REPUBLIC OF INDONESIA

FLOOD CONTROL PROJECTS IN NORTH SUMATRA

FEASIBILITY STUDY ON THE ULAR RIVER, RECONNAISSANCE ON THE TANAH ITAM ULU ESTATE, THE BOLON RIVER (SIPAREPARE, TANDJUNG, GAMBUS), AND THE SILAU/ASAHAN RIVER

MARCH 1971

PREPARED FOR
OVERSEAS TECHNICAL COOPERATION AGENCY
GOVERNMENT OF JAPAN
BY
NIKKEN CONSULTANTS, INC.

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UNITS CONVERSION RATES, ABBREVIATIONS AND ACRONYMS

Currency Equivalents 1 US$ = Rp 378

Weights and Measures (Metric System)

1 metric ton = 1,000 kilograms
= 2,205 pounds
1 kilometer = 0.62 miles
1 meter = 3.28083 feet
1 millimeter = 0.04 inches
1 hectare = 2.47 acres
1 square kilometer = 0.386 square miles

Abbreviation

ton = metric ton
kg = kilogram
lb = pound
km = kilometer
m = meter
mm = millimeter
ft = foot
in = inch

Initials and Acronyms

DPUTL: Departmen Pekerdjaan Umum Dan Tenaga Listrik
(Department of Public Works and Power)
DPUPSU: Dinas Pekerdjaan Umum Propinsi Sumatera Utara
(Department of Public Works, North Sumatra Province)
DPPSU: Dinas Pertanian Propinsi Sumatera Utara
(Department of Agriculture, North Sumatra Province)
PNP: Perusahaan Negara Perkebunan
(Government-owned Estate Enterprise)
BCU-PNP: Badan Chusus Urusan PNP
(Special Arrangement Agency for PNP)

RISPA:	Research Institute of the Sumatran Planters Association (the former name AVROS)
BAPPENAS:	An Organization in National Economic Planning and Development Board, Indonesia
IBRD:	International Bank for Reconstruction and Development
IDA:	International Development Association
ADB:	Asian Development Bank
ECAFE:	Economic Commission for Asia and the Far East
OTCA:	Overseas Technical Cooperation Agency, Japan
ECFA:	Engineering Consulting Firms Association, Japan
IRRI:	International Rice Research Institute

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24.61	25.91
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INTRODUCTION

This is the final report on the study of the survey team in Indonesia which was organized and dispatched by the Overseas Technical Cooperation Agency, Japan at the request of the Government of Indonesia.

The aim of the survey team was, as agreed by the Government of Indonesia and the Government of Japan, to make a study of the flood control of the rivers in North Sumatra, with emphasis upon the Ular River.

The survey team was composed of the following six experts:

Dr. Seiichi Sato	Head	Managing Director, NIKKEN Consultants, Inc.
Toshiro Homma	Adviser	Head of Urban River Improvement Division, River Bureau, Ministry of Construction.
Dr. Haruo Waki	River planning	Deputy Director, Nippon Koei Co., Ltd.
Sumihisa Ohira	Designing	Managing Director, Tokyo Construction Consultants Co., Ltd.
Kinichi Ohno	Economic survey	Planning Engineer, NIKKEN Consultants, Inc.
Katsuhisa Abe	Hydrology	Chief of Technical Section, CTI Engineering Co., Ltd.

After five day's discussion with the Directorate General of Water Resources Development, the survey team was in North Sumatra for twenty seven days during which time it made extensive field trips to inspect various sites and had frequent meetings for discussion with the engineering staffs of the Dinas Pekerdjaan Umum Propinsi Sumatera Utara.

During stay in Medan, the team was requested by Ir. Sudarjoko, Director of River, Directorate General of Water Resources Development (Direktorat Djendral Pengairan), Ministry of Public Works and Power (Departmen Pekerdjaan Umum dan Tenaga Listrik) to survey the rehabilitation project of Perkebunan (estate) Tanah Itam Ulu and by Ir. Sipahutar, Kepala Dinas Pekerdjaan Umum, Propinsi Sumatera Utara to survey the rivermouth dredging project of the

Silau/Asahan river. This report includes the findings on these two projects and the Bah Bolon river as well as the study of the Ular river. The locations of these projects are shown in Fig. 1 and 2.

A provisional report was made in Djakarta and forwarded to Ir. Sujono Sosrodarsono, Director General for Water Resources Development, and after coming back to Japan, the final report was made in Tokyo with some adjustment and modification.

The survey team wishes to express its gratitude to Ir. Sujono Sosrodarsono, General Director of Water Resources Development, Ir. Nainggolan, Assistant Director General, Ir. Sudarjoko, Director of River, Ir. Boesono, Director of Planning & Programming and Ir. M. Sipahutar, Kapala Dinas Pekerdjaan Umum Propinsi Sumatera Utara, Ir. Kasim Siregar, Kepala Bahagian Perairan, Dinas PUPSU, for their gracious reception, sponsorship and encouragement.

For valuable information as well as explanation in addition to whole-hearted cooperation, the survey team is deeply indebted to Mr. Sukanto, Assistant Director of Programming, DPUTL, Ir. Kusdarjono, Chief of River Division, Ir. Bambang Sumantri, Assistant to Director of River, Drs. H. Attamimi, Assistant Programming Officer, Ir. A. Situmorang, Kepala Rehabilitasi/Pembaungunan Sungai/Rawa, DPUPSU, Ir. Limbong, Kepala Tehnik, Ir. G. Harahap, Kepala Rehabilitasi/Pembaungunan Irigasi, Ir. H. Siahaan, Kepala Projek Chusus Pengerukan, Mr. Nainggolan, Mr. A. Gultom, Mr. B. Tampubolon, Mr. Murtolo, Chief Engineer of Port Belawan, Mr. Maman Salman, PN-Perkebunan VI, Mr. M. Barus Siregar, Assistant Wedana Ketjamatan Air Putih, Kab. Asahan.

Lastly the team wishes to convey its appreciation to the Embassy of Japan in Djakarta and the Consulate of Japan in Medan for their instructions and kind cooperation.

Fig. I   Location Map (I)

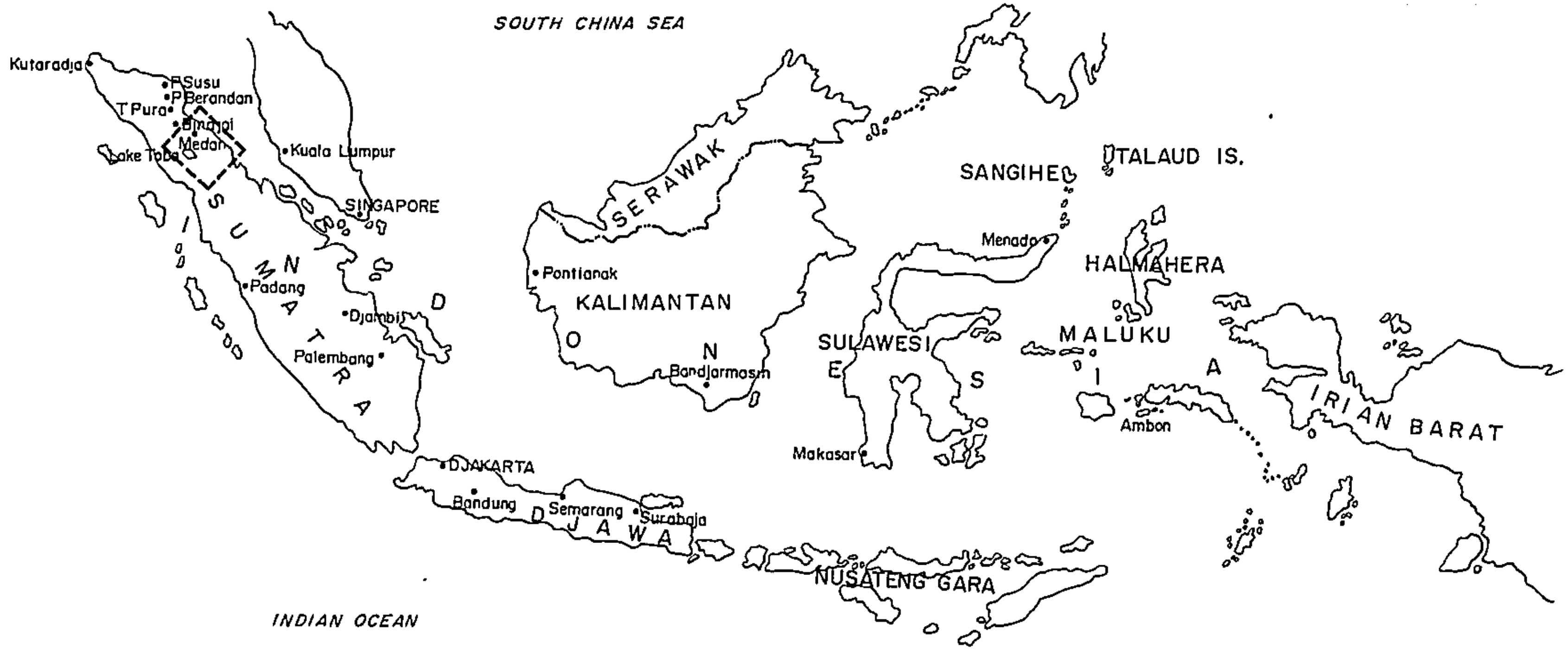
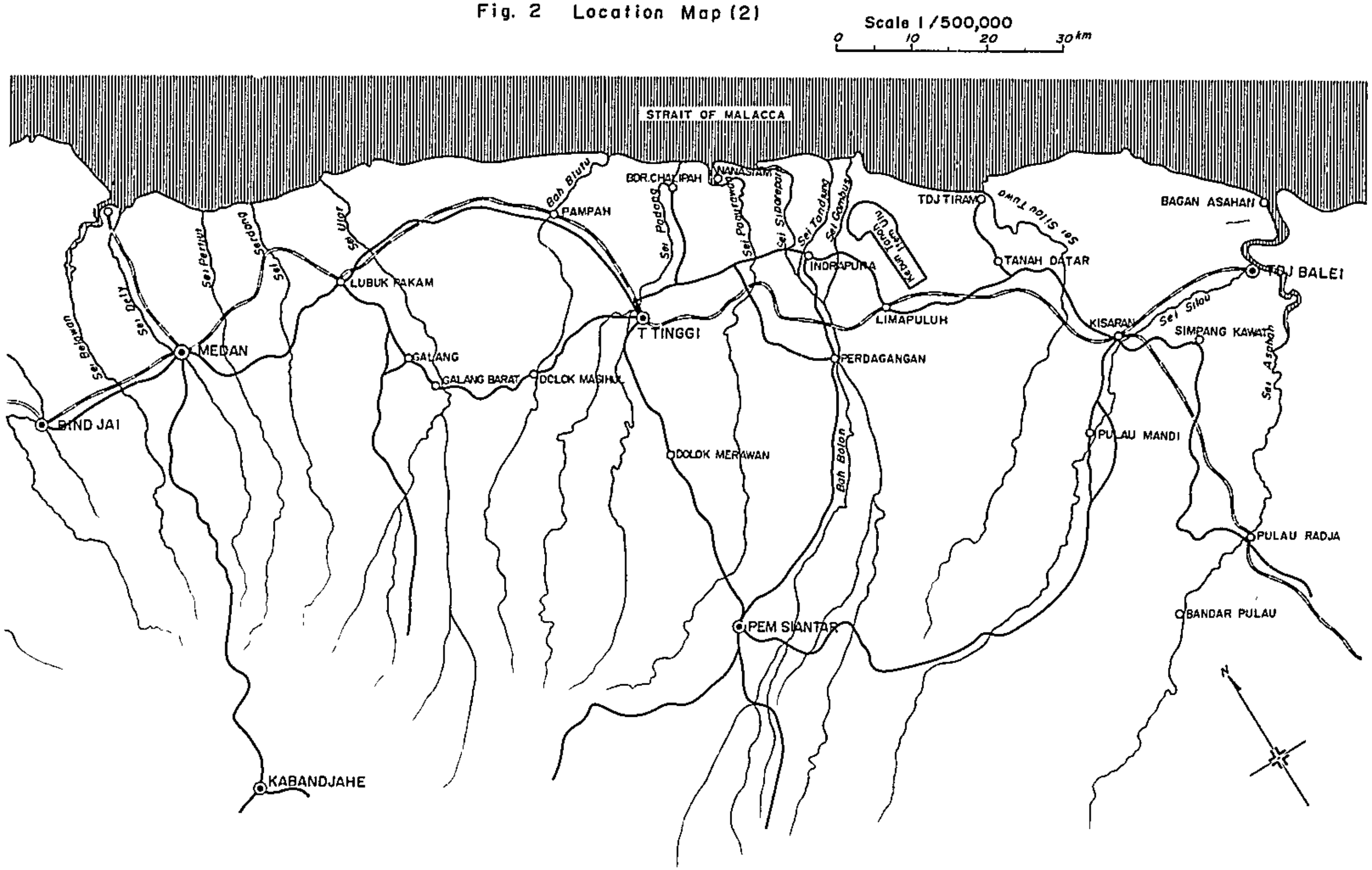


Fig. 2 Location Map (2)



PART 1

URGENT FLOOD CONTROL PROJECT
OF
THE ULAR RIVER

CHAPTER I

SUMMARY

Sumatra is the second largest island next to Kalimantan in Indonesia and covers an area of 473,606 km^2 including that of islands around it. The island of Sumatra lies in the direction of northwest and southeast within an extent ranging between about ±5° respectively from the equator and the 110th degree of east longitude, with its northwest coast abutting on the Strait of Malacca and its northeast coast on the Indian Ocean. Its land facing the Indian Ocean constitutes a mountainous district traversed by the Barisan mountains, while the part facing the Strait of Malacca is flat lowlands. The geology of the mountainous district is of pre-tertiary rocks accompanied with igneous rocks; on the other hand, the lowlands consisting of mud and sand include fertile arable land and swamps.

The climate of Sumatra is tropical and the monthly mean temperature is about 27°C though differing somewhat in different localities with the variation of only about 2°C through-out the year. The annual mean rainfall depth is about 2,300 mm showing greater depth in the mountainous district and smaller depth in the flat land. The rainy season continues in general from September to January and the dry season is from April to June, though differing somewhat in the southern and northern parts of Sumatra.

Sumatra not only abounds in rich mineral resources such as oil, bauxite, and tin but has a great productivity in its tropical agriculture, forestry, and fishery. Among others, the plantation products including palm oil, rubber, tobacco, coffee, and cocoa are the important export goods of Indonesia and, together with oil, play a vital role in acquiring the foreign currency. Rice is as well an essential agricultural product which constitutes the food resource of inhabitants.

Sumatra has a population of about 19,000,000 and is divided into eight provinces. North Sumatra Province being situated at the approximate north end of the island has an area of 70,788 km^2 and a population of 5,914,000 which represents the highest density of population in Sumatra. This Province constitutes the most important area in Sumatra seeing from the political, industrial, and communication aspects.

The principal elements of agriculture in Sumatra are plantations and paddy cultivation. Among the former the government-owned estate has an area of about 200,000 ha; the rice fields and up-land rice fields cover an area of about 500,000 ha. Also there are about 2,200 km in total length of the national, provincial, and other roads.

The main constituent of plantations in Indonesia is the government-owned plantations which are divided into twenty-eight PNP's distributed in the whole country; of which ten PNP's are in Sumatra including eight PNP's in North Sumatra. In these plantations are produced palm-oil, rubber, tobacco, coffee, cocoa, and tea. The productions comprising only palm oil, rubber, and tobacco amount to 394,500 tons per annum, or US$ 106,080,000 in value, according to the statistics for 1967.

Except those mentioned above, the ordinary agricultural products in North Sumatra include rice, maize, sweet potato, peanut, and soybean, among which rice is the most important product. The statistics for 1967 show that the demand for rice in North Sumatra was 172,000 tons, while the supply to meet it was only 146,000 tons in total made up of 60,000 tons from own province, 24,000 tons aquired from Atjeh Province, 35,000 tons provided as the government aid and 27,000 tons imported from abroad. This indicates not only that North Sumatra Province cannot attain self-sufficiency with regard to rice but that there is the basic shortage of rice as a whole.

Although it is a small river with about 1,000 km^2 of basin, the Ular river flows through the approximate center of the most important agricultural district in North Sumatra. Its river basin stretches over both of Simalungun Prefecture and Deli/Serdang Prefecture where Medan, the capital city of North Sumatra, stands. Plantations and paddy fields are well developed in and around the basin.

The Buaja river and the Denai river which have nearly the same area of basin join at the point about 40 km upstream from the estuary to form the Ular river. The area of basin at this point is about 1,000 km^2; as the river channel downstream from this point has continuous dikes on its both banks with no tributary flowing in it, the area of basin downstream from this point is the area of the river channel itself.

The national road and the railway traversing Sumatra cross over the river at the point 13.6 km upstream from the estuary.

Originating in the somma of Lake Toba and its adjoining plateau of about 1,200 m in elevation, the Ular river flows to the northeast gathering the water from numerous small streams and empties itself into the Strait of Malacca at the point about 30 km to the east from Medan.

The total length of the river is 115 km and the slope of river channel downstream from the confluence of the aforementioned two rivers varies between 1/700 and 1/1,000. In the rainy season squally rainfall continues every day with the river gradually rising and heavy rainfall visiting sometimes falls on it to cause a flood. The district inundated with flood is that downstream from the town of Galang situated about 35 km upstream from the estuary and its area amounts to more than 25,000 ha. Moreover, such inundation repeats almost every year and sometimes even several times in the year leading to a huge amount of damages.

The district where is habitually inundated with flood of the Ular river is richly cultivated with plantation crops and rice. In this district there are several government-owned plantations including PNP II-11, II-12, IV-2, VI-1, IX-9, and IX-13, of which area is about 175,000 ha in all, where palm-oil, rubber, and tobacco are produced in the main. The paddy field covers an area of about 15,000 ha.

The damages caused by the flooding occurring almost every year are estimated to reach a huge sum of Rp 182,000,000 a year on the average putting together those on the plantations, rice, and agricultural production other than rice with those on roads, railway, dikes, bridges, canals, irrigation facilities, houses, livestock, and others. Excluding those due to the impounding water on the inland, the amount of damages caused solely by the flooding of the Ular river is estimated at about Rp 168,000,000 per annum on the average. If, in addition to this, an allowance is made for the interferrences with the social and economic activities due to the traffic stoppage, the impairment of the dwellers' health from the stagnation of flood water and other damages which cannot be calculated directly in money terms, the total amount of damages due to the flooding of the Ular river would be really enormous. Therefore, it cannot be concluded but that the flood control of the Ular river is an urgently needed project.

As described in the Project Presentation for Dredging Works in Indonesia, it was thought, at first, that the flooding of the Ular river is caused by the rise in river water level due to the deposition of silt at the estuary. However, it was concluded as a result of the study made on the data supplied to us from the Indonesian Government that the flooding of the Ular river is attributable mainly to the abnormally raised riverbed on the upstream reaches of the Ular bridge (road bridge). That is, it was found that there are some places raised locally in the riverbed extending around the point about 18.7 km upstream from the rivermouth and consequently the carrying capacity on the reaches is extremely diminished. Thus it was judged that such rising in the riverbed induces overtopping of river water or destruction of dike causing inundation over the downstream land. This agrees with the fact that, in the past, the overtopping or destruction of dike occurred mainly in the upper stream of the Ular bridge, especially on the reaches between 18.7 km and 24.5 km. Therefore, the fundamentals of the flood control for the Ular river are to lower the abnormally raised riverbed in question to secure the needed sectional area of river and carrying capacity.

It is believed that the improvement project of the Ular river should be examined primarily as a part of the comprehensive river programme including not only flood control but forestry conservation, water-utilization, and land development; though the importance will be attached to the improvement of the upstream reaches of the Ular bridge as the first stage of emergency flood control in compliance with the policy of the present five-year plan which is aimed at the rehabilitation of devastation.

The sedimentation of silt at the estuary is, of course, a problem never to be overlooked. However, based on the facts that such deposition is judged to have a direct influence only on the reaches of about 3 km upstream from the rivermouth and that some rivermouth facilities at great cost will be evidently necessitated to maintain a new channel opened by dredging at the rivermouth, it was decided not to include the dredging of estuary in the emergency flood control project as the first stage.

On the other hand, it was revealed that the carrying capacity of river is more adversely affected by the Ular bridge and the railway bridge crossing the river at the point 13.6 km from the estuary. It is because the ordinary river width of 250 m - 300 m is constricted to only 64 m at this point by the cross embankments of both road and railway traversing the high-water channel.

Although the elimination of the constriction due to the Ular and railway bridges is one of the important works which must be carried out for the improvement of this river, it was decided not to include it in the present emergency flood control project as it was judged that the execution of such work will require a careful preparation and a huge sum of cost.

It is expected that the design discharge of the Ular river will be fixed probably at some value between about 1,300 m^3/sec and about 2,300 m^3/sec. In the present emergency flood control project, it was decided to adopt, as a provisional design discharge, the maximum discharge which is considered to be able to flow through the points of the bridges without causing much damage to the river channel or the bridges which will remain as they are. This discharge is estimated at 600 m^3/sec.

Based on the policicies described above, the plans were made for the excavation and dredging of river channel, the heightening and strengthening of dikes, and the setting-back of dikes on the reaches where the river width is especially narrow. The total cost for these plans are Rp 800,000,000 including the purchase cost of needed equipments and materials and the engineering expenditures. When the residual value of equipments at the time of the completion of works is deducted from the above amount, the net cost for these plans will be about Rp 650,000,000. The details of the costs are shown in Table 1-6-3 in Chapter VI. The construction period is expected to take two and half years and two years is to be allowed for the necessary preparation of working plans and other before the starting of works, as shown in Table 1-6-5 of Chapter VI.

In general, the economic effects of a flood control project comprise the direct and indirect ones. In estimating the benefits to be derived from the present project, the effects such as alleviation of damage on property and prevention of decrease in production among the direct effects will be used. As mentioned previously, the amount of these benefits is estimated at Rp 168,300,000 a year on the average. These benefits are to be received starting from the year following that in which the project completed and, on the other, the maintenance cost of about Rp 925,000 is to be expended starting from the same time. Then, as shown at the end of Chapter VII, the benefit-cost ratio is 2.4 if the discount rate is presumed at 3.5 % on the period at 20 years and the internal rate of return is 15.3 % if the period is presumed at 20 years. Seeing from these values it can be concluded that the present urgent flood control plan is sufficiently·profitable.

Lastly, it is recommended to consider the following matters as the future problems.

(1) Since the constriction of river channel by the Ular and railway bridges will constitute a weak point when the present emergency project for flood control has been executed, it is required to perform another work for eliminating the constriction in question following to the present emergency project, in parallel with a full-scale study of design flood discharge. In this, it is needed, as a matter of course, to strengthen the dikes so as to meet the design flood discharge.

If the determination of design flood discharge is delayed, the above constriction by the two bridges alone should be eliminated following to the present emergency project. This may be the second best policy.

The elimination of the constriction by the bridges requires a careful investigation which is especially desired to be made before the completion of the present emergency project.

In particular, it is necessary to conduct a careful examination of the existing foundations of the piers and abuttments.

(2) At present, the river dikes are under the management both of the public service agency and the government-owned estates. As this practice is not desirable from the viewpoint of river regulation, their functions should be intergrated to form a unified managing organization.

(3) The present emergency project contemplates to establish six rain gage stations and three water level stations to obtain the hydrological data. These facilities should be provided by all means and their controlling organization be established as well.

(4) It is necessary to investigate the production of silt and sand in the headwaters as well as the sediment transportation into the reaches of the present project in order to study the future raising of riverbed. Furthermore, it is desirable to survey the topography around the estuary every certain period of time.

CHAPTER II

BACKGROUND OF PROJECT SITE

1. General

Indonesia is an archipelago composed of about 3,000 big and small islands which are located between the Pacific and Indian Oceans. It has an area of about 1.9 million km^2 and a population of about 115 - 118 million. The grcwth rate of population at present is estimated at about 2.4 - 2.5 % per annum. GNP of the Republic of Indonesia is estimated at about US$ 80 to 90 per capita.

Sumatra is the second biggest island in Indonesia, next to Kalimantan/1. It has an area of 473,606 km^2 including the areas of surrounding islands.

Sumatra island runs in the direction from north-west to south-east between the Malacca Strait and the Indian Ocean with the mountain ridges close to the Indian Ocean side, and the broad alluvial plains bordering on the Malacca Strait side. Owing to such topography, rivers in Sumatra form rather steep slopes towards the Indian Ocean, but the rivers gently meander with many marshy lands and jungle areas on the plains on the Malacca Strait side.

Geologically, Sumatra island is covered with pretertiary rocks with igneous rocks in the mountain areas and with fertile volcanic and silty soils on the alluvial plains.

The climate of Sumatra is tropical, as it is located at the equator. Mean temperature is about 27°C varying from 26°C to 29°C according to the location. Hottest months are from April to June. Rainy season is from September to January, and dry season is from February to August. Annual mean rainfall is 2,333 mm which varies considerably from high values in the mountain areas to low values in the low lands.

Sumatra is composed of 8 provinces with a total population of 19 million,

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/1: Area of Kalimantan is 539,460 km^2

of which North Sumatra province has an area of 70,787 km^2 and the most dense population of 5,914,000 in Sumatra.

Sumatra has not only an abundant mineral resources such as petroleum, bauxite, tin, etc., but also a large potential resources of tropical agriculture, forestry and fisheries. For this reason Sumatra is called as a treasure island of Indonesia. Farming in Sumatra is composed of estate plantations and general agriculture by the inhabitants. North Sumatra has estate plantation of about 200,000 ha, paddy and upland field of about 500,000 ha, existing roads composed of national highway, provincial and prefectural roads of about 2,200 km in total length.

2. Plantations

In Indonesia, estate plantations have developed since the beginning of 20th century, being blessed with fertile soils and abundant rainfall. They produced roughly 60 % of exports in Indonesia before the war. However, the production from the plantations have decreased to 15 - 20 % of the exports in Indonesia in 1964. The area of estate plantations have also decreased from 2,500,000 ha in 1940 to 1,700,000 ha in 1961 owing to the devastation after the war. The area of plantations in Sumatra accounts for about 60 % of the total area of plantations in Indonesia. Out of 28 PNP plantations in Indonesia, 10 are in Sumatra. The plantations at present are composed of the Government-run, the Province-run, and private and foreign enterprises.

In addition, there are about 200,000 ha of small-holder rubber and substantial areas of virgin jungle. On the other hand, some of the areas of estate plantations have been occupied by illegal squatters. Furtheremore, the devastation of rivers without proper treatments for long years has caused big flood damages to the plantations and infrastructures resulting in decrease of production.

The estate sector in Sumatra in 1969 is as follows:

	Rubber (ha)	Oil-palm (ha)	Tobacco (ha)	Other (ha)	Total (ha)
Government-owned (1969)					
Atjeh					
PNP I	11,551	2,078	-	119,562 *1	133,191
North Sumatra					
PNP II	19,424	9,061	-	189 *2	28,674
PNP III	23,972	-	-	-	23,972
PNP IV	29,346	-	-	-	29,346
PNP V	25,777	959	-	-	26,736
PNP VI	-	32,220	-	570 *3	32,790
PNP VII	1,029	34,171	-	2,116 *4	37,316
PNP VIII	715	-	-	13,168 *5	13,883
PNP IX	-	-	4,282	-	4,282
Sub total/1	100,263	76,411	4,282	16,043	196,999
South Sumatra					
PNP X	16,547	2,037	-	739 *6	19,323
Total	128,361	80,526	4,282	136,344	349,513

Foreign-owned: about 90,000 ha

Jointly-owned: for rubber & oil-palm 30,000 ha

Private-owned: about 40,000 ha

The major productions of the plantations in North Sumatra are rubber, palm-oil and tobacco of which productions in 1967 are as follows:

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*1 pine and coffee, *2, *3 cocoa, *4 hard fibers, *5 cocoa and tea, *6 tea.

/1 The nine PNP's in Atjeh and North Sumatra sell all export produce through a Joint Marketing Office (JMO) with its headquarters in Medan.

	Production (ton)	Amount (US$ million)
Estate rubber	139,100	40.55
Private rubber	70,800	20.87
Palm-oil	141,300	25.44
Kernel oil	40,600	4.23
Tobacco*	2,700	14.99
Total	394,500	106.08

* Tobacco cultivated by people is less than 1 % of the estate tobacco and is omitted in the figure.

3. General Agriculture

Paddy,/1 maize, cassava, sweet potato, peanut, and soybean, etc. are cultivated generally in Sumatra besides the export production such as rubber, palm-oil, tobacco, tea, and coffee, etc..

In addition to the above, paddy is the most important. Present state of paddy in North Sumatra province is shown on the 5-year plan of the province as follows:

Paddy field	500,000 ha,	(only 25,122 ha is irrigated)
Annual production of rice	1,311,700 tons	
Shortage of rice	84,000 "	

The area is expected to be for two crops a year if well irrigated.

According to "Present situations in Sumatra", the situations of paddy and rice in North Sumatra are as follows:

/1 It is said that, at present, Indonesia produces 11,000,000 tons of polished rice from 7-8 million hectares (IRRI's data 6,738,000 ha in 1963) of paddy field and imports about 1 million tons of rice annually. Latest demand for rice is higher, because annual average consumption of rice per capita is 95 kg/person, though 160 kg/person is desired. Shortage of rice is supplemented with tapioca or maize.

(1) Paddy field (1968)

Paddy field	330,000 ha
Upland field	145,000 "
Paddy field reclaimed by the Military	3,105 "
Farmland reclaimed by estates	1,000 "
Total	479,105 ha

(2) Demand of rice (1967)

Demand	172,000 ton
Shortage	34,000 "
Supplied	146,000 "

(3) Supply for shortage of rice

Supplied by North Sumatra Province	60,000 ton
Imported	27,000 "
Procured Adjeh Province	24,000 "
Subsidized from the Central Government	35,000 "
Total	146,000 ton

North Sumatra produces vegetables of good quality a part of which is exported to Malaysia and Singapore.

CHAPTER III

GENERAL ASPECT OF THE BASIN

1. Topography

The Ular river basin stretches over both Deli/Serdang and Simalungun prefectures in North Sumatra province of which capital city is Medan. Medan has a population of about 726,300 as of end of 1968.

The Ular river has a catchment area of about 1,000 km² and river length of about 115 km. As seen in Fig. 1-3-1, the river originates in the mountains Bukit Barisan of about 1,000 - 1,200 m in elevation, uniting many small tributaries on the plateau near the towns of Seribudolok, Tjingkes, and Pem. Purba where the basin of Lake Toba divided.

The tributaries run down from the plateau in broom shape with a steep slope to Galang Barat (2.5 km south of Galang) where the Buaja river (main river) meets the Denai river and forms the Ular river. The Ular river further runs down for about 5 km in the north direction to Lubuk Pakam (the Ular bridge site) and further down about 15 km and reaches the rivermouth on the Strait of Malacca.

The river course is obviously divided into four parts shown in Fig. 1-3-2 according to the gradient. The first part, upstream of Tjingkes (about 97 km from the rivermouth), is a plateau which has a mean gradient of 1/250, the second part, downstream from Tjingkes to Gunung Meriah (about 75 km), is an undeveloped zone which has a very steep gradient of about 1/25 and is almost covered with natural forest. The third part, downstream from Gunung Meriah to Galang Barat (about 41 km), has a little gentle gradient of about 1/150 and the area around here are left undeveloped. The fourth part downstream of Galang has a mean gradient of about 1/800 and the area around here forms an arable land, where rice fields and plantations such as oil-palm, rubber, and tobacco are well developed, though some marshy area is left out of utilization.

The plateau of headwaters region is denuded by about 40 % of the total area of forest land, and remains as the natural devastated area, though only a

Fig. 1-3-1 Ular River

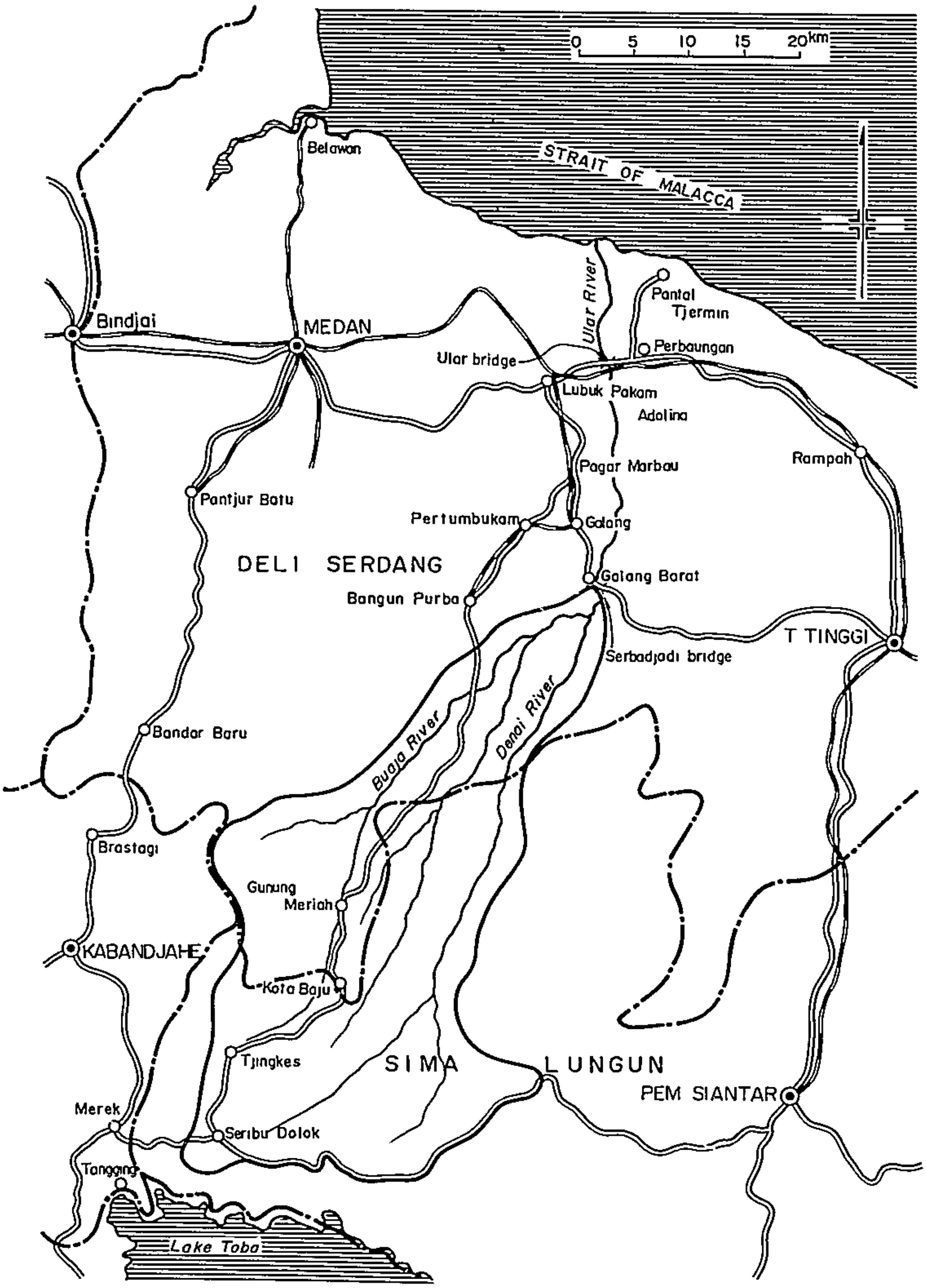
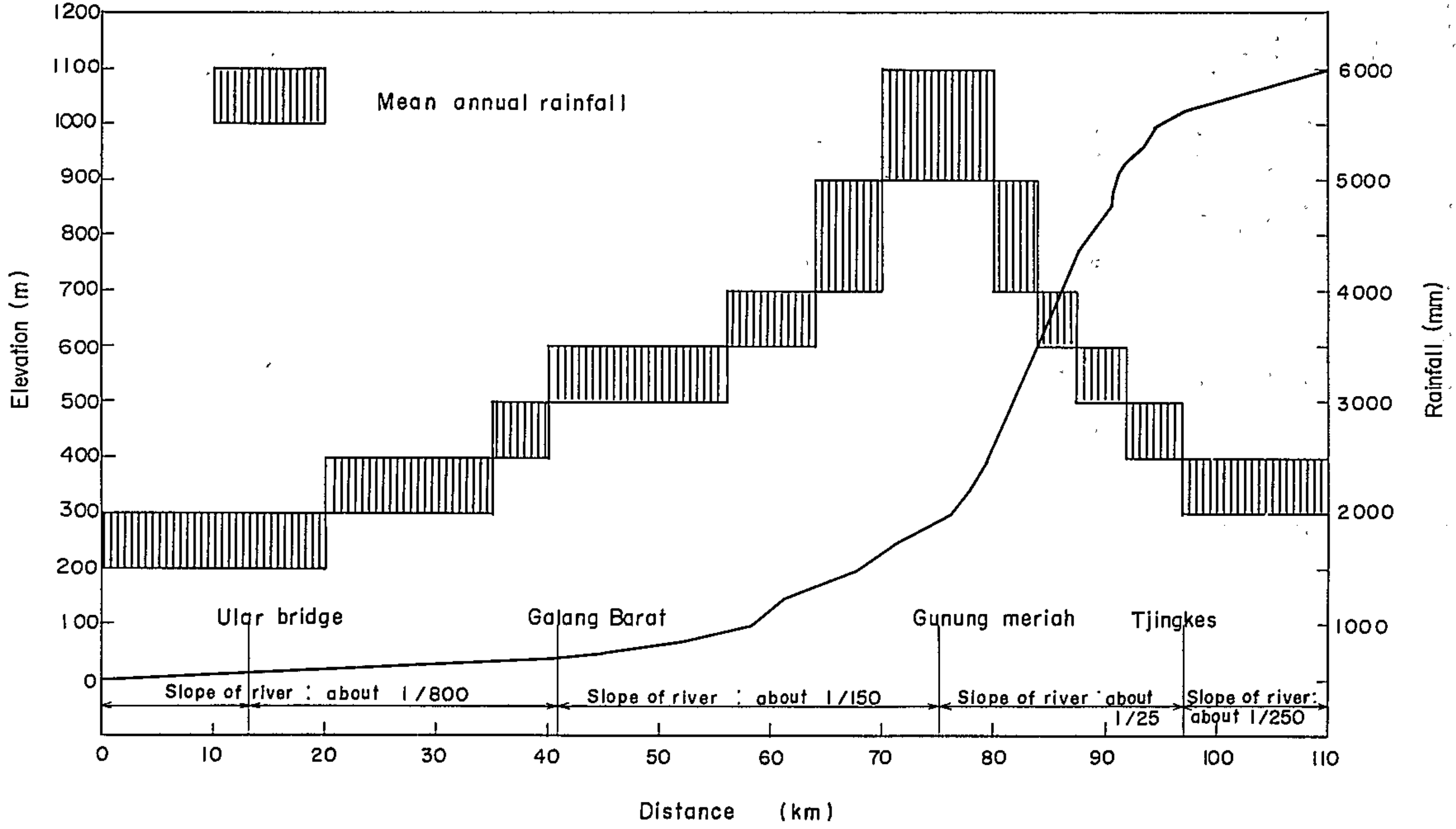


Fig.I-3-2 Profile of the Ular River



small area along the roads are cultivated for vegetables.

2. Geology

The upstream hilly area of the basin is formed of andesitic or liparitic efflusive rocks accompanied with pretertiary sedimentary rocks and the downstream plain is composed of alluvium. The geological formation of the hilly area consists of ignimbrites and underneath Paleozoic elements consisting of shale, sandstone, quartzite, and schist.

The surface soil of the headwaters region is derived from ignimbrites and weathered andesitic of liparitic efflusives which contain small soil particles of orange color mixed with comparatively large-grain quartz. The surface soil is easily decomposed into fine grains and coarse grains when met with water.

The decomposed fine grains are conveyed by water through the river to the estuary. The decomposed coarse grains deposit along the river course balancing natural river channel and flow conditions. No record of sediment load and aggradation of the river bed were available. The river bed materials sampled by our team were tested for specific weight, gradation, and acidity.

3. Rainfall and Tide

An effort was made to gather data on meteorology and oceanology/1 for the analysis of design discharge and the study of maintenance measures of rivermouth in the flood control plan of the Ular river. In conclusion, it was impossible to analyze phenomena such as run-off, littoral drift, etc., owing to insufficient data; however, some characteristics about rainfall and tide were found.

In the basin of the Ular, rainfall gage stations had covered the whole basin before around 1945, though they had been insufficient as an observation net of rainfall for flood control planning. At present, there are no rainfall gage stations in the upper basin from Galang excepting over 20 stations in the lower basin from Galang which are managed by PNP. Furthermore, there

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/1 Data on rainfall, temperature and humidity are shown in Data 2.

is no observation station for hourly rainfall in and around the basin.

It is generally said that the rainfall is caused by a difference of specific heat between land and sea and has two kinds of state, one of which is small turbulent vortex, bringing about small rainfall range which does not exceed several kilometers; the other one is the upper thin cloud which extends over a wider range and brings about rainfall of long duration though its intensity is small. The latter case does not occur so often. Heavy rainfalls are usually brought about when the above two states are combined.

Mean annual rainfall in the northern district of Sumatra during the period from 1879 to 1942 is shown in Fig. 1-3-3 which, combined with the profile of the river shown in Fig. 1-3-2, indicates a remarkably close relation between rainfall and topography. Mean annual rainfall is 1,500 mm to 2,000 mm in the plain area of the lower basin (from the rivermouth to 20 km upstream), increasing toward upstream to reach the maximum 5,000 mm to 6,000 mm just at the foot of hilly land (about 75 km from the rivermouth). It decreases again toward further upstream to 2,000 mm to 2,500 mm in the plateau in the utmost upstream (more than 90 km from the rivermouth).

Fig. 1-3-4 shows general characteristics of variation of monthly rainfall on the average for 10 years from 1960 to 1969 at Kwala Namu and Sei Putih where no missing of observation is found during that period. It is found from the figure that there exist two dry seasons, from mid January to mid April and from mid June to around the end of August, while the rainy season has also two periods from mid April to mid June and from the beginning of September to mid January. Of these two rainy seasons, we call the former small rainy season and the latter big rainy season. During big rainy season, about 50 % of annual rainfall are observed on the average. The above mentioned classification of season has been made on the average of ten years, during which period some difference can be found in classification of these two seasons. Sometimes considerably heavy rainfall is seen even in the dry season.

Correlation of daily rainfall, three-day rainfall and monthly rainfall was studied for six rainfall gage stations, Bandar Pinang, Batu Gingging, Deli Muda, Kwala Namu, Pagar Marbau and Sei Putih which were chosen out of 28 stations shown in Fig. 1-3-5: Distances between every two stations are shown in Table 1-3-1.

Fig. I-3-3 Mean Annual Rainfall in the Northern District of Sumatra from 1879 to 1942

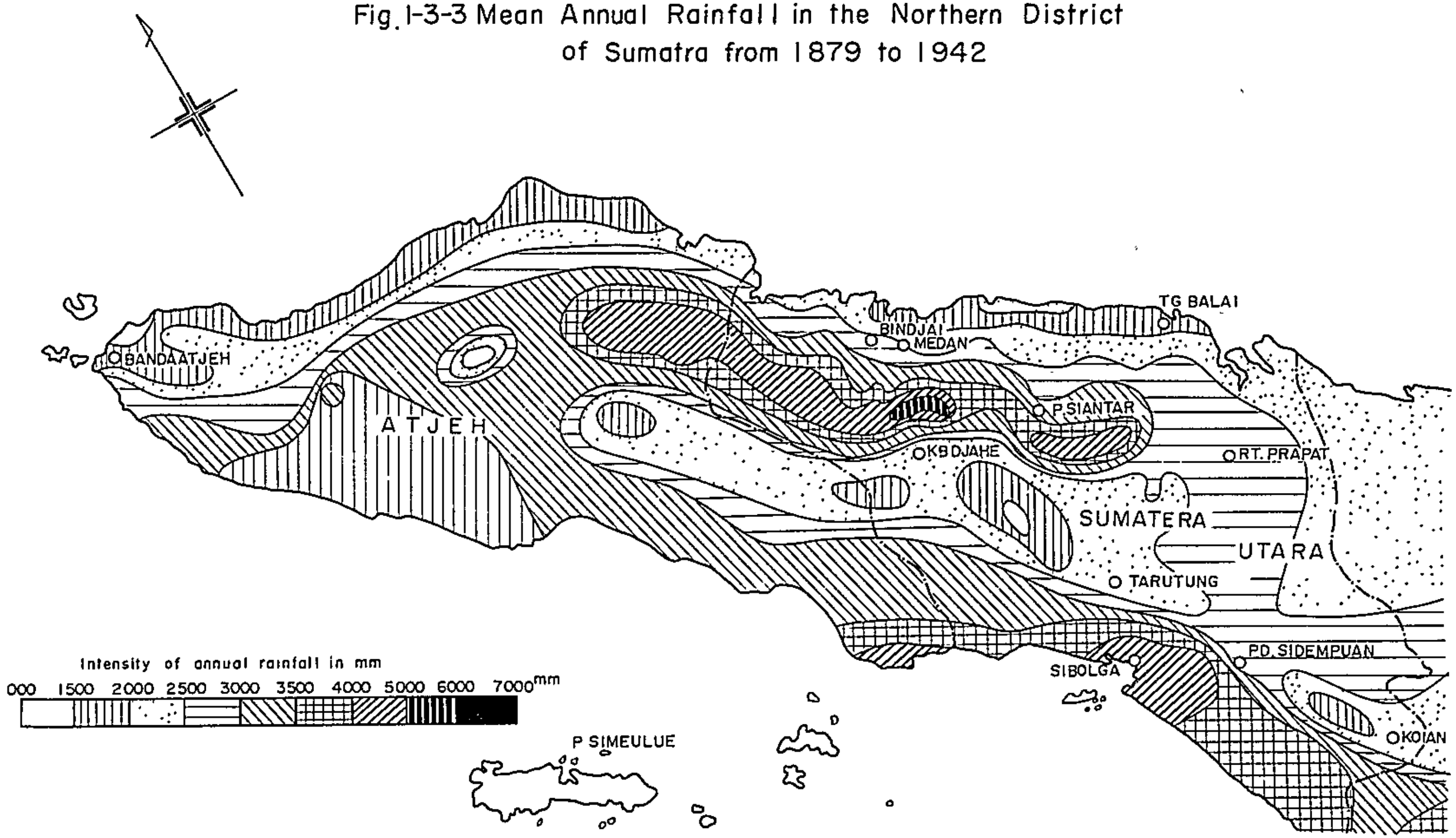


Fig.I-3-4 Mean Monthly Rainfall and Rainfall days from 1960 to 1969.

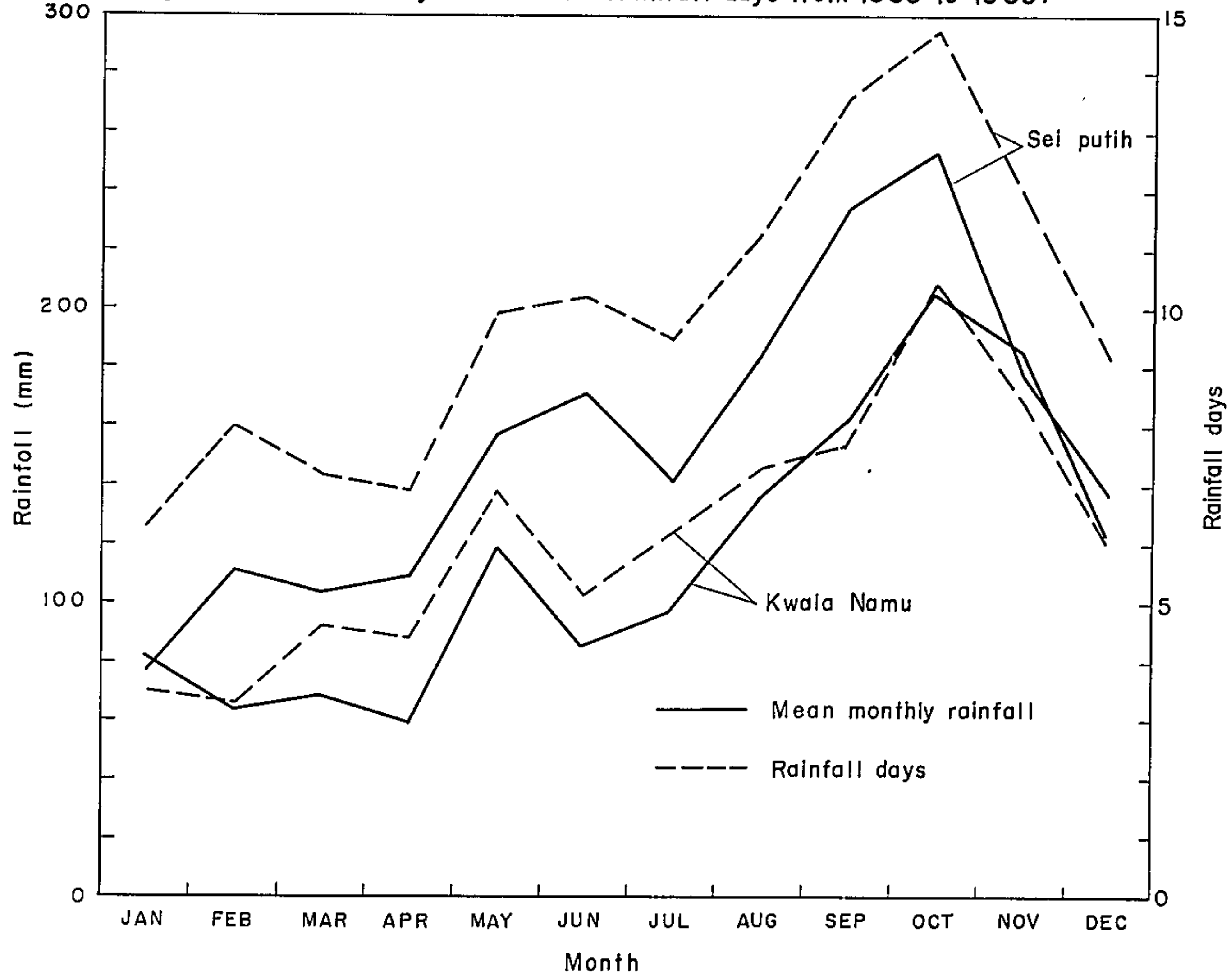


Fig. I-3-5 Location of Rainfall Gauge Stations in the Lower Basin.

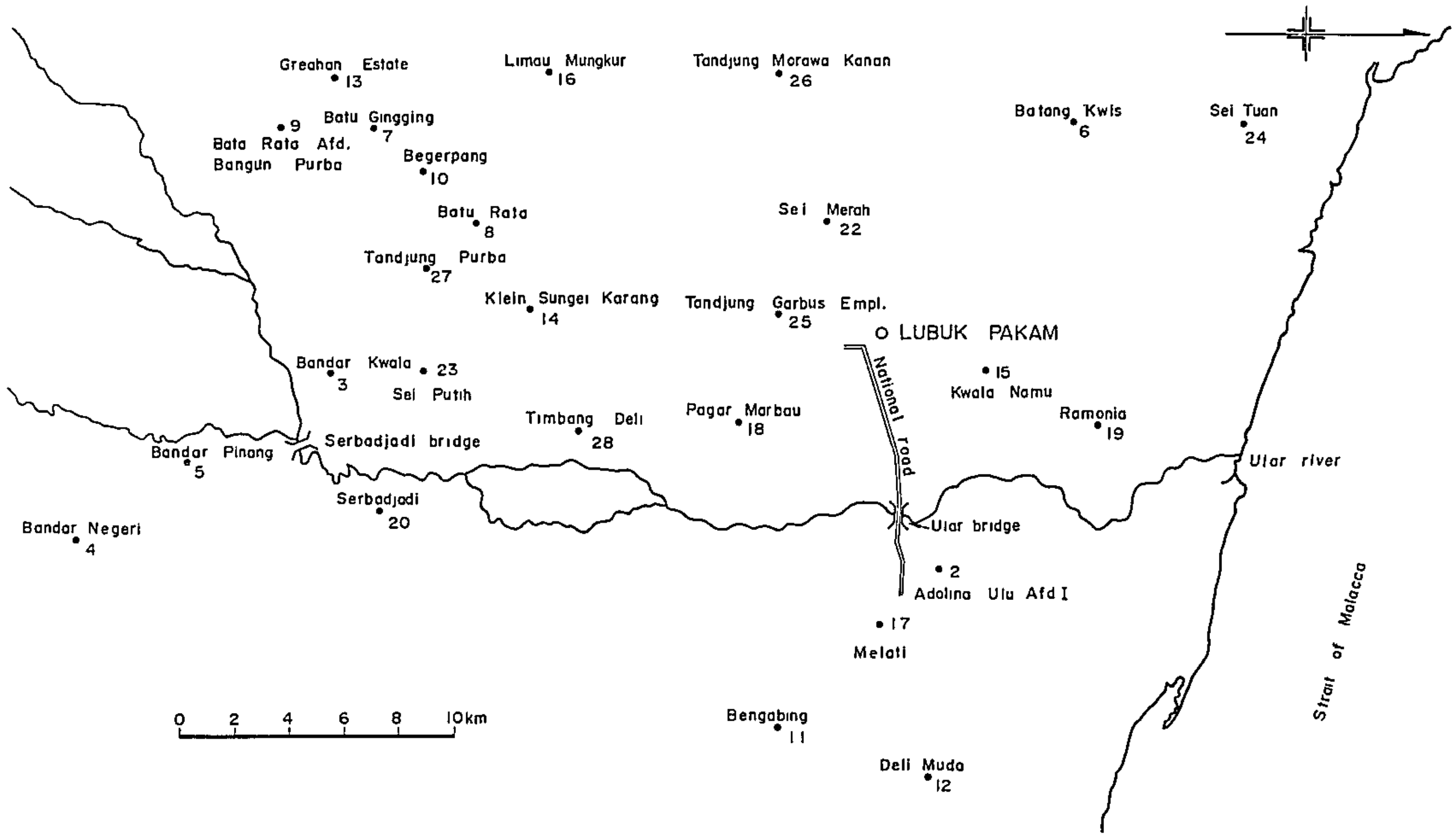


Table 1-3-1 Distance between Rainfall Gage Stations

Rainfall gage stations			Distance (km)
Bandar Pinang	and	Batu Gingging	14
"	"	Deli Muda	29.5
"	"	Kwala Namu	29
"	"	Pagar Marbau	20
"	"	Sei Putih	9.5
Batu Gingging	"	Deli Muda	26.5
"	"	Kwala Namu	19.5
"	"	Pagar Marbau	12
"	"	Sei Putih	6
Deli Muda	"	Pagar Marbau	15
"	"	Sei Putih	24
"	"	Kwala Namu	15.5
Kwala Namu	"	Pagar Marbau	9.5
"	"	Sei Putih	20.5
Pagar Marbau	"	Sei Putih	11.5

The correlation of rainfall between every two gage stations is shown in Fig. 1-3-6a to 1-3-8b. From these data, it is found that there is no correlation even in 6 km in the cases of daily rainfall and three-day rainfall, while some correlation is seen in the case of monthly rainfall.

Since hourly rainfall is not observed in and around the basin, we can not directly know the pattern of time distribution of rainfall in this district; but we may analogize it from the study made by Tadashi Tanimoto, Colombo Plan Expert, about hourly rainfall in Java, because both Sumatra and Java belong to the same tropical monsoon district and have similar topography. According to his analysis, duration time of rainfall in Java is usually about 3 hours concentrated at 15 or 16 o'clock, during which about 95 % of daily rainfall take place.

Therefore, it may be taken that the rainfall in this district has a remarkable concentration not only in area but also in time. On the other hand, most of big floods take place in the rainy season. From these facts, the mechanism of big run-off may be taken as follows: surface water is gradually accumulated in river channels as well as on mountain sides by

Fig.I-3-6a Correlation of Daily Rainfall ( ): Distance between two gage stations.

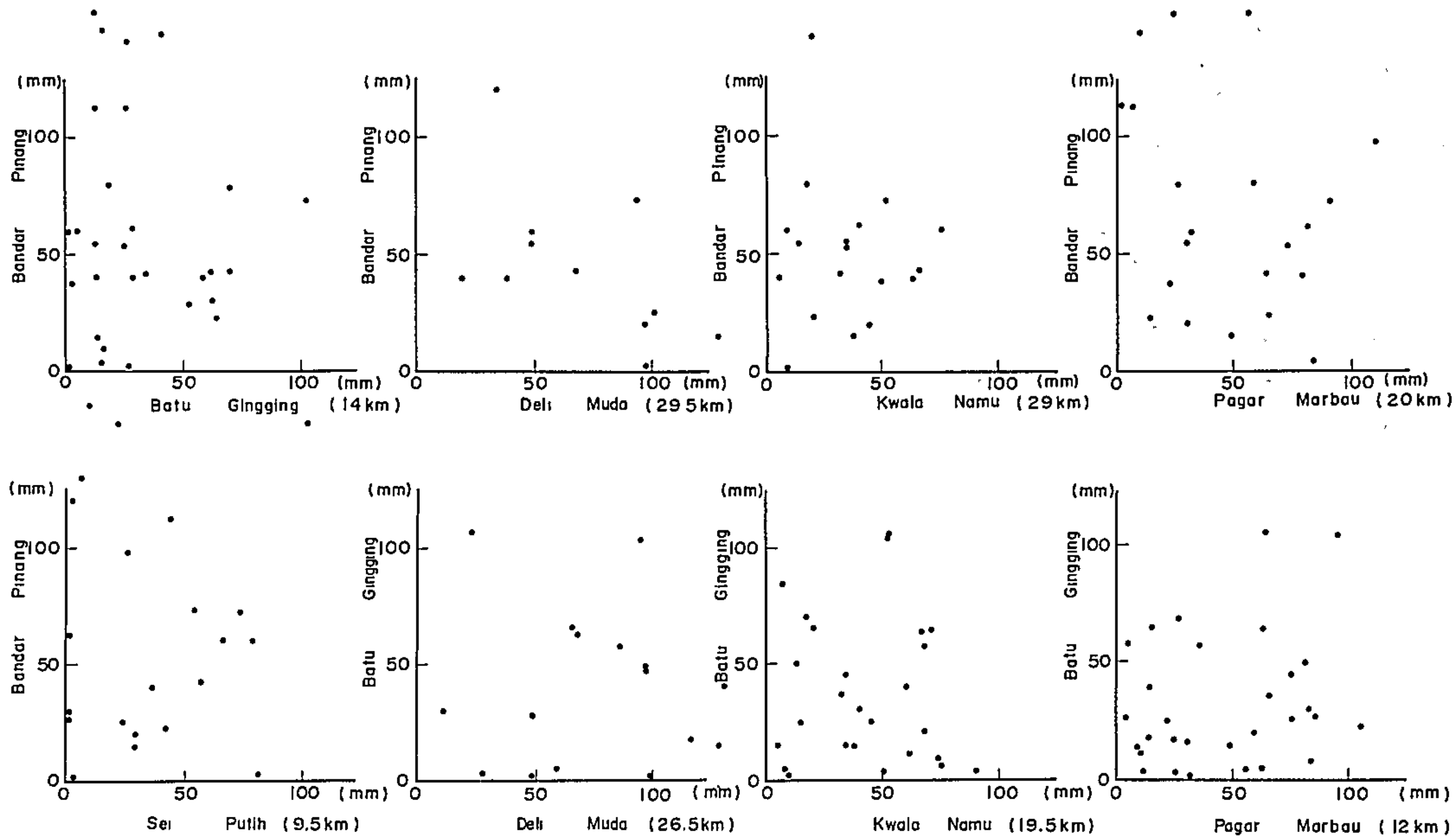


Fig.I-3-6b Correlation of Daily Rainfall.

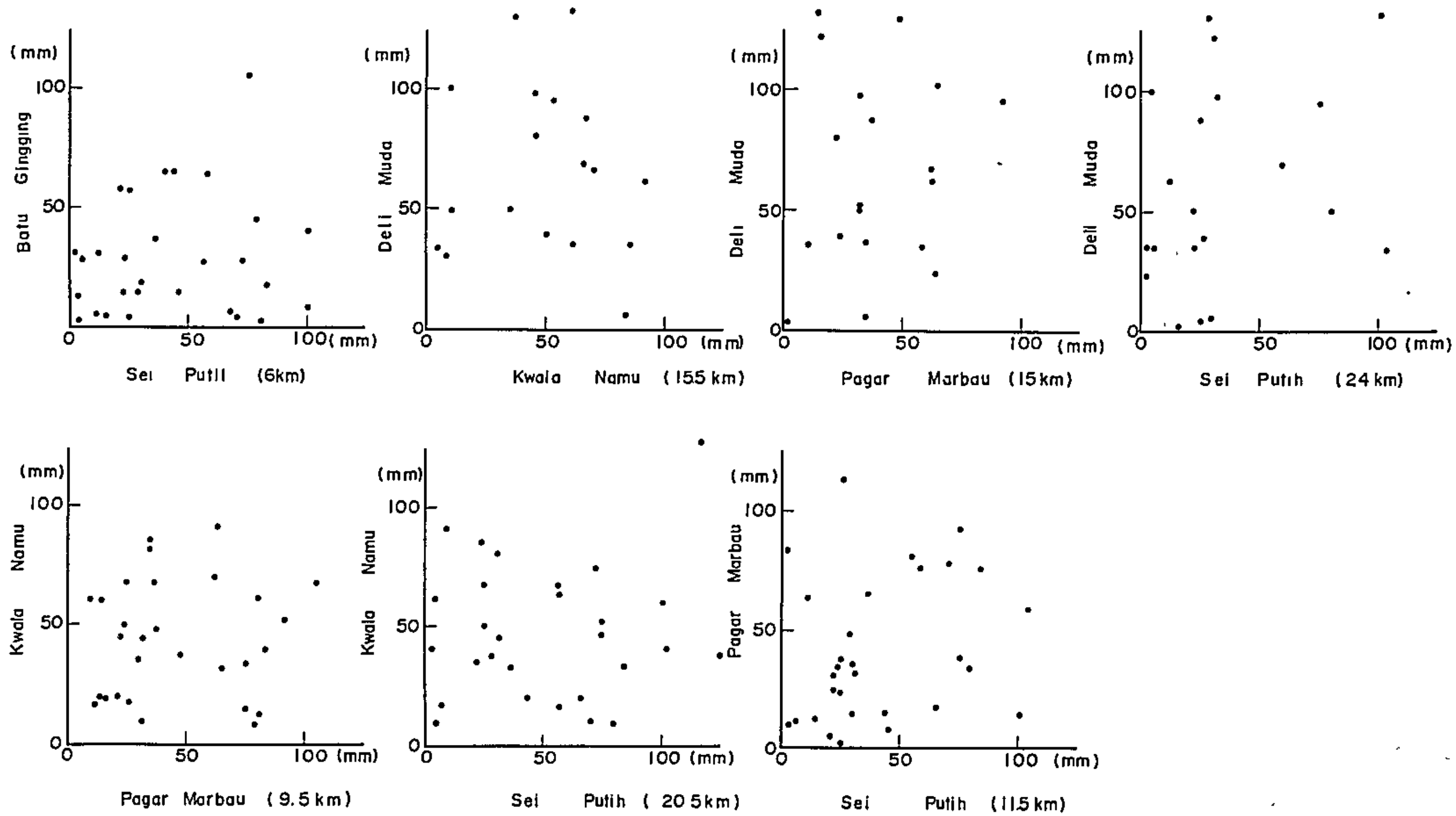


Fig.I-3-7a Correlation of Three-Day Rainfall.

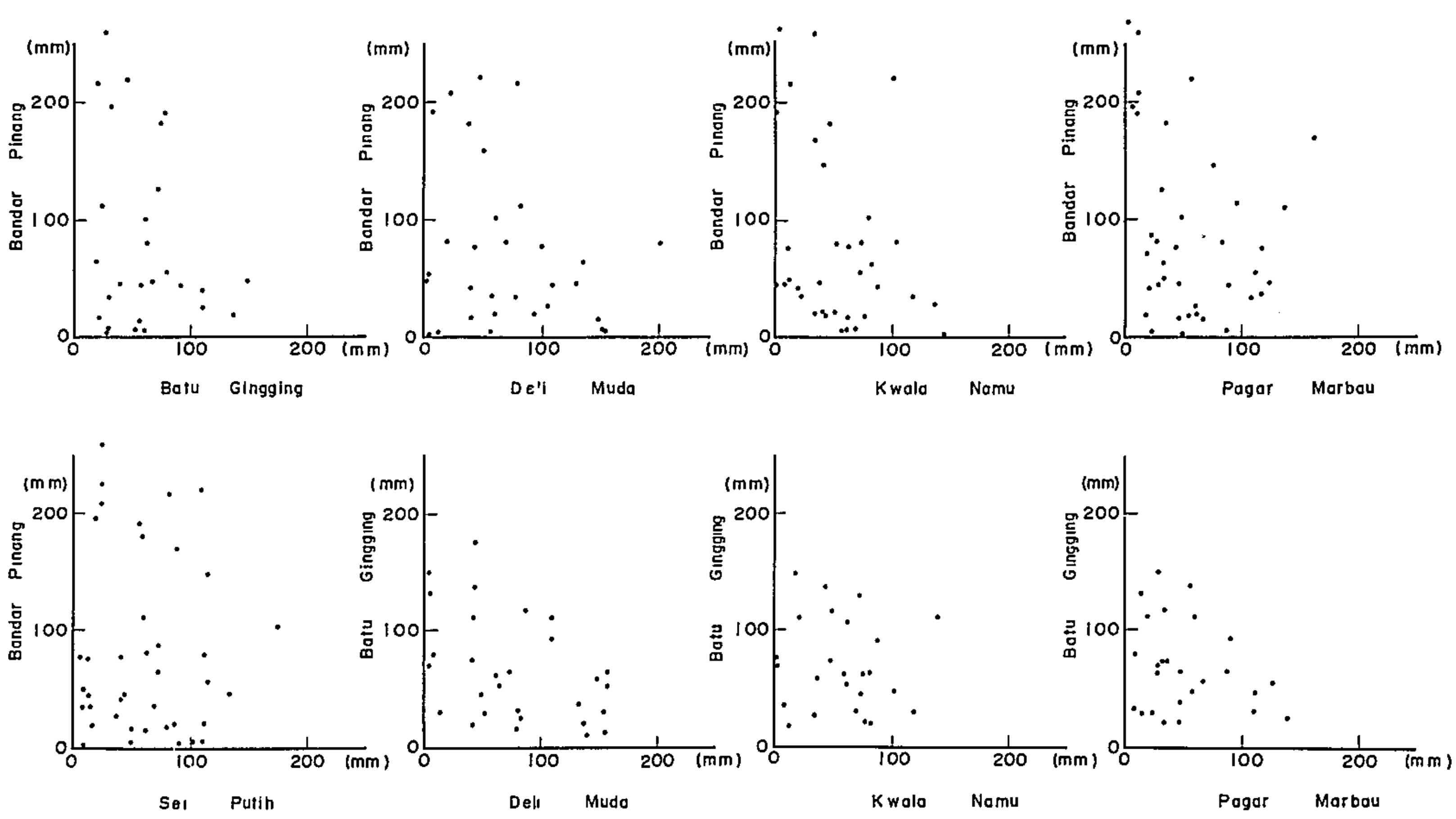


Fig.I-3-7b Correlation of Three-Day Rainfall.

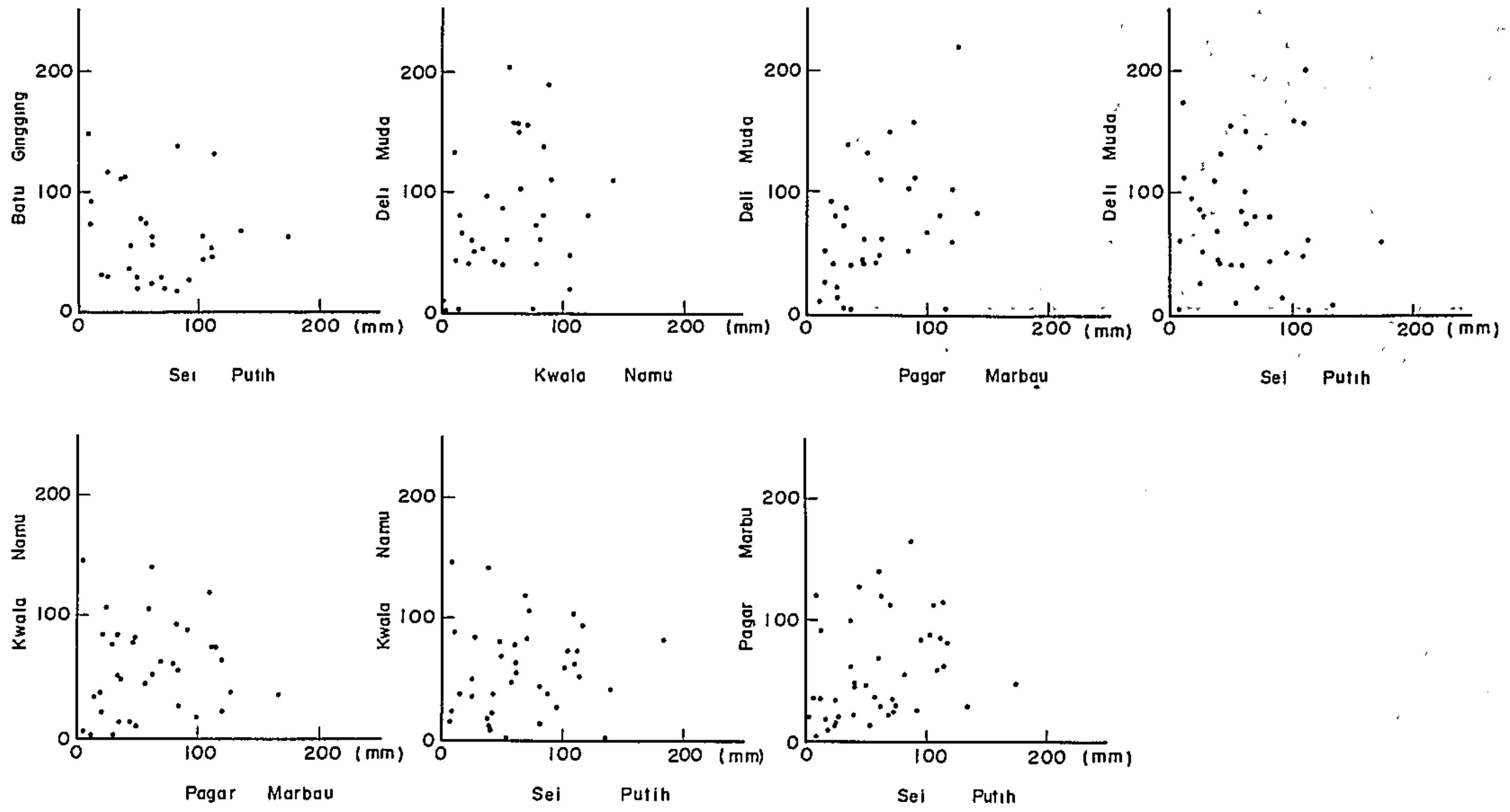


Fig.I-3-8a Correlation of Monthly Rainfall

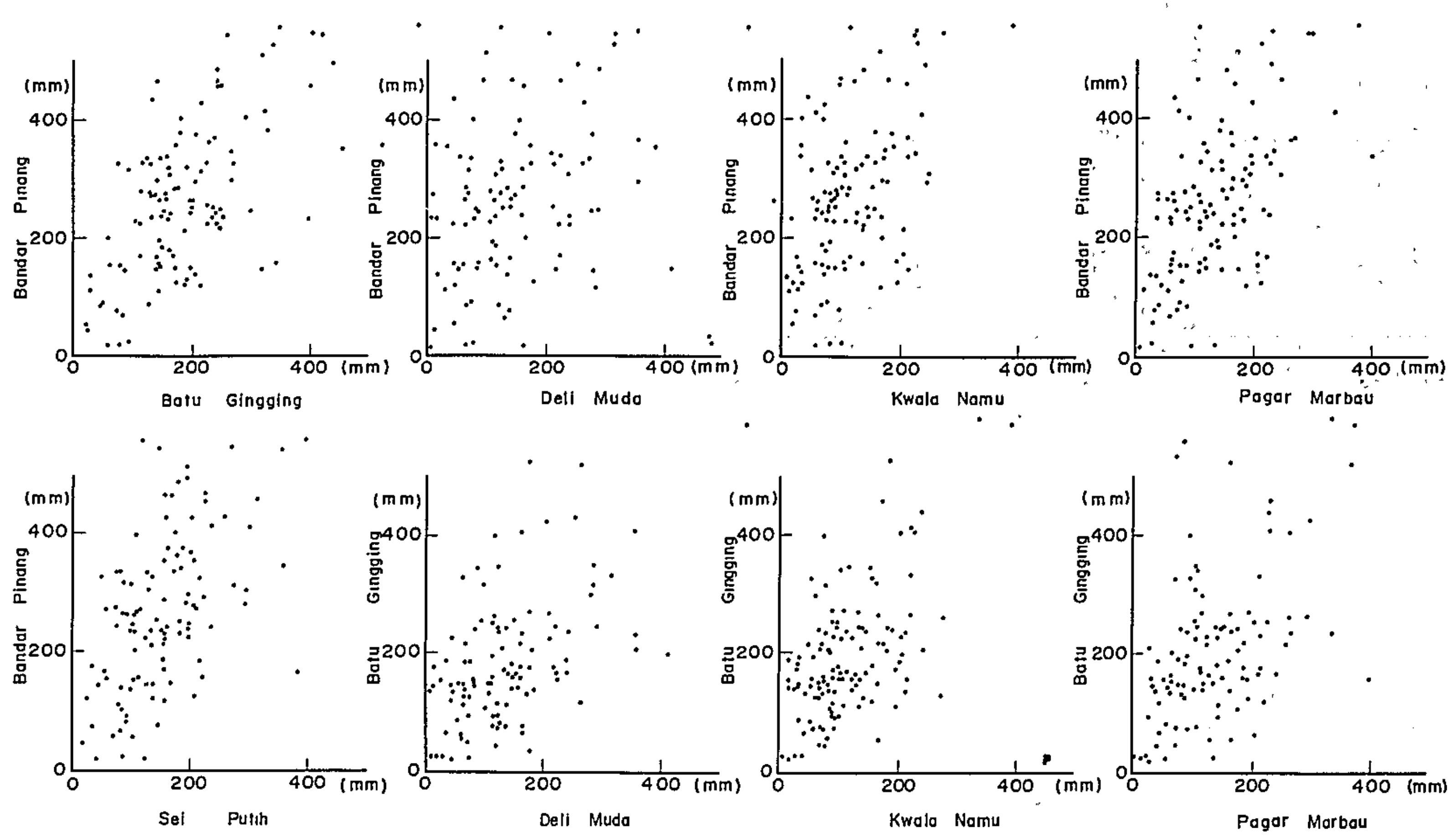
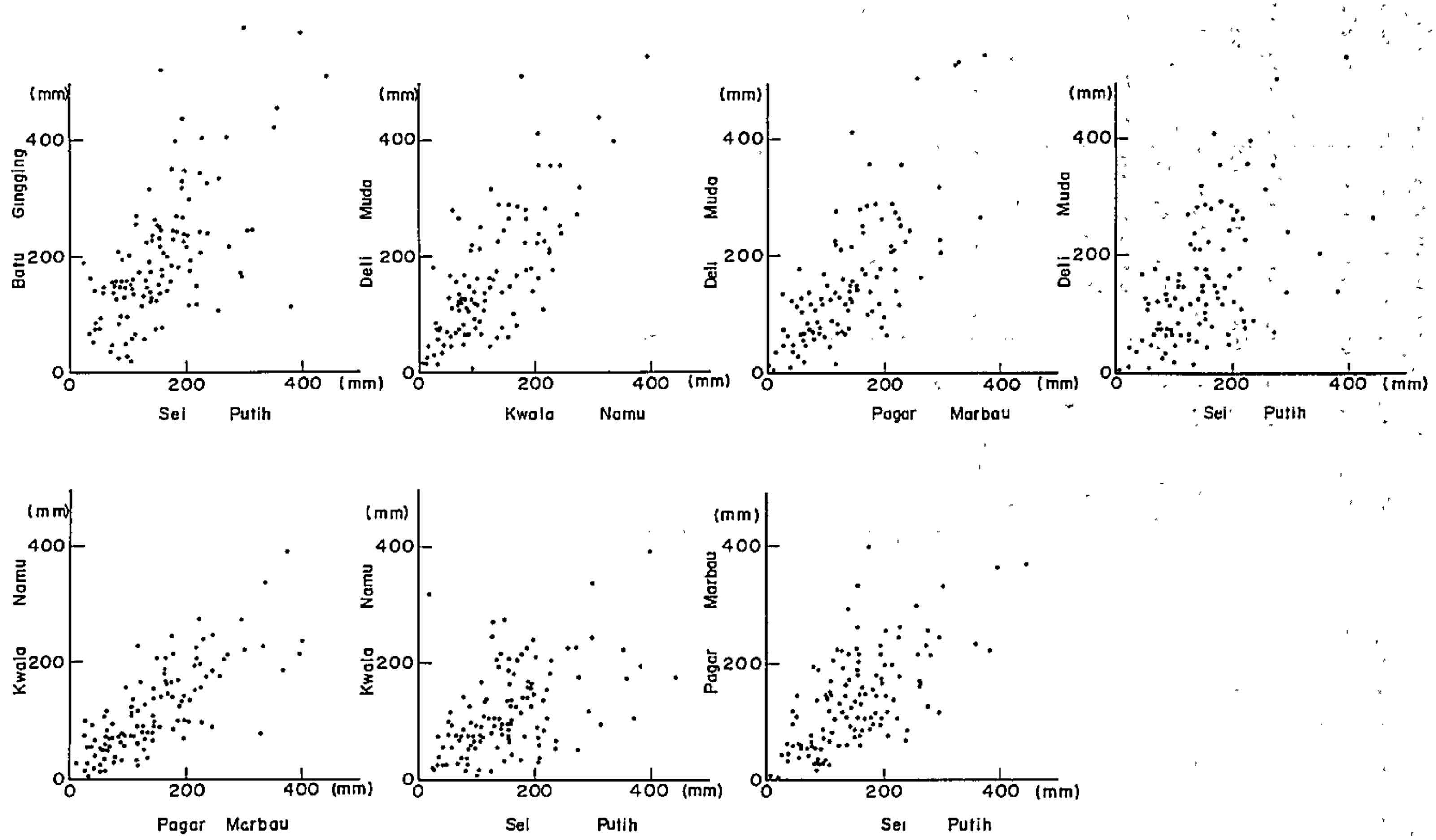


Fig. I-3-8b Correlation of Monthly Rainfall.



repeated rainfall in the rainy season. Water stage is raised with accumulation of surface water. When a concentrated heavy rainfall is superposed by chance upon a fully increased base flow, a catastrophic flood may occur.

Temperature and relative humidity in Medan city are shown in Fig. 1-3-9 and 1-3-10 according to the statistics during 5 years from 1959 to 1963. It is seen from these figures that monthly mean temperature has not so big variation during one year, the highest 27.7°C in May and the lowest 25.6°C in January, while the variation of temperature during one day is rather large. The highest 31.9°C appears at 14 o'clock and the lowest 22.6°C appears at 6 o'clock.

Mean relative humidity has somewhat remarkable variation with seasons; about 85.5 % in the season from September to January, about 81.5 % in the season from February to August. This explains heavy rainfall in the big rainy season. The hourly variation of relative humidity is very remarkable during one day. The maximum is 96.5 % at 6 o'clock, whereas the minimum is 58.6 % at 12 o'clock, according to the average for the five years.

Since there is no tide gage station at the mouth of this river, observation records of tides were collected at Belawan harbor not far from the rivermouth. Table 1-3-2 shows the monthly highest water level and the monthly lowest water level during a period from January 1969 to August 1970. The mean highest high water level was 2.732 m and the mean lowest low water level was 0.808 m in 1969, where the datum of water level is zero of the tide gage at Belawan.

It is needless to say that hydrological data such as rainfall, water level, discharge, etc. are very important elements for the study of design discharge. Sufficient equipments and facilities for collection of data are strongly desired over the whole basin of the Ular. Furthermore, it is desirable to prepare them as soon as possible, because data of long period are usually required for analysis of phenomena.

Fig.I-3-9 Monthly Temperature and Relative Humidity in Medan.

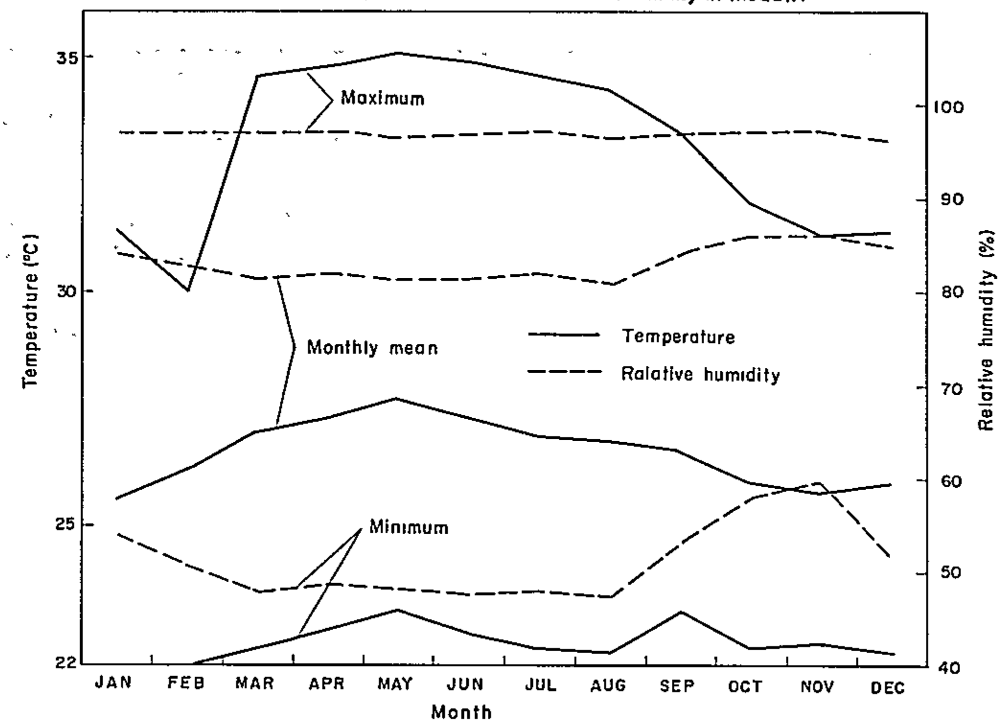


Fig I-3-10 Hourly Temperature and Relative Humidity in Medan

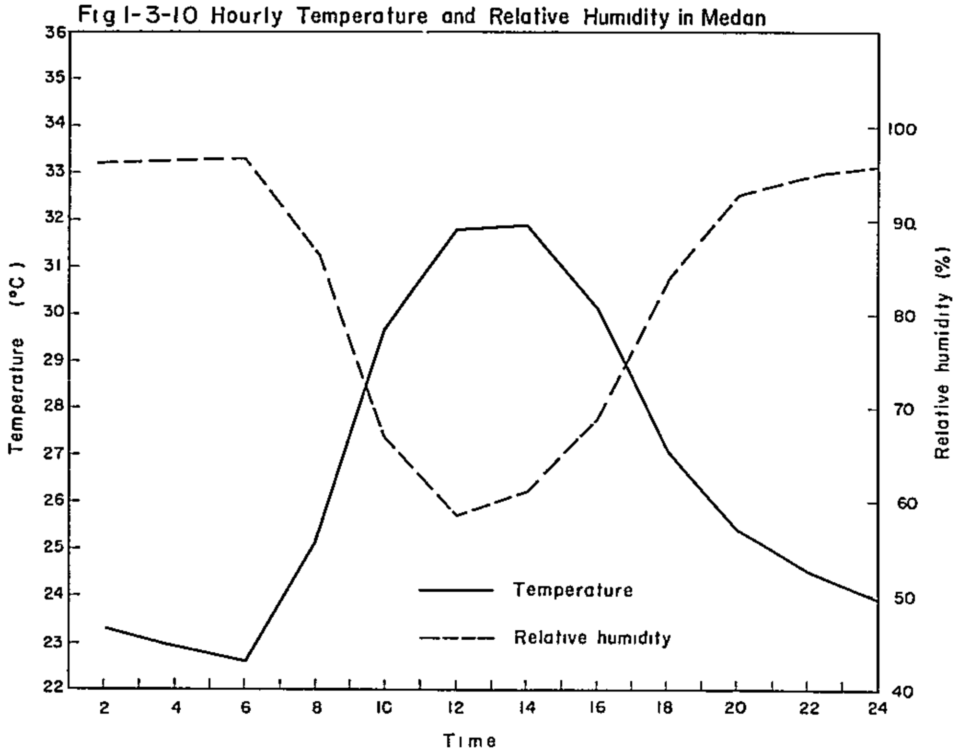


Table 1-3-2 Tide in Belawan harbour

Year	Month	Monthly highest water level		Monthly lowest water level		Monthly mean water level (m)
		Day, Hour	Water level (m)	Day, Hour	Water level (m)	
1969	JAN	20 3	2.74	19 9	0.01	1.51
	FEB	17 2	2.57	17 9	0.00	1.45
	MAR	19 15	2.57	6 9	0.12	1.45
	APR	4 15	2.75	3 8	0.26	1.54
	MAY	31 14	2.90	3 21	0.42	1.65
	JUN	1 14	2.86	1 21	0.46	1.69
	JUL					
	AUG	29 15	2.80	28 21	0.17	1.60
	SEP	26 2	2.96	14 23	0.43	1.68
	OCT	12 2	2.88	13 9	0.50	1.66
	NOV	11 2	2.82	11 9	0.42	1.64
	DEC					
1970	JAN	9 3	2.84	10 9	0.12	1.49
	FEB	9 3	2.74	8 10	0.02	1.42
	MAR					
	APR					
	MAY	5 13	3.04	22 21	0.60	1.82
	JUN	21 15	2.97	20 21	0.56	1.81
	JUL	20 15	2.96	21 22	0.29	1.83
	AUG	17 14	3.08	18 21	0.30	1.79

Highest water level (1969)		Lowest water level (1969)		Mean water level (1969) (m)
Month, Day, Hour	Water level (m)	Month, Day, Hour	Water level (m)	
SEP 26 2	2.96	FEB 17 9	0.0	1.59

Mean highest high water level (1969)	2.732 (m)	Mean lowest low water level (1969)	0.808 (m)

Datum level: Zero of tide gage at Belawan harbor.

CHAPTER IV

PRESENT ASPECT OF THE RIVER IN THE PLAIN AREA

1. River Course and Dikes

The Buaja river and the Denai river meet each other at a point about 5 km upstream of Galang Barat, forming the Ular river as seen in Fig. 1-3-1. The Ular river has continuous dikes on both sides of the reaches downstream from Galang Barat, as shown in Fig. 1-4-1. But no dikes are found along the right side bank 8 km in length upstream from the rivermouth. The reaches from 13.6 km to 18.6 km from the rivermouth have many meanderings with remarkable variation of river width.

The river channel, about 32 km in length, from Galang Barat to the rivermouth has no tributaries flowing in, and as a result, no increase of catchment area can be expected excepting the river channel itself.

The dikes of about 67.3 km in total length belong to DPUTL and PNP, and are maintained by both of them according to their belongings (35 km by DPUTL and 32.3 km by PNP). The width of the river varies along the river course and no consistency is found for the plan of improvement of the river channel.

The existing dikes are generally 1.5 m to 3.0 m in crown width, about 1.0 m to 2.5 m in height above ground level and has a slope of 1:1. Most of slope faces are covered by sodding. No revetment made of stones or concrete is found along the banks. Some groynes made of logs are found at several places of meandering. They are about 5 m to 10 m in length, built in the downstream direction.

Ular bridge of national road crosses the river at a point about 13.6 km upstream from the rivermouth and another bridge, called Serbadjadi bridge, crosses the river at Galan Barat which is located about 5 km downstream from the confluence of the Buaja and the Denai. A railway bridge crosses the river about 80 m upstream from Ular bridge. The dimensions of those three bridges are shown in Table 1-4-1.

Along the river channel from Galan Barat to the rivermouth, there are

Fig. 1-4-1 The Ular River

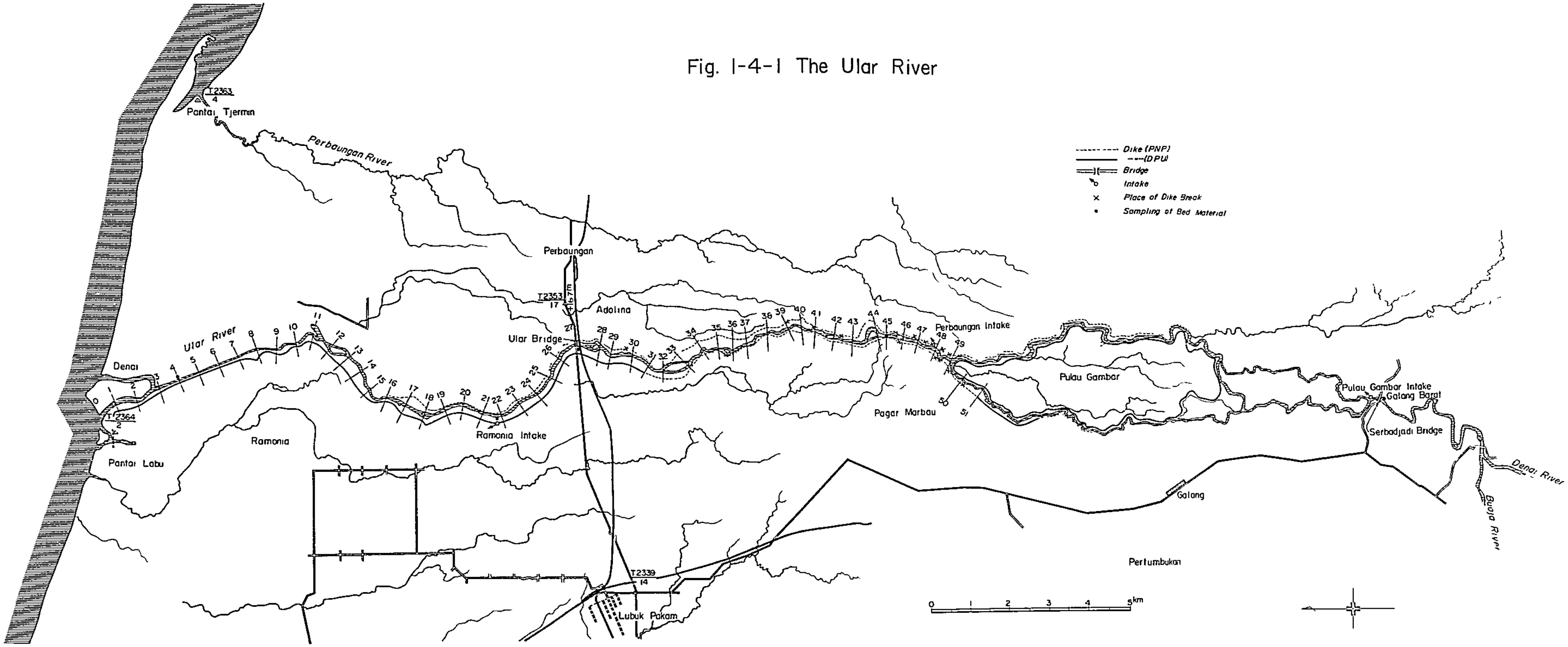


Table 1-4-1 Types and Dimensions of Bridges

Name	Distance from the rivermouth (km)	Total length (m)	Type	Spans (m)
Ular bridge	13.55	64.3	I-beam	16.0+16.15+16.75 +15.4
Railway bridge	13.63	about 63.0	Truss	about 40+23
Serbadjadi bridge	35.70	about 62.0	Truss & I-beam	about 47 (truss) + about 3x5m (I-beam)

three intakes for irrigation as shown in Fig. 1-4-1. The upstream intake, which is located at Galang Barat and called Plau Gambar intake, irrigates the area 1,100 ha of Plau Gambar which is surrounded by a circular dike just downstream of Galang Barat. The middle one, Perbaungan intake, which is located just downstream of the Plau Gambar circular dike, is for the area of 5,000 ha on the right bank side. The downstream one, Ramonia intake, which is located near Lubuk Pakam, irrigates the paddy fields of 2,500 ha on the left bank side (Table 1-4-2).

Other small intakes are found on the upstream reaches of the Ular.

Table 1-4-2 Intakes

Name of intake	Location	Area of irrigation
Ramonia	11.050 km	2,500 ha
Perbaungan	23.360 "	5,000 "
Pulau Gambar	35.480 "	1,100 "

2. Longitudinal Profile of River and Cross-sections

The longitudinal and cross-sectional maps which exactly show the actual conditions of the entire part of the river are not available, but there exist partially some maps which were made by P.N. Waskita Karya during a period from 1968 to 1969. One is a map ranging from the rivermouth to a point about 1.7 km upstream from the rivermouth and another is a map covering a range from Ular bridge 13.6 km upstream of the rivermouth to a point of 24.9 km.

These two maps have different datum levels. Sumatra Datum level/1 is used in the former, while a temporary datum level/2 is used in the latter. Connecting these two by levelling, we made a longitudinal profile of the Ular river covering a range from the rivermouth to a point of 24.9 km, as shown in Fig. 1-4-2.

Using the cross-sections measured by P.N. Waskita Karya and taking Fig. 1-4-1 and Fig. 1-4-2 into consideration, we made up cross-sections, some examples of which are shown in Fig. 1-4-3.

Fig. 1-4-2 shows that the average slope of the river bed is about 1/700 - 1/1,000 in the plain part from the rivermouth to Serbadjadi bridge at Galang Barat. However, locally abnormal slopes are found on the reaches from 13.6 km to 21.2 km. In the lower half from 13.6 km to 18.7 km, especially steep slope is seen, whereas nearly level is the slope in the upper half, 18.7 km to 21.2 km.

The abnormal profile of river bed may be taken not to be wrong as far as the relative relation is concerned, even if some errors were included. The abnormality should be exactly investigated at the earliest opportunity to make sure of it.

The river bed of the Ular river is said to have been raised over the overall length by 2 to 4 m for the past 20 years, but no data could be obtained to verify this rising. When the present state of the foundation of piers of the railway bridge is taken into considration, such rising mounting up to 2 to 4 m will be doubted.

The local abnormality of river bed mentioned above is presumed to have been caused by the settlement of silt. Because we take it that the majority of overflows occur only within the reaches from 18.6 km to 21.9 km as shown in Table 1-4-3 and, in consequence, the river flow loses its tractive force around this point, promoting the siltation downstream from here.

The river width is shown in Table 1-4-4. The river channel on the lower reaches from Ular bridge has nearly constant width of about 300 m, but the

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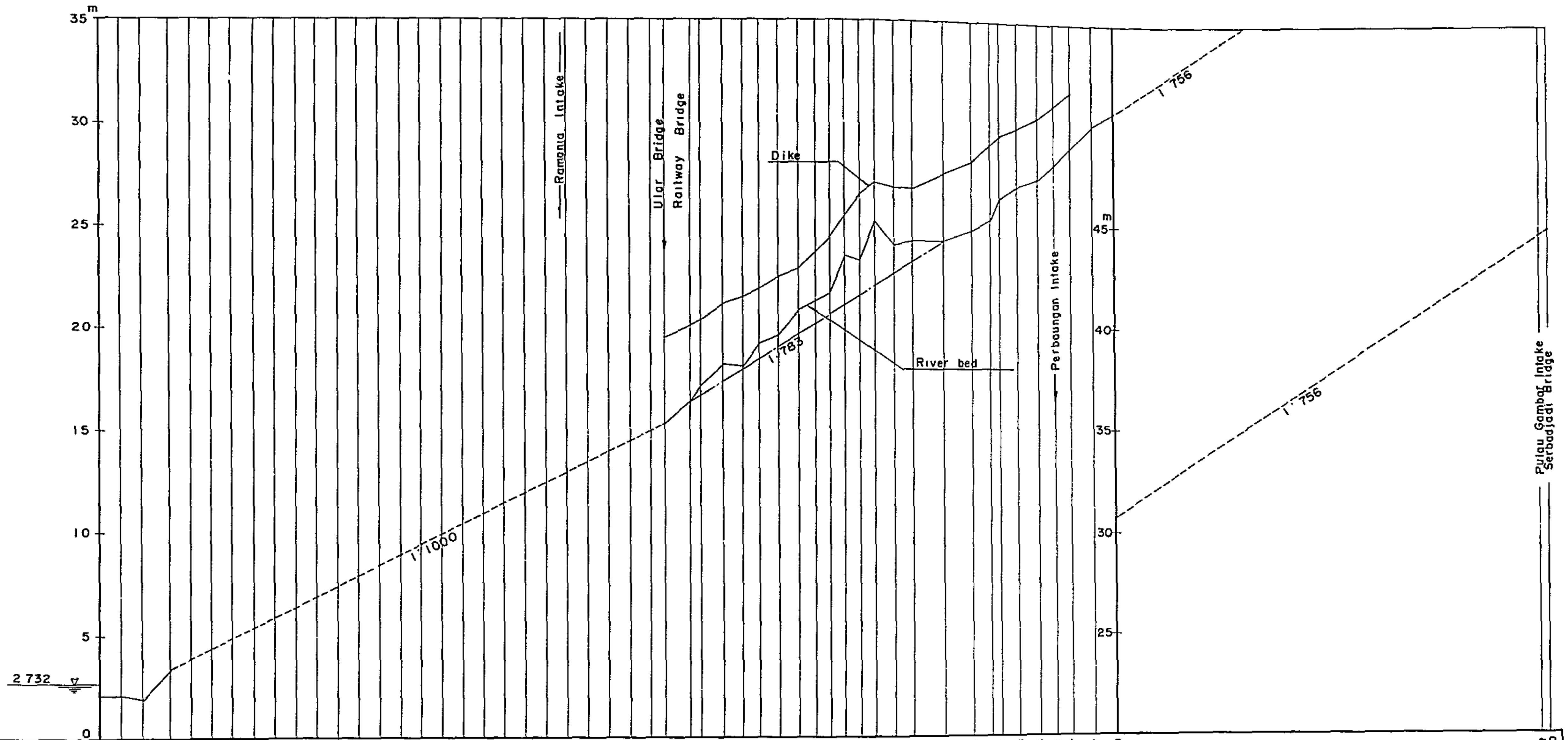
/1 This level is equal to zero of the tide gage in Belawan harbour.

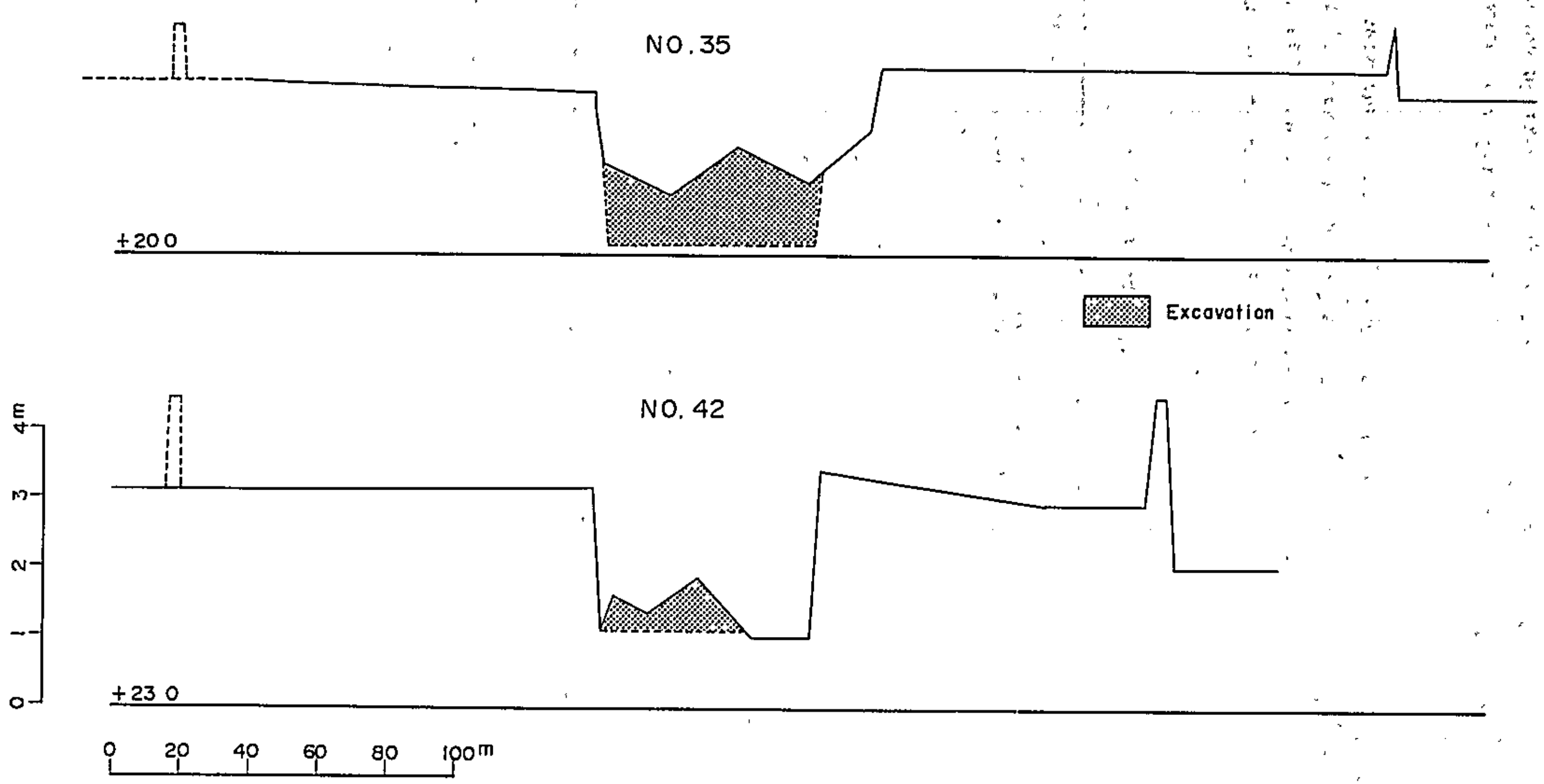
/2 The top face of right bank abutment of Ular bridge was set equal to 25 m.

Fig. 1-4-2 Longitudinal Profile of the Ular River



No of section	Distance	Cumulative distance	Mean height of river bed
0	0	0	2.12
1	510	510	2.13
2	535	1045	1.89
3	652	1697	3.40
4	500	2197	
5	500	2697	
6	500	3197	
7	500	3697	
8	500	4197	
9	500	4697	
10	500	5197	
11	500	5697	
12	500	6197	
13	500	6697	
14	500	7197	
15	500	7697	
16	500	8197	
17	500	8697	
18	500	9197	
19	500	9697	
20	500	10197	
21	500	10697	
22	500	11197	
23	500	11697	
24	500	12197	
25	500	12697	
26	500	13197	
27	353	13550	15.25
28	600	14150	16.35
29	260	14410	17.14
30	540	14950	18.18
31	460	15410	18.08
32	400	15810	19.22
33	500	16310	19.63
34	480	16790	20.82
35	400	17190	21.31
36	350	17540	21.73
37	350	17890	23.55
38	380	18270	23.36
39	380	18650	25.25
40	500	19150	24.06
41	450	19600	24.30
42	800	20400	24.33
43	750	21150	24.80
44	500	21650	25.29
45	230	21880	26.36
46	480	22360	26.98
47	540	22900	27.34
48	460	23360	28.10
49	400	23760	28.87
50	560	24320	30.07
51	560	24880	30.69
52	10600	35480	about 45.0
53	220	35700	about 45.0

Fig. I-4-3 Example of Cross-sections



width on the reaches upstream of the bridge has a remarkable variation. On the other hand, low water channel has almost constant width, ranging from 50 m to 60 m.

The present carrying capacity is extremely small within the reaches of abnormal bed. It is only about 200 m^3/sec at the points No. 40 - 42, when we assume that the coefficients of roughness are 0.025 for the low water channel, 0.045 for the high water channel, and the slope is 1/783 - 1/756 as shown in Fig. 1-4-2.

Table 1-4-3 Places of Overflow

year	1955	1965	1968	1969
Places of overflow	Aug. bank 23.5 km	Apr. 23.4 km	19.6 km	14.8 km
	" " 23.8 "		22.7 "	18.7 "
			23.2 "	19.6 "
			23.6 "	20.5 "
				22.7 "
				23.0 "
				23.2 "
				23.4 "
				23.6 "
				Dec. 22.2 "
				Aug. 24.4 "

Table 1-4-4 Slope and Width of Ular River

Range	Slope of river bed	Width of river (m)	Width of low water channel (m)
0.0 km (rivermouth) - 13.6 km (Ular bridge)	about 1/1,000	about 300	about 60
13.6 km - 18.7 km	about 1/550	250 - 500	about 50
18.7 km - 21.9 km	about 1/2,500	150 - 400	about 50
21.9 km - 24.9 km	about 1/700	about 150	about 50

3. Bed Materials

Bed materials of the Ular river were sampled at five locations shown in Fig. 1-4-1 and Table 1-4-5 and analyzed in RISPA. The results are shown in

Table 1-4-5 and Fig. 1-4-4. Fig. 1-4-5 indicates that the grain size at 65 % is almost constant along the reaches from the rivermouth to Serbadjadi bridge. It is about 1 mm.

Soil in the upper basin and the middle basin of the Ular river were analyzed also in RISPA. The results are shown in Table 1-4-6.

Fig. I-4-4 Accumulation Curve of Grain Size

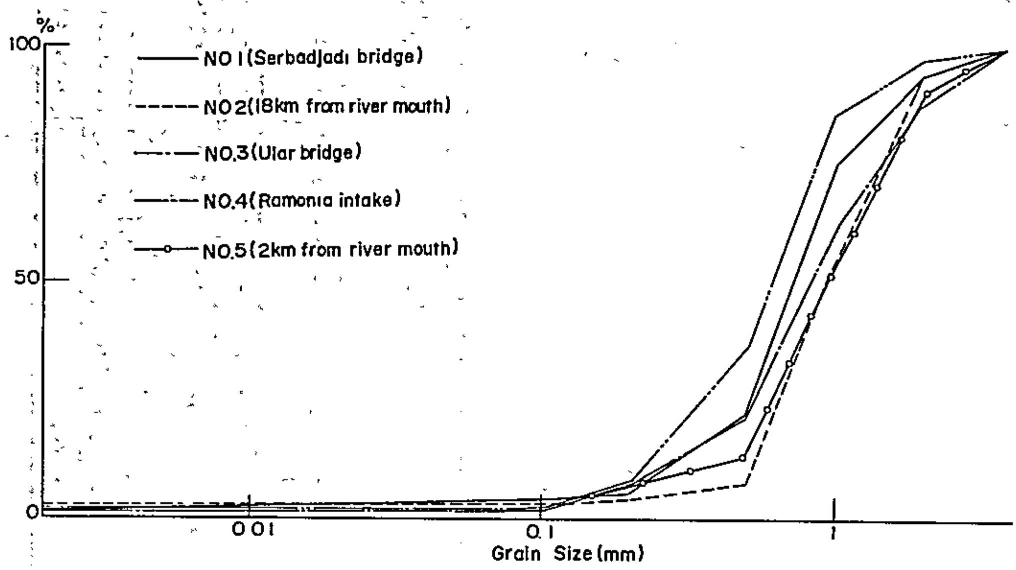


Fig. I-4-5 Grain Size and Specific Gravity of Bed Materials in the Ular River

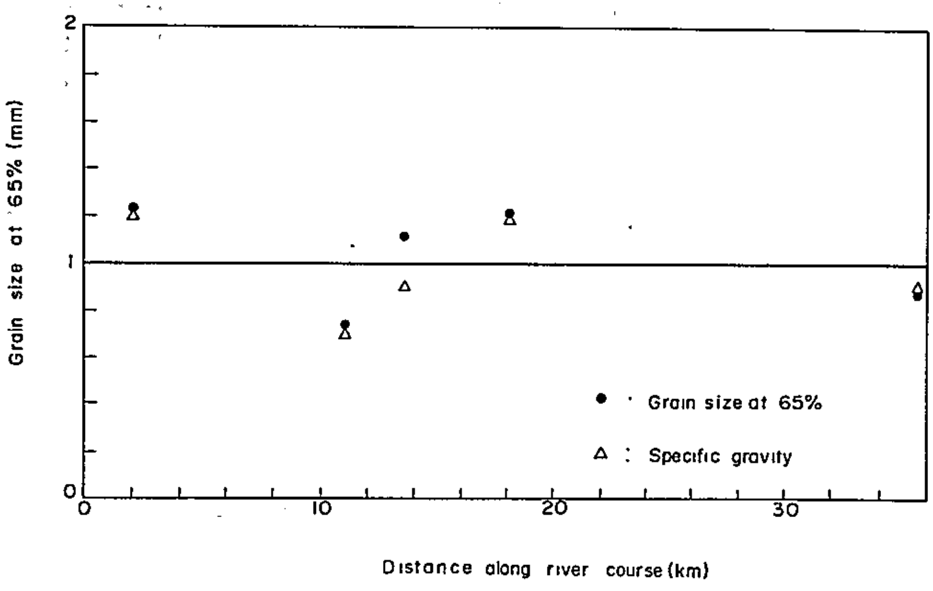


Table 1-4-5 Bed Materials of the Ular River

No. of material	Location from the rivermouth	PH	Specific gravity	Grain size (mm)								Quantity used in testing (gr)
				2	2-1	1-0.5	0.5-0.2	0.2-0.1	0.1-0.05	0.05-0.02	< 0.02	
				%	%	%	%	%	%	%	%	
1	35.7 km (Serbadjadi)	6.80	2.59	5.59	19.12	52.17	17.11	1.55	0.01	2.47	1.54	408.46
2	18.0 km	6.65	2.62	5.46	40.66	46.06	3.50	1.04	0.01	0.15	2.00	615.10
3	13.6 km (Ular bridge)	6.75	2.59	11.89	26.87	39.22	14.76	4.89	0.05	0.34	1.69	675.93
4	11.0 km (Ramonia intake)	6.80	2.57	2.32	11.57	49.40	28.58	5.70	0.10	0.36	1.79	1,402.40
5	2.0 km	6.68	2.62	9.79	35.59	40.78	8.39	3.23	0.03	0.53	1.51	1,168.86

Table 1-4-6 Soil in the Basin

No. of material	Location of sampling	PH	Specific gravity	Grain size (mm)								Quantity used in testing (gr)
				2	2-1	1-0.5	0.5-0.2	0.2-0.1	0.1-0.05	0.05-0.02	< 0.02	
				%	%	%	%	%	%	%	%	
6	Upper basin of the Ular (about 110 km from rivermouth)	5.93	2.25	3.40	6.92	23.06	2.05	39.63	4.40	17.13	3.69	100.00
7	Middle basin of the Ular (about 50 km from rivermouth)	5.35	2.56	2.75	5.23	20.68	2.43	17.56	2.63	15.24	36.87	100.00

CHAPTER V

DAMAGES CAUSED BY FLOODS

1. Land Use and Public Facilities

The basin of the Ular river stretches over both Deli/Serdang and Simalungun prefectures in North Sumatra province, and the plain which suffers from seasonal floods exists in Deli/Serdang prefecture.

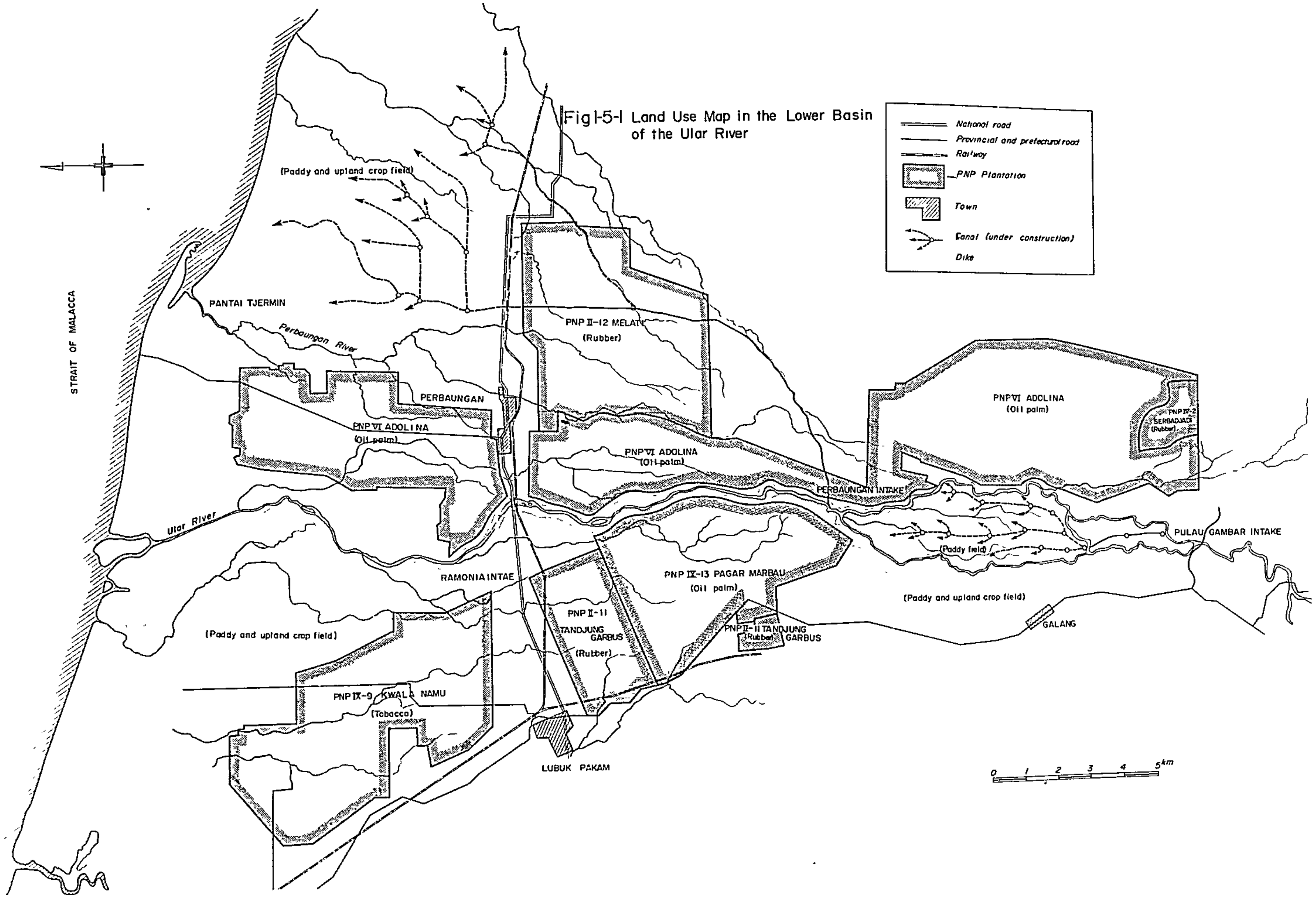
Deli/Serdang prefecture where Medan, the capital of North Sumatra, is located is most densely populated in North Sumatra. The area of the prefecture is 4,824 km^2, its population was 1,766,200 in 1968. The population density in 1971 is presumed to exceed 366 capita/km^2.

The zone which every year suffers damages from floods is the plain situated downstream from Galang and stretches over four Ketjamatan's; Galang, Lubukpakam, Perbaungan, and Pantaitjermin. This zone is one of the areas where government-owned estates are most developed in North Sumatra and comprises government-owned estates such as PNP II-11 (Tandjung Garbus), PNP II-12 (Melati), PNP IV-2 (Serbadjadi), PNP VI-1 (Adolina), PNP IX-9 (Kwala Namu), and PNP IX-13 (Pagar Marbau), where palm-oil, rubber, and tobacco are mainly produced. Those PNP's cover a total area of about 17,500 ha (see Fig. 1-5-1).

Rice fields are also well developed in that zone. The area is estimated to be 15,000 ha in total. Main intakes for them are built at Pulau Gambar, Perbaungan, and Ramonia, all of which take water from the main stem of the Ular river to irrigate paddy fields of 1,100 ha, 5,000 ha, and 2,500 ha respectively. In order to use more effectively the water taken from those intakes at Pulau Gambar and Perbaungan, new irrigation canals are now under construction by DPUPSU. When these canals have been completed, the water taken from these two intakes is expected to irrigate the paddy fields of 2,000 ha and 6,800 ha respectively (Fig. 1-5-1).

A national road and a national railroad run through this area which comprises a length of about 25 km of the former and a length of about 26 km of the latter. From this viewpoint, this area is regarded as an important point for traffics.

Fig I-5-I Land Use Map in the Lower Basin of the Ular River



The area of the flood zone amounts to about 35,000 ha, the classification of which is shown in Table 1-5-1 together with public facilities comprised in the same zone.

Table 1-5-1 Land Use and Public Facilities within the Flood Zone

(1) Land use

Kinds	A Area (ha)	B Planted or culti vated area (ha)	B/A Rate (%)	Remarks
Oil-palm	7,180	4,535	63	PNPVI, PNPIX
Rubber	3,380	2,860	85	PNPII
Tobacco	3,740	950	25	PNPIX
Paddy field	14,200	14,200	100	
Upland rice field and farm land	1,600	1,600	100	
Town	300			Lubuk Pakam, Perbaungan
Swampy and vacant area	4,700			Swampy: 2,200 ha Vacant: 2,500 ha
Total	35,100	24,145		

(2) Public facilities

Kind	Length (km)	Remarks
National road	25	
Provincial road	18	
Prefectural road	10	
National railroad	26	
Estate railroad	14	
Bridges	about 20 bridges	national road and railroad
Dikes (DPU)	35	
Dikes (PNP)	32.3	

2. Records of Floods

Most of overflows or breaks on the dikes of the Ular river were caused in a reach about 10 km upstream from Ular bridge, as seen in Fig. 1-4-1. Floods take place almost every year. The biggest ones of them were the floods in 1954 and 1955 for the past 20 years. It is regrettable, therefore, that the detail of these floods have not been recorded.

It is said, however, that the flood in 1954 was caused mainly by breaks on the left dike of the Ular river and inundated an extensive area on the left side of the river downstream from Ular bridge. The maximum depth of inundation is reported to have reached 2 m in the northern part of Kwala Namu of PNP IX-9 and that inundation is said to have continued more than one month.

In the case of the 1955 flood, it is said that the flood was caused mainly by two breaks on the right side dike, the maximum depth of inundation reached 2.5 m, the inundation continued more than three months, and many lives were lost in the right bank side area about 7 km upstream from the rivermouth. Furthermore, we were informed by a manager of PNP VI that, in Perbaungan town which is an important point of traffics in this district, the maximum depth of inundation reached about 1.4 m, its duration was about one week, and about four months were needed to repair the destroyed roads, which brought about severe obstruction to traffics. Inside the estates of PNP VI Adolina, the private railroad which is used for the transportation of estate products and materials was submerged by the flood. As a result of it, a remarkable decrease of yield were brought about by the reduction of efficiency of work.

Recently, overtoppings of river water and breaks on dikes took place more frequently --- they occurred at four places in 1968 and at nine places in 1969. The frequency of overtopping or break on dikes has a tendency to increase year after year. Moreover, they are concentrated in a reach 3 to 4 km long on the middle reaches of the main stem. The causes of these phenomena will be explained afterwards.

3. Damages Caused by Floods

The damages of public facilities, etc. are recorded by DPUPSU on some floods which occurred between 1958 and 1969. They are shown in Table 1-5-2. From this table we can find that the amount of damages caused by one flood ranges from Rp 30,000,000 to 80,000,000 and the average amount works out at about Rp 55,000,000. The damages of estates and farms, however, are not included in these amounts. As almost no data were available on the damages of estates and farms, we made a field survey concerning inundation depth and its

Table 1-5-2 Damages of Public Facilities, etc. Caused by Floods/1

	8/9 Dec. 1958		19 Nov. 1961		25/26 Nov. 1964		27 Nov. 1965		5 Dec. 1968		14 Sep. 1969	
		Amount (Rp 1,000)		Amount (Rp 1,000)		Amount (Rp 1,000)		Amount (Rp 1,000)		Amount (Rp 1,000)		Amount (Rp 1,000)
National road	15.0km	30,000	118	23,600	15.6	31,200*	10.5	21,000	8.9	17,800	13.2	26,400
Provincial road	7.5km	7,500*	3.78	3,780	7.2	7,200	3.47	3,470	2.3	2,300	2.6	2,600
Canal	13 km	13,000*	3.6	7,200	1.0	2,000	0.97	2,000	3.46	3,500	2	2,000
Irrigation facilities	5	10,000*	4	4,000	2	4,000	2	4,000	1	2,000	3	6,000
Dikes	0.7km	2,000	5.4	12,000*	0.75	1,500	5.96	6,500	5.06	6,300	6.2	11,000
Bridges	4	12,000*	2	4,000	2	6,000	4	10,000	2	2,000	4	12,000*
Houses	256	2,816*	27	270	156	1,560	-	-	12	120	5	110
Buses & cars	137	1,370*	34	340	59	590	4	40	8	80	-	-
Livestock	326	325*	193	193	129	129	-	-	-	-	-	-
Total		79,011		55,343		54,179		47,010		34,100		60,110

/1 The data are reported by DPUPSU.

duration time by hearing from people, in order to gather data as much as possible. In this field survey, we chose 52 locations in the flood zone and used one year as a unit of flooding instead of one flood.

It is hard to say that such data are sufficient to make damage maps of every year. Therefore, we made one damage map of the year 1969, as shown in Fig. 1-5-2, because we could collect more data for this year than the others. Then we made a damage potential map, Fig. 1-5-3, using all data which we could gather to date.

From these maps and the rates of planting or cultivation, the inundation area in the 1969 flood and the maximum possible inundation area are estimated under the classification of crops as shown in Table 1-5-3 and Table 1-5-4.

Table 1-5-3 Inundation Area (1969)

Unit: ha

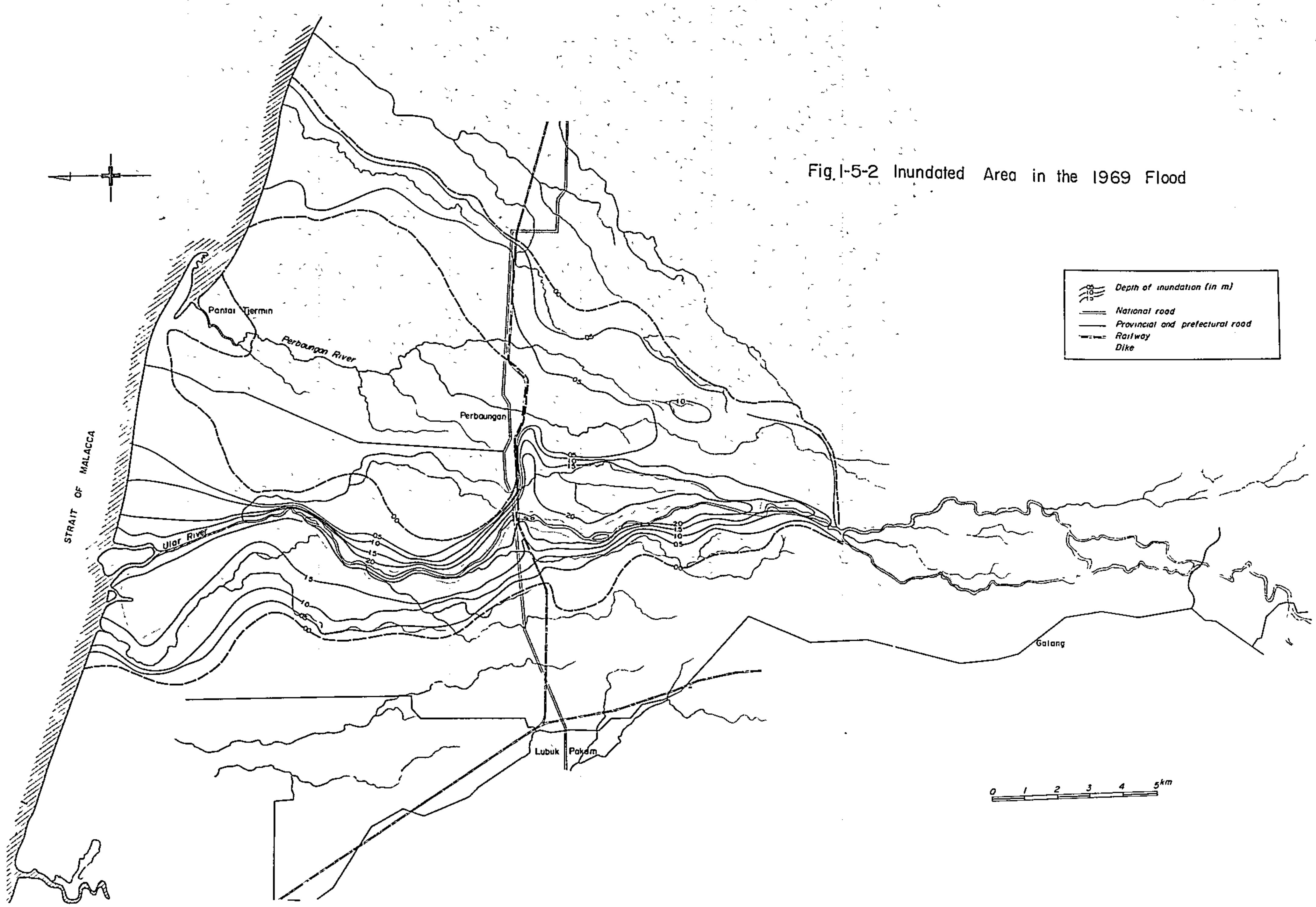
Depth (m)	0.0-0.5	0.5-1.0	1.0-1.5	1.5-2.0	2.0-	Total
Oil-palm	674	340	195	365	76	1,650
Rubber	816	748	68	0	0	1,632
Tobacco	28	30	0	0	0	58
Paddy	1,480	1,380	1,170	450	420	4,900
Upland rice field and farm land	200	100	0	0	0	300
Total	3,198	2,598	1,433	815	496	8,540

Table 1-5-4 Maximum Possible Inundation Area

Unit: ha

Depth (m)	0.0-0.5	0.5-1.0	1.0-1.5	1.5-2.0	2.0-	Total
Oil-palm	605	195	655	1,310	284	3,049
Rubber	638	1,198	400	178	0	2,414
Tobacco	168	290	180	62	0	700
Paddy	1,990	3,740	450	2,120	1,950	10,220
Upland rice field and farm land	200	150	150	0	0	500
Total	3,601	5,573	1,835	3,670	2,234	16,883

Fig. I-5-2 Inundated Area in the 1969 Flood



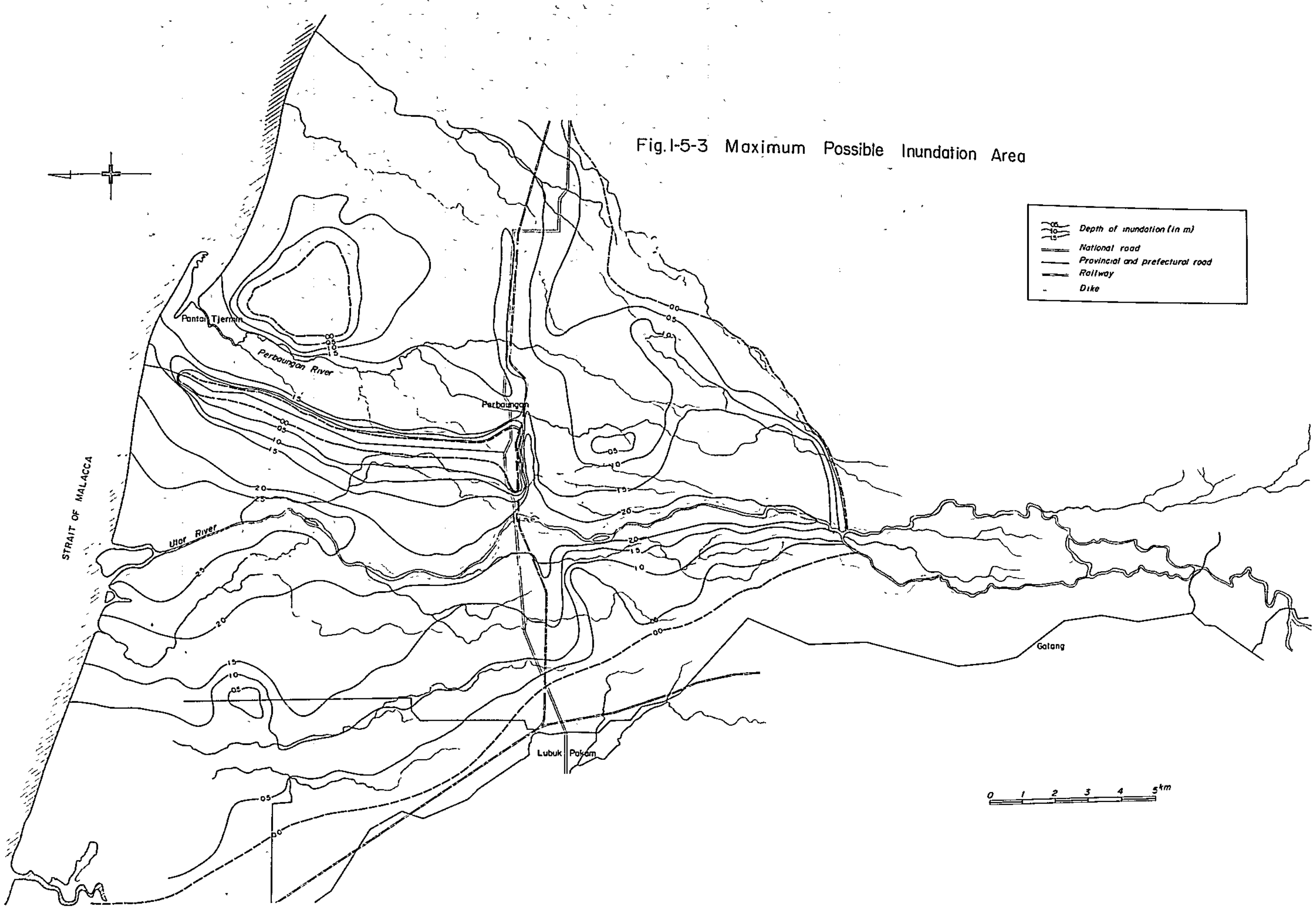


Fig. I-5-3 Maximum Possible Inundation Area
Depth of inundation (in m)
National road
Provincial and prefectural road
Railway
Dike
Pantai Tjermin
Perbaungan River
Perbaungan
STRAIT OF MALACCA
Ular River
Galang
Lubuk Pakam
0 1 2 3 4 5km

Damages of agricultural products caused by floods are generally related to the state of growth of the crops, inundation depth and its duration time. In this case, however, simplification of the relation was considered because of the limitation of data collection. After reviewing data collected by hearing from people, we gained a relation between inundation depth and inundation days, as shown in Table 1-5-5. Using this relation, we estimate amounts of damages.

Table 1-5-5 Relation between Inundation Depth and Inundation Days

Depth (m)	Duration (days)
0.5	3 - 20
1.0	5 - 30
1.5	7 - 50
2.0	10 - 60

Palm-oil:

Palm-oil yields are usually higher in rainy season than in dry season, whereas the rainfall affects the yields sometimes unfavorably since flooding takes place frequently in rainy season. When palm-oil plantations are flooded, the yields are remarkably decreased due to interruption of cropping as well as loss of fertilizer by washing and damages of production equipments, etc. Furthermore, the roots of palm-oil are not so strong against water that they begin to grow rotten due to about 20 days' inundation and some of them come to die finally.

It is very hard to grasp exactly the decrease of yield and the number of palm trees withered by inundation. From information gathered by field survey, the rate of decrease of yield due to floods is estimated at 25 - 30 % per year. Here, assuming that the rate of decrease is 30 %, we estimate the decrease of yields in the inundated area shown in Table 1-5-3 and 1-5-4.

Table D-1 in Data 3 indicates that the annual yield and the annual production cost of palm-oil are Rp 119,200 and Rp 46,700 per hectare respectively and the difference is Rp 72,500/ha. Therefore, the annual decrease of yield will be as follows:

Decrease of yield in 1969

= Rp 72,500/ha x 1,650 ha x 0.30

= Rp 35,887,500

Decrease of yield in the case of maximum possible inundation

= Rp 72,500/ha x 3,049 ha x 0.30

= Rp 66,315,750

Rubber:

Since the roots of rubber trees are so strong against water that the rate of rot or withering is smaller than palm trees. Nevertheless, the rubber cropping is stopped during floods. Consequently, the yields are decreased, because labor and time are needed to rehabilitate production facilities and equipments, damaged roads, and drainage canals for some time after the floods subsided.

Taking these facts into consideration and referring to Table 1-5-5, we assumed the rate of decrease in rubber production as follows:

Inundation depth (m)	Rate of decrease (%)
0.0 - 0.5	10
0.5 - 1.0	15
1.0 - 1.5	20
1.5 - 2.0	30

Using this table we estimate the decrease of yields in rubber production in the inundated areas shown in Table 1-5-3 and Table 1-5-4. Table D-1 in Data 3 indicates that the annual yield and the annual production cost of rubber are Rp 114,000 and Rp 47,600 per hectare respectively and the difference is Rp 66,400/ha. Therefore, the annual decrease of yield will be as follows:

Decrease of yield in 1969

= Rp 66,400/ha x (816 x 0.10 + 748 x 0.15 + 68 x 0.20) ha

= Rp 13,771,630

Decrease of yield in the case of maximum possible inundation

= Rp 66,400/ha x (638 x 0.10 + 1,198 x 0.15 + 400 x 0.20
+ 178 x 0.30) ha

= Rp 21,706,160

Tobacco:

Tobacco is so weak against water that the yield is reduced to almost nil owing to a few days' inundation. Taking this fact into consideration and referring to Table 1-5-5, we assume the rate of decrease in Tobacco production as follows:

Inundation depth (m)	Rate of decrease (%)
0.0 - 0.5	50
over 0.5	100

Using these rates of decrease, we estimate the amount of decrease in tobacco production in the areas shown in Table 1-5-3 and Table 1-5-4. According to Table D-1 in Data 3, the annual yield and the annual production cost of tobacco are Rp 162,000 and Rp 64,800 per hectare respectively and the difference is Rp 97,200/ha. Therefore, the annual decrease of yield work out as follows:

Decrease of yield in 1969
= Rp 97,200/ha x (28 x 0.5 + 30) ha
= Rp 4,276,800

Decrease of yield in the case of maximum possible inundation
= Rp 97,200/ha x (168 x 0.5 + 290 + 180 + 62) ha
= Rp 59,875,200

Rice:

According to the information from DPPSU, the yield of rice is reduced to about 2/3 of the normal when rice is inundated by floods. With reference to the information gathered by field survey, we assume the following rates of decrease under inundation depth.

Inundation depth (m)	Rate of decrease (%)
0.0 - 0.5	20
0.5 - 1.0	60
over 1.0	100

Using this table, we estimate the decrease of yields in rice production for the areas shown in Table 1-5-3 and Table 1-5-4. Table D-1 shown in Data 3 indicates that the annual yield and the annual production cost of rice are Rp 71,250 and Rp 32,000 per hectare respectively and the difference is Rp 39,250/ha. Therefore, the annual decrease of yield in rice production are estimated as follows:

Decrease of yield in 1969

= Rp 39,250/ha x (1,480 x 0.20 + 1,380 x 0.60 + 1,170 + 450 + 420) ha

= Rp 124,187,000

Decrease of yield in the case of maximum possible inundation

= Rp 39,250 x (1,990 x 0.20 + 3,740 x 0.60 + 450 + 2,120 + 1,950) ha

= Rp 281,108,500

Upland rice and field crop:

The decrease of yields is estimated for the inundated areas shown in Table 1-5-3 and Table 1-5-4 on the assumption that the rates of decrease in upland rice and field crop production are equal to the case of rice.

Table D-1 shown in Data 3 indicates that the annual yield and the production cost of upland rice and field crop are Rp 41,000/ha and Rp 16,000/ha respectively and the difference is Rp 25,000/ha. Therefore, the annual decrease of yield in upland rice and field crop production is estimated as follows:

Decrease of yield in 1969

= Rp 25,000/ha x (200 x 0.20 + 100 x 0.60) ha

= Rp 2,500,000

Decrease of yield in the case of maximum possible inundation

= Rp 25,000/ha x (200 x 0.20 + 150 x 0.60 + 150) ha

= Rp 7,000,000

The above amounts of decreases in agricultural production and the amounts of damages of public facilities, etc. previously mentioned are tabulated in Table 1-5-6.

Table 1-5-6 Amounts of Damages Caused by the 1969 Flood and Damages in the Case of Maximum Possible Inundation

Product, etc.	Amount of damage (Rp)	
	1969	Max. possible inundation
Palm-oil	35,887,500	66,315,750
Rubber	13,771,360	21,706,160
Tobacco	4,276,800	59,875,200
Rice	124,187,000	281,108,500
Upland rice & field crop	2,500,000	7,000,000
Public facilities, etc.	60,110,000	90,151,000 /1
Total	240,732,660	526,156,610

In general, the damages to agricultural products include those due to flood as well as those caused by impounded water. The flat land on the lower Ular is a fertile alluvial plain which is suited to the agricultural production. On the other hand, the land is low lying and easily submerged. Therefore, when the land which is already inundated by impounded water is flooded or when the land flooded is inundated by the impounded water, the depth, duration and area of the inundation include not only those due to the flood but those caused by the impounded water.

In order to find the amount of damages caused solely by the flood excluding any influence of the impounded water, the amount of inundation due to the impounded water during the flood in 1969 is estimated with the aid of rainfall data prepared by the rainfall gage station existing in this area.

There are several rainfall gage stations which cover the impounded water area on the lower Ular. Of these stations, the data of the Kualanamu Rainfall Gage Station have been adopted because the station is situated at the approximate center of the inundated area and, in addition, there is no observation missing during 1960 - 1969. Further, in view of the fact that the damage due

/1 This amount is a total of the maximum values in each facilities during the period from 1958 to 1969, —— a total of amounts of damages marked by asterisk * in Table 1-5-2.

to the impounded water is concentrated in the season of heavy rainfall and that it is believed to be safer for the economical analysis for flood control to underestimate the direct damage from a flood, the mean value of the annual maximum seven-day rainfalls at the Kualanamu Station during the heavy rainy season has been used to calculate the amount of impounded water on the assumption that the duration of inundation due to flood is one week. The mean value of the annual maximum seven-day rainfalls during the period from 1960 - 1969 is estimated at 136 mm. Since the average rainfall on this area, as seen in Section 4, Data 2, is about 70 % of that at the Kualanamu Station, the mean seven-day rainfall within the impounded water area will be estimated at about 90 mm. The rainfall which contributes to the impounded water is the residual amount which those of evaporation and loss into the ground are deducted from the above mean rainfall. If it is assumed that the daily evaporation is 3.5 mm and the rate of loss into the ground is 10 %, 60 mm will be the rainfall for impounded water. When the influence of the impounded water is excluded from the inundation area shown in Table 1-5-3 on the assumption that the above rainfall is included in the inundation at the time of flood in 1969, the inundation area caused solely by the flood is estimated at about 7,940 ha, which is equivalent to about 93 % of the total inundation area. The amount of damage resulting from such inundation is estimated at about Rp 164,200,000, to which the amount of damage on the public facilities, etc. is added making the total of about Rp 224,400,000. This is about 93 % of the total amount of damage of Rp 240,732,660 shown in Table 1-5-6.

Next, the maximum possible inundation area caused solely by the flood is calculated excluding the influence of the impounded water from the area shown in Table 1-5-4. The maximum possible inundation area shown in the said table is the aggregate of the inundation areas at the times of flood in the period from 1954 to 1969. In estimating the amount of impounded water at the times of above flood, the maximum value of seven-day rainfall at the Kualanamu Rainfall Gage Station in the heavy rainy season during 1960 - 1969 has been used on the same assumption as made for the flood in 1969. The value is 179 mm in September, 1966. If it is assumed that the conversion coefficient to the average rainfall on this area is 0.7, the amount of evaporation is 3.5 mm/day, and the rate of loss into the ground is 10 %, the amount of rainfall which contributes to the impounded water is estimated at about 90 mm. The rough estimate of the inundation area due to flood after excluding the influence of the impounded water caused by the above rainfall is about 15,800 ha. It is about 94 % of the total inundation area shown in Table 1-5-4 and the estimated amount of damage on the agriculture is about Rp 399,000,000. If the amount of damage on the public facilities, etc. is added to the above amount it totals to about Rp 489,000,000, or 93 % of the total amount shown in Table 1-5-6.

The amount of damage on the public facilities, etc. was investigated in six occurrences of flood among those in twelve years from 1958 - 1969 as shown in Table 1-5-2. The average amount of damage for each flood is about Rp 55,000,000 calculated on the basis of the above investigation. Comparable to it is the amount of damage from the flood in 1969 which is about Rp 60,000,000 or a little more than the average figure. Taking into consideration the fact that flood often occurs several times in a year, the amount of damage of Rp 60,000,000 is presumed to be the total amount of damages on the public facilities, etc. for the year 1969.

On the other, because of few available statistics of damage on the agricultural products the study was made of the flood damage in 1969 on which the data is available comparatively with ease. Based on the above study, the amount of damage on the agricultural products is estimated at about Rp 181,000,000 as shown in Table 1-5-6, to which the amount of damage on the public facilities is added to estimate the total amount of about Rp 241,000,000 for the flood damage in 1969 as shown in Table 1-5-6.

The average amount of damage per year for twelve years from 1958 to 1969 is 100 % of the amount of damage in 1969 where the average amount of damage for the years except those in which the six floods occurred is assumed to be equal to the amount of 1969; and 50 % where it is assumed that there was no damage during the years as indicated above.

It is supposed that the six floods shown in Table 1-5-2 were comparatively great in their scales among those occurred in twelve years from 1958 to 1969; however, as the floods have occurred, in fact, almost every year it should be allowed for that the floods occurred in the years except those when the said six floods were included. Taking this fact into consideration the amount of damage per year is estimated at 75 % of the damage in 1969. After eliminating the influence of the impounded water, the amount of damage solely due to flood may be calculated as follows.

Average annual amount of flood damage

= Rp 224,400,000 x 0.75

= Rp 168,300,000.

This amount is used for the cost-benefit analysis described in the subsequent chapter.

The above-mentioned damages do not include private plantations as well as damages from interruption of social and economic activity due to traffic stoppage and impairment of people's health due to stagnation of inundated water. If these damages are included, total amount of damages is expected to be well over Rp 170,000,000 on the annual average. Furthermore, when we think of the possible inundation area which covers over 25,000 ha, we can not help but conclude that the flood control of the lower Ular is indeed a matter of great urgency.

CHAPTER VI

URGENT FLOOD CONTROL PLAN

1. Basic Idea for Urgent Flood Control Plan

The Ular river has continuous dikes on both sides from Galang Barat to the rivermouth and no tributaries flow into this river in between. As mentioned above, the inland area on both sides of the river downstream from Pagar Marbau to the sea suffers severe damages from habitual inundation every rainy season.

The following two phenomena are regarded as principal causes of inundation: one is the flood caused by overtopping of river water or breaks on the dikes which occur frequently within the reaches between Pagar Marbau and Ular bridge, and the other one is impounded excess water due to rainfall in the inland area.

In order to relieve this area from habitual inundation, the following basic measures are considered as an effective means of flood control:

a. To prevent overtopping or break on dikes.
b. To ensure required cross-sections of river channel in the main course as well as in the estuary.
c. To maintain river channel by means of sand-arresting work so that the rise of riverbed by sediment load may be avoided.
d. To facilitate drainage of excess water in the inland in rainy season.

Of the above four measures, the first two have been adopted in the present planning, because, firstly, the overtopping of river water or break on dikes forms the principal causes of inundation and the prevention of flood is expected to bring about facilitation of drainage of excess water, secondly, the devastated river channel should be rehabilitated in compliance with five-year development plan.

In this connection we worked out an urgent flood control plan as the first step, and we call the design discharge for this urgent plan the provisional design discharge.

2. Provisional Design Discharge

In general, the design discharge is an important factor which determines the scale of flood control plan. The most desirable points for determining the design discharge are as follows: that is (1) to analyze the runoff with the data of daily and hourly rainfalls over the whole river basin and the records of water level and discharge of the river; (2) to study the occurrence probability of flood; and (3) to examine the relation between the costs of flood control work and the benefits to be derived from such work correlating it with the probability of flood discharge. However, as such data are not available in the present instance it is inevitable to employ an experimental method to examine the discharge.

According to the Dredging of Rivers in Indonesia, Project Description, DPUTL, the Water Resources Development Division, ECAFE, has suggested to use the following formula for calculating the maximum flood discharge of the rivers in Indonesia.

$$Q = 70\sqrt{A}$$

where

Q = the maximum flood discharge (m^3/sec).

A = area of river basin (km^2).

For the Ular river, of which $A = 1,000\ km^2$, the maximum flood discharge is estimated as follows applying the above formula:

$$Q = 2,200\ m^3/sec.$$

The Secretariat of ECAFE expressed its opinion in the Water Resources Series No. 30, 1966 and contended and that the modified Myer's formula, $Q = C\sqrt{A}$, gives an excessive value in Q when applied to a very large or very small river and, on the other, a too small value in Q for the river having the basin of medium range, suggesting to use a formula which envelopes the maximum recorded discharges for each area of basin. That is, the Secretariat who studied the flood data as a group comprising those of Cambodia, Main-land China, Indonesia, Laos, Malaysia and Thailand selected from such data for the Southeast and Far East Asias gathered by ECAFE has proposed to use the following empirical formula

$$Q = 0.35\ A^{1.8A^{-0.05}}$$

According to this formula, when $A = 1,000\ km^2$;

$$Q = 2,300 \text{ m}^3/\text{sec.}$$

In the above empirical formula, a fairly extensive area ranging from Indonesia to Main-land China is regarded as a group which seems too extensive as such. So, the data which were picked out only in relation to Indonesia are as shown in Table 1-6-1 and Fig. 1-6-1. The area of the Ular river basin is 1,000 km² and the rivers shown in Table 1-6-1 which have the most similar areas to it are Tjimanuk (1,608 km²) and Kali Brantas (1,618 km²). The peak discharges per unit area in these river basins are both 0.57 m³/sec/km² and the values of coefficient C are both 23.

If the peak discharge per unit area of the Ular river is presumed to be 0.57, the peak flood discharge may be estimated at;

$$Q = 570 \text{ m}^3/\text{sec}$$

and if it is assumed that C = 23, the peak flood discharge estimated by the modified Myer's formula will be;

$$Q = 726 \text{ m}^3/\text{sec.}$$

When an empirical formula enveloping only the flood data of Indonesia is to be presumed it is a curve as shown on Fig. 1-6-1. As the peak discharge per unit area corresponding to A = 1,000 km² calculated from the above curve is Q/A = 1.5, the peak flood discharge may be estimated at;

$$Q = 1,500 \text{ m}^3/\text{sec.}$$

As previously mentioned, Serbadjadi Bridge spans the river at the point about 5 km downstream from the confluence of the Buaja and Denai rivers and there is no trace of water overtopped the dike at this place in recent years. The discharge nearing close to the bottom of the truss is estimated at

$$Q = 1,300 \text{ m}^3/\text{sec}$$

on the assumption that the slope of river bed is 1/756 as shown in Fig. 1-4-2 and the coefficient of roughness is n = 0.025.

As described in the above, various values are conceivable for the discharge of this river which is estimated to range possibly between;

$$Q = 1,300 \sim 2,300 \text{ m}^3/\text{sec.}$$

Although further investigation is needed to define the design discharge, it seems appropriate that the discharge somewhat less than 1,300 m³/sec ranging to about 2,300 m³/sec should be adopted as the design discharge.

Fig. I-6-1 Relation between Peak Discharge per Unit Area and Drainage Area in Indonesia and Malaysia.

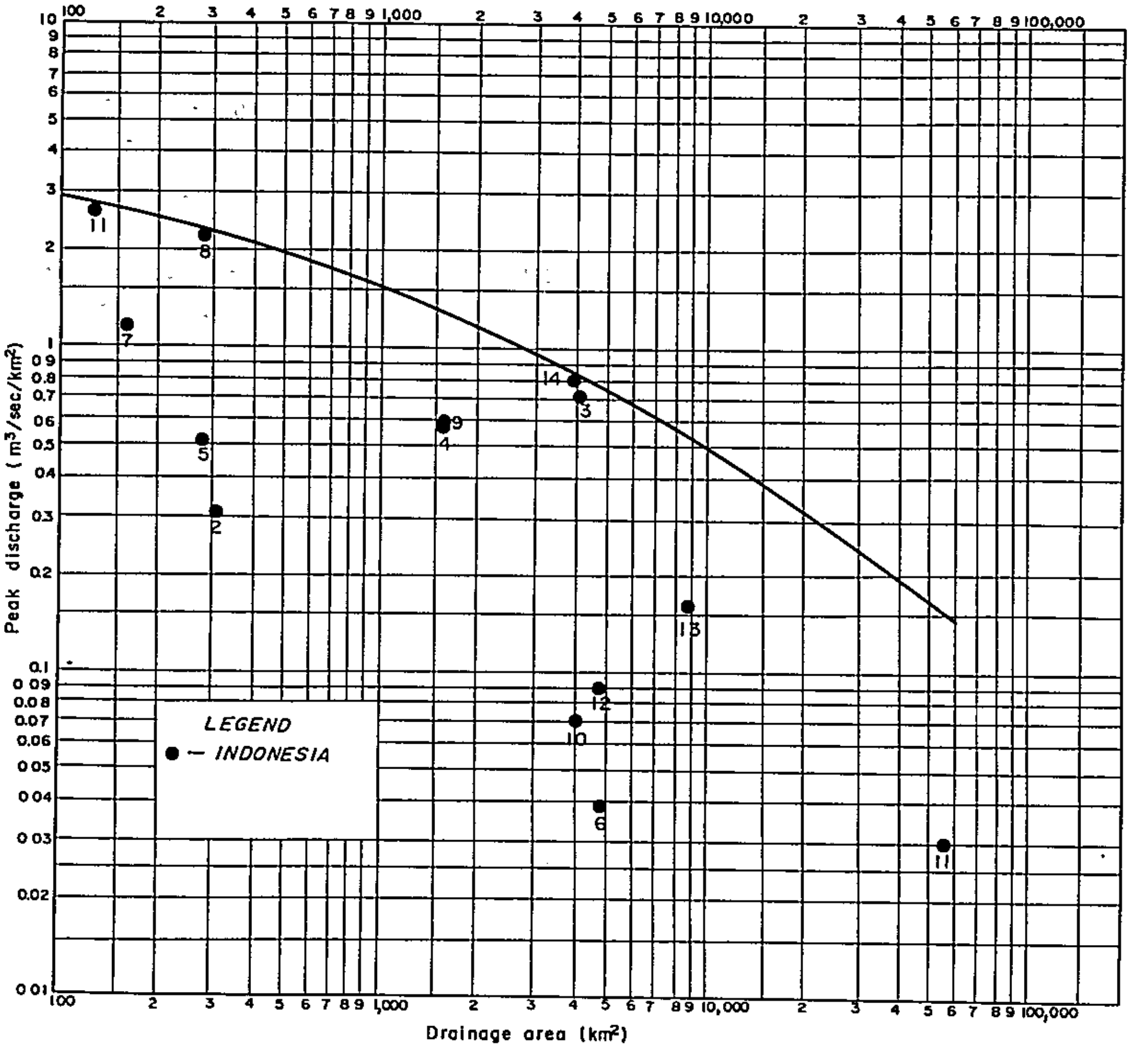


Table 1-6-1 Peak Discharges in Indonesia

Name of River	Drainage area at gauging station (km²)	Peak discharge (m^3/sec)	$C=\frac{Q}{\sqrt{A}}$	Discharge per unit area ($m^3/sec/km^2$)	Date
1. Tjisadane-Masing	129	335	30.0	2.6	
2. Tjiliwung-Rawajati-Djatinegara	318	100	6.0	0.31	
3. Tjitarum-Palumbon	4,150	2,930	46.0	0.71	
4. Tjimanuk-Tjidjeunding	1,608	910	23.0	0.57	
5. Kali Tuntang-Padasmalang	291	149	9.0	0.51	
6. Kali Tanggulangin	4,968	181	3.0	0.04	
7. Tjilaki-Tjiheulang	163	188	15.0	1.15	
8. Tjibuni-Tanggeung	289	640	4.0	2.21	
9. Kali Brantas-Sengguruh	1,618	920	23.0	0.57	
10. Asahan	4,000	237	4.0	0.06	
11. Musi	55,584	1,400	6.0	0.03	
12. Sakampaeng	4,839	460	7.0	0.09	
13. Brantas	8,900	1,390	15.0	0.16	
14. Marangin	3,900	3,130	50.0	0.8	

Sources: 1. ECAFE Flood Control Series No. 14.
2. Sain, K., and Schellekens, J.P., Determination of design floods in the Lower Mekong River Basin.

On the other hand, Ular bridge and a railway bridge span the river at the point 13.6 km upstream from the rivermouth and the long cross embankments projecting into the river area form an extreme constriction. As referred to later, this constriction constitutes a serious obstruction to greater discharges and these cross embankments should be removed from the standpoint of flood control planning. However, it is clear that the removal of these embankments and the newly building of the bridges spanning the whole width of the river will need a huge amount of cost. The present plan is the emergency project of which principal object is to rehabilitate the aggravated river in line with the Five-year Plan. Therefore, it has been decided that the maximum discharge which can pass the constricted portion without causing much trouble even though the bridge in question is not rebuilt will be adopted as the design discharge for the urgent flood control planning, i.e. the provisional design discharge. This discharge is estimated at;

$$Q = 600\ m^3/sec$$

in accordance with the examination described later.

The constriction due to the bridges should be eliminated by all means from the view point of flood control. In parallel with the study of design discharge in future, the rebuilding of the bridges in question should be contemplated in the second phase subsequent to the present project.

3. Urgent Flood Control Plan

(1) Policy of planning

The policy of planning is as follows.

a. According to the opinion expressed in the Project Presentation for Dredging Works in Indonesia, the problem of the Ular river was that of flooding due to the deposition of silt at the estuary. However, it was judged on the basis of our investigation that the dredging of its estuary will not have an effect on so far upper stream as expected and, rather, the riverbed abnormally raised near the point 18.7 km upstream from the rivermouth causes the water level in the river channel upstream from that point to rise causing habitual overtopping or break on dikes. Therefore, it was decided to lower the abnormally raised riverbed by dredging or excavating it so that the needed cross sectional area of river channel can be secured.

b. A national road bridge and a railway bridge spanning the river near the point 13.6 km upstream from the rivermouth constrict the river channel and, as mentioned in the later paragraph, the extent to which the flow is obstructed by such constriction is intensified with increased discharge. Therefore, it is desirable to rebuild both these bridges. However, in setting up the emergency programme carried out in the first stage, the maximum discharge which is deemed to be able to flow passing safely the point where the existing two bridges spanning the river will be adopted as the provisional design discharge and the river channel which permits the safe flow of such discharge will be provided for the whole reaches of the river. In this, by way of precaution, riverbed protection will be provided around the points spanned by those bridges to prevent the riverbed from local scouring.

c. As it is desirable for the stabilization of river channel that the amounts of bed load passing each cross section are nearly equal, the planning of river channel will be arranged so as to maintain the continuity of bed load as much as possible.

d. The shape of river cross section to be adopted will be of double-section, taking into consideration the stabilization of river channel.

e. The upstream section from 20.4 km point has the width of about 150 m which is remarkably narrower as compared with that of the downstream section which is about 250 m. Therefore, the dikes will be set back to ensure the river width of about 250 m.

f. As the dikes downstream from Ular bridge has a freeboard of approximate 1 m for the provisional design discharge, they will be left as it is except that some reinforcement works will be provided for them.

g. Although the present plan is provisional, the works should be designed so that no futility may be caused in the future.

(2) Influence of siltation at the estuary

In general, sediment load which is transported from upstream settles at last at and around the rivermouth due to sudden decrease of tractive force of river flow and is distributed to the neighbouring coast by the action of waves, longshore current, and tide. This results in raising the river bed for a long time with the progression of coastal line owing to the aggradation at the estuary and distribution of sediment on the sea coast.

When a rivermouth is located in low land and has no dikes around there as in the case of the Ular river, striking meanderings are often seen to take place around the rivermouth. Since a striking meandering had existed also at the estuary of the Ular, dredging works amounting to a volume of about 1,153,000 m³ were carried out in the period from April 1968 to July 1969 /1 to make a short cut to the sea with a deepchannel. However, it was found from our exploration in October 1970 that the channel was already silted up form-

/1 See a report by P.N. Waskita Karya mentioned in Bibliography.

ing a river bed almost the same as that before dredging. It may be taken that the resilting-up was principally caused by the action of sea.

Calculation of water level/1 was made on both river beds just before and after dredging, on the assumption that, for the convenience of calculation, there exist continuous dikes along the river channel as far as the neighbourhood of the rivermouth. The results are shown in Fig. 1-6-2, which indicates that the siltation at the rivermouth, even if it occurred, does not affect directly the upper reaches beyond a distance of about 3 km from the rivermouth.

Hence, we decided to make no plan of rivermouth dredging, because (1) a dredged channel at the rivermouth may be easily silted up before long if a counter measure of large scale is not carried out to maintain the dredged channel and (2) the siltation at the rivermouth is not supposed to affect directly the upper reaches more than about 3 km upstream from the rivermouth and it may be taken to take a very long time before the upper reaches are affected by it, since the aggradation in the estuary is expected to be easily flushed away by flood flow and the influence of back sand may not appear so fast on the upper reaches.

It is conceived that the rivermouth training work should be carried out at the time when the area neighbouring the rivermouth has been sufficiently developed after the improvement of the upper reaches has been completed.

(3) Backwater effect of Ular bridge and railway bridge

Ular bridge crosses the Ular river at the point 13,550 m upstream from the rivermouth and at another point only 80 m upstream from that bridge a railway bridge crosses the river. Each of those bridges has long approach bankings across the highwater channel narrowing the normal width of about 250 m to only 64 m. As a heavy contraction of flow is expected in case of flood, the influence of constriction was studied.

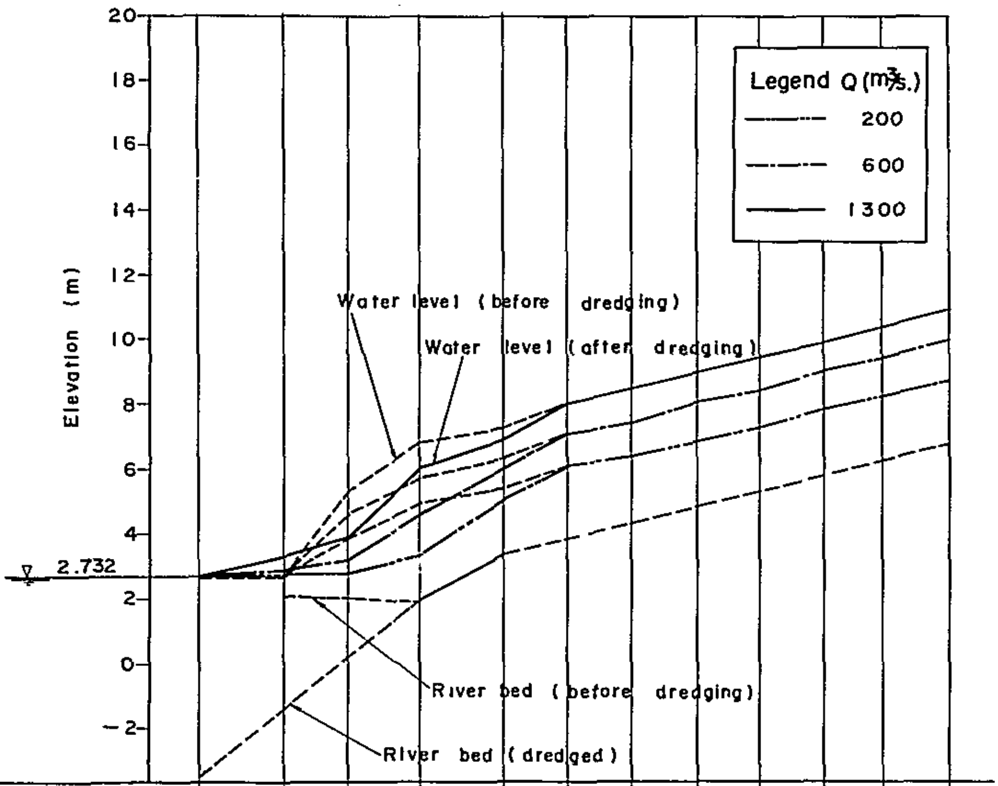
Calculation of water level in a non-uniform flow/2 with a contraction/3 were made on the following assumptions:

/1 See Appendix 1.

/2 See Appendix 1.

/3 See Appendix 1.

Fig. 1-6-2 Water Level on the Lowest Reaches of the Ular.



			-1	0	1	2	3	4	5	6	7	8	9	10
Water level	After dredging	Q=1300 (m³/s.)	2.732	3.329	3.970	6.001	6.950	8.027	9.488	8.971	9.470	9.969	10.469	10.969
		Q= 600	2.732	2.861	3.212	4.605	6.077	7.086	7.461	8.050	8.441	9.050	9.441	10.050
		Q= 200	2.732	2.747	2.803	3.399	5.089	6.089	6.412	6.851	7.338	7.835	8.335	8.834
	Before dredging	Q=1300		2.732	5.477	6.854	7.350	8.028	8.489	8.971	9.470	9.969	10.469	10.969
		Q= 600		2.732	4.678	5.760	6.309	7.086	7.461	9.050	8.441	9.050	9.441	10.050
		Q= 200		2.732	3.954	4.925	5.419	6.089	6.412	6.851	7.338	7.835	8.335	9.834
River bed (dredged)			-3.45	-1.42	0.20	1.89	3.40							
River bed (before dredging)				2.12	2.13	1.89	3.40							
Distance			-672	0	510	1045	1697	2197	2697	3197	3697	4197	4697	5197
Section number			-1	0	1	2	3	4	5	6	7	8	9	10

(1) The slopes of embankments and abutments are all vertical.
(2) The bridges cross the river in the normal direction to the river stream.
(3) The two bridges, as a whole, make one constriction.
(4) The bridges are not submerged.
(5) There are some piles and piers at the contraction.
(6) After the vena contracta, the live stream begins to expand and the flow is gradually varied until it reaches a section about 100 m downstream from Ular bridge, where the uniform-flow regime is established in the full-width channel.
(7) The slope of river bed is 1/1,000 as shown in Fig. 1-4-2.

According to these assumptions, the values of coefficients in the said formula for contraction are estimated as follows from the results of experiments made by Kindsvader, Carter, and Tracy.

$C = 0.86$

$K_r = K_w = K_\phi = K_x = K_e = K_t = 1$

$K_y = 0.89$, $K_j = 0.95$

K_f is expressed by a function of Froude number at the section of Ular bridge.

The results of calculation are shown in Table 1-6-2, which indicates that the backwater effect due to the constriction should not be overlooked in case of higher discharges and the mean velocity at the constriction may exceed 3 m/sec for the discharge higher than 600 m³/sec.

Table 1-6-2 Water level around the constriction and velocity at the section of Ular bridge (No. 27)

Discharge (m³/sec)	Water level (m)			Velocity at the section No. 27 (m/sec)
	No.27-200m	No.27	No.27+140m	
200	17.59	17.67	17.93	1.39
400	17.95	18.08	18.60	2.36
600	18.64	18.73	19.30	2.86
800	18.84	18.94	19.79	3.58
1000	19.03	19.04	20.34	4.37
1300	19.49	19.35	21.13	5.23

In general, the mean velocity which exceeds about 3 m/sec is unfavorable to the maintenance of river channel, of which river bed consists of sandy materials such as the Ular. Hence, it may be taken that the highest discharge of flow which passes through the constriction without giving excessive damages to the river bed is 600 m^3/sec. The constriction due to those bridges should be eliminated for the discharges which exceed 600 m^3/sec.

(4) River channel upstream from Ular bridge

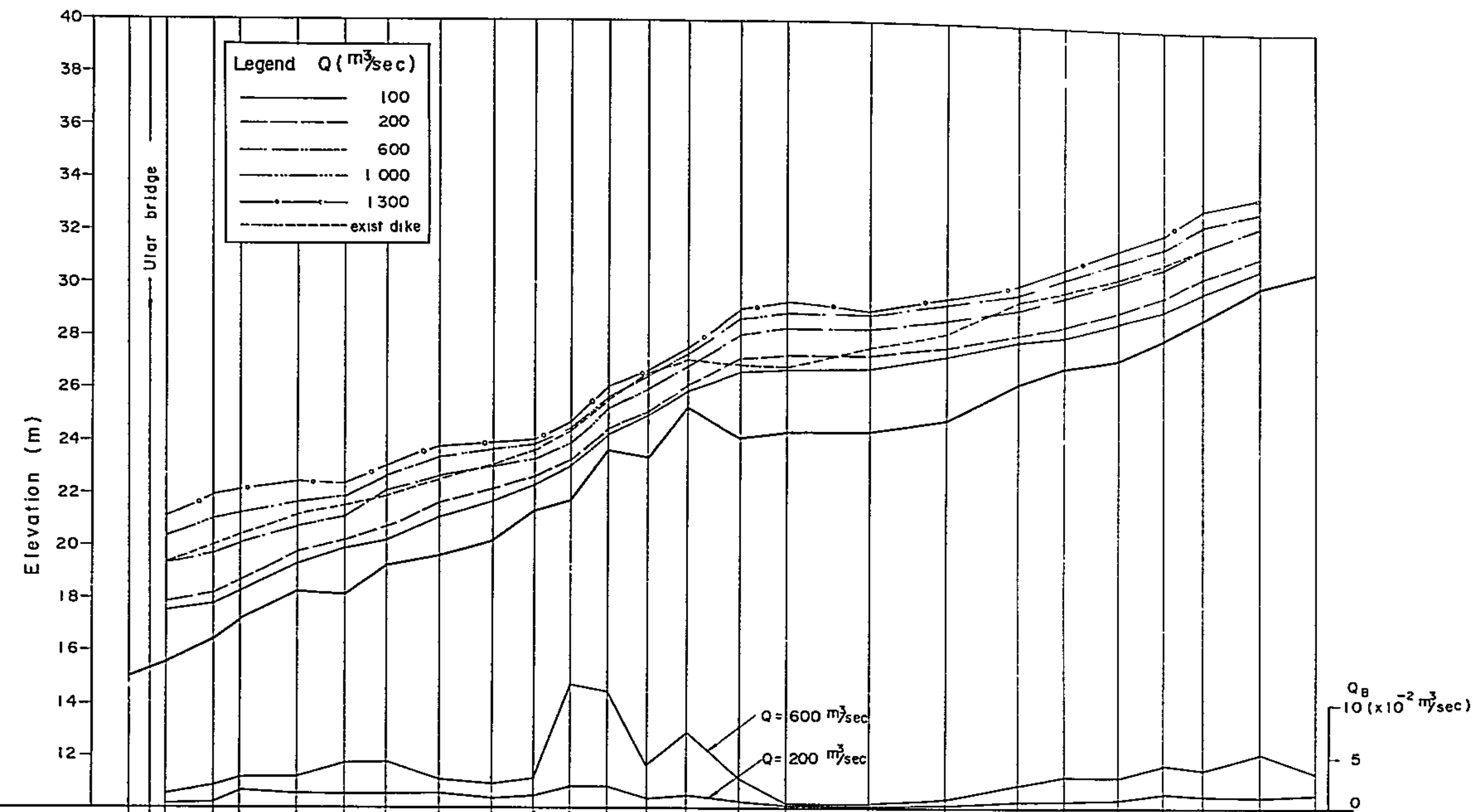
The profile of the river channel upstream from the Ular bridge is shown in Fig. 1-6-3. As previously mentioned, the riverbed near the point 18.7 km upstream from the rivermouth is raised abnormally, causing a habitual overtopping or break on dikes on the reaches upstream from this point. Judging from the surface condition around this point, it is hardly suspected that this abnormally high riverbed is caused by the existence of hard geology such as rock-bed.

Calculations were made on the water level and the bed load Q_B for the existing river channel of the above reaches starting from the water level at the immediate upper section of the Ular bridge computed in the preceding paragraph (3); the results of the calculations are shown in Fig. 1-6-3. These results indicate that the carrying capacity of the existing river channel with the water level close to the crown of dikes is about 600 m^3/sec on the reaches from the bridge to the point of 18.7 km and from the point of 21.9 km to the point of 24.9 km upstream of the former, while it is less than 600 m^3/sec or locally even as small as 200 m^3/sec on the intermediate reaches from 18.7 km to 21.9 km.

Further, the results of calculation of bed load show that the tractive capacity between No. 41 and No. 43 is particularly small. If it is presumed that the discharge of 600 m/sec from the upstream is decreased to 200 m^3/sec toward downstream from the vicinity of No. 39 due to the overflowing from the dike, the bed load transported from the upper stream will be deposited mainly on the reaches from No. 43 to the neighbourhood of No. 38.

Although one of the causes for the abnormally raised riverbed in question may be found originally in the topographical characteristics in the vicinity of this point, it is also conceivable as another important cause that the riverbed is raised by settlement of the silt and sand transported from the upper reaches due to a rapid decrease of the tractive force of flood flow as a

Fig. 1-6-3 Upper Reaches from Ular Bridge (Existing Channel)



Section number	Distance	Discharge (m³/sec) 1300	Discharge 1000	Discharge 600	Discharge 200	Design river bed	Existing dike	Existing river bed
26.9	13350							
27	13550					15.25	19.30	15.25
27.1	13690	21.13	20.34	19.30	17.93			
28	14150	21.91	20.99	19.71	18.20	16.35		16.35
29	14410	22.09	21.20	19.84	18.73	16.68	20.37	17.14
30	14950	22.39	21.62	20.38	19.70	17.37	21.14	18.18
31	15410	22.34	21.79	20.70	20.19	17.96	21.51	18.08
32	15810	23.06	22.67	21.57	20.68	18.47	21.86	19.22
33	16310	23.73	23.34	22.21	21.62	19.11		19.63
34	16790	23.90	23.67	22.67	22.17	19.72		20.92
35	17190	23.96	23.81	22.91	22.59	20.23	23.58	21.31
36	17340	24.17	24.52	23.50	23.26	20.68	24.35	21.73
37	17890	26.00	25.66	24.18	24.49	21.13	25.51	23.55
38	18270	26.51	26.43	24.61	25.06	21.61	26.51	23.36
39	18650	27.46	27.29	25.03	26.08	22.10	27.08	25.25
40	19150	28.95	28.65	25.76	27.10	22.73	26.84	24.06
41	19600	29.30	28.92	26.35	27.18	23.31	26.80	24.30
42	20400	28.88	28.83	27.01	27.23	24.33	27.56	24.33
43	21150	29.47	29.23	28.17	27.58	24.80	28.15	24.80
45	21880	29.99	29.70	29.14	28.16		29.38	26.36
46	22360	30.76	30.30	29.92	28.55		29.81	26.98
47	22900	31.48	31.02	30.46	29.08		30.36	27.34
48	23360	32.10	31.58	30.74	29.70		30.98	28.10
49	23760	33.06	32.54	31.52	30.53		31.65	28.87
50	24320	33.59	33.09	32.20	31.33			30.07
51	24880	34.90	34.43	33.74	32.48			30.69

result of habitual overtopping or break on dikes near the said point. It is believed that the more the riverbed is raised the more the overtopping of flood is induced, thus causing a vicious cycle of habitual overtopping and break on dikes. Therefore, in this emergency plan for flood control it is important to eliminate such abnormality of riverbed.

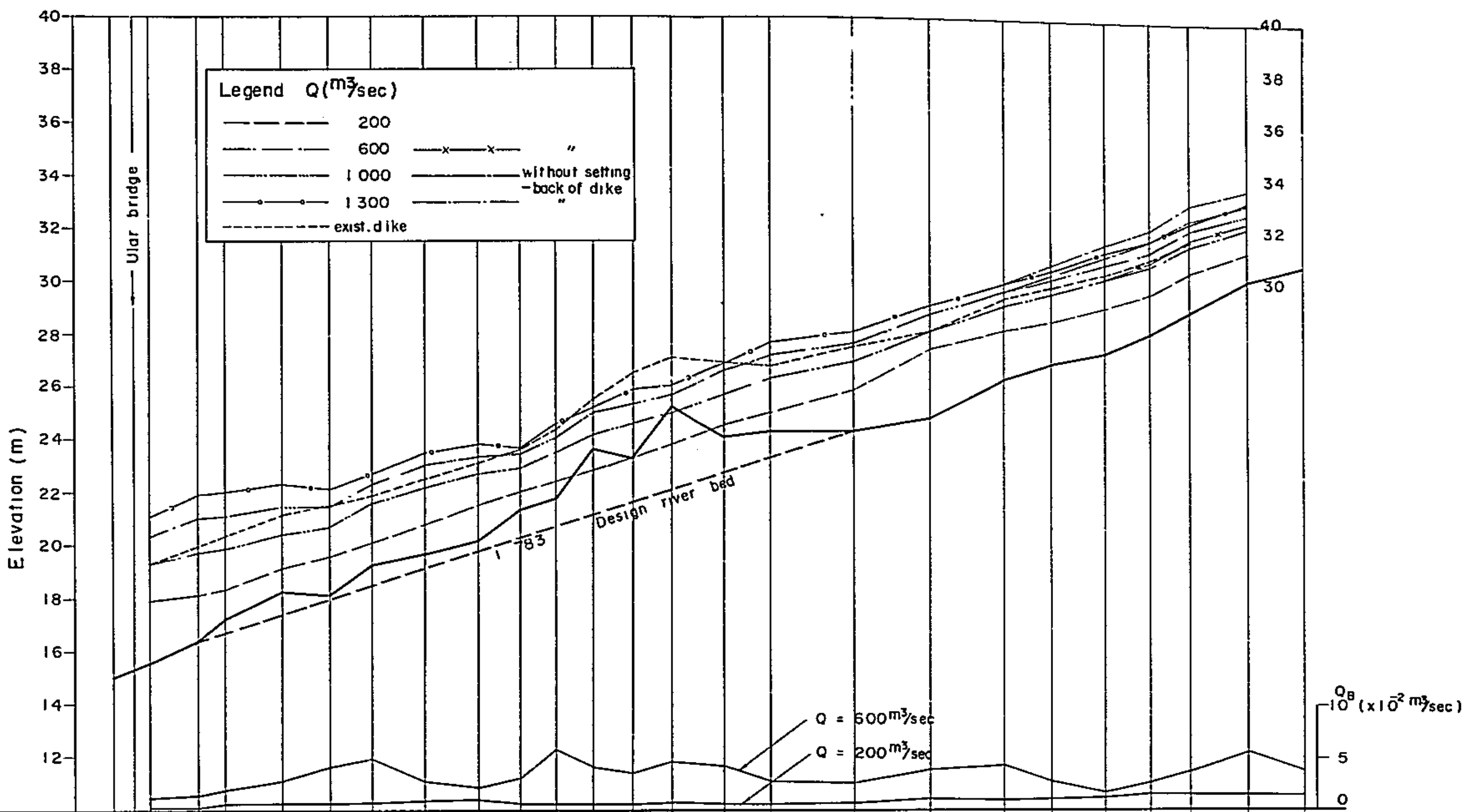
While the river width is generally ranging from 250 m to 300 m, that of the reaches between 20.4 km and 24 km from the rivermouth is particularly narrow, being only about 150 m. Fig. 1-6-4 shows the water level after the river channel from the vicinity of the Ular bridge to the point of 20.4 km has been improved with the river channel upstream from the latter point left in the present condition. It indicates that the heightening of dike is needed, as the water level exceeds the present levee height by about 50 cm in the case of $Q = 600\ m^3/sec$. However, when an improvement work of river channel is conducted in future based on a discharge more than 600 m^3/sec, the setting-back of dikes are expected with certainty in which case the heightening work of dikes at this point of time will result in the futility. Accordingly, in the emergency work, the setting-back of dike will be performed to increase the width of the river channel in question to about 250 m in order to make it agree with that of the whole downstream reaches. In this, the dike on the right bank will be set back so that no change be made on the Perbaungan intake facilities locating on the left bank at the point 23.36 km upstream from the rivermouth.

(5) Design riverbed and design cross-section of river channel

Since the present slope of riverbed of the Ular river has been formed by the flow of a long time, it is preserved in the present planning and the slope of 1/756 is adopted as shown in Fig. 1-6-5.

Consequently, the abnormal riverbed lying on the reaches between 14.1 km and 20.4 km from the rivermouth will be dredged with the bottom width of low-water channel fixed at 60 m, so that the riverbed slope can be varied gradually. Along with this, the high-water channel of the same reaches will be partially excavated to obtain its correct height. The design cross-section will be of double-section, in which a low-water channel of about 60 m in width and about 2.5 m in depth will be provided, taking into consideration that the width of existing low-water channel is approximately 60 m on the reaches from the rivermouth to the point of 35.7 km.

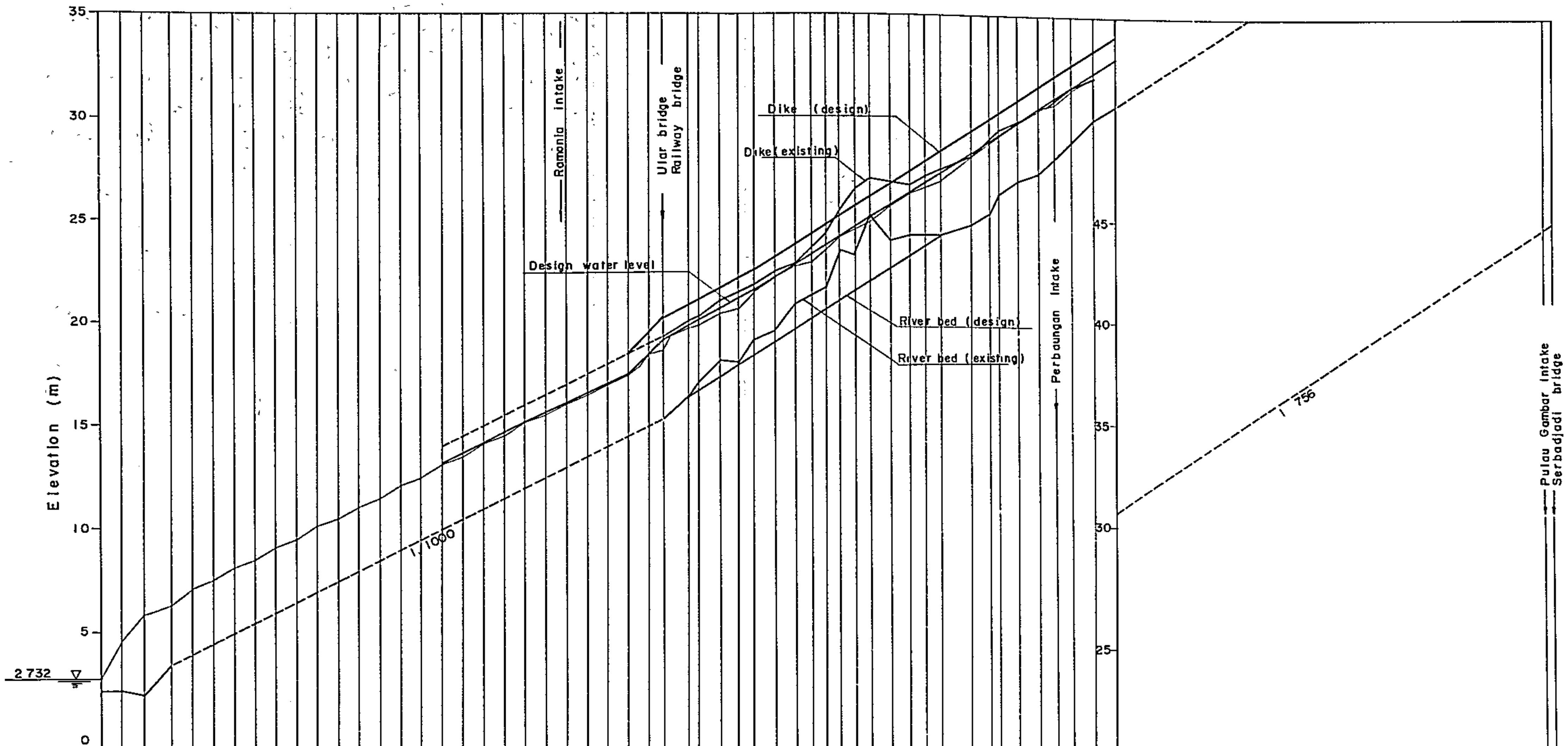
Fig. I-6-4 Upper Reaches from Ular Bridge (Design Channel)



Section number	26-9	27	27-1	28	29	30	31	32	33	34	35	36	37
Discharge (m³/sec) 1300			2115	2192	22.03	22.32	22.15	22.68	23.45	2378	23.65	2463	25.24
Discharge 1000			2034	2100	2111	2144	2149	22.24	2300	2334	2344	2404	2499
Discharge 600			1930	1971	19.84	2038	2070	21.57	2221	2267	2291	2350	2418
Discharge 200			1793	1913	18.33	1916	19.57	2008	2080	2147	2206	2238	2283
Design river bed		1525		1635	1668	1737	1796	1847	1911	1972	2023	2068	2113
Existing dike		19.30			2037	2114	2151	2186			2359	24.35	25.51
Existing river bed		15 25		16 35	17.14	19.18	18.08	1922	1963	2087	21.31	21.73	2355
Distance	13350	13550	13690	14150	14410	14950	15410	15810	16310	16790	17190	17340	17690

Section number	38	39	40	41	42	43	45	46	47	48	49	50	51
Discharge (m³/sec) 1300	25.87	2613	2689	2773	2815	2913	2998	3046	3125	3169	3240	3317	3490
Discharge 1000	25.35	2570	2661	27.19	2765	2877	2973	3016	3076	3124	3211	3273	3443
Discharge 600	24.61	2503	25.76	2635	2701	2817	2914	2992	3046	3074	3152	32.20	3374
Discharge 200	23.26	2382	2458	25.03	25.87	2748	28.18	28.54	2909	2969	3050	3131	3248
Design river bed	2161	22.10	2273	2331	2433	2480							
Existing dike	26.51	2708	26.84	26.80	2756	28.15	29.38	2981	30.36	3098	3165		
Existing river bed	2336	2525	2406	24.30	2433	2480	2636	2698	2734	2810	28.87	30.07	3069
Distance	18270	18650	19150	19600	20400	21150	21880	22360	22900	23360	23760	24320	24880

Fig. I-6-5 Design Profile of the Ular River



Section number	Distance	Existing river bed	Design river bed	Design water level	Existing dike	Design dike
0	0	2.12		2.73		
1	510	2.13		4.68		
2	1045	1.89		5.76		
3	1697	3.40		6.31		
4	2197			7.09		
5	2697			7.46		
6	3197			8.05		
7	3697			8.44		
8	4197			9.05		
9	4697			9.44		
10	5197			10.05		
11	5697			10.44		
12	6197			10.95		
13	6697			11.44		
14	7197			12.05		
15	7697			12.44		
16	8197			13.05		
17	8697			13.44		
18	9197			14.05		
19	9697			14.42		
20	10197			15.13		
21	10697			15.51		
22	11197			16.00		
23	11697			16.50		
24	12197			16.95		
25	12697			17.54	18.45	18.45
(25.3)				17.98		
26	13197			18.54		19.45
(26.2)				18.64		
27	13550	15.25		18.73	19.30	20.20
(27.4)				19.30		
28	14150	16.35	16.35	19.71		20.83
29	14410	17.14	16.68	19.84	20.37	21.10
30	14950	18.18	17.57	20.38	21.14	21.67
31	15410	18.08	17.96	20.70	21.51	22.15
32	15810	19.22	18.47	21.57	21.86	22.57
33	16310	19.63	19.11	22.21		23.21
34	16790	20.82	19.72	22.67		23.82
35	17190	21.31	20.23	22.91	23.58	24.33
36	17540	21.73	20.68	23.50	24.35	24.78
37	17890	23.55	21.15	24.18	25.51	25.22
38	18270	25.36	21.61	24.61	26.51	25.71
39	18650	25.25	22.10	25.03	27.08	26.20
40	19150	24.06	22.73	25.76	26.84	26.83
41	19600	24.30	23.31	26.35	26.80	27.53
42	20400	24.33	24.33	27.01	27.56	28.43
43	21150	24.80		28.17	28.15	29.39
44	21680	25.29				
45	21850	26.36		29.14	29.38	30.31
46	22360	26.98		29.92	29.81	30.92
47	22900	27.34		30.46	30.36	31.61
48	23360	28.10		30.74	30.98	32.20
49	23760	28.87		31.52	31.65	32.71
50	24320	30.07		32.20		33.42
51	24880	30.69		33.74		34.14

Further, the river channel where the width is extremely narrow is improved by local setting-back of dike. In particular, the width of the upstream reaches between 20.4 km point and 24.0 km point is increased to about 250 m by setting-back of levee according to the reason described in the preceding paragraph. The water level when the provisional design discharge of 600 m^3/sec flows through the above design cross-sections was calculated by the non-uniform flow formula. Based on this water level, the provisional design high-water level was determined to which a freeboard of 1.0 m was added to fix the design levee height. The design profile is as shown in Fig. 1-6-5.

(6) Works

(a) Dredging work of low-water channel

The low-water channel, 7,600 m in its length, from 13.55 km point (Ular bridge) to 21.15 km point is to be dredged with the width of riverbed kept at 60 m. The depth of such dredging is 1.08 m on the average.

The volume of dredged soil is;

$$V = 1.08 \times 60 \times 7,600$$
$$= 492,480$$
$$\doteqdot 500,000 \ m^3$$

(b) Excavation work

The high-water channel of the reaches, 3,210 m in its length, from 17.19 km point to 20.4 km point is to be excavated at the average area of 100 m^2 at each section to adjust and correct the longitudinal profile.

The excavation volume is;

$$V = 100 \times 3,210 = 321,000 \ m^3$$

In setting-back of dikes on the reaches from 20.4 km point to 24.0 km point, the excavation volume for removing the old dikes is as follows.

The average cross-sectional area being 7.0 m^2 and the length being about 4,500 m, the excavation volume is;

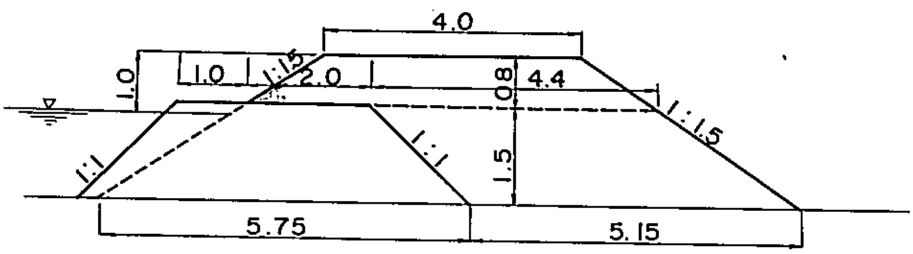
$$V = 7.0 \times 4,500 \doteqdot 31,500 \ m^3$$

The total volume of excavation works out at the following figure;

$$V = 321,000 + 31,500 \doteqdot 350,000 \ m^3$$

(c) Embankment

The side slope of the present dike is 1 : 1; however, as the deformation of slope is found in some places, the design side slope of dikes was fixed at 1 : 1.5. The crown width is to be 4.0 m taking into account the vehicle traffic for the maintenance and repair of dikes as well as the allowance for protecting the shoulder of slope and other factors. Also it is necessary that the soil of grain size as small as possible will be used for the material of dike-body in order to prevent the permeation of river water. In consideration of this point, it was decided to use the soil excavated from the high-water channel. When the height of old dikes is assumed to be 1.5 m, the standard cross-section of the planned dikes is as shown in the following figure.



The crown height of the dike upstream from the Ular bridge is to be joined to the existing dike at 12.7 km point downstream of the bridge. The dike on the left bank is to be joined to the existing dike at 27 km point. The total length of the dike to be heightened or strengthened and that to be newly constructed is 25,600 m comprising the length of 14,300 m from 12.7 km point to 27.0 km point on the left bank and that of 11,300 m from 12.7 km to 24.0 km on the right bank.

The cross-sectional area for the heightening or strengthening of the existing dikes is;

$$A_1 = \frac{4.0 + 6.4}{2} \times 0.8 + \frac{5.15 + 4.4}{2} \times 1.5$$

$$= 11.3 \text{ m}^2$$

The cross-sectional area of the new dike is;

$$A_2 = \frac{10.9 + 4.0}{2} \times 2.3 = 17.1 \text{ m}^2$$

If it is presumed that the average cross-sectional area of embankment comprises 80 % of A_1 and 20 % of A_2 by rough estimate made from the ratio of the two kinds of dike-length, then;

$$A = 11.3 \times 0.8 + 17.1 \times 0.2 = 12.5 \doteqdot 13.0 \ m^2$$

Therefore, the embankment volume is;

$$V = 13.0 \times 25,600 = 332,800 \ m^3$$

If 5 % is allowed for extra-banking, the volume of earth required for embankment is as follows:

$$V = 332,800 \times 1.05 = 349,440 \doteqdot 350,000 \ m^3$$

(d) Groin works

Groin works will be provided to protect the banks which are subjected to running-into of river flow in the low water channel, 16 km in length from 8.0 km point to 24.0 km point. They are to be provided at a rate of one work per km, or sixteen works in all.

(e) Land area

a. Area of land for the strengthening of dikes from 12.7 km point to 20.4 km point. The total length on both banks on the above reaches is 15,400 m and the average width of the needed land is 6 m.

$$\text{Land area } A = 6 \times 15,400 = 924,000 \ m^2$$

b. Area of land for the setting-back and strengthening of dikes from 20.4 km point to 24.0 km point. The length of river channel of the above reaches is 3,600 m and the average width of the needed land is 60 m.

$$\text{Area of site } A = 60 \times 3,600 = 216,000 \ m^2$$

c. Land for spoil bank in dredging. The soil dredged in the low-water channel is to be put on excess portions of the river channel near to the working place by means of dike-widening on the river side or dumping it in the abandoned river channel. As the insufficiency of land for spoil bank is predicted as a whole, some land for this purpose is to be secured somewhere on the inland. The volume of dredged soil for which the spoil bank is insufficient is estimated at 200,000 m³. If the height of dumped soil is assumed to be one meter;

$$\text{Land area } A = 200,000 \ m^2$$

d. The area of land needed for the local setting-back of dikes is estimated at 90,000 m^2 with the length of 1,000 m and the average width of 90 m.

$$\text{Land area} \quad A = 90 \times 1{,}000 = 90{,}000 \ m^2$$

e. Total area of required land.

$$A = 92{,}400 + 216{,}000 + 200{,}000 + 90{,}000 = 598{,}000 \doteqdot 600{,}000 \ m^2$$

(f) Appurtenant work.

a. Riverbed protection work on the bridge site. Riverbed protection works are to be provided for the portion of the low-water channel spanned by the Ular and railway bridges to prevent the riverbed from scouring and protect the foundations of piers and abutments. The width of the works is 25 m comprising 10 m to upstream side and 15 m to downstream side respectively from the center line of bridge and the length is 60 m, i.e., the width of low-water channel at the bridge site. It is constructed by means of fascine mattress and concrete block pavement (1 - 2 ton per piece).

Riverbed protection work of one site

$$25 \ m \times 60 \ m \times 1.0 \ m = 1{,}500 \ m^3$$

b. Relocation of driving channel to intake. The cost for relocation of driving channel to intake is to be added in expectation of any influence of the dredging on the existing Perbaungan intake.

(g) Others

There are continuous dikes on both banks of the reaches between 8.0 km and 12.7 km from the rivermouth, and these dikes have approximately one meter of freeboard in the case of the provisional design discharge. Accordingly, they are not included in the estimate of embankment work costs. On the other, the cost for local repair works on existing dikes was included in the contingencies, because it is expected that some local repair will be required in our judgement from the existing dike-slope and other conditions of dikes.

(7) Execution of work

Prior to the execution of work, it is necessary to make an exact surveying which includes the mapping of a plan of the river on a scale of about 1/2,500 and to perform some boring works for the purpose of examining the material at the location where the riverbed is abnormally raised. Five months will be needed for such survey.

On the basis of the above results, designing in detail, preparation of specification and biding, and other related works will be performed. Ten months are expected for these works.

Then, after the period which is required for ordering equipments and materials, arrival and disposition of them, the construction works are expected to start after two years from the commencement of surveying and finish in about two and half years.

However, some equipments may be procured fairly quickly. In such a case, it will be possible to commence some works a little earlier. The examination for these will be conducted at the time of detail design and the above-mentioned schedule is expected for the present.

The following equipments are assigned to these works.

(a) Dredging (soil volume: 500,000 m^3)

The work is to be executed with a dredger which is capable to operate for 6 hours per day, 25 days per month, and 8 months per year. Its operating hours per year are;

$$6 \text{ hr} \times 25 \text{ d} \times 8 \text{ m} = 1,200 \text{ hr/year}$$

As the volume of soil required to dredge in a year is 500,000

$$500,000 \times \frac{1}{2.5} = 200,000 \text{ m}^3$$

the required capacity per hour is

$$200,000 \times 1/1,200 \doteqdot 167 \text{ m}^3/\text{hr}$$

Hence, one cutter dredger of 350 ps (170 m^3/hr) is assigned. In addition, one underwater bulldozer is assigned since it seems to be necessitated to perform the work with dredging width made narrower to secure the needed water depth during the dry season when the discharge decreases.

(b) Excavation (soil volume: 350,000 m^3)

The volume of soil required to excavate in one year is 350,000 x $\frac{1}{2.5}$ = 140,000 m³ which is to be handled by bulldozers. If the bulldozer is capable to operate for 6 hours per day, 25 days per month, and 8 months per year, its operating hours per year are;

$$6 \text{ hr} \times 25 \text{ d} \times 8 \text{ m} = 1,200 \text{ hr/year}$$

The needed capacity per hour is;

$$140,000 \times \frac{1}{1,200} \doteqdot 117 \text{ m}^3/\text{hr}$$

Therefore, two bulldozers of D-50 type (11 ton) with capacity of 77 m³/hr (total capacity: 154 m³/hr) are assigned to the work, with one allotted to each of both bank sides.

(c) Embankment (soil volume: 350,000 m³)

The volume of soil required for embankment in one year is 350,000 x $\frac{1}{2.5}$ = 140,000 m³ which is to be handled by tractor shovel, dump truck and bulldozer. If these equipments are capable to operate for 6 hours per day, 25 days per month, and 8 months per year, their respective operating hours per year are;

$$6 \text{ hr} \times 25 \text{ d} \times 8 \text{ m} = 1,200 \text{ hr/year}$$

The required embankment volume being;

$$140,000 \times 1/1,200 \doteqdot 117 \text{ m}^3/\text{hr}$$

The needed number of equipments is;

Tractor shovel, Type-955 K (capacity: 130 m³/hr) ...... 1 unit
Dump truck loading 6-ton (capacity: 8 m³/hr) 117 ÷ 8 ≑ 15 units
Bulldozer, D-50 Type (for banking and compaction) ...... 1 units

As the works are performed separately on the right and left banks, two tractor shovels, sixteen dump trucks and two bulldozers are assigned to this work.

(8) Construction Costs

Table 1-6-3 Construction Cost for the Urgent Flood Control Project of the Ular River

Cost classification	Particulars	Quantity	Unit	Unit price (Rp)	Amount ($x10^3$Rp)	Foreign currency (US$)	Domestic currency ($x10^3$Rp)
Dredging*		500,000	m^3	100	50,000	0	50,000
Excavation*		350,000	m^3	25	8,750	0	8,750
Embankment*		350,000	m^3	245	85,750	0	85,750
Groin work*		16	place	450,000	7,200	0	7,200
Land		600,000	m^2	100	60,000	0	60,000
Appartenant work*					44,300	0	44,300
	Bed protection at bridge site	2	place	$18.2x10^6$	36,400		
	Relocation of driving channel	1	suit		7,900		
Material and equipment**		1	suit		321,300	850,000	0
Technical guidance		1	suit		38,542	79,614	8,448
Establishment of observation station		1	suit		15,147	25,912	5,352
Contingencies		1	suit		36,944	52,415	17,130
Subtotal					667,933	1,007,941	286,930
On-the-spot survey		1	suit		34,906	68,994	8,827
	Surveying (36 km)	1	suit		32,399		
	Geological survey	1	suit		2,507		
Detail design		1	suit		32,039	79,285	2,070
Supervision		1	suit		65,122	143,780	10,773
Subtotal					132,067	292,059	21,670
Total					800,000	1,300,000	308,600

Note: * : The unit costs of these works include the expenses required for the management of the government agencies.

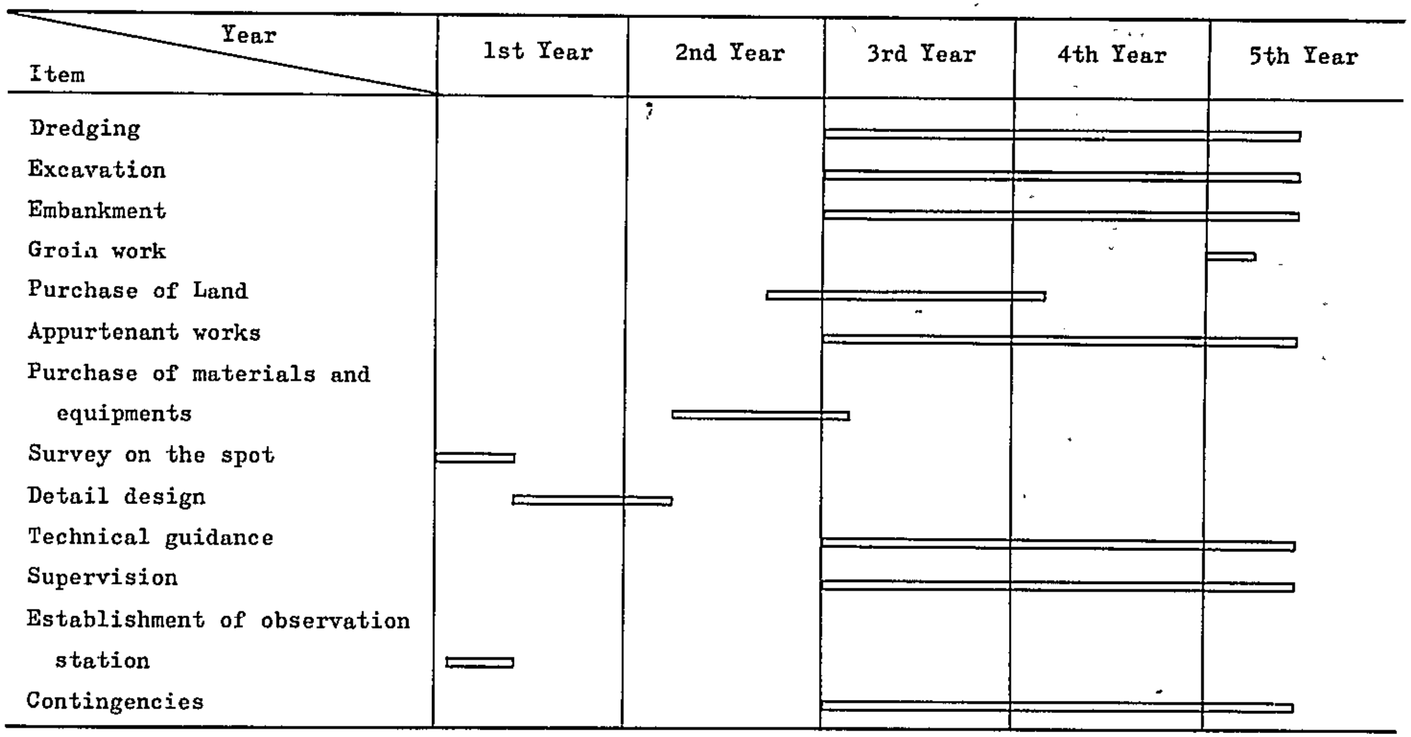
** : The residual value of equipments at the time of completion of works is Rp 151,500,000.

Table 1-6-4 Foreign Currency Needed to Acquire Necessary Equipments and Materials for Urgent Flood Control Project of the Ular River

Necessary equipments & materials	Specification	Needed quantity	Needed foreign currency (US$)	Residual value (US$)
I. Construction Equipment			320,000	118,800
1. Bulldozer	11 ton	4	80,000	36,000
2. Tractor shovel	1.2 m^3	2	40,000	18,000
3. Dump truck	6 ton	16	104,000	35,200
4. Ordinary truck	5 ton	2	10,000	3,400
5. Truck crane	10 ton	1	25,000	13,000
6. Other equipment		suit	30,000	13,200
7. Spare parts of above items		suit	31,000	0
II. Dredging Equipment			490,000	277,000
1. Dredger, 170 m^3/hr	350 PS	1	380,000	256,000
2. Underwater bulldozer	NTK 10 ton	1	20,000	9,000
3. Sand-flash pipe, floater, etc.		suit	30,000	3,000
4. General service barge		1	10,000	4,500
5. Other equipment		suit	10,000	4,500
6. Spare parts of above items		suit	40,000	0
III. General Machine			20,000	5,000
1. Surveying apparatus		suit	2,000	900
2. Copying apparatus		suit	5,000	0
3. Computer		suit	3,000	1,300
4. Portable generator	10 PS	2	3,000	1,300
5. Designing apparatus		suit	1,000	0
6. Other machine & apparatus		suit	3,000	1,300
7. Spare parts of above items		suit	3,000	200
IV. Material for river improvement		suit	10,000	0
V. Material for general office work		suit	10,000	0
Total			850,000	400,800

Note: The above figures are calculated on the basis of construction period of two and half years.

Table 1-6-5 Schedule of Urgent Flood Control Project of the Ular River



CHAPTER VII

COSTS AND BENEFITS

1. Costs

The costs needed for the urgent flood control project may be classified roughly into construction cost, equipment and material cost, and technical expenditure. They are calculated from Chapter VI as shown below:

Construction cost	Rp 292,944,000	(including contingencies)
Equipment and material cost	Rp 321,300,000	
Technical expenditure	Rp 185,756,000	
Working cost	Rp 800,000,000	

This amount is to be invested over a period of five years. According to Table 1-6-5, the schedule of works, and Table 1-6-3, the details of construction costs, the annual disbursements are as follows.

1st year	Rp 74,983,000
2nd year	Rp 329,509,000
3rd year	Rp 185,745,000
4th year	Rp 138,913,000
5th year	Rp 70,850,000

The above working cost includes Rp 151,500,000, as shown in Table 1-6-3, of the residual value of the equipment after the completion of the works.

It is presumed that the annual maintenance cost needed for repairing the dikes, riverbed protection, and groins is 0.2 % of the construction cost and equipment and material expenditure (excluding the residual value after the completion of works). The amount of such cost is estimated at about Rp 925,000 to be expended starting from the year following that in which the works completed.

2. Benefits

In general, the economic effects of a flood control project can be classified as follows.

Direct effects;

Effects on output——

Alleviation of damage on property.

Prevention of decrease in production.

Increase in production.

Effect on demand

Effect on stabilization of people's livelihood

Indirect effects;

Extending effects ——

On social and economic activities due to alleviated damage on property.

On economic activities such as flow, selling, and processing of products on which damages reduced.

Brought about effects ——

On various industrial activities following the high-degree land use enable by flood control.

Of the benefits enumerated above, those on the alleviation of damage on property and the prevention of decrease in production are appraised in the benefit calculation for the present project. Although the other benefits are equally important as the above two benefits, it is difficult to evaluate them as an economic quantity based on the data for investigation now available to us. Therefore, these other benefits are excluded from the calculation here.

The amount of damage on the public facilities, etc. shown in Chapter V is applied as the effect on the alleviation of damage on property to be credited as a benefit. The amount of damage on the agricultural products shown in the same chapter is used as the effect on the prevention of decrease in production. The average amount of benefits is Rp 168,300,000, shown in Chapter V, comprising those two resulting from the flood control. It is presumed that these benefits will be enjoyed starting from the year following that in which the works were completed.

3. Analysis of Benefit and Cost

The benefit-cost analysis is conducted by two methods, benefit-cost ratio method and internal rate of return method.

The benefit-cost ratio is calculated by the following formula:

$$a = \frac{\sum_{j=m+1}^{n} B_j \frac{1}{(1+i)^j} + S_m \frac{1}{(1+i)^m}}{\sum_{j=1}^{m} C_j \frac{1}{(1+i)^j} + \sum_{j=m+1}^{n} M_j \frac{1}{(1+i)^j}}$$

The internal rate of return is found from the following formula:

$$\sum_{j=m+1}^{n} B_j \frac{1}{(1+r)^j} + S_m \frac{1}{(1+r)^m} = \sum_{j=1}^{m} C_j \frac{1}{(1+r)^j} + \sum_{j=m+1}^{n} M_j \frac{1}{(1+r)^j}$$

In the above formulae;

a = benefit-cost ratio

B = amount of benefit

C = amount of investment

M = maintenance cost

S = residual value of equipment

i = discount rate

j = number of year elapsed as from the present

r = internal rate of return

m = the last year of works

n = the last year of benefit generating

The benefit-cost analysis is made on the conditions presumed as follows:

i = 0.035 and 0.060

m = 5

n = 20 and 50

The results of benefit-cost analysis made on the above conditions are as shown below:

Benefit-cost ratio

Discount rate (i) (%)	Last year of benefit generating (m)(years)	Benefit-cost ratio (a)
3.5	20	2.39
6.0	20	1.94
3.5	50	4.45
6.0	50	2.97

Internal rate of return

Last year of benefit generating (n)(years)	Internal rate of return (r) (%)
20	15.3
50	16.8

As obviously seen from the above table, the benefit-cost ratio is approximately 2 or more than it for each of the different conditions. Also the internal rates of return exceed 10 %, the value which, in general, is deemed desirable for a project of this nature. Therefore, it can be concluded that the urgent project of flood control for the Ular river is sufficiently profitable.

PART 2

OTHER RIVERS

CHAPTER I

TANAH ITAM ULU ESTATE

Tanah Itam Ulu Estate belongs to PNP VI and is located in Ketjamatan Lima Puluh, Kabupaten Asahan, Propinsi Sumatera Utara. This estate covers an area of about 3,000 ha of land which is 2 - 12.5 m high above sea level. A small river called Sei Pajapasir (formerly called Saluran Gemeente) flows through this estate in the middle part as shown in Fig. 2-1-1 and habitually inundates many oil-palm trees in this part every rainy season.

The climate of this area is so much affected by the mountains Bukit Barisan that the boundary between dry and wet seasons is not always clear. According to the rainfall data gathered at the Tanah Itam Ulu emplacement for the 10 years from 1960 to 1969, Table 2-1-1, the average monthly rainfall ranges from 132 mm in January to 438 mm in October. And the annual maximum monthly rainfall appears in months except the four from December to March and May.

Annual rainfall is about 2,900 mm on the average for the 10 years, and varies over a large range from the maximum of 4,068 mm in 1960 to the minimum of 1,876 mm in 1965. The maximum monthly rainfall 1,071 mm occurred in November, 1969 and the second one 958 mm appeared in July, 1960.

The floods due to such heavy rainfall menaces the area of more than 400 ha in the middle part of the estate, shown in Fig. 2-1-2 every rainy season. For instance, the area of 437.5 ha was inundated by floods for about 3 months from October 13, 1969 to January 9, 1970, and the maximum depth of stagnant water reached about 1 m.

As a result of such habitual inundation, the following damages were brought about in the past.

1. Palm-oil trees in this area grew incompletely compared with the normal and died away in a long time. So that the replantation was frequently needed.
2. Maturation of fruits was delayed by stagnant water.
3. The soundness of trees was spoiled to be easily attacked by diseases.
4. Fertilizer was lost.

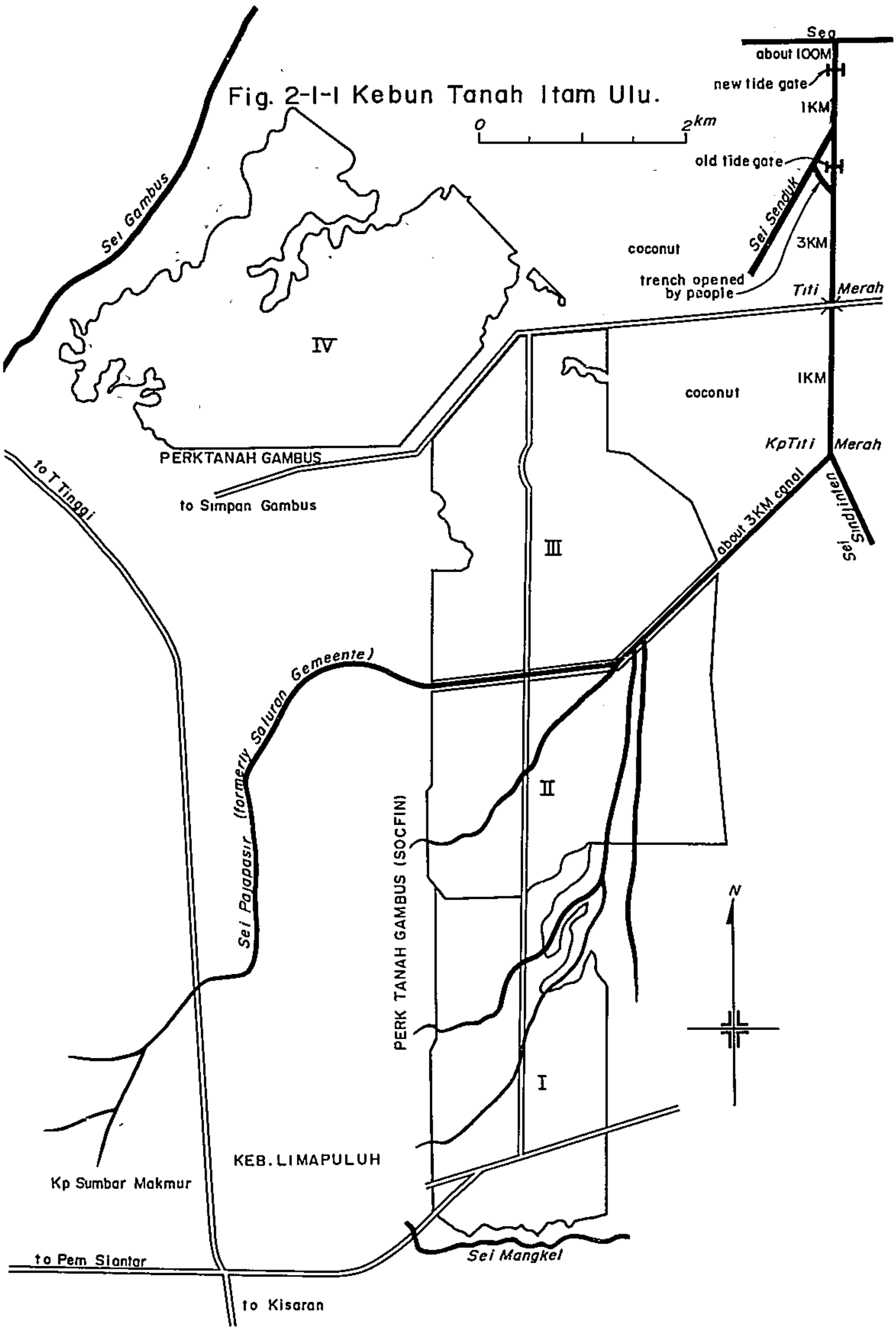


Fig. 2-1-1 Kebun Tanah Itam Ulu.
0
2km
Sea
about 100M
new tide gate
1KM
old tide gate
Sei Senduk
3KM
coconut
trench opened by people
Titi Merah
Sei Gambus
IV
1KM
coconut
PERKTANAH GAMBUS
to Simpan Gambus
Kp Titi Merah
to T Tinggi
about 3KM canal
Sei Sindilinten
III
Sei Pajapasir (formerly Saluran Gemeente)
II
PERK TANAH GAMBUS (SOCFIN)
N
I
KEB. LIMAPULUH
Kp Sumbar Makmur
to Pem Siantar
Sei Mangkel
to Kisaran

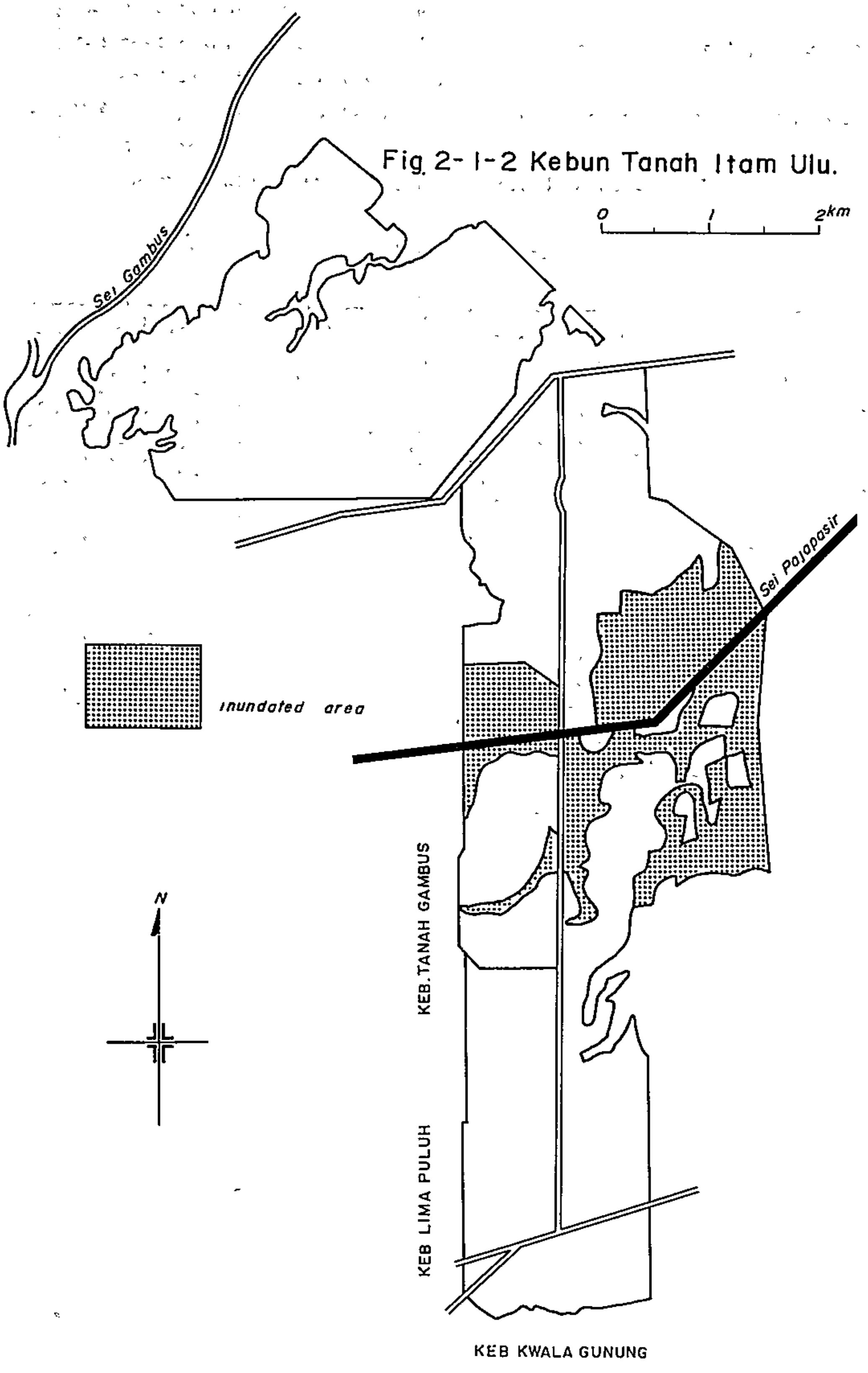


Fig. 2-1-2 Kebun Tanah Itam Ulu.

5. Maintenance cost of drainage channel was increased.
6. Adjacent estate Perkebunan Socfindo and other agricultural production suffered from inundation by flood.
7. Efficiency of work was decreased or work was stopped by interruption of the traffic.
8. Health of people in this area was impaired, especially by malarial disease.

Table 2-1-1 Rainfall at Tanah Itam Ulu Emplacement

		Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
1960	mm	106	23[illegible]	273	152	142	193	958	190	542	493	311	471	4,068
	day	6	7	7	7	6	7	12	4	11	9	13	13	102
1961	mm	45	147	145	256	160	163	187	125	209	216	82	148	1,883
	day	7	10	9	13	6	9	10	7	15	10	11	12	119
1962	mm	305	116	421	147	311	444	131	385	271	415	260	252	3,458
	day	6	4	10	7	11	8	5	9	5	12	15	13	105
1963	mm	318	236	189	105	61	237	426	120	631	515	682	280	3,800
	day	8	10	7	4	8	7	9	15	12	15	17	10	122
1964	mm	76	362	196	189	178	198	339	39	450	254	190	91	2,562
	day	4	8	7	5	6	4	10	3	10	11	10	7	85
1965	mm	25	70	54	8	43	27	23	370	248	360	331	317	1,876
	day	1	4	5	1	8	7	2	9	10	12	11	8	78
1966	mm	63	138	312	154	235	152	296	266	384	382	244	176	2,802
	day	4	4	11	9	14	12	13	11	15	15	10	8	126
1967	mm	91	186	176	168	198	341	67	213	342	448	417	195	2,842
	day	5	7	6	2	10	12	5	10	14	11	13	6	101
1968	mm	154	177	71	149	159	144	85	206	198	391	92	325	2,151
	day	6	6	9	8	8	8	10	18	16	12	7	12	120
1969	mm	137	124	237	114	173	253	386	310	111	902	1071	193	4,011
	day	4	6	5	5	9	10	10	11	10	21	19	8	118
1970	mm	127	37	169	330	62	222	168	225	378				
	day	4	3	5	13	4	7	3	5	8				

These damages were caused almost every year by habitual inundation and are presumed to have reached a large amount.

Sei Pajapasir which runs through Tanah Itam Ulu Estate has its sources in hilly lands where Limapuluh Estate is located. The upstream reaches from the western border of Tanah Itam Ulu Estate have sufficient gradient to flow without stagnation. And the gradient of the downstream reaches from the eastern border also seems to be reasonably steep, whereas the middlestream reaches have so gentle slope that the river water is always stagnated in the middle part of the estate.

No maintenance is found in the river course except the part comprised in Tanah Itam Ulu, and, moreover, many fishing fences are set up in the part between the Titi Merah bridge and the eastern border of the estate.

It is generally said that the seasonal flooding of this area is caused by the blocking of the outlet drain to the sea since the rivermouth have not been dredged and outlet drain have not been maintained for many years. This may be the cause of the habitual inundation in this area. Besides this, however, a more important cause seems to exist in inappropriateness of the slope and cross-sections of the river, especially in the part of the western border of the estate.

In order to protect this area from the habitual inundation, some flood control measures are needed. For this purpose, it is necessary to survey the topography precisely, make a study of run-off and review the present flow capacity of Sei Pajapasir along its river course.

Furthermore, Tanah Itam Ulu borders on the Gambus river on its northern side. This river is a branch from the Bah Bolon river which has a drainage area of 1,537 km^2, and, in 1945, is reported to have overflowed into the land on the right side from a location about 7 km upstream from the rivermouth. Accordingly, the influence of the overflow from the Gambus river should be also studied.

CHAPTER II

THE BOLON RIVER: THE SIPAREPARE, THE TANDJUNG, THE GAMBUS

The Bolon river originates in the mountains Bukit Barisan in North Sumatra and after flowing to the north east, it pours itself into the Malacca Strait. The river divides itself in the neighbourhood of Indrapura into three branches called the Tandjung river, the Siparepare river and the Gambus river which form an alluvial delta covering an area of about 180 km^2 (Fig. 2-2-1, 2-2-2)

The length of the river and that of the drainage area are respectively 105 km and 81 km. The river basin covers an area of 1,537 km^2 and comprises main roads 25 km in length and the following estates.

PNP IV, V and VII	rubber	16,817 ha
PNP VI and VII	oil-palm	21,999 ha
PNP VIII	tea	6,111 ha

The climate such as temperature, humidity and rainfall is almost the same as in the cases of the Ular river and Tanah Itam Ulu mentioned in the foregoing chapters. Rainfalls bring about habitual flooding which menaces an area of more than 12,000 ha. The damages in 1969 were estimated by Dinas Pekerdjaan Umum Propinsi Sumatera Utara to amount to Rp 27,650,000 as far as bridges, dikes and rice fields were concerned (Table 2-2-1).

On October 6, 1970 when we were in North Sumatra, the Bolon river overflowed at several points just downstream from the branching point and inundated an inland more than 1,700 ha (Fig. 2-2-2). In the 1966 flood, the river water of the Tandjung river overflowed at the several points downstream from Indrapura and inundated nearly 2,000 ha. Formerly in 1945, the Gambus river overflowed to both sides of its course at a point about 7 km upstream from the rivermouth. This reach is said to be almost dead due to the settlement of silt and sand.

With a view to relieve this delta from the habitual inundation, Dinas Pekerdjaan Umum Propinsi Sumatera Utara has intended to widen and deepen a drainage canal which branches off from the Tandjung river at a point about 500 m downstream of Indrapura and flows into the Malacca Strait. For this purpose,

Fig.2-2-1 The Bolon River — The Sipare², The Tandjung, The Gambus.

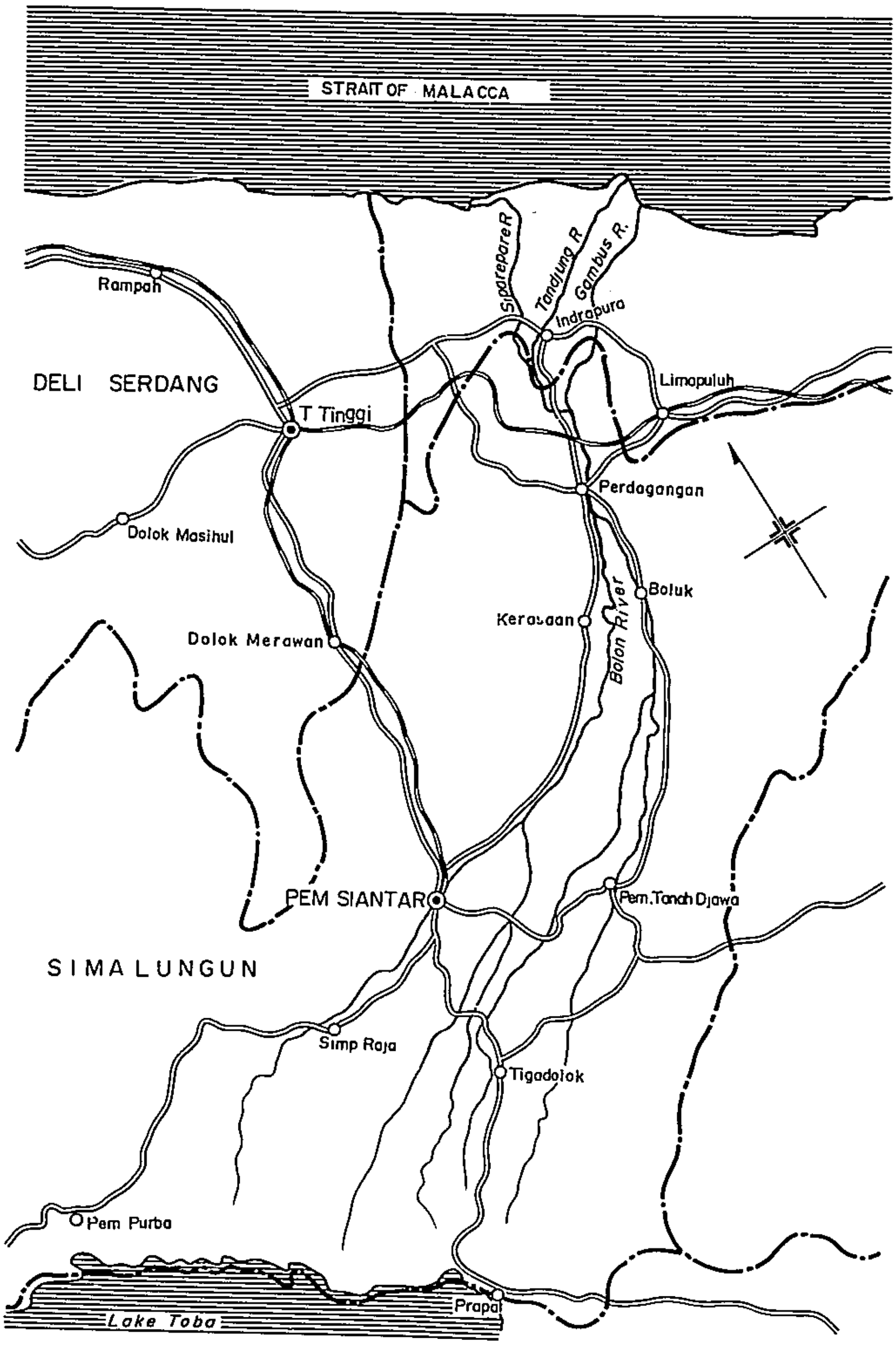


Fig.2-2-2 The Bolon River

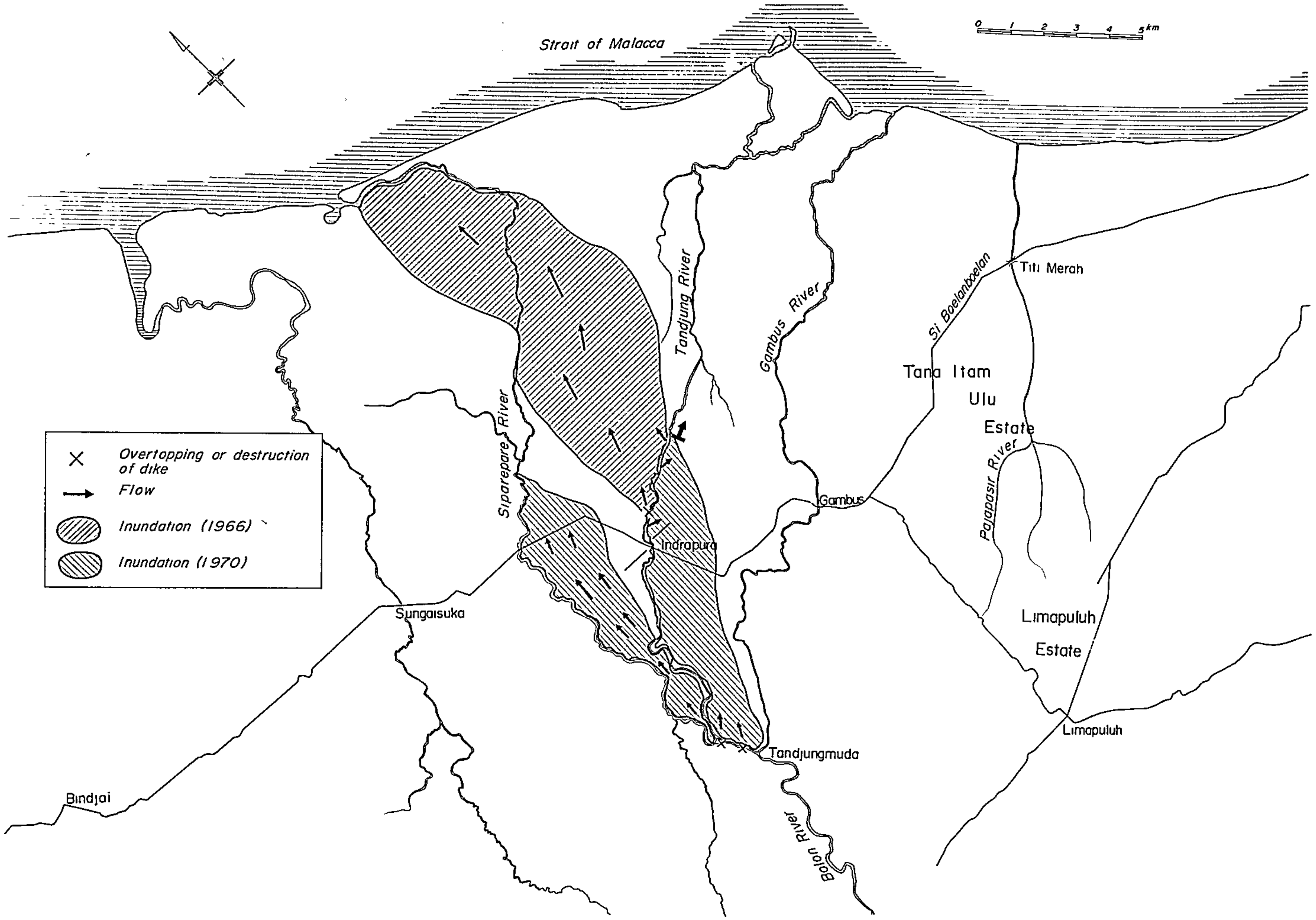


Table 2-2-1 Amount of Damages Caused by Floods of the Bolon River

Year	Roads / Bridges		Dikes		Rice fields		Total amount (Rp)
	Length Numbers	Amount (Rp)	Length (km)	Amount (Rp)	Area (ha)	Amount (Rp)	
THE TANDJUNG RIVER							
1960	2.5 km	5,000,000	0.2	7,000,000	500	500,000	12,500,000
1961	2 "	4,000,000	0.1	3,000,000	250	250,000	7,250,000
1962	3 "	6,000,000	0.15	4,000,000	500	500,000	15,500,000
	1 bridge	5,000,000					
1964	1.5 km	3,000,000	0.05	2,000,000	250	250,000	5,250,000
1965	2 "	4,000,000	0.02	2,000,000	150	150,000	6,150,000
1967	1.7 "	3,500,000	0.03	2,500,000	150	150,000	6,150,000
1968	1.2 "	2,500,000	0.025	2,500,000	200	200,000	5,200,000
1969	3 "	6,000,000	0.25	10,000,000	500	500,000	16,500,000
THE SIPARE-PARE RIVER							
1960	3 km	6,000,000	0.1	2,500,000	350	350,000	8,850,000
1961	0.75 "	1,500,000	0.05	2,000,000	250	250,000	3,750,000
1962	1.5 "	3,000,000	0.075	2,500,000	300	300,000	5,800,000
1963	1 "	2,000,000	0.02	2,000,000	150	150,000	4,150,000
1964	2 "	4,000,000	0.1	2,500,000	350	350,000	6,850,000
1965	1 "	2,000,000	0.03	1,500,000	200	200,000	3,700,000
1966	1.5 "	3,000,000	0.07	3,000,000	300	300,000	6,300,000
1967	2 "	4,000,000	0.1	5,000,000	350	350,000	9,350,000
1968	3 "	6,000,000	0.08	4,000,000	150	150,000	10,150,000
1969	3.5 "	7,000,000	0.08	4,000,000	150	150,000	11,150,000

a dredging work was started in September 1969 with the intention of removing the soil amounting to more than 2,000,000 m³ within two years.

Although the dredging work was planned originally as an urgent measure for flood control, it will be also essential to make a study of the basic plan for land development of the delta.

For this purpose, it is at first necessary to survey the topography of this area, and to examine the flow capacities of existing river channels, after studying the run-off due to rainfall. Then, the feasibility of this project should be studied.

In studying flood prevention and land use, it will be necessary to make a plan of flood plains distinguished from areas to be drained or reclaimed.

Furthermore, we hear that an aluminium-refinery factory which is expected to make use of electric power generated from the Asahan river will be located at an area near the rivermouth of the Asahan or at some place adjacent to the Asahan. If the factory is invited to this delta, the feasibility of the development project in this area will be surely increased.

CHAPTER III

THE SILAU/ASAHAN RIVER

As shown in Fig. 2-3-1, the Silau river has its origines in the mountains Bukit Barisan and, after flowing to the north east, at Tandjung Balai joins the Asahan river which has its origines in lake Toba as well as in Bukit Barisan. The catchment area of the Silau river is about 995 km^2 and the length of the river is about 99 km. Plantations, PNP III and V (rubber: 33,046 ha) and PNP VI (oil-palm: 12,628 ha) are found in the basin.

In the rainy season, every flood menaces an extensive area amounting to about 45,800 ha which comprises swampy areas located in the lowest part of the river as well as Tandjung Balai and other villages. And road about 14.5 km in length and railway about 10 km in length were frequently submerged by floods which interrupted the communication for weeks.

According to the survey by Dinas Pekerdjaan Umum Propinsi Sumatera Utara, the amounts of damages caused by floods of the Silau river are as shown in Table 2-3-1 and reach about Rp 11,000,000 on the average for the latest five years, as far as roads, dikes and paddy fields are concerned.

A swampy area which is located adjacent to the confluence of the Silau river and the Asahan river and sandwiched between these two rivers is divided into two parts by the main road connecting Tandjung Balai and Kisaran, as shown in Fig. 2-3-2. In the swampy area on the northern side of this road is built a canal Parit Sultan, and another canal called Parit Nippon is built on the southern side. These canals play an important part in draining flooded water during rainy seasons, but their drainage capacity seems to be insufficient.

Since the Silau/Asahan river and their adjacent rivers and canals have been left without maintenance, every river channel has been so much aggravated for a long time that they have been shallowed and lost their drainage capacity.

Tandjung Balai is located just at the confluence of the two rivers and has the quaies along the left bank of the Asahan river. These quaies have at

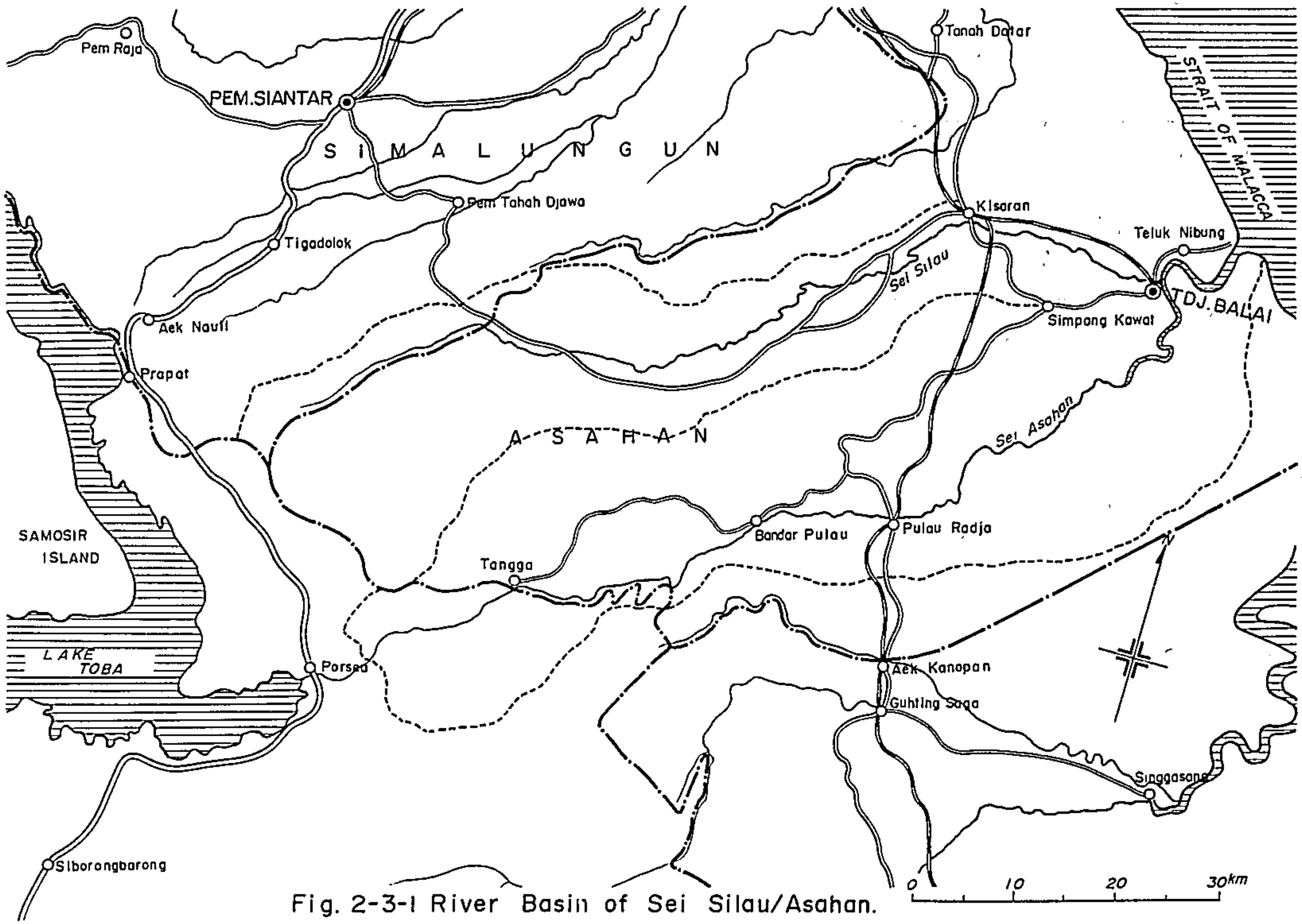


Fig. 2-3-1 River Basin of Sei Silau/Asahan.

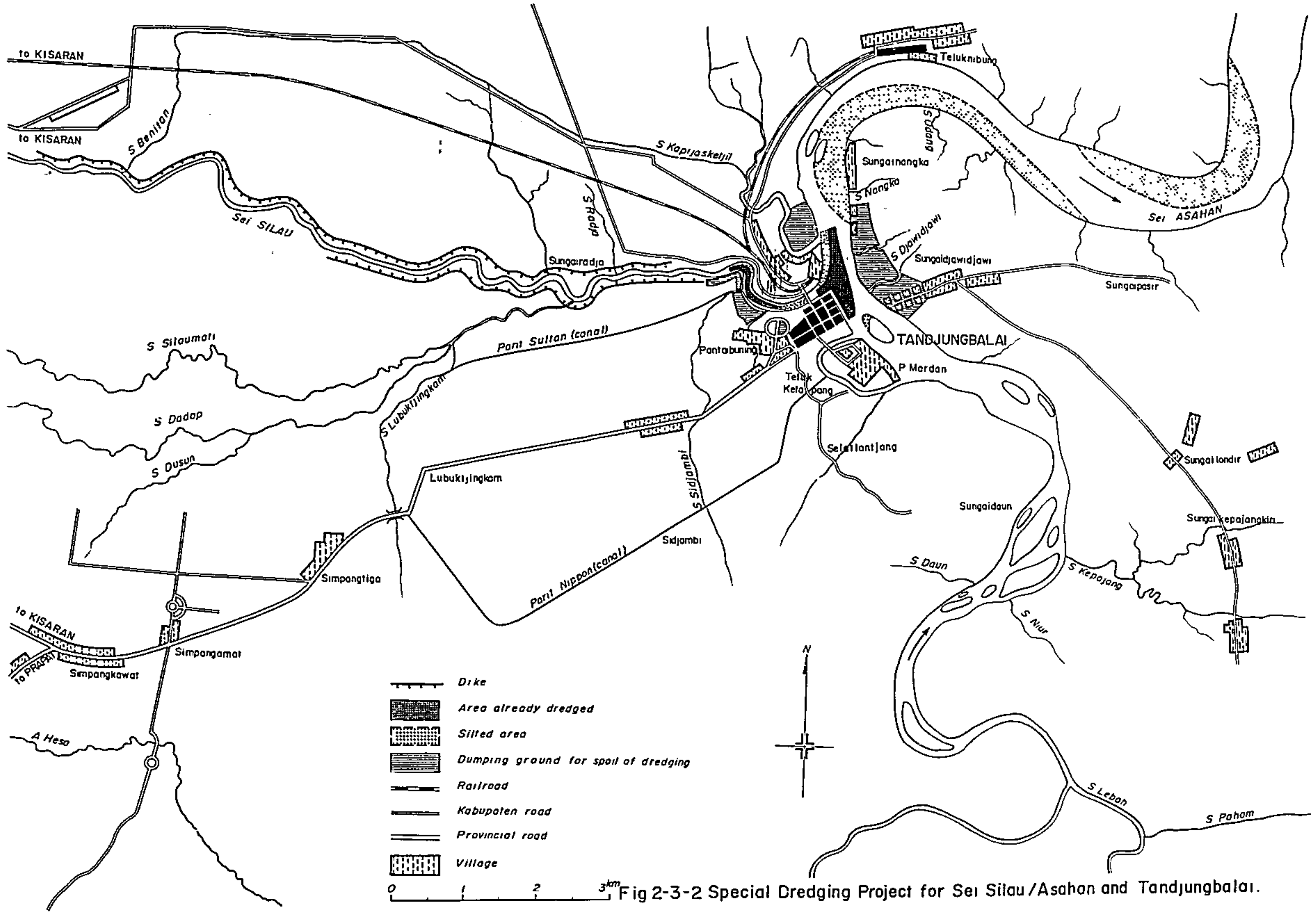


Fig 2-3-2 Special Dredging Project for Sei Silau/Asahan and Tandjungbalai.

present only a capacity of mooring ships less than one hundred tons owing to the deposit of silt, whereas this harbour was, formerly, busy with mooring the ships of 500-ton class.

Table 2-3-1 Amount of Damages Caused by Floods of the Silau River

Year	Road		Dike		Paddy field		Total amount of damages (Rp)
	Length (km)	Amount (Rp)	Length (km)	Amount (Rp)	Area (ha)	Amount (Rp)	
1960	1	2,000,000	0.05	2,500,000	150	150,000	4,650,000
1961	2	4,000,000	0.06	2,500,000	250	250,000	6,750,000
1962	1.5	3,000,000	0.05	2,500,000	200	200,000	5,700,000
1963	2.5	5,000,000	0.07	3,000,000	200	200,000	8,200,000
1964	2.2	4,500,000	0.1	5,000,000	350	350,000	9,850,000
1965	3	6,000,000	0.1	5,000,000	300	300,000	11,300,000
1966	3.5	7,000,000	0.1	5,000,000	350	350,000	12,350,000
1967	2	4,000,000	0.07	4,000,000	200	200,000	8,200,000
1968	3.5	7,000,000	0.1	5,000,000	300	300,000	12,300,000
1969	3	6,000,000	0.1	5,000,000	250	250,000	11,250,000

With a view to relieve this area from habitual inundation and rehabilitate the navigation channel, Dinas Pekerdjaan Umum Propinsi Sumatera Utara has planned a dredging work amounting to more than 6,500,000 m^3 in total and commenced the work in 1967. Of this volume of dredging, 2,500,000 m^3 has been already finished in and around the confluence of the two rivers, and is left unfinished the dredging of 4,000,000 m^3 including 3,000,000 m^3 for navigation channel.

It will be necessary to carry out a survey of precise topography and hydrology of this area for the study of feasibility of this project.

PART 3

DATA

DATA 1

Outline of the Ular River and Its Basin/1

1.	Catchment area :	1,087 km^2
2.	Length of river :	115 km
3.	Rainfall :	1,500 - 6,000 mm
4.	Evaporation :	
5.	Discharge	
	Discharge in high water season	about 200 m/sec
	in low water season	about 20 "
6.	Geology of river basin :	
	Andesitic or liparitic efflusives and alluvials	
7.	Plantations	
	PNP II : rubber	3,380 ha
	PNP VI, IX : oil palm	7,180 "
	PNP IX : tobacco	3,740 "
8.	Rice field :	14,200 "
9.	Other lands : the farmlands other than the above not so big in the Ular river basin.	
10.	Length of highway :	25 km
11.	Length of railway :	26 "
12.	Length of dike (for both banks) :	67.3 "
13.	Irrigation intakes :	3 sites
14.	Dredging : Dredging already done	1,100,000 m^3
	" in future	1,000,000 "

/1 Refer to page 5 of "Special Dredging Projects in North Sumatra" DPU NS 8 Jan. 1970

DATA 2

DATA ON RAINFALL, TEMPERATURE AND HUMIDITY

1. Rainfall Gage Stations in the Lower Basin of the Ular River

No	Rainfall gage stations	Elevation(m)	Distance from seacoast(km)	East longitude	North latitude	Period observation (years)
1	Adolina Ilir Afd. Kantor	18	13	98°11'	3°32'	31
2	Adolina Ulu Afd. I	16	9	98°57'	3°34'	23
3	Bandar Kwala	80	33	98°53'	3°22'	24
4	Bandar Negeri	110	38	98°57'	3°17'	29
5	Bandar Pinang	98	36	98°55'	3°19'	35
6	Batang Kwis	9	10	98°48'	3°37'	42
7	Batu Gingging	118	35	98°48'	3°23'	32
8	Batu Rata	65	30	98°50'	3°25'	24
9	Bata Rata Afd. Bangun Purba	118	38	98°48'	3°21'	31
10	Begerpang	64	31	98°49'	3°24'	34
11	Bengabing	18	13	99°00'	3°31'	31
12	Deli Muda	12	7	99°01'	3°34'	34
13	Greahan Estate	137	38	98°47'	3°22'	29
14	Kloin Sungei Karang	50	26	98°52'	3°26'	21
15	Kwala Namu	12	10	98°53'	3°35'	37
16	Limau Mungkur	60	30	98°47'	3°26'	7
17	Melati	16	11	98°58'	3°33'	14
18	Pagar Marbau	24	18	98°54'	3°30'	25
19	Ramunia	8	7	98°54'	3°37'	27
20	Serbadjadi	58	30	98°56'	3°23'	25
21	Sei Kari	109	38	98°32'	3°20'	26
22	Sei Merah	16	17	98°50'	3°32'	30
23	Sei Putih	54	28	98°53'	3°24'	30
24	Sei Tuan	4	5	98°48'	3°40'	25
25	Tandjong Garbus Empl.	14	17	98°52'	3°31'	22
26	Tandjong Morawa Kanan	30	21	98°47'	3°31'	44
27	Tandjong Purba	60	31	98°51'	3°24'	18
28	Timbang Deli	36	23	98°54'	3°27'	24

2. Annual Rainfall at 28 Stations in 1954, 1955 and 1969

Unit: mm

No	Rainfall gage stations	1954	1955	1969
1	Adolina Ilir Afd. Kantor	1872	1628	
2	Adolina Ulu Afd. I	2130		
3	Bandar Kwala		2358	
4	Bandar Negeri			2689
5	Bandar Pinang	3127	3045	3628
6	Batang Kwis	1893	1530	932
7	Batu Gingging			
8	Batu Rata	1866	2303	
9	Batu Rata Afd. Bangun Purba	3069	2649	2661
10	Begerpang			1800
11	Bengabing		1309	1502
12	Deli Muda			
13	Greahan Estate			2597
14	Klein Sungei Karang			3173
15	Kwala Namu	2098	1568	1320
16	Limau Mungkur	2181	3772	
17	Melati	2021	1482	2049
18	Pagar Marbau	1865	1446	
19	Ramunia	2074		
20	Serbadjadi			
21	Sei Kari			5105
22	Sei Merah			
23	Sei Putih	1767	1876	2013
24	Sei Tuan	1944		
25	Tandjong Carbus Empl.	1783	1651	1536
26	Tandjong Morawa Kanan	2062	1924	1508
27	Tandjong Purba		1911	2249
28	Timbang Deli			1991

3. Monthly Rainfall at 6 Rainfall Gage Stations in the Lower Basin of the Ular River during the Period from 1960 to 1969

Unit: mm

Gage station	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
						1960							
Bandar Pinang	122	79	153	225	511	192	375	166	467	428	147	334	3209
Batu Gingging	172	74	144	111	319	149	205	111	241	215	199	130	2070
Deli Muda	178	139	45	65	99	107	280	139	223	262	410	272	2219
Kwala Namu	194	94	54	109	163	82	183	195	182	70	207	272	1805
Pagar Marbau	217	71	60	59	172	139	160	220	246	197	149	220	1911
Sei Putih	139	148	59	123	193	216	162	381	224	202	168	126	2141
						1961							
Bandar Pinang	378	281	224	466	233	243	324	325	529	354	145	306	3811
Batu Gingging	180	170	226	140	149	153	270	75	331	522	138	159	2513
Deli Muda	147	133	44	148	81	81	176	124	313	174	282	115	1818
Kwala Namu	159	113	125	122	168	76	135	75	227	188	216	101	1705
Pagar Marbau	142	116	106	103	120	68	195	109	214	162	174	191	1720
Sei Putih	188	294	195	167	104	74	215	50	258	155	140	130	1968
						1962							
Bandar Pinang	266	111	400	337	159	312	274	361	485	170	221	342	3504
Batu Gingging	144	27	181	149	341	215	138	230	243	169	242	268	2347
Deli Muda	63	30	77	58	88	69	67	357	290	222	221	210	1752
Kwala Namu	53	26	31	33	105	50	84	207	140	204	138	224	2295
Pagar Marbau	34	14	90	78	109	127	63	216	153	214	145	117	1428
Sei Putih	87	85	176	77	222	274	76	179	180	158	159	185	1858
						1963							
Bandar Pinang	211	272	272	136	148	337	90	314	458	543	549	250	3580
Batu Gingging	189	255	136	28	171	123	49	93	402	422	406	236	2510
Deli Muda	239	148	7	17	218	75	71	126	162	205	354	123	1746
Kwala Namu	204	109	91	7	92	142	76	91	206	222	229	79	1548
Pagar Marbau	163	105	39	32	117	194	72	143	264	300	232	91	1752
Sei Putih	134	115	58	100	130	80	95	100	227	352	270	142	1803
						1964							
Bandar Pinang	120	317	152	229	279	354	240	139	492	248	118	261	2889
Batu Gingging	188	157	78	105	114	172	163	207	439	347	216	194	2380
Deli Muda	43	160	114	102	122	14	158	132	251	286	284	111	1777
Kwala Namu	18	125	70	87	90	30	129	73	240	154	168	60	1244
Pagar Marbau	43	189	75	180	145	116	130	27	230	215	184	51	1585
Sei Putih	26	89	158	154	204	206	160	85	194	198	156	91	1721

Unit: mm

Gage station	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
						1965							
Bandar Pinang	15	55	275	67	153	435	20	337	284	543	292	235	2704
Batu Gingging		20	131	83	62	134	57	158	177	261	207	237	
Deli Muda	3	43	107	128	61	47	64	226	160	317	356	241	1753
Kwala Namu	0	17	71	53	134	42	80	214	100	275	245	147	1378
Pagar Marbau	7	29	82	59	205	66	132	398	186	294	178	166	1782
Sei Putih	4	104	110	85	112	158	126	175	156	149	224	198	1601
						1966							
Bandar Pinang			267		326	243	230	250	305	741	200	86	
Batu Gingging	33	66	159	23	118	299	398	241	165	214	58	45	1819
Deli Muda	179	34	147	74	261	278	117	138	240	509	165	120	2262
Kwala Namu	25	40	90	38	155	60	74	142	248	176	169	69	1286
Pagar Marbau	54	44	151	137	223	119	95	176	245	258	168	41	1711
Sei Putih	69	35	107	83	220	206	181	186	297	276	109	71	1840
						1967							
Bandar Pinang	19	21	110	150	85	235	184	282	242				
Batu Gingging	76	95	154	146	129	251	150	329	240	518	232	93	2413
Deli Muda	166	74	25	83	69	115	112	61	85	263	165	119	1337
Kwala Namu	57	100	13	30	66	98	69	154	69	186	79	98	1019
Pagar Marbau	97	29	53	87	89	227	138	97	83	368	334	144	1746
Sei Putih	43	90	80	148	96	152	155	193	238	442	155	52	1844
						1968							
Bandar Pinang	175	46	164	261	213	297	144	554	344	368	231	411	3206
Batu Gingging	161	25		200	246	266	317	349	455	237	159	325	
Deli Muda		10	105					122					
Kwala Namu	73	0	114	86	136	167	78	114	174	212	57	55	1266
Pagar Marbau	63	0	62	67	107	164	103	107	232	269	31	70	1275
Sei Putih	35	20	52	105	155	194	138	177	359	201	99	237	1772
						1969							
Bandar Pinang	144	234	74	166	252	467	399	459	127	559	410	327	3628
Batu Gingging	87	143		140	227	252	141	246	192	584	596	224	
Deli Muda	55	17			210	91	156			542		212	
Kwala Namu	35	14	25	25	90	98	67	96	35	391	339	105	1320
Pagar Marbau	60	60	31	118	126	201	145		79	374	334	144	
Sei Putih	46	133	33	42	141	156	108	313	208	397	301	135	2013

4. Annual Maximum Rainfall Averaged over the Lower Basin of the Ular River and Annual Maximum Daily Rainfall at 6 Stations

Daily rainfall

Year	Mean in lower basin		Bandar Pinang		Batu Gingging		Deli Muda		Kwala Namu		Pagar Marbau		Sei Putih	
	Month, Day	Rainfall (mm)	M.D.	Rainfall (mm)	M.D.	Rainfall (mm)	M.D.	Rainfall (mm)	M.D.	Rainfall (mm)	M.D.	Rainfall (mm)	M.D.	Rainfall (mm)
1960	1.1	47.8	5.11	152	1.21	107	1.1	102	12.17	97	12.10	112	8.26	101
1961	1.3	57.7	1.3	152	10.13	71	7.30	67	7.30	70	12.27	65	1.3	103
1962	9.10	57.7	4.17	112	4.16	64	9.10	132	12.6	67	9.9	59	9.10	100
1963	11.28	81.5	10.16	160	11.28	104	11.18	100	1.31	74	11.28	91	11.28	75
1964	10.26	45.8	12.22	142	1.19	81	10.26	130	9.4	85	4.29	75	4.29	84
1965	8.27	38.3	6.5	144			11.1	118	8.27	91	10.30	83	12.29	82
1966	5.9	39.0			7.1	85	5.7	98	11.1	83	9.27	82	5.9	80
1967	12.15	34.4			4.3	60	12.15	80	10.23	61	6.15	80	10.10	75
1968	5.1	48.2	3.27	144					5.1	64	9.1	84	10.30	57
1969	10.16	25.7	7.6	144					10.16	68			2.13	98

Three days rainfall

Year	Mean in lower basin		Bandar Pinang		Batu Gingging		Deli Muda		Kwala Namu		Pagar Marbau		Sei Putih	
1960	12.8	70.2	10.27	206	12.31	116	12.7	131	12.17	145	12.8	140	8.24	138
1961	1.2	97.7	8.30	258	9.9	137	7.28	110	1.2	104	12.27	127	2.15	173
1962	9.9	79.2	4.16	192	5.9	112	9.9	157	12.4	77	9.9	88	5.2	134
1963	10.23	81.5	10.14	216	12.6	149	5.29	154	9.5	78	10.23	113	10.23	113
1964	9.2	80.7	9.29	182	9.2	111	10.26	149	9.2	140	4.29	112	4.29	104
1965	8.25	73.7	6.5	196			12.5	137	8.25	119	8.4	120	12.29	91
1966	5.7	88.8			7.1	135	5.7	202	9.23	105	9.26	119	5.9	113
1967	7.11	59.0			10.20	102	1.2	96	12.15	83	6.27	98	7.11	95
1968	10.29	102.4	12.30	267					4.29	93	10.29	165	4.29	116
1969	10.14	110.5	7.6	243					10.1	107			2.12	130

5. Frequency of Daily, 2-Day and 3-Day Rainfall more than 50 mm during the Period from 1961 to 1969

Frequency of daily rainfall more than 50 mm

Station \ Month	1	2	3	4	5	6	7	8	9	10	11	12
Kwala Namu	5	2	3	1	4	2	4	6	8	6	9	7
Sei Putih	3	5	3	3	7	5	6	7	9	10	6	2

Frequency of 2 days rainfall more than 50 mm

Station \ Month	1	2	3	4	5	6	7	8	9	10	11	12
Kwala Namu	5	3	3	1	5	3	4	6	11	11	11	9
Sei Putih	3	6	3	4	9	13	8	11	13	15	9	7

Frequency of 3 days rainfall more than 50 mm

Station \ Month	1	2	3	4	5	6	7	8	9	10	11	12
Kwala Namu	5	6	4	2	6	3	3	7	11	15	13	10
Sei Putih	3	5	3	4	9	11	9	9	17	20	12	8

6. Mean Temperature in Medan during 5 Years from 1959 to 1963

Unit: °C

Month \ Time	2	4	6	8	10	12	14	16	18	20	22	24	Mean	Max.	Min.
January	22.9	22.5	22.1	24.3	27.8	29.7	30.1	28.8	26.5	24.8	24.0	23.4	25.6	31.3	22.0
February	23.0	22.6	22.3	25.1	29.4	31.2	31.2	29.4	26.9	25.2	24.2	23.5	26.2	30.0	22.0
March	23.4	22.9	22.6	25.7	30.7	33.1	32.3	30.7	27.8	25.7	24.7	24.0	27.0	34.6	22.4
April	23.7	23.3	22.9	26.3	30.9	33.2	32.6	31.4	28.3	26.1	24.9	24.2	27.3	34.8	22.8
May	24.0	23.6	23.3	26.9	31.7	33.8	33.1	31.4	28.2	26.3	25.3	24.6	27.7	35.1	23.2
June	23.7	23.2	22.9	26.1	30.9	33.3	33.2	31.3	27.7	25.9	25.0	24.2	27.3	34.9	22.7
July	23.4	22.9	22.6	25.5	30.2	33.0	33.1	31.2	27.8	25.5	24.5	23.9	26.9	34.6	22.4
August	23.3	22.9	22.6	25.8	30.5	32.9	32.4	30.5	27.1	25.3	24.4	23.7	26.8	34.3	22.3
September	23.2	22.9	22.6	25.3	29.2	31.6	31.8	30.1	26.7	25.1	24.3	23.7	26.6	33.4	23.2
October	23.2	22.8	22.7	25.2	28.4	30.2	30.3	29.0	26.1	24.7	24.0	23.6	25.9	31.9	22.4
November	23.1	22.9	22.6	25.0	27.9	29.6	29.7	28.7	26.3	24.9	24.2	23.7	25.7	31.2	22.5
December	23.1	22.8	22.4	25.3	28.3	30.1	30.0	28.7	26.7	24.9	24.3	23.7	25.9	31.3	22.3
Mean	23.3	22.9	22.6	25.2	29.7	31.8	31.9	30.1	27.1	25.4	24.5	23.9	26.6	33.3	22.5

7. Mean Relative Humidity in Medan during 5 Years from 1959 to 1963

Unit: %

Month \ Time	2	4	6	8	10	12	14	16	18	20	22	24	Mean	Max.	Min.
January	95.8	96.3	96.4	85.9	69.5	61.8	63.9	70.4	83.9	93.0	94.9	95.5	84.1	97.0	54.0
February	96.5	96.6	96.8	86.1	64.6	57.9	60.9	68.8	81.9	92.9	95.1	95.9	82.8	97.1	50.6
March	96.2	96.4	96.5	84.8	61.9	53.9	59.2	66.6	81.6	92.4	94.5	95.6	81.6	97.0	48.0
April	96.3	96.6	96.8	84.3	63.0	55.4	60.1	65.6	79.9	92.5	94.9	95.9	81.8	97.2	48.8
May	95.6	95.9	95.9	82.9	61.8	54.4	58.8	66.9	82.1	91.4	94.1	95.2	81.3	96.5	48.1
June	96.1	96.3	96.3	85.8	63.9	54.1	56.5	65.2	81.6	91.4	94.3	95.6	81.4	96.9	47.7
July	96.4	96.6	96.7	87.8	64.6	54.2	55.4	66.2	82.1	92.0	94.7	95.9	81.9	97.2	48.0
August	95.4	95.8	96.1	85.3	62.9	53.7	55.3	65.8	81.5	91.5	93.4	94.9	81.0	96.5	47.4
September	96.5	96.7	96.8	88.5	70.6	60.7	61.7	69.7	84.7	93.2	95.2	96.2	84.2	97.2	52.9
October	96.7	96.8	96.9	89.2	72.2	64.2	66.8	73.7	88.9	94.4	95.7	96.5	86.2	97.2	58.1
November	96.5	96.7	96.2	89.9	74.9	67.6	67.8	75.7	85.4	93.9	95.3	95.9	86.6	97.1	59.7
December	95.4	95.6	95.7	87.3	71.6	63.6	66.0	72.1	86.3	93.5	94.7	95.2	84.7	96.2	51.5
Mean	96.1	96.3	96.5	86.6	66.8	58.6	61.0	68.9	83.5	92.7	94.7	95.7	83.1	96.9	51.7

DATA 3

DATA ON PLANTATIONS AND GENERAL AGRICULTURE

1. Palm-oil

(1) Production of palm-oil.

Palm-oil is an important export item especially in Sumatra. It is exported to the middle-east countries, Japan and the USA. The demand of palm-oil has been on the increase.

Palm-oil can be produced from crusts of nuts, and kernel oil from kernels of nuts. Ratio of production of usual palm-oil and kernel oil is about 80 % and 20 % respectively.

3 to 4 years are required to get new nuts after planting of oil-palm trees. Replanting is needed every 30 years to maintain good harvest. It is the standard estate practice to use a 30-year cycle for oil-palms. Bunches are produced throughout the year, though, a plenty of nuts grow in wet season.

Oil-palm in affected by flooding because its roots are bitten by vermin breeded in moistened soil.

PNP VI which has a planted area of 32,220 ha produced 56,500 ton of palm-oil and 13,500 ton of palm-kernel in 1969. According to this example, the annual produce per ha will be as follows.

Palm-oil	1,754 kg/ha
Palm-kernel	419 kg/ha
Total	2,173 kg/ha

Other organizations relating to PNP also informed us the annual produce was 2,000 kg/ha to 2,400 kg/ha in total of palm-oil and palm-kernel. So we adopted the following values for the calculation of benefits.

Palm-oil	1,800 kg/ha
Palm-kernel	400 "
Total	2,200 kg/ha

(2) Selling price.

Fig. D-1 shows FOB prices of palm-oil and palm-kernel from 1961 to 1967. According to this figure, it is found that the selling price of palm-oil varies from US$ 165/ton to US$ 185/ton and the mean value is US$ 178/ton. In the case of palm-kernel, the corresponding values are US$ 100/ton - US$ 130/ton and US$ 112/ton respectively.

According to the information from BCU-PNP, the latest selling price (1969 - 1970) is US$ 170/ton - US$ 210/ton for palm-oil and US$ 100/ton - US$ 120/ton for palm-kernel.

Since the selling prices of palm-oil and palm-kernel do not show so big variety during the past several years as seen in the above statistics, we decided to use the following mean values for them.

Palm-oil	US$ 178/ton
Palm-kernel	US$ 112/ton

When we assume export duty and other expenses to be 15 %, the above prices will be

Palm-oil	US$ 153/ton
Palm-kernel	US$ 98/ton

These values were used for calculation of benefits.

(3) Production cost.

Based on the annual produce and the selling prices shown above, an average yield of palm-oil per ha is calculated as follows.

$$US\$ (153 \times 1.8 + 98 \times 0.4)/ha = US\$ 315/ha$$

According to the report of IDA, production cost of palm-oil (including palm-kernel) is US$ 123.5/ha in PNP VII, which corresponds to about 39 % of selling prices.

2. Rubber

(1) Production of rubber.

Rubber plantation is the largest in scale of all kinds of plantations in Indonesia. Annual produce of rubber in Indonesia amounts to about 700,000 tons in total, though it is tending to decrease recently. Out of 10 PNP plantations

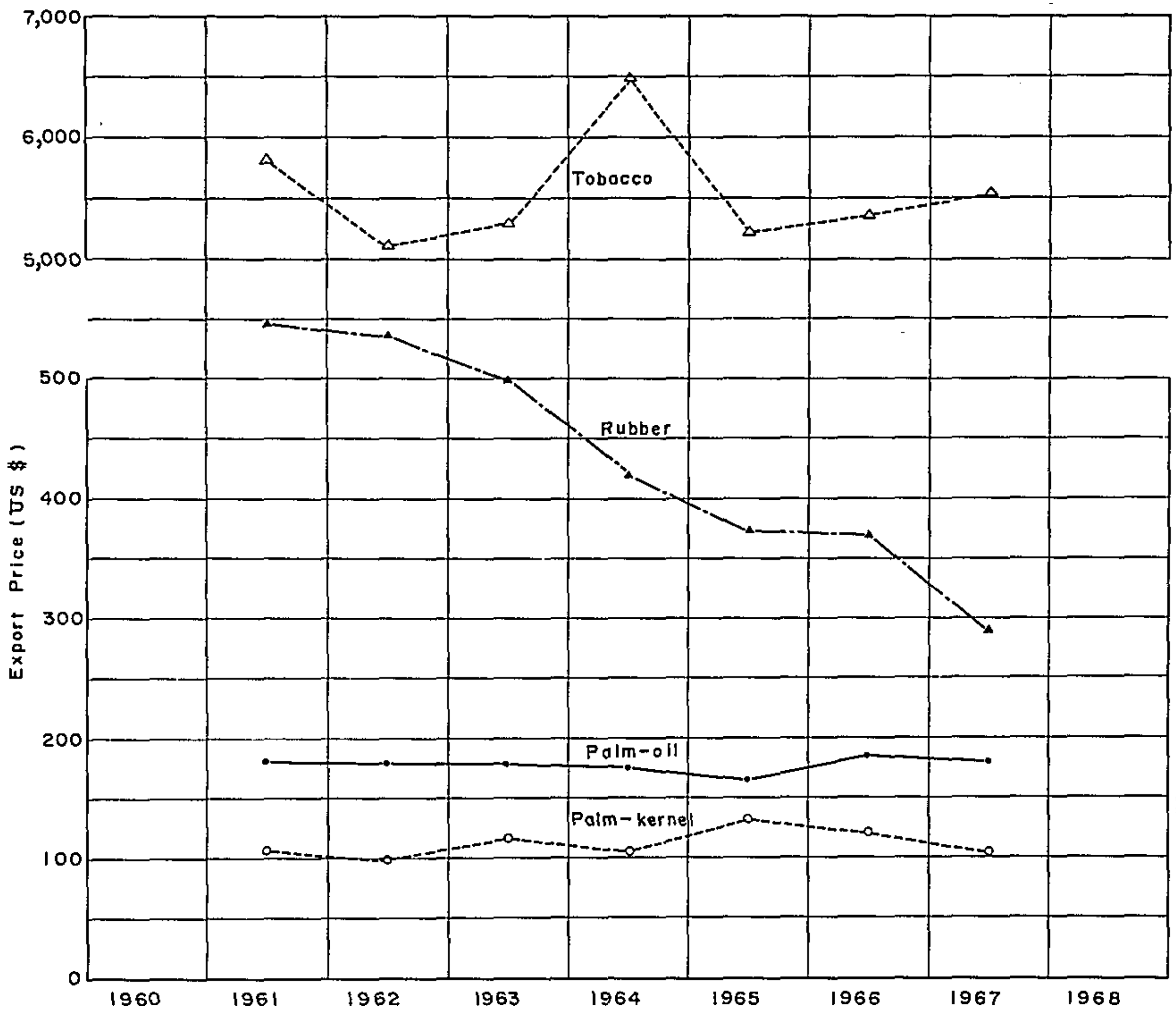


Fig. D-1 Export Prices of Palm-oil, Palm-Kernel, Rubber and Tobacco.

in Sumatra, 8 PNP's are producing rubber. Rubber is exported to east and west Europe, Pakistan, Japan and the USA.

Rubber is classified into two kinds of government-owned rubber and private rubber. The government-owned rubber is of higher quality (RSS-1 to RSS-3) than the private rubber.

The ratio of production of government-owned rubber and private rubber is about 70 % and 30 % respectively in North Sumatra.

Rubber can be produced 6 or 7 years after planting. Rubber trees usually become uneconomic under Indonesian conditions after about 25 years, due to exhaustion of bark for tapping and declining yields. It is a standard estate practice to use a 25-year cycle for rubber. Rubber tree is rather strong against water.

It was informed by BCU-PNP that annual produce of rubber varies between 800 kg/ha and 1,000 kg/ha. IDA reports 900 kg/ha - 1,100 kg/ha. Here, produce of rubber is assumed to be

1,000 kg/ha

on an average.

(2) Selling price.

Selling price of natural rubber is affected by that of synthetic rubber. IDA report says, "average prices CIF New York are expected to fall from about 20 US Cents per lb (US$ 406/ton) through 1970 to about 15-17 US Cents per lb by 1975.

Fig. D-1 shows the variation of FOB price of rubber since 1961. The price of US$ 550/ton in 1961 fell to a price of US$ 300/ton in 1967. According to the information from BCU-PNP, however, the recent (1969 - 1970) selling price is US$ 330 - 340/ton. Here, we assume US$ 340/ton for selling price. This price is presumed to include export duty and other taxes of 15 %.

If these taxes are excluded, the selling price of rubber is estimated at about US$ 300/ton. As the unit produce of rubber is 1 ton/ha as mentioned above, unit yield of rubber works out at

US$ 300/ha

This value was used for benefit - cost analysis.

(3) Production cost.

According to the survey of IDA, production cost of rubber is US$ 126/ha in PNP V, which corresponds to about 42 % of selling price.

3. Tobacco (Deli tobacco)

(1) Production of tobacco.

Deli tobacco is the cigar famous in the world. Deli tobacco is exported to Europe, but not to Japan. PNP has a common selling agency of Deli tobacco in Bremen.

Deli tobacco is planted with a rotation cycle of about six years, or may be planted only once after about five years of fallowing of the tobacco field. During the fallowing period, the field is left to the growing of bushes.

Tobacco is very weak against water, and good drainage is required for good production of tobacco.

Production of tobacco:

Only PNP IX has tobacco estates in Sumatra. Total area of the tobacco estates was 4,769 ha in 1968 and 4,282 ha in 1969. Average planted area was 4,528 ha. On the other hand, the statistics of produce during the period from 1961 to 1967 are as follows:

Year	1961	1962	1963	1964	1965	1966	1967	Mean
ton	2,214	1,667	2,401	2,124	2,825	3,438	2,635	2,472

From the mean value 2,472 ton and the above-mentioned mean value of planted area 4,528 ha, annual produce per ha of tobacco is calculated as follows:

$$2,472 \text{ ton}/4,528 \text{ ha} = 546 \text{ kg/ha} \doteqdot 550 \text{ kg/ha}$$

This figure was assumed for unit production of tobacco.

(2) Selling price.

According to export statistics during the period of 1961 - 1967 (Fig. D-1) in Belawan the mean and high selling prices of tobacco were US$ 5.5/kg and US$ 6.5/kg respectively. Here, we assume the selling price of tobacco excluding export duty and other taxes to be:

US$ 5.5/kg x 0.85 = US$ 4.7/kg

Then yield per planted area is

US$ 4.7/kg x 550 kg/ha = US$ 2,585/ha

Yield per total tobacco area is

US$ 2,585/ha x $\frac{1}{6}$ = US$ 430/ha

(3) Production cost.

No data on production cost of tobacco was available, and, here, 40 % of selling price is assumed as an annual average cost per unit tobacco area.

US$ 172/ha

Remarks:

(1) Fertilizer application for rubber: The IDA report says, "An annual application of about US$ 12 per ha should be sufficient for mature rubber, except for the last five years of production life (i.e. years 21 thru. 25) when fertilizer is no longer applied."

(2) Fertilizer application for oil-palm: The report says, "An annual application of about US$ 35 per ha should be sufficient for mature oil-palms under normal conditions, except for the last five years of their productive life (i.e. years 26 thru. 30) when fertilizer is no longer applied."

(3) Wages: The report says, "The present wage level for estate workers is Rp 22.50 for day plus Rp 137.50 in kind, equivalent to US$ 0.42" or less than US$ 0.50. The rise ratio of wage is assumed at 3 % per annum."

(4) Export duty: The report says, "The rate of export duty is currently 10 % and agricultural and other taxes account for a further 5%." (Access for the Provincial Government is required additionally for infrastructure maintenance.)

(5) Necessity of flood control: Apart from losses directly attributable to flood damage, poor drainage has resulted in low crop yields in the area exposed to floods. Moreover, in the case of rubber and oil-palm, floods

have prevented replacement of over-aged trees because replanting is possible only in the last three months of the year, which generally coincide with the flood season.

(6) IDA report says, "Dredging for the prevention of flood damages is high on the Government's priority list, but cannot be economically justified by the benefits that would accrue to PNP estates alone."

4. Rice

(1) Production of rice.

The data on rice production in recent years in the prefecture of Deli-Serdang are shown by DPPSU as follows:

Year	1965	1966	1967	1968	Remarks
A. Padi Sawah (paddy field)					
(1) Area (ha)	298,910	317,925	316,490	342,757	
(2) Production (ton)	839,621	883,792	933,701	986,788	
(3) Ton/ha	2.80	2.78	2.95	2.88	figures are understood for stalked paddy.
B. Padi Ladang (upland rice field)					
(1) Area (ha)	143,661	137,713	145,907	170,793	
(2) Production (ton)	246,741	231,891	232,435	270,180	
(3) Ton/ha	1.71	1.68	1.59	1.58	"

Remarks:

(1) Paddy and rice are usually classified in Indonesia as stalked paddy, paddy, brown rice and polished rice. Bran is produced by polishing.

(2) Production of paddy is shown as stalked paddy usually.

(3) Polished rice can be produced as much as 52 % or about a half of the stalked paddy by weight.

(4) The following figures are used as usual production of rice in Indonesia. "Well-irrigated rice fields can easily produce 4.0 tons per hectare of

stalked paddy. At present the average yield of wet-monsoon paddy is 2.7 tons per hectare and due to water shortage the dry-monsoon paddy yield is only 1.7 tons per hectare/1."

From the above tables, the following figures are assumed for the annual average production of rice.

	Padi Sawah (ton/ha)	Padi Ladang (ton/ha)
Stalked paddy	2.85	1.64
Polished rice	1.5	0.8

(2) Selling price.

Fig. D-2 shows the variation of wholesale price of polished rice. It is seen from this figure that the price in Medan rose since 1966 and reached the highest, about Rp 70/kg. The variety of price is also big during one year. From the case of the year 1968, we can see that the price varied between the lowest in January, Rp 38/kg, and the highest in May and October, Rp 68/kg, that is, the latter was about two times of the former. Generally the price of rice is low in January and February, and high in September and October.

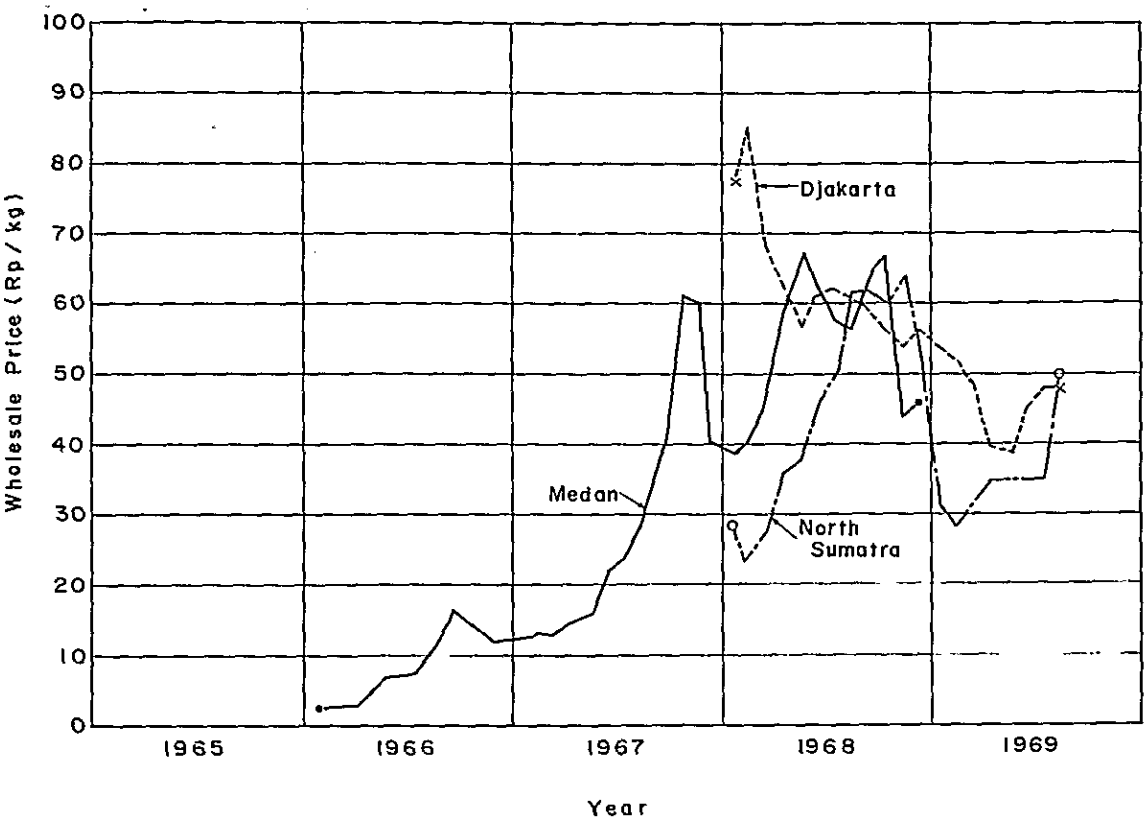
But the price of rice has been considerably stabilized since the latter half of the year 1968 by the effort of the government. So the average wholesale price and the average retail price in Medan in 1970 are assumed to be about Rp 50/kg and about Rp 55/kg respectively for the polished rice.

Computing average annual values of wholesale price from monthly wholesale prices of polished rice shown in Fig. D-2 and using data given by DPPSU and obtained by hearing from people, average annual values of wholesale price in Medan and North Sumatra province are assumed as follows:

/1: Quoted from the Sempor Project, DPWP, March 1969.

Fig. D-2

Wholesale Prices of Polished Rice at Medan, North Sumatra and Djakarta.



Average annual wholesale price of polished rice (in Rp/kg)

Year	1965	1966	1967	1968	1969	1970
Medan	-	8.2	2.88	54.0	-	(45-60)
North Sumatra	0.6	5.5	2.94	46.3	50.0	(40-60)

Notes: Figures within ( ) are by hearing from people.

The price of paddy is assumed to be Rp 25 - 30/kg, since the price is estimated generally to be 50 to 60 % of the price of polished rice. Rp 25/kg is assumed for the present cost-benefit analysis. The annual yields per hectare are computed as follows:

Padi Sawah (paddy) 2,850 kg/ha x Rp 25/kg = Rp 71,250/ha

Padi Ladang (paddy) 1,640 kg/ha x Rp 25/kg = Rp 41,000/ha

(3) Production cost.

The production cost of rice is estimated by DPPSU to be about Rp 83,000/ha for well-irrigated, well-fertilized and well-maintained rice field. This price consists of personnel expenses Rp 50,000, expenses for fertilizer Rp 23,500 and other expenses Rp 9,500 for the produce of paddy of 4 to 5 ton/ha. If we assume the average produce to be 4.5 ton/ha and the average price of paddy to be Rp 25/kg, the rate of the production cost to the yield is estimated for well-irrigated rice field as follows:

$$\text{Rate of production cost} = \frac{\text{Rp } 83{,}000/\text{ha}}{4{,}500 \text{ kg/ha} \times \text{Rp } 25/\text{kg}} \times 100$$

$$= 74\ \%$$

Most of rice fields, however, are private in the district of the Ular river and fertilizer is rarely used. Therefore, the personnel expenses is estimated to be Rp 24,000/ha if we assume that the farmers work for 120 days and the wages is Rp 200 per day. When we add Rp 8,000 per ha as some expenses for fertilizer and others, production cost will be Rp 32,000/ha in total. Therefore, the rate of production cost is calculated as follows:

$$\text{Rate of production cost of rice} = \frac{\text{Rp } 32{,}000/\text{ha}}{2{,}850 \text{ kg/ha} \times \text{Rp } 25/\text{kg}} \times 100$$

$$= 45\ \%$$

In the case of upland rice, the production cost is assumed to be about 50 % of rice. Therefore, the rate of production cost will be as follows:

$$\text{Rate of production cost of upland rice} = \frac{\text{Rp } 16{,}000/\text{ha}}{1{,}640 \text{ kg/ha} \times \text{Rp } 25/\text{kg}} \times 100$$

$$= 39\ \%$$

4. Upland Crop Field (Palawidja)[/1]

(1) Production.

The yield of palawidja is assumed to be equivalent to 1.64 ton per hectare of upland stalked paddy.

(2) Unit price

The unit price of upland crop is assumed to be equivalent to Rp 25 per kg of stalked paddy.

(3) Production cost.

The production cost of upland crop is assumed to be equivalent to that of upland rice.

The following values shown in Table D-1 and Table D-2 are used for cost-benefit analysis.

/1 Quoted from the Sempor Project, DPWP, March 1969.

Table D-1 Unit Yield and Unit Cost of Products

	Unit produce (kg/ha)	Unit price (Rp/kg)	A Unit yield (Rp/ha)	B Unit cost of production (Rp/ha)	B/A Rate of production cost (%)	A - B Profit (Rp/ha)
Palm-oil	1,800	58	119,200	46,700	39	72,500
Palm-kernel	400	37				
Rubber	1,000	114	114,000	47,600	42	66,400
Tobacco	550	1,770	162,000	64,800	40	97,200
Paddy (Sawah)	2,850	30	71,250	32,000	45	39,250
Paddy (Ladang)	1,640	30	41,000	16,000	39	25,000
Upland crop (Palawidja)			41,000	16,000	39	25,000

Table D-2 Yields and Profits of Agricultural Products in the Downstream Plain of the Ular River

Government-owned estates

Plantation	Max. possible inundation area /1		Inundation area (1969) /2	
	Yield(Rp1,000)	Profit(Rp1,000) /3	Yield(Rp1,000)	Profit(Rp1,000) /3
Palm-oil	540,572	328,788	196,680	119,625
Rubber	326,040	189,904	186,048	108,365
Tobacco	153,900	92,340	9,396	5,638
Total	1,020,512	611,032	392,124	233,628

Farm land

Rice	1,011,750	557,350	349,125	192,325
Upland rice & field crops	65,600	40,000	12,300	7,500
Total	1,077,350	597,350	361,425	199,825

Grand total	2,339,574	1,354,574	753,549	433,453

/1 Planted or cultivated area shown in Table 1-5-1

/2 Inundation area in 1969 shown in Table 1-5-3

/3 (Yield) - (Production cost)

PART 4

APPENDICES

APPENDIX 1

FORMULAS FOR HYDRAULIC CALCULATION

1. Formula for Calculation of Backwater in Non-uniform Flow

Equation of non-uniform flow is written by finite difference, as follows:

$$Z_i = Z_{i-1} + \frac{DQ^2}{2g}\left(\frac{1}{A_{i-1}^2} - \frac{1}{A_i^2}\right) + \frac{Q^2 X}{2}\left(\frac{N_{i-1}^2}{R_{i-1}^{4/3}\,A_{i-1}^2} + \frac{N_i^2}{R_i^{4/3}\,A_i^2}\right)$$

Where, according to Ida,

$$D = \alpha \frac{A^2 \int_0^B \frac{H^3}{n^3}\, d\xi}{\left(\int_0^B \frac{H^{5/3}}{n}\, d\xi\right)^3}$$

$$N = \frac{\int_0^B H^{5/3}\, d\xi}{\int_0^B \frac{H^{5/3}}{n}\, d\xi}$$

$$R = \left(\frac{1}{A}\int_0^B H^{5/3} d\xi\right)^{3/2}.$$

Notation is as follows (Fig. A-1):

- Z = Elevation of water level (m),
- g = Acceleration of gravity (m/sec^2),
- Q = Discharge (m^3/sec),
- A = Water area (m^2),
- X = Small distance between two cross-sections (m),
- D = Coefficient for correction,
- N = Equivalent coefficient of roughness for the whole cross-section,
- R = Equivalent hydraulic depth for the whole cross-section (m),
- α = Correction coefficient for vertical distribution of velocity,
- n = Manning's coefficient of roughness for every part of cross-section.

Suffix denotes number of a cross-section, from downstream to upstream.

2. Sato-Kikkawa-Ashida's Formula for Bed Load

$$Q_B = B\frac{\phi \cdot F \cdot (\tau_0/\rho)^{3/2}}{\{(\sigma/\rho) - 1\}g},$$

where

$\phi = 0.623$ for $n \geqq 0.025$,

$\phi = 0.623\ (40n)^{-3.5}$ for $n < 0.025$,

Q_B = Bed load (gr/sec),

B = Width of river (cm),

σ = Density of bed material (c,g,s,),

ρ = Density of water (c,g,s,),

g = Acceleration of gravity (cm/sec²),

τ_0 = Tractive force on river bed = $\rho g R I_e$ (gr/cm²),

R = Hydraulic depth (cm),

I_e = Gradient of energy,

n = Manning's coefficient of roughness (m,sec),

F = A function of τ_0/τ_c expressed by Fig. A-2,

τ_c = Critical tractive force on river bed (gr/cm²).

3. Kindsvader-Carter-Tracy's Method of Calculation for Flow through Constriction

$$Q = CA_3\sqrt{2g(\Delta h - h_f + \alpha_1\frac{V_1^2}{2g})}, \qquad \text{(see Fig. A-3)}$$

where

Q = Discharge (m³/sec),

C = Over-all coefficient of discharge,

$= C'K_F K_r K_W K_\phi K_y K_x K_e K_t K_j$,

A_3 = Water area at section 3 (m²),

g = Acceleration of gravity (m/sec²),

$\Delta h = h_1 - h_3$ (m),

h_f = Frictional loss (m),

α_1 = Energy coefficient at section 1,

α = Energy coefficient,

$= \frac{\int v^3 dA}{V^3 A} = 1.03 - 1.36$,

v = Velocity of water passing through at point on a water area A,

V = Mean velocity,

V_1 = Velocity at section 1,

C' = Coefficient of discharge (standard value),

= A function of m and L/b,

L = Length of the abutment in the direction of the thread of the stream,

m = Construction ratio = $1 - K_b/K_B = 1 - b/B$ for a rectangular approach section of width B and a rectangular contracted section of width b,

K_B = Conveyance of the uncontracted approach section 1 at normal discharge,

K_b = Conveyance of the contracted section 3 which has the same normal depth and roughness characteristics as the approach section,

K = Conveyance = $Q/\sqrt{S}$

= $AR^{2/3}/n$ when Manning formula is used,

S = Slope,

R = Hydraulic depth (m),

n = Coefficient of roughness,

K_F = A function of Froude number $(Q/A_3\sqrt{gd_3})$,

d_3 = Water depth at section 3 (m),

K_r = Coefficient of entrance rounding,

K_W = Coefficient of wing walls or chamfers,

K_ϕ = Coefficient of angularity of constriction,

K_y = Coefficient of side depths at abutment,

K_x = Coefficient of side slope of abutment,

K_e = Coefficient of eccentricity of constriction,

K_t = Coefficient of submergence of bridge,

K_j = Coefficient of bridge piles and piers.

Fig. A-1 Non-uniform Flow.

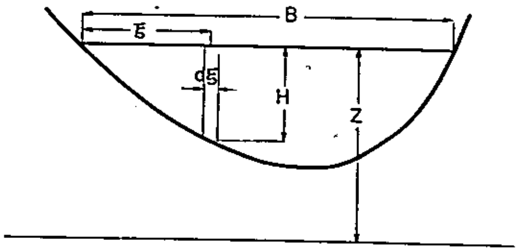


Fig. A-2 Function F.

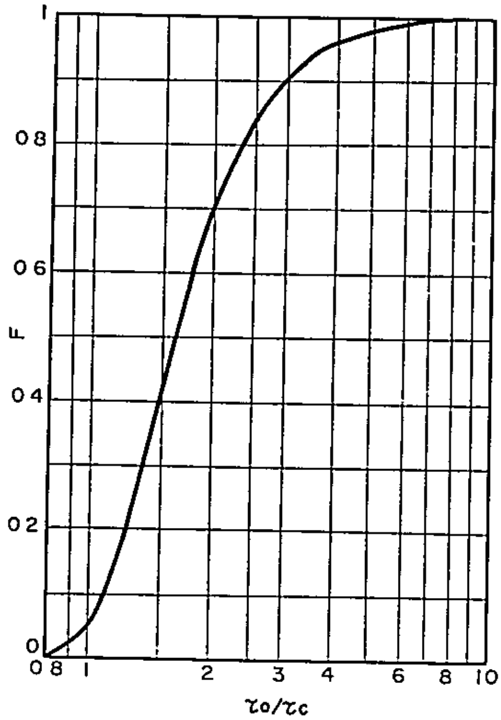
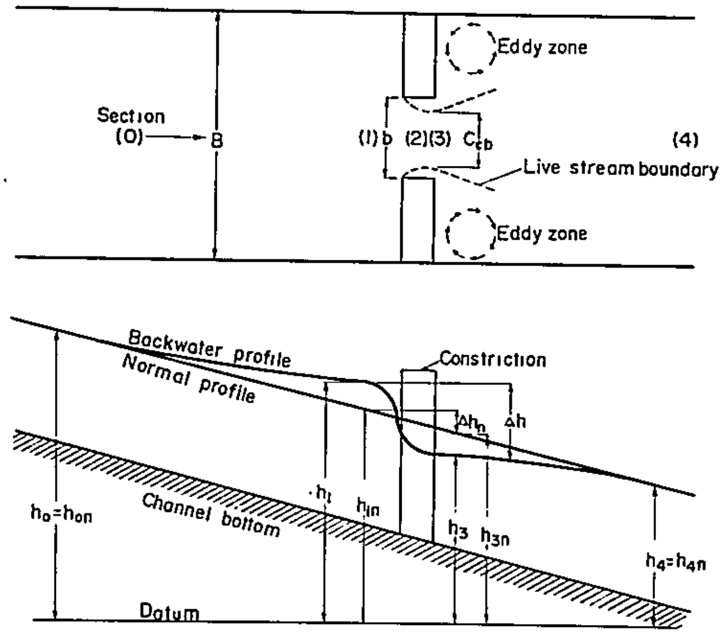


Fig. A-3 Constriction.



APPENDIX 2

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