THE REPUBLIC OF INDONESIA

PRE-FEASIBILITY STUDY REPORT
ON
WAY RAREM/ABUNG IRRIGATION PROJECT

MAY 1974

OVERSEAS TECHNICAL COOPERATION AGENCY
JAPAN

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PREFACE

In compliance with the request of the Government of the Republic of Indonesia for Japan's technical assistance in the Way Rarem/Abung Area Irrigation Project, Lampung province, Sumatra, the Government of Japan undertook to conduct a prefeasibility survey for the project and entrusted the Overseas Technical Cooperation Agency with its execution.

The agency recruited experts from the Ministry of Agriculture and Forestry, Geographical Survey Institute of the Ministry of Construction, and Japan Irrigation and Reclamation Consultants and organized a six-member survey team headed by Mr. Yoshimi Uchiyama, Chief of Tone River Basin Investigation Office, Regional Bureau of Kanto Agricultural Administration, Ministry of Agriculture and Forestry.

The team conducted survey activities in the project area from mid-October to the end of November, 1973. After its return to Japan, the team prepared a draft report on the survey which was submitted to the Directorate General of Water Resources Development, Ministry of Public Works and Power of the Government of Indonesia, by Mr. Uchiyama who visited Jakarta in March 1974 accompanied by a team member to discuss with the Indonesian authorities on the future prospect of the project.

This report contains valuable information which will prove instrumental in conducting the forthcoming feasibility study on the project.

I take this opportunity to express my deep gratitude to the Directorate General of Water Resources Development, Ministry of Public Works and Power and other competent Indonesian authorities for the unlimited assistance offered to the team. I should also like to acknowledge the elaborate cooperation extended by the staff of Embassy of Japan in Jakarta, Geographical Survey Institute of the Ministry of Construction and other offices, staff of Japan Irrigation and Reclamation Consultants, and Japanese experts stationed in Indonesia.

May 1974

Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency

LETTER OF TRANSMITTAL

Mr. Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency
Tokyo, Japan

Dear Sir,

I have the pleasure to present herewith a report on the prefeasibility study on Way Rarem/Abung Area Irrigation Project Lampung province, Sumatra, which was conducted at your request for a period of 45 days from October 11 to November 24, 1973.

The project area covers an acreage of about 120,000 ha which is partly settled by the farmers who have transmigrated from Java and other parts of Indonesia over the past years.

While the Government of Indonesia has been pursuing the policy of encouraging transmigration into the project area through creation of new farmland area, these settlers are pressed hard for improved 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.

Improvement of irrigation facilities and stabilization of farm management through introduction of paddy cropping is what is most keenly desired at present not only by the settlers but by the Government of Indonesia.

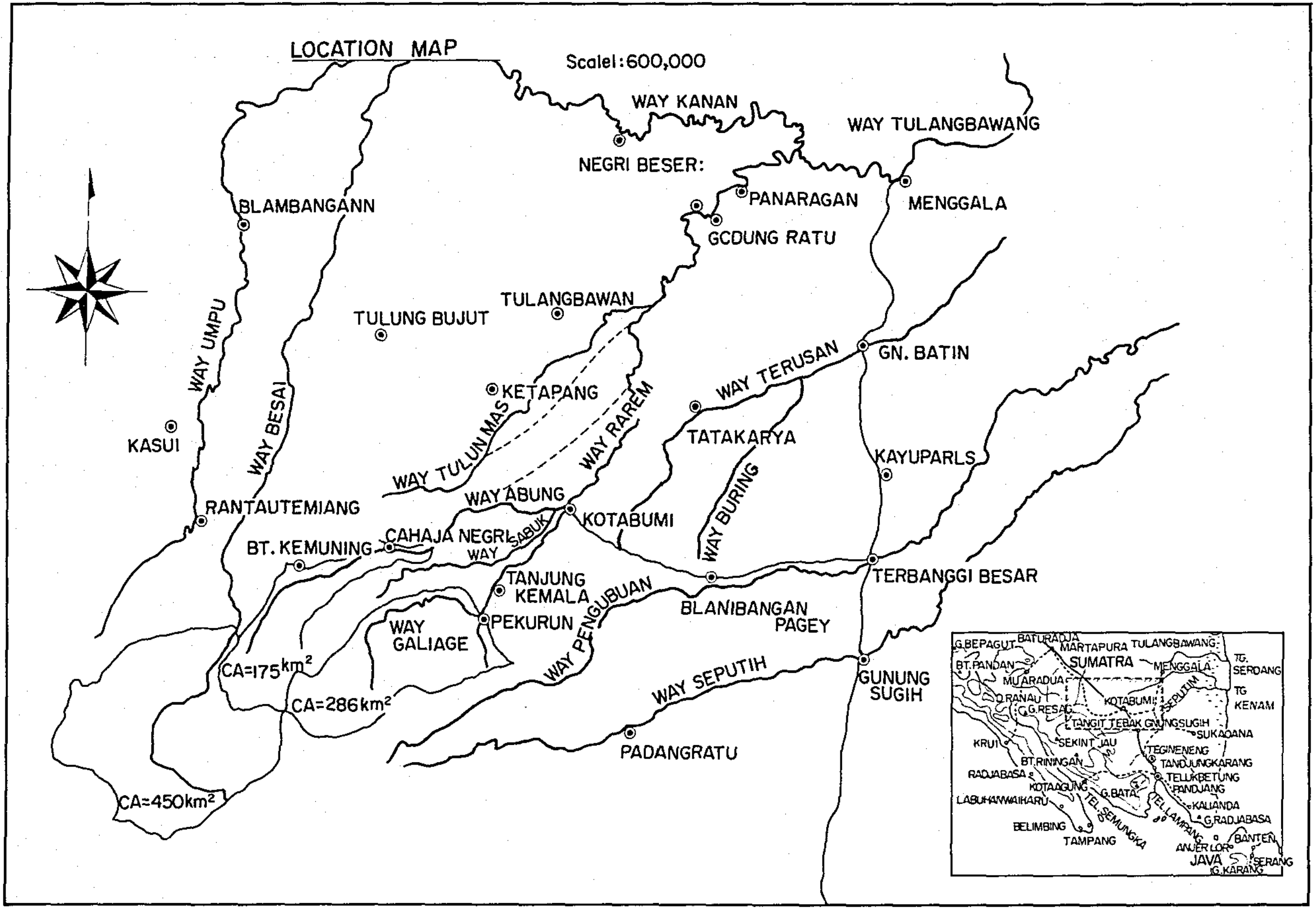
In this report, irrigation plans are proposed for respective districts, with their priority order studied in due consideration of the socio-economic condition of the entire 120,000 ha area.

I sincerely hope that a feasibility study will be conducted as soon as possible for early construction of irrigation facilities.

Kindly allow me to take this opportunity to express my appreciation and gratitude to the Director General of Water Resources Development, Ministry of Public Works and Power of the Republic of Indonesia, Ministry of Foreign Affairs, Ministry of Agriculture and Forestry, Ministry of Construction, Embassy of Japan in Jakarta, Overseas Technical Cooperation Agency and Japan Irrigation and Reclamation Consultants for their whole-hearted cooperation and assistance.

May 1974

Yoshimi Uchiyama
Leader,
Prefeasibility Survey
Team for Way Rarem/Abung
Irrigation Project


LOCATION MAP
Scale1:600,000
WAY KANAN
WAY TULANGBAWANG
NEGRI BESER:
PANARAGAN
MENGGALA
BLAMBANGANN
GCDUNG RATU
TULANGBAWAN
TULUNG BUJUT
WAY UMPU
WAY BESAI
GN. BATIN
KETAPANG
WAY TERUSAN
WAY RAREM
KASUI
WAY TULUN MAS
TATAKARYA
KAYUPARLS
WAY BURING
WAY ABUNG
RANTAUTEMIANG
KOTABUMI
BT. KEMUNING
CAHAJA NEGRI
WAY SABUK
TERBANGGI BESAR
TANJUNG KEMALA
WAY PENGUBUAN
BLANIBANGAN PAGEY
WAY GALIAGE
PEKURUN
CA=175km²
CA=286km²
WAY SEPUTIH
GUNUNG SUGIH
PADANGRATU
CA=450km²
SUMATRA
MARTAPURA
TULANGBAWANG
MENGGALA
KOTABUMI
JAVA

SUMMARY AND RECOMMENDATION

The survey this time was conducted as a prefeasibility study for Way Rarem/Abung Irrigation Project, in Lampung province, which is mapped out to cover approximately 118,000 ha. Under the policy for accelerating food production and encouraging transmigration which has been pursued by the Government of Indonesia, more than 5,000 farm households have already settled in this area. To provide these settlers with improved irrigation facilities, there is a pressing need which should be met by this project implementation. The project also aims at expanding farmland areas and inducing more settlers to further augment food production.

The project area is covered by acid soil with less phosphoric acid but generally suitable for farming. Planning of large-scale irrigation facilities entails some difficulty in the project area because it stretches in undulation. With the above conditions taken into account and in due consideration of the topography, discharge of water source and conceivable irrigation methods, the team divided the whole project area into eight areas (See Table 4-1-1 and Fig. 5-1).

In order that the project secure higher yields at the earliest possible time, the team also made a study on the construction plan of irrigation tanks for W. R/A S-1 and S-2 areas which are already covered by the existing 1/5,000 topographic map (Refer to Section 5-12). Construction of irrigation tanks will constitute the first stage development of the project.

For the second stage development under the project, the team sought the possibility of realizing paddy rice cropping in all the eight areas at least in the wet season by installing necessary irrigation facilities. One area needs the diversion of river water from the Way Besai, all other areas can be irrigated with water drawn from nearby rivers. Specifically, the team made a comparative study between gravity irrigation and pump irrigation for W. R/A S-1 and S-2 areas, and planned pump irrigation for W. R/A N-1 and N-2 areas. The latter two areas do not require diversion of water from the Besai because the river discharge is expected to be large enough for paddy rice cropping even in the dry season.

W. R/A N-3 was excluded from the project area by reason of the Rice Estate Plan, although it was initially included in the scope of study.

For the third stage development of the project, the team made a study on the irrigation plan for year-round paddy rice cropping in all areas. The study resulted in the adoption of the plan to construct a dam on the Way Besai from which irrigation water is to be supplied to each area by diverting water to the Way Abung and the Way Rarem. This plan provides room for choosing between different irrigation plans for respective areas and combining such plans with gravity or pump irrigation plans for W. R/A S areas. As a result, six different irrigation systems were formulated for further study and discussion.

Table 5-16-1 shows the benefit-cost ratio for each of the above three stages as well as for each of the six irrigation systems.

With respect to the mapping work required for the feasibility study of the project, study of all the existing maps and data disclosed that two maps should be newly prepared, i.e., 1/10,000 map covering areas which call for diversion work and 1/5,000 map covering areas to be irrigated. It was agreed that the Government of Japan would complete the 1/10,000 map prior to the feasibility study to be conducted in 1974/1975 and that the Government of Indonesia would prepare the 1/5,000 map before the irrigation plan for W. R/A N-1 and N-2 areas is implemented.

Considered from a technical point of view, it is probable that the project will yield the highest results in W. R/A S-1 and S-2 areas. In these two areas, great enthusiasm is evinced by settlers for paddy rice cropping and PROPAU and other organs are already established. It is therefore recommended that the construction work in these areas be given the top priority. The team studied gravity irrigation and pump irrigation for future development of the two areas. It is recommended that the final selection between the two irrigation methods is to be made after completion of the forthcoming feasibility study.

It is also recommended that the Way Besai dam construction plan and the diversion plan should be subjected to a close review during the feasibility study.

Hence, the team is of opinion that the mapping work should be completed at the earliest possible time in 1974 in order that the diversion plan may be fully scrutinized in the feasibility study.

It is therefore urged that the Government of Indonesia provide assistance to the project in connection with the following activities.

(1) Continued collection of hydrological data at the existing observation stations, and collection of river discharge data at two points, one immediately downstream of the confluence of the Way Buring and the Way Terusan and the other located immediately downstream of the confluence of the Way Tulung Mas and the Way Rarem.

(2) Establishment of bench marks for determining elevations of driving channels, channels for diversion of water, and the intake on the Way Besai.

(3) Collection of data required for preparing the 1/10,000 map (such as the table of control points, diapositives of aerial photos and enlarged aerial photos), and approval for the transfer of such data to Japan.

CONTENTS

CHAPTER I. INTRODUCTION

1-1. Background of the Development

In the Republic of Indonesia, in contrast to the very high population density in Java and Bali islands (more than 100 persons/km^2), Sumatra, Kalimantan and Sulawesi islands have low population density (less than 50 persons/km^2). One of the important policies of the country is to transmigrate the people from the densely populated regions to the sparsely populated areas having vast undeveloped lands. Efforts are being made constantly to enforce this policy. Lampung province, situated in the southern part of Sumatra island, is one of such transmigration areas close to Java island and where the soil is comparatively fertile. Way Rarem/Abung Area is located near the center of the province. A land reclamation plan is being made to provide farmland to the prospective settlers from Java and other islands.

Another important national policy is to increase sharply the production of foodstuff. Endeavors are being made to secure a steady supply of foodstuff by increasing agricultural production based mainly on rice production and also to elevate the farmers' income level to stabilize their livelihood. Lampung province is proposed as an area for early materialization of this policy.

The development of Way Rarem/Abung Area is a project which will be promoted with these two important national policies as a background.

1-2. Organization of the Survey Team & Assignment of Duties

Leader (General Affairs)	Yoshimi Uchiyama	Chief of Tone River Basin Investigation Office, Regional Bureau of Kanto Agricultural Administration, Ministry of Agriculture & Forestry.
Member (Mapping)	Rokuro Nakamura	Chief of National Large Scale Mapping Section, Topographic Division, Geographical Survey Institute, Ministry of Construction.
Member (Irrigation Planning)	Kazutsugu Nakanishi	Design Supervisor, Design Section, Land Improving Bureau, Ministry of Agriculture & Forestry.
Member (Farm Management)	Tsutomu Oikawa	Chief of Planning Section, Planning Division, Regional Bureau of Hokuriku Agricultural Administration, Ministry of Agriculture & Forestry.
Member (Hydrology)	Hirotaka Arai	Irrigation Engineer, Japan Irrigation & Reclamation Consultants.
Member (Coordination)	Hiroshi Kimura	Staff Development Survey Division OTCA.

1-3. Names of Officials Concerned in the Government of Indonesia

1-3-1. Counterparts

Machdiany, BIE	Local Public Works Office, Lampung Province
Ir. Hartono	Design & Planning Service, Directorate of Irrigation, Directorate General of Water Resources Development
Mohamad Syah, BIE	Design & Planning Service, Directorate of Irrigation, Directorate General of Water Resources Development
Ir. Soelaiman	Design & Planning Service, Directorate of Irrigation, Directorate General of Water Resources Development
Ir. Kamaludin	Local Agriculture Office, Lampung Province
Soewarto, BSC	Local Public Works Office, Lampung Province

1-3-2. Cooperators

Ir. Sujono Sosrodarsono	Director General of Water Resources Development, Ministry of Public Works & Power
Ir. H. Nainggolan	Assistant Director General of Water Resources Development, Ministry of Public Works & Power
Ir. Oesman Djojoadinoto	Director of Irrigation, Directorate General of Water Resources Development, Ministry of Public Works & Power
Ir. Sarwoko	Assistant Director of Irrigation, Directorate General of Water Resources Development, Ministry of Public Works & Power
Ir. Sadeli Wiramihardja	Chief of Design & Planning Service, Directorate of Irrigation, Directorate General of Water Resources Development, Ministry of Public Works & Power

Ir. Muhadi	Design & Planning Service, Directorate of Irrigation, Directorate General of Water Resources Development
Ir. Mashudi	Design & Planning Service, Directorate of Irrigation, Directorate General of Water Resources Development
Ir. Soenoto	Design & Planning Service, Directorate of Irrigation, Directorate General of Water Resources Development
Drs. Attamimi	Directorate of Planning & Programing, Directorate General of Water Resources Development
Mr. Tata Sukarta	Directorate of Planning & Programing, Directorate General of Water Resources Development
Mr. Slamat	Directorate of Planning & Programing, Directorate General of Water Resources Development
Mr. Ruslan	Directorate of Irrigation, Directorate General of Water Resources Development
Ir. A. Sadeli	Chief of Local Public Works Office, Lampung Province
Ir. Nusyirwan Zen	Chief of Local Agriculture Office, Lampung Province
Ir. Rubini Jusuf	Local Public Works Office, Lampung Province
Saifuddin Hasan, BRE	Chief of Public Works Branch Office in North Lampung Regency
Sri Poernomo, BIE	Public Works Branch Office in North Lampung Regency
Hafied, BIE	Public Works Branch Office in Central Lampung Regency
Ir. Djumli Hasan	North Lampung Regencial Office
Ir. Agusnardi	Local Public Works Office, Lampung Province
Mr. Sujaswadi	P3. S. A. Office in Lampung Province

Mr. G.B. Mayes	P3. S. A. Office in Lampung Province
Ir. Sardjono	Chief of PROSIDA Office in Lampung Province
Mr. Suparto	PROSIDA Office in Lampung Province
Mr. Poernomo	Way Djepara Project, Ministry of Public Works & Power
Mr. Djadja Suwardja	PROPAU
Mr. Soedarsono	PROPAU
Mr. Soediono	PROPAU
Mr. Supardi	Tatakarya Village
Mr. Junichi Kitamura	Colombo Plan Expert, Directorate of Irrigation, Ministry of Public Works & Power
Mr. Katsuhiko Kimura	Colombo Plan Expert, Directorate of Irrigation, Ministry of Public Works & Power
Mr. Takeshi Nomoto	"
Mr. Takashi Hayashi	"
Mr. Takeshi Ishida	"
Mr. Kazumi Ueda	"
Mr. Kazuma Nojima	Lampung Province Tani Makmul Project
Mr. Kotaro Nagai	"
Mr. Jiro Kosaka	"
Mr. Key Oka	"
Mr. Hiroshi Mori	"
Mr. Akira Shiraku	"
Mr. Koji Hattori	"
Mr. Ryonosuke Goto	"
Mr. Moriyoshi Wakabayashi	Tjhea Project

1-4. Itinerary of the Survey Team

The team arrived in Jakarta on 11th October, 1973 from Tokyo and immediately commenced the survey work.

The main activities of the experts are as follows:

ACTIVITIES OF THE SURVEY TEAM

No.	Date	Day	Stay in	Activities
1	1973 Oct. 11	Thu	Jakarta	Arrived in Jakarta from Tokyo by CY 501.
2	12	Fri	- ditto -	Paid a courtesy visit to the Embassy of Japan; Paid a courtesy call on the Director General of Water Resource Development, D.P.U.T.L.
3	13	Sat	- ditto -	Prepared for the survey.
4	14	Sun	Bandung	Moved to Bendung.
5	15	Mon	- ditto -	Discussion with staffs of D.P.U.T.L. in Bandung concerning the survey.
6	16	Tue	Jakarta	Returned to Jakarta
7	17	Wed	Telukbetung	Moved to Telukbetung by Garuda.
8	18	Thu	Kotabumi	Paid a courtesy call on the Local D.P.U.T.L. and the Local Agriculture Office, Lampung.
9	19	Fri	- ditto -	Paid a courtesy call on the Local D.P.U. Lampung Utara; Conducted a general field survey on the Way Rarem.
10	20	Sat	- ditto -	Conducted a general field survey on the Way Rarem transmigration area.
11	21	Sun	- ditto -	Conducted a general field survey on the Way Abung.
12	22	Mon	Telukbetung	Conducted a general field survey at the Way Abung weir site; Moved to Telukbetung.

13	Oct.	23	Tue	Telukbetung	Collected data and information at P3 S.A.; Discussion with counterparts concerning the survey.
14		24	Wed	Jakarta	Returned to Jakarta.
15		25	Thu	Bandung	Discussion with the Director of Irrigation concerning the survey; Moved to Bandung.
16		26	Fri	- ditto -	Discussion with the staff of D.P.U.T.L. in Bandung concerning the general field survey.
17		27	Sat	- ditto -	Holiday - Lebaran.
18		28	Sun	- ditto -	- ditto -
19		29	Mon	- ditto -	Arranged collected data.
20		30	Tue	- ditto -	Discussion with Colombo plan experts concerning irrigation methods.
21		31	Wed	- ditto -	Discussion with staffs of D.P.U.T.L. in Bandung concerning Mapping, Irrigation planning and Hydrology; Visited L.P.M.A. for data collection.
22	Nov.	1	Thu	Jakarta	Returned to Jakarta; Intra-team discussion on the interim report.
23		2	Fri	Telukbetung	Moved to Telukbetung.
24		3	Sat	- ditto -	Discussion with counterparts concerning the schedule of individual surveys; Mr. Nakamura (mapping expert) left for Japan.
25		4	Sun	Kotabumi	Moved to Kotabumi.
26		5	Mon	- ditto -	Conducted a survey of the Way Terusan and wells in the project area; Conducted a survey of farm management.
27		6	Tue	- ditto -	Conducted a survey of the Way Tulang Mas and the Way Besai; Conducted a survey of farm management.
28		7	Wed	- ditto -	Conducted a survey of farm management.

29	Nov.	8	Thu	Kotabumi	Checked the discharge of the Way Rarem; Conducted a survey of farm management.
30		9	Fri	Telukbetung	Visited P.T. Daya Itoh for data collection; Conducted a survey of farm management; Moved to Telukbetung.
31		10	Sat	- ditto -	Visited the PROSIDA Way Seputih irrigation project office in Banjarjaya for data collection; Went to Metro in order to collect data; Conducted a survey of farm management.
32		11	Sun	- ditto -	Arranged collected data; Team leader arrived in Jakarta from Tokyo by JAL 711.
33		12	Mon	- ditto -	Collected data and information at P3 S.A.; Team leader paid courtesy call on the related authorities in Jakarta.
34		13	Tue	Kotabumi	Team leader arrived at Branti airport by Garuda; Moved to Kotabumi.
35		14	Wed	- ditto -	Conducted a survey of weir site; Visited PROPAU and P. T. Daya Itoh for data collection.
36		15	Thu	Telukbetung	Conducted a survey on the Way Sabuk, Way Abung and Way Besai; Visited the PROSIDA - Way Seputih irrigation project for inspection of irrigation facilities; Moved to Telukbetung.
37		16	Fri	- ditto -	Paid a courtesy call on the related authorities in Tanjungkarang.
38		17	Sat	Jakarta	Returned to Jakarta by Garuda.
39		18	Sun	- ditto -	Intra-team discussion on the interim report on Way Rarem project.
40		19	Mon	- ditto -	Preparation of the interim report; Discussion with Mr. Sedeli of D.P.U.T.L. in Bandung concerning Way Rarem Project.

41	Nov.	20	Tue	Jakarta	Preparation of the interim report.
42		21	Wed	- ditto -	- ditto -
43		22	Thu	- ditto -	Courtesy call on the related authorities in Jakarta.
44		23	Fri	- ditto -	Submitted the interim report with explanation to the Director General of Water Resources Development D.P.U.T.L.
45		24	Sat		Left Jakarta for Tokyo.

CHAPTER II. OUTLINE OF THE PROJECT AREA

The project area lies in the central part of Lampung province around longitude 105°E and latitude 5°S and is divided into two areas, namely, the Way Rarem/Abung area and the Way Abung area. It covers an acreage of 118,300 ha which is apart from the project area of the irrigation projects for the Way Seputih and the Way Djepara which are already under way and for the Way Umpu and the Way Pengbuan which are about to be started.

Topographically, the area is hilly, sloping gently from southwest to northeast, and has an elevation of less than 50 m. Belt-like swamps are found along many small rivers which intrude deep into the hills.

More than 5,000 farm households have settled in the southern half of the Way Rarem/Abung area, and many of these settlers have already learned the technics of rice cultivation in Java island.

Their goal is to engage themselves in the new agricultural management centered on rice cultivation.

CHAPTER III. PRESENT SITUATION

3-1. Climate

As the project area lies in the tropics, the annual variation of temperature is small and the mean air temperature is about 27°C throughout the year, with virtually no seasonal fluctuation.

Table 3-1-1 Mean Monthly Air Temperature in Way Seputih Area
Period: 1971/1972

Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
27.1	26.9	26.6	26.5	26.6	26.7	27.2	26.8	26.8	26.7	26.6	27.0

(Degrees in Centigrade)

With the exception of the monsoon wind which is incidental to the tropical climate, no strong wind or typhoon occurs in this area. The average wind velocity is less than 2 m/sec.

Table 3-1-2 Wind Velocity at Tandjunkarang
Period: 1963/1967

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
knot/hr	0.06	0.06	0.05	0.06	0.05	0.06	0.05	0.05	0.06	0.05	0.04	0.05
m/sec	1.9	1.9	1.5	1.9	1.5	1.9	1.5	1.5	1.9	1.5	1.2	1.5

Rainfall clearly divides the climate in this area into the wet and the dry seasons. The duration of the wet and dry seasons varies by year and about 70% of the annual rainfall of 2,600 mm 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 3-1-3.

An average 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 continuous drought was four months recorded in 1967), and this seems to be the cause of unstable dry season cropping.

Table 3-1-3 Average Monthly Rainfall at Various Observation Stations

(Unit: millimeters)

Station Name	Period	Wet season			Dry season						Wet season		
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Kasui	1931-1953	277	243	267	256	170	108	106	89	84	138	220	267	2225
Tulung Bujut	1931-1941	371	337	377	361	197	138	100	94	119	178	229	450	2951
Kotabumi	1931-1941	339	278	322	266	191	147	135	85	138	143	259	320	2623
Gunung Sugih	1931-1957	374	302	289	278	143	148	127	84	98	158	258	358	2617
Bukit Kemuning	1952-1960	475	388	447	333	276	124	146	105	107	152	302	366	3221

The average monthly relative humidity is high in general, being about 77% and is characterized by a small seasonal variation like the air temperature. Such high temperature and humidity provide favorable conditions for the growth of crops.

Table 3-1-4 Average Monthly Humidity in Way Seputih Area

Period: 1971/1973

Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
78	78	73	72	75	72	71	75	75	75	80	79

(Percent)

The amount of evaporation is about 2.1 mm/day on the average according to the data on the Way Seputih area.

Table 3-1-5 Average Monthly Evaporation in Way Seputih Area

(Period: 1971/1973

Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1.6	1.8	1.9	2.4	2.4	2.7	3.1	2.5	1.7	1.9	1.6	1.6

(mm per day)

3-2. Land Condition

The project area has an undulating topography; vast plateaus, rivers and swampy lowlands continue alternately in its southern part near Kotabumi and in the southwestern part of the Abung area, but flat topography prevails in the northern part.

The area extends from south to north, and is divided into two parts by a belt of lowland which stretches east to west in the central part north of Tatakarya. Thus, a saddle-shaped topography is formed. The highest elevation in the southern part is El. 55m, and is El. 30m in the northern part and El. 20m in the central lowland part respectively.

Some lowlands lie along the Way Rarem which flows along the western boundary of the area. As mentioned later, such a topography exerts much influence on the planning of irrigation works.

The greater part of the area is covered with acid soil comprising yellowish brown and reddish brown podzols deficient in phosphoric acid and subjected to intensive leaching. Some alluvial soil is distributed in the lowland along the western boundary where some paddy fields are found, and latsol which is peculiar to the tropics is distributed in the southwest of Kotabumi.

Land use condition in Rarem/Abung area (83,000 ha), which has been the main object of the present survey is as follows. With the exception of about 8,000 ha of farmland belonging to the native people of Lampung, all the existing farmland was created after 1965 by settlers. Out of 18,000 ha of reclaimed farmland, 12,000 ha is allotted to general transmigrants and 6,000 ha to the retired Air Force servicemen. At present, these reclaimed lands cover the southern half of Rarem/Abung area, and the northern half (Panaragan region) is scheduled to be reclaimed in and after 1974.

Such farmland and waste land are used alternately by rotation at an interval of two or three years to maintain the soil fertility.

Except a very small paddy field area in the swamps, farmland in this area mostly consists of ordinary dry fields.

In this survey, a thorough investigation of the land use in Abung area was not possible due to the limited time. It is known, however, that this area was developed by the settlers in 1950's and is different from the Rarem/Abung area in that paddy is cultivated in swamps to a substantial degree.

3-3. Water Utilization

Both Way Rarem/Abung area and Abung area are not provided with irrigation and drainage facilities. The rivers in the two areas are still in their primeval condition, and they inundate the neighbouring land in the flood season. However, the Way Umpu and Way Pengubuan Project for which a feasibility study was made in 1973 - 1973 is soon to be implemented in the vicinity of the project area. Also, a largescaled project aiming at a maximum intake of 25 cu. m/sec from the Way Seputih for irrigation of 25,000 ha is under way with the loan from the World Bank and is nearing completion. Further, on the Way Sekampung in central Lampung, the intake facilities having a capacity of about 50 cu. m/sec have been in use for nearly forty years.

Under the transmigration program of the government about 9,000 farm households have settled in the project area, and they are placing their hope on the construction of the irrigation facilities.

3-4. Road Condition

Way Rarem/Abung area is surrounded almost by the roads. Except in some sections, these roads are simple asphalt paved or gravel paved, and are as narrow as having only one lane but motor traffic is not hindered. The construction of the foundations of the bridges crossing small rivers in the area are being progressed smoothly and the superstructure work is also being carried out steadily.

Inside the area, however, roads are unpaved, and though they are wide enough to be used as farm roads, these roads become impassable in the wet season even for jeeps, making it extremely difficult to transport agricultural products and materials.

The road conditions in the Abung area are even worse than in Way

Rarem/Abung area, and there is only one main road that runs across this area. Even this road has only a few kilometers of gravel paved sections.

Since Abung area has heavily undulated topography, the roads have steep slopes and light rainfall hinders the passage of motorcars in the wet season.

3-5. Outline of Agriculture

Agriculture in Way Rarem/Abung area comprises the ordinary upland field cropping by the settlers and the intensive estate agriculture by the Lampung natives who grow coffee, pepper, oil palm, rubber, etc. in an area corresponding to 10% of the total project area.

The rest of the area is forest and waste land. In the Way Rarem/Abung area, which has been the main object of the present survey, about 12,000 ha in the southern half have been allotted to ordinary settlers by 1973. Accordingly, ten villages have been established and about 5,500 households have settled in this area. In addition, about 6,000 ha have been allotted to those related to the Air Force (retired servicemen, bereaved families, etc.).

Most of the settlers are the transmigrants from the paddy field zones in Java island and they have a strong desire for cultivating paddy field rice. However, due to the lack of irrigation facilities they are engaged in the upland field farming at present, growing chiefly upland rice and cassava.

The farmland allotted to each farm household is uniformly 2 ha, including 0.25 ha for homestead.

The pattern of farm management is almost the same throughout the area, because of the little difference in the native place and the date of settlement of settlers and also because of the uniform land allotment and land condition.

In the homestead of 0.25 ha, trees are planted around the house for shade and for production of coconuts, etc. In the ordinary upland field of 1.75 ha, mixed cropping of upland rice, cassava, maize, soybeans and peanuts is conducted. Some farmers use their homestead for such mixed cropping. The general cropping pattern of main upland crops is shown in Figs. 3-1 and 3-2; however, it varies to some extent, and the seeding time of each crop has a wide range of about one month.

Fig. 3-1 Cropping Methods of Various Crops

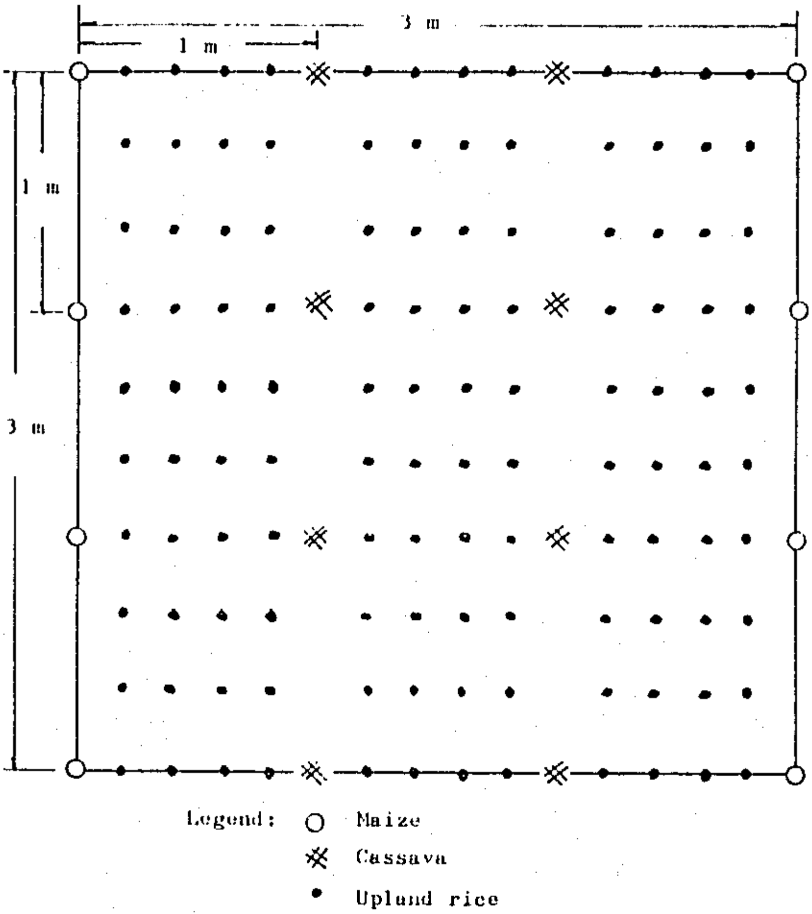
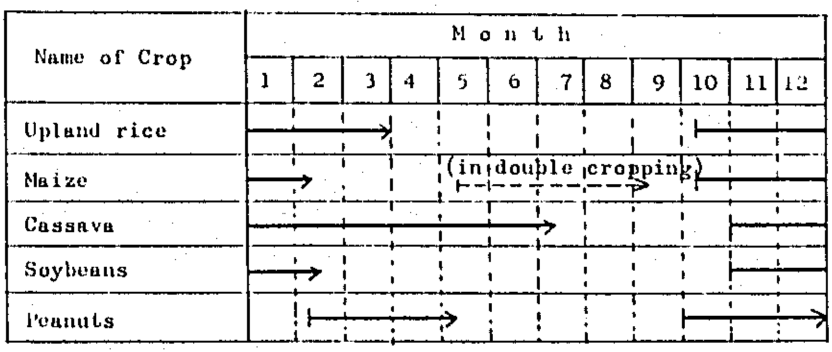


Fig. 3-2 Cultivation Period of Various Crops



As farming depends on man power aided by small farming implements, much labor is required and this restricts the increase of cultivated land area. Plowing work which calls for the greatest labor is carried out using a hoe called cangkul, but its efficiency is so low that one farmer can cover only 70 to 80 sq. m of alang-alang field per day (seven hours labour). In the case of harvesting of upland rice, too, the yield of dry stalk per man per hour is only 4 kg if the neck of spike is reaped with a tool called ani-ani.

Consequently, of the 2 ha land allotted to each farm household, the cultivated acreage is 1.1 ha on the average. The remainder is waste lands on which alang-alang grows wild, and it is used in rotation at an interval of two or three years. This practice serves to maintain the soil fertility. However, the farmers interviewed by the team stated that, as already pointed out by some people, it was not a planned but forced rotation resulting from the shortage of labor. All farmers are willing to increase the farming acreage, only if sufficient labour force is available, in order to improve their income.

In the case of cassava which is another principal crop comparable to upland rice, much man power also is required for digging out, peeling, cutting, removing harshness in water, smashing by hand, steaming, drying and finishing into product, OYEK and selling it. It appears that the heavy labour required for these works sets limits on any further expansion of management scale.

The interview with five settlers in Tatakaya and Dayasakti about the present yield, income and expenditure revealed that the yield per ha is 1.5 tons in dry stalk for upland rice, 0.7 ton in the wet season and 0.2 ton in the dry season for maize, 0.6 ton for soybeans and 0.8 ton for peanuts. The yield of cassava ranges widely from 1.5 tons to 4 tons, and the cause of this seems to be the difference in the planting density for intercropping. The team has learned that where the field is solely planted with cassava the yield is 15 to 20 t/ha.

CHAPTER IV. PROJECT IMPLEMENTATION PLAN

4-1. Outline of Project Implementation Plan

4-1-1. Acreage and Division of the Area

The project implementation plan is prepared for the acreage covered by this prefeasibility study as shown below.

Way Rarem/Abung Area	83,000 ha
Way Abung Area	35,300 ha
Total	118,300 ha

Studies were conducted to divide Way Rarem/Abung area into a number of regions, taking into consideration the topography, discharge from water source, and irrigation method as described below.

(1) In regions where water sources in the project area are available, such sources will be utilized to the greatest extent.

(2) In regions where the elevations of land and nearby rivers permit gravity irrigation, water will be drawn from such rivers.

(3) In regions where gravity irrigation is not practicable, water will be pumped up from nearby rivers.

An intake point will be selected on the downstream side of the confluence of the Way Rarem and the Way Galing for gravity irrigation of the southern half of the area by reason of its elevation.

By drawing water from this intake point, the southern half of the area can be irrigated but not the northern half where the elevation becomes higher again.

If Way Rarem/Abung area is divided into two regions, the southern and the northern, by the lowland running east to west across the center, the acreage of respective regions will be as follows:

Northern half	48,000 ha
Southern half	35,000 ha
Total	83,000 ha

As for the southern half region, it is considered that 70% of the area, excluding swam;s, steep slopes not suitable for farming, and forests and other zones which must be preserved, can be developed into farmland.

It is assumed that 10% of this prospective farmland area should be excluded since it will be occupied by roads and canals indispensable for farming.

Since 0.25 ha. out of 2 ha. allotted to each farm household is used as building lot and homestead, the acreage needing irrigation turns out to be as follows:

$$35{,}000 \text{ ha} \times 0.7 \times 0.9 \times 7/8 = 20{,}000 \text{ ha.}$$

Thus, the estimated acreage to be irrigated in the southern half region is 20,000 ha.

If the unit water requirement for rice cultivation is assumed at 1,000 ha/lit./s, the total water requirement is 20.0 t/s.

Natural flows of the Way Rarem and the Way Galing in the wet season have been studied on the assumption that the necessary quantity of irrigation water is taken at the point near the confluence of the two rivers. The result of the study has made it clear that the total water requirement can be met by natural flow even in the 1/5 drought year (1962) except in the month of December. This means that by taking 20.0 t/s of water at the said intake point and conveying through a driving channel for about 20 km, it will be possible to irrigate 20,000 ha in the southern half of the Way Rarem/Abung area.

The acreage to be irrigated in the northern half region can be calculated in the same way:

$$48{,}000 \text{ ha} \times 0.7 \times 0.9 \times 7/8 = 26{,}460 \text{ ha}$$

The acreage and water requirement are respectively taken at 27,000 ha and 27 t/s. Irrigation of this region will call for the installation of several large pumping stations.

As regards Way Abung area, the Abung Hulu area and the Tulung Mas area (hereafter called "W.A.H area" and "W.T area") are the two areas for which investigation for irrigation planning is being carried out by the Government of Indonesia. The central highland area (hereafter called "W.A area") situated inbetween the above two areas is also studied in this report.

According to the plan mapped out by the Government of Indonesia, the irrigation acreages in WAH and WT areas are as follows.

W.A.H area	7,751 ha
W.T area	2,923 ha

The acreage of WA area excluding these two irrigation acreages is about 14,000 ha. The acreage requiring irrigation in this area of 14,000 ha can be calculated in the same way as in the case of the Way Rarem/ Abung area:

$$14{,}000 \times 0.7 \times 0.9 \times 7/8 = 8{,}000 \text{ ha}$$

While WAH area and WA area will have to depend on the Way Abung for the supply of irrigation water, the discharge of this river is not sufficient even in the wet season to meet the water requirement of the entire area (7,751 ha + 8,000 ha = 15,751). Water will be diverted from the neighboring Way Besai in the wet season to secure the requirement.

The water requirement of the WT area will basically be met by the natural flow of the Way Tulung Mas.

Table 4-1-1

(In hectares)

Area	Zone	Total Average	Available Acreage	Acreage of Farm-land	Acreage to be Irrigated	Remarks
W.R/A	S-1	26,000	19,000	17,000	15,000	
	S-2	9,000	6,300	5,700	5,000	
	Sub-total	35,000	25,300	22,700	20,000	
	N-1	6,500	4,500	4,000	3,500	
	N-2	41,500	29,800	5,700	5,000	
	N-3			21,100	18,500	
	Sub-total	48,000	34,300	30,800	27,000	
	Total	83,000	59,600	53,500	47,000	
Abung	W.A.	14,000	10,100	9,100	8,000	
	W.A.H.	10,300	9,900	8,900	7,751	
	W.T.	4,300	3,700	3,300	2,923	
	Others	6,700	---	---	---	Highland, etc.
	Total	35,300	23,700	21,300	18,674	
Total		118,300	83,300	74,800	65,674	

4-2. Farming Program

As regards the farming program after implementation of the project, the following two types are conceivable in terms of the amount of effective water intake from the Way Rarem and the topographical features.

(1) Farming program for areas where year-round irrigation will become possible for the whole allotted acreage.

(2) Farming program for areas where, due to the limited intake discharge, the irrigation will become possible for the whole allotted acreage only during the wet season, and the dry season farming consists of second cropping in partly irrigable fields and upland crop cultivation.

The conditions and the directions of farming under these two programs are shown briefly in Table 4-2-1.

Table 4-2-1 Farming Types for Development

Division of Area	Farming Pattern		Method of Farm Management
(1) Area where year-round irrigation is possible	(Wet season) Paddy	(Dry season) Paddy	Double cropping of paddy is performed for the whole acreage to increase the production.
(2) Area where irrigation is possible only in the wet season	(Wet season) Paddy	(Dry season) Paddy Upland crops	Second cropping of paddy is performed in the irrigable part of the allotted acreage but upland crop cultivation is performed in the remaining part which cannot be irrigated due to its topography. In such case, upland crops will be commercialized to increase the income since increased productivity of paddy cultivation will make it possible to secure efficiently the self-sufficing foodstuff.

It is necessary to formulate the farming program for the above two farming patterns, but what should be studied and taken into consideration when formulating such programs are the followings.

(1) Since the effective water intake from Way Rarem is limited, water-saving varieties and cultivation techniques should be developed, so that water can be used effectively and the paddy field acreage increased.
In particular, it should be noted that if a variety which needs a shorter cultivation period is developed, the wet season irrigation water can be used to some extent for the second cropping.

(2) In areas where paddy cropping is performed in the wet season and the upland crops are cultivated in the dry season, the shortened period of paddy cultivation will enable the upland farming to receive the benefit of wet season rainfall at the initial stage, and thus the increase of yield can be expected.

(3) For the upland farming in the dry season, the crops which need a shorter cultivation period should be selected so that the residual moisture content of the wet season can be utilized, and the improvement of varieties should be promoted to meet this demand.
From the above standpoint, it is advisable to select maize, soybean, or sorghum which can resist drought damage as the second crop.

Note: A new variety of maize developed in Japan requires a cultivation period of only about three months. If this variety is grown after a paddy variety which needs four months to grow, both can be harvested within the wet season and the yield can be greatly increased.

(4) As stated before (see Chapter 3-5), shortage of labor is the greatest restrictive factor for expansion of farming acreage. Improvement of working methods is therefore very important for the future farm management of 2 ha.

However, any mechanization which requires a sharp increase of expenditure and the introduction of sophiscated techniques is not preferable judging from the actual condition of the project area. Rather, it would be necessary to introduce and popularize the labor-saving technique stage by stage.

Note: It may as well be recommended to make a reexamination of the family farming method depending on simple implements which used to be pursued in Japan for operational holding of 1 to 2 ha. At the same time, the feasibility of forming a joint utilization organization of farming machines should be studied and it is necessary to establish a system for introducing advanced farming techniques suitable for this area.

(5) It goes without saying that the establishment and extension of advanced farming technics including fertilization and pest and disease control bear closely on future development.

(6) Maize, soybean and sorghum are the only upland crops that promise a substantial income in areas where paddy is not grown in the dry season. The cropping pattern for these crops should therefore be studied carefully in the forthcoming feasibility study. If upland fields alone are to be cultivated throughout the year, introduction of highly profitable perennial crops such as coffee and pepper should be studied.

Note: A farm household survey conducted on this subject disclosed the fact that the majority of farmers are neither interested in perennial crops nor have the techniques of growing them because they are from the paddy field areas in Java island. It is believed, however, that this problem can be solved through accelerated extension and guidance services for farmers.

4-3. Hydrology

Observation of water level of the Way Rarem was started in April 1971 at the station near the Way Konang bridge (Tandjung Kemala) by the Government of Indonesia, but the discharge observation has not been initiated.

Discharge observation was conducted several times at the confluence of the Way Rarem and the Way Galing by a British hydrological survey team, but no useful data are available.

Therefore, the runoff is estimated from the data on observations made in the past in the area around the project area.

Rainfall records of the project area and its vicinity as of October 1973 (Table 4-3-1) are available, but they are not perfect because no observation was made for a certain period and sometimes the observation was suspended for quite a long period.

As can be seen in Table 4-3-1 and Fig. 4-1, the observation periods of the observation stations differed, and a small number of stations were not distributed uniformly. Therefore, it was not possible to estimate the precipitation of the project area from the rainfall data of the respective stations.

Accordingly, the rainfall records of Bt. Kemuning are used for the Wai Besai and Rarem basins and the rainfall records of Kotabumi for the project area. They may involve some errors.

Fig. 4-1. Rainfall Observation Station and River State Gauging Station

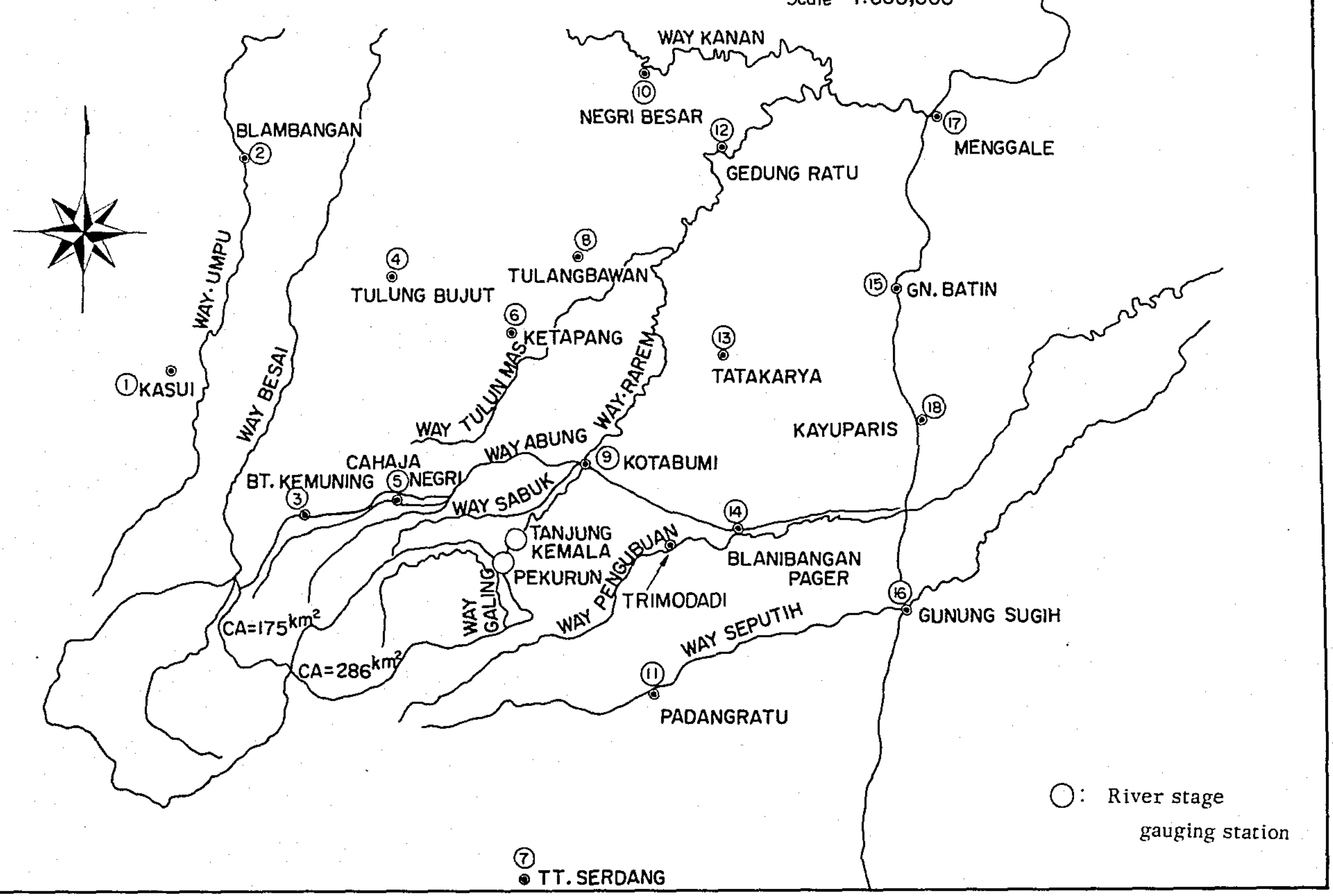


Table 4-3-1 Rainfall Observation Station and Observation Period

	Observation Station	Daily Rainfall	Monthly Rainfall	Remarks
1	Kasui	---------	1917-1938, 1940-1941, 1952-1953	
2	Blambangan	---------	1917-1919, 1928-1938, 1940-1941, 1952-1960	
3	BT.Kemuning	1959-1968, 1972-1973	1952-1960	
4	Tulung Bujut	1962-1973	1930-1938, 1940-1941	
5	Cahaja Negri	1972-1973	---------	
6	Ketapang	1971-1973	---------	
7	TT. Serdang	---------	1930-1938, 1940-1941	
8	Tulangbawan	---------	1917-1938, 1940-1941	
9	Kotabumi	1951-1972	1918-1938, 1940-1941 1952-1960	
10	Negeri Besar	---------	1917-1938, 1940-1941	
11	Padangratu	1961-1962	1952-1960	
12	Gedung Ratu	1971-1973	---------	
13	Tatakarya	1973	---------	
14	Blanibangan Pager	1972-1973	---------	DAYA-ITOH
15	GN. Batin	1972-1973	---------	
16	Gunung Sugih	1961-1964	1917-1938, 1940-1941 1952-1947	
17	Menggala	1971-1973	1917-1938, 1940-1941 1954-1960	
18	Kayuparis	1972-1973	---------	

4-3-1. Estimation of Runoff

Among the Way Pengubuan, Way Seputih and Way Sekampung, the first two rivers are relatively close to Way Rarem/Abung area and they present close resemblances in specific discharge per 100 km^2 and runoff ratio as seen in Tables 4-3-3 and 4-3-4. Thus, it seems possible to some extent to apply the conditions of these two rivers to Way Rarem/Abung area.

Table 4-3-2 Discharge Observation Station and Observation Period

	River	Station	Catchment Area	Period
1.	W. Pengubuan	Trimodadi	180 km^2	1937 - 1940
2.	W. Seputih	Negaraadji	500	1937 - 1940
3.	W. Sekampung	Argoguruh	2,054.69	1959 - 1961 1964 - 1968 1971 - 1973

Table 4-3-3 Way Pengubuan

Catchment area: 180 km^2

Observation period: 1937-1940

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Mean discharge	m^3/sec	18	17	12	12	9	8	7	4	3	2	2	8
Specific discharge/ 100 km^2	m^3/sec	10.0	9.4	6.7	6.7	5.0	4.4	3.9	2.2	1.7	1.1	1.1	4.4
Ratio of runoff	%	17.6	16.7	11.8	11.8	8.8	7.8	6.9	3.9	2.9	2.0	2.0	7.8

Table 4-3-4 Way Seputih

Catchment area: 500 km^2

Observation period: 1937 - 1940

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Mean discharge	m^3/sec	38	35	27	25	20	20	13	7	6	5	5	17
Specific discharge/100 km^2	m^3/sec	7.6	7.0	5.4	5.0	4.0	4.0	2.6	1.4	1.2	1.0	1.0	3.4
Ratio of runoff	%	17.4	16.1	12.4	11.5	9.2	9.2	6.0	3.2	2.8	2.3	2.3	7.6

Table 4-3-5 Way Sekampung

Catchment area: 2,054.69 km^2

Observation period: 1959 - 1961
1964 - 1968
1971 - 1973

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Mean discharge	m^3/sec	121	111	105	94	70	40	33	23	27	40	43	80
Specific discharge/100 km^2	m^3/sec	5.9	5.4	5.1	4.6	3.4	1.9	1.6	1.1	1.3	1.9	2.1	3.9
Ratio of runoff	%	15.4	14.1	13.3	11.9	8.9	5.1	4.2	2.9	3.4	5.1	5.5	10.2

Since the basin of the Way Pengubuan adjoins Way Rarem/Abung area, the condition of the former area are adapted to the latter area.

The discharge observations were made at Trimodadi on the Way Pengubuan in the years from 1937 to 1940. The monthly runoff coefficients are calculated from the relation between the rainfall and the runoff. Using these coefficients, the runoff at the dam site and in the project area is calculated for each month of the base year.

Table 4-3-6 Runoff Coefficient of Way Pengubuan Area

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Mean Monthly Rainfall	mm 339	278	322	266	191	147	135	85	138	143	259	320
Rainfall in Volume	m^3 61.0×10^6	50.0×10^6	58.0×10^6	47.9×10^6	34.4×10^6	26.5×10^6	24.3×10^6	15.3×10^6	24.8×10^6	25.7×10^6	46.6×10^6	57.6×10^6
Runoff	m/sec 18	17	12	12	9	8	7	4	3	2	2	8
Runoff in Volume	m^3 48.2×10^6	41.1×10^6	32.1×10^6	31.1×10^6	24.1×10^6	20.7×10^6	18.7×10^6	10.7×10^6	7.8×10^6	5.4×10^6	5.2×10^6	21.4×10^6
Runoff Coef-ficient	0.8	0.8	0.6	0.6	0.7	0.8	0.8	0.7	0.3	0.2	0.1	0.4

The runoff coefficients are expected to decrease in the project area because of its flat topography, but these coefficients are used since no other data are available at present. It is desirable to determine the runoff coefficients by conducting discharge observation in the project area prior to the feasibility study. The rainfalls observed at Kotabumi are used in making Table 4-3-6 since they are the only rainfall records of the area around the project area available.

4-3-2. Base Year for Irrigation Planning

In order to find out the runoff at the dam site, a probable rainfall which occurs about once in five years during the wet season is used. Then the droughty year corresponding to a non-excess probability 1/5 is estimated on the assumption that the rainfall distribution is normal, and the runoff is obtained using the monthly rainfall of that year.

Table 4-3-7 Rainfall by Season

Observation station: BT. Kemuning

Period	Rainfall in Wet Season	Rainfall in Dry Season	Yearly Rainfall	Period	Rainfall in Wet Season	Rainfall in Dry Season	Yearly Rainfall
1952	2291 mm	596 mm	2887 mm	1960	1934 mm	744 mm	2678 mm
1953	2291	718	3009	1961	1467	591	2058
1954	2054	941	2995	1962	1850	678	2528
1955	2292	1382	3674	1963	1665	557	2222
1956	2130	1155	3285	1964	2415	956	3371
1957	1804	787	2591	1965	1994	221	2215
1958	2758	934	3692	1966	-	1018	-
1959	2709	823	3532	1967	2174	496	2670

Table 4-3-8 Calculation of Probable Rainfall

No.	Period	Xi	Xi-Xo	$(Xi-Xo)^2$	No.	Period	Xi	Xi-Xo	$(Xi-Xo)^2$
1	1958	2,758	636.1	404,623.21	9	1954	2,054	-67.9	4,610.41
2	1959	2,709	587.1	344,686.41	10	1965	1,995	-127.9	16,358.41
3	1964	2,415	293.1	85,907.61	11	1960	1,935	-187.9	35,306.41
4	1955	2,292	170.1	28,934.01	12	1962	1,850	-271.9	73,929.61
5	1952	2,291	169.1	28,594.81	13	1957	1,804	-317.9	101,060.41
6	1953	2,291	169.1	28,594.81	14	1963	1,665	-456.9	208,757.61
7	1967	2,174	52.1	2,714.41	15	1961	1,467	-654.9	428,894.01
8	1956	2,130	8.1	65.61					
					Total		31,828		1,793,037.75

$$Xo = \frac{31,828}{15} = 2,121.9$$

$$\frac{1}{a} = \sqrt{\frac{2}{n} \sum_{i=1}^{n} (Xi - Xo)^2} = \sqrt{\frac{2 \times 1793,037.75}{15}} = 489.0$$

From Table 4-3-8, the probable rainfall x for the normal variable ξ is $x = x_o + (1/a)\ \xi = 2121.9 + 489.0\ \xi$

As for non-excess probable value, $S(x) = 1/5$, ξ is -0.5951, therefore $x = 2121.9 - 489.0 \times 0.5951 = 1830.9$ mm

The year in which the rainfall was nearest to this value was 1962 as shown in Table 4-3-7, and this year is presumed as the droughty year corresponding to 1/5 probability.

4-3-3. Runoff

As paddling is started in December for optimum planting, runoffs of respective areas are calculated starting from November of the previous year (1961). Table 4-3-9 shows the monthly rainfalls from November 1961 to November 1962 at Bt. Kemuning and Kotabumi.

Table 4-3-9

	BT. Kemuning	Kota Bumi	Remarks
Nov.	mm 108	mm 152	1961
Dec.	237	-	"
Jan.	344	259	1962
Feb.	329	142	"
Mar.	346	306	"
Apr.	296	212	"
May	84	141	"
Jun.	81	138	"
Jul.	131	198	"
Aug.	141	176	"
Sep.	33	101	"
Oct.	208	-	"
Nov.	227	291	"

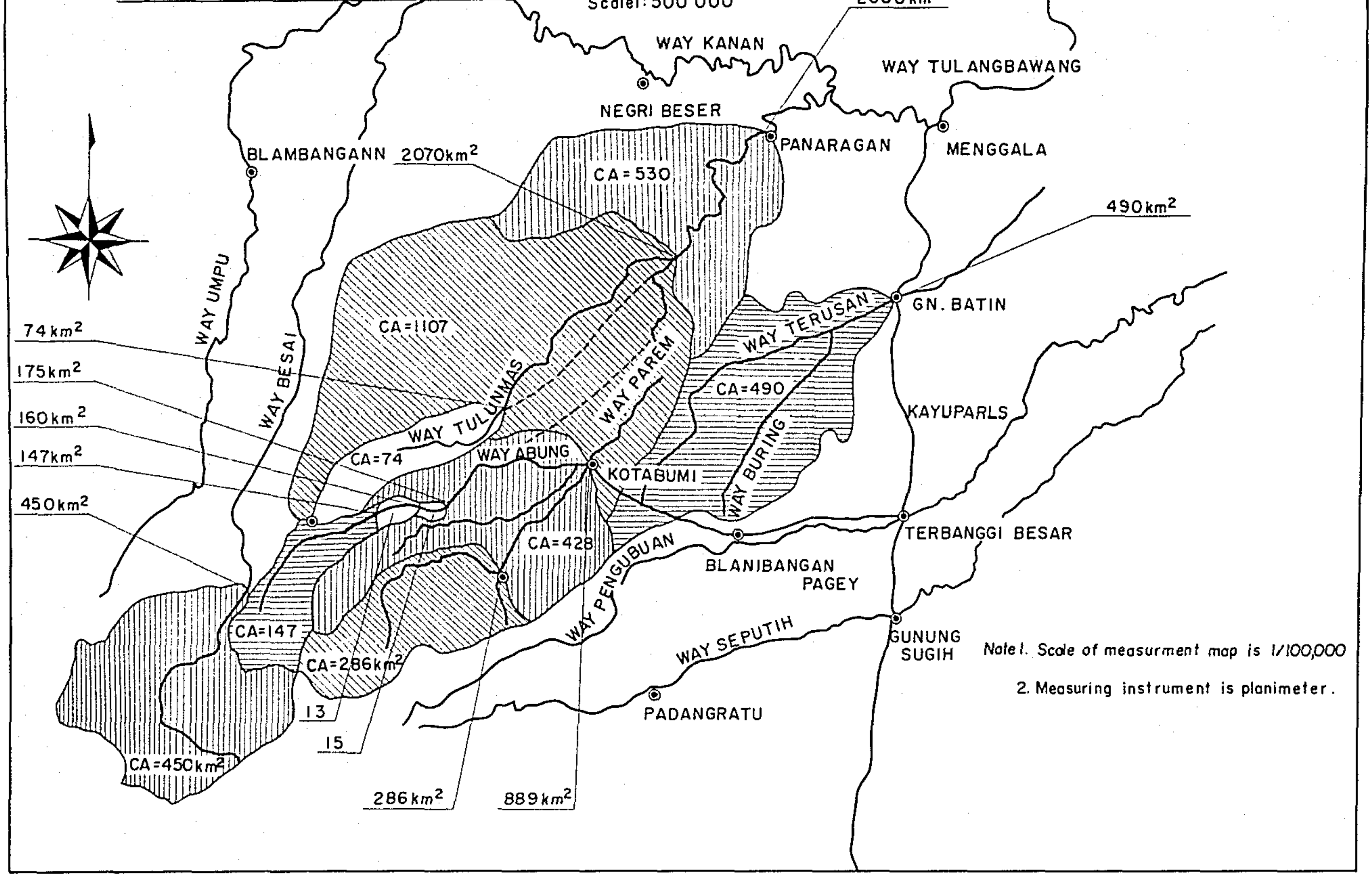
The runoffs in the droughty year at the intake point of the Way Rarem, Way Besai, Way Abung and Way Tulung Mas and the confluence of the Way Rarem and Way Tulung Mas are calculated using the coefficients shown in Table 4-3-6. The calculations were made using the rainfalls at Kotabumi, and the results are shown in Table 4-3-10.

As shown in Fig. 4-2, the acreage of catchment area is 286 km^2 (upstream section) and 889 km^2 (downstream section) and 175 km^2 (downstream section) for the Way Abung; 74 km^2 for the Way Tulung Mas; and 2,070 km^2 (upstream section) and 2,600 km^2 (downstream section) for the confluence of the Way Rarem and Way Tulung Mas.

Table 4-3-10

Catchment Area	Way Rarem		Way	Way Abung			Way Tulung Mas	Confluence of W. Tul. Mas & W. Rarem	
	Upstream Section	Downstream Section	Besai	Upstream Section	Midstream Section	Downstream Section		Upstream Section	Downstream Section
Month	km² 286	889	450	147	160	175	74	2,070	2,600
Nov. '61	m³/s 1.2	3.7	1.9	0.6	0.7	0.7	0.3	8.7	11.
Dec. '61	10.	31.	16.	5.2	5.6	6.1	2.6	72.	91.
Jan. '62	29.	91.	46.	15.	16.	18.	7.5	210.	264.
Feb. '62	31.	97.	49.	16.	17.	19.	8.0	224.	282.
Mar. '62	22.	69.	35.	11.	12.	14.	5.7	159.	200.
Apr. '62	20.	61.	31.	10.	11.	12.	5.2	145.	182.
May '62	6.3	20.	10.	3.2	3.5	3.9	1.6	46.	57.
Jun. '62	7.2	22.	11.	3.7	4.0	4.4	1.9	52.	65.
Jul. '62	11.	35.	18.	5.8	6.1	6.7	2.8	80.	100.
Aug. '62	11.	33.	17.	5.4	6.1	6.7	2.8	80.	100.
Sep. '62	1.1	3.4	1.7	0.6	0.6	0.7	0.3	8.0	10.
Oct. '62	4.4	14.	6.9	2.3	2.5	2.7	1.1	32.	40.
Nov. '62	2.5	7.8	3.9	1.3	1.4	1.5	0.6	18.	23.

Fig 4-2 Outline of Catchment Area



The runoff per 1.0 km^2 and that of the Way Terusan were calculated using the rainfall at Kotabumi for planning irrigation tanks and pumping facilities to be installed in the project area. The results are shown in Table 4-3-11.

Table 4-3-11

Month	Runoff per 1.0 km^2	Way Terusan	Remarks
	m^3/sec	m^3/sec	
Nov.	0.01	4.9	1961
Dec.	0.02	9.8	"
Jan.	0.08	39	1962
Feb.	0.05	25	"
Mar.	0.07	34	"
Apr.	0.05	25	"
May	0.04	20	"
Jun.	0.04	20	"
Jul.	0.06	29	"
Aug.	0.05	25	"
Sep.	0.01	4.9	"
Oct.	0.01	4.9	"
Nov.	0.01	4.9	"

Notes: The catchment area of the Way Terusan is 490 km^2.

4-3-4. Design Flood Discharge

At the present stage, sufficient data are not available to calculate a design flood discharge. Therefore, such discharge is determined on the basis of the design flood discharge of the Way Umpu Project which has been computed using the rainfall at Bt. Kemuning (see "Feasibility study on Way Umpu Irrigation Project").

$$\frac{696}{205} \times 286 \times 1.2 = 1.165 \doteq 1,200 \; m^3/sec$$

where, the catchment area of Way Umpu is 205 km^2 and the design flood discharge is 696 m^3/sec, and an allowance of 20% is considered.

4-4. Basic Approach to Irrigation Planning

The project area is divided into the Way Rarem/Abung area and the Way Abung area according to the major water sources, and each of them is further divided into smaller areas by topography, discharge of water source and irrigation system (see the attached drawing "Outline of W/R and W/A").

Specifically, Way Rarem/Abung area is divided equally into the northern and southern halves, namely, W. R/A-S and W. R/A-N, by a strip of lowland stretching from east to west. W. R/A-S is divided by a 40 m contour line into the higher and lower areas, namely, W. R/A S-1 area and W. R/A S-2 area, whereas W. R/A-N is divided into W. R/A N-1, W. R/A N-2 and W. R/A N-3 areas according to the discharge of water source and location.

Way Abung area, on the other hand, is divided into three areas as already described, namely, W.A.H. area and W.T. area which are both planned by the Government of Indonesia and W.A. area which is the central hilly land extending between the former two areas.

4-4-1. Base Year for Irrigation Planning

1962 is taken as the base year for irrigation planning (see Section 4-3-2).

4-4-2. Irrigation Method

Irrigation method: Flood irrigation for paddy field

Irrigation period:	First cropping of paddy	December	– April
		January	– May
	Second cropping of paddy	June	– October
		July	– November

4-4-3. Water Requirement

The approximate water requirement is assumed as follows.

Diversion requirement (gross duty of water)=$1.0m^3/sec/1,000$ ha

4-5. Road Improvement Plan

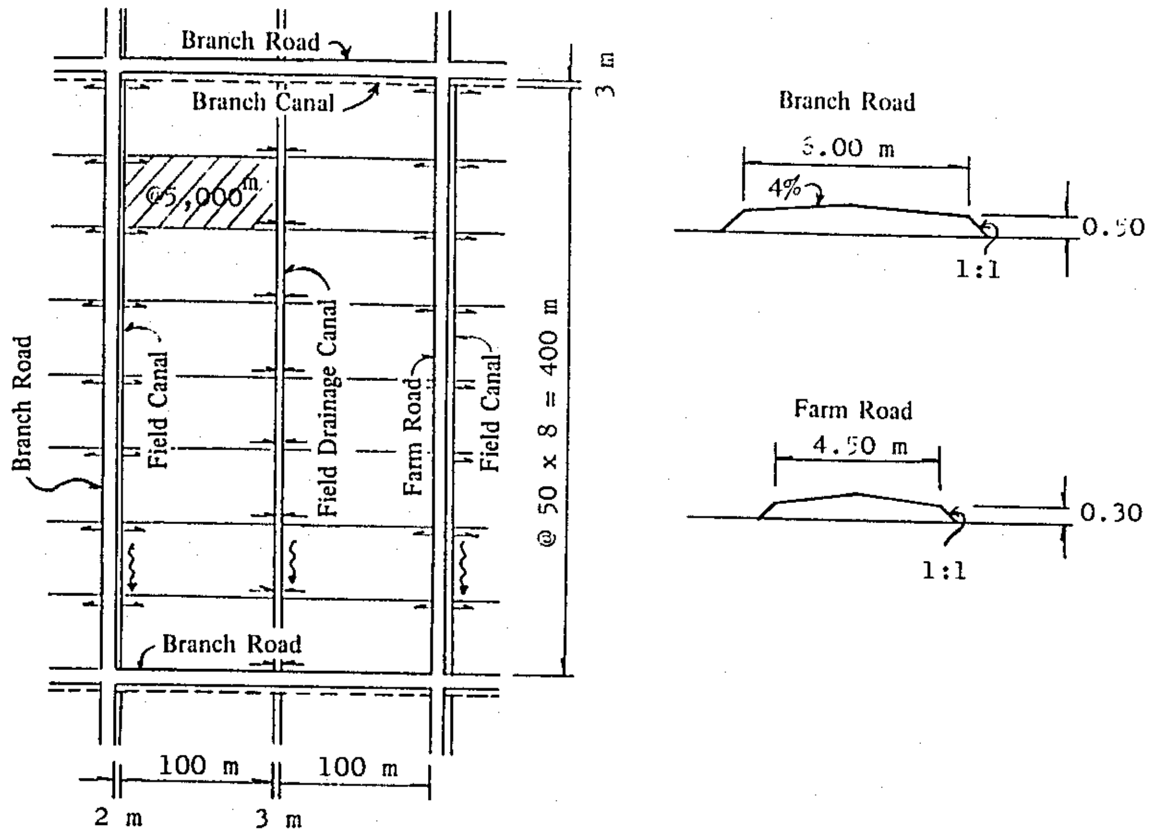
The road improvement plan for the project area should cover the national highway which passes through Kotabumi, existing roads in the project area, inspection roads for main and secondary canals, branch roads and farm roads required after field reclamation, as well as temporary roads which are necessary for construction of dam, headworks and pump stations.

Canal inspection roads will serve as farm roads and have a width of 6.0 m. For the convenience of future transportation of agricultural products, portions of the roads described above will have to be paved with gravel or asphalt.

4-6. Field Reclamation Plan

The total farmland area planned to be irrigated under the project is approximately 65,674 ha which will be arranged in blocks each covering an area of 4 ha. Each block will be divided into 8 plots each having an area of 0.5 ha (50 m x 100 m). Branch roads having a width of 6.0 m will be constructed in a lattice-like arrangement at intervals of 400 m, with a farm road built along the field canal between each pair of branch roads. Block arrangement should be planned with consideration given to the housing sites to be created along main or secondary canal and existing roads as well as the slopes.

Fig. 4-3 Typical Pattern of Farmland



Paddy Field Plan

Plot arrangement	50 x 100 m 0.5 ha
Block arrangement	102.5 x 403 m 4.0 ha

Farm Road Plan

Branch road	width 6.0 m (Approx. 49 km per 1,000 ha)
Farm road	Width 4.5 m (Approx. 24 km per 1,000 ha)

Canal Plan

Branch canal	Approx. 25 km per 1,000 ha
Field canal	Approx. 55 km per 1,000 ha
Field drainage canal	Approx. 55 km per 1,000 ha

4-7. Benefit-Cost Ratio

As described in the section dealing with farm management plan, an attempt to analyze the project's economic benefit inevitably entails many problems which need to be tackled from a technical viewpoint in the forthcoming feasibility study. In this report, therefore, the investment effect (annual benefit-cost ratio) of the project is studied within the limits of data and materials collected during the prefeasibility survey.

Calculations were made on the basis of the following presumptions and conditions.

1. Several years may be required after completion of the project before farm management can be stabilized and production reaches the planned level. The year in which the target figure is attained is assumed.

2. Paddy cultivation in the wet season will be made possible for the entire project area. The possibility of dry season paddy cultivation will be studied in connection with the amount of investment required.

3. "The 2nd Stage Development" presented in Table 5-16-1 indicates the development stage in which paddy cultivation will become possible for the entire area only in the wet season and in part of it in the dry season. In this stage, therefore, part of the area irrigable with water with the wet season intake facilities will be planted with paddy and the remaining area will be used for growing upland crops suitable to the dry season.

4. "The 3rd Stage Development" presented in the same table indicates the development stage when that part of the area where upland crops alone are cultivated will be planted with paddy in the dry season through reinforcement of intake facilities. For this development stage, the construction cost required and the investment effect are studied separately.

5. "Whole" appearing also in the same table indicates the stage in which the whole project area will be planted with paddy in both dry and wet seasons.

6. Of a number of upland crops suitable for cultivation in the dry season such as maize, soybean and sorghum, maize is selected for the purpose of this study.

7. The target yield of paddy and maize is set as follows:

   The yield of paddy is set at 5 t/ha of dry stalk which is the target yield under the Umpu-Pengubuan Area Development Project for which a survey was conducted last year.

   The yield of maize, on the other hand, is taken at 2.5 t/ha on the basis of the yield recorded in Daya Itoh plantation. The yield at this plantation is about 3.5 t/ha for Metro variety grown in the wet season with ample management practices. 70% of this yield is taken as the target value since maize will be grown in the dry season in the project area.

8. The net earning used in the calculation of the net value of paddy and maize production is that appearing in the report of production cost survey prepared by Dinas Pertanian Propinsi Lampung. Since it is likely that the labour cost involved in the production cost will be reduced substantially in the near future through introduction of labour-saving machinery and equipment, 70% of the value shown in the report is used. This makes the net earning rate of paddy 61% and that of maize 26%.

9. The report on the survey conducted by Dinas Pertanian Kabupaten Lampung Utara on the prices of agricultural products does not include data on unhusked rice. For this reason, the farm gate price was checked through interviews with farmers, and it was found out that the price of unhusked rice ranged between Rp 24 and Rp 30 per kg. Since rice price is generally on the upward trend, Rp 30 is taken for the purpose of this study.

   The price of maize is taken at Rp 20 because the market price is in the range of Rp 15 to 25.

10. On the strength of the above assumptions and conditions, the net value of production per ha is set as follows.

Paddy	5 t x 30 Rp x 0.61 = $91.5 10^3$ Rp	
Upland Crops	2.5 t x 20 Rp x 0.26 = $13 10^3$ Rp	
Change from Upland Crops to Paddy	91.5 - 13 = $78.5 10^3$ Rp	

11. Values indicated in Table 5-1-16 were obtained by the following calculating methods.

(1) Increased net earning = Net earning of crops - Operation & Maintenance cost

(2) Justifiable investment

$$= \frac{\text{Increased net earnings}}{\text{Rate of interest} + \dfrac{1}{\text{Durable years of new project}}}$$

(3) Efficiency of investment = $\dfrac{\text{Justifiable investment}}{\text{Project Cost}}$

The investment efficiency calculated according to the above method is described in Section 5-16.

4-8. Calculation of Operation and Maintenance Cost

The approximate cost of operation and maintenance was calculated as given below.

Pumping facilities	2% of construction cost + personnel expenses + fuel cost
Other structures	2% of construction cost
Water management	Personnel expenses

Values obtained by the above calculation methods are shown in Section 5-15.

CHAPTER V. CONSTRUCTION PLAN

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

(1) First Stage

The first stage development is intended primarily for quick yield and will be implemented by constructing reservoirs for storing water drawn from small rivers. Topographically, construction of reservoirs is possible in W. R/A S-1 and S-2 areas and W. A. area. However, since W. A. area still involves many unknown factors in connection with the plan of construction of the reservoir, the first stage development depending only on the reservoir is not considered for this area.

Utilization of underground water of the wells in the project area using portable pumps may be taken into consideration upon further detailed study.

(2) Second Stage

The second stage development is an irrigation project which makes the wet season paddy cultivation possible for the whole project area. In this stage, partial diversion of water will be necessary to cover the shortage of river discharge.

(3) Third Stage

The third stage development is an irrigation project which makes possible the twice a year paddy cultivation for the whole project area. Diversion of river water by constructing the Besai dam will be planned in this stage.

5-1. W. R/A S-1 Area

This area is the southern half of W. R/A area which is divided by a strip of lowland stretching from east to west, and its elevation is generally lower than 40 m. The area has many small rivers. Some of these rivers flow directly into the Way Rarem but most of them flow north to join the Way Terusan and run out of the area.

W. R/A S-1 and S-2 areas are already occupied by about 5,500 farm households of retired airforce servicemen and transmigrants supported by the government. Construction of irrigation facilities is therefore an urgent need in these two areas.

The acreage of W. R/A S-1 area is as tabulated below (Ref. Table 4-1-1).

Table 5-1-1

Unit: ha

Name of Area	Total Acreage	Available Acreage	Farmland Acreage	Acreage to be irrigated
W. R/A S-1	26,000	19,000	17,000	15,000

5-1-1. First Stage Development (See Section 5-12)

(1) Irrigation Planning

The Way Rarem is the water source of this area. Since this area is extensive and the water level of the Way Rarem is lower compared to the elevation of the benefited area, the construction of facilities for driving water to the benefited area requires a huge amount of funds and a long construction period. In order to attain the investment effect at the earliest possible time, therefore, reservoirs will be constructed on small rivers (17 sites: total storage capacity = 2,450 thousand m^3) so as to irrigate the area with the discharge of small rivers.

It is expected that these reservoirs can be used most efficiently after the second and subsequent development stages by supplying surplus water from the Way Rarem, the main water source in this area.

(2) Irrigable Area

The irrigable area is as tabulated below (Refer to Table 5-12-4).

Table 5-1-2

Unit: ha

Kind of Field	Wet Season	Dry Season	Total
Paddy Field	1,200	100	1,300
Upland Field	---	1,100	1,100
Total	1,200	1,200	2,400

(3) Construction Work

Reservoir   17 sites: total storage capacity = 2,450,000 m^3; total dam volume = 378,000 m^3

(4) Construction Cost

1,712 10^6 Rp (Ref. Sec. 5-14 and 5-16).

(5) Investment Efficiency

Paddy field	1,300 ha x 91.5 10^3 Rp/ha (See Sec. 4-7)	= 119 10^6 Rp
Upland field	1,100 ha x 13 10^3 Rp/ha	= 14 10^6 Rp
Total		133 10^6 Rp

(6) Operation and Maintenance Cost

31 10^6 Rp (See Sec. 5-15)

(7) Benefit-Cost Ratio

At an interest rate of 6% ; 0.76 (See Sec. 5-16)
" 12% ; 0.43 (")

5-1-2. Second Stage Development

(1) Irrigation Planning

The discharge of the Way Rarem will be likewise utilized for irrigation. In the wet season, the total water requirement ($Q = 15\ m^3/s$) for paddy cropping will be obtained from the Way Rarem. In the dry season, irrigation will be conducted within the limit of the river discharge.

The following two intake plans are proposed for this stage.

Headworks plan	Construction of headwork ($H = 24$ m; dam volume = 503,000 m^3) at a point downstream of the confluence of the Way Rarem and the Way Galing for gravity irrigation through a headrace ($Q = 20.7\ m^3/s$; $L = 20$ km).
Pump irrigation .... plan	Construction of a pumping station (ø1,400 mm, 3,000 PS x 6 units) at a point downstream of Kotabumi and the confluence of the Way Rarem and Way Abung for pump irrigation through pipelines (ø3,100 mm, $L = 5$ km x 2 sets).

(2) Irrigable Area

The irrigable area which can be expanded by the second stage development is as tabulated below.

Table 5-1-3

Unit: ha

Intake Method	Kind of Field	Wet Season	Dry Season	Total
Headworks	Paddy field	13,800	1,700	15,500
	Upland field	-	12,100	12,100
	Total	13,800	13,800	27,600
Pumping Station	Paddy field	13,800	3,000	16,800
	Upland field	-	10,800	10,800
	Total	13,800	13,800	27,600

(3) Construction Work

Intake Method	Irrigation Facilities		Cost Allocation	Water Balance
Headworks Plan	Headwork :	H=24 m, L=560 m, dam volume = 503,000 m^3	W. R/A S-1 & S-2	See Table 5-13-1
	Head race :	Q=20.7 m^3/s, L=18.7 km	"	
	Shiphon & aqueduct :	Q=20.7 m^3/s, L=1.3 km	"	
	Main canal :	Q_{mean}=9.1 m^3/s, L=28 km	Exclusive	
	Secondary canal :	Q_{mean}=1.8 m^3/s, L=67 km	"	
Pumping Station Plan	Pumping station :	Q=22.1 m^3/s, ϕ1,400 mm x 3,000 PS x 6 units	W. R/A S-1 & S-2	See Table 5-13-2
	Pipeline :	ϕ3,100 mm x 2 sets, L=5 km	"	
	Main canal :	Q_{mean}=9.1 m^3/s, L=28 km	Exclusive	
	Secondary canal :	Q_{mean}=1.8 m^3/s, L=67 km	"	

(4) Construction Cost, Investment Effect, Operation and Maintenance Cost, and Benefit-Cost Ratio (See Sec. 4-7, 5-14, 5-15 and 5-16).

Table 5-1-5

Intake Method	Construction Cost	Investment Effect		Operation & Maintenance cost	Benefit-Cost Ratio	
					6%	12%
Headworks Plan	$6,010\ 10^6$ Rp	Paddy field	: 15,500 ha x $91.5\ 10^3$ Rp/ha = $1,419\ 10^6$ Rp	$123\ 10^6$ Rp	2.62	1.59
		Upland field	: 12,100 x 13 = 517			
		Total	1,576			
Pumping Station Plan	9,456	Paddy field	: 16,800 ha x 91.5 = 1,538	351	1.52	0.92
		Upland field	: 10,800 x 13 = 140			
		Total	1,678			

5-1-3. Third Stage Development

(1) Irrigation Planning

Irrigation water that can be secured for dry season paddy cropping by the second stage development is limited (Q = 1.8 3.4 m^3/s). In order that paddy may be grown in the whole area (15,000 ha) in the dry season, a dam will be constructed in this stage on the Besai for diversion to the Way Abung. This diversion will be made possible by the Way Besai headwork (L = 50 m) to be constructed in the second stage and a new tunnel (Q = 26.6 33.2 m^3/s, L = 4 km).

For irrigation of this area with headworks and head race, another headwork will be constructed on the Way Abung (L = 30 m, located 30 km upstream of Kotabumi) and water will be diverted to the Way Rarem through this head race (Q = 17.5 m^3/s, L = 10 km). In this case, the irrigation plan for W.A.H., W.A. and W.T. areas (Plan 3 described in detail in Sec. 5-6-3, 5-7-3 and 5-8-2) should be reviewed because it will exert influence on this headworks plan.

If this area is to be irrigated by pumps, water diverted from the Way Besai to the Way Abung will make it possible to pump up water from near Kotabumi. In this case, too, the effect of the above-mentioned Plan 3 for W.A.H., W.A. and W.T. areas should be studied.

(2) Irrigable Area

The acreage of irrigable area that can be expanded by the third stage development is as tabulated below.

Table 5-1-6

Unit: ha

Intake Method	Kind of Field	Wet Season	Dry Season	Total
Headworks Plan	Paddy Field	---	13,200	13,200
	Upland Field	---	---	---
	Total	---	13,200	13,200
Pumping Station Plan	Paddy Field	---	11,900	11,900
	Upland Field	---	---	---
	Total	---	11,900	11,900

(3) Construction Work

Table 5-1-7

Intake Method		Irrigation Facilities	Cost Allocation	Water Balance
Headworks Plan	Separate intake for W.A.H., W.A. and W.T. (Plan 1)	Besai dam: Capacity = 247,000 $10^3 m^3$ Dam volum= 7,800 $10^3 m^3$	W.R/A S-1, S-2, W.A.H. & W.A.	See Table 5-13-6
		Besai tunnel: D 4.4 m, L = 4 km	W.R/A S-1, S-2, W.A.H. & W.A.	
		W. Abung headwork(+37 km): $Q = 25.5\ m^3/s$, L = 30 m	W. R/A S-1, S-2 & W.A.	

Table 5-1-7

Cont'd

Intake Method		Irrigation Facilities	Cost Allocation	Water Balance
		W.A - W.R. head race: $Q = 17.5 m^3/s$, L = 10 km	W.R/A S-1 & S-2	
	Common intake for W.A.H. & W.A. and Separate intake for W.T. (Plan 2)	Besai dam: Capacity = $256,000 10^3 m^3$, dam volume= $8,000 10^3 m^3$	W.R/A S-1, S-2, W.A.H. & W.A.	See Table 5-13-7
		Besai tunnel: D = 4.3 m, L = 4 km	W.R/A S-1, S-2, W.A.H. & W.A.	
		Abung headwork (+37 km): $Q = 37.9 m^3/s$, L = 30 m	W.R/A S-1, S-2, W.A.H. & W.A.	
		W.A. - W.R. head race: $Q = 17.5 m^3/s$, L = 10 km	W.R/A S-1 & S-2	
	Common intake for W.A. and W.T. and separate intake for W.A.H. (Plan 3)	Besai dam: Capacity = $283,000 10^3 m^3$, dam volume= $9,000 10^3 m^3$	W.R/A S-1, S-2, W.A.H., W.A.& W.T.	See Table 5-13-8
		Besai tunnel: D = 4.8 m, L = 4 km	-do-	
		Abung headwork (+ 37 km): $Q = 29.9 m^3/s$, L = 30 m	W.R/A S-1, S-2, W.A.& W.T.	
		W.A - W.R. head race: $Q = 17.5 m^3/s$, L = 10 km	W.R. S-1 & S-2	

Table 5-1-7

Cont'd

Intake Method		Irrigation Facilities	Cost Allocation	Water Balance
Pumping Station Plan	Separate intake for each of W.A.H. W.A. & W.T. (Plan 4)	Besai dam: Capacity = 158,000 $10^3 m^3$ dam volume= 5,000 $10^3 m^3$	W.R/A S-1, S-2, W.A.H. & W.A.	See Table 5-13-9
		Besai tunnel: D = 4.4 m, L = 4 km	W.R/A S-1, S-2, W.A.H. & W.A.	
	Common intake for W.A.H. and W.A. and separate intake for W.T. (Plan 5)	Besai dam: Capacity = 166,000 $10^3 m^3$ dam volume= 5,300 $10^3 m^3$	W.R/A S-1, S-2, W.A.H. & W.A.	See Table 5-13-10
		Besai tunnel D = 4.3 m, L = 4 km	W.R/A S-1, S-2, W.A.H. & W.A.	
	Common intake for W.A. & W.T. and separate intake for W.A.H. (Plan 6)	Besai dam: Capacity = 194,000 $10^3 m^3$ dam volume= 6,200 $10^3 m^3$	W.R/A S-1, S-2, W.A.H., W.A. & W.T.	See Table 5-13-11
		Besai tunnel: D = 4.8 m, L = 4 km	-do-	

(4) Construction Cost, Investment Effect, Operation & Maintenance Cost, and Benefit-Cost Ratio (See Sec. 4-7, 5-14, 5-15, and 5-16).

Table 5-1-8

Intake Method		Construction Cost	Investment Effect	Operation & Maintenance Cost	Benefit-Cost Ratio 6%	Benefit-Cost Ratio 12%
Head-works Plan	Plan 1	13,000 10^6Rp	13,200 ha x 78.5 x 10^3Rp/ha = 1,036 10^6Rp	229 10^6Rp	0.81	0.45
	Plan 2	12,891	" " "	227	0.82	0.46
	Plan 3	13,588	" " "	239	0.76	0.43
Pumping Station Plan	Plan 1	5,610	11,900 ha x 78.5 x 10^3Rp/ha = 934 10^6Rp	264	1.55	0.87
	Plan 2	5,666	" " "	265	1.53	0.86
	Plan 3	5,970	" " "	270	1.45	0.81

5-2. W. R/A S-2 Area

This area constitutes another part of the southern half of Way Rarem/Abung area and its elevation is generally higher than 40 m. As in W.R/A S-1 area, many small rivers are found in this area. The acreage of this area is as tabulated below (Refer to Table 4-1-1).

Table 5-2-1

Unit: ha

Name of Area	Total Acreage	Available Acreage	Farmland Acreage	Acreage to be Irrigated
W. R/A S-2	9,000	6,300	5,700	5,000

5-2-1. First Stage Development (See Section 5-12)

(1) Irrigation Planning

Same as in the case of W. R/A S-1 area, reservoirs will be constructed on small rivers (13 sites, total storage capacity = 3,145,000 m^3) to irrigate the area with the discharge of small rivers and the water stored in the reservoirs.

(2) Irrigable Area

The acreage irrigable by the first stage development is as follows. (See Table 5-12-4).

Table 5-2-2

Unit: ha

Kind of Field	Wet Season	Dry Season	Total
Paddy field	1,900	200	2,100
Upland field	-	1,700	1,700
Total	1,900	1,900	3,800

(3) Construction Work

Reservoirs	13 sites: total storage capacity - 3,145,000 m^3; total dam volume - 315,000 m^3

(4) Construction Cost

1,493$10^{6}$Rp (Refer to Section 5-14 and 5-16).

(5) Investment Effect

Paddy field	2,100 ha x 91.5$10^{3}$Rp/ha	=	192$10^{6}$Rp
	(See Section 4-7)		
Upland field	1,700 x 13	=	22
Total		=	214

(6) Uoperation and Maintenance Cost

28$10^{6}$Rp (Refer to Section 5-15)

(7) Benefit-Cost Ratio

1.59 at an interest rate of 6%
0.90 " " 12%
(See Section 5-16)

5-2-2. Second Stage Development

(1) Irrigation Planning

As in the case of W. R/A S-1 area, this area will depend on discharge of the Way Rarem for the supply of irrigation water. The total water requirement for wet season paddy cropping ($Q= 5.5\ m^3/s$) will be obtained from this river, and the dry season irrigation will be conducted within the limit of the river discharge. Intake facilities constructed for W. R/A S-1 area will also be used for this area.

Since the area is situated at a high elevation unsuitable for gravity irrigation, pumps will be installed at an upstream point in W. R/A S-1 area. If water is to be pumped from the Way Rarem, the two-stage pumping system will be employed.

Two intake methods, namely, headworks plan and pumping station plan, are studied same as in the case of S-1 area.

(2) Irrigable Area

The acreage of irrigable area that can be expanded by the second stage development is as tabulated below.

Table 5-2-3

Unit: ha

Intake Method	Kind of Field	Wet Season	Dry Season	Total
Headworks Plan	Paddy field	3,100	1,000	4,100
	Upland field	--	2,100	2,100
	Total	3,100	3,100	6,200
Pumping Station Plan	Paddy field	3,100	1,000	4,100
	Upland field	--	2,100	2,100
	Total	3,100	3,100	6,200

(3) Construction Work

Table 5-2-4

Intake Method	Irrigation Facilities	Cost Allocation	Water Balance
Headworks Plan	Headwork : H = 24 m, L = 560 m, dam volume = 503,000 m^3	W. R/A S-1 & S-2	See Table 5-13-1
	Head race : Q = 20.7 m^3/s, L = 18.7 km	- do -	
	Siphon & aqueduct : Q = 20.7 m^3/s, L = 1.3 km	- do -	
	Main canal : Q_{mean} = 3.1 m^3/s, L = 10 km	Exclusive	
	Secondary canal : Q_{mean} = 0.6 m^3/s, L = 23 km	"	
	Pump : Q = 5.5 m^3/s, ø 1,000 mm x 600 PS x 3 units	"	
Pumping Station Plan	Pump : Q = 22.1 m^3/s, ø 1,400 mm x 3,000 PS x 6 units	W. R/A S-1 & S-2	See Table 5-13-2
	Pipeline : ø 3,100 mm x 2 sets, L = 5 km	- do -	
	Main canal : Q_{mean} = 3.1 m^3/s, L = 10 km	Exclusive	
	Secondary canal : Q_{mean} = 0.6 m^3/s, L = 23 km	- do -	
	Pump : Q = 5.5 m^3/s, ø 1,000 mm x 600 PS x 3 units	- do -	

(4) Construction Cost, Investment Effect, Operation and Maintenance Cost, and Benefit-Cost Ratio (See Sec. 4-7, 5-14, 5-15 and 5-16)

Table 5-2-5

Intake Method	Construction Cost	Investment Effect	Operation & Maintenance Cost	Benefit/Cost Ratio 6%	Benefit/Cost Ratio 12%
Headworks Plan	2,074 x 10^6Rp	*Paddy field* : 4,100 ha x 91.5$10^3$Rp/ha = 376$10^6$Rp *Upland field* : 2,100 x 13 = 27 Total 403$10^6$Rp	63$10^6$Rp	1.71	1.05
Pumping Station Plan	3,126 x 10^6Rp	*Paddy field* : 4,100 ha x 91.5 = 376$10^6$Rp *Upland field* : 2,100 x 13 = 27 Total 403$10^6$Rp	114$10^6$RP	1.00	0.61

5-2-3. Third Stage Development

(1) Irrigation Planning

Irrigation water that can be secured for dry season paddy cropping by the first and second stage development is limited ($Q = 1.2\ m^3/s$). In order that dry season paddy cropping can be made possible for the whole area (5,000 ha), water must be drawn from the Way Besai dam which is planned to be used for the irrigation of W. R/A S-1, W.A.H., W.A., and W.T. areas.

(2) Irrigable Area

The acreage of irrigable area that can be increased by the third stage development is as follows.

Table 5-2-6

Unit: ha

Intake Method	Kind of Field	Wet Season	Dry Season	Total
Headworks Plan	Paddy field	---	3,800	3,800
Pumping Station Plan	Paddy field	---	3,800	3,800

(3) Construction Work

Same as for W. R/A S-1 area (See Table 5-1-7).

(4) Construction Cost, Investment Effect, Operation and Maintenance Cost, and Benefit-Cost Ratio (See Sec. 4-7, 5-14, 5-15, and 5-16).

Table 5-2-7

Intake Method W. Rarem	Intake Method W. Abung	Construction Cost	Investment Effect	Operation & Maintenance Cost	Benefit/Cost Ratio 6%	Benefit/Cost Ratio 12%
Head-works Plan	Plan 1	4,726 10^6Rp	3,800 ha x 78.5 10^3Rp/ha = 298 x 10^6Rp	105 10^6Rp	0.53	0.30
	Plan 2	4,843	" " "	107	0.51	0.29
	Plan 3	4,998	" " "	110	0.49	0.27
Pumping Station Plan	Plan 4	1,870	" " "	88	1.46	0.82
	Plan 5	1,960	" " "	90	1.36	0.77
	Plan 6	2,270	" " "	95	1.16	0.65

5-3. W. R/A N-1 Area

This area adjoins the Way Terusan and the eastern boundary of the project area. The elevation is lower than 30 m.

The acreage of this area is as tabulated below (Refer to Table 4-1-1).

Table 5-3-1

Unit: ha

Name of Area	Total Acreage	Available Acreage	Farmland Acreage	Acreage to be Irrigated
W. R/A N-1	6,500	4,500	4,000	3,500

(1) Irrigation Planning

Since this area is far from the Way Rarem, irrigation water will be taken from the nearby Way Terusan. Pump irrigation will be required because of the water level of the Way Terusan and the area's elevation. Since no data is available on river discharge in this area, complete reliance on the run-off values given in Table 4-3-11 may court errors. To avert this danger, the acreage to be irrigated is reduced to 3,500 ha. Although it is believed that the Way Terusan can supply the water requirement for this area (3.8 m^3/s) throughout year, further studies should be made to justify the feasibility of this irrigation plan.

Development in stages and water source planning by different methods are not considered for this area.

(2) Irrigable Area

The acreage of irrigable area is as follows.

Table 5-3-2

Unit: ha

Kind of Field	Wet Season	Dry Season	Total
Paddy Field	3,500	3,500	7,000

(3) Bed Protection Work

Pump	Q = 3.8 m^3/s, ø800 mm x 900 PS x 3 units
Pipeline	ø1,800 mm x 1 set, L = 4 km
Consolidation Work	1,500 m^2
Main Canal	Q_{mean} = 2.1 m^3/s, L = 7 km
Secondary Canal	Q_{mean} = 0.4 m^3/s, L = 16 km

(4) Construction Cost

1,965$10^6$Rp (See Sec. 5-14 and 5-16).

(5) Investment Effect

Paddy Field 7,000 ha x 91.5$10^3$Rp/ha = 640$10^6$Rp (See Sec. 4-7)

(6) Operation and Maintenance Cost

106$10^6$Rp (See Sec. 5-15).

(7) Benefit-Cost Ratio

3.01 at 6% and 1.81 at 12% (See Sec. 5-16).

5-4. W. R/A N-2 Area

This area lies in the north of the strip of lowland which stretches from east to west to divide Way Rarem/Abung area, and adjoins W. R/A N-1 area.

The acreage of this area is as tabulated below. (See Table 4-1-1).

Table 5-4-1

Unit: ha

Name of Area	Total Acreage	Available Acreage	Farmland Acreage	Acreage to be Irrigated
W.R/A N-2	(41,500)*	(29,800)*	5,700	5,000

* Includes acreage of W. R/A N-3 area.

(1) Irrigation Planning

This area depends on the Way Rarem for the supply of irrigation water which will be pumped at the downstream of the confluence of the Way Ratem and the Way Tulung Mas. The intake point will be so selected that the pipeline length can be minimized.

At this intake point, discharge of more than 50 m^3/s can be expected in the wet season. In the dry season, however, the available discharge declines to about 6 m^3/s. The irrigable area is set at 5,000 ha on the basis of this dry season discharge.

As in the case of W. R/A N-1 area, stagewise development and water source planning by different methods are not considered.

(2) Irrigable Area

The acreage of irrigable area is as tabulated below.

Table 5-4-2

Unit: ha

Kind of Field	Wet Season	Dry Season	Total
Paddy Field	5,000	5,000	10,000

(3) Construction Work

Pump	$Q = 5.5\ m^3/s$, ø1,000 mm x 1,500 PS x 3 units
Pipeline	ø2,200 mm x 1 set, L = 5 km
Bed Protection Work	2,000 m^2
Main Canal	$Q_{mean} = 3.1\ m^3/s$, L = 10 km
Secondary Canal	$Q_{mean} = 0.6\ m^3/s$, L = 23 km

(4) Construction Cost

3,317 10^6 Rp (See Sec. 5-14 and 5-16).

(5) Investment Effect

Paddy field 10,000 ha x 91.5 10^3 Rp/ha = 916 10^6 Rp (See Sec. 4-7).

(6) Operation and Maintenance Cost

175 10^6 Rp (See Sec. 5-15).

(7) Benefit-cost Ratio

2.47 at 6% annual interest rate and 1.49 at 12% annual interest rate (See Sec. 5-16).

5-5. W. R/A N-3 Area

This area adjoins W. R/A N-1 and N-2 areas and extends northwards as far as the Way Tulungbawang. The elevation is lower than 35 m.

The acreage of this area is as follows (See Table 4-1-1).

Table 5-5-1

Unit: ha

Name of Area	Total Acreage	Available Acreage	Farmland Acreage	Acreage to be Irrigated
W. R/A N-3	(41,500)*	(29,800)*	21,100	18,500

* Includes the acreage of W. R/A N-2 area.

(1) Irrigation Planning

This area will be irrigated with water pumped up from the Way Tulangbawang. It is considered that a suitable intake point can be found near Umb. Bakem downstream of the confluence of the Way Tulangbawang and the Way Kanan. Since the two rivers join on the upstream of the intake point, discharge larger than the area's water requirement (20.2 m^3/s) can be expected even in the dry season.

(2) Irrigable Area

The acreage of irrigable area is as tabulated below.

Table 5-5-2

Unit: ha

Kind of Field	Wet Season	Dry Season	Total
Paddy Field	18,500	18,500	37,000

(3) Bed Protection Work

Pump	$Q=20.2\ m^3/s$, ø1,200 mm x 3,200 PS x 3 units
Pipeline	ø3,000 mm x 2 sets, L = 5 km
Consolidation Work	2,000 m^2
Main Canal	$Q_{mean} = 11.3\ m^3/s$, L = 35 km

Secondary Canal Q_{mean} = 2.2 m^3 s, L = 83 km

(4) Construction Cost

12,220 10^6 Rp.

(5) Investment Effect

Paddy Field 37,000 ha x 91.5 10^3 Rp ha = 3,385 10^6 Rp

(6) Operation and Maintenance Cost

663 10^6 Rp

(7) Benefit-Cost Ratio

2.5 at 6% and 1.5 at 12%.

The Government of Indonesia is formulating a Rice Estate Plan for about 20,000 ha of land in this area. If this plan is brought into execution, irrigation plans for part of W. R/A N-1 and N-2 areas and the greater part of W. R/A N-3 area will have to be revised. However, no revision will be required for the irrigation plan for other parts of the project area.

W. R/A N-3 area is excluded from the project area since the team was informed that the Government of Indonesia has the intention to implement the said estate plan.

5-6. W.A.H. Area

This area is a narrow strip of land extending along the left bank of the Way Abung, and it has already been covered by a preliminary survey conducted by the Government of Indonesia.

The acreage of this area is as shown in the following table (See Table 4-1-1).

Table 5-6-1

Unit: ha

Name of Area	Total Acreage	Available Acreage	Farmland Acreage	Acreage to be Irrigated
W.A.H.	10,300	9,700	8,900	7,751

5-6-1. First Stage Development

Since the area extends along the left bank of the Way Abung and therefore lacks suitable sites for reservoir construction, the first stage development is not considered.

5-6-2. Second Stage Development

(1) Irrigation Planning

Although water from the Way Abung will be used preferentially for irrigation of this area, the river does not offer sufficient discharge for paddy cropping in the entire area (7,751 ha) even in the wet season. The shortage will therefore be covered by diverting the adjoining Way Besai planned for wet season cropping in Way Abung area by constructing headworks and tunnel.

The following plans will be studied with respect to the intake point for W.A. and W.T. areas as well as the intake method for W.R/A S-1 and S-2 areas.

Plan 1 (and Plans 3, 4 and 6) ... Separate headworks plan under which headwork providing necessary intake water level for W.A.H. area will be constructed at a point nearest to the area, i.e., a point 25 km upstream of Kotabumi selected by the Government of Indonesia.

Plan 2 ... Common headworks plan for W.A.H., W. R/A and W.A. areas under which the discharge required for W.A. area as well as for W. R/A S-1 and S-2 areas will be obtained from the same headwork constructed at a point 37 km upstream from Kotabumi on the Way Abung for diverting water to the Way Rarem.

Plan 5 ... Common headworks plan for W.A.H. and W.A. areas under which the intake water level required for W.A. area will be obtained by the headwork constructed at a point 32.5 km upstream from Kotabumi on the Way Abung. This river is closest to W.A. area and assures sufficient water supply for both W.A.H. and W.A. areas.

(2) Irrigable Area

The acreage of irrigable area is as tabulated below.

Table 5-6-2

Unit: ha

	Kind of Field	Wet Season	Dry Season	Total
Plan 1 (& 3,4,6)	Paddy field	7,751	500	8,251
	Upland field	--	7,251	7,251
	Total	7,751	7,751	15,502
Plan 2 (5)	Paddy field	7,751	350	8,101
	Upland field	---	7,401	7,401
	Total	7,751	7,751	15,502

(3) Construction Work

Table 5-6-3

	Facilities for Diversion	Cost Allocation
Plan 1 (& 3,4,6)	Besai headwork: Q = 7.6 m^3/s, L = 50 m	W.A.H. W.A.
	Besai tunnel : D = 2.3 m, L = 4 km	- do -
Plan 2 (& 5)	Besai headwork: Q = 9.6 m^3/s, L = 50 m	- do -
	Besai tunnel : D = 2.3 m, L = 4 km	- do -

Table 5-6-4

	Irrigation Facilities	Cost Allocation	Water Balance
Plan 1 (& 3,4,6)	W. Abung headwork (+25 km): $Q = 12.4\ m^3/s$, L = 30 m	Exclusive	See Table 5-13-3
	Main canal: $Q_{mean} = 4.5\ m^3/s$, L = 64.2 km	- do -	
Plan 2	W. Abung headwork (+37 km): $Q = 37.9\ m^3/s$, L = 30 m	W.A.H. W.A., W.R A S-1 & S-2	
	Head race: $Q = 20.4\ m^3/s$, L = 21 km	W.A.H. & W.A.	
	Main canal: $Q_{mean} = 4.5\ m^3/s$, L = 54.2 km	Exclusive	
Plan 5	W. Abung headwork (+32.5 km) $Q = 20.4\ m^3/s$, L = 30 m	W.A.H. & W.A.	
	Head race: $Q = 20.4\ m^3/s$, L = 17 km	- do -	
	Main canal: $Q_{mean} = 4.5\ m^3/s$, L = 54.2 km	Exclusive	

(4) Construction Cost, Investment Effect, Operation and Maintenance Cost, and Benefit-Cost Ratio (See Sec. 4-7, 5-14, 5-15 and 5-16).

Table 5-6-5

	Construction Cost	Investment Effect				Operation & Maintenance Cost	Benefit-Cost Ratio 6%	Benefit-Cost Ratio 12%
Plan 1 (& 3,4,6)	$3.435 x 10^6$ Rp	Paddy field	8251^{ha}	x $91.5 10^3$ Rp/ha	= $755 10^6$ Rp	10^6 Rp		
		Upland field	7251	x 13	= 94	69	2.46	1.49
		Total			849			
Plan 2		Paddy field	8101	x 91.5	=741			
	3.670	Upland field	7401	x 13	= 96	74	2.25	1.37
		Total			837			
Plan 5		Paddy field	8101	x 91.5	=741			
	3.639	Upland field	7401	x 13	= 96	73	2.28	1.38
		Total			837			

5-6-3. Third Stage Development

(1) Irrigation Planning

Water requirement for dry season paddy cropping will be filled by the Way Besai dam which is connected with the Way Abung through a tunnel.

(2) Irrigable Area

The acreage of irrigable area that can be increased by the third stage development is as shown in the following table.

Table 5-6-6

Unit: ha

	Kind of Field	Wet Season	Dry Season	Total
Plan 1 (& 3,4,6)	Paddy field	----	7,251	7,251
Plan 2 (& 5)	Paddy field	----	7,401	7,401

(3) Construction Work

Table 5-6-7

	Irrigation Facilities	Cost Allocation	Water Balance
Plan 1	Besai dam : Capacity=247,000$10^3m^3$, dam volume = 7,800$10^3m^3$	W.A.H.,W.A., W. R/A S-1 & S-2	Table 5-13-6
	Besai tunnel: D = 4.4 m, L = 4 km	- do -	
Plan 2	Besai dam : Capacity=256,000$10^3m^3$, dam volume = 8,000$10^3m^3$	- do -	Table 5-13-7
	Besai tunnel: D = 4.3 m, L = 4 km	- do -	
Plan 3	Besai dam : Capacity=283,000$10^3m^3$, dam volume = 9,000$10^3m^3$	W.A.H.,W.A., W.T., W.R/A S-1 & S-2	Table 5-13-8
	Besai tunnel: D = 4.8 m, L = 4 km	- do -	
Plan 4	Besai dam : Capacity=158,000$10^3m^3$, dam volume = 5,000$10^3m^3$	W.A.H.,W.A., W. R/A S-1 & S-2	Table 5-13-9
	Besai tunnel: D = 4.4 m, L = 4 km	- do -	
Plan 5	Besai dam : Capacity=166,000$10^3m^3$, dam volume = 5,300$10^3m^3$	W.A.H.,W.A., W. R/A S-1 & S-2	Table 5-13-10
	Besai tunnel: D = 4.3 m, L = 4 km	- do -	
Plan 6	Besai dam : Capacity=194,000$10^3m^3$, dam volume = 6,200$10^3m^3$	W.A.H.,W.A., W.T.,W.R/A S-1 & S-2	Table 5-13-11
	Besai tunnel: D = 4.8 m, L = 4 km	- do -	

(4) Construction Cost, Investment Effect, Operation and Maintenance Cost, and Benefit-Cost Ratio (See Sec. 4-7, 5-14, 5-15 and 5-16)

Table 5-6-8

Intake Method	Construction Cost	Investment Effect			Operation & Maintenance Cost	Benefit-Cost Ratio 6%	Benefit-Cost Ratio 12%
Plan 1	12.788 10^6 Rp	Paddy field	7,251x78.5 10^3 Rp/ha	= 569 10^6 Rp	225 10^6 Rp	0.35	0.20
Plan 2	13.058	"	7,401x78.5	= 581	230	0.35	0.35
Plan 3	12.638	"	7,251x78.5	= 569	223	0.36	0.20
Plan 4	10.861	"	7,251x78.5	= 569	191	0.45	0.25
Plan 5	11.685	"	7,401x78.5	= 581	206	0.42	0.23
Plan 6	11.293	"	7,251x78.5	= 569	199	0.43	0.24

5-7. W.A. Area

This area is a hilly land extending between W.A.H. area and W.T. area. Construction of reservoirs is possible because the area has small rivers.

The acreage of the area is as follows (See Table 4-1-1).

Table 5-7-1

Unit: ha

Name of Area	Total Acreage	Available Acreage	Farmland Acreage	Acreage to be Irrigated
W.A.	14,000	10,100	9,100	8,000

5-7-1 First Stage Development

The effect of the project can be expected by constructing reservoirs on small rivers just as in W. R/A S-1 and S-2 areas. However, since this plan still involves unknown factors as described in Chapter V, the benefit of reservoir construction scheme will not be made at this stage.

5-7-2 Second Stage Development

(1) Irrigation Planning

Part of the water requirement of this area will be filled by the storage of reservoirs and surplus water of W.A.H. area will be drawn through a head race from headwork constructed on the Way Abung. Surplus water from W.A.H. area will be stored in the reservoirs for effective water utilization. Water requirement of the area, however, cannot be fully met by this development both in the wet and dry seasons.

Accordingly, to obtain sufficient irrigation water required for wet season paddy cropping, diversion of water from the Way Besai to the Way Abung will be conducted by constructing headwork and tunnel.

The following plans will be studied with respect to the intake point for W.A.H. and W.T. areas and intake method for W. R/A S-1 and S-2 areas.

Plan 1 ... Intake of water from the same headwork constructed at a point 37 km upstream from Kotabumi on the Way Abung for W. R/A S-1 and S-2 areas.

Plan 2 ... Intake of additional water for W.A.H. from the said headwork.

Plan 3 ... Intake of additional water for W.T. area from the said headwork.

Plan 4 ... Intake of water required for this area from the headwork constructed at a point 32.5 km upstream from Kotabumi which is closest to W.A. area, and which assures necessary water level for the area.

Plan 5 ... Intake of additional water for W.A.H. area from the headwork to be constructed under Plan 4.

Plan 6 ... Intake of additional water for W.T. area from the headwork to be constructed under Plan 4.

(2) Irrigable Area

The acreage of irrigable area is as tabulated below.

Table 5-7-2

Unit: ha

Kind of Field	Wet Season	Dry Season	Total
Paddy field	8,000	800	8,800
Upland field	---	7,200	7,200
Total	8,000	8,000	16,000

(3) Construction Work

Table 5-7-3

Intake Method	Facilities for Diversion	Cost Allocation
Plans 1,3,4 & 6	Besai headwork: Q=7.6 m^3/s, L=50 m	W.A. & W.A.H.
	Besai tunnel : D=2.3 m, L=4.0 km	- do -
Plans 2 & 5	Besai headwork: Q=9.6 m^3/s, L=50 m	- do -
	Besai tunnel : D=2.6 m, L=4.0 km	- do -

Table 5-7-4

Intake Method	Irrigation Facilities	Cost Allocation
Plan 1	W. Abung headwork (+37 km): Q = 25.5 m^3/s, L = 30 m	W.A.,W.R/A S-1 & S-2
	Head race : Q=8.0 m^3/s, L=4.0 km	Exclusive
	Reservoir : Capacity=2,000,000 m^3, dam volume = 270,000 m^3	- do -
	Main canal : Q_{mean} = 4.9 m^3/s, L = 41 km	- do -
	Secondary canal: Q_{mean} = 1.0 m^3/s, L = 36 km	- do -

Table 5-7-4 (Cont'd)

Intake Method	Irrigation Facilities	Cost Allocation
Plan 2	W. Abung headwork (+37 km): $Q = 37.9\ m^3/s$, L = 30 m	W.A.,W.A.H., W. R/A S-1 & S-2
	Head race : $Q = 20.4\ m^3/s$, L = 21 km	W.A.& W.A.H.
	Reservoir : Capacity = 2,000,000 m^3, dam volume = 270,000 m^3	Exclusive
	Main canal : $Q_{mean} = 4.9\ m^3/s$, L = 24 km	- do -
	Secondary canal: $Q_{mean} = 1.0\ m^3/s$, L = 36 km	- do -
Plan 3	W. Abung headwork (+37 km): $Q = 29.9\ m^3/s$, L = 30 m	W.A.,W.T. (3rd),W.R/A S-1 & S-2
	Reservoir : Capacity = 2,000,000 m^3, dam volume = 270,000 m^3	Exclusive
	Main canal : $Q_{mean} = 4.9\ m^3/s$, L = 31 km	- do -
	Head race : $Q = 12.4\ m^3/s$, L = 14 km	W.A.& W.T. (3rd)
	Secondary canal: $Q_{mean} = 5.4\ m^3/s$, L = 4 km	- do -
	- do - : $Q_{mean} = 1.0\ m^3/s$, L = 32 km	Exclusive
Plan 4	W. Abung headwork (+32.5 km): $Q = 8.0\ m^3/s$, L = 30 m	- do -
	Reservoir : Capacity = 2,000,000 m^3, dam volume = 270,000 m^3	- do -
	Main canal : $Q_{mean} = 4.9\ m^3/s$, L = 41 km	- do -
	Secondary canal: $Q_{mean} = 1.0\ m^3/s$, L = 36 km	- do -

Table 5-7-4 (Cont'd)

Intake Method	Irrigation Facilities	Cost Allocation
Plan 5	W. Abung headwork (+32.5 km) $Q = 20.4\ m^3/s$, L = 30 m	W.A.,& W.A.H.
	Reservoir : Capacity = 2,000,000 m^3, dam volume = 270,000 m^3	Exclusive
	Head race : $Q = 20.4\ m^3/s$, L = 17 km	W.A.& W.A.H.
	Main canal : $Q_{mean} = 4.9\ m^3/s$, L = 21 km	Exclusive
	Secondary canal: $Q_{mean} = 1.0\ m^3/s$, L = 36 km	- do -
Plan 6	W. Abung headwork (+32.5 km): $Q = 12.4\ m^3/s$, L = 30 m	W.A.& W.T. (3rd)
	Reservoir : Capacity = 2,000,000 m^3, dam volume = 270,000 m^3	Exclusive
	Main canal : $Q_{mean} = 4.9\ m^3/s$, L = 31 km	- do -
	Head race : $Q = 12.4\ m^3/s$, L = 10 km	W.A.& W.T. (3rd)
	Secondary canal: $Q_{mean} = 5.4\ m^3/s$, L = 4 km	- do -
	- do - : $Q_{mean} = 1.0\ m^3/s$, L = 32 km	Exclusive

Note: See Table 5-13-14 for water balance.

(4) Construction Cost, Investment Effect, Operation and Maintenance Cost, and Benefit-Cost Ratio (See Sec. 4-7, 5-14, 5-15 and 5-16).

Table 5-7-5

Intake Method	Construction Cost	Investment Effect				Operation & Maintenance Cost	Benefit-Cost Ratio	
							6%	12%
Plan 1	$4,344 10^6$ Rp	Paddy field	8,800 ha	x $91.5 10^3$ Rp/ha	= $805 10^6$ Rp	$86 10^6$ Rp	2.17	1.28
		Upland field	7,200	x 13	= 94			
		Total			= 899			
Plan 2	4,312	"			= 899	86	2.18	1.29
Plan 3	4,271	"			= 899	85	2.21	1.30
Plan 4	4,392	"			= 899	87	2.14	1.26
Plan 5	4,292	"			= 899	86	2.19	1.29
Plan 6	4,279	"			= 899	85	2.20	1.30

5-7-3. Third Stage Development

(1) Irrigation Planning

Water requirement for dry season paddy cropping will be stored in the Besai dam and drawn to the Way Abung through the head race for diversion. The irrigation plan for this stage will be mapped out to include the dry season water requirement for paddy cropping. Hence, the following two plans will be studied in addition to the plans for the second stage development.

Plan 3 ... Intake of water for W.T. area as well as for W.A. area from the headwork studied under Plan 1 for the second stage development, to be drawn through an exclusive canal (L = 200 m) to W.T. area from a point on the head race.

Plan 6 ... Intake of water for W.T. area as well as for W.A. area from headwork studied under Plan 4 for the second stage development, to be drawn to W.T. area through an exclusive canal from a point on the head race.

(2) Irrigable Area

The acreage of irrigable area that can be expanded by the third stage development is as shown below.

Table 5-7-6

Unit: ha

Kind of Field	Wet Season	Dry Season	Total
Paddy field	----	7,200	7,200

(3) Construction Work

Same as the construction work tabulated in 5-6-3 (See Table 5-6-7).

(4) Construction Cost, Investment Effect, Operation and Maintenance Cost, and Benefit-Cost Ratio (See Sec. 4-7, 5-14, 5-15 and 5-16).

Table 5-7-7

	Construction Cost	Investment Effect	Operation & Maintenance Cost	Benefit-Cost Ratio 6%	Benefit-Cost Ratio 12%
Plan 1	7,900 10^6 Rp	7,200 ha x 78.5 10^3 Rp/ha = 1,464 10^6 Rp	139 10^6 Rp	0.70	0.39
Plan 2	8,446	" " "	149	0.64	0.36
Plan 3	8,280	" " "	146	0.66	0.37
Plan 4	6,921	" " "	122	0.83	0.47
Plan 5	7,268	" " "	128	0.78	0.44
Plan 6	7,330	" " "	129	0.77	0.43

5-8. W.T. Area

This is a strip of land extending along the right bank of the Way Tulung Mas. Same as in the case of W.A.H. area, this area has already been covered by the prefeasibility study conducted by the Government of Indonesia.

The acreage of the area is as tabulated below (See Table 4-1-1).

Table 5-8-1

Unit: ha

Name of Area	Total Acreage	Available Acreage	Farmland Acreage	Acreage to be Irrigated
W.T.	4,300	3,700	3,300	2,923

5-8-1. Second Stage Development

(1) Irrigation Planning

This area will be covered by gravity irrigation with water drawn from the headwork on the Way Tulung Mas. The Way Tulung Mas satisfies the water requirement for wet season paddy cropping but not for the dry season paddy cropping.

(2) Irrigable Area

The acreage of irrigable area is as follows.

Table 5-8-2

Unit: ha

Kind of Field	Wet Season	Dry Season	Total
Paddy field	2,923	200	3,123
Upland field	---	2,723	2,723
Total	2,923	2,923	5,846

(3) Construction Work

Headwork	$Q = 4.7\ m^3/s$, $L = 20\ m$
Main Canal	$Q_{mean} = 1.8\ m^3/s$, $L = 31.5\ km$
Secondary Canal	$Q_{mean} = 0.4\ m^3/s$, $L = 13\ km$

(4) Construction Cost

$1,205 10^6$ Rp (See Sec. 5-14 and 5-16).

(5) Investment Effect

Paddy field	3,213 ha x $91.5 10^3$ Rp/ha	= $285 10^6$ Rp	(See Sec. 4-7)
Upland field	2,723 x 13	= 35	
Total		= 320	

(6) Operation and Maintenance Cost

$25 10^6$ Rp (See Sec. 5-15).

(7) Benefit-Cost Ratio

2.49 at 6% annual interest rate and 1.54 at 12% annual interest rate (See Sec. 5-16)

5-8-2. Third Stage Development

The plan to satisfy the water requirement for dry season paddy cropping with water from the Besai dam is studied below.

(1) Irrigable Area

The acreage of irrigable area that can be increased by the third stage development is as follows.

Table 5-8-3

Unit: ha

Kind of Field	Wet Season	Dry Season	Total
Paddy field	---	2,723	2,723

(2) Construction Work

Table 5-8-4

Intake Method	Irrigation Facilities	Cost Allocation
Plan 3	Besai dam : Capacity = 283,000 $10^3 m^3$, dam volume = 9,000 $10^3 m^3$	W.T.,W.A.H.,W.A., W. R/A S-1 & S-2
	Besai tunnel: D = 4.8 m, L = 4.0 km	- do -
	W. Abung headwork (+37 km): Q = 29.9 m^3/s, L = 30 m	W.T.,W.A.,W.R/A S-1 & S-2
	W.T. Head race: Q = 4.4 m^3/s, L = 200 m	Exclusive
	Head race: Q = 12.4 m^3/s, L = 14 km Q = 5.4 m^3/s, L = 4 km	W.T. & W.A.
Plan 6	Besai dam : Capacity = 194,000 $10^3 m^3$, dam volume = 6,200 $10^3 m^3$	W.T.,W.A.,W.A.H., W. R/A S-1 & S-2
	Besai tunnel: D = 4.8 m, L = 4.0 km	- do -
	W. Abung headwork (+32.5 km): Q = 12.4 m^3/s, L = 30 m	W.T. & W.A.
	W.T. Head race: Q = 4.4 m^3/s, L = 200 m	Exclusive
	Head race: Q = 12.4 m^3/s, L = 10 km Q = 5.4 m^3/s, L = 4 km	W.T. & W.A.

(3) Construction Cost, Investment Effect, Operation and Maintenance Cost, Benefit-Cost Ratio (See Sec. 4-7, 5-14, 5-15 and 5-16).

Table 5-8-5

Intake Method	Construction Cost	Investment Effect	Operation & Maintenance Cost	Benefit-Cost Ratio 6%	12%
Plan 3	4,993x10^6Rp	Paddy field 2,723 ha x 78.5$10^3$Rp/ha = 214$10^6$Rp	88$10^6$ Rp	0.33	0.18
Plan 6	4,505	" " " "	"	0.39	0.22

5-9. Other Irrigation Plan

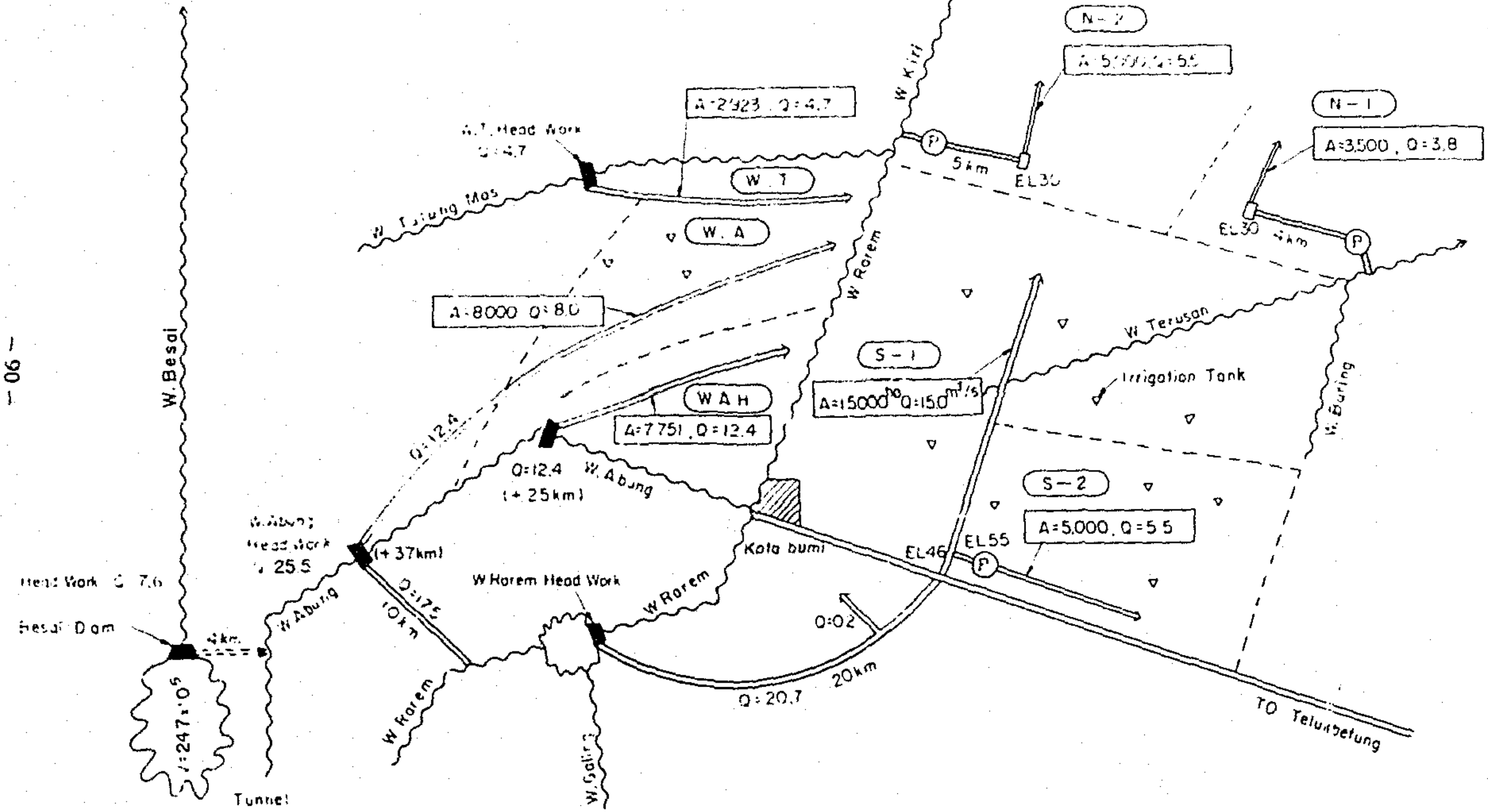
For those parts of W. R/A S-1, N-2 and N-3 areas which extend along the Way Rarem, it may be well possible to establish an irrigation plan under which a diversion weir will be constructed at a point downstream of the confluence of the Way Rarem and the Way Abung and an irrigation canal will be stretching north therefrom. This plan, however, needs a close study after completion of detailed topographical map.

5-10. Diversion of the Way Besai

The Way Besai has a catchment area of about 450 km^2 in the vicinity of a point about 10 km upstream of Bt. Kemuning, so that the river discharge is large enough to allow for transfer basin work. No farmland development is planned in the area extending immediately downstream of the said point, but the team learned that reclamation of about 80,000 ha farmland is planned in the further downstream areas. The transfer basin is not considered to cause water shortage in the downstream farmland area newly created by the said plan. Before the completion of the Besai dam, however, studies should be made on the influence of its storage of outlet on the downstream farmland or prospective farmland area.

5-11 Diagram of Irrigation System

Fig 5-1 Plan-1, Diagram of Irrigation System



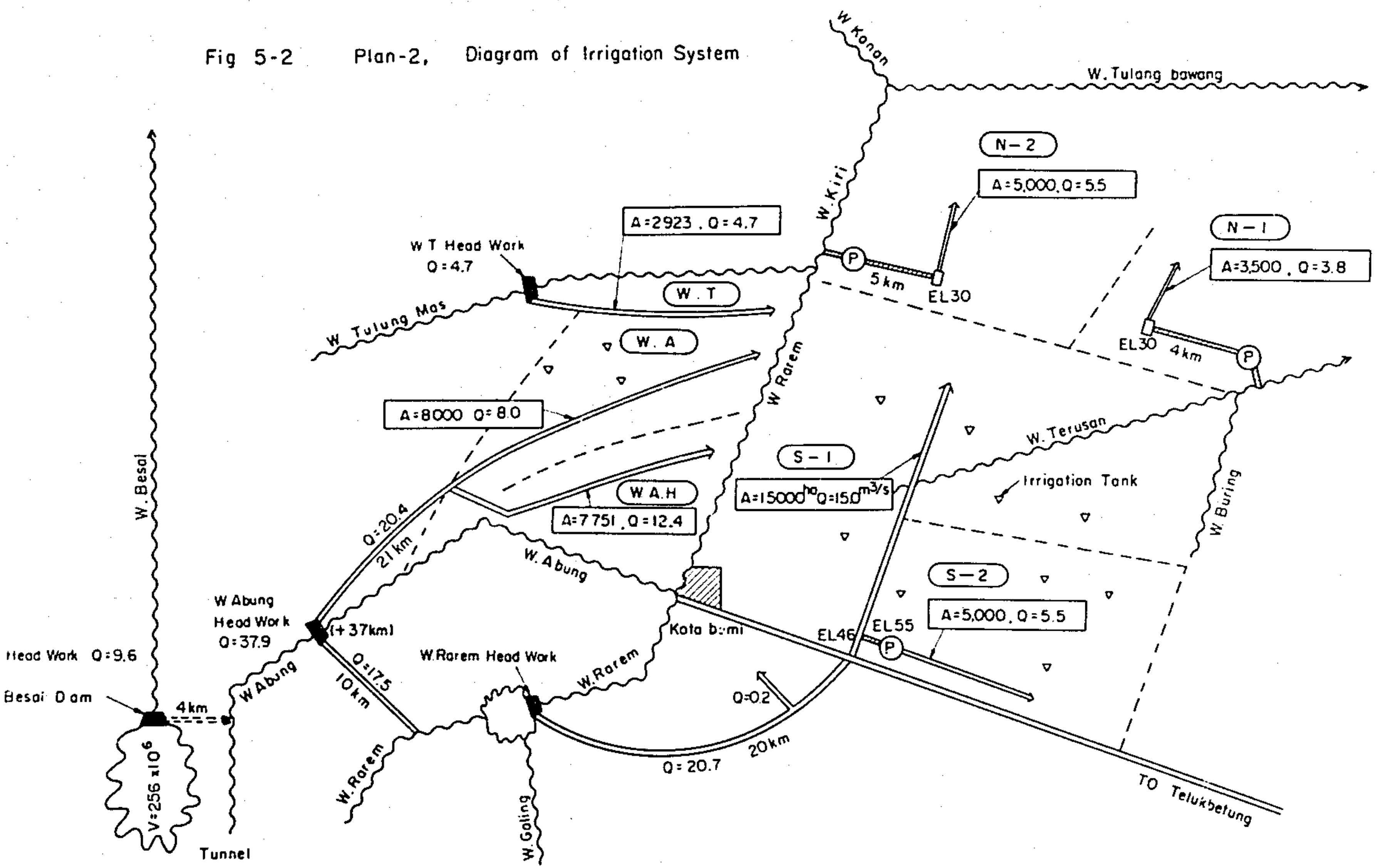
Tunnel

D = 2.3m Q = 7.6 (2nd Stage W A H, W A)

D = 4.4 Q - 28.8 (3rd Stage W A H, W A, S-1, S-2)

Note:(Kml: from confluence of W.Abung and W.Roren.

Fig 5-2 Plan-2, Diagram of Irrigation System



Tunnel

D = 2.6 m   Q = 9.6 (2nd Stage W A H , W. A)

D = 4.3   Q = 26.9 (3rd Stage W A H , W. A , S−1 , S−2)

Fig 5-3 Plan-3, Diagram of Irrigation System

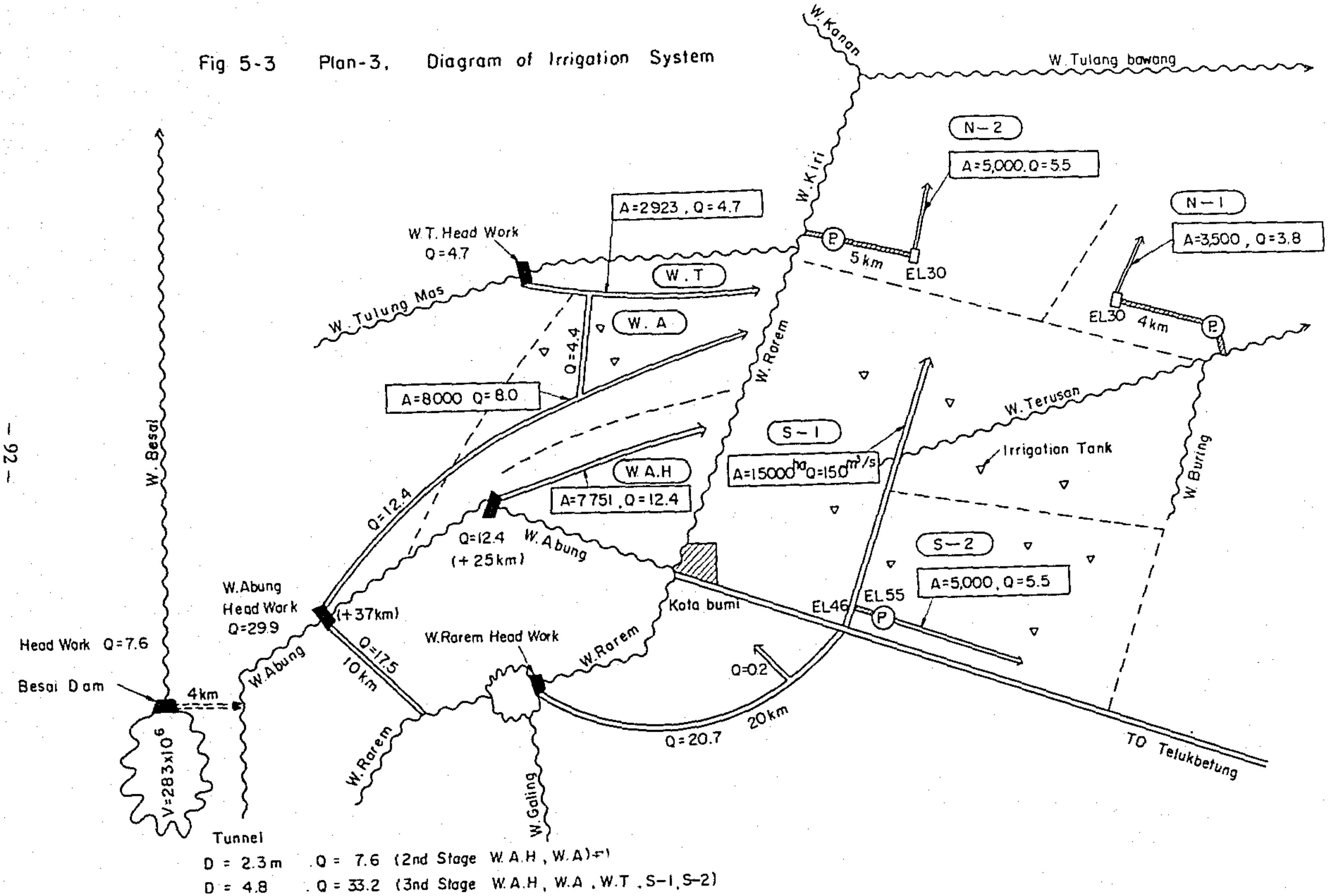


Fig 5-4 Plan-4, Diagram of Irrigation System

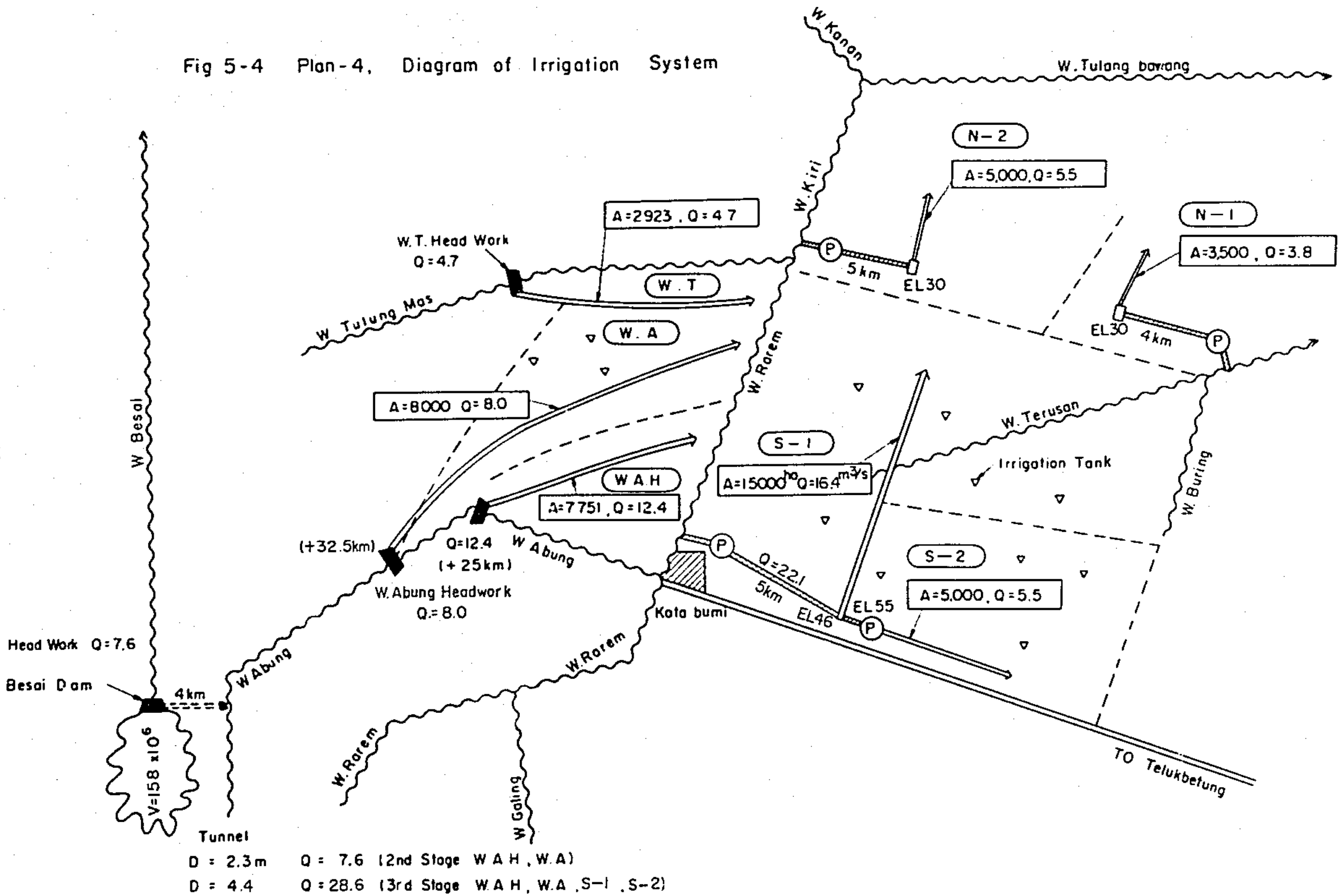


Fig 5-5 Plan-5, Diagram of Irrigation System

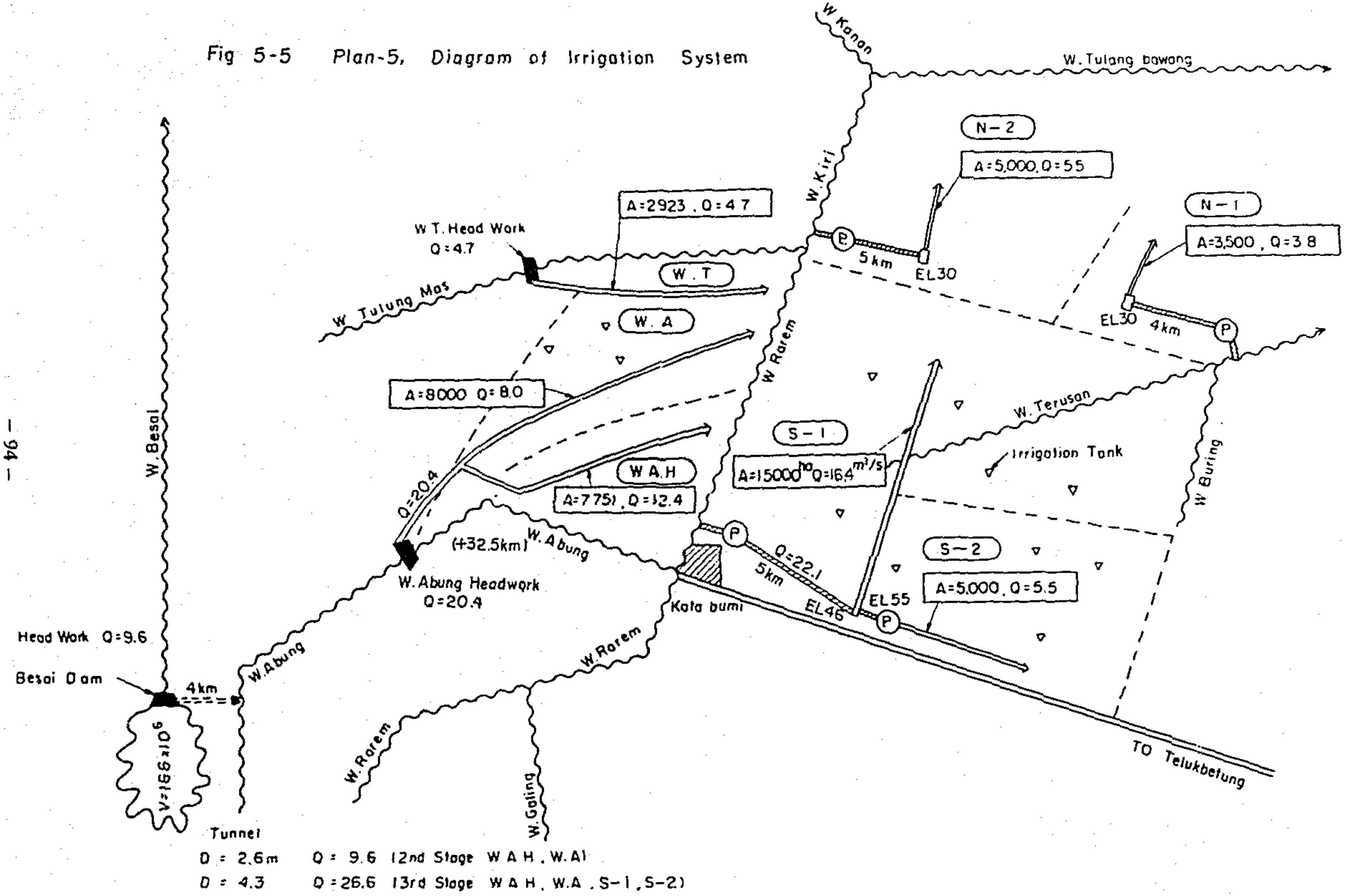
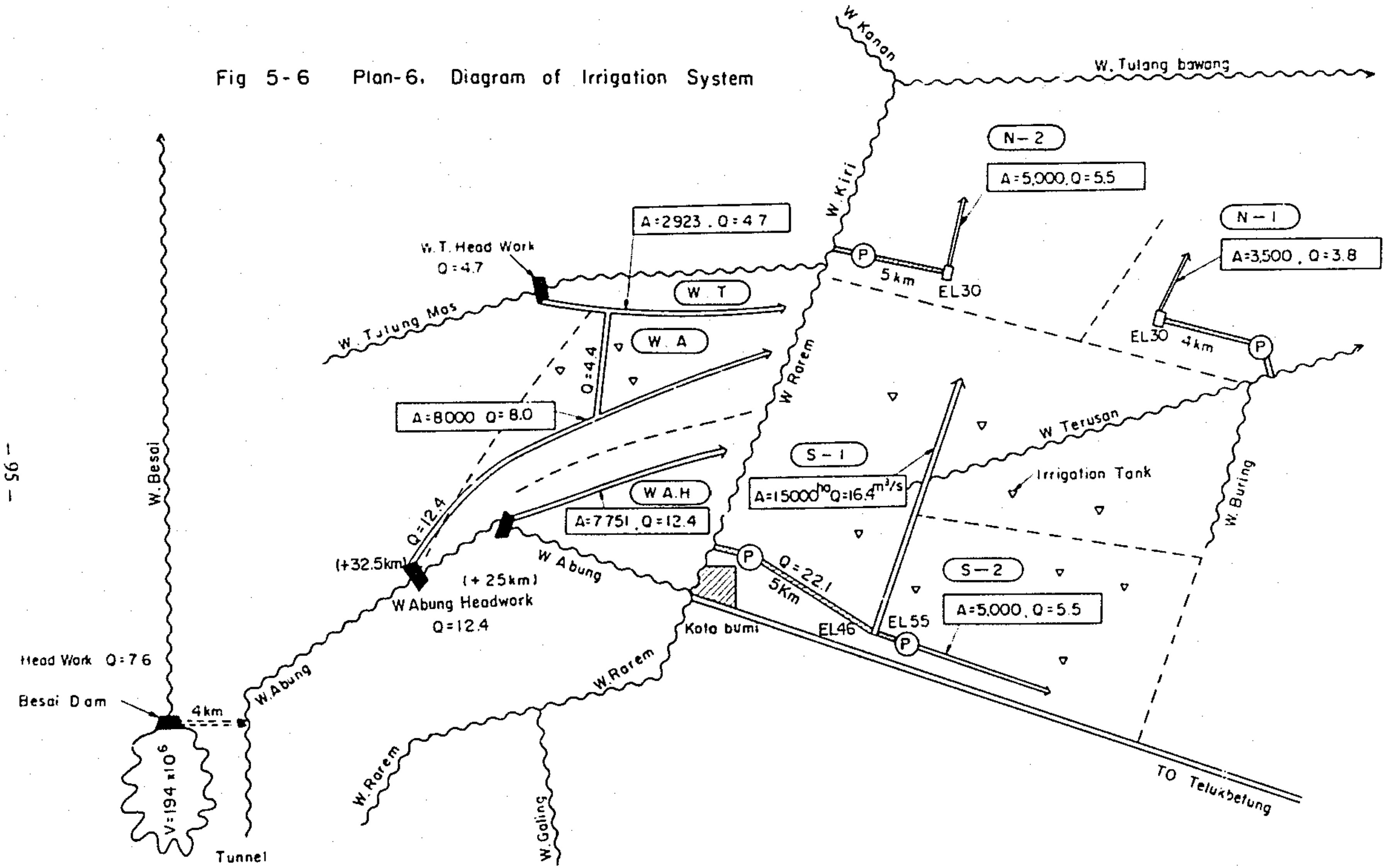


Fig 5-6 Plan-6. Diagram of Irrigation System



D = 2.3m Q = 76 (2nd Stage W A H, W A)

D = 4.8 Q = 33.0 (3rd Stage W A H, W A, W T, S-1, S-2)

5-12. Plan of Reservoirs

Thirty (30) small earth dams (reservoirs) will be constructed in W. R/A S-1 and S-2 areas. These reservoirs are planned to be constructed in an area of about 20,000 ha shown on the 1/25,000 and 1/5,000 scale maps obtained so far.

The dam volume will range between 10,000 and 40,000 m^3 and the dam height between 7 and 11 m including the foundation, and the dam length between 80 and 300 m. Since all the reservoirs will be constructed for effective storage and utilization of water, water will be drawn in by means of an outlet conduit and will be led to the benefited areas on the downstream. Specifications of these reservoirs are given in Table 5-12-1.

With the overflow depth taken at 0.5 - 1.0 m, the spillway will be the side weir type having a length of 5 to 60 m.

Further, all the reservoirs will be so designed as to be able to store surplus water in the main canal and branch canals which will be drawn into the reservoirs by means of the lateral canals.

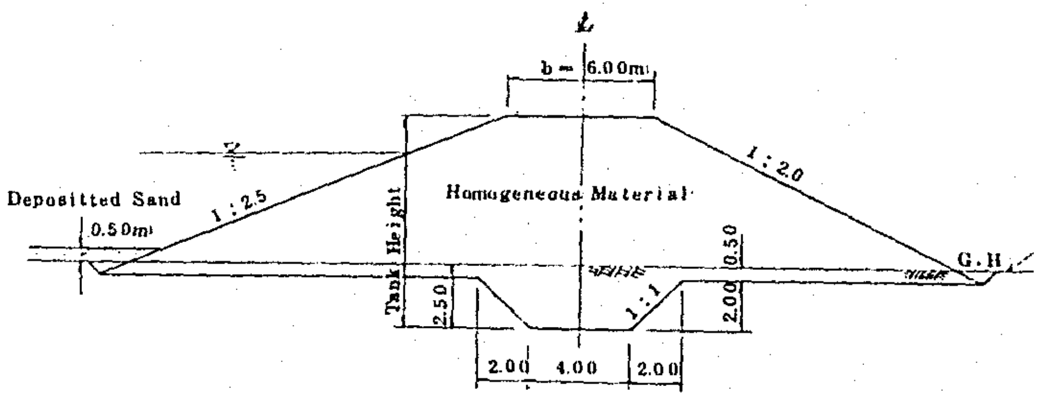


Fig. 5-7 Standard Section of Irrigation Tank

These thirty (30) reservoirs were classified into three groups (A, B and C) according to the ratio of storage capacity to the catchment area, V/A, in order to determine the irrigable area (See Table 5-12-2), and the water balance was calculated for the representative reservoirs (Nos. 13, 17 and 28) of the three groups (See Tables 5-12-5 and 5-12-10).

The water balance calculation was made to obtain the largest irrigable area where no shortage of storage capacity would occur.

The ratio of the irrigable area to the storage capacity was obtained from the results of the water balance calculation, and the irrigable area was determined for each group of reservoirs. The results are as shown in Tables 5-12-3 and 5-12-4.

Table 5-12-1 Basic Data of Irrigation Tank in Way Rarem/Abung S-1 & S-2 Areas

No.	Catchment Area	Minimum Elevation	Top of Embank-ment	Height of Embankment		Length of Embankment	Design Water Level	Design Water Depth	Storage Capacity	Full Water Area	Volume of Embank-ment	V/v	V/A
	A ha	El m	El m	m	Foundation + 2.5 m	m	El m	m	V 1000m³	ha	v 1000m³		
1	160	26.0	32.0	6.0	8.5	80	30.0	3.5	354	23.3	10	35.4	2.21
2	50	26.5	31.0	4.5	7.0	250	29.0	2.0	101	6.9	22	4.6	2.02
3	40	29.5	35.0	5.5	8.0	230	33.0	3.0	100	6.2	28	3.6	2.50
4	20	29.5	35.0	5.5	8.0	230	33 0	3.0	69	3.5	26	2.7	3.45
5	190	32.5	38.0	5.5	8.0	170	35.5	3.0	214	14.0	17	12.6	1.13
6	180	30.5	35.5	5.0	7.5	240	33.0	2.5	375	25.0	19	19.7	2.08
7	140	29.0	36.0	7.0	9.5	90	34.0	4.5	257	11.6	12	21.4	1.84
8	200	35.5	41.0	5.5	8.0	110	39.0	3.0	214	15.0	13	16.5	1.07
9	60	35.5	41.0	5.5	8.0	170	39.0	3.0	72	5.0	19	3.8	1.20
10	70	35.5	41.0	5.5	8.0	170	39.0	3.0	49	3.6	19	2.6	0.70
11	50	33.5	38.0	4.5	7.0	240	36.0	2.0	51	4.2	21	2.4	1.02
12	50	31.5	37.0	5.5	8.0	210	35.0	3.0	66	4.1	22	3.0	1.32
13	90	31.5	37.0	5.5	8.0	220	35.0	3.0	61	3.5	26	2.3	0.68
14	105	26.5	34.0	7.5	10.0	230	32.0	5.0	145	5.4	36	4.0	1.38
15	70	33.5	41.0	7.5	10.0	210	39.0	5.0	155	5.8	33	4.7	2.21
16	50	36.5	42.0	5.5	8.0	230	40.0	3.0	64	4.0	25	2.6	1.28
17	60	34.5	41.0	6.5	9.0	230	39.0	4.0	102	5.3	30	3.4	1.70
Sub-total for S - 1									2449		378		

Table 5-12-1 (Cont'd)

No.	Catchment Area	Minimum Elevation	Top of Embank-ment	Height of Embankment		Length of Embankment	Design Water Level	Design Water Depth	Storage Capacity	Full Water Area	Volume of Embank-ment	V/v	V/A
	A ha	El m	El m	m	Foundation + 2.5 m	m	El m	m	V 1000m^3	ha	v 1000m^3		
18	110	38.0	46.0	7.5	10.0	120	44.0	5.0	359	15.0	19	18.9	2.26
19	25	42.5	48.0	5.5	8.0	220	46.0	3.0	64	4.0	26	2.5	2.56
20	740	37.5	44.0	6.5	9.0	250	41.5	3.5	214	12.2	35	6.1	0.29
21	1130	38.5	45.5	7.0	9.5	160	43.0	4.0	535	26.5	25	21.4	0.47
22	120	42.5	49.0	6.5	9.0	150	47.0	4.0	248	15.0	20	12.4	2.07
23	75	44.5	50.0	5.5	8.0	120	48.0	3.0	145	8.6	15	9.7	1.93
24	45	44.5	49.0	4.5	7.0	230	47.0	2.0	73	6.3	21	3.5	2.04
25	1830	36.5	45.0	8.5	11.0	130	42.0	5.0	857	40.0	24	35.7	0.47
26	270	42.5	47.5	4.5	7.0	170	45.0	2.0	82	7.7	17	4.8	0.30
27	35	38.5	46.0	7.5	10.0	160	44.0	5.0	102	4.0	25	4.1	2.91
28	50	43.5	51.0	7.5	10.0	240	49.0	5.0	133	7.0	39	3.4	2.66
29	810	42.5	47.5	4.5	7.0	150	45.0	2.0	172	16.1	14	12.3	0.21
30	190	39.5	45.0	5.5	8.0	300	42.5	2.5	161	12.0	35	4.6	0.85
Sub-total for S-2									3145		315		

Table 5-12-2 Classification of Irrigation Tank

Ranking	Tank Number	V / A	Catchment Area Aha	Storage Capacity V 1000m^3	Remarks
1	29	0.21	810	172	A Group
2	20	0.29	740	214	
3	26	0.30	270	82	
4	25	0.47	1830	857	
5	21	0.47	1130	535	
6	13	0.68	90	61	
7	10	0.70	70	49	
8	30	0.85	190	161	
9	11	1.02	50	51	
10	8	1.07	200	214	
Sub-total			5380	2396	
11	5	1.13	190	214	B Group
12	9	1.20	60	72	
13	16	1.28	50	64	
14	12	1.32	50	66	
15	14	1.38	105	145	
16	17	1.70	60	102	
17	7	1.84	140	257	
18	23	1.93	75	145	
19	2	2.02	50	101	
20	22	2.07	120	248	
Sub-total			900	1414	
21	6	2.08	180	374	C Group
22	1	2.21	160	354	
23	15	2.21	70	155	
24	3	2.50	40	100	
25	19	2.56	25	64	
26	28	2.66	50	133	
27	27	2.91	35	102	
28	24	3.04	45	73	
29	18	3.26	110	359	
30	4	3.45	20	69	
Sub-total			735	1784	
Total			7015	5594	

Planting Area by Irrigation Tank

The planting areas by other irrigation tanks are presumed as follows by the calculation of water balance which tank numbers are 13, 17 and 28. (cf. Table 5-12-5 ~ 5-12-10)

Table 5-12-3

Group	Tank Number	Storage Capacity 1000m³	Planting Area Wet ha	Planting Area Dry ha	Group	Tank Number	Storage Capacity 1000m³	Planting Area Wet ha	Planting Area Dry ha
A	29	172	116	17	C	6	375	169	11
	20	214	144	21		1	354	160	11
	26	82	55	8		15	155	70	5
	25	857	576	84		3	100	45	3
	21	535	360	52		19	64	29	2
	13	61	41	6		28	133	60	4
	10	49	33	5		27	102	46	3
	30	161	108	16		24	73	33	2
	11	51	34	5		18	359	162	11
	8	214	144	21		4	69	31	2
Sub-total		2,396			Sub-total		1,784		
B	5	214	105	10					
	9	72	35	4					
	16	64	31	3					
	12	66	32	3					
	14	145	71	7					
	17	102	50	5					
	7	257	126	13					
	23	145	71	7	S-1	1 ~ 17	2,449	1,226	119
	2	101	49	5					
	22	248	122	12	S-2	18 ~ 30	3,145	1,882	239
Sub-total		1,414			Total		5,594	3,108	350

The total planting areas are as shown in the table 5-12-4, in round number.

Table 5-12-4

Area	Tank Number	Wet Season ha	Dry Season ha	Total ha
S-1	No. 1 ~ No. 17	1,200	100	1,300
S-2	No. 18 ~ No. 30	1,900	200	2,100
Total		3,100	300	3,400

Table 5-12-5 Calculation of Water Balance for the Irrigation Tank, Tank Number 13, Wet Season

Year	Month	Period of ten days	Days	Rainfall	Effective Rainfall	Run-Off Coefficient	Inflow of Tank C·A=90	Paddling Consumptive Use	Paddling Area	Paddling Shortage	Irrigation Consumptive Use	Irrigation Area	Irrigation Shortage	Gross Water Requirement	Surplus or Shortage	Storage Capacity	Remarks
					R		V		A	S		A	S	$V_R = \frac{A \times S}{0.8} \times 10$	$V - V_R$		
				mm	mm		m^3	mm	ha	mm/ha	mm	ha	mm/ha	m^3	m^3	m^3	
1961	Nov.	1st	10	72	57	0.1	6,480										
		2nd	10	26	18	"	2,340										
		3rd	10	54	43	"	4,860									61,000	Full Capacity 61,000 m^3
	Dec.	1st	10	(13)	(9)	0.4	4,680	1,300	1.37	1,291	80	Average 6.2	71	27,620	-22,940	38,060	
		2nd	10	(83)	(58)	"	29,880	1,300	1.37	1,242	80	Average 19.8	22	26,720	+ 3,160	41,220	
		3rd	11	(34)	(24)	"	12,240	1,300	1.37	1,276	88	Average 33.5	64	48,660	-36,420	4,800	
1962	Jan.	1st	10	89	71	0.8	64,080				80	41.0	9	4,620	+59,460	61,000	* Over flow
		2nd	10	110	88	"	79,200				80	"	–	–	+79,200	61,000	*
		3rd	11	60	42	"	43,200				88	"	46	23,580	+19,620	61,000	*
	Feb.	1st	10	3	0	0.8	2,160				80	"	80	41,000	-38,840	22,160	
		2nd	10	126	99	"	90,720				80	"	–	–	+90,720	61,000	*
		3rd	8	43	33	"	30,960				64	"	31	15,890	+15,070	61,000	*
	Mar.	1st	10	140	107	0.6	75,600				80	"	–	–	+75,600	61,000	*
		2nd	10	45	36	"	24,300				80	"	44	22,550	+ 1,750	61,000	*
		3rd	11	121	96	"	65,340				88	"	–	–	+65,340	61,000	*
	Apr.	1st	10	116	93	0.6	62,640				80	"	–	–	+62,640	61,000	*
		2nd	10	70	55	"	37,800				80	"	25	12,820	+24,980	61,000	*
		3rd	10	26	21	"	14,040				80	"	59	30,240	-16,200	44,800	
	May	1st	10	73	58	0.7	45,990						–	–	+45,990	61,000	*
		2nd	10	51	41	"	32,130						–	–	+32,130	61,000	*
		3rd	11	17	8	"	10,710						–	–	+10,710	61,000	*

Note 1. In the column of rainfall and effective rainfall, the values in parentheses are assumed, owing to the shortage of measured data.
2. The effective rainfall are decided to be 80 % of the total rainfall from 5 mm to 80 mm.
3. As for the run off coefficient, see the table 4-3-6.

Table 5-12-6 Calculation of Water Balance for the Irrigation Tank, Tank Number 13. Dry Season

Year	Month	Period of ten days	Days	Rainfall	Effective Rainfall	Run-Off Coeffi-cient	Inflow of Tank C·A=90	Paddling			Irrigation			Gross Water Requirement	Surplus or Shortage	Storage Capacity	Remarks
								Consump-tive Use	Area	Shortage	Consump-tive Use	Area	Shortage				
					R		V		A	S		A	S	$V_R = \frac{A \times S}{0.8} \times 10$	$V - V_R$		
				mm	mm		m^3	mm	ha	mm/ha	mm	ha	mm/ha	m^3	m^3	m^3	
1962	May	1st	10	73	58	0.7	45,990										
		2nd	10	51	41	"	32,130										
		3rd	11	17	8	"	10,710									61,000	Full Capacity
	Jun.	1st	10	59	47	0.8	42,480	1,300	0.20	1,253	80	Average 0.9	33	3,510	+38,970	61,000	* Over flow
		2nd	10	52	42	"	37,440	1,300	0.20	1,258	80	Average 2.9	38	4,530	+32,910	61,000	*
		3rd	10	27	17	"	19,440	1,300	0.20	1,283	80	Average 4.9	63	7,070	+12,370	61,000	*
	Jul.	1st	10	37	26	0.8	26,640				80	6.0	54	4,050	+22,590	61,000	*
		2nd	10	45	30	"	32,400				80	"	50	3,750	+28,650	61,000	*
		3rd	11	116	91	"	83,520				88	"	–	–	+83,520	61,000	*
	Aug.	1st	10	20	10	0.7	12,600				80	"	70	5,250	+ 7,350	61,000	*
		2nd	10	102	82	"	64,260				80	"	–	–	+64,260	61,000	*
		3rd	11	54	43	"	34,020				88	"	45	3,380	+30,640	61,000	*
	Sep.	1st	10	80	64	0.3	21,600				80	"	16	1,200	+20,400	61,000	*
		2nd	10	0	0	"	0				80	"	80	6,000	- 6,000	55,000	
		3rd	10	21	14	"	5,670				80	"	66	4,950	+ 720	54,280	
	Oct.	1st	10	(10)	(7)	0.2	1,800				80	"	73	5,480	- 3,680	50,600	
		2nd	10	(9)	(5)	"	1,620				80	"	75	5,630	- 4,010	46,590	
		3rd	11	(23)	(16)	"	4,140				88	"	72	5,400	- 1,260	45,330	
	Nov.	1st	10	124	99	0.1	11,160						–	–	+11,160	56,490	
		2nd	10	46	37	"	4,140						–	–	+ 4,140	60,630	
		3rd	10	121	97	"	10,890						–	–	+10,890	61,000	*

Table 5-12-7 Calculation of Water Balance for the Irrigation Tank, Tank Number 17, Wet Season

Year	Month	Period of ten days	Days	Rainfall	Effective Rainfall	Run-Off Coeffi-cient	Inflow of Tank C·A=60	Paddling			Irrigation			Gross Water Requirement	Surplus or Shortage	Storage Capacity	Remarks
								Consump-tive Use	Area	Shortage	Consump-tive Use	Area	Shortage				
					R		V		A	S		A	S	$V_R = \frac{A \times S}{0.8} \times 10$	$V - V_R$		
				mm	mm		m^3	mm	ha	mm/ha	mm	ha	mm/ha	m^3	m^3	m^3	
1961	Nov.	1st	10	72	57	0.1	4,320										
		2nd	10	26	18	"	1,560										
		3rd	10	54	43	"	3,240									102,000	Full Capacity 102,000 m^3
	Dec.	1st	10	(13)	(9)	0.4	3,120	1,300	1.67	1,291	80	Average 7.5	71	33,610	-30,490	71,510	
		2nd	10	(83)	(58)	"	19,920	1,300	1.67	1,242	80	Average 24.2	22	32,590	-12,670	58,840	
		3rd	11	(34)	(24)	"	8,160	1,300	1.67	1,276	88	Average 40.9	64	59,360	-51,200	7,640	
1962	Jan.	1st	10	89	71	0.8	42,720				80	50.0	9	5,630	+37,090	44,730	
		2nd	10	110	88	"	52,800				80	"	–	–	+52,800	97,530	
		3rd	11	60	42	"	28,800				88	"	46	28,750	+ 50	97,580	
	Feb.	1st	10	3	0	0.8	1,440				80	"	80	50,000	-48,560	49,020	
		2nd	10	126	99	"	60,480				80	"	–	–	+60,480	102,000	* Over flow
		3rd	8	43	33	"	20,640				64	"	31	19,380	+ 1,260	102,000	*
	Mar.	1st	10	140	107	0.6	50,400				80	"	–	–	+50,400	102,000	*
		2nd	10	45	36	"	16,200				80	"	44	27,500	-11,300	90,700	
		3rd	11	121	96	"	43,560				88	"	–	–	+43,560	102,000	*
	Apr.	1st	10	116	93	0.6	41,760				80	"	–	–	+41,760	102,000	*
		2nd	10	70	55	"	25,200				80	"	25	15,630	+ 9,570	102,000	*
		3rd	10	26	21	"	9,360				80	"	59	36,880	-27,520	74,480	
	May	1st	10	73	58	0.7	30,660						–	–	+30,660	102,000	*
		2nd	10	51	41	"	21,420						–	–	+21,420	102,000	*
		3rd	11	17	8	"	7,140						–	–	+ 7,140	102,000	*

Table 5-12-8 Culculation of Water Balance for the Irrigation Tank, Tank Number 17, Dry Season

Year	Month	Period of ten days	Days	Rainfall	Effective Rainfall	Run-Off Coeffi-cient	Inflow of Tank C·A=60	Paddling			Irrigation			Gross Water Requirement	Surplus or Shortage	Storage Capacity	Remarks
								Consump-tive Use	Area	Shortage	Consump-tive Use	Area	Shortage				
					R		V		A	S		A	S	$V_R = \frac{A \times S}{0.8} \times 10$	$V - V_R$		
				mm	mm		m³	mm	ha	mm/ha	mm	ha	mm/ha	m³	m³	m³	
1962	May	1st	10	73	58	0.7	30,660										
		2nd	10	51	41	"	21,420										
		3rd	11	17	8	"	7,140									102,000	Full Capacity
	Jun.	1st	10	59	47	0.8	28,320	1,300	0.17	1,253	80	Average 0.8	33	3,000	+25,320	102,000	* Over flow
		2nd	10	52	42	"	24,960	1,300	0.17	1,258	80	Average 2.4	38	3,820	+21,140	102,000	*
		3rd	10	27	17	"	12,960	1,300	0.17	1,283	80	Average 4.1	63	6,000	+ 6,960	102,000	*
	Jul.	1st	10	37	26	0.8	17,760				80	5.0	54	3,380	+14,380	102,000	*
		2nd	10	45	30	"	21,600				80	"	50	3,130	+18,470	102,000	*
		3rd	11	116	91	"	55,680				88	"	–	–	+55,680	102,000	*
	Aug.	1st	10	20	10	0.7	8,400				80	"	70	4,380	+ 4,020	102,000	*
		2nd	10	102	82	"	42,840				80	"	–	–	+42,840	102,000	*
		3rd	11	54	43	"	22,680				88	"	45	2,820	+19,860	102,000	*
	Sep.	1st	10	80	64	0.3	14,400				80	"	16	1,000	+13,400	102,000	*
		2nd	10	0	0	"	0				80	"	80	5,000	- 5,000	97,000	
		3rd	10	21	14	"	3,780				80	"	66	4,130	- 350	96,650	
	Oct.	1st	10	(10)	(7)	0.2	1,200				80	"	73	4,570	- 3,370	93,280	
		2nd	10	(9)	(5)	"	1,080				80	"	75	4,690	- 3,610	89,670	
		3rd	11	(23)	(16)	"	2,760				88	"	72	4,500	- 1,740	87,930	
	Nov.	1st	10	124	99	0.1	7,440						–	–	+ 7,440	95,370	
		2nd	10	46	37	"	2,760						–	–	+ 2,760	98,130	
		3rd	10	121	97	"	7,260						–	–	+ 7,260	102,000	*

Table 5-12-9 Calculation of Water Balance for the Irrigation Tank, Tank Number 28, Wet Season

Year	Month	Period of ten days	Days	Rainfall	Effective Rainfall	Run-Off Coeffi-cient	Inflow of Tank C·A=50	Paddling			Irrigation			Gross Water Requirement	Surplus or Shortage	Storage Capacity	Remarks
								Consump-tive Use	Area	Shortage	Consump-tive Use	Area	Shortage				
					R		V		A	S		A	S	$V_R = \frac{A \times S}{0.8} \times 10$	$V - V_R$		
				mm	mm		m^3	mm	ha	mm/ha	mm	ha	mm/ha	m^3	m^3	m^3	
1961	Nov.	1st	10	72	57	0.1	3,600										
		2nd	10	26	18	''	1,300										
		3rd	10	54	43	''	2,700									133,000	Full Capacity 133,000 m^3
	Dec.	1st	10	(13)	(9)	0.4	2,600	1,300	2.00	1,291	80	Average 9.0	71	40,270	-37,670	95,330	
		2nd	10	(83)	(58)	''	16,600	1,300	2.00	1,242	80	Average 29.0	22	39,030	-22,430	72,900	
		3rd	11	(34)	(24)	''	6,800	1,300	2.00	1,276	88	Average 49.0	64	71,100	-64,300	8,600	
1962	Jan.	1st	10	89	71	0.8	35,600				80	60.0	9	6,750	+28,850	37,450	
		2nd	10	110	88	''	44,000				80	''	–	–	+44,000	81,450	
		3rd	11	60	42	''	24,000				88	''	46	34,500	-10,500	70,950	
	Feb.	1st	10	3	0	0.8	1,200				80	''	80	60,000	-58,800	12,150	
		2nd	10	126	99	''	50,400				80	''	–	–	+50,400	62,550	
		3rd	8	43	33	''	17,200				64	''	31	23,250	- 6,050	56,500	
	Mar.	1st	10	140	107	0.6	42,000				80	''	–	–	+42,000	98,500	
		2nd	10	45	36	''	13,500				80	''	44	33,000	- 19,500	79,000	
		3rd	11	121	96	''	36,300				88	''	–	–	+36,300	115,300	
	Apr.	1st	10	116	93	0.6	34,800				80	''	–	–	+34,800	133,000	* Over flow
		2nd	10	70	55	''	21,000				80	''	25	18,750	+ 2,250	133,000	*
		3rd	10	26	21	''	7,800				80	''	59	44,250	-36,450	96,550	
	May	1st	10	73	58	0.7	25,550						–	–	+25,550	122,100	
		2nd	10	51	41	''	17,850						–	–	+17,850	133,000	*
		3rd	11	17	8	''	5,950						–	–	+ 5,950	133,000	*

Table 5-12-10 Calculation of Water Balance for the Irrigation Tank, Tank Number 28. Dry Season

Year	Month	Period of ten days	Days	Rainfall	Effective Rainfall	Run-Off Coeffi-cient	Inflow of Tank C·A=50	Paddling			Irrigation			Gross Water Requirement	Surplus or Shortage	Storage Capacity	Remarks
								Consumptive Use	Area	Shortage	Consumptive Use	Area	Shortage				
					R		V		A	S		A	S	$V_R = \frac{A \times S}{0.8} \times 10$	$V - V_R$		
				mm	mm		m^3	mm	ha	mm/ha	mm	ha	mm/ha	m^3	m^3	m^3	
1962	May	1st	10	73	58	0.7	25,550										
		2nd	10	51	41	"	17,850										
		3rd	11	17	8	"	5,950									133,000	Full Capacity
	Jun.	1st	10	59	47	0.8	23,600	1,300	0.13	1,253	80	Average 0.6	33	2,290	+21,310	133,000	* Over flow
		2nd	10	52	42	"	20,800	1,300	0.13	1,258	80	Average 1.9	38	2,950	+17,850	133,000	*
		3rd	10	27	17	"	10,800	1,300	0.13	1,283	80	Average 3.3	63	4,690	+ 6,110	133,000	*
	Jul.	1st	10	37	26	0.8	14,800				80	4.0	54	2,700	+12,100	133,000	*
		2nd	10	45	30	"	18,000				80	"	50	2,500	+15,500	133,000	*
		3rd	11	116	91	"	46,400				88	"	–	–	+46,400	133,000	*
	Aug.	1st	10	20	10	0.7	7,000				80	"	70	3,500	+ 3,500	133,000	*
		2nd	10	102	82	"	35,700				80	"	–	–	+35,700	133,000	*
		3rd	11	54	43	"	18,900				88	"	45	2,250	+16,650	133,000	*
	Sep.	1st	10	80	64	0.3	12,000				80	"	16	800	+11,200	133,000	*
		2nd	10	0	0	"	0				80	"	80	4,000	- 4,000	129,000	
		3rd	10	21	14	"	3,150				80	"	66	3,300	- 150	128,850	
	Oct.	1st	10	(10)	(7)	0.2	1,000				80	"	73	3,650	- 2,650	126,200	
		2nd	10	(9)	(5)	"	900				80	"	75	3,750	- 2,850	123,350	
		3rd	11	(23)	(16)	"	2,300				88	"	72	3,600	- 1,300	122,050	
	Nov.	1st	10	124	99	0.1	6,200						–	–	+ 6,200	128,250	
		2nd	10	46	37	"	2,300						–	–	+ 2,300	130,550	
		3rd	10	121	97	"	6,050						–	–	+ 6,050	133,000	*

5-13 Calculation of Water Balance in each area

1. Culculation of Water Balance in S-1 & S-2 area, Plan-1, 2, 3, 2nd Stage

Table 5-13-1

Month	S-1							S-2				
	Available Discharge			Water Requirement				Available Discharge				
	River C.A= $286km^2$	Tank	Total	Irrigation	City Water	Total	Shortage	River	Tank	Total	Vater Require-ment	Shortage
Dec.	10.2	0.9	11.1	10.9	0.2	11.1	-	-	1.2	1.2		-
Jan.	29		29.0	15.0	"	15.2	-	13.8		13.8	3.6	-
Feb.	31		31.0	15.0	"	15.2	-	15.8		15.8	5.5	-
Mar.	22		22.0	15.0	"	15.2	-	6.8		6.8	5.5	-
Apr.	20	0.9	20.9	15.0	"	15.2	-	5.7	1.2	6.9	5.5	-
May	6.3		6.3		"	0.2	-	6.1		6.1	5.5	-
Jun.	7.2		7.2	1.3	"	1.5	-	5.7		5.7	-	-
Jul.	11		11.0	1.8	"	2.0	-	9.0		9.0	0.9	-
Aug.	11		11.0	1.8	"	2.0	-	9.0		9.0	1.2	-
Sep.	1.1	0.9	2.0	1.8	"	2.0	-	-	1.2	1.2	1.2	-
Oct.	4.4		4.4	1.8	"	2.0	-	2.4		2.4	1.2	-
Nov.	2.5		2.5		"	0.2	-	0.2		2.3	1.2	-

2. Culculations of the Water Balance in S-1 & S-2 area, Plan 4, 5, 6, 2nd Stage

Table 5-13-2

Month	S-1									S-2					
	W.-Rarem Dis-charge C.A= $889km^2$	W.-Abung Dis-charge	Available Discharge			Water Requirement			Short-age	S-1 Water Require-ment	Available Discharge			Water Require-ment	Short-age
			River	Tank	Total	Irriga-tion	City Water	Total			River	Tank	Total		
Dec.	31	6.1	24.9	0.9	25.8	10.9	0.2	11.1	-	10.2	14.7	1.2	15.9	3.6	-
Jan.	91	18.0	73.0		73.0	16.4	"	16.6	-	16.6	56.4		56.4	5.5	-
Feb.	97	19.0	78.0		78.0	16.4	"	16.6	-	16.6	61.4		61.4	5.5	-
Mar.	69	14.0	55.0		55.0	16.4	"	16.6	-	16.6	38.4		38.4	5.5	-
Apr.	61	12.0	49.0	0.9	49.9	16.4	"	16.6	-	15.7	33.3	1.2	34.5	5.5	-
May	20	3.9	16.1		16.1		"	0.2	-	0.2	15.9		15.9		-
Jun.	22	4.4	17.6		17.6	2.2	"	2.4	-	2.4	15.2		15.2	0.9	-
Jul.	35	6.7	28.3		28.3	3.4	"	3.6	-	3.6	24.7		24.7	1.2	-
Aug.	33	6.7	26.3		26.3	3.4	"	3.6	-	3.6	22.7		22.7	1.2	-
Sep.	3.4	6.7	2.7	0.9	3.6	3.4	"	3.6	-	2.7	-	1.2	1.2	1.2	-
Oct.	14	2.7	11.3		11.3	3.4	"	3.6	-	3.6	7.7		7.7	1.2	-
Nov.	7.8	1.5	6.3		6.3		"		-	0.2	6.1		6.1		-

Note 1. The total amount of discharge of Way Abung is used for the W.A.H, W.A. and W. T. area.

3. Calculations of Water Balance in W.A.H area, Plan 1 ~ 6, 2nd Stage

Table 5-13-3

Month	Plan–1, 3, 4, 6					Plan–2, 5				
	Available Discharge C·A=175km²	Water Requirement			Shortage	Available Discharge C·A=147km²	Water Requirement			Shortage
		A	B	Total			A	B	Total	
Dec.	6.1	6.1		6.1	–	5.2	5.2		5.2	–
Jan.	18	8.4	2.9	11.3	–	15	7.2	3.8	11.0	–
Feb.	19	8.4	4.0	12.4	–	16	7.2	5.2	12.4	–
Mar.	14	8.4	4.0	12.4	–	11	7.2	5.2	12.4	1.4
Apr.	12	8.4	4.0	12.4	0.4	10	7.2	5.2	12.4	2.4
May	3.9		4.0	4.0	0.1	3.2		5.2	5.2	2.0
Jun.	4.4	0.5		0.5	–	3.7	0.4		0.4	–
Jul.	6.7	0.7		0.7	–	5.8	0.6		0.6	–
Aug.	6.7	0.7		0.7	–	5.4	0.6		0.6	–
Sep.	0.7	0.7		0.7	–	0.6	0.6		0.6	–
Oct.	2.7	0.7		0.7	–	2.3	0.6		0.6	–
Nov.	1.5					1.3				

Note 1. In the plan–1, 3, 4, 6, the planting areas in wet season are A=5250ha, B=2501ha.
2. In the plan–2, 5, the planting areas in wet season are A=4500ha, B=3251ha.
3. The catchment area of plan–5 is 160km², however, this is substituted by that of plan–2 for convinience' sake.

4. Calculations of Water Balance in W.A area, Plan 1 ~ 6, 2nd Stage

Table 5-13-4

Month	River Discharge C·A=147km²	Plan–1, 3, 4, 6						Plan–2, 5					
		W.A.H Water Require-ment	Available Discharge			Water Require-ment	Shortage	W.A.H Water Require-ment	Available Dicharge			Water Require-ment	Shortage
			River	Tank	Total				River	Tank	Total		
Dec.	5.2	5.2	–	0.8	0.8	5.8	-5.0	5.2	–	0.8	0.8	5.8	-5.0
Jan.	15	8.3	6.7		6.7	8.0	-1.3	11.0	4.0		4.0	8.0	-4.0
Feb.	16	9.4	6.6		6.6	8.0	-1.4	12.4	3.6		3.6	8.0	-4.4
Mar.	11	9.4	1.6		1.6	8.0	-6.4	11.0	–		–	8.0	-8.0
Apr.	10	10.0	–	0.8	0.8	8.0	-7.2	10.0	–	0.8	0.8	8.0	-7.2
May	3.2	3.2	–		–		–	3.2	–		–		–
Jun.	3.7	–	3.7		3.7	0.6	–	0.4	3.3		3.3	0.6	–
Jul.	5.8		5.8		5.8	0.8	–	0.6	5.2		5.2	0.8	–
Aug.	5.4	–	5.4		5.4	0.8	–	0.6	4.8		4.8	0.8	–
Sep.	0.6	0.6	–	0.8	0.8	0.8	–	0.6	–	0.8	0.8	0.8	–
Oct.	2.3	0.3	2.0		2.0	0.8	–	0.6	1.7		1.7	0.8	–
Nov.	1.3	–	1.3		1.3				1.3		1.3		

Note 1. As for the water requirement of W.A.H area, the inflow to the river from the catchment area between two head works is taken into consideration.
2. The catchment area of plan 4, 5, 6 is 160km², however, this is substituted by that of plan 1, 2, 3 for convenience' sake.

5. Calculations of Water Balance in W. T. area, Plan 1-6, 2nd Stage.

Table 5-13-5

Month	Available River Discharge C·A=74km²	Water Requirement			Shortage
		A	B	Total	
Dec.	2. 6	2. 6		2. 6	-
Jan.	7. 5	3. 6	0. 8	4. 4	-
Feb.	8. 0	3. 6	1. 1	4. 7	-
Mar.	5. 7	3. 6	1. 1	4. 7	-
Apr.	5. 2	3. 6	1. 1	4. 7	-
May	1. 6		1. 1	1. 1	-
Jun.	1. 9	0. 2		0. 2	-
Jul.	2. 8	0. 3		0. 3	-
Aug.	2. 8	0. 3		0. 3	-
Sep.	0. 3	0. 3		0. 3	-
Oct.	1. 1	0. 3		0. 3	-
Nov.	0. 6				

Note 1. In the Planting area in wet season, A is 2250 ha and B is 673 ha in Area.

Note 2. In this area, 1st stage is not considered.

6. Calculation of Water Balance in Besai Plan - 1, 3rd Stage

Table 5-13-6

Month	W. Abung & W. Tul. Mas								
	Available Discharge				Water Requirement				Shortage
	River W.A	River W.T.M	Tank	Total	W.A.H	W.T	W.A	Total	
Dec.	6.1		0.8	6.9	9.0		5.8	14.8	7.9
Jan.	18			18.0	12.4		8.0	20.4	2.4
Feb.	19			19.0	12.4		8.0	20.4	1.4
Mar.	14			14.0	12.4		8.0	20.4	6.4
Apr.	12		0.8	12.8	12.4		8.0	20.4	7.6
May	3.9			3.9					
Jun.	4.4			4.4	9.0		5.8	14.8	10.4
Jul.	6.7			6.7	12.4		8.0	20.4	13.7
Aug.	6.7			6.7	12.4		8.0	20.4	13.7
Sep.	0.7		0.8	1.5	12.4		8.0	20.4	18.9
Oct.	2.7			2.7	12.4		8.0	20.4	17.7
Nov.	1.5			1.5					
Total									100.1

Month	W. Rarem											
	Available Discharge						Water Requirement				Shortage
	River W.R	W.A Water Requirement	Available Discharge	Tank S-1	Tank S-2	Total	W.R/A S-1	W.R/A S-2	City Water	Total	
Dec.	10.2			0.9	1.2	12.3	10.9	3.6	0.2	14.7	2.4
Jan.	29					29.0	15.0	5.5	"	20.7	–
Feb.	31					31.0	15.0	5.5	"	20.7	–
Mar.	22					22.0	15.0	5.5	"	20.7	–
Apr.	20				1.2	21.2	15.0	5.5	"	20.7	–
May	6.3					6.3			"	0.2	–
Jun.	7.2					7.2	10.9	3.6	"	14.7	7.5
Jul.	11					11.0	15.0	5.5	"	20.7	9.7
Aug.	11					11.0	15.0	5.5	"	20.7	9.7
Sep.	1.1			0.9	1.2	3.2	15.0	5.5	"	20.7	17.5
Oct.	4.4					4.4	15.0	5.5	"	20.7	16.3
Nov.	2.5					2.5			"	0.2	–
Total											63.1

Month	W. Besai Dam				
	River Discharge	Available Discharge	Water Requirement	Surplus or Shortage	Accumulated Storage Capacity
Dec.	16	14.0	10.3	3.7	
Jan.	46	44.0	2.4	21.6	
Feb.	49	47.0	1.4	45.6	
Mar.	35	33.0	6.4	26.6	
Apr.	31	29.0	7.6	21.4	
May	10	8.0	–	8.0	
Jun.	11	9.0	17.9	-8.9	-8.9
Jul.	18	16.0	23.4	-7.4	-16.3
Aug.	17	15.0	23.4	-8.4	-24.7
Sep.	1.7	–	36.4	-36.4	-61.1
Oct.	6.9	4.9	34.0	-29.1	-90.2
Nov.	3.9	1.9	–	1.9	
Total					

Note 1. The available discharge at Besai damsite is defined as follows
River Discharge – Minimum of mean monthly discharge (2 m^3/sec).

2. Storage Capacity:

$$90.2 \times 30^{\text{days}} \times 86{,}400 \times \frac{1}{0.95} \fallingdotseq 246{,}000{,}000 \text{ m}^3$$ (Available Storage Capacity)

1,000,000 " (Sedimentation Volume)

Total 247,000,000 "

7. Culculation of Water Balance for Besai Plan-2, 3rd Stage

Table 5-13-7

Month	W. Abung & W. Tul. Mas									W. Rarem											W. Besai Dam				
	Available Discharge				Water Requirement				Shortage		Available Discharge					Water Requirement				Shortage	River Discharge	Available Discharge	Water Requirement	Surplus or Shortage	Accumilated Storage Capacity
	River W.A	River W.T.M.	Tank	Total	W.A.H.	W.T	W.A	Total		River W.R	W.A Water Requirement	Available Discharge	Tank S-1	Tank S-2	Total	W.R/A S-1	W.R/A S-2	City Water	Total						
Dec.	5.2		0.8	6.0	9.0		5.8	14.8	8.8											2.4		14.0	11.2	2.8	
Jan.	15			15.0	12.4		8.0	20.4	5.4											–		44.0	5.4	38.6	
Feb.	16			16.0	12.4		8.0	20.4	4.4											–		47.0	4.4	42.6	
Mar.	11			11.0	12.4		8.0	20.4	9.4											–		33.0	9.4	23.6	
Apr.	10		0.8	10.8	12.4		8.0	20.4	9.6			Equal to Plan-1								–		29.0	9.6	19.4	
May	3.2			3.2																–		8.0	–	8.0	
Jun.	3.7			3.7	9.0		5.8	14.8	11.1											7.5		9.0	18.6	-9.6	-9.6
Jul.	5.8			5.8	12.4		8.0	20.4	14.6											9.7		16.0	24.3	-8.3	-17.9
Aug.	5.4			5.4	12.4		8.0	20.4	15.0											9.7		15.0	24.7	-9.7	-27.6
Sep.	0.6		0.8	1.4	12.4		8.0	20.4	19.0											17.5		–	36.5	-36.5	-64.1
Oct.	2.3			2.3	12.4		8.0	20.4	18.1											16.3		4.9	34.4	-29.5	-93.6
Nov.	1.3			1.3																–		1.9	–	1.9	
Total									115.4											63.1					

Note 1. This case is the same as the previous plan in the draft report, however the storage capacity is slightly bigger than the previous one, because, the Way Abung head work is shifted towards upstream.

2. Storage Capacity $93.6 \times 30^{\text{days}} \times 86{,}400 \times \frac{1}{0.95} \fallingdotseq 255{,}000{,}000\ m^3$ (Available Storage Capacity)

1,000,000 " (Sedimentation Volume)

Total 256,000,000 "

8. Calculation of Water Balance for Besai Plan -3, 3rd Stage

Table 5-13-8

Month	W. Abung & W. Tul. Mas									W. Rarem											W. Besai Dam				
	Available Discharge				Water Requirement				Shortage	Available Discharge						Water Requirement				Shortage	River Discharge	Available Discharge	Water Requirement	Surplus or Shortage	Accumulated Storage Capacity
	River W.A	River W.T.M	Tank	Total	W.A.H	W.T	W.A	Total		River W.R	W.A Water Requirement	Available Discharge	Tank S-1	Tank S-2	Total	W.R/A S-1	W.R/A S-2	City Water	Total						
Dec.	6.1	2.6	0.8	9.5	9.0	3.4	5.8	18.2	8.7											2.4	16	14.0	11.1	2.9	
Jan.	18	7.5*		22.7	12.4	4.7*	8.0	25.1	2.4											–	46	44.0	2.4	41.6	
Feb.	19	8.0*		23.7	12.4	4.7*	8.0	25.1	1.4											–	49	47.0	1.4	45.6	
Mar.	14	5.7*		18.7	12.4	4.7*	8.0	25.1	6.4											–	35	33.0	6.4	26.6	
Apr.	12	5.2*	0.8	17.5	12.4	4.7*	8.0	25.1	7.6				Equal to Plan–1							–	31	29.0	7.6	21.4	
May	3.9	1.6		5.5					–											–	10	8.0	–	8.0	
Jun.	4.4	1.9		6.3	9.0	3.4	5.8	18.2	11.9											7.5	11	9.0	19.4	-10.4	-10.4
Jul.	6.7	2.8		9.5	12.4	4.7	8.0	25.1	15.6											9.7	18	16.0	25.3	-9.3	-19.7
Aug.	6.7	2.8		9.5	12.4	4.7	8.0	25.1	15.6											9.7	17	15.0	25.3	-10.3	-30.0
Sep.	0.7	0.3	0.8	1.8	12.4	4.7	8.0	25.1	23.3											17.5	1.7	–	40.8	-40.8	-70.8
Oct.	2.7	1.1		3.8	12.4	4.7	8.0	25.1	21.3											16.3	6.9	4.9	37.6	-32.7	-103.5
Nov.	1.5	1.6		3.1					–											–	3.9	1.9	–	1.9	
Total									114.2											63.1					

Note 1. The available discharges of W.T.M with * mark are substituted with the water requirement of W.T with * mark for convenience' sake.

2. Storage Capacity $103.5 \times 30^{\text{days}} \times 86{,}400 \times \frac{1}{0.95} \fallingdotseq 282{,}000{,}000 \text{ m}^3$ (Available Storage Capacity)

1,000,000 " (Sedimentation Volume)

Total 283,000,000 "

9. Culculation of Water Balance for Besai Plan–4, 3rd Stage

Table 5-13-9

Month	W. Abung & W. Tul. Mas									W. Rarem											W. Besai Dam				
	Available Discharge				Water Requirement				Shortage	Available Discharge						Water Requirement				Shortage	River Discharge	Available Discharge	Water Requirement	Surplus or Shortage	Accumulated Storage Capacity
	River W.A	River W.T.M	Tank	Total	W.A.H	W.T	W.A	Total		River W.R	W.A Water Requirement	Available Discharge	Tank S-1	Tank S-2	Total	W.R/A S-1	W.R/A S-2	City Water	Total						
Dec.									7.9	31	6.1	24.9	0.9	1.2	27.0	10.9	3.6	0.2	14.7	–	16	14.0	7.9	6.1	
Jan.									2.4	91	18	73.0			73.0	16.4	5.5	"	22.1	–	46	44.0	2.4	21.6	
Feb.									1.4	97	19	78.0			78.0	"	"	"	"	–	49	47.0	1.4	45.6	
Mar.									6.4	69	14	55.0			55.0	"	"	"	"	–	35	33.0	6.4	26.6	
Apr.		Equal to Plan–1							7.6	61	12	49.0	0.9	1.2	51.1	"	"	"	"	–	31	29.0	7.6	21.4	
May										20	–	20.0			20.0			"	0.2	–	10	8.0	–	8.0	
Jun.									10.4	22	4.4	17.6			17.6	10.9	3.6	"	14.7	–	11	9.0	10.4	-1.4	-1.4
Jul.									13.7	35	6.7	28.3			28.3	16.4	5.5	"	22.1	–	18	16.0	13.7	2.3	0.9
Aug.									13.7	33	6.7	26.3			26.3	"	"	"	"	–	17	15.0	13.7	1.3	2.2
Sep.									18.9	3.4	0.7	2.7	0.9	1.2	4.8	"	"	"	"	17.3	1.7	–	36.2	-36.2	-34.0
Oct.									17.7	14	2.7	11.3			11.3	"	"	"	"	10.8	6.9	4.9	28.5	-23.6	-57.6
Nov.										7.8	–	7.8			7.8			"	0.2	–	3.9	1.9	–	1.9	
Total									100.1											28.1					

Note 1. Storage Capacity $57.6 \times 30^{\text{days}} \times 86{,}400 \times \frac{1}{0.95} \doteqdot 157{,}000{,}000\ m^3$ (Available Storage Capacity)

1,000,000 " (Sedimentation Volume)

Total 158,000,000 "

10. Calculation of Water Balance for Besai Plan–5, 3rd Stage

Table 5-13-10

Month	W. Abung & W. Tul. Mas									W. Rarem											W. Besai Dam				
	Available Discharge				Water Requirement				Shortage	Available Discharge						Water Requirement				Shortage	River Discharge	Available Discharge	Water Requirement	Surplus or Shortage	Accumulated Storage Capacity
	River W.A	River W.T.M	Tank	Total	W.A.H	W.T	W.A	Total		River W.R	W.A Water Requirement	Available Discharge	Tank S-1	Tank S-2	Total	W.R/A S-1	W.R/A S-2	City Water	Total						
Dec.									8.8	31	5.2	25.8	0.9	1.2	27.9	10.9	3.6	0.2	14.7	–		14.0	8.8	5.2	
Jan.									5.4	91	15.0	76.0			76.0	16.4	5.5	"	22.1	–		44.0	5.4	38.6	
Feb.									4.4	97	16.0	81.0			81.0	"	"	"	"	–		40.0	4.4	42.6	
Mar.									9.4	69	11.0	58.0			58.0	"	"	"	"	–		33.0	9.4	23.6	
Apr.		Equal to Plan–2							9.6	61	10.0	51.0	0.9	1.2	53.1	"	"	"	"	–		29.0	9.6	19.4	
May										20	–	20.0			20.0			"	0.2	–		8.0	–	8.0	
Jun.									11.1	22	3.7	18.3			18.3	10.9	3.6	"	14.7	–		9.0	11.1	-2.1	-2.1
Jul.									14.6	35	5.8	29.2			29.2	16.4	5.5	"	22.1	–		16.0	14.6	1.4	-0.7
Aug.									15.0	33	5.4	27.6			27.6	"	"	"	"	–		15.0	15.0	–	-0.7
Sep.									19.0	3.4	0.6	2.8	0.9	1.2	4.9	"	"	"	"	17.2		–	36.2	-36.2	-36.9
Oct.									18.1	14	2.3	11.7			11.7	"	"	"	"	10.4		4.9	28.5	-23.6	-60.5
Nov.										7.8	–	7.8			7.8			"	0.2	–		1.9	–	1.9	
Total									115.4											27.6					

Note 1. Storage Capacity $60.5 \times 30^{\text{days}} \times 86{,}400 \times \frac{1}{0.95} \doteqdot 165{,}000{,}000\ m^3$ (Available Storage Capacity)

1,000,000 " (Sedimentation Volume)

Total 166,000,000 "

11. Calculation of Water Balance for Besai Plan–6, 3rd Stage

Table 5-13-11

Month	W. Abung & W. Tul. Mas									W. Rarem											W. Besai Dam				
	Available Discharge				Water Requirement					Available Discharge						Water Requirement									
	River W.A	River W.T.M	Tank	Total	W.A.H	W.T	W.A	Total	Shortage	River W.R	W.A Water Requirement	Available Discharge	Tank S-1	Tank S-2	Total	W.R/A S-1	W.R/A S-2	City Water	Total	Shortage	River Discharge	Available Discharge	Water Requirement	Surplus or Shortage	Accumulated Storage Capacity
Dec.									8.7											–	16	14.0	8.7	5.3	
Jan.									2.4											–	46	44.0	2.4	41.6	
Feb.									1.4											–	49	47.0	1.4	45.6	
Mar.									6.4											–	35	33.0	6.4	26.6	
Apr.	Equal to Plan–3								7.6	Equal to Plan–4										–	31	29.0	7.6	21.4	
May									–											–	10	8.0	–	8.0	
Jun.									11.9											–	11	9.0	11.9	-2.9	-2.9
Jul.									15.6											–	18	16.0	15.6	0.4	-2.5
Aug.									15.6											–	17	15.0	15.6	-0.4	-2.9
Sep.									23.3											17.3	1.7	–	40.6	-40.6	-43.5
Oct.									21.3											10.8	6.9	4.9	32.1	-27.2	-70.7
Nov.									–											–	3.9	1.9	–	1.9	
Total									114.2											28.1					

Note 1. In case that Way Abung headwork is shifted towards downstream, the inflow to the river from the catchment area between two headworks is neglected.

2. Storage Capacity $70.7 \times 30^{\text{days}} \times 86{,}400 \times \frac{1}{0.95} \doteqdot 193{,}000{,}000\ m^3$ (Available Capacity)

1,000,000 " (Sedimentation Volume)

Total 194,000,000 "

5-14 Estimation of Project Cost

The total project cost is estimated as follows on the basis of table presented in the previous reconnaissance survey report.

Table 5-14-1

Unit 10^6 Rp

Item	Plan-1	Plan-2	Plan-3	Plan-4	Plan-5	Plan-6
Preparations & studies	300					
Model tests	60					
Design & construction supervision	1,300	"	"	"	"	"
Compensation	120					
Sub total	1,780	1,780	1,780	1,780	1,780	1,780
2nd stage transfer basin	970	1,090	970	970	1,090	970
3rd stage transfer basin	33,818	34,545	39,175	22,240	23,400	27,617
Sub total	34,788	35,635	40,145	23,210	24,490	28,587
Irrigation Facilities in S-1, 1st stage	1,507	1,507	1,507	1,507	1,507	1,507
" " , 2nd "	5,291	5,291	5,291	8,324	8,324	8,324
" S-2, 1st "	1,314	1,314	1,341	1,314	1,314	1,314
" , 2nd "	1,824	1,824	1,824	2,752	2,752	2,752
" N-1, whole	1,730	1,730	1,730	1,730	1,730	1,730
" N-2, "	2,920	2,920	2,920	2,920	2,920	2,920
" W.A.II, 2nd stage	2,432	2,566	2,432	2,432	2,539	2,432
" W.A, 2nd "	3,446	3,371	3,382	3,489	3,354	3,389
" W.T, 2nd "	1,060	1,060	1,060	1,060	1,060	1,060
Sub total	21,524	21,583	21,460	25,529	25,500	25,428
Total	58,092	58,998	63,385	50,518	51,770	55,795
Contingencies	5,877	5,998	6,594	4,845	5,014	5,561
Total	63,969	64,966	69,979	55,363	56,784	61,356
City water supply facilities for Kotabumi	600	"	"	"	"	"
Contingencies	60	"	"	"	"	"
Total	660	660	660	660	660	660
Grand Total (10^6Rp)	64,629	65,656	70,639	56,023	57,444	62,016
" (10^6Yen)	48,000	48,700	52,400	41,600	42,600	46,000

Rp415=¥308

5-15 Operation and Maintenance Cost

Operation and maintenance costs are as shown in the table 5-15-1 and 5-15-2 from the obove-mentioned method 4-8.

Table 5-15-1

Unit in 10^6Rp

Area	Stage	Plan-1				Plan-2				Plan-3			
		Pumping Facili-ties	Other Struc-tures	Water Manage-ment	Total	Pumping Facili-ties	Other Struc-tures	Water Manage-ment	Total	Pumping Facili-ties	Other Struc-tures	Water Manage-ment	Total
S-1	1st	-	30	1	31		30	1	31		30	1	31
"	2nd		106	17	123		106	17	123		106	17	123
"	3rd		229		229		227		227		239		239
S-2	1st		26	2	28		26	2	28		26	2	28
"	2nd	23	36	4	63	23	36	4	63	23	36	4	63
"	3rd	22	83		105	22	85		107	22	88		110
N-1	whole	67	35	4	106	67	35	4	106	67	35	4	106
N-2	whole	111	58	6	175	111	58	6	175	111	58	6	175
W. A. H.	2nd		60	9	69		65	9	74		60	9	69
"	3rd		225		225		230		230		223		223
W. A	2nd		76	10	86		76	10	86		75	10	85
"	3rd		139		139		149		149		146		146
W. T	2nd		21	4	25		21	4	25		21	4	25
"	3rd										88		88
Total		223	1124	57	1404	223	1144	57	1424	223	1231	57	1511

Table 5-15-2

Unit in 10^6Rp

Area	Stage	Plan-4				Plan-5				Plan-6			
		Pumpin Facili-ties	Other Struc-tures	Water Manage-ment	Total	Pumping Facili-ties	Other Struc-tures	Water Manage-ment	Total	Pumping Facili-ties	Other Struc-tures	Water Manage-ment	Total
S-1	1st		30	1	31		30	1	31		30	1	31
"	2nd	167	167	17	351	167	167	17	351	167	167	17	351
"	3rd	165	99		264	165	100		265	165	105		270
S-2	1st		26	2	28		26	2	28		26	2	28
"	2nd	55	55	4	114	55	55	4	114	55	55	4	114
"	3rd	55	33		88	55	35		90	55	40		95
N-1	whole	67	35	4	106	67	35	4	106	67	35	4	106
N-2	whole	111	58	6	175	111	58	6	175	111	58	6	175
W.A.H	2nd		60	9	69		64	9	73		60	9	69
"	3rd		191		191		206		206		199		199
W.A	2nd		77	10	87		76	10	86		75	10	85
"	3rd		122		122		128		128		129		129
W.T	2nd		21	4	25		21	4	25		21	4	25
"	3rd										79		79
Total		620	974	57	1651	620	1001	57	1678	620	1079	57	1756

5-16 Estimate of Economic Benefit

Table 5-16-1 Economic Benefit of Each Area

Area	Stage	Plan	Season	Cropping Pattern	Planting Area	Net Production Value	Project Cost	O & M Cost	B/C		Social Priority
									6% interest	12% interest	
					ha	10^6 Rp	10^6 Rp	10^6 Rp			
W.R/A. S-1	1st		W	Paddy	1,200	133	1,712	31	0.76	0.43	I
			D	Paddy	100						
			D	Upland Crops	1,100						
	2nd	1, 2, 3	W	Paddy	13,800	1,576	6,010	123	2.62	1.59	I
			D	Paddy	1,700						
			D	Upland Crops	12,100						
		4, 5, 6	W	Paddy	13,800	1,678	9,456	351	1.52	0.92	
			D	Paddy	3,000						
			D	Upland Crops	10,800						
	1st + 2nd	1, 2, 3	W	Paddy	15,000	1,709	7,722	154	2.29	1.36	I
			D	Paddy	1,800						
			D	Upland Crops	13,200						
		4, 5, 6	W	Paddy	15,000	1,811	11,168	382	1.46	0.87	
			D	Paddy	3,100						
			D	Upland Crops	11,900						
	3rd	1	D	Paddy	13,200	1,036	13,000	229	0.81	0.45	
		2	"	"	"	"	12,891	227	0.82	0.46	
		3	"	"	"	"	13,588	239	0.76	0.43	
		4	"	"	11,900	934	5,610	264	1.55	0.87	
		5	"	"	"	"	5,660	265	1.53	0.86	
		6	"	"	"	"	5,970	270	1.45	0.81	
	Whole	1	W, D	Paddy	30,000	2,746	20,722	383	1.43	0.82	
		2	"	"	"	"	20,613	381	1.44	0.82	
		3	"	"	"	"	21,310	393	1.39	0.79	
		4	"	"	"	"	16,778	646	1.51	0.82	
		5	"	"	"	"	16,834	647	1.51	0.82	
		6	"	"	"	"	17,138	652	1.48	0.80	
W.R/A. S-2	1st		W	Paddy	1,900	214	1,493	28	1.59	0.90	I
			D	"	200						
			D	Upland Crops	1,700						
	2nd	1, 2, 3	W	Paddy	3,100	403	2,074	63	1.71	1.05	I
			D	"	1,000						
			D	Upland Crops	2,100						
		4, 5, 6	W	Paddy	3,100	403	3,126	114	1.00	0.61	
			D	"	1,000						
			D	Upland Crops	2,100						
	1st + 2nd	1, 2, 3	W	Paddy	5,000	617	3,567	91	1.72	1.01	I
			D	Paddy	1,200						
			D	Upland Crops	3,800						
		4, 5, 6	W	Paddy	5,000	617	4,619	142	1.21	0.71	
			D	Paddy	1,200						
			D	Upland Crops	3,800						
	3rd	1	D	Paddy	3,800	298	4,726	105	0.53	0.30	
		2	"	"	"	"	4,843	107	0.51	0.29	
		3	"	"	"	"	4,998	110	0.49	0.27	
		4	"	"	"	"	1,870	88	1.46	0.82	
		5	"	"	"	"	1,960	90	1.38	0.77	
		6	"	"	"	"	2,270	95	1.16	0.65	

Table 5-16-1 (Cont'd)

Area	Stage	Plan	Season	Cropping Pattern	Planting Area	Net Production Value	Project Cost	O & M Cost	B/C		Social Priority
									6% interest	12% interest	
					ha	10^6 Rp	10^6 Rp	10^6 Rp			
	Whole	1	W, D	Paddy	5,000	916	8,293	196	1.09	0.62	
		2	"	"	"	"	8,410	198	1.07	0.61	
		3	"	"	"	"	8,565	201	1.05	0.60	
		4	"	"	"	"	6,489	230	1.29	0.75	
		5	"	"	"	"	6,579	232	1.27	0.73	
		6	"	"	"	"	6,889	237	1.21	0.70	
W.R/A. N-1	Whole		W, D	Paddy	7,000	640	1,965	106	3.01	1.81	2
W.R/A. N-2	Whole		W, D	Paddy	10,000	916	3,317	175	2.47	1.49	3
W.A.H	2nd	1, 3	W	Paddy	7,751						
		4, 6	D	Paddy	500	849	3,435	69	2.46	1.49	
			D	Upland Crops	7,251						
			W	Paddy	7,751						
		2	D	Paddy	350	837	3,670	74	2.25	1.37	
			D	Upland Crops	7,401						
			W	Paddy	7,751						
		5	D	Paddy	350	837	3,639	73	2.28	1.38	
			D	Upland Crops	7,401						
	3rd	1	D	Paddy	7,251	569	12,788	225	0.35	0.20	
		2	"	"	7,401	581	13,058	230	0.35	0.20	
		3	"	"	7,251	569	12,638	223	0.36	0.20	
		4	"	"	7,251	569	10,861	191	0.45	0.25	
		5	"	"	7,401	581	11,685	206	0.42	0.23	
		6	"	"	7,251	569	11,293	199	0.43	0.24	
	Whole	1	W, D	Paddy	15,502	1,418	16,223	294	0.88	0.50	
		2	"	"	"	"	16,728	304	0.85	0.48	
		3	"	"	"	"	16,073	292	0.89	0.51	
		4	"	"	"	"	14,296	260	1.03	0.58	
		5	"	"	"	"	15,324	279	0.95	0.54	
		6	"	"	"	"	14,728	268	0.99	0.56	
W.A	2nd		W	Paddy	8,000						
		1	D	Paddy	800	899	4,344	86	2.17	1.28	
			D	Upland Crops	7,200						
		2	"	"	"	"	4,312	86	2.18	1.29	
		3	"	"	"	"	4,271	85	2.21	1.30	
		4	"	"	"	"	4,392	87	2.14	1.26	
		5	"	"	"	"	4,292	86	2.19	1.29	
		6	"	"	"	"	4,279	85	2.20	1.30	
	3rd	1	D	Paddy	7,200	565	7,900	139	0.70	0.39	
		2	"	"	"	"	8,446	149	0.64	0.36	
		3	"	"	"	"	8,280	146	0.66	0.37	
		4	"	"	"	"	6,921	122	0.83	0.47	
		5	"	"	"	"	7,268	128	0.78	0.44	
		6	"	"	"	"	7,330	129	0.77	0.43	
	Whole	1	W, D	Paddy	16,000	1,464	12,244	225	1.28	0.73	
		2	"	"	"	"	12,758	235	1.22	0.69	
		3	"	"	"	"	12,551	235	1.22	0.69	
		4	"	"	"	"	11,313	209	1.41	0.80	
		5	"	"	"	"	11,560	214	1.37	0.78	
		6	"	"	"	"	11,609	214	1.37	0.78	

Table 5-16-1 (Cont'd)

Area	Stage	Plan	Season	Cropping Pattern	Planting Area	Net Production Value	Project Cost	O & M Cost	B/C 6% interest	B/C 12% interest	Social Priority
					ha	10^6 Rp	10^6 Rp	10^6 Rp			
W. T	2nd	1 ~ 6	W	Paddy	2,923						
			D	Paddy	200	320	1,205	25	2.49	1.54	
			D	Upland Crops	2,723						
	3rd	3	D	Paddy	2,723	214	4,993	88	0.33	0.18	
		6	"	"	"	"	4,505	79	0.39	0.22	
	Whole	1, 2, 4, 6	W, D	Paddy	5,646	320	1,205	25	2.49	1.54	
		3	"	"	5,846	534	6,198	113	0.86	0.49	
		6	"	"	5,846	534	5,710	104	0.96	0.54	
Whole Project		1	W, D	Paddy	91,625	8,418	63,969	1,404	1.37	0.78	
		2	"	"	91,625	8,418	64,996	1,424	1.35	0.77	
		3	"	"	94,348	8,632	69,979	1,511	1.27	0.73	
		4	"	"	91,625	8,418	55,363	1,651	1.50	0.87	
		5	"	"	91,625	8,418	56,784	1,678	1.46	0.84	
		6	"	"	94,348	8,632	61,356	1,756	1.38	0.79	

Table 5-16-2 Table of Economic Benefit (B/C)

Area	Stage	Plan - 1		Plan - 2		Plan - 3		Plan - 4		Plan - 5		Plan - 6	
		6%	12%	6%	12%	6%	12%	6%	12%	6%	12%	6%	12%
W.R/A, S-1	1st	0.76	0.43	0.76	0.43	0.76	0.43	0.76	0.43	0.76	0.43	0.76	0.43
	2nd	2.62	1.59	2.62	1.59	2.62	1.59	1.52	0.92	1.52	0.92	1.52	0.92
	3rd	0.81	0.45	0.82	0.46	0.76	0.43	1.55	0.87	1.53	0.86	1.45	0.81
	Whole	1.43	0.82	1.44	0.82	1.39	0.79	1.51	0.82	1.51	0.82	1.48	0.80
W.R/A, S-2	1st	1.59	0.90	1.59	0.90	1.59	0.90	1.59	0.90	1.59	0.90	1.59	0.90
	2nd	1.71	1.05	1.71	1.05	1.71	1.05	1.00	0.61	1.00	0.61	1.00	0.61
	3rd	0.53	0.30	0.51	0.29	0.49	0.27	1.46	0.82	1.38	0.77	1.16	0.65
	Whole	1.09	0.62	1.07	0.61	1.05	0.60	1.29	0.75	1.27	0.73	1.21	0.70
W.R/A, N-1	Whole	3.01	1.81	3.01	1.81	3.01	1.81	3.01	1.81	3.01	1.81	3.01	1.81
W.R/A, N-2	Whole	2.47	1.49	2.47	1.49	2.47	1.49	2.47	1.49	2.47	1.49	2.47	1.49
W.A.H	2nd	2.46	1.49	2.25	1.37	2.46	1.49	2.46	1.49	2.28	1.38	2.46	1.49
	3rd	0.35	0.20	0.35	0.20	0.36	0.20	0.45	0.25	0.42	0.23	0.43	0.24
	Whole	0.88	0.50	0.85	0.48	0.89	0.51	1.03	0.58	0.95	0.54	0.99	0.56
W.A	2nd	2.17	1.28	2.18	1.29	2.21	1.30	2.14	1.26	2.19	1.29	2.20	1.30
	3rd	0.70	0.39	0.64	0.36	0.66	0.37	0.83	0.47	0.78	0.44	0.77	0.43
	Whole	1.28	0.73	1.22	0.69	1.25	0.71	1.41	0.80	1.37	0.78	1.37	0.78
W.T	2nd	2.49	1.54	2.49	1.54	2.49	1.54	2.49	1.54	2.49	1.54	2.49	1.54
	3rd					0.33	0.18					0.39	0.22
	Whole	2.49	1.54	2.49	1.54	0.86	0.49	2.49	1.54	2.49	1.54	0.96	0.54
Whole Project		1.37	0.78	1.35	0.77	1.27	0.73	1.50	0.87	1.46	0.84	1.38	0.79

As shown in Table 5-16-1, comparison between the investment for dry season paddy cropping and its economic benefit reveals that the investment effect does not reach the acceptable level in some area. It is to be pointed out, however, that twice rice culture including both wet and dry season croppings is economically justifiable, provided that the annual interest rate is 6%. It could be said the double cropping of paddy in the entire project area, except the W.A.H. and W.T. areas, will prove to be a sufficiently profitable undertaking.

If double cropping of paddy is practised in the whole project area, the production of unhusked rice will reach the level of about 470,000 tons, which is equivalent to the total production of 470,000 tons of both wet paddy and upland paddy recorded in Lampung province in 1972. Therefore, the introduction of the double cropping of paddy will contribute largely to the stabilization of the country's food supply and also to the regional economic development of the Lampung province.

CHAPTER VI PREPARATION OF MAPS

6-1. Present Availability of Maps

Regional development in any country presupposes availability of detailed information on the existing conditions of the area to be covered, and maps and aerial photos are very useful in grasping such existing conditions. Surveys for regional development and the planning of the implementation of the development projects definitely require maps and aerial photos prepared on such scales as would fit the purposes of such activities.

Maps and aerial photos of the project area of the Way Rarem/Abung Irrigation Project in Indonesia now available are the followings.

(1) Topographical Map (Scale: 1/100,000)

This is the only topographical map of Lampung province prepared according to unified specifications. However, since this map was drawn up a long time before World War II, it does not accurately show the present conditions. Large rivers and arterial roads generally are close to the existing conditions, indication of individual villages along highways and roads is not accurate, and no railway lines are shown. The contour interval is 50 m, and the sheet lines represent 20' of longitude and latitude respectively. Photo-printed copies of this map can be obtained from Directorate of Geology in Bandung.

(2) Map of a Scale of 1/5,000

Preparation of this map is now in progress at the Directorate of Irrigation, Ministry of Public Works, for use in the irrigation planning work. When using this map in the actual planning work, care must be taken of the abbreviations and generalization which are quite notable when compared with the Japanese National Large Scale Map. It is being prepared by the offset surveying method without resorting to airphotos in the mapping stage. The map, therefore, involves inaccuracy resulting from the departure from the route of traversing. The contour interval is 1 m. but since the interpolation method is adopted, it is not possible to detect local transition of slope. The base map for producing blue copies is being kept at the Directorate of Irrigation in Bandung.

(3) Aerial Photo (Scale: 1/50,000)

This is an infrared air photo taken by KLM Aerokart in 1967 by order of FAO. Among all the maps and air photos currently available in the province, this air photo may be considered most reliable. Original films are kept at KLM Aerokart Indonesia in Djakarta, and photo mosaics prepared from them can also be obtained from KLM.

(4) Other Maps

Besides the maps mentioned above, there are other maps prepared from them on scales of 1/250,000 and 1/1,000,000, and their copies can be obtained from Directorate of Geology in Bandung.

In addition, 1/25,000 chart prepared as the index map of the aforementioned 1/5,000 map is available. This chart serves as an expedient guide map of the project area.

At present, joint air photo taking covering the project area is being conducted by the Indonesian Army and the Australian Army for preparation of a new 1/50.000 topographical map which is expected to be completed within 1974.

In Sumatra, triangulation nets are established along the western mountain range but not in the eastern flatland area.

6-2. Basic Policy for Map Preparation

By reason of their intrinsic nature, maps demand a long period of time and much expenses before they are completed. The rough-and-ready method never produces good results. Preparation of an accurate map is possible only when it is backed up by scrupulously designed plans and proper surveying. Development plans worked out using inaccurate maps often call for alteration or revision at a later date. Considering the waste of time, cost and labour ensued from such alteration or revision, it is absolutely necessary to allot sufficient time for the preparation of maps before formulating any development plan.

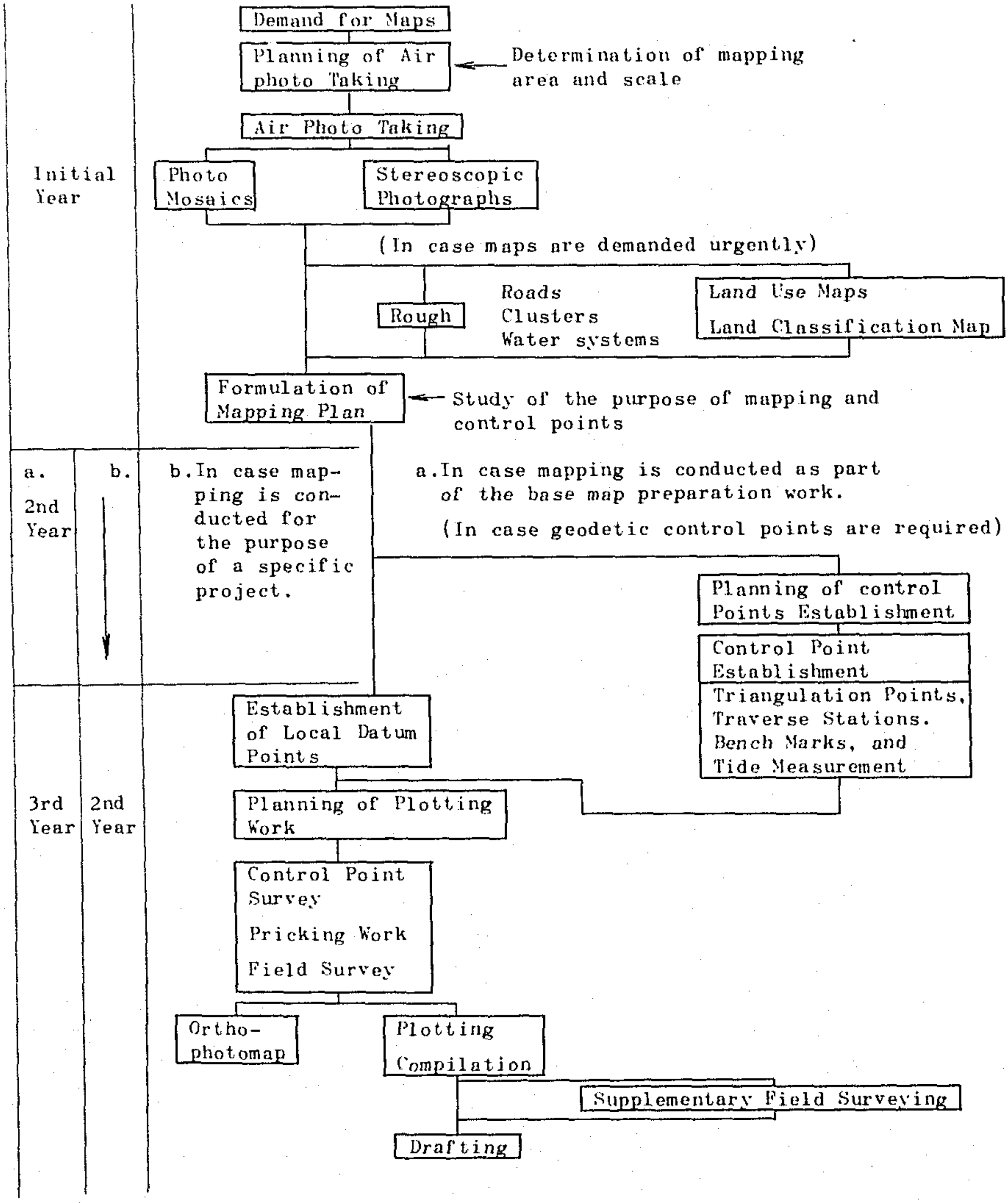
It is important that the maps which are necessary for planning regional development should contain such data and information required in each stage of development. Maps are required to be more and more accurate with the progress of development. In the long run, therefore, it will prove economical to prepare maps in such a way that their accuracy and scale can be improved gradually according to the progress of development.

Preparation of accurate maps presupposes establishment of control points, and this is a vital condition if an extensive area is to be mapped.

Maps should preferably be prepared on the basis of control points established by the government according to the unified standard even if they are to be used for the purpose of a specific project which covers a relatively small area. If this is not feasible, establishment of local datum points should precede the actual mapping work.

The following flow chart illustrates how large scale maps covering unmapped areas should be prepared. In working out the mapping plan for the project area, the fundamental policy shown in this chart should in principle be observed.

Basic Policy for Preparing Large Scale Maps
Covering Unmapped Area



6-3. Mappingof Benefited Area.

As described in Section 6-1, the whole of Abung area and the southern part of Rarem area are already covered by the 1/5,000 map prepared by the Indonesian Government. The Indonesian Government will also undertake the mapping work covering the northern part of Rarem area.

After a careful study of the above-mentioned 1/5,000 map, the team reached the conclusion that the map to be prepared on the same scale to cover the remaining part of the project area will prove useful if prepared with the following cautions taken into account.

(1) The existing air photos should be used to the maximum extent when plotting details of the map even if it is to be prepared by the conventional offset method. This will offset to a substantial degree the deficiency of field survey.

(2) The map should show not only the symbols but also the coordinate and height on which it is based. Such data are important prerequisites to implementing development plans on the strength of the map.

(3) A check system should be established for mapping. The map will be improved immensely in quality if they are sampled at random in the course of preparation and checked against the air photos.

Since there is probability that the 1/5,000 map now being prepared will not be completed before the 1974 feasibility study, the team proposes that the existing 1/5,000 air photos be enlarged two-fold (to a scale of 1/25,000) for use in the field work. Air photos not only substitute for maps but prove more instrumental in implementing certain types of survey if the user possesses some basic knowledge about them. Field survey can be facilitated to the maximum extent by air photo interpretation with a stereoscope. The specialists expected to participate in the forthcoming feasibility study are therefore urged to train themselves in the air photo interpretation technique in advance.

A technical review of the mapping method made on the assumption that the 1974/1975 feasibility survey will be conducted as originally planned leads to the conclusion that it is most advisable, for both accuracy and time-saving purpose, to prepare the map of the entire benefited area according to unified specifications. This can be done by taking full advantage of the existing 1 50,000 air photos and by conducting photogrammetry. In case this method is employed, the recommendable scale should be 1/10,000 because of the scale of the existing air photos. The existing 1/5,000 map of the southern area was checked by field survey and air photo. From the result of this study, it is believed that maps prepared by the above method will generally excel the existing 1/5,000 map in many respects.

6-4. Mapping of Upstream Part of Benefited Area

Unlike the other flatland part of the benefited area, this part is hilly and mountainous and small in area. Surveying and mapping will therefore entail difficulty and incur a high cost. The most efficient method conceivable for preparation of a map which would meet the expectation of the irrigation specialists is described in the following sections.

6-4-1. Mapping of Way Rarem Upstream Area

Areas to be mapped and purpose of mapping

a. The area extending from a point near Pekurn on the confluence of the Way Rarem and the Way Galing to the vicinity of Kotabumi. Mapping of this area is required to plan the construction of a head race through which water diverted from the Way Rarem will be conveyed to the benefited area.

b. The area extending from the downstream side of Tjahajannegeri to Tandjung Kemala. Mapping of this area is required to plan the construction of a head race for diverting water from the Way Abung to the Way Rarem.

The two areas combined have an acreage of about 325 km^2, and they are shown in Fig. 6-1 as areas A and B.

Method of preparation

The 1/10,000 maps will be prepared by photogrammetry using the existing 1/50,000 air photos.

Conformity to the existing 1/5,000 map prepared by the Indonesian government will be maintained. For this purpose, the elevation (28 m) of the triagulation station used for preparation of the said map will be adopted. The station (T 1635) is located to the northwest of Kotabumi. Further, bench marks will be established along the arterial roads to facilitate future surveys and planning.

As for the coordinate, the data of past triagulation will be used with traversing conducted for confirmation of locational relationship between respective triangulation points. In addition, control point survey required for plotting will be carried out.

6-4-2. Mapping of Way Besai Upstream Area

Area to be covered and purpose of mapping

Water of the Way Besai is planned to be diverted to the Way Abung and then to the Way Rarem as part of the long range irrigation improvement programme. For the purpose of studying the feasibility of this transfer basin plan, a topographical map covering the upstream areas of the Way Besai and the Way Abung is to be prepared. The two areas combined, shown as area C in Fig. 6-1, have an acreage of 50 km^2 and extend radially from T1711.

Method of preparation

The team was informed that a 1 50,000 air photo covering this area in NW-SE direction is available. It would be advisable if a 1 10,000 map could be prepared by photogrammetry using the said air photo.

Since field surveying in this area is considered to entail difficulty, aerial triangulation and mapping will be conducted by pricking of the existing triangulation points in the office. Since no direct levelling will be conducted, elevations cannot be connected with those in the downstream area. However, it is believed that map prepared by this method will amply meet the purpose of studying the feasibility of the diversion plan.

6-4-3. Mapping of Northern Half of Way Rarem/Abung Area Covered by Irrigation Plan

A 1 5.000 topographic map is required for implementing a feasibility study on ihe irrigation plan for W. R/A N-1 and N-2 areas. This map is planned to be prepared by the Indonesian government before the forthcoming feasibility study.

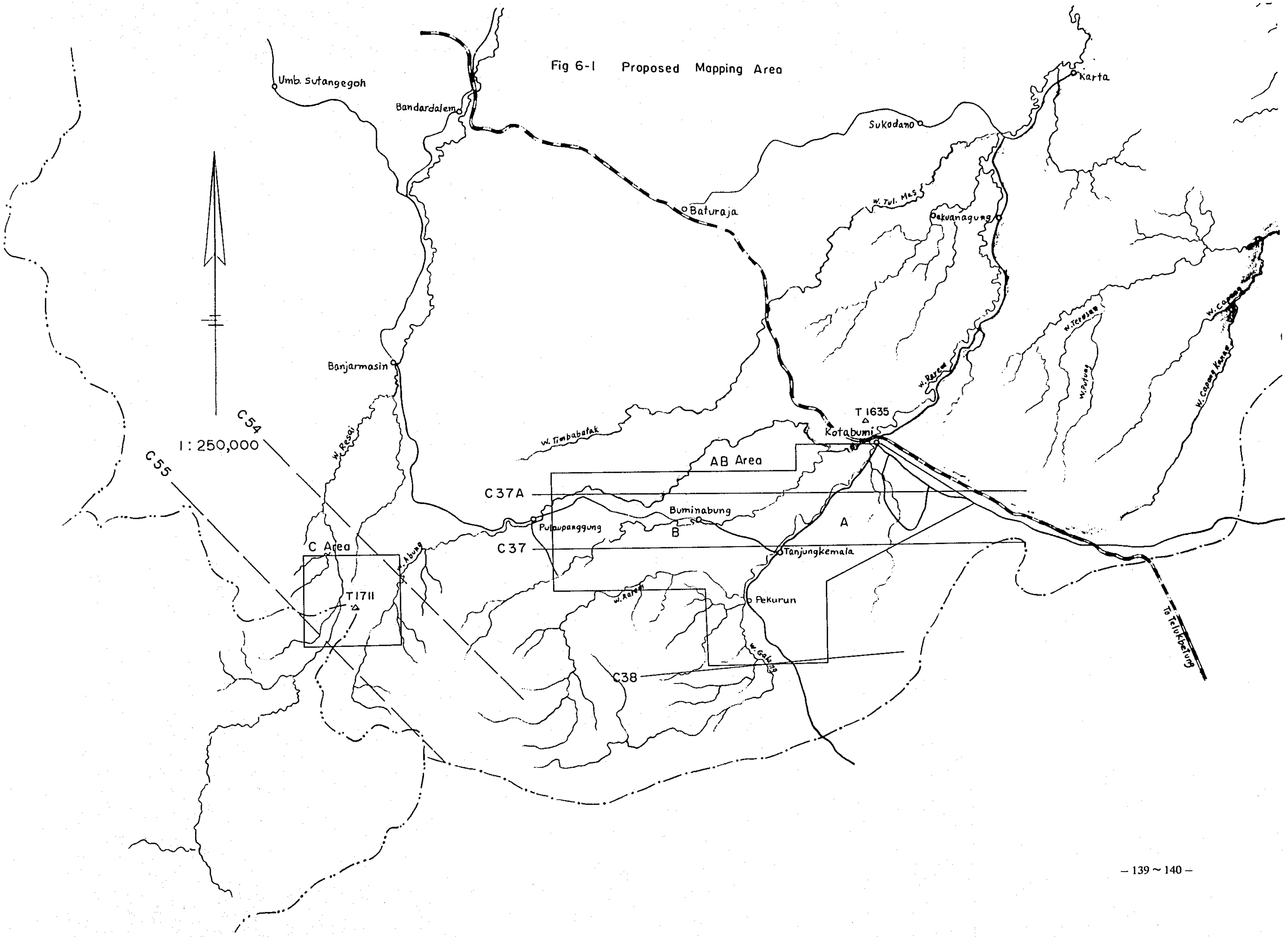


Fig 6-1 Proposed Mapping Area

CHAPTER VII CITY WATER SUPPLY PLAN FOR KOTABUMI

Kotabumi city, the capital of North Lampung province, is said to have a population of about 20,000. All daily necessities required in desas and their suburbs are supplied from this city and products from the neighbouring areas are all collected in this city and transported to Tandjungkarang. Since the city is thus functioning as a local distributing and collecting centre, it is likely that its urbanization will be prompted in the coming years by agricultural development in the surrounding farmland areas and inflow of population.

In Kotabumi city, 10 to 15 m deep wells are the only source of citizen's drinking water. In the dry season when the yield of wells declines, many citizens are obliged to use water of the Way Rarem for domestic purposes. As a solution to the prevailing water shortage, it is considered justifiable to include city water supply for this city in the construction plan of a head race to Way Rarem/Abung South area.

Taking the design population to be served at 50,000 with the future increase taken into account, and assuming that the maximum water consumption per day per person is 200 l, the following values can be obtained.

Estimated maximum water consumption per day = 200 / day / person x 50,000 persons = 10,000 m^3 / day.

Assuming, again, that the water consumption at the filtration plant and the conveyance loss in the channel are 15% and 20% respectively of the estimated maximum daily water consumption shown above, the design water volume to be delivered turns out to be as follows.

Design water delivery = 10,000 m^3/day x 1.15 0.8 864,000 = 0.2 m^3/sec.

Water will be diverted from the Way Rarem, led through the head race to be constructed for irrigation, and then supplied to the filtration plant from upstream of Desa Condimas.

APPENDIX

A. LIST OF DATA COLLECTED

Since the team arrived in Indonesia on 11th October 1973, the following data were collected by each expert with the cooperation of the Ministry of Public Works and Power and the Ministry of Agriculture.

These data will be used as the basis for the project formulation.

1. Maps

(1). Topographical Map of Way Rarem area	1 : 100,000
(2). Topographical Map of Way Rarem area	1 : 5,000 & 1 : 25,000
(3). Topographical Map of Way Abung area	1 : 5,000

2. Irrigation

(1). Geological Map	1 : 20,000
(2). General Map of the confluence of Way Galing and Way Rarem	1 : 2,000 (D.P.U. in Lampung)
(3). General Map of the confluence of Way Galing and Way Rarem	1 : 5,000 (D.P.U. in Kotabumi)
(4). Highway Map between Kebunkaret, Rejat and Kempung Kelapa	(D.P.U. in Kotabumi)
(5). Risalah Singkat Proyek Transmigrasi Way Abung Kabupaten Lampung Utara	(D.P.U. in Lampung)
(6). Risalah Singkat Proyek Transmigrasi Punggur Kabupaten Lampung Tengah	(D.P.U. in Lampung).
(7). Transmigration Placement viewed from the Irrigation Aspect	(D.P.U. in Lampung).
(8). Obyek Transmigrasi Panaragan Lampung Utara Way Abung	(D.P.U. in Lampung).
(9). Proyek Irigasi Way Abung Lampung Utara	(D.P.U. in Bandung).
(10). Penyelidikan Geologi Teknik Dan Mekanika Tanah Rencana Bandung Way Abung (Hulu) Lampung Bagian Pertama: Geologi Teknik.	(D.P.U. in Bandung).
(11). Perhitungan Estimate Irrigation Requirement Dengen Perhitungan Evapotranspiration Methods Hargreaves	(D.P.U. in Bandung).
(12). Perhitungan Evapotranspiration (Consumtive use) menurut Methode Hargreaves	(D.P.U. in Bandung).
(13). Capaciteit Skromme - Way Sekampung	(D.P.U. in Metro).
(14). Unit Cost Calculation	(D.P.U. in Lampung).
(15). Unit Cost	(Way Seputih Project).
- " -	(D.P.U. in Lampung).
- " -	(D.P.U. in Metro).
(16). Selinan dari Surat Keputusan Gubernur/Kepala	(D.P.U. in Kotabumi)
(17). Design Map of Way Djepara Project	(D.P.U. in Lampung).
(18). Road Map of Lampung Province	(D.P.U. in Lampung).

3. Hydrology.

(1) Water level data at the confluence of Way Galing and Way Rarem October 1973.	(D.P.U. in Kotabumi)
(2) Daily rainfall data in Blambangan Pagar 1972, Jan.–Oct. 1973	(P.T. Daya Itoh).
(3) Table of weather condition in Blambangan Pagar, Sept. 1972–Feb. 1973	(P.T. Daya Itoh).
(4) Water discharge of Way Seputih in Negaraadji 1939	(D.P.U. in Tanjungkarang).

(5) Daily rainfall data

Bukitkemuning	1959, 1960, 1972, 1973.
Bandarjaya	1970, 1971.
Kotabumi (DIPERTA)	1951, 1960, 1971, 1972.
Kotabumi (D.P.U.)	1959, 1961, 1963, 1973
Tatakarya	Apr., Nov. 1973
Cahaya Negeri	1972, 1973.
Gedung Ratu	1971, 1973.
PK. Tulung Buyut	1971, 1973.
Lempuyang - Kayuparis	1972, 1973.
Proyek Gula Gm. Batin	1972, 1973.
Menggala	1971, 1973
Ketapang	1971, 1973 (P3 S.A.)

(6) Water discharge of Way Rarem in Pekurun Feb. Apr. July Aug. 1973 (P3 S.A.)

(7) Map of Rainfall observation stations (P3 S.A.)

(8) Map of water level observation station (P3 S.A.)

(9) Climatological data in Way Seputih Project 1971, 1972 (D.P.U. in Way Seputih Project).

(10) Water level data of Way Rarem and Way Besai

Way Rarem	Apr. 1971, Oct. 1973
Confluence of Way Rarem and Way Galing	Sept. 1972, Oct. 1973
Way Besai	Apr. 1971, Oct. 1973 (D.P.U. in Kotabumi)

(11) Water discharge of Way Sekampung and Way Seputih.

Way Sekampung	July 1959, 1961, 1964, 1968, 1971, Apr. 1973.
Way Seputih	March, June 1973.

4. Farm Management

(1) Lampung Dalem Angka 1972 (Kantor Sensus & Statistik Prop. Lampung).

(2) Statistik Pertanian 1967 1971 (Dinas Pertanian Propinsi Lampung).

(3) Sensus Penduduk 1971 (Kantor Sensus Dan Statistik Propinsi Lampung).

(4) Rencana Pembangunan Lima Tahun Tahap Kedua: 1974/1975–1978/1979, (Perwakilan Departemen Pertanian Propinsi Lampung).

(5) Farm Land Area of Kabupaten and Kecamatan in Lampung Province 1971 (Dinas Pertanian Prop. Lampung).

(6) Planted area and yield of Perennial crop in Lampung Province 1968, 1973. (Dinas Pertanian Prop. Lampung).

(7) Data on wages and working hours with each plant. 1972 (Dinas Pertanian Prop. Lampung).

(8) Data on production cost of crops with each Kabupaten or plant 1972 (Dinas Pertanian Prop. Lampung).

(9) Data on yield and fertilization of lowland rice with each Kabupaten 1969, 1972 (Dinas Pertanian Prop. Lampung).

(10) Data on extent and area which were damaged by blight and harmful insects or disaster with each plant in Lampung Province, 1970, 1972 (Dinas Pertanian Prop. Lampung).

(11) Data on extent and area which were damaged by blight and harmful insects or disaster with each Kabupaten and fields. 1972, 1973 (Dinas Pertanian Propinsi Lampung).

(12) Data on price of agricultural products with each month in North Lampung. 1971, 1972 (Dinas Pertanian Prop. Lampung).

(13) Data on price of agricultural products with each Kabupaten May. 1973 — (Dinas Pertanism Prop. Lampung).

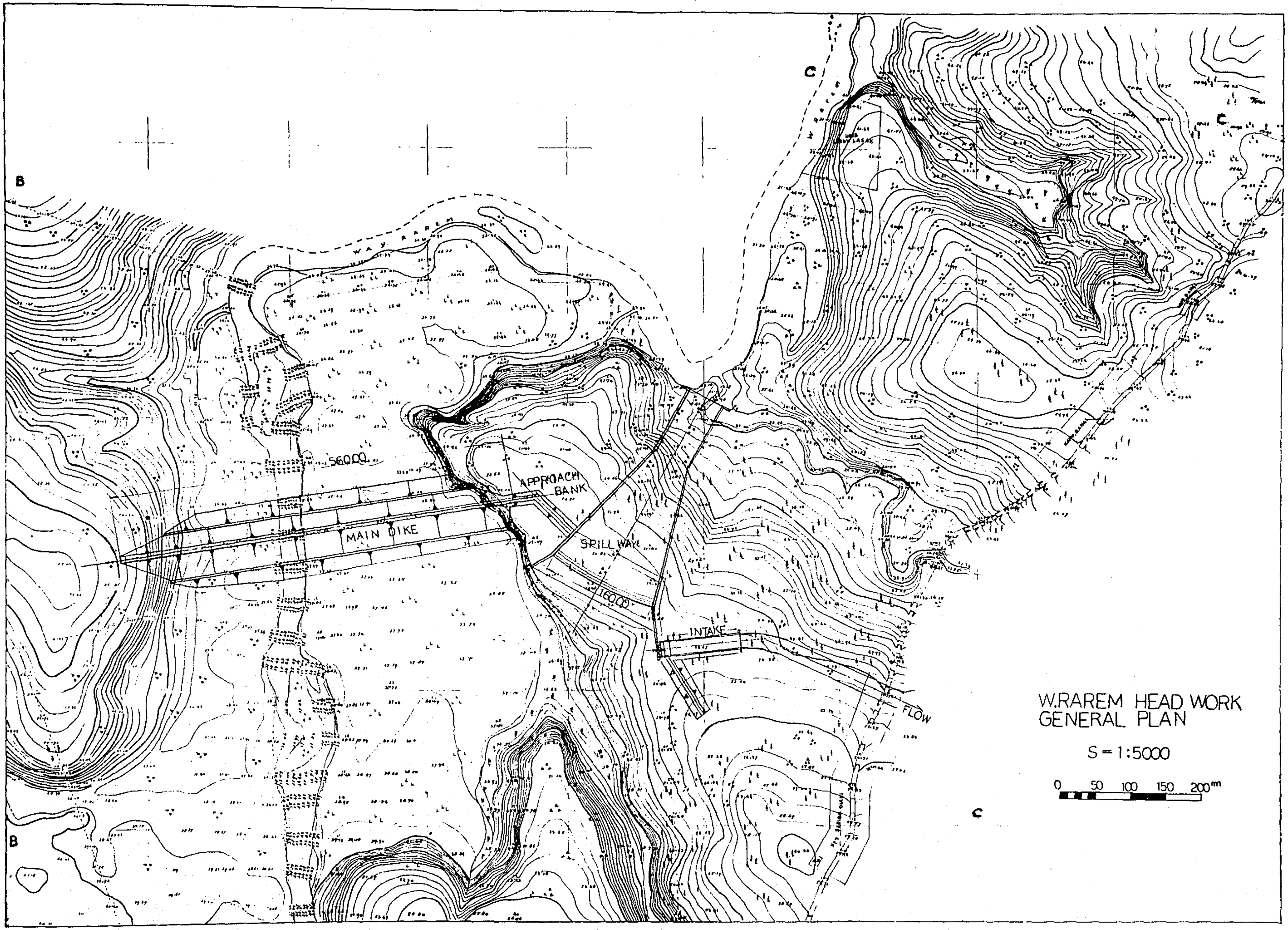
(14) Settlement of transmigrations project in Lampung Province. 1952 Feb. 1973 — (Direktorat Transmigrasi Prop. Lampung).

(15) Data on results of transmigration in survey area and planning in the future, and map concerned. — (Kentor Transmigrasi Kabupaten Lampung Utara).

(16) Soil map of Lampung Province. — (Lembaga Penelitian Tansh Bogor).

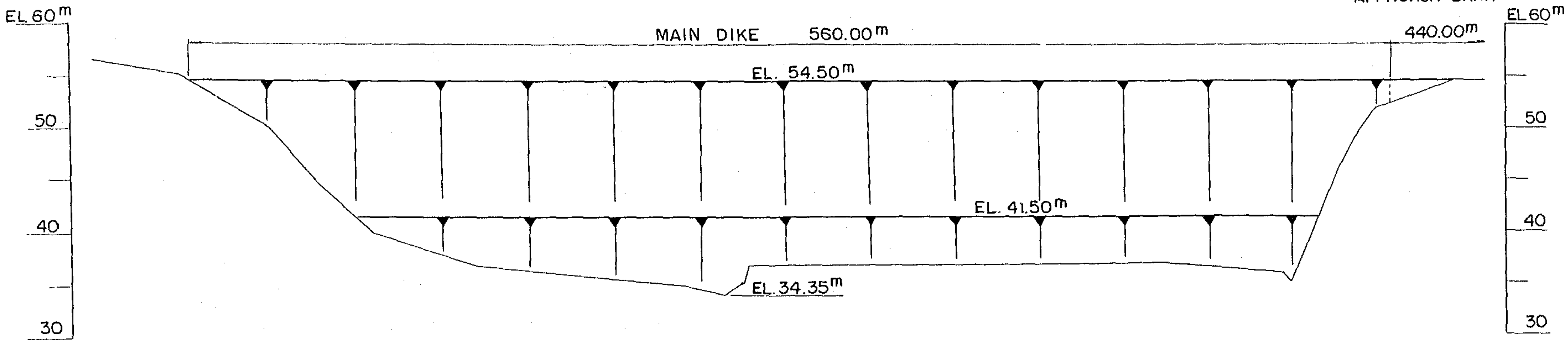
(17) Map showing the site and name of Ketjamatan and Desa in North Lampung. — (Dinas Pekerjaan Umum Prop. Lampung).

(18) Report on Circulation and Production of Cassava. — (Dinas Pertanian Prop. Lampung).


W.RAREM HEAD WORK
GENERAL PLAN
S = 1:5000
0 50 100 150 200m
MAIN DIKE
APPROACH BANK
SPILL WAY
INTAKE
FLOW
560.00
160.00
WAY RAREM
B
B
C
C
C

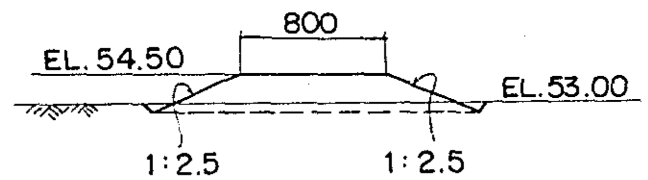
W. RAREM HEAD WORK UPSTREAM ELAVATION

Scale : H = 1 : 2000 , V = 1 : 400



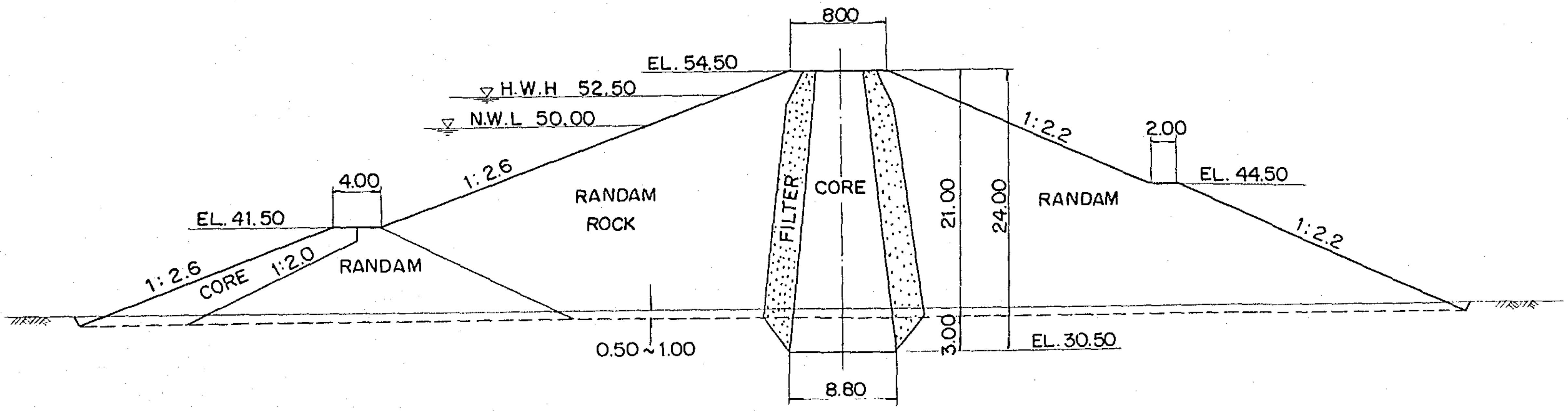
APPROACH BANK SECTION

S = 1 : 400



TIPICAL SECTION

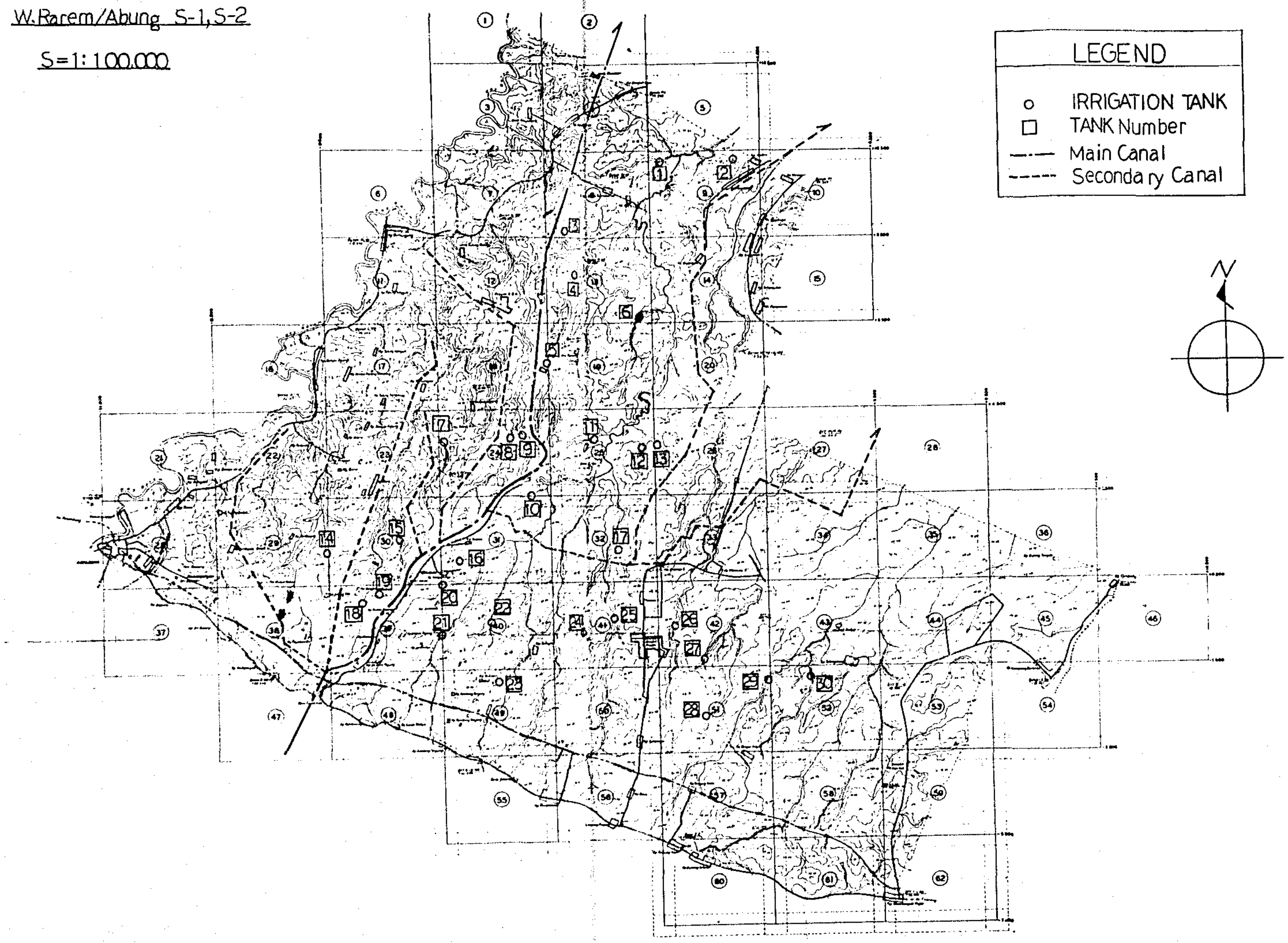
S = 1 : 400

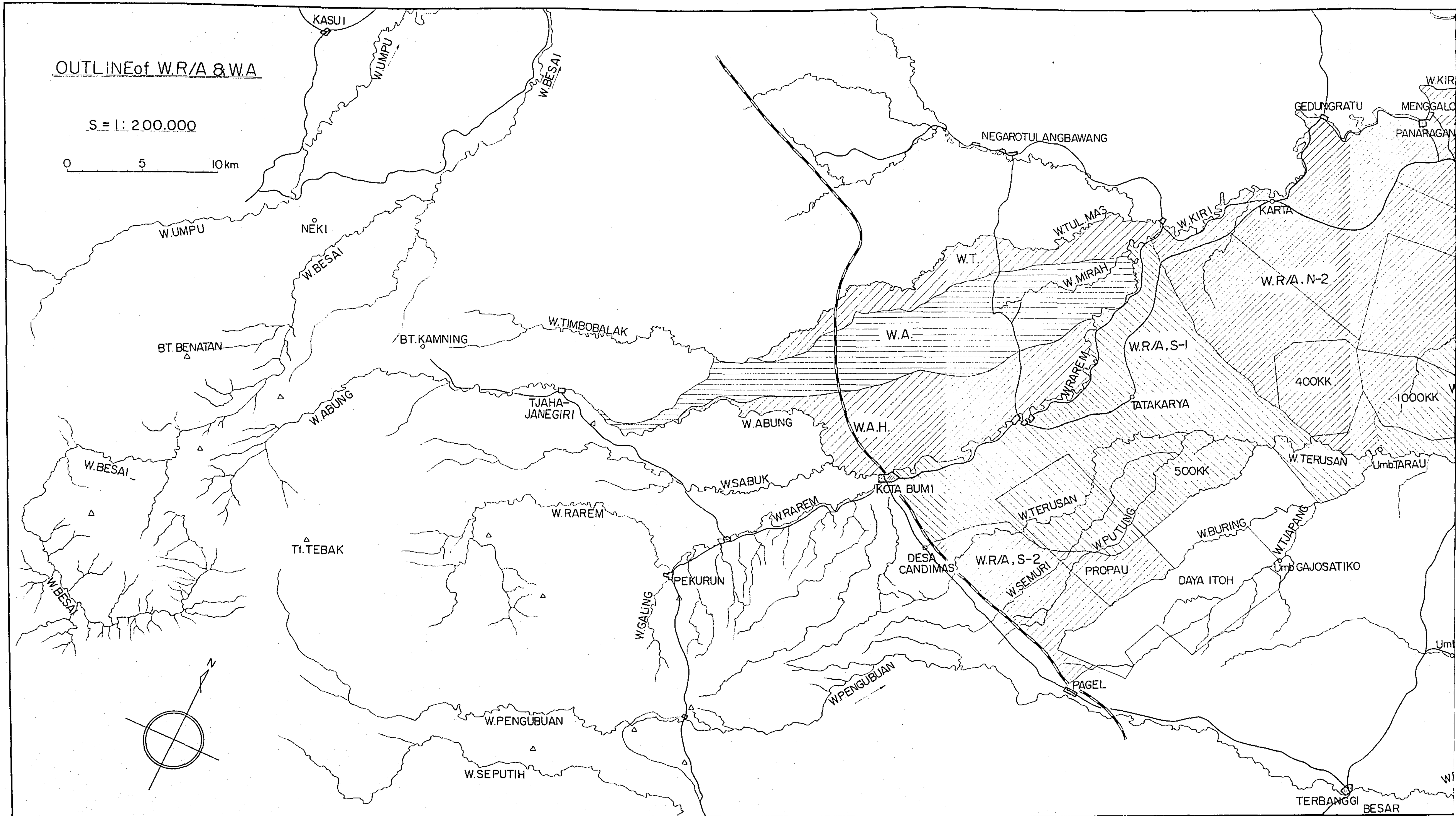


LOCATION MAP of IRRIGATION TANK

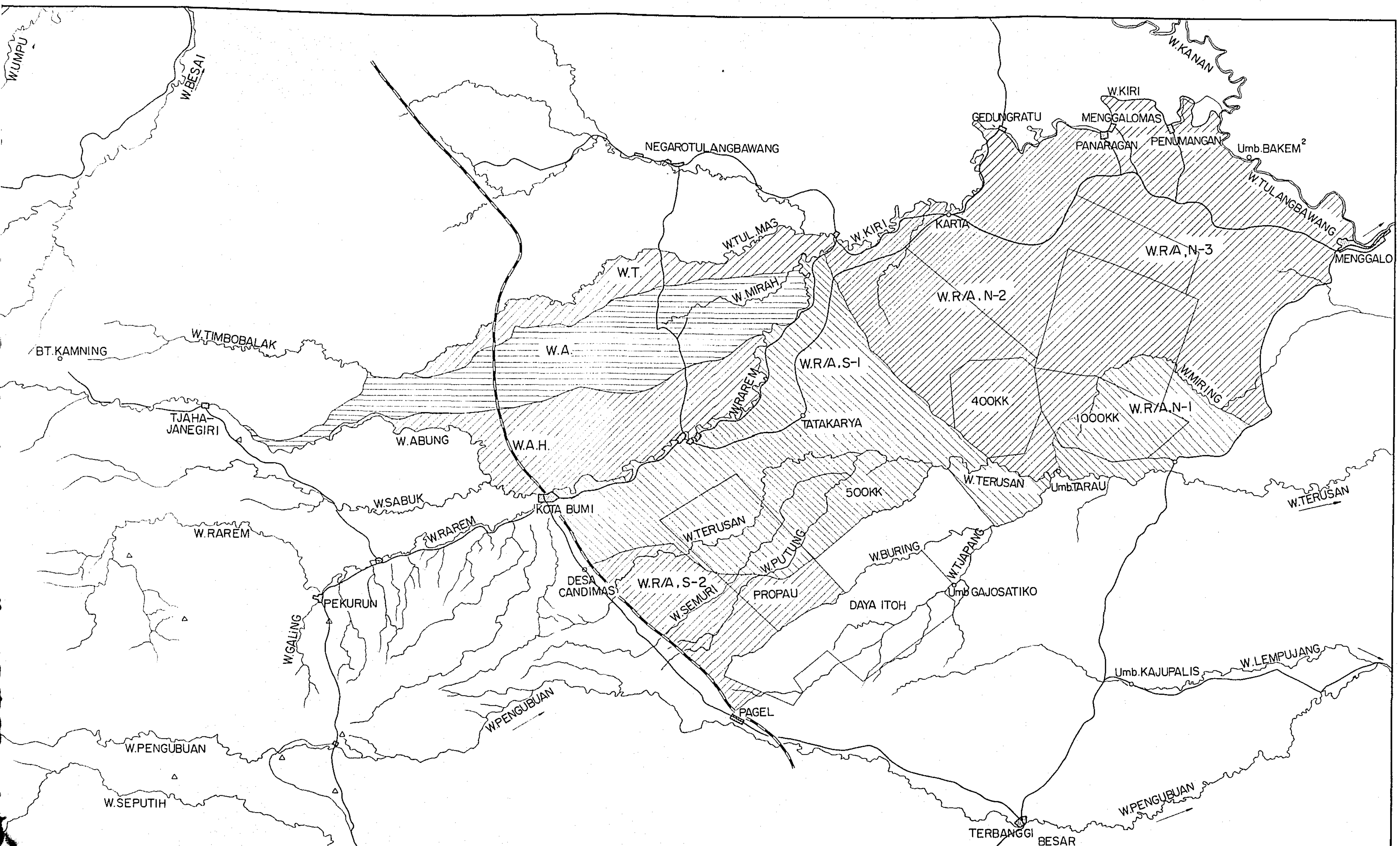
W.Rarem/Abung S-1,S-2

S=1:100.000





OUTLINE of W.R/A & W.A
S = 1: 200.000
0 5 10km
KASUI
W.UMPU
W.BESAI
NEKI
BT. BENATAN
BT. KAMNING
W.TIMBOBALAK
W.ABUNG
TJAHA-JANEGIRI
Tt. TEBAK
W.RAREM
PEKURUN
W.GALING
W.PENGUBUAN
W.SEPUTIH
W.SABUK
KOTA BUMI
DESA CANDIMAS
PAGEL
NEGAROTULANGBAWANG
W.TUL.MAS
W.T.
W.MIRAH
W.A.
W.A.H.
W.R/A. S-1
W.R/A. S-2
W.R/A. N-2
W.RAREM
TATAKARYA
W.KIRI
KARTA
GEDUNGRATU
MENGGALO
PANARAGAN
400KK
1000KK
500KK
W.TERUSAN
Umb.TARAU
W.PUTUNG
W.SEMURI
PROPAU
DAYA ITOH
W.BURING
W.TJAPANG
Umb.GAJOSATIKO
TERBANGGI BESAR
N


W.UMPU
W.BESAI
W.KANAN
W.KIRI
GEDUNGRATU
MENGGALOMAS
PANARAGAN
PENUMANGAN
Umb.BAKEM²
NEGAROTULANGBAWANG
W.TULANGBAWANG
KARTA
W.KIRI
W.TUL.MAS
W.R/A.N-3
MENGGALO
W.T.
W.MIRAH
W.R/A.N-2
W.TIMBOBALAK
BT.KAMNING
W.A.
W.R/A.S-1
W.RAREM
400KK
W.MIRING
TJAHA-
JANEGIRI
TATAKARYA
1000KK
W.R/A.N-1
W.ABUNG
W.A.H.
W.TERUSAN
Umb.TARAU
W.SABUK
500KK
W.TERUSAN
KOTA BUMI
W.RAREM
W.RAREM
W.TERUSAN
W.PUTUNG
W.TJAPANG
W.BURING
DESA
CANDIMAS
W.R/A.S-2
Umb GAJOSATIKO
PEKURUN
PROPAU
W.SEMURI
DAYA ITOH
W.GALING
W.LEMPUJANG
Umb.KAJUPALIS
W.PENGUBUAN
PAGEL
W.PENGUBUAN
W.SEPUTIH
W.PENGUBUAN
TERBANGGI
BESAR