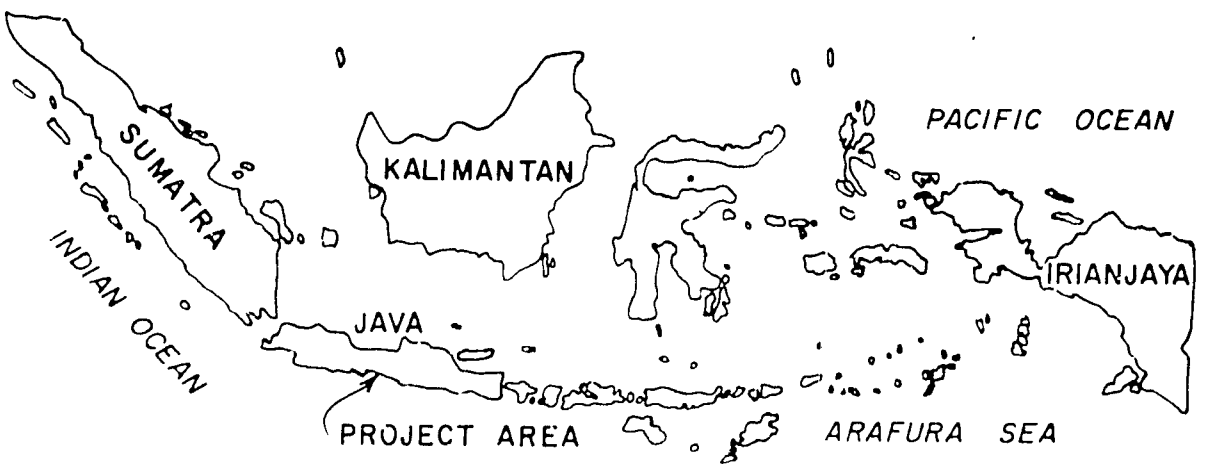
MINISTRY OF PUBLIC WORKS AND ELECTRIC POWER
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
DIRECTORATE OF RIVERS AND SWAMPS

THE CITANDUY RIVER BASIN DEVELOPMENT PROJECT

MASTER PLAN



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ENGINEERING CONSULTANTS, INC.
DENVER, COLORADO, U.S.A. BANJAR, INDONESIA

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EXECUTIVE SUMMARY

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MAY 1975

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"GLOSSARY"

ABBREVIATIONS AND TERMS

R. I.	Republic of Indonesia
U.S.A.I.D.	United States Agency for International Development
A.M.S.	United States Army Map Service
BAPPENAS	National Planning Board
BAPPEMKA	District Planning Board
BIMAS	Mass guidance for agricultural intensification with government credit at low interest
INMAS	Same as BIMAS but without government credit
BULOG	National agency for price control, stock and distribution of rice
DOLOG	Provincial Agency administering BULOG program
B.U.U.D.	Village Cooperative Unit
A.E.S.	Agricultural Extension Service
LPMA	Institute of Hydraulic Engineering
Rough Rice	(Gabah) Threshed rice (with hull), unmilled at 14 percent moisture
Milled Rice	(Beras) Rice that is dehulled and polished
Wet Stalk Rice (or Padi)	- Unthreshed rice - still in the panicle (head or ear) - tied in a bundle, cut 15 to 20 cm below the panicle, not dried. (Conversion to rough rice 59%) (Conversion to milled rice 40%)
Dry Stalk Rice (or Padi)	- Same as above but dried. (Conversion to rough rice 77%) (Conversion to milled rice 52%)

MEASUREMENT AND CONVERSION FACTORS

Length

1 meter	=	39.37 inches	=	3.2808 feet
2.54 centimeters	=	1 inch		
0.3048 meter	=	1 foot		
1,000 meters	=	1 kilometer	=	0.6214 statue mile
1.60935 kilometer	=	1 statute mile		

Area

1 hectare	=	2.47 acres	=	10,000 square meters
1 square kilometer	=	100 hectares	=	247 acres

Volume

1 cubic meter	=	1,000 liters	=	1.308 cubic yards
1 cubic meter	=	0.0008107 acre feet	=	35.3144 cubic feet
1 liter	=	0.2642 gallon	=	0.03531 cubic foot
1,233.5 cubic meters	=	1.0 acre foot	=	325,851 gallons

Temperature

$^{o}C = 5/9\ (^{o}F-32)$

$^{o}F = 9/5\ \ ^{o}C + 32$

Currency

1 rupiah	=	100 sen	=	$0.0024 U.S. approx.
1 U.S. Dollar	=	414 rupiah	=	41,400 sen

Weight

1 kilogram	=	2.2046 pounds		
1 metric ton	=	1,000 kilograms	=	2,204.6 pounds
2,000 pounds	=	1 ton	=	907.18 kilograms
1 kwintal (kw)	=	100 kilograms	=	220.463 pounds
1 metric ton (t)	=	1,000 kilograms	=	2,204.63 pounds
1 liter (rice)	=	800 grams	=	1.764 pounds

METRIC SYSTEM ABBREVIATIONS

	Unit	Abbreviation or Symbol	Equivalent of meter
LENGTH:	millimeter	mm	0.001
	centimeter	cm	0.01
	meter	m	1.0
	kilometer	km	1,000.0
AREA:	square centimeter	cm^2	0.0001 m^2
	square meter	m^2	1.0 m^2
	hectare	ha	10,000 m^2
	square kilometer	km^2	1,000,000 m^2
VOLUME:	cubic meter	m^3	1.0 m^3
	liter	l	1,000 cm^3 = 0.001 m^3
	million cubic meters	MCM	
MASS AND WEIGHT:	kilogram	kg	1,000 g
	metric ton	t	1,000 kg
FLOWING WATER:	liter per second	l/s or lit/sec	
	cubic meter per second	cms or m^3/s or m^3/sec	

CONVERSION RATES FROM STALK RICE (PADI) TO ROUGH RICE (GABAH) TO MILLED RICE (BERAS)

Klasifikasi	Classification	Conversion Rates: Percent (%)									
1. Padi Basah di Desa	Wet stalk rice in the village	100	119	122	123	130	145	154	156	169	250
2. Padi Kering di Desa	Dry stalk rice in the village	84	100	103	104	109	122	130	132	143	208
3. Padi Kering Lumbung di Desa	Dry stalk rice stored in village	82	97	100	101	106	119	127	128	139	204
4. Padi Kering Lumbung di Pabrik	Dry stalk rice stored at mill	81	96	99	100	105	118	125	127	137	200
5. Padi Kering Giling di Pabrik	Dry stalk rice ready for milling	77	92	94	95	100	111	119	120	130	192
6. Gabah Basah di Desa	Wet rough rice in the village	69	82	84	85	90	100	106	108	116	169
7. Gabah Kering di Desa	Dry rough rice in the village	65	77	79	80	84	94	100	101	110	161
8. Gabah Kering Lumbung di Desa	Dry rough rice stored in the village	64	76	78	79	83	93	99	100	109	159
9. Gabah Kering Giling di Pabrik*	Dry rough rice ready for milling*	59	70	72	73	77	86	91	92	100	147
10. Beras	Milled rice	40	48	49	50	52	59	62	63	68	100

Source: Petunjuk Pengelolaan Penggilingan Padi
Perusahaan Pertaniah Negara, Jakarta (1972)

Rice Mill Management Instructions
Government Agricultural Enterprises, Jakarta

*Dried to 14% Moisture.

CHAPTER I

INTRODUCTION

General

The Citanduy Project Area, consisting of some 446,000 hectares, is composed of two distinct and easily identifiable geographic areas. They are:

1. The Citanduy Ciseel River System which stretches from the headwaters of the Citanduy River in the west to the origins of the Cikawung River in the east, and from the headwaters of the Ciiolang River in the north to the start of the Ciseel River in the south. The topography of the 350,000 hectares encompassed by the system encourages further subdivision - The upper watershed of the Citanduy and Ciseel Rivers and the lower Citanduy Ciseel River System. The dividing lines are the points where the two rivers emerge from the uplands onto the flood plain.

2. The Segara Anakan and its tributaries (other than the Citanduy River System), which extends from the Sidareja lowlands and the origin of the Cikujang River in the west to the Jeruklegi River in the east, and from the headwaters of the Cihaur River in the north to Nusa Kambangan in the south. This portion, including the water areas of the Segara Anakan and its environs, covers about 96,000 hectares. Again, both topography and physiographic characterisrics of the area simplify further subdivision - The Segara Anakan and its environs and the Sidareja and Sidareja East areas. The former is an area of about 32,500 hectares, which includes the Segara Anakan itself and the surrounding tidal forest. The latter includes the balance of the area (63,500 hectares).

Each of these four areas, while they constitute separate and apparently independent units, are actually quite interdependent. This is not meant to imply that development programs cannot be undertaken independently for each region, but it can be said that their interrelationship is such that any developmental effort expended on one is certain to produce secondary effects in one or more of the others.

The basic objective is to carry out c omprehensive study to determine an optimal pattern of utilization of water and land resources which will lead to increased agricultural production and the attendant improvement in the standard of living of the inhabitants of the area. This, in turn, will be a positive contribution to the national developmental effort.

During the course of the study, four principal subprojects were identified:

1. A comprehensive water management scheme for the lower Citanduy/Ciseel River System.

2. A comprehensive water management scheme for the upper Citanduy/Ciseel River System.

3. The reclamation of the Segara Anakan and its environs.

4. A comprehensive water management scheme for the Sidareja East area.

Each of these four principal subprojects is composed of several work items, some of them common to two or more subprojects.

The one very basic need, common to all subprojects, is the need for a management system orienting, coordinating, and directing the development efforts. Naturally, because of the great variance in the environment and the respective problems in each of the subproject areas, it would be desirable if the overall management organization would be composed of four sections, each dealing with its own peculiar problems.

Another of the problems common to all subprojects to a greater or lesser degree is that of erosion and/or sedimentation. While common to all, this basic problem manifests itself in different ways in the various areas.

Still a third land and water problem common to all is irrigation and drainage. Again, solutions to this problem will vary from subproject to subproject.

Incidental and intangible benefits will be common to all subprojects. Among them are improved public water supply, improved public health and sanitation, and many other improvements both of a social and an infrastructural nature.

Flood control is a very real need, but it is in the lower Citanduy/Ciseel River System that floods create havoc to a varying degree each year. To a lesser extent, the Segara Anakan area is also menaced by flood problems. Recommendations for improvements to handle the recurring annual floods include such measures as channel corrections, levee systems, diversion weirs, floodways, multiple-purpose dams and storage reservoirs, and cut-off levees.

Hydroelectric power development is one activity that is principally associated with the lower Citanduy/Ciseel River System subproject. There are some very minor power production potentials associated with some of the other multiple-purpose storage dams, but they are so small that they may be essentially dismissed from further consideration.

Water and land reclamation features are quite well confined to the Segara Anakan area, although there are some minor problems of this category in the lower Citanduy/Ciseel River System. Such features include the transformation of a lagoon from salt water to fresh, creation of new lands by hydraulic fill, flushing of lands suffering from salt water encroachment, and improved drainage of presently irrigated lands.

Improvement of fluvial and overland transportation are also important considerations of both the Segara Anakan and the lower Citanduy/Ciseel River System.

In all four subprojects, there will be concentrated efforts to produce beneficial environmental impacts wherever possible, and to mitigate adverse impacts where they cannot be completely avoided.

All of the subproject features outlined in the previous paragraphs must receive full attention, but it is doubly imperative that this attention be focused through a closely coordinated program of integral development. Any less intensive program will fail to achieve the potential high level of success that this project area possesses. All of the necessary steps and approaches are fully described and analyzed in this report.

Authorization

This Master Plan was prepared as a part of the Scope of Work of the Contract between the Directorate General of Water Resource Development of the Ministry of Public Works and Electric Power, Republic of Indonesia, and Engineering Consultants, Inc. The contract, signed on July 23, 1973, was for consulting services for the Citanduy Basin Development Project. All work was performed in accordance with the terms and requirements of this contract, and as further approved by the Steering Committee.

Purpose and Scope

The purpose of the Citanduy River Development Project is defined as the development and optimum utilization of the total land, water, and human resources in the Project Area. It involves water management, flood control, irrigation and drainage, reclamation, water storage, multiple-purpose structures, land use and agricultural practices, erosion and sedimentation control, inland navigation, and management systems. The objectives of the work and services described are:

1. To carry out a comprehensive study to determine an optimal pattern of the utilization of the water and land resources within the Project Area.
2. To identify the management system necessary to achieve this pattern of utilization.
3. To consider the environmental impacts of the project.
4. To prepare a Master Plan for the step-by-step development of the Project Area that will lead to the pattern of utilization identified in the study.
5. To prepare feasibility studies for two selected subprojects in the Master Plan for early implementation.

Previous Investigations

According to Indah Karya,[1/] interest in solving some of the problems which arise with discouraging frequency in the Citanduy River basin dates back to many years ago. The solutions to these problems would pose a considerable challenge under the best of conditions, but with the Citanduy River serving as a boundary between the provinces of West Java and Central Java, the problems are compounded and magnified by such competitive actions as "levee battles". Most of the developmental efforts to date have been concentrated on either the lower Citanduy/Ciseel River system or the Segara Anakan and its environs. In the upper watershed areas efforts have been pretty well confined to small irrigation projects and such soil conservation measures as reforestation, the greening program, and contour farming.

In 1938, prior to World War II, the West Java Public Works Office proposed a scheme for harnessing the Citanduy River based on the construction of a complete levee system supplemented by a series of river channel shortening and straightening measures and the construction of strategic flood diversion structures. From the study of existing aerial photos, it can be readily seen that some of these proposed measures were put into effect. The old channel improvement measures are particularly easy to locate on the photos.

However, with the exception of the construction of the Pataruman weir, which was started by the Japanese and completed subsequent to the termination of World War II, interest in undertaking any improvement measures on the Citanduy River languished until late in the 1940's. At that time, Blommenstein[2/] proposed a plan for the control of the lower Citanduy System as well as the reclamation of the Segara Anakan area.

Under the Blommenstein plan the Segara Anakan and the surrounding tidal forest would be converted into a giant polder by leveeing the Citanduy River on both sides and diverting its discharge directly into the Indian Ocean, and by closing off the Segara Anakan from the sea by means of cut-off levees located at the eastern and western outlets to the

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1/ Numbers in the text refer to the list of previous reports studied and reviewed prior to the preparation of this work, and which are enumerated at the end of this section.

sea, respectively. He further proposed that the resulting polder be drained by pumping. He concluded that entry of local rainfall runoff would thus flush the salt water and the area could eventually be converted to productive agriculture.

Subsequent investigations have brought out the impracticability of this plan, principally due to the shortage of electric power for pumping. Instead, Indah Karya[3] proposed that the Segara Anakan should be reclaimed by diverting the flood flows of the Citanduy River into the Segara Anakan. It was estimated that this would result in completely silting in the Segara Anakan within a period of 28 to 30 years.

As a further management measure for the Citanduy River, the Blommenstein proposal included the diversion of a portion of the Citanduy River flow for irrigation purposes in the Lakbok area of West Java, while another portion would be diverted for irrigation purposes in the Sidareja area of Central Java. Runoff water from the basin between the right side levees of the Citanduy River and the Ciseel River would be channeled to the South Lakbok swamp and passed to the Segara Anakan area by means of an inverted siphon under the Citanduy River.

Most of the subsequent schemes for the control of the lower Citanduy River system have included treatment of the Ciseel River as well, but have not included the Segara Anakan as a possible reservoir for the Citanduy flood waters which might be diverted into Central Java. Reclamation of the Segara Anakan was approached as a separate and distinct project.

Following the promulgation of the First Five-Year Plan by the Government of Indonesia in 1969, the Ministry of Public Works and Electric Power issued certain decrees indicating those projects or areas in which the government had an interest in immediate development. The Segara Anakan and the Citanduy River were included as projects of this category. The following listed ministerial decrees classified the Citanduy River as being in Group "A", which signified that its control was in the national economic interest. At this time, only six rivers in the nation met the specifications established for this category.[12] Once the Citanduy River was accorded this classification, a Citanduy River Project organization was set up by the same decrees.

1. 133/kpts/1969, dated April 1, 1969.
2. 134/kpts/1969, dated April 1, 1969.

Early in 1969, P. T. Indah Karya was commissioned to draw up a comprehensive development program for the Citanduy River basin. Its report[1] was published almost concurrently with the promulgation of the previously mentioned ministerial decrees. It is interesting to note that one of the principal conclusions was that "It is obvious that nothing can be done to develop the river basin if no measures are first taken to tackle the problem of floods, since all development projects in the river basin would otherwise carry too many risks."

The Indah Karya report acknowledged the importance of the Wanareja swamp as a natural flood control reservoir, and also noted that the railroad fill and bridge 1452 actually served as a control structure for the release of flood waters from the swamp. However, it was also noted that this was not the basic function of the fill and the bridge and that the retention of flood waters by these structures was a potential hazard for the stability of these important transportation links.

To relieve this undesirable situation, it was proposed that a system of upstream flood control structures be located on the Citanduy River and its principal tributaries. For control of the Citanduy River above its confluence with the Cimuntur River, two alternate possibilities were suggested.

1. Pasirangin Dam and reservoir located just downstream from the town of Tasikmalaya. This scheme would include the construction of an emergency spillway and diversion canal to divert exceptional flood flows into the Ciwulan River for direct disposal into the Indian Ocean.

2. Manonjaya and Ciamis Dams and reservoirs. The creation of these two additional flood storage reservoirs would diminish the importance of the Ciwulan diversion.

No structures were proposed for the Cimuntur River but other land and water management measures such as terracing, reforestation, and other conservation measures were proposed as flood control possibilities.

For the control of flooding on the Cijolang River, the construction of the Matenggeng Dam and reservoir was recommended. This dam site was especially attractive because of the relatively small amount of cultivated land that would be taken out of production.

For various reasons, no large dams or reservoirs were considered for control of the Cikawung River. In the first place, the effect on flooding in the Citanduy River is limited by the small size of the river's basin. High land-use intensity and population density are other adverse features that discourage the creation of large storage reservoirs. Below the confluence of the Citanduy and the Cikawung Rivers, there are no other suitable locations for the construction of flood control dams and reservoirs. In fact, there are no tributaries of any consequence until the Ciseel River joins the Citanduy River at Tunggilis.

For the control of flooding on the Ciseel, it was considered that the ideal solution would consist entirely of upstream control measures, with no levees on either side of the Ciseel. The principal thought behind this proposal was that levees on the Ciseel impede both the natural drainage from rainfall in the lower Ciseel basin, as well as the runoff of Citanduy flood waters when that river overtops or breaks its levees. The Binangun site, just upstream from the Gunung Putri weir, was selected as the ideal location for a flood control dam and reservoir. An alternate possibility was the Pangasinan structure located below the confluence of the Ciseel and the Cikembang River. This would be a long structure that would utilize both the Ciseel and Cikembang Rivers as storage reservoirs. Still a third possibility considered was the construction of the Cikembang Dam on the river of that name and located just south and east of the town of Ciamis.

This report concluded that upstream flood control alone would be sufficient if the structures just discussed were to be constructed. This would allow the Wanareja swamp to be converted to agricultural lands and the drainage situation in the South Lakbok swamp would be improved as well.

These upstream flood control measures would be further supplemented by river training works on the downstream portions of the two principal rivers, the Citanduy and the Ciseel. Typical river training measures proposed were:

1. Completion of channel improvements in progress since 1938.

2. Raising, strengthening, and relocating levees.

3. Clearing of vegetation between river banks and levee locations.

4. Construction of the Cilongkrang diversion structure to divert a maximum of 100 m^3/s from the Citanduy River to the Cibeureum River and on into the Segara Anakan.

5. Construction of diversion works at Nusawuluh to divert approximately 200 m^3/s to the Cikujang River and thence into the Segara Anakan, and 20 m^3/s into the South Lakbok area. In both cases, the diversion was not only to relieve the flood situation, but also to form a sedimentation project for the reclamation of the existing low swampy areas.

Following the completion of adequate flood control measures, the next step proposed was the development of a sound irrigation program for the entire flood plain of the two rivers below Banjar. The amount of additional irrigation supplied would depend upon the quantity of water stored by the proposed flood control reservoirs. In addition to irrigation requirements, it was felt that there would be sufficient stored water available to provide:

1. Flush water for Banjar township.
2. Flushing water for desalinization of the soils in the Cibeureum and lower Ciseel areas.
3. Improved inland water transportation between Kalipucang and Cilacap.
4. Water supply for unspecified purposes.

While not specifically mentioned in the proposed program, it is assumed that adequate drainage would be developed concurrently with the irrigation rehabilitation and expansion program. Drainage would also have to form an integral part of the land reclamation program proposed to be undertaken simultaneously with the irrigation program.

The form of land reclamation proposed for both the Segara Anakan and the South Lakbok areas was the accelerated reclamation through sedimentation. The completion of this phase of development was estimated to require from 28 to 35 years.

Hydroelectric power development was also included as an integral part of the overall comprehensive development scheme. Even though total potential energy production was small, it was still sufficient to be a significant consideration.

Last, but not least, the Indah Karya report took up the matter of adequate project management at all levels. Because the project area lies within the jurisdiction of two different political provinces, it was proposed that overall comprehensive direction and management should rest in an Exploitation Authority. To insure effective management, this authority should operate under the national government, and not under either of the two provinces concerned. As fast as dictated by development needs, this overall Authority should be augmented by such sub-Authorities as:

1. Flood control authority.
2. Irrigation authority.
3. Land reclamation authority.
4. Electric power authority.

Following the publication of the comprehensive development program for the Citanduy basin, P. N. Indah Karya undertook an analysis of the influence of this development on the harbor at Cilacap. The results of this study was published in July 1970.[3] In general, it was concluded that the work on the Citanduy basin and the Segara Anakan reclamation would not adversely affect the channel in Cilacap harbor.

Late in 1970, Bovay Engineers, Inc., a consulting firm with headquarters in the U.S.A., carried out a reconnaissance feasibility study of water resources development in Indonesia.[16] The Citanduy River basin was included in the projects reviewed by Bovay. The principal conclusions expressed in their report were as follows:

1. Development of an integrated program involving flood control, irrigation, hydroelectric power, reclamation, and water supply for domestic and industrial uses is the proper approach for developing the Citanduy basin and should produce great benefits.

2. Possible modifications to the suggested plan, outlined in the report cited above (1969 Indah Karya report) which should be incorporated in future feasibility studies include:

   Re-examination of site locations chosen for construction of dams and reservoirs. Indications are that alternative sites are available and possibly may offer more economical construction advantages when all elements of a multi-purpose project are considered (type of dam, outlet works, spillway, powerhouse, irrigation structures, et cetera).

3. The information available at this time indicates the Citanduy basin has excellent possibilities for successful economic development.

Further studies at a reconnaissance level were initiated by P. N. Indah Karya following publication of the Bovay report. The rather voluminous report of the results of this study was published in 1971.[4/] It is interesting to note some of the introductory remarks presented in this report:

"In developing the Citanduy River Basin, Social Overhead Capital projects will have the priority over Direct Productive Activity projects. Social Overhead Capital can be defined as activities consisting of principal services, of which primary, secondary and tertiary production activities can function." . . . . . .

"The development of the Citanduy River Basin by developing water resources and multipurpose river basin planning, can also be included as an SOC category which meets the following four requirements:

1. Development should serve to facilitate, or in a sense as a base, for developing economic activities.

2. Services provided by Government agencies or private enterprises under governmental supervision.

3. Services which cannot be imported.

4. The required investment to provide these services is characterized by its indivisible technical and high ratio of output investment."

The principal conclusions presented in this report were as follows:

1. Dams on the Citanduy reduce the magnitude and frequency of the Citanduy floods (floods on the Ciseel would still be uncontrolled).

2. Reservoirs will be constructed in the Citanduy and tributary rivers Cijolang and Ciseel.

3. The Citanduy River Basin Project can be accounted for from the economic as well as the social point of view ..... the benefit/cost ratio is between 1.9 and 2.2 at an interest rate of 3.25 percent with an estimated life of 50 years.

The principal recommendations for further design and planning of the Citanduy River basin were:

1. A special study should be carried out to determine construction priorities of the reservoir in the Citanduy River Basin.

2. A comprehensive study should be made for the development of settlement patterns and transportation to guarantee optimum social/economic development in the Citanduy River Basin (see also recommendation No. 7).

3. A survey of sediment, transportation, and redeposition.

4. A survey for design of technical irrigation.

5. Hydrological research.

6. Survey for the designing and planning hydraulic electric power.

7. A special study is required to determine a time schedule for construction and strategy for the development of the Citanduy River Basin.

During 1970 and 1971, Indah Karya was also preparing a river training program for the Directorate of Rivers and Swamps. A report was issued in two parts; one part in 1970, and the second part in 1971.[5] This report noted that river control and training was the first step in an integral flood control program for the Citanduy River basin. The conclusion was reached that physical limitations of the Cibeureum River precluded the use of the proposed Cilongkrang diversion as a significant flood control measure. It was recommended that the capacity of 100 m^3/s formerly proposed be reduced to 10 m^3/s and its function be confined to the supply of irrigation water for the Sidareja area. This report also concluded that the levee elevations recommended would not be overtopped except by floods of a 20 year frequency. It felt that this degree of security was sufficient until the flood control structures recommended for the Citanduy and Cijolang Rivers could be completed some 8 to 10 years in the future. These conclusions were based on the assumption that the Nusawuluh diversion works would be completed with a combined design capacity of 210 m^3/s.

The importance of controlling the Ciseel flood waters in the comprehensive flood control scheme for the Citanduy River system was early recognized by Indah Karya. In 1971, this organization contracted with the Directorate of Rivers and Swamps to conduct a geological and soils mechanics investigation for the location of the proposed Binangun Dam and reservoir. The general conclusions reached were:

1. Many of the geological formations found in the area are quite permeable, and additional tests will be required to determine what remedial measures would be recommended.

2. The soft alluvial clay underlying the proposed dam site is unsuitable as a dam foundation and must be removed.

3. Suitable materials for an earthfill dam are readily available at the dam site.

In 1972, the Directorate General of Water Resources Development issued a technical report on principles of flood control in Indonesia. This report, written by Ir. Sarbini,[11] used the current control program on the Citanduy River as an example. The program outlined by the Ministry for the Citanduy included the following steps:

1. River training and flood regulation system were considered to be absolutely essential before further development could be feasible.

2. The second step was the development of irrigation systems to more intensively support agricultural development, especially rice cultivation.

3. The reclamation of the Segara Anakan and its environs to make the land available for agricultural purposes.

4. The fourth step was the construction of dams and reservoirs for positive upstream flood control, for irrigation water for dry season cropping, and for hydropower purposes.

In addition to the basic steps listed above, the report also recognized the importance of reforestation in flood control in the Citanduy basin. Such steps would be particularly important in flood control on both the Cimuntur and the Cikawung Rivers. Control of the Cijolang would be accomplished by a multi-purpose dam located at Matenggeng, while control of the Ciseel would be effected by a dam and reservoir located near Binangun.

This report estimated that downstream flood control features recommended for the Citanduy River system would give protection against a twenty-year flood, and that the subsequent addition of the upstream control features would considerably increase the protection offered. However, this safety factor was for levee overtopping only. It did not consider levee failure.

Since the Matenggeng dam site was given a high priority as a multi-purpose structure, the Institute of Hydraulic Engineering undertook a foundation and soil mechanics investigation of the site in 1971. In general, it was found that satisfactory conditions existed for the foundation. However, the abutment materials were found to be quite permeable. This would call for some special treatment in the design of the structure. Construction materials were judged to be satisfactory, although the haul distance might be a disadvantage. Certain precautions were recommended in the use of some of the available material.

In 1972, Indah Karya undertook a further study to determine a priority of construction for the three dams proposed for construction on the Citanduy River. Their report was published in December 1972.[8] Of the three dams proposed in the 1969 report (Pasirangin, Manonjaya, and Ciamis) the Pasirangin was eliminated from further consideration because of the high population concentration and the large amount of productive farm land found within the projected area to be flooded by the reservoir. On the basis of other considerations, the Manonjaya proposal was placed ahead of the original Ciamis site.

However, during the course of this investigation, another factor was introduced. It was found that if the Ciamis dam site was moved downstream to a point where the Citanduy and the Cikembang Rivers more closely approach one another, then there existed the possibility of the construction of two dams (one on each of the two rivers) with the reservoirs interconnected by a tunnel system. The flexibility of this possible combination with regard to both flood control and irrigation was very attractive and the conclusion was reached that first priority for further study should be allocated to the Ciamis-Cikembang combination. It was also noted that the construction of the storage reservoir on the Cikembang, in combination with the dam proposed for the Ciseel River at Binangun, would give even further control of the Ciseel flood producing area.

Because of the high priority assigned the Manonjaya site in the previously discussed report, a foundation exploration and soil mechanics investigation was undertaken in 1973.[9] It was determined that with certain precautions an adequate dam could be designed for this location.

In the latter half of 1973, Ir. Sarbini published an evaluation of the execution of the Citanduy Project flood control and reclamation measures to date.[12] In general, he concluded that the downstream flood control measures had been satisfactorily implemented and were serving the local community. He also suggested that certain irrigation and drainage improvements could be undertaken, but that their design must consider the reclamation schedule of the Segara Anakan and its environs. Finally, it was recommended that the development of a master plan for the Citanduy Basin be undertaken along with further investigative efforts on certain specific aspects of the developmental program adopted to date.

It is worthy of note that governmental agencies other than the Directorate General of Water Resources Development are also interested in the development plans for the Citanduy basin. In 1969, Ir. Soerjono of the Directorate General of Forestry of the Ministry of Agriculture published a report on the flood problem of the Citanduy River system.[13] In general, this report agreed with the proposed flood control plan of the Directorate General of Water Resources Development. However, the report also introduced the concept of relocation of the estuary of the Citanduy River so that it would discharge directly into the Indian Ocean. The Consultant has included this concept as a part of the activities included in the reclamation of the Segara Anakan rather than as a flood control measure.

The West Java Forestry Planning Brigade also contributed to the accumulating knowledge concerning the Citanduy River basin. Their paper on forestry conditions in the basin was published in March 1974.[19] The general conclusion on flood control was that a successful reforestation program on the upper watershed areas of the Citanduy River would accomplish a reduction in the sediment arriving at the potential reservoir sites of some 3,250 tons per year.

The Faculty of the Civil Technical Institute, U.G.M., Yogyakarta also participated in this program by conducting several model tests on the Nusawuluh structure. Their conclusions and recommendations are presented in three separate publications.[20] [21] [22]

The reports prepared previously by other consultants and technicians are listed on the following pages. These reports contain much useful data and information. All available studies and reports concerning the development of the lower Citanduy/Ciseel River system have been carefully considered. The entire range of alternatives suggested in previous investigations, as well as the indicated desires and preferences of the client have been given further study. The details of the scheme determined to be the most feasible are contained in subsequent sections of this report, along with the technical evaluations and economic, social, and environmental implications of the project.

List of Previous Reports Studied

1. Development Programme for the Citanduy River Basin (including) Segara Anakan and Its Surrounding Area, P. N. Indah Karya, 1st Edition, 1969, 2nd Edition, October 1972.

   A Federal Welfare Plan for the Western Part of Java, Prof. Dr. Ir. W. J. van Blommenstein, December 1948.

3. The Influence of the Development in the Citanduy Watershed, Segara Anakan, and Surroundings to the Cilacap Harbor, P. N. Indah Karya, July 1970.

4. Reconnaissance Report for the Development of Citanduy River Basin and Segara Anakan and Surroundings, P. N. Indah Karya, 1971.

5. Notes of Explanations and Calculations River Training from Railway Bridge 1452 as Far as the Ciseel/Citanduy Confluence, P. N. Indah Karya, 1971.

6. Design Analysis for Nusawuluh Floodway, P. N. Indah Karya, 1971.

7. Explanatory Notes on Differential Leveling Second Order Precision (Spirit Level) and the Installation of the Citanduy Bench Marks, Based on the Cilacap Mean Sea Level Datum, N. V. Pancha Bawana, 1972.

8. Citanduy Project, Three Reservoir Damsites in the Citanduy River, P. N. Indah Karya, December, 1972.

9. Report on the Soil Mechanics Investigation for the Design of Cirahong Reservoir Dam, Manonjaya-Eastern Priangan, Institute of Hydraulic Engineering, April 1973.

10. A Survey on the Geology and Soil Mechanics of the Gunung Putri Area of the Citanduy Project, P. N. Indah Karya, June 1971.

11. Flood Control in Indonesia with Citanduy Downstream Course as a Case, Ir. Sarbini, 1972.

12. The Evaluation of Citanduy Flood Control Execution and Reclamation Considerations, Ir. Sarbini, 1973.

13. Citanduy Flood Problem, Ir. Soerjono, Department of Agriculture, Directorate General of Forestry, Forestry Research Institute, 1969.

14. Agricultural Survey Area I, Left Citanduy, Survey Team of the Faculty of Agriculture, Gajah Mada University, 1973.

15. Hydrometeorological Data Collecting and Processing, Citanduy Project, 1973-1974, Biro Teknik Umum VIDEO.

16. Reconnaissance Feasibility Studies, Water Resources Development, Indonesia, Teluk Lada Area, Tjitanduj River Basin, Solo River Basin, Bovay Engineers, Inc., December 1970.

17. Explanatory Notes, Water Balance, Irrigation/Drainage Project, Sidareja Plain, P. N. Indah Karya, December 1972.

18. Soil Investigations of the Rawa Lakbok Area Near Banjar, Soils Observation Institute, 1938.

19. Forest Condition in the Citanduy Water Basin, West Java Forestry Planning Brigade, March 1974.

20. Report on the Hydraulic Model Test for the Emergency Spillway Construction, Nusawuluh, Citanduy, Faculty of Civil Technical Institute, U.G.M., Yogyakarta, August 1971.

21. Report on the Hydraulic Model Test of the Flood Diversion Construction and Permanant Reclamation of Nusawuluh Citanduy, Faculty of Civil Technical Institute, U.G.M., Yogyakarta, August, 1971.

22. Report on the Hydraulic Model Test of the Flood Diversion, Construction, Its Location and Canal Direction, and Permanent Reclamation of Nusawuluh Citanduy, Faculty of Civil Technical Institute, U.G.M., Yogyakarta, 1972.

23. Reconnaissance Alternate Study Reclamation Scheme Segara Anakan and Surrounding Swamps (With Emphasis on the Biological Process), P. N. Indah Karya, 1973.

24. Djeruklegi Reservoir as Potential Source for Cilacap Water Supply, P. N. Indah Karya, 1971.

25. A Study of the Ecological Aspects and Fishery in the Segara Anakan, Purwito Martosubroto and Achmad Sudrajat, Research Institute for Sea Fishery, Jakarta, 1974.

26. The Rawa Lakbok, An Eutrophic Topogenous Peat Deposit in Java, B. Polak, Institute for Soil Research, Buitenzorg, Java.

27. City Water Supply, Public Works Service, Tasikmalaya, 1973.

CHAPTER II

GENERAL DESCRIPTION

Physical

Geography

The Citanduy Project is located on the southern coast of the island of Java, about 300 kilometers southeast of the capital city of Jakarta. It lies between approximately 7°00' and 7°40' south latitude and 108°15' (west of the town of Tasikmalaya) and 11[illegible]°15' east longitude (about the town of Cilacap). It is bounded on the east by the Serayu River basin; on the north by the Cimanuk River basin; on the north and west by the Citarum River basin; and on the south and west by the Indian Ocean, the Ciwilas River basin, and several small river basins all discharging into the Indian Ocean (See Plate II-1 and Plate II-2).

By the contract, neither Nusa Kambangan nor Cilacap were included within the project area. However, subsequent studies indicated that both areas had to be considered to a certain degree. Nusa Kambangan cannot be ignored because the swampy areas on its north coast must logically be included in the proposed reclamation plan, while at least two quarry/borrow pit sites for the cut-off levee materials will be located on the island. The city of Cilacap's future fresh water supply is an important justification for the proposed reclamation project, and, should the reclamation scheme become a reality, adequate measures must be taken to avoid any possible undesirable silting effects on Cilacap harbor.

As indicated on Plate II-2 and Plate II-3, the Citanduy Project area is composed of two distinct and easily identifiable geographic segments, the names and respective areas of which are:

1.	The Citanduy/Ciseel River system	350,000 ha
2.	The Segara Anakan and its tributaries other than the Citanduy River system	96,000 ha
	Total Citanduy Project area	446,000 ha

The Citanduy/Ciseel River System, as shown on Plate II-4, stretches from the headwaters of the Citanduy River in the west to the origins of the Cikawung River in the east, and from the headwaters of the Cijolang River in the north to the origins of the Ciseel River and the Cikaso River in the south. The system discharges either into the Segara Anakan or into the Indian Ocean through the strait between Nusa Kambangan and the mainland, depending upon the prevailing tidal flow. The topography of the area encompassed by the system and the characteristics of the two principal rivers in the system lend themselves to further subdivision - the upper watershed of the Citanduy/Ciseel System and the Lower Citanduy/Ciseel River System. The dividing lines are the two points where the two rivers emerge from the uplands into the flood plain. For the Citanduy River and all its principal tributaries except the Ciseel River, the line of demarcation is further fixed by railroad bridge 1452 on the main line of the railroad from Bandung to Yogyakarta. The respective areas of the two subdivisions are:

1.	Citanduy/Ciseel Upper Watershed System	290,000 ha
2.	Citanduy/Ciseel Lower System	60,000 ha
	Citanduy/Ciseel River System	350,000 ha

The Segara Anakan and its tributaries (other than the Citanduy/Ciseel River System), as shown on Plate II-3, extends from the Sidareja Lowlands and the origin of the Cikujang River in the west to the headwaters of the Jeruklegi River in the east, and from the headwaters of the Cihaur River in the north to Nusa Kambangan in the south. Again, the topography and the physiographic characteristics of the 96,000 ha encompassed by the area simplify further subdivision - The Segara Anakan and its envisions and the Sidareja East and North area. This delineation is shown on Plate II-2, and the respective areas are:

1.	The Segara Anakan and its environs	32,500 ha
2.	The Sidareja East and North area	63,500 ha
	The total Segara Anakan area	96,000 ha

Each of these four areas, while they constitute separate and apparently independent units, are actually quite interdependent. This is not meant to imply that development programs cannot be staged independently for each area, but it can be said that their mutual interrelationships are such that any developmental effort expended on one is certain to produce secondary effects in one or more of the others. Furthermore, in subsequent portions of this report, it will be shown that a certain amount of overlap cannot be avoided in the formulation of subprojects. For instance, Plate II-5 indicates that for subproject operation purposes the area of the water management scheme proposed for the Lower Citanduy/Ciseel system also includes the Matenggeng Dam and its reservoir, which is located some 11 to 12 km north of the confluence of the Cijolang River and the Citanduy River. Furthermore, the Sidareja area, which is the northwest tip of the Segara Anakan subproject area, is also included within the Lower Citanduy/Ciseel subproject area. Finally, some 20,500 ha along the upper side of the Segara Anakan subproject area are common to both this subproject area and the Sidareja East and North area.

Physiography

From the physiographic point of view, the Citanduy Basin Project area is dominated by three prominent features as shown on Plate II-3. These are:

1. Volcano Sawal with a summit elevation of 1,764 m, and lying entirely within the northwest segment of the project area.

2. The Citanduy River which flows a total length of some 175 km from its origin at elevation 1,721 m on the northwest slopes of Mount Sawal to its sea-level discharge into the Indian Ocean. From Banjar to the sea the river broadens into the broad Citanduy Valley, which includes Segara Anakan in its lower reaches.

3. The Segara Anakan, a brackish water lagoon which forms the lower end of the Citanduy Valley and which, except for two narrow straits at the east and the west, is blocked off from the Indian Ocean by Nusa Kambangan.

Citanduy River Morphology. The headwaters of the Citanduy River are on the north and west slopes of Volcano Sawal. Its total upper drainage basin, which covers the north, west, and south slopes is about 32,000 ha. The Cimuntur River, a principal tributary of the Citanduy River, collects the runoff from the north and east slopes. As can be seen on Plate II-3, the drainage pattern is quite symmetrical in this area. This upper reach of the river has a total length of some 20 km from its origin to a point west of Tasikmalaya. In this length, the river drops some 1,371 m from its origin to an elevation of about 350 m.

The drainage pattern in the upper reach of the river is incised in residual soils formed from weathered Quarternary volcanic material and Tertiary basalt and andesites, Volcanic ash and debris are mixed with the soils. At higher elevations the soils are andasols; at lower elevations the soils are latasols. The unique properties of these two kinds of tropical clay soils in the Citanduy River basin have been described by Wesley.[1] Because of these relatively deep and steeply sloping channels, the annual rainfall of some 4,200 mm (two-thirds of which is considered to be surface runoff) is safely carried away with little or no flood danger.

Downstream from Tasikmalaya the Citanduy River flows through a narrow, V-shaped valley with steep side slopes and varying in depth from 75 to 100 m. This midstream section, which terminates at Banjar, has a total length of some 62 km and drops 335 m in elevation to an altitude of 15 m at Banjar. In some parts the river meanders in its own alluvium, in which case the average slope is lower, being about 2.5 m/km. A short distance above Banjar the Citanduy River is joined by the Cimuntur River. Below the town of Banjar lies the Citanduy flood plain, which is the area that is plagued by frequent and devastating floods.

The dense drainage patterns, other than the symmetrical drainage pattern of Mount Sawal, are the drainage systems of the hills areas in the Citanduy basin. The middle reach of the Citanduy River lies in this section. On the northern boundary of the basin the hills are the surface expression of an east-west trending anti-clinorium. Below 1,000 m elevation the soils are latosols; above 1,000 m andasols are found. The major tributaries along the northern boundary of the basin are the Cimuntur, the Cijolang, and the Cikawung River.

On the southern boundary of the drainage basin, the most northern slopes of the Southern Mountains drain into the Ciseel River. The headwaters of the Ciseel River are below elevation 1,000 m, and the surrounding soils are latasols. The Cikembang and the Cikaso River are both tributaries of the Ciseel River, and all come out of the Southern Mountains.

The region between the northern and southern hills is known as the Central Depression Zone, a syncline which contracts from its widest lateral extent at the mouth of the Citanduy River to a narrow canyon upstream of the Cimuntur River confluence. Within the canyon reach, the Citanduy River is deeply incised in volcanic rocks and has a slope of approximately 8 m/km.

In many cases in this area, small tributary channels have been obliterated by agricultural practices. In this land-hungry basin, farmers transform small tributary channels into a series of cascading rice paddies. The slopes flanking the tributary are also terraced so that the basin becomes a quiltwork of paddies with only a very small drainage channel alongside the paddies. In the absence of extreme rainfall, this type of transformed drainage basin functions very well in that the release of flood waters is well controlled.

1/ Some Basic Engineering Properties of Halloysite and Allophane Clays in Java, Indonesia, L. D. Wesley, Lyon and Associates.

Below the town of Banjar, the Citanduy River is joined by two additional tributaries, the Cijolang River and the Cikawung River. At this point, the Citanduy River flows through the Wanareja swamp, an area which has historically served as a natural storage area for flood waters racing through the narrow valleys and down the steep gradients which characterize the upper and middle reaches of the river. As the gradient suddenly flattens and the valley widens into the flood plain, the river has traditionally sought relief by overflowing into the swamp. This is the beginning of the lower reach of the Citanduy River, a stretch of about 91 km which drops from an elevation of 15 m at Banjar to sea level at the Indian Ocean. Table II-1 lists some important guideposts along this reach of the river and the respective channel widths at these points. Also included is the same information for the Ciseel River from the point where it emerges from the hills onto the flood plain (Binangun No. 2 dam site) to its confluence with the Citanduy River.

Table II-1

Channel and Flood Plain Widths

Reach	Length of Reach in km	Bankful Width of the River Channel in m
Citanduy River from Banjar Dam site (km 90.5) to the confluence with the Cijolang River (km 76.0)	14.5	75
Citanduy River from the confluence with the Cijolang River (km 76.0) to Bridge 1452 (km 52.3)	23.7	80
Citanduy River from Bridge 1452 (km 52.3) to the proposed cross connection (km 36.0)	16.3	80
Citanduy River from the proposed cross connection (km 36.0) to the Nusawuluh Weir (km 22.5)	13.5	80
Citanduy River from Nusawuluh Weir (km 22.5) to the confluence with the Ciseel River (km 14.5)	8.0	85
Ciseel River from Binangun No. 2 Dam site (km 39.0) to the proposed cross connection (km 18.0)	21.0	40
Ciseel River from the proposed cross connection (km 18.0) to the confluence with the Citanduy River (km 0.0)	18.0	40
Citanduy River from the confluence with the Ciseel River (km 14.5) to the Segara Anakan (km 0.0)	14.5	82

Upon emerging from the Wanareja swamp, the Citanduy River meanders through its flood plain until it reaches the sea. The flood plain is composed of sedimentary deposits built up from sediment brought down from the upper reaches of the river. The form of the cross section of the river and its flood plain is typical of such formations; i.e., it is in the form of a flattened "M" with the areas adjacent to the river sloping away from it instead of toward it. This formation tends to create natural floodways parallel to the main river course. The Ciseel River has followed the same pattern after emerging onto the flood plain; i.e., it has meandered in its course parallel to the Citanduy River. Bed slopes of both rivers are about 0.2 m/km on the plain. Neither river has the flow carrying capacity in the lower reaches that it has in the middle and upper reaches.

Here in their lower reaches both rivers make their final effort to relieve the pressure of excess flow from above by spreading out onto the lower areas of the flood plain. In the past, prior to any development, the natural storage of flood waters on the alluvial plain relieved the extreme lower reaches of the burden of carrying large peak flows that are carried in the higher reaches. The absence of any levee at all on the right bank of the extreme lower reaches of the Citanduy River along with the absence of any signs of serious flooding in this area leads to the conclusion that the river seldom floods there because it has consistently overcome man's efforts to confine it to its banks during its journey through the flood plain.

The Ciseel River joins the Citanduy River near the town of Tunggilis, which is about 14 km above the mouth of the principal river. While the Ciseel River is fairly small in comparison with the Citanduy River, if the flood crests arrive simultaneously at the confluence, the resultant backwater of both rivers is further inducement for both of them to spread out over the flood plain as just described.

It is interesting to note what man has done to date on the Citanduy River in his attempts to bring it under control. Prior to 1931, the reach of the Citanduy River between railroad bridge 1452 and its confluence with the Ciseel River had a meander length of 51 km. The valley length between the same two locations is 32 km, which gives a 1931 sinuosity of 1.6. Our studies indicate that in this same reach of the river it is possible to identify 13 natural cutoffs that were probably made by the river itself. In the same stretch of river, 13 man-made cutoffs were constructed after 1935. On the 1971 aerial photographs of the area, it is possible to locate 26 oxbow lake remnants, which tends to confirm this historical record. From 1948 until the disastrous flood of 1968, there is no record of any additional river training measures being undertaken. However, the river works have reduced the sinousity of the previously described reach of the Citanduy River from 1.6 to 1.2 in 1971. One subreach of this section of the river is now straight for a distance of 10 km.

In most cases, the response of any river which is shortened so severely is drastic. The response of the Citanduy River has been different in that there has been no significant response to a nearly 30-percent increase in river slope for the reach of river in question. A study of the 1935 and 1968 survey maps as well as the 1971 aerial photographs indicates that the banklines of meanders not cut off by developments have remained unchanged by upstream and downstream cutoffs. The bank lines of cutoff reaches have retained their original man-made straight form.

In the 38 km reach of the Citanduy River between Banjar and railroad bridge 1452 only one cutoff has been attempted. This man-made cutoff channel did not develop into the main channel. Instead, the river finally formed its own natural cutoff at another location on the gooseneck bend. Today, there is flow through the small man-made cutoff channel as well as flow through the natural channel, with an island between the two.

There are no indications of any attempts to alter the course of the Ciseel River or to introduce any other kind of river training measures. However, the natural flow pattern of this river has been altered by such measures as diverting the Cikaso River into the Ciseel River at the point where the former emerges onto the flood plain and the diversion of the Cilisung drain into the Ciseel River. However, the present situation of parallel rivers, parallel drains, and parallel levees, both natural and man-made, has created a nightmare drainage arrangement that functions very inadequately, if at all.

After passing through the flood plain, the Citanduy River finally terminates into a narrow strait which separates Nusa Kambangan from the mainland. The river mouth is unobstructed by sediment deposits because of this narrow strait

which is capable of carrying the sediment either into the Segara Anakan, or into the Indian Ocean, depending on the pervailing tide.

The Segara Anakan. The name "Segara" indicates that this once was an inland sea protected from the Indian Ocean by Nusa Kambangan. The origin of this inland sea has not been completely established to the satisfaction of all concerned. One theory is that the entire area underwent a subsidence so that it served as a reservoir for the Citanduy River, the Cibeureum River, the Cihaur River, the Cikande or Jagadenda River, and other tributaries to the area. The other theory, and probably the most logical, is that the present level of Segara Anakan is the result of the worldwide rise in sea level that occurred following the close of the last glacial age.

In any event, at that time the Citanduy Valley became an area of progressive sedimentation starting at the upper reaches at the head of a long inlet formed by the encroaching sea waters. With the passage of time, sediment has been deposited by the tributaries, particularly the Citanduy River during high tide periods. This material has not been carried away by the ebb tides, and the water area has gradually been reduced to its present size. Ultimately, this alluviation would culminate with the filling of the waters of the Segara Anakan by the several rivers that carry their sediment loads into the lagoon.

During the period 1924 to 1970, map and photographic evidence indicates that the encroachment into the water area has been most pronounced on the east and north sides. During this period of 46 years, it is estimated that the water area was reduced by some 1,800 ha. About half of this land growth took place on the eastern side.

From an examination of Plate II-6, it can be seen that the Segara Anakan is not a deep lagoon. The 0.00 contour shown on the plate is LWS (Low Water Spring), or low water level tide at waxing moon. This is the equivalent to -1.10 MSL. Thus the depth of water in the lagoon varies from 0.20 m to 2.6 m below MSL. Of course, there are certain well-defined channels which cross the area and are used for inland transportation routes by small boats at the present time.

Surrounding the brackish water lagoon is a tidal mangrove forest. The total area of the Segara Anakan and its environs is:

1.	The Segara Anakan lagoon, plus sloughs and estuaries	8,150 ha
2.	The tidal swamps and forests surrounding the Segara Anakan	24,350 ha
	Total area Segara Anakan and environs	32,500 ha

The details are shown in Table II-2.

This brackish water lagoon has two openings to the Indian Ocean through which it is subject to tidal action by this sea. One opening is a long narrow opening on the east and the other is located at the southwest corner of the lagoon. The latter is probably the more important as it is both shorter and wider than the eastern channel and carries a much greater proportion of the tidal runs that affect the lagoon.

Table II-2

Areas of Tidal Swamp and Associated Saline Areas, Segara Anakan and Environs

Zones	Landscape Areas (hectare)					
	Tidal Swamp (Mangrove) TS	Tidal Swamp (Formerly Cultivated) TS (C)	Tidal Marsh TM	Cultivated Formerly Tidal Swamp CTS	Cultivated Formerly Tidal Marsh CTM	Totals
West Citanduy	119	---	---	122	---	241
Citanduy-Cibeureum	1,928	558	---	2,658	823	5,967
Cibeureum-Jagadenda	1,882	294	---	1,468	721	4,365
Jagadenda-Ujungalong	4,128	11	206	510	1,774	6,629
Ujungalong-Sapuregel	2,962	---	---	---	---	2,962
Sapuregel-Donan	1,564	---	---	34	41	1,639
East Donan	844	---	---	39	41	924
Nusa Kambangan	1,737	---	---	---	114	1,851
Islands in Segara Anakan	390	---	---	---	---	390
Totals	15,[illegible]	863	206	4,831	3,514	24,968

Figures include minor waterways, as total reclamation land area is 24,350 ha.

Geology

The geology of the Citanduy Basin includes parts of two of the major structural units of Java, the Bandung Zone and the Southern Mountains. These two units, although once part of the same geanticline, differ considerably with respect to land forms, rock types, and structure. Their historical development too has been more complementary than similar, with only relatively short periods during which the two zones acted as a unit. A generalized geologic map of the basin is shown on Plate II-7.

Geomorphology. The most important geologic feature of the Citanduy Basin is the Citanduy valley which averages about 12 km in width and has an overall length of some 50 km, including Segara Anakan. There is another flat, mountain-ringed valley spanning an area of about 15 by 8 km, which is drained by the Cikawung River, a tributary of the Citanduy River. This tributary valley is the result of a structural bifurcation of the Bandung Zone and is the link of the Solo Zone, the eastward continuation of this downdropped crest of the Java Geanticline.

The trough of the Bandung Zone northeastward of Banjar is full of volcanic debris that has engulfed the former valley floor of the Citanduy River and its tributaries. These low dipping deposits virtually leveled the former undulations of the land surface with the deposition of more than 100 m of volcanic breccia, tuff, and sand. The form and relief of the predepositional surfaces are unknown, but the relief was probably not as great as that of today. The source of the Quaternary volcanic rocks was Volcano Sawal. A short distance below its confluence with the Cimuntur River, the Citanduy River reaches the end of the Sawal volcanic rocks and emerges into the broad Banjar Plain, the upper end of the Citanduy Valley.

The Citanduy Valley has a generally planar floor interrupted by hills representative of the older rocks that underlie the valley alluvium. These hills are usually smooth and fairly well rounded and are composed of volcanic breccias or sandy sediments of marine origin. Although the hills are structurally controlled, mostly crestal portions of relatively small anticlines, they may also be considered to be erosional remnants of the older Citanduy Valley surface. Rocks of

these types also underlie much of the watersheds of the Ciseel, Cijolang, and Cikawung Rivers. Land forms in these watersheds are usually simple, small scale ridges and valleys within the sedimentary terrains or rounded hills in the volcanics.

At the southern end of the Citanduy Valley, an island, Nusa Kambangan, is separated from the coast line by a series of narrow waterways and Segara Anakan. The Segara Anakan is the southern end of a branch of the trough of the Bandung Zone and has been downdropped along the fault or flexture that separates it from Nusa Kambangan. Despite the structural subsidence during Pleistocene times, the present submergence of the lagoon is probably the result of post-glacial eustatic rise of sea level.

To the east of the Citanduy River there are a number of relatively small rivers that enter the Segara Anakan directly. The area from which these rivers flow is a plain similar to that of the Citanduy River except that there are a number of areas, apparently nearly surrounded by natural levees, that lie at a lower level than their surroundings. These areas are subject to floods of some duration because of the difficulty of the flood flows draining from the inundated areas.

Geologic Units. Most of the geologic units in the basin are composed of volcanic material, whether as the direct result of volcanic activity, as units that comprise eroded and redeposited volcanic sediments, or as weathered volcanic products. The reef limestones and the marine sediments in the south and southwestern part of the basin are essentially the only non-volcanic rocks present.

The limestone is of Miocene age and is associated with a series of often marly marine sediments and volcanic breccias. Occurrences of the reef deposits are somewhat spotty but they do follow particular horizons and the location of outcrops is generally not difficult. The volcanic breccias seem to be more widespread than the carbonate rocks and are frequently found unassociated with the limestones. The marine sandstones and mudstones, however, form the bulk of the Miocene rocks.

Most of the Pliocene rocks appear to be marine siltstones and fine-grained sandstones. Locally a basal conglomerate is also present. These rocks are, like the Miocene formations, locally closely folded and somewhat faulted. There are also fairly large accumulations of Pliocene volcanic rocks, mostly breccia, tuff, and tuff-breccia.

The Quaternary rocks are the volcanic breccias with relatively minor amounts of tuff-breccia and tuffaceous sandstone that were derived from Mount Sawal. These rocks are found in the northwestern part of the basin; their extent from Sawal toward the southeast, in the direction of Banjar, is about 30 kilometers. There are also Quaternary river deposits, alluvial terraces, and the alluvial plains of the Citanduy River itself.

Historical and Structural Geology. The structural geology of Indonesia is probably the most complex of any region of comparable size in the world. The archipelago forms the border area between the continental shields of Southeast Asia and Australia at its juncture with the deep sea basins of the Western Pacific and the Eastern Indian Oceans. The two more or less stable parts of the archipelago are the Sunda Shelf, which extends southeasterly from the eastern part of the Malay Peninsula and the adjacent South China Sea, and the Sahul Shelf, which borders Australia on the north. The remainder of the area, the larger part in fact, is mobile and the earth movements which began in the region during Triassic time have continued through to the present. The geologic history of the region is traced in great detail in Van Bemmelen's classic, "The Geology of Indonesia", and the summary presented herein is taken entirely from this source.

The sequence of events that affect, indeed have created Java, began in early Tertiary time, although the summary that follows begins during the middle part of that period.

Java is structurally dominated by a geanticline in the south and a geosyncline lying to its north. These gross structures are further subdivided. The geanticline, which contains the entire Citanduy Basin, comprises the Bandung Zone on the north and the Southern Mountains, which border the Indian Ocean. In general, the Bandung Zone is a trough formed by the collapse of the crestal portion of the geanticline, while the Southern Mountains, the southern limb of the geanticline, have been subjected to uplift as recently as Pleistocene time. The Bandung Zone is an area of Quaternary volcanism, while in the Southern Mountains, there has been essentially no volcanic activity since Pliocene time, at least in the areas adjacent to the Citanduy Valley.

The sequence of geologic events recorded in the rocks of the Citanduy Basin starts with the subsidence below sea level of the non-volcanic geanticline that had been formed during the Oloigocene. Volcanic activity began at this time followed by, or more likely, contemporaneously with, the development of reefs and the deposition of marine sediments. These Miocene deposits were then arched up in another geanticlinal structure toward the end of the Miocene, and parts of its crest and northern limit subsided to form the trough of the Bandung Zone. The break between the Southern Mountains and the Bandung Zone is a prominent scarp-like rise that follows the north coast of Nusa Kambangan and the mountains to the southwest of the Citanduy Valley. The hills, such as Gunung Sangkur and Kabanaran, which stand isolated in the Citanduy Valley are subsidiary anticlinal structures which developed on the limbs of the geanticline from the compressive forces at the time of another uplift during the Pleistocene. Further subsidence in the Bandung Zone followed and Sawal Volcano developed and filled the upper end of the valley with volcanic debris. Sawal is now considered extinct.

Seismicity. Although Indonesia is seismically very active, destructive earthquakes have not been common over the years. Many earthquakes occur every year, but most have their epicenters in the adjacent seas and the remainder are distributed over a very large area so that earthquake frequency at a specific place is relatively low.

South Java, in general, has more frequent and more intense earthquakes than North Java, but the destructive effects are probably similar because of the types of geologic formation that underlie the two regions. North Java comprises an area that is largely underlain by young alluvial deposits, while the south is mostly older, more indurated rocks.

Two broad categories of earthquakes can be defined on the basis of cause. The first are related to volcanic activity and are usually the result of rapid subsidence of the ground due to the withdrawal of magmatic material from beneath a nearby volcano. The second type, which are normally of greater intensity and affect a much broader area, are tectonic earthquakes which are caused by shifts which occur during the isostatic readjustment of large blocks within the earth's crust. This type of earthquake usually has a far greater destructive potential than the shallow-seated, volcanic tremors.

A country-wide map showing the expected accelerations caused by earthquakes is available. The map shows lines of equal seismic acceleration as a fractional part of gravity. On this map, the Citanduy River basin is portrayed as lying almost entirely between the 0.15 and 0.30 isosisms, with the higher value line encompassing the Segara Anakan. Other maps in the publication indicate that most of the earthquakes of record have been of the shallow focus type, and that recorded quakes to date from the area have been of an intensity greater than 6.75 on the modified Mercalli scale.

Soils

Upper Watersheds. A general knowledge of the soils of the upper watersheds of the Citanduy/Ciseel River system is desirable in order to better understand the correlated phenomena of erosion and runoff in the upper watersheds and sedimentation in the lower reaches of the system. According to the broad soil map of Java,[2/] the following general soil groups are found in the upper Citanduy/Ciseel River watersheds:

1. Organic Soils
2. Hydromorphic Alluvial Soils
3. Alluvial Soils
4. Regosols
5. Lithosols
6. Andosols
7. Brown Latosolic Soils
8. Reddish-Brown Latosolic Soils
9. Red-Yellow Podzolic Soils
10. Yellow Podzolic Soils
11. Grumosols
12. Mediterranean Soils

The soils to the east of Volcano Sawal at lower elevations are Reddish-Brown Latosolic Soils. These are the soils that are giving the reddish color to the river and stream sediments. They have formed in highly weathered volcanic material, the weathering being to depths of more than 10 meters in places.

At moderately high elevations, Brown Latosolic Soils are found and at elevations of 1,000 meters or more, darker or more yellowish-colored Andosols, Regosols, and Lithosols are usually found. These soils of higher elevations result in the stream sediments having a yellowish-gray color rather than the typical reddish color of the Cijolang and Cimuntur Rivers. The headwaters of the Citanduy River have their origin on the slopes where these higher elevation soils are found.

It appears that altitude may be the main determining factor in the difference in soil color. Also, the higher soils may remain wet longer, with very little drying out, which likely is a factor that results in the formation of the more reddish-colored soils of lower elevations. However, length of time of weathering may also be a factor, the more reddish soils being formed in older volcanic material than the browner or more yellowish soils.

It should also be mentioned that the Andosols in the higher elevations characteristically have surface soils that are fairly high in organic matter. Also, in places there is evidence of periodic volcanic deposits, with weathering and soil formation between periods of deposition. The result is a sequence of buried land surfaces, a rather characteristic phenomenon in areas of recent volcanic activity. Volcano Sawal showed that there have apparently been several showers of ash with weathering in between in alternate layers of organic yellow soil and dark gray organic soils, which would indicate old buried land surface, a rather characteristic phenomenon.

The other soils of the upland areas, Regosols, Lithosols, Red-Yellow Podzolic Soils and Grumosols, are found throughout the hilly and mountainous areas of the Citanduy basin. The Alluvial Soils are found principally on the flood plain of the Citanduy/Ciseel River system, although scattered areas are found along streamways in the hilly areas.

2/ Peta Tanah Tindjau Propinsis Djawa Barat dan Tengah, Lembaga Penelitian Tanah, 1966, scale 1:250,000.

Physical Properties. All of the principal soils encountered in the upper watershed area of the Citanduy/Ciseel River system have been classified according to their erodability.[3] The following statements concerning erosion are based mainly on such groupings:

Andosols - Sometimes called Humid Mountain Soil or Highland Mountain Soil. They are moderately sensitive to gully-type erosion, but are highly permeable.

Reddish-Brown Latosolic Soils (also known as latentic soils), Red-Yellow Soils, and Podzolic Mediterranean Soils - They are all sensitive to both sheet and gully erosion when cultivated.

Regosols - Sometimes called Volcanic Ash Soils or Crater Ash Soils, since they consist of volcanic ash and tuff. They are very sensitive to gully-type erosion, but are highly permeable.

Lithosols - Usually contain limestone. This soil is very easily eroded so that steep reliefs are formed.

Grumosols - Very easily eroded by gully action, but resistant to sheet erosion.

In consideration of previous classifications and discussions, certain conclusions may be drawn as to the erosion hazards to be expected from the tributary basins which affect the downstream portion of the Citanduy/Ciseel River system:

The Citanduy River above its confluence with the Cijolang River - About 60 percent of the watershed is composed of Reddish-Brown and Brown Latosolic Soils and Andosols, 25 percent is Regosols, 10 percent is a Red-Yellow Podzolic Soil, Reddish Brown Latosolic Soils, and Lithosols, and 5 percent is Andosol. Thus, approximately 95 percent of this watershed is sensitive to erosion where disturbed by cultivation and other activities of man.

The Cijolang River - About 75 percent of this watershed is composed of Red-Yellow Podzolic, Reddish Brown and Brown Latosolic Soils, and Lithosols, and about 20 percent is Regosols. About 95 percent of this watershed is sensitive to erosion where disturbed by cultivation or other activities of man.

The Ciseel River - Above the point where the Ciseel River emerges into the flood plain of the Citanduy River, the soils are predominantly Reddish-Brown and Brown Latosolic Soils, Red-Yellow and Yellow Podzolic Soils, Lithosols, and Regosols. Hence, this area is also sensitive to erosion where disturbed by cultivation or other activities of man.

Soils of the Segara Anakan. Reconnaissance-level soil maps of the area are available. The 1:250,000 scale map produced by the Soil Research Institute in Bogor is an example. The Segara Anakan area is found on the Central Java sheet, where it is indicated that the area consists principally of hydromorphic alluvial soils, dark grey alluvial soils, and a small area of red-yellow latosols. However, since the lower areas covered by the alluvial soils were of more interest from the standpoint of reclamation, it was decided that some rather random spot checks would be made of the soils in these areas. The sample sites as shown on Plate II-8 were not truly selected at random, as preference was given to sites not too far from the banks of sloughways, mainly on the basis of easy access from boats.

The soils at all sampling sites were wet when sampled and, since all of the sites are more or less influenced by periodic tidal flows, are naturally perpetually wet. However, the timing of sample collection was such that in most places water level was somewhat below land surface.

3/ Citanduy Flood Problems, Ir. Soerjono, Department of Agriculture, Directorate General of Forestry, Forestry Research Institute, 1969.

The reaction or pH of soils in place in salty tidal swamp or tidal marsh areas is characteristically nearly neutral, and this was borne out in the field in places where tested by colorimetric indicator. In general, because of the wetness and clayiness of the soils, soil pH by colorimetric means was not particularly satisfactory, but wet soil surfaces and water drained from auger samples, where tested, indicated neutral or near neutral reaction. This typical reaction of these continually wet soils in place may be in extreme contrast with the pH of samples on the laboratory after drying and oxidation has occurred. This is discussed in subsequent portions of this report.

All of the soils sampled were hydromorphic and significantly saline in some parts of the profile. The following additional general observations were made:

1. Essentially no stratification was observed in deposited material to depths of sampling (usually about 140 or 150 cm, although deeper penetrations below 2 meters were made in some places).

2. Pieces of mollusk shell were not found to depths of sampling with the exception of two sites - TS16B and TS26. However, no doubt very small pieces would not have been observed in such clayey soil material at the time of sampling.

3. Concretions or nodules were not noticed at any of the sites. Very small concretions would not have been noticed in such clayey soil material at the time of sampling unless they were sufficiently abundant and of size easily felt. A few larger concretions also could have gone undetected at the time of sampling.

4. The content of organic matter, including only partially decomposed plant remains, was appreciable in the soils, but in general the soil material is definitely mineral rather than organic. Sample site TS2 is the only site with organic matter concentration high engough in the lower subsoil to be classed as organic. But even here the plastic behavior of the material was more of clayey than peaty nature.

5. The field ripeness classification (estimated n class) was found to be a useful and significant means of characterizing layers in these continually wet soils. In general, the uppermost layers are riper (firmer) than lower layers, and, in general, soils in young tidal swamp areas are distinctly less ripe than those in older tidal swamp areas.

6. In areas of mangrove-type vegetation, the uppermost 20 cm or so of soil contains a network of both vertical and lateral roots, with some roots extending deeper. There are many small crab and possibly other animal holes. Although distinctly clayey, water moves fairly rapidly through tubular openings in the upper parts of these soils as observed in sample pits below water level. No mounds of any significance, such as may have been built by crustaceans, were observed at the sample sites or elsewhere.

7. No firm substratum layers were encountered except at sites TS20 and TS22 in the eastern part. Here, unrelated firm "blue-gray" mudstone was encountered at rather shallow depths. Pieces brought up by auger could be crumbled by strong finger pressure.

8. Tidal sloughways are stable for many years, as brought out by photo and map comparisons, and by observations in the field. However, some exceptions occur, such as the narrowing of the Penikel mainly by reed growth to the east of the Cihaur confluence.

9. Tidal swamp areas subject to distinct tidal fluctuations have a natural system of drainageways that are quite effective in surface drainage.

Soil Profile Ripeness Classes. Soil profile ripeness classes are based on the degree of ripeness of horizons and the depth of ripeness. Since reclamation in this study is considered only in connection with paddy rice production, the profile ripeness classes shown in Table II-3 are set up as a special set on the basis of a continually high water table and production for paddy rice only.

Table II-3

Soil Profile Ripeness Classes

Soil Profile Ripeness Class	Symbol	Definition
Ripe	R	Ripe to > 20 cm and ripe or w-alpha below to > 40 cm; or, ripe and w-alpha to > 50 cm with w-alpha < 20 cm thick; or, ripe and w-gamma or higher w class to > 60 cm with w-alpha < 10 cm thick and w-beta or w-gamma < 10 cm thick.
Half Ripe	HR1	w-alpha to > 50 cm; or, w-alpha and w-beta or w-gamma to > 70 cm with w-beta < 20 cm thick or w-gamma < 10 cm thick.
Half Ripe Medium	HR2	w-beta to > 60 cm; or, w-beta and w-gamma to [illegible] with w-gamma < 10 cm thick.
Half Ripe Toward Unripe	HR3	w-beta to > 30 cm with w-gamma below to > 60 cm; or, w-beta and w-gamma to > 70 cm with w-gamma < 20 cm thick.
Unripe	UR	Any profile less ripe than those above; commonly w-gamma throughout or w-gamma over w-delta.

In the definitions shown in the table, depths are from the soil surface, and the progression of profile classes is from ripe to less ripe. Also, any higher w class can in part take the place of the w class designated. Thus a profile with w-alpha to 20 cm and w-beta to 65 cm would have a profile ripeness class HR2. Sands and loamy sands with less than 3 percent organic matter, and unrelated firm or hard substratum are not classified, but for ripeness interpretive purposes they can be considered "ripe", since physical ripening problems associated with these soil materials are expected to be minimal. Part of the basis for setting up these special classes is that the uppermost 10 to 15 cm of the soil is ordinarily puddled by wet tillage in preparation for rice transplanting, and this, in effect, is equivalent to creating a significantly less "ripe" physical condition for the uppermost part of the soil.

The soils of tidal swamp areas that are ripe have relatively good bearing capacity and can be walked on by a man without problem. Soils that are half ripe but toward ripe (HR1) can be walked on without difficulty or hazard of sinking other than a few centimeters. Soils that are medium half ripe (HR2) can be walked across with some difficulty, and sinking perhaps up to 5 or 10 cm or so. Soils that are half ripe but toward unripe (HR3) can be walked across only with difficulty, and sinking in places perhaps as much as 15 or 20 cm or so. Soils that are unripe (UR) can only be walked across with great difficulty, and sinking as much as 30 cm or more. Totally unripe material (w-delta), such as in unvegetated recently formed mud banks, cannot be walked across by a man because of deep sinking.

The physical ripening of soils in tidal swamp or tidal marsh areas is essentially a dehydration process. To a more or less degree, this can be caused through gradual natural changes, or more rapidly through changes in drainage brought about by man's activities. The firming up of the upper part of such soils is an important factor in their reclamation for agricultural use.

The deposition of highly clayey material in water favors a rather loose arrangement of the laminar-shaped clay particles into something akin to a random micro-honeycomb structure. On drying, or partial drying, there is a partial

collapse of the honeycomb structure that is accompanied by a change in the points of contact of the clay particles. This change is irreversible; consequently, the loss in water is in part an irreversible loss. Shrinkage and expansion of a clayey ripe soil occurs on drying and rewetting, but in going from an unripe soil to a ripe soil, the expansion on rewetting is not to the same volume as that occupied by the unripe soil. The ripening process, therefore, results in an overall decrease in soil volume (or increase in bulk density) that is mostly irreversible. The consequence is some degree of land surface subsidence.

Lower Citanduy/Ciseel System. As previously mentioned, a soil map, scale 1:250,000 already exists for the entire project area. In addition, in 1973 a semi-detailed soil survey was performed on the left bank of the Citanduy River from Banjar to the Segara Anakan. The results of this work are shown on Plates II-9, II-10, and II-11. The soils on the right bank of the Citanduy are similar except in the Lakbok area, where some 3,000 hectares of peat soils are found.

Lakbok Peat Area. The peat deposits in the Rawa Lakbok, which is the largest topogeneous peat marsh in Indonesia, originated in a basin, which to the south and west is bordered by hills, culminating in the Gunung Sangkur. Gunung Mandalare is situated to the northwest. Those ridges are separated by a depression through which the Citanduy River formerly flowed into the Rawa Lakbok. The elevation in the Rawa itself varies from 10 meters in the north to 7.5 meters in the south. The Rawa covers a total area of about 3,000 hectares and varies in depth up to six meters.

According to B. Polack,[4] the Rawa Lakbok existed in a primeval state until about 1924, when reclamation efforts were undertaken by volunteers recruited from the people of the area. Their efforts were apparently quite successful, for today the actual swamp area has shrunk to about 200 hectares, which is a fraction of its original size. However, the peat soils are still there as a reminder of the past.

A reconnaissance-type soil survey was conducted in 1938.[5] It covered an area of some 10,500 hectares, which included the Rawa Lakbok as well as its environs. The general observation was that even though rice is grown with some success in the higher areas bordering the peat soil areas, the deeper peat soils are not too good for rice cultivation. If adequate drainage is installed, the peat soils dry much too rapidly during the dry season and the crop suffers for lack of moisture. In the wet season, these low-lying lands do nor drain sufficiently to provide the dry environment required during the ripening process and the crop suffers from too much water.

On the other hand, in the higher and better drained parts in the environs of the swamp, dry land crops such as coconuts, etc. flourish. However, it is evident that a well planned "controlled drainge" system will have to be installed before the full production potential of these soils can be realized. Concurrently with the drainage investigations, research should be initiated to determine if rice production is the optimum use for these lands, or if they could more profitably be dedicated to the intensive cultivation of dry land crops.

Sedimentation

Sediments are produced by rainfall impact, mass movement of residual soils, and by stream channel erosion in the headwater areas of the Citanduy basin. These sediments are transported by the river system to the alluvial plain. In the

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4/ The Rawa Lakbok, An Eutrophic Topogeneous Peat Deposit in Java, B. Polack, Institute for Soil Research, Buitenzorg, Java.

5/ Soils Investigation of the Rawa Lakbok Area Near Banjar, J. Th. White, Soils Observation Institute, Bandung, 1938.

undeveloped system, some of the sediments were transported directly through to the mouth of the Citanduy River, but a significant portion of the material was temporarily stored on the flood plain with the flood waters; and some sediments were left as a permanent deposit on the flood plain.

On a superficial basis, it appears that the main source of supply of suspended load to the rivers is slope wash from unvegetated soil slopes. The degree of slope, steep or gentle, probably has little effect on sediment yield rates. The primary control appears to be exerted by antecedent soil moisture conditions. Drying of the surface soil layer causes the aggregation and separation from the main soil body of clay particles. These aggregates are easily displaced by rain-drop impact, and overland sheet and rill flow entrains the particles and moves them to the nearest waterway. The thickness of this layer of easily detached soil is generally fairly thin, usually under one-half centimeter. This is essentially the maximum depth that can be removed in one intense rainstorm. If no fairly lengthy period of dry, hot weather intervenes, the next rainstorm will probably remove only a negligible amount of soil.

The residual soils on Volcano Sawal and the hill areas, which together make up 85 percent of the Citanduy drainage basin, are being eroded by rainfall impact and by stream channel cutting. The sediment yield from these headwater areas is crudely estimated to be 15 million metric tons per year. That is an average of about 5 mm of soil removed from over the entire headwater area each year.

Landslides and other mass movements of soils and loose rock that reach an active watercourse are probably a significant source of sediment also as the flowing water easily entrains material from the toes of such masses. The evaluation of landslide prevalence in the basin is very difficult because of the land preparations carried out by farmers. As soon as a slide, even a small one, moves down, it is terraced and farming begins, frequently rice culture. The slides generally provide more gentle slopes for this purpose than the pre-existing hill side slopes. Locally, it sometimes appears that landslides have been deliberately encouraged!

Actually, the sediment yield in the Citanduy basin varies greatly from one small watershed to another. For example, on the east side of Volcano Sawal, one stream is red with sediment and bars of silt are deposited along the bank lines. In the neighboring stream, clear water is cascading down a river bed covered with large boulders. In general, more sediments are obtained from the east side of the volcano than from the west side.

Analyses of suspended sediments samples collected in the Citanduy River system show that the suspended sediment is mostly silt. The river waters in the Citanduy basin have a very turbid appearance. The Citanduy River proper and its tributary, the Cimuntur River, are reddish in color even at low flow. In the Cijolang River and the Cikawung River, suspended sediments give the water a more grayish appearance.

Within the river channel system there is some active bank-line erosion taking place. In the lower reaches, the erosion is in the form of slip-circle failures of a few meters of bank-line length. Local reaches of some bank-lines have a scalloped appearance. There is no net river channel widening and very little channel migration because the slip-circle areas fill in with sediments deposited by the river.

There are no records of past and present rates of deposition on the alluvial plain. In local spots along the natural levee, there are silt deposits eight centimeters thick that appear to have been deposited by one flood.

Sediments delivered to the mouth of the Citanduy River are either carried into the Segara Anakan or out to the Indian Ocean depending on the direction of tidal flow. From data available, there has been no build-up of Citanduy sediments in the strait connecting the west side of Segara Anakan to the Indian Ocean but Telute Bulu to the west of Pasir Kabujutan has changed its shore line completely and a new strip of land about 200 to 300 meters wide along the shore line indicated on the 1:50,000 Djodjok-Kidon map sheet is cultivated to rice. At ebb tide most of the Citanduy sediments are delivered directly to the Indian Ocean. At rising tide the sediments are first being transported into the Segara Anakan and only a small percentage of the sediment load is being flushed to the ocean with the outgoing tide.

Hydrography

Climate. The climate of Indonesia is primarily influenced by the trade winds, which are, in turn, affected by the monsoons. The monsoons are steady winds of low to moderate intensity that blow over Indonesia from the northwest and southeast for about six months in the year. The climate of western Java is influenced by the Northwest and Southeast Monsoons. The rainfall associated with the Northwest Monsoon, from November through April, is usually significantly greater.

During the wet season, approximately November through April, the North Pacific trade winds are reinforced by the winds diverging from the high pressure centers which occur at this time of the year at about 30° latitude in both hemispheres. These winds pass over the hot equatorial seas (mean surface temperature 29°C) picking up moisture as they go. Because of the block of continental air over Indo-China the direction of the monsoonal movement changes to southerly and finally to southeasterly while crossing the equator. During the remaining months of the year, the Asian temperature pattern causes a reversal in the differential pressure with a corresponding change in the direction of movement of the air mass. As the South Pacific trade wind receives a major contribution from the south hemispher winter in Australia its moisture content is larger, and the rainfall in Java during this period is significantly less. In the Project Area, the low level wind conditions tend to be variable to easterly or southeasterly for all of the year.

To establish the varying climate conditions within the Project Area, climatological data were collected from the stations located at Cilacap, Tasikmalaya and Bandung. The data from Bandung were included to give some idea of conditions at the higher elevations in the basin. Information for these stations is given in Table II-4.

Table II-4

Meteorological Stations In and Near the Project Area

Station	Location	Elevation	Period of Record1/
Tasikmalaya (Airfield)	7° - 29'S 108° - 15'E	350 m MSL	1960, 1971-73
Cilacap	7° - 44' S 109° - 01' E	6 m MSL	1961-1970
Bandung	6° - 54' S 107° - 36' E	772 m MSL	1952-1971

1/ Available for use in hydrologic studies

The station at Tasikmalaya is the only meteorological station located in the Project Area. The station at Cilacap, however, is located immediately on the southwest boundary of the Project Area. Of the two stations, the data from Cilacap appear to be the most reliable as far as consistency and general trends are concerned. The data from Tasikmalaya were quite sparse and exhibited some erratic tendencies. Other data were located, but were not included because of the location of the station being too far away from the Project Area.

The climate in the Project Area is typified by high and relatively constant temperatures and relative humidity. A graphical display of the variations of average monthly climatological data is shown on Plate II-12.

Temperature. The annual temperature range is very small and it would be extremely difficult to attempt to distinguish season by temperature. The constancy of temperature is due to the tropical waters which surround Java. Mean monthly temperatures are shown in Table II-5 for the four stations previously mentioned. It is interesting to note that the general trend of temperature for Cilacap and for Tasikmalaya is the reverse of that for Bandung and Jakarta.

The average temperature in the Citanduy basin is approximately 25°C, and monthly average values have ranged from 32°C at Cilacap to 18°C at Tasikmalaya. At Bandung, the minimum monthly temperature has fallen to 11.7°C, which could provide some indication of the higher-elevation lows in the Project Area. The deviation of the mean monthly from the mean annual temperature is rarely more than 1°C and the difference between maxima and minima is about 7°C in the Cilacap area and from 6°C to 11°C in the Tasikmalaya area. Based on a very cursory review, temperatures in Indonesia have ranged from 1.6°C to 38.5°C.

Table II-5

Mean Temperature

Month	Temperature in Degrees Centigrade				
	Cilacap 1/	Cilacap 2/	Tasikmalaya 3/	Bandung 4/	Jakarta 4/
January	26.7	27.2	25.5	22.8	25.7
February	27.0	27.6	25.8	22.7	25.6
March	26.8	27.4	25.8	23.0	26.0
April	27.1	27.5	25.1	23.4	26.6
May	27.1	27.1	25.1	23.6	26.6
June	26.1	26.3	24.4	23.2	26.3
July	25.2	25.4	23.8	22.7	26.1
August	24.6	25.1	24.6	23.0	26.6
September	25.2	25.8	24.0	23.4	26.6
October	26.5	26.6	25.0	23.5	26.7
November	26.8	27.1	25.0	23.0	26.4
December	27.8	27.1	25.2	22.8	25.9
Average	26.4	26.8	24.9	23.1	26.2

1/ 1961-1972 As reported
2/ 1961-1972 Average of maximum and minimum readings
3/ 1971-1973 Average of maximum and minimum readings
4/ 1952-1971 As reported

Relative Humidity. Relative humidity is high and relatively constant throughout Indonesia, probably as a result of the warm tropical waters surrounding the islands. The average annual humidity in the Project Area is estimated to be 82 percent. The average monthly humidity in Bandung has ranged from 51 percent to 86 percent; in Tasikmalaya, from 70 percent to 84 percent; and in Cilacap, from 78 to 91 percent. The values of mean relative humidity are given in Table II-6. The method used to calculate most of these values is not known. As humidity varies considerably during the day, these values may only generally reflect the mean.

Table II-6

Mean Relative Humidity

Month	Humidity in Percent			
	Cilacap 1/	Tasikmalaya 2/	Bandung 3/	Jakarta 4/
January	84.5	79	83	86
February	83.8	80	78	87
March	84.2	80	78	85
April	85.8	80	82	84
May	84.1	82	79	84
June	83.7	80	77	83
July	83.7	81	75	80
August	82.7	78	72	78
September	81.2	78	70	77
October	82.9	77	72	79
November	84.2	81	79	82
December	85.1	80	81	84
Averuage	84	80	77	83

1/ 1961-1972 As reported
2/ 1971-1973 Average of readings at 0700 and 1300 hours
3/ 1952-1971 Method for estimating mean not known
4/ 1866-1935 Method for estimating mean not known

Sunshine. The percent of sunshine hours is shown in Table II-7 for the stations at Cilacap, Tasikmalaya, and Bandung. The data within the Project Area are not complete nor, in the instance of Tasikmalaya, do they appear to be valid for a long-time average. In addition the values do not appear to substantiate the temperature pattern in the Project Area.

Table II-7

Percent of Sunshine Hours

Month	Percent of Sunshine Hours		
	Cilacap 1/	Tasikmalaya 2/	Bandung 3/
January	46	40	53
February	59	39	54
March	51	54	57
April	53	59	60
May	60	38	65
June	59	47	70
July	49	54	69
August	66	56	71
September	69	39	70
October	54	40	63
November	42	43	55
December	39	34	57

1/ Partial records 1960, 1962-1965
2/ Partial records 1960, 1971-1973
3/ 1952-1971

At Cilacap, 100 percent sunshine hours represents the period from 0800 to 1600 hours. At Tasikmalaya, 100 percent represents the period from 0700 to 1600 hours.

Wind. The lower elevation wind pattern does not correspond to the regional upper air pattern. Table II-8 shows the data at Cilacap and Tasikmalaya. The predominant wind direction is from the southeast quadrant for most of the year but varies from west to south to east at Cilacap during January through March.

Table II-8

Wind Direction and Velocity

Month	Cilacap 1/		Tasikmalaya 2/	
	Direction	Average Velocity in knots	Direction	Average Velocity in knots
January	Variable	4.8	E	4.0
February	Variable	4.9	E	4.3
March	Variable	5.4	SE	4.0
April	E/SE	6.3	E	4.0
May	E/SE	7.7	E	4.0
June	E/SE	8.5	E	4.3
July	E/SE	9.4	E	4.6
August	E/SE	9.9	E	4.6
September	SE/E	10.3	E	5.0
October	SE/E	8.9	E	4.6
November	SE/E	7.1	S	4.3
December	E/SE	5.3	S	4.3
Average		7.4		4.3

1/ 1961-1972, anemometer 11 m above ground surface
2/ 1971-1973, anemometer approximately 5 m above ground surface

As shown in the table, average wind velocities along the ocean are much greater than inland. July through October have substantially higher average velocities; these months coincide with the dry season or the Southeast Monsoon. In other words, during these months the high altitude winds are traveling in the same direction. The yearly average wind speeds at Cilacap are higher than those experienced inland most likely because of the off- and on-shore breezes.

Evaporation. There are no evaporation data recorded in or near to the Project Area except from a station at the Pataruman weir. This station at the weir was established by the Project Office in January, 1974 and uses a pan equivalent to the U.S.W.B. Class "A" pan. None of the recorded data has yet been reduced.

Data from four stations in Java were located and are shown in Table A-15. In general, these data are from stations with similar climatological and physical characteristics such as low elevation, high rainfall, and constant, high average humidity.

The data from Cirebon are reported to be from a De Wild balance pan apparatus. The other stations for which data are available are also assumed to have used the same type of apparatus. The 1942 publication of "Observations Made at Secondary Stations" by the Royal Magnetic and Meteorological Observatory states that "Wild's evaporation balances are used and placed underneath, not inside the meteorological screen.

The project hydrologic studies, in which evaporation data are used, require an estimate of lake evaporation. The Consultant knows of no empirical relationship between lake evaporation or Class "A" pan evaporation and De Wild

evaporimeter data. Therefore, an estimate of Class "A" pan evaporation was made using an empirical relationship reported by J. E. Christiansen.[6]

The equation used to calculate evaporation is

$$E = 0.473\, R\, C_t\, C_w\, C_h\, C_s\, C_e\, C_m \quad \text{(A-1)}$$

in which

- E = evaporation in inches,
- R = solar radiation at the top of the atmosphere in units of equivalent evaporation at 20°C in inches. At 7°30'S latitude, the solar radiation ranges from 14.48 inches in June to 19.09 inches in December,
- C_t = temperature coefficient,
- C_w = wind coefficient,
- C_h = humidity coefficient for average noontime humidity,
- C_s = sunshine percentage coefficient,
- C_e = elevation coefficient,
- C_m = station coefficient.

An empirical relation was used to convert wind velocities at the station level to wind velocity at 10 meters above ground surface. The equation used to make this adjustment is

$$W = W_x \left(\frac{Z}{Z_x}\right)^{1/7} \quad \text{(A-2)}$$

where

- W = the desired wind velocity at height Z,
- W_x = the wind velocity at anemometer height Z_x

Maximum, minimum, and mean relative humidity were converted to noontime humidity using the equation

$$H_n = 0.10\, H_x + 0.4\, H_i + 0.18\, H_m + .032\, H_m^2 \quad \text{(A-3)}$$

in which

- H_n = noontime humidity
- H_x = mean monthly maximum humidity
- H_i = mean monthly minimum humidity
- H_m = mean monthly mean humidity

The results from Eqn A-3 were checked by one year of data consisting of two hourly readings of relative humidity as well as average maximum and minimum values.

Pan evaporation was calculated using Eqn A-1 and the coefficients given in the referenced publication. A coefficient of 0.7 was used to convert the estimate for Class "A" pan evaporation to lake evaporation.[7] The estimates of annual lake evaporation using the data from Cilacap and Tasikmalaya are 1,400 mm and 1,290 mm respectively. The monthly distribution of these annual values is shown in Table II-9.

6/ Christiansen, S. E., Pan Evaporation and Evapotranspiration from Climate Data, ASCE, Journal Irrigation and Drainage Division, June, 1968.

7/ Kohler, M. A., Lake and Pan Evaporation, Water Loss Investigation, Vol. I, Lake Hefner Studies, U.S. Geol. Surv. Circ. 229, pp 127-150, 1952.

Table II-9

Evaporation Data

Month	Evaporation in mm					
	Madiun	Kening	Pasuruan Exp. Sta. 3/	Cirebon 4/	Cilacap 5/	Tasikmalaya 5/
January	127	65	60	56	101	109
February	118	67	48	53	101	99
March	140	62	48	58	106	114
April	138	75	56	62	108	113
May	152	74	62	76	110	92
June	150	108	79	87	106	90
July	146	140	99	111	110	100
August	174	61	122	138	133	114
September	201	126	141	146	149	113
October	205	81	134	126	148	121
November	144	63	98	96	122	114
December	149	68	53	67	106	112
Total	1,844	1,090	1,000	1,076	1,400	1,290

1/ 1958-1971 2/ 1967-1972 3/ 1966-1970 4/ 1936-1946 5/ Lake Evaporation

Note: Station evaporation believed to be from De Wild evaporimeters. Cilacap and Tasikmalaya values computed by Christiansen and multiplied by a factor 0.7.

The estimates of evaporation at Cilacap for August and September are high because of the correspondingly high average wind velocity for these months. Some thought was given to the adjustment of the wind coefficient because the lower Project Area is located back from the ocean and is protected from the full force of the wind by Nusa Kambangan and the relatively higher land at the southwest edge of the Project Area. The possibility that the high average wind velocities were associated with rainfall and, therefore, not a factor in evaporation was also considered. This latter idea was discounted when the daily rainfall at Cilacap was checked for the same period from which the wind data were collected. No adjustment was made to the wind factor.

Rainfall. The network of rainfall stations in and close to the Project Area is quite dense, but there is no coverage in the higher regions of Volcano Sawal and along the high hills forming the northern boundary of the basin. Some of the rainfall records are long-term, going back as far as 1879. There are 46 stations within the project area which have at least five years of consecutive record, and perhaps twenty other stations, adjacent to the basin, which were also considered. The location of most of these stations is shown on Plate II-13. The network is operated by the Institute of Meteorology and Geophysics which has its main office in Jakarta.

The earliest stations in the basin were established at Cilacap and Manonjaya in 1879, closely followed by a station at Tasikmalaya in 1885. A fairly large number of stations was installed between 1915 and 1917 and then additional stations followed periodically after this time.

In mid-1971, the Citanduy Project Organization installed Hallman recording rain gages at ten rain gage stations in the basin. Each of these gages is located next to an ordinary rain gage, and is mounted on a concrete footing and enclosed by a wire fence.

Table II-10 lists most of the stations in and near the Project Area and gives some pertinent data for each of these stations.

Table II-10

Pertinent Data on Rain Gaging Stations

Station No.	Name of Station	Elevation (m)	Duration of Record
1	Dayeuhluhur	198	1915 - 1970
1 a	Warnasari	180	1950 - 1970
4	Majenang [1]	23	1897 - 1970
5	Wanareja	25	1915 - 1970
5 a	Cikukun	100	1918 - 1970
5 b	Panulisan	170	1951 - 1968
5 c	Moncolimo	80	1951 - 1969
6	Cigabel	72	1917 - 1931
6 a	Selogedang	70	1931 - 1970
6 b	Ciwulen	115	1931 - 1968
7	Patenggeng	210	1917 - 1969
7 a	Kawung	25	1926 - 1970
8	Ciseru (Pegadingan)	144	1912 - 1970
8 a	Pasir Canggah	25	1921 - 1930
8 b	Karang Anyar	100	1921 - 1970
8 c	Nanggela	230	1921 - 1945
8 e	Matenggeng	97	1951 - 1968
9	Cisalak	152	1915 - 1928
9 a	Samudra [2]	290	1911 - 1970
10	Karang Pucung	50	1915 - 1970
10 a	Wanasuka	200	1951 - 1968
10 b	Carui	50	1953 - 1970
11	Lumbir	51	1915 - 1970
13	Sidareja	26	1915 - 1970
13 a	Cimanggu	40	1928 - 1970
13 b	Patimuan	6	1935 - 1970
13 c	Kedungreja	4	1951 - 1968
13 d	Rejodadi	40	1953 - 1969
13 e	Gandrung Mangu	15	1954 - 1970
13 g	Tambakrejo	-	1961 - 1970
13 h	Bumirejo	45	1954 - 1960
13 i	Rejomulya	-	1961 - 1970
205 a	Leles [2]	710	1921 - 1970
206	Garut [2]	710	1892 - 1970
222 a	Singaparna [2]	418	1934 - 1970
223	Panjalu [1]	790	1910 - 1973
223 a	Tarikolot (Pagerageung)	360	1918 - 1970
223 b	Ciawi	500	1918 - 1970
223 c	Rajapolah [1]	455	1918 - 1973
14	Kawunganten	75	1915 - 1973
15	Jeruklegi	9	1915 - 1973
16	Cilacap	6	1879 - 1973
224 a	Panawangan	-	1939 - 1970
225	Kawali [1]	300	1909 - 1973
226	Rancah [1]	350	1910 - 1970
227	Sindangrasa	465	1913 - 1941
228	Buniseuri	300	1912 - 1969
228 a	Dayeuh Manggung [2]	1333	1926 - 1969
229	Karangsari	200	1915 - 1970
229 a	Ciamis [1]	208	1912 - 1941
229 b	Maloya	250	1920 - 1931
230	Tasikmalaya (airfield) [1]	350	1885 - 1972
231	Manonjaya	290	1879 - 1970
231 a	Pasirmalang [2]	252	1917 - 1970
244	Langkap Lancar [1,2]	490	1912 - 1957
244 a	Kahuripan	300	1913 - 1968
245	Banjar (Pataruman) [1]	40	1906 - 1970
245 a	Cisaga	139	1950 - 1968
246	Batulawang	25	1911 - 1953
247	Binangun [1]	20	1911 - 1970
247 a	Pamarican	2	1939 - 1970
247 b	Panunjang	200	1951 - 1970
248	Langen	16	1906 - 1970
249	Banjarsari	15	1906 - 1968
250 b	Cikupa	400	1939 - 1970
253	Kalipucang	18	1913 - 1947

Adequate maintenance and replacement of equipment has not been carried out for many rainfall stations. As a result, many station records have been interrupted and even discontinued. Therefore, many stations required intensive analysis to make them usable for the hydrologic studies.

Available Data. The historical monthly rainfall records for 39 stations were assembled from the following sources:

1. Berlage, Prof. Dr. Ir. H. P. "Rainfall in Indonesia, 1879-1941" Institute of Meteorology and Geophysics.
2. Institute of Meteorology and Geophysics, "Mean Rainfall in Java and Madura, 1931-1960, Meteorological Note No. 8, Part 1".
3. Institute of Meteorology and Geophysics, "Rain Observations in Indonesia," annual volumes 1961 to 1970.
4. Institute of Meteorology and Geophysics, unpublished files 1971, 1972.
5. Files in the Institute of Meteorology and Geophysics in Jakarta.

None of the station records is complete. No records are available for the year 1949 at any of the 39 stations. Records for all other years are available at one station and generally at four or more after 1915. The period of missing records may be for one month or as long as several years. The period of available monthly record for the 39 stations is shown on Plate II-14.

Daily rainfall records were collected from 25 stations located within the basin. If possible, records were collected for the period 1950 through 1973. These data are on file in the ECI office.

The records from the ten recording rain gages located in the basin are in the form of unprocessed charts. Some of these data were made available and were converted to rainfall depths. The selected locations of the gages are good and the data could prove to be useful if they are processed and kept complete. These data are filed in the Citanduy Project office in Banjar.

Evaluation of Monthly Records. In general, the monthly records appear to be reliable as only a few stations exhibited erratic tendencies. The major causes of these erratic deviations from the norm are thought to be the relocation of the gage and errors in measurement. In some instances, it appears that a partial record has been inserted as a monthly record.

Twenty-seven stations were selected for detailed analyses based on the length of record and location of the stations. The time period selected for these analyses is 1915 to 1972. Estimates of missing monthly records were made using procedures recommended by the U.S. Weather Bureau. The normal-ratio method was used in most cases. In this method the mean annual precipitation values are used to weigh each station to the index station. Precipitation at the index station is calculated by the equation:

$$Px = 1/3 \left(\frac{Nx}{Na} Pa + \frac{Nx}{Nb} Pb + \frac{Nx}{Nc} Pc \right) \quad \text{(A-4)}$$

where

P = monthly rainfall in mm,
N = mean annual rainfall in mm,
X = represents index station,
a, b, c, = represent correlation stations.

It is desirable to use three stations which are located around the station with the missing data, however, this was not always possible. In a few cases only one station was used. Some judgment was necessary for selecting the index stations in those years with very limited data. Seldom were the same stations used for the entire period over which the data were made complete. For periods when no record exists at any station, the monthly average based on historical record was used. If an extreme value was noted in a station record, it was also checked with data from neighboring stations and accepted or substituted by a correlated value. Much latitude was given to the possibility for an extreme value before any change was made.

After the missing data in the historical record were estimated, a consistency check was made using a double-mass analysis which is a comparison of the accumulated annual precipitation of a station with that of a group of "base" stations. The criteria for the selection of a base station are that it be advantageously located, and have a long-term, reliable record. Only eight stations out of the 27 required a correction due to inconsistency and none of the corrections changed the normal values appreciably.

The eight stations having adjusted records are Samudra (9a), Karangpucung (10), Kawali (225), Rancah (226), Ciamis (229a), Manonjaya (231), Pamarican (247a), and Banjarsari (249).

The average monthly precipitation for the 27 rain gage stations is given in Table II-11.

Table II-11

Average Monthly Precipitation for Stations Located in Citanduy River Basin 1/
(For Period 1915 - 1972)

Station No.	Station Name	Approximate Elevation in m	Precipitation in mm												
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1	Dayeuhluhur	198	393	366	390	311	236	148	122	101	117	300	425	432	3,340
4	Majenang	28	357	323	346	275	190	127	81	66	76	223	362	365	2,790
5c	Moncolimo	80	404	358	362	283	206	146	109	96	112	243	360	390	3,068
6a	Selogedang	70	360	330	340	270	184	128	81	63	82	217	339	349	2,743
7a	Kawung	25	333	301	337	257	179	120	78	59	70	214	334	334	2,616
9a	Samudra	200	428	387	436	344	260	163	110	88	117	310	444	477	3,566
10	Karangpucung	50	354	332	349	280	192	132	83	61	84	246	357	373	2,841
10b	Carui	50	355	327	337	268	188	129	89	64	80	222	345	361	2,763
11	Lumbir	51	352	329	349	281	209	148	106	77	90	259	366	380	2,946
13b	Patimuan	6	246	238	249	214	169	131	100	72	78	223	260	255	2,235
14	Kawunganten	75	286	278	298	262	214	284	156	113	112	319	376	344	2,942
15	Jeruklegi	9	310	287	299	273	236	222	159	139	140	367	410	361	3,196
16	Cilacap	6	328	273	297	316	297	283	237	163	141	375	448	400	3,554
223	Panjalu	700	354	314	351	287	211	123	94	71	83	191	312	367	2,758
223a	Tarikolot	860	344	317	348	260	217	113	108	76	97	226	326	371	2,802
223c	Rajapolah	455	381	330	372	275	218	127	139	91	113	259	378	390	3,073
225	Kawali	300	427	349	383	286	222	146	115	84	103	228	338	418	3,098
226	Rancah	350	431	351	393	296	235	152	104	89	120	240	345	411	3,168
229	Kalangsari	200	489	409	433	326	263	170	145	129	131	280	368	469	3,609
229a	Ciamis	228	394	373	367	276	226	151	150	101	110	259	310	391	3,109
230	Tasikmalaya	350	388	370	397	283	245	167	166	104	126	277	354	394	3,270
231	Manonjaya	290	383	362	378	276	230	154	144	95	109	252	316	391	3,089
245	Banjar	40	339	304	313	233	175	127	99	69	72	201	282	310	2,523
247a	Pamarican	2	310	298	308	226	174	123	105	64	69	190	247	282	2,395
248	Langen	16	453	416	414	319	225	165	119	97	120	271	398	420	3,416
249	Banjarsari	15	279	280	291	214	167	116	108	64	70	188	225	258	2,260
253	Kalipucang	18	279	254	267	253	211	167	158	100	94	277	319	316	2,692

1/ Based on estimated historical records.

Annual and Monthly Basin Rainfall. The rainfall over the Project Area is primarily characterized by high intensity storms of short duration and limited areal extent. These storms are usually convectional in origin as they are triggered by warm air rising off the land mass in the late afternoon. In addition, it is expected that the topography would produce a local orographic effect along the northern boundary of the area and on the southeast side of Volcano Sawal. As mentioned before, there is insufficient data to quantitatively estimate the effect of topography on rainfall in these higher areas.

A very general isohyetal map was constructed from the available data and rainfall trends based on the lower-level rainfall were followed in the higher elevation areas. In other words, if the rainfall was increasing with elevation based on lower-elevation data, the increase was assumed to carry into the ungaged areas if there was some physical justification for the continued increase. The isohyetal map based on average annual rainfall from 1915 to 1972 is shown on Plate II-15. The Theissen Polygon method for areal averaging of precipitation was used to check the annual values obtained from the isohyetal method and to estimate the monthly distribution of the annual values. The mean annual rainfall on the Project Area and its sub-basins, estimated by the Theissen Method and from the isohyetal map are shown below.

Table II-12

Mean Annual Rainfall in mm

Area	Theissen Method	Isohyetal Map
Upper Citanduy Basin	3,121	3,090
Cimuntur Basin	2,917	3,300
Cijolang Basin	3,143	3,500
Cikawung Basin	2,773	3,100
Ciseel Basin	2,629	2,600
Segara Anakan	2,907	2,850
Project Area	2,870	3,000

The values of monthly and annual rainfall calculated by the Theissen Method for the period 1915 to 1972 for all the sub-basins are shown in Tables A-20 to A-25 in the Meteorology Appendix. The decimal portion of the average values has been dropped by the computer and, therefore, the sum of the average values as shown does not exactly equal the total.

The annual rainfall over the Project Area is estimated to be approximately 3,000 mm. With reference to the areal distribution of the annual rainfall, some of the largest rainfall occurs to the southeast around Cilacap. Proceeding to the northwest, a rain shadow is indicated in the Lower Citanduy/Ciseel Rivers area. Rainfall is then assumed to increase to the north due to orographic lifting over the hills forming the northern basin boundary. Farther up the Citanduy River, the rainfall is greatest on the southeastern side of Volcano Sawal. On the northwestern or lee side of the Volcano, the rainfall decreases to the edge of the basin. In the southeastern sector of the Project Area there is a variation in annual rainfall of over 1,200 mm even though the terrain is generally flat. Within the Project Area, there appear to be localized areas which are subject to high annual rainfalls and which are in contradiction with the overall general pattern. From the records of the 27 stations selected for analysis, the maximum recorded annual rainfall was 6,601 mm at Jeruklegi (15) in 1968 and the minimum value reported was 922 mm at Banjar (245) in 1953.

There are two pronounced rainfall seasons in the basin. The wet season occurs from November through April and the dry season covers July through September. The other months can be included in either season. Individual

rain gaging stations in the basin have had periods of as long as four months without measured rainfall. Two months is the longest period that an entire tributary basin showed no rainfall.

The following subsections discuss the rainfall on each of the tributary basins and subproject areas. A choice of annual rainfall by Theissen Method or Isohyetal Method was made for each area based on the physical characteristics of the basin and the location of the rain gages. The monthly distribution was estimated by the Theissen Method.

Upper Citanduy Basin: This basin consists of the Citanduy River basin above the Cimuntur River and is the catchment area for the proposed Ciamis, Manonjaya, and alternative Banjar dams. The Theissen and isohyetal estimates of annual rainfall are approximately the same. The mean annual rainfall is estimated to be 3,121 mm, the monthly distribution is shown in Table II-13. The annual rainfall varied from a maximum of 5,179 mm in 1968 to a minimum of 1,784 mm in 1963. The maximum average basin one month rainfall was 728 mm in December 1946. Zero rainfall will occasionally be recorded basin-wide during the dry season. The monthly distribution of the mean annual precipitation ranges from 13 percent in December to 3 percent in August.

The largest rainfall occurs in the upper portion of the basin on the southern slopes of Volcano Sewal. Annual rainfalls in this area are expected to exceed 3,500 mm. Still further up in the basin the rainfall diminishes probably because of its location in the lee of the volcano.

Cimuntur Basin: The Cimuntur Basin extends into the higher elevations lands along the northern boundary and on Volcano Sawal where there is no adequate coverage by rain gaging stations. The estimate of mean annual rainfall was taken from the isohyetal study and amounts to 3,300 mm, which is 14 percent more than the estimate by the Theissen Method. The annual rainfall ranged from 4,823 mm in 1968 to 1,802 mm in 1918. The maximum single month basin rainfall was 709 mm in December, 1957. Zero rainfall was recorded periodically in the dry period of July through August. On two occasions, the basin rainfall for September was less than 1 mm. The monthly distribution of mean annual rainfall ranges from 14 percent in January to 3 percent in August. The monthly distribution of annual rainfall is shown in Table II-13.

The mean annual rainfall ranges from 3,000 mm near the mouth of the river to over 3,500 mm on the eastern slopes of Volcano Sawal and along the northern boundary.

Cijolang Basin: The Cijolang Basin extends into the mountainous area in the north-central part of the Citanduy Basin and is the catchment area for Materggeng Dam. There are no rain gages located in the middle or upper watershed, and the basin is located on the windward side of the mountain range. For these reasons, the annual rainfall was estimated by isohyetal method. The mean annual rainfall is estimated to be 3,500 mm, which is 10 percent more than the estimate by the Theissen Method. The monthly distribution is given in Table II-13. By the Theissen Method the maximum annual basin rainfall was 4,568 mm in 1956, and the minimum was 1,606 mm in 1953. The maximum monthly rainfall amount was 750 mm in 1926; zero rainfall has occurred in all months between May and October. The monthly distribution ranges from 13 percent in December to 3 percent in August.

The mean annual rainfall is greater than 3,500 mm in most of the upper watershed and decreases to about 3,100 mm near the mouth of the Cijolang River.

Cikawung Basin: The Cikawung Basin also has a significant part of its catchment area in the high elevation ridges along the northern border. The mean annual rainfall is estimated to be 3,100 mm by the isohyetal method which is about 12 percent greater than the estimate by the Theissen Method. The monthly distribution is shown in Table II-13. The annual rainfall varied from a maximum of 4,435 mm in 1968 to a minimum of 1,668 mm in 1963. The maximum one month rainfall was 695 mm in December 1958 and zero rainfall may occur periodically in the dry period June through September. The monthly distribution of rainfall ranges from 13 percent in January to 2 percent in August.

The main stream of the Cikawung River flows through a relatively low rainfall producing area of about 2,800 mm. Its major tributaries, however, all have their source in the northern boundary ridge which receives about 3,500 mm per year.

Ciseel Basin: The Ciseel Basin provides runoff for the Cikembang and Binangun Dams. The mean annual rainfall is approximately 2,629 mm, which is the lowest basin average in the Project Area. The annual rainfall estimates by both methods are very close. The maximum annual rainfall was 3,923 mm in 1968 and the minimum was 1,014 in 1953. The monthly distribution of the mean annual rainfall is shown in Table II-13. The maximum monthly basin rainfall was 654 mm in July 1957, and the minimum is zero which has occurred in all of the dry season months. The monthly distribution ranges from 13 percent in January to 3 percent in August.

The lower Ciseel Basin is in a severe rain shadow and some areas receive less than 2,400 mm per year. The rainfall gradually increases to the west up to some value over 3,000 mm. It is this latter area which would provide inflow to the proposed dams.

Segara Anakan: The average annual rainfall, estimated by the Theissen Method, is 2,907 mm; the monthly distribution is given in Table II-13. The annual basin rainfall has ranged from 4,678 mm in 1968 to 1,654 mm in 1953. The maximum monthly basin rainfall was 808 mm in October 1920. Little or no basin rainfall may be recorded occasionally in the dry season for periods up to two months and four-month basin rainfalls of less than 12 mm have occurred. The monthly distribution of rainfall ranges from 13 percent in November to 3 percent in August.

The rainfall is highest along the ocean in the southeastern area and decreases from 3,500 mm there to about 2,800 mm in the north and about 2,400 mm in the west.

Lower Citanduy/Ciseel River System Subproject Area: This area is defined as the area that will receive benefits from the comprehensive water management scheme. The area, for the most part, is located in a rain shadow and receives some of the lowest annual rainfall in the Project Area. The annual rainfall is estimated to be 2,800 mm from the isohyetal map. The monthly distribution, which is shown in Table II-13, was based on an average of the distributions of the Segara Anakan and the Ciseel Basin.

Table II-13

Monthly Distribution of Mean Annual Rainfall
(in millimeters)

Month	Upper Citanduy Basin	Cimuntur Basin	Cijolang Basin	Cikawung Basin	Ciseel Basin	Segara Anakan	Lower Citanduy/ Ciseel Basin
Jan	397	449	455	394	330	304	325
Feb	345	370	392	363	316	288	307
Mar	379	403	424	384	330	302	321
Apr	291	307	322	304	244	268	259
May	232	241	248	211	194	216	206
Jun	142	155	161	143	133	178	157
Jul	133	119	130	93	117	141	129
Aug	94	99	101	71	75	102	90
Sep	115	116	119	87	91	112	95
Oct	246	248	280	254	216	293	256
Nov	350	356	406	394	272	359	321
Dec	397	437	462	404	311	344	334
Total	3,121	3,300	3,500	3,100	2,629	2,907	2,800

Hydrology. The hydrology of the Citanduy River Basin Project is a complex subject and much too lengthy to be included here. A complete treatment of the hydrology of the project area is included in Appendix B - Hydrology. Short statements on the physiography and morphology of the Citanduy/Ciseel River System and the Segara Anakan are presented in an earlier portion of this chapter.

Tides. Unfortunately, the tide gaging station located in the port of Cilacap has not been in working order for several years, and none of the old data could be located. There are no other tidal gaging stations within the immediate vicinity of the Segara Anakan. The installation of tide gages at several critical points within the subproject area is now underway, but significant results will not be available until the design and pre-construction phase of this proposed subproject. Therefore, all tidal measurements and movements for the study of the project area must be based on published prediction tables.[8] On Plate II-16, the data from the recently installed recording gage in Cilacap has been superimposed on the corresponding tide table predictions. Predicted and actual tide movements are strikingly similar.

However, the action of the tides is a complex phenomenom, and at least a general knowledge of their actions is essential before undertaking the planning and construction of any work affected by them. The theoretical oscillations of tides in the open ocean and coastal waters conform to the mathematical cosine curve (See Plate II-17). Bays and sounds, size, shape, and alignment of coastal indentations, and river estuaries all will exert some effect on net tidal swing (See Plate II-18).

The tide at Cilacap appears to be of the semi-diurnal type with inequality. Although the normal time lapse from high water to the following high water is 12.42 hours for this type of tide, this does not mean that the time from high to low and from low to high is necessarily equal. In areas such as that of the Segara Anakan, it is the usual thing for inequalities to exist.

8/ Tide Tables, Indonesian Archipelago, 1974. Dinas Hidrografi TNI Angkatan - Republik Indonesia.

All tidal predictions for Cilacap are based on a datum plane 110 cm below mean sea level (MSL), which is about the minimum low water level. The tide tables do indicate the magnitude of variation that can be expected due to wind direction, velocity, and duration; barometric conditions; proximity to the estuary; ocean currents; and river flood flows and stages. Table II-14 indicates the extreme high and low tides to be expected at Cilacap in 1974.

It can be seen from this table that the maximum difference between high and low tides occurs during the months of March, May, and September for 1974. However, this may not be true for every year. The change of the relationships of the sun and the moon can cause a gradual tidal swing. All of which emphasizes the importance of the rapid and efficient installation of the tide gages in the Segara Anakan area.

The predicted maximum range of 200 cm represents a high tide of one meter above mean sea level and a low tide of one meter below mean sea level. The maximum highs and lows do not occur on the same day, and thus these ranges are not experienced on one particular day. They may be spaced as much as two weeks apart; i.e., the maximum high tide may occur at the beginning of the month, while the minimum low tide may not occur until the latter part of a given month.

Table II-14

Monthly Range of Tides at Cilacap (In 1974)

Month	Tides (centimeters)		
	High	Low	Difference
January	180	20	160
February	190	10	180
March	210	10	200
April	200	10	190
May	210	10	200
June	200	10	190
July	190	00	190
August	190	10	180
September	210	10	200
October	190	00	190
November	200	10	190
December	190	10	180
Yearly Average			188

Magnitude and Frequency of Floods

To assist in making an analysis of the benefits accruing to flood control, an estimate was made of the area flooded for a given return period and a given level of protection. An analysis of this type was done and published in the Hydrology Appendix. Since that time new and, hopefully, more valid estimates of area flooded have been obtained.[9/] These newer data showed significant changes to the areas flooded, and based on the description of the floods, two events, which were previously used, were replaced. These data are shown below. Also shown are estimates of peak discharge derived from average daily discharge at Banjar or Pataruman stream gages and an estimate of the return period for these discharge values.

9/ Catatan Banjar Pada Daerah Aliran Sungai Citanduy Hilir Dari Tahun 1968, Sampai Dengan Semester I Tahun 1974.

Table II-15

Data for Historic Floods

Date	Area Inundated in ha		Peak Discharge in m^3/s	Return Period in years
	Old	New		
Jul, 1968	20,700	20,700	1,460	10
Nov, 1969	-	8,970	710	1.8
Jul, 1970	-	5,900	530	1.3
Oct, 1971	1,820	5,099	460	1.2
Nov, 1971	4,200	- not used in final analyses		
Jan, 1972	4,500	- not used in final analyses		
Jul, 1973	7,200	6,024	850	2.3
Sep, 1973	25,000	18,400	1,400	9

The new areas were used in the analysis. The areas were reduced to allow for the land flooded on the indicated dates that will still be flooded after implementation of the project. These lands are in the Wanareja Swamp and Lower South Lakbok areas. The reductions were also based on the previously mentioned report.

These adjusted data are plotted on Plate II-19 and it was assumed from this plot that the existing levee system provides protection against the 1.5-year flood.

The studies to determine the area flooded, assuming different levels of protection, were based on the volume of spill. The volume of spill is that volume which flows overbank if no levees are constructed or which flows over and through the levees at failure. Failure was assumed to occur when the levees were overtopped. Three conditions were analyzed: (1) assuming no levees and a bankful capacity of 600 m^3/s; (2) assuming levees have been constructed so as to contain the 10-year runoff; and (3) assuming levees have been constructed to contain the 25-year runoff. For each of these conditions, the 10-year, 25-year, and 50-year stream flows were routed through the system.

The spill volumes for three conditions are shown below.

Table II-16

Spill Volume in MCM

Return Period	10-year	25-year	50-year
No Protection	111	157	197
10-year Protection	-	79	115
25-year Protection	-	-	88

Curves of these data were plotted and an estimate was made of the volume of spill for 1.5-year protection. Using the relation between volume of spill and return period for various levels of protection, and the relation between volume of spill and area inundated for 1.5-year protection, the final curves of area inundated versus return period for no-protection, existing conditi[illegible], 10-year, 25-year and 50-year protection were developed. These curves are shown in Plate II-20.

Land Use

Table II-17 indicates that the total agricultural land area within the project is 415,086 hectares. Since the total project area is 446,000 hectares, the difference is accounted for in non-agricultural land and water areas. This project area land use table is a compilation from the land use statistics for the districts of Tasikmalaya, Ciamis, and Cilacap; portions of each which comrpise the Citanduy River Project area. These district statistics are shown on Tables II-18, II-19, and II-20, respectively.

Table II-17

Use Pattern of Agricultural Land in the Citanduy Project, 1972

District	Land-Use Categories (hectares/percent)						
	Lowland Rice	Upland Crops	Home Gardens 1/	Forest	Plantation	Other 2/	Total
Ciamis	43,484 26	41,800 25	11,247 7	17,857 10	48,448 29	5,914 3	168,750 100
Cilacap	39,362 21	56,599 30	24,371 13	52,886 28	11,206 6	3,345 2	187,769 100
Tasikmalaya	18,202 31	14,650 25	3,923 7	7,899 13	12,702 22	1,191 2	58,567 100
Grand Total	101,048 24	113,049 27	39,541 10	78,642 19	72,356 17	10,450 3	415,086 3/ 100

Sources: Land Use Department, Agricultural Extension Service, Plantation Directorate, Smallholder Estates, and Forestry Departments.

1/ Includes Homes and Yards.
2/ Includes waste lands, government lands, etc.
3/ Total project area is 446,000 ha. The difference is accounted for in non-agricultural land and water areas.

Table II-18

Land-Use Pattern for Tasikmalaya District, 1972

Sub-Districts	Land-Use Categories (hectares)						
	Lowland Rice	Upland Crops	Home Gardens 1/	Forest	Plantation	Other	Total
Pagerageung	2,384	1,792	378	1,420	551	347	6,881
Ciewi	2,367	3,147	540	1,346	543	-	7,943
Rajapolah	1,957	45	312	-	603	-	2,917
Cisayong	2,606	902	225	1,325	1,049	25	6,132
Indihiang	3,395	406	462	962	583	247	6,055
Tasikmalaya	935	171	610	-	370	-	2,086
Cibeureum	2,075	1,451	575	50	1,395	57	5,603
Manonjaya	1,456	2,549	537	107	3,146	160	7,955
Cineam	1,027	4,187	275	2,689	4,462	355	12,995
Total	18,202	14,650	3,923	7,899	12,702	1,191	58,567

Source: Land Use Departments, Agricultural Extension Service, Plantation Directorate, Smallholder Estates, and Forestry Departments.

1/ Includes Homes and Yards.

Table II-19

Land-Use Pattern for Ciamis District, 1972

Sub-Districts	Land-Use Categories (hectares)						
	Lowland Rice	Upland Crops	Home Gardens[1]	Forest	Plantation	Other	Total
Ciamis	2,394	2,064	1,155	1,144	5,743	91	12,591
Cikoneng	1,551	1,887	652	1,235	268	37	5,640
Cijeungjing	1,030	1,740	583	-	4,332	42	7,727
Panumbangan	1,072	1,066	392	1,100	481	279	4,390
Panjalu	2,570	1,177	440	1,245	2,091	2,119	9,642
Cihaurbeuti	1,167	1,057	340	2,534	224	35	5,357
Lawali	1,836	2,589	485	115	817	555	6,397
Panawangan	2,378	2,664	407	217	666	1,226	7,558
Buniseuri	1,454	1,709	240	274	480	62	4,219
Pancah	2,693	4,080	335	712	3,711	182	11,713
Cisaga	2,015	2,843	754	2,879	3,563	82	12,136
Pajadesa	1,834	2,527	435	-	374	194	5,364
Banjar	2,882	627	822	592	5,482	348	10,753
Banjarsari	3,610	2,980	1,777	1,774	3,348	89	12,978
Lakbok	6,022	628	827	-	601	88	8,166
Cimaragas	1,226	2,682	632	20	5,030	18	9,608
Pamarican	3,175	4,047	622	1,175	3,873	356	13,248
Padaherang	3,953	2,735	674	735	5,872	65	14,034
Kalipucang	612	2,698	275	2,106	1,492	46	7,229
Total	43,484	41,800	11,247	17,857	48,448	5,914	168,750

Source: Land Use Departments, Agricultural Extension Service, Plantation Directorate, Smallholder Estates, and Forestry Departments.

1 Includes Homes and Yards.

Table II-20

Land-Use Pattern for Cilacap District, 1972

Sub-Districts	Land-Use Categories (hectares)						
	Lowland Rice	Upland Crops	Home Gardens[1]	Forest	Plantation	Other	Total
Cilacap	1,578	974	2,936	14,379	-	383	20,250
Jeruklegi	1,198	3,643	1,432	3,208	-	142	9,623
Kawunganten	7,188	3,813	3,674	5,800	1,563	404	22,442
Sidareja	3,482	3,584	3,083	1,385	3,886	336	15,756
Kedungreja	8,093	922	2,361	4,500	-	778	17,154
Gandrungmangu	4,764	3,492	2,170	3,612	-	26	14,064
Karangpucung	1,713	6,579	610	2,708	-	71	11,681
Majenang	3,347	4,914	2,085	5,800	-	83	16,229
Wanareja	3,230	7,420	2,935	2,510	1,629	423	18,147
Dayeuhluhur	2,118	13,144	1,359	5,588	2,256	591	25,056
Cimanggu	2,651	8,114	1,226	3,396	1,872	108	17,367
Total	39,362	56,599	24,371	52,886	11,206	3,345	187,769

Source: Land-Use Departments, Agricultural Extension Service, Plantation Directorate, Smallholder Estates, and Foresty Departments.

1 Includes Homes and Yards.

The most extensive single crop is lowland rice, which occupies 24 percent of the agricultural land area. The term lowland rice includes rice paddies in the hill areas as long as these are watered by either rainfall or irrigation. During the rainy season such land is nearly all given to rice crop, but during the dry season other crops are grown where there is a water supply present and drainage conditions will permit the growing of crops other than rice. It is expected that diversification of production on these lands has far greater potential than presently evident. What is necessary to bring this about is a more favorable market price situation for crops other than rice. This will occur as development of the economy proceeds.

Upland-type crops are those which are chiefly grown under rainfed conditions in rolling or hilly terrain. However, the so-called upland crops are not confined exclusively to the upland. These crops can be, and are, grown on the lowlands wherever drainage conditions permit (which is usually restricted to the dry season). The main upland crops are cassava, corn, and sweet potatoes. Of lesser importance are peanuts, soybeans, and table beans. Numerous other food-type crops are grown for local consumption.

Forest areas cover 19 percent of the agricultural land area. (See Plate II-21). All forest land is in government ownership. The major forest type is teak, although pine and mahagony exist in small proportions. The forests are professionally managed on a single-purpose basis for lumber production. Very few, if any, natural stands of timber remain. The mountain slopes have been largely cleared for farming by squatters. The tree plantations largely exist where access was no problem, consequently they occupy rolling foothill lands for the most part.

Plantation crops, including those grown by smallholders, occupy 17 percent of the project area. Of the plantation crops, coconut trees occupy the greatest area and produce the greatest value. Rubber is second in extent and importance. Other plantation crops include cloves, tea, coffee, palm sugar, and citronella. The production of these crops by smallholders having only a fraction of a hectare is common.

Lower Citanduy/Ciseel River System. The land-use data in Table II-21 was compiled from the subdistricts which lie principally within the subproject area in order to obtain a representative land-use pattern. The derived percentages were then applied to the total subproject area with the following results:

Lowland Rice	-	36 percent	-	33,480 hectares
Upland Crops	-	15 percent	-	13,950 hectares
Home Gardens	-	12 percent	-	11,160 hectares
Plantations	-	24 percent	-	22,320 hectares
Forest	-	11 percent	-	10,230 hectares
Other	-	2 percent	-	1,860 hectares
Total		100 percent	-	93,000 hectares

The subdistricts of Banjar and Padaherang have a high percentage of their land area devoted to plantations. The table shows that Kedungreja Subdistrict has 26 percent of its land area in forest, but in fact this land is tidal swamp and mangrove area near Segara Anakan under the jurisdiction of the Forest Department.

Table II-21

Land-Use Pattern for the Lower Citanduy (Ciseel River System

District / Sub-District	Land-Use Categories (hectares / percent)						
	Lowland Rice	Upland Crops	Home Gardens 1/	Forest	Plantation	Other	Total
Ciamis:							
Banjar	2,892 27	627 6	822 8	592 5	5,482 51	348 3	10,753 100
Banjarsari	3,610 28	2,980 23	1,177 9	1,774 13	3,348 26	89 1	12,978 100
Lakbok	6,022 74	628 8	827 10	- 0	601 7	88 1	8,166 100
Padaherang	3,953 28	2,735 19	674 5	735 5	5,872 42	65 1	14,034 100
Subtotal	16,467 36	6,970 15	3,500 8	3,101 7	15,303 33	590 1	45,931 100
Cilacap:							
Sidareja	3,482 22	3,584 23	3,083 19	1,385 9	3,886 25	336 2	15,756 100
Kedungreja	8,093 47	922 5	2,861 17	4,500 26	- 0	778 5	17,154 100
Subtotal	11,575 35	4,506 14	5,944 18	5,885 18	3,886 12	1,114 3	32,910 100
Grand Total	28,042 36	11,476 15	9,444 12	8,986 11	19,189 24	1,704 2	78,841 100

1/ Land in villages

Segara Anakan Reclamation. The land-use pattern in this area is represented by five subdistricts of the Cilacap District. Land-use statistics for these five sub-districts are shown in Table II-22. The percentages shown in the table indicate the portions of land use categories encountered in the whole Segara Anakan Subproject area. Within the area to be reclaimed from tidal swamps and mangroves, only 25 percent of the lands are being farmed, the remainder being waste land.

Table II-22

Land-Use Patterns for the Segara Anakan Area

Sub-District	Land-Use Categories (hectares)					
	Lowland Rice	Upland	Forest Lands	Home Gardens	Other	Total
Cilacap	1,578	974	14,379	2,936	383	20,250
Jeruklegi	1,198	3,643	3,208	1,432	142	9,623
Kawunganten	7,188	3,813	5,800	3,674	1,967	22,442
Kedungreja	8,093	922	4,500	2,861	778	17,154
Gandrungmangu	4,764	3,492	3,612	2,170	26	14,064
Total	22,821	12,844	31,499	13,073	3,296	83,533
Percent	27.3	15.4	37.7	15.7	3.9	100.0

Source: Agricultural Extension Service, Cilacap

Socio - Economic

Population

The population of the Citanduy Basin was 2.5 million persons in 1972. The density was 600 persons per square kilometer. The basin comprises 3.4 percent of the island of Java (with Madura) and has 3.3 percent of its population.

Table II-23

Population Data - Citanduy River Basin, 1962 and 1972

District	Area km^2	1962		1972		Annual Growth Rate
		Population	Density per km^2	Population	Density per km^2	
Tasikmalaya	516	475,351	921	576,818	1,118	1.95%
Ciamis	1,905	890,392	467	1,073,025	563	1.89%
Cilacap	1,772	647,073	365	860,135	485	2.88%
Total	4,193 1/	2,012,816	480	2,509,978	599	2.24%

Source: Bappemka Tasikmalaya and Ciamis. District Government, Cilacap.

1/ Combined area of political subdivisions lying wholly or largely within the watershed boundaries. Planimetered area of Citanduy Basin is 446,000 ha.

Java itself is the most densely settled area in the archipelago constituting only 6.6 percent of the land area comprising the Indonesian nation, but having 63.8 percent of the total population.

Due to the productivity of the land, which varies from place to place, and also to the location with respect to highway and railroad routes, the density of the population is highly varied, geographically speaking. In the lower reaches of the basin where the tidal swamps border the Segara Anakan, population is sparse. Large areas there are not suitable for habitation at all. The few residents of the Segara Anakan live in isolated villages where most of the houses are constructed on wood pilings to elevate them above the water level at high tide. The population of these floating villages is reported to be about 8,000 persons.

For the purpose of describing the population conditions that exist within the Segara Anakan and its environs, a land area of 24,350 hectares is assumed. This comprises the tidal swamps and forests and saline areas. The total population is estimated at 25,000 persons, approximately equally divided between fishing and farming. This population lives in the eight floating villages previously mentioned and around the borders of the swamps.

Heavier settlement, denoted by more frequent and larger villages, occurs along the highways that traverse the basin from west to east and from northwest to southeast along the right and left sides of the Citanduy valley. The density of subdistricts varies from 193 persons per square kilometer in the Dayeuhluhur subdisirict to 7,370 for the Tasikmalaya subdistrict.

The pattern of settlement here is typical of the entire island of Java, and consists of interspersed blocks of farmland and residential areas. Farmers reside in villages apart from their agricultural holdings, which may consist of several small, separated plots. The villages are densely settled and occupy, where possible, the higher areas of ground so that the lower flat areas can be cropped for rice. The density of the village lands is about 2,500 to 5,000 persons per square

kilometer. The cities are even more densely occupied and may have double that population per unit of land area.

The cities of Tasikmalaya, Ciamis, Cilacap, and Banjar are connected by both the major highway and the railroad. Their estimated populations are:

Tasikmalaya	-	128,000
Ciamis	-	26,000
Banjar	-	30,000
Cilacap	-	88,000

Other principal towns in the basin are those constituting the subdistrict headquarters. The population of these smaller towns is not reported separately.

Population Growth. Population records are maintained at the district and subdistrict level. Births and deaths are recorded and, together with the periodic population censuses, these figures provide reliable population statistics. The population growth rate for the 1962-1972 decade is 2.24 percent annually. This compares with the reported rate of 1.9 percent for Java and 2.1 percent for Indonesia as a whole. This population growth, on top of the already dense population situation, poses the problem of maintaining parallel advancements in employment opportunities.

In the Segara Anakan, due to the relative isolation of the settlements, the people must do without many of the prequisites of community life that others enjoy. The result of this is that the quality of life is affected by a "time lag". In other words, conditions affecting these people are about the same as the rest of the population was living under several decades ago. These influences affect life expectancy, educational achievement, and general living conditions. On purely a judgment basis, it can be assumed that population growth within the area would lag behind the rest of the country for two main reasons. Infant mortality and general health conditions have not been improved to the same extent as elsewhere. Secondly, lack of opportunity causes the young, mobile sector of the work force to leave the area to seek better opportunities.

Census data do not reveal the characteristics of the population of the Segara Anakan area separately from the rest of the Cilacap District. The subdistricts which include the Segara Anakan have 52 percent of their population in the under 15 age group. It can be assumed that the Segara Anakan has the same proportions. Quite clearly, there will remain considerable pressure on the resources of the area as these young people come into the work force and child-bearing age.

If the present growth rate of the Citanduy Basin were to continue,the basin population would increase to 4.7 million persons by year 2000. A continuation of this rate of growth would vastly reduce the per capita resources. The means to make sufficient offsetting advances in productivity is not in sight, considering built-in time lags in both population control and productivity increases. Consequently, renewed efforts must be made to upgrade agricultural productivity.

The Economy

Economic activity in the Citanduy River Basin is dominated by subsistence farming. The main crop is rice which accounts for three-fourths of agricultural production. Farms are exceedingly small and labor-intensive due to the extreme overpopulation that exists throughout the entire arable land area. As a result, there is an observable high degree of unemployment and underemployment. It follows, too, that there is practically no mechanization in agriculture and industry.

productivity of labor is low per man-hour and incomes are depressed. However, utilization of the farm land resource is complete.

While these negative factors in the economy can be easily recognized and the causes determined, the solution leading toward an improved level of manpower productivity and income is more difficult to conceive. Family planning, out-migration, education and training, and improved farming systems such as irrigation and drainage, flood mitigation, and better rice varieties are all necessary, but the gains from these cannot come in time to forestall further decline in living standards unless the pace of development is accelerated. Concern for the fair distribution of income must enter into development planning so that the rewards of the development process go principally to those population sectors which most need the help.

Table II-24 shows the estimated employment situation for the Citanduy River basin. It is based on sparse data and should be viewed only as an approximation.

Table II-24

Estimated Employment in Citanduy Basin, 1972

Item	Numbers	Percent of Employed Labor Force	Percent of Total Population
Total population (rounded)	2,510,000		100
Labor Force	778,000	100	31
Employed in Agriculture	622,400	80	
Employed in Manufacturing	31,100	4	
Employed in Government	70,000	9	
Employed in Other	54,500	7	
Disguised Unemployment	351,000		14
Residual	1,381,000		55

Source: Bappemka and Staff Estimates

The supply of workers is so great for the jobs to be distributed among them that large numbers of persons in the employed labor force category undoubtedly have only partial-year employment at these jobs. As explained previously, farmers engage in part-time work off the farm as much as the labor market will absorb. If the disguised unemployment category were to be considered within the labor force, it would represent 36 percent of the persons available for gainful employment.

It is estimated that 80 percent of the population are engaged in agriculture as a primary occupation. The income in this sector is 60 percent of total personal income in the basin. The average annual per capita income in agriculture is Rp 16,560 ($40), whereas in all the other economic sectors it is Rp 44,298 ($107). These data are shown in Table II-25.

The per capita income figures in Table II-25 compare with estimates for Indonesia as a whole which varied between $75 and $100. The Citanduy basin is understandably low because of its isolation from the mainstream of commercial activities in which wages and profits are higher. The income is not equitably distributed among the people. Estimates indicate that 40 percent of the regional income is received by 20 percent of the people, the next 30 percent of the population get 33 percent of all income, and the lower-paid half of the population receives only 27 percent of the aggregate income in the region.

Table II-25

Estimated Personal Income, Citanduy Basin, 1972

	Population	Income			
		Per Capita		Total (millions)	
		Rp	$	Rp	$
Agriculture	2,007,982	16,560	40	33,244	80.3
Non-agricultural	501,996	44,298	107	22,232	53.7
Total	2,509,978	-	-	55,476	134.0
Rounded		21,942	53	55,476	134.0

Source: Bappemka and Staff Estimates

Managerial and professional people have a wide range of remuneration which may include housing and utilities, rice allotment, household help, and transportation. It is understood that it is fairly common practice for some professional and managerial workers to have two jobs. Table II-26 illustrates some representative wage levels.

Table II-26

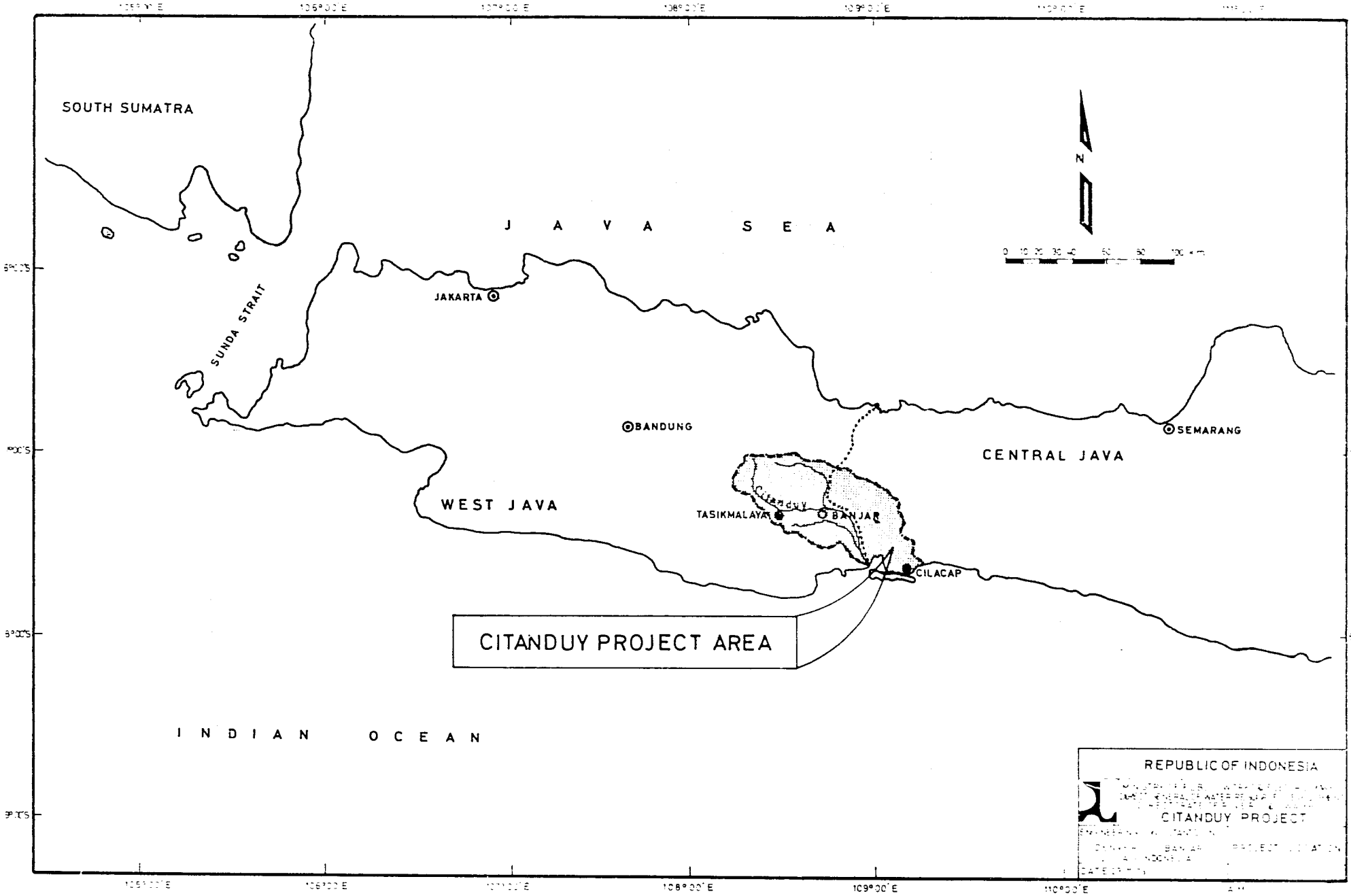
Representative Wage Levels in Selected Occupations

Occupation	Per Day		Per Month	
	Rp	$	Rp	$
Rice field workers: men	250	.60		
women	150	.36		
Handicraft industry worker	80	.20		
Tapioca factory worker	140	.34		
Skilled worker, construction	350	.85		
Truck or bus driver	500	1.20		
Mechanic or Electrician	1,000	2.50		
Office Clerk			6,500	16
High school teacher			20,000	48
Factory manager			30,000	72
Professional: engineer, etc.			31,000	75

Source: Local survey

Within the Segara Anakan area, the principal activity is fishing. There are reportedly about 4,000 fishermen in the area. The average catch per fisherman in 1972 was 123 kilograms valued at Rp 9,745 ($24). These figures place the fisherman in the low income category for the people in the Citanduy basin.

About 30 percent of the lands surrounding the Segara Anakan which at one time were tidal swamp and tidal marsh areas have been cultivated on an intermittent and scattered basis. Since these soils are affected by the brackish water intrusions from the Segara Anakan to different degrees, their suitability for agricultural use is highly variable. It is estimated that there are about 3,500 families engaged in farming here. Most of the farming is carried on within the area administered by the Forestry Department. The production from these lands is generally quite low. Due to the salinity, the yield of rough rice is only about one ton per hectare in the rainy season. During the dry season, the effects of salinity generally preclude any significant production.



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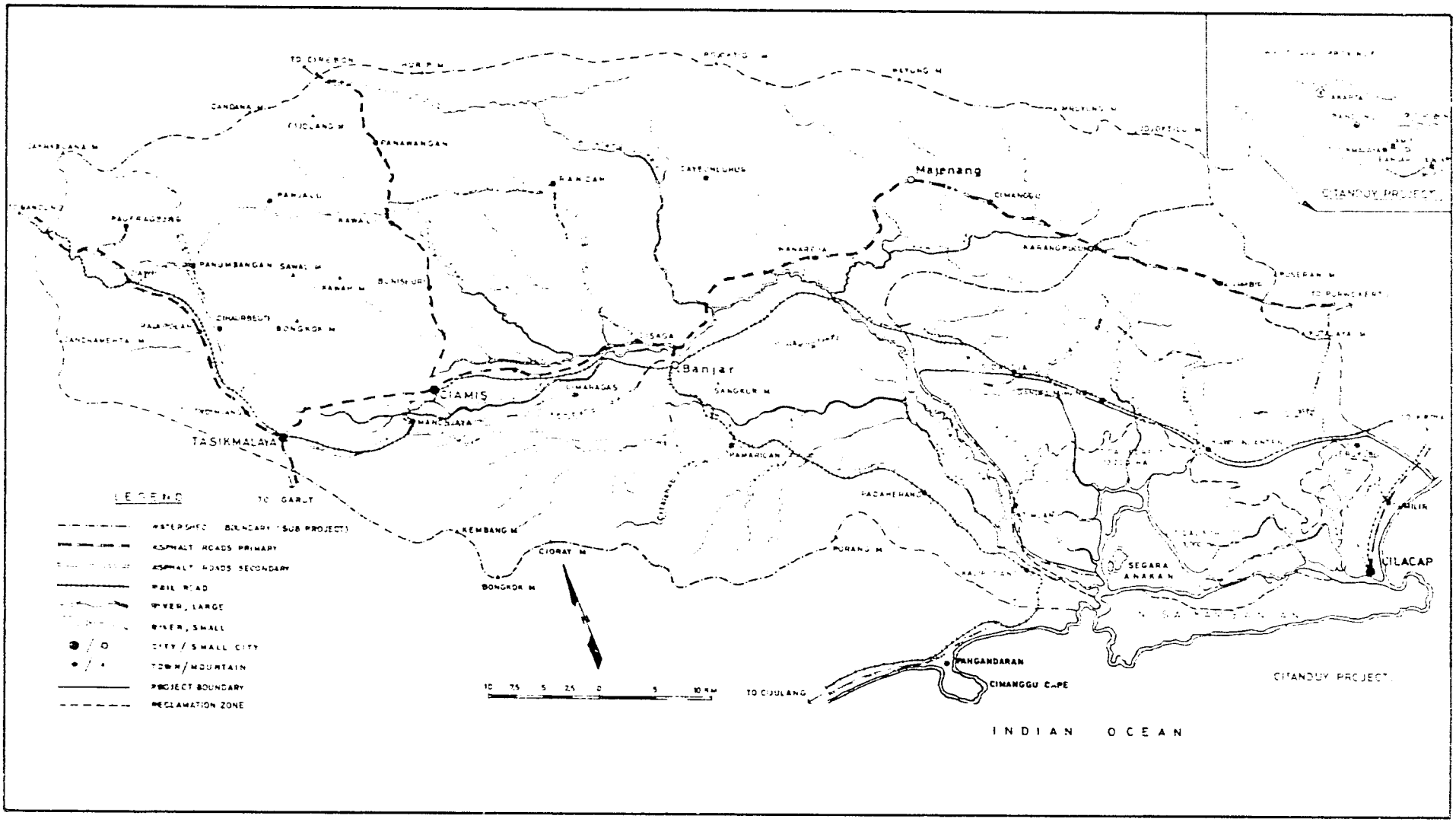
50

PLATE II-1

ENGINEERING CONSULTANTS, INC.



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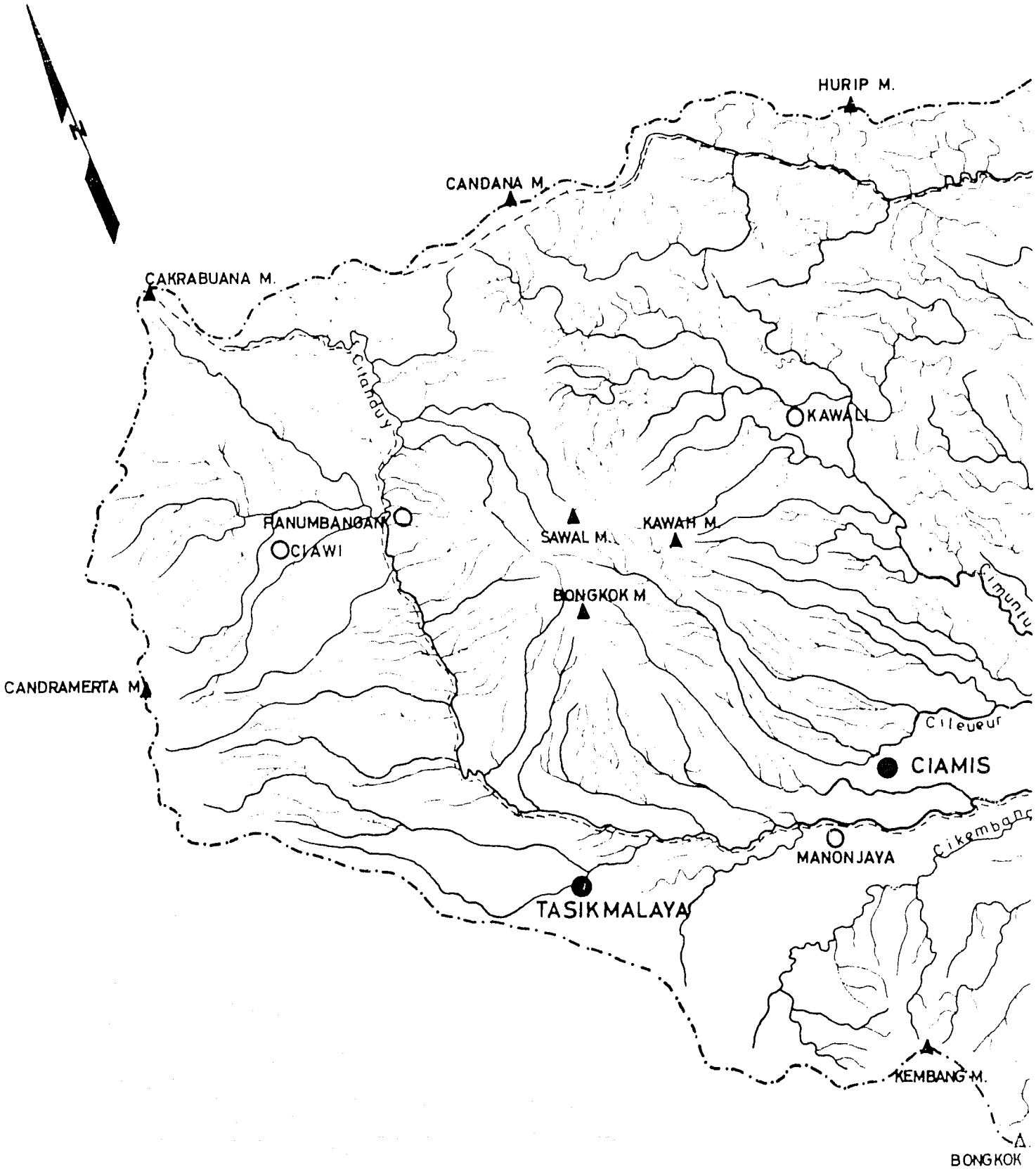
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CANDANA M.
CAKRABUANA M.
Citanduy
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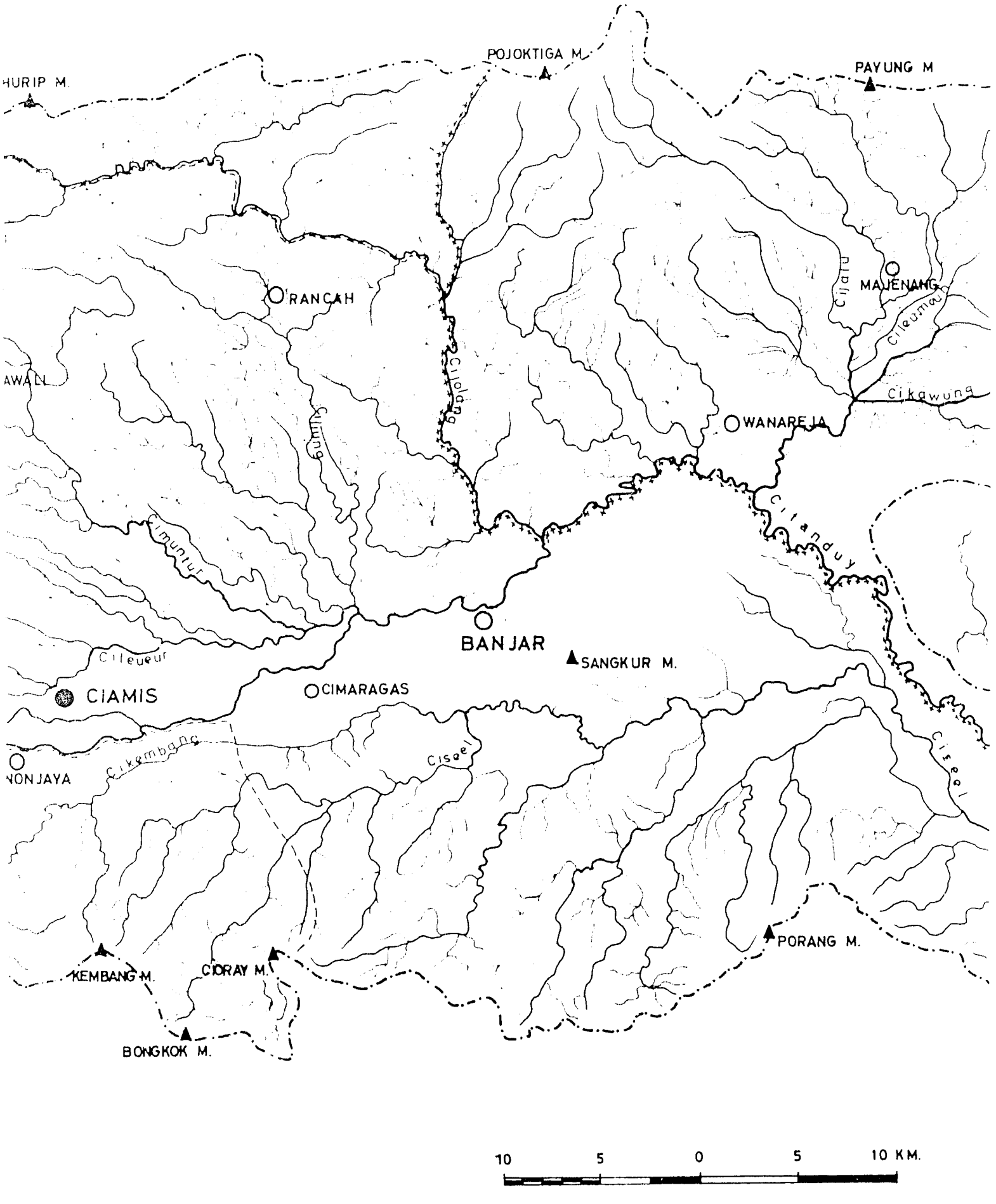
HANUMBANGAN
CIAWI
SAWAL M.
KAWAH M.
BONGKOK M
Cimuntu
CANDRAMERTA M.
Cileueur
CIAMIS
MANONJAYA
Cikembang
TASIKMALAYA
KEMBANG M.
BONGKOK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POJOKTIGA M.
PAYUNG M
RANCAH
MAJENANG
Cijalu
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Cumung
WANAREJA
Cimuntur
Cilanduy
BANJAR
SANGKUR M.
Cileueur
CIAMIS
CIMARAGAS
Cikembang
Cisoel
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PORANG M.
KEMBANG M.
CIDRAY M.
BONGKOK M.
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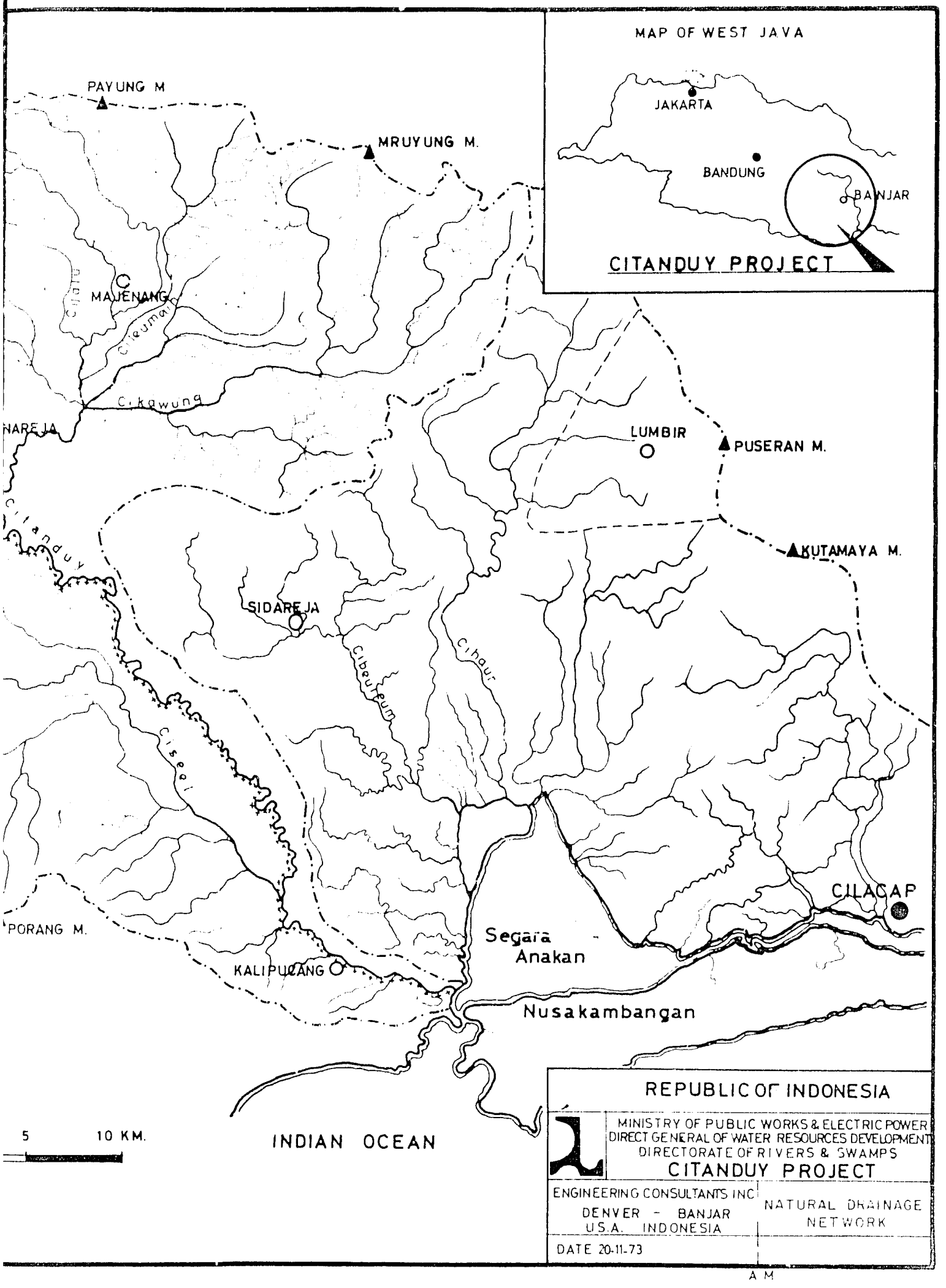
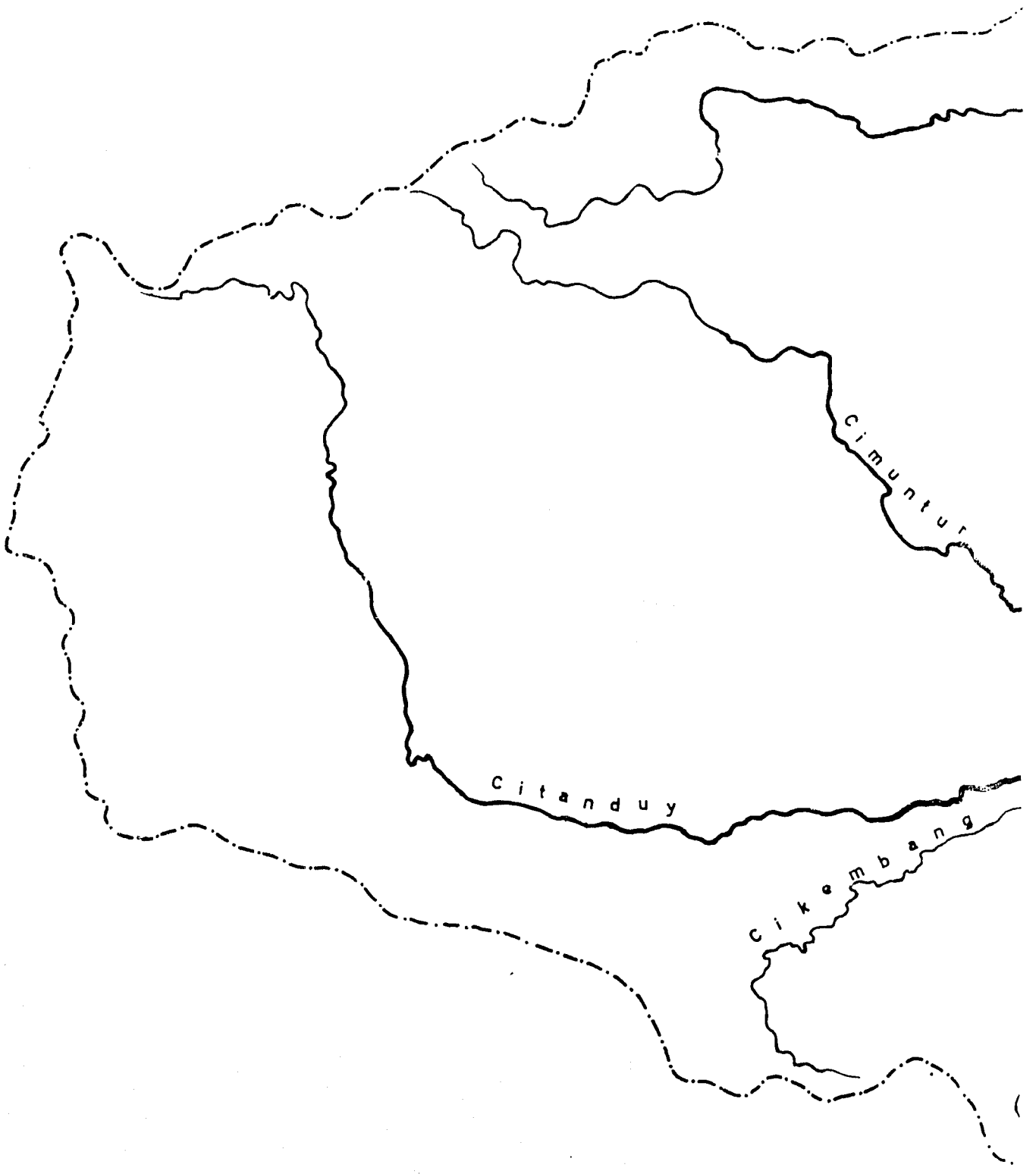

MAP OF WEST JAVA
JAKARTA
BANDUNG
BANJAR
CITANDUY PROJECT
PAYUNG M
MRUYUNG M.
MAJENANG
Cikawung
NAREJA
LUMBIR
PUSERAN M.
KUTAMAYA M.
SIDAREJA
Cibeuteum
Cihaur
Citanduy
Cisegel
PORANG M.
KALIPUCANG
Segara Anakan
Nusakambangan
CILACAP
INDIAN OCEAN
5
10 KM.
REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS & ELECTRIC POWER
DIRECT GENERAL OF WATER RESOURCES DEVELOPMENT
DIRECTORATE OF RIVERS & SWAMPS
CITANDUY PROJECT
ENGINEERING CONSULTANTS INC
DENVER - BANJAR
U.S.A. INDONESIA
NATURAL DRAINAGE NETWORK
DATE 20-11-73
A M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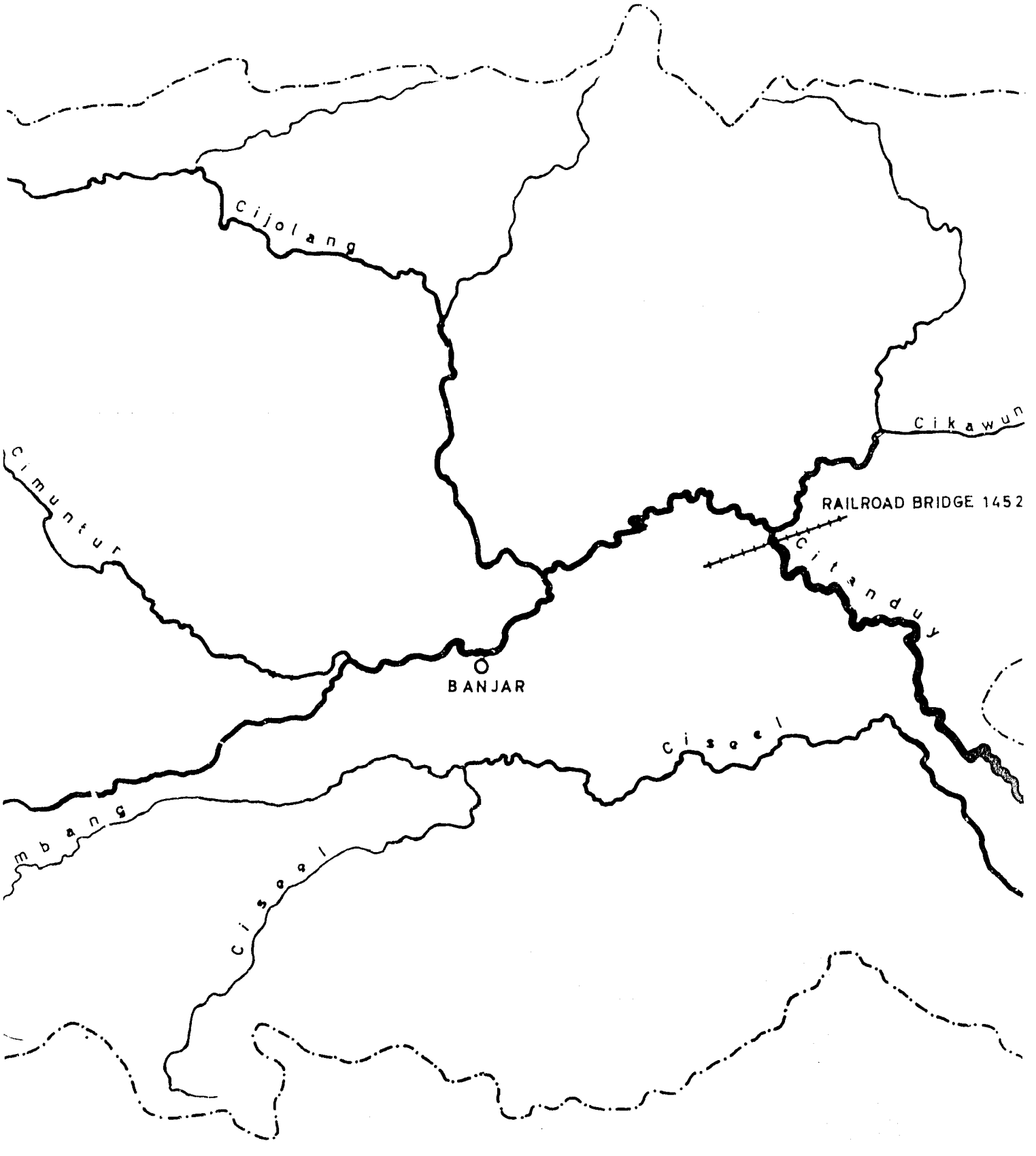
Citanduy
Cikembang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Citanduy
BANJAR
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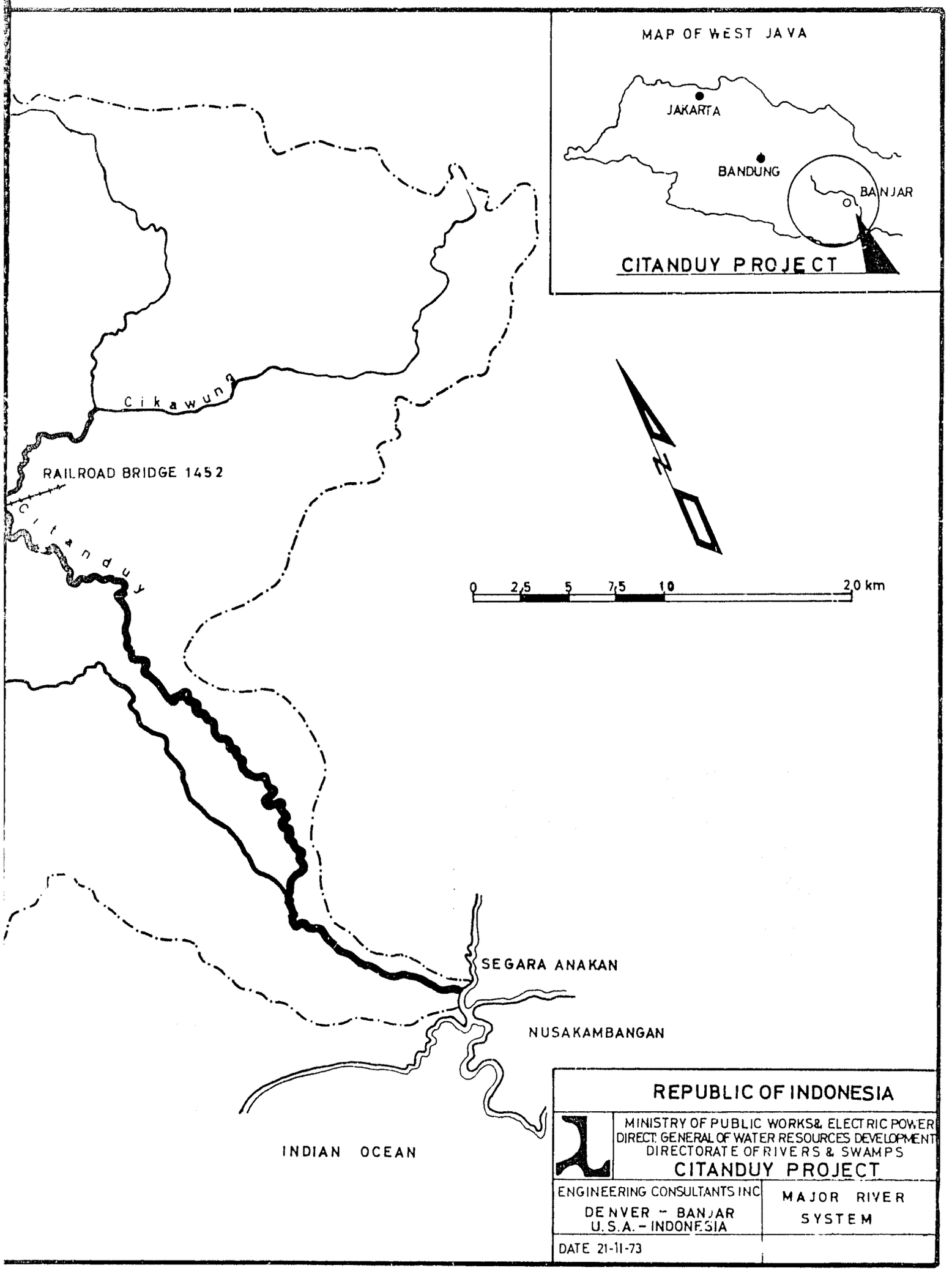
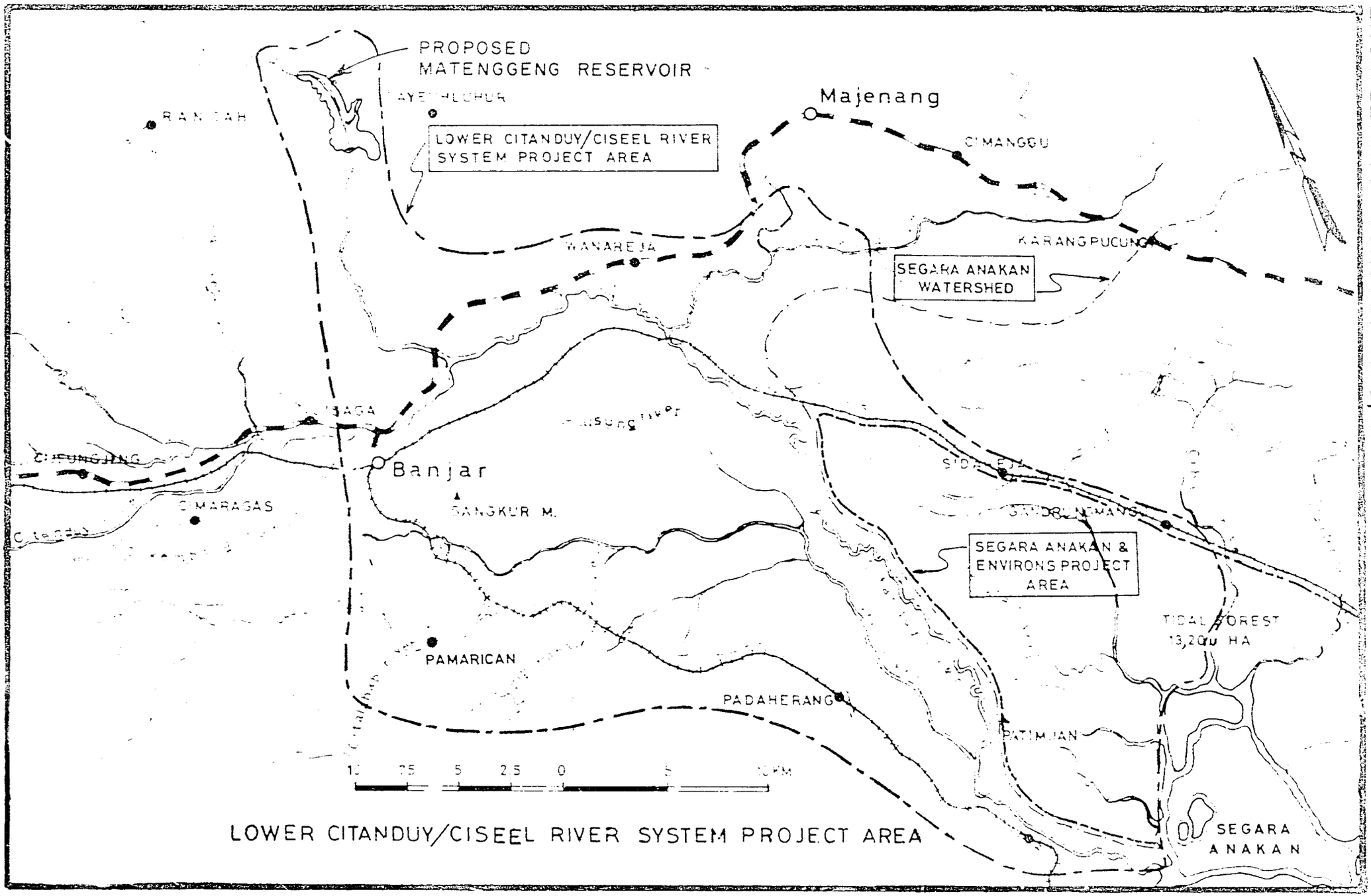
Cisael


MAP OF WEST JAVA
JAKARTA
BANDUNG
BANJAR
CITANDUY PROJECT
Cikawung
RAILROAD BRIDGE 1452
Citanduy
N
0 2.5 5 7.5 10 20 km
SEGARA ANAKAN
NUSAKAMBANGAN
INDIAN OCEAN
REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS & ELECTRIC POWER
DIRECT. GENERAL OF WATER RESOURCES DEVELOPMENT
DIRECTORATE OF RIVERS & SWAMPS
CITANDUY PROJECT
ENGINEERING CONSULTANTS INC
DENVER - BANJAR
U.S.A. - INDONESIA
MAJOR RIVER SYSTEM
DATE 21-11-73

A.M.



LOWER CITANDUY/CISEEL RIVER SYSTEM PROJECT AREA

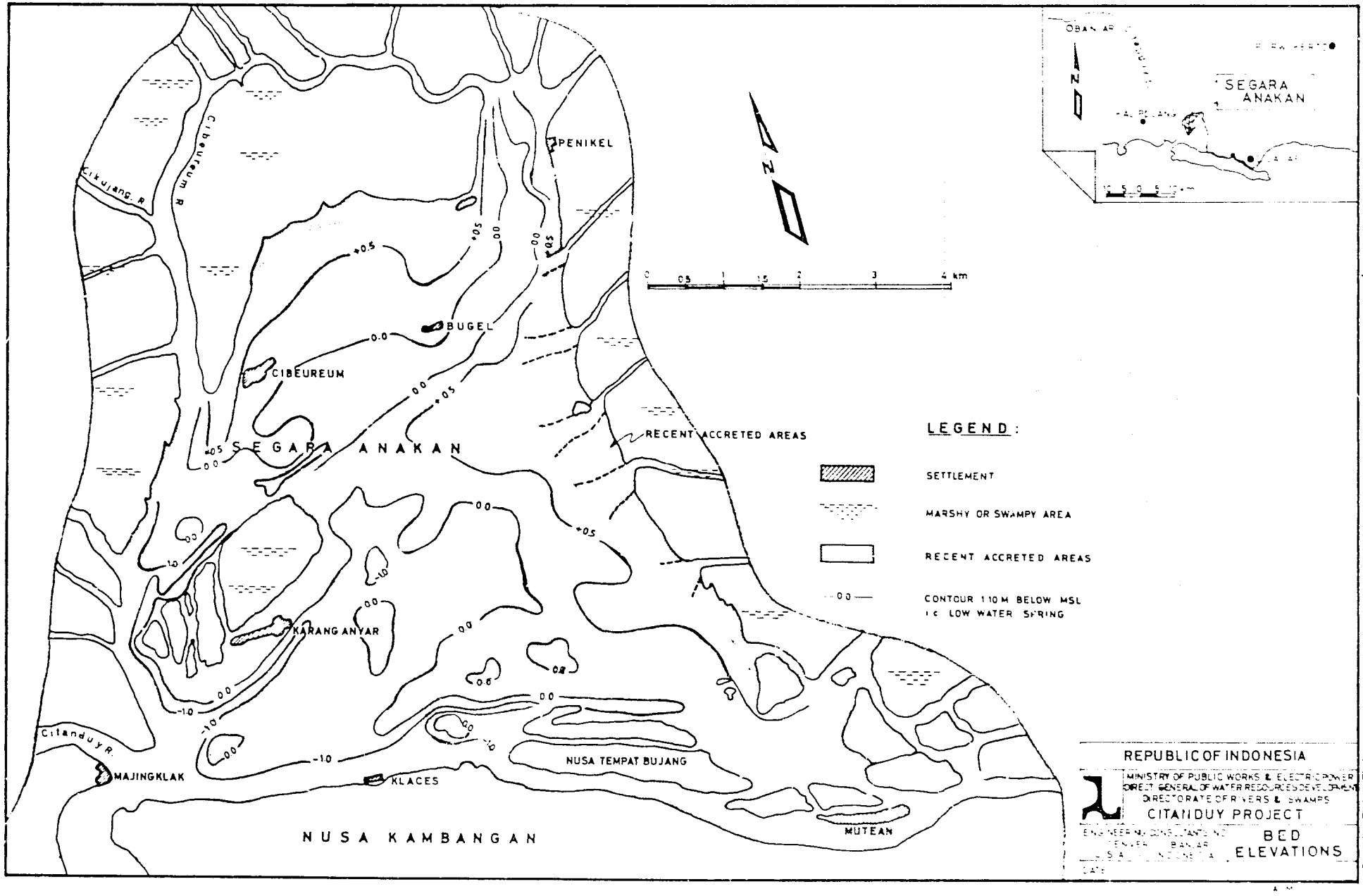


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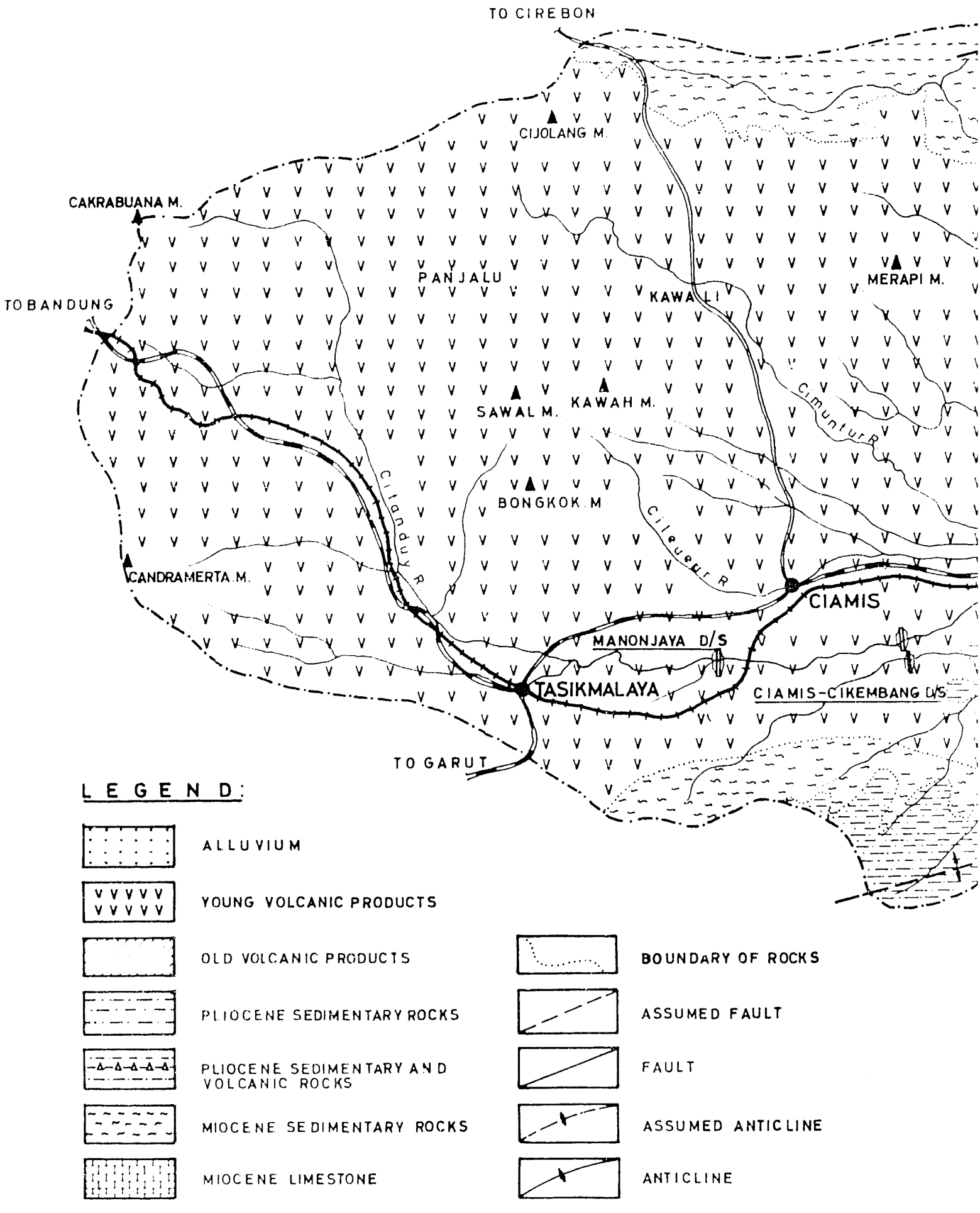
PLATE II-6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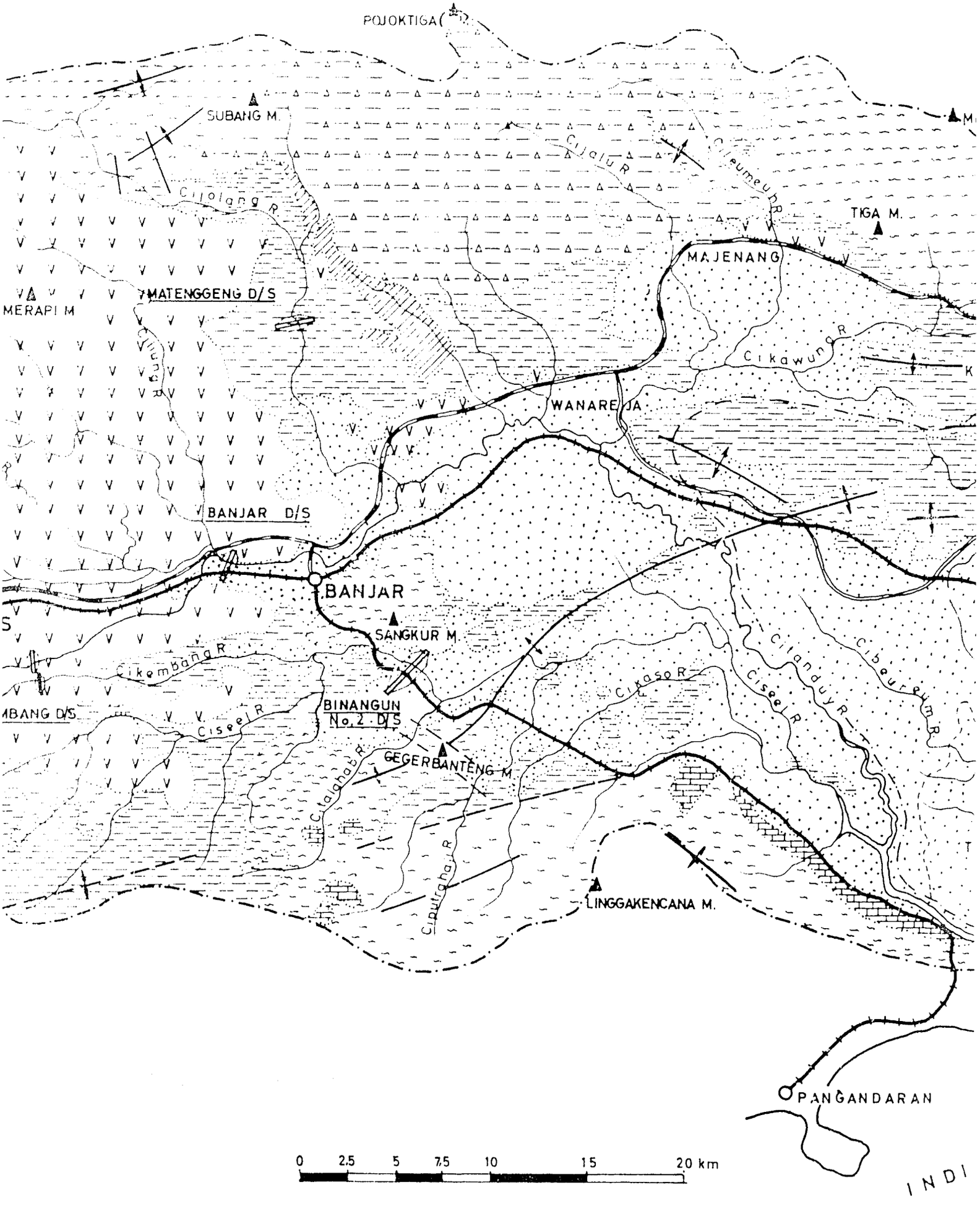
CAKRABUANA M.
TO BANDUNG
PANJALU
KAWALI
MERAPI M.
SAWAL M.
KAWAH M.
BONGKOK M
CANDRAMERTA M.
Citanduy R.
Cimuntur R.
Cileueur R.
CIAMIS
MANONJAYA D/S
TASIKMALAYA
CIAMIS-CIKEMBANG D/S
TO GARUT
LEGEND:
ALLUVIUM
YOUNG VOLCANIC PRODUCTS
OLD VOLCANIC PRODUCTS
PLIOCENE SEDIMENTARY ROCKS
PLIOCENE SEDIMENTARY AND VOLCANIC ROCKS
MIOCENE SEDIMENTARY ROCKS
MIOCENE LIMESTONE
BOUNDARY OF ROCKS
ASSUMED FAULT
FAULT
ASSUMED ANTICLINE
ANTICLINE



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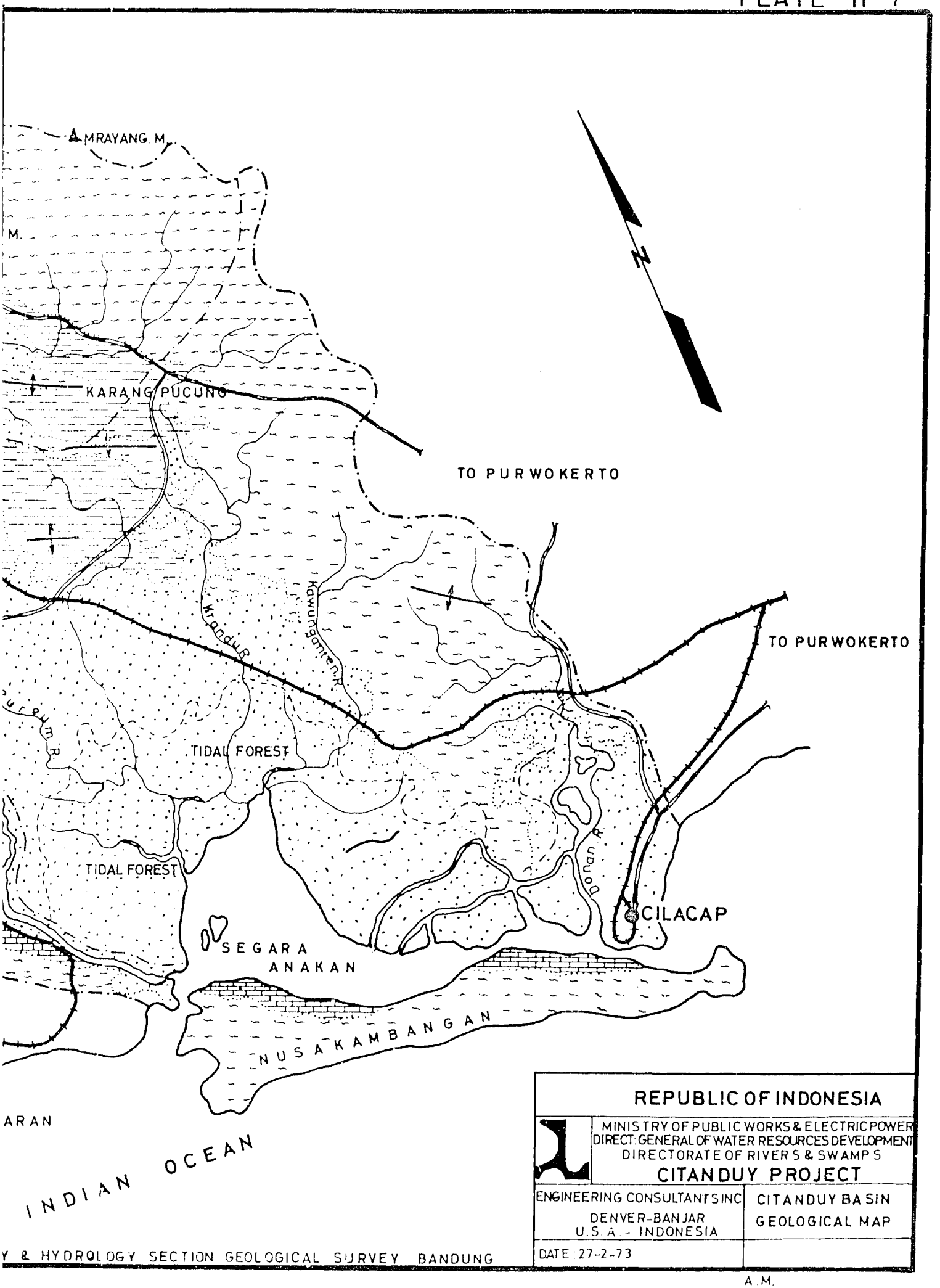
MRAYANG M.
M.
KARANG PUCUNG
TO PURWOKERTO
TO PURWOKERTO
Kawungantenan R.
Krandu R.
TIDAL FOREST
TIDAL FOREST
Donan R.
CILACAP
SEGARA ANAKAN
NUSAKAMBANGAN
ARAN
INDIAN OCEAN
N
REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS & ELECTRIC POWER
DIRECT: GENERAL OF WATER RESOURCES DEVELOPMENT
DIRECTORATE OF RIVERS & SWAMPS
CITANDUY PROJECT
ENGINEERING CONSULTANTS INC
DENVER-BANJAR
U.S.A. - INDONESIA
CITANDUY BASIN
GEOLOGICAL MAP
DATE: 27-2-73
Y & HYDROLOGY SECTION GEOLOGICAL SURVEY BANDUNG

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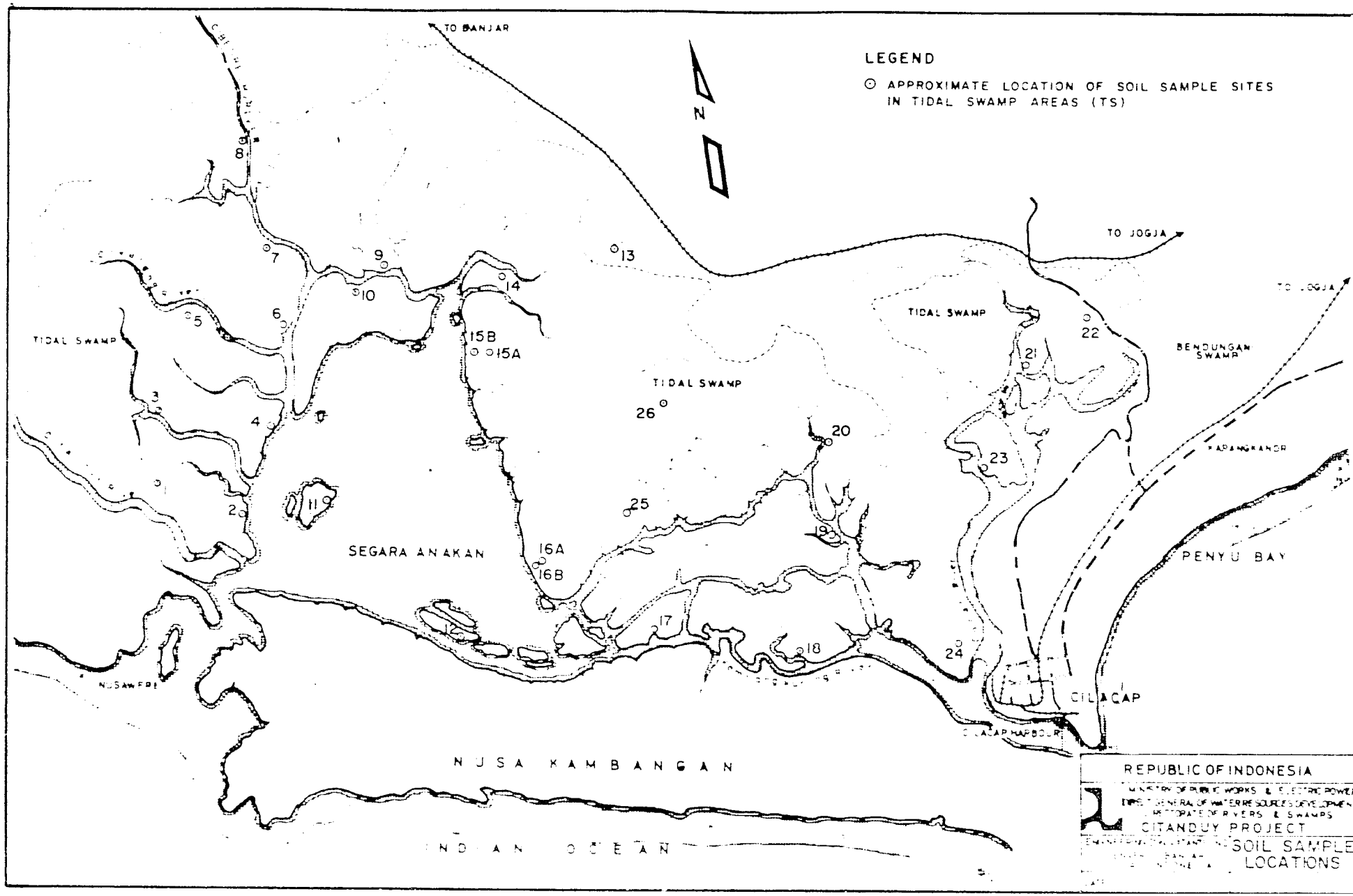

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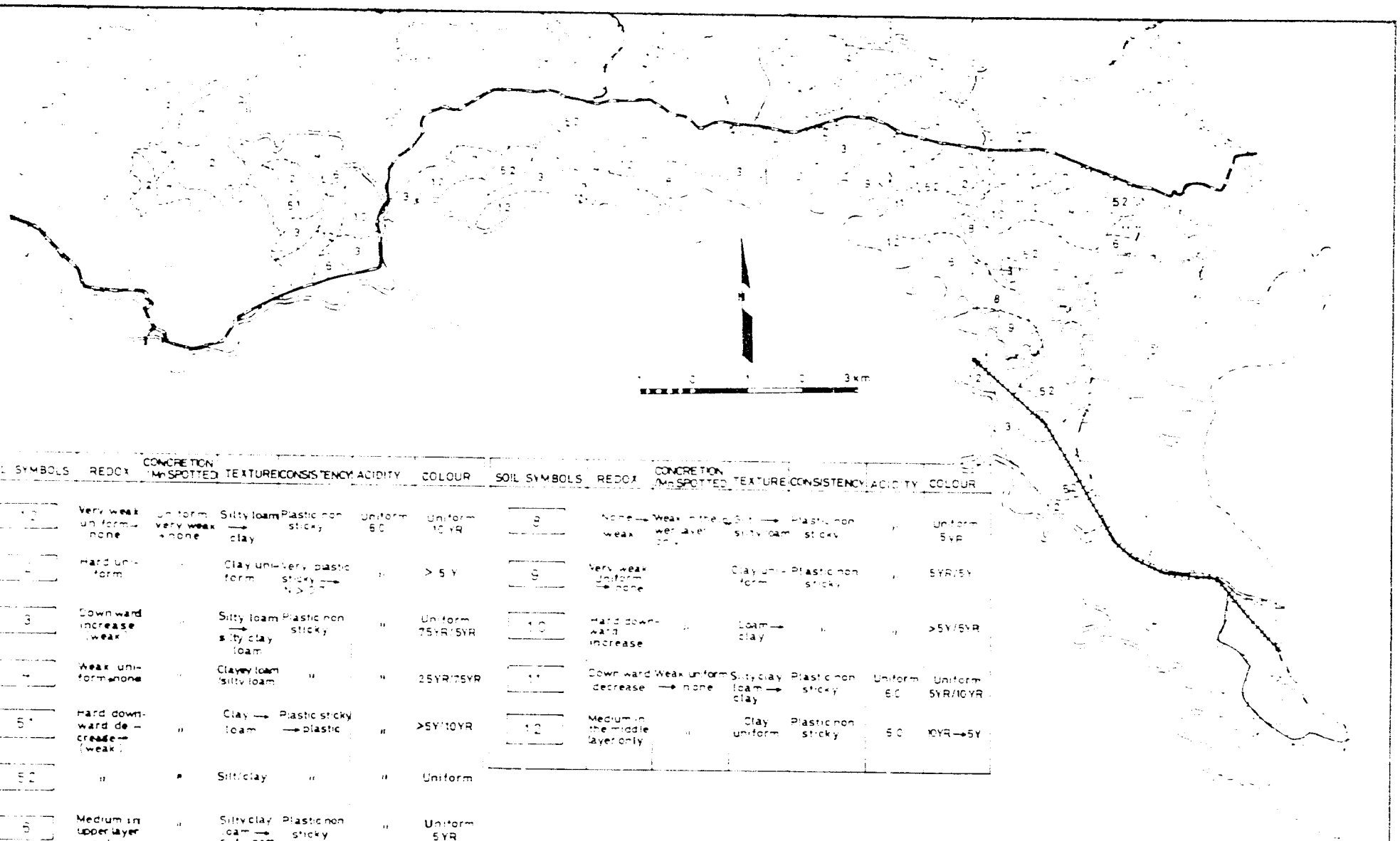
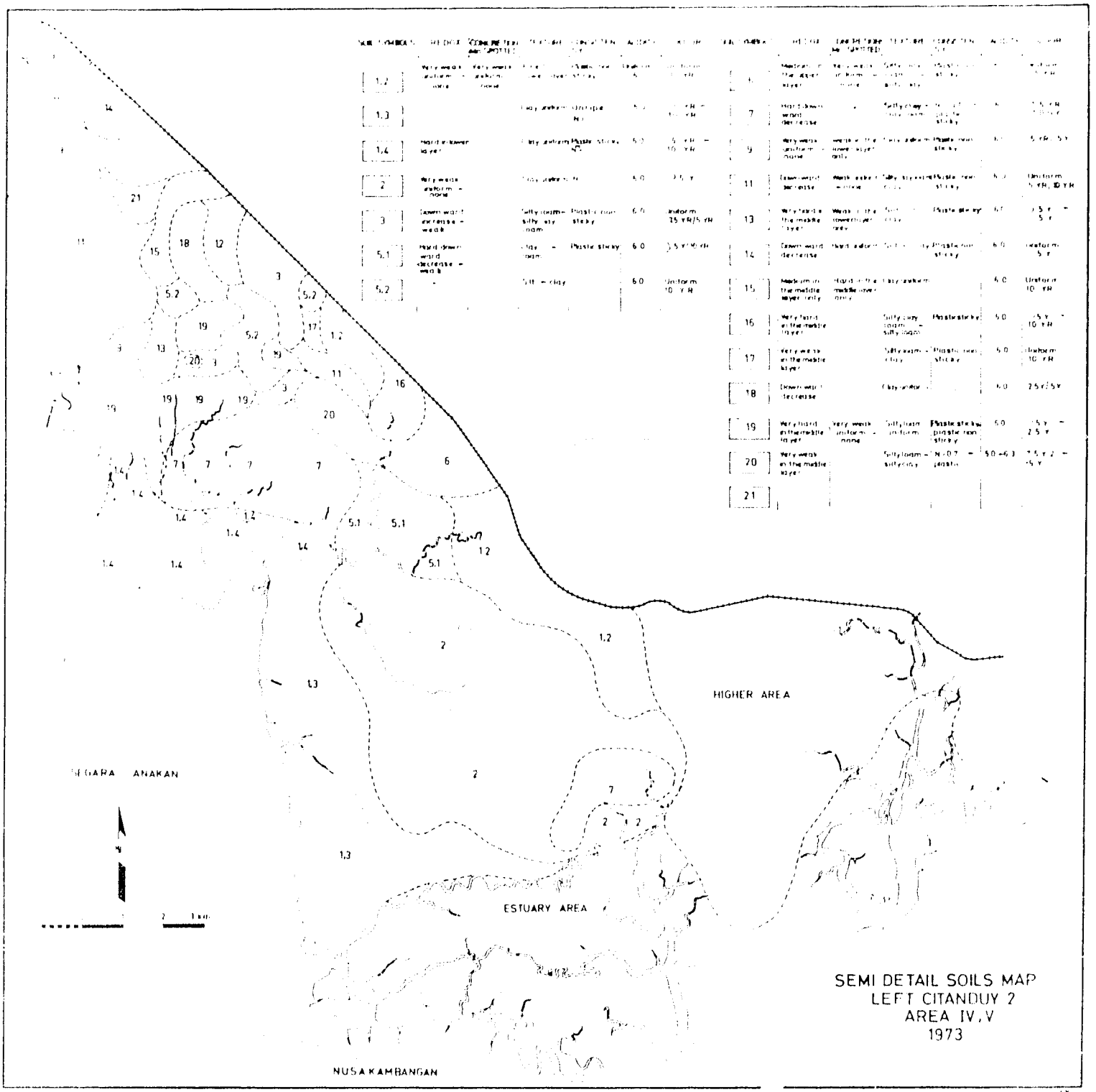
PLATE II-8



SOIL SYMBOLS	REDOX	CONCRETION (Mn SPOTTED)	TEXTURE	CONSISTENCY	ACIDITY	COLOUR
12	Very weak uniform → none	Uniform very weak → none	Silty loam → clay	Plastic non sticky	Uniform 5.0	Uniform 10 YR
2	Hard uniform	"	Clay uniform	Very plastic sticky → N>30	"	> 5 Y
3	Downward increase (weak)	"	Silty loam → silty clay loam	Plastic non sticky	"	Uniform 7.5YR/5YR
4	Weak uniform → none	"	Clayey loam (silty loam	"	"	2.5YR/7.5YR
5.1	Hard downward decrease → (weak)	"	Clay → loam	Plastic sticky → plastic	"	>5Y/10YR
5.2	"	"	Silt/clay	"	"	Uniform
6	Medium in upper layer only	"	Silty clay loam → silty loam	Plastic non sticky	"	Uniform 5YR
7	Hard downward decrease	"	Clay → silty clay loam	N>30 → plastic sticky	"	7.5YR/10GY

SOIL SYMBOLS	REDOX	CONCRETION (Mn SPOTTED)	TEXTURE	CONSISTENCY	ACIDITY	COLOUR
8	None → weak	Weak in the wet layer only	Silt → silty loam	Plastic non sticky	"	Uniform 5YR
9	Very weak uniform → none		Clay uniform	Plastic non sticky	"	5YR/5Y
10	Hard downward increase	"	Loam → clay	"	"	>5Y/5YR
11	Downward decrease	Weak uniform → none	Silty clay loam → clay	Plastic non sticky	Uniform 5.0	Uniform 5YR/10YR
12	Medium in the middle layer only	"	Clay uniform	Plastic non sticky	5.0	10YR → 5Y

SEMI DETAIL SOILS MAP
LEFT CITANDUY 2
AREA (I, II, III)
1973



SEMI DETAIL SOILS MAP
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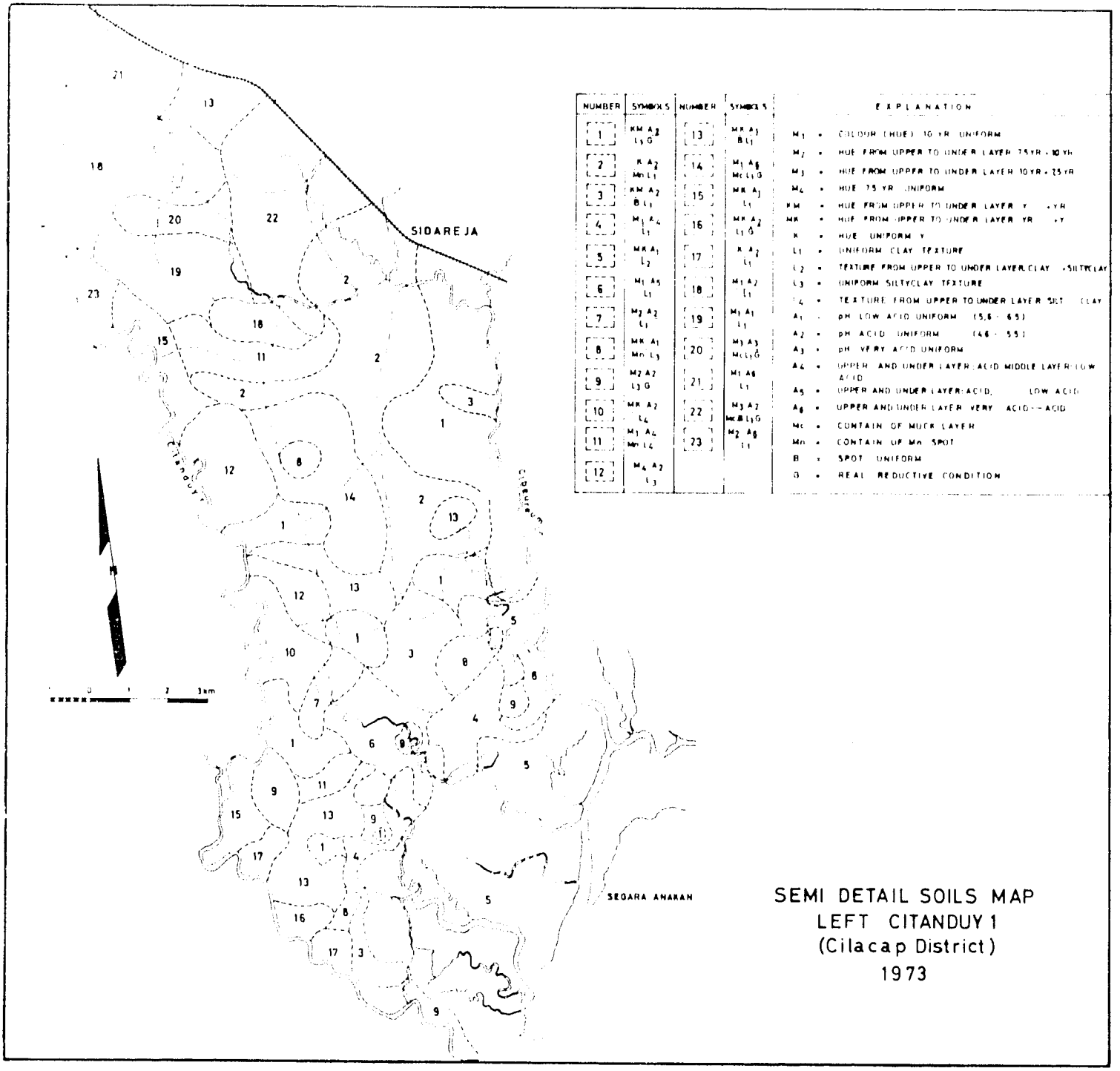
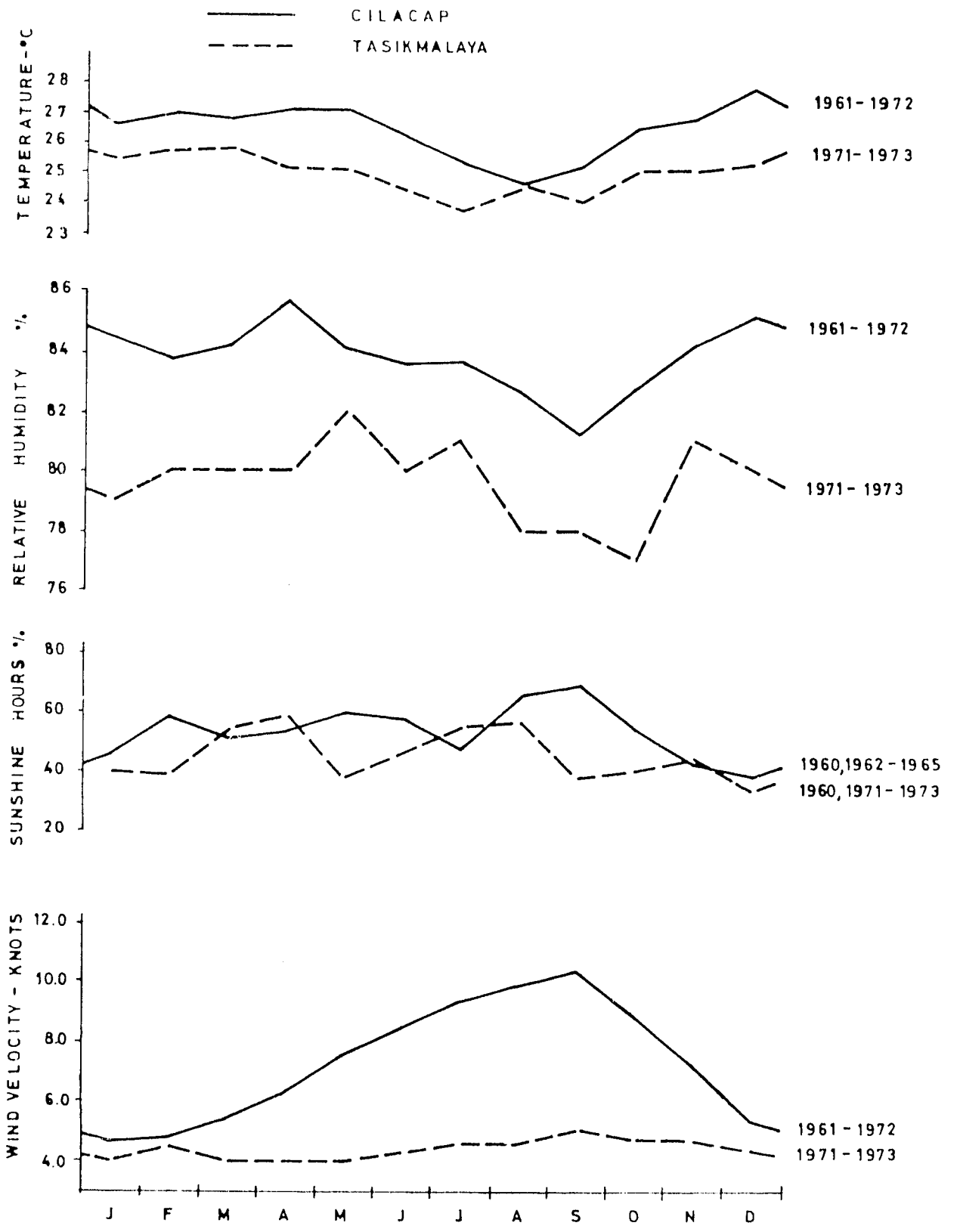
AREA IV, V
1973



SEMI DETAIL SOILS MAP
LEFT CITANDUY 1
(Cilacap District)
1973



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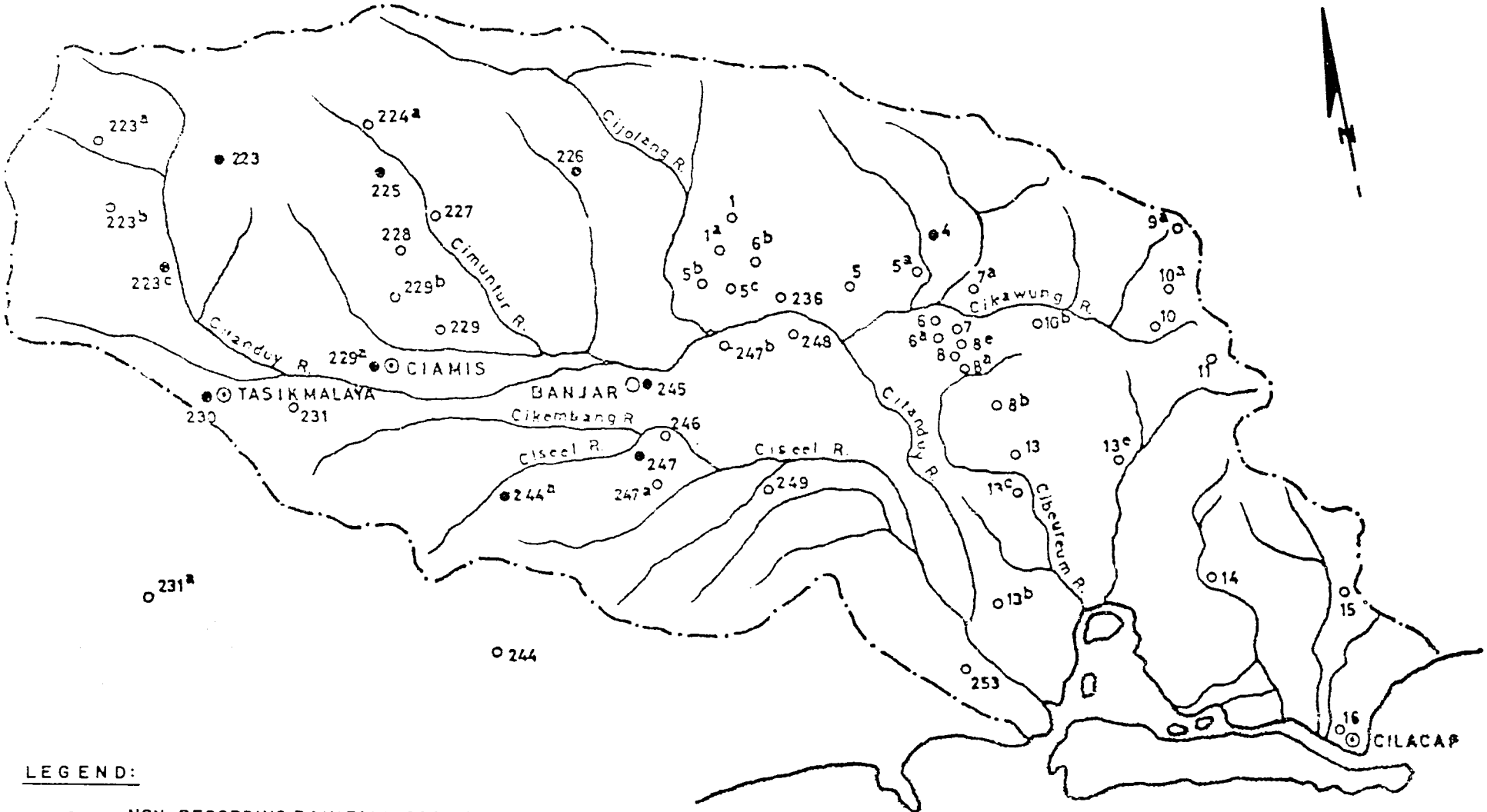
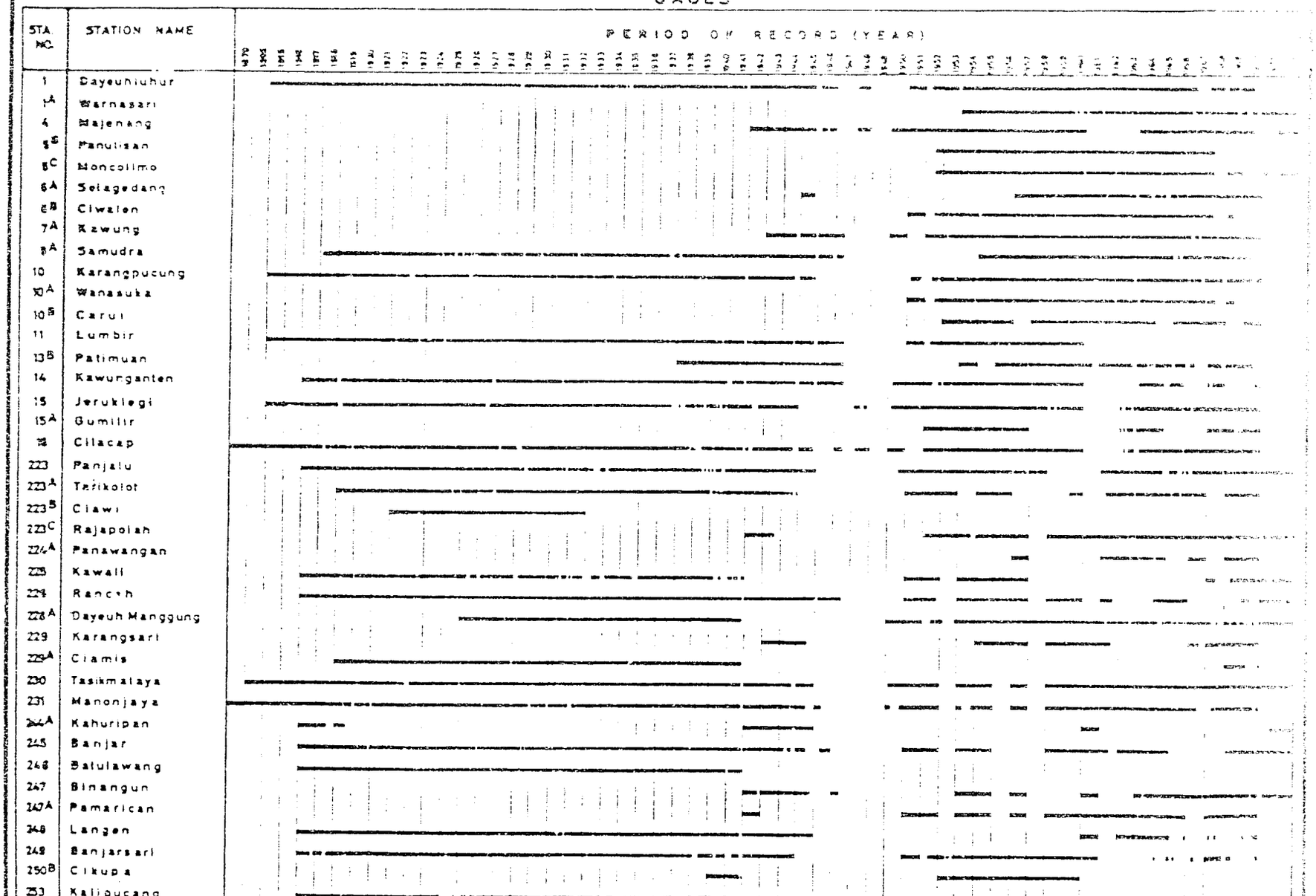


LOCATION OF SELECTED RAIN GAGING STATIONS

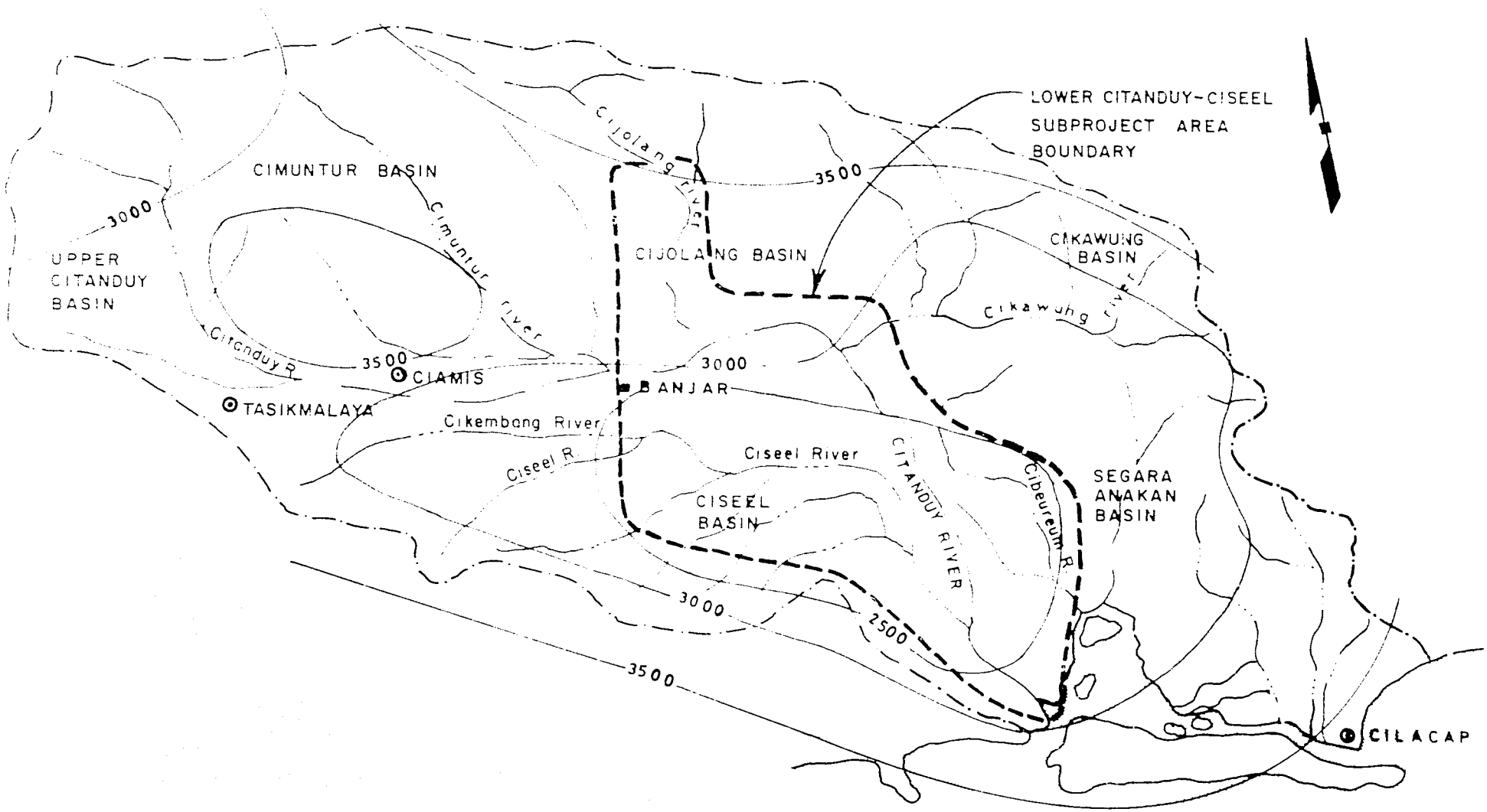
RECORD PERIOD FOR PRECIPITATION GAGES



Sta. #16 missing records for AUGUST 1881, AUGUST-SEPTEMBER 1891, AUGUST-SEPTEMBER 1896, MAY 1912

Sta. #230 missing records for FEBRUARY 1888, APRIL 1890, JULY-SEPTEMBER 1902, JUNE 1908, JULY-AUGUST 1914

Sta. #231 missing records for JANUARY-FEBRUARY 1888, FEBRUARY 1889, AUGUST-SEPTEMBER 1896, AUGUST 1898, SEPTEMBER 1902, DECEMBER 1913, JANUARY AND JULY-OCTOBER 1914



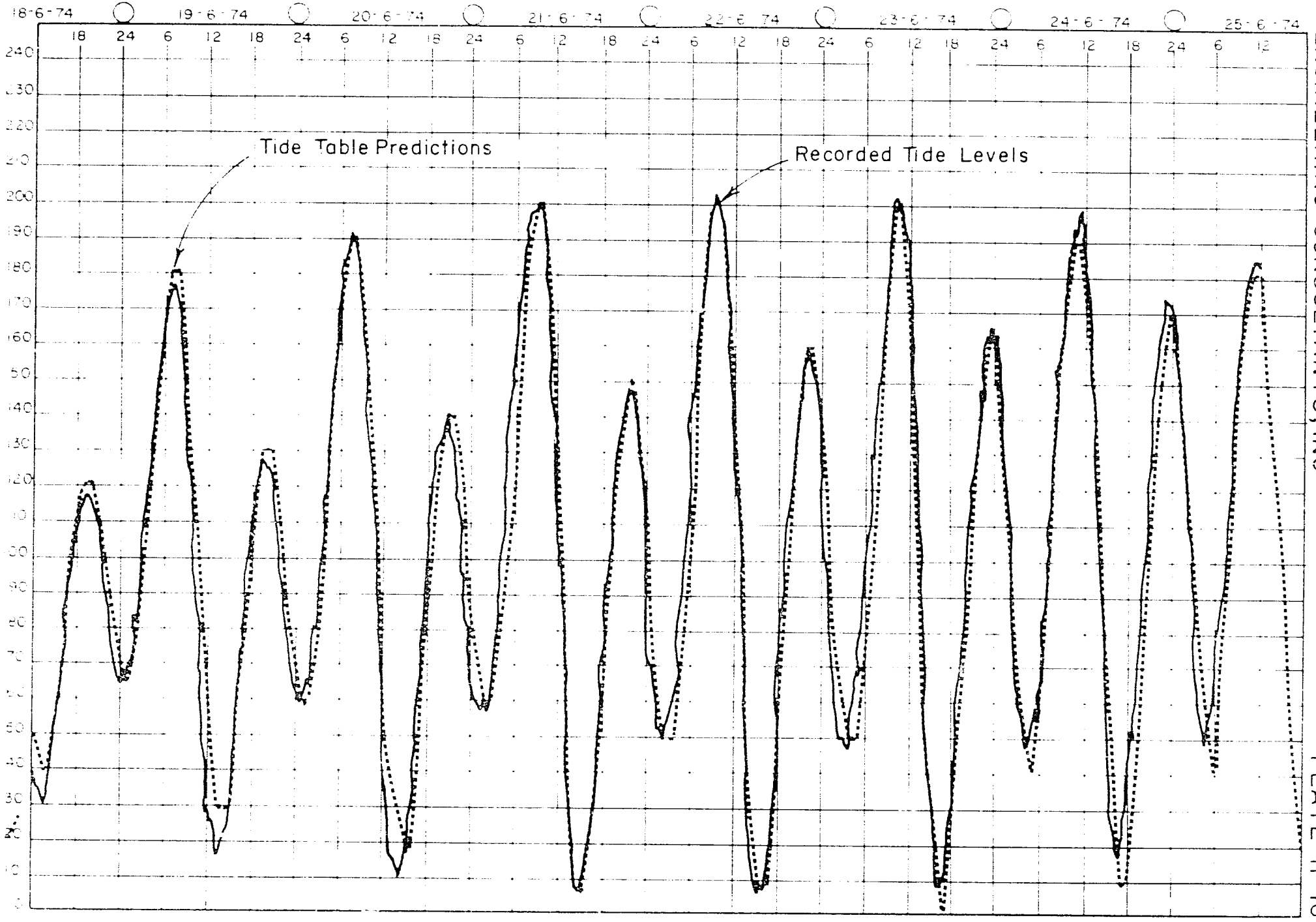
MEAN ANNUAL RAINFALL (mm)

1915 _ 1972

ENGINEERING CONSULTANTS, INC.

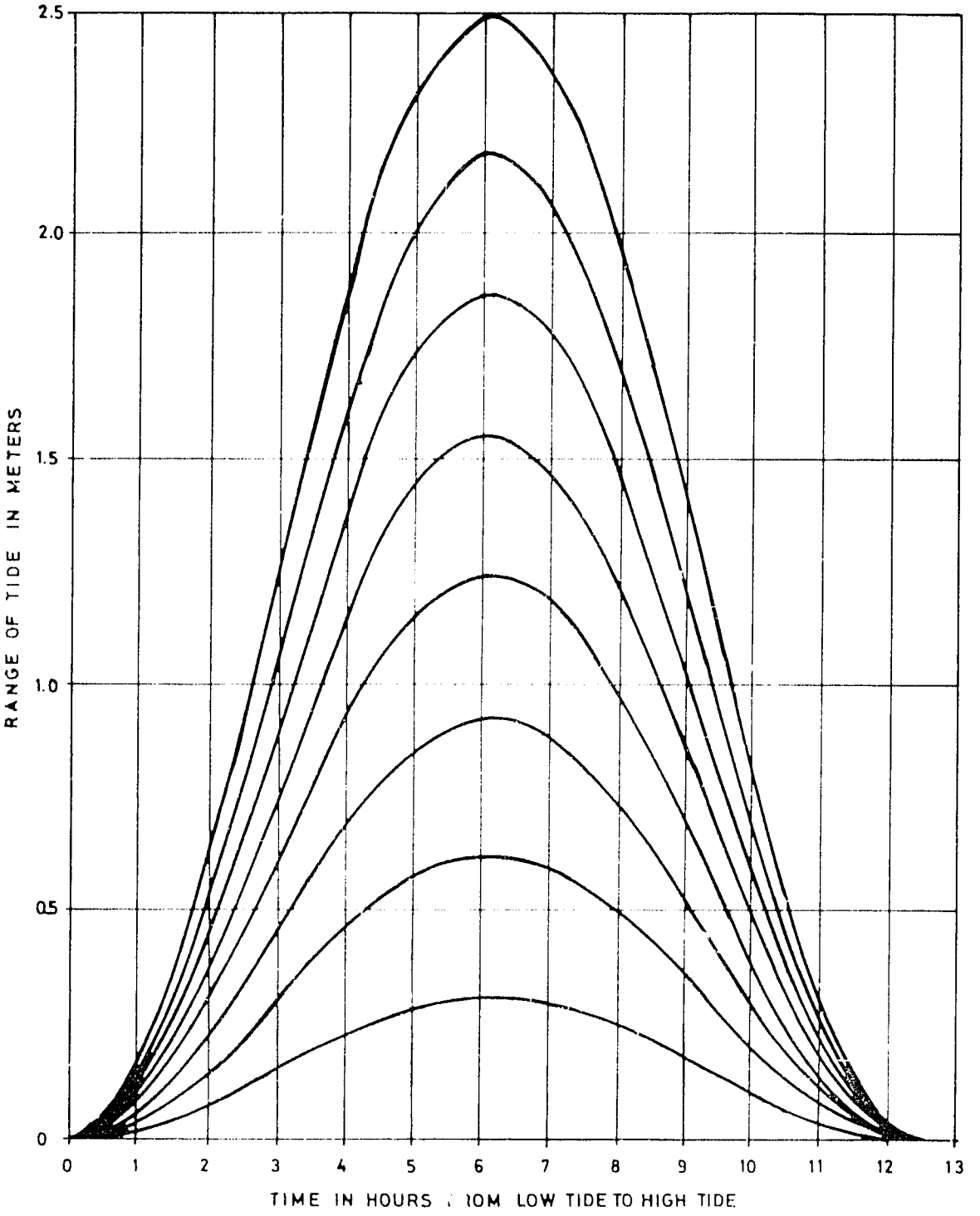
PLATE II-15

PREDICTED AND RECORDED TIDE LEVELS - CILACAP HARBOR

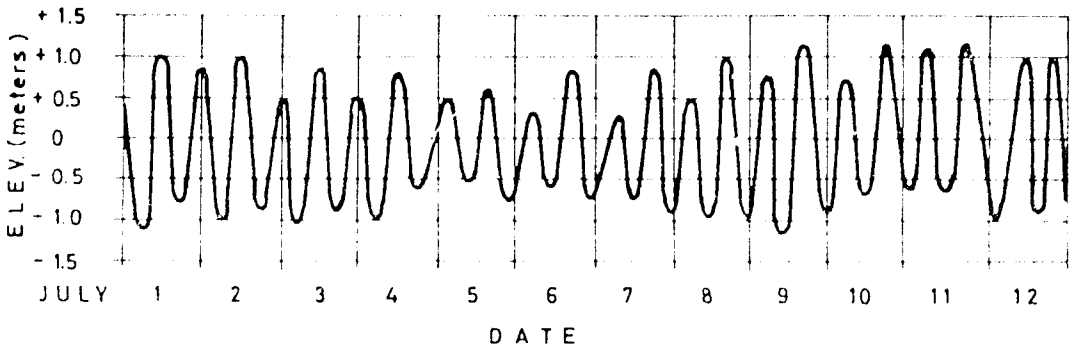


ENGINEERING CONSULTANTS, INC.

PLATE II-16

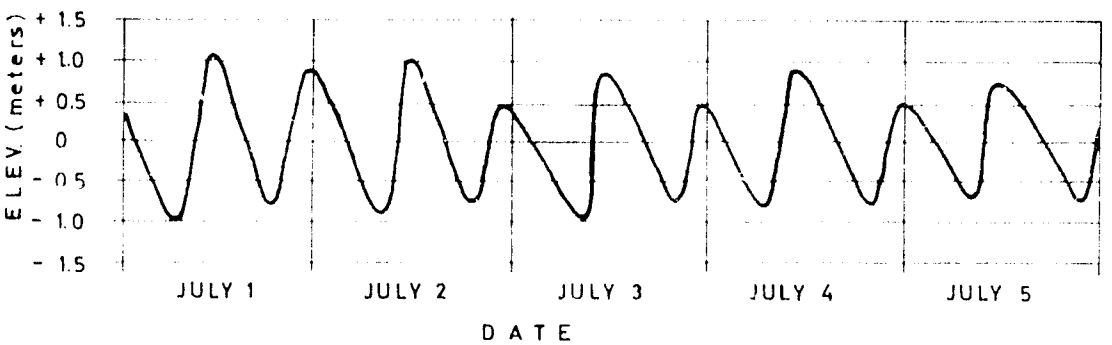


THEORETICAL TIDE CURVES

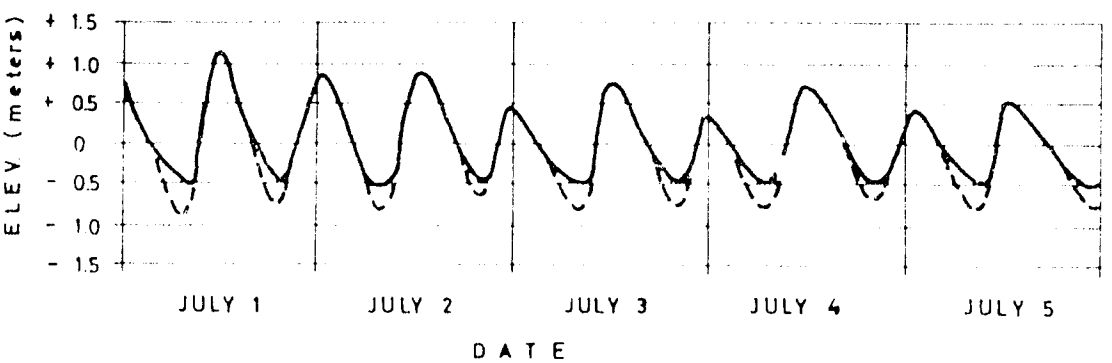


TYPICAL OCEAN TIDE ON OPEN COASTLINE

NORMAL CONDITION

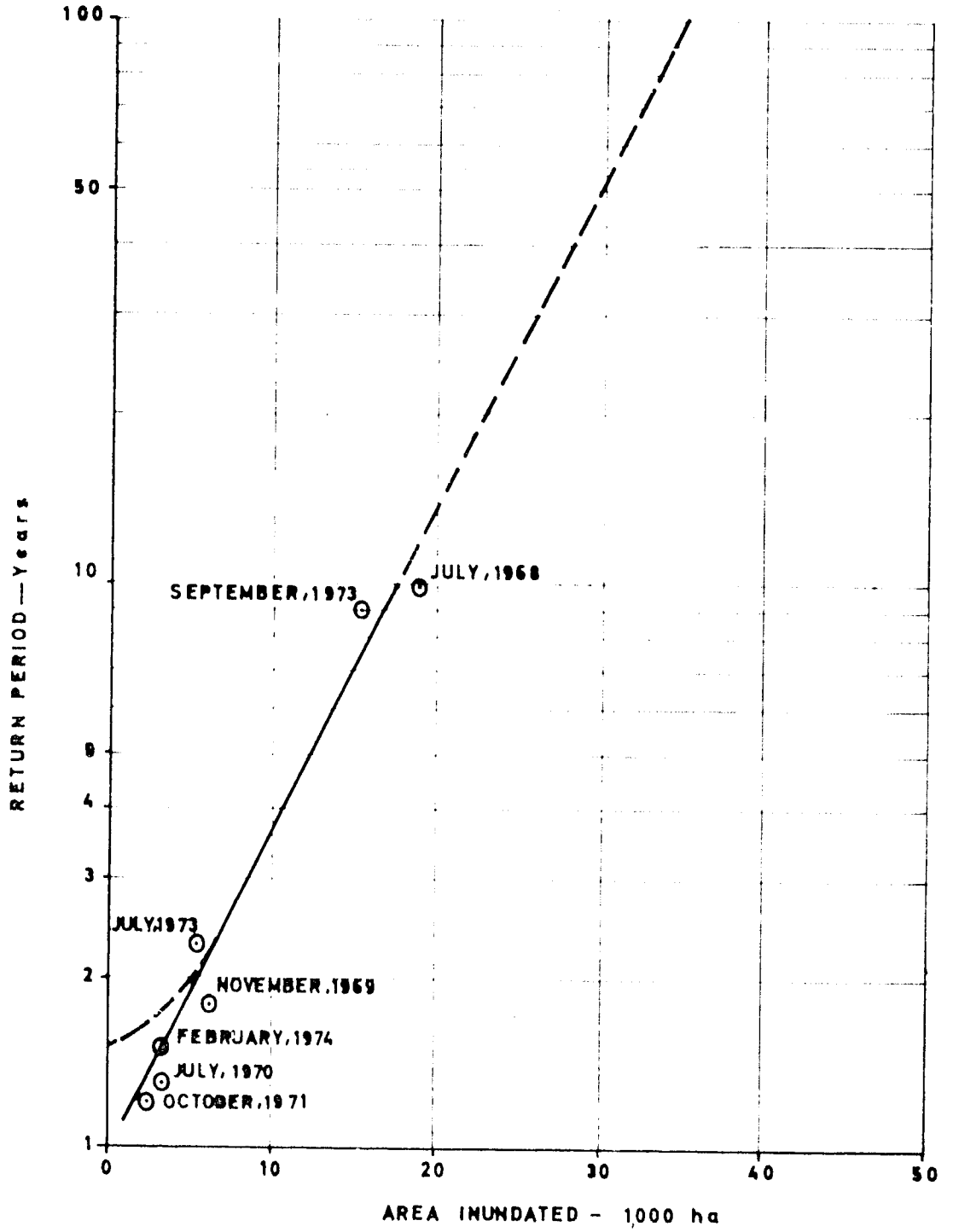


WITH SILTED FORESHORE



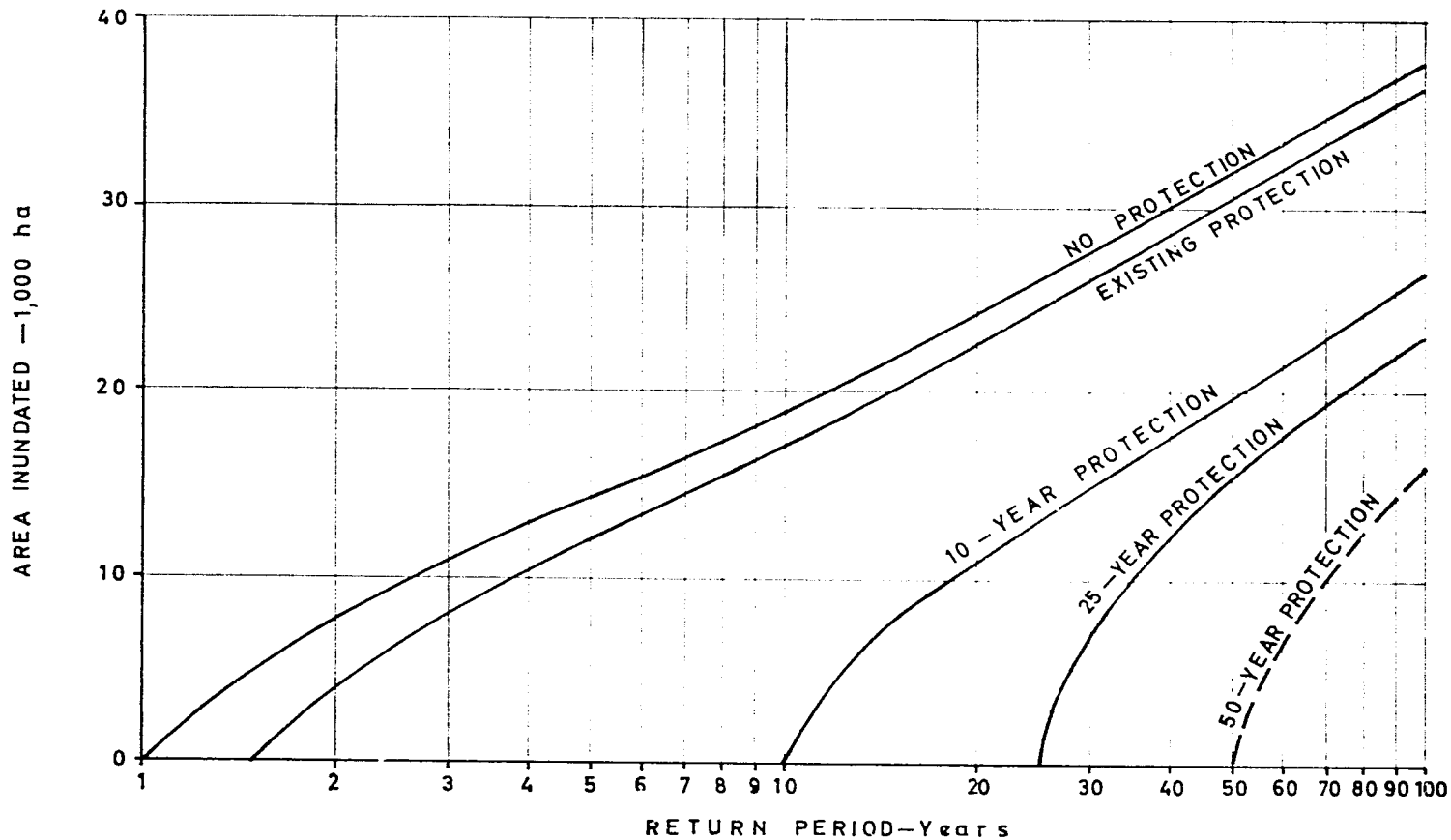
TYPICAL ESTUARY TIDES

TYPICAL TIDES



AREA INUNDATED
VS
RETURN PERIOD

A.M.

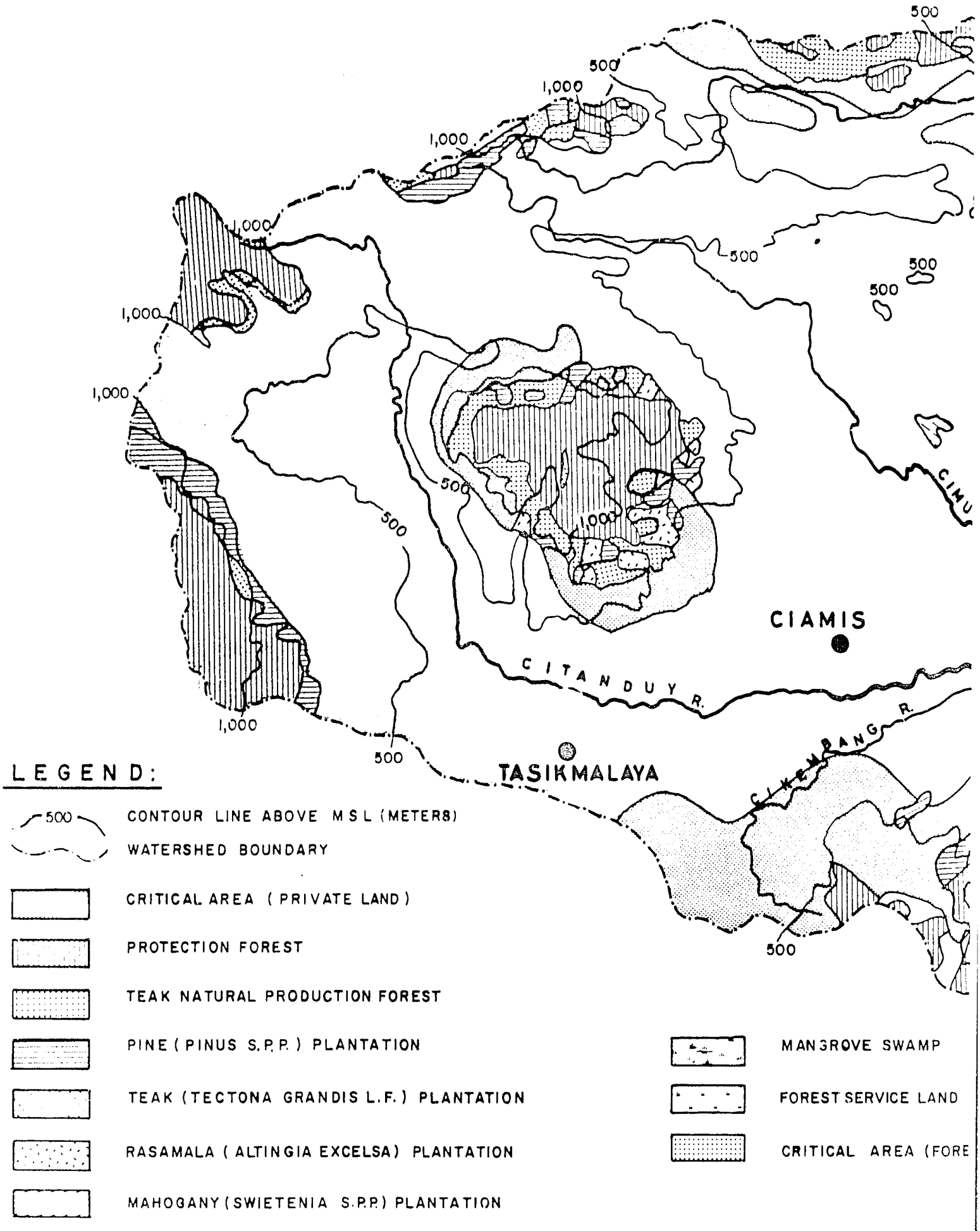


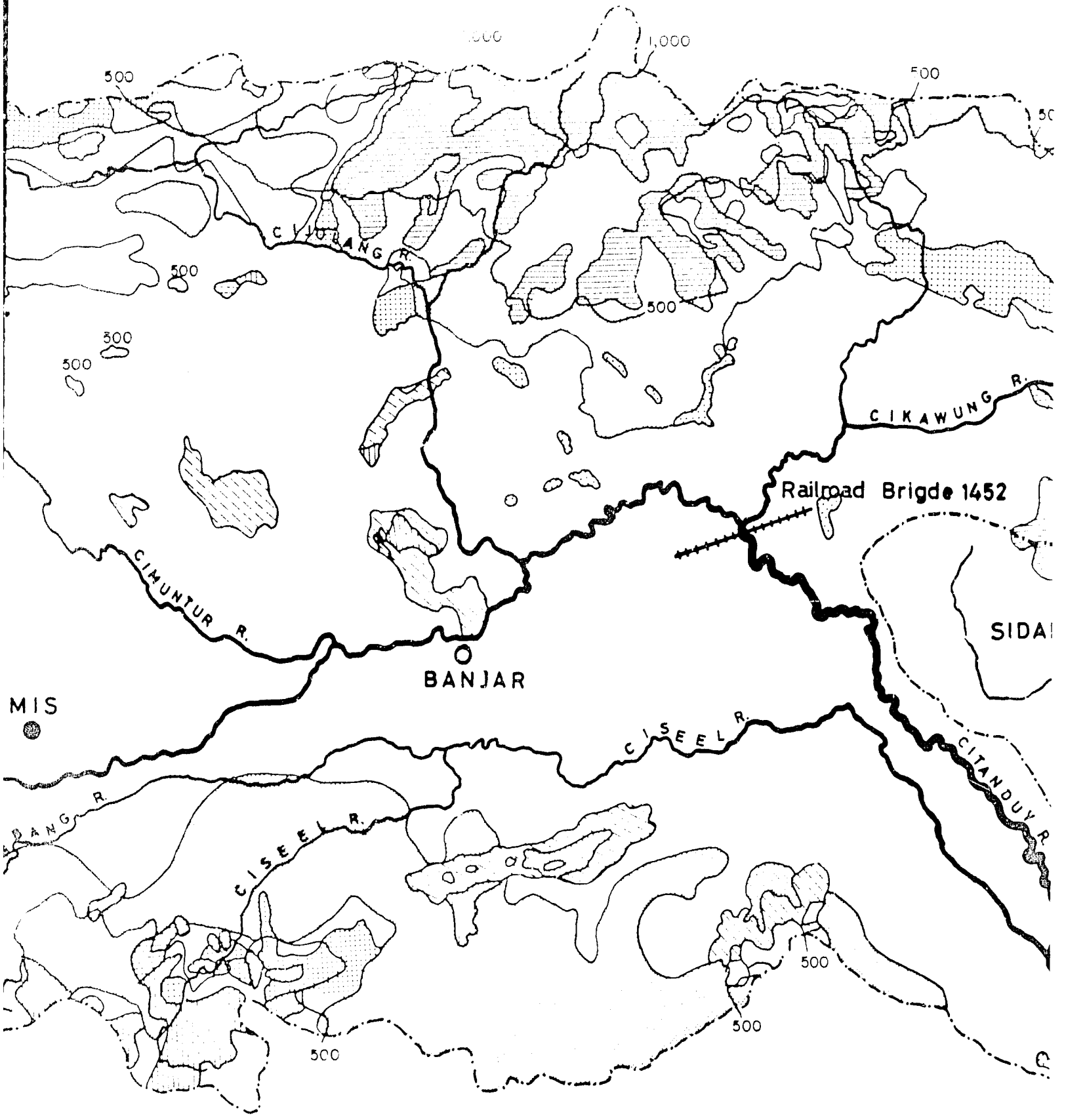
FREQUENCY AND AREAL EXTENT
OF FLOODING

ENGINEERING CONSULTANTS, INC.

PLATE II-20

A.M.

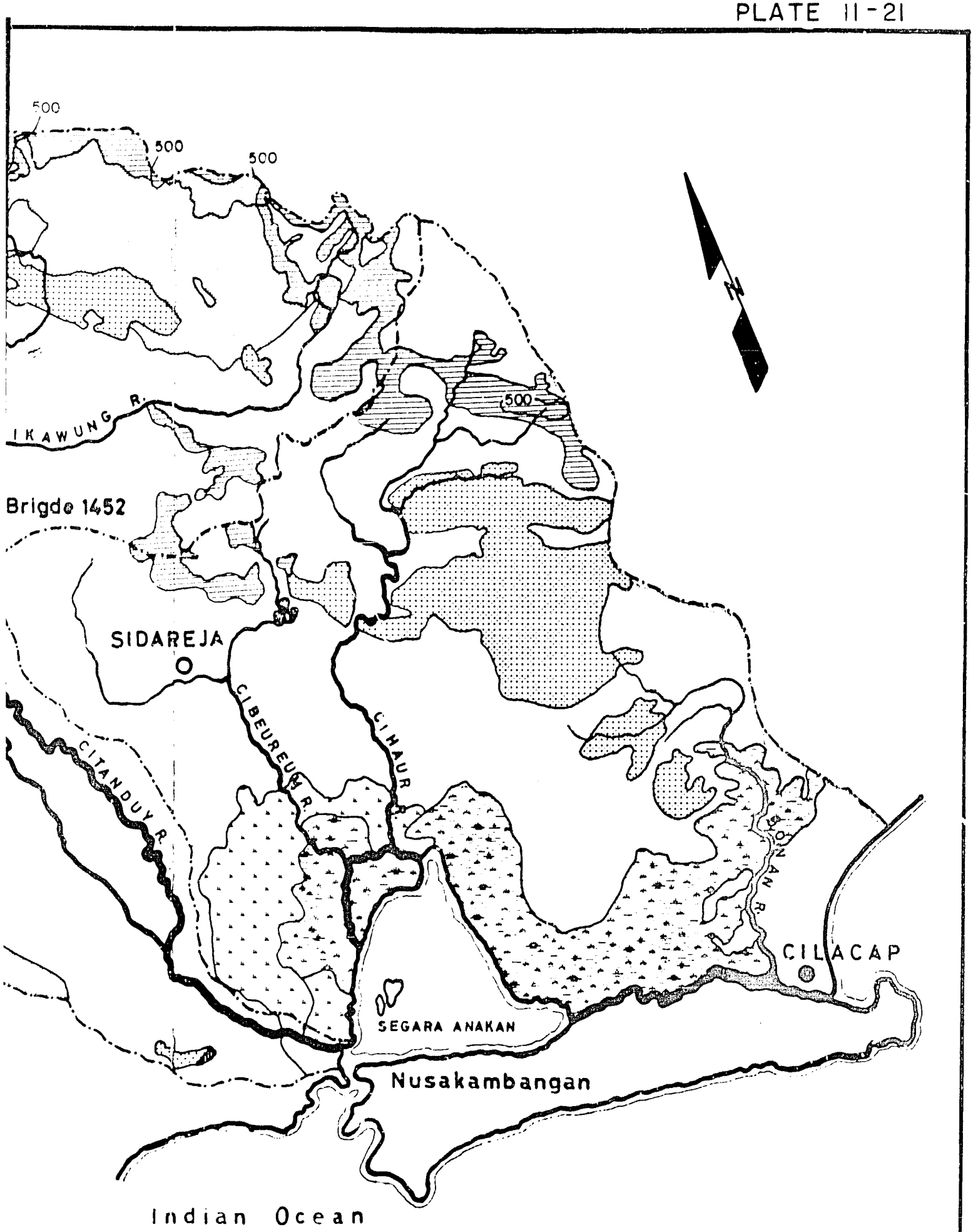

500
1,000
CIAMIS
CITANDUY R.
TASIKMALAYA
CIKEMBANG R.
CIMU
LEGEND:
500 CONTOUR LINE ABOVE M S L (METERS)
WATERSHED BOUNDARY
CRITICAL AREA (PRIVATE LAND)
PROTECTION FOREST
TEAK NATURAL PRODUCTION FOREST
PINE (PINUS S.P.P.) PLANTATION
TEAK (TECTONA GRANDIS L.F.) PLANTATION
RASAMALA (ALTINGIA EXCELSA) PLANTATION
MAHOGANY (SWIETENIA S.P.P.) PLANTATION
MANGROVE SWAMP
FOREST SERVICE LAND
CRITICAL AREA (FORE



NGROVE SWAMP

EST SERVICE LAND (SOME RICE PADDIES)

TICAL AREA (FOREST LAND)



FORESTRY TYPE MAP

CHAPTER III

PROBLEMS AND NEEDS

Land and Water Management

Flood Control

Precipitation in the mountains is collected by the dense drainage network and transported in steeply sloping, high capacity river channels to the alluvial plain. At Banjar, where the Citanduy River enters the flood plain, the river has dropped about 1,700 meters in 85 kilometers distance. From there to the sea, the river meanders an additional 83 kilometers, but drops only 15 meters. Below Banjar, the Citanduy River flows by the Wanareja Swamp, an area which serves as a natural storage area for overbank discharges of flood waters. The flood plain is composed of sedimentary deposits, and the river channel has aggraded to form a flattened "M" with the areas adjacent to the river sloping away from it instead of towards it. This configuration tends to create natural waterways parallel to the main river course. Near the town of Tunggilis, the Citanduy River is joined by its last major tributary, the Ciseel River.

In the natural state, the Citanduy and Ciseel Rivers flood peak attenuation resulted from the natural swamp storage and the relief resulting from the flood plain overflows.

The volume of runoff from the volcano and hills regions is large for two principal reasons. First, the rainfall in the highlands is large, averaging more than 3,000 mm/year. Secondly, the percent of rainfall which runs off as surface flow is high. On Volcano Sawal, where the annual precipitation ranges as high as 4,200 mm, two-thirds of this rainfall appears as surface runoff. In the lower hills, where annual rainfall is less, the runoff is about half of the rainfall.

On a yearly basis, large volumes of flood waters are delivered to the alluvial plains as many as a dozen times. The distribution of rainfall throughout the year is such that the peak flood stage at Banjar for the year has occurred at least four times in the so-called dry season in the last 23 years.

According to presently available information, some flooding occurs in the lower Citanduy River basin each year, causing varying degrees of flood damage. Direct damages are experienced in terms of loss of human life, losses of farm and business incomes and property values, hazards to personal and public health, personal inconvenience, damages to transportation systems, and disruption of all types of activities.

Agricultural losses from floods are of several kinds. They include damages to crops; damages to land in the form of scour, streambank erosion, gullying and valley trenching, infertile overwash or deposition of sediment and swamping; damages to buildings, roads, and livestock; damages to irrigation and drainage facilities; and indirect losses such as delays in field work and disruption or delays in marketing of farm products.

There are also numerous other indirect costs of flood damages. These include the cost of government aid in restoring roads and other community facilities, emergency provision of food supplies and health services, the disruption of transportation to and from other areas of the country, pollution of drinking water sources, disruption of educational services, and hazards of outbreaks of malaria and other diseases.

Even in the adjacent areas which are not directly hit by floods, adverse effects on the general economy are felt because of the disruption of normal government and commercial activities. While emergency help is being given to the flooded areas and while the transportation, communication, and electrical power facilities are being restored, government funds required for restoration must be diverted from their regular purposes.

The general location of areas flooded during two major storms of recent occurrence (July 1968 and September 1973) are shown on Plate III-1 and Plate III-2, respectively. The area inundated during the July 1968 flood was reported to be 20,700 ha, or 22 percent of the subproject area. The area inundated during the September 1973 flood was reported to be 18,400 ha, or 20 percent of the project area. The areas shown on the plates are affected to some extent by floods every year. The 1968 and 1973 floods were serious because of the long duration of runoff-producing rainfall and the failure of man-made flood control facilities.

Damage or failure of the flood control levees was a major contributing factor to the extent of the area inundated by the 1968 and 1973 floods. Damages to the levees usually consist of overtopping, breaks, or embankment slides. During the July 1968 flood, the levee system was reported damaged or breached in 28 locations including 5 on the left bank of the Citanduy, 8 on the right bank of the Citanduy, 6 on the left bank of the Ciseel, 3 on the right bank of the Ciseel, and one on the Cilisung drain. Breached sections had a range of from 10 to 100 m in length. During the September 1973 flood, 21 damaged or breached sections were reported. The major break occurred on the left bank of the Citanduy River at Kedungdadap, causing the inundation of 9,450 ha in the Sidareja area.

The damaging or breaching of the levee system occurs annually and, although usually within the same general reach of river, not at the same locations. The Cilisung drain is an exception to this observation, since it is repeatedly damaged or breached just above its confluence with the Ciseel River and below a sharp bend in alignment. For the previously mentioned minor storms occurring between the period 1968 to 1974, the reported number of damaged or broken levee locations varied from 1 to 6; a significant contribution to the estimated average inundated area of 4,000 ha/year.

The flood of September 1973 indicated that the flood control system as it now stands has its shortcomings. The breaches in the levee and the difficulties encountered in the mobilization of the maintenance and relief crews during the emergency period would indicate that the overall organization requires some realignment.

A recent levee profile survey indicates that there is an inconsistency in levee crown. Differences of fifty centimeters between the crown elevation on one side of the river and the crown elevation on the other side of the river have been found.

As is often the case, one of the weakest links in the levee system operation is the maintenance program, or lack thereof. It is concluded that many of the levee breaches suffered in the 1973 flood could have been avoided if an adequate levee maintenance program had been in effect. There is no substitute for an effective levee maintenance program. Special emphasis needs to be placed on preventative maintenance.

Irrigation

Based on construction and method of operation, the irrigation systems in Indonesia may be divided into three types:

1. Technical irrigation systems
2. Semi-technical irrigation systems
3. Simple irrigation systems

The degree of sophistication of each system decreases in the same order as they are listed.

It can be stated as a general condition that virtually all of the irrigation systems are in need of rehabilitation and improvement. The principal cause for this has been lack of an adequate maintenance program. The hierarchy for management of a maintenance program exists within the Public Works organization, but the limited budget has not permitted the type of operation and maintenance program which is needed.

The more common problems are:

1. Siltation has reduced the carrying capacity of canals.
2. Gates on turnout structures do not function properly.
3. Large numbers of illegal bamboo pipe turnouts.
4. Lack of adequate maintenance roads along primary canals.
5. Some of the planned and needed structures and distribution canals are incomplete or never were built.
6. Canal leakage.
7. Deteriorated weirs and gates.
8. Inadequate means of measuring discharges.
9. Shallow canals.
10. Shortage of irrigation water in dry season.
11. Tertiary distribution network not constructed or constructed incorrectly.

The problem of getting wider coverage with the water supply available during the dry season can be partially alleviated by improvements to the system so that water conveyence losses are minimized. Additionally, installation of gaging devices and control structures would result in more equitable distribution of the water among farmers.

The system of financing operation and maintenance by feedback of tax revenues from higher to subsidiary levels of government gives rise to problems of allocating limited funds. A more direct system of collection and application of money specifically for local irrigation facilities is needed. This would foster greater reliance on self-help and direct participation at the village level.

In the Lower Citanduy/Ciseel Subproject area there are 17,336 hectares under irrigation systems, of which 9,767 hectares are classed as technical, 2,420 hectares semi-technical, and 5,149 hectares simple.

In the Upper Citanduy/Ciseel Subproject area there are 27,887 hectares under irrigation systems, of which 3,865 hectares are classed as technical, 2,021 hectares semi-technical, and 22,001 hectares simple.

The Segara Anakan Subproject area has no major irrigation at the present time. There are two small technical irrigation systems which irrigate a total of 1,367 hectares.

The Central Java Subproject area has 4,547 hectares served by technical irrigation systems, 1,100 hectares under semi-technical systems, and 6,433 hectares under simple systems. The total area under all systems is 12,080 hectares.

Drainage

The major drainage problem is that the flood plain is very flat. Levees which provide flood protection impede natural drainage. There is no outlet for internal drainage water when the Citanduy and Ciseel Rivers are at high stage.

There is an existing drainage system carrying storm runoff and irrigation return flow from the North Lakbok area to South Lakbok via the Citisung drainage canal. This drain discharges into the Ciseel River. The capacity of this drainage system has been substantially reduced because of siltation, and the levees have been breached often during high water. A large area in South Lakbok is rendered relatively useless because of poor drainage.

The Cirapuan drain above Padaherang has inadequate capacity and has had a cross drainage structure blocked by local people.

Flap gates are utilized to prevent backwater flooding from rivers and to discharge waters when stream levels are low. But in the areas between the Citanduy and the Ciseel Rivers, these structures are inoperative due to poor maintenance. As a consequence, they fail to prevent backwater during high river stages.

In the lower Sidareja area the flat topography and surface flooding contribute to poor drainage during high tides. During the dry season salt water intrusion occurs in this area. Existing plans call for irrigating the plains above these poorly drained areas, but the drainage problem will persist unless relief is afforded through tidal control.

Other areas suffer from impeded surface drainage in various degrees. These situations must be improved before full agricultural development can take place. No program for rehabilitation of irrigation and flood control works can be fully effective unless accompanied by an adequate surface drainage system.

Domestic and Municipal Water Supplies

The high rate of annual rainfall and the subsurface geology contribute to widespread occurrence of shallow ground water and make it possible to utilize shallow, hand-dug wells for domestic water supplies. Hand pumps are usually used to lift the water but frequent use is made of a bucket and rope, in which case the well is not covered.

According to the Public Health officials, the close proximity of these wells to streams, fish ponds and wasteways, and their shallowness, give rise to probable pollution from human and animal wastes. The ponds and open sewers comprise the principal disposal system for sewage. Apparently the problem is greater during the dry season, when percolation from surface ponds contributes more to the ground water in the wells.

The problem therefore appears to be not so much the availability of domestic water as the quality. Use of polluted water is a health hazard even if the water is boiled for drinking and cooking. Exposure to illness is quite possible when the water is used for washing and bathing. It is not customary among most of the local residents to boil their water.

In the lower reaches of the basin the intrusion of salt water into the streams and ground water during the dry season results in domestic water supplies of low quality. Chemical analysis of ground waters indicates a higher concentration of soluble salts in the areas bordering the inland side of the Segara Anakan than elsewhere. The intensity of this concentration generally varies in inverse proportion to the distance away from the Segara Anakan. In these areas water for home use is obtained from surface streams and from catchment of rain water.

Only a few of the towns of the basin have a central water system. It appears from interviews conducted with public health and public works officials, that this type of development in the Citanduy basin is generally considered low priority for the near future. There have been some exploratory investigations made for a central water supply for the

city of Cilacap, looking into obtaining water from either the Jeruklegi or the Serayu Rivers. There has also been some progress made in developing natural springs as sources for town water supplies.

Tasikmalaya city has a central water supply and distribution system which was built about 1928. The supply source is a spring approximately 10 kilometers west of the city. The system consists of a collection system at a natural spring and about 46 kilometers of distribution pipeline. The distribution system has about 60 points within the city at which a user can tap into the pipeline and attach a supply line to his residence. The system operates under gravity pressure.

The present system has a capacity of about 10 liters per second, which is adequate for only about 10,000 people, whereas the population of Tasikmalaya is 140,000. Needless to say the majority of the city residents are not connected to the system.

The city of Banjar has a central water system which was installed about two years ago. The system consists of a cistern at a spring source, and a pipeline into town where residents can tap on at specified points. The capacity is 5 liters per second which will serve 5,000 people out of the city population of 40,000. This system delivers untreated water. During the dry season the water supply is inadequate. During heavy rains, the water is turbid.

Other similar systems are scheduled to be installed at subdistrict capital towns Panjalu and Rancah in the near future. The water supply program also includes 50 hand-dug wells with manual pumps in other villages. The progress of this program depends upon the availability of funds.

Public Waste Disposal

The system of waste disposal in the cities and towns consists of open sewers and gutters. In the business section of the cities, these sewers are placed in clay pipe underground at the edge of the street. The raw sewage is dumped directly into the nearest natural waterway without treatment. As would be expected, this means of waste disposal is a source of bad odor, insects, and water pollution in the streams. In the dry season the problems are more intense because the supply of flushing water is reduced.

In dealing with the waste disposal problems and needs, it would be preferable to identify solutions which can be accommodated by successive stages, building upon facilities that already exist. The burying of the sewers probably ought to have first priority. This could be followed by central sewage treatment plants. A role that storage reservoirs could play with respect to sewage disposal would be in stabilizing the flow of streams so that the supply of flushing water and dilution water is adequate in all seasons.

Industrial wastes are not of large magnitude because the manufacturing sector is small. Some of the plants discharging untreated wastes are rubber plantations, batik dyeing works, and spinning mills. In the case of the petroleum refinery under construction at Cilacap, waste treatment and disposal is a concern in planning for reclamation of the Segara Anakan. Its sponsors have given the city of Cilacap assurances that the industrial wastes, will not be allowed to pollute the waters of Cilacap harbor.

Land Reclamation

Erosion. Approximately 30 percent of the area of the Citanduy Basin is low-lying and flat. This area has no erosion problem. Another 50 percent of the basin area lies between 35 and 500 meters elevation and has gently undulating to hilly topography. These lands have small erosion potential because they are mostly terraced for paddy rice culture. For all practical purposes rice paddies are free of erosion problems. The remaining basin area amounting to 20 percent of the total, is situated above 500 meters elevation. From 500 meters to the top of the watershed divide the slopes become successively steeper, with some areas having 45 degree slopes (one meter rise for each meter horizontal distance). It is estimated that about 5 percent of the area of the river basin, or 20,000 hectares, is above elevation 1,000 meters, and is characterized by extremely steep, mountainous topography.

The soils on these steeper slopes are fine-textured and erosive. The high rainfall can erode these lands extensively if vegetative cover is not maintained. Originally, all these steep areas were occupied by dense rain forests which served to minimize soil erosion. However, at the present time large areas of the steep mountain slopes are lacking adequate forest cover. Due to the population pressure, annual cropping is practical on nearly all the available clear land areas, even on many of the steeper areas.

Plate II-21 is a map depicting the extent of various forestry types in the basin. The areas shown as critical areas on the map show severe erosive characteristics. The total extent of these critically eroding lands, all of which are at the higher elevations, is 74,000 ha. These are the lands which urgently require attention in respect to soil conservation measures. Thirty-four thousand hectares, or 46 percent of the lands, are under the Forest Service jurisdiction. The Forest Service has the plans and capability to reforest these problem lands, but has been faced with limited budgets for accomplishing their program. The 40,000 hectares in private ownership similarly require reforestation or conservation measures, but the accomplishment of these remedial measures is made more difficult because the individual owners cannot afford to sacrifice the annual food production that they now obtain from the land. The lands are usually planted to cassava, being too steep and erosive for rice paddies. Where rice paddies are attempted on these steep areas, numerous slides and breaks occur.

Sedimentation. Sediments are produced by rainfall impact, mass movements of residual soils, and by stream channel erosion in the headwater areas of the basin. These sediments are transported by the river system to the alluvial plain. Probably the major source of sediment is from the deforested lands that are left in a denuded state or that are planted to upland crops. With no protective covering these soils are easily dislodged and transported through the river system.

Landslides and other mass movements of soil and loose rock that reach an active watercourse are probably a significant source of sediment also, as the flowing water easily entrains material from the toes of such masses. The evaluation of landslide prevalence is made difficult by farmers' land preparations. As soon as a slide moves down, the new contiguration is terraced and farming resumes, so that the evidence of the slide quickly becomes obscured.

The sediment yield of the branch watersheds in the basin varies greatly from one area to another due to the topographic characteristics and the ground cover. Forests and plantations produce little sediment because the direct impact on soil by rainfall is prevented. Rice producing areas are not large source of sediment because the rainfall is harmlessly dissipated. Built-up areas, trails, roads and upland crop lands are large contributors of sediment.

The volume of sediments transported is estimated to be large. Aggradation of the Citanduy stream channel in the flood plain has been caused by sediment deposition and presents the problem of containing the flood discharges. Sedimentation of the Segara Anakan lagoon is proceeding relatively rapidly, in a geologic time sense, building new land but at the same time destroying fishery values in the lagoon. In the upper watershed, sedimentation poses a threat to the storage capacity and therefore the length of useful life of potential reservoirs.

Saltwater Intrusion. In the lower reach of the Citanduy basin the extremely low, flat topography permits tidal action to extend considerable distances up the Citanduy and the rivers draining into the Segara Anakan lagoon. The reclamation area of the Segara Anakan comprises about 24,000 hectares of tidal swamps, tidal marshes and partially cultivated areas which were formerly tidal lands. These lands are highly salinized, although they are otherwise potentially productive rice lands. A large proportion of these lands is no higher than the elevation of high tides, and is therefore periodically inundated by brackish water. In the dry season, the effect is the greatest.

Inland from this area surrounding the Segara Anakan lagoon, there is an area which is under consideration for irrigation development by diversion of water from the left bank of the Citanduy. Some 6,000 hectares of this area are believed to be influenced adversely by salt water intrusion inasmuch as salt water encroaches up the Cibeureum River as far as Sidareja. Much of the area is affected by tidal influences, high water table, and poor surface drainage. Improved surface drainage is a prerequisite to successful irrigation. In the absence of tidal fluctuations the system of natural drainageways would be more effective in carrying off excess water and this would permit the salts to be leached out of the soils.

The Cilacap peninsula, being a sand spit, has a salt water aquifer throughout. This is overlain by a thin layer of fresh water percolate. In the dry season, the fresh water layer is depleted and the shallow domestic water wells become salty. The rapid growth of the city requires that a central potable water supply system be installed for domestic, municipal and industrial purposes.

Other minor areas near the seacoast are similarly affected by salt water and tidal influences. In excess of 30,000 hectares overall would be favorably influenced by control of the tides in the Segara Anakan subproject and by converting it into a fresh water lagoon.

Forestry. Forest areas cover approximately 19 percent of the land area of the basin. Various figures for the area in forests are reported by government agencies and it is believed that the reason for this lies principally in differences in classifications for cutover land and crop and swamp lands administered by the Forest Service. Plate II-21 depicts the types of forest and critical areas (so classified by the Forest Service) in the basin.

The map shows extensive critical erosion areas which are associated with forestry classifications. These lands are estimated to cover about 74,000 hectares. They have been denuded by the harvest of timber and not replanted. The restoration of these lands requires special soil conservation practices and replanting either to trees or permanent grass cover because of the rough, steep topography and erosive soil. Various proven methods of soil conservation structures could be implemented. The work force for this and the capital budget would have to be coordinated between the West and Central Java provinces.

The boundaries and lands officially designated forestry lands are not clearly resolved because of lack of cadastral surveys and because of the problem of squatters who cleared the forests for farming. Classification of the lands according to proper land use is a prerequisite to restoration. Natural areas need to be established to set aside lands for unique

types of plants and animals. Management needs to be intensified to prevent illegal harvest of timber and firewood. Access roads into the forest areas are badly needed.

Electric Power

The basin area is inadequately supplied with electric power. This stems from several causes. Due to the fact that the region is relatively remote from the more well-developed commercial and industrial areas of Java, there has not been great pressure for development of the infrastructure, which includes electric power. Additionally, even for those areas served by the power system, development of local customer demand has been retarded in the past by low personal income levels. All users of electricity have been inhibited by the lack of reliability of the supply of energy. At the present time, however, there are clear indications that the demand for electricity is outrunning the supply, and that the economic and social development of the region would benefit significantly from improved power supplies.

Source of Electric Power Supplies

The government agency Perusahaan Listrik Negara (PLN) supplies electric power to parts of the basin. Areas not served by PLN are either entirely without electrical service (which is most of the area), or they rely upon small diesel generating units. The basin is included in PLN Administrative Districts 10 and 11. District 10 covers the Central Java portion, but PLN power is supplied only to Cilacap. District 11 covers the West Java portion. At present there is no interconnection between these two districts.

In District 10, the installed capacity is 64 MW. This is reduced to 47 MW during the dry season because some of the generating capacity (27.5 MW) is hydro. Additions to the system which are already committed consist of turbine and diesel peaking units, and a 100 MW steam plant at Semarang.

In District 11, which is the eastern portion of West Java, the installed capacity is 60 MW, of which 58 MW are hydro. Low water in the dry season limits the system capability to about 40 MW. The District obtains some of its power from the Jatiluhur Project, a hydro installation with installed capacity of 125 MW. Jatiluhur also supplies power to District 12, which includes Jakarta. Due to its commitments to supply irrigation water, the Jatiluhur Project is not able to generate base load at full capacity.

The source of power in the West Java portion of the basin is from a 5 MW hydro plant at Plengan, which is about 125 km to the west. The West Java area of the Citanduy basin uses about 5 percent of the entire system load in District 11.

Cilacap, in Central Java, draws power from the Ketenger generating system. A new 150 kV line leading to Cilacap is already under a loan commitment. This will provide the power needed to meet the rapidly growing commercial and industrial demand there.

Local Power Use

In the Citanduy basin power usage per customer is very small. The West Java area is served out of the Tasikmalaya PLN office. In 1973, that load center reportedly distributed a total of 21.7 million kWh to 17,971 customers. The average delivery per customer was 1,200 kWh, with revenue per customer being Rp. 9,900 ($24) for that year. The service

reached only about five percent of the homes in the area. Three-fourths of the energy was consumed by households. Most households are furnished power at a flat rate. The rates are presently under review for increases to catch up to current operating costs.

Interconnections Between Systems

Service into the West Java portion of the basin is by means of a single circuit 30 kV transmission line from the hydro generating plant at Plengan. This is a radial system which provides no reserve. Although there are transmission connections with the rest of District 11, most of the load centers do not have the reliability which would be provided by a loop transmission system. Voltage sag to 90 volts occurs in the evening almost daily in Banjar, and outages are frequent. This variability is very destructive to electrical equipment, and discourages use.

There are proposed system interconnections which could enhance the capability of both District 10 and 11 generating and distribution systems. One interconnection has been proposed between Tegal and Cirebon along the north coast. Another possibility would be through Banjar, which is only 33 km from a proposed District 10 transmission line extension to Majenang.

A recent consultant's report, (Chas. T. Main - West Java Power System Long Range Plan, 1972) contained the following regarding interconnection: "Interconnection (of the West Java system) with the Central Java system between Cirebon and Tegal and between Tasikmalaya and Cilacap would enable extensive generation development in the Cirebon and Cilacap areas resulting in overall system economics." Therefore, the location of a hydroelectric power project in the basin would have a special advantage, being midway between the two load centers and approximately on the route of proposed interconnections.

Future Power Demand

The overall electric power demand in Indonesia is reported to be doubling every five years. PLN has planned to add 1,105 MW of generating capacity during the period 1973-1978. While the greatest load growth is taking place in the Jakarta area (40 percent increase per year), all regions have large potential demands. The demand for peaking power for West and Central Java was estimated by Chas. T. Main, Inc. to be growing at 13.5 percent annually. It is understood that this projection is being revised upward by PLN.

Agricultural Development

General

Throughout the entire Citanduy basin the economy is dominated by agriculture. Eighty percent of the population is directly engaged in agriculture. The livelihoods of a significant share of the remainder also indirectly relate to agriculture through the transportation, processing and marketing of the agricultural output.

Subsistence farming dominates the private agricultural sector. Farms are extremely small (average size is less than one hectare), crop yields are lower than they should be, and output per man hour in agriculture is extremely low and poorly rewarded. Annual per capita income in agriculture is only about Rp. 16,500 ($40).

Land use is reasonably well diversified as shown in the tabulation below; however. lowland rice is the most extensively grown single crop.

Crop	Percent of Agricultural Land Area
Lowland Rice	24
Upland Crops	27
Home Gardens	10
Forest	19
Plantations	17
Other	3
Total	100

Lowland Rice

In 1972 lowland rice was grown on 101,000 hectares of land. A total of 170,000 hectares of rice was harvested, making the land use intensity 168 percent. During the rainy season all of the rice paddies are planted to rice, but during the dry season areas not having the advantage of irrigation are faced with the risk of failure and reduced yields.

Rice is grown on extremely small plots. Nearly all of the cultural operations are performed by labor intensive methods, as has been the custom for centuries. Some of the more affluent farmers use water buffalo to plow and harrow the land in preparation for new plantings. Harvesting is generally done with the "ani-ani" knife which is used to cut each stalk of rice individually. From 200 to 300 days of work are required per hectare of rice, with the whole family contributing to various operations. Nearly all of the farmers try to grow two crops per year.

The yield of lowland rice averaged 2,257 kilograms of rough rice per hectare harvested in the period 1968 through 1972. The soil and water conditions are quite variable within the basin, so that the average yields reported by subdistricts varied between 1,639 kilograms to 2,734 kilograms per hectare. These yields are the average for wet and dry seasons, and it usually could be expected that the dry season yields would be less and the wet season yields would be higher.

In recent years, Indonesia has had to import over a million tons of milled rice per year to meet rapidly growing consumption requirements. The production of rice in the basin now is just sufficient to meet the local demand. While it is fortunate that such a heavily populated region can be self-sufficient in food (if it were not, more people would probably leave it), the area cannot prosper until it produces a marketable surplus of products. All of the presently arable land is in production, but rice production could be increased by improvement and extension of irrigation and by increasing lowland rice yield per hectare. It would be desirable to have a rice research program within the area. This would enable concentration on local problems and would be of importance in terms of education and demonstration.

The per hectare yield of lowland rice could readily be doubled. In order to do this the new high yield varieties (HYV's) should be adopted by all the farmers. It is estimated that 70 percent of the farmers in the Tasikmalaya District have adopted the HYV's, while 30 percent of farmers in the Ciamis District have done so and less than 30 percent in the Cilacap District.

To accomplish this widespread conversion, the BIMAS and INMAS programs would have to be expanded to make the package of HYV seed, pesticide, fertilizer and credit available to all farmers. At the present time, these production necessities are available only in limited quantity. Where there has been more demand for the BIMAS program than could

be met with the available supply, it has been restricted to farmers having irrigation because the program gives its maximum response under irrigated conditions.

Cultural practices could be upgraded by applying the results of crop research performed in Indonesia and elsewhere. This includes land preparation, seedling methods, pest and disease control, harvest practices and grain drying and handling. These improvements are already being accepted by some farmers, but the progress being made needs to be hastened by additional guidance through the Agricultural Extension Service.

Irrigation and drainage facilities are badly in need of rehabilitation. Some extensions to existing systems could be made. There are several potential new irrigation areas that should be developed. Inadequate operation and maintenance and poor water distribution and management contribute to low efficiencies in the existing irrigation systems. These factors could be vastly improved, and production would be improved markedly.

Drainage facilities are in poor condition. These need to be put back into good operating order and augmented with additional drains. The drainage problem relates both to irrigation runoff and to flooding from the major rivers.

Flood control is essential for protection of the flood plains, which are largely planted to lowland rice. Floods cannot be controlled by the existing levee system. Recurrent serious floods significantly reduce agricultural production, damage irrigation and drainage facilities, and discourage the higher grade use of the land.

Improvements are needed in rice storage, milling, grading and marketing. Some progress is being made, but it needs to be accelerated. The numbers of extension agents available to carry on guidance programs is far too limited. Government sources of credit are likewise insufficient to meet the full need and obtaining credit involves considerable official routine. Transportation modes are primitive throughout the basin, except along the highway and the railroad. Vast areas are not accessible by motor vehicles.

Upland Crops

Upland crops are those which are chiefly grown under rainfed conditions on rolling or hilly terrain. However, the so-called upland crops are not confined to the upland. These crops can be, and are, grown on the lowlands whenever drainage conditions permit (which is usually restricted to the dry season). The main upland crops are rice, cassava, corn and sweet potatoes. Of lesser importance are peanuts, soybeans, table beans and numerous other food-type crops.

The upland rice crop represents about 10 percent of the total rice growing area, but only 4 percent of the total annual production. The average yield is less than half that of lowland rice. Upland rice is grown only during the wet season. Research workers feel that with improved upland varieties and with better cultural practices the average yield should more than double. However, most of the research and extension effort has been applied to lowland rice in the past.

Upland crop production is just sufficient to meet local needs. If production were increased, it would provide an additional means of increasing farm and non-farm income. Corn, peanuts, cassava and soybeans offer good potential for cash crops. More supplies of these crops would help to generate demand, particularly if the crops could be produced more efficiently and at less cost than at present.

Nearly all of the described problems and needs relating to lowland rice also apply in varying degrees to upland crops. Although a large effort is needed to upgrade rice production, a companion program is needed for other crops in order to diversify the diet of the people, broaden their income opportunities, and contribute to exportable surplus of food and agricultural products.

Water resource development cannot help upland crop production as much as it can benefit lowland rice. However, significant benefits could be gained from drainage facilities inasmuch as these facilities would permit the use of lowland rice areas for more diversified farming during the dry season.

Plantations and Smallholders Estate Crops

In the Citanduy basin large plantations total nearly 20,000 hectares. Nearly all of the large plantations are owned by the government and are devoted to rubber production. The range in size of these large plantations is between 30 and 3,220 hectares.

Smallholder estate crops grown in the Ciamis and Tasikmalaya Districts, total 52,000 hectares. Records obtained from the subdistrict units of the Cilacap District did not include smallholder estate crops, but an estimate of 15,000 hectares was derived by apportionment of the Cilacap District total. The area of estate crops grown per smallholder is not available, but is likely to be close to the one-sixth hectare average size reported for West Java Province.

The tabulation below shows the breakdown of estate crops grown by smallholders in the Ciamis District in 1972. This crop distribution pattern is probably representative of the basin as a whole.

Crop	Hectare
Coconut	34,732
Rubber	1,658
Clove	899
Tea	186
Coffee	327
Palm Sugar	446
Citronella	1,869
Total	40,117

Only coconut and rubber are produced in sufficient quantity to be exported from the Citanduy Basin. The estimated value of coconut production in 1972 was Rp. 8,219 million ($19,853,000). The value of rubber production was $1,355 million ($3,272,000).

Most of the basic problems of the plantation crops are recognized by the agricultural officials and are pointed out in the evaluation of Pelita I (first five year plan). With respect to the rubber crop these are as follows:

1. Lack of incentive to produce high quality because of marketing system.
2. Not sufficient capital for replacement of trees and proper maintenance of trees and equipment.
3. The need for more research and extension activities.
4. Deficiency in management skills.

With respect to coconut plantations the main problems involve:

1. Lack of capital for replacement and proper maintenance.

2. The production is low because up to 50 percent of the coconut palms are too old or are in a damaged condition.

3. Not enough seedlings of the improved varieties to fill requirements.

4. The marketing system is poor.

5. Research and extension programs on coconut production are largely lacking.

6. Management skills need improvement.

The other plantation crops such as citronella, coffee, tea, pepper, vanilla, cacao, etc. suffer these deficiencies to the same degree or greater than the two major crops. Each of the crops has gone through a series of crises which have left the industry in a serious situation.

The important decision that has to be made is the extent to which further development in plantation and estate crops is economically sound. For example, natural rubber has been for several years in less demand due to the lower cost for synthetic rubber. With the recent increased cost of petroleum, it appears that natural rubber can again be competitive over at least the short run. The question is how long this situation will last.

Smallholders are disadvantaged in marketing their production. Their volume of output is small, transportation into much of the region is difficult, little knowledge of market conditions is available, product quality is usually poor, and credit for smallholders operations is costly if available at all.

Livestock

Production from livestock constitutes only a small proportion of farm income in the Citanduy basin. The highly intensive use of the land for rice production and other food crops precludes the use of land solely for livestock feed and grazing. Traditionally, meat and livestock products have not been of primary importance in the Indonesia diet.

The following tabulation shows livestock numbers in the Citanduy basin.

Livestock	Numbers
Horses	3,264
Cattle	12,309
Buffalo	27,376
Goats	169,153
Sheep	119,883
Swine	3,752
Chickens	1,509,806
Ducks	247,123

Cattle and buffalo are kept primarily for their use as draft animals, and secondarily for meat. When the price of meat is high, some of the cattle will be butchered even while they are still of a working age. A few cows and heifers are maintained for breeding, but are not used as draft animals. Most of the cattle and buffalo numbers that slaughtered, therefore, consist of females and old bulls. There is very little milk production. There is a growing demand for beef,

particularly for export to Singapore, which makes it difficult to maintain or increase numbers of buffalo and cattle. Water buffalo are used for field work, but many farmers cannot afford to keep or hire them. They are seldom seen here being used as dray animals.

Goats and sheep are kept in small numbers for their meat and wool. The goats are not milked. Most of the goats and sheep are kept in small corrals or cages near the residence and are turned out daily to be herded along the roadsides. Green forage is also cut and brought to the enclosure sometimes.

The problem of increasing the numbers of ruminants for meat production is chiefly that of limited available feed. Due to the demand for food crops, crop land cannot be devoted extensively to livestock feed. Some capacity for expansion of grazing exists in areas such as roadways and rubber and teak plantations.

It is believed that the areas having rough topography and critical erosion problems could be productively used for livestock pasture, thus increasing the production potential for meat and other livestock products. This use must be economically competitive with other existing and potential uses for the land, however. Expansion of livestock production has not received much attention because of the urgent need for increasing production of rice which is the traditional food staple. Naturally, rice can more efficiently meet food needs than can livestock, but there remains the requirement for more animal protein in the diet.

Fisheries

The production of fish in farm fish ponds is a small but important enterprise in the Citanduy basin. Fish are one of the most important sources of animal protein in the diet. These farm ponds are usually small, in the order of 300 square meters in area, and less than a meter in depth. The production per hectare of surface area may be as high as two tons in favorable conditions. In 1973 an average yield of slightly over 2 tons per hectare was reported in the Ciamis District, and the area of fish ponds was estimated to be about 6,200 hectares. In 1972 the production was about 10,200 tons.

Fish are also produced in rice paddies. The full extent of this kind of fish farming is not available. In the Ciamis District the reported area used for production of fish in rice paddies was 125 hectares in 1972. The production was reported to be 47 tons.

Some fish are produced in the natural swamps. In the Ciamis District in 1972 there were 2,500 hectares of swamp utilized for fish, from which 260 tons of fish were produced. During the rainy season the swamps can be stocked with fingerlings which will grow to sizeable fish by the end of the dry season when the swamp dries up. This stocking and fishing program is sponsored at the village level.

There are a few small lakes in the basin but little data is available on their use for fish production. The rivers and creeks are all heavily fished by the villagers. No program of artificial fish planting in the streams is carried on. The natural production in streams is low, mainly because of the large amount of sediment carried by the streams. Eels and shrimp are caught, as well as fish. The eels have some local demand, but most are shipped out to Jakarta. Fishermen in the region use a wide and ingenious variety of nets, traps, and lines. Reported production from the Citanduy River (west side only) during 1973 was 37 tons of fish, 15 tons of shrimp, and 9 tons of eels.

The water surface area of the Segara Anakan lagoon, sloughs and estuaries is 8,150 hectares. The lagoon itself is 4,300 hectares. This is a brackish water body with low fish production. The progressive shallowing of the waters due to

deposition of river sediments is gradually reducing fish production. In 1972 the catch was 493 tons, according to the Fisheries Service. Indah Karya has reported that the annual production has ranged between 300 and 700 tons of shrimp and fish. The output is marketed and consumed locally, being little more than needed for the local fishermen families own use.

A principal activity at Cilacap is the marketing of the offshore catch of salt water fish along the southern coast of Java. The coastal waters are productive and are being increasingly exploited by commercial fishermen. Market facilities and freezing plants for fish and shrimp are being expanded as a part of the regional development program for Cilacap. In 1972 the catch consisted of 3,799 tons of shrimp and 4,297 tons of fish. The principal markets are Yogyakarta, Jakarta and Bandung. When the new freezing facilities become available it will be possible to export the shrimp and fish to Japan, where a strong demand exists.

To obtain greater production in farm fish ponds three principal items are needed. The first is an expanded program of guidance and assistance for the farmers in fish culture, and management of the farm ponds. The second is an improved year-round water supply source for those ponds which are not within an irrigation system having a dry season water supply. The third is an improved supply of fingerlings for stocking the rearing ponds.

River fishery would be greatly improved by reducing the quantity of sediment in the streams. Only the hardiest varieties of fish can live in the extremely turbid water of the Citanduy and its tributaries. Augmentation of stream flows during the dry season by means of storage reservoirs would be highly beneficial. Additionally, with improved habitat, it would be profitable to initiate a program of fish stocking on the upgraded streams.

The Segara Anakan fishery will probably be reduced to virtually nothing in another 20 years unless some action is taken to eliminate the problem of sedimentation of the lagoon. An estimated 4,000 families depend on the Segara Anakan fishery for a livelihood.

The use of insecticides and pesticides poses a problem to fish being raised in farm ponds and in rice paddies. Low toxicity chemicals should be used by farmers.

The fishing methods and gear utilized by fishermen in inland waters are crude and primitive. Consequently, the productivity per fisherman is limited.

Legal and Institutional Factors

Land Management

There is need for a standardized government-wide system of forestry and land use planning and management. The procedures and methods used in West Java, which is managed under a governmental type of organization, do not completely conform with the procedures and methods of Central Java which employs an Enterprise system of management (Perhutani). The authority and basis for such a revision in organization must come from the central government.

Policy for land management should be reviewed and national priorities established. The multiple-use concept of management of forest, grazing lands and plantation lands would be a move in the right direction in order to get the optimal production out of land resources. Regulations which would promulgate the new policies would have to be written.

Following that, indoctrination training would be necessary to ensure that all administrators and workers are made familiar with the revisions. The relationship of the Citanduy Multipurpose Authority to the operational programs of land management would have to be made abundantly clear. In order to apply new policies it is essential that the field level practices be modernized.

There are strong indications that at present most of the agency funds are needed to maintain the administrative level personnel structure, and too little is left over for field operations. To overcome this problem, management efficiency and structure analyses will have to be made. Additionally, too many projects undertaken simultaneously is bound to lead to too small an effort on each to be truly efficient.

At the present time there are too many agencies reporting data independently and no official effort to check for and reconcile discrepancies. Better organization is needed in data collection, and a central publication agency (or at least a coordinated system applied by agencies) should be established so that source material would be published on a consistent and continuing basis. As it now stands, there are few reliable statistics that can be utilized to record accomplishments of development.

Water Management

Water management cannot be treated as a separate problem from land management. The same problems listed above in relation to land management confront administrators and planners in water resource development. Some of the problems of combining the land and water management efforts would be corrected if an overall Citanduy Multipurpose Authority were established.

National water policy, laws and regulations all need to be modernized and clarified. Much of the law still incorporates the old Dutch policies and laws, and would benefit from thorough review in terms of present day objectives.

The time will soon be at hand when conflicts over water appropriation and rights of use will arise. The legal and institutional apparatus to resolve problems involving competitive water uses will be needed.

Water management activities need to be better coordinated between the several government agencies and the village sectors. The two provincial governments need to conform their policies and practices. The new organization established as the overall authority will be confronted with this coordination problem and with the necessity to work within the traditional framework which the people can understand and appreciate. Leadership and direction exercised by the authority must be matched by a responsibility for the results of the program.

Finally, at the grass roots level, the water user must be brought to regard the water resource as something to be utilized wisely and shared equitably with his neighbors. This means a guidance program to bring about a fuller appreciation of a farmer's own responsibilities for wise use of the irrigation water, and sharing in the maintenance and costs for upkeep of the system. All of these things require an appropriate system of incentives, rules, and penalties to make the organization and practices successful.

Infrastructure

The infrastructure of the Citanduy basin needs to be strengthened in numerous respects in order to facilitate economic development and improve the general welfare. The concern herein is chiefly for those elements of the infrastructure which could be improved through water resource development. However, almost anything done to stimulate the economic base of the region would have a beneficial effect on community structure and public facilities. Consequently, one could expect land reclamation, reforestation, flood control, irrigation, fisheries and hydroelectric power development all to build towards an improved infrastructure. A discussion of the conditions and problems follows.

Public Education

Educational achievement in the region is far below desirable levels. This is due to a long-standing lack of cultural penetration in the isolated communities, a lack of adequate schools and sufficient teachers, and insufficient capital resources at the government and family levels. Only 44 percent of the children in the eligible age group are attending school. The drop-out rate beyond primary school is very great as indicated by the fact that only 2 percent of the adult population has completed high school. Obviously, high school education is not available to the majority of the eligible age students because only 12 out of the 30 subdistricts have a high school within their boundaries. Forty-five percent of the population is below 17 years of age, meaning that the need for increasing educational facilities, opportunities, and participation is already at hand. The progress that the present generation of youth makes will depend on the education it will receive in the next decade. Simply attaining literacy will not be sufficient; these young people need to be educated in modern technological skills and professional fields.

Public Health

Facilities for public health are operated by the district governments. These consist of hospitals, maternity clinics and general health care clinics. Nearly all medical personnel - doctors, practical nurses, midwives and assistants - are employed by the public health departments. As far as can be determined the extent of health services performed by the private sector is quite limited. However, there reportedly are 35 private health services (clinics) in the Cilacap District. The doctors employed by the public hospitals are also allowed to engage in private practice. Following is a tabulation of health facilities and personnel in the Citanduy basin:

Item	Number
Facilities:	
Hospitals	6
Clinics	309
Private clinics	35
Maternity clinics	52
Personnel:	
Medical doctors	41
Midwives and assistants	483

Quite obviously, the number of doctors is far too few to provide professional care to a broad sector of the population. The doctors and the principal hospitals are located at the cities of Tasikmalaya, Banjar, Ciamis and Cilacap and the towns of Sidareja and Matenggeng. Data could not be obtained on infant mortality. However, the general impression

gained was that the infant mortality rate, although high, is declining and that the improvement has been the principal cause for the declining median age. The practice of midwifery is long established, and apparently conducted effectively judging from the birth rate figures. The lack of passable roads to most of the villages in the basin undoubtedly precludes the necessary professional care in many cases of illness. The major health hazards reported in the Citanduy basin in 1972 are tabulated below:

Sickness	Cases	Deaths
Malaria	1,846	
Cholera	1,193	130
Typhoid	91	2
Dysentery	6,707	
Tuberculosis	5,382	
Diarrhea/Enteristis	31,095	

One of the most serious health hazards in the area is malaria which is most prevalent in the lowlands near the Segara Anakan. It is reported that the salt water breeding mosquito, Anopholes Sundiacus, is particularly difficult to control in the isolated reaches of the Segara Anakan.

Another serious hazard is cholera, a sickness caused primarily from polluted drinking water supplies. The shallow wells are easily polluted from surface sources. The largest source of pollution are the domestic fish ponds, which also frequently serve as sewage lagoons. Seepage into wells cannot be prevented. The local people do not exercise proper care in preparing the water for drinking. Chlorination or boiling would be sufficient, if carried out. Death from cholera is not uncommon. In 1972 there were 94 reported deaths from cholera in the Cilacap District, 15 in the Tasikmalaya District, and 21 in the Ciamis District.

Generally speaking, the greatest hazard to health is poor sanitation. Improvements in sanitary water supplies, proper sewage disposal and insect and rat control are all badly needed. Additionally, education in hygiene is necessary. To a large degree the heavy incidence of dysentery, diarrhea and cholera which characterize these rural areas could be controlled by greater attention to sanitation.

Transportation

The following tabulation shows the extent of transportation routes within the Citanduy basin:

Type	Kilometers
Railroad	198
Highway	252
Secondary Road	408
Village Road	1,148
Total	2,006

The railroad connects the major cities. The main railroad crosses Java in an east-west direction and passes through Tasikmalaya, Ciamis and Banjar. Branch lines extend southeastward from Banjar down the west and east sides of the Citanduy basin to the coast. The rolling stock is observed to be quite old and is reported to be difficult to maintain. The condition of the line from Banjar to Kalipucang is very bad. The railroad is suffering from intense competition with highway transport, and is likely to experience further reductions in traffic and revenues. The recent installation of a

petroleum pipeline from the port of Cilacap to points in Central Java has markedly reduced the tonnage of shipmenrs carried by rail out of Cilacap.

The existing road system is inadequate for efficient movement of goods to market. The main highway needs to be improved by providing a stronger and wider road base, by eliminating blind curves, by reducing grades, and by upgrading bridges. The primary road system needs to be extended to all of the subdistrict towns. Secondary roads are needed to connect all of the villages. Maintenance of roads is poor, and little progress can be seen toward upgrading the road standards in this region. Secondary roads are usually passable in the dry season but travel is slow and rough. In the rainy season the condition of these roads is not dependable. Village roads are not usually passable except by jeeps and trucks. The highest road classification in the basin is Class III.

A principal difficulty being experienced with highway maintenance lies with the heavy truck and bus traffic, which is increasing rapidly. Restrictions need to be applied on loaded truck and bus weights. Traffic safety facilities such as signs, lane marking and stop signs are needed.

The vast areas that remain almost completely isolated from motorized transport are at a severe disadvantage in communications and marketing. Farmers cannot freely transport their products away, and are largely at the mercy of middlemen who come and buy on their own terms. In-shipments of goods is likely impeded. Services to the communities cannot be efficiently provided under the present transportation handicaps. For example, agricultural extension services and public health and family planning are difficult to extend to the remote areas. Increased mobility of the population and work force is essential to the advancement of the economy.

While surface transportation development is not a primary target of water resource development in the Citanduy basin, flood control and irrigation development would complement the further improvement of transport services through the protection which flood control would afford and through the increased commerce which follows irrigation development. Transportation improvements will have to proceed hand-in-hand with the other water-related projects if optimal progress is to be obtained.

Commercial inland water transportation has been limited to a route from Cilacap through the Segara Anakan to Kalipucang. A small ferry based in Cilacap makes a daily round trip carrying both passengers and freight. Eight months of record in 1972 showed that the ferry carried 8,400 passengers and had total revenues for the period amounting to Rp. 784,116 ($1,894).

A large number of dugout canoes ply the waters of the Segara Anakan and the lower reaches of the rivers. These boats are used for fishing and transport of rice, firewood and other items of local trade. Prospects for expansion of shipping on the waters of the Segara Anakan or the river leading into it appear extremely limited unless reclamation becomes a reality. Then it would be expected that extensive boat traffic would build up to serve the farming sector, leading to a need for improvement in small boat landing facilities.

Cilacap is the only ocean port on the southern coast of Java. The condition of the harbor facilities has deteriorated in recent years, but arrangements have been made under the Colombo Plan to deepen the harbor and rehabilitate the port facilities. The economic expansion foreseen for Cilacap is largely based on its role as an ocean shipping point. Below is a tabulation of the number of ships calling at Cilacap since 1965.

Year	Number of Ships
1965	72
1966	48
1967	60
1968	58
1969	82
1970	91
1971	143
1972	153

There are presently no commercial aircraft landing facilities in the basin. Emergency landing fields are maintained at Tasikmalaya City and near the town of Langensari, about 6 kilometers east of Banjar. A landing strip is planned at the city of Cilacap.

Marketing

Marketing of the products of agriculture and industry is largely done under the free enterprise system, except in the cases of government-owned rubber and coconut plantations. So far as could be determined there is no wide-spread cooperative marketing being carried on. Strong cooperative organizations are precluded by poor communications and transportation as well as various problems of management and financing. There is a cooperative market batik handicraft at Tasikmalaya. A cooperative poultry production and marketing association is operating at Ciamis. There are other local production and marketing crops associated with the government sponsored BUUD cooperatives which make rice purchases from the farmers for the BULOC program, and it is intended that the BUUD cooperatives will include other activities in behalf of farmers in the future.

Some of the factors that would have to be improved for more effective cooperative marketing would be training for management, improved communication and transportation, and adequate amounts of operating capital at reasonable cost. Another serious limitation for which relief is not foreseen in the short run is the fact that subsistence type farming produces extremely small quantities of farm products surplus to family needs. This is not conductive to efficient cooperative marketing operations.

Each larger village has a central retail market. These markets are owned by the municipality, with nominal rent being charged for the booths. There is much room for improvement in the sanitary aspects of these markets. There is no running water or refrigeration. There are surprisingly few houseflies, but the passageways are not maintained in clean condition and the odors are offensive.

Inasmuch as rice is the chief crop, its marketing is of the greatest importance. Improvements needed to make rice marketing more favorable for producers, chiefly by reducing the marketing margin, include better roads and communications, education in marketing management and institutions, capital for cooperatives and for farm financing, improved local milling and storage facilities and introduction of rice driers. Rice marketing would benefit from the use of rice grading standards. The system of grades already exists, but is not used to a significant extent. Implementation of the market grading system would reward growers and millers who produce a quality product. When Indonesia enters the world market as an exporter, the use of grading structure will be mandatory.

Marketing of copra is handled through middlemen who assemble enough for truck shipment to the central shipping ...s and oil extraction mills. Similarly, middlemen negotiate at the farm level for peanuts, corn, soybeans and other

minor crops. The bargaining is usually to the disadvantage of the farmer due to his lack of knowledge about market conditions and lack of alternative sales outlets.

For all products in general, farmers need better farm-to-market roads, improved means of communication to obtain market information, storage, financing, and (above all) greater production of marketable goods.

Environmental Considerations

Historical Sites

The Ciung Wanara Historical Reservation is located just upstream of Banjar at the confluence of the Citanduy River and the Cimuntur River. It covers an area of approximately 30 hectares, and is important primarily for the mythical significance of Ciung Wanara, a legendary character dating back about 900 years. This is a heavily wooded area having the appearance of very old natural vegetation, but whether it is original forest is questionable. The area is visited by quite a large number of persons throughout the year, since it is located on the main highway and is an attractive rest stop for travelers.

This reservation is within the area that would be inundated by the potential Banjar Dam. A meeting was held at Ciamis for the purpose of obtaining the public viewpoint regarding this problem. As would be expected, opinion was divided, with the elders of the community expressing concern for the preservation of historical sites such as this one, and others voicing the desire to make adjustments and accommodations in order to facilitate needed developmental programs. Very careful consideration must be given to this problem if further thought is given to construction of Banjar Dam.

Throughout the area there are scattered many small cemeteries, which are probably in the category of a religious or holy nature. For instance, the small village at the point where the Citanduy River discharges into the Segara Anakan has both a mosque and a small cemetery. There is another one which would be affected at the potential Banjar Dam site. Others undoubtedly exist at other dam sites in the basin. Care would have to be exercised to ensure that these were not desecrated during construction. Local civic and religious leaders should be asked to participate in appropriate relocation planning.

As far as is known at the present, there are no known archeological sites within the areas being considered for development. Prior to construction of any dams, the reservoir areas would have to be checked out by knowledgeable authorities in the field of archeology, so that excavations could be performed during construction.

Ecology

The ecological systems in the Citanduy Basin have all been profoundly altered by man's long occupancy and intensive use of the area. Few natural remnants exist either of the vegetation or animal life. Consequently, what is of concern in developmental planning is to avoid further displacements in the present ecological situation to the extent feasible.

The upper reaches of the watershed are rough, erodible areas which urgently need stabilization of vegetative growth in order to hold the rock and soil in place and conserve runoff. The ecological balance in these areas has been severely disrupted by overexploitation of forest resources and conversion of steep land to crop production. The plant

and animal life and other organisms appropriate to the environment of these areas have in large measure been replaced with non-adapted species. The results have been creation of a critical erosion situation and an accompanying high rate of sediment movement in the rivers and reduction of the productivity of the lands. The problem is to get the areas back to a stabilized situation once again.

The middle reaches of the Citanduy River basin are intensively farmed. Rice paddies are perhaps one of the most effective devices for conserving water and soil in place. Consequently, the large areas in paddy cultivation are not a problem. However, cultivation of upland type crops on rolling terrain does create an erosion problem. Contouring terracing and vegetative residues and mulches can all be applied to an advantage on these lands. This is done to a considerable extent, but it needs to be extended. There is the question of incentive which affects whether a farmer will take such protective steps or not. A farmer may fail to see what gain he might receive by putting in greater conservation effects and investments. One way to deal with this is through an intensive extension service educational compaign. Another would be to offer some kind of financial subsidy to farmers who will implement the right kinds of conservation programs on their land.

The ecology of the Segara Anakan has felt less of the impact of man than the other areas of the basin, although the rate of sedimentation in the lagoon has accelerated because of the man-made erosion in the upper watershed. Population= of the area is sparce, being limited to about 8,000 persons in the "floating villages", which are built over the water on stilts. The inhabitants of these villages depend chiefly on the fish resources of the lagoon for their livelihoods. It is likely that the Segara Anakan waters are over-fished.

The mangrove swamps have a land elevation close to or somewhat above mean high tide level. Pioneer-type mangrove plants become established in mud banks being built up through sedimentation. Conservative estimates indicate that, if left unchecked, the sedimentation build-up will continue at a rate such that in a period of 30 to 35 years the entire Segara Anakan will be filled by mangrove swamps. This will not only render the Segara Anakan useless as a fishery, but it will bring on the certain deterioration of the higher lands on the inland side through poor drainage and salt water intrusion. The sediments that cause this are derived chiefly from the Citanduy River and its tributaries, and to a lesser extent from the rivers that are tributary to the lagoon; i.e. the Kayumati, Cibeureum, Cikujang and Jagadenda. The ecology of the mangrove swamp progresses through an evolutionary cycle during which the mangroves start, mature and eventually are replaced with other vegetation as sediment is brought onto the land surfaces by overflow of the streams at flood stages. Through this process upward building of the land surface continues. Eventually over a long period of time, with vegetation more adapted to fresh water environment, the landscape takes on more of the characteristics of a flood plain. The changes just described involve the loss of some life systems and the gain of others.

The ecology of Nusa Kambangan island has not been explored because access is restricted. It appears that most of the island is in a relatively wild state although it is doubtful whether the forest landscape is original growth. Some parts may still be in their natural state but these areas appear to be limited based on inspection of aerial photos and reconnaissance observations. Most of the area has the appearance of being cut over and in secondary growth. The northern shore, except for a short distance on both the east and west, is bordered by low-lying tidal swamps that border the Segara Anakan. These tidal areas would be subject to the same changes described earlier for mangrove swamps.

Inland fresh water swamps have a community of plants and animals quite different from either the surrounding farm lands or the tidal swamps. They serve as nesting and rearing grounds for water birds and are used for fish farming. As the water surface recedes during the dry season, the areas bordering the swamps are used for rice growing. The North

Lakbok swamp is a small residual wet area remaining after a large swamp forest was cleared and drained about 50 years ago. About 3,000 hectares of peat soil was exposed in the process. This soil requires farming practices different from the alluvial soils prevalent in the area. Controlled drainage is traditionally considered to be one of the key practices required for successful utilization of peat soils. Once proper drainage is established, it is quite possible to obtain normal agricultural production from them, but this does not necessarily mean rice. Investigation of an optimal drainage and irrigation system is needed, as well as determination of the optimal cropping use. The other swampy areas, should they be drained in the process of reclamation, will experience a significant alteration of their present ecological systems.

Reservoir sites all have an altered ecology resulting from intensive cultivation and settlement on the lands involved. Inundation of the lands would not raise any problems of destruction of natural plant and animal communities.

Fish and Wildlife

There are very few areas left in the basin that still enjoy the presence of game fish and/or other wildlife. About the only remaining area of any consequence in this respect is the Segara Anakan. A report entitled, Reconnaissance Alternate Study, Reclamation Scheme, Segara Anakan and Its Surrounding Swamps (Especially on the Biological Process), P. N. Indah Karya, 1973, provided a useful inventory of types of birds, fish, shrimp, plankton, mosquitos and plant life found within the area. Another report, A Study of the Ecological Aspects and Fishery in the Segara Anakan, Research Institute for Sea Fishery, 1974, deals with the fish catch and production potential and the role of the lagoon in shrimp production. As previously discussed, the sedimentation process that is taking place acts to reduce the fish production in the lagoon. The effect on shrimp production, both within the lagoon and offshore, is thought to be less disadvantaged by the shallowing process, as long as the mangrove area remains. Reduction of the mangrove area would likely reduce the breeding ground for shrimp.

Few land animals were observed in the Segara Anakan swamps during the investigation probably indicating that they have been exploited almost to extinction for food. Likewise, throughout the basin there are few wild animals left. To our knowledge no survey of wild animal population has ever been made anywhere in the basin. It is certain that the clearing of forest at high elevations has greatly reduced the habitat for wild birds and animals. Restoration of these forests could result in a significant comeback of wildlife, particularly if given proper protection from hunters.

The high turbidity of the streams of the Citanduy basin is adverse to fish and the food chain which is essential for fish production. The range of organisms that can exist in a stream is severely reduced by sediment pollution. Accordingly, the so-called trash species and scavengers such as carp and catfish are best adapted to survival in the streams. Of course, these are used widely for food in Asia, probably because they are almost the only fish surviving in natural waters.

Human Factors in Environment

Almost all, or possibly essentially all, of the Citanduy basin has been and is under the impact of man. The impacts have been the result primarily of forest cutting and agricultural endeavors. Detrimental operations in the upper portion of the basin have been and are responsible for more intensive runoff and accelerated erosion. The results in the lower portions of the basin have been increased sedimentation and flooding. There are only very limited areas that are natural; that is, undisturbed by man. There are enough well-managed forest lands and crop lands to indicate that, with proper techniques, the intensity of runoff and the rate of erosion can be minimized. The natural intensity of runoff and the natural rate of erosion cannot be attained in an absolute sense.

Thus the primary environmental impacts of the general area are rapid runoff and accelerated erosion. The inadequate forest and agricultural practices over a significant area of the Upper Citanduy/Ciseel River System cause such impacts. The inhabitants in the Lower Citanduy/Ciseel River System suffer the consequences.

In the case of forestry practices, for example, the clear cutting of the teak and the inadequate re-establishment of teak and a ground cover, expose the readily erodible soil to the full impact of intensive periodic precipitation. Runoff and erosion are excessive. Practices are available to minimize this severe impact on a short-term and on a long-term basis. Where the forest practices are adequate, the runoff is less intensive and there is a minimum of erosion and scouring.

There is intensive pressure to place more land under cultivation for subsistence and/or cash crops. Clearings are made in the forest, even on excessively steep slopes. Often open row crops are cultivated in inadequately designed terraces. Such practices result in excessively high runoff and excessive, accelerated erosion. Where slopes are not too steep and the terraces are properly designed, the runoff and erosion are evidently not excessive.

In almost all the upland forests, the forests are not mixed, but rather are reforestation efforts consisting of one type of tree to each area subject to reforestation. The monoculture thus practiced may appear to make economic sense, but it is potentially a dangerous practice from an ecological point of view. It is understood that to date there has been no serious epidemic attack in the teak forests. However, that is no reason to feel that a disease or pest cannot or will not invade and cause a very serious epidemic over large areas. The same comments are also applicable to rubber plantations and other concentrated tree crops.

The pollution of streams with silt as a result of man-caused soil erosion has been mentioned. Stream pollution also occurs from the discharge of untreated sewage into natural watercourses. This is a serious source of health hazard from cholera, gastro-enterities, dysentery and typhoid. The problem persists year-round, but is particularly bad in the dry season when stream flow is reduced. The waters of the Segara Anakan are contaminated because the lagoon as a whole is the sump for disposal of excreta. Yet it is used as a water supply for washing and bathing by the residents. The Segara Anakan is going to be increasingly subject to industrial pollution from construction and operation of the P. T. Pertamina refinery at Cilacap, as well as from the expanded use of the harbor. The creation of the industrial estate at Cilacap will also give rise to increased pollution from industrial waste discharges.

Extreme population pressure on the land and water resources of the basin causes degradation of the environment in different ways from the standpoint of malaria control. For example, the movement of people into and out of the high-malaria-incidence Segara Anakan area probably results in spread of the disease to other areas. Thus it can have an impact in areas well removed from the Segara Anakan vicinity.

Security needs of the population are not well met. Hazards from flooding expose a large proportion of the residents of the flood plain area to occasional-to-frequent harm or loss of assets. Agricultural resources are stretched too far among the exceedingly dense population, resulting in low income levels, under-and-unemployment, and outmigration of the younger element of the work force. Social unrest can develop out of the dissatisfactions that are felt, and personal initiative can be reduced. The quality of life of all of the residents of the basin is inhibited by virtue of the lack of adequate potable water, by the absence of proper sanitary facilities, and by the relative isolation and remoteness due to lack of good roads.

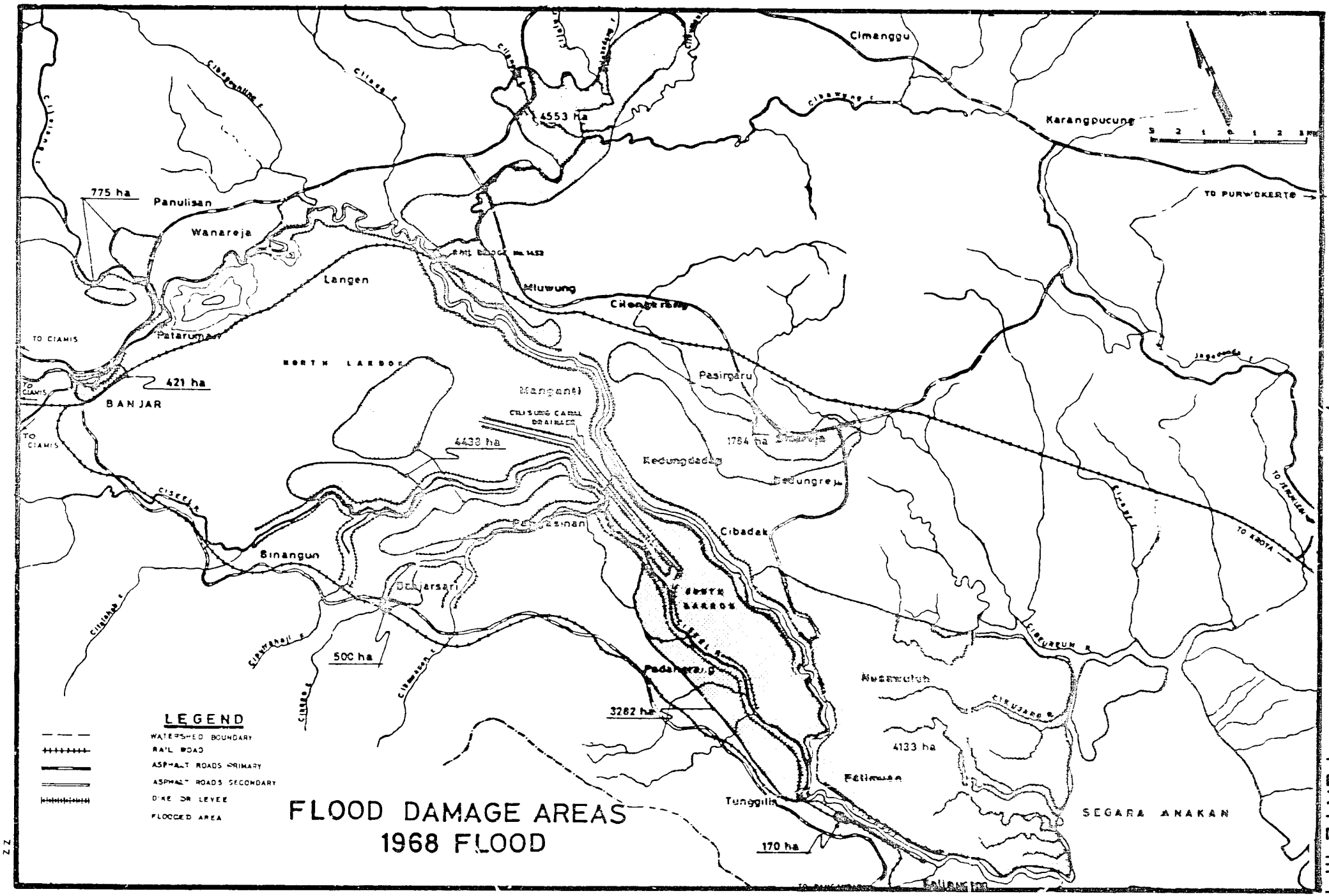


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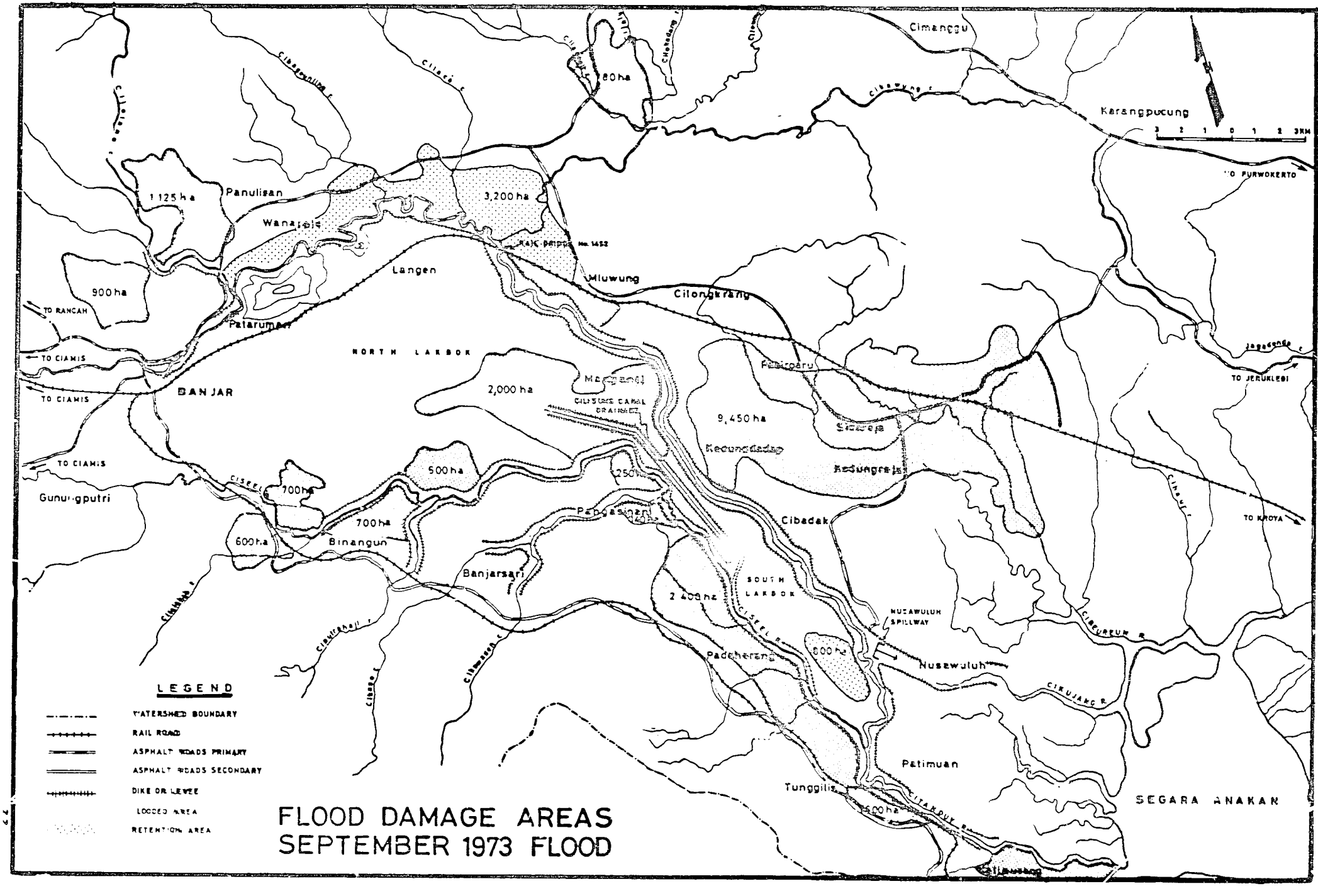
PLATE III-1



FLOOD DAMAGE AREAS
SEPTEMBER 1973 FLOOD

ENGINEERING CONSULTANTS, INC.

PLATE III-2

CHAPTER IV

DEVELOPMENT PLAN

We have previously stated that the Citanduy Project area can be conveniently divided into two distinct geographic units, and that each of these two principal units can be further subdivided into two subproject areas. Thus it can be said that the Citanduy Basin Development Project is composed of four subprojects:

1. The upper Citanduy/Ciseel River system.
2. The lower Citanduy/Ciseel River system.
3. The Segara Anakan and its environs.
4. The Segara Anakan watershed (other than the Citanduy/Ciseel River system).

Each of these four subprojects is an independent unit in many ways, but in other ways each is quite dependent on the other. There are many problems which are common to all areas; but each individual area has its own unique problems as well.

In the previous chapter, we identified the problems and needs of the project area. Now we must establish an order of priority for the solution of these problems, suggest ways and means of solving them, and present a recommended schedule for their solution.

Since the basic objective of this study is to determine an optimal pattern of utilization of water and land resources which will lead to increased agricultural production and the attendant increase in the standard of living of the inhabitants of the area, we have concentrated on the search for solutions to the physical problems of the project area and then have shown how these solutions would contribute to the improvement of the socio-economic conditions of the area. The principal physical problems which have received our attention and the attendant socio-economic improvements expected are:

A. Physical

1. Erosion and sedimentation.
2. Flood mitigation.
3. Land reclamation.
4. Irrigation and drainage rehabilitation.
5. Irrigation and drainage extension.
6. Hydro-electric power development.
7. Environmental impacts.

B. Socio-Economic

1. Increased agricultural production.
2. Increased employment opportunities.
3. Improved income distribution.
4. Improved standard of living.
5. Improved community development.
6. Improved management systems.

During the course of our investigations of the developmental possibilities of the project area and in the identification of viable subprojects, it soon became apparent that the logical geographical subdivisions of the area also applied to subproject formulations. The subprojects identified (in order of priority) were:

1. A comprehensive water management scheme for the Lower Citanduy/Ciseel River system.
2. The reclamation of the Segara Anakan and its environs.
3. A comprehensive water management scheme for the Upper Citanduy/Ciseel River system.
4. A water management scheme for the balance of the project area.

A Comprehensive Water Management Scheme for the Lower Citanduy/Ciseel River System

General

Lack of flood control inhibits development in all categories; i.e., irrigation, drainage, other improved agricultural practices, industrial development, and infrastructural improvements. A potential investor will purposely avoid an area where frequent floods may result in loss of income or purchasing power or, even worse, complete destruction of an investment.

Any system designed to mitigate flood damage on the lower Citanduy/Ciseel River system should ultimately be composed of a combination of both upstream and downstream control measures. Furthermore, utilization of all valuable crop land, through the judicious use of all existing flood control features, both natural and man-made may effect cash flow requirements for the projects and the economics of the development program.

Despite the pressure for immediate alleviation of the frequent suffering and damage sustained from floods in this system there appears to be a certain advantage in a two-stage development scheme. The first stage would provide immediate relief through the upgrading of the existing levee system to provide security against 25-year frequency floods. Included would be the diversion of the Ciseel River into the Citanduy River at a point where the Ciseel River emerges from the hills onto the floodplain and where the distance between the rivers is a matter of a couple of kilometers. The second stage would be the provision of upstream storage facilities to provide further protection and security against floods of a lower frequency of recurrence.

As shown on Plate II-5, the portion of the Citanduy River that is included in the plans for Stage I extends from the rivers mouth at the Segara Anakan (km 0+000) to a point in the town of Banjar (km 83+500). The part of the Ciseel River included in these plans is that portion from its confluence with the Citanduy River (km 14+500 of the Citanduy River = km 0+000 of the Ciseel River) to the point where the river emerges from the hills onto the floodplain (km 39+000). Plate IV-5 (consisting of 3 sheets) and IV-5A show the selected reaches of both rivers.

The Citanduy River is rather unique in that the lower 52.5 km has only one major tributary, the Ciseel River. However, for 18 km of its lower length, the Ciseel River parallels the Citanduy River at distances varying from about two to four kilometers. This 18 km length of land between the two rivers has posed a perennial drainage problem caused both by local rainfall runoff and flood waters from the Citanduy and/or the Ciseel River.

In an effort to improve the North Lakbok drainage as well as to supply irrigation water to portions of South Lakbok, the Cilisung drain was constructed approximately midway between the two rivers, with a discharge into the Ciseel River at about km 10. This move only further compounded the drainage problem, for when the Ciseel River floods, the backwater effects cause the Cilisung Drain to overflow. In fact, one of the few areas with a record of repeated levee failures is at the confluence of the Ciseel River and the Cilisung Drain.

The 8 km length between the Ciseel River and the Cilisung Drain averages about one kilometer or so in width. It also suffers from local drainage problems because of the parallel waterways which have levees on both sides. To correct this situation, another main drain was constructed and its effluent passes under the Cilisung Drain through an inverted siphon located just upstream from the confluence of the drain and the Ciseel River. This drain, which has no levee system, picks up all local drainage below the inverted siphon and dumps it into the Ciseel River at about km 3 through a sluiceway structure fitted with flap gates. When the Ciseel River is flooding, the drain is unable to function.

Levees along the Ciseel River not only have upset the local drainage situation between it and the Citanduy River, but they also obstruct the entrance of local drainage from the lands to the west of the Ciseel River. To relieve this situation, the channel of the Cirapuan River was improved so that it could intercept the local drainage and dump it into the Citanduy River below the Ciseel River confluence at about km 13. Since this outlet structure is also equipped with flap gates, the drain does not function when either the Citanduy River or the Ciseel River is flooding.

The end result of all the previously described piece-meal drainage works is the creation of a tract of land 18 km long by 3 to 4 km wide and traversed by four principal drainage ways, three of which do not function when the Ciseel River is flooding. Furthermore, the adverse effects on drainage are not limited to the area just described, but extend up into the North Lakbok area as well.

The obvious relief measure would be the diversion of the Ciseel River into the Citanduy River at the point where the distance between the two rivers is a minimum. This would leave the present lower Ciseel River channel free to handle the drainage from the Cikaso River as well as the Cilisung Drain. The construction of an inverted siphon under the proposed Ciseel cutoff would facilitate the normal functioning of the Cilisung Drain.

Flood Routing

The project floods were routed through the river system and peak discharge values were estimated at various locations in the river system. The storage routing method was used to determine the lower limit of flood peak attenuation, while the kinematic wave method was used to determine the travel speed of the flood wave. The solution for both methods was programmed for the Monroe 1665 desk computer. After a number of hydrographs was routed by means of the computer, tables of percent attenuation and travel times between points in the river were prepared. These tables greatly simplified the routing. The routed hydrographs were given a floodpeak travel speed equal to that of the kinematic wave and an attenuation equal to approximately 60 percent of the attenuation calculated by storage routing. The hydraulic geometry was determined from information collected at the stream gaging stations, from 1968 and 1973 topographic surveys, and from aerial photographs and coefficients necessary to the solution of the equations were established.

The routing began at Banjar and from there the Citanduy River hydrograph was routed downstream and combined with hydrographs from the tributary rivers at the appropriate locations. For the routing, it was assumed that the Wanareja Swamp was available as an off-channel storage facility, and that the Ciseel River was diverted into the Citanduy River at km 36.

Many alternative regulations are possible, depending on the number and location of dams considered. To determine the most suitable and least costly plan, the following conditions were evaluated for the 25-year flood:

1. Unregulated river system.

2. River system regulated with Banjar Dam, Matenggeng Dam, or Binangun No. 2 Dam.

3. Uncontrolled diversion at the Nusawuluh Weir, controlled diversion to a maximum of 200 m^3/s, or no diversion.

4. Any combination of the above.

5. With and without the Ciseel connection to the Citanduy River about 15 km upstream from the existing mouth of the Ciseel River.

The resultant flood peaks at several locations in the system generated while routing the 25-year flood are shown on Plate IV-1. This tabulation does not include results for the "without Ciseel connection" condition. From this display of the results, it can be surmised that a single dam at any of the locations has no major effect on the floodpeaks except in the immediate vicinity of the dam.

Water surface profiles for flows in the lower reaches of the Citanduy and Ciseel Rivers were computed using the Water Surface Profile Program HEC-2 developed by the U.S. Army Corps of Engineers. In the reach of the Citanduy River between RR Bridge 1452 and Banjar, river stages were estimated by employing the Cikawung stream gaging station rating curve and river cross sections taken in 1968 and 1973.

From these studies, levee heights were assumed and levee and dam costs were estimated. Dam costs were estimated based on the assumption of a single purpose flood control dam at each site. It is evident from the cost study that a protection system of levees only at $9.9 millions (Rp. 4,087 millions) is by far the least costly alternative. The next least costly alternative which would provide the same protection consists of Matenggeng Dam and levees at a cost of $ 20 millions (Rp. 8,300 millions). Because of the low costs of the "levees only" condition, it was assumed that this would be the solution most probably implemented. Therefore, all additional flood routing studies were made for the condition of providing protection with levees alone.

The 10-year and 50-year floods were then routed through the system and levee profiles were estimated. Hydrographs at selected points along the Citanduy River for the 10-, 25-, and 50-year floods are shown on Plates IV-2, IV-3, and IV-4. A tabulation of the peak flows and the elevation of the design levees on the Citanduy and Ciseel Rivers are shown on Table IV-1. The levee profiles for the 10-, 25-, and 50-year floods on the Citanduy and Ciseel Rivers are shown on Plates IV-5 and IV-5A which are composed of four (4) sheets. Table IV-1 shows levee elevations assuming the Ciseel connection has been constructed. Plates IV-5 and IV-5A show levee grades for both conditions.

Additional studies were done using the 25-year flood to determine what effect changing the direction of the storm, or the assumed travel times would have on the flood peaks and the resultant levee heights. In addition, the 2-day storm was routed to determine if the 2nd day, 25-year rainfall would increase the peak discharge.

The result of adding in a second day rainfall was to raise the flood peak by a maximum of 4 percent. The results of changing the direction of the storm track were to increase the water levels when the storm proceeded in a downstream direction and to decrease the water levels when the storm track moved upstream. Shortening the travel time or increasing the speed of the flood wave peak tended to raise the water levels. These results are shown on Table IV-2.

It must be remembered that the return period of the design condition relates to a discharge, not to a rainfall. Therefore, the higher or lower discharges that resulted from varying the direction of the same storm would be assigned a larger or a smaller return period. The recommended facilities protect against the design discharge.

Table IV-1

Design Discharge and Levee Elevations

Location	Design Discharge in m^3/s	Levee Elevation in m MSL
Citanduy River		
Banjar		
10-year	1,450	25.1
25-year	1,750	26.3
50-year	2,060	27.5
Cijolang		
10-year	1,600	21.0
25-year	1,900	22.0
50-year	2,080	22.7
Bridge 1452		
10-year	1,440	13.7
25-year	1,710	14.6
50-year	1,910	15.3
Ciseel Connection		
10-year	1,500	10.7
25-year	1,820	11.8
50-year	2,000	12.3
Nusawuluh Weir		
10-year	1,500	8.7
25-year	1,820	9.8
50-year	2,000	10.3
Immediately below Nusawuluh Weir		
10-year	800	6.8
25-year	950	7.8
50-year	1,100	8.6
Ciseel River		
Binangun No. 2 Damsite		
10-year	430	20.4
25-year	525	21.2
50-year	640	22.1
Confluence with the Ciputrahaji River		
10-year	500	14.8
25-year	570	15.8
50-year	700	16.3

Table IV-2

Results of Varying Design Parameters

Location	Design Condition		Rain from Northwest		Rain from Southeast		2-Day Rainfall		Shortened 1/ Travel Time		Ciseel and Citanduy Peak Coincide	
	Q in m^3/s	Levee Elev. in m MSL	Q in m^3/s	Water Level in m MSL	Q in m^3/s	Water Level in m MSL	Q in m^3/s	Water Level in m MSL	Q in m^3/s	Water Level in m MSL	Q in m^3/s	Water level in m MSL
Banjar km 83	1,750	26.3	1,750	25.8	1,750	25.8	1,750	25.8	1,750	25.8		
Cijolang River km 72	1,900	22.0	2,000	21.9	1,740	21.0	1,900	21.5	2,100	22.0		
Bridge 1452 km 56	1,710	14.6	1,920	14.8	1,480	13.3	1,740	14.2	2,020	15.1		
Ciseel Connection km 36	1,820	11.8	2,100	12.1	1,500	10.2	1,900	11.5	2,260	12.6	2,300	12.7
Nusawuluh Weir km 22.5	1,820	9.8	2,040	10.0	1,450	8.0	1,900	9.5	2,200	10.5	2,230	10.5

1/ Travel Times of wave peak reduced by one-half.

Levee Design

It was determined that a freeboard of 50 cm would be adequate for each of the selected discharge frequencies. No allowance was made for wave runup because of the limited lengths of unobstructed fetches. The theoretical levee heights for each of the three cases studied were plotted as shown on Plates IV-5 and IV-5A.

However, before the quantities of new earthwork could be calculated, it was first necessary to plot the height of the existing bank lines and the crown heights of the existing levee systems. Once these profiles had been determined, typical levee sections were plotted so that volumes of both the existing earthwork as well as the proposed earthwork could be calculated.

For purposes of calculating earthwork, it was necessary to adopt some standard cross section for the proposed new levee work. Those adopted for the Citanduy and Ciseel Rivers are shown on Plate IV-6. It must be recognized that these are typical sections and no more. Field conditions such as foundation and embankment materials, height of levee, available compactive effort, and berm and borrow pit conditions will determine the final section selected.

As shown on Plate IV-7, provisions must be made for passing zones on the levee crown and for access ramps. It is recommended that a wide section to serve both purposes be placed at intervals no greater than 5 km.

Total estimated earthwork quantities involved in the proposed scheme to upgrade the existing levees are shown in Table IV-3. Quantities for protection against the 10-, 25-, and 50-year frequency discharges are shown.

Table IV-3

Earthwork Quantities (Compacted Fill)

Location	Levee Length (Meters)	Volume (Cubic Meters)
10 - Year Frequency		
Citanduy River		
0 + 000 - 22 + 500	36,000	568,000
22 + 500 - 52 + 300	59,000	385,000
52 + 300 - 83 + 500	26,000	110,000
Ciseel River	34,000	550,000
Cijolang River	8,000	55,000
Cikawung River	10,000	66,000
Totals	173,000	1,734,000
25 - Year Frequency		
Citanduy River		
0 + 000 - 22 + 500	36,000	1,004,900
22 + 500 - 52 + 300	59,000	1,094,600
52 + 300 - 83 + 500	26,000	377,000
Ciseel River	34,000	860,600
Cijolang River	8,000	146,900
Cikawung River	10,000	156,000
Totals	173,000	3,640,000
50 - Year Frequency		
Citanduy River		
0 + 000 - 22 + 500	36,000	1,314,100
22 + 500 - 52 + 300	59,000	1,431,400
52 + 300 - 83 + 500	26,000	493,000
Ciseel River	34,000	1,125,400
Cijolang River	8,000	192,100
Cikawung River	10,000	204,000
Totals	173,000	4,760,000

Levee Costs

The cost estimates for upgrading the existing levee system to provide adequate protection against the 10-, 25-, and 50-year frequency discharges are shown in Tables IV-4, IV-5, and IV-6, respectively. This cost estimate, which includes all protection measures, averages about Rp. 23,600,000/km ($ 57,100/km) for the 25-year frequency protection.

The item for "Excavation" covers the work involved in the Ciseel River cutoff connection. The section to be excavated included a bottom width of 10 m, side slopes of 1.5 : 1, and an average depth of 4 to 5 m. This section will provide more earth than that required to construct the levee section proposed for each side of the river.

Table IV-4

Levee Construction Cost Summary
(10-Year Frequency)

Item	Unit	Quantity	Costs Rps. (1,000's) Unit	Costs Rps. (1,000's) Total	Costs US $ Total
Excavation	m^3	100,000	0.5	50,000	120,773
Compacted Fill	m^3	1,734,000	0.6	1,040,400	2,513,043
Road Surface	km	150	621	93,150	225,000
Siphon (Cilisung)	L.S.	---	---	82,800	200,000
Bank Protection	L.S.	---	---	103,500	250,000
Clearing	m^2	500,000	0.1	50,000	120,773
Right-of-Way	ha	100	1,500	150,000	362,319
Subtotal				1,569,850	3,791,908
Contingencies (15%)				235,478	568,786
Engineering and Administration (12%)				188,382	455,029
Total				1,993,710	4,815,723

Table IV-5

Levee Construction Cost Summary
(25 - Year Frequency)

Item	Unit	Quantity	Costs Rps. (1,000's) Unit	Costs Rps. (1,000's) Total	Costs US $ Total
Excavation	m^3	100,000	0.5	50,000	120,773
Compacted fill	m^3	3,640,000	0.6	2,184,000	5,275,362
Road Surface	km	150	621	93,150	225,000
Siphon (Cilisung)	L.S.	---	---	82,800	200,000
Bank Protection	L.S.	---	---	103,500	250,000
Clearing	m^2	1,800,000	0.1	180,000	434,783
Right-of-Way	ha	350	1,500	525,000	1,268,116
Subtotal				3,218,450	7,774,034
Contingencies (15%)				482,767	1,166,105
Engineering and Administration (12%)				386,214	932,884
Total				4,087,431	9,873,023

Table IV-6

Levee Construction Cost Summary
(50 - Year Frequency)

Item	Unit	Quantity	Costs Rps. (1,000's) Unit	Costs Rps. (1,000's) Total	Costs US $ Total
Excavation	m^3	100,000	0.5	50,000	120,773
Compacted Fill	m^3	4,760,000	0.6	2,856,000	6,898,551
Road Surface	km	150	621	93,150	225,000
Siphon (Cilisung)	L.S.	---	---	82,800	200,000
Bank Protection	L.S.	---	---	103,500	250,000
Clearing	m^2	2,160,000	0.1	216,000	521,739
Right-of-way	ha	450	1,500	675,000	1,630,435
Subtotal				4,076,450	9,846,498
Contingencies (15%)				611,468	1,476,975
Engineering and Administration (12%)				489,174	1,181,580
Total				5,177,092	12,505,053

Table IV-7 shows the results and costs for the flood protection program that could be provided by levee rehabilitation and improvement and other proposed works. These values are utilized in the analysis of project justification.

Table IV-7

Flooding Prevented and Costs for 10-, 25-, and 50-Year Protection Levels*

Protection	Flooding Prevented (ha)	Construction Cost	
		Rp. (1,000's)	US $
10-Year	5,236	1,993,710	4,815,723
25-Year	5,923	4,037,431	9,873,023
50-Year	6,139	5,177,092	12,505,053

*Flooding prevented is expressed as average annual equivalents.

For reasons explained in Appendix B - Hydrology and in Appendix J - Dams and Levees, the 25-year level of protection has been selected as being the most appropriate for the comprehensive water management scheme for the Lower Citanduy/Ciseel River system.

Irrigation and Drainage

The locations of the irrigation systems included in this subproject are shown on Plate IV-8, and they are shown in schematic fashion on Plate IV-10. The irrigation system for the Banjar Plains is being designed by the Directorate of Irrigation hence is considered to be an existing project and is excluded from discussion of potential projects for the Master Plan. The major drainage systems are shown on Plate IV-9. The recommended plan of development consists of the rehabilitation of the existing major irrigation and drainage systems and extension of technical irrigation to the South Lakbok and the Panulisan areas. These are short-term objectives which can be accomplished in the immediate future in conjunction with the first stage flood control plan. Further extension of irrigation to the Wanareja swamp, Cikaronjok swamp, new Cikaso area, and the sump areas of South Lakbok are long-range objectives. Development of the Wanareja swamp requires further flood control measures on the Citanduy River, while the development of the new Cikaso area requires intensive surface drainage measures and development of a source of water supply. Development of the swamp areas of South Lakbok, on the other hand, depends upon an economical pumped drainage system. Full details of the recommended plan are given in Appendix F - Irrigation and Drainage.

The total area to be rehabilitated is 12,447 ha, which includes extension to some of the existing areas. The irrigation systems to be included in the rehabilitation effort are:

1. North Lakbok
2. Gunung Putri I and II
3. Citalahab
4. Rawa Onom
5. Ciputrahaji
6. Cikaso

Completion of the recommended rehabilitation and reconstruction measures will result in multiple benefits. The improved conveyance system will permit controlled distribution of service water and the introduction of water management measures, both of which are important factors in multiple cropping and in the attainment of higher yields. Completion of the existing systems will bring 100 percent of the irrigable area under an effective irrigation system. Improved surface drainage will improve production in low-lying areas that are continually wet, especially in the rainy season.

The implementation of an effective flood control and drainage program will permit extension of irrigation to Panulisan and South Lakbok. The irrigable areas are 600 ha and 3,200 ha respectively. Panulisan can be irrigated from the Cijolang River by constructing a new left bank diversion at the existing Bantarheulang diversion structure. Surface drainage will be the most difficult part of the development of this low-lying area. The initial development of South Lakbok will provide irrigation for 3,200 ha. An additional area of 2,200 ha could be developed in the future with the installation of a pumped drainage system. Service water would be diverted from the Citanduy River at the existing Pataruman diversion structure and will be conveyed to South Lakbok through the Cilisung Drain. There is an existing diversion structure on this drainage canal.

The major drains shown on Plate IV-9 will be improved to the extent that they will have the capacity to protect against prolonged flooding from surface runoff due to 10-year rainfall. Drains to be improved include the Kalen Kendal, Kelapa Sawit, Cigaron, Cilisung, and Cirapuan. The proposed diversion of the Ciseel River to the Citanduy River will relieve the pressure on the South Lakbok area. The Ciseel River channel will serve as the main collector drain for the Cikaso River and the North Lakbok drainage area. No further improvements are required in that reach of the channel except to construct a closure dike at its confluence with the Citanduy River. The existing levee along the left bank of the channel in the vicinity of the South Lakbok sump areas would be removed. This area would be utilized to store flood water and prevent backwater in the channel when it cannot drain into the Citanduy River.

Irrigation Costs

A summary of the irrigation and drainage construction costs for the recommended immediate level of development is given in Table IV-8. The costs are based on 1974 prices, and the total development cost is estimated to be Rp. 2,180,544 million ($5.267 million). Annual operation and maintenance costs are based on a unit cost of Rp. 5,500/ha ($13.28/ha), which gives a total annual cost of Rp. 89,359 million ($215,842).

Table IV-8

Summary of Irrigation and Drainage Construction Cost
Lower Citanduy/Ciseel River System

Item	Total Cost	
	Rupiah (1000)	Dollars
Rehabilitation of Existing Irrigation Systems		
1. North Lakbok	561,619	1,356,566
2. Rawa Onom	86,064	207,883
3. Gunung Putri I	28,980	70,000
4. Gunung Putri II	86,940	209,998
5. Ciputrahaji	131,839	318,450
6. Citalahab	44,630	107,800
7. Cikaso	67,299	162,558
Subtotal	1,007,371	2,433,255
Construction of New Irrigation Systems		
1. South Lakbok	766,618	1,851,732
2. Panulisan	112,829	272,531
Subtotal	879,447	2,124,263
Improvement of Existing Major Drains	293,726	709,482
Total Construction Cost	2,180,544	5,267,000

Water Supply

The available water supply in the basin has been studied in two separate but complementary analyses. The first was an overall water balance analysis for the Citanduy/Ciseel River system, considering first implementation of projects which are being considered for immediate development and, secondly, a case of full development at some future date. The analysis utilized synthetic, estimated, and recorded monthly runoff at key points in the system covering a period of 24 years - 1950 through 1973. The second analysis compared the available water supply, based on a cropping schedule of two crops per year or 5 crops in two years, for the irrigation systems recommended for development in the Lower Citanduy/Ciseel subproject. Details of both analyses are given in Appendix F - Irrigation and Drainage. The irrigation systems included in either analysis are shown schematically on Plate IV-10.

The water balance analysis considered two cases of development. Case 1 considers the existing irrigation systems plus projects that are expected to be implemented in the near future. Case 2 considers the condition wherein all potential irrigation projects have been implemented. Both cases were studied for both the Citanduy and Ciseel River systems. The Citanduy River System was divided into two areas with the point of diversion being Banjar. The first area was called the Citanduy River at Banjar. There is a streamgaging station at this point and consequently inflows from upstream tributaries, upstream diversions and return flows are accounted for in the record. Since no future increase in upstream diversions is expected, the flows at Banjar can be used as the basis for determining their adequacy for meeting future diversions at and below this point. The second area was called the Citanduy River below Banjar. The available flows below Banjar consist of inflows from the Cijolang and Cikawung Rivers, local inflows and the net flow from the Citanduy River at Banjar. As was the case at Banjar, the inflows take into account the upstream diversions and return flows in the Cikawung River. No appreciable future diversions are expected in that area. The Case 1 and Case 2 diversion requirements in the Citanduy River System can be summarized as follows:

At Banjar:

Case 1 - Irrigation diversions for 11,120 ha
Banjar water supply - 1.7 MCM/mo
Case 2 - Irrigation diversions for 13,320 ha
Banjar water supply - 1.7 MCM/mo

Below Banjar:

Case 1 - Irrigation diversions for 6,628 ha
Flush water or Segara Anakan supplement - 26 MCM/mo
Case 2 - Irrigation diversions for 11,228 ha
Flush water or Segara Anakan supplement - 26 MCM/mo

The Ciseel River system was also divided into two areas. The first was the areas irrigated by the Ciseel River tributaries and the second the areas irrigated directly from the Ciseel River. The tributary areas include the Citalahab, Ciputrahaji and Cikaso Rivers. There will be no future diversions from these rivers therefore, there is no Case 2. The areas that can be irrigated from the Ciseel River are Gunung Putri I & II, the new Cikaso area, and South Lakbok. South Lakbok can also be irrigated from the Citanduy River and was included in the analysis of that system. The Case 1 analysis for the Ciseel River included Gunung Putri I & II and the new Cikaso area, while Case 2 includes the Case 1 systems plus the fully developed South Lakbok area. Case 1 and Case 2 diversion requirements in the Ciseel River System can be summarized as follows:

Ciseel River Tributaries:

Case 1 - Irrigation diversions for 2,886 ha

Ciseel River:

Case 1 - Irrigation diversions for 4,300 ha
Case 2 - Irrigation diversions for 9,700 ha

The Case 1 and Case 2 diversion requirements are based on average conditions. That is the irrigation systems included in the analysis were assumed to be in various stages of growth and an average crop factor for rice was used. Overall irrigation efficiencies were assumed to be 68 percent, assuming that all systems are either rehabilitated or new. The diversion requirements were compared with the available dry season river flows for 24 years of record. Table IV-9 shows a summary of the occurrence of monthly water shortages that would exist in each case.

Table IV-9

Summary of Monthly Water Shortages

	Case 1				Case 2			
	July	August	September	October	July	August	September	October
Citanduy River System								
At Banjar	0	2	4	1	0	2	5	1
Below Banjar	0	2	4	3	0	2	8	3
Ciseel River System								
Tributaries	3	14	4	6	-	-	-	-
Ciseel River	1	9	4	6	5	16	8	7

As can be seen from the table, the majority of the shortages occur in August or September. If a cropping intensity of 2 crops per year is adopted, these months can be avoided. However, if a more intensive cropping pattern is adopted, i.e. 5 crops in 2 years or 3 crops per year, the shortages become more serious. A separate analysis showed that storage reservoirs could eliminate shortages in both river systems.

Average monthly diversion requirements were computed for the irrigation systems in the Lower Citanduy/Ciseel subproject. The systems include all the case 1 systems shown on Plate IV-8 with the exception of Banjar Plains and the new Cikaso area. The diversion requirements were based on a cropping intensity of 2 crops per year and 5 crops in 2 years. The cropping schedule was assumed to be as follows:

For 2 crops per year:

Crop 1 October through February
Crop 2 March through July

For 5 crops in 2 years:

Crop 1 November through mid-March
Crop 2 Mid-March through July
Crop 3 September through mid-January
Crop 4 Mid-January through May
Crop 5 June through mid-October

The diversion requirements were calculated for both the "without" and "with" subproject situations. For the "with" subproject situation the overall irrigation efficiency was assumed to be 68 percent. For the "without" subproject situation the assumed overall irrigation efficiencies, in the systems requiring rehabilitation, ranged from 20 percent to 49 percent, depending upon the condition of the system.

The diversion requirements in each case were compared with the available river flows. The available river flows in this analysis were based on flow-duration curves which show the percent of time the flow has been available during the month. The results of the analysis are shown in Tables IV-10 and IV-11. As can be seen from the tables, irrigation rehabilitation is necessary, particularly in the Ciseel River system.

Table IV-10

Summary of Comparison of Diversion Requirement with Water Available; Without the Project - Lower Citanduy/Ciseel River System

System	Source of Water	Area ha	Water Availability	
			2 crops/year	2.5 crops/year
North Lakbok	Citanduy R.	5,700	No problem	May be 1 month problem in the dry season
Rawa Onom	Cijolang R.	1,028	No problem	No problem
Gunung Putri I	Ciseel R.	750	May be 1 month problem in dry season	Not enough water for dry season
Ciputrahaji	Ciputrahaji R.	1,706	Not enough water for dry season	Not enough water for dry season
Citalahab	Citalahab R.	630	Not enough water for dry season	Not enough water for dry season
Cikaso	Cikaso R.	290	Not enough water for dry season	Not enough water for dry season

Table IV-11

Summary of Comparison of Diversion Requirement with Water Available; With the Project

System	Source of Water	Area ha	Water Availability	
			2 crops/year	2.5 crops/year
North Lakbok	Citanduy R.	7,033	No problem	No problem
North and South Lakbok	Citanduy R.	10,233	No problem	May be 1 month problem in dry season
Rawa Onom & Panulisan	Cijolang R.	1,628	No problem	No problem
Sidareja 1/	Citanduy R.	7,119	No problem	No problem
Sidareja 2/	Citanduy R.	7,119	No problem	May be 1 month problem in dry season
Gunung Putri I & II	Ciseel R.	1,500	May be 1 month problem in dry season	Not enough water for dry season
Ciputrahaji	Ciputrahaji R.	1,706	May be 1 month problem in dry season	Not enough water for dry season
Citalahab	Citalahab R.	630	May be 2 month problem in dry season	Not enough water for dry season
Cikaso	Cikaso R.	550	May be 2 month problem	Not enough water for dry season

1/ Without South Lakbok 2/ With South Lakbok

The results of either analysis support the following conclusions, assuming that the existing systems have been rehabilitated.

Citanduy River System:

1. There is enough water available to grow 2 crops of rice per year both for the Case 1 and Case 2 level of development.

2. For a cropping intensity of more than 2 crops per year water shortages could develop in the dry season. The shortages would have some significance under the Case 2 level of development.

3. A multipurpose dam at Banjar would eliminate all water shortages. The Matenggeng Dam would eliminate any shortages below Banjar.

Ciseel River System:

1. There is enough water available to grow 2 crops of rice per year, although some shortages would occur in the month of October.

2. There is not enough water available in the Ciseel River or its tributaries to grow more than 2 crops per year.

3. It is better to irrigate South Lakbok from the Citanduy River.

4. A storage reservoir on the Ciseel River, either at Binangun No. 1 or No 2, would eliminate water shortages in the Ciseel River.

5. South Lakbok could be irrigated from the Ciseel River if a storage reservoir is built.

Storage Reservoirs

We have already established that storage reservoirs for flood mitigation on the Citanduy/Ciseel River system cannot be justified from an economical point of view. However, this does not mean that they would not be feasible for storage of irrigation water and/or hydroelectric power generation.

Nine potential damsites have been identified in the Citanduy River Basin; two of the nine are single-purpose flood control reservoirs, and the balance are of multi-purpose category. They are as follows:

A. Multi-purpose

1. Pasirangin
2. Ciamis
3. Cikembang
4. Manonjaya
5. Binangun No. 1
6. Binangun No. 2
7. Matenggeng

B. Single-purpose

1. Banjar
2. Banjar Alternative (including Cimuntur)

All of the potential damsites are shown on Plate IV-11 except the Banjar Alternative. Banjar Alternative (which is really two dams - Banjar Alternative and Cimuntur) is shown on Plate J-9 of the Dams and Levees Appendix. Plate IV-12 is a schematic

representation of the respective drainage areas of eight of the proposed damsites. Banjar Alternative is not shown because the sum of the Banjar Alternative plus the Cimuntur Dam is practically the same as the Banjar Dam.

Eight of the proposed damsites have been studied and analyzed and compared with one another at a reconnaissance level of investigation. The ninth, Matenggeng, has been studied at the feasibility level. The evaluation factors used for the eight dams are shown on Plate IV-13, while the comparison curves are shown on Plate IV-14. Detailed geological descriptions of the foundation conditions for each damsite may be found in Appendix C - Geology.

As we have pointed out previously, none of the proposed dams can be justified as a flood control structure alone. However, of all the possibilities, the Matenggeng Dam in combination with a levee system would be the best of the possible combinations. The Pasirangin Dam and Binangun No. 2 Dam have been eliminated as potential sites because of the large amount of cultivable land that would be inundated, the large number of families that would be dispossessed, and the high cost of relocation of utilities. The Manonjaya, Ciamis and Cikembang sites were eliminated from further consideration because of limited storage capacities as well as low power potentials. The Banjar and Banjar Alternative possibilities were bypassed principally because of the high cost of utility relocation and other socio-economic factors.

Binangun No. 1 damsite deserves further investigation as a possible source of additional water for bringing more land under irrigation in the areas downstream of its location on the Ciseel system.

Matenggeng Dam was studied at the feasibility level for its potential primarily as a hydro-electric power installation. It proved to be economically justified. The maximum development at the site (dam height of 120 meters) would yield an average annual power generation of 32,200 kW, firm generation of 24,500 kW and internal rate of return equal to 12.6%. The maximum rate of return would be achieved with the dam height of 105 meters. This case would yield an average annual generation of 30,700 kW, firm generation of 19,800 kW and rate of return of 13.4%. The cost of the 120 meter dam and power facilities would be Rp 33 x 10^9; while the smaller development would cost Rp. 27.3 x 10^9. This dam also serves to a limited extent as a storage reservoir for irrigation water and localized flood control.

Seven of the proposed damsites were also compared on the basis of cost estimates in which the embankment cost was the basic parameter. Table IV-12 presents a cost comparison for the dams considered. The cost estimate for Matenggeng Dam is shown on Table IV-13.

Table IV-12

Comparative Costs - Proposed Dam Sites - Citanduy/Ciseel River System

Cost Item	Total Cost (US $) (1,000's)								
	Binangun No. 1	Binangun No. 2	Manonjaya	Ciamis	Cikembang	Banjar	Banjar M. P.	Banjar Alt.	Cimuntur
1. Embankment	7,350	7,200	8,775	18,300	6,300	7,875	13,950	8,550	4,050
2. Foundation Work	1,103	1,440	1,775	2,745	945	788	2,093	855	405
3. Spillway	1,838	1,800	2,194	4,575	---	394	3,488	428	177
4. Diversion & Outlet Works	1,470	1,080	2,194	4,575	1,575	1,181	2,093	1,283	608
5. Mechanical	515	504	614	1,281	189	---	977	---	---
6. Reservoir Clearing and Access	221	72	263	549	189	79	419	86	41
7. Land Rights	2,660	6,100	940	880	300	1,280	3,240	440	250

Table IV-12 (Continued)

Cost Item	Total Cost (US $) (1,000's)								
	Binangun No. 1	Binangun No. 2	Manonjaya	Ciamis	Cikembang	Banjar	Banjar M.P.	Banjar Alt.	Cimuntur
8. Power Plant	---	---	4,875	6,370	---	---	---	---	---
9. Relocations (Rail and Highway)	---	1,500	---	---	---	3,000	3,000	---	---
Total Basic Cost	15,157	19,696	21,610	39,275	9,493	14,597	29,260	11,842	5,557
10. Contingencies	3,031	3,939	4,322	7,855	1,900	2,919	5,852	2,368	1,114
11. Construction Camp	303	394	432	786	190	291	585	233	111
12. Field Investigations	758	985	1,081	1,964	475	730	1,463	582	278
13. Engineering & Administration	1,819	2,364	2,593	4,713	1,140	1,752	3,511	1,397	667
Total Cost	21,068	27,378	30,038	54,593	13,203	20,289	40,671	16,182	7,727

Cost Item	Total Cost (Rp.) (1,000,000's)								
	Binangun No. 1	Binangun No. 2	Manonjaya	Ciamis	Cikembang	Banjar	Banjar M.P.	Banjar Alt.	Cimuntur
1. Embankment	3,043	2,981	3,633	7,576	2,608	3,260	5,775	3,540	1,677
2. Foundation Work	457	596	726	1,136	391	326	867	354	167
3. Spillway	761	745	908	1,894	---	163	1,444	177	84
4. Diversion & Outlet Works	608	447	908	1,894	652	489	867	531	252
5. Mechanical	213	209	254	530	78	---	404	---	---
6. Reservoir Clearing & Access	91	30	109	227	78	33	173	36	17
7. Land Rights	1,101	2,525	389	364	124	530	1,341	182	104
8. Power Plant	---	---	2,018	2,637	---	---	---	---	---
9. Relocations (Rail and Highway)	---	621	---	---	---	1,242	1,242	---	---
Total Basic Cost	6,274	8,154	8,945	16,258	3,931	6,043	12,113	4,820	2,301
10. Contingencies	1,255	1,631	1,789	3,252	787	1,208	2,423	964	461
11. Construction Camp	125	163	179	325	79	120	242	96	46
12. Field Investigations	314	408	448	813	197	302	606	241	115
13. Engineering & Administration	753	979	1,073	1,951	472	725	1,454	578	276
Total Cost	8,721	11,335	12,434	22,599	5,466	8,398	16,838	6,699	3,199

Table IV-13

Matenggeng Dam and Powerplant - Summary of Estimated Costs for Project Features
Dam Crest Elevation 215 - Dam Height 120 Meters

Item	Cost	
	Rp. (1000)	Dollars
Land and Rights (2,700 hectares)	2,525,000	6,099,000
Access Roads and Bridges	455,400	1,100,000
Construct Dam Embankment	9,831,337	23,747,190
Construct Diversion and Spillway Structures	1,477,727	3,569,374
Construct Emergency Spillway	128,340	310,000
Construct Outlet Works	500,550	1,209,070
Construct Power Intake Structure and Approach Channel	462,616	1,117,430
Construct Power Waterways	3,061,754	7,395,540
Construct Power Facilities Complete with Equipment	4,389,600	10,602,900
Construct Transmission Line to Main System (8 km)	298,080	720,000
Subtotal	23,130,398	55,870,504
Contingencies (20%)	4,626,082	11,174,096
Construction Cost	27,756,480	67,044,600
Construction Camp (2%)	555,130	1,340,900
Field Investigations (5%)	1,387,820	3,352,200
Engineering and Administration (12%)	3,330,780	8,045,400
Total Subproject Cost	33,030,210	79,783,100

Hydroelectric Power Facilities

The proposed Matenggeng Dam and Powerplant would be located on the Cijolang River about 10 kilometers north of the confluence of the Cijolang and Citanduy rivers. This is the most favorable site for a major dam in the Citanduy basin because of the site topography and the relatively less-populated area that would be inundated.

The dam would be 120 meters high with a crest length of 650 meters. A power outlet tunnel would lead from an arm of the reservoir to a powerhouse downstream of the dam in order to maximize the operating head. The design turbine head is 175 meters. It is anticipated that a rockfill dam with an impervious core would be selected for construction at this site. The volume of fill would amount to 7.6 million cubic meters. All materials necessary to construct an earth- or rockfill dam are available within short distances of the proposed damsite.

The powerplant would consist of four power units each rated at 25,000 kilowatts, for a total installed capacity of 100,000 kilowatts. The plant factor would be 24 percent, based on the plant's firm power capability. The relatively low plant factor is proposed for the installation in order to allow for peaking generation during periods of high load demand in the national power system. The four installed units allow for flexibility in meeting the power load demand as well as providing flexibility in maintenance procedures without appreciably affecting the total plant output.

The powerhouse would be located slightly upstream of the Bantarheulang weir off the left bank of the Cijolang River, thereby allowing for delivery of irrigation water to the existing Rawa Onom irrigation system. The powerhouse location will also allow for water delivery to the newly proposed Panulisan irrigation tract which is discussed elsewhere in this report.

The average annual power output of the plant will be about 32,000 kilowatts considering energy capabilities. Annual firm generation would be 215 million kilowatt hours. Average annual secondary energy generation would be slightly more than 69 million kilowatt hours.

Although the dam does not have a large effect on attenuation of flood peaks on the main Citanduy river system, there would be some beneficial effects in the local area downstream of the dam. The storage and releases through the powerplant will provide a regulated water supply (a minimum of 1.44 MCM per day) for downstream irrigation, domestic use, or streamflow maintenance as may be required.

Construction of the dam and powerplant would cost Rp. 33,030 million ($79,783,000) and take four years. Operation and maintenance costs would amount to Rp. 66.24 million ($160,000) annually.

Subproject Cost

Because of their interdependencies, the flood mitigation measures and irrigation and drainage schemes were analyzed in combination. The three cases of 10-, 25-, and 50-year level of protection were considered, but the 25-year protection level is being recommended for early implementation.

The flood control and irrigation and drainage scheme cost, broken down into foreign exchange and Rupiah costs, is shown on Table IV-14. The cost for the flood protection system would be Rp. 4,037 million ($9,874,000). Irrigation and drainage works would cost Rp. 2,181 million ($5,266,000) for a combined total program cost of Rp. 6,268 million ($15,140,000).

Table IV-14

Domestic and Foreign Cost Summary Flood Control and Irrigation and Drainage Scheme

Item	Domestic Cost		Foreign Cost		Total Cost	
	Rupiah Millions	Dollars Thousands	Rupiah Millions	Dollars Thousands	Rupiah Millions	Dollars Thousands
Flood Control (25 Year Protection)	3,757	9,078	330	796	4,087	9,874
Irrigation Rehabilitation	836	2,018	172	415	1,008	2,433
New Irrigation	780	1,883	100	241	880	2,124
Major Drainage Improvements	254	614	39	95	293	709
Total	5,627	13,593	641	1,547	6,268	15,140

All costs are rounded to the nearest one million Rupiahs and the nearest one thousand dollars.

Environmental Considerations

No archeological sites are known to exist in the subproject area, but the Ciung Wanara historical site is located just upstream of the confluence of the Citanduy and Cimuntur Rivers. Its location is just outside the subproject area, but it would be inundated should the Banjar Dam become a reality. It is highly unlikely that the Banjar Dam would be built, but if this should come to pass, special measures will have to be developed to safeguard this site.

Since this is a densely populated area that has been under intensive cultivation for quite some time, it is felt that the existence of wildlife is insignificant. Certainly, there are no natural forest areas remaining. Except in the area surrounding the sites for the proposed dams, especially for the Matenggeng Dam, little or nothing can be done to greatly affect the environment as it now exists. However, should the Matenggeng Dam become a reality, an excellent opportunity will be provided for the creation of a national park and/or game preserve in the environs of the storage reservoir. This should be done to avoid human pollution of the waters of the reservoir as well as for esthetic and recreational reasons.

It is in the environmental impact on the human element that great benefits will be brought about by the successful culmination of this project. Improved drainage will lower the incidence of malaria and intestinal diseases within the area. Public health in general will benefit from the improved water supply and waste disposal conditions. Malnutrition and other health hazards which accompany flooding conditions will be materially reduced by the proposed flood mitigation measures.

Reduction in the potential for damage or complete loss of crops, livestock, and/or real estate through reduction in flood hazard will add immeasurably to the security of the small farmers and businessmen who inhabit the area. Not only will this additional security assist him in the realization of his physiological needs, but will also serve as an added incentive to invest time, labor, and capital in improving the production obtained from the land which he works. The end result should be the more equitable distribution of social and economic opportunities for the rural people who inhabit the subproject area.

The Reclamation of the Segara Anakan and Its Environs

General

As its name implies, the Segara Anakan subproject is a comprehensive reclamation scheme involving both land and water. Its basic objective is to make more arable land available to the people of the subproject area and surrounding areas, thereby improving not only the living standards of the subproject inhabitants, but also contributing to the national development effort through increased agricultural production and through other economic and social benefits.

The problem in the Segara Anakan and its associated tidal swamps and marshes is one of too much salt water from the Indian Ocean and insufficient drainage. The many square kilometers of low terrain surrounding the Segara Anakan are easily inundated by even moderately high tides. Even the higher grounds above the areas subject to inundation by the tides are adversely affected as a result of tidal action to a varying degree. Here again the principal problem is one of inadequate drainage and the salinity problems associated with this deficiency. There are possible solutions to the problem:

1. Prevent the tidal flows from entering the lagoon and traveling up the estuaries and sloughs.
2. Fill in the lowlands so that the ground elevation is higher than the tidal elevations.
3. A combination of the first two suggested approaches.
4. Reclamation of the area solely for fish production.

The tide control alternative, including cut-off levees, the diversion of the Citanduy River to direct discharge into the Indian Ocean, and tide gates to relieve the local inflow of fresh water from the balance of the tributaries of the Segara Anakan, has been selected as the best reclamation scheme. The tangible and intangible benefits occurring to the subproject, and the speed with which these benefits can be realized, far outweigh the disadvantages.

The evaluation of the selected scheme must include two alternatives. The first allows for the inclusion of a diversion of 200 m^3/s flood flows from the Citanduy River. Ramifications of the diversion are an increased sediment load into the Segara Anakan, resulting in additional costs for dredging and for disposing of the dredged spoil. The second alternative is to eliminate the Nusawuluh Diversion, and to construct levees along the Citanduy River so as to provide the same protection as was afforded by the diversion. If the diversion is removed, fewer tide gates would be required to pass the flood discharge and dredging will not be required to preserve the capacity of the lake.

Flood Routing Through Tide Gates

The upper limit water level criterion in the Segara Anakan is that the water level should not exceed an elevation of +0.3 m MSL for more than ten days for proper drainage, and that paddies should not be inundated for more than three days. The selected tide gate size is 4 m by 1.5 m. The gate opening would operate as an orifice with an orifice discharge coefficient of 0.65; and the gate would be designed for a gate coefficient of 0.8.

A capacity curve for the Segara Anakan and the land area up to 1.0 m MSL was developed from the 1:5,000 map sheets and from sounding data. Some assumptions were necessary concerning the effects of the recommended land fill program on the capacity of the flood pool. Capacities at selected elevations are shown below:

Elevation in m MSL	Capacity of Segara Anakan and Flooded Areas (MCM)
1.0	216.0
0.3	134.5
MSL	111.6
-0.3	89.6
-2.1	18.6

Runoff hydrographs were developed from 3-day rainfall for return periods of 10 years, 25 years, and 50 years. The base flow was estimated to be equal to 150 percent of the maximum average monthly runoff.

The tidal cycle was represented by a cosine curve with the high tides and the low tides 12 hours apart. Average high and low tides were set at +0.5 m MSL and -0.7 m MSL based on tide prediction tables.

Routing the flood hydrographs through the Segara Anakan and the tide gates was accomplished by a reiterative trial and error procedure. The routing was done for two conditions; first that Nusawuluh Diversion was operating with a maximum diversion of 200 m^3/s and second that the Diversion was inoperative or removed. No routing was done for the case of uncontrolled diversion at Nusawuluh.

From these routing studies it is concluded that:

1. One hundred gates will provide total protection from the 25-year rainfall on the Segara Anakan catchment plus a maximum diversion of 200 m^3/s from the Citanduy River.

2. Seventy five gates will provide total protection from the 25-year rainfall on the Segara Anakan catchment if the Nusawuluh Diversion has been removed.

The results of the studies are shown on Plate IV-16.

If the water level is raised to +0.2 m MSL at the beginning of the dry season to make more water available for dry season irrigation, the water level would rise a little higher for a little longer but the conclusions would still be valid.

Conversion from Salt Water to Fresh Water

An estimate of the length of time required to desalinize the Segara Anakan lagoon was based on two hypothetical model studies. In the first model, a known volume of pure water enters the salty reservoir and is completely mixed thus diluting the concentration. After complete mixing, the same volume is removed. This process is repeated and eventually, the salt concentration approaches the salt concentration of the inflow. In the second model, the inflow, mixing, and outflow all occur simultaneously. Under actual conditions, the inflow and mixing are continuous and the outflow is periodic.

The effective fresh water to be used as inflow was estimated to be the volume of runoff from the entire catchment less the amount originating on the tidal swamp and associated saline land areas. The runoff was estimated as rainfall less evapotranspiration or evaporation depending on the land use. The runoff was estimated for both average rainfall and for the lowest basin rainfall of record during the period 1915 to 1973.

Estimates of the time for conversion were made using initial salt concentrations of 25,000 ppm and 40,000 ppm. The results of the model analysis are shown in Table IV-15. The two models provide essentially the same results. The following comments should be kept in mind when evaluating these results:

1. There is no complete mixing of fresh water with salty water. No doubt some partial mixing would occur, but to a considerable degree the lighter, fresher water would tend to ride over the heavier, saltier water, the depth of the fresher water gradually increasing.

   Ion diffusion plus some mixing would gradually decrease the salt concentrations in deeper places, but some of these deeper places may remain significantly salty for a long period of time. These need not be considered significant in the reclamation of associated land areas of paddy rice so long as the upper part of the lake water is not significantly saline for a sufficient depth. Even so, the overall trend in time would be for a continuing decrease in salinity throughout the lake waters.

2. The fresh water is assumed to be pure for the model, whereas it actually contains a very low concentration of salts.

3. The model does not involve any gradual movement or ion diffusion of salt from the lower parts of soils, below the perpetually wet level, into sloughs or channels.

   There is no doubt that this will occur at some very slowly decreasing rate, possibly over a number of years. This need not be of concern under prevailing rainfall conditions so long as the upper parts of the soils are sufficiently free of salt for paddy rice production. Once reclaimed, rainfall is expected to be sufficient to maintain the upper parts of the soils relatively free of salts to depths required for unaffected paddy production.

Although these differences slightly modify the precise applicability of the models to what may be actual conditions, and even allowing for considerably lower-than-average runoff, it seems very probable that the Segara Anakan can be essentially desalinized within a 2-year period from the start of operations of tide gates and cut-off levees.

A program was written for the Monroe 1665 Programmable Desk Computer which allowed a variation in the salt concentration of the inflow. The program was written for a process similar to Model 1. If the total dissolved solids concentration of the inflow is assumed to be 200 ppm, the number of months to achieve a total concentration of less than 400 ppm in the lagoon increases by 1 or 2 months from the values shown in Table IV-15.

Table IV-15

Desalinization of the Segara Anakan

Beginning Month	Initial Concentration in ppm	No. of Months to Concentration Less than 400 ppm	
Model 1 - Average Conditions			
September	25,000	4	(4)
	40,000	4	(5)
December	25,000	4	(5)
	40,000	4	(5)
Model 1 - Dry Conditions			
September	25,000	6	(6)
	40,000	6	(7)
December	25,000	8	(10)
	40,000	11	(12)
Model 2 - Average Conditions			
September	25,000	4	
	40,000	4	
December	25,000	4	
	40,000	5	
Model 2 - Dry Conditions			
September	25,000	6	
	40,000	6	
December	25,000	9	
	40,000	11	

( ) Assumes inflow concentration of 200 ppm.

Hydrology

The hydrologic studies associated with the reclamation of the Segara Anakan include the estimation of average runoff values and an operation study to evaluate the dry season irrigation needs.

There are no flow records available in the Segara Anakan catchment, therefore, monthly runoff was estimated by using a combination of water budget method and the antecedent coefficient technique. The total area contributing to runoff is 960 km^2. For the purpose of estimating runoff and water use, estimates were made of present and future land use. A water use rate was assigned to each of the different land use categories. Average runoff conditions were assumed. It was assumed that rainfall first went to meet the needs of the various land uses. The contribution of the remaining or excess rainfall to runoff was determined by applying coefficients which define the fractional contribution of the current or preceding months excess rainfall to runoff.

Estimates of monthly runoff were also made by applying an area-precipitation factor to the synthetic runoff for the Citanduy River at Banjar.

The runoff calculated using the water budget method is considered more representative of the basin. The estimates of runoff are shown in Table IV-16.

Table IV-16

Average Monthly Runoff from the Segara Anakan Watershed

Month	Runoff from Water Budget Method in MCM	Runoff from Citanduy River Correlation in MCM
January	172	221
February	153	178
March	153	201
April	134	150
May	94	147
June	64	103
July	31	76
August	11	62
September	5	39
October	104	100
November	132	133
December	193	196
Total	1,301	1,606

Two methods were used while estimating the dry season supplemental irrigation needs. The first method considered monthly rainfall of a certain probability of occurrence. The second method made use of the estimated historic basin rainfall. The studies were done for a cropping calendar of 2 crops per year.

Rainfall on the catchment area is the major source of irrigation water. Initially, it is used as effective precipitation; the remainder flows into the Segara Anakan where a portion is retained and the rest flows to the ocean. The volume of water in the Segara Anakan available for irrigation is 23 MCM. If, at the beginning of the dry season, the water level is allowed to rise 0.2 m, the available storage becomes 37 MCM. The final source included in the analysis was flow diverted from the Citanduy River at Manganti.

The water use is equal to the crop water requirement; the domestic, municipal, and industrial use for Cilacap (which is 2.6 MCM/mo), and the evaporation. The irrigation system is essentially a closed one and almost no water is lost. Deep percolation, return flows, and system losses all flow back into the Segara Anakan and are again available for diversion. Groundwater was not considered in the analysis.

Based on a monthly distribution of annual low rainfall for return periods of 20-, 10-, and 5-years, only minor shortages occurred. Using over 50 years of historic basic rainfall, it was estimated that three crops would have failed assuming a supplemental diversion from the Citanduy of 10 m^3/s. This quantity is approximately equal to the amount of water that would reach the Segara Anakan from the planned diversion of 20 m^3/s at Manganti for the Sidareja Irrigation Scheme.

Cut-Off Dikes

Cut-off dikes would be required at both the west and the east outlets of the Segara Anakan, and on the Donan River as well. The exact locations must be compatible with such engineering and other design criteria as:

1. Technical soundness.
2. Practical construction considerations.
3. Economic considerations.
4. Areas proposed for future industrial complex in Cilacap.

Alternate locations at each of the three proposed cut-off dike sites are shown on Plate IV-17 for the Donan River and Sapuregel River sites, and on Plate IV-18 for the western outlet site. Echo soundings were taken at each of the selected alternate sites. The resulting profiles are shown on Plate IV-19. Those sites selected as being the most desirable of the various alternatives considered were:

1. Donan River site - Site C
2. Sapuregel site - Site B
3. Western outlet - Scheme B

The typical dike cross section selected for this proposed operation is shown on Plate IV-20. It is a zoned-type structure consisting of the following features:

1. Rockfill zone
2. Transition zone
3. Impervious zone
4. Dike crest elevation - +2.0 m MSL
5. Dike crest width - 10 m
6. Dike side slopes - Ocean side - 2:1
   - Lake side - 5:1

Control Gates and Structures

The cut-off dikes must include some type of tide gate structure so that the water level of the fresh water lake could be controlled while prohibiting the entrance of salty water from the ocean. We have already discussed the tide gate routing study that was performed. Plate IV-21 shows the typical tide gate structure. It will be constructed in units of three gates and, if at all possible, will be constructed "in the dry" on solid rock foundations. Maximum number required would be 99, and the minimum number would be 75. The structures would be so designed that a one-lane road could pass over the top of them. If desired, cantilever sections could be provided so that ultimately a two-lane road could be accommodated.

Tide Control Dikes

As explained in Appendix J - Dams and Levees, and as shown on Plate IV-13, a tidal action control dike will be required between the mainland and Nusa Were. This dike would be a dumped rock fill type and about 700 m in length. Its basic purpose is to prevent sediment deposition of the Citanduy River in the tide gate discharge channel.

Protection Levees

As shown on Plate IV-17, a protection levee will be required between the cut-off dike on the Donan River and the cut-off dike on the Sapuregel River. Furthermore, as shown on Plate IV-18, protection levees will be required on the east side of the new Citanduy River channel to prohibit that river from spilling over into the Segara Anakan during flood time.

Final levee section for these locations will be determined during the design procedures, but in general they will be about the same as that recommended for the Citanduy River protection levees.

Civil Works Costs

As shown on Table IV-17, total construction costs for the Scheme B closure are Rp. 6,804.798 million ($16,436,000).

Table IV-17

Cost Summary Comparison

Item	Total Cost (Millions)			
	Scheme A		Scheme B	
	Rp.	$	Rp.	$
East Outlet (Donan River)	986.169	2.382	986.169	2.382
East Outlet (Sapuregel River)	985.485	2.380	985.485	2.380
West Outlet (Citanduy River)	2,889.736	6.980	3,407.633	8.231
Subtotal	4,861.390	11.742	5,379.287	12.993
Contingencies (15%)	729.209	1.761	806.893	1.949
Subtotal	5,590.599	13.503	6,186.180	14.942
Engineering and Administration (10%)	559.060	1.350	618.618	1.494
Total Construction Cost	6,148.659	14.853	6,804.798	16.436

Irrigation and Drainage

Two areas have been identified for immediate development within the subproject area; the Sidareja Plains and the proposed reclamation area surrounding the Segara Anakan. Their respective locations are shown on Plate IV-22.

The successful development of either depends upon control of tidal fluctuations in the Segara Anakan caused by the Indian Ocean and improvement of surface drainage. An irrigation system has already been designed for the Sidareja Plains which would serve an area of 7,119 ha. The success of the Sidareja system is highly dependent on improved surface drainage which, in turn, is dependent on tidal control. Approximately 2,200 ha of the proposed service area falls within the boundaries of the proposed reclamation area, and must be reclaimed before it can be irrigated.

The area could be reclaimed by the implementation of the Segara Anakan subproject. Furthermore, the area could be irrigated for less cost per hectare by the methods proposed for the reclamation area. Therefore, it would be best to exclude the 2,200 ha from the Sidareja system and consider expanding the service area in the vicinity of the town of Sidareja.

The recommended irrigation and drainage system for the Segara Anakan reclamation area is discussed in detail in Appendix F - Irrigation and Drainage. There is a natural aendritic pattern of rivers and channels in the reclamation area surrounding the Segara Anakan. These natural waterways, which are fed by the runoff from the entire watershed, will be used as a source of irrigation water for the reclaimed area. Furthermore, since tidal fluctuations will be eliminated, they

will serve effectively as the main drainage channels carrying the surface runoff from the field drains. Diversions from the natural channels to main farm ditches will be made by small, lowlift pumps. The pumps would be either permanently mounted, or mounted on barges for portability, and each would serve an area of approximately 40 ha. The total irrigable area is 21,000 ha, therefore 525 low-lift pumps would be required.

Each low-lift pump would have a capacity of 227 m^3/hour (1,000 GPM) and would require a 5 to 10 HP diseel engine. The pump size should be particularly well suited to the reclamation area. One pump serving an area of 40 ha can meet the normal irrigation requirements with 10 hours of pumping per day, and during periods of maximum demand, with 21 hours of pumping.

Farm ditches will be provided to convey the water to the farmers' field ditches. The field ditches would be located such that any 5-hectare unit will be served by a main or subfarm ditch. The ditches would be sized for the maximum pump discharge of 227 m^3/hour. Concrete diversion boxes will be provided at the junction of the main and sub-farm ditches.

Full development of the reclamation area depends upon adequate drainage. In the absence of tidal fluctuations in the Segara Anakan, the present system of natural channels should be quite effective in carrying off excess runoff in a matter of hours. New drainage measures will consist of deepening or widening existing channels and the development of a surface drainage system in conjunction with the irrigation system. Surface drains will be located to pick up surface runoff from each field and carry it to a natural drainage channel for disposal. The surface drains would have a capacity of 6.0 l/s/ha.

Estimated irrigation and drainage system construction costs, based on 1974 prices, are given in Table IV-18. The total cost is estimated to be Rp. 1,552 million ($3.75 million). Annual operation and maintenance costs are estimated to be Rp. 186.921 million ($451,500), which includes O & M for the low-lift pumps.

Table IV-18

Irrigation and Drainage System Construction Cost - Segara Anakan Reclamation Area

Item	Unit	Quantity	Unit Price Rupiah (1,000)	Total Cost Rupiah (1,000)	Total Cost Dollars (1,000)
Low-lift Pumps Distribution	each	525	1,449	760,725	1,837.5
System and Drains	ha	21,000	25.84	521,640	1,260.0
Subtotal				1,282,365	3,097.5
Contingencies (10%)				128,236	309.7
Subtotal				1,410,601	3,407.2
Engineering & Administration (10%)				141,071	340.8
Total Construction Cost				1,551,672	3,748.0

Use: Rp. 1,552 million
U.S. $ 3.75 million

Domestic, Municipal and Industrial Water Supply

The stabilized fresh water reservoir resulting from the Segara Anakan reclamation represents the most adequate and economic supply of all the alternative water sources proposed for the city of Cilacap. To avail itself of the water supply, it is merely necessary for the city to construct an intake in the Segara Anakan and a pipeline to an onshore treatment plant. No storage facility would be required to obtain the water supply. The pipeline and treatment plant would be necessary for any potential water supply development, such as that proposed in the Indah Karya report, "Jeruklegi Reservoir As A Potential Source for Cilacap Water Supply", September 1971. Consequently, they are not included in this study.

An intake gallery would be placed at some point either in the river bed, or in a sump on the adjacent land area in the Segara Anakan where the water table would be stable and free from pollution and salt water intrusion. The quantity of water required is small in relation to the total available in the reclaimed lake, but it has nevertheless been included in the operation studies.

The initial requirement has been established as 1,000 liters per second, which amounts to about 225 gallons per day per capita for a population of 100,000 people. The present population of Cilacap is 88,000 persons.

Settlement of Subproject Lands

It has been estimated that it would require about 2 years to convert the salty lagoon waters to a fresh water lake. At the conclusion of this period, a part of the area which is already under cultivation for lowland rice will begin to receive the benefits of the reclamation. Development of the land will be spread out over a period of some eight to ten years, with the area now covered by mangroves taking the longest development time because of the more difficult clearing and land preparation problems, and the need for allowing the upper part of such soils to firm up.

The lands to be reclaimed would be settled by new farm families recruited from Central and West Java. The first priority for new settlers should be given to families living on lands that will be required for future subprojects in the Citanduy basin. A tentative assumption has been made in this analysis that the farms would be one hectare in size. This matter is subject to future determination of farm family income objectives by the national government.

In order to give proper direction to the new farming operations in the reclamation area, an intensive program of agricultural extension and farmer education must be developed for the farmers of the area. The subproject plan provides for this.

About 3,500 families are engaged in farming in and around the area at present. Another estimated 17,500 farm families would be needed to develop the 21,000 hectares of reclaimed land.

Provision is made for establishment of about 14 new villages within the reclamation area. The total new population, including the farmers and additional families needed to provide community services, would be about 145,000 persons.

Fisheries, Wildlife, and Recreation

There are reportedly about 4,000 fishermen presently engaged in fishing the Segara Anakan. The 1972 catch of fish was reported to be 493 tons, which provided each fisherman with gross income of Rp. 9,745 ($24).

Because of the continuous process of sedimentation that is taking place without the project, the fishery values are expected to decline from the present levels to zero in about 20 years.

After reclamation, management of the water area of the Segara Anakan for commercial fishery is expected to produce a significant increase in fish production. A conservative average yield per hectare would be 1,000 kilograms per hectare, if proper fish stocking and management techniques are carried out. The subproject includes these provisions.

The area of the Segara Anakan contains little wildlife other than small amphibians, monkeys and birds. These would be displaced by the reclamation process, but mitigation of these losses could be provided by reserving an area to be established as a wildlife sanctuary. The island of Nusa Kambangan should have its wildlife protected if any parts of the island are occupied or utilized in any way during and after the reclamation activity.

Recreation activity is certain to be increased in the area because creation of the stabilized fresh water lake will promote a large day-use visitation for fishing and boating. Reservation of some of the reclaimed land area for parks, picnic grounds and nature study areas would attract people from the mainland areas, particularly at Cilacap. Swimming would also be possible, since the lagoon is expected to be free of pollution and the water will not contain the amount of suspended sediment now present.

Subproject Cost

The total subproject cost, broken down into foreign exchange and Rupiah costs, is shown on Table IV-19. It is a total of Rp. 11,035.171 million ($26,654,999).

Environmental Considerations

No historical sites nor archeological sites have been reported within the subproject area. However, there are a number of burial sites which will have to be properly protected.

It is acknowledged that the conversion of a salt-water lagoon to a fresh water lake will irreversibly alter the ecological environment of the Segara Anakan. However, the consultant feels that the beneficial impacts to be had from the conversion will far outweigh any adverse impacts. This is not a unique area as far as Indonesia is concerned. Therefore, elimination of the salt water environment will not necessarily mean the complete loss of such a natural phenomenon. In any event, if left completely to the devices of nature, the ecology would naturally undergo drastic changes, for it is estimated that under present rates of buildup, within 35 to 40 years the Segara Anakan will be completely silted shut.

It is a matter of record that the fishing industry is presently on the decline. One of the objectives of this subproject is to replace the declining salt-water fishing industry with a well-managed fresh water fishery.

As with other subprojects within the Citanduy Basin project area, the beneficial environmental impacts on the human element will be truly significant. At the present time, many of the infrastructural amenities normally supplied by the govern-

ment are lacking within the subproject area for such reasons as lack of adequate transportation and communication, lack of proper housing facilities, low individual incomes, etc. The economic and other benefits which this subproject can bring to this area will be accompanied by social benefits to the extent that living standards of the inhabitants will be greatly improved.

Table IV-19

Foreign and Domestic Costs Summary
(Scheme B and With Nusawuluh in Place)

Item	Unit	Quantity	Foreign Currency Unit Cost Rp. (000)	Foreign Currency Amount Rp. (000)	Foreign Currency Amount $	Domestic Currency Unit Cost Rp. (000)	Domestic Currency Amount Rp. (000)	Domestic Currency Amount $
Major Structures:								
1. Tide gates	ea	99	1775.0	175,725	424,457	295.0	29,205	70,543
2a. Excav. Earth	m^3	1,530,200	0.290	443,758	1,071,879	0.124	189,745	458,321
2b. Excav. Rock	m^3	161,300	1.050	169,365	409,094	0.450	72,585	175,326
3. Concrete, Struct.	m^3	12,810	9.600	122,976	297,043	23.520	301,291	727,757
4. Steel, Rein	t	578	224.00	129,472	312,734	24.400	14,103	34,066
5. Misc. Metal	t	132	559.0	73,788	178,232	62.0	8,184	19,768
6. Rockfill	m^3	507,900	2.325	1,180,868	2,852,337	1.194	606,433	1,464,813
7. Transition Fill	m^3	144,900	.820	118,818	287,000	0.422	61,148	147,700
8. Impervious Fill	m^3	254,000	.700	177,800	429,469	0.335	85,090	205,531
9a. Excava.Rock	m^3	702,000	1.000	702,000	1,695,652	0.500	351,000	847,826
9b. Excava.Earth	m^3	421,400	0.290	122,206	295,184	0.124	52,254	126,216
10. Levee, Earthfill	m^3	125,000	0.700	87,500	211,353	0.335	41,875	101,147
11. Levee, Rockfill	m^3	60,000	0.400	42,000	101,449	0.335	20,100	48,551
Subtotal				3,546,276	8,565,883		1,833,013	4,427,565
Irrigation Drainage:								
1. Low-lift Pumps	ea	525	1.035	543,375	1,312,500	414.0	217,350	525,000
2. Distribution	ha	21,000	---	---	---	2484	521,640	1,260,000
System and Drains Subtotals				543,375	1,312,500		738,990	1,785,000
Miscellaneous:								
1. Relocation						82.80	41,400	100,000
2. Land Clearing	ha	16,000				20.70	331,200	800,000
3. Land Filling	m^3	4,600,000	0.214	984,400	2,377,778	0.200	920,000	2,222,222
4. Surveys	ha	25,000				2.898	72,450	175,000
5. Settler Assistance	ha	25,000				8.280	207,000	500,000
6. Fish Stocking	ha	4,000				30,636	122,544	296,000
Subtotals				984,400	2,377,778		1,694,594	4,093,222
Totals, Direct Items				5,074,051	12,256,161		4,266,597	10,305,787
Contingencies & Engineering Costs (Des.& Superv.)				1,016,714	2,455,831		677,809	1,637,220
Total Project				6,090,765	14,711,992		4,944,406	11,943,007

A Comprehensive Water Management Scheme for the Upper Citanduy/Ciseel River System

General

Land, water, and forest programs are frequently closely related and the development of one will have effects on the development of the others. If orderly development is to take place, it will be necessary to approach the planning and use o the Citanduy River basin resources in a comprehensive way, emphasizing the water relations among the various resources anc the effects the development of one resource will have on the other resources. Poor management of one resource may well exert adverse effects not only on that resource, but on related resources as well.

The indiscriminate cutting of forests in the past has contributed greatly to erosion and resultant heavy sediment loads in the basin's rivers, to destruction of wildlife, and to other changes in the physical environment. Therefore, it is essential to plan and manage all resources in a comprehensive way; evaluating the costs and benefits of using one resource not only in relation to economic factors, but also in relation to possible social impacts and costs to other resources.

It has been estimated that excessive erosion and runoff on the so-called critical lands of the upper watershed have reduced crop yields by as much as one-third of their former productivity. Thus the basic problem on the upper watershed lands is to teach the landowner the value of managing his resources for a stable and productive operation. Pressure to increase crop production on one hand and declining water and land resources on the other are on a headlong collission course. New ideas and recommendations must be developed and demonstrations planned to show how soil and water can be conserved

Upstream Water Management Program

The objectives of an upstream water management improvement program include, but are not limited to, the following

1. To strengthen the government's capacity for watershed planning, managing, and developing critical land areas.

2. To prepare detailed watershed management plans for at least four subwatersheds for demonstrations of good conservation methods and practices. Each of these to be about 250 ha in size.

3. To execute the plans so developed including the construction of terraces, waterways, and check dams; modification of agricultural and estate practices; reforestation and the related greening movement; and other indicated erosion and flood mitigation measures necessary to demonstrate how conservation measures can help the manager of the land.

4. To develop improved cultural techniques, through applied research in forestry, rainfed farm crops, and horticulture, that will facilitate optimum land use and rural development, giving special attention to social and economic requirements.

5. To strengthen the capacity of the government to progressively apply results to other areas and to build a cadre of professional and subprofessional workers by overseas and on-the-job training and short technical training sessions.

6. To instill in the local people an appreciation of the real nature and condition of the problems they face, and to demonstrate methods of attacking them. Thus local people will become involved in the decision making process and will thereby learn to make their own decisions for the improvement of their individual status.

7. To assess the extent to which population pressures on land can be relieved as a consequence of transmigration and family planning and to relate these conditions to the rehabilitated soil and water resources.

It is estimated that the execution of a plan of the magnitude proposed will require five years and a total budget cost of Rp. 844.17 million ($2,039,060).

Irrigation and Drainage

The location of the irrigation system included in this subproject area is shown on Plate IV-8. Due primarily to the lack of adequate maintenance, most of the systems are in need of major rehabilitation. Therefore, the rehabilitation of ten existing technical or semi-technical irrigation systems has been included in the subproject development plan. The total service area of the systems to be rehabilitated is 5,926 ha. Rehabilitation improvements will include rebuilding of diversion structures, canal improvements including bank stabilization, rehabilitation of distribution structures, and provisions of new gates and gaging equipment. These measures will allow proper management of the system and reduce water losses, which will help to alleviate dry season water shortages.

Extension of irrigation in this subproject area, primarily in rural systems or rainfed areas, has been implemented through the use of INPRES budgets. This policy should be continued. However, some improvements could be made. For example, budget analyses need to be more detailed with respect to the quantities of work involved and the time required for the completion of the work. The budgets should be adequate to insure that construction, once undertaken, can be completed within a reasonable length of time.

The only major irrigation system that could be constructed in the subproject area is in the Banjar Plains. The Irrigation Service is in the process of designing a technical irrigation system which will serve an area of 887 ha. A diversion structure will be built on the Citanduy River and, in addition to the irrigation diversions, an additional 1.7 MCM/mo will be diverted for water supply and flush water for the city of Banjar.

Rural or simple irrigation systems are also in need of rehabilitation, especially to prevent water losses in the canals. Maintenance of these systems is the responsibility of the local farmers. However, a system is required whereby Public Works can upgrade community participation in the improvement of the system. Public Works should advise the community in all the technical matters and supervise the implementation of a rehabilitation program.

A cost estimate for rehabilitation of the ten major irrigation systems is given in Table IV-20. The total cost would be Rp. 558 million ($1.35 million), based on 1974 prices. The estimated annual O & M cost would be Rp. 32.6 million ($78,744), based on a unit cost of Rp. 5,500/ha ($13.28/ha).

Subproject Cost

It is estimated that the total development program recommended for this subproject will cost Rp. 1,302.49 million ($3.148 million). The cost detail is shown in Table IV-20.

Table IV-20

Cost Estimate for Rehabilitation of Major Irrigation Systems - Upper Citanduy/Ciseel River System

System	Area ha	Unit Cost Rp/ha	Total Cost Rp (000)
1. Cimulu	1,950	70,000	136,500
2. Cipalih/Nagawiru	730	70,000	51,100
3. Citanduy - Indihiang	500	70,000	35,000
4. Wangundireja	376	70,000	26,320
5. Cikalang	110	70,000	7,700
6. Cigede	869	70,000	60,830
7. Cigayam	382	70,000	26,740
8. Jagabaya	600	70,000	42,000
9. Ciloganti	220	70,000	15,400
10. Cimarongmong	189	70,000	13,230
Subtotal			414,820
Contingencies (20%)			82,964
			497,784
Engineering and Administration (12%)			59,734
Total			557,518
Use: Rp. 558 million ($1.35 million)			

Environmental Impact

Soil and water conservaiion measures recommended for the upper watersheds will have beneficial impacts on both the biological resources and the ecological systems as they now exist. We do not foresee any detrimental impacts in this category.

The recommended sedimentation control measures should improve the visual appearance of the streams and rivers within the subproject area. This should also improve the environment for river fishing.

As with the subprojects previously discussed, perhaps the greatest environmental impact of direct benefit to the human element will be the improvement in land and water quality. The entire basin is a rural area and there are no expectations that the subprojects will cause any significant changes in air quality or sound level. Certainly the measures recommended in this plan will enhance the visual aspects of the entire project area.

A Water Management Scheme for the Balance of the Project Area

General

For the most part, the area included in this subproject is located in Central Java and is composed of the upper portions of the Segara Anakan drainage basin. In other words, those areas that are not included in the Segara Anakan reclamation subproject, nor in the Lower Citanduy/Ciseel subproject. The 7,119 ha Sidareja Plains irrigation system is under construction by the government, so is excluded from the discussion of potential projects for the Master Plan.

Irrigation and Drainage

A well planned rehabilitation program is necessary for the development of this subproject area. The existing major systems should be brought up to full technical standards. Rural irrigation systems need assistance from Public Works in the form of technical guidance programs. Furthermore, a sound program of operation and maintenance must be implemented and adequate budgetary funds must be made available.

All of the major irrigation systems need rehabilitation in one form or another. The locations of the systems are shown on Plate IV-22. Rehabilitation measures will allow proper water management of the systems, reduce water losses, and help to alleviate dry season water shortages. Rehabilitation improvements will include desilting of canals, structure repairs, and provision of new gates and gaging equipment. There are eight major irrigation systems to be rehabilitated, and the total area involved is 5,647 ha.

The rural or simple irrigation systems also need some rehabilitation. Maintenance of these systems is the responsibility of the local farmers. However, a system is required whereby Public Works can upgrade community participation in improving the systems. They should advise the community in all technical matters and supervise the implementation of a rehabilitation program. INPRES budgets can be used to rehabilitate or construct new simple irrigation systems.

The Cihaur area, shown on Plate IV-23, could be developed in the future. The water balance analysis indicates that there is enough water available in the Citanduy River to supply irrigation water to the area, if a cropping intensity of 2 rice crops per year is used. The primary drawback to immediate development is poor surface drainage and salt water intrusion caused by the tidal effects of the Indian Ocean through the Segara Anakan. These problems can only be solved if measures are implemented to control the tidal effects such as the recommended Segara Anakan subproject.

The source of water for the Cihaur area would be the Citanduy River. Diversions could be made at the Monganti Diversion structure, which is presently under construction, and conveyed to the Cibeureum River through the proposed Sidareja canal system. A check dam and pumping station would be required on the Cibeureum River to serve the proposed 2,100 ha service area. A total lift of approximately 8 m would be required to serve the entire area. As shown on Plate IV-23, two lifts are recommended. The first would be a lift of 3 m at the Cibeureum River which would command an area of 1,255 ha. A relift of 5 m would be required to irrigate the remainder of the area.

Subproject Costs

Table IV-21 shows the estimated cost for rehabilitation of the major irrigation systems, based on 1974 prices. The estimated total cost is Rp. 393 million ($949,275). The total area to be rehabilitated is 5,647 ha. Annual operation and maintenance costs would be Rp. 31.06 million ($75,020) based on a unit cost of Rp. 5,500/ha ($13.28/ha).

Table IV-22 shows the estimated cost of the proposed Cihaur irrigation system. The estimated total cost is Rp. 581 million ($1.406 million). The cost includes the check dam, pumping plants, and the distribution system. The total annual O & M cost is estimated to be Rp. 26.04 million ($62,898). The unit cost would be Rp. 12,400/ha ($29.95/ha) and consists of Rp. 6,900/ha ($16.67/ha) for the pumps, etc. and Rp. 5,500/ha ($13.28/ha) for the distribution system.

Table IV-21

Cost Estimate for Rehabilitation of Major Irrigation Systems - Central Java Areas

	System	Area ha	Unit Cost Rp/ha	Total Cost Rp. (000)
1.	Cileumpuyang	400	60,000	24,000
2.	Cilopadang	237	60,000	14,220
3.	Cileumeuh	1,549	30,000	46,470
4.	Pahonjean	300	60,000	18,000
5.	Sindangsari	561	60,000	33,660
6.	Cijalu	1,449	60,000	86,940
7.	Cilaca	751	60,000	45,060
8.	Wanareja	400	60,000	24,000
	Subtotal			292,350
	Contingencies (20%)			58,470
				350,820
	Engineering & Administration (12%)			42,098
	Total			392,918
	Use: Rp. 393 million ($949,275)			

Table IV-22

Cost Estimate for Proposed Cihaur Irrigation System

Item	Unit	Quantity	Cost Unit Rp	Cost Total Rp (000)
Pumping Plants	ha	2,100	60,000	126,000
Primary & Secondary Canals	ha	2,100	90,000	189,000
Major Structures	ha	2,100	18,000	37,800
Minor Structures	ha	2,100	8,000	16,800
Tertiary System	ha	2,100	30,000	63,000
Subtotal				432,600
Contingencies (20%)				86,520
				519,120
Engineering & Administration (12%)				62,294
Total				581,414
Use: Rp. 582 million ($1.406 million)				

	NO REGULATION	REGULATION WITH MATENGGENG DAM	REGULATION WITH BINANGUN No.2 DAM		REGULATIO WITH CITANDU DAM [1]
Citanduy river at Banjar	1750 (17)				1160 (15)
Citanduy river routed to Cijolang river	1530 (23)				1000 (19)
Citanduy river plus Cijolang river	1900 (22)	1710 (23)			1520 (18)
Citanduy river routed to Cikawung river	1650 (30)	1520 (31)			1340 (25)
Citanduy river plus Cikawung river	1880 (29)	1720 (31)			1680 (24)
Citanduy river after routing through Wanareja swamp	1710 (33)	1560 (34)			1530 (27)
Citanduy river at cross - connection with Ciseel river	1600 (39)	1450 (40)			1420 (33)
Citanduy river plus Ciseel river	1820 (39)	1640 (40)	1540 (40)	1740 (39)	1720 (30)
Citanduy river at Nusawuluh diversion WITH NO DIVERSION	1820	1640	1540	1740	1720
WITH 200 m^3/s DIVERSION	1620	1440	1340	1540	1520
WITH UNCONTROLLED DIVERSION	950	880	840	920	910

1) ALTERNATE BANJAR SITE, CIMUNTUR RIVER UNCONTROLLED

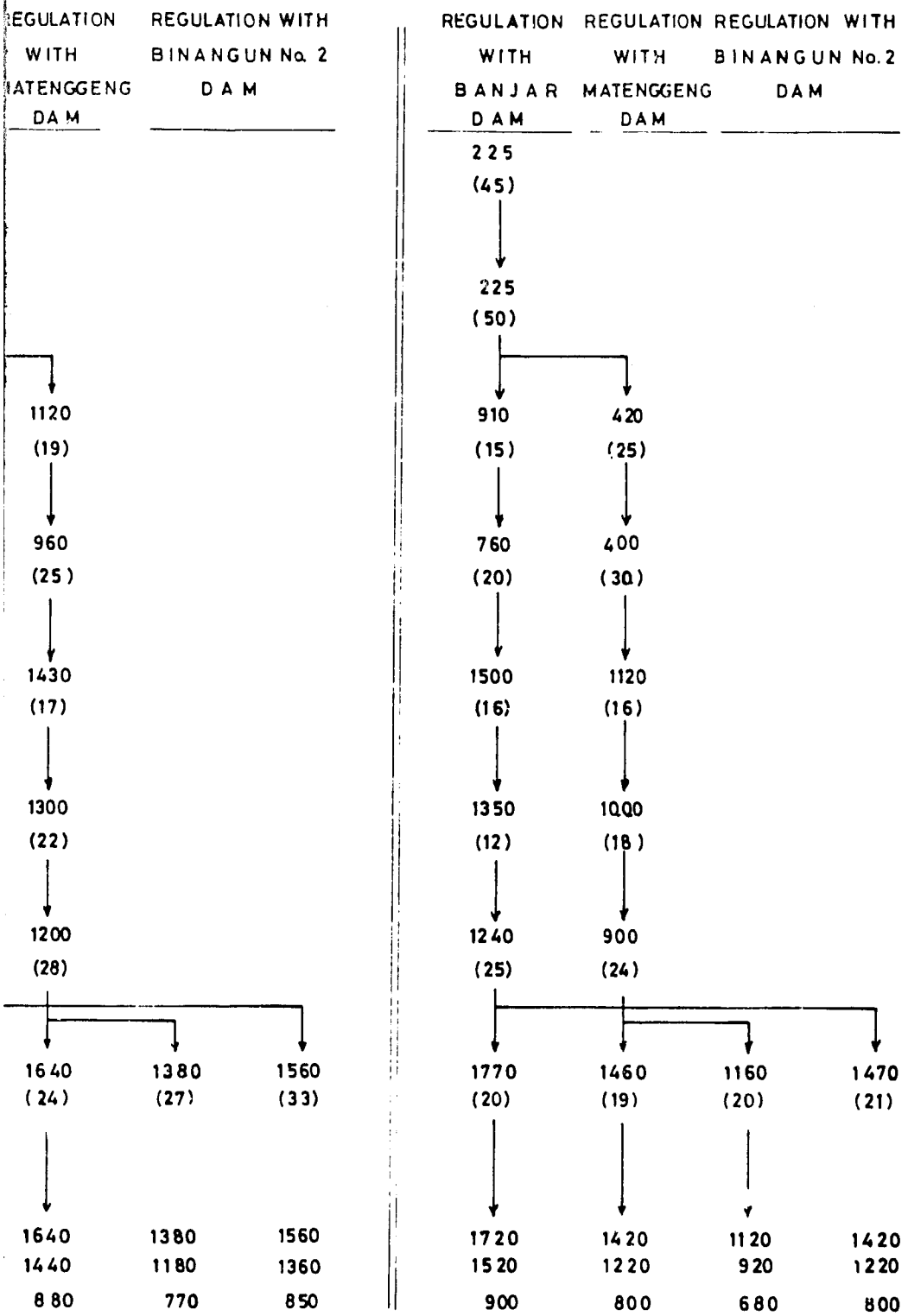
NO REGULATION	REGULATION WITH MATENGGENG DAM	REGULATION WITH BINANGUN No.2 DAM
1750 (17)		
1530 (23)		
1900 (22)	1710 (23)	
1650 (30)	1520 (31)	
1880 (29)	1720 (31)	
1710 (33)	1560 (34)	
1600 (39)	1450 (40)	
1820 (39)	1640 (40)	1540 (40) 1740 (39)
1820	1640	1540 1740
1620	1440	1340 1540
950	880	840 920

REGULATION WITH CITANDUY DAM 1)	REGULATION WITH MATENGGENG DAM	REGULATION WITH BINANGUN No. 2 DAM
1160 (15)		
1000 (19)		
1520 (18)	1120 (19)	
1340 (25)	960 (25)	
1680 (24)	1430 (17)	
1530 (27)	1300 (22)	
1420 (33)	1200 (28)	
1720 (30)	1640 (24)	1380 (27) 1560 (33)
1720	1640	1380 1560
1520	1440	1180 1360
910	880	770 850

REGULATION WITH BANJAR DAM	REGU WI MATE DA
225 (45)	
225 (50)	
910 (15)	42 (25
760 (20)	400 (30
1500 (16)	112 (16
1350 (12)	100 (18
1240 (25)	90 (24
1770 (20)	146 (19
1720	142
1520	122
900	80

UR RIVER UNCONTROLLED

CIT



PEAK DISCHARGE in m^3/s
(TIME FROM BEGINNING OF RAINFALL)

NOTE: RAINFALL ASSUMED TO BEGIN IN ALL BASINS AT THE SAME TIME.

25 - YEAR FLOOD ROUTING
IN THE
CITANDUY RIVER SYSTEM

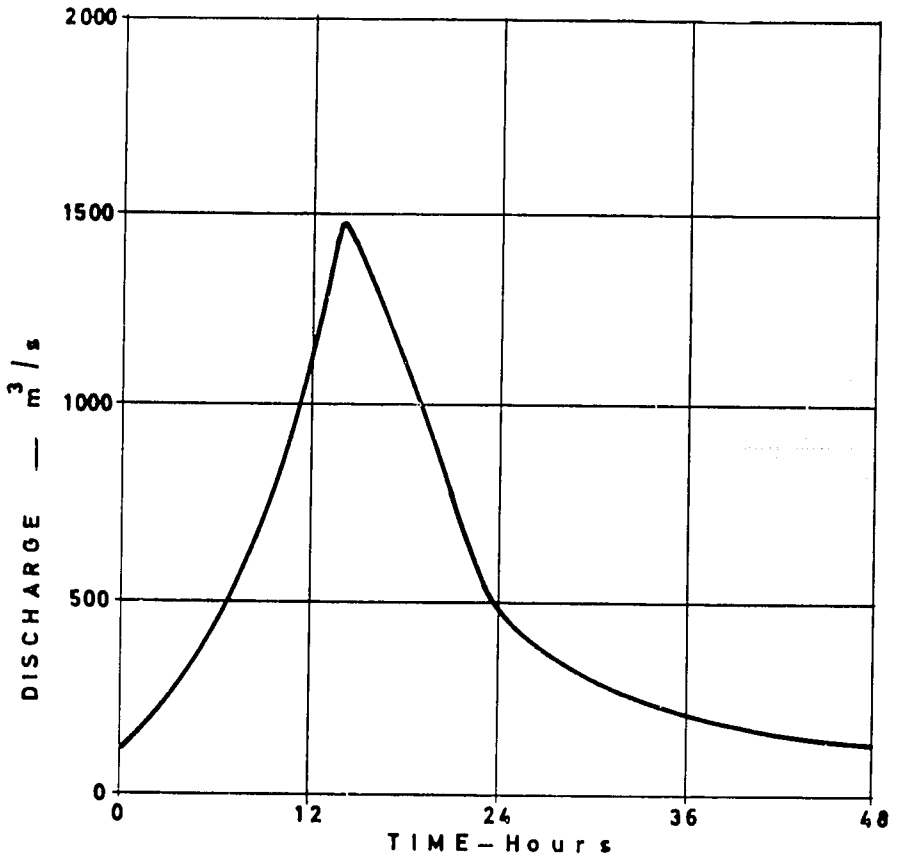
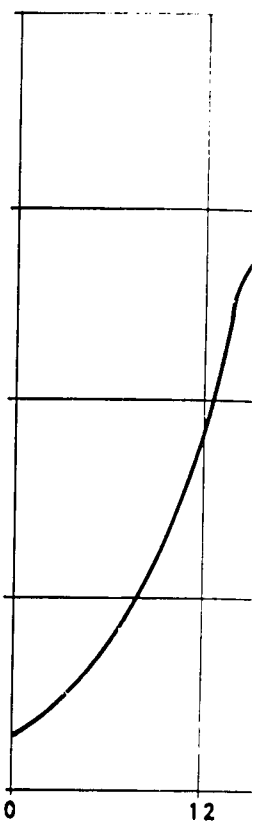


Fig. A. At Banjar



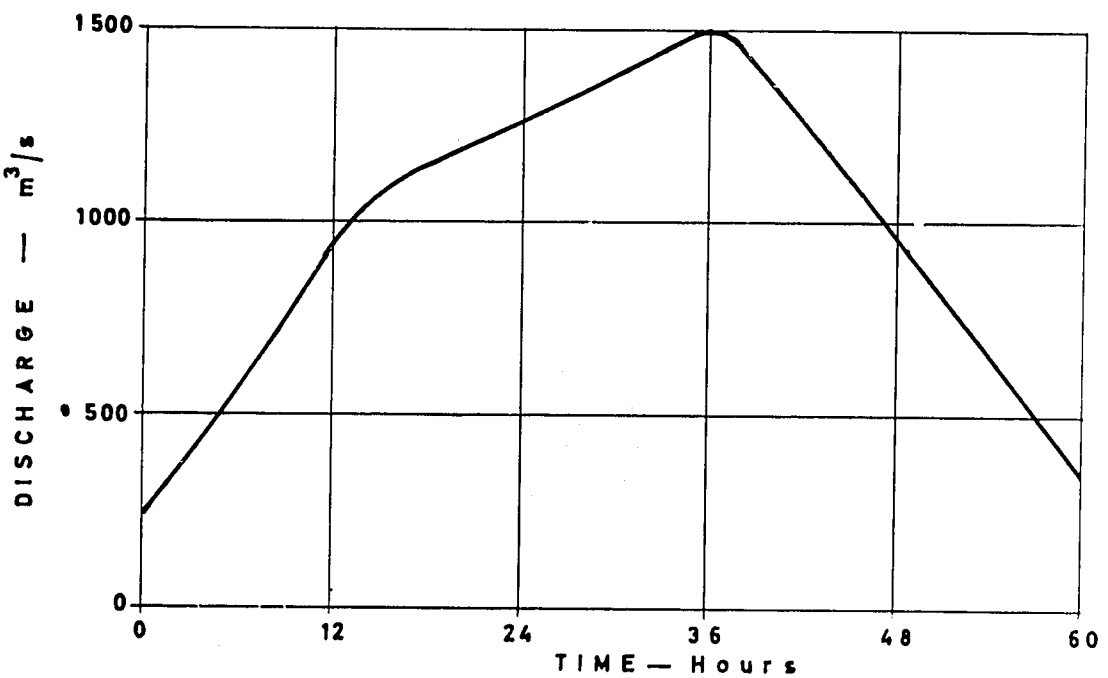
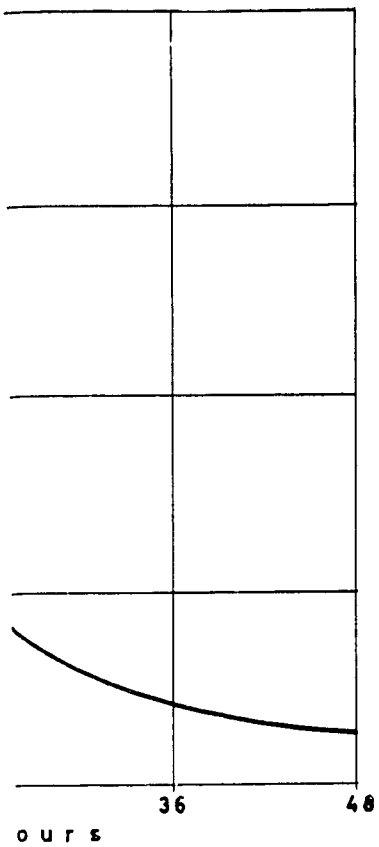


Fig. D. At Ciseel Connection



At Banjar

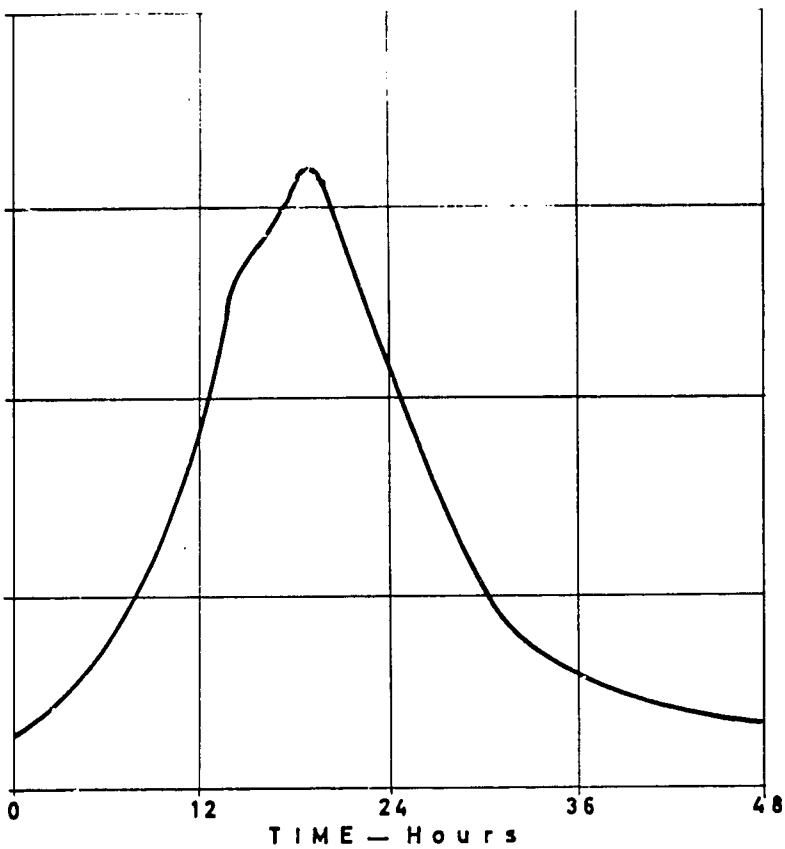


Fig. B. At Cijolang River

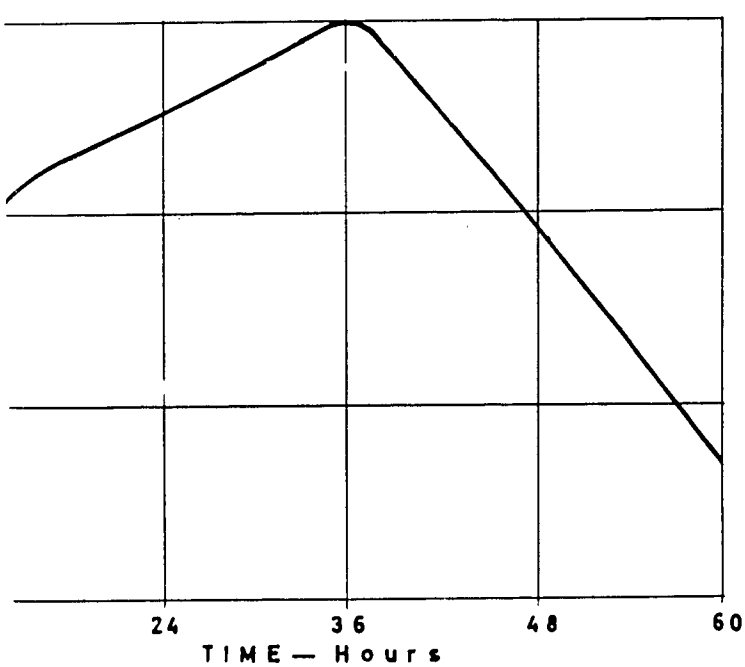


Fig. D. At Ciseel Connection

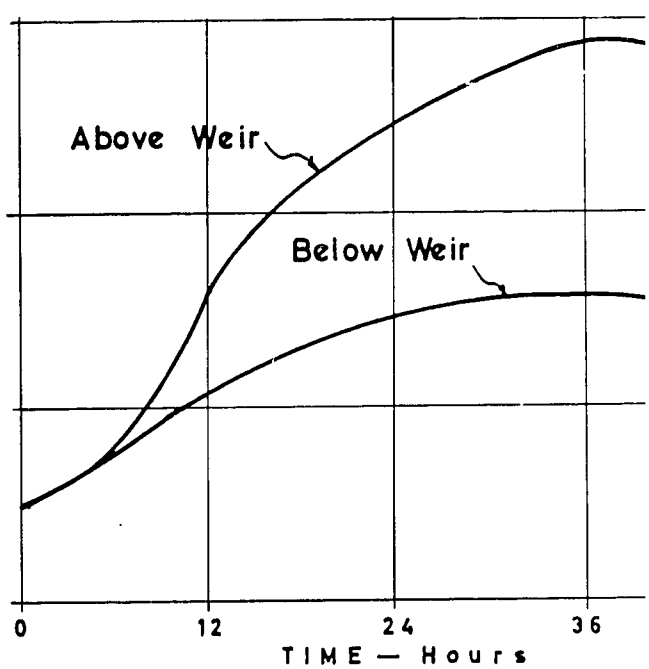
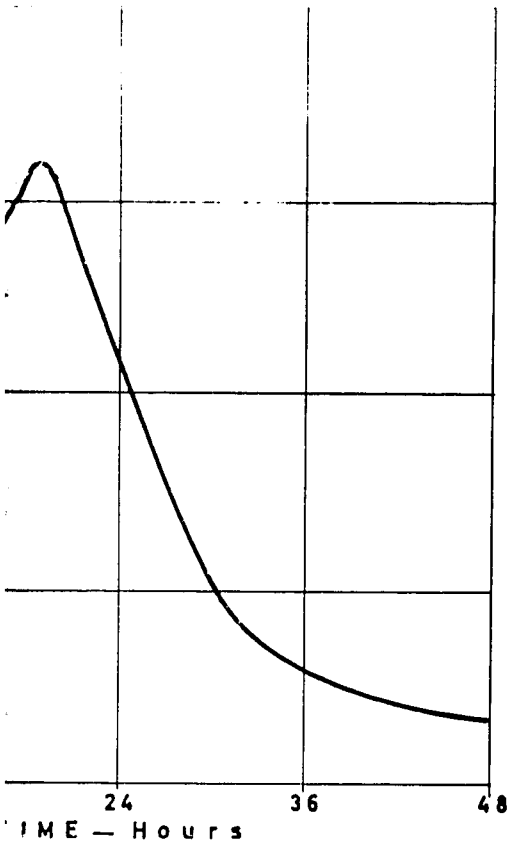


Fig. E. At Nusawuluh We

10-YEAR HYDROGRA



g. B. At Cijolang River

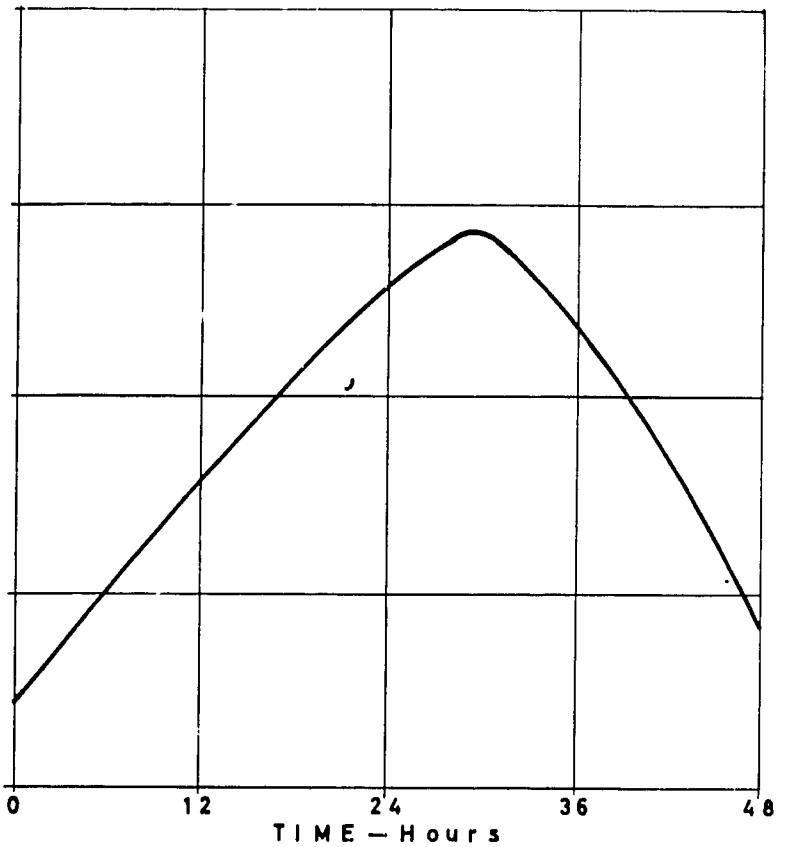


Fig.C. At RR Bridge 1452

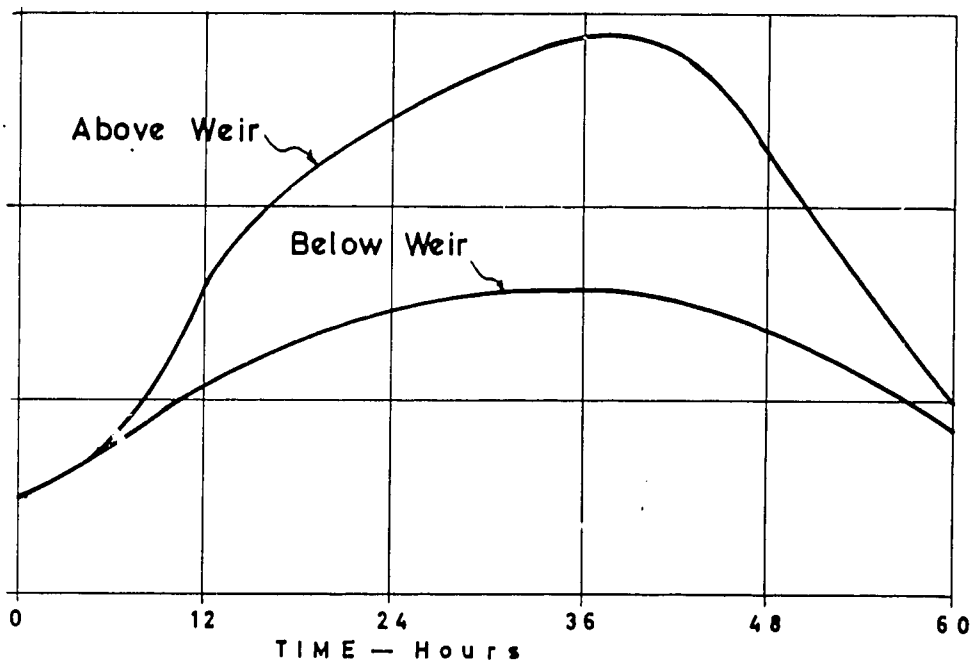


Fig. E. At Nusawuluh Weir

10-YEAR HYDROGRAPHS CITANDUY RIVER

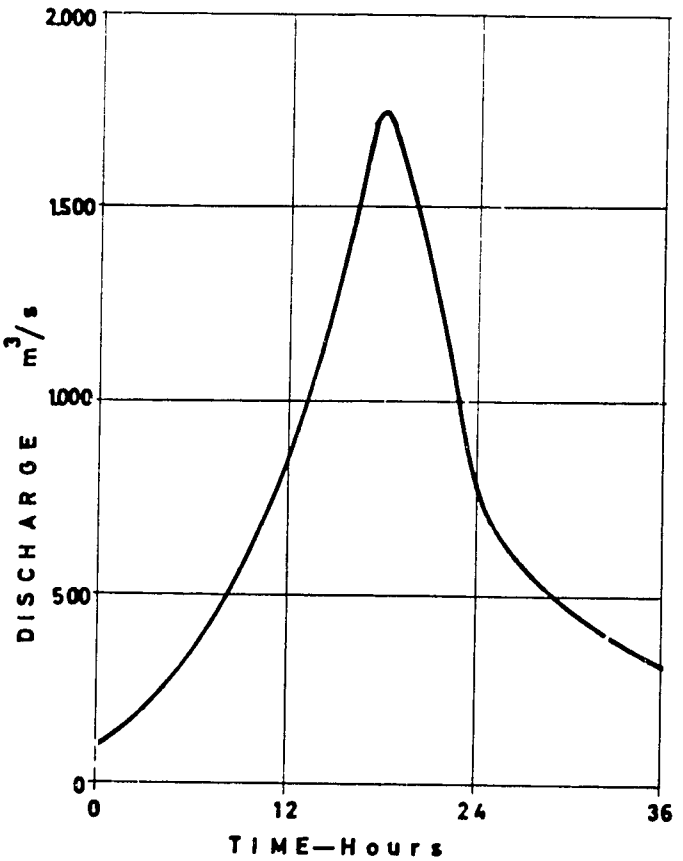


Fig.A. At Banjar

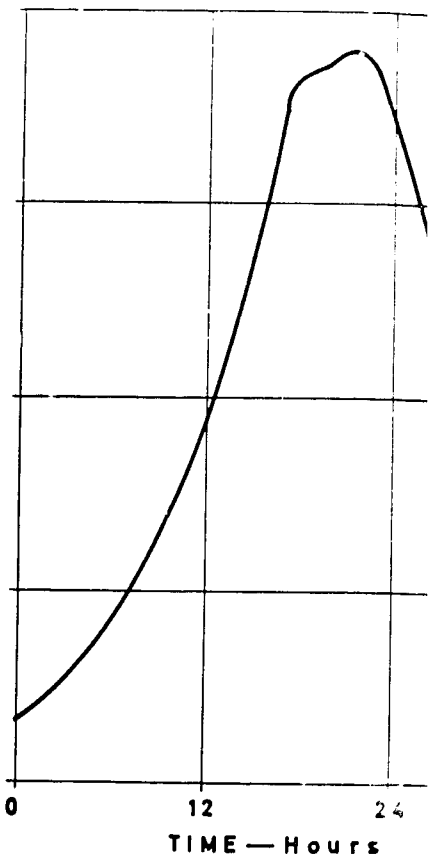


Fig. B. At Cij

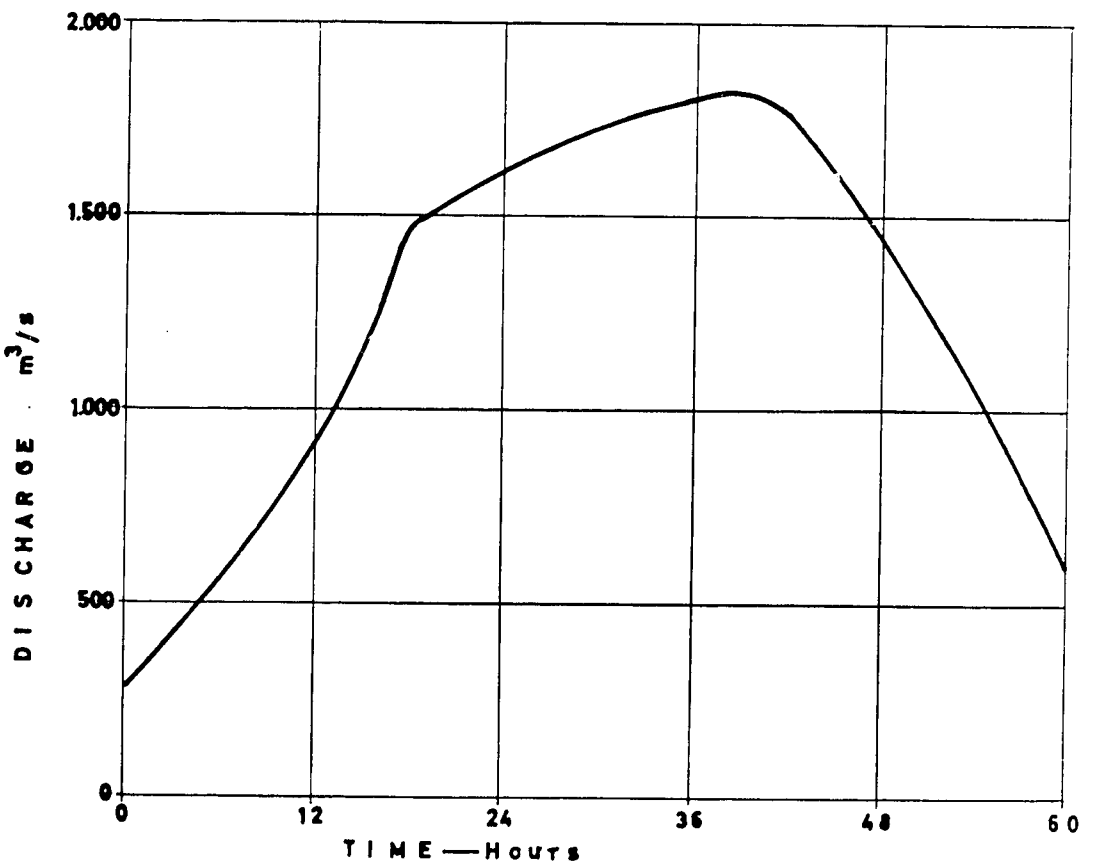


Fig.D. At Ciseel Connection

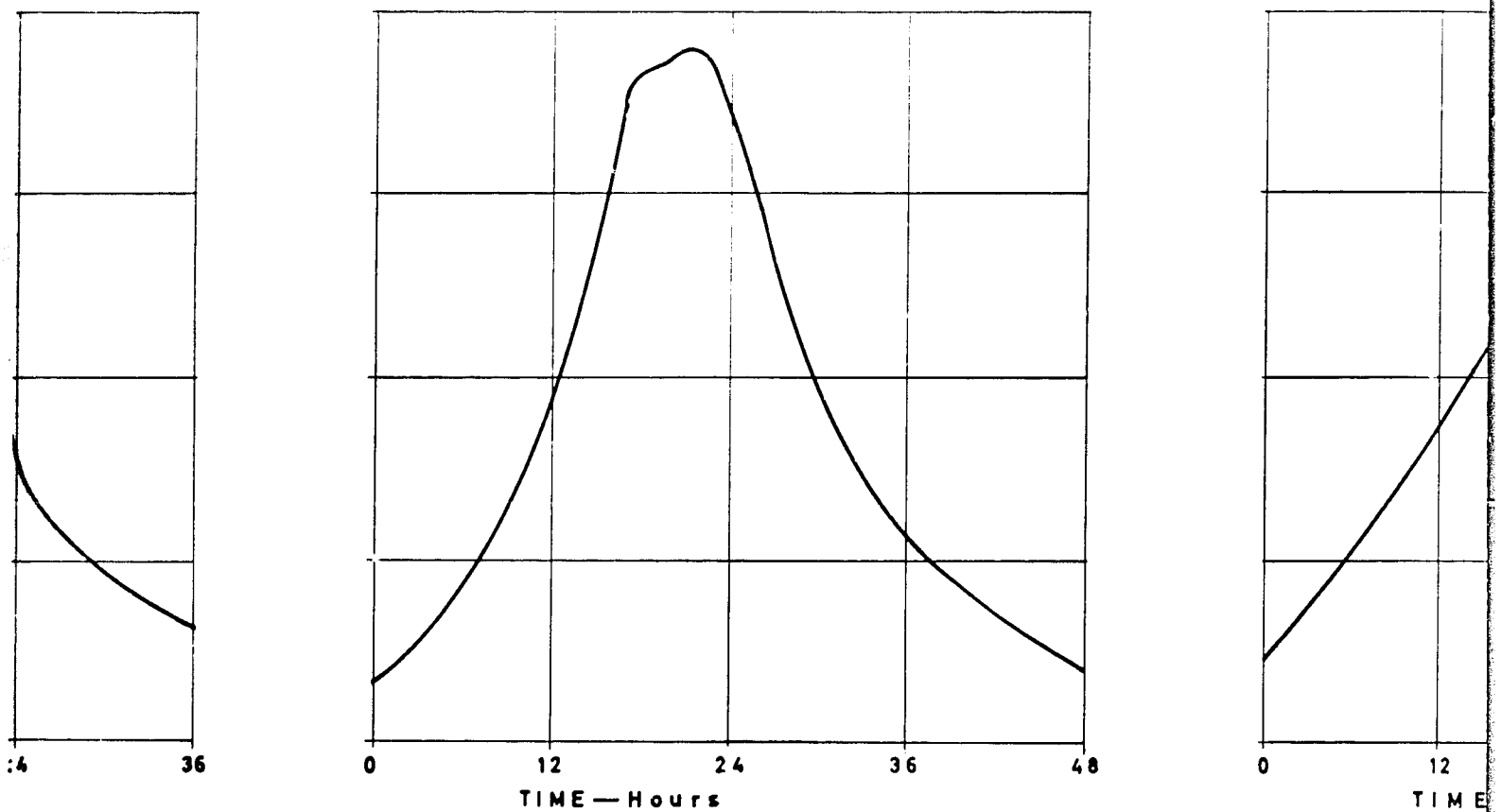


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Fig. B. At Cijolang River

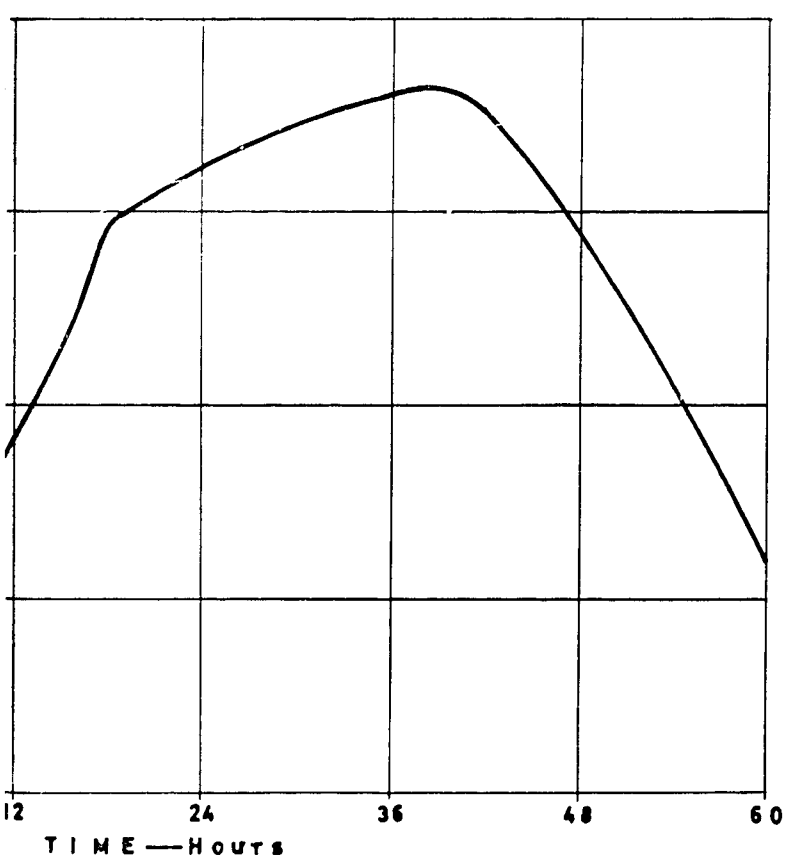


Fig. D. At Ciseel Connection

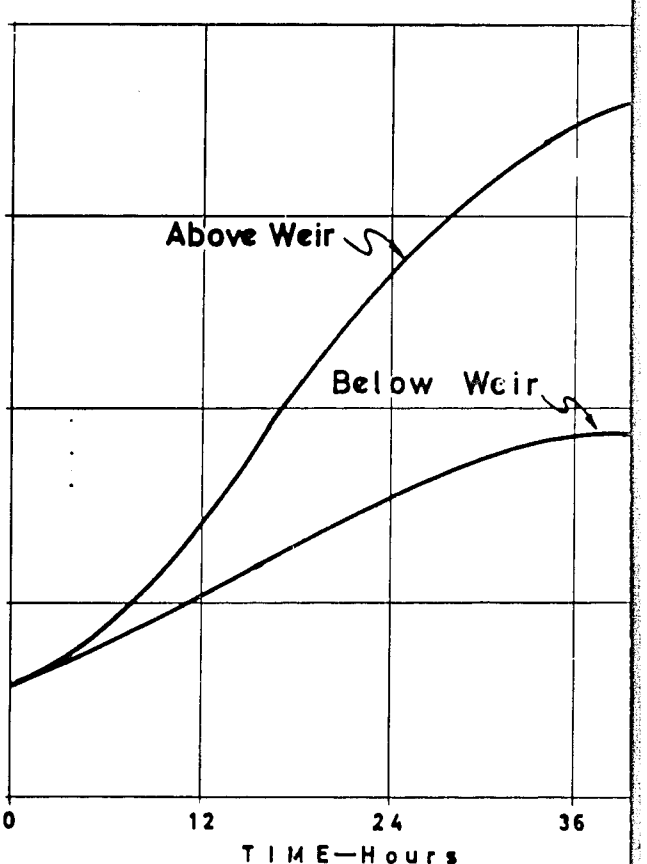
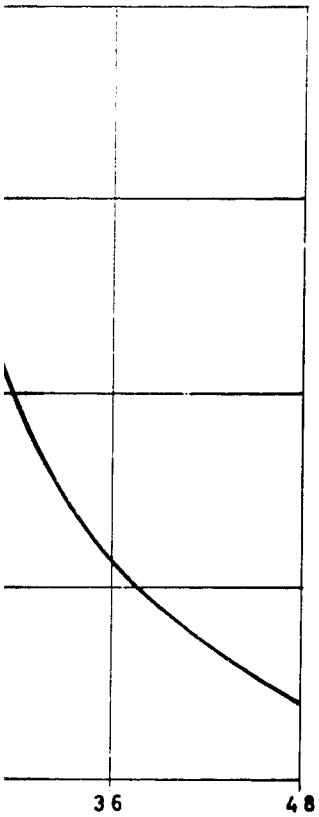


Fig. E. At Nusawuluh

25-YEAR HYDROGRAPHS CI



ang River

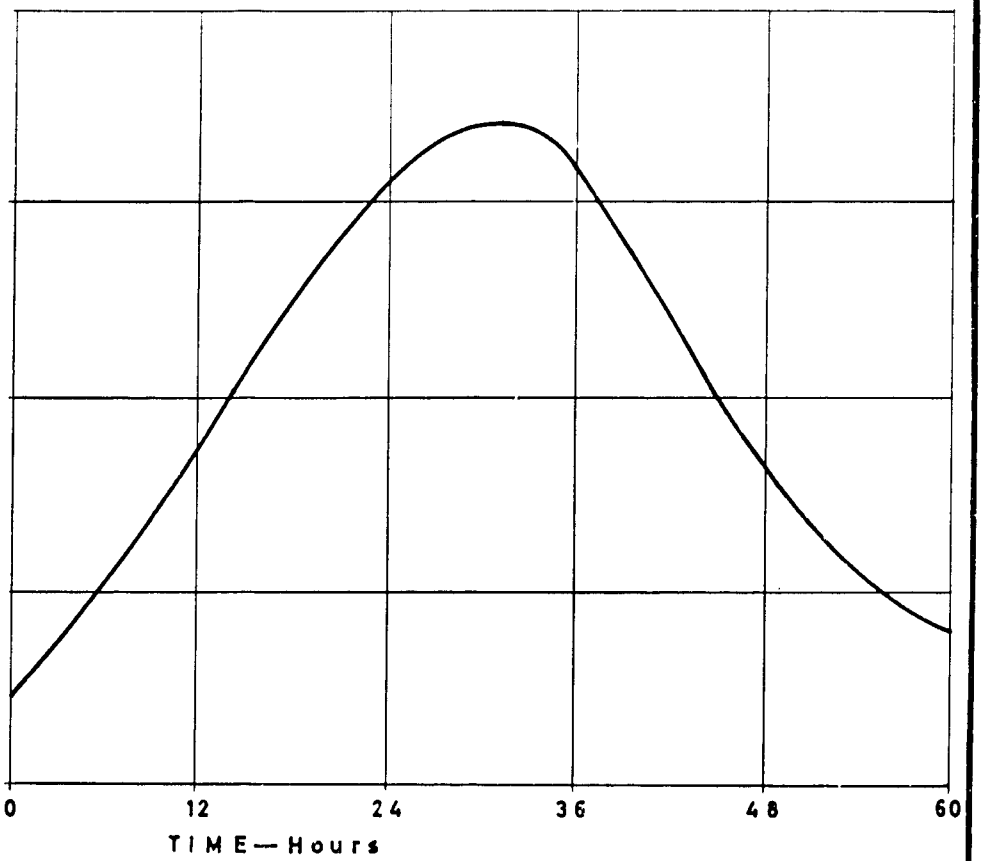


Fig. C. At RR Bridge 1452

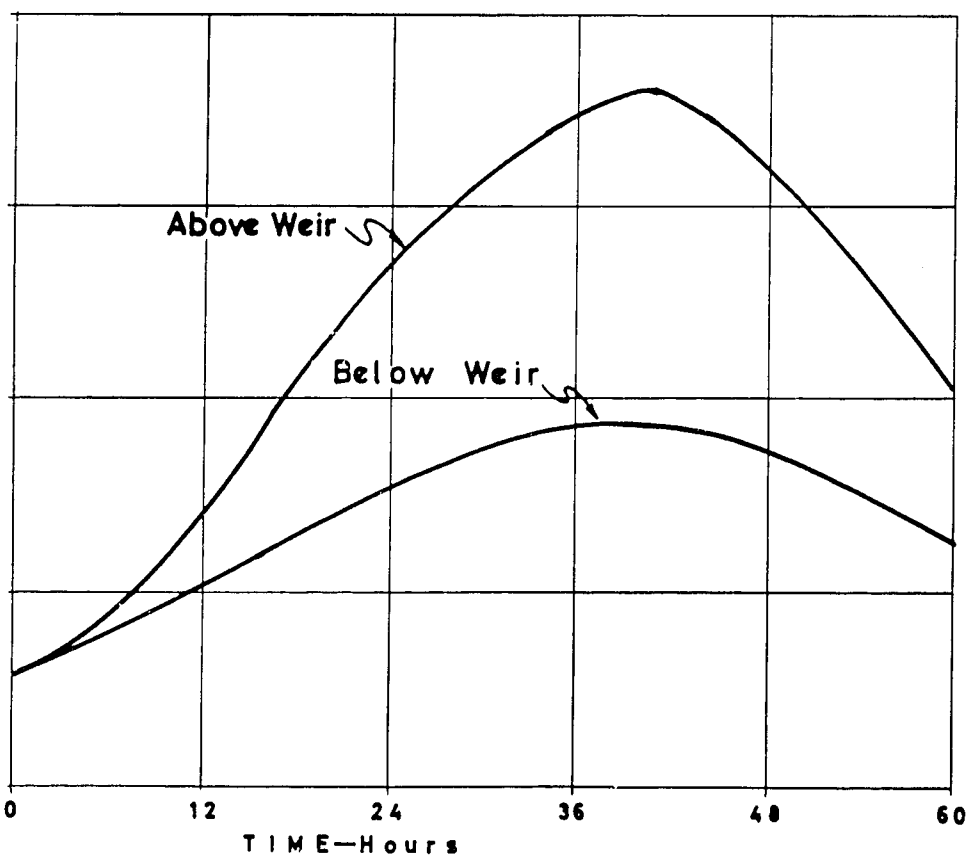


Fig. E. At Nusawuluh Weir

25-YEAR HYDROGRAPHS CITANDUY RIVER

A.M.

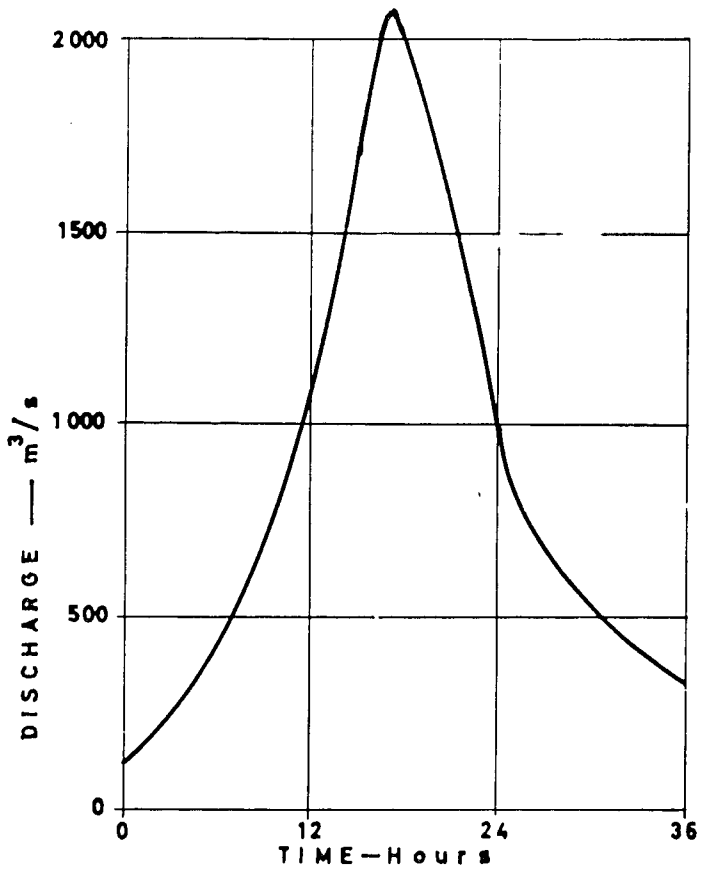


Fig. A. At Banjar

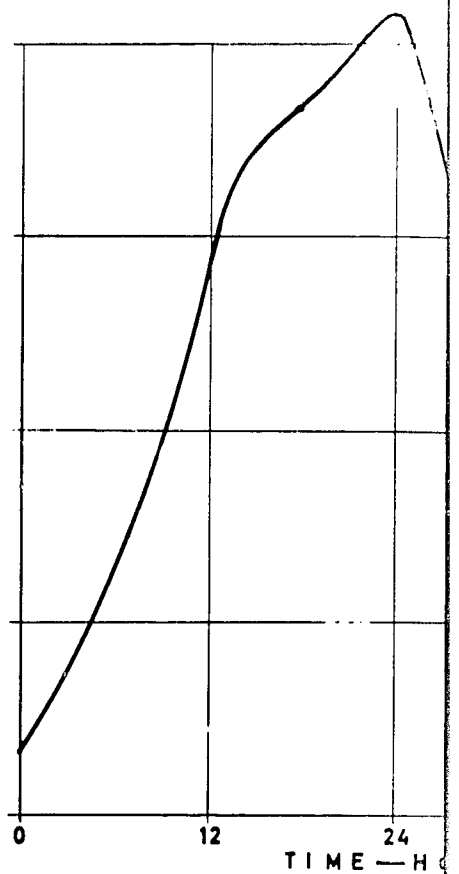


Fig .B.At Cijo

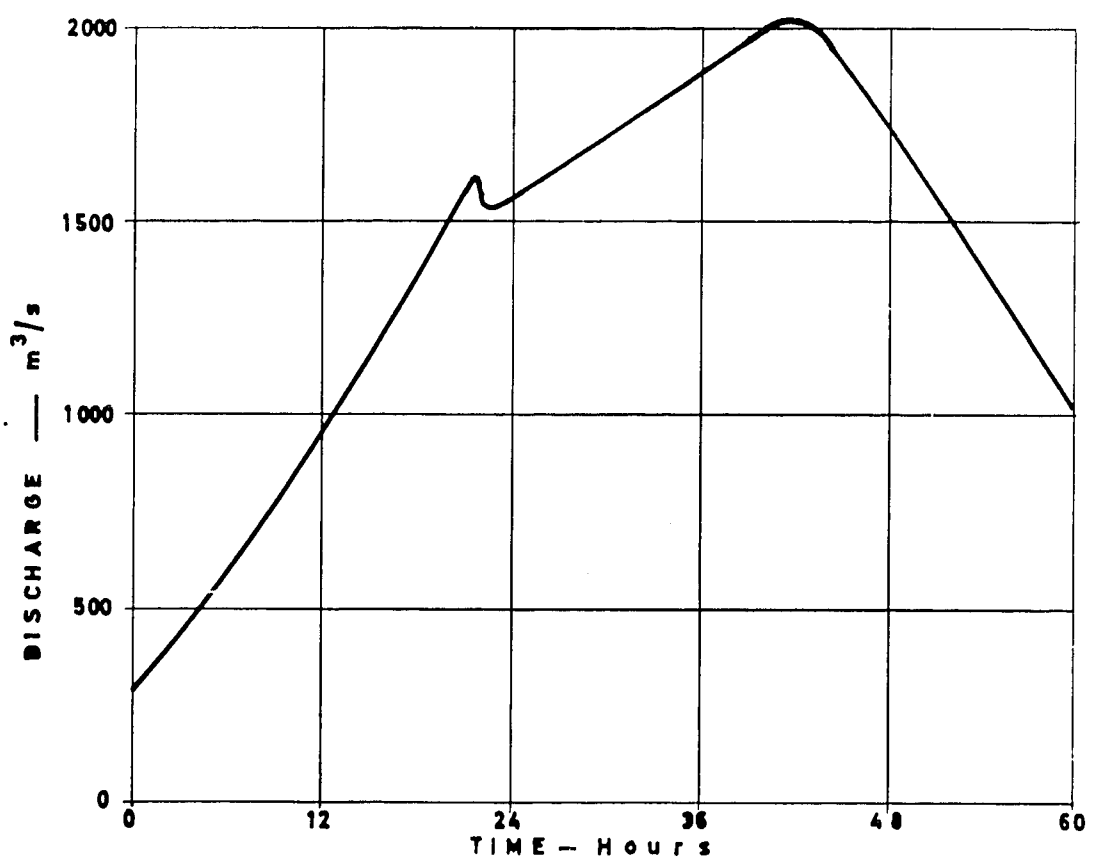


Fig.D. At Ciseel Connection

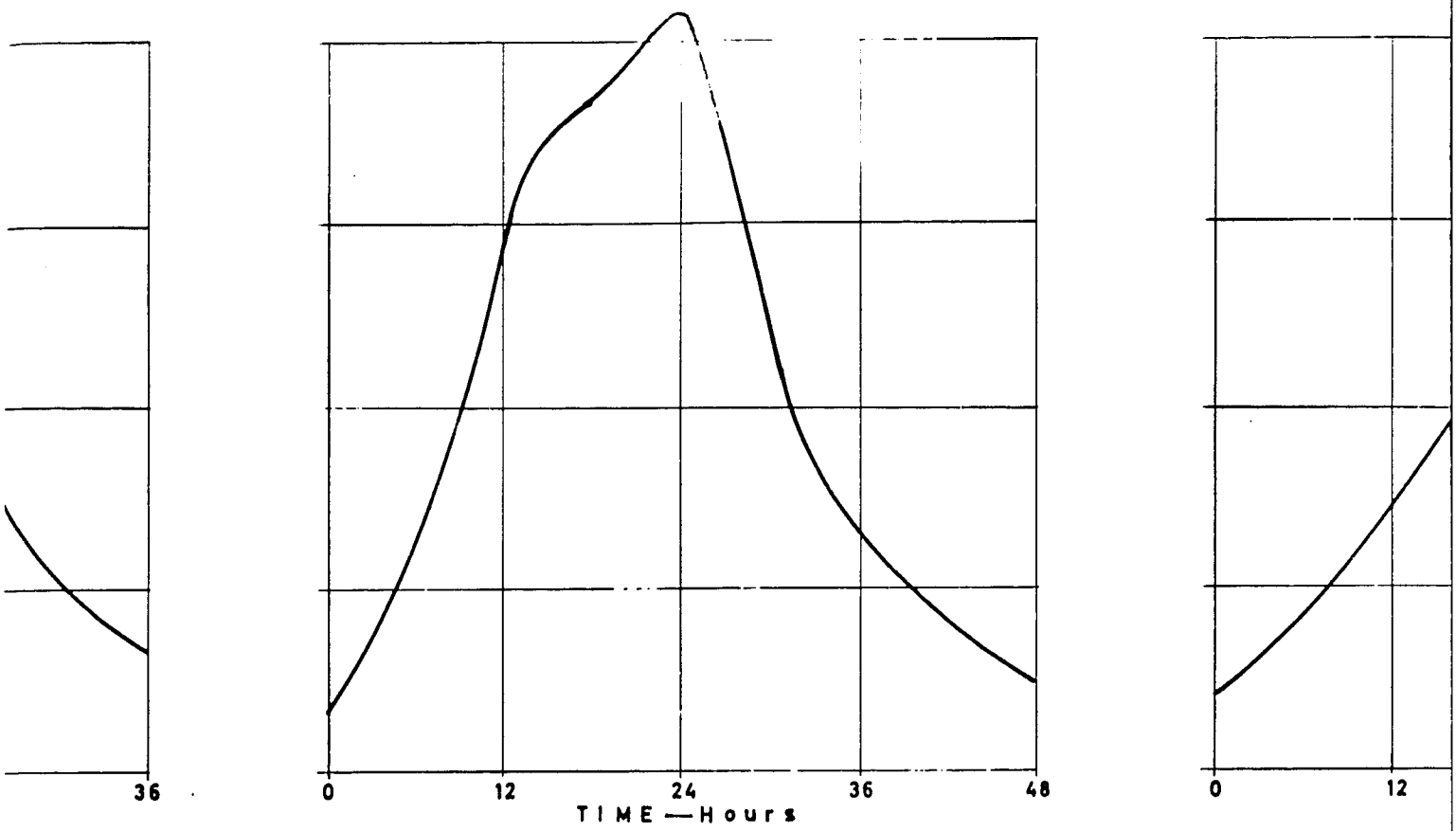


Fig .B.At Cijolang River

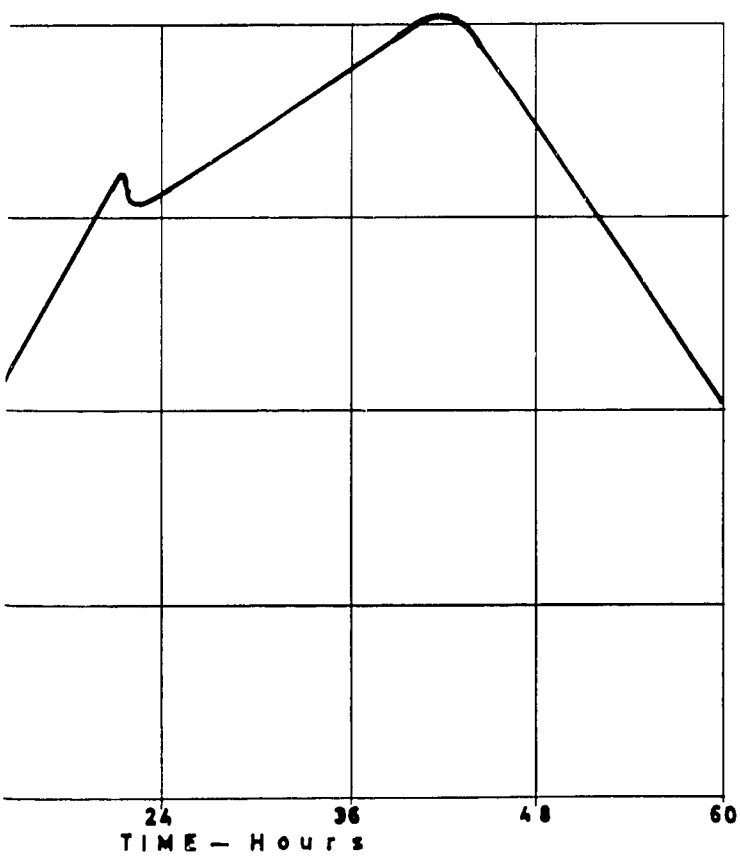


Fig.D. At Ciseel Connection

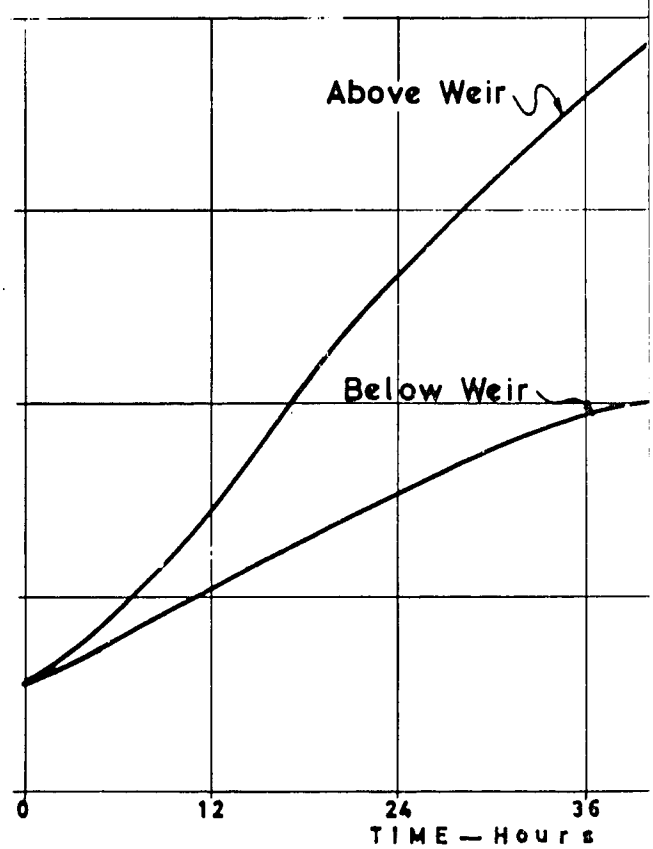
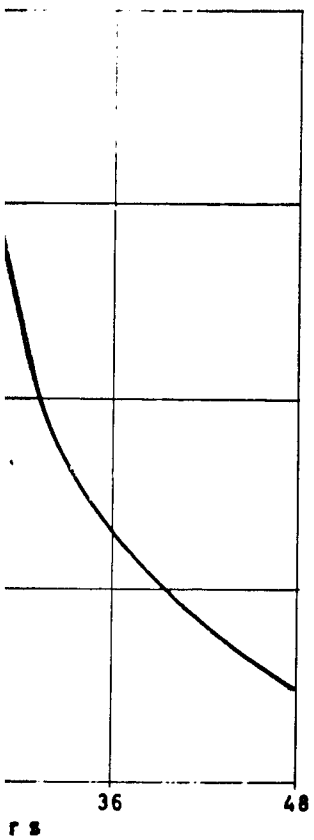


Fig . E. At Nusaw

50 - YEAR HYDROGR



ng River

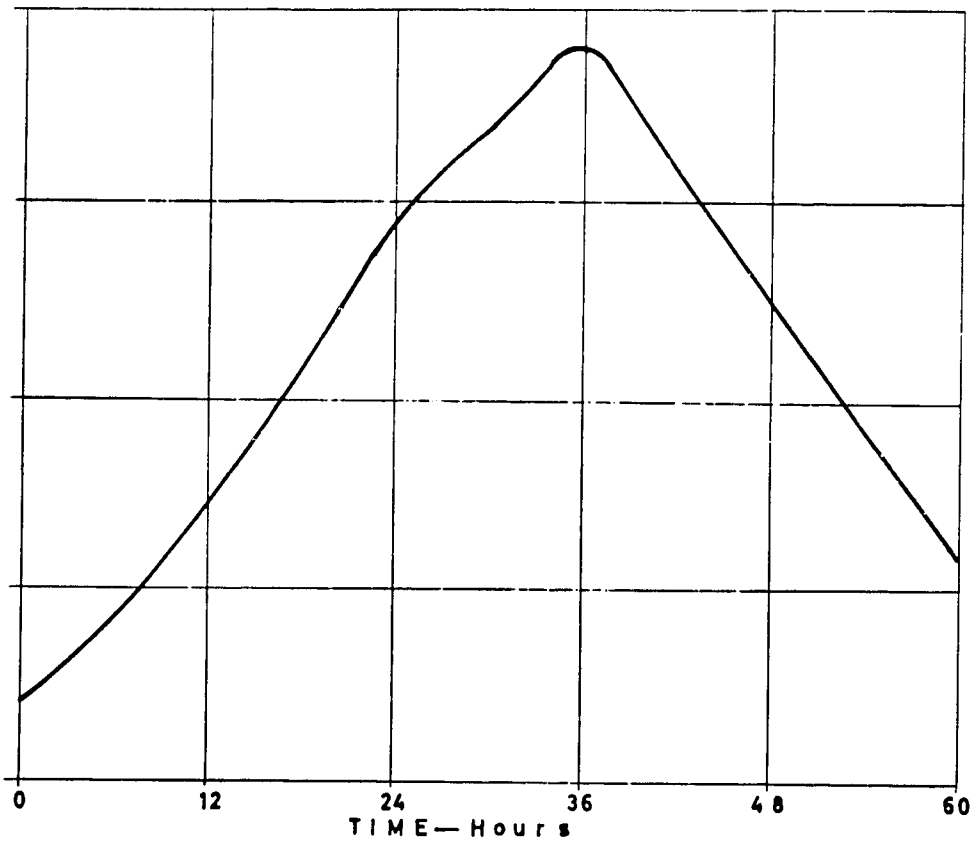


Fig.C. At RR.Bridge 1452

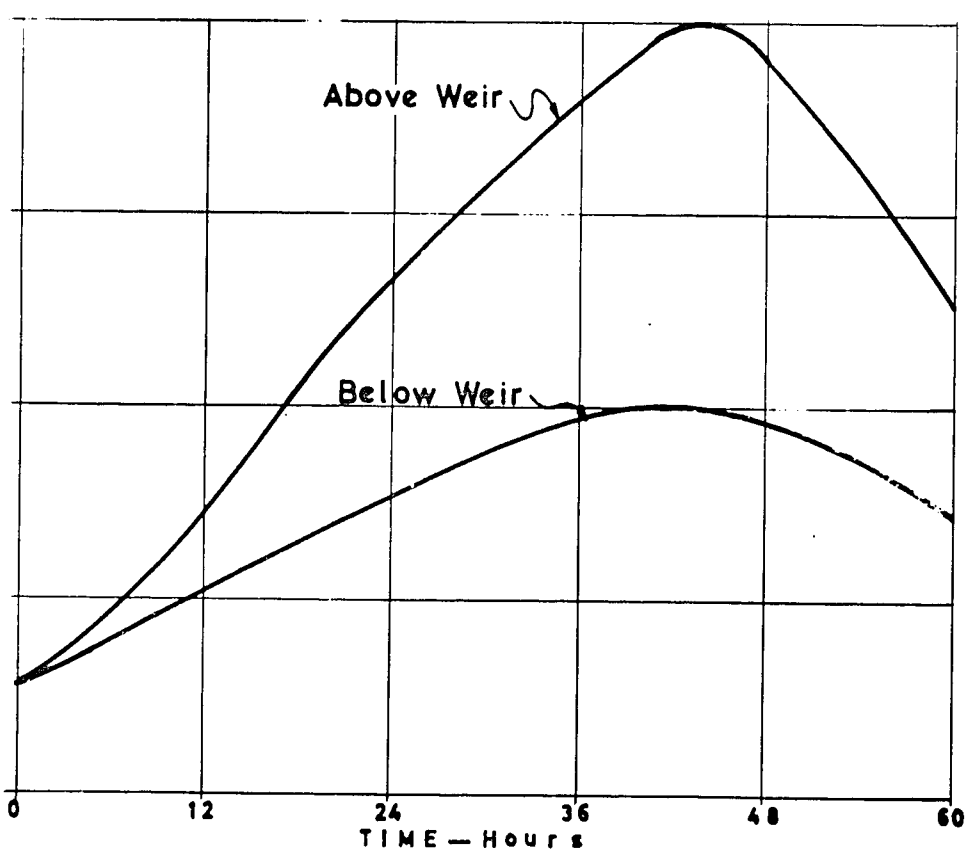


Fig . E. At Nusawuluh Weir

50-YEAR HYDROGRAPHS CITANDUY RIVER

A.H.

ENGINEERING CONSULTANTS, INC.

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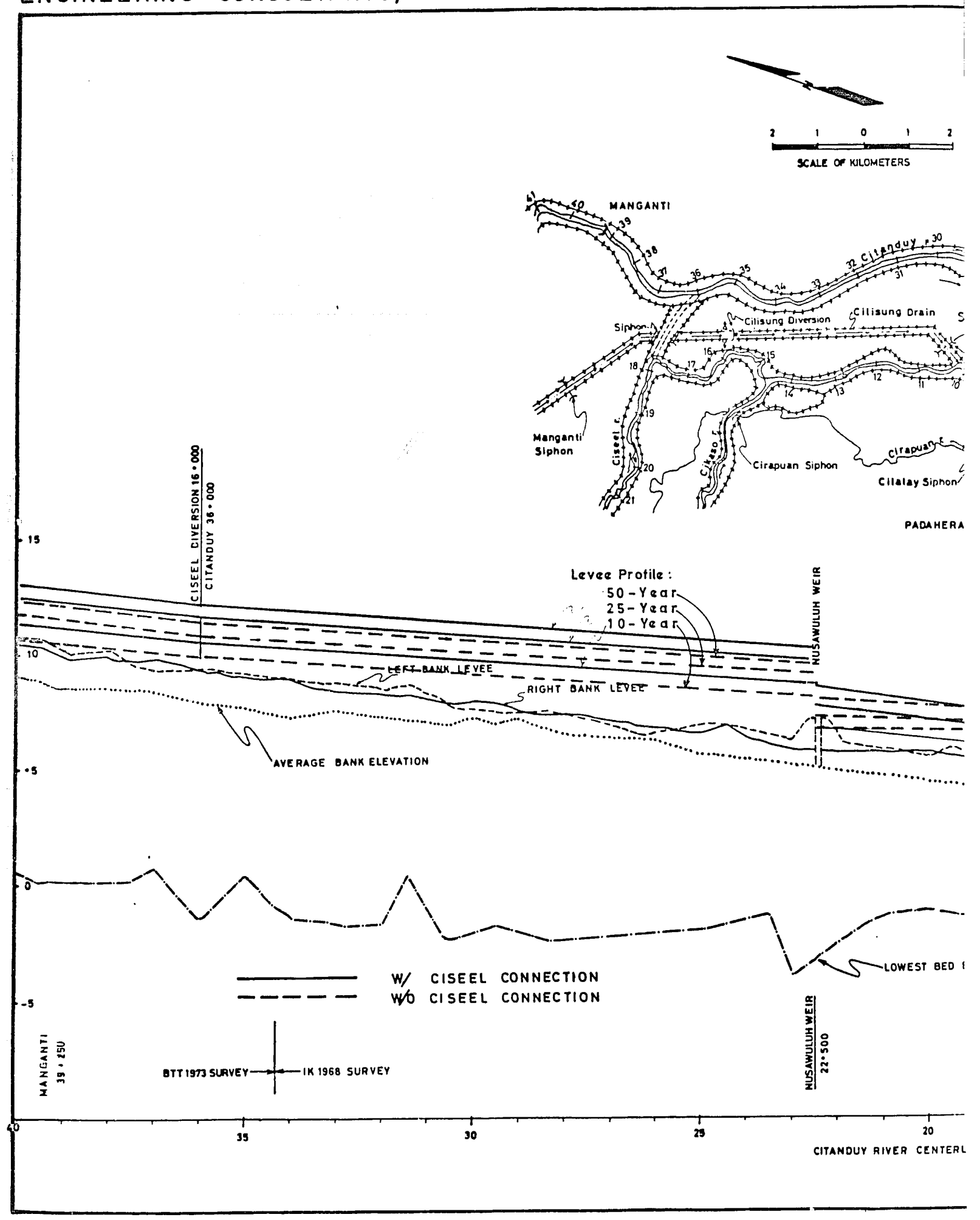
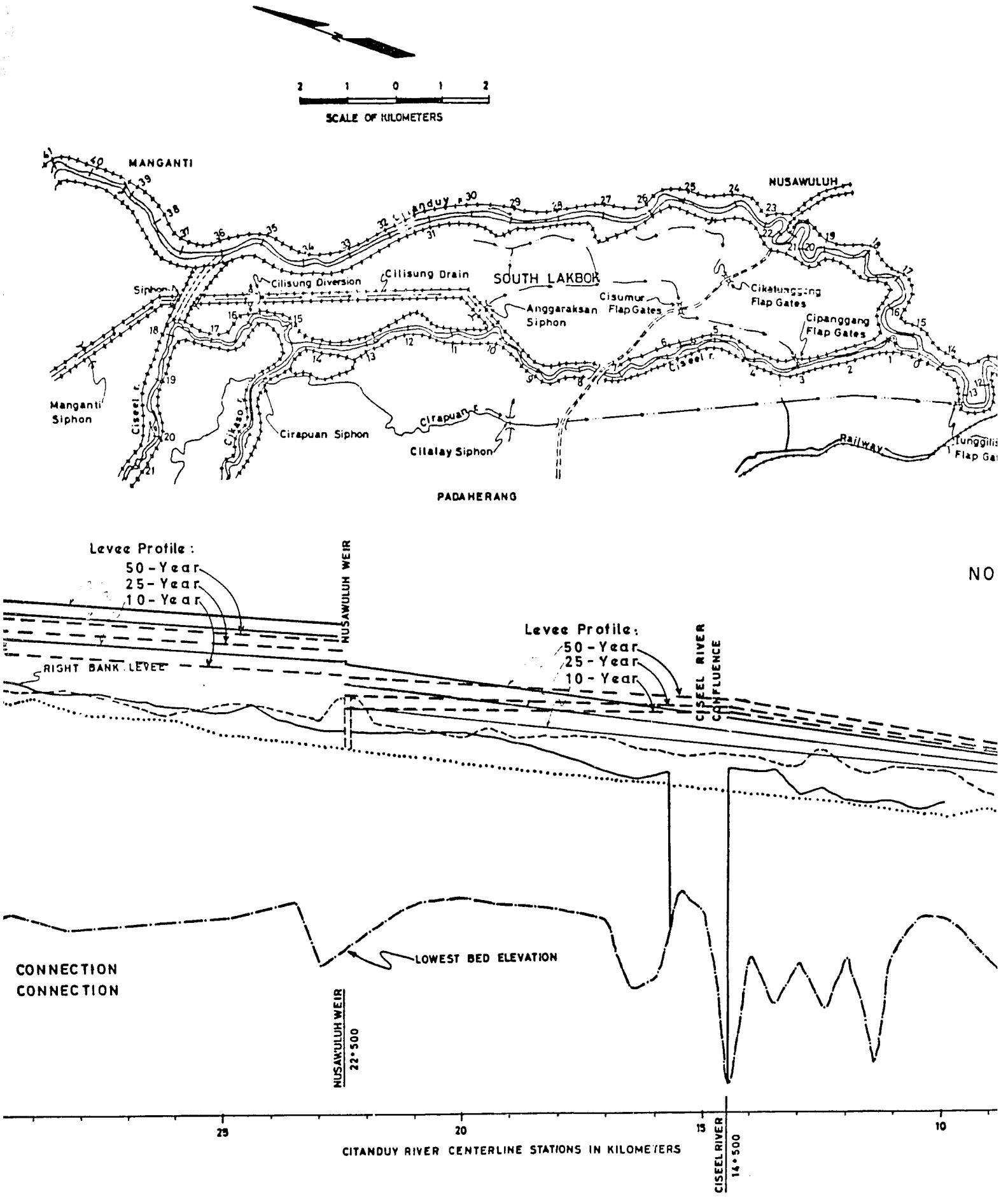
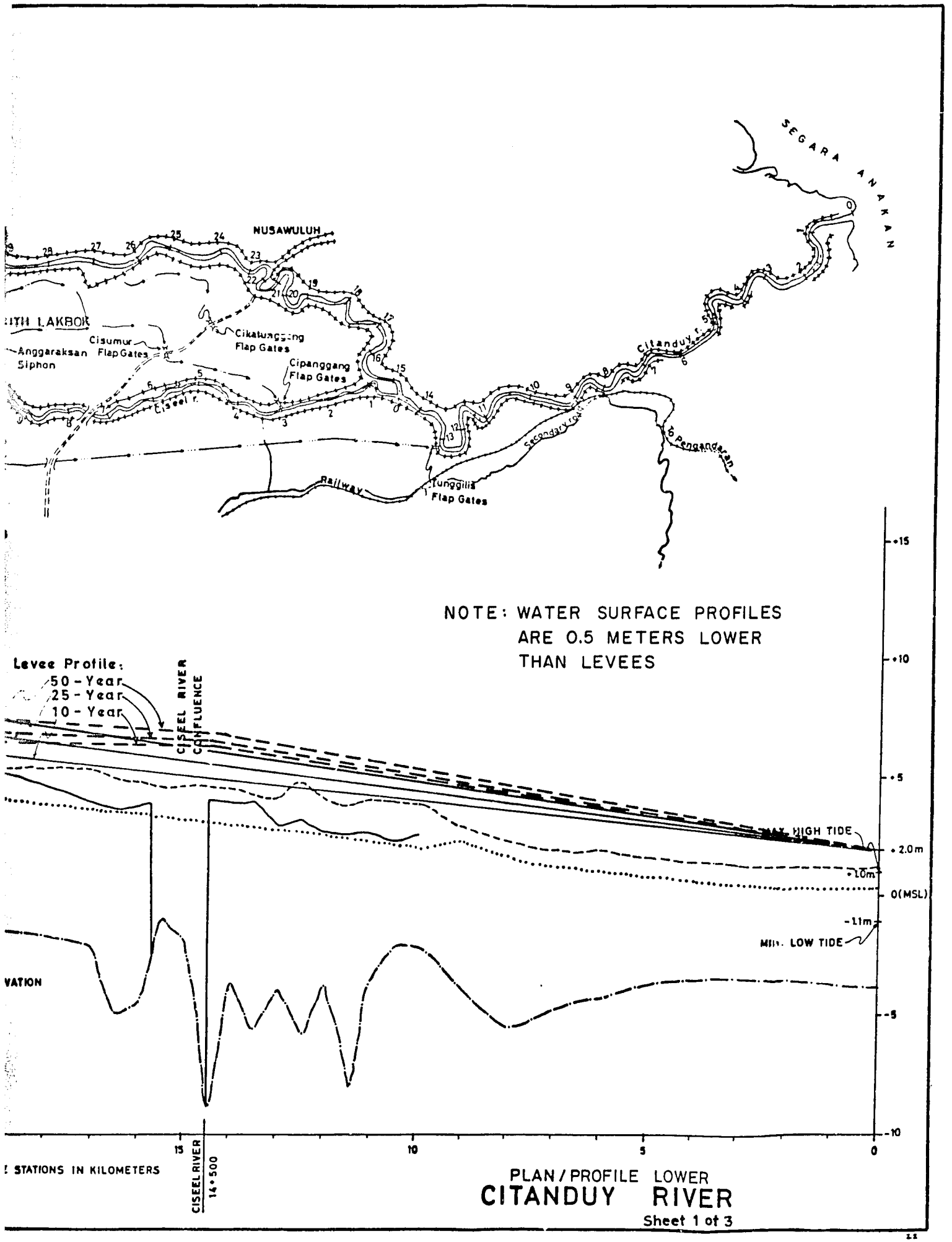
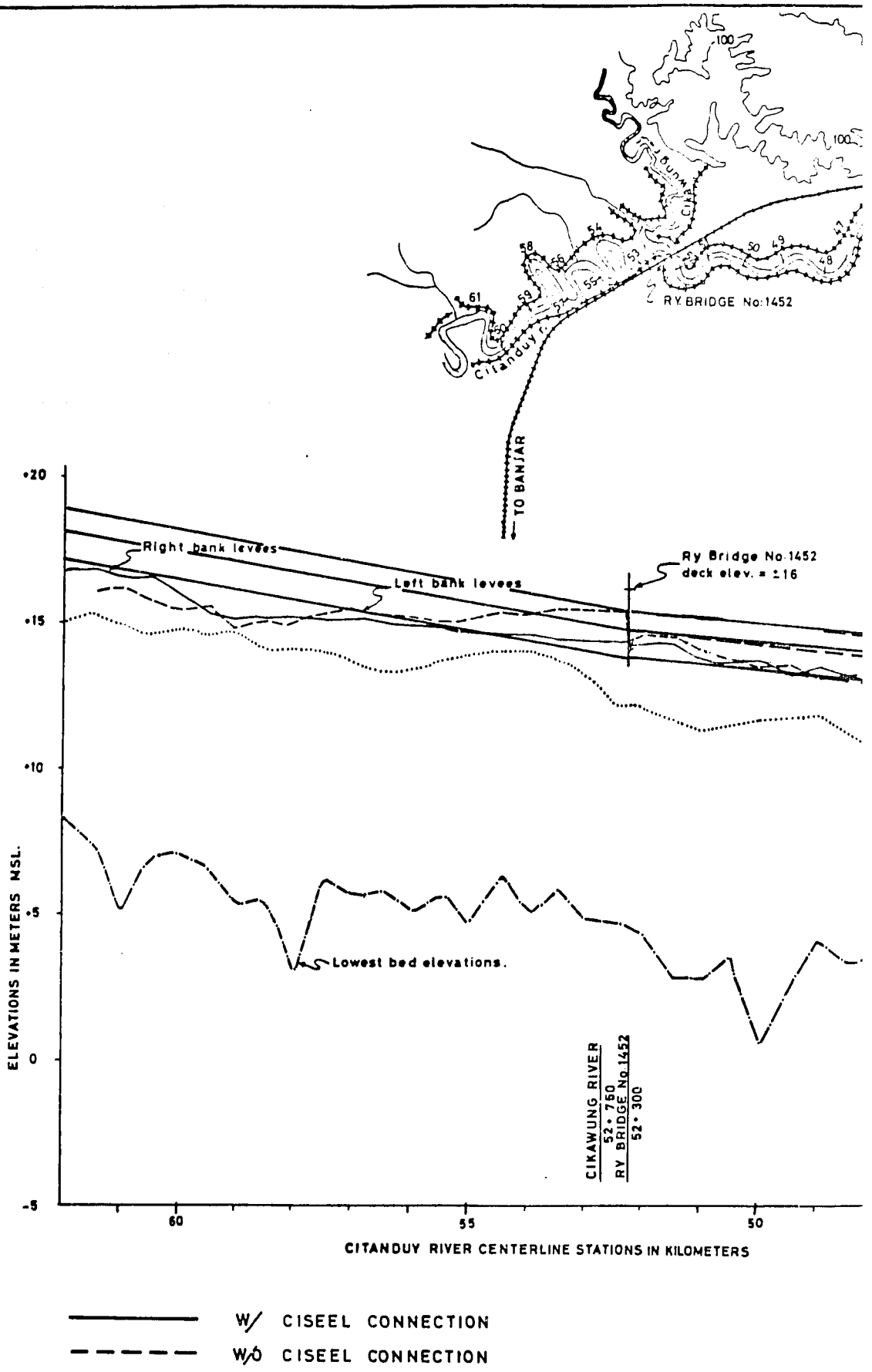
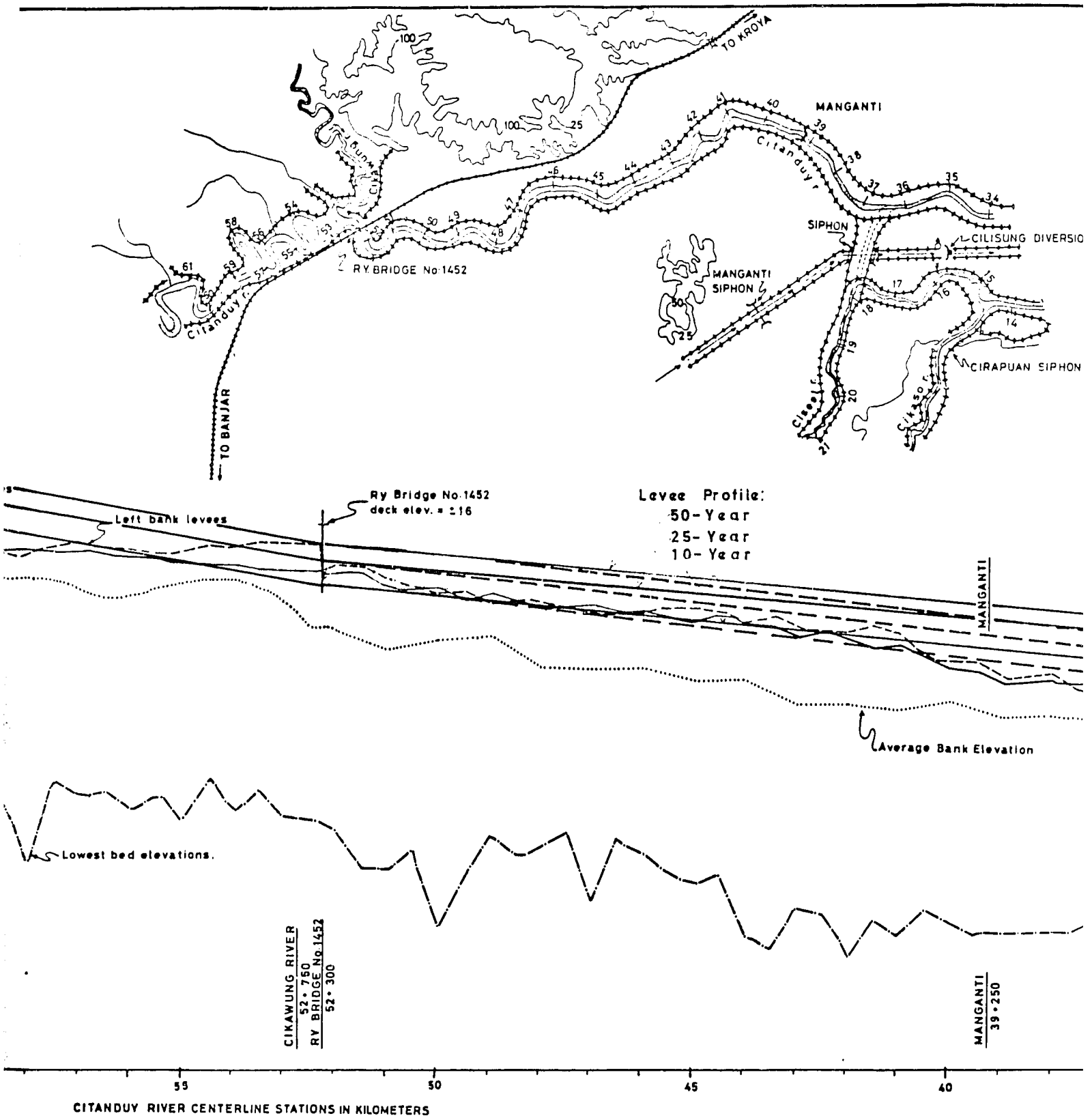



2 1 0 1 2
SCALE OF KILOMETERS
MANGANTI
NUSAWULUH
Citanduy R.
Cilisung Diversion
Cilisung Drain
SOUTH LAKBOK
Siphon
Cisumur Flap Gates
Cikatunggang Flap Gates
Anggaraksan Siphon
Cipanggang Flap Gates
Ciseel r.
Manganti Siphon
Cikaso r.
Cirapuan Siphon
Cirapuan r.
Citalay Siphon
Railway
Tunggilis Flap Gates
PADAHERANG
Levee Profile :
50 - Year
25 - Year
10 - Year
NUSAWULUH WEIR
RIGHT BANK LEVEE
Levee Profile :
50 - Year
25 - Year
10 - Year
CISEEL RIVER CONFLUENCE
NO
LOWEST BED ELEVATION
CONNECTION
CONNECTION
NUSAWULUH WEIR 22+500
CISEEL RIVER 14+500
25
20
15
10
CITANDUY RIVER CENTERLINE STATIONS IN KILOMETERS



PLAN / PROFILE LOWER
CITANDUY RIVER
Sheet 1 of 3


RY. BRIDGE No:1452
Citanduy R.
TO BANJAR
Right bank levees
Left bank levees
Ry Bridge No 1452
deck elev. = ±16
Lowest bed elevations.
CIKAWUNG RIVER
52 + 760
RY BRIDGE No.1452
52 + 300
ELEVATIONS IN METERS MSL.
+20
+15
+10
+5
0
-5
60
55
50
CITANDUY RIVER CENTERLINE STATIONS IN KILOMETERS
W/ CISEEL CONNECTION
W/O CISEEL CONNECTION

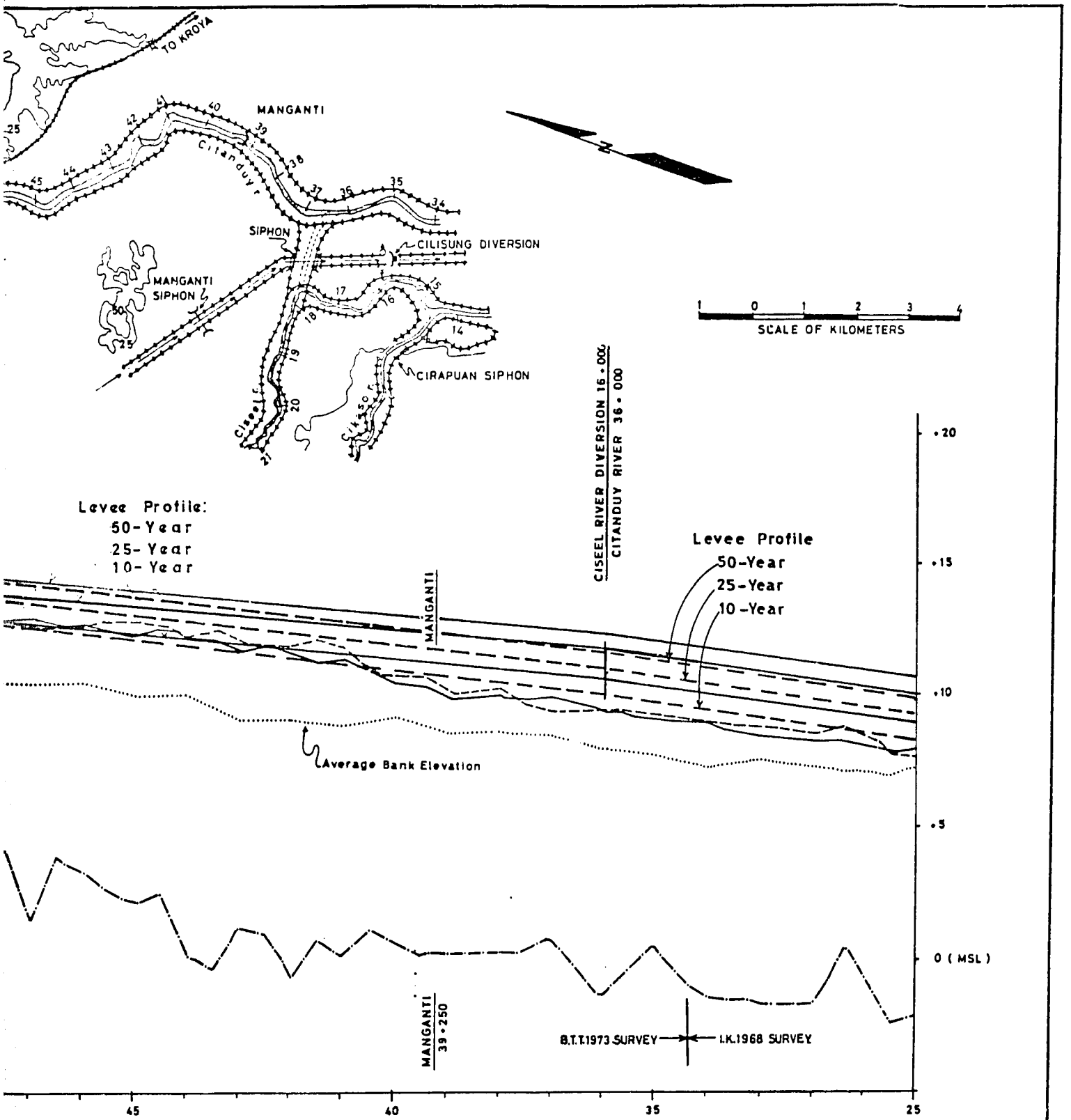


CISEEL CONNECTION

CISEEL CONNECTION

NOTE: WATER SURFACE PROFIL
ARE 0.5 METERS LOWE
THAN LEVEES

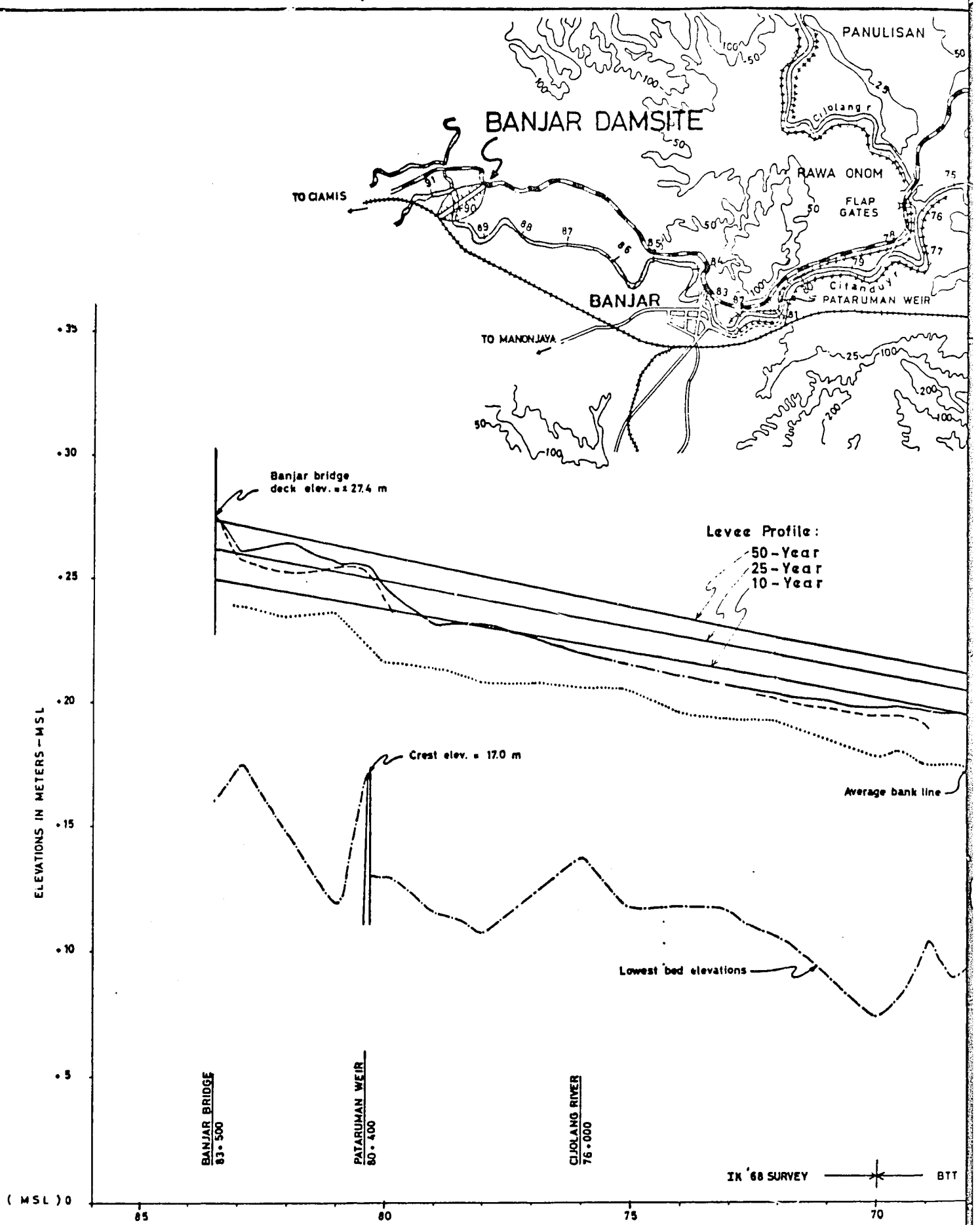
PLATE IV-5

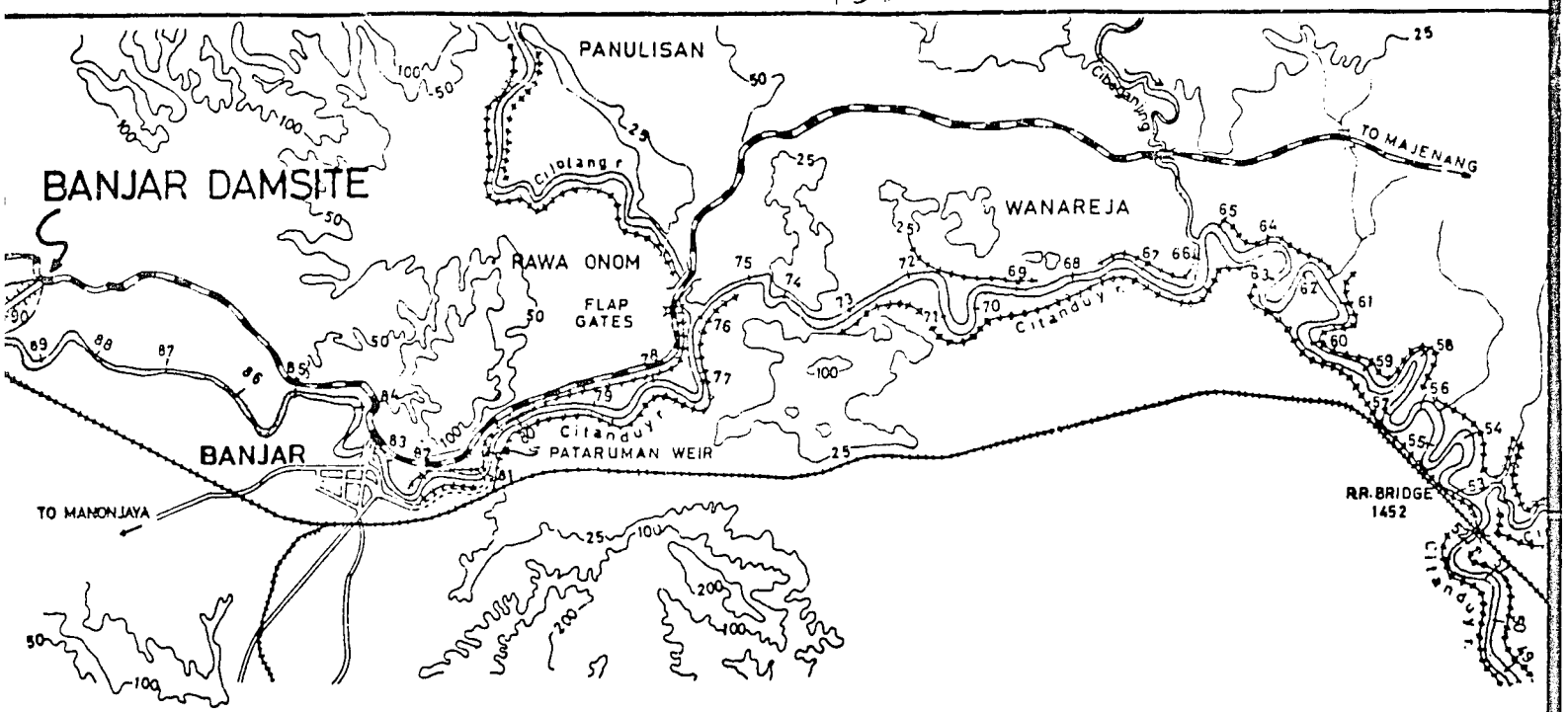


NOTE: WATER SURFACE PROFILES ARE 0.5 METERS LOWER THAN LEVEES

PLAN / PROFILE LOWER
CITANDUY RIVER
Sheet 2 of 3

DSR.


BANJAR DAMSITE
PANULISAN
Cijolang r
RAWA ONOM
FLAP GATES
TO CIAMIS
BANJAR
Citanduy
PATARUMAN WEIR
TO MANONJAYA
Banjar bridge deck elev. = ± 27.4 m
Levee Profile:
50-Year
25-Year
10-Year
Crest elev. = 17.0 m
Average bank line
Lowest bed elevations
ELEVATIONS IN METERS - MSL
(MSL) 0
BANJAR BRIDGE 83+500
PATARUMAN WEIR 80+400
CIJOLANG RIVER 76+000
IK '68 SURVEY
BTT
85
80
75
70
CITANDUY RIVER CENTERLINE STATIONS IN



NOTE: WATER SUR
ARE 0.5 ME
THAN LEVE

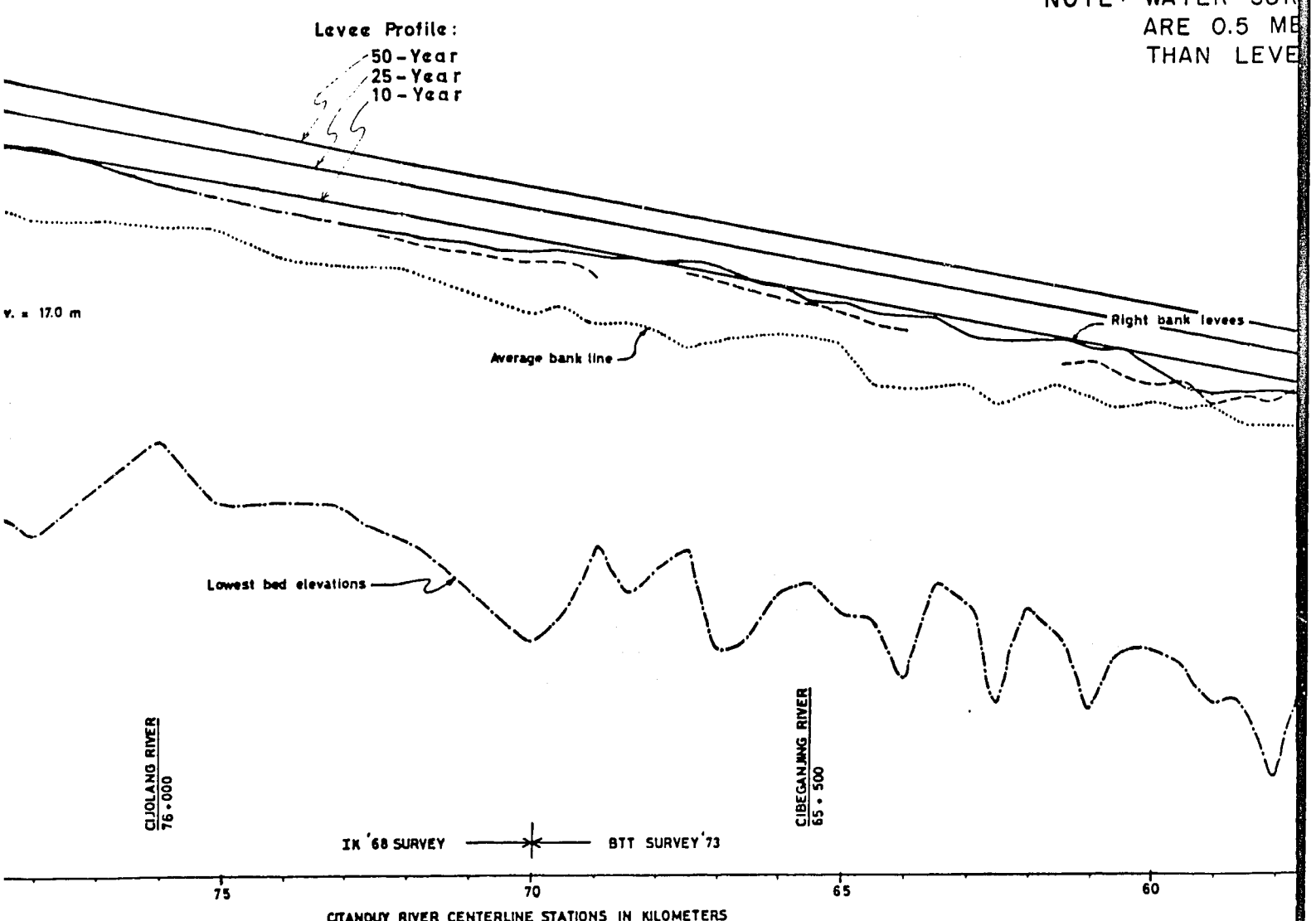
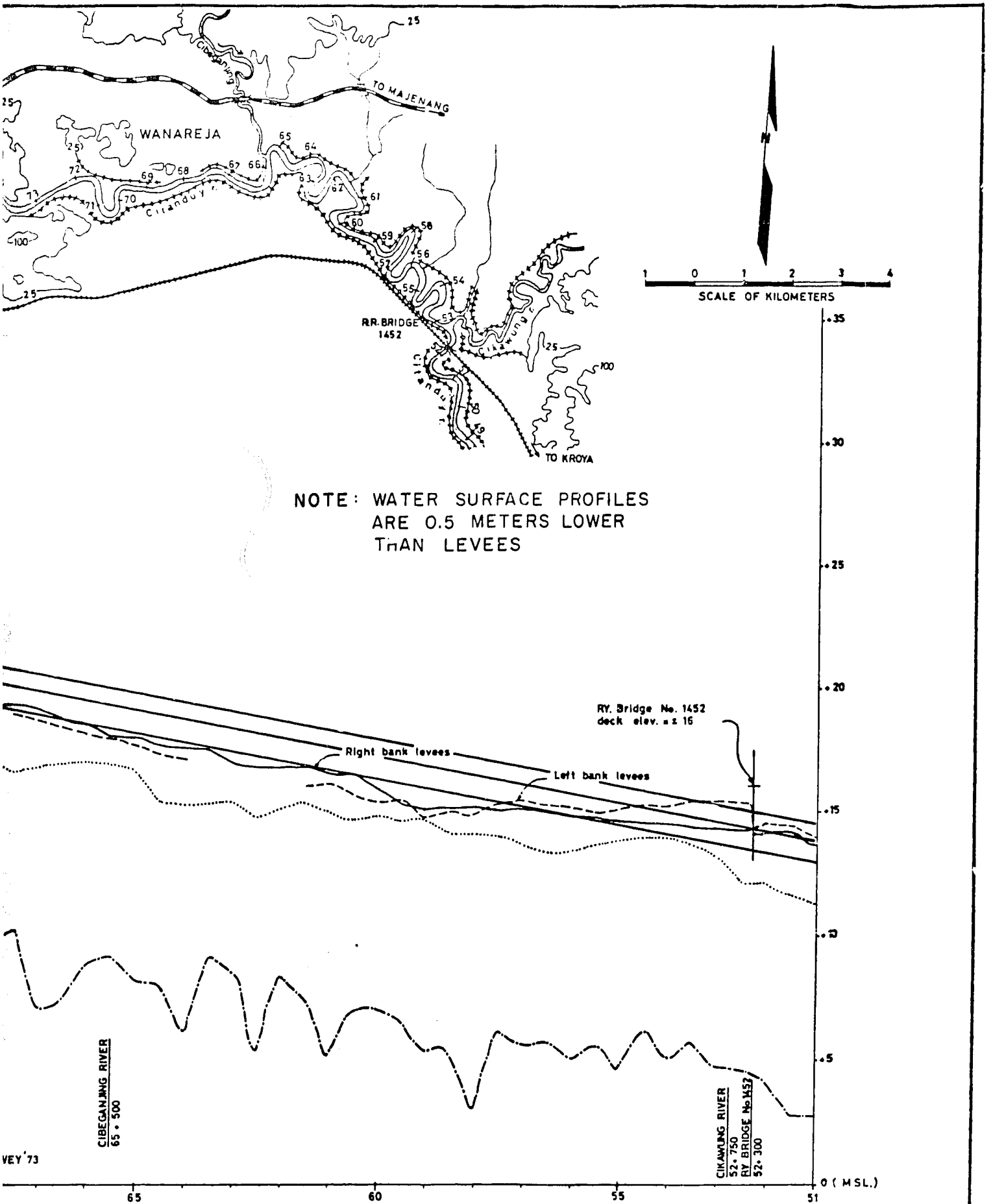
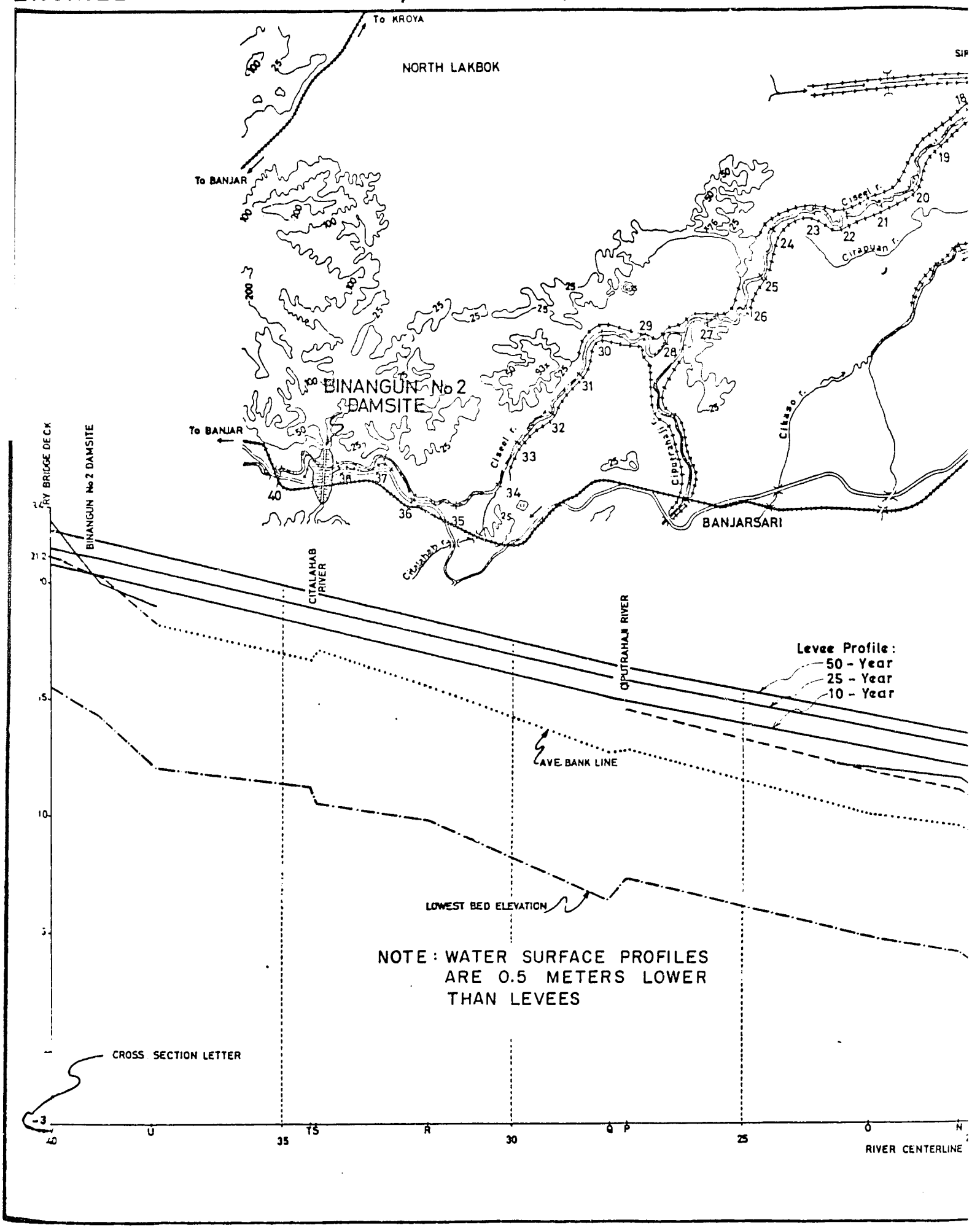
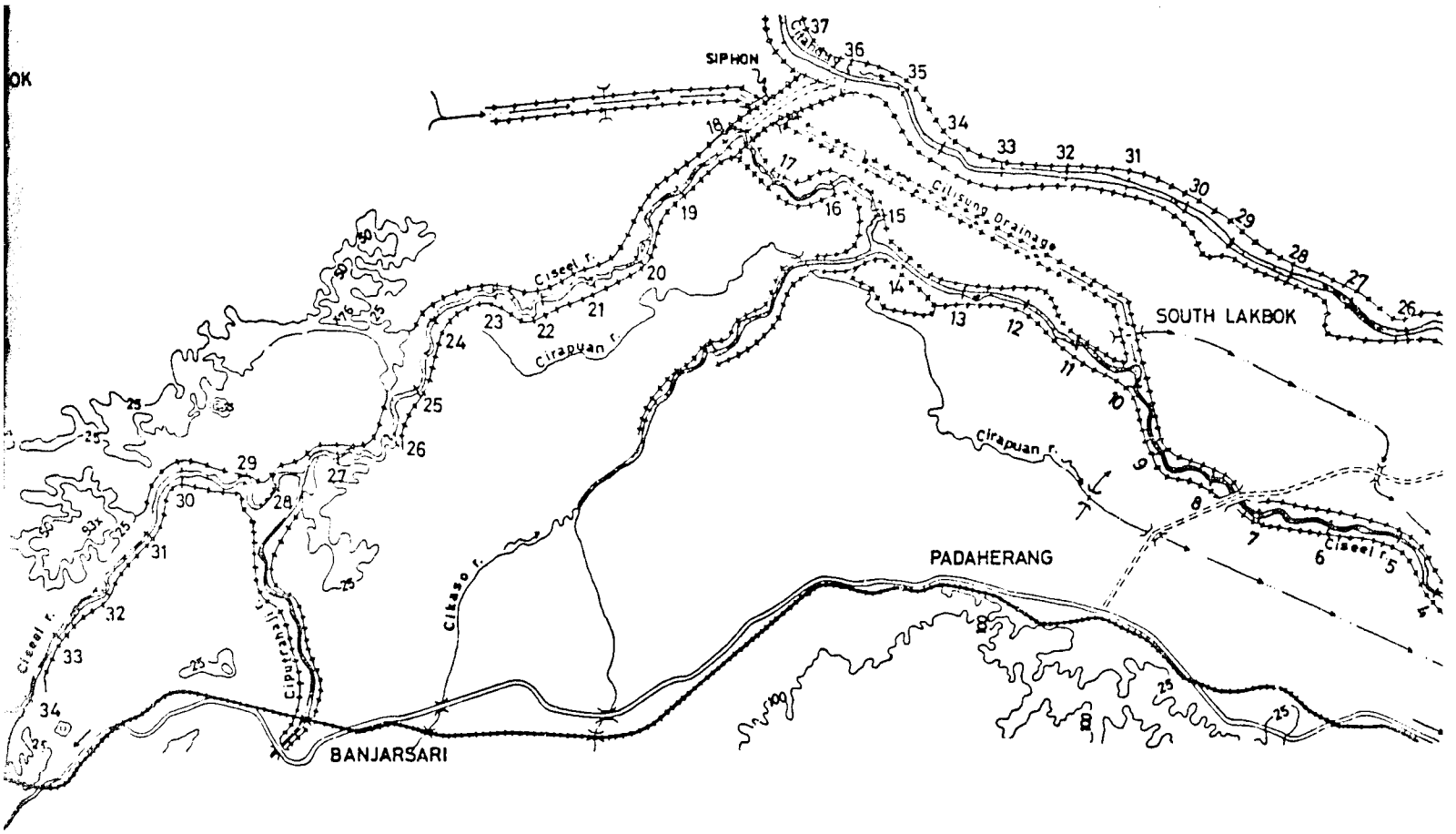


PLATE IV-5



PLAN / PROFILE LOWER
CITANDUY RIVER
Sheet 3 of 3


To KROYA
NORTH LAKBOK
To BANJAR
BINANGUN No 2 DAMSITE
To BANJAR
Ciseel r.
Cirapuan r.
Citasso r.
Cipuraqueli
Citalahab r.
BANJARSARI
BINANGUN No 2 DAMSITE
CITALAHAB RIVER
CIPUTRAHAB RIVER
Levee Profile:
50 - Year
25 - Year
10 - Year
AVE. BANK LINE
LOWEST BED ELEVATION
NOTE: WATER SURFACE PROFILES ARE 0.5 METERS LOWER THAN LEVEES
CROSS SECTION LETTER
RIVER CENTERLINE


SIPHON
Cilisung Drainage
Ciseel r.
Cirapuan r.
SOUTH LAKBOK
PADAHERANG
Cikaso r.
Ciputrahaji r.
BANJARSARI

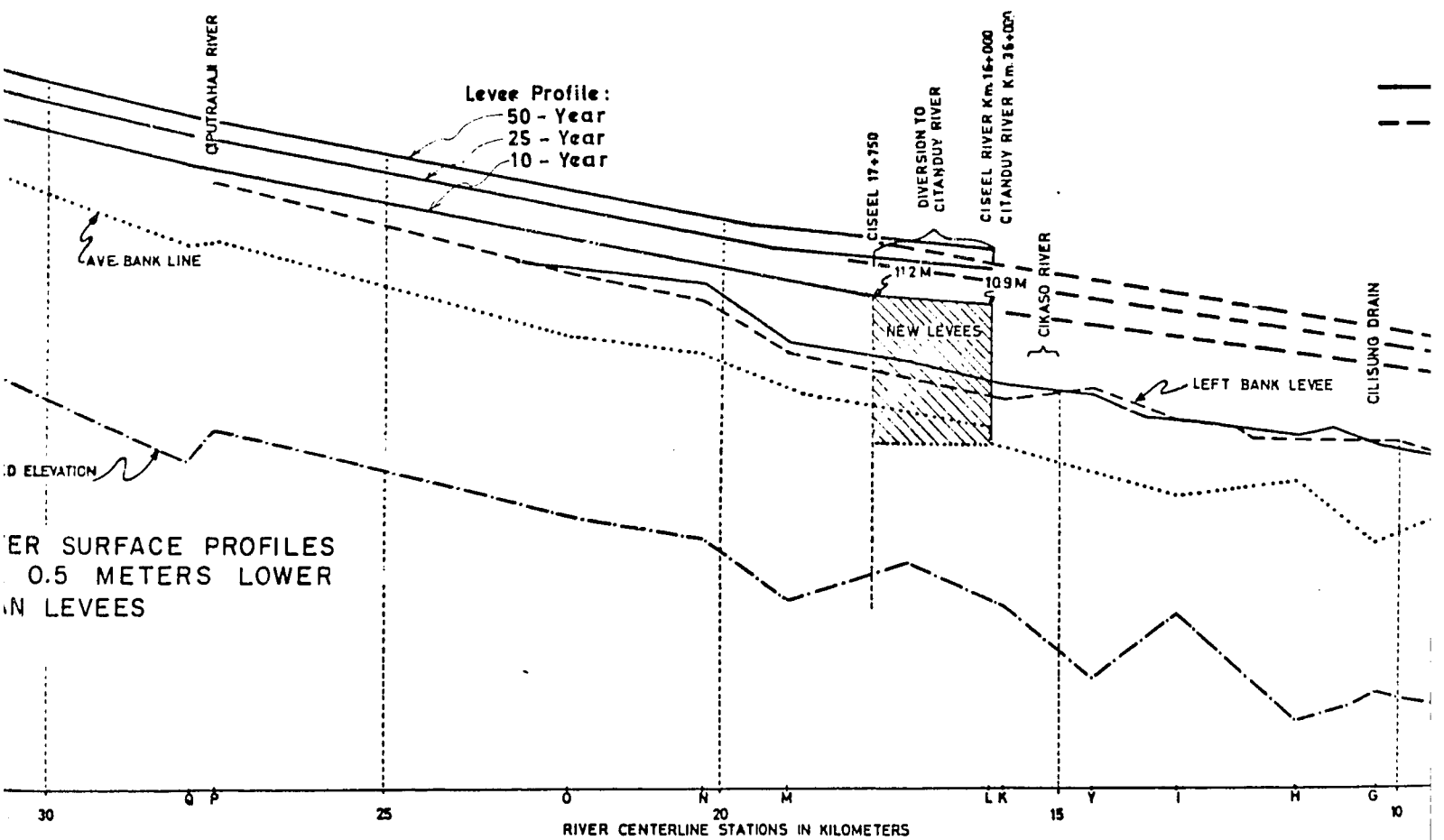
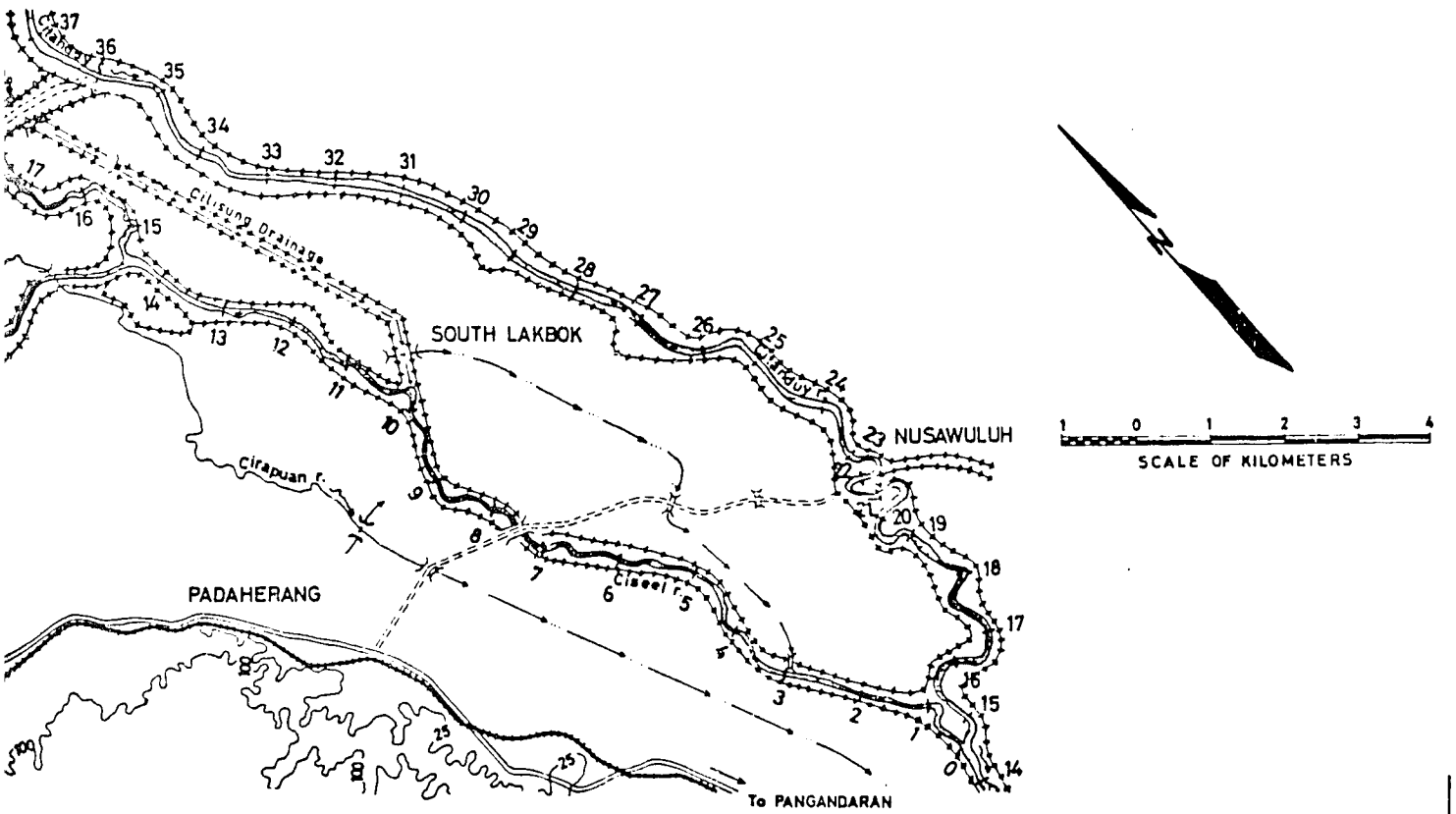
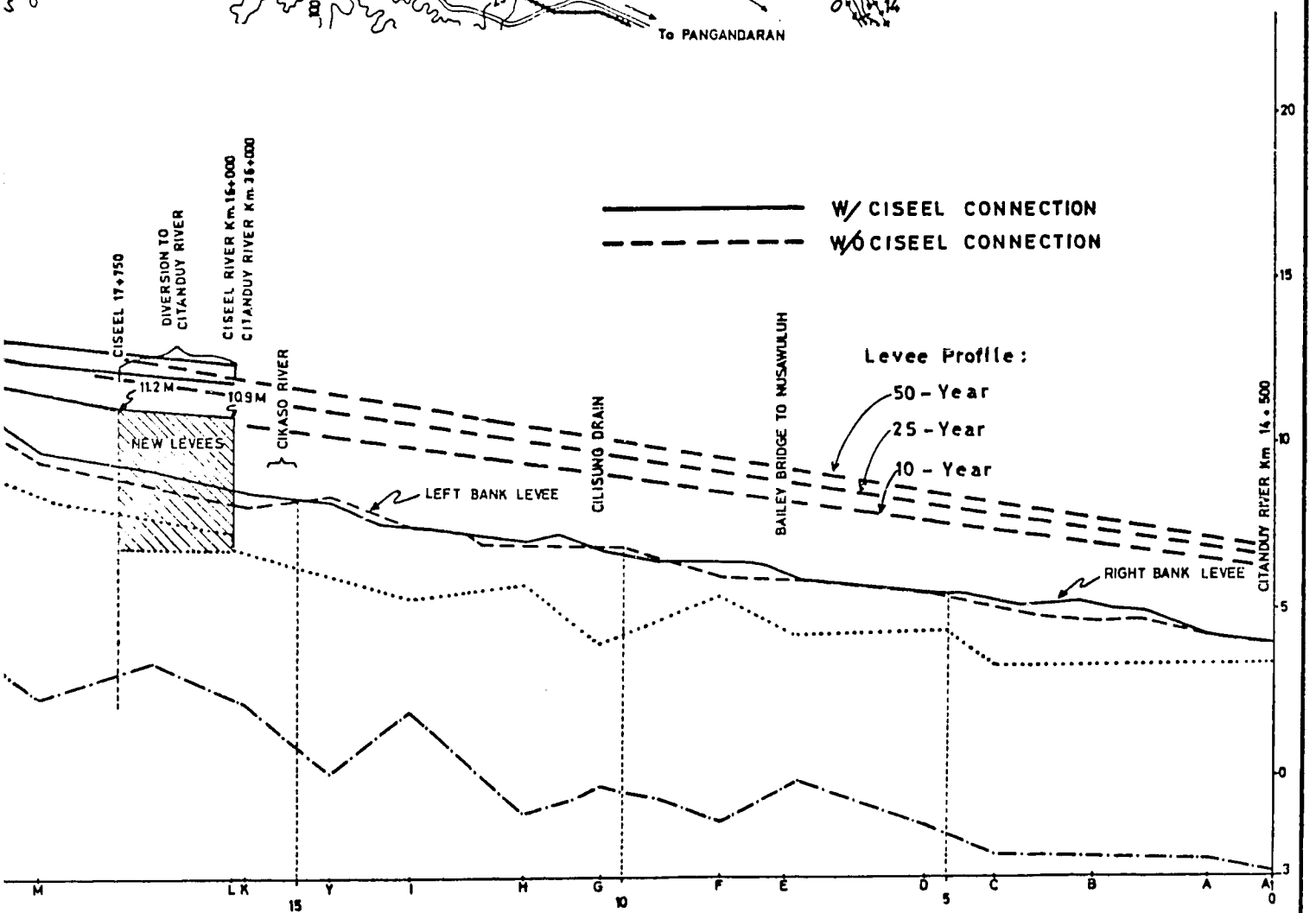

CIPUTRAHAJI RIVER
Levee Profile:
50 - Year
25 - Year
10 - Year
AVE. BANK LINE
CISEEL 17+750
DIVERSION TO CITANDUY RIVER
CISEEL RIVER Km.16+000
CITANDUY RIVER Km.36+000
11.2 M
10.9 M
NEW LEVEES
CIKASO RIVER
LEFT BANK LEVEE
CILISUNG DRAIN
D ELEVATION
ER SURFACE PROFILES
0.5 METERS LOWER
N LEVEES
30
Q P
25
O
N
20
M
L K
15
Y
I
H
G
10
RIVER CENTERLINE STATIONS IN KILOMETERS

PLATE IV-5A





PLAN/PROFILE OF LOWER
CISEEL RIVER

TYPICAL LEVEE SECTION

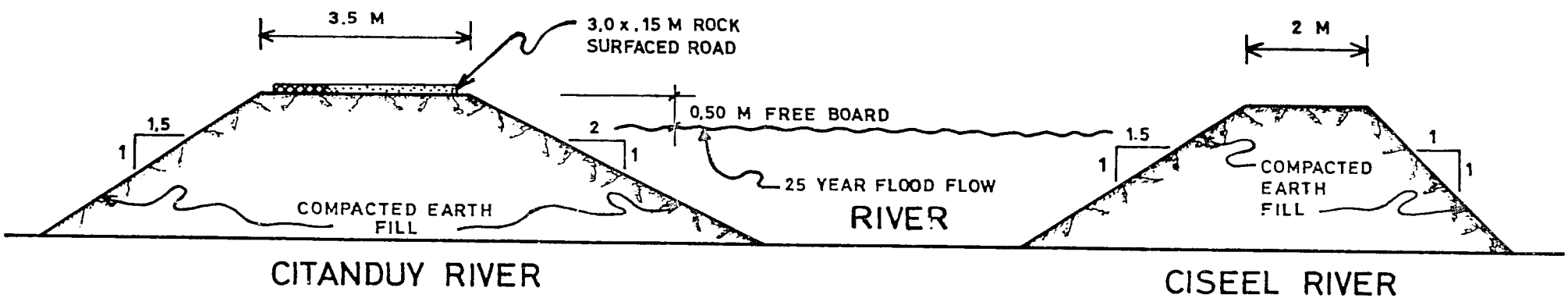


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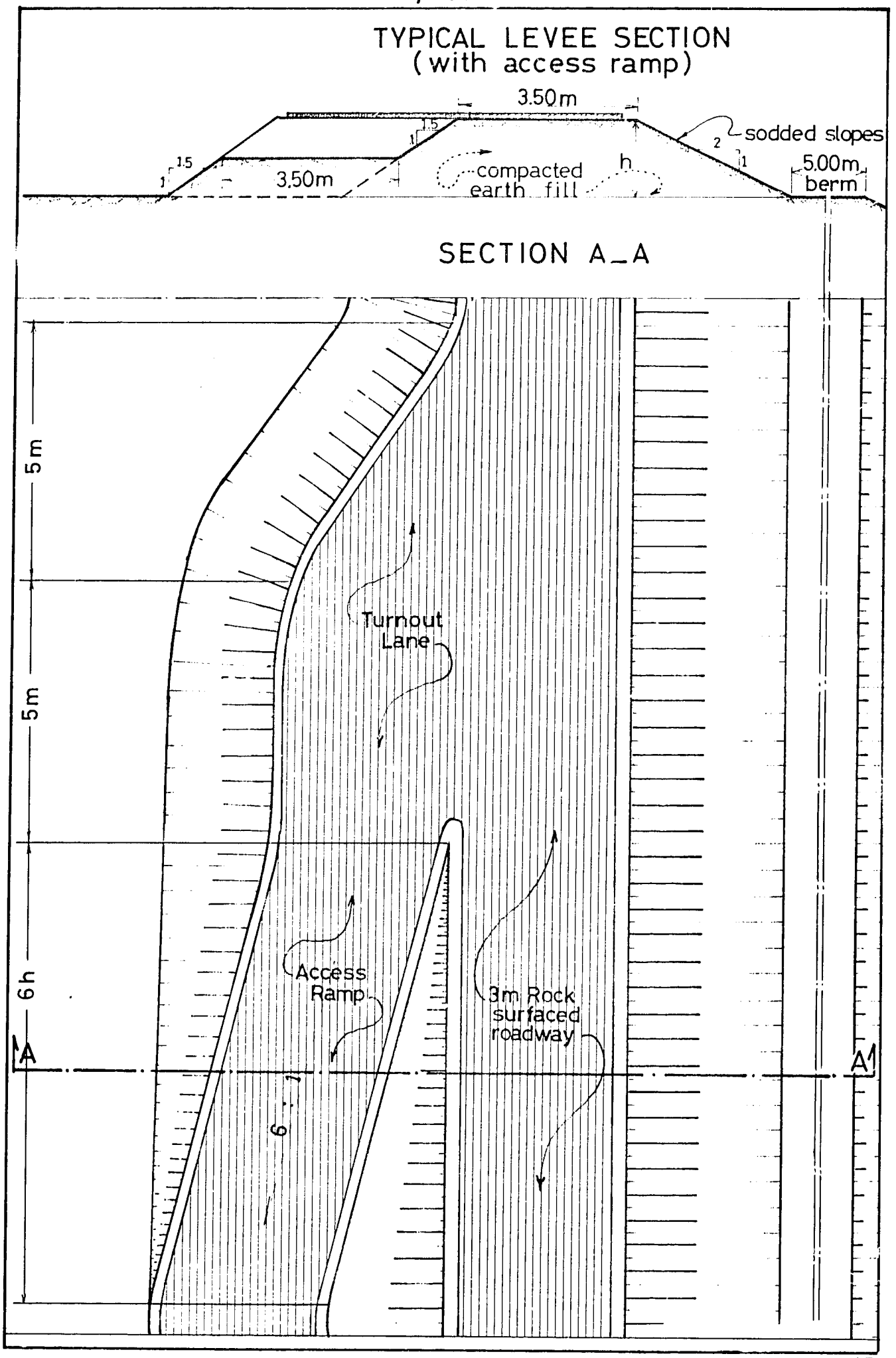
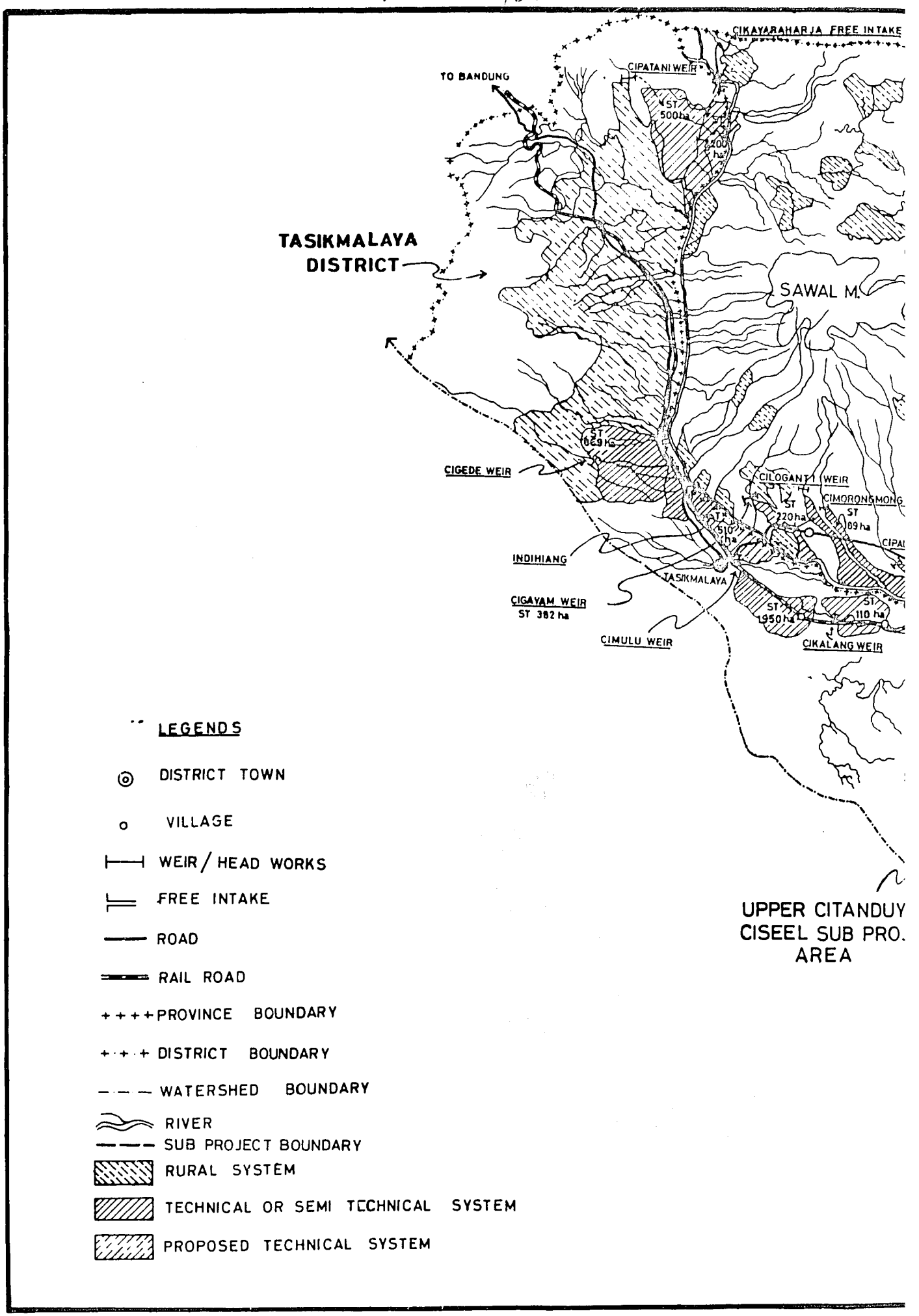
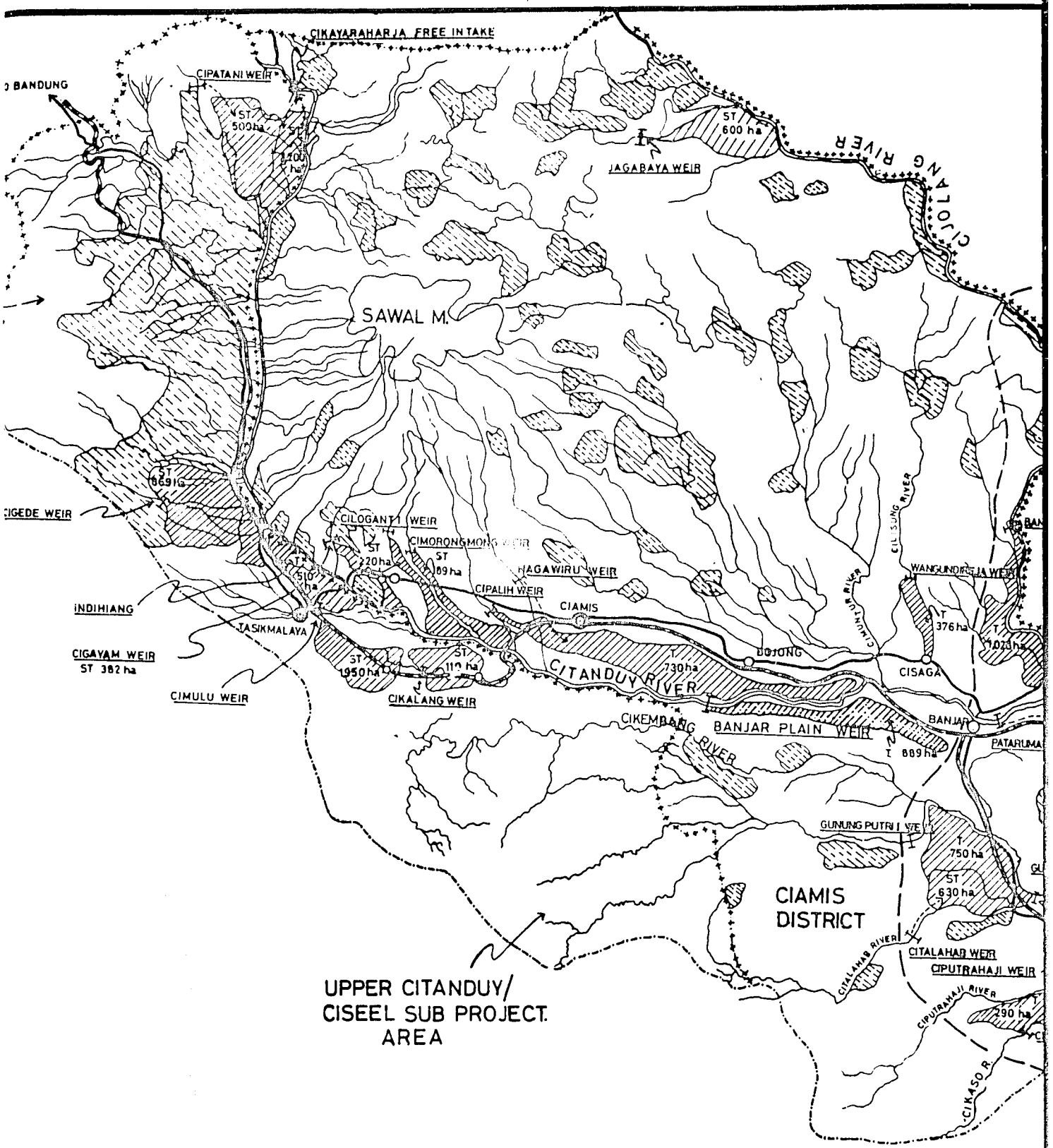
PLATE IV-6

MH

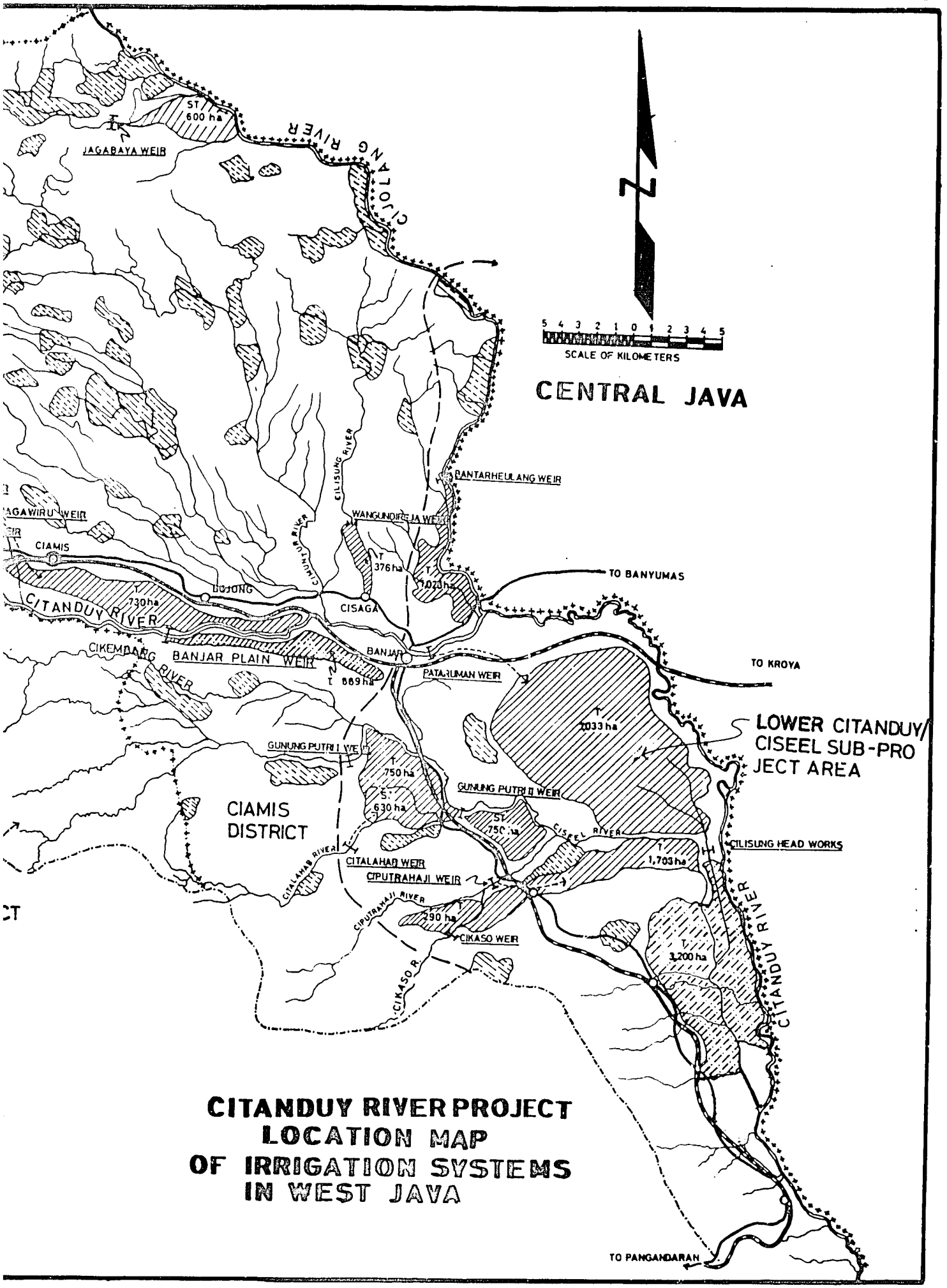

TYPICAL LEVEE SECTION
(with access ramp)
3.50m
1.5
1
1.5
1
3.50m
compacted
earth fill
h
2
1
sodded slopes
5.00m
berm
SECTION A_A
5m
5m
6h
Turnout
Lane
Access
Ramp
3m Rock
surfaced
roadway
A
A'
6
1


CIKAYARAHARJA FREE INTAKE
TO BANDUNG
CIPATANI WEIR
ST 500ha
200 ha
TASIKMALAYA DISTRICT
SAWAL M.
ST 629 ha
CIGEDE WEIR
CILOGANTI WEIR
CIMORONGMONG
ST 220ha
ST 89 ha
510 ha
INDIHIANG
TASIKMALAYA
CIGAYAM WEIR
ST 382 ha
CIMULU WEIR
ST 950 ha
ST 110 ha
CIKALANG WEIR
UPPER CITANDUY
CISEEL SUB PRO.
AREA
LEGENDS
DISTRICT TOWN
VILLAGE
WEIR / HEAD WORKS
FREE INTAKE
ROAD
RAIL ROAD
PROVINCE BOUNDARY
DISTRICT BOUNDARY
WATERSHED BOUNDARY
RIVER
SUB PROJECT BOUNDARY
RURAL SYSTEM
TECHNICAL OR SEMI TECHNICAL SYSTEM
PROPOSED TECHNICAL SYSTEM



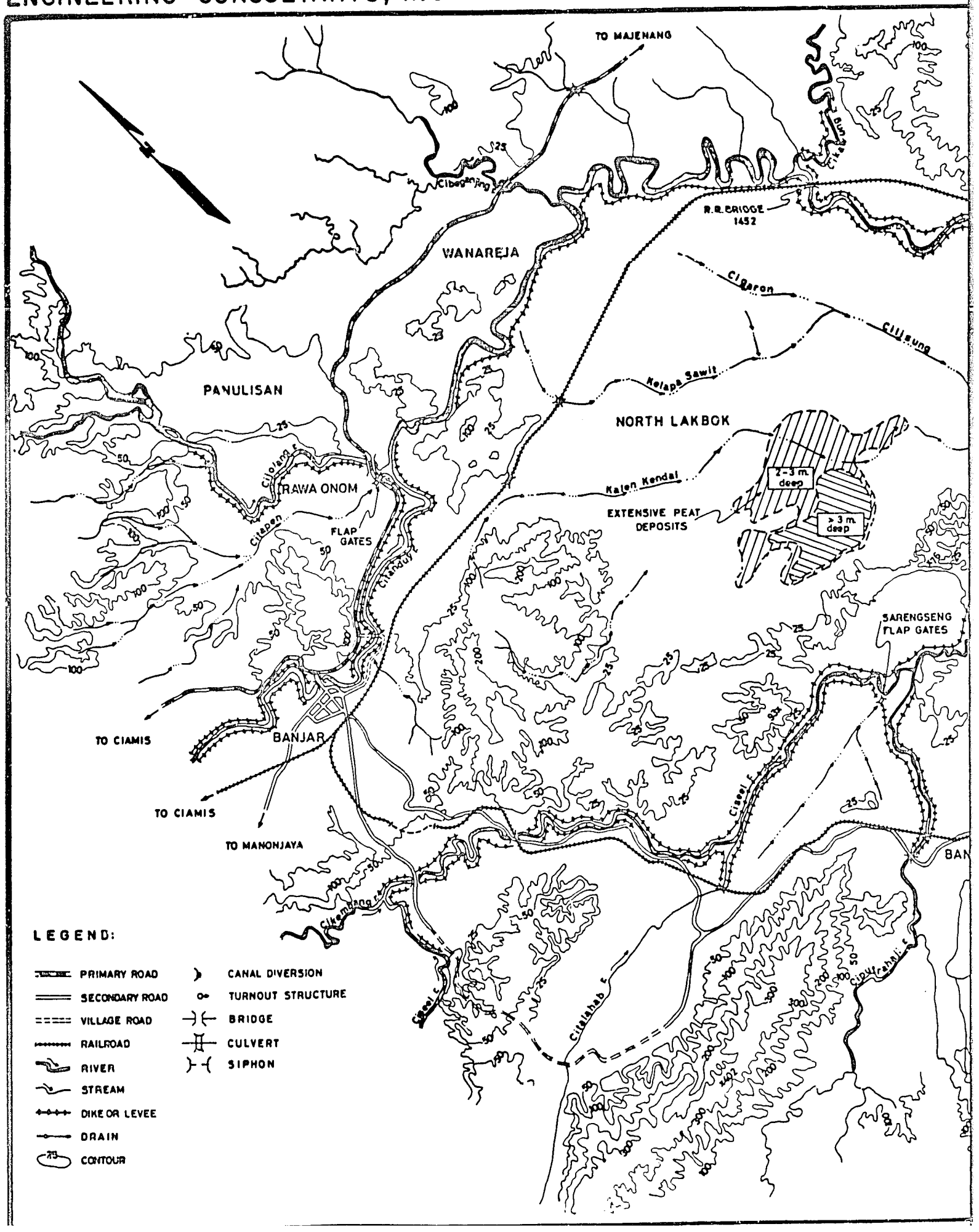
CITANDUY RIVER P
LOCATION MA
OF IRRIGATION SY
IN WEST JAVA

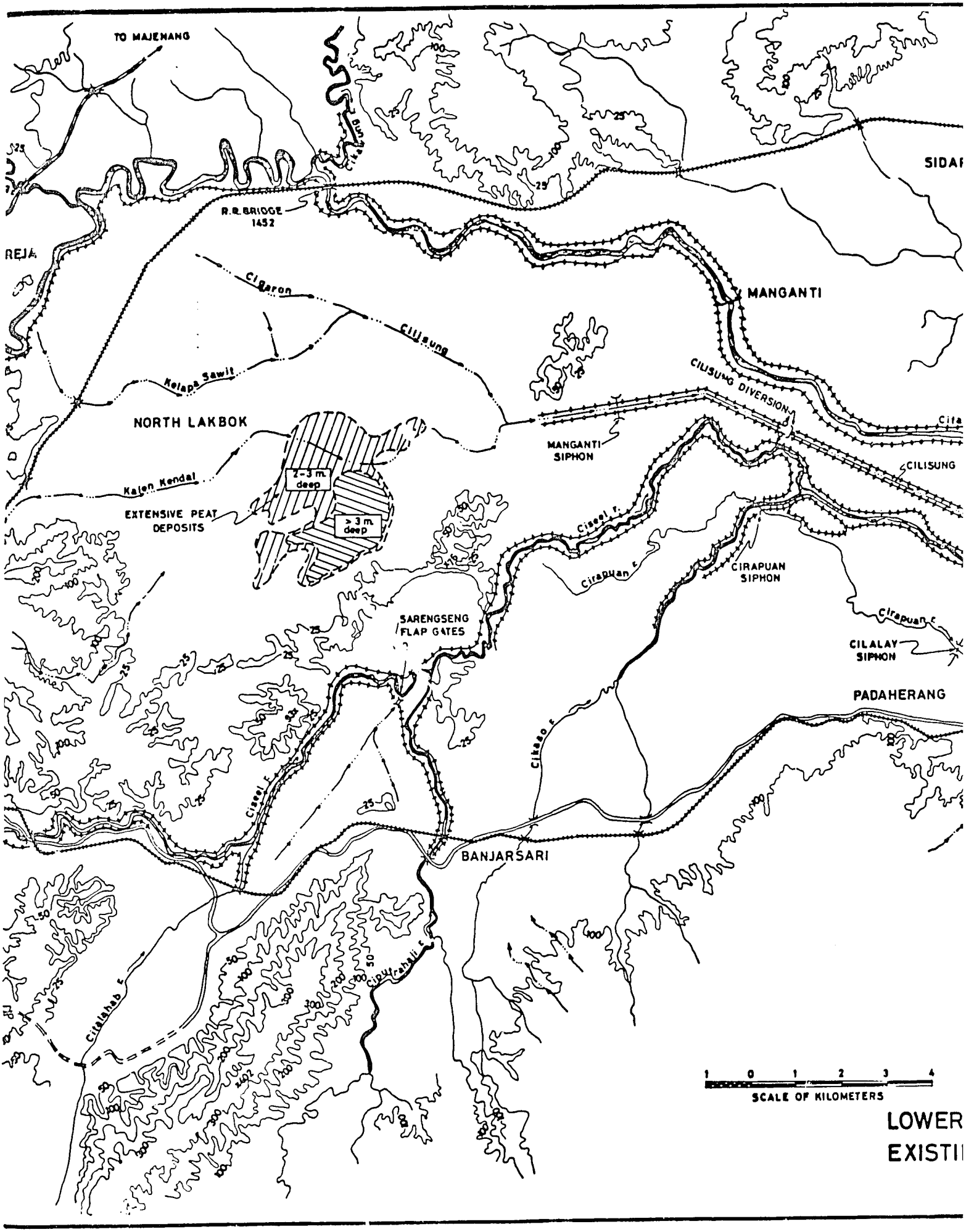
SYSTEM



CITANDUY RIVER PROJECT
LOCATION MAP
OF IRRIGATION SYSTEMS
IN WEST JAVA

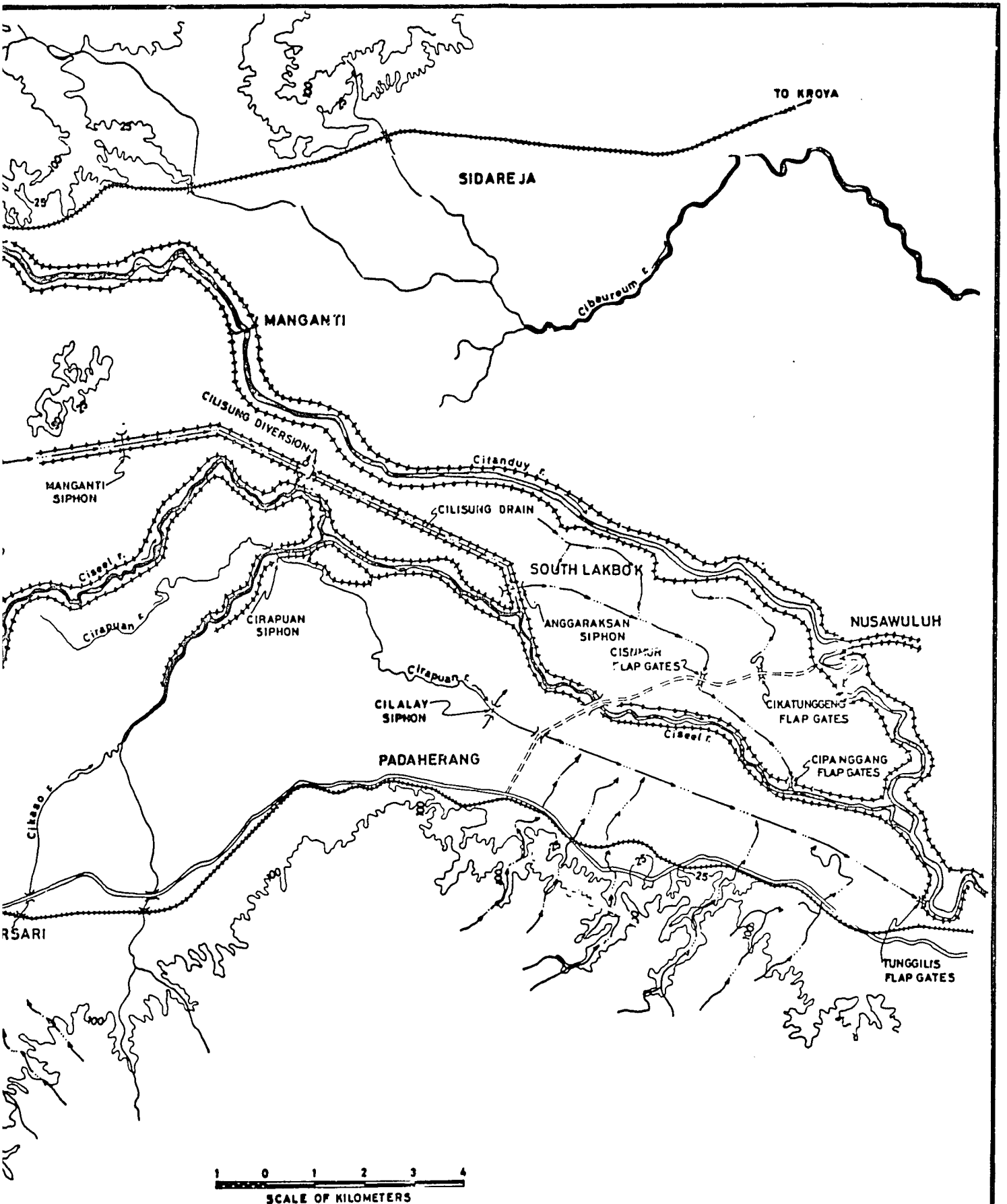
ENGINEERING CONSULTANTS, INC.



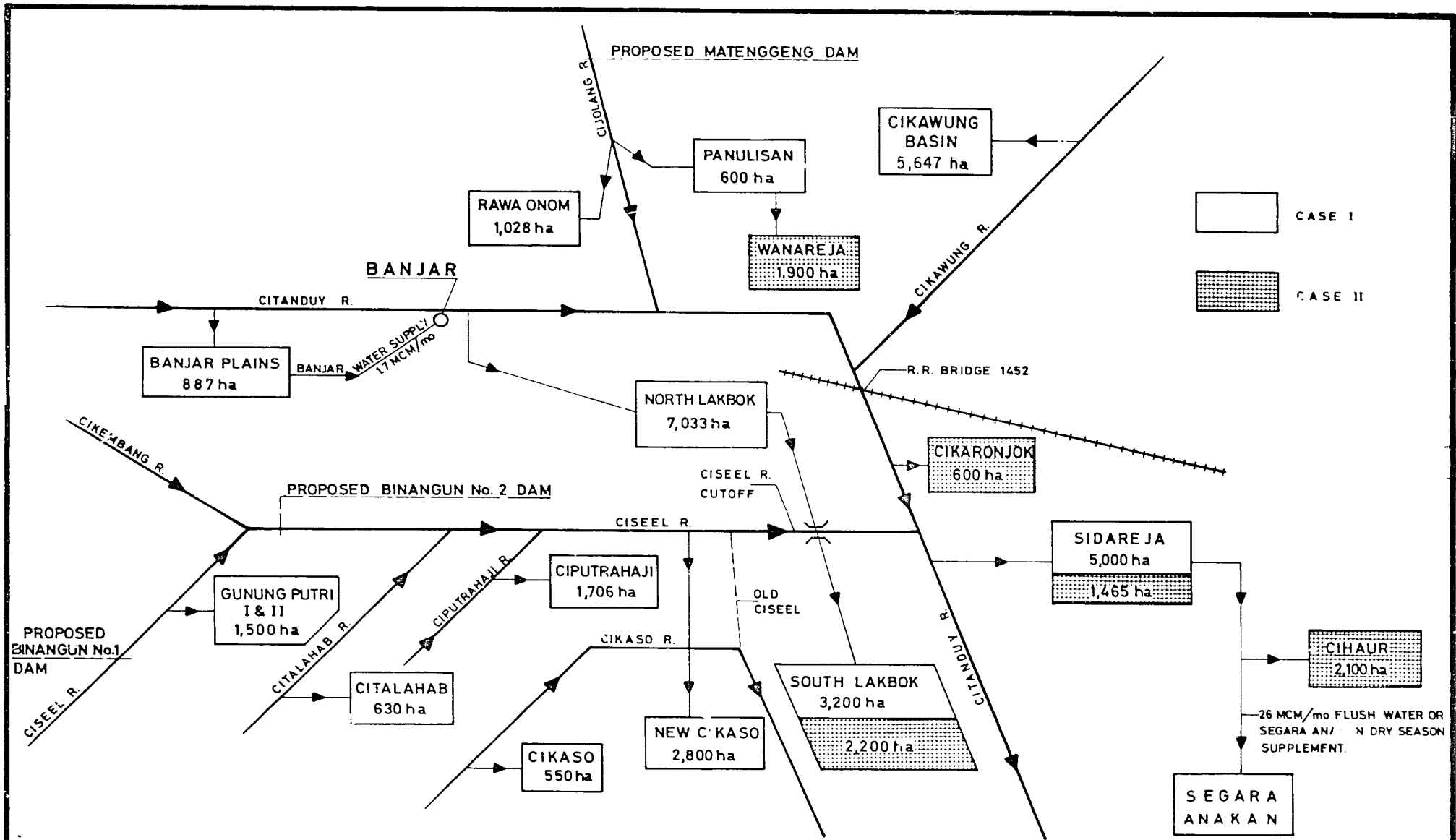


LOWER
EXISTI

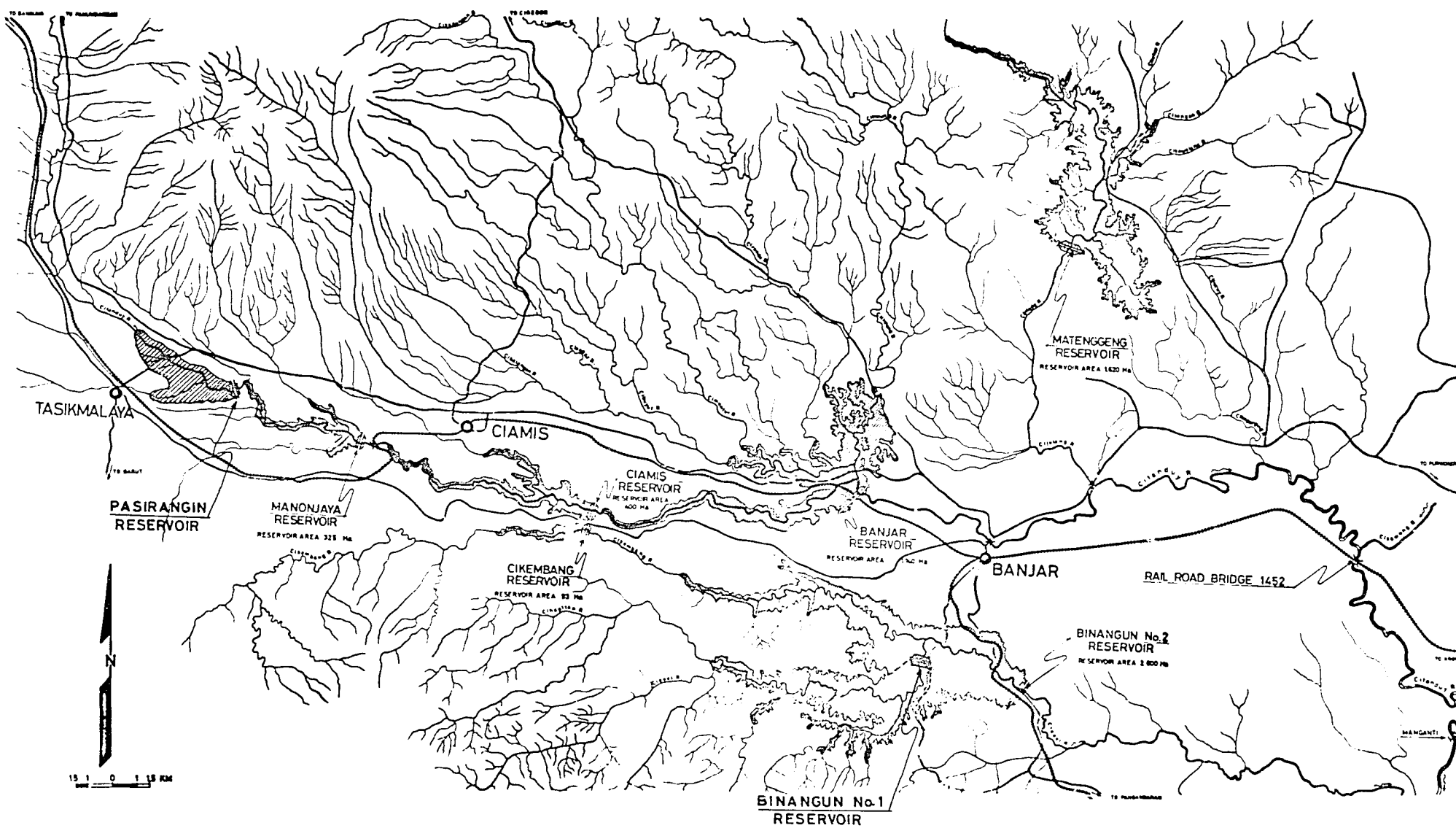
PLATE IV-9



LOWER CITANDUY/CISEEL RIVER SYSTEM
EXISTING MAJOR RIVER AND DRAINAGE SYSTEMS



SCHEMATIC DIAGRAM
CITANDUY/CISEEL RIVER IRRIGATION SYSTEM

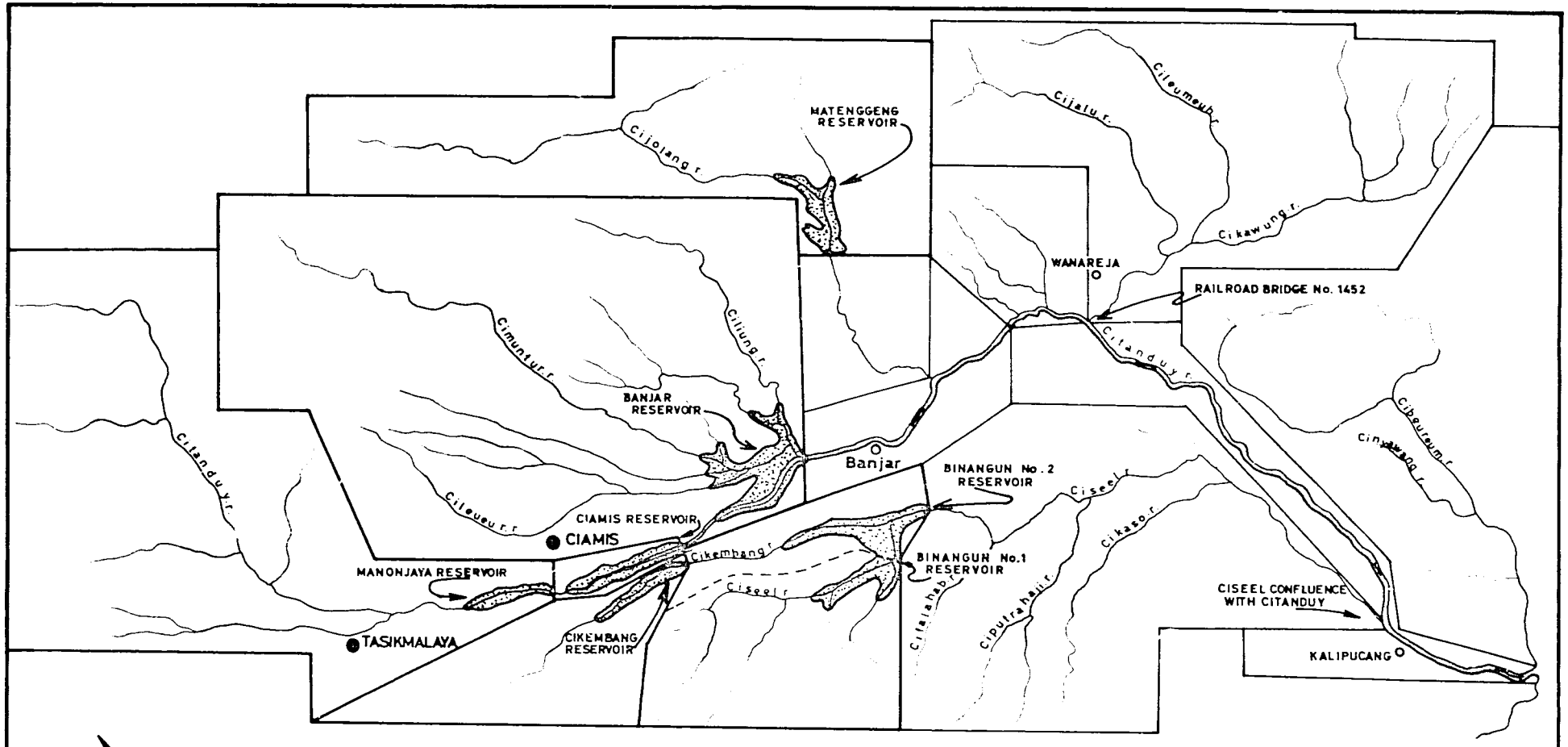


LOCATION OF PROPOSED DAMSITES

ENGINEERING CONSULTANTS, INC.

PLATE IV-II

MH



WATERSHED	RESERVOIR SITE	DRAINAGE AREA	% OF FLOOD PRODUCING AREA *
CITANDUY			
"	MATENGGENG	400	16
"	BANJAR	1,300	52
"	CIAMIS	650	26
"	MANONJAYA	600	24
CISEEL			
	BINANGUN No. 1	190	38
"	BINANGUN No. 2	340	69
"	CIKEMBANG	94	19

* THE FLOOD PRODUCING AREA OF THE CITANDUY RIVER IS 2500 km² MEASURED AT RAILROAD BRIDGE No. 1452.
THE CISEEL FLOOD PRODUCING AREA IS 500 km².

REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS & ELECTRIC POWER
DIRECT GENERAL OF WATER RESOURCES DEVELOPMENT
DIRECTORATE OF RIVERS & SWAMPS
CITANDUY PROJECT

ENGINEERING CONSULTANTS, INC
DENVER - BANJAR
U S A - INDONESIA

WATERSHED COMPARISONS FOR PROPOSED RESERVOIRS

A M

ENGINEERING CONSULTANTS, INC.

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PLATE IV - 12

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MULTIPLE PU

Damsite	Watershed	River	ENGINEERING							WATER S		
			Elevation Top of Dam	Height of Dam	Reservoir Area	Total Storage Capacity	Embankment Volume	Storage Cap. per MCM of Emb. Vol.	Rank	Active Storage Volume	Act. Storage Volume per MCM Emb. Volume	Ra
			MSL	m	ha	MCM	MCM	MCM		MCM	MCM	
Manonjaya	Citanduy	Citanduy	265	80	470	120	3.9	31	4	55	14	4
Ciamis	Citanduy	Citanduy	180	100	440	160	6.1	26	5	78	13	5
Banjar Multipurpose	Citanduy	Citanduy	80	60	1,620	460	6.2	74	3	290	47	3
Binangun No. 1	Ciseel	Ciseel	55	33	1,330	270	2.5	110	2	154	63	2
Binangun No. 2	Ciseel	Ciseel	48	28	3,050	485	2.4	202	1	220	92	1
Cikembang			180	70	150	35	2.1	17	7	18	9	7
Ciamis-Cikembang	Citanduy	Citanduy & Cikembang	180	—	590	195	8.2	24	6	96	12	6

FLOOD CONTROL DAMS

Damsite	Watershed	River	ENGINEERING							FL		
			Elevation Top of Dam	Height of Dam	Reservoir Area	Total Storage Capacity	Embankment Volume	Storage Cap. per MCM of Emb. Vol.	Rank	Drainage Area	Control Flood Producing Area	Ra
			MSL	m	ha	MCM	MCM	MCM		km²	%	
Banjar	Citanduy	Citanduy	70	50	1,280	282	3.5	80	1	1,300	52	1
Alternate Banjar	Citanduy	Citanduy	80	55	440	115	3.8	30	3	690	28	2
Cimuntur	Citanduy	Cimuntur	80	55	250	60	1.8	33	2	435	17	3

MULTIPLE PURPOSE DAMS

ENGINEERING					WATER SUPPLY						FLOOD CONTRO				
Reservoir Area	Total Storage Capacity	Embankment Volume	Storage Cap. per MCM of Emb. Vol.	Rank	Active Storage Volume	Act. Storage Volume per MCM Emb. Volume	Rank	Firm Water Yield	F.W.Y. per MCM of Embankment Volume	Rank	Drainage Area	Control Flood Producing Area	Rank	Flood Surcharge Storage Volume	Fld. Storag per M Emb.
ha	MCM	MCM	MCM		MCM	MCM		MCM/mo	MCM/mo		km²	%		MCM	MC
470	120	3.9	31	4	55	14	4	26	7	4	600	24	6	31	8
440	160	6.1	26	5	78	13	5	30	5	5	650	26	4	45	7
1,620	460	6.2	74	3	290	47	3	85	14	1	1,300	52	2	80	13
1,330	270	2.5	110	2	154	63	2	22	9	3	190	38	3	31	13
3,050	485	2.4	202	1	220	92	1	33	14	1	340	69	1	70	29
150	35	2.1	17	7	18	9	7	4	2	7	94	19	7	15	7
590	195	8.2	24	6	96	12	6	34	4	6	650	26	4	60	7

FLOOD CONTROL DAMS

ENGINEERING					FLOOD CONTROL							
Reservoir Area	Total Storage Capacity	Embankment Volume	Storage Cap. per MCM of Emb. Vol.	Rank	Drainage Area	Control Flood Producing Area	Rank	Flood Storage Volume	Flood Stor. Vol. per MCM of Emb. Vol.	Rank	Reduction of Flood Peak at Damsite	Rank
ha	MCM	MCM	MCM		km²	%		MCM				
1,280	282	3.5	80	1	1,300	52	1	230	66	1	93	1
440	115	3.8	30	3	690	28	2	98	26	2	86	2
250	60	1.8	33	2	435	17	3	46	26	2	80	3

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SE DAMS

LY			FLOOD CONTROL								POWER			
Firm Water Yield	F.W.Y. per MCM of Embankment Volume	Rank	Drainage Area	Control Flood Producing Area	Rank	Flood Surcharge Storage Volume	Fld. Surch'g Storage Vol. per MCM Emb. Vol.	Rank	Reduction of Flood Peak at Damsite	Rank	Firm Power	Installed Capacity	Annual Energy	Rank
CM/mo	MCM/mo		km²	%		MCM	MCM		%		Mw	Mw	Kwh	
26	7	4	600	24	6	31	8	3	10	6	4	25	32×10^6	3
30	5	5	650	26	4	45	7	4	15	5	9	35	71×10^6	2
85	14	1	1,300	52	2	80	13	2	52	3	—	—	—	—
22	9	3	190	38	3	31	13	2	82	2	—	—	—	—
33	14	1	340	69	1	70	29	1	90	1	—	—	—	—
4	2	7	94	19	7	15	7	4	5	7	—	—	—	—
34	4	6	650	26	4	60	7	4	20	4	10	35	79×10^6	1

CONTROL				
Flood Storage Volume	Flood Stor. Vol. per MCM of Emb. Vol.	Rank	Reduction of Flood Peak at Damsite	Rank
MCM				
230	66	1	93	1
98	26	2	86	2
46	26	2	80	3

NOTES:

1. The figures shown are based on a preliminary analysis of each site.
2. Firm water yields and firm power are based on dry period reservoir inflows for 24 years of synthesized flow records.
3. The percent control of the flood producing area is the ratio of the drainage area controlled to the total area producing major floods.
4. The flood producing area of the Citanduy watershed is 2,500 km² measured from railroad bridge No.1452
   The flood producing area of the Ciseel watershed is 500 km².
5. The percent reduction of flood peaks at the damsite is a measure of the available flood storage capacity and the attenuation of major flood peaks by reservoir routing.
   In the case of multiple purpose reservoirs, they were assumed to be at maximum pool when the storm occured.
6. This table shows the maximum values at each. See Plate No. J-11 for variations in the parameters with height of dam.
7. The reservoir area includes all land within the elevation of the top of dam.

DAMSITE EVALUATION FACTORS

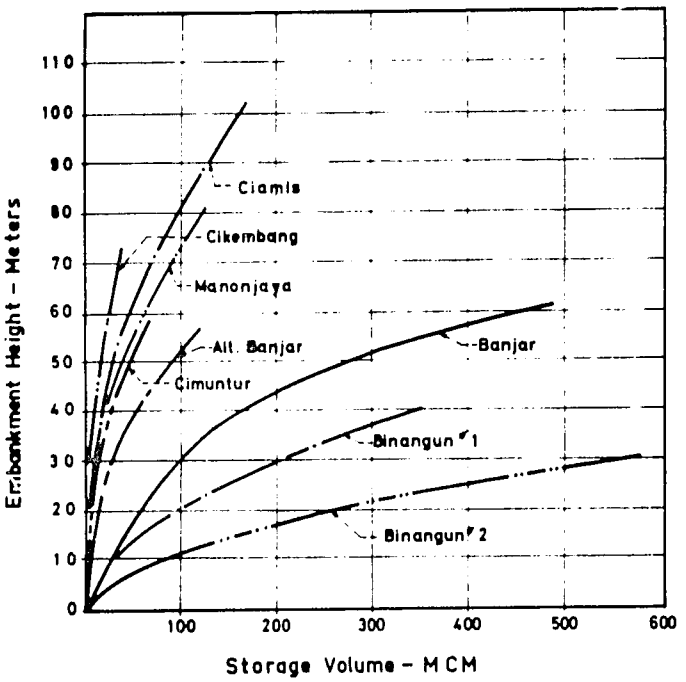


FIGURE .1

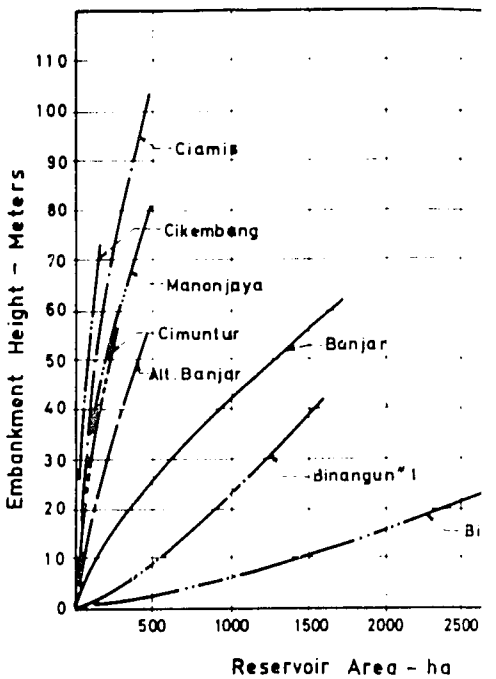


FIGURE .2

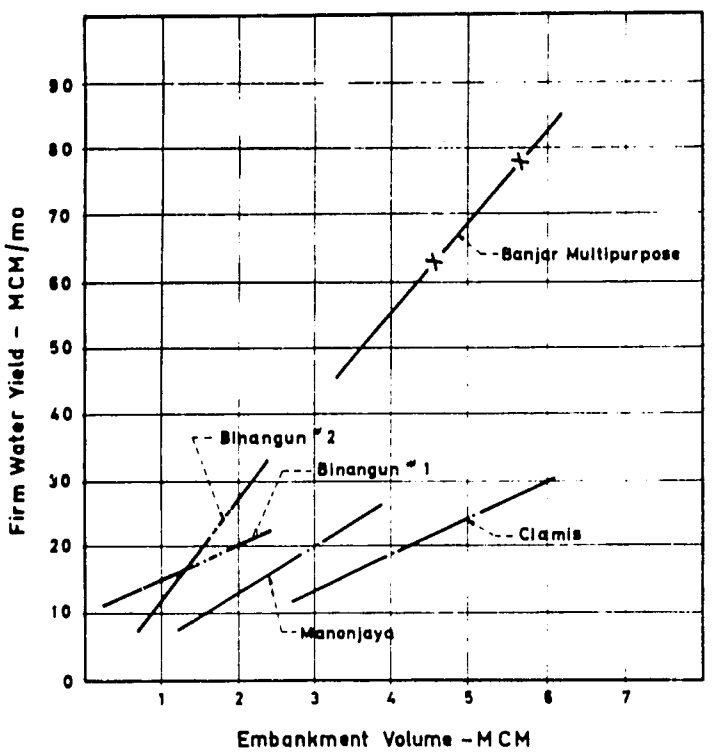


FIGURE . 4

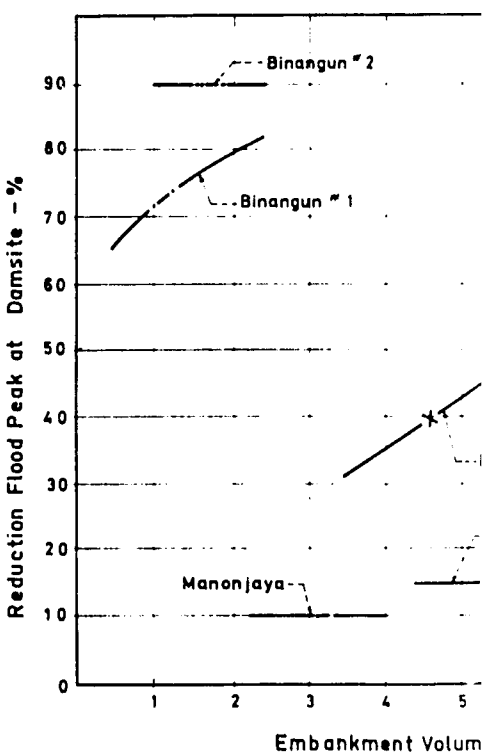
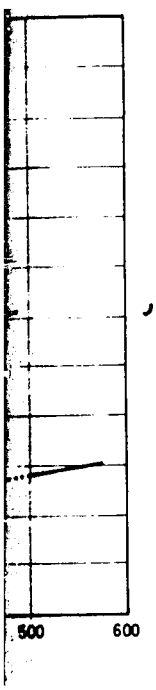


FIGURE.5



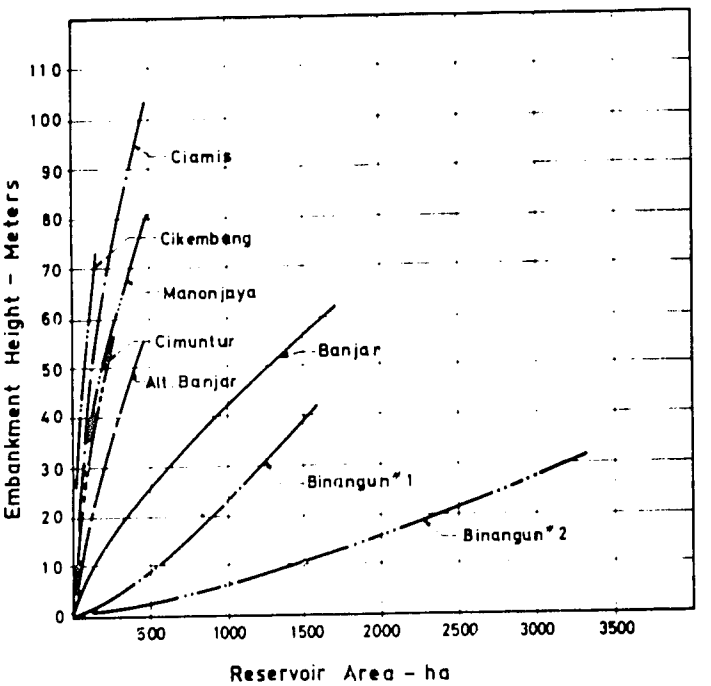


FIGURE .2

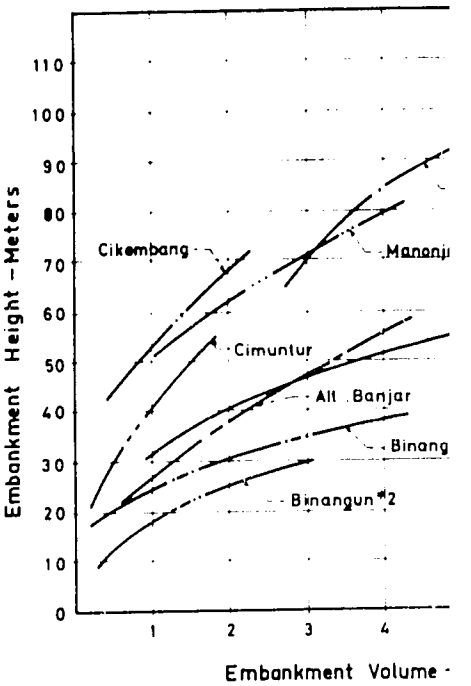
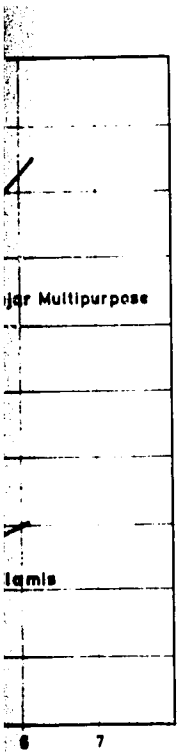


FIGURE .3



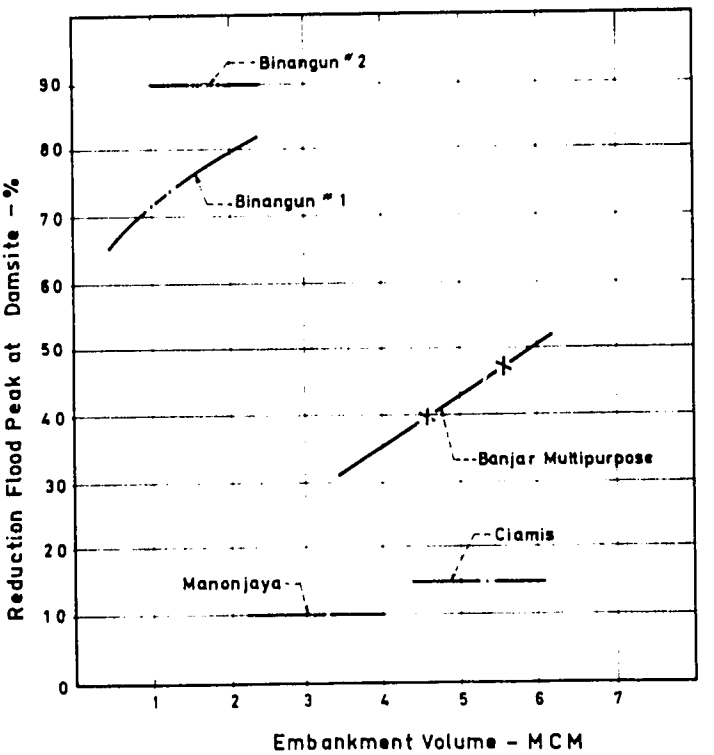


FIGURE.5

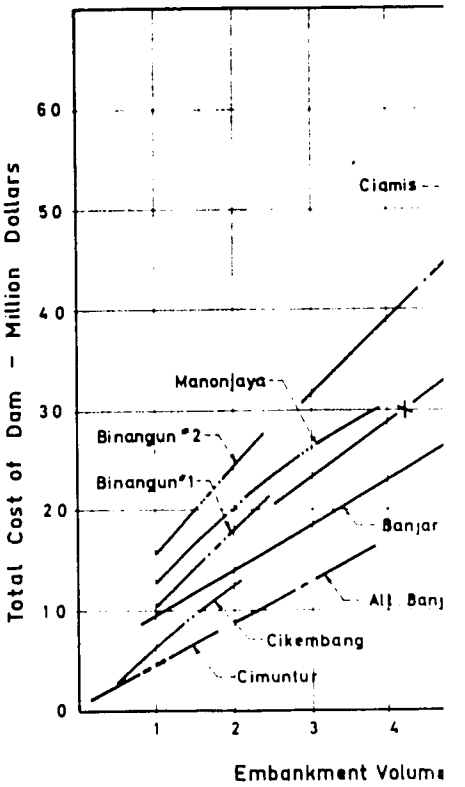


FIGURE.6

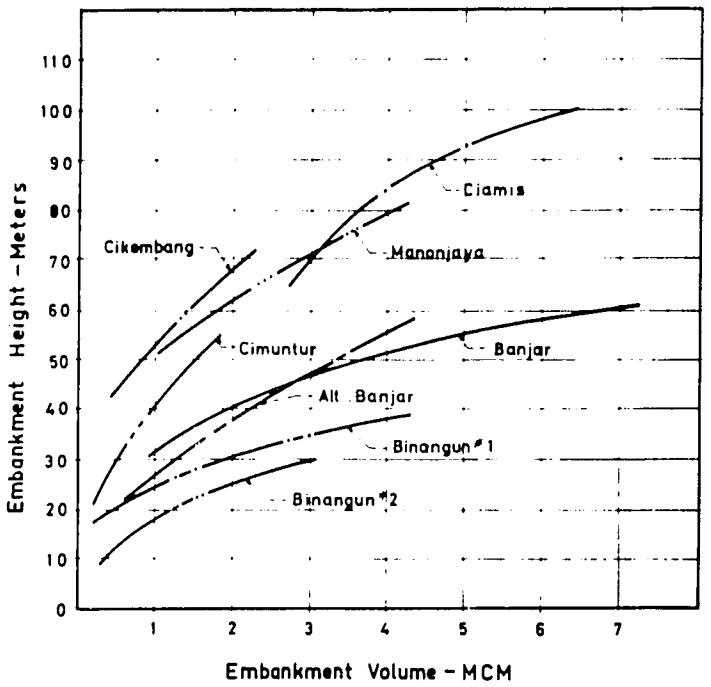


FIGURE . 3

LEGEND:

- Banjar Dam
- Alternate Banjar Dam
- Cimuntur Dam
- Ciamis Dam
- Cikembang Dam
- Manonjaya Dam
- Binangun # 1 Dam
- Binangun # 2 Dam
- Banjar Multipurpose Dam

NOTES:

1. Storage capacity and reservoir area curves are based on 1: 50,000 AMS topographic maps.
2. Embankment volumes are based on 1: 5,000 topographic maps except for Alternate Banjar and Cimuntur Dams for which only 1:50,000 maps are available.
3. Cost curves in figure 6 are for estimated total construction cost including all contingencies.

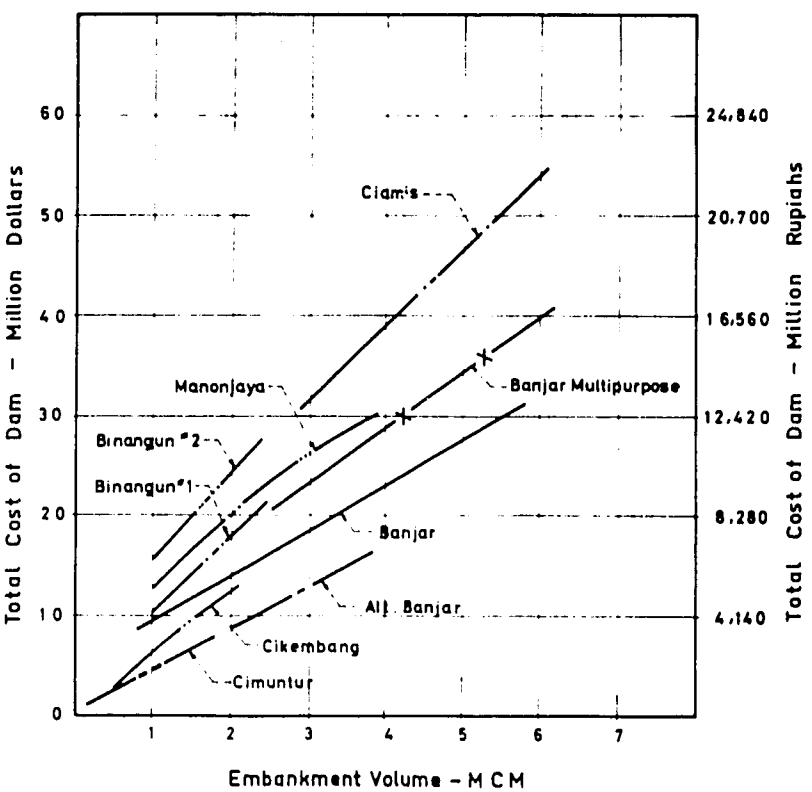


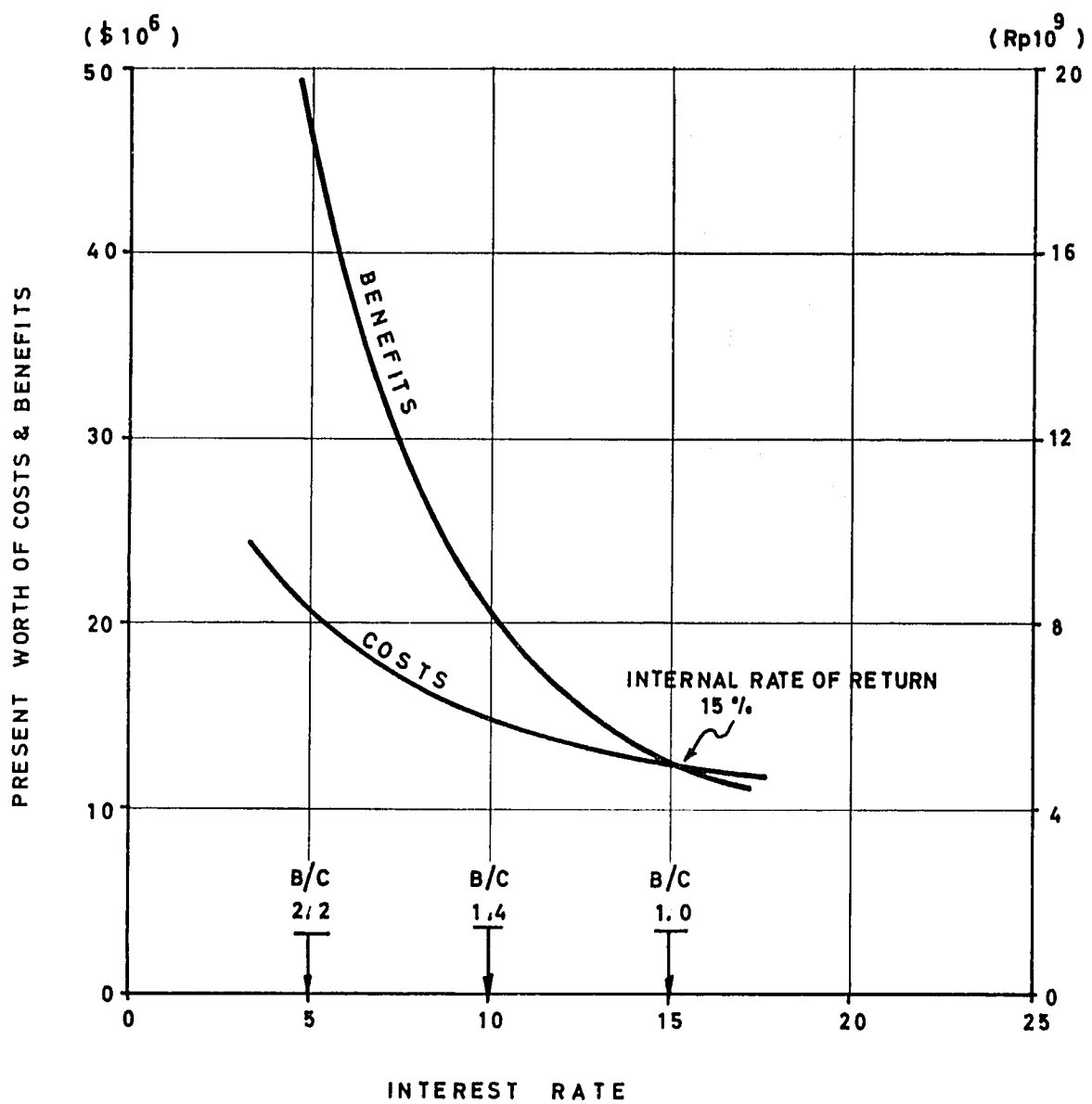
FIGURE . 6

DAMSITE COMPARISON CURVES

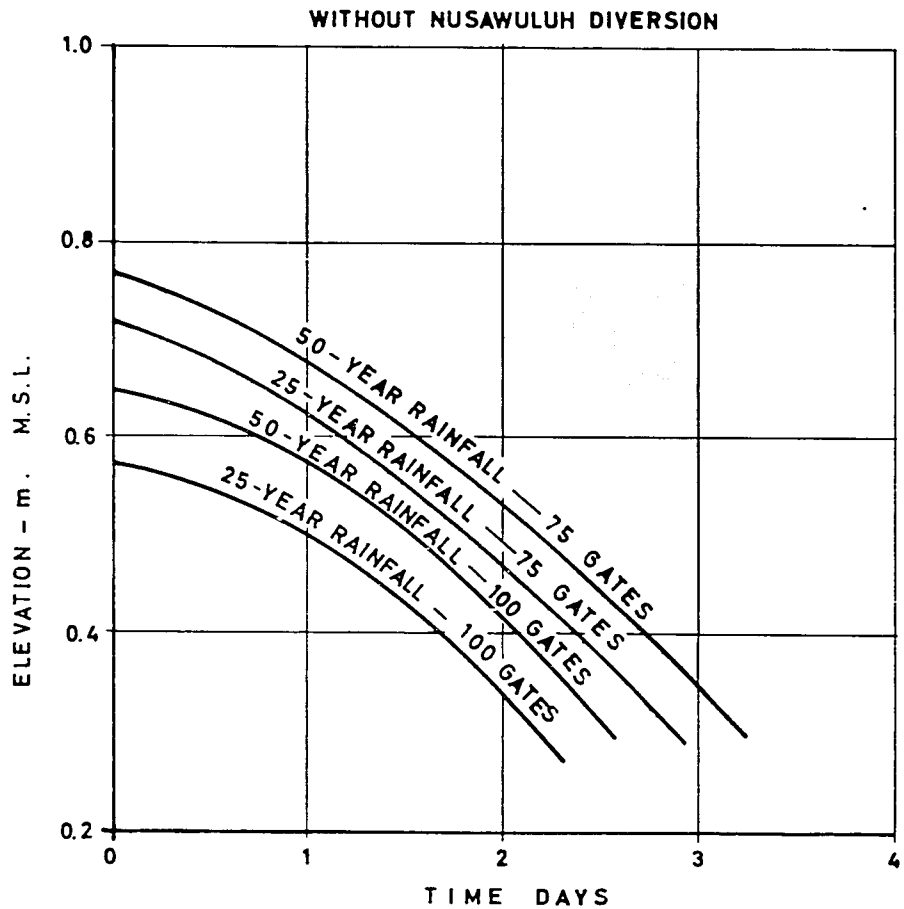
RESULTS OF ECONOMIC ANALYSIS

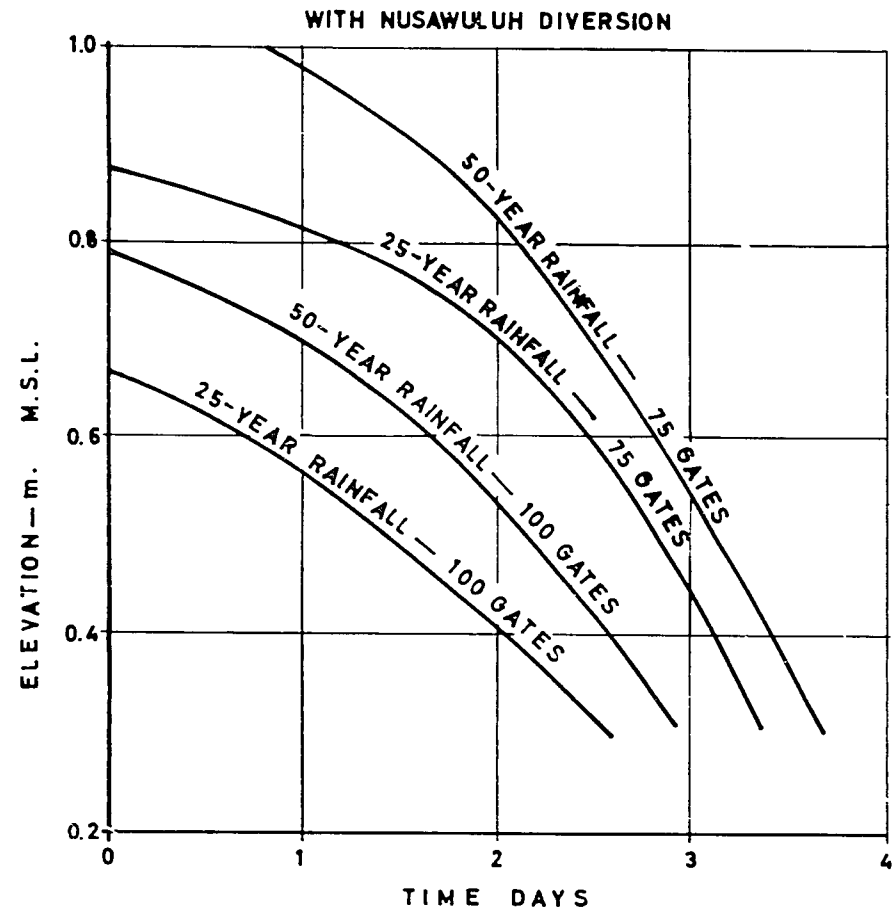
Flood Control and Irrigation & Drainage

(25 year flood protection)



A.M.





TIDE GATE ROUTING

ENGINEERING CONSULTANTS, INC.

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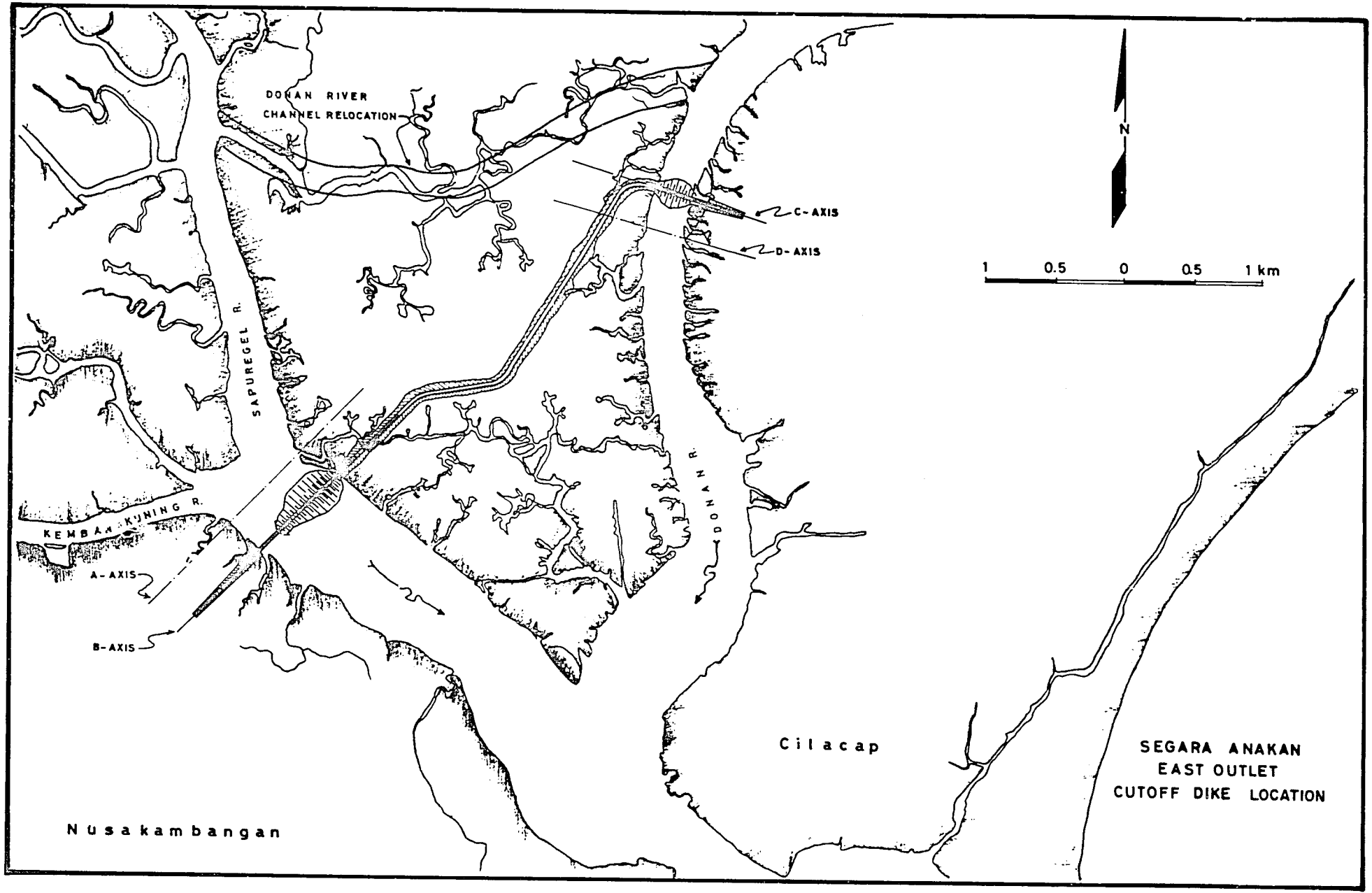
PLATE IV-16

A.M.



ENGINEERING CONSULTANTS, INC.

PLATE IV-17

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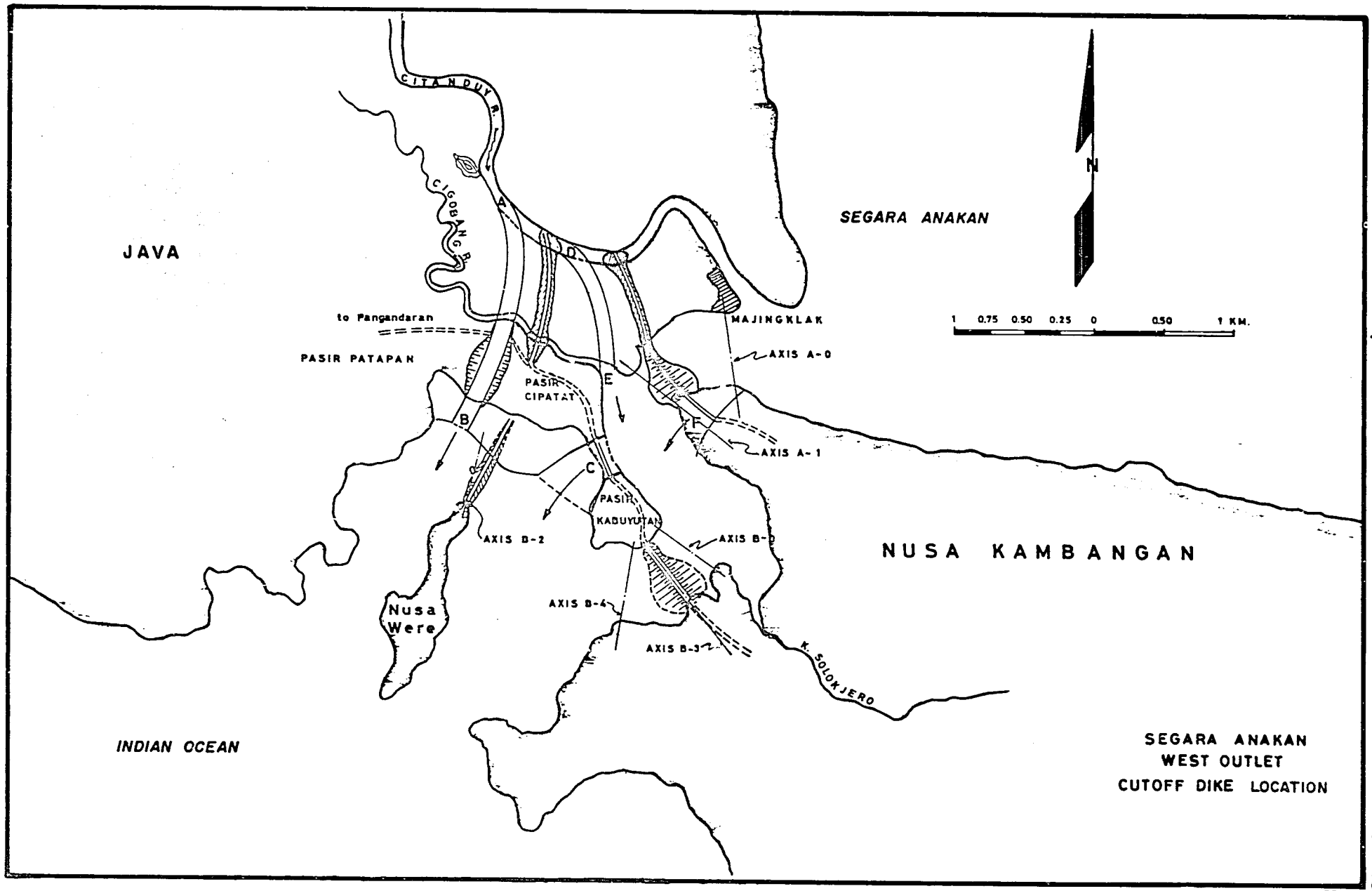
ZZ



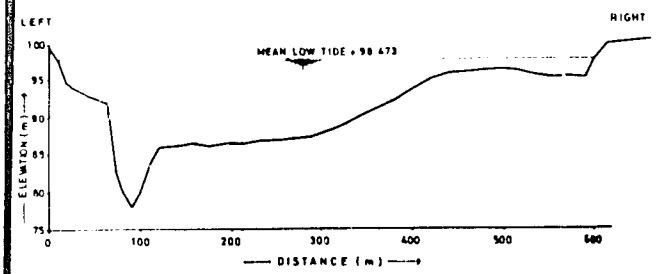
SEGARA ANAKAN
WEST OUTLET
CUTOFF DIKE LOCATION

ENGINEERING CONSULTANTS, INC.

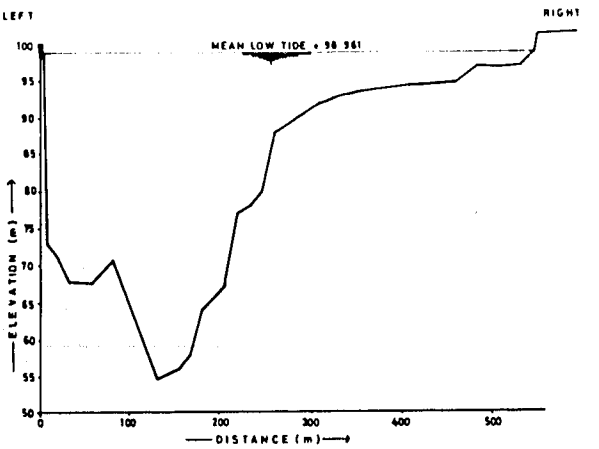
PLATE IV-18

WEST OUTLET

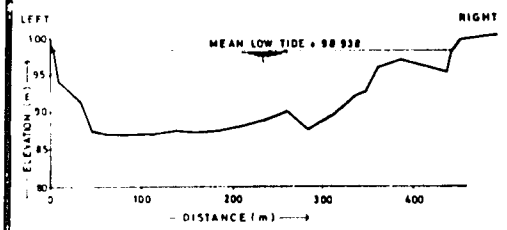
CROSS SECTION A-0



CROSS SECTION B-4

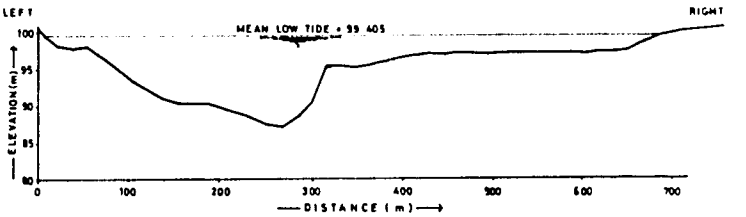


CROSS SECTION A-1

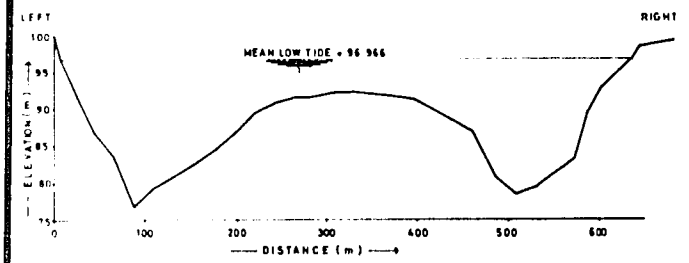


EAST OUTLET

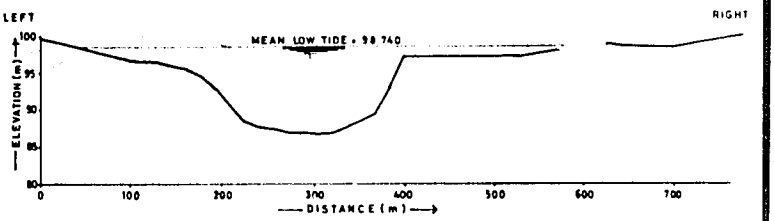
CROSS SECTION SAPUREGEL A



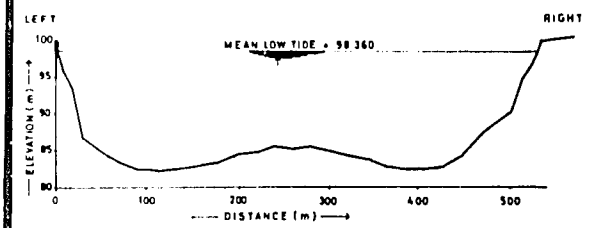
CROSS SECTION B-2



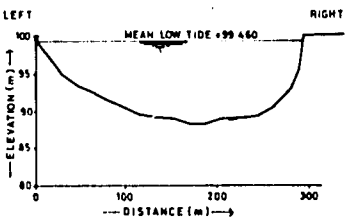
CROSS SECTION SAPUREGEL B



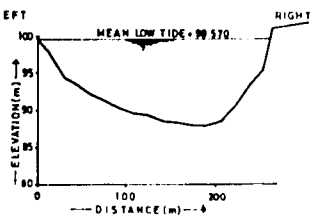
CROSS SECTION B-0



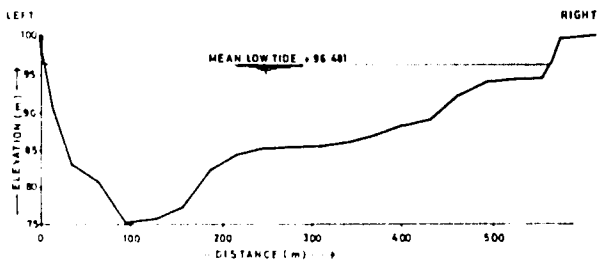
CROSS SECTION DONAN RIVER (UPPER)>C



CROSS SECTION DONAN RIVER (LOWER) D



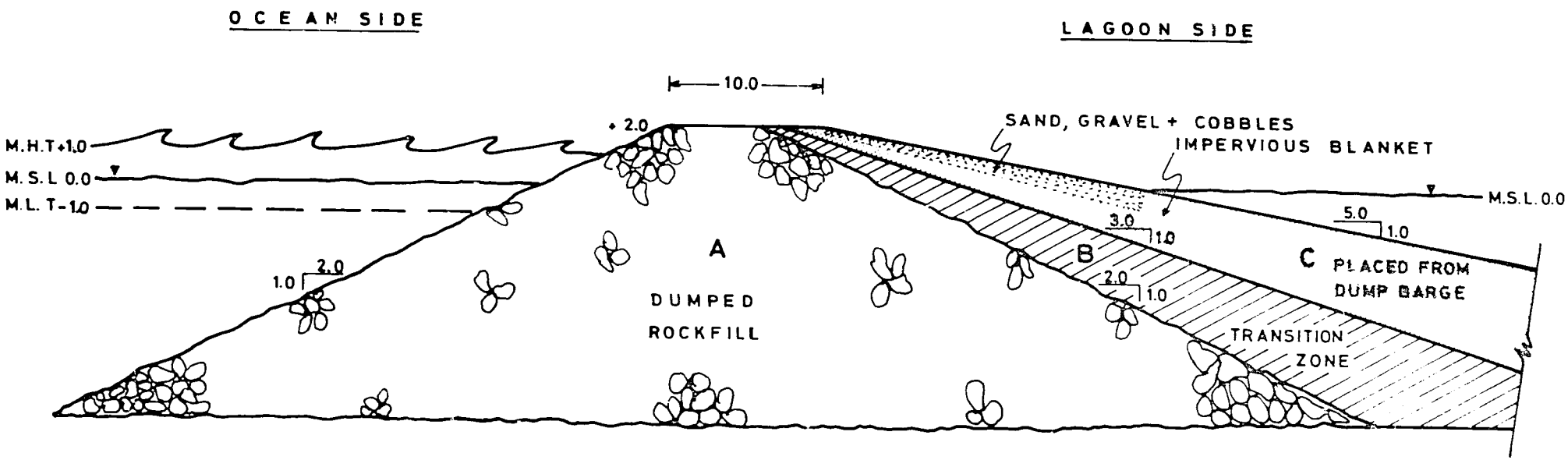
CROSS SECTION B-3



SEGARA ANAKAN

OUTLET CROSS SECTIONS

(ECHO SOUNDINGS)



CUTOFF DIKE TYPICAL CROSS SECTION

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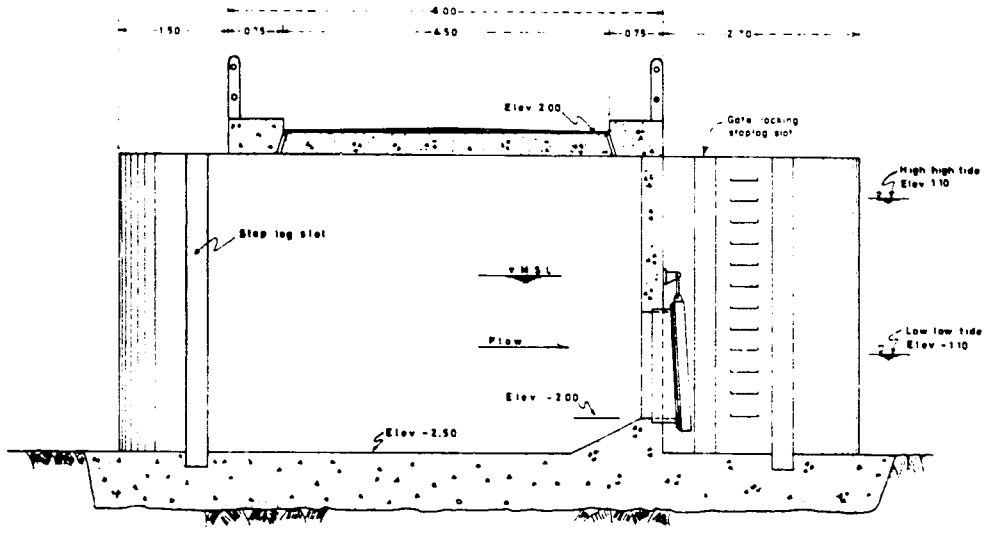
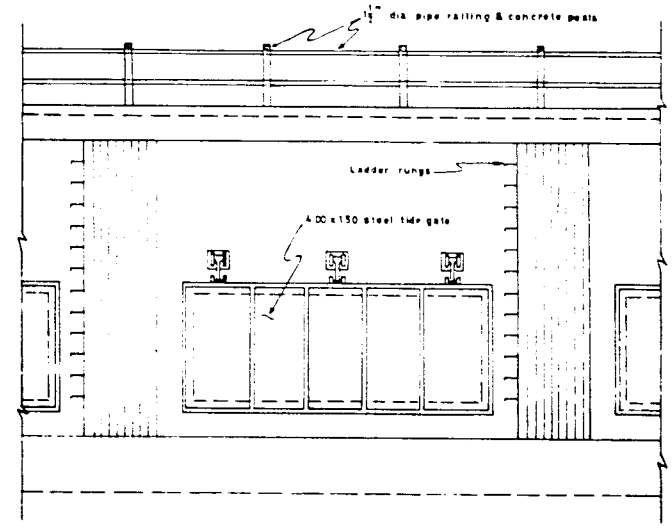
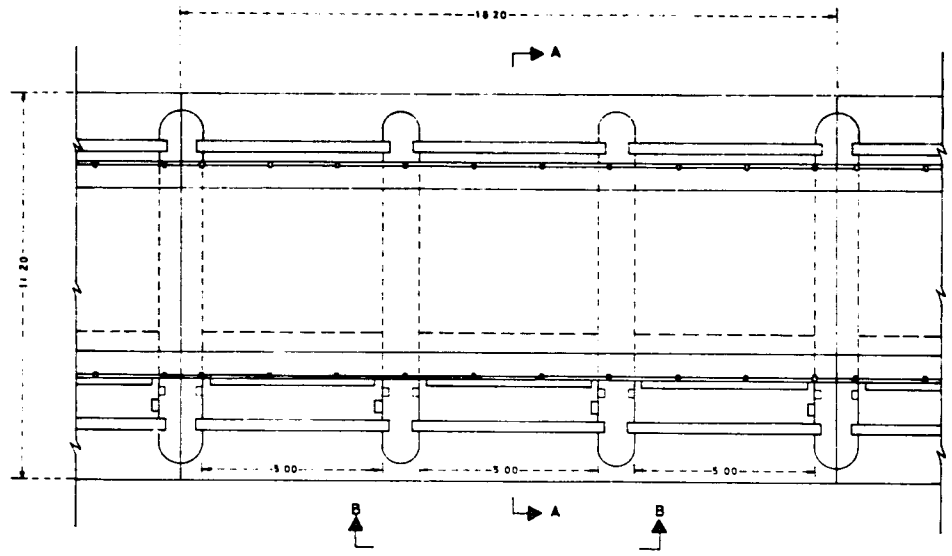
PLATE IV-20



SECTION A-A



SECTION B-B



PLAN

(typical construction unit)

TIDE GATE STRUCTURE

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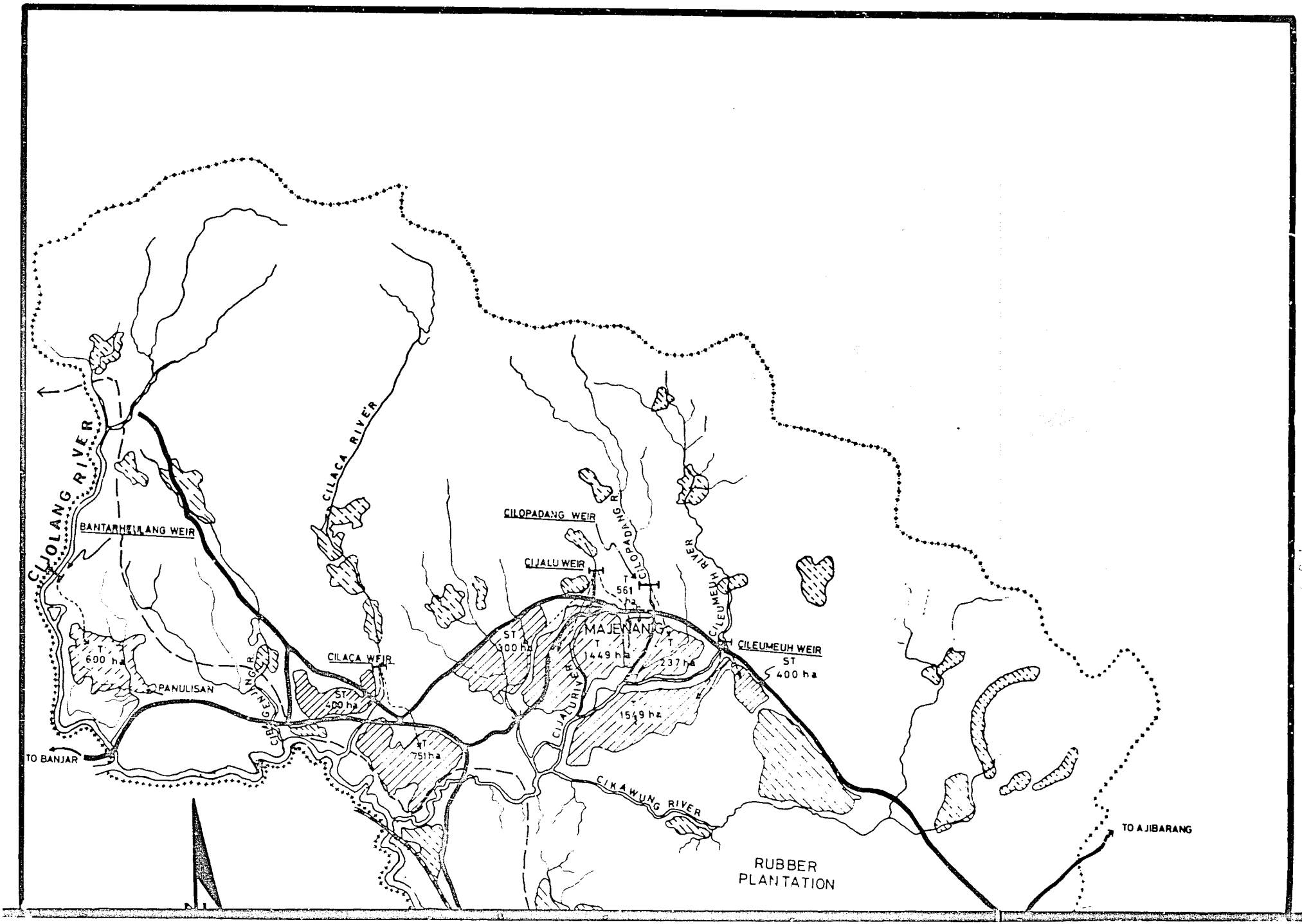
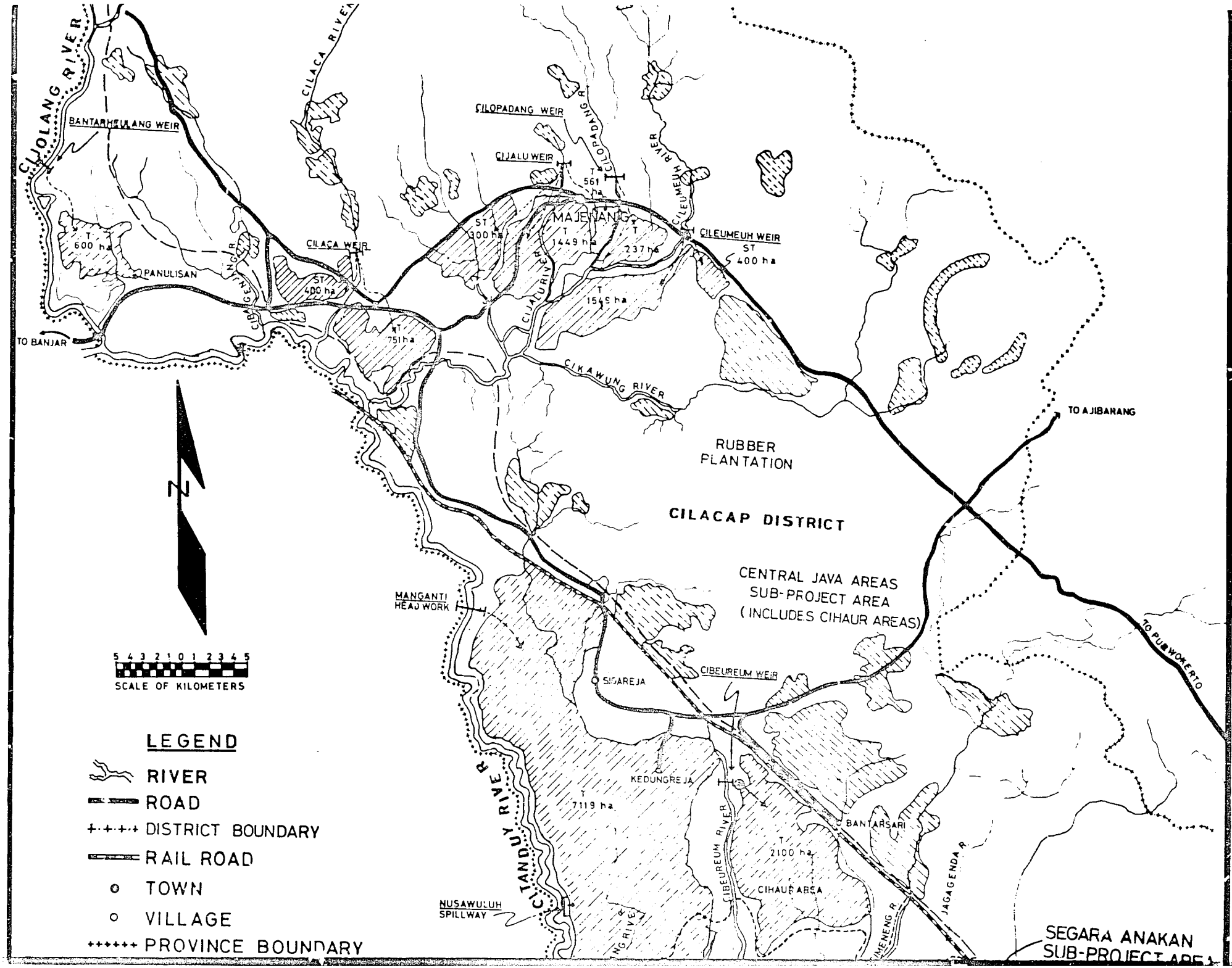
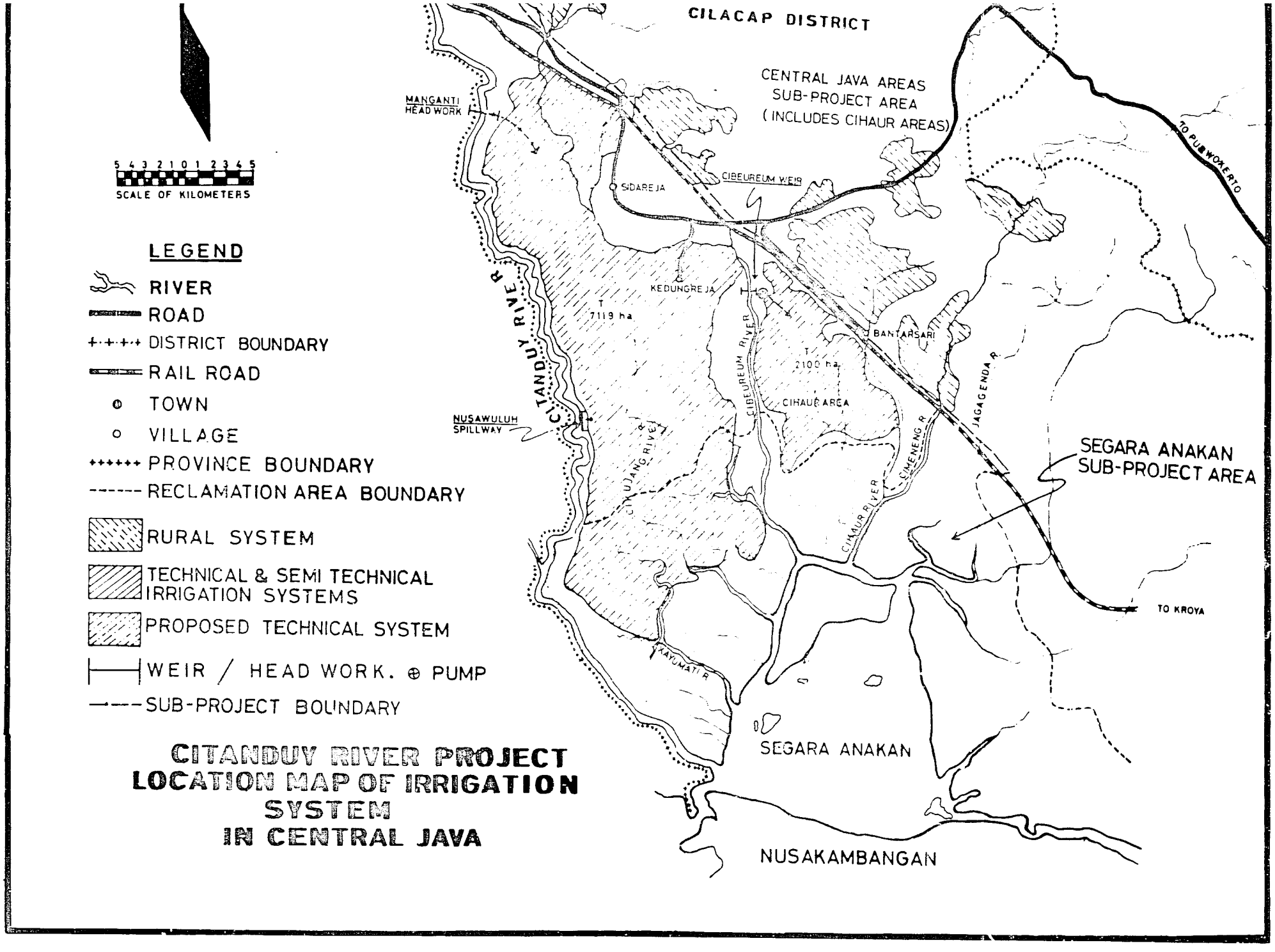
PLATE IV-21


CIJOLANG RIVER
BANTARHEULANG WEIR
CILACA RIVER
CILOPADANG WEIR
CILOPADANG R.
CIJALU WEIR
CILEUMEUH RIVER
CILEUMEUH WEIR
ST
400 ha
MAJENANG
T
561 ha
ST
300 ha
T
1449 ha
T
237 ha
T
600 ha
PANULISAN
CILACA WEIR
ST
400 ha
CIBAGENDING R.
CIJALU RIVER
T
1549 ha
T
751 ha
TO BANJAR
CIKAWUNG RIVER
RUBBER
PLANTATION
TO AJIBARANG

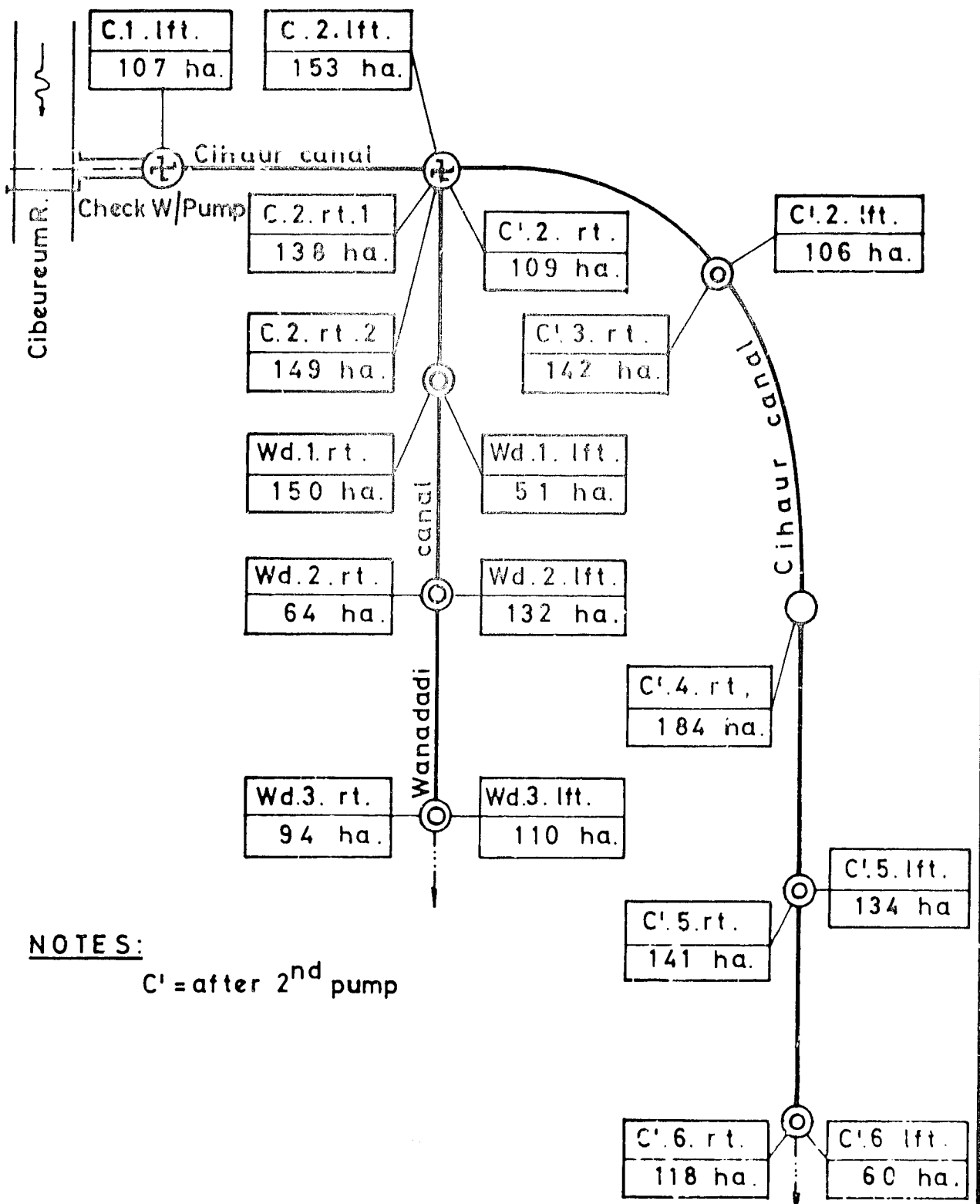

CIJOLANG RIVER
BANTARHEULANG WEIR
CILACA RIVER
CILOPADANG WEIR
CILOPADANG R
CIJALU WEIR
CILEUMEUH RIVER
MAJENANG
CILEUMEUH WEIR
CILACA WEIR
PANULISAN
CIBAGENDING R
CIJALU RIVER
CIKAWUNG RIVER
TO BANJAR
TO AJIBARANG
RUBBER PLANTATION
CILACAP DISTRICT
CENTRAL JAVA AREAS SUB-PROJECT AREA (INCLUDES CIHAUR AREAS)
TO PURWOKERTO
MANGANTI HEAD WORK
SIDAREJA
CIBEUREUM WEIR
KEDUNGREJA
CIBEUREUM RIVER
BANTARSARI
CIHAUR AREA
JAGAGENDA R
CIMENENG R
CITANDUY RIVER
NUSAWULUH SPILLWAY
SEGARA ANAKAN SUB-PROJECT AREA
SCALE OF KILOMETERS
LEGEND
RIVER
ROAD
DISTRICT BOUNDARY
RAIL ROAD
TOWN
VILLAGE
PROVINCE BOUNDARY

INC.



CITANDUY RIVER PROJECT
LOCATION MAP OF IRRIGATION SYSTEM
IN CENTRAL JAVA

SCHEMATIC DIAGRAM
PROPOSED CIHAUR IRRIGATION SYSTEM.



NOTES:

C' = after 2nd pump

CHAPTER V

ECONOMIC ANALYSES

Lower Citanduy/Ciseel River System

Economic Analysis of Recommended Plan

There are two subprojects in the recommended plan for the Lower Citanduy/Ciseel River System. One subproject is the combined Flood Control and Irrigation and Drainage Scheme. The other subproject is the proposed Matenggeng Dam and Power plant. The economic analysis treats these two subprojects separately.

Combined Flood Control and Irrigation and Drainage Scheme. For the optimum beneficial effect in the Lower Citanduy/Ciseel area, a combination program of flood control and irrigation improvements is necessary. Consequently, the two components are combined in the economic analysis. The flood control plan being recommended will provide protection against floods having a return period of 25 years.

Costs. The economic costs for the total scheme follows:

	Rp. (1,000)	$
Construction:		
Flood Protection	4,087,431	9,873,023
Irrigation and Drainage	2,180,543	5,267,010
Annual O & M (Incremental):		
Flood Protection	132,066	319,000
Irrigation and Drainage	57,701	139,374

Benefits. The annual benefits of the flood control facilities would be Rp. 1,064 million ($2,570,000). These benefits include prevention of damages in agriculture, industry and government. No estimate could be made of intangible values such as human safety, inconvenience and health, or of the negative impacts of flood hazards on regional economic and social development.

The annual benefits of the irrigation and drainage program are based on increases in the net income accruing to farmers as a result of the improved and extended facilities. At full development, after a buildup period of five years for each development block, the annual benefits would amount to Rp. 1081 millions ($2,611,000). However, because the flood control and irrigation and drainage facilities cover much of the same area, the irrigation and drainage benefits must be reduced to eliminate any possible double-counting of benefits. This is done by limiting irrigation and drainage benefits to the costs for the irrigation and drainage facilities.

At full development the combined benefits from the Lower Citanduy/Ciseel Flood Control and Irrigation Drainage Scheme would amount to:

	Rp. (1,000)	$
Annual Benefits	1,323,000	3,195,682

Internal Rate of Return. When costs and benefits are converted to a common time basis, the internal rate of return is 15 percent. The primary beneficiaries of the subproject would be the low income group of people - the rural people - whose annual incomes are less than half of the average national per capita income. The scheme is both technically and economically feasible and should be undertaken without further delay.

Matenggeng Dam and Powerplant. The economic justification of the dam and powerplant is based on a comparison with the most likely alternative generating plant capable of producing a comparable type and quantity of electric power. A demonstration that the hydroelectric project would produce power at a lower cost than the most likely alternative shows the project to be justified. At any positive internal rate of return, the hydroelectric plant is economically superior to the alternative.

The powerplant is capable of producing for peak load, which is higher value power than base load. Therefore, Matenggeng was compared with the most likely alternative thermal peaking plant, which is an oil-fired gas turbine plant.

Costs. A summary of cost (1974) is as follows:

	Rp. (Thousands)	$
Construction	33,030,210	79,783,100
Annual operation and maintenance	66,240	160,000
Replacement Costs (in 35th year)	3,229,000	7,800,000

The construction cost includes Rp. 2,525 million ($6,099,000) for land acquisition. Also included are construction access roads and a transmission line to deliver the output to an interconnection point on the main system. Construction would require four years.

Power Benefits. The price of petroleum fuel used in the analysis of the alternate comparison is Rp. 4,140 ($10.00) per barrel. The current price for turbine fuel in indonesia is Rp. 6,446 ($15.57). By assuming that the long-term fuel price will be about one-third lower than the present price, the analysis of benefits appears to be conservative.

The power values derived for the benefit analysis of Matenggeng hydroelectric plant are Rp. 5,246 ($12.67) per kilowatt of installed capacity, Rp. 17.79 (42.98 mills) per kilowatt hour of firm peaking energy generated and Rp. 8.9 per kilowatt hour of secondary energy. The annual project benefits are calculated as follows:

	Rp. (1,000)	$
Capacity: 100×10^3 KW at Rp. 5,246	524,600	1,267,150
Firm Energy: 214.6×10^6 KWH at Rp. 17.79	3,817,700	9,221,500
Total Firm Energy Benefits	4,342,300	10,488,650
Secondary Energy = 69×10^6 KWH at Rp. 8.9 =	614,100	1,483,350
Total Power Benefits	4,956,400	11,972,000

Irrigation and Flood Control Benefits. Minor irrigation benefits will accrue to Matenggeng Dam because the power releases from the reservoir during the dry season can be used to alleviate irrigation shortages downstream of the

dam. However, realization of these benefits will not occur until after the irrigation systems are operating efficiently.

Flood control benefits attributable to Matenggeng Dam will be limited to the rice land along the Cijolang River downstream of the dam and thus are small when compared to power benefits. The total value of irrigation and flood control benefits will amount to Rp. 173 million per year after the irrigation development period.

Internal Rate of Return. The internal rate of return is 12.6 percent at maximum power development. This economic analysis is based on firm power generation, secondary energy, irrigation and flood control. Other favorable incidental effects of the project which have not been evaluated include recreation, fishery streamflow regulation, environmental protection (air pollution) and gains accruing to the national balance-of-payments account. These values may be quite significant.

Upper Citanduy/Ciseel River System

Economic Analysis of Recommended Plan

The rehabilitation of the irrigation and drainage systems in the upper basin has been studied at a reconnaissance level of detail. Consequently, the economic analysis must draw from data developed for the rehabilitation of irrigation and drainage systems in the lower Citanduy/Ciseel area. The lower and upper areas are similar with respect to agricultural potential and farming practices. The principal crop grown under irrigation is rice. The upstream area has the advantage over the downstream area of being relatively free from flooding damages because its lands do not lay in a major floodplain. On the other hand, the more hilly upstream area probably requires more labor and greater care for maintaining the rice paddies and terraces. Economic justification is analyzed on the basis of future increased costs and benefits relative to the projected future situation without the subproject.

Costs. Rehabilitation of the irrigation and drainage facilities would cost Rp. 559 millions ($1,350,000) and require four years time. Increased operation and maintenance costs would amount to Rp. 32.58 million ($78,700) at full development.

Benefits. The estimate of increased net income realized by the farmers under these systems considers the adequacy of the irrigation systems without and with the subproject. With the rehabilitation completed, some yield improvement is anticipated for the wet season because of improvements in irrigation water supply and drainage facilities, the greatest gains from the subproject would accrue because of the improvement in irrigation coverage in the dry season. The crop yield data and irrigation water supply correlations developed for the Lower Citanduy/Ciseel area were utilized in estimating increased crop yields and net farm income for the upstream irrigation systems proposed to be rehabilitated.

During the period of construction when the irrigation facilities are disrupted, appropriate reductions in farm income are charged against the irrigation benefit account. A buildup period of 5 years after construction is complete on each system is assumed necessary to attain full scale benefits. At full development, the project benefits would amount to Rp. 358,200 thousand ($865,200). These income benefits constitute the direct effects of the project on the farmers. In addition, secondary and intangible benefits would be significant. The subproject would promote economic growth in the region, add to the much-needed domestic production of rice, and provide employment for a large, otherwise underemployed, work force during construction.

Internal Rate of Return. The internal rate of return for this subproject is 22 percent. This program should be undertaken immediately.

Reclamation of the Segara Anakan and its Environs

Economic Analysis of Recommended Plan

The costs of the subproject are analyzed in comparison with the benefits from land reclamation, fishery and domestic, municipal and industrial water supply benefits to determine the internal rate of return. The analysis covers a period of 50 years.

Costs. A summary of costs is as follows:

	Rp. (Millions)	$(Thousands)
Construction	10,633.470	25,684
Surveys and Settler Assistance	279.450	675
Initial Fish Stocking	122.544	296
	11,036.464	26,655
Annual Operation and Maintenance	254.971	616
Replacement costs for pumps, once every 12 years	543.375	1,313
Annual fish restocking and Management	45.126	109
Annual Dredging after year 20	625.554	1,511

Benefits. Agricultural benefits from land reclamation would amount to Rp. 150,717 ($364) per hectare at full development. Farmers could grow two or more crops of rice per year because irrigation would be provided. The development of the newly reclaimed land would proceed by stages and full production levels would be achieved in ten years. These benefits total Rp. 3,165 million ($7,644,000).

Fishery benefits would be proportional to the volume of water contained in the fresh water lagoon. After initial stocking the fish harvest would build up to give a net gain in fish production of Rp. 300 million ($725,000) in the 9th year of operation. Thereafter production would decrease due to sedimentation unless Nusawuluh weir were closed. A stable fishery benefit of Rp. 207 million ($500,000) would be maintained continuously after year 20. If Nusawuluh weir would be closed to stop the sediment contributions from the Citanduy River, the fishery benefits in the long run would be twice as great.

Water supply for Cilacap is valued at the cost savings from avoiding construction and operation of the potential Jeruklegi reservoir on the Donan River upstream from Cilacap. The annual equivalent benefit would be Rp. 433 million ($1,046,000).

In addition to the direct, tangible benefits on which the economic analysis is based, there would be many other favorable effects. These include increases in domestically-produced rice, improved public health, higher income levels for the low-income rural people, potential transportation improvements, recreational opportunities and employment impacts during and after construction.

Internal Rate of Return. The test of economic justification is made by discounting costs and benefits to place them on a common time basis. The difference between the costs and benefits becomes zero when the cost and benefit streams are discounted at 18 percent. This is the rate of yield on the project costs, or the internal rate of return. This subproject is both technically and economically feasible and should be undertaken as quickly as possible.

Central Java Areas

Economic Analysis of the Rehabilitation Scheme

The rehabilitation scheme and the Cihaur new land irrigation scheme are unrelated to each other in that they could be handled independently. Therefore, the economic analysis treats them separately.

Costs. The cost of rehabilitating the 5,647 hectares under eight major technical and semi-technical irrigation systems is estimated to be Rp. 393 million ($949,275). It is proposed that this work would be divided into three approximately equal stages and accomplished over a four year construction period. The increased O & M costs would amount to Rp. 16.645 million ($40,206) which is Rp. 2,948 ($7.12) per hectare. These O & M costs would commence upon completion of construction of each stage of the rehabilitation work.

Benefits. The beneficial effects of irrigation and drainage rehabilitation are based on the feasibility grade study of a similar proposed program in the Lower Citanduy/Ciseel area. Crop yield assumptions are necessarily related to water supply conditions. In the Lower Citanduy/Ciseel study there were eight systems having a wide assortment of water supply situations ranging from rainfed conditions on land having drainage deficiencies, through partial water supplies in both the wet and the dry seasons, to fully adequate water supplies and no remaining drainage deficiencies. This array of conditions provided a sufficient basis for associating crop yields with the water situtations in the Central Java areas. It is on this basis that the increased net farm income is estimated. After allowing for a 5 year buildup period, the annual benefits for the total system would amount to Rp. 360.18 million ($870,000).

Internal Rate of Return. This rehabilitation of irrigation and drainage works would give an internal rate of return amounting to 27 percent. It is felt that this program should be initiated as quickly as possible.

Economic Analysis of Cihaur Irrigation

Introduction of irrigation to this area would improve crop production in both the wet and dry seasons. The estimates of costs and benefits assume that the Segara Anakan subproject would be built first, thus providing the requisite control of tidal effects. If this necessary control is not provided, the benefits of irrigation would be significantly less than shown here.

Costs. The estimated costs to construct the Cihaur system is Rp. 582 million ($1,406,000). This includes all conveyance and drainage works. The period of construction would be four years. Annual operation and maintenance costs are estimated to be Rp. 12,400 ($29.95) per hectare, or Rp. 26 million ($62,898) for the project.

Benefits. Estimated subproject benefits are based on the feasibility study of irrigation rehabilitation and extension in the Lower Citanduy/Ciseel area. Major improvements could be expected from irrigation in the dry season. In the wet season, there would be some yield improvement from irrigation and drainage. Salt water intrusion into the area would be prevented by construction of the Segara Anakan, but benefits were not claimed in the Segara Anakan feasibility report.

At full development the annual benefit per hectare would be Rp. 101, 016 ($244). It is estimated that a 10 year buildup period would be needed to reach full development. Total benefits would be Rp. 212 million ($512,400).

Internal Rate of Return. Development of the Cihaur new land irrigation system would yield an internal rate of return of 14 percent.

CHAPTER VI

MANAGEMENT

General

It has been the opinion of many authorities for some time that the critical erosion and flood problems arising in the Citanduy River Basin and the other tributaries to the Segara Anakan have become extremely serious to the inhabitants living in the basin, especially those living in the downstream areas. The geographical location of the river divides the two provinces of West and Central Java. This has caused some problems in the overall management of the river system and in the solution of many of its difficulties. Work done to date in the river basin by the two provinces has not been coordinated and no common objectives have been developed. Most of the river work that has been done was to protect the interests of the people on either side of the river by building a system of levees, each side building their structures a little higher to prevent the river from overflowing into their respective side. This has caused each province to be on the defensive, completely disregarding the immense potentials that could be developed under a coordinated program.

Concurrently, the development of the land and water resources has also been the concern of a number of the various departments of the government. Some coordination has been accomplished between the departments, but because of differing objectives and individual problems, activities have not always been coordinated for the most effective development of the resources. The result has been that conflict of interest have frequently occurred among the developers and the consumers of land and water products. Furthermore, in the provinces, different approaches to the administration of land and water problems has caused conflict of interests and, in some cases, direct countermanding directives.

To avoid the continuation of situations and problems such as these and others that might arise and may have far-reaching consequences, it is important that policies and legal authorizations be formulated by one directing body so that land and water resources may be developed in an orderly fashion for both the good of the local people and in the national interest.

Most of the program for the development of the land and water resources for the Citanduy River Basin would come under the direct supervision of the Minister of Public Works and Electric Power. It thus appears logical that the authority for the Citanduy Basin be established under this ministry if efficient and effective management is to be achieved.

Once the Authority is established, then a central committee of the several ministries involved would have to be established to coordinate their services. Together the various ministers provide the Minister of Public Works and Electric Power with information upon which to formulate policy and directives to the board of directors of the watershed authority. This is shown on Plate VI-1.

The several ministries and services have local branches down to the different levels of government depending on the nature of the service. For example, the Ministry of Agriculture has offices down to the subdistrict level with officials who make regular visits to the villages and community complexes. The Authority organization recommended is structured to provide a direct line of administration to the managers carrying out the orders at the site or project level.

Organization

Board of Directors

The Board, composed of from four to seven members, should be appointed by the Minister of Public Works and Electric Power. The members should be men of wide experience in carrying out policies from above and formulating these policies into direct action plans for implementation within the overall objectives and purposes of the authority. Agency coordination is done at this level so that assistance below this level is under the direction of the General Manager through his lines of administration.

General Manager

The General Manager would have a staff commensurate with the number of programs or subprojects in operation within the basin. At the moment it is envisaged that his three principal assistants would be the Manager, Upstream Development; the Manager, Lower Citanduy/Cisee! subproject; and the Manager, Segara Anakan subproject. This is outlined on Plate VI-1.

Subproject Manager

As shown on the organizational chart, each subproject Manager would initially have two functioning staffs: Construction and Operation and Maintenance. Naturally, in the early stages the former would be the dominant group. As construction progresses, the O & M staff would gradually build-up to full strength. The Construction staff would gradually be reduced as the works become operational. At the end of the construction period the Construction staff would be disbanded and the O & M staff would then handle all operations.

Operations

Coordination, stimulation, and participation in executing all the programs or subprojects will be done through the managers' level. Each manager will have a technical staff that can work directly with the landowner, or in construction development, to assure technical soundness, and adapting the programs and policies to the situations as they may arise from day to day. However, the main function of the staff members will be to coordinate the work of agency people so that all benefits now established on a nationwide basis will also be made available to the residents of the area supervised by the Authority.

Loans and grants would be made available to the Authority by the central government. These would be for specific purposes during the construction and development stages of the program.

The Authority would also have the power through the Ministry to make assessments for its goods and services. Such funds could be used for the operation and maintenance of the activities of the authority. The Authority would not levee taxes, but could recommend increases to maintain its works of improvements.

To plan and encourage increased agricultural production is an obligation of the Authority in accordance with the government program of self-support. The Authority would introduce the cultivation of industrial crops of higher value than that of rice that could stimulate processing industries, and which could also improve labor potentials. Additional responsibilities of the Authority would include the following:

1. Plan and stimulate activities to maintain and upgrade soil qualities and to reduce erosion.

2. Plan and initiate a forest economy that will assist and improve the income of the people in these areas.

3. Program activities to intensify the use of irrigation water and to develop irrigation and drainage programs that use water resources in an effective manner.

4. Undertake and stimulate fisheries and recreation as a use of reservoir waters.

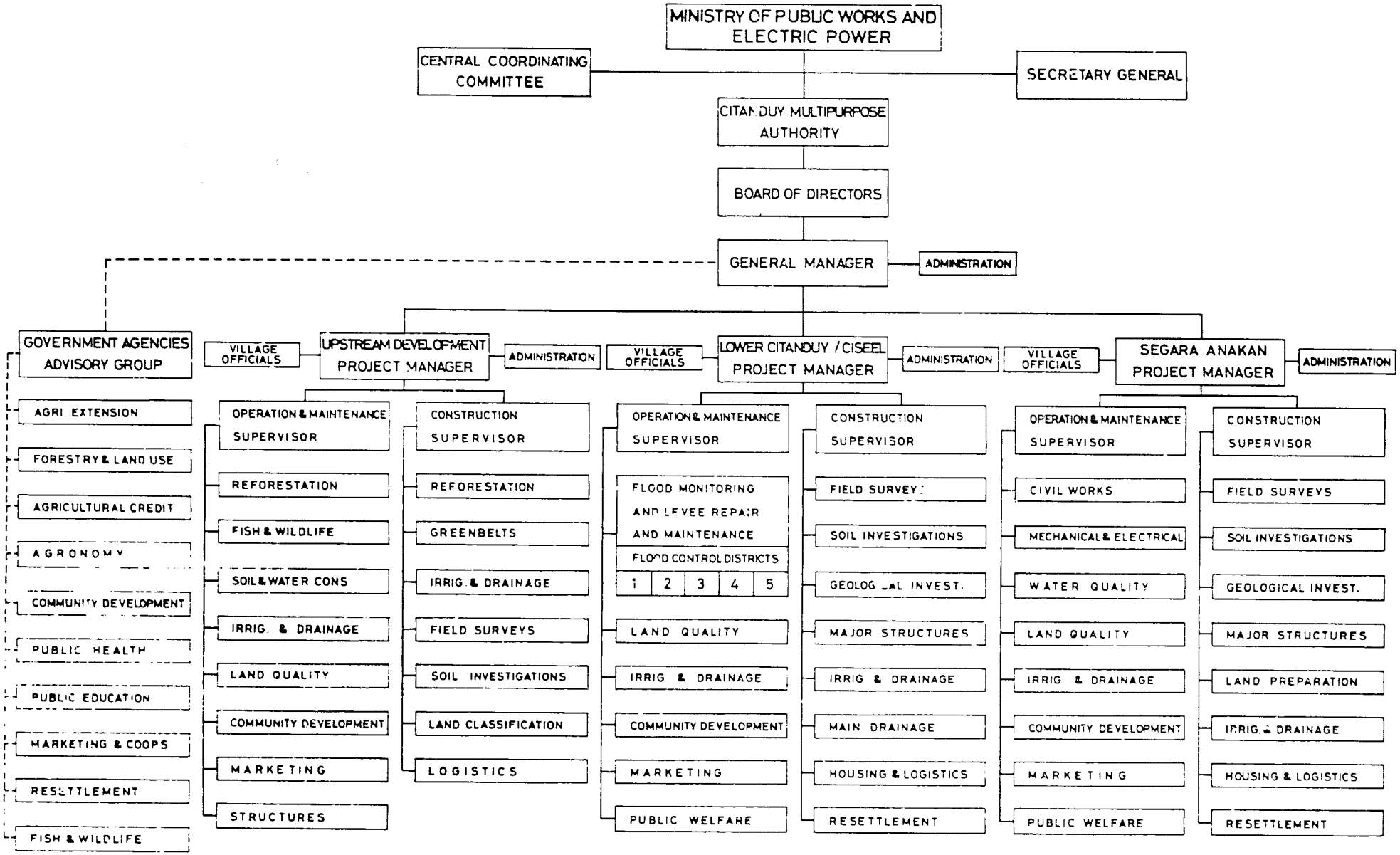
5. Establish and maintain a flood warning system and an adequate levee maintenance and repair organization.

The successful operation of any or all of these activities implies participation by the local people. This is shown graphically on Plate VI-1 and, more specifically for irrigation organization, on Plate VI-2.

Proper operation and maintenance of irrigation systems is an especially important responsibility of the Authority, for it is the lack of this important operation that has been the principal factor in the deterioration of the present irrigation systems. The O & M of the principal canals and structures will be handled by the Irrigation Service and coordinated by the Irrigation and Drainage staff member of the Authority. However, traditionally O & M has broken down at the level of the tertiary canal systems, principally because the operation and maintenance of these highly important features of the system has been the responsibility of the individual farmers. Improper handling of this responsibility is not necessarily due to a lack of enthusiasm on the part of the individual farmers, but rather it is more often due to a lack of training on how to carry out these functions as well as a chronic shortage of funds to enable them to perform even the more rudimentary repair jobs.

In order to overcome these inherent difficulties that plague the proper O & M of irrigation systems at the water application level, it is suggested that in every subproject at least one demonstration irrigation plot be established. The Agriculture Extension Service of the Ministry of Agriculture would be asked to assume the responsibility for the management of these demonstration areas and to carry out short-term on-farm training courses for the local farmers. The objectives would include not only the training in proper maintenance methods, but also the proper application of irrigation water in order to obtain optimum benefits from a minimum amount of available water. These activities would be coordinated by the irrigation O & M staff member of the authority, who would also see that all participating farmers would be well informed as to whom they should turn to seek further assistance, both technical as well as financial. As indicated on Plate VI-2, an agricultural credit bank accessible to the local small farmer would be an integral part of the O & M scheme. Also, any funds generated by the Authority could be made available for tertiary maintenance work when needed.

ORGANIZATION CHART
CITANDUY BASIN DEVELOPMENT AUTHORITY



TYPICAL ORGANIZATION CHART FOR IRRIGATION SYSTEMS

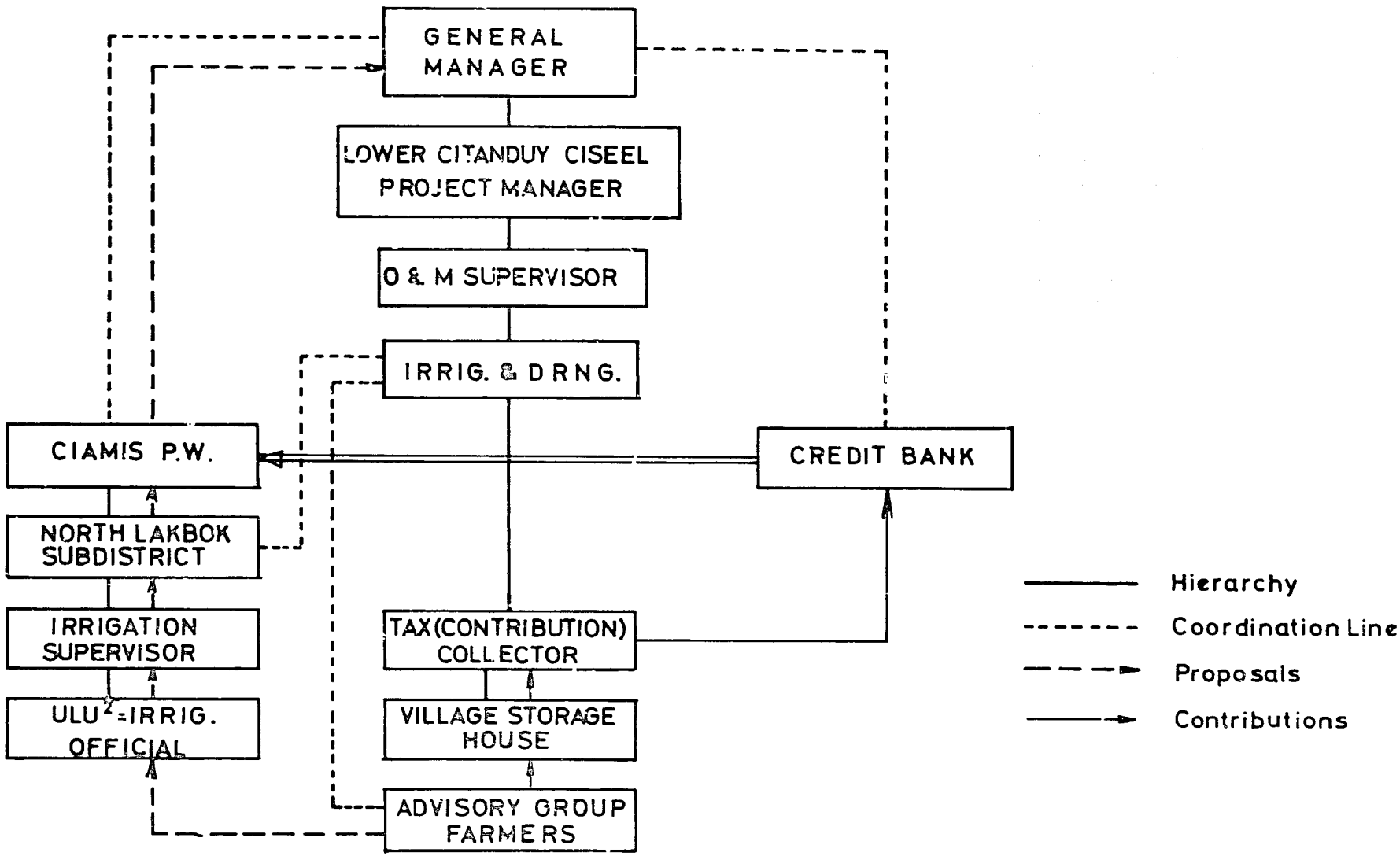


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PLATE VI-2

A.M.

CHAPTER VII

CONSTRUCTION SCHEDULING AND CASH FLOW

Construction Schedule

Plate VII-1 has been prepared to show the scheduling recommended for all the component parts of the proposed development program for the Citanduy River Basin Project. The respective costs and the cash flows are shown on following pages.

Comprehensive Water Management Scheme for the Lower Citanduy/Ciseel River System

For this top priority project, it is recommended that the engineering and preconstruction activities be started immediately and that they be planned for completion within two years. At the end of the first year it is estimated that the plans and specifications will be far enough advanced to allow the initiation of construction work on all phases of the subproject. Drainage rehabilitation is scheduled for completion within four years, while both irrigation rehabilitation and new construction as well as flood control work is scheduled for completion over a period of five years.

For Matenggeng Dam, the engineering and preconstruction work has been programmed over a period of 2 years starting in 1981. Construction work is scheduled for completion in four years starting in 1983.

Reclamation of the Segara Anakan and Its Environs

For reasons explained elsewhere, the design and preconstruction activities for this subproject, even though recommended for immediate initiation, will be spread over a period of six years. Initiation of construction is scheduled for the year 1977 and for completion within 10 years.

Comprehensive Water Management Scheme for the Upper Citanduy/Ciseel River System

As explained elsewhere, the balance of the work contemplated forthe project area has been lumped under this heading for management and scheduling convenience. The land management demonstration areas have been scheduled for implementation as quickly as possible. This program is presently scheduled to run over a period of five years.

The design and preconstruction work for both the new irrigation as well as the rehabilitation work has been scheduled for 1981, with construction spread over a period of four years. Since the successful implementation of the Cihaur Irrigation system depends upon scheduled improvements in drainage, the implementation of this project is not foreseen until at least 1985.

Cash Flow

The expenditure of construction funds for the subprojects scheduled in Plate VII-1 is shown on Table VII-1. Operation and maintenance costs, which will start slow at the beginning of the project and then increase to a set annual figure

thereafter, are shown on Table VII-2. For convenience, the costs were not carried past the end of this century, even though the life of the project will extend well past this date. A complete summary of both construction costs and operation and maintenance costs is shown on Table VII-3. Again, for the sake of convenience, the total cost table does not extend past the end of this century.

Domestic and Foreign Currency Requirements

The domestic and foreign currency requirements for each of the subprojects and for the total plan of development are shown in Table VII-4. There are some very minor discrepancies in the conversion from U.S. dollars to Rupiahs because of rounding. The total cost of the Citanduy River Basin development is Rp. 19,680 millions ($47.5 millions) of which approximately 36 percent or Rp. 7,152 millions ($17.3 millions) would be in foreign exchange and 64% or Rp. 12,528 millions ($30.2 millions) could be in the domestic currency.

Table VII-1

Schedule of Construction Costs for Citanduy Basin Development Project

(Millions of Rupiahs)

Year	Subproject						Total Costs
	Lower Citanduy/Ciseel			Segara Anakan	Upper Citanduy/ Ciseel	Central Java Areas	
	Flood Control	Irrigation and Drainage	Matenggeng Dam				
1975	81.75	43.61		220.70			346.06
76	1,062.74	543.70		220.70	168.88		1,996.02
77	980.99	354.07		3,641.28	168.88		5,145.22
78	784.79	442.44		3,549.12	168.88		4,945.23
79	588.59	496.15		1,331.52	168.88		2,585.14
1980	588.59	300.57		1,362.20	168.88		2,420.24
81			971.47	602.88	11.18	7.86	1,593.39
82			1,637.63	29.76	100.46	70.26	1,838.11
83			6,217.46	27.84	178.56	149.04	6,572.90
84			7,605.28	24.00	178.56	188.16	7,996.00
1985			10,380.91	16.32	90.24	187.20	10,674.67
86			6,217.46	7.68		186.24	6,411.38
87						123.84	123.84
88						62.40	62.40
89							
Total	4,087.45	2,180.54	33,030.21	11,034.00	1,403.40	975.00	52,710.60

Table VII-2

Schedule of O & M Costs for Citanduy Basin Development Project
(Millions of Rupiahs)

Year	Subprojects: Lower Citanduy/Ciseel: Flood Control	Lower Citanduy/Ciseel: Irrigation & Drainage	Lower Citanduy/Ciseel: Matenggeng Dam	Segara Anakan	Upper Citanduy/Ciseel	Central Java Areas	Total Costs
1975							
76							
77							
78		42.00					42.00
79	79.07	42.00		41.40			162.47
1980	158.15	56.67		124.20			339.02
81	237.22	89.32		207.00			533.54
82				269.10			595.64
83				300.15			626.69
84						10.35	637.04
85					10.86	20.70	658.25
86					21.72	31.06	679.47
87			66.24		32.58	39.74	765.25
88						48.42	773.93
89						57.10	782.61
1990							782.61
91							782.61
92							782.61
93							782.61
94							782.61
95							782.61
96							782.61
97				925.70 1/			1,408.16
98				925.70			1,408.16
99				925.70			1,408.16
Total	4,744.40	1,837.75	861.12	7,620.90	456.12	778.37	16,298.66

1/ Increase due to dredging costs if Nusawuluh weir is not closed.

Table VII-3

Schedule of Total Costs for Citanduy Basin Development Project
(Millions of Rupiahs)

Year	Subproject: Lower Citanduy/Ciseel: Flood Control	Lower Citanduy/Ciseel: Irrigation & Drainage	Lower Citanduy/Ciseel: Matenggeng Dam	Segara Anakan	Upper Citanduy/Ciseel	Central Java Areas	Total Costs
1975	81.75	43.61		220.70			346.06
76	1,062.74	543.70		220.70	168.88		1,996.02
77	980.99	354.07		3,641.28	168.88		5,145.22
78	784.79	484.44		3,549.12	168.88		4,987.23
79	667.66	538.15		1,372.92	168.88		2,747.61
1980	746.74	357.24		1,486.40	168.88		2,759.26
81	237.22	89.32	971.47	809.88	11.18	7.86	2,126.93
82			1,637.63	298.86	100.46	70.26	2,433.75
83			6,217.46	327.99	178.56	149.04	7,199.59
84			7,605.28	324.15	178.56	198.51	8,633.04
85			10,380.91	316.47	101.10	207.90	11,332.92
86			6,217.46	307.83	21.72	217.30	7,090.85
87			66.24	300.15	32.58	163.58	889.09
88						110.82	836.33
89						57.10	782.61
1990							782.61
91							782.61
92							782.61
93							782.61
94							782.61
95							782.61
96							782.61
97				925.70			1,408.16
98				925.70			1,408.16
99				925.70			1,408.16
Total	8,831.85	4,018.29	33,891.33	18,654.90	1,859.52	1,753.37	69,009.26

Table VII-4

Domestic and Foreign Currency Requirements

Item	Domestic Currency		Foreign Currency		Total Cost	
	Rupiahs millions	Dollars thousands	Rupiahs millions	Dollars thousands	Rupiahs millions	Dollars thousands
Water Management Scheme for the Lower Citanduy/Ciseel River System:						
Flood Control (25-year protection)	3,757	9,078	330	796	4,087	9,874
Rehabilitation of Existing Irrigation Systems	836	2,018	172	415	1,008	2,433
New Irrigation Systems	780	1,883	100	241	880	2,124
Major Drainage Improvements	254	614	39	95	293	709
Subtotal	5,627	13,593	641	1,547	6,268	15,140
Reclamation of the Segara Anakan and its Environs:						
Major Structures	2,105	5,084	4,253	10,273	6,358	15,357
Irrigation - Drainage	894	2,160	658	1,589	1,552	3,749
Land Filling	1,056	2,551	1,180	2,850	2,236	5,401
Other 1/	889	2,148	--	--	889	2,148
Subtotal	4,944	11,943	6,091	14,712	11,035	26,655
Water Management Scheme for the Upper Citanduy/Ciseel River System:						
Rehabilitation of Existing Irrigation Systems	446	1,077	112	271	558	1,348
Water Management Program	682	1,648	162	391	844	2,039
Subtotal	1,128	2,725	274	662	1,402	3,387
Water Management Scheme for Balance of Project Area:						
Rehabilitation of Existing Irrigation Systems	314	758	79	191	393	949
New Irrigation Systems	515	1,244	67	162	582	1,406
Subtotal	829	2,002	146	353	975	2,355
TOTAL	12,528	30,263	7,152	17,274	19,680	47,537

1/ See item listing in Table IV-19.

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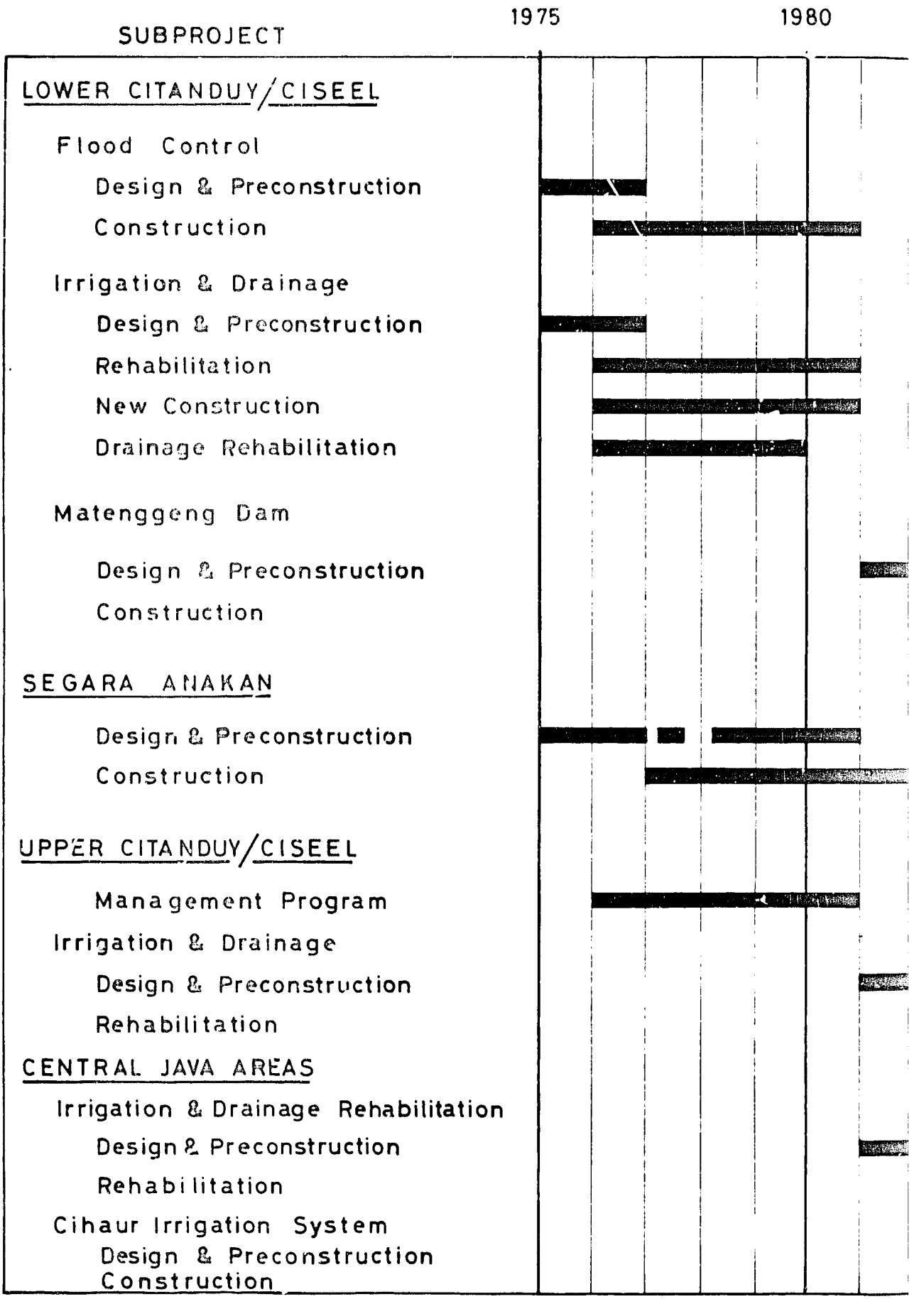
CONSTRUCTION SCHEDULE FOR C



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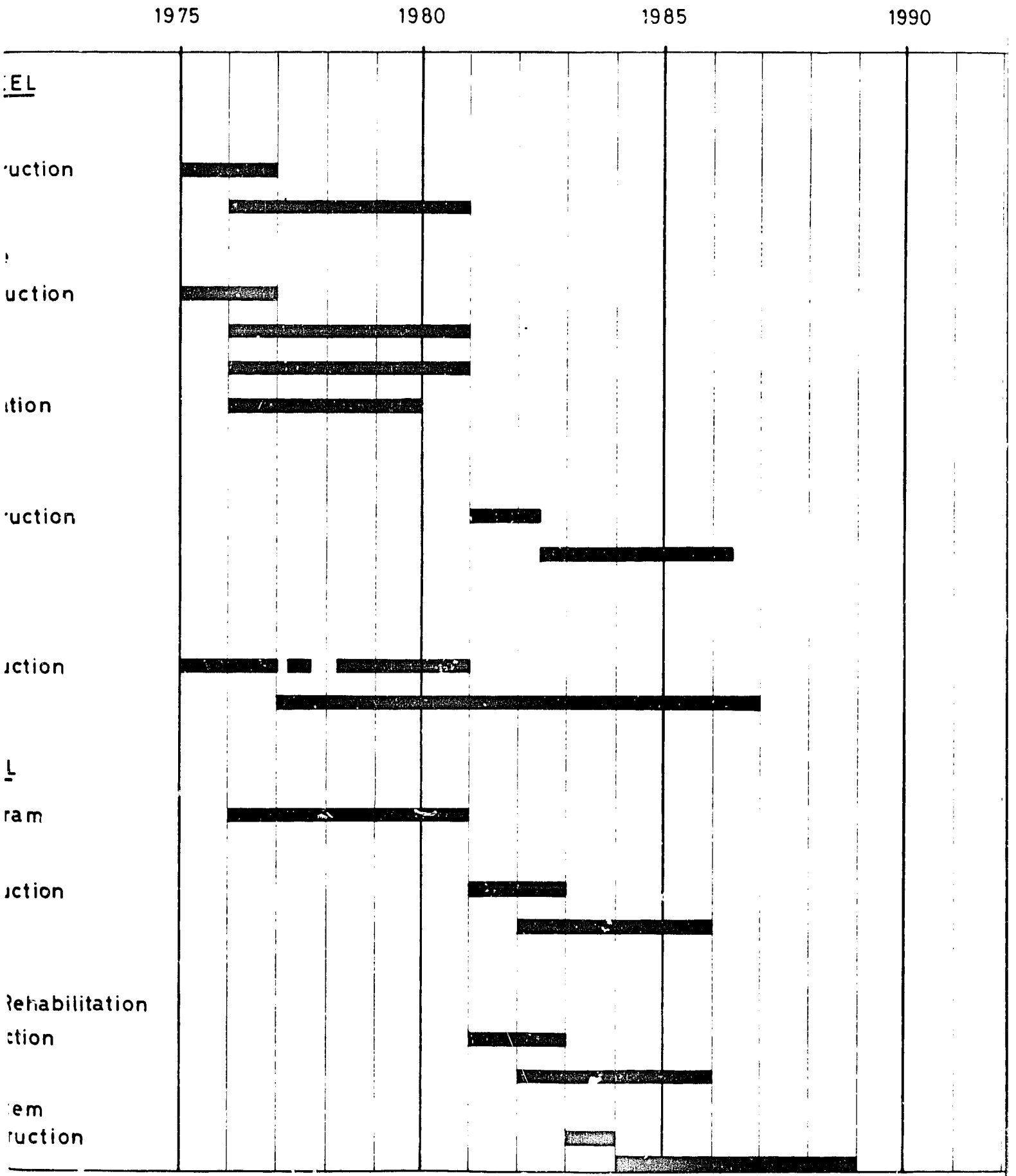
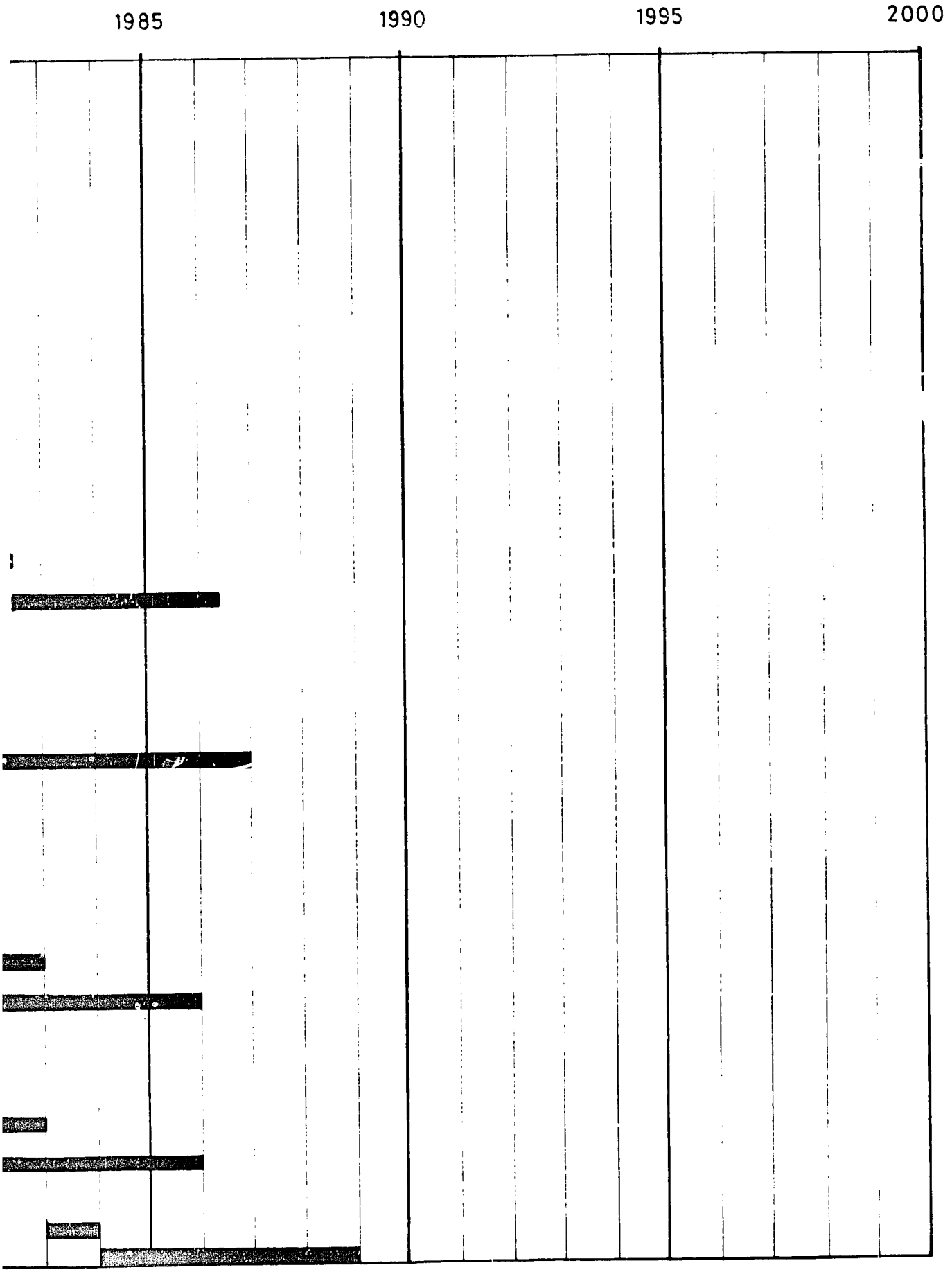
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