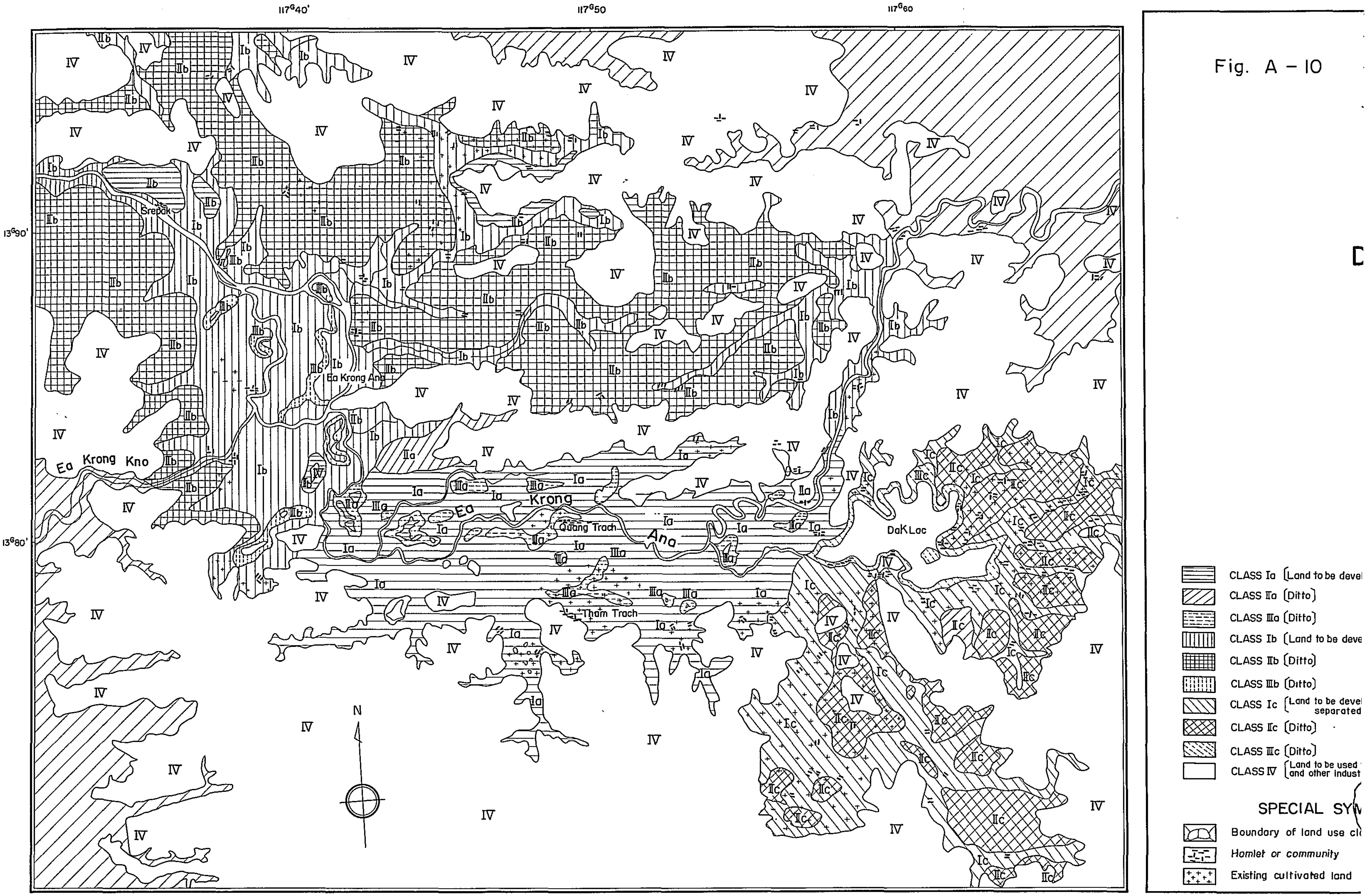
/ Especially

Especially, the waters of the Ea Krong Buk and the Ea Krong Pach, the upstreams of the Ea Krong Ana, have rather strong alkaline reaction of PH 8.2 to 8.3. Compared with this, the waters of the Da P'Heui and other streams that flow into the valley from the south are low in alkaline reaction, with PH value of 7.8 or so.

The alkalinity of the downstream of the Ea Krong Ana below the confluence with the Da P' Heui and other tributaries is reduced to PH 8.0 or so, and is further reduced to PH 7.8 at Ban Trap. The water of Ea Krong Kno also has alkaline reaction of PH 8.0 slightly lowre than that of the upstream of the Ea Krong Ana. The water of the Srepok, below confluence of the Ea Krong Ana and the Ea Krong Kno has alkaline reaction of BH 7.8.

All of these water include no excessive quantity of such injurious element for plant growths as chorine, boron etc., and they are rated at excellent or good quality according to the Scofield's standard for irrigating water.

Fig. A - 10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Srepak
Ea Krong Ana
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N
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Existing cultivated land

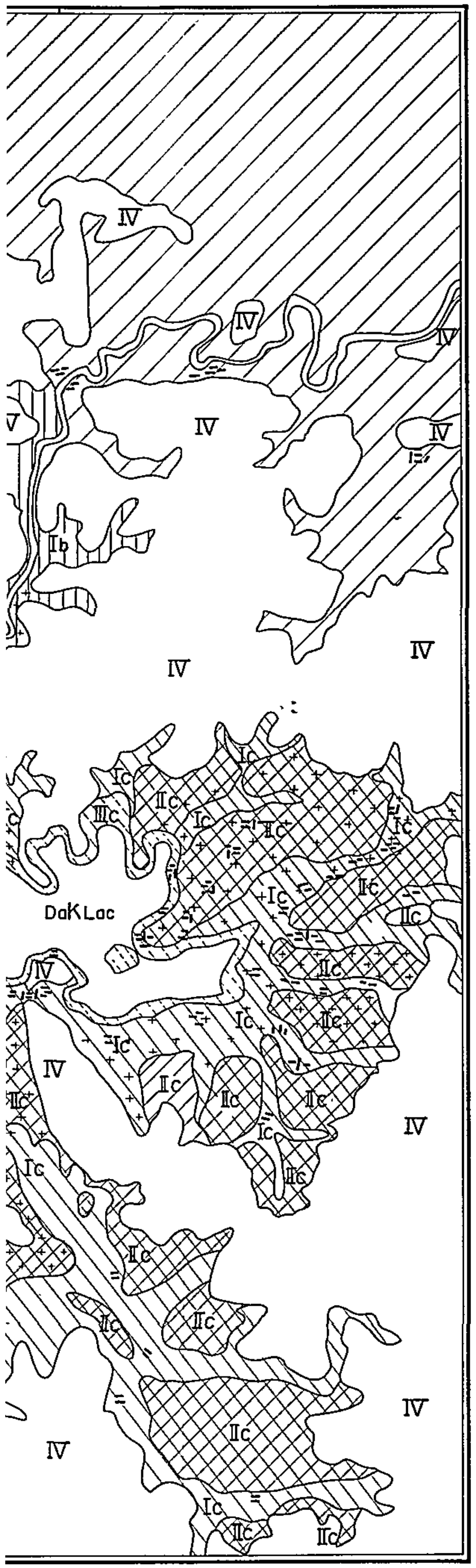


Fig. A – 10

LAND USE MAP

OF

DAR LAC VALLEY IN UPPER SREPOK BASIN

VIET – NAM

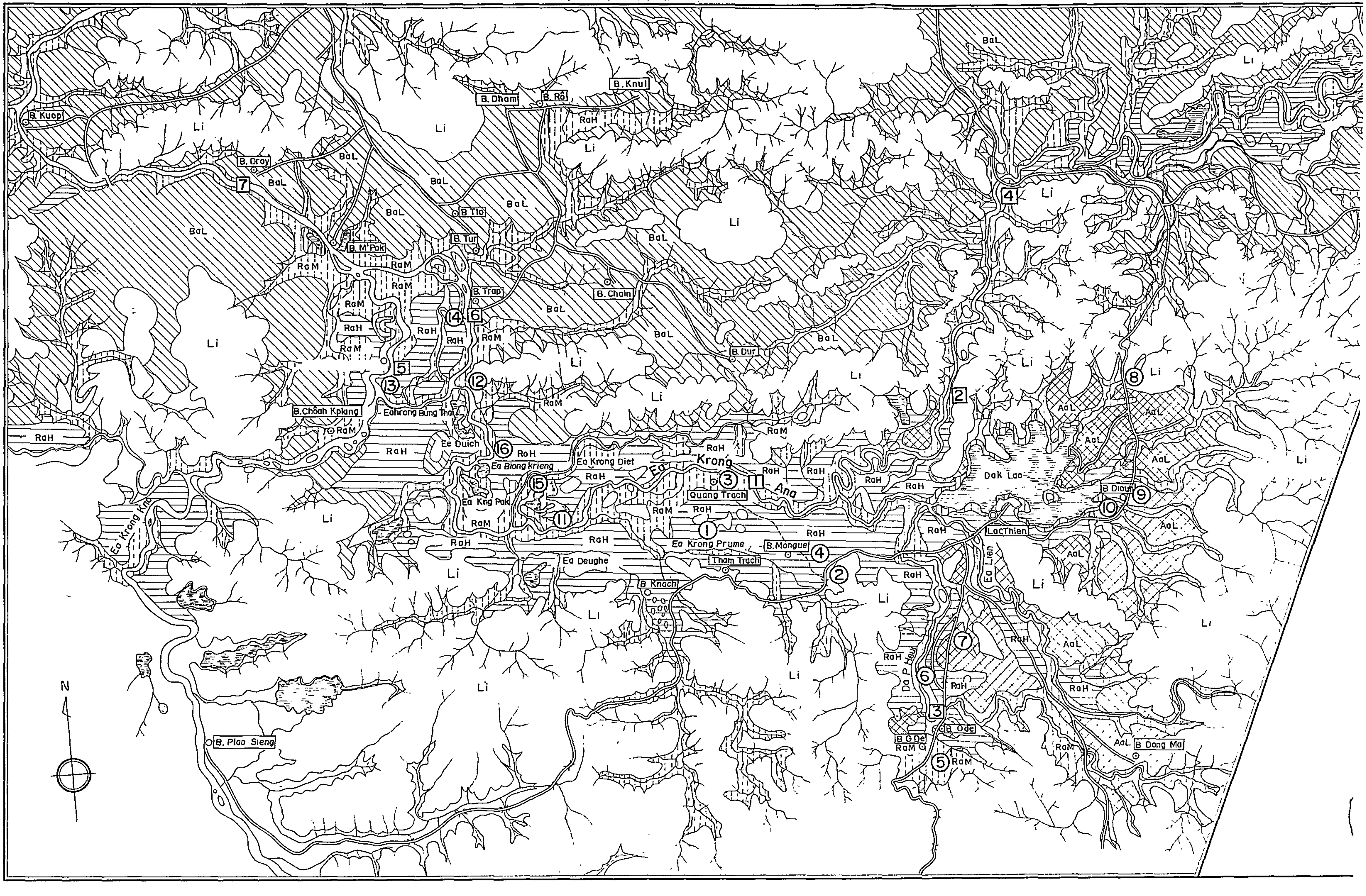
SCALE 1/100,000

LEGEND

CLASS Ia	(Land to be developed at 1st stage)	Fairly fertile, medium to heavy textured, flat to very gentle slopping with gradient less than 2%, poorly drained especially in the rainy season, adapted for paddy livestock farming by strip-border irrigation in the main.
CLASS IIa	(Ditto)	Rather infertile, medium to coarse textured, gentle sloping to undulating with gradient less than 10 % well drained even in the rainy season, adapted for upland livestock farming by applying contour furrow irrigation in the main. Sprinkler can be used except rice culture.
CLASS IIIa	(Ditto)	Considerably fertile, mostly very heavy textured, rich in humus, almost flat, very poorly drained even in the dry season, frequently inundated even in the dry season, adapted for paddy irrigation farming after completely drained.
CLASS Ib	(Land to be developed at 2nd stage)	Same as class Ia, can be developed after the completion of the flood control project of Ea Krong Kno at the second stage of Comprehensive Upper Srepok Project.
CLASS IIb	(Ditto)	Same as class IIa, can be developed at the second stage of Comprehensive Upper Srepok Project.
CLASS IIIb	(Ditto)	Same as class IIIa, can be developed at the second stage of Comprehensive Upper Srepok Project.
CLASS Ic	(Land to be developed by other separated project)	Same as class Ia, can be developed by the completion of Da P'Heui, Ea Lien, Da K'Lac and other independent projects separated from Krong Kno and Krong Ana Project.
CLASS IIc	(Ditto)	Same as class IIa, can be developed by the completion of Da P'Heui, Ea Lien, Da K'Lac and other independent projects separated from Krong Kno and Krong Ana Project.
CLASS IIIc	(Ditto)	Same as class IIIa, can be developed by the completion of Da P'Heui, Ea Lien, Da K'Lac and other independent projects separated from Krong Kno and Krong Ana Project.
CLASS IV	(Land to be used for forestry, grazing and other industry without irrigation)	Rolling to hilly with steep slope more than 15%. shallow soil depth, generally unadaptable for irrigation farming, can be used for forestry, grazing and other purpose.

SPECIAL SYMBOLS

- Boundary of land use class
- Hamlet or community
- Existing cultivated land

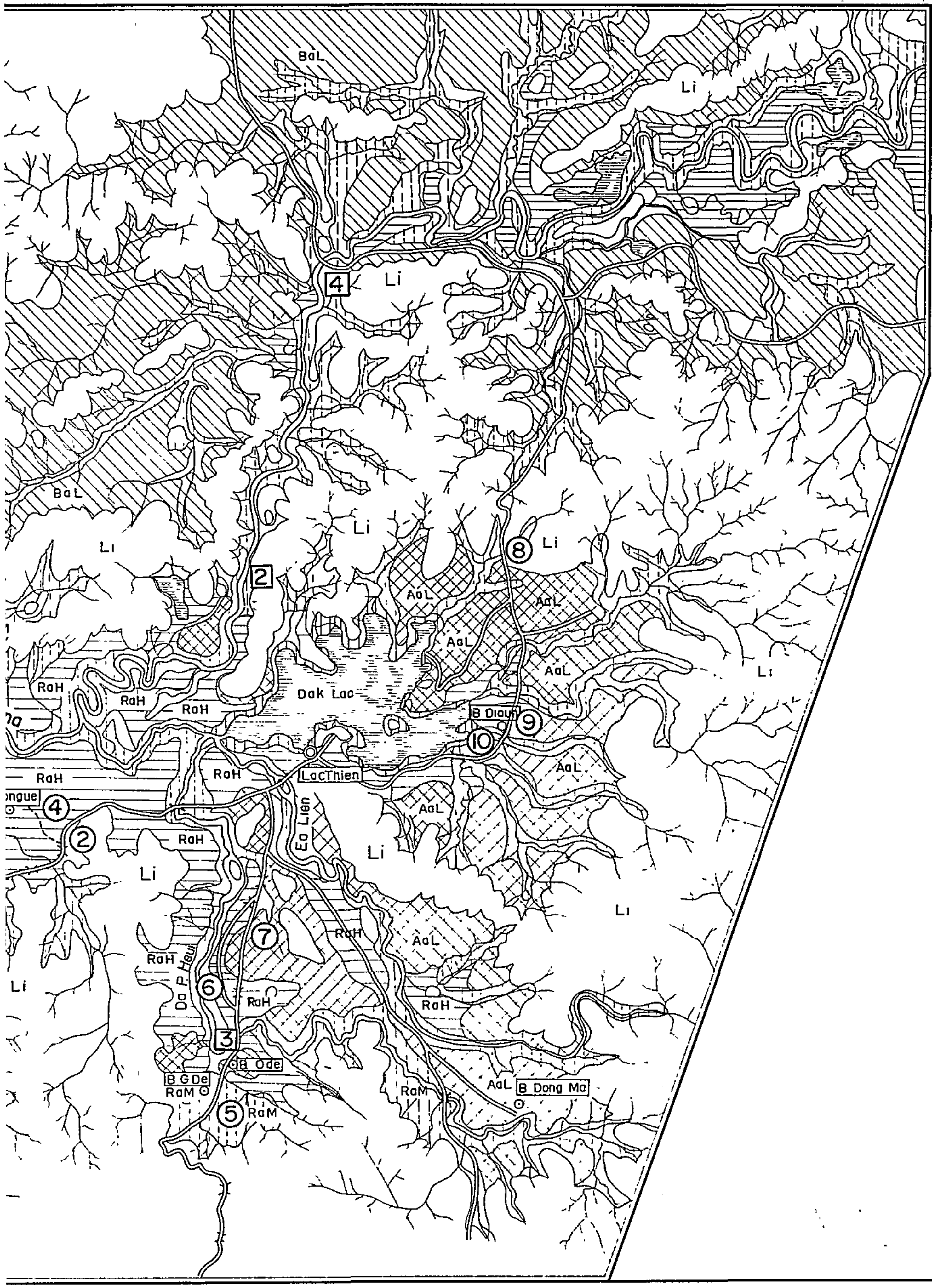


B. Kuop
B. Droy
B. Dham
B. Rô
B. Knul
B. Tlo
B. Tur
B. M'Pok
B. Trap
B. Chain
B. Dur
B. Choah Kplang
Eahrong Bung Thai
Ee Duich
Ea Biong krieng
Ea Krong Diet
Ea Krong Ana
Quang Trach
Ea Kng Pak
Ea Krong Prume
B. Mongue
Tham Trach
Ea Deughe
B. Knach
Dak Lac
B. Dioun
Lac Thien
Ea Lien
Da P. Heu
B. Ode
B. G De
B. Dong Ma
B. Plao Sieng
Ea Krong Kno
N
Li
BaL
RaM
RaH
AaL

Fig. A-9

SOIL MAP OF DAR LAC VALLEY IN UPPER SREPOK BASIN VIET - NAM

SCALE 1/100,000



LEGEND

RaM	Recent alluvial medium textured gley soils
RaH	Recent alluvial heavy textured gley soils
Rag	Recent alluvial humic gley soils
AaL	Ancient alluvial lateritic soils
BaL	Basaltic latosols
Li	Lithosols (mostly shallow and weak podsolic)

SPECIAL SYMBOLS

- Lake or pond
- River or stream
- Highway or road
- Town or village
- (3) Sampling site of soil
- [4] Sampling site of water

APPENDIX 5

CLASSIFICATION OF THE PROJECT AREA BY LAND CAPABILITY

The classification of land capability in the whole area of the Darlac Valley with the explanatory note of the farm units, irrigation method and other farming procedures to the land of each class are illustrated in Fig. A-10 LAND USE MAP OF DARLAC VALLEY.

The main soil groups distributed in this area are the recent alluvial medium textured gley soils, the recent alluvial heavy textured gley soils, the recent alluvial humic gley soils, the ancient alluvial lateritic soils and basaltic residual latosol soils. Based upon their physiacl and chemical natures along with their irrigation engineering characteristics, the possible uses of these soil groups are presumed as follows.

The recent alluvial medium textured gley soils and the recent alluvial heavy textured gley soils are much alike each other in their properties and natures except the texture of surface soil, and both of them can be utilized for profitable irrigation farming rather easily and almost in the same way. Thus, both these lands are rated at the first class.

The recent alluvial humic gley soils rate as the third class despite of their relatively high natural fertility. This is because of their narrow distribution on the lowest depressions to be inundated periodically in the rainy season.

The basaltic residual latosols and the ancient alluvial lateritic soils are distributed on the land of the highest elevation in the irrigable area, so the land of these soils are not suffered by inundation. But the land rates as the second class mainly because of its low natural

/ fertility

fertility and disadvantageous configulation for irrigating water conveyance. The mountainous area around the lowland of the valley is covered by lithosols with father shallow soil layer depths and steep surface gradients greater than 15 percent as well as high elevations more than 500 meters. As these lands can be scarcely used for irrigation farming of common crops and may be used for homeseads, wooded lands for fuels, grazing and grassland for livestocks, and orchards etc., they are rated at the fourth class. In the light of our investigation on the soil natures and properties, local meteorologic conditions, topographical features, and socio-economic factors, the adapted crops, the adapted farming units, and the adapted irrigation methods are contemplated and summarized as shown in Table A-10.

As shown in Table A-10', the most adapted farming unit specific to each class should be established and extended for the complete agricultural development of the total Darlac Valley. But,,as far as the present first stage development project is concerned, the greater part more than 80 percent of the project area belongs to the land rated at the first cass. In this case, therefore, the paddy livestock farming unit should be taken up as the standard form of irrigation farming management where the adapted rotative cropping pattern is framed up by combining paddy rice, the principal crop, with several additional crops.

As regards the lands rated at the second or third class, it is recommendable to be utilized as the reservation site for grazing lands, grass fields, cemetries and wooded lands for under the joint control of farming communities instead of to be disposed of as the cropping fields for individual settlers by reason of their narrow distributions and low natural fertilities.

TABLE A - 10. Rating of land use in Dar Lac Valley - Central Flat lowland area and essential items of irrigation farming management on land of each class (1st stage development plan)

Rating	Soil group	Area (ha)	Proportional extent (%)	Adapted crop	Designed value of irrigation engineering characteristics of soils: Apparent Specific gravity	Field capacity (% Volume)	Wilting Point (% Volume)	Available moisture holding capacity (% Volume)	Intake formula (mm/hr)	Adapted irrigation method: Irrigated crop	Land gradient	Irrigation method	Adopted farming type
I	Recent alluvial medium textured gley soils	800	16.0	Rice, maize, beans tobacco, kenaf, sweet-potato, onion, vegetables, pasture grass (paspalum) etc.	1.20	42	20	22	$D = 6.0\ T^{0.6}$	Paddy	Less than 2 %	Strip border method	Paddy-livestock farming
											2 % - 10 %	Strip border with corrugation method	
	Recent alluvial heavy textured gley soils	4000	80.0	Ditto	1.30	46	22	24	$D = 5.0\ T^{0.5}$	Rice, beans, vegetables	Less than 2 %	Downhill small furrow method	
	(1st stage development area)	(1000)								Maize, kenaf, tobacco, sweet potato, peanut, tomato, fruits (banana, papaya etc.)	Less than 2 %	Downhill large furrow method	
											2% - 5 %	Contour large furrow method	
II	Ancient alluvial lateritic soils, Basaltic residual latosol soils	100	2.0	Coffee, rubber, tea, paddy, tobacco, maize, beans, vegetables, fruits, pasture grass etc.	1.40	38	18	20	$D = 50.0\ T^{0.8}$	Paddy, beans, vegetables (cabbage, rape etc.)	Less then 2 %	Downhill furrow method Contour small furrow method	Upland-livestock farming
										Maize, beans, etc. fruits	Less then 2 %	Downhill large furrow method	
											2 % - 10 %	Contour large furrow method	
											More than 10%	Contour ditch method	
										Sprinkler can be used except rice culture			
III	Recent alluvial humic gley soils	100	2.0	Paddy (especially floating paddy), rush, lotus, water convolvulus. etc.	1.10	50	24	26	$D = 4.0\ T^{0.3}$	Paddy (including floating paddy) and aquatic plants	Less than 2 %	Strip border method	Paddy-livestock farming
IV	Lithosols			Outside of irrigation area									Forestry, grazing and other purpose

APPENDIX 6

AGRICULTURAL DEVELOPMENT

For the successful development of agriculture in the Darlac Basin, the combined management of paddy culture and dairy farming is recommended by introducing stock-raising into the farming unit in view of the natural and economical conditions in this Basin, and the farming unit of sustainable management is framed on the basis of our soil survey and agricultural research. The stardard acreage of a farming unit is determined at 2 hectares for paddy livestock farming.

This farming unit is to be applied to each farmers settled in the central lowland area of the Darlac Valley, and also to other areas of the Darlac Valley.

The essentials of this proposed farming unit are outlined in the following paragraphs.

1) Land use of a farming unit

Out of 2 hectares in total, 1.8 hectares are used for cropping and 0.1 hectare for homestead, and remaining 0.1 hectare for grassland with forest. Besides, the common lands of the village should be provided for pastures, grasslands for stock-raising and forest lands for fuels.

2) Adapted crops and cropping pattern

As for the adapted crops in this project area, most of plants usually cultivated in other tropical monsoon climatic region can be grown up in general and the adapted rotative cropping pattern should be framed up in consideration of efficient utilization of farmland, growing period and photoperiodic sensibility of crop, protection against harm

/insects

insects and diseases as well as effective use of family labours for profitable farming. Paddy rice is grown up as the most principal crop, and vegetables such as chinese cabbage, onion, red pepper, and tomato etc. are also cultivated for domestic demand and for sale, pasture grasses are planted for domestic animals, kenaf, tobacco, ramie, peanut, green bean and sweet potato are cultured mainly for sale. The cropping pattern for a farming unit is graphically shown in Fig. A-11. The main points of it are summarized as follows.

a) All annual crops are planted so as to be grown up during about 10 months excluding September and October and to avoid flood damage.

b) As a rule, the successively repeated culture of the same crop should be avoided.

c) The production of crops is concentrated to the irrigation farming in the dry season. In the early rainy season, the farmland is used for the culture of special early-matured crops such as vegetables which can be harvested before the flooding period. Soon after the rainy season, the soil moisture in wet land is used for the germination of seed and the growth of young plant.

At the practice of such a rotative cropping, special consideration should be paid for the selection of the adapted crop variety, especially in the case of paddy culture, it is very important to select the variety adapted to the local climate and other natural conditions. At present, the farmers in this area use customarily the Indica variety of paddy with a long growing period extending over 250 to 280 days from April to next January. By suing such a late-matured

/ variety

variety, the farmer can not undertake to culture two crops a year even if the proper irrigation facilities would be completed. In regard to this, it is worth special mention that some adapted paddy varieties were found out at the experimental field of the Nippon Koei Co. Ltd. on the Central Highland in 1963. According to the experimental results, some varieties such as "Taichū - 65" bred in Formosa, "Norin-65", "Sasashigure" and "Kakuta" bred in Northern Japan are well adapted to the cropping conditions in this area, and they can be harvested within 120 to 150 days after sowing with rich returns of 3.0 to 3.5 tons of unhulled rice per hectare. At the practice of irrigation farming, the diversification of crops should be accomplished by taking up such adapted varieties of crops as mentioned above.

3) Livestock

The most fundamental object of livestock raising in this farming unit is the production of stable manure necessary for the maintenance and increase of the productivity of farmland along with the production of animal products for the increase of farming profit. For this purpose, 2 milk cows, 2 swines and 11 poultries are raised, and stable manure of at least 20 tons can be obtained and are applied on farm for supplying proper amounts of humus and nutrients into soils annually which meet the organic matter requirement for a cultivated land of 1.8 hectares.

4) Fertilization

According to the results of our soil survey, the lowland soils have

/ rather

rather high natural fertility in comparision with the other soils in Viet Nam. Even so, the application of a proper quantity of chemical fertilizer is necessary in order to have the satisfactory returns by irrigation farming. In this case, proper amount of nitrogenous fertilizer with 0.03 ton of element, phosphatic fertilizer with 0.02 ton of element, and potassic fertilizer with 0.01 ton of element are to be applied per hectare of farm land. Furthermore, it is desirable to apply 0.1 ton of calcium carbonate or calium silicate into soils so as to neutralize the soil acidity and to increase the resistance of crops to disease damages every 10 years.

5) Adapted irrigation method

According to the results of our investigations and soil survey, this irrigable land is mostly distributed on flat area with gradient of less than 2 percent, and composed of soils with high water holding capacity and rather low intake-rate. At the practice of irrigation farming, therefore, the adapted irrigation method should be applied in conformity with the specific condition of the irrigated field, and it is recommended to take up the following methods; the strip border method for paddy, the down hill small furrow method or the contour small furrow method for green bean, soybean, vegetables etc., the down hill large furrow method or the contour large furrow method for maize, kenaf, sweet potato and other row crops and for tall vegetables such as tomato, eggplant etc., and for fruits. At the practical application of these method, it is necessary to evaluate the basic factors for the methods such as the net water

/ requirment

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/ requirment

requirement, the irrigation interval and the frequency of irrigation etc. based upon the irrigation engineering characteristics of soils and the consumptive use of water by crops in each growing periods for the accomplishment of the most efficient and profitable water application.

6) Immigration scheme

As described in the preceding chapter, the irrigable area in this basin is about 8,000 hectares. Out of this area, about 1,000 hecates including about 500 hecatres of existing farmland is taken up as the area for the first stage development. In this area, some 500 households of farmers settled already, and 2 hectares of land were owned by each household. Then, the land to be newly settled is about 7,000 hectares in total, and so some 3,500 households of farmers can be settled. At the beginning of irrigation farm management, some special fund is necessary to be provided by farmers. Regarding this, the Government of Viet Nam is carrying out a special subsidiary policy to promote the immigration as explained in detail in APPENDIX 3 of this report.

/ In addition

In addition to the governmental subsidy, the newly settled farmer are required to provide some fund for the establishment of a unit farm as follows.

Fund needed for a newly settled farm

Item	Amount	Remarks
Buildings	50 U.S.$	House, cattle shed, barn, silo etc. This figure shows the expenses expect the subsidiary aid from the Government.
Farm implements	50	Individual and public instruments and machinery
Livestocks	20	Calf, shoat and chiken for breeding
Total	120 U.S.$	

Accordingly, the total fund to be prepared for new settlers of 3,500 households is estimated at 420,000 U.S. Dollars.

As for the existing farmers, the following fund is required for the improvement of an existing farm.

Fund required for an existing farm

Item	Amount	Remarks
Buildings	30 U.S.$	Cattle shed, silo etc.
Farms implements	50	Individual and public instruments and machinery
Livestock	20	Calf, shoat and chiken for breeding
Total	100 U.S.$	

/ Then,

Then, the total amount of fund needed for all existing farmers of 500 households is estimated at 50,000 U.S. Dollars.

After all, total fund to be provided by farmers amounts to 470,000 U.S. Dollars.

According to our agronomic research on farming management in this basin, almost farmers seem to be unable to raise such funds by themselves. Therefore, it is desirable to prepare such a special fund on the long credit of the Credit Association for the New Hamlet Establishment.

7) Net profit of a paddy livestock farming unit

The management of irrigated farm is undertaken at the third year after the start of irrigation system construction, and the farm unit is improved year by year and generally completed during 8 years. The process of a farm unit improvement, including the cultivated area by kind of crops, annual gross income by cropping, number of livestock, annual gross income by livestock raising and balance sheet of a farm unit management during 15 years after the beginning of irrigation system construction, is illustrated in detail in Tables A-11 to A-15.

As shown in these tables, the annual net profit of the farming unit is gradually increasing year by year with the advance of irrigation farm management, and is relatively greater than those in other areas of Viet Nam. This is mainly due to the fact that the productivity of land in this area is high as compared with those in other areas.

As is shown in Table A-15, the net profit increases rather rapidly, and it is only in the first year of farming that a deficit of 192 U.S. Dollars

/ occurs.

occurs. And in the 10th year after the farm establishment, the net profit of a unit farm of 2 hectares is estimated at about 104 U.S. Dollars (equal to about 8,320 piastres) /1 as the remainder of substructing annual expenses of 610 U.S. Dollars (equal to 48,800 piastres) from annual gross income of 714 U.S. Dollars (equal to 57,120 piastres). The annual repayment for construction cost of irrigation system is estimated at about 27 U.S. Dollars (equal to 2,160 piastres) per hectare or 54 U.S. dollars (4,320 piastres) per unit farm on the assumption that 350,000 U.S. Dollars of loan for the construction is repayable during the period of 28 years at an interest rate of 3.5 percent per annum without paying the interest and the capital for the first 7 years after the commencement of the construction.

This annual repayment is first imposed on farmers in 6th year after the farm establishment, however, the net profit of the farmer in the same year is estimated at about 40 U.S. Dollars (equal to 3,200 piastres) even if the annual farming expenditure of 580 U.S. Dollars (equal to 46,400 piastres) including above annual repayment for construction cost of 54 U.S. Dollars per unit farm is subtracted from the annual gross income of 620 U.S. Dollars (equal to 49,600 piastres). Consequently, in the 6th year the farmers will be able to pay the annual repayment for construction cost of irrigation system. Then, at the stage of 13th year after establishment (in the 15th year after the start of irrigation system construction), the net profit of a unit farm is estimated at

---

/1 U.S. Dollar is converted to piastre by the following rate for conveniency.

1 U.S.$ = 80 piastres

/ 124 U.S. Dollars

124 U.S. Dollars (equal to 9.920 piastres) that is the remainings after subtracting total annual farm expenses of 610 U.S. Dollars (equal to 48,800 piastres) inclusive of annual repayment of 54 U.S. Dollars from annual gross income of 734 U.S. Dollars (equal to 58,720 piastres), and the farmers will reserve it as capital for the further development.

Since them, the net profit of this unit farm is expected to increase year by year successively with the advance of irrigation farming.

Fig. A-II

Cropping pattern on paddy livestock farming unit field of 2 hectares during 7 years after the beginning of irrigation system construction

The management of unit farm is scheduled to be commenced by newly settled farmers and existing farmers at the 3rd year of irrigation system construction

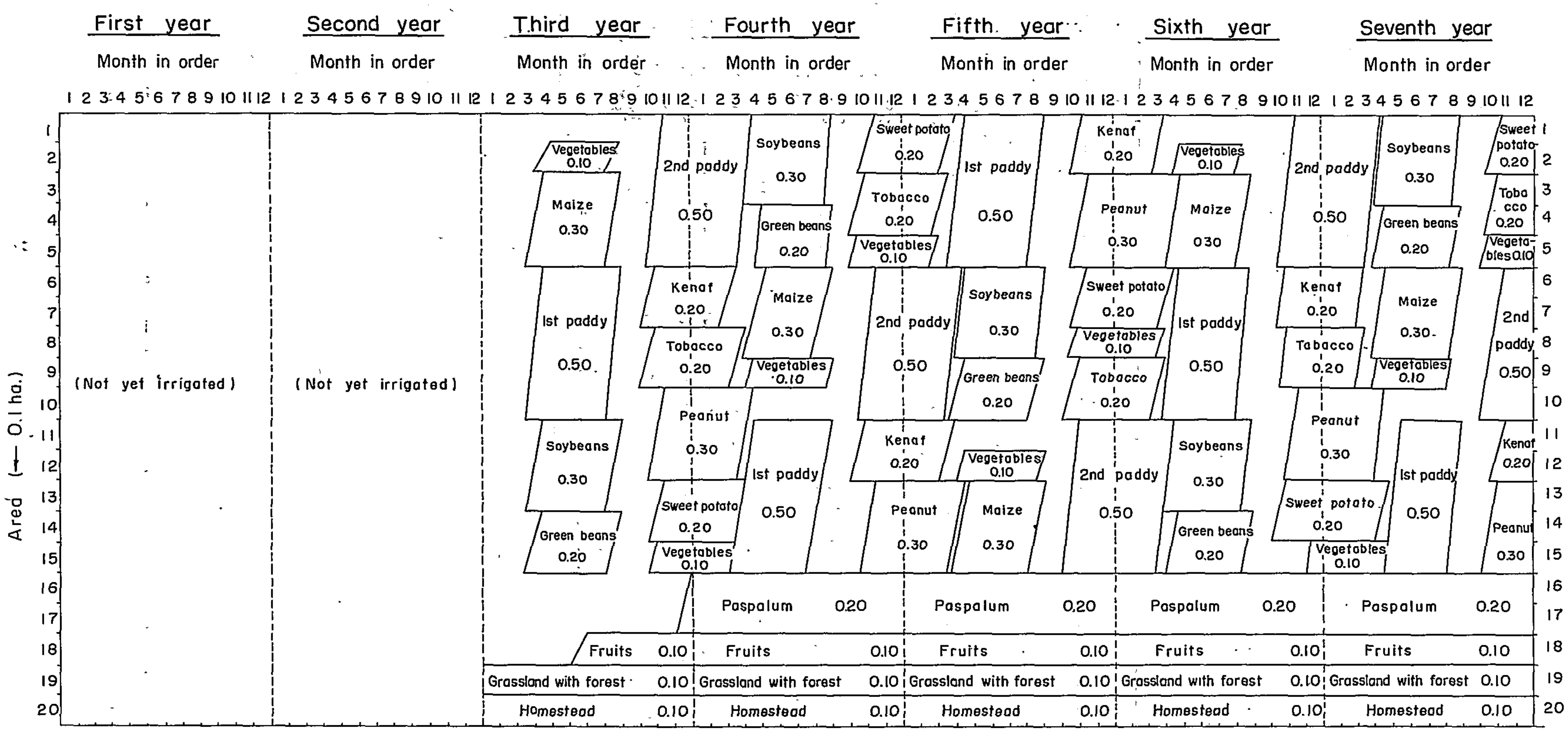


Table A - 11 Harvested area by kind of crops on a paddy livestock farm unit in Dar Lac Project Area during 15 years after the beginning of irrigation system construction

- Irrigation farming management is commenced by newly settled farmers as well as existing farmers at the 3rd year after the beginning of irrigation system construction.

Year in order (after the beginning of irrigation system construction)

Kind of crop	1st year			2nd year			3rd year			4th year			5th year			6th year			7th year			8th year~15th year
	Area (ha)	Unit yield (ton/ha)	Yield (ton)	Area (ha)	Unit yield (ton/ha)	Yield (ton)	Area (ha)	Unit yield (ton/ha)	Yield (ton)	Area (ha)	Unit yield (ton/ha)	Yield (ton)	Area (ha)	Unit yield (ton/ha)	Yield (ton)	Area (ha)	Unit yield (ton/ha)	Yield (ton)	Area (ha)	Unit yield (ton/ha)	Yield (ton)	
1st paddy					—		0.50	2.00	1.00	0.50	2.50	1.25	0.50	3.00	1.50	0.50	3.00	1.50	0.50	3.00	1.50	
2nd paddy		—			—						3.00	1.50	0.50	4.00	7.00	0.50	4.00	7.00	0.50	4.00	2.00	
Soybeans		—			—		0.30	1.50	0.45	0.30	2.00	0.60	0.30	2.00	0.60	0.30	2.00	0.60	0.30	2.00	0.60	
Green beans		—			—		0.20	1.00	0.20	0.20	1.50	0.30	0.20	2.00	0.40	0.20	2.00	0.40	0.20	2.00	0.40	
Paspalum		—			—					0.20	50.00	10.00	0.20	70.00	14.00	0.20	70.00	14.00	0.20	70.00	14.00	(Similar to 7th year)
Maize		—			—		0.30	1.50	0.45	0.30	2.00	0.60	030	3.00	0.90	0.30	3.00	0.90	0.30	3.00	090	
Tobacco		—			—					0.20	1.00	0.20	0.20	1.00	0.20	0.20	1.00	0.20	020	1.00	0.20	
Peanut		—			—					0.30	1.50	0.45	0.30	1.50	0.45	0.30	1.50	0.45	0.30	1.50	0.45	
Kenaf		—			—					0.20	2.00	0.40	0.20	2.00	0.40	0.20	2.00	0.40	0.20	2.00	0.40	
Sweet potato		—			—					0.20	10.00	2.00	0.20	20.00	4.00	0.20	20.00	4.00	0.20	20.00	4.00	
Fruits		—			—					0.10	3.00	0.30	0.10	5.00	0.50	0.10	8.00	0.80	0.10	10.00	1.00	
Vegetables		—			—		0.10	10.00	1.00	0.10	15.00	1.50	0.20	15.00	3.00	0.20	15.00	3.00	0.20	15.00	3.00	
Total :—∠1		—			—		1.40			3.10			3.20			3.20			3.20			(Similar to 7th year)

∠1 Figure shows the accumulated area of total crops.

Table A - 12 Annual gross income by cropping at a paddy livestock farm unit of 2 hectares in Dar Lac Project Area during 15 years after the beginning of irrigation system construction ∠1

Kind of crops	unit price (U.S.$/ton) ∠2	1st year (U.S. $)	2nd year (U.S. $)	3rd year (U.S. $)	4th year (U.S. $)	5th year (U.S. $)	6th year (U.S. $)	7th year (U.S. $)	8th year ~ 15th year
1st paddy ∠3	50	—	—	50.0	62.5	75.0	75.0	75.0	
2nd paddy	50	—	—	—	75.0	100.0	100.0	100.0	
Soybeans ∠4	40	—	—	18.0	24.0	24.0	24.0	24.0	
Green beans	40	—	—	8.0	12.0	16.0	16.0	16.0	
Paspalum ∠4	2	—	—	—	20.0	28.0	28.0	28.0	
Maize ∠4	40	—	—	18.0	24.0	36.0	36.0	36.0	— Similar to 7th year —
Tobacco	400	—	—	—	80.0	800	80.0	80.0	
Peanut	100	—	—	—	45.0	45.0	45.0	45.0	
Kenaf	150	—	—	—	60.0	60.0	60.0	60.0	
Sweet potato	5	—	—	—	10.0	20.0	20.0	20.0	
Fruits ∠5	40	—	—	—	12.0	20.0	32.0	40.0	
Vegetables ∠5	10	—	—	10.0	15.0	30.0	30.0	30.0	
Total : —		—	—	104.0	439.5	534.0	546.0	554.0	— Similar to 7th year —

NOTE • ∠1 : U.S. $ can be converted to piastre at the following rate : 1 U.S. $ = 80 Piastres.

∠2 Unit price of farm product is estimated upon the base of the international market price shown by F.A.O. Report. in 1960, and is lower than the current price shown by the following list in "Bilan des Realisations Gouvernementales":

Rice ---------2,500 Piastres/ton, Maize --------- 3,000 Piastres/ton, Beans ------12,000 Piastres/ton,
Vegetables --- 4,000 Piastres/ton, Kenaf -------- 14,000 Piastres/ton, Ramie ----- 30,000 Piastres/ton,
Cotton -------10,000 Piastres/ton, Tobacco --- 28,000 Piastres/ton,

∠3 : Out of total paddy products, 45kgs with price of 22.5 U.S. $ are used for self supplied food by farmers.

∠4 : Most products of soybeans, paspalum and maize are used for self supplied feed of domestic animals.

∠5 : The gross income obtained from horticultural cropping is estimated by using rather low unit price in consideration of expensive packing and freight charges under the condition of far distant location from stable market at the early stage of irrigation farming.

Table A - 13 Number of livestock raised in a paddy livestock farm unit during 15 years after the beginning of irrigation system construction ∠1

Kind of livestock and animal product	(Unit)	Year in order (after the beginning of irrigation system construction)														
		1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year	9th year	10th year	11th year	12th year	13th year	14th year	15th year
Cow, for milking	(head)	—	—	—	—	—	—	—	1	1	1	2	2	2	2	2
Cow, for sale	(head)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Calf, younger than 12 months	(head)	—	—	—	—	1	—	—	1	—	—	—	1	—	—	1
Calf, yearling	(head)	—	—	—	—	—	1	—	—	1	—	—	—	1	—	—
Calf, 2 years old	(head)	—	—	—	—	—	—	1	—	—	1	—	—	—	1	—
Calf, for sale	(head)	—	—	—	—	—	—	—	—	1	1	2	2	2	2	1
Milk, for sale	(kl)	—	—	—	—	—	—	—	2	2	2	4	4	4	4	4
Swine for raising	(head)	—	—	—	1	2	2	2	2	2	2	2	2	2	2	2
Swine, for sale	(head)	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—
Shoat, for raising	(head)	—	—	1	—	—	—	—	—	—	1	1	—	—	—	—
Shoat, for sale	(head)	—	—	—	—	—	5	5	5	5	5	5	5	5	5	5
Poultry, for raising	(head)	—	—	—	—	—	11	11	11	11	11	11	11	11	11	11
Chicken, for raising		—	—	—	—	11	11	11	11	11	11	11	11	11	11	11
Poultry, for sale		—	—	—	—	—	—	5	5	5	5	5	5	5	5	5
Egg, for sale		—	—	—	—	—	500	500	800	800	1,000	1,000	1,000	1,000	1,000	1,000

NOTE :— ∠1 As a rule, livestock capital is made up by bringing up young animal which is obtained at the early stage of irrigation farming.

Table A - 14 Annual gross income by livestock raising at a paddy livestock farm unit in Dar Lac Project Area during 15 years after the beginning of irrigation system construction

Kind of animal product	Unit price [1] (U.S. $)	Year in order														
		1st year (U.S. $)	2nd year (U.S. $)	3rd year (U.S. $)	4th year (U.S. $)	5th year (U.S. $)	6th year (U.S. $)	7th year (U.S. $)	8th year (U.S. $)	9th year (U.S. $)	10th year (U.S. $)	11th year (U.S. $)	12th year (U.S. $)	13th year (U.S. $)	14th year (U.S. $)	15th year (U.S. $)
Milk	15/kl	–	–	–	–	–	–	–	30	30	30	60	60	60	60	60
Calf	20/head	–	–	–	–	–	–	–	–	20	20	40	40	40	40	20
Cattle	60/head	–	–	–	–	–	–	–	–	–	–	–	–	–	–	60
Shoat	3/head	–	–	–	–	–	15	15	15	15	15	15	15	15	15	15
Swine	20/head	–	–	–	–	–	–	–	–	–	–	20	20	–	–	–
Egg	0.02	–	–	–	–	–	10	10	16	16	20	20	20	20	20	20
Poultry	1	–	–	–	–	–	–	5	5	5	5	5	5	5	5	5
TOTAL :—							25	30	66	86	90	160	160	140	140	180

NOTE :— [1] Unit price of livestock product is estimated so as to be used for raw material of dairy industry which is expected to be enterprised in the near future.

Table A – 15 Balance sheet of a paddy livestock farm unit with area of 2 hectares in Dar Lac Project Area during 15 years after the beginning of irrigation system construction

Item		year in order (after the beginning of irrigation system construction)														
		1st year (US $)	2nd year (US $)	3rd year (US $)	4th year (US $)	5th year (US. $)	6th year (U S. $)	7th year (U S $)	8th year (U.S $)	9th year (U S. $)	10th year (U.S. $)	11th year (U.S.$)	12th year (U.S.$)	13th year (U S. $)	14th year (U.S $)	15th year (U.S. $)
1. INCOME •		–	–	104.0	439.5	5340	571.0	5840	620.0	640.0	6440	714.0	714.0	6940	694.0	7340
a) Cropping		–	–	1040	4395	534.0	5460	5540	5540	5540	5540	554.0	5540	5540	554.0	5540
b) Livestock		–	–	–	–	–	250	30.0	660	860	90.0	160.0	160.0	140.0	140.0	180.0
c) Wage etc.		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2. OUTGO •		–	–	2940	385.0	4570	5000	542.0	580.0	591.0	5920	6100	610.0	6100	610.0	610.0
a) Depreciation of buildings	∠1	–	–	5.0	50	5.0	50	5.0	50	50	50	50	5.0	50	50	5.0
b) Depreciation of farm implements		–	–	50	50	5.0	50	50	5.0	50	5.0	50	50	50	50	5.0
c) Redemption for farm construction cost	∠2	–	–	–	–	–	–	–	200	200	200	200	20.0	200	20.0	200
d) Repayment for irrigation system construction cost	∠3	–	–	–	–	–	–	–	540	540	54.0	54.0	54.0	54.0	54.0	54.0
e) Operation and maintenance cost of irrigation system	∠4	–	–	200	200	20.0	20.0	200	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
f) Repayment for initial deficit of farming	∠5	–	–	–	40.0	600	70.0	90.0	–	–	–	–	–	–	–	–
g) Living expense	∠6	–	–	2000	2200	240.0	260.0	2800	300.0	3000	3000	300.0	3000	3000	300.0	3000
h) Self-supplied food	∠7	–	–	25.0	250	250	250	250	25.0	25.0	25.0	25.0	250	25.0	250	25.0
i) Supplementary feed	∠8	–	–	–	–	2.0	8.0	10.0	100	100	10.0	10.0	10.0	10.0	10.0	100
j) Self-supplied feed	∠9	–	–	–	–	30.0	37.0	37.0	56.0	67.0	71.0	860	860	86.0	860	860
k) Seed	∠10	–	–	–	–	50	50	50	5.0	50	50	5.0	5.0	50	5.0	50
l) Fertilizer	∠11	–	–	250	500	500	500	500	50.0	500	50.0	50.0	50.0	50.0	50.0	50.0
m) Agricultural chemicals		–	–	90	10.0	100	10.0	10.0	100	100	10.0	10.0	100	100	100	10.0
n) Insurance		–	–	–	–	–	–	–	100	100	100	100	10.0	10.0	10.0	100
o) Tax and public impost		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
p) Employed labor		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
q) Miscellaneous and contingency		–	–	50	5.0	5.0	50	50	100	100	10.0	10.0	100	10.0	10.0	10.0
3. BALANCE • (1-2)		–	–	-192.0	+52.5	+75.0	+69.0	+40.0	+40.0	+49.0	+490	+1040	+104.0	+84.0	+84.0	+124.0

• NOTE

∠1 Construction cost of buildings is subsidized by Government.

∠2 At the beginning of irrigation farming, about 120 U.S.$ are necessary for the construction of irrigating farm and the debt is redempted at the annual interest rate of 5 % by yearly uniform installments spread over 10 years after the unredeemable period for 5 years.

∠3 Repayment for irrigation system construction cost is estimated at 20 U.S.$ per ha annually at maximum.

∠4 Figure includes working cost of irrigation administration organization of 10 U.S.$ per ha. annually.

∠5 Initial deficit of farm management is estimated at about 200 U.S.$ at the beginning of irrigation farming as shown in the last line of balance of this table.

∠6 Sum of living expenditure and self supplied food is corresponding to total living cost which is gradually increasing from 200 U.S.$ per annum to 300 U.S $ per annum with the advance of irrigation farming

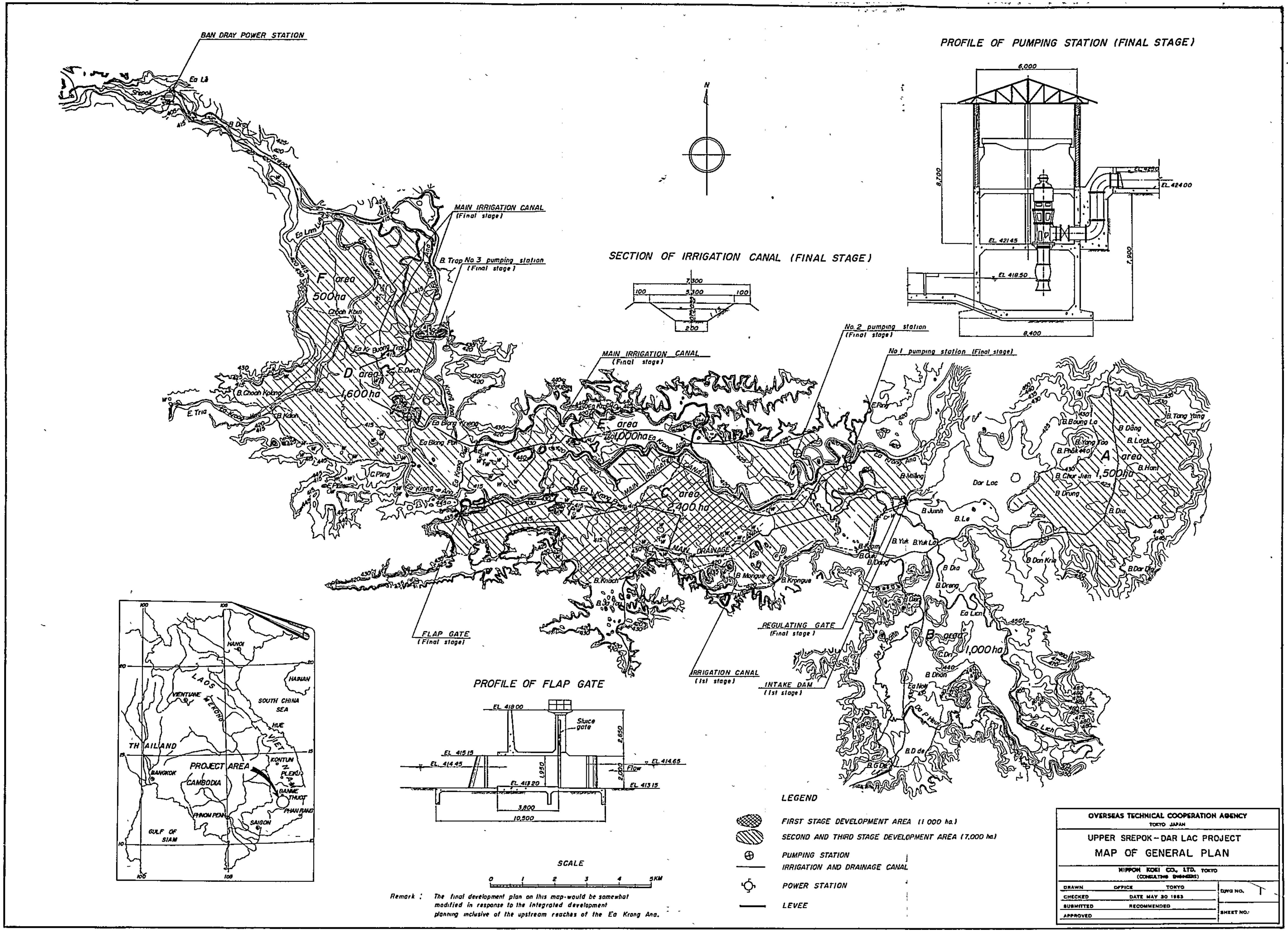
∠7 Food demand by 5 members in a family including 3 children is estimated at 3 grown-up persons, and 450 kgs of rice, 20 kgs of fruits and 100kgs of vegetables are self-supplied by using farm products with total price of 12.5 U.S.$ per ha. annually.

∠8 Rather small amount of calcium and sodium chloride salt are required as the supplementary feeds for animals.

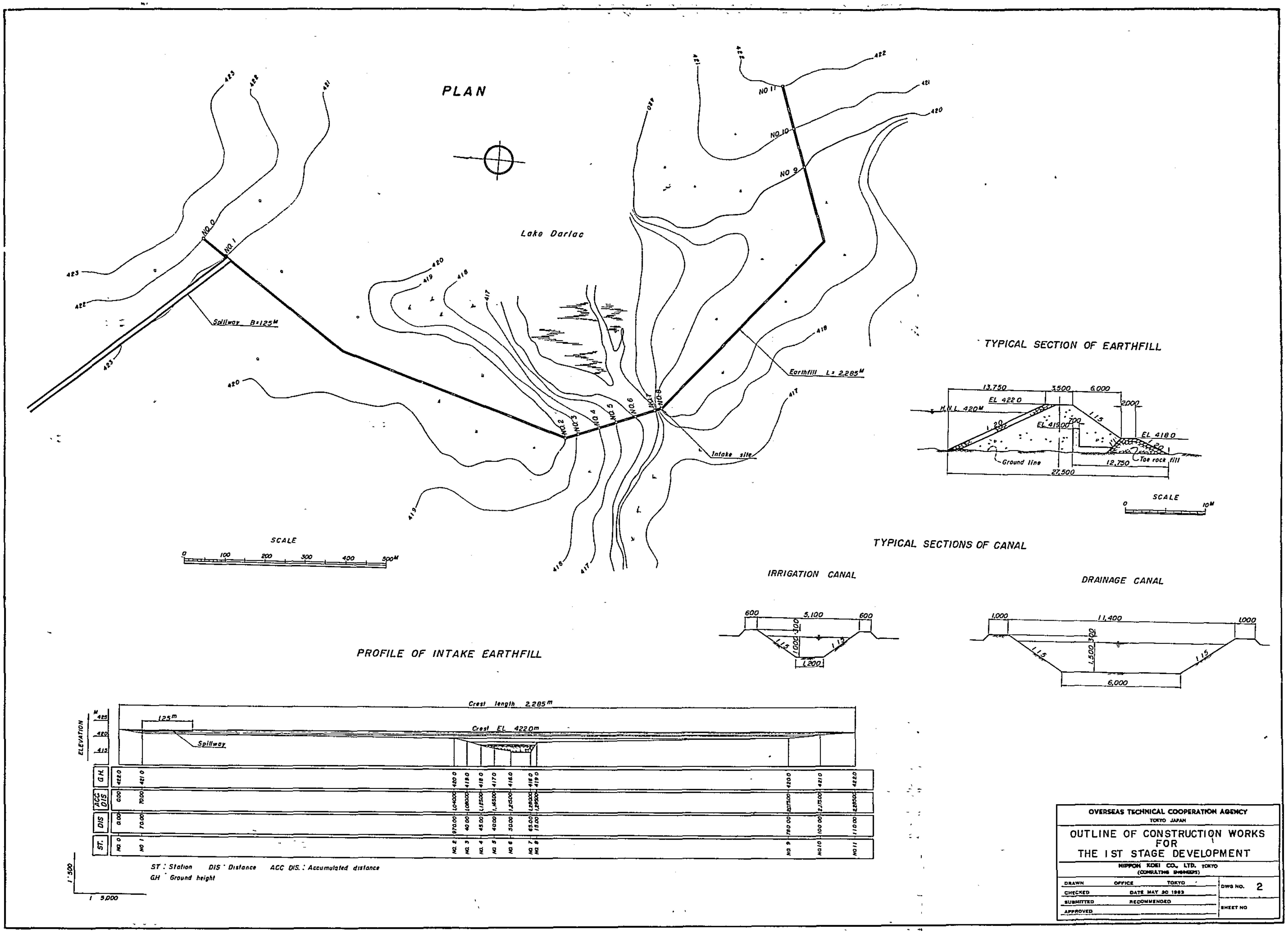
∠9 The Feed requirements of domestic animals are computed by the use of America Nation Research Council Standard. The greater part of soybeans, maize, and paspalum products are given to animals as their feeds.

∠10 Besides the seeds of principal crops granted freely by Government, some specific seeds are necessary to be provided by farmers themselves

∠11 For the successful production of irrigating farm crops on lowland in Dar Lac Valley, nitrogeneous fertilizer of 150 kgs/ha., phosphatic fertilizer of 100 kgs/ha., potassic fertilizer of 20 kgs/ha. are necessary to be given annually, though the soils in this area have relatively high natural fertility. Moreover, lime or calcium silicate with amounts of 100 kgs/ha. should be given every 10 years.



BAN DRAY POWER STATION
PROFILE OF PUMPING STATION (FINAL STAGE)
6,000
8,700
7,900
8,400
EL. 422.0
EL. 424.00
EL. 421.45
EL. 418.50
SECTION OF IRRIGATION CANAL (FINAL STAGE)
7,300
5,300
100
2.00
MAIN IRRIGATION CANAL
(Final stage)
No. 3 pumping station
(Final stage)
No. 2 pumping station
(Final stage)
No. 1 pumping station (Final stage)
F area
500 ha
D area
1,600 ha
E area
1,000 ha
C area
2,400 ha
A area
1,500 ha
B area
1,000 ha
MAIN DRAINAGE
Dar Lac
FLAP GATE
(Final stage)
REGULATING GATE
(Final stage)
IRRIGATION CANAL
(1st stage)
INTAKE DAM
(1st stage)
PROFILE OF FLAP GATE
EL. 418.00
Sluice gate
2,650
EL. 415.15
EL. 414.45
1,950
2,000
Flow
EL. 414.65
EL. 413.20
EL. 413.15
3,800
10,500
SCALE
0 1 2 3 4 5KM
Remark : The final development plan on this map would be somewhat modified in response to the integrated development planning inclusive of the upstream reaches of the Ea Krong Ana.
LEGEND
FIRST STAGE DEVELOPMENT AREA (1,000 ha.)
SECOND AND THIRD STAGE DEVELOPMENT AREA (7,000 ha.)
PUMPING STATION
IRRIGATION AND DRAINAGE CANAL
POWER STATION
LEVEE
HANOI
LAOS
VIENTIANE
MEKONG
HAINAN
SOUTH CHINA SEA
HUE
VIET NAM
THAILAND
PROJECT AREA
KONTUM
PLEIKU
BANMETHUOT
BANGKOK
CAMBODIA
PHNOM PENH
SAIGON
PHAN RANG
GULF OF SIAM
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN
UPPER SREPOK - DAR LAC PROJECT
MAP OF GENERAL PLAN
NIPPON KOEI CO., LTD. TOKYO
(CONSULTING ENGINEERS)
DRAWN
OFFICE TOKYO
CHECKED
DATE MAY 30 1963
SUBMITTED
RECOMMENDED
APPROVED
DWG NO. 1
SHEET NO.


PLAN
Lake Darlac
NO.0
NO.1
NO.2
NO.3
NO.4
NO.5
NO.6
NO.7
NO.8
NO.9
NO.10
NO.11
Spillway B=125M
Earthfill L= 2,285M
Intake site
SCALE
0 100 200 300 400 500M
TYPICAL SECTION OF EARTHFILL
13,750
3,500
6,000
2,000
EL 422.0
H.W.L. 420M
1:20
1:15
EL 415.00
700
EL 418.0
1:20
Ground line
12,750
Toe rock fill
27,500
SCALE
0 10M
TYPICAL SECTIONS OF CANAL
IRRIGATION CANAL
600
5,100
600
300
1,000
1:1.5
1:1.5
1,200
DRAINAGE CANAL
1,000
11,400
1,000
300
1,500
1:1.5
1:1.5
6,000
PROFILE OF INTAKE EARTHFILL
Crest length 2,285m
125m
Crest EL 422.0m
Spillway
ELEVATION
425
420
415
G.H. 422.0 421.0 420.0 419.0 418.0 417.0 416.0 416.0 419.0 420.0 421.0 422.0
ACC DIS 0.00 70.00 1,040.00 1,080.00 1,125.00 1,165.00 1,215.00 1,280.00 1,295.00 2,075.00 2,175.00 2,285.00
DIS 0.00 70.00 970.00 40.00 45.00 40.00 50.00 65.00 15.00 780.00 100.00 110.00
ST. NO.0 NO.1 NO.2 NO.3 NO.4 NO.5 NO.6 NO.7 NO.8 NO.9 NO.10 NO.11
ST : Station DIS : Distance ACC DIS. : Accumulated distance
GH : Ground height
1:500
1:5,000
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN
OUTLINE OF CONSTRUCTION WORKS
FOR
THE 1ST STAGE DEVELOPMENT
NIPPON KOEI CO., LTD. TOKYO
(CONSULTING ENGINEERS)
DRAWN
OFFICE TOKYO
CHECKED
DATE MAY 30 1963
SUBMITTED
RECOMMENDED
APPROVED
DWG NO. 2
SHEET NO