THE REPUBLIC OF INDONESIA

MINISTRY OF PUBLIC WORKS AND ELECTRIC POWER

DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT

FEASIBILITY STUDY

ON

THE WAY RAREM IRRIGATION PROJECT

— MAIN REPORT —

MARCH 1976

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO

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FOREWARD

In compliance with the request of the government of the Republic Indonesia for technical cooperation on the Way Rarem Irrigation Project, Lampung Provice, Sumatra, the government of Japan envisaged to conduct a feasibility study for the project and entrusted the study work to Japan International Cooperation Agency.

The Agency organized a survey team consisting of eight members headed by Dr. S. Sasaki, Director - general of Japan Irrigation and Reclamation Consultants (Foundation) and conducted the feasibility study covering the Way Rarem project area (approx. 46,000 ha) for a period of three months from June, 23, 1975.

The survey team carried out field investigations in close cooperation with Indonesian authorities. After its return to Japan, the team made various studies and analyses of data in accordance with the material and information obtained during the stay in Indonesia. Consequently the final report has been completed and is herewith submitted to the government of Republic of Indonesia.

I sincerely hope that this report will contribute to the implementation of this project and the regional development in Lampung for the further economic growth in Indonesia, and thus serve in promoting friendly relations between Indonesia and Japan.

I take this opportunity to express my deep gratitude to the government of the Republic of Indonesia, for the valuable and helpfull assistance extended throughout the survey period.

March 1976

SHINSAKU HOGEN
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Mr. Shinsaku Hogen
President
Japan International Cooperation Agency

Dear Sir,

I have the honour to present herewith a report on the feasibility study for the Way Rarem Irrigation Project in Lampung province, the Republic of Indonesia, of which the field survey was conducted for a period of three months from June 23, 1975 to September 22. The report was made also on the bases of the discussion of the draft report for a period of 10 days from February 3 to 12 in 1976 and the comments of the Government of Indonesia.

The project area covers an acreage of about 46,000 ha in which the transmigrants have settled mainly from Java island with the households of about 12,600 and this transmigration scheme is scheduled to be almost completed. Actually, however, these settlers are pressed hard for irrigation facilities whose absence has compelled them to engage chiefly in upland field cultivation which yields a rather poor profit even in the wet season. Arrangement of irrigation facilities and stabilization of farm management through introduction of paddy cropping is what most keenly contributes not only to the transmigrants, but also to the regional development, and what is desired by the Government of Indonesia.

In this report, a irrigation plan is proposed in due consideration of the socio-economic condition of the entire 46,000 ha area and it's feasibility is clarified.

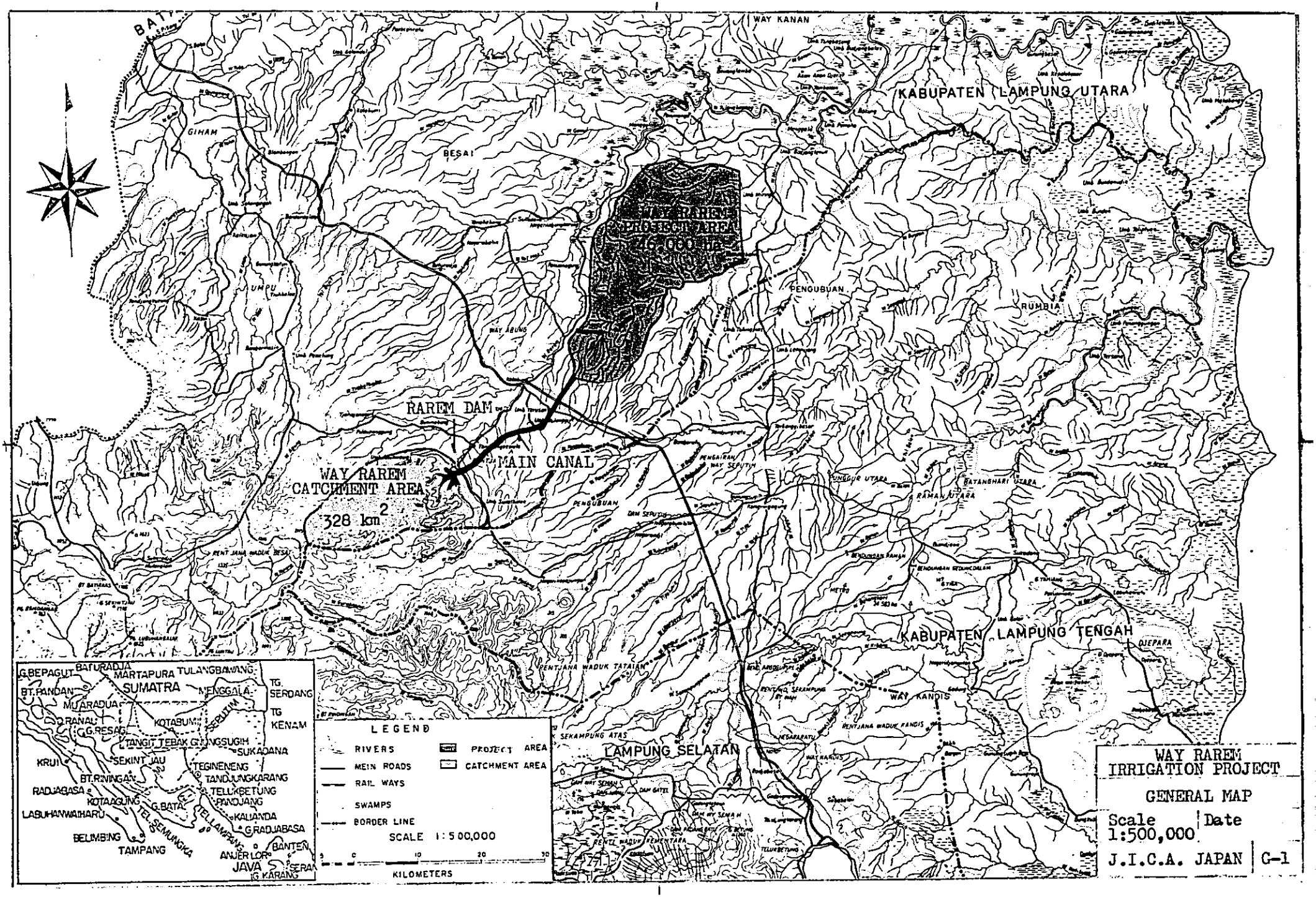
I sincerely wish the project to be realized as soon as possible in accordance with this report.

In closing, I avail myself of this opportunity to express my deep gratitude to Directorate General of Water Resources Development, Ministry of Public Works and Electric Power of the Republic of Indonesia, Ministry of Foreign Affairs, Embassy of Japan in Jakarta, Ministry of

Agriculture and Forestry, Japan International Cooperation Agency, Advisory Group, Japanese Colombo Plan experts in Indonesia and Nippon Koei Co., Ltd. for valuable and unlimited cooperation and assistance throughout the survey period and in the compilation of this report.

March 1976

Shiro Sasaki
Director-General
Japan Irrigation and Reclamation
Consultants (Foundation)


WAY KANAN
KABUPATEN LAMPUNG UTARA
GIHAM
BESAI
WAY RAREM
PROJECT AREA
46,000 ha
UMPU
PENGUBUAN
RUMBIA
WAY ABUNG
RAREM DAM
MAIN CANAL
WAY RAREM
CATCHMENT AREA
328 km 2
PENGAIRAN WAY SEPUTIH
PENGUBUAN
RENTJANA WADUK BESAI
KABUPATEN LAMPUNG TENGAH
DJEPARA
RENTJANA WADUK TATAIAN
WAY KANDIS
RENTJANA WADUK KANDIS
LAMPUNG SELATAN
RENTJANA WADUK PEMENTARA
TELUK BETUNG
G.BEPAGUT
BATURADJA
MARTAPURA
TULANGBAWANG
SUMATRA
MENGGALA
TG. SERDANG
BT. PANDAN
MUARADUA
TG KENAM
G.RANAU
G.G.RESAK
KOTABUMI
SEKAMPUNG
TANGIT TEBAK
GUNGSUGIH
SUKADANA
KRUI
SEKINT JAU
BT.RINGAU
TEGINENENG
TANJUNGKARANG
RADJABASA
TELUKBETUNG
KOTAAGUNG
G.BATA
PANDJANG
LABUHANWATHARU
TELUKSEMUNGKA
KALIANDA
G.RADJABASA
BELIMBING
TAMPANG
TELUKLAMPUNG
BANTEN
ANJER LOR
SERA
JAVA
G.KARANG
LEGEND
RIVERS
MEIN ROADS
RAIL WAYS
SWAMPS
BORDER LINE
PROJECT AREA
CATCHMENT AREA
SCALE 1:500,000
5 0 10 20 30
KILOMETERS
WAY RAREM
IRRIGATION PROJECT
GENERAL MAP
Scale 1:500,000
Date
J.I.C.A. JAPAN
G-1

SUMMARY AND RECOMMENDATION

SUMMARY

1. The Way Rarem Irrigation Project is situated in the North Lampung region, Sumatra, the Republic of Indonesia and the project area estimated to be 46,000 ha is vast and flat land which is extending in the north-west side of Kotabumi city, the capital of North Lampung.

The Rarem river forms the western border and the national road and railway run along the southern side, and therefore, the area has conveniences of transportation and water utilization.

In the area, the transmigrants mainly from Java island have already settled with the households of about 12,600 and barely raise the upland cultivation.

The present study was carried out to investigate the feasibility of an irrigation project for the area which will make the irrigated paddy cropping possible, increase the yield for food products, realize the economical stability for the transmigrants in the area and further, contribute to the regional development.

2. According to the survey results in the project area and it's vicinity of about 60,000 ha, the present land use mainly consists of the upland of 16,700 ha, grass land of 17,500 ha and forest of 17,300 ha, and village, road, river, swamp and others exist among those lands.

In addition, the land capability study classifies the surveyed area to be irrigable area of 28,000 ha, irrigable, but limited arable area of 10,000 ha, non-irrigable area of 14,700 ha, and village, public yard, etc. of 7,300 ha.

3. The irrigation for the area depends on the gravity system. The dam site is proposed near the confluence of the Rarem river and the Galing river and the irrigation water is drawn to the project area by main and secondary canals.

Judging from the conditions of land, topography, climate, hydrology and others for the area, the project which has the net irrigation area of 20,000 ha for paddy cropping, is technically and economically the optimum scale and has strong realization.

The comparative study, on the net irrigation area shows that the case of the net irrigation area of 25,000 ha has the less economical evaluation and the problem that about 80 percent of the yearly river discharge must be diverted.

4. The future land use of the project is planned that the area of 46,000 ha consists the paddy field of 20,000 ha (of which 5,000 ha is used for the paddy cropping in the dry season), upland of 8,000 ha, homestead of 4,000 ha, and public yard, river, steep land etc. of 14,000 ha. Each land in the above land use is selected by the aforementioned land capability.

5. The outline of the irrigation facilities is as follows.

(1) Rarem dam

Location:	at the place about 460 m in the downstream from the confluence of the Rarem river and the Galing river.
Type:	rockfill dam with center core
Dam height:	23.70 m
Dam length:	650.00 m
Dam body:	430,000 m^3
Total storage:	22 x 10^6 m^3
Effective storage:	7 x 10^6 m^3
Construction:	mainly by equipment

(2) Canal

Type	:	earth canal
Total length		
main canal	:	65 Km
Secondary canal:		152 Km

Max. intake discharge : 16.57 m^3/sec.
Construction : mainly by equipment

6. The project cost amounts to US$59,000,000 of which the costs for main civil work and construction equipment are estimated US$2,092,000 and US$13,644,000 respectively, and the project cost includes the costs for land compensation, engineering and administration, interest during the construction period and contingencies.

The costs of construction equipment, materials unavailable locally. engineering service and others are assumed to be covered by overseas loans. The domestic and foreign currencies required are estimated US$29,550,000 and US$29,450,000 respectively and their portion is about 50-50.

The construction period is 6 years and the target year is assumed 10 years after the commencement of construction.

7. The standard farm management of one agricultural household depends on the paddy field of 1.25 ha, the upland field of 0.5 ha, and the homestead, etc. of 0.25 ha. The total area is 2.0 ha.

The project area can have the agricultural households of 16,000 at the target year (12,600 households at present) with the above standard farm. These households are expected to raise the paddy cropping of 20,000 ha in the wet season and 5,000 ha in the dry season. Besides, it is expected that the second cropping on the remaining 15,000 ha in the dry season is given over to soybean and green manure, and the leguminous forage and coffee are raised in the upland of 8,000 ha all the year around.

8. With the proper implementation of the project, the dry paddy yield will be increased to 4.4 tons/ha for the dry season cropping and 4.0 tons/ha for the wet season cropping, respectively. The total dry paddy production estimated under "With Project" is 102,000 tons, which is sufficient for meeting the future domestic demand.

9. The gross income will be Rp. 420,000 and the total production cost will be Rp. 155,000, respectively, in the standard farm of 1.75 ha after the project. Assuming that the living expenses including taxes are Rp. 138,000, the capacity to pay estimated is Rp. 127,000. On the other hand, the gross income will be Rp. 130,000, the total production cost Rp. 18,000, and the capacity to pay Rp. 5,000, respectively, for the standard farm in case of "Without Project".

10. The annual net production value will be Rp. 6,548 million under "With Project", while it will be Rp. 2,188 million under "Without Project". The incremental net value of the project is estimated at Rp. 4,360 million or US$10,506,000.

11. Assuming that the full benefit is attained in 5 years after the proposed cropping is started, the economic feasibility of the project is evaluated for 60 years from the 6th year after the commencement of construction. The estimated internal rate of return of 13.6% shows that the project is efficient from the economic viewpoint.

RECOMMENDATION

1. The technical recommendation to implement the project is as follows.

   1) In order to assure the storage capacity of the Rarem dam, it is desirable that the topographic survey on the dam basin is carried out again

   2) Drilling survey on the foundation of the Rarem dam, soil test of the materials especially for the core and transition zones of the dam, and the permeability test for the cut-type canal should be conducted because of the few test results.

   3) The selection of the proposed route for the main canal and it's survey should be performed again.

   4) The borrow pit for the embankment material of the main canal in the benefited area should be studied on the location, the property of soil, etc.

5) For the confirmation of percolation loss of water on the irrigated paddy field, field percolation test and checking of surface soil depth should be carried out.

2. The conservation of the catchment area of the Rarem river is important, because it is indispensable to assure stable river discharge for the irrigation to the project area. Some concrete countermeasures to the cutting of trees and the erosion along the river coast should be studied.

3. The proper operation and maintenance of the Rarem dam itself is very important, and the dam may have the possibility to be used as a fishing pond or even a leisure center in the future.

4. The due considerations should be paid to the safety control to the personnel near the dam and along the canals.

5. It is necessary to organize a cooperation association such as water control association systematically from the commencement of irrigation in order to distribute the water effectively and efficiently to each plot.

6. The irrigation plans due to the basin transfer from the Besai river and the pumping up which were studied in the pre-feasibility study will suggest the future possibility as a development plan for the remained area in this regency.

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APPENDIX

S-1 Land Use Map

S-2 Soil Map

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G-3 Geological Map of Dam Site

D-1 General Plan of Rarem Dam

D-2 Typical Cross Section and Profile of Rarem Dam

SEPARATE BOOK: STUDY REPORT

ABBREVIATION AND CONVERSION TABLE

Japan International Cooperation Agency	J I C A.
Ministry of Public Works and Electric Power	D P U T L
Bureau of Logistics	Bulog
Indonesian People's Bank	B R I.
Central Research Institute of Agriculture	C R I A
Rural Education Center	B P M D
Regional Farmer's Cooperative	B U U D
Village Farmer's Cooperative	K U D
Gross Domestic Product	G D P
Operation and Maintenance	O & M
Lampung Hydrological Network Programme	P 3 S A
Way Rarem	Rarem river
Way	River
Desa	Village
Millimeter(s)	mm
Centimeter(s)	cm
Meter(s)	m
Kilometer(s)	Km
Square centimeter(s)	cm^2
Square meter(s)	m^2
Square kilometer(s)	Km^2
Cubic meter(s)	m^3
Kilogram(s)	Kg
Metric ton(s)	ton
Meter per second	m/sec
Cubic meter per second	m^3/sec
Hectare	ha
Elevation	EL
Centigrade degree(s)	°C
Hour(s)	hr
Minute(s)	min.
Percent	%
Rupiah(s)	Rp
U.S. dollar(s)	U.S.$
Yen(s)	¥
Lump sum	L.S.

Currency Equivalent US$1.00 = 415 Rp = 300 Yen

I. INTRODUCTION

1.1 Scope of the Project

The Way Rarem Irrigation Project is situated in the North Lampung region, Sumatra, the republic of Indonesia, in the northeast side of Kotabumi, the capital of North Lampung.

The area is located at the east longitude of 104°53' and the south latitude of 4°40'. It is bordered by three rivers in the north, east and west, and a railway in the south. The whole area is a flat plateau having approximately 18 km, width from west to east and 50 km length from south to north, and its total area is about 83,000 ha. (The coverage area of the feasibility study for the project is 55,000 ha and the project area is decided to be 46,000 ha of the above area.)

The Government of the Republic of Indonesia has promoted the transmigration project to settle the families from Jawa in the area and at present there are about 13,000 families of transmigrants.

The Government of the Republic of Indonesia has aimed at contributing to increase the yield for food products and to realize an economical stablity in the area, and to encourage the transmigration scheme of this country by implementing an irrigation project in the area.

1.2 Past and Present Status of the Project

In 1972, the Government of the Republic of Indonesia requested the Government of Japan to conduct surveys for the irrigation projects in this area.

In compliance with the request of the Government of the Republic of Indonesia, the reconnaissance survey and the pre-feasibility study were respectively carried out in 1972 and 1974 by the Overseas Technical Cooperation Agency responsible for the implementation of technical cooperation programme of the Government of Japan.

Futher, the Japan International Cooperation Agency which is the later self of the above said Agency, took over its cooperation programme with a topographic mapping survey which was conducted in 1974 and a partial and preparatory survey which was carried out in March 1975 within the framework of the feasibility study, and in 1975, the field survey of the present feasibility study was carried out.

The transmigration scheme aimed at the area, has been implemented as a governmental project since 1965 and is scheduled to be completed by 1975. During this period, the road construction and other works in the area have been undertaken by the World Food Program (WFP715).

Many concession areas for corn, cassava, rosella, sugar cane and other culivations have been approved in the region bordering along the east side and the north part of the area where rice estate was planned around 1973, is turned into concession area.

In the Lampung Province, the large scale irrigation projects in Way Sekampung and Way Septih have just about been completed, while the irrigation projects in Way Jepara, Way Umpu and Way Pengubuan are financed with loans from Japan's Overseas Economical Cooperation Fund and are now under construction.

Although there are many governmental authorities connected with the project, the actual irrigation construction work comes under the jurisdiction of the Directorate General of Water Resources Development, Ministry of Public Works and Electric Power.

1.3 Terms of Reference and Survey Extent

The contents of the feasibility study have been described in the memorandam which the Director of Irrigation and the Japanese study team leader signed on June 28, 1975, and in the other related documents (Refer to appendix I). The main points are summarized below.

The coverage area in this feasibility study is approximately 55,000 ha which consists of mainly transmigration area, and the objective of the study is to investigate the feasibility of an irrigation project for the area.

1. Comparative study of irrigation plannings for the objective area is carried out mainly on the basis of the gavity intake system from the Way Rarem, and the scale of an irrigation project is determined.
2. Farm management systems for this area are studied.
3. Evaluation of this project is examined.
4. The influences to the adjacent area which might be affected by the water source planning for the area are reviewed along the results of the prefeasibility study.

The field work for the feasibility study was carried out with the personnel and in the period shown in Appendix II. At the same time, the Indonesian side surveyed the proposed dam site and route of main canal, as well as carrying out drilling survey, soil test and water quality test.

The field work carried out by the study team mainly consists of the surveys on hydrology, geology, soil, irrigation, agriculture and agro-economy. Rock and soil analytical tests on the samples taken from the area were performed in Japan.

1.4 Previous Reports and Available Data

There are three previous reports made in reference to the Way Rarem Irrigation Project. These are summarized as follows:

(1) Reconnaisance Survey Report on Way Rarem/Abung Irrigation Project.

This report, submitted in March 1973, was made in accordance with the field work during August and September in 1972 which was performed by the Overseas Technical Cooperation Agency in Japan.

The total coverage area is 118,300 ha which consists 83,000 ha of the Rarem area and 35,300 ha of the area on the left side of the Abung river, a tributary of the Rarem river.

The irrigation plan in this report calls for a dam to be proposed in the upstream of the Rarem river to provide a water source for the Rarem area and a diversion dam to be planned on the Besai river for supplementary purposes. Discharge of the Besai river is diverted to the Abung area to also provide irrigation water for the Abung area and a pumping station is planned to compensate the shortage of river discharge to the Rarem area at the confluence of the Rarem and Abung rivers, that is, near Kotabumi city.

The project includes the plan of the city water supply for Kotabumi and becomes a multipurpose project.

(2) Pre-feasibility Study Report on Way Rarem/Abung Irrigation Project.

This report, submitted in May 1974, was made in accordance with the field survey during October and November in 1973 which was carried out by the Overseas Technical Cooperation Agency in Japan.

The total coverage area is the same as in the reconnaissance survey, that is, 118,300 ha. In this report, the coverage area is divided into eight sub-districts due to topography, discharge from water source and irrigation method. Namely, the Rarem area of 83,000 ha is divided into two southern sub-districts (total: 35,000 ha) and three northern sub-districts (total: 48,000 ha). The Abung area of 35,300 ha is divided into three sub-districts.

The project is planned to be implemented in the following three stages.

The development in the first stage is intended primarily for quick yield and implemented by constructing many irrigation tanks on the small rivers in the area.

The development in the second stage is an irrigation project which makes the wet season paddy cultivation possible for the whole project area. For this stage of the project, the northern half of the Rarem area is irrigated by pumping stations and with respect to the southern half, the comparative study of the following two irrigation plans is carried out. Namely, one is the pumping-up irrigation which all of the diversion discharge is pumped up from the Rarem river in the vicinity of Kotabumi city. The other is the gravity irrigation by a dam proposed in the upstream of the Rarem river (but which includes some pumping-up from the main canal to the higher part).

The third stage development is an irrigation project which makes possible the double cropping of paddy cultivation for the whole project area. Diversion of river water by constructing the Besai dam and its basin transfer from the Besai river through the Abung river to the Rarem river, is planned.

This project also includes the plan of the Kotabumi city water supply.

(3) Mapping Survey Report on Way Rarem/Abung Irrigation Project

This is the report prepared by the Japan International Cooperation Agency as a part of the feasibility study and submitted in March, 1975. It is a summary of the field works carried out during three months from September, 1974 and in March, 1975.

The above surveys were carried out on the strength of the pre-feasibility study conducted in 1973 and they constitute part of the feasibility study for an irrigation project of 35,000 ha in the southern part of the Rarem area.

The objective of the surveys was to prepare a 1/10,000 topographic map covering an area of about 375 km^2 which embraces dam sites and main canal and to check the existing 1/5,000 map of the adjacent area in order to facilitate the study of the proposed irrigation plan, as well as to conduct the general preparatory work for the purpose of the feasibility study. (The coverage area for the feasibility study was altered to approximately 55,000 ha which consists of mainly transmigration area, within the total area of 83,000 ha in the Rarem area.)

Besides these reports, there are other available data which include the 1/5,000 topographic map for the benefited area, the 1/10,000 topographic map covering the proposed dam site and route of main canal, the monthly rainfall records at Kotabumi over the last 45 years, the discharge record at the proposed dam site for about three years, the results of the survey conducted in 1975 and others. These available data are all listed up in Appendix III.

II. GENERAL BACKGROUND OF ECONOMY AND AGRICULTURE

2.1 Economic and Agricultural Background

Indonesia covers a geographical area of approximately 1.9 million km^2, comprising 0.14 million km^2 in Jawa and Madura Islands and 1.76 million km^2 in the Outer Territory in which Sumatra, Kalimantan, Sulawesi, Irian and many other small islands are included. According to the Statistic Indonesia 1972/1973, among 13.2 million ha of her net farm lands 45% or 5.9 million ha are concentrated in Jawa and Madura Islands and the remaining 55% or 7.3 million ha scatter over the Outer Territory. The proportion of cultivated area to each geographical area is estimated at 42% in Jawa and Madura Islands and 4% in the Outer Territory, respectively. These figures clearly show that the Outer Territory has enormous potentiality for further agricultural development.

The total population of Indonesia has increased from 97 million in 1961 to 123 million in 1972 with an average annual growth rate of 2.4%. According to the official statement made, the population growth rate will be about the same for the next decade.

About 32 million ha of harvested area in Indonesia produced about 44% of the Gross Domestic Product (GDP) in 1972 and then agriculture still plays the most important part in her economic sector, although the mining sector has shown a remarkable progress in recent years. In the 1972 crop season, the estimated production of major staple food crops comprised 25.3 million tons of dry stalk paddy harvested from 7.9 million ha, 2.3 million tons of maize from 2.2 million ha, 10.4 million tons of cassava from 1.5 million ha and 0.5 million tons of soybean from 0.7 million ha. As for the typical perennial crops in the same season, 239,000 tons of rubber, 22,000 tons of coffee and 269,000 tons of palm oil were harvested from 2,074,000, 388,000 and 1,851,000 ha of productive lands, respectively.

Paddy production in Indonesia has increased throughout the First Five-Year Plan (1969 to 1973) through expansion of the cropped area as well as the increased unit yield resulting from the construction and rehabilitation of irrigation facilities, the introduction of high-yielding varieties, and the technical guidance and financial support given for the application of fertilizers and agro-chemicals. During the past four years since 1970, the total harvested area of paddy fields increased from 8.1 to 8.4 million ha and the average yield of dry paddy rose from 2.4 to 2.6 tons/ha, making the annual growth rates of 0.9% and 2.1%, respectively.

The aforementioned satisfactory increase in paddy production has however been insufficient to meet the growing domestic demand resulting from the population growth and the increased home consumption of grains. Thus, Indonesia still has to import a large amount of staple food from abroad every year. For example, 1.1 million tons of rice and 80,500 tons of wheat flour were imported in the 1974 crop season.

Under the Second Five-Year Plan (1974 to 1978), the Government is still putting much stress on the improvement of agricultural sector in the expectation that the annual growth of output goes on at the rate of 4.6% in terms of GDP. The basic concept of the principal policies in the sector is to realize staple foodstuff self-sufficiency and to secure more income for individual farmers. For taking measures to enforce the above policies, such irrigation projects as the rehabilitation of present systems and the construction of new facilities are being broadly promoted throughout the country in combination with various institutional supporting works as well as transmigration schemes. As a result, attainment of the target in the agricultural sector can be expected by increasing the productivity of the existing paddy fields in Jawa and Madura Islands and also by the expansion of paddy fields newly reclaimed in the Outer Territory.

2.2 Institutional Services for Agriculture

2.2.1 Land tenure

Land tenure in Indonesia is applied by "Land Reform Law" as the Basic Agrarian Law No.5 of 1960. It is executed under the responsibility of the Directorate General of Agrarian belonging to the Ministry of Interior. Local activities are carried out by the Provicial Agrarian Offices.

According to the law, the maximum private ownership of farmland is enacted as 15 ha for irrigated paddy field and 20 ha for non-irrigated land. This system is based on the custom in native villages having long history and the application of law is under the obligation of the village chief. The whole lands except which revert to village are administered as government lands in care of provincial or prefectural offices. Both transmigrants and estate planters can acquire the right of land utilization for the above government lands when qualified to undertake farm operation after two- or three-year temperary using period.

2.2.2, Credit

The Indonesian People's Bank (BRI) is the state bank specialized in farm credit all over the country. To provide loan services, the bank has established a broad network formed of many regional offices and more than 200 branch offices (Unit Desa BRI). The bank is authorized to finance BIMAS and INMAS credit activities for qualified individual farmers. Besides, using own credit funds, the bank provides the loans to various agricultural associations including farmers' cooperatives at regional level (BUUD) and village level (KUD) as well as the Bureau of Logistics (Bulog). The bank's total liquid assets stand at Rp.8,005 million at present. The loan condition is based on the monthly interest of 1% with 7-month maturity period under BIMAS program, 3-year repayment period in case of cattle credit and 7-year payment period including 2-year grace period for the construction of on-farm irrigation service facilities.

2.2.3 Cooperatives

Farmers' cooperative system in Indonesia has been strengthened through constant endeavor made by the Government. As a result, many co-operatives composing of BUUD and KUD are in full activity in advanced paddy cultivation areas of Jawa. In the Outer Territory, on the other hand, there seems to be less substantial cooperatives mainly due to the lack of intensive agricultural region, limitation of skillful farmers and a small number of trained staff for administration.

2.2.4 Research

Agricultural research works in Indonesia are undertaken by the Central Research Institute of Agriculture (CRIA) under the control of the Ministry of Agriculture. The research activities are centralized. The Central Research Institute is located at Bogor in Jawa and has three branch stations, one each in West Jawa, South Sulawesi and West Sumatra. Further, three more branch stations will be established in the Central Jawa, East Jawa and South Kalimantan, respectively. The CRIA performs an important function in seed breeding and supports extension services in addition to its original research works.

2.2.5 Extention

The Indonesian Government set up the Agency for Agricultural Education, Training and Extension as one of the extraministerial bureaus under the Ministry of Agriculture when it was reorganized in August, 1974. This agency is building up a smooth and well-oiled organization to attain its aim. For this purpose, the Government plans to increase the number of the Training Center from 5 to 14 and the Agricultural Information Center from 1 to 10, respectively, as national level center getting the finance from the World Bank.

The Agricultural Development Center with an additional function of seed multiplication center will be established at few places. The main activity of this center is considered to be the operation of the provincial experiment and training stations.

There are 335 Rural Exention Centers throughout the whole country. These centers were originally called the Rural Education Center (BPMD) operated since 1950. According to the new extension program, Rural Extension Centers lay emphasis on the training of farmers for water management, fertilizing method, cropping management, better use of agrochemicals and quality control of farm products.

2.2.6 Transmigration

Transmigration to the Outer Territory is proceded with the strong support under the management of the Ministry of Manpower, Transmigration and Cooperatives. The Government provides a budget of Rp.350,000 covering all costs required to each migrated family in case of government transmigration. The total number of farm families migrated from Jawa and Madura recorded 27,000 for the period from 1972 to 1974.

2.2.7 Irrigation

All the planning, designing, construction and administration of the main system, i.e., reservoir, intake, primary and secondary canals, and turnout as well as the rehabilitation of the existing works are the resposibility of the Directorate General of Water Resources Development, the Ministry of Public Works and Electric Power. As for terriary system composing of tertiary canals and on-farm irrigation service facilities, construction, operation and maintenance are carried out by farmers themselves under the control of the Ministry of Agriculture. In this case, the Ministry of Public Works and Electric Power assists in the design and construction supervision of the tertiary system.

2.3 Agricultural Situation in Lampung Province

Lampung Province is located in the southeast and of Sumatra Island. Due to this position close to Jakarta of Jawa Island, it belongs to the same commercial and economic circules of the metropolis. Its whole area covers 33,000 km^2 and the population totals 3.1 million. About 80% of the working population estimated at 0.9 million are engaged in agriculture and fishery.

Although topography widely varies in the province from mountainous areas at elevations 1,500 to 2,000 m above sea level to the low-lying swamps along the coast, most part of the region forms comparatively flat arable plains.

Agriculture in Lampung Province originally had been characterized by the inhabitants' garden farming growing coffee and pepper. After the enforcement of the transmigration schemes in Lampung Province since 1920, the ordinary upland field farming characterized by mixed-cropping of upland paddy and cassava gradually formed the main part of agricultural production. After the First Five-Year Plan in 1969, the governmental irrigation projects* have been realized in Lampung Province which was designated as one of the principal regions for increased paddy production in the Outer Territory. Since then, the irrigation facilities have been increased, keeping pace with the transmigration of the inhabitants from Jawa Island. Furthermore, national and private plantations have recently acquired the concession of the Provincial Agrarian Office for land utilization necessary for growing cash crops on a large scale. In the 1972 crop season, Lampung Province attained the level of producing 2.9% of GDP from its farm land comprising 3.4% of the entire territory of Indonesia.

Although the agricultural production in Lampung Province has attained a considerably successful level as mentioned above, it still is far from meeting the growing domestic demand for staple foodstuff. The reason is that the completion of irrigation system has delayed considerably without being able to keep pace with the promotion of transmigration schemes all over the province. This situation grew worse and the domestic paddy production could not meet the increased provincial demand due to high annual population growth of 5.2% during the period from 1966 to 1971. Accordingly, 17,990 tons of rice in total were transported from Jakarta in 1973.

At present, various institutional supports for agriculture in Lampung Province are being provided. Such supports given and planned under the First and Second Five-Year Plans are as summarized below.

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*The successful implementation of Argoguruh Irrigation Project by Dutch is considered to be reflected in the promotion of these governmental irrigation projects.

(1) All services required for the promotion of settlement is provided by the Provincial Transmigration Office. The following table is made on the basis of data as of 1974 and new transmigrants totaling 36,000 families in the area of 216,000 ha are scheduled for the Second Five-Year Plan.

Region	Existing schemes	Total area (ha)	Total household	Total population
North Lampung	4	57,500	25,659	91,671
Central Lampung	16	156,019	88,292	412,852
South Lampung	5	42,800	12,399	52,770
Lampung Province	25	256,319	126,350	557,293

(2) Planning and design of irrigation system as well as construction operation and maintenance of main facilities are carried out by the DPUTL of Lampung Province. As shown in the following table, the total area for which the original irrigation plan has been carried through is only 25% of the whole.

Progress of works	No. of projects	Total area (ha)	Project financed by Japan
Completed	5	94,047	-
Under construction	2	23,700	Way Jepara
Under design	2	20,600	Way Umpu, Way Pengubuan-I
Under feasibility study	1	65,000	Way Rarem
Under master planning	6	160,400	-
Total	16	363,747	

(3) Other institutional supporting services are rather well organized at provincial level. But its function is still insufficient to provide broad and effective backups for each village throughout the province mainly due to lack of funds and staffs.

The Lampung Tani-makmur Project for which technical assistance was given by the Japanese Government during the period from 1972 to 1977 has created a special feature of the institutional services in the province.

Seed multiplication is carried out by the Department of Agriculture of Lampung Provincial Office. There are two special seed farms mainly for the training of multiplication, and also six seed farms throughout the province for the supply of seeds to the local people.

One of the trial fields under direct control of the CRIA in Bogor is situated at Purbolinggo near the central province. Its main function is to conduct test planting at on-farm level in conformity with CRIA's trial program for both upland and lowland field crops.

The Indonesian Government is now planning to reorganize these agencies mentioned above into the Agricultural Development Center with the function of provincial key station for experiment, training, seed multiplication, extension, etc.

III. THE PROJECT AREA

3.1 Location and Topography

The coverage area of the project is situated in the northeast side of Kotabumi, the capital of North Lampung. The area is located at the east longitude of 104°53' and the south latitude of 4°40'.

The Rarem river forms the western border, the Tulangbawang river, in which the Rarem river merges, forms the northern border, while the eastern border is formed by the road that runs from Menggala near the Tulangbawang river to the Gn. Batin village, the Terusan river and the farm of the Daya Itoh, which is a merger of Itoh Shoji Co., Ltd of Japan and an Indonesian company. The southern border is formed by the railway running from Tandjunkarang, the provincial capital in Lampung through Kotabumi and on to Palenbang, the capital city of the South Sumatra Province.

The whole area is a flat plateau having approximately 18 km width from west to east and 50 km length from south to north, and its total area is about 83,000 ha.

Topographically, the area is hilly, sloping gently from southwest to northwest, and has an elevation of less than 50 m. Small tributaries of the Terusan and Miring rivers run through the area providing the valleys with natural drainage. The area along some of the small rivers, however, is rather swampy.

3.2 Climate

Since the project area lies in the tropics, there is little annual temperature change. The yearly average is about 27°C with almost no seasonal fluctuations. The mean monthly temperatures in the benefited area were taken as follows from the records at Menggala and Bandarjaya.

Table 3-1 Mean Monthly Air Temperature
Period: 1972 ∿ 1974

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
26.6	26.8	27.1	27.7	27.3	26.9	27.1	27.2	26.9	27.4	27.3	27.0	27.1

(Degrees Centigrade)

With the exception of the monsoon wind which is incidental to the tropical climate, no strong wing or typhoon occurs in the area. Applying the records at Menggala to the area, the yearly average is 58 km/day or 0.67 m/sec.

Table 3-2 Mean Monthly Wind Velocity
Period: 1972 ∿ 1974

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
60	54	51	51	52	56	68	68	66	66	53	52	58

(Kilometers per day)

Rainfall clearly divides the climate in the area into the wet and dry seasons. The duration of the wet and dry seasons varies by year and about 70% of the annual rainfall of 2,450 mm at Kotabumi is concentrated in the period of November to April. In this period, the monthly rainfall exceeds 200 mm and more than 10 rainy days are observed each month. Therefore, this period can be called the wet season and the remaining period of the year the dry season as shown in Table 3.3.

As mean monthly rainfall of about 80 mm can be expected even in the dry season, but drought may continue for about 30 days in this season (the maximum continous drought was four months recorded in 1967).

Table 3-3 Mean Monthly Rainfall at Various Observation Station

Station	Period	Wet Season				Dry Season						Wet Season		
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Kotabumi	1918∿1975	347	269	309	249	170	118	98	89	106	148	223	321	2447
Gn. Batin	1973∿1974	273	218	282	214	204	149	58	155	245	172	213	390	2573
Pekurun	1973∿1975	347	421	140	285	156	37	120	165	256	105	253	245	2530
Bk. Kemu	1952∿1974	384	362	419	309	252	118	105	87	88	131	237	370	2862

(Millimeters)

Mean monthly relative duration of sunshine in the benefited area is obtained as in the following table by using the records at Bandarjaya.

Table 3-4 Mean Monthly Relative Duration of Sunshine
Period: 1971 ∿ 1973

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
48	57	53	53	53	54	70	62	53	56	47	39	54

(Percent)

Mean monthly relative humidity is high in general, being about 80% and is characterized by a small seasonal variation such as the air temperature. Such high temperature and humidity provide favorable condition, for the growth of crops. The mean monthly relative humidity is taken as follows from the records at Menggala and Bandarjaya.

Table 3-5 Mean Monthly Relative Humidity
Period: 1971 ∿ 1974

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
81	82	82	83	82	80	77	78	79	77	79	81	80

(Percent)

Evaporation from open water is taken as follows from the observation data at Menggala.

Table 3-6 Mean Monthly Evaporation from Open Water
Period: 1972 ∿ 1974

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
4.8	5.0	5.2	5.2	4.7	4.4	4.8	4.7	4.7	5.2	5.1	5.4	4.9

(Millimeters per day)

3.3 Hydrology

The water sources for the irrigation to the area can be asked for the Rarem river, the small rivers or the groundwater in the area. Actually, however, judging from the results of the geological survey and others, the available value of water table groundwater is not high and the quantity of artesian groundwater is not also expected.

The Rarem river starts from the Tebak mountain (the top elevation: 2115 m) which is located about 40 km in the southwest from Kotabumi city, flows to the northwest while gathering the many tributaries, namely Way Galing, Way Sebuk, Way Abung, Way Tulung Mas and others, and merges in the Tulangbawang river at the place of about 10 km in the downstream from Panaragan village, and the Tulangbawang river reaches to the estuary about 100 km in the downstream from Panaragan.

The total length of the Rarem river is about 154 km and the slope of the river bed is averagely 1/150. When the river is divided into the mountaneous, hilly and flat parts, the length (L) and the average slope (I) of the river bed are as follows.

Mountaneous part (as far as Pekurun): L = 44 km, I = 1/40
Hilly part (as far as Kotabumi): L = 20 km, I = 1/1,000
Flat part (as far as Panaragan): L = 90 km, I = 1/8,000

The proposed dam site is located at Pekurun about 16 km is the southwest from Kotabumi city and its catchment area is 328 km^2. The conservation of the catchment area is managed to the local government except the small part under the Kehutanan office. Since 1969, however, the culting of the tree has been rapidly sprawled and it is said that 70 - 80% of the catchment area has no function as the reserved forest in 1974.

The small rivers in the benefited area are mostly the tributaries of the Turusan river in the Septih river basin.

There are few discharge records of each river as shown in the following tables, and therefore, the design discharges are obliged to be assumed by using the correlations between discharge and rainfall, etc.

The yearly rainfall in the mountaneous part of the catchment area of each river is assumed to be about 2,800 mm from the records at Bk. Kemuning (Refer to Table 3-3) and there is the difference of about 300 m from that in the plain area.

The discharge observation records have been collected in the Lampung Hydrological Network Program (P.3.S.A. office).

Table 3-7 Rarem River Discharge Record at Pekurun
Catchment Area: 328 km^2

(m3/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1971	-	-	-	28.60	17.60	12.90	10.10	7.60	6.80	8.90	19.40	32.10	-
1972	41.80	21.40	33.60	20.30	21.10	11.50	6.70	6.10	4.80	3.73	4.78	7.80	15.30
1973	10.59	13.62	24.64	20.16	19.54	14.48	8.16	7.74	12.59	9.17	12.72	37.26	15.89
1974	15.66	22.50	16.27	21.02	14.64	7.75	7.73	9.00	10.47	11.60	12.54	19.08	14.02

(Note: The data from April, 1971 to September, 1972 were assumed by using the water level records of D.P.U.T.L. at Tanjunkemala)

Table 3-8 Rarem River Discharge Record at Kotabumi

Catchment Area: 913 km²

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1974	44.72	75.45	54.67	61.61	42.26	21.09	18.39	19.59	27.67	31.66	38.98	56.10	40.97

(m³/sec)

Table 3-9 Abung River Discharge Record at Ogan Enam

Catchment Area: 170 km²

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1974	-	-	-	-	-	8.23	5.75	7.19	7.94	8.07	12.02	14.59

(m³/sec)

Table 3-10 Turusan River Discharge Record at Gn. Batin

Catchment area: 543 km²

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1972	-	-	-	-	-	-	-	-	-	0.13	0.71	4.89	-
1973	-	-	-	-	-	-	6.79	5.34	15.06	-	-	-	-
1974	9.47	27.48	33.93	22.67	11.32	2.78	3.89	5.17	9.63	6.99	19.76	31.48	15.38

(m³/sec)

3.4 Water Quality

The results of the water quality tests show that the pH is about 7.5 and the total solids is about 80 ppm. None of the metalic solids were of concentrations considered to be harmful for irrigation purposes. The water is also considered to be reasonable safe as drinking water, although the iron and magnesium concentrations are registered 1.80 and 1.20 ppm respectively.

3.5 Geology

The project area is located in the northeast of the Tebak mountain in the Barisan range. The topography is an undulating plateau becoming gradually lower toward the northeast. Accordingly a large number of small valleys is existed in this direction.

The surface of the undulating plateau is covered with weathered tuff. This weathered tuff is distributed till 1/3 in the south of the benefited area. The thickness of the tuff is some 10 m around the dam site, and being 3 ∿ 4 m in the south of that area. The weathering of soil is considerably progressed, though the permeability is comparatively high, and the colour being yellowish brown. The sedimentary rock of Tertiary deposit is horizontally piled under this layer, and consisting of alternate strate of the tuff, sandstone, clay, shale, pumice, conglomerate. This sedimentary rock is only outcroped partially on the bottom of valleys in the dam site and main canal, but the Tertiary deposit being outcroped at 2/3 of the north in the benefited area. The outcroped Tertiary deposit in that area consists mostly of clay layer, and sand being found in small part. The clay layer is weathered volcanic ash in grayish white colour, and its permeability being low. Andesite and volcanic breccia are laid under the Tertiary deposit, and these are slightly exposured thereabout in the dam site, no outcrop being found in the benefited area.

The thickness of Alluvial deposit on the Rarem river is 8.0 ∿ 9.0 m in the dam site. The tuff is existed under this deposit, and becoming as bed rock of the dam. The permeability is fairly high. Firm volcanic breccia having low permeability is exposured at the right side of the dam site. Rock and aggregate as material are yielded adjacent to the dam site.

3.6 Soils and Land Classification

3.6.1 Soils

In accordance with the classification criteria* on soils in tropical and subtropical regions prepared by Dr. P. Buringh, the soils in the Project area are broadly classified into three groups, i.e, Ferrallitic soil group, Tropical Podzolic soil group and Tropical Alluvial soil group. Outlines of these soil characteristics are summarized below and the details are presented in the Study Report.

(1) In the Project area, Ferrallitic soil group is represented by Lateritic soils covering an area of 19,300 ha. Hillside of plateau facing small rivers is dotted with these soils. The soils are also observed in the natural forest existing on some parts of the plateau. The soils have very deep layer of weathered red clay, but lack in weatherable minerals. The pH values show strongly to very strong acid. Additionally, the high phosphate fixation causes the infertility.

(2) Tropical Podzolic soil group extending over 39,00 ha of grasslands and upland fields in the Project area is further subdivided into Red Podzolic soils and Yellow Podzolic soils. The former originates from weathered volcanic tuff often with quartz and the latter from tertiary soils. Both soils are featured by a well developed argillaceous layer, i.e., surface horizon is much lower in clay content and much higher in sand portion and then clay accumulates in the second layer as argillaceous horizon. As a result, the surface soils are very permeable, but the soils of second layer are fairly impermeable, so that these soils have moderately deep effective soil depth. Below the upper part of the second layer, iron oxides are abundantly redistributed by the effect of seasonal fluctuation of

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* ; Dr. P. Buringh, in his report titled "Introduction to the study of soils in tropical and subtropical regions" and revised in 1970, sets up the soil classification criteria on tropical and subtropical soils on the basis of terminology and concepts explained in the Soil Survey Manual (1951) and the Comprehensive System of Soil Classification (1960 to 1967) both prepared by the United States Department of Agriculture (USDA).

groundwater table. The pH value shows medium to strongly acid throughout the soil profile. Although these soils have rather high base saturation due to small cation exchange capacity, fertility still remains at a very low level due to poor content of weatherable minerals.

(3) Tropical Alluvial soil group is too young deposits observed in low-elevated strips of 1,200 ha along the small river in the Project area. The young soils deposited at the transition from the plateau to a small valley bottom during short periods of heavy discharge by rainfall are almost permanently wet, and the effective soil depth is moderately thick. Since the deposits consist of base-leached materials of fine texture and grayish to gray colour, soil fertility is very poor. Furthermore, the pH values show very strong to extremely acid.

3.6.2 Land classification

So far as land capability is concerned, the Project area is classified into four classes in accordance with the modified classification standard of the United States Bureau of Reclamation Manual of Irrigated Land Use. The lands of Classes I, II and III are suitable for irrigation farming from the economical viewpoints. The lands of classes IV and VI are marginally suitable and economically not suitable, respectively, for irrigation farming. The following table presents the summary of land classification.

Land grade	Area (ha)	Proportional extent (%)
Class	22,000	36.6
Class III	6,000	10.0
Class IV	10,000	16.7
Class Vi	14,700	24.5
Right of way	7,300	12.2
Total	60,000	100.0

3.7 Socio-economic Situation

3.7.1 Administration

The administrative district that controls the Project area was switched from the county offices of Negeri Abung and Negeri Tulang Bawang to the special executing offices of Way Abung I and II Transmigration Schemes before the first settlement in 1965. Since then, both local offices within the jurisdiction of Lampung Provincial Transmigration Office have promoted both Way Abung I and II Transmigration Schemes getting the support of foodstuff supply for settlement construction from the World Food Program. Under the two local offices, there are 21 villages of Unit Desa in the Project area.

3.7.2 Population

The population data for 1974 were obtained from the prefectural office of North Lampung and both local offices. The total population in the Project area is approximately 60,000. The number of households is about 12,600, comprising 3,000 of governmental transmigrants and 9,600 of spontaneous transmigrants. All farmers live in the settlements situated along the main road running on the ridges of plateaus.

3.7.3 Transportation network

Transport facilities from the Project area to Kotabumi, the prefectural consuming center, and to Pandjang, the provincial domestic port, are adequate. A narrow-gauge railway system traverses the Lampung Province and the southern edge of the Project area, connecting with Pandjang.

The Project area is served by a two-lane bituminous paved highway running parallel with the railway and the two branch roads, the Terbanggi Besar - Menggala - Panagalan road adjacent to northeastern and northern part of the Project area and the Kotabumi - Bumi Agung - Panagalan road running through the eastern edge of the Project area along the Rarem River. These roads are managed by the Provincial Road Administration. The improvement of the abovementioned highway is now in progress as a part of the Trans Sumatra Highway Project. Interior roads within the

Project area consist of earth roads and gravel roads 10 to 18 m wide with a total length of 215 km. The interior roads, even the main route connecting with both of the aforesaid branch roads, are essentially impassable to motor traffic during the wet season and also after heavy rains in the dry season.

3.7.4 Domestic Water Supply

Shallow surface wells are the usual sources of domestic water especially for drinking. The water level of these wells is characterized by the seasonal fluctuation between 1 to 2 m below the groundsurface in the wet season and 8 to 12 m below the groundsurface in the dry season. The streams are used for bathing and washing as well as for hygienic purposes, fish culture and watering of animals. In the dry season, when stream flows are low, the concentration of polluted materials poses serious inherent dangers to the general health of the people in the Project area.

3.7.5 Other public services

There is no electrical and telecommunication services in the Project area. Mail services are carried on at three post offices. Health and medical facilities for people are insufficient. There are no doctors available in the Project area, and nurses provide general medical services and assistance during childbearing at three clinics.

3.8 Present Status of Agriculture

3.8.1 Land tenure, use and distribution

Out of 83,000 ha mentioned in the original plan of the Government, the Provincial Agrarian Office already endowed two private plantations with land concession of 11,500 ha in total. Beisdes, there are also 11,500 ha of miscellaneous areas such as residential districts around Kotabumi and along the highway, detached areas due to the existence of the said concession areas, etc. Present condition of land use in the remaining 60,000 ha was investigated. The results show that the surveyed area comprises 15,700 ha of upland field, 100 ha of lowland

paddy field, 1,000 ha of perennial crop field, 17,500 ha of grass land, 17,300 ha of forest, 1,100 ha of swamp and 7,300 ha of villages including public yards.

Each farm family settled in the Project area through the Way Abung I and II Transmigration Schemes is allocated 2.0 ha, consisting of 1.0 ha to be irrigated, 0.75 ha of upland and 0.25 ha of garden as well as homestie. For the delay of construction planning concerning irrigation water supply system and also the shortage of family labor force, most transmigrants operate rain-fed farming on half of their farm lands of 1.75 ha and abandon the rest as grass land covered with alang-alang.

3.8.2 Cropping pattern

Typically, the farm lands are cultivated with rain-fed upland paddy in the wet season. Around two months before harvesting upland paddy, cassava is mix-planted on the same field. In addition, combined cropping of maize in the wet season and groundnut as well as green bean in the dry season generally prevails in the Project area. Average cropping share of the typical pattern is formed of 0.51 ha for mixed-planting of upland paddy and cassava, 0.11 has for single cropping of upland paddy, 0.06 ha for maize, 0.03 ha for groundnut and 0.02 ha for green bean.

Transmigrants having settlement history of more than five years usually grow coconut, banana, coffee, pepper, clove and other perennial cash crops in their gardens, the area of which totals 0.11 ha on an average.

3.8.3 Farming practices

Farming practice based on mixed-cropping of upland paddy and cassava most commonly used in the Project area is very simple, and most part of farm operation is relying on manual power, and very little animal power is used. In general, labor requirement for the farming is met by family labor. At peak time of farm operation which occurs in September and October, farmers use their children for harvesting and, if the family labor force is insufficient, they hire additional laborers from other families within the village paying them in kind as wages. Anyway, the quality of farm operation is largely affected by the shortage of available labor force in the whole Project area during

the above peak time. Although lowland paddy is being cultivated in swamps of 100 ha only, no irrigation, even well water pumping irrigation, can be observed at all in the entire Project area.

Land preparation starts on upland paddy field in the middle of October. After first application of fertilizer, seeds are dropped into small holes drilled with wooden bar when moisture content in surface soils is sufficient for germination after getting three or four plentiful rains at the beginning of wet season. Weeding is done by hoe and sickle once or twice. Plant protection is not commonly carried out. Seedlings of cassava are planted between furrows on upland paddy fields around the beginning of January. Well-known feature of paddy harvesting is to cut panicle alone with a small knife called "Ani-ani" during the period from the end of March to mid-April. Cassava is usually harvested by hand from the middle of August to the beginning of September.

3.8.4 Use of inputs

Normally both seeds and seedlings required are procured by farmers themselves at the rate of 25 to 30 kg/ha for upland paddy, 20 kg/ha for maize, 60 to 70 kg/ha for groundnut and 20 to 25 kg/ha for green bean, and 6,700 or 10,000 seedlings/ha for cassava.

Applications of chemical fertilizers, lime, manure and agrochemicals hardly prevail in the Project area. In some cases of upland paddy cultivation carried out by settlers having experiences of more than five years sfter migration, approximately 30 to 40 kg/ha of urea and triple superphosphate in total are used on upland paddy fields.

3.8.5 Livestock

About 400 head of cattle and buffaloes as well as 80,000 ducks and fowls are raised in the Project area. The number of cattle has stepwise increased year by year due to prevailing cow subsidy system established by the Government. Livestock products are mostly used for home consumption.

3.8.6 Yield and production

Crop yield in the Project area mostly depends on the amount and distribution of rainfall during the wet season. Another unfavorable factor is the soil condition. Upland crop cultivation in the Project area relies on the poor natural fertility of the virgin soil, and the soil fertility is readily lost by cultivaton since no countermeasures whatsoever have been taken for soil conservation. Moreover, strong soil acidity in addition to reduced soil fertility begins to show harmful effect on crop yield, especially maize and then upland paddy, only after a several years from the initial settlement.

In the light of official data and the results of farm survey, an average yield and total production of upland field crops in the Project area are summarized in the following table.

Crop	Season	Crop area (ha)	Yield (ton/ha)	Production (ton)
Upland paddy	wet	7,800	1.2	9,360
Maize	wet	700	0.4	280
Cassava	dry	6,400	12.8	81,920
Groundnut	dry	400	0.6	240
Green bean	dry	300	0.6	180

3.8.7 Market and price

After drying harvested paddy by exposure to the sun, threshing is mainly done by hand beating on a straw mat. Cassava, as an important cash crop in the Project area, is collected directly from each farmer by the village farmers' cooperatives or brokers having their bases in Telukbetung, the provincial consuming center. Most of upland paddy, maize, groundnut and green bean produced are consumed by the farmers themselves and some parts are sold on local markets.

Farm gate prices of farm inputs and outputs have been taken into consideration on the basis of the official data obtained through the farm survey. As of the end of 1974, the price per kg was Rp.55, 40, 5, 230 and 170 for upland paddy, maize, fresh cassava, groundnut and green bean, respectively.

3.8.8 Farm income

There seems to be a slight difference in the cultivated area of each farm in the Project area, although farmers with longer experience in the settlement naturally have better chances of cultivating more land than an average farmer.

The average annual farm income and outgo per family in the Project area estimated from the results of the farm survey and the official information are as shown below by Rupiah.

A.	Gross income	116,400
	(Farm income	99,400)
	(Non-farm income	17,000)
B.	Gross outgo	16,500
	(Farm expenses	13,300)
	(Taxes	3,200)
C.	Net farm income (A-B)	99,900
D.	Living expenses	95,900
E.	Net revenue (D-C)	4,000

3.8.9 Agricultural supporting services

A foundation for providing agricultural guidance to settlers in the Project area has been established by the Prefectural Agricultural Office, and it is propagated as standard cropping calendar through the special executing offices of Way Abung I and II Transmigration Schemes.

In the above executive offices, a total of seven extension workers makes their efforts to train the leading farmers at seven demonstration plots for the guidance of improved farming practices upon such crop cultivation as maize, groundnut, soybean and onion.

There are three branch offices of BRI in the Project area for providing farm credit. However, the banks' activities are still nearly at a standstill because most farmers cannot easily utilize any service of BRI for lack of loan repayability arising from very poor agricultural production.

Village farmers' cooperatives principally serve drying and processing facilities of cassava and also function as collector of cassava in the Project area.

IV. THE PROJECT

4.1 Outline of the Project

The main purposes of the Way Rarem Irrigation Project are to increase the yield for food products and to realize an economical stability in the area, and to encourage the transmigration scheme of this country by implementing an irrigation project for the paddy cropping in the area.

The coverage area of the project is located in the northeast side of Kotabumi, the capital of North Lampung region. The project area is 46,000 ha which mainly consists of the transmigration area. The settlement of transmigrants has made progress on schedule and has been almost completed.

At present, about 12,600 households have settled in the area, but at full development, 16,000 households are planned to be settled. Each household is alloted 1.25 ha of paddy field, 0.50 ha of upland crop field, and 0.25 ha for homestead, etc., making a total of 2.00 ha.

In all, a total of 20,000 ha of paddy field and 8,000 ha of upland crop field will be provided. The wet season paddy will be cultivated in 20,000 ha of land among which 5,000 ha will be used for the second paddy cropping in the dry season. The second cropping on the remaining 15,000 ha during the dry season will be given over to soybean and green manure. The 8,000 ha upland field will be used for the cropping of leguminous forage and coffee.

The intake facility for the irrigation to the area will be the Rarem Dam of 23.70 m in height which is proposed at the place about 460 m downstream from the confluence of the Rarem river and the Galing river in the vicinity of the Pekurun village. Irrigation water will be led through 65 Km of main canal and 152 km of secondary canal.

The construction period will last 6 years, with the project target being reached within 10 years. The total project cost amounts to US$59,000,000. Construction materials unavailable locally, construction equipment and engineering costs will be covered by overseas loans. The portion of domestic to foreign capital is about 50-50.

The inclemental net value of about US$10,506,000 for a year will be produced with the implementation of the project and its economic evaluation is estimated that the internal rate of return is 13.6%.

The plan of city water supply to Kotabumi was decided to be excluded from the present feasibility study because the plan has been separately studied.

In this chapter, the engineering study, the project cost estimate and others are described, while the agricultural development is described in the next chapter.

4.2 Development Concept

4.2.1 General

The water source for the irrigation to the area could be asked for the Rarem river, the small rivers or the groundwater in the area. Actually, however, the available value of the groundwater is not high and the irrigation plan by the small irrigation tanks in the area is not so effective to cover such a big area as in this project from technical and economical points of view. Therefore, the water source is asked for the Rarem river.

The intake method from the Rarem river is generally divided into two systems, namely, the gravity irrigation by dam facility and the pumping-up irrigation by a large scale pump station. As a result of comparison, however, the former is more economically feasible. (Refer to Table 4-3 and 8.2 of the Study Report).

It would not be acceptable to connect the Project with other rivers in the neighbourhood by the basin transfer plans such as from the Way Besai through the Way Abung to the Way Rarem at this stage because these rivers have respectively the irrigation plans.

4.2.2 Planning of the water source

As a result of study, the dam site was proposed about 460 m in the downstream of the confluence of the Rarem river and the Galing river.

The catchment area at this point is 328 Km^2 which mainly consists of 195 Km^2 for the Rarem river and 133 Km^2 for the Galing river. The monthly discharge of the 1 in 5 year probability at the point was obtained as in the following table by using the correlation between the river discharge records at Pekurun and the rainfall records at Bekitkemuning, etc.

Table 4-1 Monthly Discharge of 1/5 Year Probability

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
16.5	21.5	25.0	21.0	15.0	9.8	7.4	6.8	6.2	5.8	8.8	14.5	158.3

(m^3/sec).

Therefore, there is the river discharge of 416 x $10^6 m^3$ for a year on the basis of the 1 in 5 year probability, which means 1,268 mm of the yearly rainfall in the catchment area flows into the river.

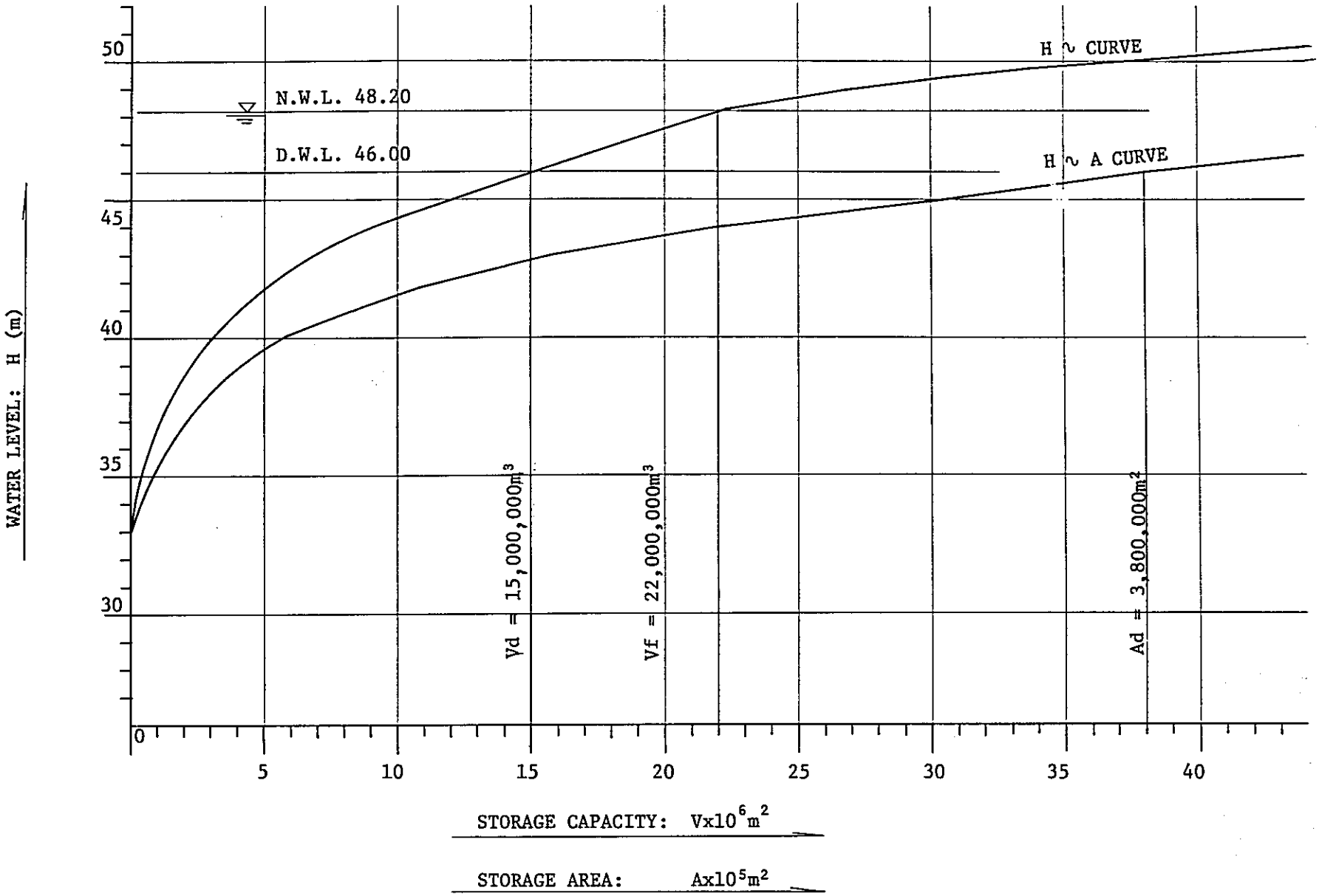
The flood discharge on a 1,000 year probability basis was calculated to be 1,300 m^3/sec, this being the value used for the design of spillway, etc.

The elevation of the river bed at the proposed dam site is 33 m, while the ground elevation in the benefited area is around 40 m at the nearest place to the proposed dam site and the canal length between both places is about 33 Km. Therefore, the intake facility naturally becomes a dam structure. (hereinafter referred to as the Rarem dam).

The water level - storage capacity and water surface area curves of the Rarem dam are shown in Fig. 4-1. Taking the dam's economical useful life as 60 years, the dead water volume will be about 15,000,000 m^3 and its elevation about 46.0 m. Therefore, the bed elevation of the intake should be at least 46.0 m and the lowest intake water level will be put at about 48.0 m, after taking the elevation of the benefited area into consideration, too.

Fig. 4-1 WATER LEVEL, STORAGE CAPACITY AND SURFACE AREA CURVE

(H ~ V.A CURVE)



On the other hand, the discharge records at Pekurun show big daily and monthly fluctuations in the river discharge and it is said that much of the forest in the catchment area has been cleared recently. Therefore, it is desirable that the Rarem dam is assured by the regulating function to stabilize the irrigation because the storage surface area of the dam is large.

After considering the safety of the gate operation and the bearing capacity of the dam foundation, a combined dam type is taken to be rather dangerous and therefore, the spillway of the dam was decided to be the overflow type. The total of this overflow depth and the freeboard of the dam require about 4.5 m, and the top elevation of the dam is decided by summing up the planned intake water level, regulating water depth, overflow depth of the spillway and the freeboard.

If planning intake water level, that is, the top elevation of the dam is raised, the irrigation water can be conveyed to the higher benefited areas, and if the intake water level is kept fixed and the effective water depth, that is, the effective storage volume is increased, it will be possible to increase the irrigation area.

Actually, however, the elevation and shape of the both banks at the proposed dam site limits the maximum top elevation of the dam to be about 58.0 m, which means a maximum planning full water elevation of about 53.5 m.

4.2.3 Irrigation plan

The irrigated paddy is proposed for the main crop in the project area and the block system which divides the irrigation area into 4 or 5 was adopted because of the big irrigation area and the rotation system in the dry season.

As a result of the comparative study on the various cropping patterns, the following pattern which is taken as the most available one from the viewpoints of labor availability, farming practice, peak intake discharge, yearly diversion requirement, fluctuation of the dam water level and others. The unit diversion requirement of each block and it's average are also shown in the following table.

Table 4-2 Cropping Pattern and Unit Diversion Requirement

Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sep.	Oct.
Pattern												
Type 1					1.25					0.75		
2					1.25					0.50		
3					1.25							
4					1.25							
Diversion Requirement												
Type 1	0.067	0.641	0.822	0.775	0.453	0.278	0.152	1.897	1.461	1.469	1.222	0.169
2	0.006	0.350	0.977	0.758	0.519	0.433	0.091	1.856	1.480	1.484	1.325	0.281
3		0.119	0.909	0.520	0.575	0.586	0.185					
4		0.029	0.607	1.129	0.615	0.715	0.366	0.009				
Average	0.018	0.285	0.829	0.796	0.540	0.503	0.094	1.881	1.469	1.475	1.263	0.214

(ℓ/sec/ha)

The main canal from the intake of the Rarem dam to the benefited area, first runs through about 24 Km of the undulating plateaus and then crosses the railway near Candimas village which is about 6 Km east of Kotabumi. The area near the railway is the higher part with the ground elevation of about 50.0 m. The elevation of the ground from the higher part to the end of the Propau area which is the trans-migration area for air force falls from 55.0 m to 35.0 m in the distance of 12 Km and at the slope of 1/800. The canal runs for another 29 Km of the proposed route with the flat elevation from 35.0 m to 32.0 m to the northern direction. The ground elevation in the rest of the project area tends to rise again in the northern parts.

Therefore, most of the main canal in the benefited area become the canal of bank type. The determination of the planning water level in the main canal at both upstream and downstream edges in the benefited area to make the height of the embankment small is one of the major factors to decide the project scale, that is, the location and acreage of the benefited area, the height of the Rarem dam and others.

4.2.4 Optimum scale of the Project

The Rarem dam has the strong function to assure the intake water level to draw water to the benefited area. The net irrigable area without the regulating function, that is, as a headwork, is estimated approximately 19,000 ha. However, it is found that the assurance of a little of the regulation function to the Rarem dam is effective to make the taking of water stable as described in the following.

The highest intake water level possible for the Rarem dam is 53.50 m and therefore, the upstream edge of the benefited area may come up to about 45.00 m. However, since the elevation of most of the objective area is below 35.00 m, there is no particular advantage gained by increasing the height of the planning intake water level, that is, the dam height without the regulating function.

Therefore, it was decided to make the planning intake water level of the Rarem dam about 48.00, and to equip it with the regulating function, and to determine the optimum full water elevation and dam height.

In this case, the surveyed area, 60,000 ha is classified as in the following on the premise of the paddy cropping under gravity irrigation.

(1)	Class II, and III (Irrigable and arable land)	28,000 ha.
(2)	Class IV (Irrigable, but limited arable land)	10,000 ha.
(3)	Class VI. (Non-irrigable)	14,000 ha.
(4)	Village and public yard	7,300 ha.
	Total	60,000 ha.

This gives a total of 38,000 ha of irrigable land. However, if the public yard and the land necessary on farm work, etc., are excluded, the irrigable area in classes II and III will be reduced by 20% and that in class IV by 30%, leaving a net irrigable area of 29,400 ha. Besides, taking it into consideration that the class IV includes the steep land along the small rivers in the area, a more realistic net irrigable area will be decided between 19,000 ha and 25,000 ha.

A comparative study was carried out when assuming the net irrigation area at 20,000 ha or 25,000 ha. The result is as follows. Futher, the result of the irrigation plan by pumping up from the Rarem river near Kotabumi city in case of 20,000 ha is shown as Case III.

Table 4-3 Result of Comparative Study on Net Irrigation Area

Item	Case I	Case II	Case III
Wet season paddy field	20,000 ha	25,000 ha	20,000 ha
Dry season paddy field	5,000 ha	6,000 ha	10,000 ha
Top elevation of Dam	EL52.70 m	EL55.00 m	-
Full water elevation	EL48.20 m	EL50.50 m	-
Dam height	23.70 m	26.00 m	-
Effective storage volume	7 x 10^6 m^3	25.8 x 10^6 m^3	-
Total head			30.0 m
Annual cost	US$2,087,000	US$2,711,000	US$4,369,000
Annual benefit	US$6,115,000	US$7,533,000	US$8,341,000
B/C (Discount rate 5%)	2.93	2.78	1.91
Project cost	US$59,000,000	US$78,000,000	US$79,000,000

In case of the net irrigation area of 25,000 ha, the ratio of the yearly diversion discharge to the yearly river discharge on the basis of the 1 in 5 year probability becomes about 80% and this value is considered to be excessive as an irrigation plan. Further, the transmigration scheme to the project area is scheduled to be completed by the end of 1975/76 fiscal year and therefore, the increase of the population in the area is estimated on the basis of the natural increase in the future.

Consequently, the net irrigation area of 20,000 ha was selected as the optimum project scale from the viewpoints of land condition, water resources, population, economical consideration and others, and the irrigation system is decided the gravity system due to the Rarem dam with the height of 23.70 m. The project area was decided as follows:

(1)	Total area of paddy field	20,000 ha
(2)	Total area of upland crop field	8,000 ha
(3)	Total area of homestead, etc.	4,000 ha
(4)	Public yard, river course, steep land, etc.	14,000 ha
	Total	46,000 ha

In order to extend the net irrigation area to 25,000 ha in future, it is necessary to heighten the dam, enlarge the canal width and in advance establish the longitudinal plan of the main canal in anticipation of the allowance of head losses at the Syphons. Actually, however, the rehabilitation works are difficult to construct from technical point of view and it would be better to ask the other water source for the small rivers in the benefited area due to irrigation tank or pumping up because most of 5,000 ha extended, are located at the lower parts along the small rivers.

4.2.5 Water balance

Table 4-4 shows the calculation on the water balance of the Rarem dam when the net irrigation area is 20,000 ha. The ratio of the yearly diversion discharge to the yearly river discharge on the basis of the 1 in 5 year probability is about 60%. (The ratio in case of the irrigation area of 25,000 ha is about 80%). The amount of paddy field available for the dry season is calculated to be 4,700 ha but, the planning paddy field area for the dry season was decided to be 5,000 ha.

Table 4-4

Water Balance of the Rarem Dam

Net irrigable area

wet season : 20,000 ha.

dry season : 4,700 ha.

Elevation of full water surface: 48.20 m

Planned intake water level : 47.72 m

Bed elevation of canal : 46.00 m

Month	Diversion requirement				River Discharge	Water Loss								B-(A+C)	Storage Capacity	Water level of the Dam
						Evaporation			Leakage		River maintaining flow		EQ			
	qd	q	W.L	A	B	W.A	q1	Q1	q2	Q2	q3	Q3	C			
	ℓ/S/ha	m^3/S	m	10^3m^3/month	10^3m^3/month	Km^2	10^3m^3/month/Km^2	10^3m^3/month	m^3/day	10^3m^3/month	m^3/day	10^3m^3/month	10^3m^3/month	10^3m^3/month	10^3m^3	m
Nov.	0.018	0.36	46.18	933	22,810	5.88	154.20	907	11,000	330	17,280	518	1,755	20,122	22,000	48.20
Dec.	0.285	5.70	46.93	15,267	38,837	"	167.40	984	"	341	"	536	1,861	21,709	"	"
Jan.	0.829	16.57	47.72	44,409	44,194	"	149.42	879	"	"	"	536	1,756	- 1,971	20,029	47.50
Feb.	0.796	15.92	47.68	38,514	52,013	5.20	139.44	725	10,015	280	"	484	1,489	12,010	22,000	48.20
Mar.	0.540	10.80	47.35	28,927	66,960	5.88	160.58	944	11,000	341	"	536	1,821	36,212	"	"
Apr.	0.503	10.06	47.30	26,075	54,432	"	156,30	919	"	330	"	518	1,767	26,590	"	"
May	0.157 0.094	3.14 0.44	46.71	8,410 1,178	40,176	"	146.63	862	"	341	"	536	1,739	28,849	"	"
Jun.	0.002 1.881	0.04 8.84	47.20	104 22,913	25,402	"	133.20	783	"	330	"	518	1,631	754	"	"
Jul.	1.469	6.90	47.04	18,481	19,802	"	147.25	866	"	341	"	536	1,743	- 422	21,578	48.00
Aug.	1.475	6.93	47.04	18,561	18,213	5.70	146.63	836	10,789	334	"	536	1,706	- 2,054	19,524	47.40
Sep.	1.263	5.94	46.90	15,396	16,070	5.10	139.80	713	9,762	293	"	518	1,524	- 850	18,674	47.10
Oct.	0.214	1.01	46.33	2,705	15,535	4.86	162.44	789	9,337	289	"	536	1,614	11,216	22,000	48.20

4.3 Project Facilities

As being afore-mentioned, the optimum scale of the project entails a total project area of 46,000 ha, 20,000 ha of which is used for the paddy field in the wet season and 5,000 ha in the dry season.

Agricultural development in the project area is described in the next chapter. The diagram of the irrigation water distribution system and the plans of the main structures are attached as drawings in this report.

The scale of each of the irrigation facilities is listed up as follows.

4.3.1 Rarem dam

Division	Item	Dimension
General	Name of river	Way Rarem
	Location	Pekurun
	Dam type	Center core type rockfill dam
	Foundation	Tuff, tuff-breceia, claystone, pumice-tuff
Reservoir	Catchment area	328 Km^2
	Top elevation of Dam	El 52.70 m
	Full water elevation	El 48.20 m
	High water elevation	El 50.70 m
	Dead water elevation	EL 46.00 m
	Dam height	23.70 m
	Dam length	650.00 m
	Top width	8.00 m
	Freeboard	2.00 m
	Total storage	22 x $10^6 m^3$
	Effective storage	7 x $10^6 m^3$
	Dead water volume	15 x $10^6 m^3$
	Full water area	5.9 Km^2
	Dam Body	430,000 m^3

Division	Item	Dimension
Spillway	Type	Overflow chute type
	Designed flood discharge	1,300 m^3/S
	Overflow depth	2.50 m
	Crest length	153.00 m
	Type of dissipator	Stilling basin III
Temporary diversion channel	Type	Diversion tunnel, standard horseshoe type
	Designed flood discharge	600 m^3/S
	Total length of channel	780.80 m
	Length of tunnel	333.20 m
	Diameter	7.0 m
	Flow type	Free flow
Intake	Gate type	Sluice gate
	Designed intake water level	EL 47.72 m
	Peak intake discharge	16.57 m^3/S
	Yearly intake discharge	255 x $10^6 m^3$
Construction	Construction period	4 years
	Yearly workable day	166 days
	Daily standard construction volume	1,240 m^3

4.3.2 Canal

The canal in the paddy field is proposed to be dual-purpose canal since the small rivers and streams form natural drainage within the area. The drainage canal, however, is required from the end of field canals to these rivers and streams.

Division	Item	Scale
Main canal	Total length	64,865 m
	Breakdown of total length	
	Earth canal	62,515 m
	Syphon (7 places)	2,250 m
	Culvert (2 places)	100 m
	Designed discharge	16.57 - 3.44 m^3/S
	Max. velocity for earth canal	0.60 m/S
	Diversion structure	16 places
	Cross Bridge	29 places
	Diversion work	14 places
	Turn out	4 places
	Cross drain	40 places
	Waste way & spillway	10 places
Secondary canal	Total length	152,460 m
	Max. discharge	4.42 m^3/S
	Cross bridge	300 places
	Turn out	150 places

4.3.3 Paddy Fields

Item	Scale
Wet season paddy field	20,000 ha
Dry season paddy field	5,000 ha
Standard plot	100 m x 50 m
Tertiary canal	26 m/ha
Field canal	52 m/ha
Branch road (5 m width)	69 m/ha
Farm road (3 m width)	35 m/ha
Border	227 m/ha

Moreover, the road rehabilitation work of about 60 Km in the benefited area in order to transport the project inputs and outputs, the construction of offices, quarters and two pilot farms of which each scale is about 40 ha, are proposed in the project work.

4.4 Construction Schedule

4.4.1 General

The construction period is expected to require 6 years, considering the scale of the construction, equipment and labor required. In the first year (1977), surveys, designs, temporary work and the construction of offices and quarters will be started. In the second year, work will commence on the dam and main canal. In the final year (1982), it is expected that up to 80% of the project area will be irrigated in the dry season.

The number of workable days per year will be around in the 166 to 232 days range. These figures were calculated from the daily rainfall records at Kotabumi and vary in accordance with the type of work.

4.4.2 Construction of the Rarem dam

The Rarem dam is decided to be a rockfill dam of center core type, and it's dam body is estimated 430,000 m^3, and the total storage is 22,000,000 m^3. The work will commence the temporary work (for a period of 16 months) in the second year and in the third year, the constructions of the dam body (period: 26 months) and the spillway (period: 23 months) are planned to start, and in the fifth year the construction of the intake (period: 9 months) is expected to start. The net construction period for the dam work is estimated 4 years.

The weathered tuff which is broadly distributed near the proposed dam site is used for the core materials of the embarkment and the andesite at the Bukit Butong mountain located about 5 Km up stream from the dam site on the left side of the Galing river is used for the rock materials. The loose rock during the excavation by the bench cut is used for the transition materials.

4.4.3 Construction of the Main Canal

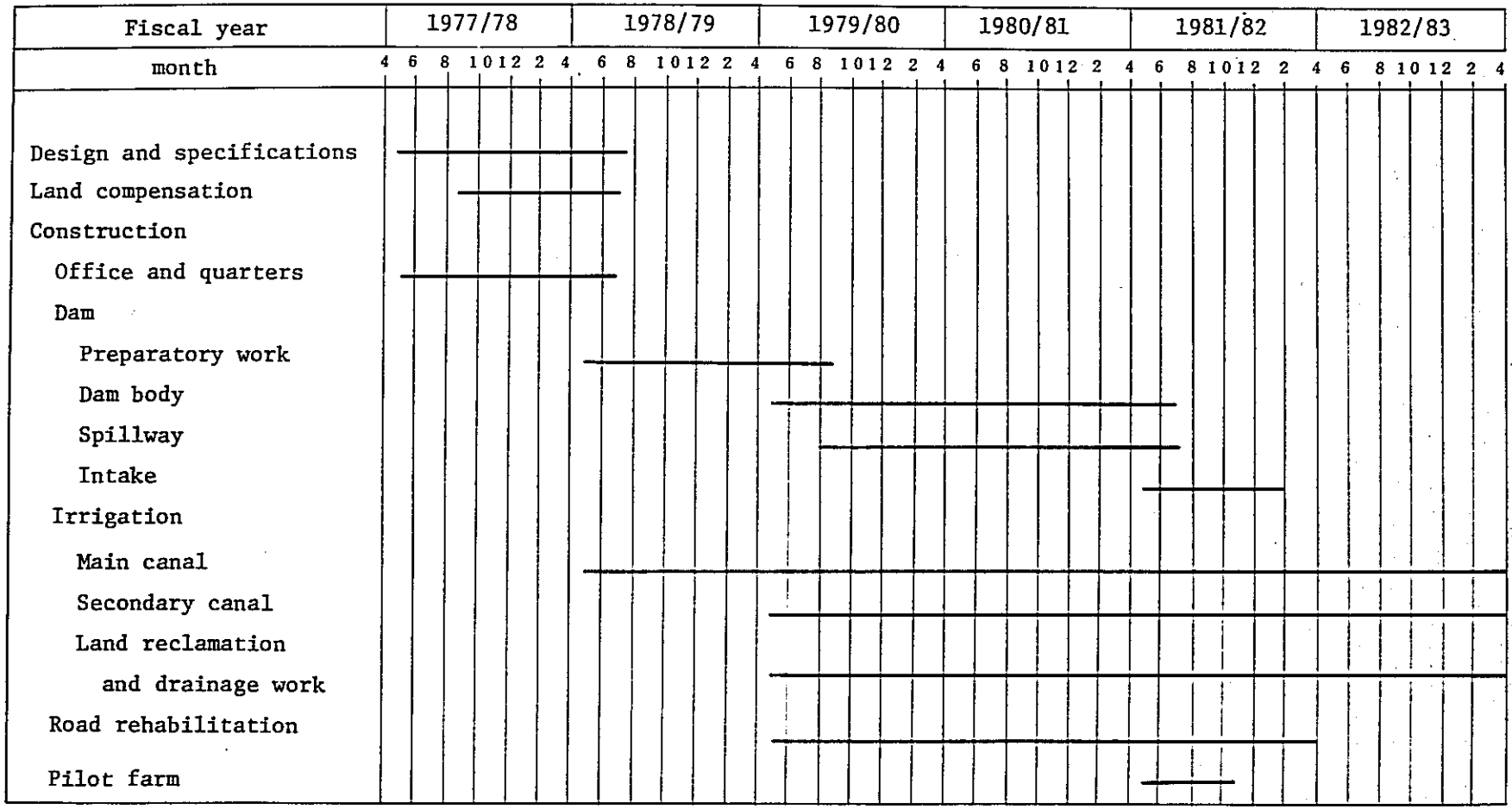
From the economical point of view earth canal is mostly planned for the main canal and also the construction period can be shorten. The total length of the main canal is about 65.0 km and its planning discharge range from 16.57 m^3/sec to 3.44 m^3/sec.

The construction is proposed to be carried out mainly by equipment and at four job sites from the economical viewpoint and the scale of the construction volume.

The volume of excavation is estimated about 4,500,000 m^3 and that of embankment about 31,000 m^3 for the length of 33 km in the upstream part. Therefore, the disposal of the surplus soil is one of the problems in the upstream part.

On the contrary, in the downstream part for about 32 km, the volume of excavation and embankment is estimated 500,000 m^3 and 3,400,000 m^3 respectively. The selection of the borrow pits, therefore, becomes one of the indispensable study items in the downstream part.

Fig. 4-2 Construction Schedule



4.5 Project Cost

4.5.1 General

The project cost described here is the total of all expenses to be in curred in the implementation of the project selected on the basis of the afore-mentioned optimization. The project cost is estimated by the systems that the construction will be carried out by local contractors and the construction equipment is lent to the contractors by the Government of Indonesia. Further, the estimation by the international contract system including a foreign constructor (the construction equipment is supplied by the contractor) is attached is attached. (Refer to the Note of 4.5.2).

The object of a loan shall include the construction equipments, materials to be not obtained locally and engineering costs, Regarding the costs required for the procurement of these equipment and materials, and the engineering services to be paid in foreign currency, the standard prices in Japan in October, 1975 are adapted including the transportation expenses. The labor and material costs to be locally procured are based on the standard prices at Kotabumi city in August, 1975 as shown in Table 4-5.

The construction costs for preparatory work, road rehabilitation, office and quarters and pilot farm, and land compensation expenses are all estimated in local currency. The materials for the construction of other main civil works except the above works are supplied by the following portion.

The materials to be locally purchased are fuel and lubricants for construction machinery, cement for the works of secondary canal, masonry and mortar facing, round reinforcement bar for the work of secondary canal, sand, gravel, stone, timber, log, dynamite, ANFO, nail wire, sod, concrete pipe for underdrain, small gate, core box, etc.

The imported materials are the cement and round reinforcement bar except the above local works, deformed reinforcement bar, admixture, metal form and consumables (pipe, cramp, joint, formtie, etc.), miscellaneous articles for excavating and crushing rock including tunnel work (cap, fuse, bits rods, winch, muck, trally,

Table 4-5 Standard Unit Cost

Item	Unit	Price
		Rp
Common labourer	Man day	375
Skilled labourer A	"	500
Skilled labourer B	"	450
Foreman	"	450
Operator	"	600
Assistant	"	450
Driver	"	500
Helper	"	375
Earth worker	"	375
Explosive keeper	"	600
Miner	"	600
Black smith	"	600
Electrician	"	700
Carpenter	"	600
Rigger	"	600
Steel worker	"	600
Leader of brick layer	"	600
Brick layer	"	375
Square timber	m^3	30,000
Log	"	26,500
Cement	package	1,600
Cement	ton	40,000
Sand	m^3	1,500
Stone	"	2,500
Sod	m^2	105
Round reinforcement bar	ton	295,000
Nails	kg	168
Wire	"	126
Binding wire	"	315
Dynamite	"	788

rail, etc.), equipments for grounting estimated as material depreciation cost, large gate, elastic joint filler and others.

The estimation is made on the basis of convension rate at 1 US$ = 300 yen and the of local currency at 1 US$ = 415 Rupiah.

4.5.2 Project cost

The breakdown of the construction costs for the main civil works is shown in the Study Report. These costs include labor and material costs for the construction of the preparatory work (including the temporary work and surveys), dam, main and secondary canals, road rehabilitation, office and quarters, land reclamation and pilot farm. For the amount of overhead charge and taxes, 25 percent of the construction cost is estimated.

The land compensation expenses consist of the compensations for the land inundated by the dam, for the land of perennial crop where the main canal runs, for the borrow pit, etc. The construction equipment costs, as shown in Table 4-6, include the cost of the transportation and spare parts. The construction equipments are obliged to be fully depreciated, and the equipments used in the later half of the construction period are scheduled to be purchased in one lot in the third year.

The engineering and administration costs are estimated to be a little more than 9 percent of the total of the costs of main civil work, land compensation and construction equipment. The portion of domestic and foreign currency is assumed to be 1 : 4 and the engineering services of foreign consultants are estimated about 350 to 400 man months.

The physical contingency is estimated 5 percent for foreign portion, 10 percent for domestic of all direct costs which consist of the costs for the main civil work, land compensation, construction equipment, and engineering and administration. The interest during the construction period is estimated only in the foreign currency. The annual interest is expected to be 4.5 percent (compound), with the annual disbursement cost for each year as the capital. The price contingency is estimated

the sumamount of the compound interest based on the annual disbursement cost, assuming that the interest on domestic currency is almost 12 percent per year, and on foreign currency almost 6 percent per year. The paid interest is also included in the capital for foreign currency.

All of these costs are summarized in Table 4-7.

Table 4-6 Cost of Construction Equipment and Spare Parts

Unit : 1,000 US$

Name of Equipment	Standard	Units	Unit Price	Amount
(1) Construction Equipment				
Bulldozer	11 ton	14	22	280
- ditto -	14 ton	58	31	1,798
- ditto -	21 ton	15	48	720
Tractor shovel	1.4 m^3	41	26	1,066
Power shovel	1.2 m^3	17	109	1,853
Scraper	9.3 m^3	29	17	493
Tractor	21 ton	29	44	1,276
Dump truck	15 ton	96	35	3,360
Tamping roller	6 ton	10	16	160
- ditto -	10 ton	1	16	16
Vibrating roller	8 ton	1	36	36
Sheep's foot roller	10 ton	1	15	15
Tire rollers	10 ton	1	15	15
Crushing plant	600 x 900	1	94	94
Batcher plant	0.75m^3 x 2	2	341	682
Agitator truck	0.8 m^3	4	7	28
Crawler drill	10 m^3	1	14	14
Air compressor	4.6m^3/min	1	6	6
- ditto -	9.0m^3/min	4	9	36
Rammer	80 ∿100kg	16	-	8
Sinker	24 kg	15	-	7
Rake	2.4 ton	10	3	30
Tamper	120 kg	151	-	103
Water tanker	1.750 ℓ	1	7	7
Conveyor	38 t/hr	9	3	27
Vibrator	ϕ32	7	-	2
Water pump	ϕ40	5	-	1
- ditto -	ϕ130	5	-	4
Concrete pump	ϕ130	1	24	24
Other equipment				243
Sub-total				12,404
(2) Spare parts				1,240
Total				13,644

Table 4-7 Project Cost

Unit : 1,000 US$

Item	Domestic	Foreign	Total
1. Main Civil Work			
1) Preparatory work	1,701	-	1,701
2) Dam	1,714	2,802	4,516
3) Main canal	4,883	1,277	6,160
4) Secondary canal	5,714	361	6,075
5) Road rehabilitation	250	-	250
6) Office and quarters	113	-	113
7) Land reclamation and drainage work	1,967	-	1,967
8) Pilot farm	138	-	138
Sub-total	16,480	4,440	20,920
2. Land Compensation Expenses	120	-	120
3. Construction Equipments and Spare Parts	-	13,644	13,644
4. Enginering and Administrative Cost	600	2,400	3,000
5. Physical Contingency	1,720	1,026	2,746
Total	18,920	21,510	40,430
6. Interest during Construction Period	-	4,255	4,255
7. Price Contingency	10,630	3,685	14,315
Grand total	29,550	29,450	59,000

Note:

The project cost on the basis of the international contract system including a foreign constructor is shown as in Table 4-8 and the different points in the estimation are as follows. (Refer to Study Report)

(1) Foreign labourer's cost is estimated.

(2) The construction equipment cost is estimated the sum of the depreciation cost, the cost of maintenance and repair, and the transportation expenses.

(3) The construction supervision cost for the contractor, that is, the cost of salary, insurance, living, travelling and others for foreign and domestic engineers and managing staff, and the clerical cost of employee are included.

(4) The general expenses, direct and indirect at the contractor's offices out of site and appropriate profit are estimated instead of overhead charge.

The construction cost estimated on the basis of the above points is shown in Table 4-8. In this table, the construction costs of the temporary work, and the office and quarters are inserted into the construction cost of the main civil works such as dam and main canal, etc. Besides, the estimation expects the joint construction with the foreign contractor for the construction of the dam and main canal, and the works for the secondary canal and land reclamation is expected to be done by the local contractors.

Table 4-8 Construction Cost by the Contract System

Unit : 1,000 US$

Item	Domestic	Foreign	Total
1. Main civil Work			
1) Preparatory work	263	-	263
2) Dam	2,248	4,896	7,144
3) Main canal	5,355	8,289	13,644
4) Secondary canal	5,562	1,894	7,456
5) Road rehabilitation	250	-	250
6) Land reclamation and drainage work	2,019	3,860	5,879
7) Pilot farm	138	-	138
(Sub-total)	15,835	18,939	34,774
2. Land Compensation Expenses	120	-	120
3. Engineering and Administrative Cost	600	2,400	3,000
4. Physical Contingency	1,655	1,061	2,716
Total	18,210	22,400	40,610

4.5.3 Annual disbursement program

Details of each cost item are provided in the Study Report. The overall costs are summarized in Table 4-9. Operation and maintenance costs of the facilities after completion of construction is expected to run to about 2 percent of the costs of main civil work per year.

Table 4-9 Annual Disbursement Program

Unit : 1,000 US$

Portion	1977	1978	1979	1980	1981	1982	Total
Domestic	1,142	1,924	5,472	8,364	7,636	5,012	29,550
Foreign	2,506	5,740	15,720	2,985	1,607	892	29,450
Total	3,648	7,664	21,192	11,349	9,243	5,904	59,000

V. AGRICULTURAL DEVELOPMENT

5.1 Selection of Crops

The analysis of the national economy, as described in Chapter II, suggests that the staple foodstuff self-sufficiency should be taken into primary consideration in Indonesia. The staple foodstuff self-supply, of course, contributes to the saving of foreign currency for import. Its aim is to secure sufficient quantity of foodstuff to meet the increasing demand caused by the population growth with the annual rate of 2.4% and also to improve the nutritive and dietetic conditions of the nation. Thus, the introduction of irrigated paddy cultivation, on which the Government is laying considerable emphasis under the Second Five-Year Plan, would be the most suitable way for Indonesia to attain the abovementioned objectives.

The irrigated paddy cultivation could be also considered as the most appropriate way of promoting agricultural development in the Project area for the purposes of increasing individual farmers' income and production of staple foodstuff for local consumption as well as for domestic supply to Jakarta.

From the viewpoint of agronomy and plant physiology, there is no major constraint on paddy cultivation in the Project area, if irrigated properly. Minor constraint due to the nature of the soil is the very low content of weatherable minerals resulting in strongly acid soil and poor soil fertility. Originally, irrigated paddy has high adaptability to wide range of soil reactions. However, for expecting high paddy yield with less farming cost under the tropic-humid climate characterized by annual precipitation of more than 2,500 mm, such soil management based on cultivation of green manure and leguminous forage crops is indispensable in the Project area.

According to the governmental farm land distribution program, each settler is provided with 1.0 ha of irrigated paddy field and 0.75 ha a of non-irrigated upland field. The settlers are desirous of conducting paddy cultivation in the Project area and they have the experiences of growing sufficient familiarity with paddy in Jawa. Moreover, in

view of the cropping pattern most commonly adopted in the existing transmigration areas equipped with irrigation facilities in the Lampung Province, there is a growing tendency that every farmer will use more than 1.0 ha of the farm land for irrigated paddy cultivation so far as sufficient labor force is available. Perennial crops are usually grown to save labor force in the abovesaid developed areas in the province. Among those perennial crops such as coffee, pepper and clove grown most widely in and around the Project area, coffee is the most recommendable crop because it is highly resistant to diseases and soil acidity.

Introduction of draft cattle subsidized by the Government for successful promotion of the intensive irrigated farming requires individual farmers to self-supply feed for the cattle. Therefore, cultivation of fodder crops becomes necessary in some parts of the area where perennial crops are being cultivated.

Consequently, taking into consideration the plant physiological environment, soil condition and labor situation in the Project area, it is proposed that the future cropping pattern should be decided with lowland paddy as main crop, soybean as second crop, crotalaria as green manure and leguminous forage crops, and coffee as perennial crop.

5.2 Proposed Cropping Pattern

It is topographically difficult along the Rarem River adjacent to the west boundary of the Project area to find a place suitable for taking in irrigation water to be supplied to the Project area by gravity. Thus, irrigation water must be conveyed through a 30-km long canal running from the proposed dam site located in the upper reaches of the Rarem River. The results of the hydrological and civil engineering studies made suggest that the dam to be constructed at the proposed site will assure perfect supplemental irrigation for the wet season paddy cropping, but during the dry season it will function mainly in accordance with the natural river flow discharge and double cropping of paddy will be possible only in a limited area of the wet season paddy field. Keeping the abovementioned extent of the available irrigation water supply in mind, therefore, rainfall situation should be fully taken into account when formulating the paddy cropping schedule directly related to the decision of optimum scale of the Project facilities.

As described in Sections 3.2 and 3.3, enough effective rainfall can be expected from November to the beginning of May and high river flow discharge at the dam site can be expected until the beginning of July. Puddling which requires peak irrigation water requirement should be done during the above period for both the wet and dry season croppings. Harvesting during the period of heavy rainfall from December to March should be avoided as much as possible because such will pose the problem of drying harvested paddy. To minimize the scale of Project facilities for cost saving, the peak irrigation water requirement must be reduced by dividing the whole Project area into several blocks to perform farm operation in turn.

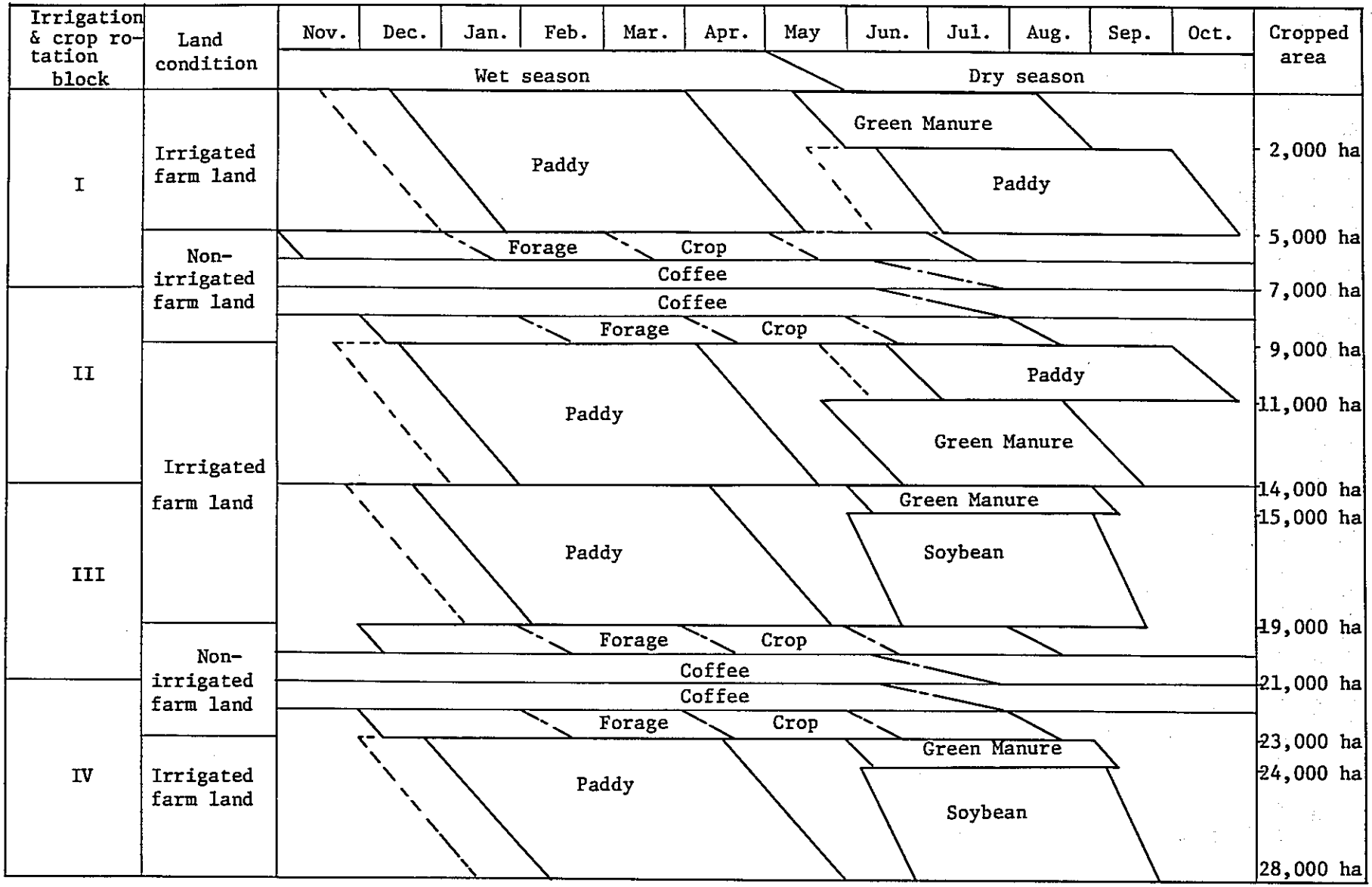
Peak time of labor force requirement for paddy cultivation will occur during the transplanting and harvesting periods. Taking into consideration the available manpower of individual farm families in the Project area, the maximum size of paddy field to be cultivated without any hired labor is estimated at 1.25 ha in net. Transplanting and harvesting on 1.25 ha of paddy field require 45 days, respectively. In case of double cropping, the nursery and land preparatory works for the dry season cropping should be carried out after the harvesting work for the wet season cropping is completed.

As for soybean and crotalaria, seeding work should be done within June for securing good germination in expectation of the available soil moisture content and harvesting work should be completed at least one month before starting the nursery work for wet season paddy cropping.

In consequence, the proposed cropping pattern is set up as shown in Fig. 5-1 upon consideration of the aforesaid situation. As for the cropping schedule at the individual farm family level, rotation cropping system is adopted as shown in the following table.

Crop	Season	1st year	2nd year	3rd year	4th year
Paddy	wet	1.25 ha	1.25 ha	1.25 ha	1.25 ha
	dry	0.75	0.50	-	-
Soybean	dry	-	-	1.00	1.00
Green manure	dry	0.50	0.75	0.25	0.25
Forage	yearly	0.25	0.25	0.25	0.25
Coffee	yearly	0.25	0.25	0.25	0.25

Fig. 5-1 Proposed Cropping Pattern



5.3 Prospective Change in Land Use

The assessment of the probable changes in the future land use under the condition of "Without Project" and "With Project" is necessary for the economic evaluation of the Project in regard to net area of 28,000 ha of farm land out of the gross irrigable area of 38,000 ha. The process mentioned hereinafter is used for the assessment.

The engineering study made on the optimum scale of the Project facilities has made clear that the total net area of 20,000 ha in the wet season and 5,000 ha in the dry season can be most economically irrigated.

As the maximum size of paddy field cultivated by using only the available family labor is 1.25 ha in net, it is assumed that a total of 16,000 farm households would irrigate 1.25 ha each of farm land. It is proposed to set the target of settlement in the Project area at 16,000 households. The reason is that the total population of the existing 12,600 farm households will grow at an annual rate of 3 % and new farm households will strongly desire to resettle in the Project area if irrigated. Therefore, a surplus of farm land for 3,400 households is considered sufficient to meet the future demand.

According to the proposed cropping pattern made, 8,000 ha of non-irrigated upland field and 4,000 ha of homeyard in addition to 20,000 ha of irrigated paddy field are necessary for the proposed 16,000 farm households. The official program of the village settlement requires an additional area of at least 8,000 ha for public yards, and 6,000 ha for the proposed irrigation and drainage systems.

Under the condition of "Without Project", no substantial changes in the land use can be expected in future. Rain-fed upland field cropping will be continued in the present cropping area at the rate of 0.90 ha per farm household, comprising 0.70 ha for mixed planting with upland paddy and cassava throughout the year, 0.15 ha for single upland paddy and 0.05 ha for maize for the wet season cropping. Groundnut instead of maize will be cultivated during the dry season. Thus, the total harvest area is estimated at 13,600 ha for upland paddy, 800 ha for maize, 11,200 ha for

cassava and 800 ha for groundnut. Due to the meager soils and uncertain rainfalls, crop yield will remain at a low level same as under the present condition, i.e., 1.4 tons/ha of upland paddy, 0.5 ton/ha of maize, 14.0 tons/ha of cassava and 0.5 ton/ha of groundnut.

Under the condition of "With Project", the gross irrigable area is classified into classes II, III and IV as explained in Section 3.4.2. The respective area of each class is 22,000, 6,000, and 10,000 ha. The entire class II lands of 22,000 ha should be allocated to irrigated paddy field, comprising 20,000 ha for net production field and 2,000 ha for on-farm irrigation service facilities. Out of 6,000 ha of class III lands, 4,000 ha should be allocated to non-irrigated upland field. For perennial crop field, 2,000 ha of class IV lands in addition to the remaining 2,000 ha of class III lands should be arranged.

5.4 Improved Farming Practices

The future intensive farming under proper irrigation will positively require the introduction of farm operation using draft animals to raise the production level with the limited labor force available, and also to make possible the use of better practices, such as better land preparation to secure uniform distribution of water and to prevent oxygen deficiency, timely intercultivating and weeding, efficient plowing-in of green manure, etc. The introduction of such draft animals is indispensable for paddy cultivation of high yielding varieties, and it should be supported by the government subsidy so that it will be carried out most effectively.

Present surface soils having coarse texture and lacking in organic matters should be improved by plowing-in of crop residuals and green manure. This operation together with soybean cropping will also gradually increase the nitrogen content of surface soils, and thus less chemical fertilizer application will be expected.

With the introduction of high yielding varieties of lowland paddy, pest and disease control becomes important. For making wide-sphere extermination, plant protection should be organized under the control of extension workers.

5.5 Farm Inputs

Although the most economical level of farm inputs depend on various factors affecting crop production, studies were made on the basis of the experimental data in Indonesia and the results of the chemical and physical soil analysis.

The recommended varieties of the proposed crops are Pelita I/1* and Pelita I/2* as high yielding varieties of irrigated paddy, Sumbing and Shakti varieties of soybean, crotalaria for green manure and forage crops, and Palembang EK-1 variety of coffee. The rate of seeding is determined taking into consideration the customary amount broadly applied in the country, i.e., 25 kg/ha for paddy, 30 kg/ha for soybean and 30 kg/ha for crotalaria, annually, and 2,500 seedlings/ha for coffee in the initial stage.

To achieve satisfactory yield at the full development stage of the Project, a suitable timing for application of fertilizers is indispensable. The effect of fertilizer application, particularly for irrigated paddy cropping using high yielding varieties, is significant. The fertilizer requirements estimated are as shown hereinafter.

The application of lime is essential to neutralize strong acid soils extending over the Project area. Therefore, 0.8 ton/ha of lime should be applied every year to maintain optimum pH value for vigorous growth of soybean and green manure crop.

The use of agro-chemicals to control pests and diseases is quite important to avoid the decrease in crop yields. The agro-chemical requirements estimated are as shown in the following table.

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*; These improved varieties were produced by the CRIA at Bogor, 1971, by crossbreeding with IR-5 and Syntha.

Materials	Dry season paddy	Wet season paddy	Soybean	Green manure	Coffee
Fertilizer nutrient (kg/ha)					
N	75	70	9	-	120
P	30	25	20	-	120
K	-	-	-	-	120
Lime (ton/ha)	-	-	0.8	0.8	-
Agro-chemicals (kg/ha)					
Insecticide	20	20	2	-	1
Fungicide	10	10	-	-	2
Rodenticide	1	1	1	-	-

5.6 Requirements for Farm Labor and Draft Animal

The following table shows the estimated farm labor requirements per household with 1.75 ha of net farm land based on the proposed cropping pattern.

Month	1st year	2nd year	3rd year	4th year
Jan.	64	64	65	65
Feb.	12	23	30	39
Mar.	8	4	6	7
Apr.	45	41	34	27
May	64	60	64	63
June	62	60	49	56
July	29	21	20	19
Aug.	9	11	11	12
Sep.	18	29	23	25
Oct.	47	29	-	-
Nov.	18	12	4	3
Dec.	56	51	42	32
Total	432	405	348	348

As shown in the above table, the peak labor requirement occurs in December to January and April to June. It is related to the land preparation as well as transplanting and harvesting of wet season paddy and planting of dry season crops. In these months, the family labor force which is estimated at 65 man-days per month(2.6 laborers/family x 25 workable days/month) on an average will be barely enough. If the shortage of labor force occurs, it will be covered by mutual aid within each village in the Project area.

The raising of livestock, especially draft cattle, is one of the most important works for paddy cultivation as well as the improvement of soil fertility by supplying stable manure. For the rapid increase in number of draft cattle for intensive irrigated farming, Bali cattles are proposed to be introduced into the Project area by fully utilizing the government subsidy system. During the six years throughout the construction period, one pair of cows would be provided to each two households.

5.7 Anticipated Crop Yield

For the estimation of prospective yield under the condition of "With Project", the experimental data in Indonesia and the data obtained at the farm survey carried out in the developed paddy cultivation area of the Lampung Province are fully referred to.

If the proper farming practices accompanied by the proposed farm inputs are performed, the target yield of crops can be expected to attain such a high level at the full development stage as 4.4 tons/ha for dry season paddy, 4.0 tons/ha for wet season paddy, 1.2 tons/ha for soybean, 20 tons/ha for green manure and forage crops and 0.7 ton/ha for coffee. These estimations, of course, reflect upon soil acidity and allocation of land use.

5.8 Project Inputs and Outputs

The annual quantity of farm input required under the condition of "With Project" is calculated at 625 tons of paddy, 240 tons of soybean and 330 tons of leguminous forage crop, respectively, for seed and also 4,000 tons of urea, 2,200 tons of triple superphosphate, 3,200 tons of high synthetic fertilizer, 6,400 tons of lime, 550 tons of insecticide,

250 tons of fungicide and 40 tons of rodenticide. The annual farm harvests are estimated at 102,000 tons of dry paddy, 9,600 tons of soybean, 2,800 tons of coffee and 220,000 tons of fresh leguminous forage crop.

5.9 Market and Price

As described in Section 2.3, around 20,000 tons of rice are transported from Jakarta to the Lampung Province every year for meeting the increased provincial demand due to high annual population growth of approximately 5%. The marketable amount of rice at the full development stage of the Project is estimated at about 80,000 tons of paddy or 48,000 tons of milled rice. Taking into consideration the increasing domestic demand for rice in future, this marketable amount would easily find outlets not only within the province but also in Jakarta.

As to soybean and coffee, the marketable amount is expected to be around 9,000 and 2,500 tons, respectively. This fact indicates that the Lampung Province definitely has the possibility of possessing a large exportable surplus stock of these crops.

According to the farm survey, the farm-gate price of dry paddy in the Project area ranged from Rp.50/kg to Rp.60/kg in 1974. This farm-gate price is much higher than in Jawa, one of the largest rice producing and consuming centers. For example, in the 1974 crop season, there was a regional difference of approximately Rp.15/kg. The difference was mainly due to the shortage of paddy in the Lampung Province. In view of such price fluctuation caused by the demand and supply situation of staple foodstuff in the respective local market in the country, therefore, the economic farm-gate prices of agricultural inputs and outputs are set as shown below for the sake of economic evaluation of the Project. In the above, the international market prices worked out on the basis of the 1973/1974 trend and the transportation cost as well as various intermediary expenses have been taken into primary consideration. To estimate the farm budgets under the condition of "Without Project" and "With Project", the financial prices are also set as shown in the following table, taking the results of the farm survey into account.

Farm inputs	Economic price	Financial price	Farm outputs	Economic price	Financial price
Urea	Rp.38/kg	Rp.60/kg	Dry paddy	Rp.75/kg	Rp.52/kg
TSP	17	60	Soybean	65	88
DAP	54	60	Coffee	200	200
			Cassava	6	5
			Maize	32	43
			Groundnut	235	240

5.10 Farm Income

Using the proposed quantity of each farm input and the economic farm gate prices set, the farm production cost is calculated. The estimation of crop production is also based on the anticipated yield and the economic farm gate price. The results obtained for "With Project" and "Wighout Project" are summarized in the following table.

The difference in the net production value could be regarded as the benefit attributable to the Project.

Crop	Production value (Rp./ha)	Production cost (Rp./ha	Net value (Rp./ha)	Total crop area (ha)	Total net value (million Rp.)
"With Project"					
Lowland paddy					
Wet season	300,000	68,000	232,000	20,000	4,640
Dry season	330,000	70,000	260,000	5,000	1,300
Soybean	82,800	35,800	47,000	8,000	376
Coffee	140,000	60,000	80,000	4,000	320
Green manure & forage crop	-	8,000	-8,000	11,000	-88
Total				48,000	6,548

Crop	Production value (Rp./ha)	Production cost (Rp./ha)	Net value (Rp/ha)	Total crop area (ha)	Total net value (million Rp.)
"Without Project					
Upland paddy	105,000	15,000	90,000	13,600	1,224
Cassava	84,000	6,000	78,000	11,200	873.6
Maize	16,000	2,500	13,500	800	10.8
Groundnut	117,500	18,000	99,500	800	79.6
Total				26,400	2,188

"Annual incremental net production value"

Total (1) - Total (2) = Rp.6,548 million - Rp.2,188 million

= Rp.4,360 million (US$10,506,000)

VI. ORGANIZATION AND MANAGEMENT

6.1 General

As described in Sections 2.2, 2.3 and 3.6.9, the respective Departments and Agencies independently take charge of agricultural supporting services. Though the representatives of the organizations cooperate with one another to a certain extent, the officials are under direct control of their departmental superious. Timely decisions can hardly be expected on the spot and each department follows its own policy and program.

For the successful implementation of the Project, it would be advisable to establish an efficient and interrelated organization to design and construct irrigation facilities, take charge of operation and maintenance of the irrigation system, and provide overall institutional supports for the intensive irrigated farming. The proposed organization is as outlined below.

6.2 Coordination Committee

In order to make clear the responsibility for the management of the Project, the Coordination Committee will be organized both at the provincial and prefectural levels. The provincial committee will be staffed with the representatives of the Departments and Agencies concerned. The prefectural committee, which will be under direct control of the Governor of North Lampung Prefecture, will be joined by the representatives of irrigation project offices under the Provincial DPUTL as well as the delegates from the branch offices of BRI, BUUD and the Bureau of Logistics.

The main functions of the respective Coordination Comittees are to coordinate the various activities with respect to the Project implementation carried out by each authority and to exchange views fully and timely on operation and maintenance of the Project.

6.3 Project Office

The Provincial DPUTL will establish an independent office responsible for the design, construction, operation and maintenance of the Project facilities. In view of the Project scale, it is proposed that the Project Office will promote the design work at Telkbetung, the seat of the Lampung Provincial Office, and the construction supervision and the operation and maintenance at Kotabumi, the seat of the North Lampung Prefectural Office, adjacent to the Project area. The Project Office will have at least two divisions, the Construction Division and the O & M Division.

The Construction Division will be responsible for the design and construction of all civil engineering works during the construction period, and will be disorganized upon completion of all construction work. Main functions of this Division are (1) to acquire the land necessary for the construction of Project facilities, (2) to plan, design and supervise all construction activities, and (3) to assist farmers in the design and construction of on-farm irrigation service facilities including tertiary canals. The minimum staff required for this Division are one superintendent, one division chief, 10 design and construction engineers, 15 construction supervisors, five technicians, five administrative staffs and 10 drivers including several mechanics.

The O & M Division will be responsible for the operation and maintenance of all the Project facilities. The main functions of this Division are (1) to operate the irrigation intake gates on Rarem Dam, (2) to control the main diversion weir for providing irrigation water under the rotation block system in the dry season, (3) to maintain the dam as well as all the main and secondary canals and control structures, (4) to gather actual irrigation water requirements according to rainfall pattern, precipitation, cropping pattern and irrigated area, and (5) to train and guide the farmers on operation of on-farm service facilities.

It is recommeded that the Project Office will formulate basic rules for covering the annual operation and maintenance cost of the Project facilities and, if possible, make contributions toward repayment of the capital cost. The minimum staff required for this Division are one superintendent, one division chief, two irrigation engineers, four assistant irrigation engineers, two dam keepers, eight technicians, five administrative stuffs, twenty gate operators, and 10 drivers including several mechanics.

6.4 Agricultural Development Center

The Agricultural Development Center will be established by reorganizing the Lampung Tani-makmur Project Office upon completion of its mission sometime in 1977. The experimental works now being carried out at the CRIA's testing farm and the training for seed multiplication conducted under the Provincial Agricultural Office will be transferred and strengthened under the supervision of the Center. At that time, the Center will also take charge of re-education and regular training of the extension workers.

It is recommendable to carry out such experiments as variety test of improved varieties of paddy under irrigated conditions and determination of the optimum use of fertilizers and agro-chemicals for paddy clutivation.

After the implementation of the Project, about 30,000 ha in total will be cultivated annually with the improved varieties of paddy. The total quantity of seeds required for the 5-year renewal is estimated at approximately 750 tons. Thus, the minimum area of seed farm required for annual seed production is calculated at 25 ha.

6.5 Extension Services

For carrying out the irrigation farming successfully in the Project area, the existing extension service system will be stepwise expanded. In future, four branch offices of the Provincial Agricultural Rural Extension Center, directly controlled by the Provincial Agricultural Office and technically supported by the Agricultural Development Center, will be established in the Project area.

The task of the extension worker is to give guidance to the farmers on the selection of suitable cropping pattern, green manuring practices and optimum use of fertilizers and agro-chemicals, and on proper irrigation farming method.

Training of farmers, which is one of the important objectives of the Project, will be conducted by the leading farmers who will attend the regular training course to be held at the Rural Extension Center. Group meetings of the voluntary organization such as the rural youth club will also be held with the assistance of the leading farmers and the extension workers.

6.6 Credit

To ensure effective management of the credit services, it is desirable to increase the number of branch office of the BRI in the Project area. Credit to the farmers will be of the following three kinds.

(1) The short-term credit will be provided to the farmers for the purchase of farm inputs in accordance with the advice of the extension service staff. The loans will be made at a monthly interest rate of 1% with 7-month maturity period in line with the BRI's current terms of credit.

(2) The medium-term credit will be provided for such items as the collection of farm products and the purchase of cattle and farming tools. The terms of loan will be based on the monthly interest of 1% with 3-year repayment period.

(3) The long-term credit will be provided for the construction of on-farm irrigation service facilities and initial investment cost for the establishment of farmers' cooperatives at the village level. The interest rate will be set at 12% per annum and the repayment period is seven years including 2-year grace period.

6.7 Cooperatives

The establishment of the proper structure of farmers' organization is the key factor for the success of the modern farming. It is proposed to establish one regional farmers' cooperative (BUUD) and 21 village farmers' cooperatives (KUD) in the Project area.

The BUUD, having close correlations with the Project Coordination Committee and the Provincial Agricultural Office, will assist to establish and manage the KUD. Under the direct supervision of the KUD, a network of branch cooperatives will be formed in the Project area according to the development plan.

The BUUD will provide special assistance and make arrangements for the supply of farm requisites and marketing of surplus farm products to be managed by the individual KUDs. Furthermore, the BUUD will carry out the training of the KUD staff periodically and the supervision and auditing of KUD.

The main activities of the KUD will be the farm requisite supply, services for processing, storing and marketing, and water management services. After consulting with the extension workers, farm requisites such as fertilizers, fungicides, rodenticides and insecticides required in the Project area will be ordered from private companies named "P.N. Pertani" and "P.T. Pusuri" by the KUDs. Those materials will be stored at the warehouse of each KUD to be installed and thereafter distributed to the individual farmers.

The processing, storing and marketing services will be handled by each KUD in close connection with the Bureau of Logistics (Bulog). After the Project implementation, around 100,000 tons of paddy products will be produced every year, but there is no rice mill in the Project area at present. At least 21 new rice mills each having milling capacity of 2 tons/hr will have to be established and operated under the control of the KUD.

As mentioned above, on-farm irrigation service facilities will be constructed by the farmers themselves. The KUD will assist the farmers in such construction works upon consultation with the Project Office and provide them with materials required. If the water charge system for repaying the Project capital cost by farmers themselves will be introduced into the Project area in future, the KUD will be responsible for the collection of the water charge.

In addition to the above services, the KUD will manage the government subsidized system for cow raising which will be established in the Project area in order to provide the individual farmers with animal power absolutely necessary for conducting the intensive paddy cultivation.

6.8 Pilot Farm

To promote more efficiently the extension work in the Project area, the establishment of a pilot farm is necessary because the demonstration farm now available in the Project area is insufficient. One block commanded by an irrigation turnout allocated at the tertiary canal will be used to conduct one or two pilot farms in the Project area. The main purposes of the pilot farm are to give every facility to the extension works in promoting their activities and to demonstrate the future farm operation system to the individual farmers. The overall management of the pilot farm will be the responsibility of Rural Extension Center under the direction of Agricultural Development Center.

6.9 Expatriate Assistance

Such a large scale of irrigation projects as an intensive agricultural development necessitates experienced professional services at all levels of a responsible organization. In order to carry out the detailed design work and to assist the Government in the sucessful implementation of the Project including the construction of the Project facilities, the preparation and realization of an appropriate operation program of the Project, and guidance and extension of improved farming practices, qualified experts specialized in designing, construction supervision of dam and canal, irrigation, mechanical works, soil mechanical engineering, operation and maintenance of irrigation system, agricultural extension and agronomy are required throughout the design period, the construction period and the on-farm operation period. The number of experts required is provisionally estimated at 150 man - month for the design and 250 man - month for the construction supervision and on-farm development service.

VII. ECONOMIC APPRAISAL AND FINANCIAL JUSTIFICATION

7.1 General

In order to ascertain the feasibility of the Way Rarem Irrigation Project, the evaluation is conducted from the economic, financial and social viewpoints. For this purpose, the economic feasibility of the Project is appraised by using the internal rate of return method. Sensitivity analysis attempts to grasp the change of economic situation resulting from the implementation timing of the irrigation facilities, the agricultural productivity and the price fluctuation relevant to construction works and farm products. Financial justification is made in two ways, i.e., farm budget analysis for confirming the soundness of the Project in view of individual farm family, and repayability analysis of financial cost to check the financial viability of the Project in terms of water charge. Socio-economic impacts of the Project are briefly assessed, keeping it in mind that the Project affects more or less the acceleration of regional development.

The following basic assumptions for the economic appraisal of the Project are taken into consideration.

(1) The construction period for the entire Project area is six years.

(2) Zero point is fixed at the end of the fifth year from the commencement of the Project works.

(3) On-farm service facilities will be completed by the end of the sixth year after the commencement of the Project construction.

(4) Irrigation water will be conveyed to 80 % of paddy field newly reclaimed in the Project area at the biginning of the sixth year when dam works are completed.

(5) The first production increase will be expected from the sixth year and full production level will be attained in the eleventh year in the abovementioned 80 % area. As for the remaining 20 % area,

the production increase will be expected from the seventh to twelfth year reckoned from the Project commencement. It is assumed that the production benefit will increase in arithmetical progression during the six years mentioned above.

(6) In the economic analysis, only the direct benefit is counted and any indirect or intangible benefit is not taken into account.

(7) The current prices as of August in 1975 are used in the estimation of the construction cost. At the same time, the exchange rate of Rupiah to US Dollar is taken as Rp. 415 equivalent to US$1.

(8) Farm gate prices of agricultural products for the economic evaluation are forecasted, taking into consideration the future trend of both international and domestic market prices as well as costs for intermediate transportation, storage and others. The prices to be used in the financial evaluation are set up based on the actual prices gathered through the farm survey carried out in the Project area in August, 1975.

(9) The economic useful life of the Project is taken as 60 years as normally recognized in Indonesian standard for such irrigation projects.

7.2 Economic Evaluation

7.2.1 Project cost

The economic construction cost totals US$40.43 million comprising the local currency of US$18.92 million and foreign currency of US$21.51 million. This amount covers the cost of the civil works including dam, irrigation canals, on-farm irrigation service facilities and rehabilitation of the existing road network, and also the cost of land compensation as well as engineering and administrative services. The economic construction cost and the annual disbursement of capital cost are as shown in the unit of US$ thousand in the following tables.

Portion	1977	1978	1979	1980	1981	1982	Total
Local	1023	1,545	3,939	5,397	4,417	2,599	18,920
Foreign	1,847	4,224	5,560	5,414	3,838	627	21,510
Total	2,870	5,769	9,499	10,811	8,255	3,226	40,430

The annual cost of operation, maintenance and replacement of the Project facilities is calculated at US$420,000 in total. This does not include the costs of providing farmers in the Project area with more intensive institutional services such as credit, extension, training, research, etc. The reason is that threse institutional costs are regularly budgeted by the government through its respective agency.

7.2.2 Project benefits

Project benefits are composed of the primary benefit and the secondary benefits.

Primary benefit is attributed to the difference between the cases of "With Project" and "Without Project". The primary benefit is regarded as the tangible fruit resulting from the improved paddy cultivation followed by irrigation water supply. The annual primary benefit at the full development stage of the Project is estimated at US$10,506,000.

Secondary benefits excluded from the economic appraisal are expected to accure from the improvement of local transportation and domestic water supply system upon completion of the Project. The ameliorated road network connecting the Project area and the Trans Sumatra Highway will not only facilitate broad circulation of farm inputs and outputs but also realize all weather type of human and vehicular traffics throughout the whole Project area.

The existing water sources for municipal water supply in Kotabumi City are very limited at present and will become insufficient to meet the future increased demand resulting from the population growth and the urbanization of the area around the city. Studies on a development

program for new water sources are being made at the prefectural office of North Lampung. As a prospective new water source, it is considered beneficial to take in municipal water from the main canal at a place near Kotabumi.

7.2.3 Internal rate of return

For the calculation of internal rate of return (IRR), the cost and benefit streams are firstly prepared on the basis of the assumption mentioned before, then the IRR is computed at 13.6%*. In consequence, the IRR indicates that the Way Rarem Irrigation Project is economically feasible.

7.3 Sensitivity Analysis

To analyze the effect of the following conditions on the feasibility of the Project, the IRR is computed for each case.

(1) The completion of irrigation network will be delayed by two years.

(2) The target yield of paddy will decrease to 3.3 tons/ha for the dry season and 3.0 tons/ha for the wet season, respectively.

(3) Economic cost of the Project will increase by 25% from the normal level.

(4) Economic price of paddy will fluctuate within 20%.

The results of calculation are summarized in the following table.

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*; In case that paddy fields of 25,000 ha in net are newly reclaimed, the total economic construction cost is estimated at US$52.55 million comprising the local currency portion of US$25.52 million and the foreign currency portion of US$27.03 million. The annual operation, maintenance and replacement costs are calculated at US$550,000 in total. The annual benefit attributable to the Project at the full development stage is computed at US$12,533,000. As a result, the IRR becomes 12.9%.

Case	Construction timing	Construction cost	Paddy Production	Paddy Price	IRR
1	Normal	Normal	Normal	20% rise	17.7%
2	Normal	25% rise	Normal	20% rise	15.2%
3	Normal	25% rise	Normal	Normal	11.9%
4*	Normal	Normal	Normal	20% fall	8.9%
5	Normal	25% rise	Normal	20% fall	7.7%
6	Normal	25% rise	10% fall	20% fall	5.0%
7	2-year delay	Normal	Normal	Normal	11.7%
8	2-year delay	25% rise	Normal	Normal	10.3%
9	2-year delay	25% rise	Normal	20% fall	7.1%
10	2-year delay	25% rise	10% fall	20% fall	4.6%

7.4 Financial Justification

7.4.1 Farm budget analysis

On the basis of the data collected at the farm survey conducted in the Project area, the farm budget of a farm household under the future conditions of "With Project" and "Without Project" is estimated taking the average harvested area at 3.0 ha in case of "With Project" and 1.65 ha in case of "Without Project", respectively, as the most typical size of a farm household. The results of calculation are given in the following table.

Item	Without Project (Rp.)	With Project (Rp.)
(1) Farm Income		
Crop income	106,600	416,000
Other income	23,400	4,000
Gross Farm Income	130,000	420,000
(2) Production Cost		
Crop production cost	17,600	151,000
Other expenses	400	4,000
Gross Production Cost	18,000	155,000

* This estimation also corresponds with IRR in case that paddy cultivation area will decrease by 20% due to the shortage of river flow discharge.

(3)	Net Farm Income (1) - (2)	112,000	265,000
(4)	Living Expenses		
	Food consumption	76,000	95,000
	Other living expenses	28,700	36,200
	Total Living Expenses	104,700	131,200
(5)	Taxes	2,300	6,800
(6)	Gross Outgo (2) + (4) + (5)	125,000	293,000
(7)	Capacity to Pay (1) - (6)	5,000	127,000

The annual increase in crop income upon completion of the Project is expected at Rp.309,400 or US $747 per family. Although the crop production cost will also rise for sustaining intensive farming in case of "With Project", the net farm income, which is defined as the difference between gross farm income and gross production cost, will attain the level of Rp.265,000 or US $640 a year.

According to the results of the farm survey, the average family size in the Project area is estimated at 4.6 persons. Thus the annual per capita income under the condition of "With Project" will be Rp. 57,600 or US $139, indicating substantial increase in comparison with that of Rp.3,900 or US $9 for "Without Project".

The net reserve will grow from Rp.5,000 or US $12 to Rp.127,000 or US $241 a year notwithstanding the anticipated increase in living expenses. This surplus of net reserve between both "Without Project" and "With Project" means that the capacity to pay for watering cost is enough if the water charge is imposed upon individual farm households in the future.

7.4.2 Financial evaluation

Financial cost of the Project is calculated at US $44.69 million, which includes interest during construction of 4.5% per annum. Interest is calculated only for the foreign currency portion taking into consideration the assumption that the local currency portion is provided by the Government with interest free.

In order to assess repayability of the Project, the necessary annual payment including capital repayment with interest as well as operation, maintenance and replacement costs is estimated on the basis of the financial cost. Then, the anticipated charge on the irrigation water to be collected from the beneficiaries is computed.

Financial evaluation of the Project viability is made by comparing the anticipated water charge with the prospective capacity to pay.

Repayment amount of the capital cost with interest cost is estimated on the following financial conditions assumed.

(1) Foreign currency portion:

Total capital cost	US $25.77 million
Annual interest rate	5 %
Repayment period	30 years after completion of the Project works

(2) Local currency portion:

Total capital cost	US $18.92 million
Annual interest rate	free
Repayment period	same as the above

Annual operation, maintenance and replacement costs are estimated at US $420,000 as explained in Section 7.2.1.

Based on the above conditions, the annual amount of repayment required is calculated at US $2,727,000 comprising US $1,676,000 of the foreign currency portion of capital cost, US $631,000 of the local currency portion of capital cost and US $420,000 of operation, maintenance and replacement costs.

Since the annual paddy cropping area of 25,000 ha in net will get the benefit from irrigation, the anticipated water charge is estimated at US $109/ha a year, whichis equivalent to US $170 or Rp.70,550 per farm family*.

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*, The average paddy cropping area per family is 1.25 ha for the wet season and 0.3125 ha for the dry season, respectively.

In Indonesia, there primarily is no traditional custom that the capital costs required for construction of irrigation system have been collected from beneficial farmers. The Government has led to impose the costs indirectly through the land tax. It is, however, considered under the present situation that the land tax includes not only water charge but also other various charges based on the broader context of the overall taxation policy which forms a major source of tax income at the provincial and district levels.

Although the Government may not intend to impose new water charge in any irrigation project area at present, the increase in farm income attributable to the Project will work out farmer's potentiality for any tax imposition. If the total annual repayment is to be repaid by the beneficiaries, the amount of water charge required will come to about 55% of the capacity to pay in the typical farm budget in case of "With Project". This fact means that any beneficiary in the Project area has considerably positive repayability of the capital cost for the construction of irrigation systems.

7.4.3 Fund requirement

To anticipate the financial requirement for the Project construction at the implementation time, the Project cost including the contingency for price escalation is estimated. As the construction cost is expected to be affected by recent inflationary trend both in the world and in Indonesia, the following assumption is tentatively made for the computation of the financial requirement.

(1) Foreign currency portion: 6% compound rate per annum during the construction period (1977 to 1982)

(2) Local currency portion: 12% compound rate per annum during the above period

With the said condition, total fund requirement is estimated at US $59 million including interest cost of US $4.26 million and price escalation contingency of US $14.31 million, respectively, during the construction period. The details are given in Table 4.7 and the disbursement schedule is summarized in the following table.

Portion	1977	1978	1979	1980	1981	1982	Total
Local	1,142	1,924	5,472	8,364	7,636	5,012	29,550
Foreign	2,506	5,740	15,720	2,985	1,607	892	29,450
Total	3,648	7,664	21,192	11,349	9,243	5,904	59,000

Note: (1) Figures indicate US$ thousand.

(2) Taking such severe assumption of price escalation into account as 10% compound rate per annum for foreign currency portion and 20% compound rate per annum for local currency portion, total fund requirement increases to US $73 million. The disbursement schedule is as shown below.

Portion	1977	1978	1979	1980	1981	1982	Total
Local	1,228	2,225	6,807	11,193	10,989	7,761	40,203
Foreign	2,590	6,150	17,526	3,472	1,957	1,139	32,834
Total	3,818	8,375	24,333	14,665	12,946	8,900	73,037

Note: Figures indicate US$ thousand.

7.5 Socio-economic Aspects of the Project

The Project construction will have both plus and minus impacts on the socio-economic condition in the Project area. In order to operate the Project fruitfully, maximizing of prospective plus impacts and minimizing of anticipated minus impacts should be taken into careful consideration from the stage of designing to operation of the Project.

As one of the plus socio-economic impacts, the Project execution creates the employment opportunity and the transfer of technological knowledge. The large construction work can offer numerous employment opportunity to the people not only in the Project area but also in the region of North Lampung. Especially Kotabumi is a rather over-populated city with scarce job opportunity, therefore the increase in working op-

portunity by the Project will no doubt provide benefit to solve the problem of unemployment even though the working period is limited. Besides, the Project will offer considerable job opportunities to Indonesia. This fact will result in obtaining experience in various work fields and training skill on the jobs. Through the above, Indonesia will accumulate sufficient knowledge and skill for the future development by themselves.

Secondly, the living condition of the farmers in the Project area will be substantially improved by the growing per capita consumption of own farm income obtained from increased agricultural production as the result of the Project operation. Social security and economic stability will be promoted largely through increased consumption of commercial goods and service by farmers, which will stimulate the activity in the other sectors of economy at regional level as well as provincial level.

On the other hand, major minus impact could be the inflation in local markets in and around the Project area caused by massive employment of laborers and puchasing materials for construction works and consumptive goods during the construction period.

APPENDIX I. TERMS OF REFERENCE AND SURVEY EXTENT

1.1 Objective and Outline of the Study

The objective area of the feasibility study in this time is the southern part of the Way Rarem-Abung area where it covers the acreage of approximately 35,000 ha, and the objective of the study is to investigate the feasibility of a irrigation project in this area.

The outline of the study is as follows.

1. Comparative study of irrigation plannings for the objective area will be carried out mainly on the basis of the gavity intake system from the Way Rarem, and the scale of a irrigation project will be determined.
2. Farm management systems for this area will be studied.
3. Evaluation of this project will be examined.
4. The influences to the adjacent area which might be affected by the water source planning for the area will be reviewed along the results of the prefeasibility study.

1.2 Contents of the Study

The Term will carry out the followings.

1.2.1 Survey in Indonesia

1. Collection of data, information and bibliography necessary for the study.
2. Field surveys
   1) General field survey
   2) Discharge observation
   3) Survey on the proposed canal routes and the proposed sites for main irrigation structures.
      The ground control survey necessry for the study is undertaken by the Government of Indonesia.
   4) Survey on the water requirement
      The survey on water requirement will be done at a few points to check the values due to the calculation methods, if necessary.

5) Water quality survey
The water quality test is undertaken by the Government of Indonesia.

6) Ground water survey
The ground water survey will be done in connection with the drilling survey, if possible.

7) Geological survey (including the technical advice for the drilling survey and tests at drilled holes which are undertaken by the Government of Indonesia).

8) Soil survey

9) Soil mechanical survey
The soil mechanical test at laboratory is undertaken by the Government of Indonesia.

10) Soil analytical survey
The soil analytical test is undertaken by the Government of Indonesia and the feasibility study team.
The soil analytical test of which the feasibility study team takes the partial charge will be conducted in Japan.

11) Survey on vegetation condition

12) Agronomic survey (including the interviews with the farmers of the area).

13) Agro-economic survey

1.2.2 Prospective work in Japan

1. Arrangement of the data collected
2. Test and analysis of samples
The samples brought back from Indonesia will be tested and analyzed. The items of testing are as follows;
   1) Rock test
   2) Soil analytical test
3. Study on the project plan
   1) Study on the discharge of water sources
   2) Composition of geological plan and profile, and study on borrow-pit and quarry site.

3) Composition of soil map, land use and land classification map.

4) Arrangement of the existing farm management method.

5) Estimation of prospective farm management method:
Decision of cropping pattern, estimation of agricultural products, study on farm machinery, etc.

6) Decision of water requirement and drainage discharge

7) Rough comparative study on project plans

8) Slection of a proposed project plan:
Selection of the location and acreage of the benefited area, the irrigation and drainage plan, planning of city water supply, etc.

9) Determination of the size of irrigation facilities

10) Study on the construction plan

11) Estimation of the project cost

12) Study on farm household economy:
Present and future condition of farm budget.

4. Project evaluation

The project evaluation which includes the economic evaluation, financial appraisal, repayment plan and others will be studied on the proposed project plan.

5. Others

Besides the above works, the conclusion of the feasibility study will be arranged including the study on the operation and maintenance plan of the facilities concerned and plan of water management, and the recommendation on the transmigration scheme, organization of farm household, marketing system, extension service, pilot scheme and others.

APPENDIX II, LIST OF FEASIBILITY STUDY TEAM, ADVISORY GROUP AND WORK SCHEDULE

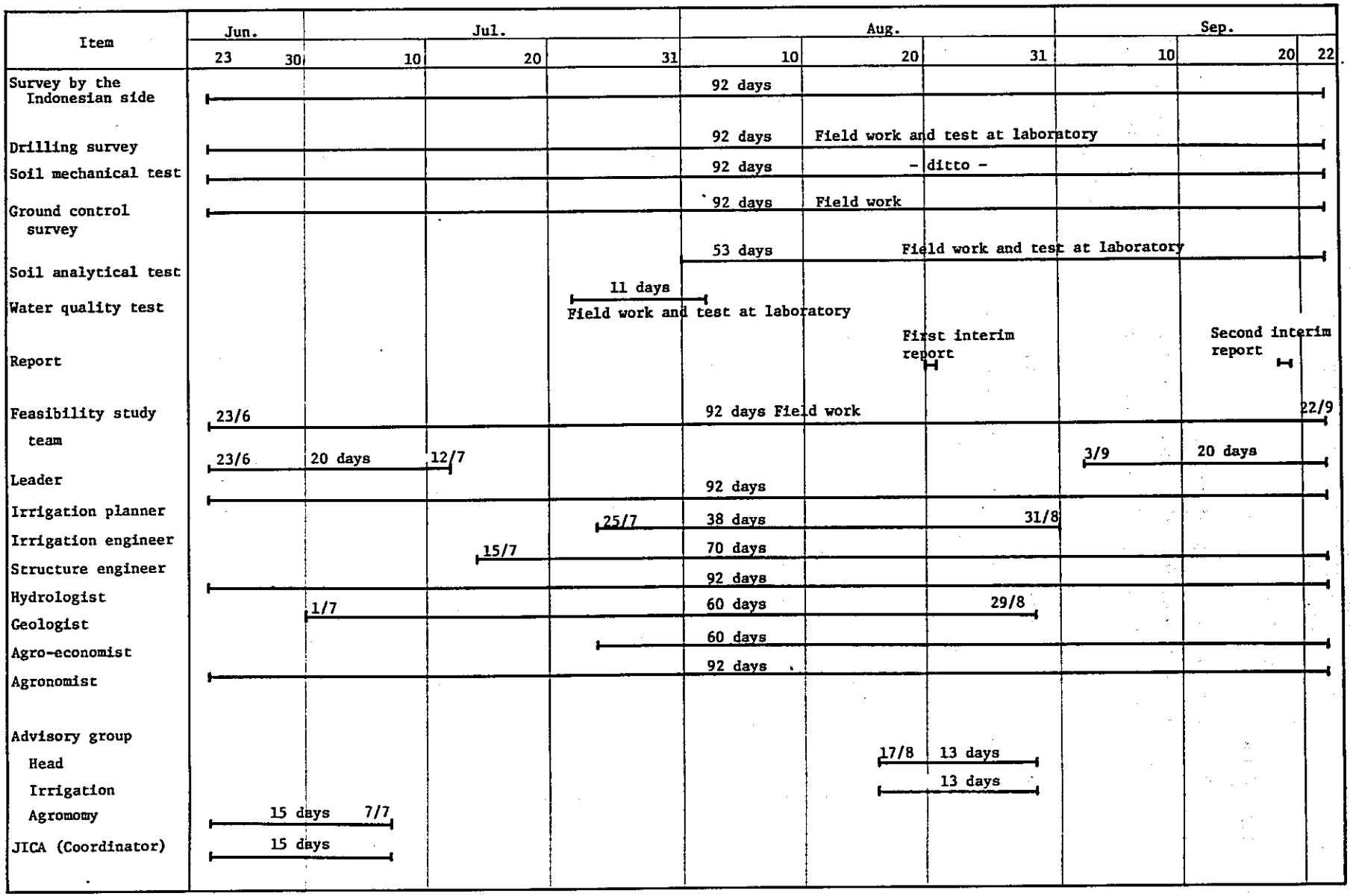
2.1 List of Feasibility Study Team

Item	Japanese Feasibility Study Team		Counterpart	
Team Leader	Shiro Sasaki	Japan Irrigation & Reclamation consultants (JIRCO)	Ir. Oesman Djojoadinoto: Abdullah A.G.: Drs. Slameto Hadiwijono:	Dit. Irigasi - ditto - - ditto -
Irrigation Planner	Takeshi Nomoto:	- ditto -	Ir. Sadeli Wiramiharja: Ir. Hartono:	- ditto - (part-timer) - ditto -
Irrigation Engineer	Seigo Kikuchi:	- ditto -	Ir. Mashudi:	- ditto - (part-timer)
Structure Engineer	Shigenori Kuwahara:	- ditto -	Ir. Muslim Tranpubolon:	- ditto -
Hydrologist	Yoshitami Iseki:	- ditto -	Ir. Muhadi: Amran BIE:	- ditto - (part-timer) - ditto -
Geologist	Torakiho Moritani:	- ditto -	Temmy Suhendi:	C.V. ACE
Agro-economist	Tadao Yoshikawa:	Nippon Koei Co., Ltd	Ir. Abdul Rojak:	Univ. Pejajaran
Agronomist	Yutaka Matsumoto:	- ditto -	Ir. Yus Umar Hamzah:	- ditto -
Tropographical Survey			Ir. Apep Soelaman:	Dit. Irigasi (part-timer)

2.2 List of Advisory Group

Head	Yoshimi Uchiyama	Chief of Tone River Basin Investigation Office, Regional Bureau of Kanto Agricultural Administration, Ministry of Agriculture and Forestry
Irrigation	Kazutsugu Nakanishi	Design supervisor, Design Section, Land Improvement Bureau, Ministry of Agriculture and Forestry
Agro-economy	Michio Hiura	Deputy Chief of Planning Section, Land Improvement Bureau, Ministry of Agriculture and Forestry
Agronomy	Kenro Kawashima	Deputy Chief of Resources Section, Land Improvement Bureau, Ministry of Agriculture and Forestry
(Coordinator	Toshiyuki Kasai	Japan International Cooperation Agency, (J.I.C.A.)

2.3 Work Schedule



APPENDIX III. AVAILABLE DATA

3.1 Maps

1)	Topographical map of Sumatora	S=1:1,790,000
2)	Topographical map of Lumpung province	S=1: 250,000
3)	Topographical map of Way Rarem area	S=1: 100,000
		S=1: 25,000 &
		S=1: 5,000
4)	Topographical map of Way Rarem damsite	S=1: 500
5)	Plan and profile of proposed main canal	S=1: 500
6)	Index map of areal photograph	S=1:1,000,000
7)	Geological map of Sumatora	S=1:2,000,000
8)	Geological map of Kotabumi & Gedongrat	S=1: 200,000
9)	General map of geology	S=1: 100,000
10)	Soil map of Lampung province	S=1: 250,000
11)	Road map of Lampung province	S=1: 250,000
12)	Map of Kecamatan in Lampung province	S=1: 500,000
13)	Map of Way Abung & Panaragan transmigration project	S=1: 50,000
14)	Map of Way Abung transmigration scheme	S=1: 100,000
15)	Map of concession area in Lumpung province	S=1: 250,000
16)	Map of meteorological stations in Lumpung	S=1: 500,000
17)	Map of quarry site attached papers in Lumpung	S=1: 500,000
18)	Expectable maximum accelaration chart in Indonesia	S=1:7,500,000

3.2 Irrigation

1) Transmigration placement viewed from the irrigation aspect
2) Proyek Irrigasi Way Abung Lampung Utara
3) Penyelidikan Geologi Teknik Dan Mekanika Tanah Rencana Bandung Way Abung (Hulu) Lampung Bagian Pertama: Geologi Teknik

4) Perhitungan estimate irrigation requirement Dengen Perhitungan Evapotranspiration methods Hargreaves
5) Perhitungan evapotranspiration (Consumtive use) menurut method Hargreaves
6) Capaciteit Skromme-Way Sekampung
7) Table of unit cost at Kotabumi in 1975
8) Setandar Perentjanaan Saluran dan Bangunan^{2}nja Vol. 1, 2, 4, 5, 6, 7, 8
9) Reconnaissance report Projek Irigasi Way Rarem
10) Reconnaissance survey on Way Rarem/Way Abung Irrigation project
11) Feasibility study on Way Umpu Irrigation Project
12) Feasibility study on Way Pengubuan Irrigation Project
13) Prefeasibility study report on Way Rarem/Abung Irrigation Project
14) Mapping survey report on Way Rarem/Abung Irrigation project
15) Contour line of ground water
16) Boring machine & boring materials of D.P.U. Lumpung
17) Simbol mark of structures
18) Compensation of Lumpung Utara
19) Results of water quality test in 1975
20) Results of drilling survey in 1975 at greenhouse
21) Water requirement for C4-63 variety at greenhouse
22) Water & fertilizer of N & P for cone at greenhouse
23) Fertilizer of N & P at dry season in Way Seputih
24) Material list of D.P.U. laboratory

3.3 Farm management and agriculture

1) Lampung Dalem Angka 1974
2) Statistik Pertanian 1967-1971
3) Data on yield and fertilization of low land rice with each Kabupaten 1969 - 1972
4) Data on extent and area which were damaged by blight and harmful insects or disaster with each plant in Lampung province 1970 - 1972
5) Data in extent and area which were damaged by blight and harmful insects or disaster with each Kabupaten and fields 1972, 1973

6) Settlement of transmigrations project in Lampung province 1952-Feb. 1973
7) Data on results of transmigration in survey area and planning in the future, and map concerned
8) Plan of model village
9) Agricultural statistics in Indonesia
10) Transmigration Policy

3.4 Meteorology

Item	Location	Data Collected		
		Mean Daily	Mean Ten Days	Mean Monthly
Air temperature	Blanibang Pagar	Sep.72-Jan.75	-	-
	Bandarjaya	May 71-Mar.73	May 71-Dec.74	May 71-Mar.73
	Menggala	-	Jan.72-Dec.74	-
	Kasui	-	Mar.74-Dec.74	-
	Pajar bulan	-	Mar.74-Dec.74	-
	Tandjunkarang	-	-	1963-1967
Wind velocity	Bandarjaga	-	Sep.74-Dec.74	-
	Menggala	-	Jan.72-Dec.74	-
	Kasui	-	Jul.74-Dec.74	-
	Pajar bulan	-	Jun.74-Dec.74	-
	Tandjunkarang	-	-	1963-1967
Relative humidity	Bandarjaga	May 71-Mar.73	May 71-Dec.74	May 71-Mar.73
	Menggala	-	Jan.72-Dec.74	-
	Kasui	-	Mar.74-Dec.74	-
	Pajar bulan	-	Mar.74-Dec.74	-
	Tanjunkarang	-	-	1963-1967
Vapor pressure	Bandarjaga	-	Jan.74-Dec.74	-
	Menggala	-	Jan.72-Dec.74	-
	Kasui	-	Mar.74-Dec.74	-
	Pajar bulan	-	Mar.74-Dec.74	-
Wind direction	Kasui	-	Jul.74-Oct.74	-
	Pajar bulan	-	Jun.74-Dec.74	-

Item	Location	Data Collected		
		Mean Daily	Mean Ten Days	Mean Monthly
Evaporation	Bandarjaga	May 71-Mar.73	May 71-Dec.73	May 71-Mar.73
	Menggala	-	Jan.72-Dec.74	-
	Kasui	-	Jul.74-Dec.74	-
	Pajar bulan	-	Jun.74-Dec.74	-
Sunshine duration	Bandarjaga	-	May 71-Dec.73	-
	Menggala	-	Jan.72-Dec.74	-
	Kasui	-	Mar.74-Dec.74	-
	Pajar bulan	-	Mar.74-Dec.74	-
	Tardjunkarang	-	-	1963-1967
Radiation	Bandarjaga	-	Sep.74-Dec.74	-
	Menggala	-	Jan.72-Dec.74	-
	Kasui	-	Jul.74-Dec.74	-
	Pajar bulan	-	Jan.74-Dec.74	-
Rainfall	Bandarjaga	-	May 71-Dec.74	May 71-Dec.74
	Menggala, Met	Feb.73-Apr.75	Jan.72-Dec.74	Jan.72-Dec.74
	"	1971-1973	-	1917-1938
				1940-1941
				1954-1960
	Kasui	Jan.72-Jun.75	Jan.74-Dec.74	1917-1938
				1940-1941
				1952-1953
				Jan.73-Dec.74
	Pajar bulan	-	Jan.74-Dec.74	Jan.74-Dec.74
	Tatakarya	Dec.73-Dec.74	-	Jan.73-Dec.74
	Kotabumi Diperta	1951-Jan.75	-	1918-1938
				1940-1941
	Kotabumi DPU	Jul.73-Jan.75	-	-
	Blanibangan Pagar	1972-Jun.75	-	-
	Padangratu	1961-1962	-	1952-1960
	B.T. Kemuning	1959-1968	-	Jan.73-Dec.74
		1972-1973	-	1952-1960
	Lebuay Atas	-	-	Jul.74-Dec.74
	Telang Bayur	-	-	Jun.73-Dec.74
				Jan.74-Dec.74

Item	Location	Data Collected		
		Mean Daily	Mean Ten Days	Mean Monthly
	Tangkit Inas		-	Jan.74-Dec.74
Rainfall	Kayu Palis	1972-1973	-	Jan.72-Dec.74
	Ketapan	1971-1973	-	Jan.74-Dec.74
	Gedung Rotu	1971-1973	-	Dec.71-Oct.74
	Srimenanti	Jan.72-May 75	-	Jan.72-Dec.73
	Blanibangan			1917-1919
	Umpu			1928-1938
				1940-1941
				1952-1960
				Nov.71-Dec.74
	Kebun Teba	-	-	Jun.73-Dec.74
	Sumberjaya	Feb.72-Jan.75	-	Feb.72-Dec.74
	Nakau	-	-	Jan.68-Dec.74
	Rantautemiang	-	-	Jul.72-Dec.74
	Pekarun	Aug.73-Jun.75	-	Aug.73-Dec.74
	Gunung Batin	1972-1973	-	May 73-Dec.74
	Ferbanggi Besar	-	-	Jan.73-Dec.74
	Cahaga Negri	1972-Sep.74	-	-
	Tulangbawan	-	-	1917-1938
				1940-1941
	Negri Besar	-	-	1917-1938
				1940-1941
	Gunung Sugih	1961-1964	-	1917-1938
				1940-1941
				1952-1957
Isohyetal line map	Lampung province			(1911-1940)

3.5 Hydrology

Item	Location		Data collected
River water level	Way Rarem:	Pekurun	Sep.72 - Oct. 73
		Tandjunkemala	Apr.71 - Oct. 73
		Kotabumi	Oct., Nov. 74
	Way Besai:	Banjarmasin	Apr. 71 - Oct. 73
	Way Abung:	Organ VI	Oct., Nov. 74
	Way Turusan:	Tatakarya	Oct., Nov. 74
River discharge	Way Rarem:	Pekurun	Sep. 72 - Dec. 74
		Tandjunkemala	Oct. 74
		Kotobumi	Jan. 74 - Dec. 74
	Way Besai:	Banjarmasin	Jan. 72 - Dec. 74
		Petai	Sep. 74 - Dec. 74
	Way Abung:	Organ VI	May 74 - Dec. 74
	Way Turusan:	Tatakarya	Oct., Nov. 74
		Gn. Batin	Sep. 72 - Dec. 74
	Way Pengubuan:	Trimodadi	1937 - 1940
	Way Umpu;	Rantautemiang	Oct. 73 - Dec. 74
		Negri umpu batin	Jun. 72 - Dec. 74
	Way Seputih:	Negeri Ajitur	Sep. 37 - Dec. 40
		Gedong harta	Jan. 73 - Dec. 74
		Gedong harta	Apr. 71 - Dec. 74
River discharge	Way Umpu kanan:	Pakuan Patir	Jun. 72 - Dec. 74
	Way Sekampung:	Kunyir	Jan. 68 - Dec. 74
		Jurai	Jan. 68 - Dec. 74
		Argoguruh	Jul. 59 - 1961
			1964 - 1968
			1971 - Apr. 73
			Feb. 74 - Dec. 74
		Pajora haya	Jan. 68 - Dec. 74
	Way Waya:	Banyuwangi	Jan. 68 - Dec. 74

Item	Location	Data collected
	Way Talayan: Sumber Sari	Jan. 68 - Dec. 74
Ground water level	Lampung Province	Aug. 1974
Location map of wells	Lampung Province	Aug. 1974
Rating curve	Pekurun Kotabumi and Banjarmasin	
Flood discharge	Hasper's method Melchior's method	

APPENDIX IV PLAN OF PREPARATORY WORKS FOR THE PROJECT IMPLEMENTATION

4.1 SPECIFICATION FOR SURVEY WORKS

1. Scope

This specification is applied to the technical section of the surveying for the preparatory works which will be carried out by the Government of Indonesia for the implementation of the Way Rarem Irrigation Project. When any questions about the technical articles which have not been specified in this specification are entertained, the instruction of the surveying engineer of the government shall be obtained for these.

2. Content of the works

The content of the works consists of the topographic survey on the basin of the Rarem dam and the route survey on the main canal. The scale of the works is shown in Table-1.

Table-1 Plan of Survey Works

Item	Plan			Longitudinal section	Cross section
	Scale	Size	Area		
		Km x Km	Km^2	Km	m
Topogrophic survey on the dam basin	1/5,000		8.0		
Route survey on the the main canal	1/1,000	0.2 x 27.0	5.4	27.0	200mx1,350 places = 270,000
Total			13.4	27.0	270,000

3. Method

3.1 Topographic survey on the basin of the Rarem dam

(1) In order to confirm the storage volume of the Rarem dam, the following work shall be carried out for making the topographic map of the Dam basin in a 1/5,000 scale with 2.5 m contour interval and the elevation less than 50.00 m.

(2) Proper logitudinal base line and crossing lines perpendicular to the base line shall be established and survey points at the intervals of 50 meters lengthwise and crosswise shall be established covering the area by grid. No matter whether it is on land or river bed, additional survey points shall be established on survey lines at place where slope gradient varies much.

(3) Each survey point shall be measured by direct leveling. The leveling route shall be closed by means of using the frame of the area as main route or by other means like that.

(4) Horizontal position and elevation shall be all connected with the datum of this project.

(5) Accuracy standard

(a) Horizontal accuracy
Errors in distance between arbitray survey points shall be within 1/5,000.

(b) Elevation accuracy

Leveling survey closure error shall be within 5 cm $\sqrt{S(Km)}$ and error in contour position shall be within 0.5 m above or below the true contour position.

3.2 Route survey on the main canal

(1) In order to decrease the volume of earth work for the upstream part of the main canal as much as possible, the following work shall be carried out for making the map of plan and profile in a scale of 1/1,000 with 1.0 m contour interval, and the cross sections in a scale of 1/500.

(2) The I.P. position of the center line shall be selected in the field in accordance with 1/10,000 scale route map roughly made which will be separately submitted. Longitudinal profile and cross-sectional surveys shall also be carried out along the line.

(3) The interval between longitudinal profile survey points shall be within 20 m, and, at places where slope gradient varies, additional establishment of survey points shall be required.

(4) Horizontal position and elevations at the beginning, intermediate and end points shall be connected with the datum of the project.

(5) Accuracy standard

(a) Horizontal accuracy

Errors in distance between arbitray survey points shall be within 1/2,000.

(b) Elevation accuracy

Leveling survey closure error shall be within 3 cm $\sqrt{S(Km)}$ and error in contour position shall be within 0.25 m above or below the true contour position.

(6) It can be taken into consideration that the planning water level of the main canal will be gradually decreased from the elevation, 50.0 m to 40.0 m.

(7) The survey result shall be shown as in the maps of plan and profile, and the I.P. positions surveyed shall be kept by concrete pegs or something in the field as far as possible.

4.2 SPECIFICATION FOR GEOLOGICAL AND SOIL MECHANICAL SURVEY

1. Scope

This specification is applied to the technical section of the geological and soil mechanical survey for the preparatory works which will be carried out by the government of Indonesia for the implementation of the Way Rarem Irrigation Project. When any questions about the technical matters which have not been specified in this specification are entertained, the instruction of the geological engineer of the government shall be obtained for these.

2. Outline of the work content

The content of the works consists of the surveys on the foundation of the dam site, the materials for the embankment of the dam, the ground for the proposed route for the earth canal of cutting type and the material for the earth canal of bank type.

3. Work content and method

3.1 Drilling survey on the foundation of the dam site

(1) This survey shall be carried out in addition to the surveys which were conducted in the 1975/76 fiscal year and the same special specifications can be applied.

(2) The survey is divided into the drilling, standard penetration test and field permeability test at the three places, that is, at the center lines of the spillway and diversion tunnel, and at the toe of the coffer dam of the proposed Way Rarem dam.

(3) The drilling length at each hole shall be 20 m, but if the drilling reachs to the rock layer, the drilling shall be continued 3.0 m in depth for the rock layer.

(4) As a rule, the standard penetration test and the field permeability test shall be carried out at intervals of 1.5 m and 4.0 m repsectively.

(5) Scale of the works is as follows.

Table-2 Plan of drilling survey on the foundation of the dam site

Location	No.	Drilling length (m)	Penetration test (times)	Permeability test (times)
Center line of spillway		20.0	13	5
Center line of diversion		20.0	13	5
Toe of coffer dam		20.0	13	5
Total	(3 holes)	60.0	39	15

3.2 Soil survey on the materials for the dam embankment

(1) This survey shall be carried out in addition to the surveys which were conducted in the 1975/76 fiscal year and the survey shall depend on the same special specicition and EARTH MANUAL (United States, Department of the Interior Bureau of Reclamation 1968) or METHOD OF SOIL TEST (The Japanese Society of Foundation Engineering 1969).

(2) The survey shall be divided into the soil mechanical test and material test of the disturbed samples obtained by test pit or others on the materials of core, gravel and rock for the dam embankment.

(3) The items of the test shall be as follows.

Core material: specific gravity, moisture content, consistency, compaction, triaxial compression (U-U and C-U) and permeability

Gravel: specific gravity, grain size analysis, and stability

Rock: specific gravity, water absorption, compression and stability.

(4) The disturbed samples for the core material shall be collected from the three parts, that is, upper (2.0 ∿ 2.5 m in depth), middle (3.0 ∿ 3.5 m) and lower (4.5 ∿ 5.0 m) parts of the test pit (1.5 x 1.5 x 5.0 m).

(5) The samples for gravel shall be collected from the test pits (1.5 x 1.5 x 3.0 m) which shall be dug at the dam site and river bed in the downstream at the rate of one piece from one hole.

(6) The samples for rock shall be collected from the proposed quarry site.

(7) Scale of the works is as follows:

Table-3 Plan of soil survey on the materials for the dam embankment

Location	No.	Test pit (m)	Samples (pieces)
Borrow pit (core material)	DT21	1.5 x 1.5 x 5.0	3
	DT22	"	3
	DT23	"	3
Total	(3 holes)		9
River bed (gravel)	DT24	1.5 x 1.5 x 3.0	1
	DT25	"	1
	DT26	"	1
Total	(3 holes)		3
Quarry site (rock)	DT27	-	1
	DT28	-	1
	DT29	-	1
Total	(3 places)		3

3.3 Drilling and soil survey on the proposed route for the main canal of cutting type.

(1) This survey shall be carried out in addition to the surveys which were conducted in the 1975/76 fiscal year and the survey shall depend on the same special specifications, the MANUAL or the METHOD which are mentioned in 3.1 and 3.2.

(2) The survey shall contain the drilling, standard penetration test and permeability test at the hills where the main canal will cross in order to study the seepage volume and the slope of cutting. (Refer to 4.1, Specification for survey works)

(3) The drilling length at each hole shall be 10 m, but if the drilling reachs to the rock layer, the drilling shall be continued 3.0 m in depth for the rock layer.

(4) As a rule, the standard penetration test and the field permeability test using packer shall be carried out at intervals of 1.5 m and 3.0 m repsectively.

(5) Scale of the works is as follows:

Table-4 Plan of drilling and soil survey on the proposed route for the main canal of cutting type

Location	No.	Drilling length (m)	Penetration test (times)	Permeability test (times)
Proposed route for the main canal of cutting type	C21	10.0	6	3
	C22	10.0	6	3
	C23	10.0	6	3
	C24	10.0	6	3
	C25	10.0	6	3
Total	(five holes)	50.0	30	15

3.4 Soil survey on the material for the earth canal of bank type

(1) This survey shall be carried out in addition to the surveys which were conducted in the 1975/76 fiscal year and the survey shall depend on the same special specifications, the MANUAL or the METHOD which are mentioned in 3.2.

(2) The survey is to test the embankment material for the earth canal of bank type proposed in the benefited area. The samples shall be collected at the borrow pits which are proposed at the hilly places located at the border between the benefited area and the lower part along the Way Rarem, and at the higher parts along the proposed canal route. The disturbed samples shall be collected from the test pit (1.5 x 1.5 x 3.0 m) at the rate of two pieces per one hole, that is, one at the upper part (1.0 ∿ 1.5 m in depth) and the other at lower part (2.5 ∿ 3.0 m).

(3) The items of the test shall be specific gravity, moisture content, consistency, compaction, triaxial compression (U-U and C-U) and permeability.

(4) The scale of the works is as follows:

Table-5 Plan of the soil survey on the embankment material of earth canal

Location	No.	Test pit (m)	Samples (pieces)
Borrow pits	CT21	1.5 x 1.5 x 3.0	2
	CT22	"	2
	CT23	"	2
	CT24	"	2
	CT25	"	2
Total	(five holes)		10

4.3 Specification for field permeability test (well permeameter method)

1. Scope: This specification describes a test method for determining the permeability of a soil in place. The method consists of measuring the rate at which water flows outward from an uncased well under constant head. It is particularly useful for estimating canal seepage and percolation loss of water on irrigated paddy fields to be newly reclaimed.

2. Apparatus: The apparatus for this test shall consist of the following:

(1) Augers: Hand auger suitable for excavating permeability wells.

(2) Reservoir: A 200-liter calibrated metal drum with gage tube.

(3) Valve: A bob-float valve with operating arm.

(4) Float: A wooden float with brass stem.

(5) Casing: A galvanized iron casing for float, 90 mm in diameter by by 300 mm in height.

(6) Counter-weights: Brass counterweights.

The above apparatus can easily be procured in Japan. The C.I.F. Jakarta price is estimated at around US$1,000 or Rp.415,000.

3. Materials

(a) Density Sand: A previous coarse sand (or fine gravel) shall be used for backfilling test wells used in the well permeameter test. Clean washed sand of No. 4 to No. 8 sieve size or gravel of 9.5 mm to No. 4 sieve size is recommended for this purpose.

(b) Water: The water to be used for well permeameter tests shall be clean. Small amounts of sediment or other suspended matter in the water will become deposited in the soil adjacent to the well and greatly reduce the flow. The water should preferably be from the same source as that expected to be used in the canal.

4. Calibration

(a) Water Reservoir: The volume of the 200-liter-drum reservoir shall be calibrated in 100-cm^3 increments (measured by weight) with the top of the tube level with the top of the drum. Then the tube readings will decrease downward and permit volume determinations by subtracting figures. During calibration, after each increment of water is drawn off, a mark is placed on the plastic tubing.

(b) Density Sand: The density of the pervious sand used for filling the test wells shall be determined prior to use. The density shall be determined by pouring the sand into a pipe with dimensions approximately those of the test well to be used. The pouring height shall be aproximately that to be used in the well. The calibrated density of the sand can be computed from the weight used to fill the pipe, the depth of sand, and the volume of the pipe.

5. Procedure

(a) Size of Test Well: The test well may be of any desired dimensions so long as it conforms to the rule that the depth should be between 10 and 50 times the radius. A well excavated with a 10-cm-diameter auger to a depth of 60 cm is about the smallest practicable size, and for some purposes it should be larger. A 15-cm-diameter well is preferable to a 10-cm-diameter well because the volume of soil being tested around the well is larger. The maximum well size will be limited in previous soils by the capacity of the equipment to supply sufficient water to maintain a constant head.

(b) Preparation of Test Well: Wells for permeameter tests shall be prepared with care in order to cause as little disturbance to the surrounding soil as possible. They may be excavated with a hand augar. After the well is excavated, the sides and bottom shall be lightly brushed or shaved where necessary to remove any accumulation or compaction of the soil, and the loose soil shall be removed from the well bottom.

It is often difficult to auger a well below the water table, but this can sometimes be done by inserting a casing during well excavation and later pulling it after it has been filled with sand.

After the well has been cleaned, it shall be backfilled with pervious sand. The sand shall be placed in the well to a level of about 15 cm below the water level to be maintained. The galvanized casing containing the float shall be placed on top of the sand and pervious sand shall be poured between the outside of the casing and the well. Care should be taken to install the casing in a vertical position, so the float will operate freely without sticking. When a test is to be conducted with the water level some distance below the ground surface, the casing can be lowered on the float by the light chain to the top of the backfill sand, and a little sand dropped around the casing to hold it in place during the test. The rubber slipwasher on the float stem is to prevent falling sand particles from becoming lodged between the float stem and casing guide. The sand around the casing need not be weighted, as it is not considered in computations for well radius. Depth measurements in the test well can be conveniently made from a common baseline formed by stretching a string across the tops of two stakes driven on either side of the well.

(c) Sand for Test Well: The sand (or fine gravel) placed in the test well serves two purposes: First, it serves in place of a casing to support the sides of the well against sloughing during saturation of the soil; and secondly, it provides a means of indirectly measuring the average radius of the well which is necessary for permeability computations but which is otherwise rather difficult to measure accurately. For determing the average radius of the well, the weight of sand used in the well and depth of sand are recorded. The volume is then computed from the sand density previously determined. The radius is determined from the volume and depth of the cylindrical well filled with sand.

(d) Setting up Test Equipment: The reservoir should be set on a platform or cribbing at a convenient height. The 12-mm tube on the side of the casing can be used as a thermometer well, or the flexible water hose from the float valve can be connected to it. The length of the light chain from the float stem to the valve operating arm should be adjusted and the counterweight positioned to balance the float when it is in water.

(e) Water Temperature: Because of the wide variation in temperatures in the field and the change in water viscosity due to temperature, it is necessary to record water temperature during the test and to correct the coefficient of permeability to a 20°C standard. The temperature of the water in, or the ground around, the test well should be taken. The temperature in a well where the water level is some distance below the ground surface can be obtained with reasonable accuracy by lowering a thermometer into the well on the top of the backfill sand, leaving it there for 5 minutes and reading it quickly upon removal.

It is desirable, if possible, to have the water introduced into the soil at a temperature somewhat above that of the soil. This will result in a decreasing temperature gradient as the water flows through the soil and will tend to prevent the clogging of voids in the soil with bubbles of air coming out of solution. The presence of air may unduly decrease the flow of water through the soil.

(f) Records of Discharge and Time: The field permeability test is conducted by recording the gate tube readings on the 200-liter reservoir at timed intervals. From these data, it is possible to plot a curve showing the accumulative discharge against time and to compute discharge rates for any time period. Usually the steady-state flow causing a straight line on the curve will occur within an 8-hour period for soils with moderate to high permeability. If this condition does not occur within that time, the minimum time as discussed below shall be used as a guide to determine test duration.

(g) Test Duration: The test should be run long enough to develop a saturated envelope in the soil but not long enough to build up the water table or produce an excessively large saturated envelope which will cause erroneous results. Thus, there is introduced a concept of minimum and maximum time limits within which the test results are valid.

(1) Minimum time: The minimum time for the duration of the test is the time required to discharge the minimum volume (cubic centimeter) of water into the soil to form a saturated envelope of hemispherical shape with a radius B. This is determined by the formula:

$$V_{min} = 2.09\ Y_s \left[h \sqrt{\frac{2}{\sinh^{-1}(\frac{h}{r})-1}} \right]^3 \qquad (1)$$

where: V_{min} = minimum volume, cubic centimeter,

Y_s = specific yield of the soil,

h = depth of water in well, centimeter, and

r = well radius, centimeter

The bracketed quantity is the theoretical determination for radius B.

This equation can be solved conveniently and the minimum volume determined by the monographs which are available from the Bureau of Reclamation, Engineering and Research Center in U.S.A.

(2) Maximum time: The maximum time for test duration is the time necessary to discharge through the test well the maximum volume of water as determined by equation (1) above, substituting 15.0 for 2.09 and in this case using an assumed minimum value

$$V_{max} = 2.05\ V_{min} \qquad (2)$$

6. Calculations

(a) Computation of Coefficient of Permeability: The aforesaid monographs have been developed to aid in computing coefficients of permeability for the well permeameter test. The rate of water flow from the test well as obtained from the slope of the accumulative time-volume curve mentioned above, together with the effective radius of the well, the height of water in the well, and water or ground temperature, is needed to use the monograph. Also, when the water table, or an impervious soil layer which has the same effect in reducing seepage, is relatively near the test well, its position should be determined. This determination will enable the water table to be classified as low or high, as illustrated in the following figure-1. If a monograph is not available or the range of the monograph is not sufficient, the coefficient of permeability for various conditions may be computed as follows:

(1) Low water table: When the distance from the water surface in the test well to the groundwater table (or an impervious soil layer which is considered for test purposes to be equivalent to a water table) is greater than three times the depth of the water in the well, a low water table condition exists as illustrated by condition I as shown in the figure-1. For the determination of the coefficient of permeability under such a condition, equation (3) given below should be used.

(2) High water table: When the distance from the water surface in the test well to the groundwater table (or an impervious layer) is less than three times the depth of water in the well, a high water table condition exists as illustrated by conditions II and III. Condition II shows a high water table condition with the water table below the well bottom, and for this condition equation (4) given below should be used.

Condition III shows a high water table condition with the water table above the well bottom. For this condition equation (5) given below should be used.

$$K_{20} = \frac{Q}{2\pi h^2} \cdot \left[\log_e \left\{ \frac{h}{r} + \sqrt{1 + \left(\frac{h}{r}\right)^2} \right\} - 1 \right] \cdot \frac{\mu T}{\mu 20} \qquad (3)$$

$$K_{20} = \frac{3Q \cdot \log_e \frac{h}{r}}{\pi h \ (h + 2\ Tu)} : \frac{\mu T}{\mu 20} \qquad (4)$$

$$K_{20} = \frac{Q \cdot \log_e \frac{h}{r}}{\pi Tu \ (2h - Tu)} \cdot \frac{\mu T}{\mu 20} \qquad (5)$$

where: K_{20} = coefficient of permeability at 20°C,

h = height of water in the well,

r = radius of well,

μT = viscosity of water at temperature T,

$\mu 20$ = viscosity of water at 20°C,

Tu = unsaturated distance between the water surface in the well and the water table, and

Q = discharge rate of water from the well for steady state condition (cubic centimeter per second) determined experimentally as follows:

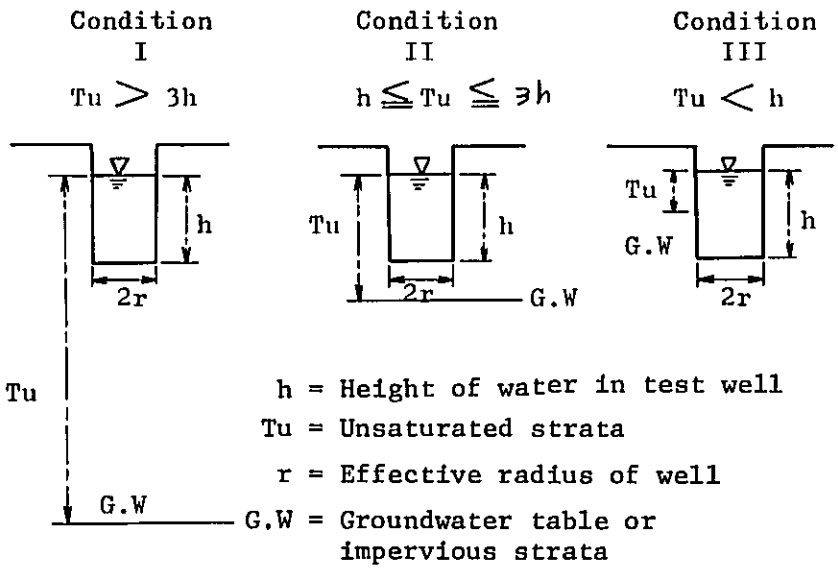
$$Q = \frac{\pi r^2 \Delta h}{t_2 - t}$$

where; t = time at the starting of observation,

t_2 = time at the decreasing of water depth in the well by T, and

Δh = decreasing discharge of water.

Figure-1 Relationship between depth of water in the test well and distance to water table in well permeameter test



0 1 2 3 4 5 km

S = 1 : 100,000

30km

MAIN CANAL

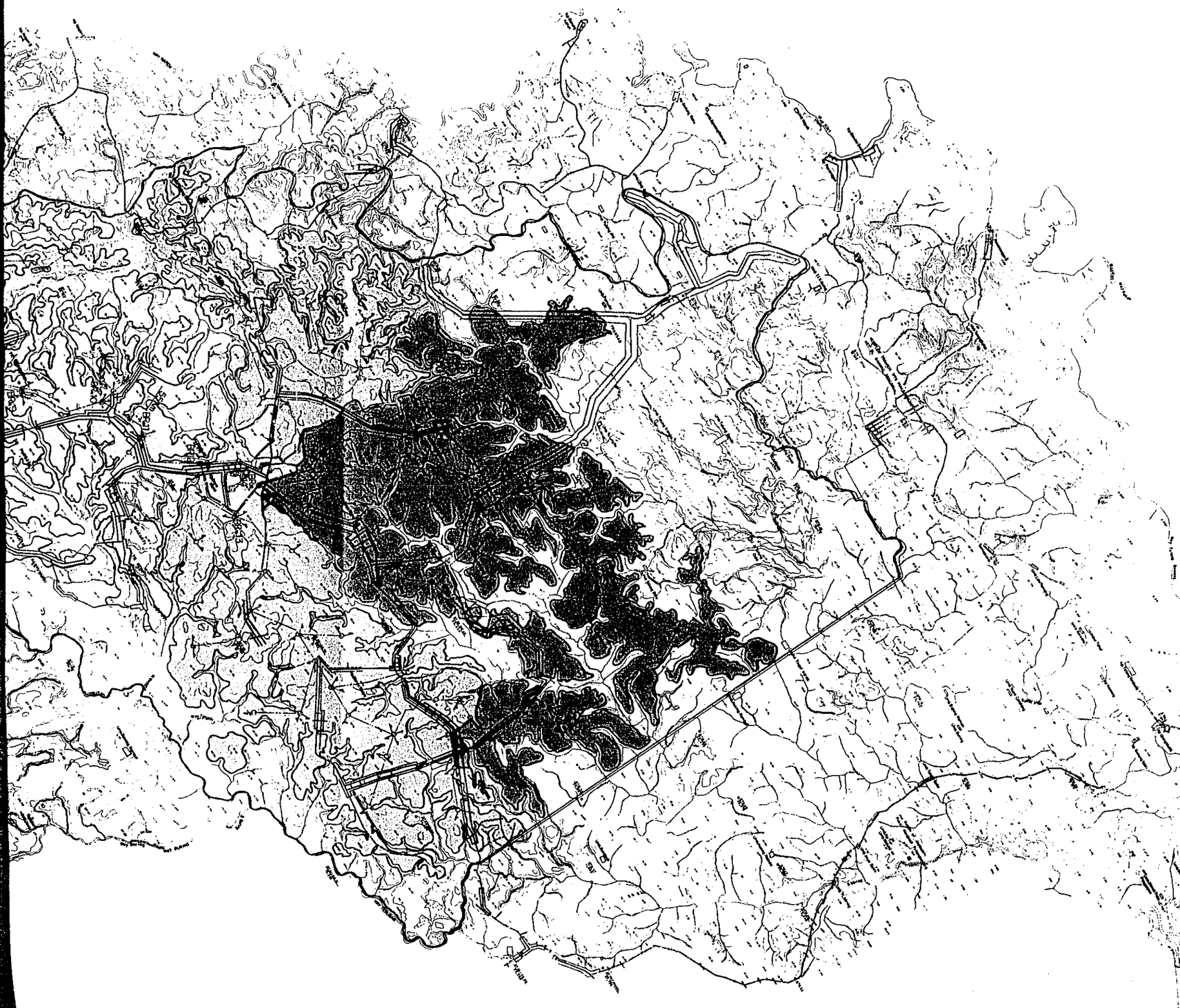
RAREM DAM

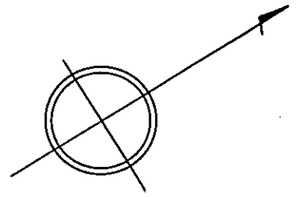
WAY RAREM
IRRIGATION PROJECT
GENERAL MAP OF
IRRIGATION PLAN

SCALE	DATE
1:100,000	1976

J.I.C.A. JAPAN I-1


0 1 2 3 4 5 km
S= 1 : 100,000





LEGEND

- PROJECT AREA
- A B C — IRRIGATION BLOCK
- MAIN CANAL
- SECODARY or TERTIARY CANAL
- TURN OUT ON MAIN CANAL
- TURN OUT

WAY RAREM IRRIGATION PROJECT	
GENERAL MAP OF IRRIGATION PLAN	
SCALE 1:100,000	DATE 1976
J. I. C. A. JAPAN	I-2

DIAGRAM OF DISTRIBUTION SYSTEM

Gross Irrigation Area	:	25,000 ha
Net Irrigation Area	:	20,000 ha
Maximum Design Canal capacity	:	16,576 l/s

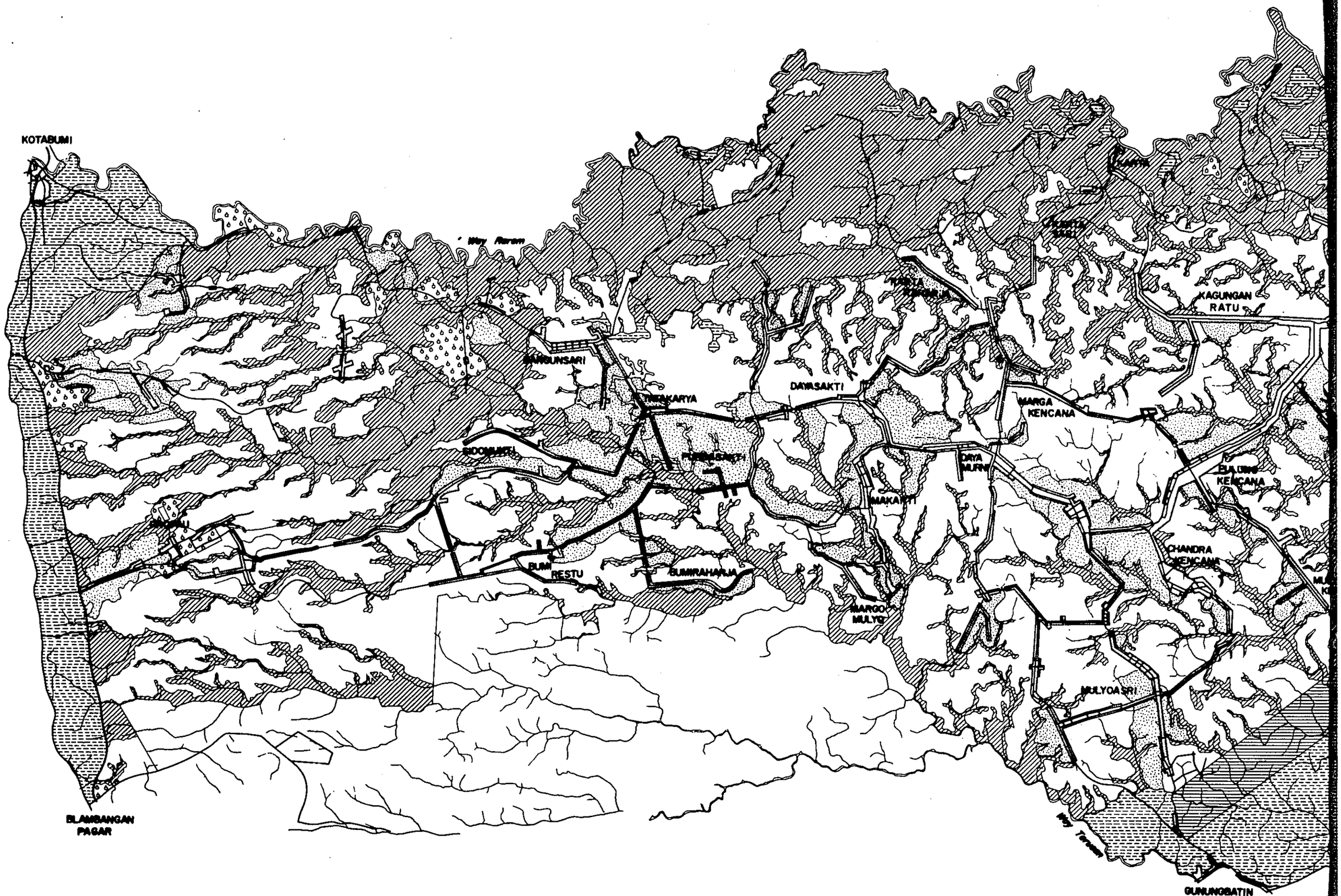
LEGEND

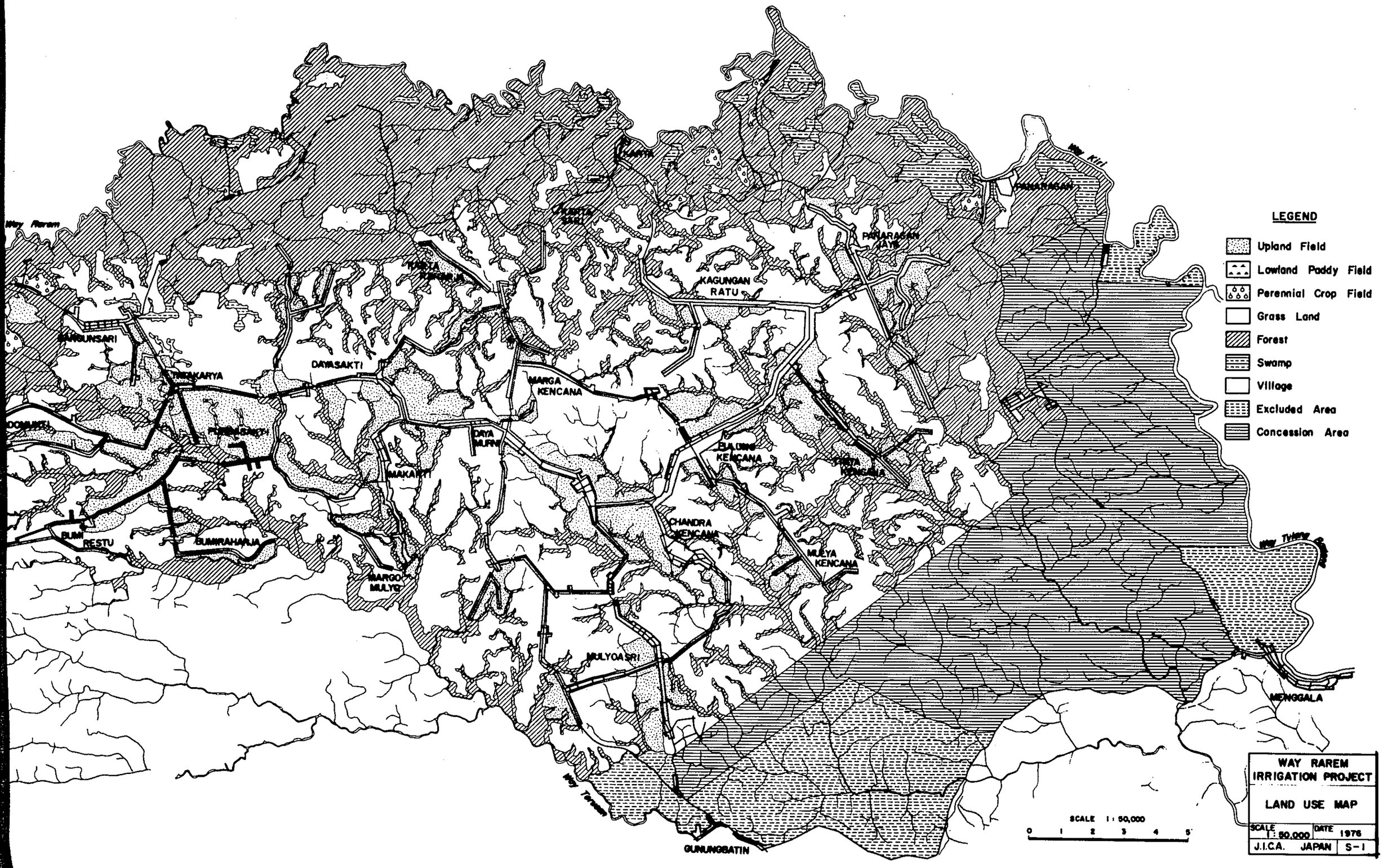
- Main Canal
- Secondary Canal
- Tertiary Canal
- Diversion Work
- Turn Out
- Net Irrigable Area / Diversion Requirement

LEGEND

LEGEND

WAY RAREM IRRIGATION PROJECT	
DIAGRAM OF DISTRIBUTION SYSTEM	
SCALE	DATE 1976
J.I.C.A. JAPAN	I-3

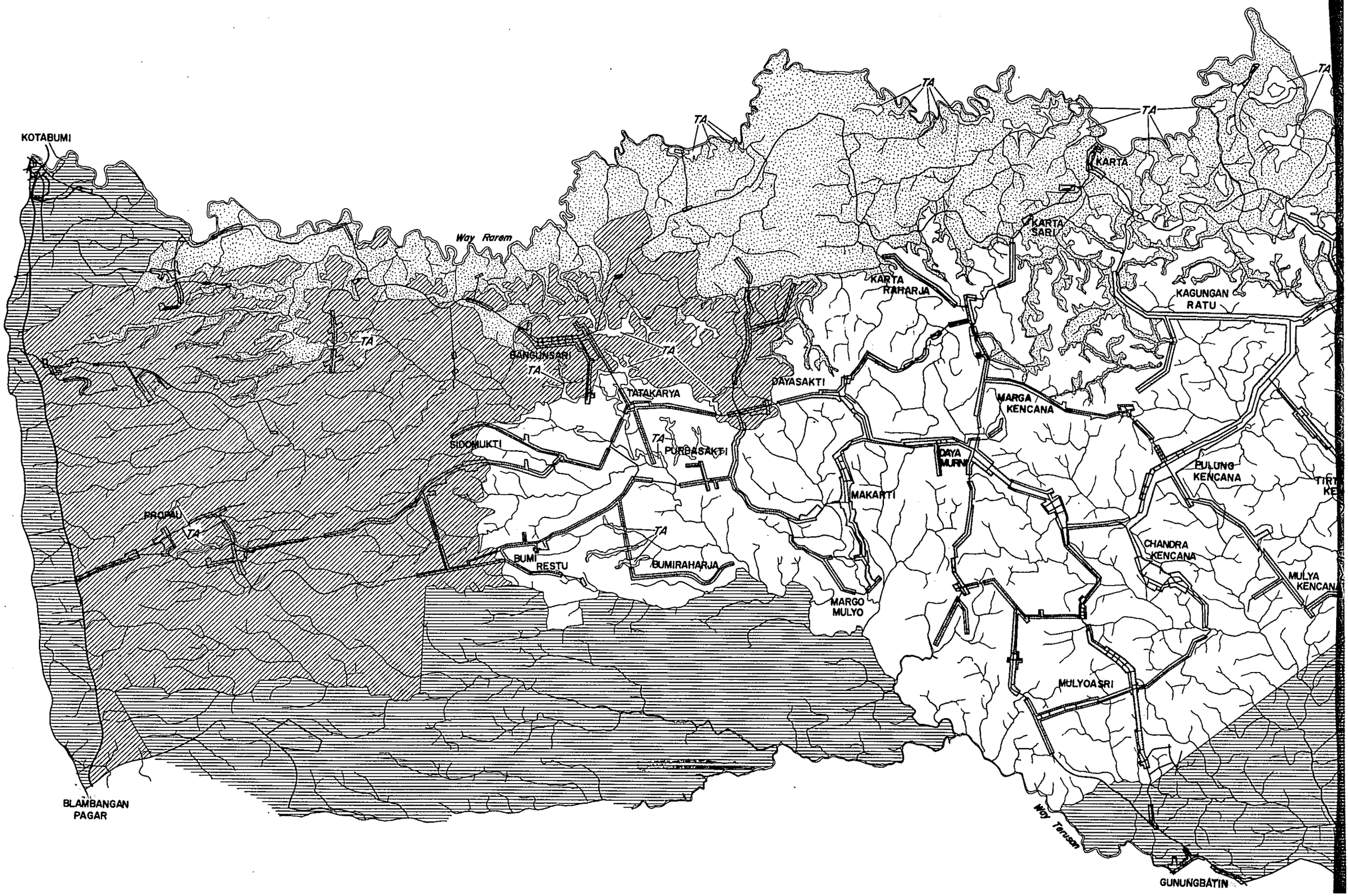

KOTABUMI
BUMIRESTU
SUMIRAHAYU
BLAMBANGAN PAGAR
BUMISARI
DAYASAKTI
MARGA KENCANA
DAYA MURNI
MAKARTI
MARGO MULYO
MULYOASRI
KAGUNGAN RATU
CHANDRA KENCANA
GUNUNGBATIN

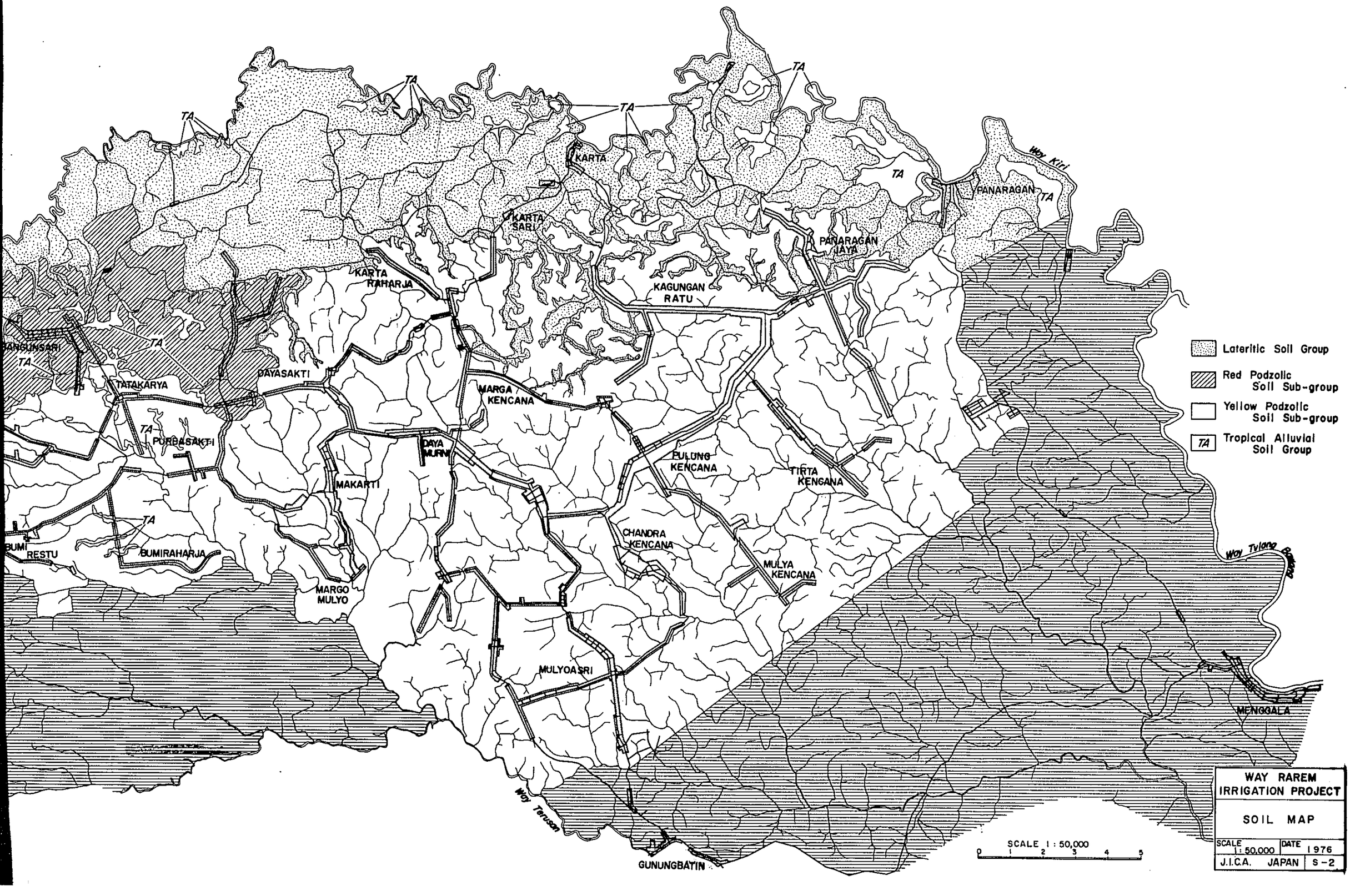


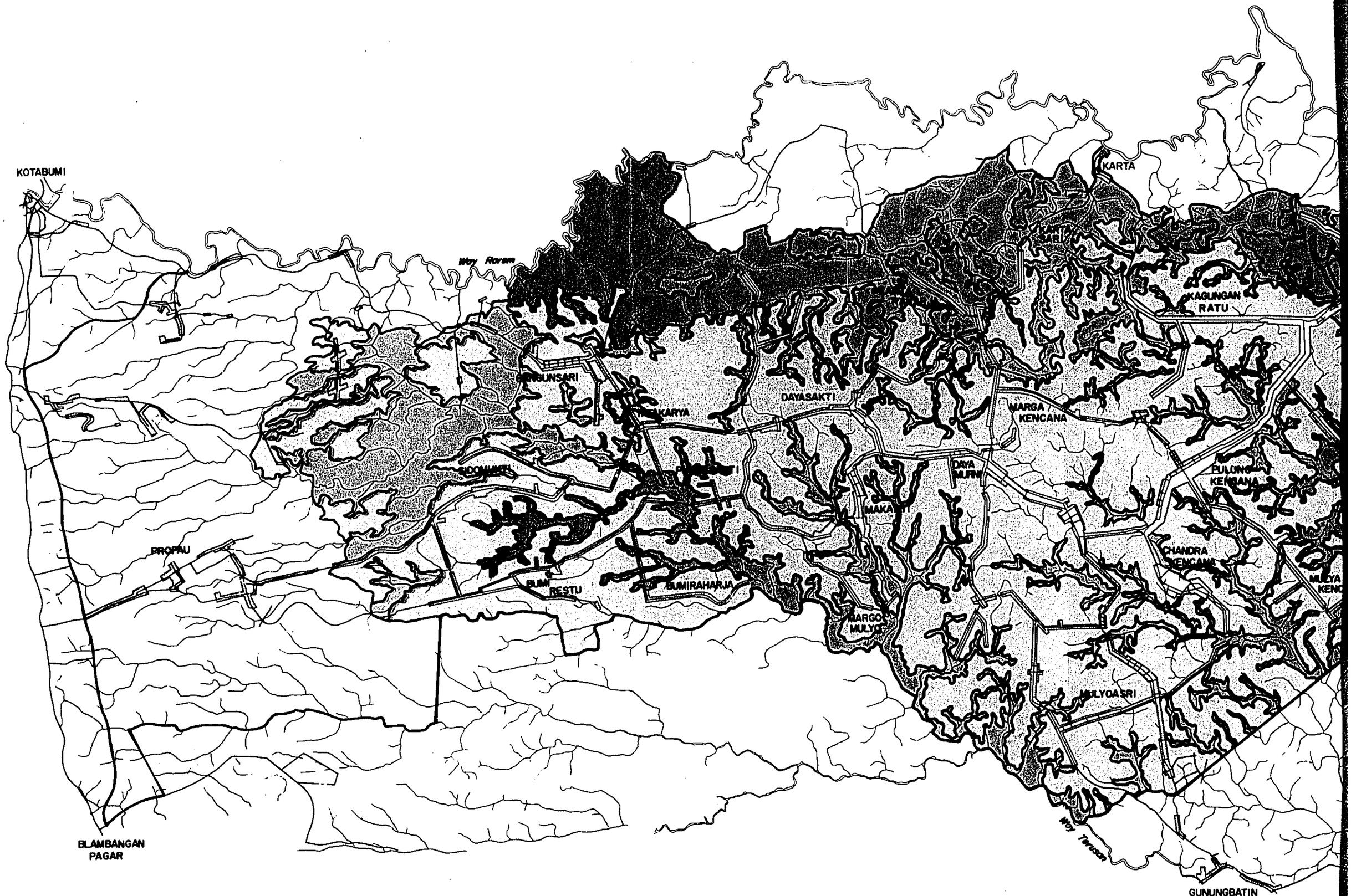
WAY RAREM IRRIGATION PROJECT

LAND USE MAP

SCALE 1 : 50,000	DATE 1976
J.I.C.A. JAPAN	S-1


KOTABUMI
Way Rarem
TA
BANGUNSARI
TATAKARYA
SIDOMUKTI
PURBASAKTI
PROPAU
BUMI RESTU
BUMIRAHARJA
DAYASAKTI
KARTA RAHARJA
KARTA
KARTA SARI
KAGUNGAN RATU
MARGA KENCANA
DAYA MURNI
MAKARTI
BULUNG KENCANA
CHANDRA KENCANA
MULYA KENCANA
MARGO MULYO
MULYOASRI
BLAMBANGAN PAGAR
Way Tarusan
GUNUNGBATIN


TA
KARTA
KARTA SARI
KARTA RAHARJA
KAGUNGAN RATU
PANARAGAN JAYA
PANARAGAN
Wai Kiri
BANGUNSARI
TATAKARYA
DAYASAKTI
PURBASAKTI
MARGA KENCANA
DAYA MURNI
MAKARTI
PULUNG KENCANA
TIRTA KENCANA
CHANDRA KENCANA
MULYA KENCANA
BUMI RESTU
BUMIRAHARJA
MARGO MULYO
MULYOASRI
Wai Tarusan
GUNUNGBATIN
Wai Tulung Buntung
MENGGALA
Lateritic Soil Group
Red Podzolic Soil Sub-group
Yellow Podzolic Soil Sub-group
Tropical Alluvial Soil Group
SCALE 1 : 50,000
0 1 2 3 4 5
WAY RAREM IRRIGATION PROJECT
SOIL MAP
SCALE 1:50,000
DATE 1976
J.I.C.A. JAPAN
S-2


KOTABUMI
Way Rarem
KARTA
KAGUNGAN RATU
DAYASAKTI
MARGA / KENCANA
DAYA MURNI
BULONG KENCANA
MAKA
CHANDRA KENCANA
MULYA KENC
PROPAU
BUMI RESTU
SUMIRAHARJA
MARGO MULYO
MULYOASRI
Way Terusan
BLAMBANGAN PAGAR
GUNUNGBATIN

KARTA

KARTA BARU

PANARAGAN

PANARAGAN JAYA

Way Kiri

KAGUNGAN RATU

DAYASAKTI

MARGA KENCANA

DAYA MURNI

MAKARTI

BUDING KENCANA

CHANDRA KENCANA

MULYA KENCANA

SUMIRAHARJA

MARGO MULYO

MULYOASRI

Way Tenuan

GUNUNGBATIN

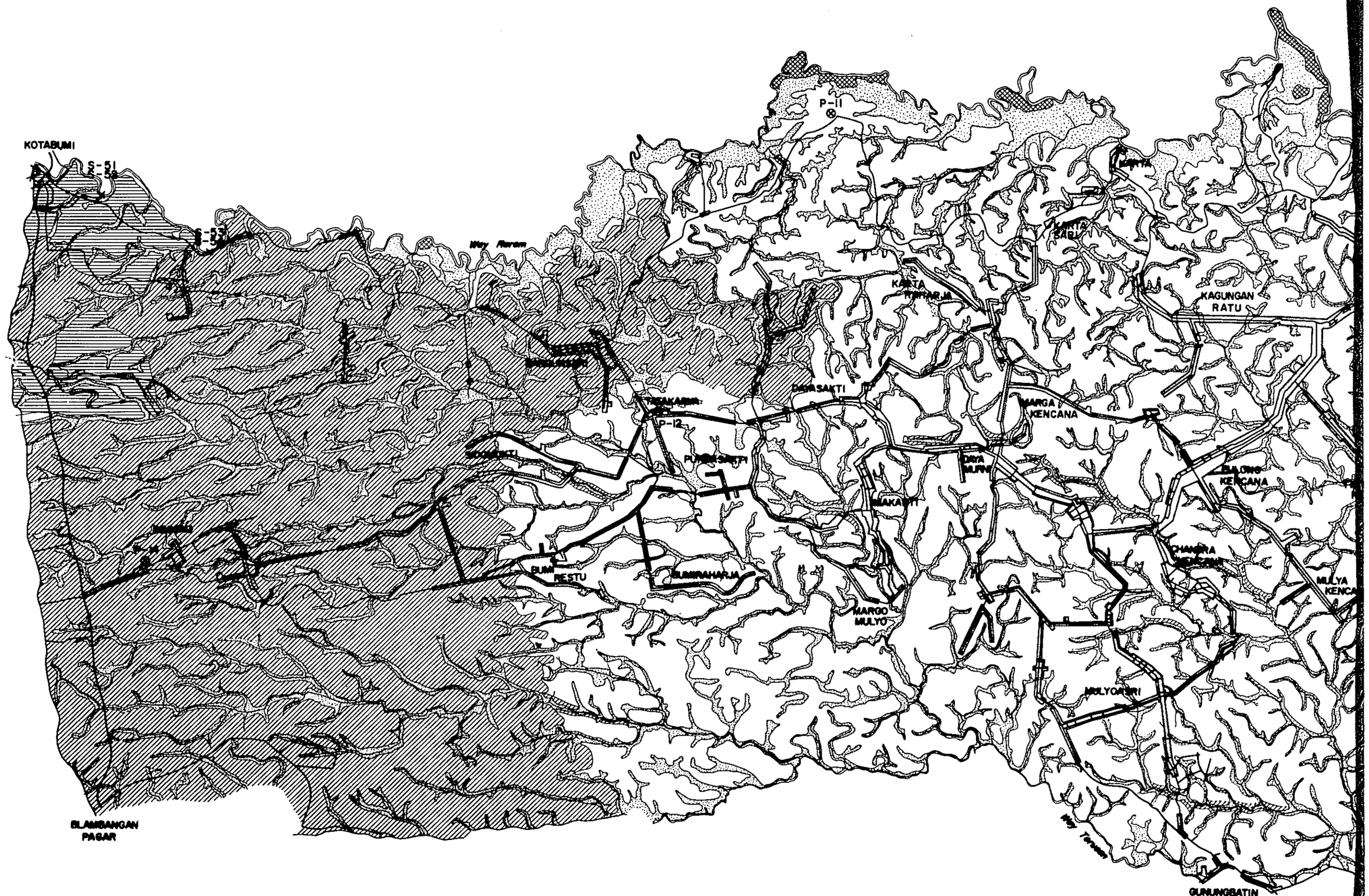
Way Tulang Bawang

MENGGALA

LEGEND

- Class II
- Class III
- Class IV
- Class VI

WAY RAREM IRRIGATION PROJECT	
LAND CLASSIFICATION MAP	
SCALE 1:100000	DATE 1976
J.I.C.A. JAPAN	S-3


KOTABUMI
S-51
S-53
Way Rarem
P-11
P-12
TEGAKARYA
DAYA SAKTI
PUMI RESTU
SUMBERHARJA
KARTA HARJA
KARTA SARI
KAGUNGAN RATU
MARGA KENCANA
DAYA MURNI
BLAKANG
BALING KENCANA
CHANDRA KENCANA
MULYA KENCANA
MARGO MULYO
MULYOASRI
Way Tenong
GUNUNGBATIN
BLAMBANGAN PAGAR

P-11

P-12

KARTA

KARTA SARI

KARTA HARJA

KAGUNGAN RATU

PANARAGAN JAYA

PANARAGAN

WAY KIRI

PASAR SAKTI

MARGA KENCANA

DAYA MURNI

MAKARTI

PUSPA SAKTI

PUSPA RESTU

SUMBER HARJA

MARGO MULYO

BALURAN KENCANA

PUTRA KENCANA

CHANDRA KENCANA

MULYA KENCANA

MULYO SARI

WAY TENONG

WAY TENONG

MENGGALA

GUNUNGBATIN

LEGEND

- Deposite
- Natural levee deposite
- Weathered tuff with quartze
- Weathered tuff
- Tertiary formation
- ⊗ Seismic prospecting
- ⊠ Aggregate
- × Sampling point

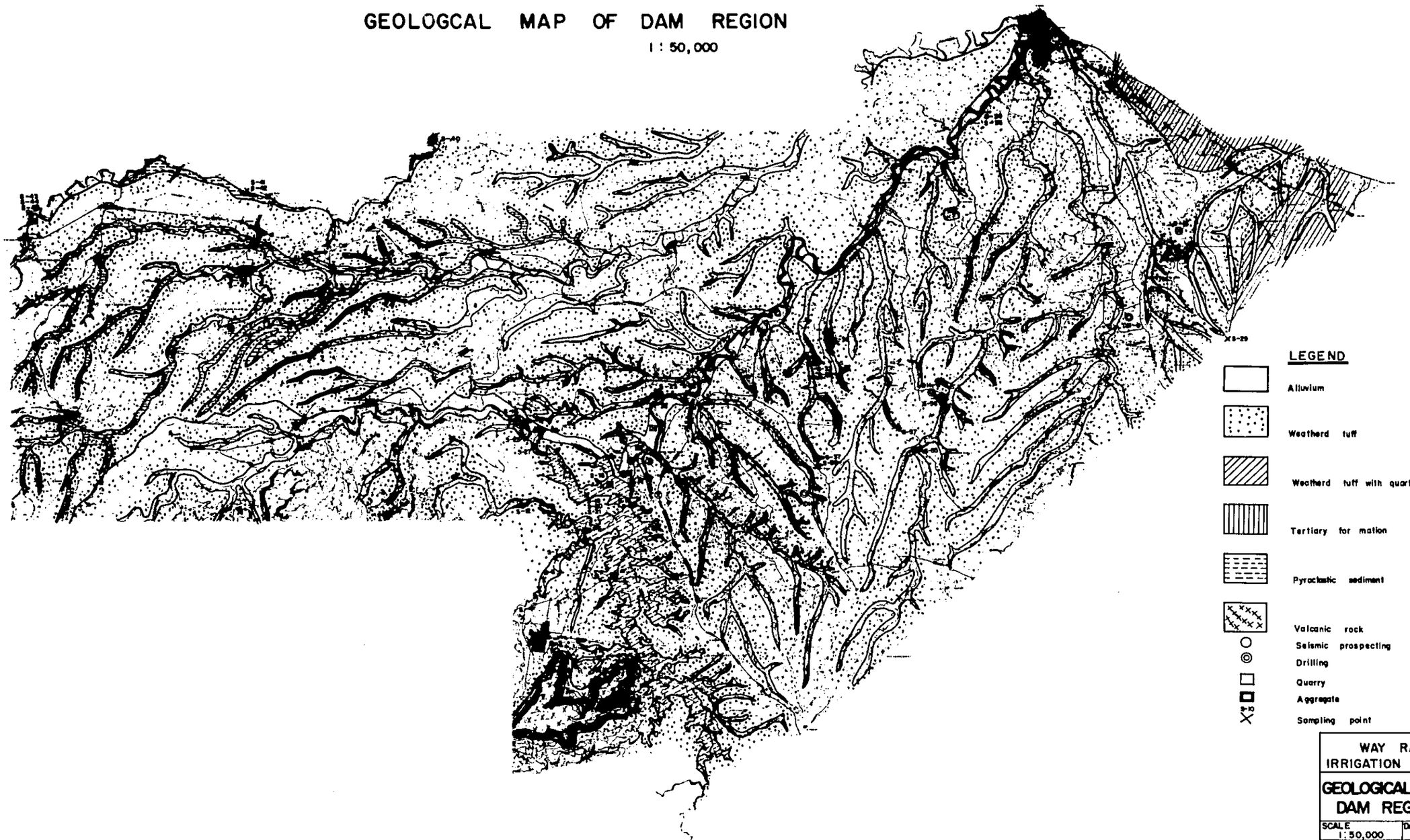
SCALE 1 : 50,000

0 1 2 3 4 5

WAY RAREM IRRIGATION PROJECT		
GEOLOGICAL MAP (GENERAL)		
SCALE 1:50,000	DATE	1976
J.I.C.A. JAPAN		G-1

GEOLOGCAL MAP OF DAM REGION

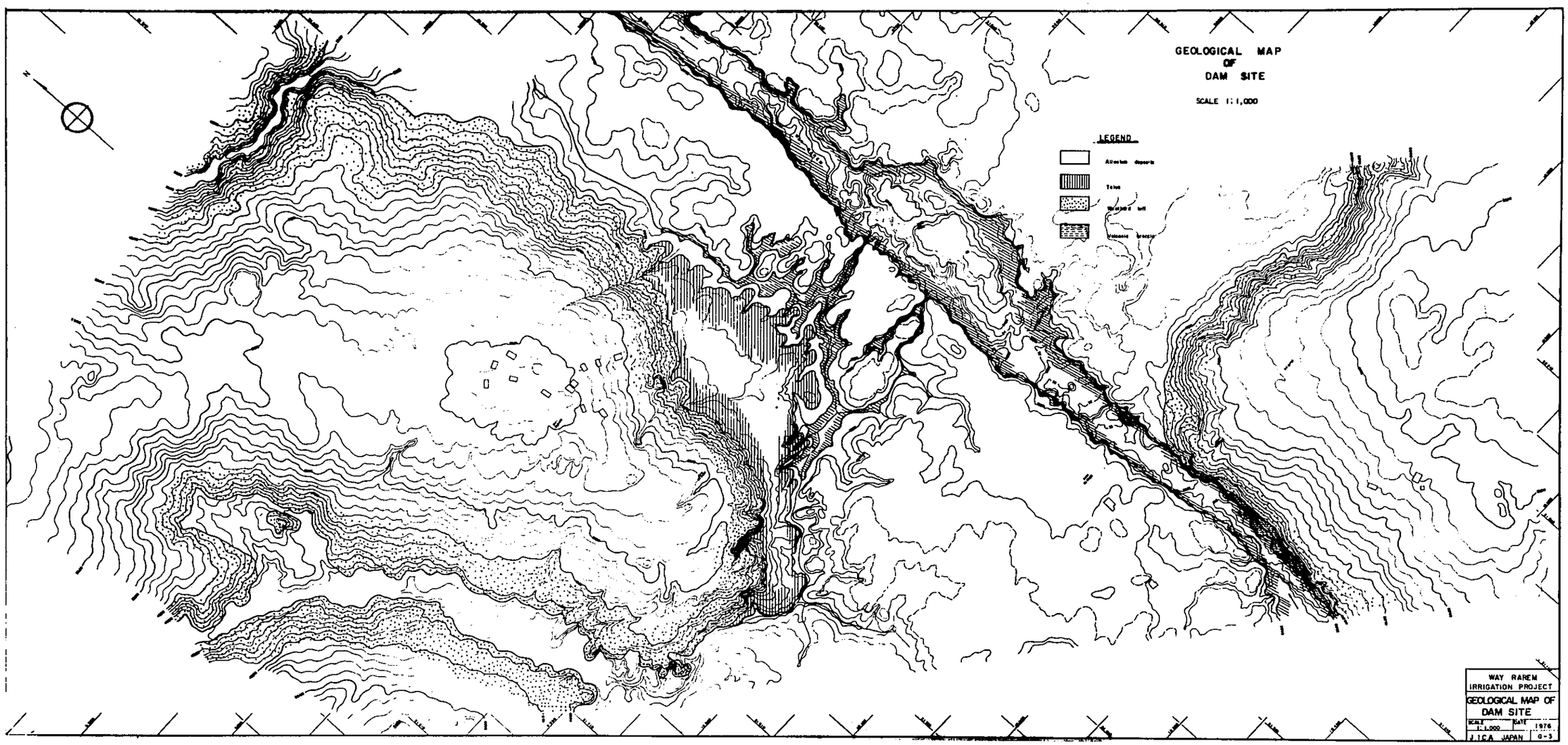
1 : 50,000

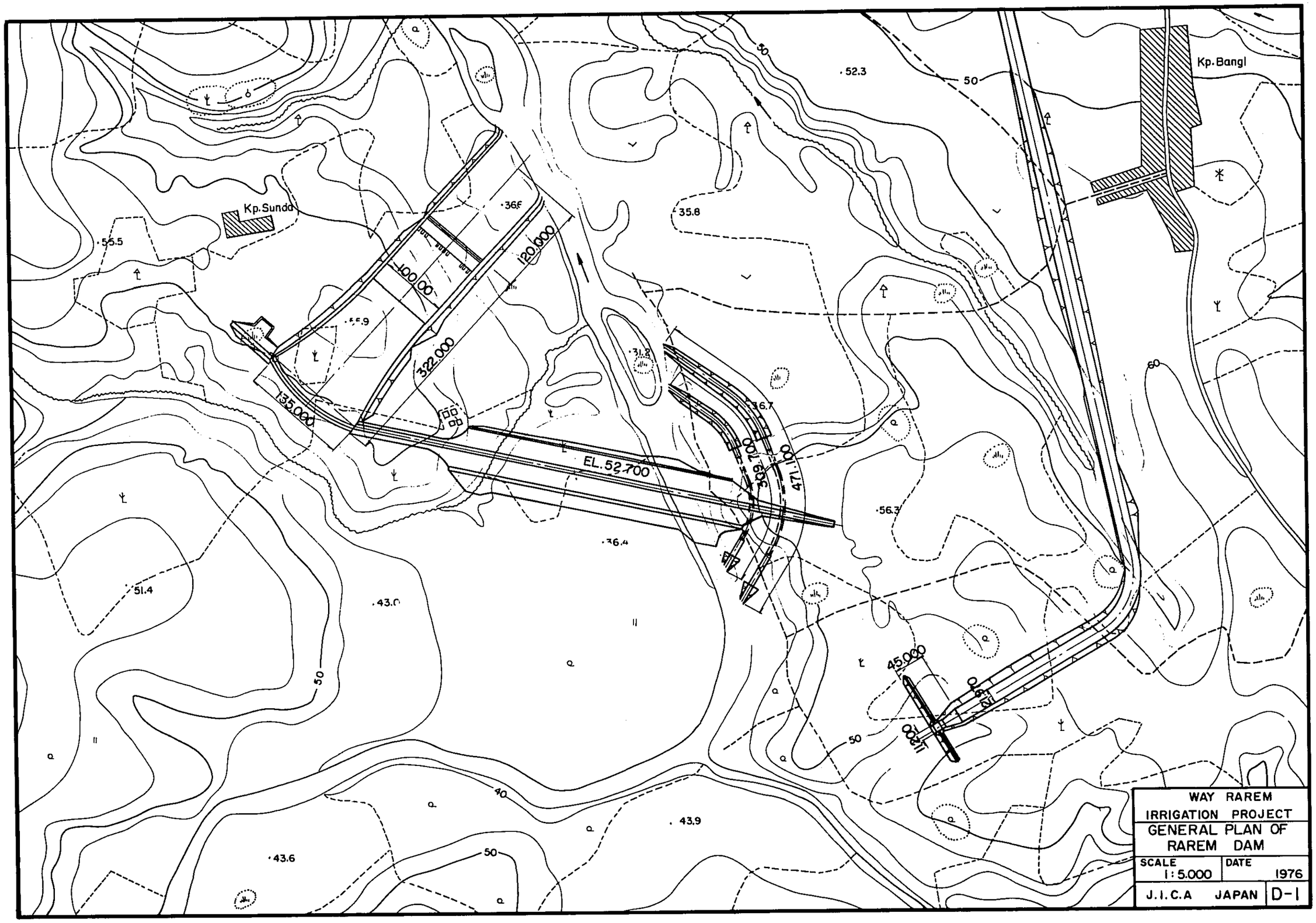


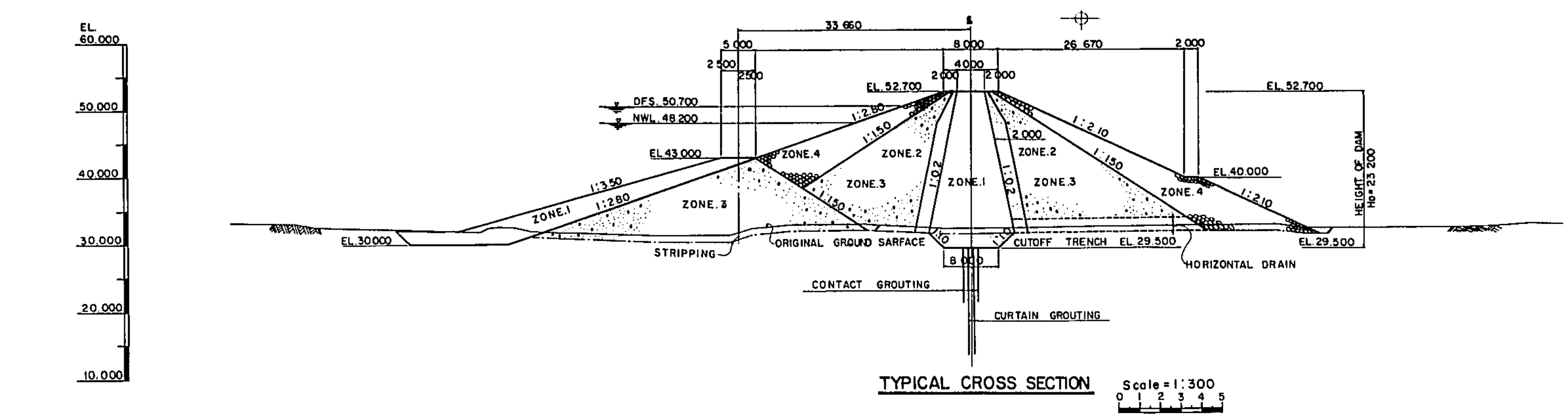
WAY RAREM
IRRIGATION PROJECT

GEOLOGICAL MAP OF DAM REGION

SCALE 1:50,000	DATE 1976
J.I.C.A JAPAN	G-2

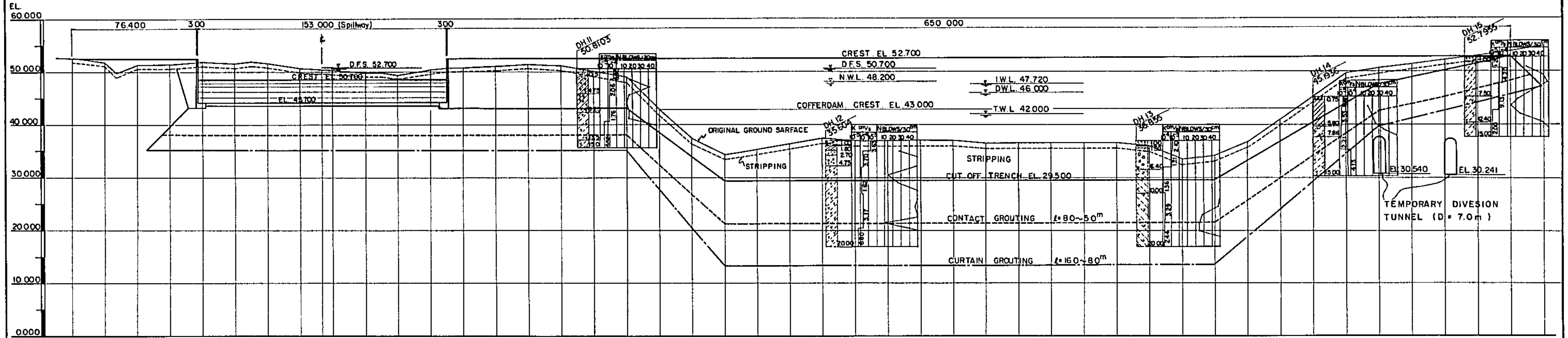

GEOLOGICAL MAP
OF
DAM SITE
SCALE 1:1,000
LEGEND
WAY RAREM
IRRIGATION PROJECT
GEOLOGICAL MAP OF
DAM SITE
SCALE
1:1,000
DATE
1976
J.I.C.A. JAPAN
G-3


Kp.Sunda
Kp.Bangl
55.5
55.9
36.8
35.8
52.3
31.8
36.7
56.3
36.4
51.4
43.0
43.9
43.6
50
40
60
100.00
120.000
32.000
135.000
EL. 52.700
309.700
471.100
45.000
WAY RAREM
IRRIGATION PROJECT
GENERAL PLAN OF
RAREM DAM
SCALE
1:5.000
DATE
1976
J.I.C.A JAPAN
D-1



TYPICAL CROSS SECTION

Scale = 1:300



Excavation Height of Foundation EL.(m)		43.300 43.300 43.300	43.700	43.700	43.300 43.300	43.300	43.300	34.000	29.500	29.500	29.500	29.500	29.500	44.000	47.500	50.000	52.500
Ground Height EL.(m)	52.700	51.800 51.900 52.000	50.600	50.000	51.000 51.000	51.500	49.100	37.500	34.500	37.000	36.500	33.300	34.000	49.500	50.500	52.000	53.500
Total Distance (m)	0	71.4 76.4 80.0	153.2	180.0	230.0 240.0	280.0	340.0	380.0	400.0	480.0	580.0	680.0	700.0	780.0	800.0	840.0	880.0
Distance (m)	0	71.4 5.0 3.6	73.2	26.8	50.0 10.0	40.0	60.0	40.0	20.0	80.0	100.0	100.0	20.0	80.0	20.0	40.0	40.0
Station No	NO.0 +20.0	+91.4 +96.4 NO.1	+73.2	NO.2	(IP.1) +50.0 IP.2	NO.3	+60.0	NO.4	+20.0	NO.5	NO.6	NO.7	+20.0	NO.8	+20.0	+60.0	NO.9
Curve					IA = 58°30' IA = 29°15'												

LONGITUDE

Scale Vertical = 1:300 Horizontal = 1:1000

WAY RAREM IRRIGATION PROJECT

TYPICAL CROSS SECTION AND PLOFILE OF RAREM DAM

SCALE 1:300 DATE 1976

J.I.C.A.. JAPAN D-2