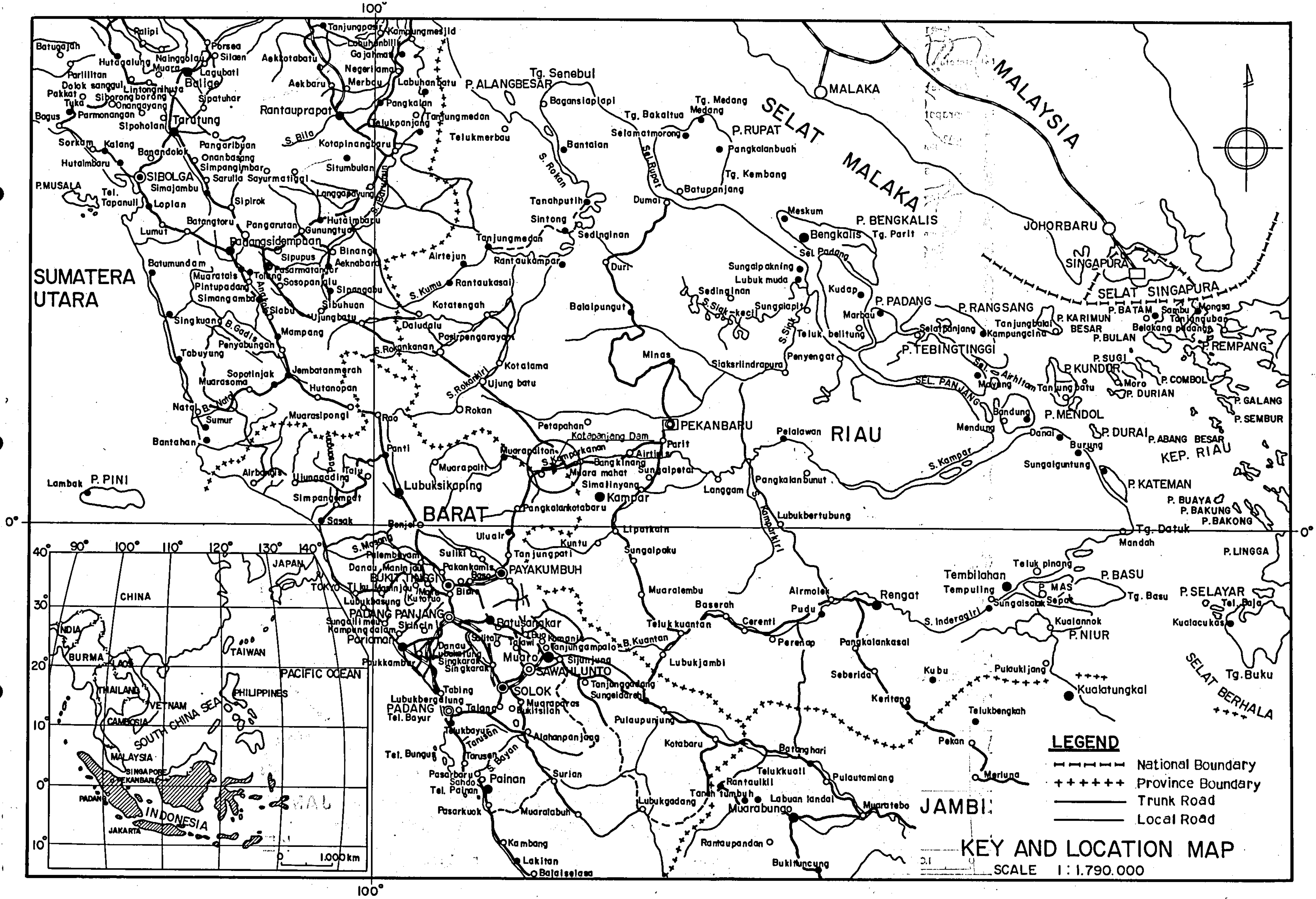
REPUBLIC OF INDONESIA
PERUSAHAAN UMUM LISTRIK NEGARA

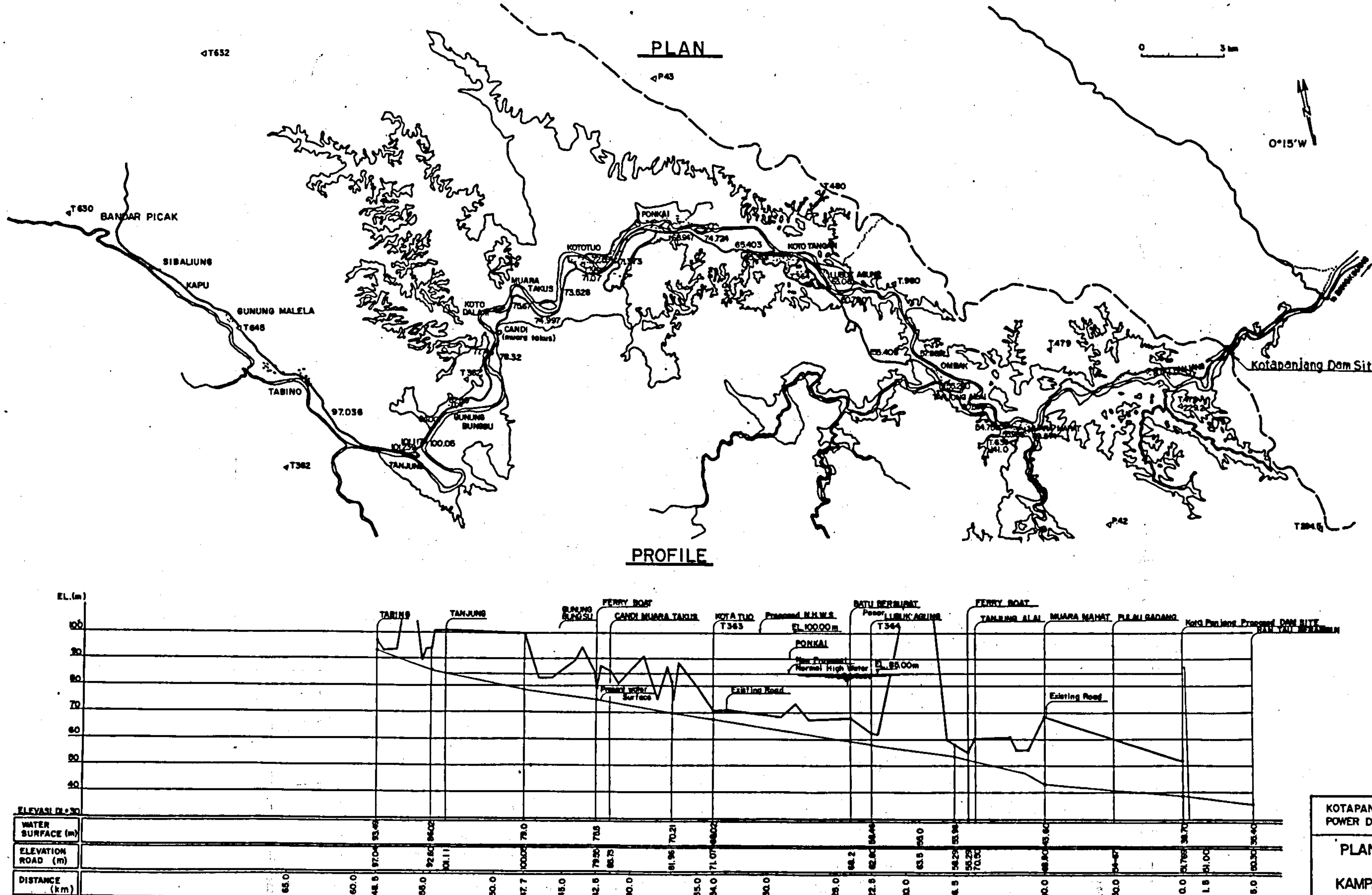
INTERIM REPORT
OF
FEASIBILITY STUDY
ON
THE KOTAPANJANG HYDRO ELECTRIC POWER DEVELOPMENT PROJECT

MARCH 1983

JAPAN INTERNATIONAL COOPERATION AGENCY

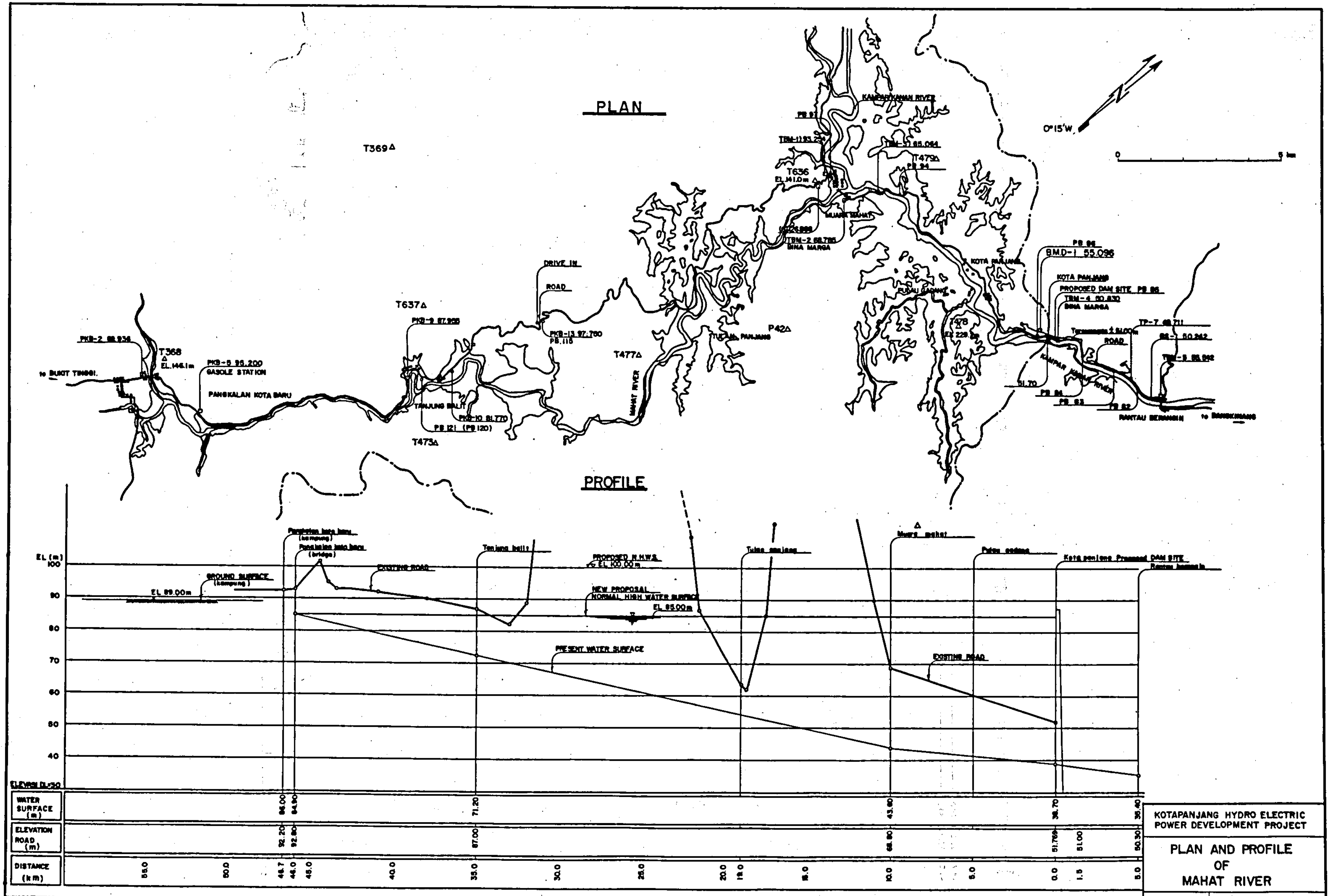


KEY AND LOCATION MAP
SCALE 1 : 1.790.000
LEGEND
National Boundary
Province Boundary
Trunk Road
Local Road
SUMATERA UTARA
BARAT
RIAU
JAMBI
MALAYSIA
SELAT MALAKA
SELAT SINGAPURA
SELAT BERHALA
KEP. RIAU
SINGAPURA
JOHORBARU
MALAKA
PEKANBARU
SIBOLGA
PAYAKUMBUH
BUKIT TINGGI
PADANG PANJANG
SAWAHLUNTO
SOLOK
PADANG
Balige
Tarutung
Rantauprapat
Padangsidempuan
Bengkalis
Dumai
Kampar
Lubuksikaping
Batusangkar
Muaro
Pariaman
Painan
Rengat
Tembilahan
Kualatungkal
Muarabungo
P. RUPAT
P. BENGKALIS
P. PADANG
P. RANGSANG
P. TEBINGTINGGI
P. KARIMUN BESAR
P. BATAM
P. BULAN
P. REMPANG
P. KUNDUR
P. MENDOL
P. DURAI
P. KATEMAN
P. BASU
P. NIUR
P. SELAYAR
P. LINGGA
P. PINI
P. MUSALA
P. ALANGBESAR
Kotapanjang Dam
S. Kampar
S. Rokan
S. Siak
S. Inderagiri
B. Kuantan
Batanghari
0°
100°
CHINA
JAPAN
TOKYO
INDIA
BURMA
LAOS
THAILAND
VIETNAM
CAMBODIA
TAIWAN
PHILIPPINES
MALAYSIA
SINGAPORE
PEKANBARU
PADANG
JAKARTA
INDONESIA
SOUTH CHINA SEA
PACIFIC OCEAN
1.000 km



KOTAPANJANG HYDRO ELECTRIC POWER DEVELOPMENT PROJECT

PLAN AND PROFILE OF KAMPAR KANAN RIVER



KOTAPANJANG HYDRO ELECTRIC POWER DEVELOPMENT PROJECT

PLAN AND PROFILE OF MAHAT RIVER

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GLOSSARY

Badan Perencanaan Pembanguan Nasional (BAPPENAS)	National Planning and Development Board
Badan Perencanaan Pembangunan Daerah (BAPPEDA)	Provincial Planning and Development Board
Badan Koordinasi Penanaman Modal (BKPM)	Investment Coordination Committee
Biro Pusat Statistik	Central Bureau of Statistics
Bupati	Chief of Kabupaten (Regency)
Camat	Chief of a Kecamatan (District)
Departmen Pekerjaan Umum (DPU)	Department of Public Works
Desa	Village
Dinas Kehutanan	Forestry Service
Dinas Pendidikan dan Kebudayaan (PDK)	Education and Culture Service
Dinas Perikanan	Fisheries Service
Dinas Perindustrian	Industries Service
Dinas Perkebunan Rakyat	People's Tree Crops Service
Dinas Pertambangan	Mining Service
Dinas Pertanian Rakyat	People's Agricultural (food crops) Service
Dinas Transmigrasi	Transmigration Service
Directorat Penyelidikan Masaalah Air (DPMA)	Water Resource Research Institute
Kabupaten	Regency
Kantor Sensus dan Statistik	Statistics and Census Office
Kecamatan	District
Kepala Desa	Chief of a village

(to be continued)

Glossary (cont.)

Kepulauan Riau	The regency of Island Riau
Kotamadya	An incorporated city, the same level of government as a regency/kabupaten
Perusahaan Umum Listirik Negara (PLN)	National Power Corporation
P.T. Perkebunan (PTP)	Government Estate Company
Rencana Pembanguna Lima Tahun Ketiga (REPELITA)	Five Year Development Plan
Sumatera Barat	West Sumatra
Unit Pelaksana Proyek (UPP)	Project Execution Unit

CHAPTER 1

BACKGROUND AND SUMMARY OF STUDY

Chapter 1 Background and Summary of Study

1.1 Background

1.1.1 Background of the Project

The Province of Riau is located in the central region of Sumatra, the largest oil producing province in Indonesia with an annual output of approximately 150 million barrels. The province has an extensive land area of 94,562 km^2 in which four major rivers including the Kampar River are found. Despite abundant resources, the economy of Riau is relatively underdeveloped compared with other provinces.

The Government of Indonesia, however, is promoting the Third Five-Year Plan (1979/80 to 1983/84, REPELITA III) in order to improve the quality of living of the general public and to ensure balanced regional development, and is planning to promote a Fourth Five-Year Plan (1984/85 to 1988/89, REPELITA IV) to follow. It is expected, therefore, that regional development, including the strengthening of social infrastructure, an industrial location plan, and transmigration programs in Riau will be accelerated rapidly once such regional development projects are implemented.

On the other hand, power facilities of the Perusahaan Umum Listrik Negara (PLN) in the Province of Riau generated only 18,724 kW as of 1981. The power distribution network is also inadequate, the region having a low electrification rate of only 6.6 percent. The power demand is mainly in urban areas and their vicinity, with the power being supplied by means of independent (captive) diesel engine generators.

PLN power demand in Riau in recent years has shown very high growth rates of 18.0 percent over the eight year period from 1973 to 1981, and 34.0 percent over the two year period from 1979 to 1981, except for Kepulauan Riau. Power demand in the province, therefore, will rise rapidly in the near future according to progress with the Five-Year Plans mentioned in the foregoing and the improvement of the power distribution network as well as development of power sources.

In order to meet increasing power demand, PLN has noted the abundant water resources in the province and is actively engaged in promotion of power project developments such as hydraulic resources and establishment of main transmission network systems. The development of water resources will undoubtedly contribute greatly to the national economy through petroleum conservation on a large scale.

The Kotapanjang Hydro Electric Power Development Project based on this background is regarded as a vital project constituting the core of regional development in the Province of Riau.

The Government of Indonesia, having recognized the necessity and urgency of the Project, requested the Government of Japan to provide technical cooperation for a feasibility study on the Kotapanjang Hydro Elecric Power Development Project in 1981. In response to this request, the Government of Japan appointed the Japan International Cooperation Agency (JICA) as the executing body to implement this feasibility study and decided to send a field investigation mission to Indonesia.

1.1.2 Objectives of Study

The objective of this investigation is to carry out a study of the feasibility level of the Project, including field investigation works and an optimum development plan formulation, and to verify the technical, economic and financial viability of the Project.

1.1.3 Scope of Interim Report

The investigation is scheduled to be carried out, according to the Scope of Work specified in the Feasibility Study for the Kotapanjang Hydro Electric Power Development Project, over three phases, as listed below.

(1) Preliminary Investigation

(2) Detailed Field Investigation

(3) Feasibility Design

This report is a summary of part of the findings obtained through field investigations carried out by the JICA Mission from January 24, 1982, to December 5 of the same year, and homework done on the basis of the above.

1.1.4 Study Activities

The JICA-organized Mission consisting of 13 members, with Mr. Yoshiaki Shimada as leader of the Mission for implemention of the field investigation, was dispatched to Indonesia. The Mission members included experts on civil engineering, hydrology, geology, surveying, electricity and economics.

The survey work was done between January 24 and March 6, and between June 24 and September, 1982, as preliminary investigation work, including reconnaissance and preliminary field investigation. Detailed field investigations were carried out from September to December 5, 1982. The schedule of field investigations is as shown in Fig. 1.1.

First, field reconnaissance was carried out to determine local conditions, and the necessary data and information were collected in joint cooperation with governmental agencies concerned. Further, technical specifications were prepared for the field investigation work, and these were then submitted to PLN.

Actual field investigation work was undertaken by local contractors appointed by PLN, and under the supervision of JICA Mission members. Major investigation works included the following:

Fig. 1.1 Schedule for Field Investigation

Assignment of responsibility	Name	1981/1982 (Jan. – Mar.)	1982 (June – Dec.)
1 Mission leader	Y. Shimada	24 – 6	24 – 31; 5 – 3; 21 – 5
2 Deputy Mission leader (Civil engineer)	S. Yamada	24 – 6	25 – 8; 31 – 5
3 Civil engineer	T. Mimuro	24 – 21	24 – 8; 31 – 5
4 Hydrology, meteorology & water quality	A. Kakita	24 – 21	
5 Hydrology, meteorology & water quality	Y. Yoshida		25 – 5
6 Geology and seimic prospecting and boring	T. Moritani	24 – 6	24 – 3; 31 – 5
7 - Ditto -	K. Nakamata	24 – 21	25 – 5
8 Drilling	S. Makino		25 – 6
9 Aerial photogrammetry	J. Ishii	24 – 21	
10 Topographical surveying	Y. Koike		25 – 21
11 Levelling	S. Shirahama		24 – 21
12 Power demand/supply, transmission & sub-station	T. Murata		5 – 3; 31 – 5
13 Economics	H. Takanashi	24 – 6	5 – 19

(1) Surveying

Topographic survey, cross sectional survey, levelling, control point survey and aerial photogrammetry

(2) Geological Investigation

Drilling, seismic prospecting, test adit excavation, test pit excavaition, grouting and material test

(3) Meteorological and Hydrological Investigation

Installation of a gauging station and rainfall observatories, and water quality analysis

Of the above, control point survey, the aerial photogrammetry, material test and installation of a gauging station were not completed during the investigation periods due to a delay in the initiation of field work. It is decided that this work would be continued under the supervision of PLN staff. For preparation of photogrammetric mapping, an expert from the JICA Mission will be dispatched to Indonesia after completion of the actual aerial photography.

A local office for the JICA Mission and a dormitory were constructed at Bangkinang about 15 km downstream of the prospective Dam site by PLN's Project Region III (Wilayah III). Using this location as a base, field investigation was carried out.

In parallel with the investigation work, a power supply/demand survey, power generation survey, transmission line/sub-station survey, transportation survey, land and compensation survey and socio-economic and environmental survey were carried out.

The process of the field investigation is shown in Table 1.1.

Table 1.1 Process of Field Investigation

Item	1981/1982 Jan.	Feb.	Mar.	1982 Apr	June	July	Aug	Sept.	Oct.	Nov.	Dec.	Remarks
Topographic Investigation												
Field reconnaissance	24	21			24		1					
Ground surveying							2		17		4	
Control point survey									19		5	Under investigation
Photogrammetric mapping												Aerial photography not completed
Geological Investigation												
Field reconnaissance	24	21			24			27		5 24		
Drilling investigation							13			7		
Seismic prospecting								17	30			
Test adit excavation								4	30			
Test pit excavation									23	8		
Grouting test								4	25			
Material test										10	5	Under testing
Meteorological & Hydrological Investigation												
Data collection	24	21				25		8				
Installation of a gauging station									23		5	Under construction
Installation of rainfall observatories									21	5		
Water quality analysis									9	10		
Power Supply/Demand Survey								5	3 31		5	
Power Generation Survey	24	21				25					5	
Transmission Line/Substation Survey									31		5	
Transportation Survey								5	3 31		5	
Land and Compensation Survey						25			19			
Socio-Economic & Environmental Survey	24	6						5	19			
Reports												
Technical specifications		6 16										
Inception report												
Bimonthly reports												
Interim report											6	Under preparation

1.1.5 Executing Organization and Personnel Concerned

The Government of Indonesia appointed the PLN of the Ministry of Mines and Energy as the executing agency for the feasibility study of the Kotapanjang Hydro Electric Power Development Project.

The PLN entrusted the work related to topographic and geological investigation and meteorological/hydrological investigation to local contractors, and sent counterpart staff to the site in order to carry out such investigation under close cooperation with JICA members. The PLN staff engaged in the ivnestigation work are as listed in Table 1.2.

Upon implementation of the investigation, useful information and data were provided by various agencies of the Government of Indonesia.

Table 1.2 PLN Staff Concerned

COUNTERPART TEAM

Chief	:	Drs. C.S. Hutasoit	(KDSR-PLN Pusat)
Deputy Chief	:	Ir. P. Sihombing	(KDPS-PLN Pusat)
Members	:	1. Ir. Soepartomo/ Ir. Ridzaluddiri	(KDSV-LMK)
		2. Drs. Roediyarto BE/ Ir. Ibnu Subroto	(KSPR-PISF&P)
		3. Ir. Udibowo C	(Geologist, DSR-PLN Pusat)
		4. Ir. Widhoyoko	(Electrical Eng. DSR-PLN Pusat)
		5. Ir. Yudi Pagih	(Surveyor Eng. PISF&P)
		6. Ir. Iswardi Yahya	(Electrical Eng. DPS-PLN Pusat)
		7. Drs. Afandi	(Socio Economist DSR-PLN Pusat)
		8. Masni Kamal BE	(Pikitring Sumbar & Riau)
		9. Ma'mur Hafan BSc.	(Geologist, DSV-LMK)
Project Manager	:	Ir. Januar Muin	(Pikitring Sumbar & Riau)
Deputy Project Manager/ Site Manager	:	Ir. Muhadi	(Pikitring Sumbar & Riau)
Resident Engineer	:	Ir. Yusuf Mahadar	(Pikitring Sumbar & Riau)

Supervisor:

- Topographical, Aerial and hydrological Survey	:	1. Drs. C.S. Hutasoit	(KDSR-PLN Pusat)
		2. Ir. Andy Purnama	(DSR-PLN Pusat)
		3. Ruskali BIE	(DSR-PLN Pusat)
- Soil Investigation	:	Didi Sulasdi BSc.	(PISF & P)

Field Supervisor:

- Aerial Survey	:	1. Ir. Basuki Rahardjo N	(DSR-PLN Pusat)
		2. Ir. Hanggoro	(DSV-LMK)
- Topographic Survey	:	Nasli Karsa	(DSV-LMK)
- Hydrological Installation	:	Abdul Rahman	(DSV-LMK)
- Soil Investigation	:	T. Aritonang	(DSV-LMK)

1.2 Summary

(1) Power Supply and Demand

The annual average increase rate in electric power demand over the most recent eight years between 1973 and 1981 under the Wilayah III was as high as 16 percent and the average increase rate in terms of peak load was 19 percent. Of the above, data on the Province of Riau show even higher values, respectively, of 18 percent and 20 percent. The last two years, in particular, showed extremely high increase rates of 34 percent and 29 percent respectively.

Future power demand in Riau is estimated at 403.7 GWh in 1990 and 1,260.2 GWh in 2000 against a value of 45.8 GWh in 1981. The annual growth rate during this period is thus estimated at 19 percent. Peak load, on the other hand, is estimated at 112.4 MW in 1990 and 287.7 MW in 2000, against a value of 12.3 MW in 1981. The average annual growth rate is, therefore, 18 percent.

Prediction of power demand was integrated by classification into four categories, i.e., household use, commercial use, public use and industrial use. In making a prediction, trends of past data, the transmigration policy of the Government of Indonesia, existing private (captive) power generation facilities, PLN distribution network plan and applicants of new industrial factories to be connected to PLN, were taken into account.

The power supply plan was evaluated against such power demand, and it was concluded that it would be necessary to initiate operation of a hydro electric power plant in Kotapanjang by the year of 1989/90.

(2) Topographic and Geological Conditions

The Kampar Kanan is a large river running to the east through central Sumatra Island, and joining the Kampar Kiri River near Langgam.

It then flows into the Straits of Malacca. The Barisan Mountains constituting the source of the Kampar Kanan River form the skeletal structure of Sumatra Island, extending from the northwest to the south-east. The altitude of the mountainous region decreases gradually, showing the topographic features of a peneplain around the reservoir area and proposed Dam site.

The geological structure of the Kampar Kanan River basin consists of sedimentary rocks of pre-tertiary, tertiary quarternary sediment, partially distributed but granite of plutonic rock and young volcanic rocks.

Formation tends to run from the northwest to the southeast in line with the geological structure of Sumatra Island and the mountains also run continuously from the northwest to the southeast, reflecting the geological structure. Rock formed by new volcanic erruptions are distributed along the Barisan Mountains from the northwest to the southeast.

Rock constituting the Dam site is dacite tuff assumed to be of the pre-tertiary. Hard rock can be observed near the riverbed, while thick weathered rock can be seen on the slopes of the mountains.

It is judged that the rock portion from which the upper weathered rock is eliminated can adequately bear the foundation rock of the Dam, according to the findings of geological survey.

(3) Power Development Plan

(a) Study on the Development Method

In formulating the power development plan, a comparative analysis was carried out of a one-dam development plan and a two-dam plan. To be specific, the former plan centered on construction of a 58 m high dam at Kotapanjang while the latter plan called for building a 30.5 m high dam at Kotapanjang and a 38 m high dam at Mahat. In the course of the studies and assessment, the former plan proved to be the more feasible.

(b) Selection of Dam Site and Type of Dam

Three locations - upstream, midstream and downstream - were selected as candidate sites for the Dam site, and comparative study was made at each axis as to the appropriateness of a concrete-gravity-type dam. And studies were made of a fill-type dam at the midstream location from the topographic point of view.

As a result, it was found that it would be best to build a concrete-gravity-type dam at the downstream axis. Comparison of construction costs between a fill-type dam and a concrete-gravity dam revealed that a concrete-gravity dam would be advantageous. Because spillway and diversion work costs in the case of fill-type dam would be substantially higher. This is due to the fact of that precipitation of this basin is heavy and thus a large flood discharge will be caused, resulting in higher costs for construction and the need for flood countermeasrues after completion of the dam.

(c) Determination of Dam Height and Installed Capacity

As for the height of the Dam, water levels of 100 m, 85 m and 76 m for the reservoir were carefully studied.

As a result, it was found that the 85 m of high water level would be the best from the economical point of view. If the high water level exceeds 85 m, social and environmental problems will arise, as the lowest elevation of the Buddhist remains (CANDI) at Muara Takus, upstream on the Kampar Kanan River, are 86.4 m, and the elevation of Pangkalan Kota Baru (population 8,600) upstream on the Mahat River is 87 m; both of these would be inundated. To determine the installed capacity of the plant, maximum discharge was varied to nine different cases and evaluated accordingly. It is considered that maximum discharge of 342 m^3/s and a installed capacity of 111,000 kW would be most optimum, taking account of cost-benefit analysis and load curves in future.

Further detailed studies, however, are scheduled for the issues mentioned in this section.

(4) Power Transmission Line and Sub-station Plan

Approximately 70 km of the transmission line between the switchyard of the Kotapanjang power plant to the Pekanbaru Sub-station (tentative name) was studied for this Project. It was decided that a 150 kV - double circuit transmission line should be installed.

It is also recommended that a transmission network connecting major power demand centers in each Regency (kabpaten) and Pekanbaru should be completed parallel with completion of the Project (1989/90), considering the future power demand trends.

(5) Estimation of Construction Cost

The total construction cost of the proposed Kotapanjang Hydro Electric Power Project is estimated at 176,541 x 10^3 US dollars. This is composed of a foreign currency portion of 93,433 x 10^3 US dollars and a domestic currency portion of 83,108 x 10^3 US dollars. The estimate indicates that the construction cost per kW is 1,590 US dollars, while the construction cost per kWh is 0.33 US dollars. These costs are sufficiently competitive compared with costs of other hydro electric projects in Indonesia.

The preliminary cost-benefit ratio of the Project is calculated at 1.84 from the annual cost and benefit analysis.

(6) Compensation

Houses and land to be submerged due to creation of the reservoir are estimated to be 2,650 houses (about 3,000 families) and cultivated land of approximately 9,000 ha.

For families whose homes are subject to inundation, alternative resettlement sites are selected as close as possible to existing locations within areas under development or areas already under construction.

Relocated routes are proposed. Since the 35 km provincial road would be submerged, the route of such road to be relocated will be determined after consultation with authorities concerned of Indonesia.

Table 1.3 General Features of Kotapanjang Hydro Electric Power Plant

(1)	Reservoir		
	Catchment area		3,337 km^2
	Gross storage capacity		1,250 x 10^6 m^3
	Effective storage capacity		900 x 10^6 m^3
	Surface area		120 km^2
	High water level		85 m
	Low water level		73.5 m
	Effective depth		11.5 m
(2)	Dam		
	Type		Concrete gravity type
	Height		58 m
	Crest length		267 m
	Surface slope	Upstream	1 : 0.15 (fillet)
		Downstream	1 : 0.80
	Dam volume		249,000 m^3
(3)	Spillway		
	Spillway type		Overflow, chute and dentated sill type
	Gate type		Roller gate
	Gate (H x W x Units)		18 m x 12 m x 5 units
	Design flood		9,000 m^3/s (200-year flood)

(to be continued)

Table 1.3 (cont.)

(4) Intake	
Width	13 m x 3
Gate type	Sluice gate
Number of units	3 units
(5) Penstock	
Type	Buried type
Length	77 m
Number of units	3 units
Diameter	5.00 m ∿ 4.18 m
Design discharge	114 m^3/s each penstock
(6) Power House and Tailrace	
Type	Ground type
Length	79.5 m
Width	26.5 m
Tailrace	Open channel type 80 m in length
(7) Generating Equipment	
Turbine	
Type	Vertical shaft Kaplan type
Installed capacity	37,000 kW x 3 units
Effective head	38.7 m
Rated discharge	114 m^3/s/units
Number of revolutions	167 r.p.m.
Generator	
Type	3-phase AC generator

(to be continued)

Table 1.3 (cont.)

Capacity	44,000 kVA x 3 units
Voltage	11 kV
Frequency	50 Hz
Main transformer	
Type	Outdoor 3-phase oil immersed oil natural air forced
Capacity	44,000 kVA x 3 units
Voltage	11/150 kV
(8) Transmission line and Substation	
Transmission line	
Section	Power station to Pekanbaru
Length	70 km
Phase	3-phase system
Voltage	150 kV
Number of circuits	Double
Conductor	ASCR 330 mm^2
Support	Steel tower
Substation	
Location	Pekanbaru
Type	3-phase oil natural transformer with forced air circulation
Capacity	25 MVA x 2
Voltage	150/20 kV

CHAPTER 2

FIELD INVESTIGATION

Chapter 2 Field Investigation

2.1 Outline of Field Investigation

In the first place the Dam axes 1, 2, 3 and 4 were selected in advance on the map, and then the axes 1, 3 and 4 were selected as a result of the field reconnaisance of Kotapanjang was carried out in these three Dam axes. (see to Fig. 2.1)

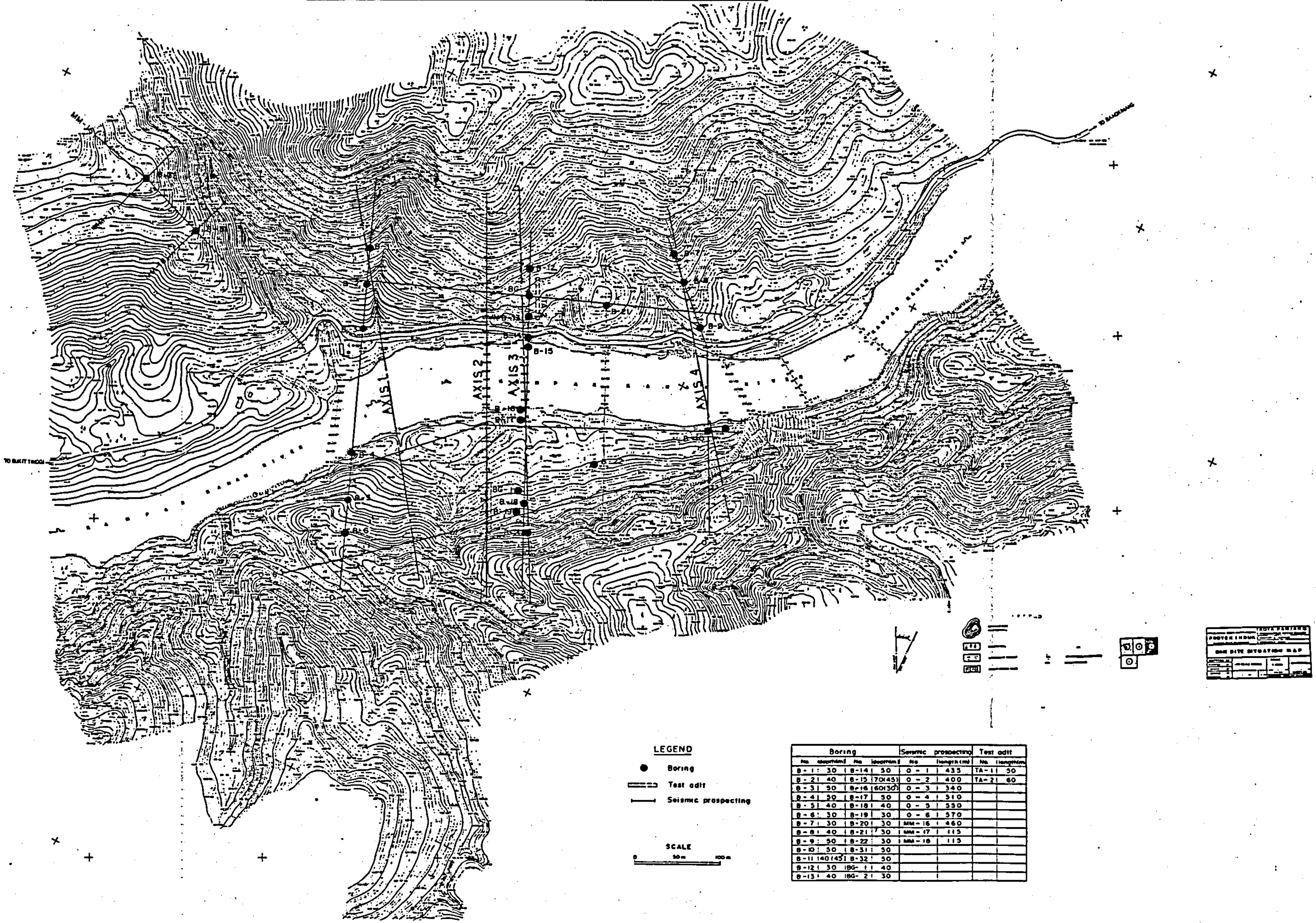
The geological investigation was carried out on the Dam axes 1, 3 and 4 through drilling and other surveys.

The surveying consists of the topographic survey covering the aforesaid Dam axes and the levelling survey along the river. The control point surveying of the reservoir area was also carried out.

The meteorological investigation and the hydrological investigation will be carried out by installing one gauging station and four pluviometric stations in Rantau Berangin located downstream from the Dam and in the drainage basin respectively.

The outline of the various investigation works is described in the followings.

Fig. 2.1 LOCATION OF DAM AXIS



LEGEND

● Boring

Test adit

Seismic prospecting

SCALE

0 50m 100m

Boring				Seismic prospecting		Test adit	
No.	depth(m)	No.	depth(m)	No.	length(m)	No.	length(m)
B-1	30	B-14	50	O-1	435	TA-1	50
B-2	40	B-15	70(45)	O-2	400	TA-2	60
B-3	50	B-16	60(30)	O-3	340		
B-4	50	B-17	50	O-4	310		
B-5	40	B-18	40	O-5	550		
B-6	30	B-19	30	O-6	570		
B-7	30	B-20	30	MM-16	460		
B-8	40	B-21	30	MM-17	115		
B-9	50	B-22	30	MM-18	115		
B-10	50	B-31	50				
B-11	140(45)	B-32	50				
B-12	30	BG-1	40				
B-13	40	BG-2	30				

2.2 Topographic Survey

2.2.1 Objectives of Survey

Of existing topographic maps, there were only maps of 1:250,000 scale prepared in 1944, and maps of 1:100,000 scale prepared in 1946 available at the time of initiation of the survey. Those maps were usable for investigation of the entire basin area, but were inadequate for detailed studies due to the small scale. It was thus decided to take aerial photographs of an area of 2,000 km^2, including the reservoir and its vicinity, so as to prepare a topographic map of 1:10,000 scale for an area of approximately 550 km^2 of the reservoir.

For planning and design of the feasibility study, a topographic map for the area of about 77 ha of the proposed Dam site was prepared to a scale of 1:1,000. For the borrow area and quarry site, it was originally intended to be prepared of a topographic map of 1:1,000 scale only for an area of 6.25 ha of the borrow site at Kuok site. Nevertheless, due to a delay in the aerial photography mentioned above, topographic maps were also prepared for areas in relation to the geological investigation except for Kuok site.

In order to obtain data for planning and design of the Dam, 10 cross sectional lines were surveyed for the river of the Dam site. Further, for study of the power development planning and investigation of necessary compensation for the submerged area levelling survey were performed respectively for 60 km and 55 km upstream of the Mahat River and the Kampar Kanan River.

2.2.2 Surveying

Ground survey work was undertaken by P.T. HEXA KUERA as contracted by the PLN, while the surveying was carried out between August 2 and October 17, 1982. This was followed by the office work in Jakarta completed on December 4 of the same year.

Photogrammetric survey was carried out by P.T. MEGAPLANA under contract to PLN. Ground control point survey was initiated on October 19, 1982 and is being continued as of the end of December, 1982. The photogrammetric survey is therefore not completed as of the end of December, 1982, due to the delay in the aerial photography work.

Equipment used in the surveys is as follows:

(1) Ground Survey

Transits	Wild	T-2
	Nikon	NT-5
	Wild	T-0
Levels	Wild	NA-2
	Nikon	AE
Rangefinders	K.E. Unc	Ronger
	Wild	D13S
	Steel Tapes	
	Esron Tapes	
Plane Table	one set	

(2) Control Point Survey

Transits	Wild	T-2
	Karlzeiss	THEO10A
Rangefinders	Topcon	DMC-2

(1) Field Reconnaissance

Field reconnaissance was carried out twice; from January 24 to February 21 and from June 24 to August 1, 1982.

Clearing of traverse lines for the topographic survey was done for each Dam site and its vicinity and clearing of survey lines was done for the cross sectional survey. Route selection was also carried out for levelling survey. Further, reconnaissance was undertaken on existing triangulation control points for the control point survey and data collected for their locations and elevations.

(2) Ground Survey

(a) Topographic Survey

Surveying was carried out over an area of 6.25 ha of the borrow site as well as an area of 77 ha of the proposed Dam site and respective topographic maps were prepared to a scale of 1:1,000.

For the Dam site, control point marks were established within the range of the topographic map and supplemental traverse points were set by the traverse surveying. Topography was plotted by means of plane table and stadia survey. Concrete marks of 10x10x100 cm were embedded at each control point (see Fig. 2.1). For the borrow site, control point was established on the road and supplemental traverse points were observed by a closed traverse and map was drawn by means of stadia surveying.

(b) Cross Sectional Survey

Cross sectional survey was carried out for 10 sections of the river at the Dam site and the cross sections mapped to a scale of 1:1,000.

Surveying was done up to an elevation of 120 m for both banks of the river for each section and soundings made of the river. itself. Concrete markers of 10x10x100 cm were embedded at each control point (see Fig. 2.2).

(c) Levelling Survey

Levelling survey was performed for a distance of 60 km between Rantan Berangin, about 5 km downstream of the Dam site, and

Pangkalan Kota Baru, located at upperstream on the Mahat River. Levelling survey was also done for a distance of 55 km between Muara Mahat up to triangulation point T.630 upstream on the Kampar Kanan River.

Efforts were made to find existing bench marks but these could not be found so existing triangulation stations T.636, T.368 and T.479 were checked, and T.636 (elevation 141.0 m) was adopted as the control point.

As for the levelling route, an existing road following the river was used. Road kiloposts (of concrete), other firm concrete structures, etc. were also used as temporary bench marks (see Fig. 2.2). At the Dam site, a concrete marker of ϕ 60x100 cm was buried as the bench mark (elevation 55.096 m) for the construction work (see Fig. 2.3).

(3) Photogrammetric Survey

For the photogrammetric works, control point survey is being carried on at present. Using an existing topographic map of 1:100,000 scale, reconnaissance and point selection were carried out, and ground control point necessary for the aerial photography were set by November 10, 1982. Control point survey is being done as a rule by means of closed traverse, and approximately 50 percent of the necessary work was completed as of November 29, 1982. Further, 20x20x80 cm concrete markers were embedded as new control points, and wooden markers planted for traverse points.

2.2.3 Findings of Survey

(1) Topographic Survey

As a result of the survey, the following topographic maps were produced:

Dam site	:	77 ha area (4 maps)
Borrow area	:	6.25 ha area (1 map)
Scale	:	1:1,000
Spacing of contour lines	:	2 m (1 m as called for)
Accuracy in traverse survey	:	Observation error: 40" Double angle difference: 50"

(2) Cross Sectional Survey

As a result of the survey, the following cross sections were obtained:

Location	:	Dam site
Number of cross sections	:	10 sections (5 sheets)
Elevation of river banks	:	120 m
Survey spacing on river bed	:	up to 10 m
Accuracy	:	20 mm $\sqrt{D}$ (D: distance in km)

(3) Levelling Survey

The following longitudinal sections were obtained:

- Along the Mahat River

Extended length	:	60 km
Accuracy	:	30 mm $\sqrt{S}$ (S: distance of one way in km)

- Along the Kampar Kanan River

Extended length	:	55 km
Accuracy	:	30 mm $\sqrt{S}$ (S: distance of one way in km)

Locations and elevations of major bench marks are listed in Table 2.1.

2.3 Geological Investigation

2.3.1 Objectives of Investigation

The objectives of the geological investigation are summarized as follows.

(1) A geological reconnaissance was carried out in the reservoir area, periphery of the dam, quarry and borrow site aiming to grasp the topographical and geological aspects and at preparing the field investigation plan.

(2) Drilling survey was carried out at the Dam site, quarry and borrow site.

(3) Test adits were excavated at the Dam site aiming at a direct visual observation of the geological characteristics.

(4) Cement milk was injected aiming at identifying the state of the foundation bedrock of the Dam, and grouting tests were carried out aiming at obtaining the data for design of the Dam.

(5) Seismic prospecting was carried out aiming at identifying the geological aspects of the Dam site and quarry.

(6) Permeability tests were carried out in the drilling holes located on the Dam axis to know the coefficient of permeability.

(7) Test pits were excavated, aiming at identifying the state of amount of gravel and sand in the borrow site.

(8) Samples of rock was submitted to material tests in the laboratory.

2.3.2. Investigation Work

Geological investigation was carried out by P.T. WIRATMAN under contract to PLN and field work was carried out between August 13 and November 8, 1982. Material tests started from November 10, and the work is still being continued in Jakarta as of the end of December, 1982. Analysis of results of seismic prospecting is also underway in Bandung, as of the end of December, 1982.

Items covered by the investigation were as follows:

(1) Topography, geology and collapsed lands in the reservoir area

(2) Distribution of mineral resources and mining rights in the reservoir area

(3) Geological reconnaissance around the Dam site

(4) Investigation of aggregates (quarry site and borrow site) as construction materials.

Survey volumes by item are listed in Table 2.2.

Table 2.2a LIST OF GEOLOGICAL SURVEY

LOCATION		No.	DRILLING (m)	WATER PRESSURE TEST (Times)	SAMPLING (Pieces)	GROUTING TEST (Times)	TEST ADIT EXCAVATING (m)	TEST PIT EXCAVATING (m)	SEISMIC PROSPECTING (m)
DAM SITE	AXIS-1	B- 1	30	5	2				
		2	40	6	2				
		3	50	9	2				
		4	50	9	2				
		5	40	7	2				
		6	30	5					
	AXIS-4	7	30	5					
		8	40	7					
		9	50	9	2				
		10	50	9	2				
		11	(45°) 40	12	2				
	AXIS-3	12	30	4	1				
		13	40	7	2				
		14	50	9	2				
		15	(45°) 70	13	2				
		16	(30°) 60	10	2				
		17	50	9	2				
		18	40	8	2				
		19	30	5	1				
		20	30	5	1				
	POWER HOUSE	21	30		1				
		22	30		2				
	RIGHT BANK	BG-1A	40			7			
		B	40			7			
		C	40			7			
		D	40	7		7			
		E	40			7			
		F	40	7					
	LEFT BANK	BG-2A	30		2	5			
		B	30			5			
		C	30			5			
		D	30	5		5			
		E	30			5			
		F	30	5					
	RIGHT BANK	TA-1			3		60		
	LEFT BANK	2			3		50		
	AXIS-1	O-1							435
	3	2							400
	4	3							340
	LEFT BK	4							510
	RIGHT BK	5							550
	"	6							570
SUB TOTAL			1330	177	42	60	110		2805

LOCATION		No.	DRILLING (m)	WATER PRESSURE TEST (Times)	SAMPLING (Pieces)	GROUTING TEST (Times)	TEST ADIT EXCAVATING (m)	TEST PIT EXCAVATING (m)	SEISMIC PROSPECTING (m)
QUARRY SITE	QR-Ⅱ	B-23							
		24	25						
		25	30.5						
		MS-7							330
		8							
		9							
		10							
		11							210
	QR-Ⅲ	B-26	40						
		27	40		1				
		28	60		2				
		MN-12							220
		13							220
		14							220
		15							165
	QR-Ⅳ	B-31	50		3				
		32	50		2				
		MM-16							460
		17							115
		18							115
	QR-Ⅰ	B-33	24.5		2				
BORROW SITE	MUARA MAHAT	B-29	15						
		TP-1			1			3	
	NEW M. MAHAT	B-30	5						
		TP-2			1			3	
		3			1			3	
	PULAU GADANG								
		TP-4			1			2.6	
	KUOK								
		TP-5			1			3	
		6			1			3	
RESERVOIR		Ka-1			2				
		Kl-1			1				
		Q-1			1				
SUB TOTAL			340		19			17.6	2055
TOTAL			1670	177	62	60	110	17.6	4860

Table 2.2.b List of Material Test

A. For Sand Gravel:		
a. Specific gravity and absorption		6 pieces
b. Natural water content		6 "
c. Gradation analysis		6 "
d. Compaction test or relative density		6 "
e. Permeability test		6 "
	Total	30 pieces
B. For Drilling Core and Rock Sample:		
a. Unconfined compression test		81 pieces
b. Specific gravity and absorption		81 "
c. Natural water content		81 "
d. Tension test		81 "
e. Shearing test		81 "
f. Elasticity coefficient test		81 "
	Total	486 pieces
C. Microscopic Check:		5 sheets

(1) Geological Reconnaissance

The geological reconnaissance was carried mainly on foot, and outcrops along the Kampar Kanan River and the Mahat River were investigated by boat.

(2) Drilling

Rotary boring machines (small type with capability of 150 to 200 m depth) were employed for boring investigation. Although vertical boring was applied to most areas, inclined boring was also applied for some areas with inclination angles of 45° and 30°. The latter was aimed to grasp the geology under the riverside and river bed. The following locations were selected in advance at the Dam site for boring based on the topography: the Dam axis, the powerhouse site and four quarry sites. In addition, shallow boring was carried out at two borrow sites. The range of boring depths was between 15 and 70 m, and the number of boring holes was 22 for the Dam site, totalling 910 m in length, and 10 holes and 340 m in length for the quarry site.

(3) Test Adit Excavation

Test adit excavation was implemented on both banks near Dam axis 3 in order to observe the bedrock directly. The standard dimensions were 1.8 m height, 1.8 m width in a horizontal adit at the bottom, being 60 m in length for the right bank and 50 m in length on the left bank. Air picks and dynamite were used for the excavation.

(4) Grouting Test

Grouting tests were aimed at obtaining basic data for consolidation grouting and curtain grouting, execution of which will be necessary for dam foundation improvement. One location each for the right and left banks on Dam axis 3 was selected for grouting tests. Measured values are being analyzed at present. The depth of test grouting was 40 m for six holes on the right bank, and 30 m for six holes on the left bank.

(5) Seismic Prospecting

For seismic prospecting, a 24-component refractive wave explorator for civil engineering was used, with dynamite being employed as the seismic source. The prospecting covered to a total length of

4,860 m and 15 measuring lines consisting of a length of 2,805 m in 6 measuring lines at the Dam site and a length of 2,055 m in 9 measuring lines at 3 locations at the quarry site. Analysis of the measured values is underway at present.

(6) Permeability Test

Permeability test was carried out in order to grasp the numerical values of permeability so that necessary fundamental data would be available for establishment of the implementation program for curtain grouting. Although so-called "Lugeon Test" had been generally employed in the past, an alternative method was applied to directly obtain the coefficient of permeability (k), since the "Lugeon Value" tends to be a vague value in terms of underground water. Holes subject to bore testing numbered 20 on the Dam axis. An outline of the method is as follows: while boring from the ground surface, the permeability test was carried out simultaneously at 5 m inervals (top 5 m not subject to test). To be more specific, a single packer was placed at a point 5 m above the bottom of the hole and fresh water of a given quantity was charged to the bottom of the hole. The filling rate per unit time was reduced as time passed by, with the rate becoming constant after a certain period of time. The permeability coefficient (k) was calculated by the filling pressure and filling rate at that time.

(7) Test Pit Excavation

Test pit excavation was carried out at four borrow sites in order to grasp the quantities of sand and gravel. Although it was originally planned that a vertical pit of 3 m depth be excavated for confirmation of the strata order, and to sample materials for laboratory testing, vertical drilling became difficult since the full water season had arrived during the investigation and the level of underground water had increased. Drilling was therefore done by means of rotary boring equipment and the necessary number of test samples taken.

(8) Material Tests

Material tests were done in order to determine dynamic characteristics of the dam foundation rock and the appropriateness of the materials as aggregates.

2.3.3 Findings of Investigation

(1) Geology of Project Area

The area around the proposed Dam site shows topographic conditions of peneplain. Banks of the Dam site are gently sloped at approximately 20° to 30° and the gradient of the river is about 1:1,100, with a gentle flow.

The proposed Dam site is selected at a point of relatively narrow valley width (river bed width 50 to 60 m).

Dam axis 1 is located at the uppermost point in the Project area. It has a mean slope gradient of 25° for the left and right banks. A large creak cuts into the immediate upstream of the left bank ridge, and creeks also cut into the upstream and downstream of the Dam axis on the left bank ridge, showing a thin ridge shape.

Dam axis 3 is located 150 m downstream of axis 1, and has a mean slope gradient of 28° for the right bank and 38° for the left bank.

Dam axis 4 is located 200 m downstream of Dam axis 3 and has an average slope gradient of 50° for the right bank and 25° for the left bank. The left bank also shows a thin ridged shape, with creeks cutting into the immediate upstream and downstream. The right bank, on the other hand, is of steep gradient and a nearly vertical rock board slope continues downstream. Of the three Dam axes, Dam axis 4 has the narrowest valley width.

The geological classification of the Kampar Kanan River basin is shown in Table 2.3, based on the geological map "Pekanbaru Quadrangle (scale: 1:25,000)" (not published yet) prepared by the Geological Survey Institute of Indonesia (see Fig. 2.5).

Table 2.3 Stratigraphy of Project Site

Geological Age		Formation	Lithofacies
Cenozoic	Quaternary	Alluvium	Gravel, sand, clay and tuffaceous clay
		Terrace Deposits	Mainly fine sand containing clay and gravel
	Tertiary	Telisa Formation	Grey calcareous mudstone, containing thin limestone, siltstone, minor glauconitic sandstone
		Sihapas Formation	Conglomerate, fine sandstone, siltstone with quartz pebble often reddish color
Palaeozoic	Carboniferous	Bohorok Formation	Tuff and tuffaceous shale with thin conglomerate
		Kuantan Formation	Wack, conglomeratic wack and turbidite, phyllite, shale, muscovite schist, alternation of sandstone and siltstone

As for geology around the Dam site, it consists of dacitic tuff, assumed to be of Bohorok formation in the Palaeozonic Cargonferoud Age. Along the river bed and the left bank road, extended hard rock outcrops are observed while the distribution of outcrops is less on the mountain side due to the thick weathered stratum. Although cavities of various sizes are distributed in the outcrops along the river, these are attributed to washing away of weak stratum on the ground surface by river erosion. It is therefore assumed that similar cavities are not found underground.

The surface soil is of 20 to 50 cm in depth, and talus material is distributed over the slopes of the mountain. The river bed shape is concave due to the gentle flow and well selected round gravel and sand are deposited over the bed to a thickness of 2 to 3 m thickness. On both banks of the river, low level terrace, mainly made of fine sand carried over by periodic flooding are distributed over a limited area.

(2) Dam Site

(a) Test Adit

Test adits were excavated on the left and right banks near Dam axis 3, as shown in Fig. 2.1. Elevations and lengths of test adits are as listed below. They are located about midpoint of the Dam height and approximately 25 m down from the crest.

No.	Length (m)	Elevation (m)
TA-1 (Right bank)	60	62.4
TA-2 (Left bank)	50	66.8

Quality classification of foundation rock was made according to the classification criteria listed in Table 2.4.

Results of the test adit are shown in Fig. 2.6, and the observation record of the test adit is summarized below.

(i) TA-1 (Right Bank)

Talus consisting of clay and rock is distributed from the test adit mouth to 13 m depth, followed by dacitic tuff. C_L class foundation rock slightly soft and D class rock in some portions lie from the test adit mouth to approximately 23 m depth. Foundation rock below 23 m depth consists of C_M class rock, however, seam being distributed in small proportions. C_M class is comparatively hard foundation rock.

(ii) TA-2 (Left Bank)

Every test adit consisted of dacitic tuff. D class foundation rock which is highly weathered was found from the test adit mouth to approximately 18 m depth, followed by irregular slightly weathered C_L class and comparatively hard C_M class foundation rock. Yet, seam is partially distributed.

(b) Drilling

Drilling was executed at the locations shown in Fig. 2.1. Geological sections of the Dam axes prepared by the drilling investigation and test adit are shown in Figs. 2.7, 2.8 and 2.9.

In each Dam axis, weathered stratum is distributed, with the thickness tending to increase as the elevation increases. Sedimentation is assumed to be distributed to a thickness of 2 to 4 m at each Dam axis.

Mean depths of classified foundation rock from the surface identified by the boring investigation are shown in Table 2.5.

Table 2.5 List of Depths by Classification of Foundation Rock

(unit: m)

		Left Bank			Center of River Bed	Right Bank		
		Near Crest	Near Mid-point	Near Bottom		Near Crest	Near Mid-point	Near Bottom
Dam Axis 1	C_L	10	7	-	-	18	14	7
	C_M	18	18	6	3	24	18	10
	C_H	25	26	22	8	28	23	20
Dam Axis 3	C_L	18	7	2	-	10	10	5
	C_M	25	14	5	4	15	14	10
	C_H	27	38	22	7	45	42	14
Dam Axis 4	C_L	8	10	-	-	-	6	4
	C_M	28	15	7	2	15	15	9
	C_H	50	34	23	11	42	28	18

(c) Tentative Evaluation of Investigation

Evaluation of foundation rock by respective class as dam foundation is as follows.

D class foundation rock which is highly weathered is of soil or clay and none of the original rock structure remains. This rock is excavated thus inappropriate as dam foundation and should be excavated completely.

C_L class foundation rock is slightly soft with closely developed cracks. It may be used as the foundation for the top portion of the Dam where less resistance to large load is needed if adequate foundation improvement is provided.

C_M class foundation rock, which is comparatively hard, is softened in some parts and slightly cracked. It is composed mainly of fresh and tight rock, and is suitable with treatment for a 60 m high class concrete-gravity and a rock-fill dam.

C_H class foundation rock, which is fairly hard, consists of generally fresh, hard and tight rock and is appropriate for dam foundation.

Comparison of geological conditions at each Dam axis reveals no significant or clear differences except for the right bank of Dam axis 1, the left bank of Dam axis 3 and the left bank of Dam axis 4 which have more deeperly weathered rock (D class and C_L class).

It will be necessary to carry out detailed investigation after making an overall evaluation by adding results of the analysis of the seismic prospecting.

(3) Aggregate

(a) Quarry Sites

Quarry sites for dam aggragates are the four locations shown in Fig. 2.10. Findings of the boring and shaft investigation are as follows:

(i) QR-I Site

The QR-I site is located approximately 9 km upstream of the Dam site. The investigation location and geological records are shown in Fig. 2.11.

Foundation rocks are of hard sandstone assumed to be falling under the Kuantan formation of the pataeozonic era. Outcrop observed on the right and left banks of the Kampar Kanan River show progressed weathering conditions and may be crushed easily by hammer, while the deep portions are of hard rock blocks.

It was confirmed by the boring investigation results that fresh and hard foundation rock is present under the completely weathered beds of siltstone and sandstone of the Sihapas Formation at a bed depth of 10 m from the surface. It was judged that the quality of the hard sandstone was appropriate for concrete aggragate use.

This Kuantan Formation is assumed to be distributed extensively around the QR-I site as a lower stratum of Shihapas Formation, as shown in the geological map in Fig. 2.5.

(ii) QR-II Site

The QR-II site is located on the left bank of the Kampar Kanan River and about 7 km upstream of the proposed Dam site. The location map and geological section records are shown in Fig. 2.12.

The investigation location corresponds to the boundary between shale that it is assumed belongs to the Palaeozonic Bohorok Formation and granite, and the outcrops along the road consist of soil and clay.

Boring was carried out in the shale distributed area and it was judged inappropriate as a quarry site since highly weathered rock (D class) was distributed to a depth of 30 m and hard granite distribution could not be expected.

(iii) QR-III Site

The QR-III site is a mountainous location on the right bank of the Kampar Kanan River, approximately 1.7 km upstream of the Dam site. The location map and geological section records are shown in Fig. 2.13.

The QR-III site, as in the case of the Dam site, is composed of dacitic tuff assumed to belong to the Bohorok Formation. The outcrops along the river bank are composed of hard rock but it was judged inappropriate as a quarry site since it was found that highly weathered rock (D class) was distributed to a depth of 30 m.

(iv) QR-IV Site

The QR-IV site is a mountain with a geographically favorable location on the left bank of the Kampar Kanan River. It is at immediate upstream of the Dam site. The location map and geological section records are shown in Fig. 2.14.

The QR-IV site, similar to the Dam site condition, is composed of dacitic. The boring results indicate that C_L class bedrock is distributed to a depth of 30 m or so, though D class layer is relatively thin at 5 m. It cannot be said, therefore, that the geological conditions are favorable. On the other hand, however, outcrops of hard rock are continuously observed along the creek downstream of the QR-IV site and the transport distance is relatively short. Taking into account the above mentioned favorable conditions, it is desirable to evaluate the appropriateness of this site as a quarry, by incorporating the results of the seismic prospecting and material tests.

(b) Borrow Site

Boring and test pit investigations were carried out at the four locations shown in Fig. 2.15 in order to assess these as borrow sites for Dam aggregates.

It was commonly found at all sites that sand and gravel were mixed in nearly uniform quantities. Gravel is hard and round with an approximate size to a fist in which sandstone, andesite and chart are mixed. The sand is mainly fine grained.

The layer thickness exceeds 3 m at every site, and all being are judged to be appropriate as borrow sites.

(c) Tentative Evaluation of Investigation

Of the materials found in the area covered by this investigation, those ones produced in the QR-I quarry and in the four borrow sites seem to present satisfactory quality as concrete aggregates.

As for the material produced at the QR-IV quarry, there are some problems related to its quality, but a further detailed investigation is required in view of its proximity to the Dam site.

The final conclusion shall be drawn after carrying out detailed aggregate tests and concrete tests, because the aforesaid QR-I quarry and borrow sites are presumed to have sufficient capacity.

2.4 Meteorological and Hydrological Investigation

2.4.1 Objectives of Investigation

Objectives of the investigation may be summarized as follows:

(1) Field reconnaissance in order to grasp present meteorological and hydrological conditions in the Kampar Kanan basin

(2) Collection of existing data on rainfall, meteorological conditions, discharge, sedimentation, etc. necessary for hydrological analysis

(3) Selection of location and installation of new rainfall observatories and a gauging station in the basin

(4) Water quality analysis and measurement of sedimentation, and guidances thereof

(5) Discharge observations to establish the rating curve of the new gauging station, and guidances thereof

2.4.2 Investigation Work

Investigation work was done during the two phases of the preliminary field investigation (January - March, and July - September) and detailed field investigation (September - December) in 1982 with the cooperation of PLN staff concerned.

Installation work for the new rainfall observatories and a gauging station was done by P.T. HEXA KUERA under contract to the PLN.

(1) Field Reconnaissance

Field reconnaissance was carried out in order to grasp the present character of rivers in the Kampar Kanan River basin and existing rainfall and weather observatories and gauging stations.

(2) Collection of Meteorological and Hydrological Data

Necessary data for hydrological analysis were collected from concerned organizations in the Province of Riau, Bandung and Jakarta. Organizations giving cooperation were as follows:

1) Provincial Public Works (P.U. Riau)
2) Public Works (P.U. Jakarta)
3) Directorat Penyelidikan Masalah Air (DPMA), Bandung
4) Meteorologi Dam Geofisika (BMG), Jakarta

(3) Installation of Rainfall Observatories and a Gauging Station

Locations of rainfall observatories and a gauging station were studied on map and the final selection was made based on field reconnaissance findings.

(4) Sampling and Analysis of Data

The sampling location for water quality analysis and measurement of suspended sediments was chosen at the new station located at Rantau Berangin. Sampling was done at low water level, mean water level and at flood. The highest water level observed during the investigation period was 2.5 m (discharge 500 m^3/s) at the tentative staff-guage.

Analysis and measurements were performed by the JICA Mission with the cooperation of the PLN staff at the Bankinang Office.

(5) Discharge Gauging

Discharge gauging was done 40 times at Rantau Beragin Gauging Station, for a water level range of 0.67 m to 2.35 m. For verification of the discharge curve obtained at the said gauging station, gaugings were carried out twice at the Danau Bingkang Gauging Station located downstream of the Rantau Beragin Gauging Station and once at the Lubuk Sipopay Gauging Station of the Mahat River.

Discharge gauging was also carried out downstream of Dam axis 4 in order to calculate tailrace water level and design water level.

2.4.3 Findings of Investigation

(1) Field Reconnaissance

As a result of the field reconnaissance, location of each observatory for meteorological conditions, rainfall and discharge was shown in Table 2.6 and Fig. 2.16. All of four gauging stations are automatic water level recording types, out of which three stations owned by the PLN are controlled by DPMA under contract. Discharge is observed four times per year in the latter stations. After completion of the proposed Kotapanjang Dam, existing Lubuk Sipopay Gauging Station and two rainfall observatories of Tanjung Pauh and Batu Bersurat will be submerged in the reservoir.

(2) Collection of Meteorological and Hydrological Data

Rainfall data have been collected since 1900, but there have been many periods without observation. Discharge data are available only for the most recent five year period. Since data are not necessarily adequate to carry out hydrological analysis, additional data have been collected extensively for the basin in order to supplement existing information.

Table 2.6 Existing Hydrological Stations in the Drainage Basin

Station	Name of River	No.	Name of Station	Location	Owner
Weather Station	Kampar Kanan	DPMA/1	Pasar Kampar	0 21' N 101 50' E	DPMA
Precipitation Station	Do	DPMA/1	Pasar Kampar	0 21' N 101 50' E	DPMA
	Do	58	Bangkinang	0 18' N 100 55' E	BMG
	Mahat	57b	Tanjung Pauh		Do
	Do	28	Tanjung Barik		Do
	Do	57	Pangkalan Kota Baru		Do
	Kampar Kanan	58d	Batu Bursurat		Do
	Mahat	57c	Muara Paiti		Do
Gauging Station	Kampar Kanan	3	Danau Bingkang		DPMA
	Mahat	10	Lubuk Sipopay		DPMA
	Kampay Kanan	11	Muara Paiti		DPMA
	Do	12	Tanjung		PLN

Emphasis was placed mainly on collection of daily rainfall and discharge data and other meteorological data such temperatures, humidity and evaporation rates. Data for hydrographs and suspended sediment were also collected (see Fig. 2.16).

(3) Installation of Rainfall Observatories and a Gauging Station

In the field reconnaissance work done from January to March, 1982, the JICA Mission proposed installation of new rainfall observatories and a gauging station and prepared technical specifications after studying prospective locations by map and field survey. Locations of these new installations are as follows:

		Basin	Location
Rainfall observatories	:	Kampar Kanan River	Korugohru
			Tanjung
			Rantau Berangin
		Mahat River	Kenon Bintang
Gauging station	:	Kampar Kanan River	Rantau Berangin

Installation of rainfall observatories was begun in late October, 1982, and four were completed by early November. For the gauging station, on the other hand, construction was substantially delayed because of a delay in starting of the construction work and flood in the rainy season, etc. It is now being continued under the supervision of the PLN. The location of the station is shown in Fig. 2.17.

Equipment for rainfall observatories and the gauging station are all of the automatic recording type (one month roll). Specifications of the equipment are as follows:

Instrument	Type	Manufacturer	Remark
Rain gauge	Automatic recording	THIES	One-month roll
Water level gauge	Automatic float-type	A. OTT	One-month roll

(4) Water Sampling and Analysis

For suspended sediment in the Kampar Kanan River, some data were provided by DPMA, while data on the water quality are being analyzed at present by Bangkinang Water Supply Station. Final data have not yet been obtained.

During the reconnaissance period, water quality samplings were done twice and sediment samplings eight times by the JICA Mission for analysis and measurement. The results are shown in Tables 2.7 and 2.8. Since the maximum discharge observed during the investigation period was 467 m^3/s, it will be necessary to make further observations continously. For suspended sediment, on the other hand, meetings were held and guidance given to the PLN staff so that they would be able to continue this investigation.

Judging from field investigation, the Kampar Kanan River is of a mildly acidic nature with a slightly high ion phosphate content. Some ions that may be harmful to human beings are found in traces in the water. No adverse effects on residents along the river caused by the water appear evident at present, however.

(5) Discharge Observation

In order to determine the rating curve at the newly established Rantau Berngin Gauging Station, 40 discharge observations were carried out. Further, to verify rating curves at the Danau Bingkang Gauging Station and the Lubuk Sipopay Gauging Station, actual measurements were undertaken once for the former and twice for the latter. Moreover, actual measurements were repeated 14 times downstream of Dam axis 4 in order to calculate the tailrace water level and design water level.

For rating curves, continuous observations are required since the discharge may vary between low and mean water levels. Therefore, meetings were held with the PLN staff to provide necessary guidance for further observations.

Discharge observations at the Rantau Berangin Gauging Station were done for water levels ranges between 0.67 m and 2.35 m, and discharges of 92.98 m^3/s and 438.60 m^3/s to establish a rating curve equation. As a result, the following equation was obtained:

$$Q = 62.885 H^2 + 67.659 H + 18.199$$

(see Table 2.9 and Fig. 2.18)

The equation for the present rating curve at Danau Bingkang may be expressed as follows, according to current gauging results:

$$Q = 26.306 H^2 + 131.985 H + 12.164$$

Since this equation appears to be more appropriate than the previous one, it should be used in place of the old equation (see Table 2.10 and Fig. 2.19).

According to current gauging results, the existing equation may be used for the rating curve of the Lubuk Sipopay Gauging Station (see Table 2.11 and Fig. 2.20).

According to results of gauging at downstream of Dam axis 4, the following rating curve equation was obtained.

$$Q = -0.333 H^2 + 171.000 H - 102.667$$

Nevertheless, this equation should be applied up to a water level of 4.00 m only (see Table 2.12 and Fig. 2.21).

CHAPTER 3

ELECTRIC POWER SUPPLY AND DEMAND

Chapter 3 Electric Power Supply and Demand

Electric power demand was predicted on the basis of the past data and information trends provided by PLN, existing industries to be connected to PLN network, and new industries, and transmigration policy of the Government of Indonesia. The demand forecast revealed that power demand in the Province of Riau will be 1,260 GWh by the year of 2000, and the peak load will be 288 MW, with an average annual increase rates of 19 percent in terms of power demand and 18 percent in terms of peak load (see Fig. 3.1 and Table 3.1).

As shown in Fig. 3.1 and Table 3.1, it would be necessary to complete the Kotapanjang Hydro Electric Power Project by 1989/90.

Upon completion of the proposed Kotapanjang Hydro Electric Power Development Project, the Hydro Electric Station would constitute the major supply power source, while the use of the existing old diesel generators would be terminated, the relatively new diesel generator would be used as base supply sources, and the other generators would work as stand-by sources.

Fig.3.1 Peak Load Forecast in Riau (excluding Kepulauan Riau)

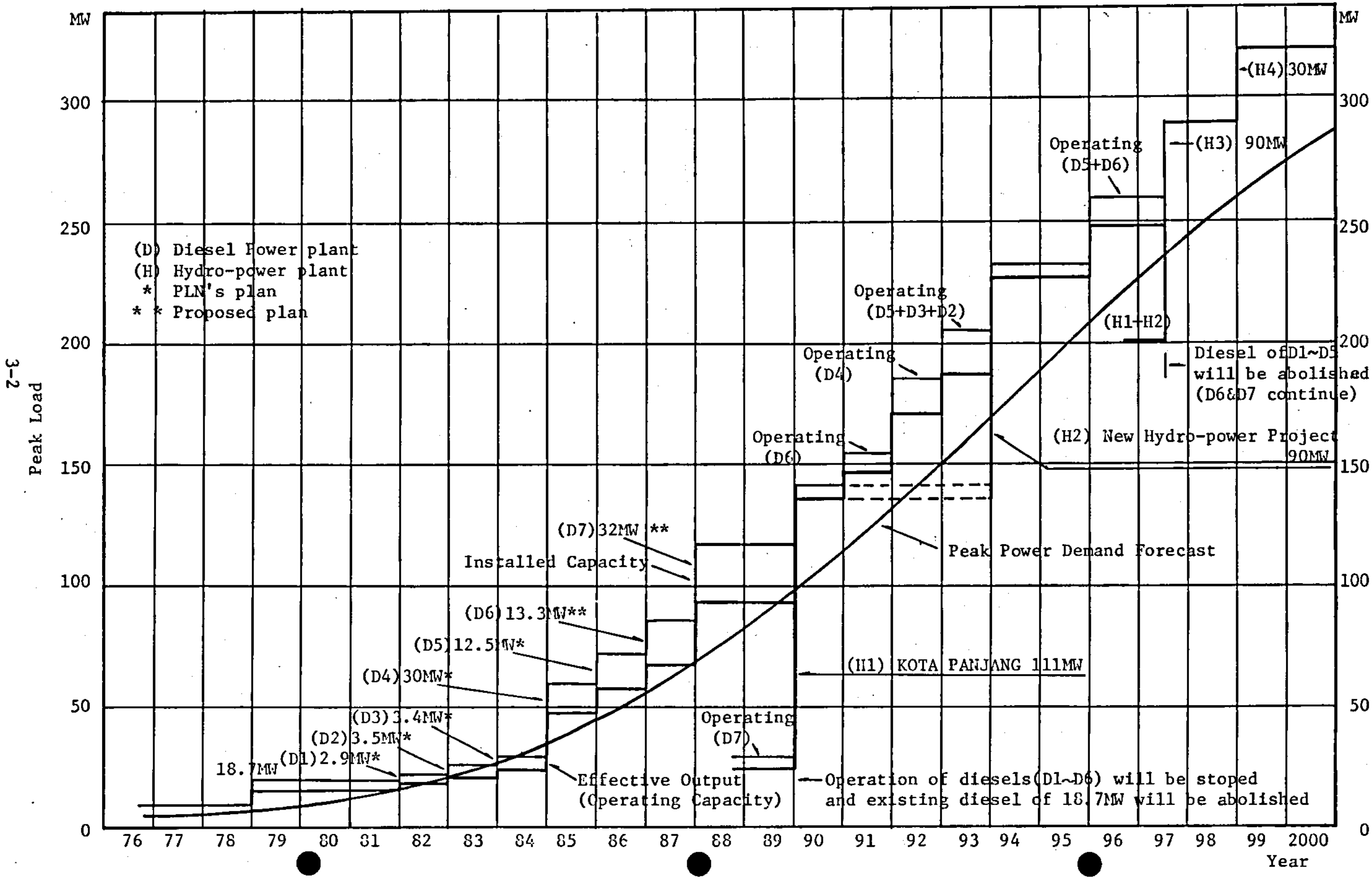


Table 3.1 Power Demand Forecast in Riau Province
(excluding Kepulauan Riau Regency)

Item / Year	1981	1990	2000	Annual growth average rate
Power demand (GWh)	45.8	403.7	1260.2	19 %
Residential (GWh)	25.5	122.8	358.2	15 %
Commercial (GWh)	7.7	39.6	158.4	17 %
Public (GWh)	7.2	34.4	98.7	15 %
Industry (GWh)	5.4	206.9	644.9	29 %
Peak load (MW)	12.3	112.4	287.7	18 %
Generated energy (GWh)	58.7	492.3	1482.6	19 %

3.1 Present Power Supply Facilities

The total installed capacity of power generation in Riau as of the end of 1981 was 18,724 kW, with a peak load of 12,351 kW (see Table 3.2). Other than those of PLN facilities, there are more than 60 private power generating facilities in operation, providing a total of 279,162 kVA or approximately 223 MW. (see Table 3.3)

In the Province of West Sumatra, on the other hand, total installed capacity is 40,896 kW, with a peak load of 23,992 kW (see Table 3.4). More than 50 captive power facilities are in operation in addition to PLN facilities, which amount to 39,154 kW or approximately 31 MW. (see Table 3.5)

It is a common feature found between the two provinces that each PLN facility is supplying power in its vicinity only, being independent of every other, and that major power users are providing necessary energy themselves using their own power generating facilities.

3.2 Past Power Supply and Demand

The actual data on supply/demand over the past nine years are shown in Tables 3.6 and 3.7.

According to the data, the average annual growth rate of power demand in Wilayah III, excluding Kepulauan Riau, was about 16 percent and the average annual growth rate of peak load was approximately 19 percent (excluding Kepulauan Riau).

3.3 Power Demand Forecast

Prediction of power demand was carried out for the Province of Riau. In so doing, power demand was classified into four categories, namely residential use, commercial use, public use and industrial use and the results of forecasting were integrated and shown in Table 3.1 and Fig. 3.1.

Basic conditions for power demand forecast were as follows:

Population in Riau is 2,233,700 as of the end of 1981.

Future population growth rate is estimated at 4.1 percent.

Number of family members per household is assumed 5.

Target by PLN electrification rate :

	Urban Area	Rural Area
1983/84	50 %	7 %
1988/89	60 %	13 %
1993/94	65 %	20 %
1998/99	70 %	30 %
2003/04	75 %	40 %

Indonesian Government transmigration plan :

1982/83	7,925 families
1983/84	22,500 "
1984/85 ~ 1988/89	70,000 "
1989/90 ~ 1993/94	80,000 "

Target level of annual power consumption per household (kWh) :

	Urban Area	Rural Area
1983	1,500 kWh	700 kWh
1988	1,800 "	800 "
1993	2,000 "	950 "
1998	2,500 "	1,000 "
2003	3,000 "	1,200 "

Power demand by each category is estimated in the manner described below.

(1) Residential use

Assuming that annual power consumption per household is 1,220 kWh for urban area and 750 kWh for rural area, and the annual average growth rate based on PLN target is estimated as 2.6 percent for urban area and 1.8 percent for rural area.

From the foregoing, the power demand for the residential use is estimated as follows:

Year	1981	1990	2000
Urban Area	19.7 GWh	59.9 GWh	121.4 GWh
Rural Area	5.8 "	62.9 "	237.8 "
Total	25.5 GWh	122.8 GWh	358.2 GWh

(2) Commercial use

The annual power consumption per commercial customer is estimated at 2,590 kWh for urban area and 1,090 kWh for rural area, and the annual average growth rate of consumption per customer would be 7.5 percent for urban area and 7.0 percent for rural area.

From the foregoing, the power demand for the commercial use is estimated as follows:

Year	1981	1990	2000
Urban Area	6.1 GWh	27.7 GWh	87.0 GWh
Rural Area	1.6 "	11.9 "	71.4 "
Total	7.7 GWh	39.6 GWh	158.4 GWh

(3) Public use

The annual power consumption per public customer is estimated at 9,940 kWh for urban area and 2,990 kWh for rural area, and the annual average growth rate of cosumption per customer is estimated likewise at 7.8 percent for urban area and 3.0 percent for rural area.

From the foregoing, public demand wil be as follows:

Year	1981	1990	2000
Urban Area	5.8 GWh	26.6 GWh	85.9 GWh
Rural Area	1.4 "	7.8 "	12.8 "
Total	7.2 GWh	34.4 GWh	98.7 GWh

(4) Industrial use

Power demand for industrial use is classified into following three sub-categories.

(a) Customer A: Existing factories under contract with PLN for electric supply

Total number : 15
Total contracted capacity : 2,263.5 kVA

(b) Customer B: Those with captive power facilities: in future, however, they will receive power from PLN.

Total number : 50

Total installed capacity : 86,725 kVA

(c) Customer C: New industrial customers under the new projects provided by the following organizations.

- BKPM (Investment Committee)
  Those applying for establishment of new factories

- PLN
  Those applying for power supply contracts.

- Perkebunan (Agricultural Plantation)
  Those under the Plantation Projects (palm, coconut, rubber, etc.)

- Kahutanan (Forestry Bureau)
  Those intending to establish factories for foresty related products (timber, plywood, etc.)

Power demand for the aforementioned is summarized below.

Year	1981	1990	2000
Industrial Customer A	5.4 GWh	5.4 GWh	5.4 GWh
Industrial Customer B	-	1.7 "	190.1 "
Industrial Customer C	-	199.8 "	449.4 "
Total	5.4 GWh	206.9 GWh	644.9 GWh

CHAPTER 4

BASIC PROJECT STUDIES

Chapter 4 Basic Project Studies

4.1 Power Generation Project

4.1.1 Outline of Project Area

The Kotapanjang Hydroelectric Development Project is for the area located approximately 10 km downstream of Muara Mahat, which is the confluence of the Kampar Kanan River, a tributary of the Kampar River, and a minor tributary. The distance from Pekanbaru, the provincial capital of Riau, is about 85 km, and the distance from Bangkinang is 20 km or so. Also, the Pekanbaru - Padang trunk road passes along the left bank of the Dam site, providing easy access to the Project area.

The Kampar River has an extensive basin area of 4,530 km^2, being the largest in scale of the four major rivers (Rokan River, Siak River, Kampar River and Indoragiri River) in the Province of Riau. It flows through the center of the province, passing near Pekanbaru, being, therefore, a very important river.

The Kampar Kanan River originates at the Mt. Amas (elevation 2,271 m) and the Mt. Hidjau (elevation 2,274 m) of the Barisan Mountains, flowing down and being joined by a number of tributaries between the steep mountains. It then passes through a region of gentle quasi-plain /plateau. The river joins the Mahat River near Muara Mahat, then reaches the Kotapajang Dam site. It flows from there down the flat alluvial plain from the vicinity of Rantau Berangin to join the Kampar Kiri River and become the Kampar River, which in turn flows into the Straits of Malacca.

The Kotapanjang Dam site is closely surrounded at a distance of one kilometer by river banks and is located in an area where the river is narrow. It is, therefore, a relatively small dam but has a reservoir of large capacity.

The mountainous area of the basin has the greatest rainfall in Indonesia. Annual rainfall reaches as much as 3,500 to 4,000 mm, ranking the fifth in the world. Even in the plains area downstream of the basin, rainfall amounts to 2,000 to 3,000 mm per year. Discharge of the river is, therefore, affluent. The annual mean discharge over the eleven year period between 1971 and 1981 at the Dam site was approximately 185 m^3/s and the annual mean runoff was about 5,800 million m^3.

The river gradient in the Project area is gentle, being 1:1,070 or so at the Kampar Kanan River, 1:1,500 or so at the Mahat River in the proposed reservoir, and about 1:1,090 at Rantau Berangin, downstream of the Dam.

Based on the foregoing conditions, it is concluded that dam type power generation is the optimum means.

4.1.2 Discharge Analysis

(1) Dam Site Discharges

Discharges at the proposed Kotapanjang Dam site were determined based on the discharge data collected at the Danau Bingkuang Gauging Station (C.A. = 4,035 km^2) located approximately 65 km downstream of the Dam site, and rainfall data at the Pasar Kampar Rain-Gauge Station. Since the discharge data obtained at the Danau Bingking Gauging Station were only for the five-year period between 1977 and 1981, data for the period between 1971 and 1976 were prepared by carrying out runoff analysis using a tank model based on rainfall data obtained at the Pasar Kampar Rain-Gauge Station, in order to obtain long-term data, in addition to the 1977-1981 discharge data obtained by means of catchment area conversion.

Flow duration flew into the reservoir over the 11 year period was as shown in Table 4.1. Discharges at the Mahat Dam site necessary for the comparison of the two-step development plan were also obtained by means of catchment area conversion, using the discharge data of the Kotapanjang Dam site.

Discharge duration at the Mahat Dam site is as shown in Table 4.2.

Table 4.1 Discharge Duration of River at Proposed Kotapanjang Dam Site

(C.A. 3,337.0 km^2)

(Unit: m^3/s)

Year	Maximum Discharge	35 days Discharge	Wet Discharge (95 days)	Mean Discharge (185 days)	Low Water Discharge (275 days)	Drought Discharge (355 days)	Minimum Discharge	Annual Average
1971	832.92	306.00	158.84	110.12	80.09	47.05	39.04	150.20
1972	1,156.94	406.11	216.24	129.81	80.76	51.39	49.05	191.29
1973	1,303.43	531.92	307.00	179.20	128.47	69.74	59.73	255.33
1974	1,205.66	313.34	158.84	113.12	94.44	76.75	68.07	161.82
1975	1,202.32	434.81	201.55	142.49	109.45	74.75	62.07	205.45
1976	1,260.05	451.16	234.59	139.49	89.43	59.73	57.40	208.82
1977	733.47	422.46	223.25	148.16	101.78	59.06	47.39	193.97
1978	670.74	397.77	274.64	171.19	80.09	41.38	36.37	199.04
1979	544.26	330.70	208.23	130.48	87.10	42.38	36.71	165.56
1980	477.86	287.32	195.21	131.81	84.96	55.06	47.05	155.39
1981	552.94	341.04	199.55	119.80	66.41	33.70	30.37	156.60
Total	9,940.59	4,222.64	2,377.95	1,515.67	1,002.77	606.00	533.25	2,043.49
Average	903.66	383.76	216.24	137.82	91.10	55.06	48.39	185.77

Table 4.2 Discharge Duration of River at Proposed Mahat Dam Site

(C.A. 1.075.0 km^2)

(Unit: m^3/s)

Year	Maximum Discharge	35 days Discharge	Wet Discharge (95 days)	Mean Discharge (185 days)	Low Water Discharge (275 days)	Drought Discharge (355 days)	Minimum Discharge	Annual Average
1971	268.32	98.58	51.17	35.98	25.80	15.16	12.58	48.48
1972	372.70	130.83	69.66	41.82	26.02	16.56	15.80	61.49
1973	419.90	171.36	98.90	57.73	41.39	22.47	19.24	82.24
1974	388.40	100.94	51.17	36.44	30.42	24.73	21.93	52.25
1975	387.32	140.07	64.93	45.90	35.26	24.08	20.00	65.68
1976	405.92	145.34	75.57	44.94	28.81	19.24	18.49	67.30
1977	236.29	136.10	71.92	47.73	32.79	17.42	15.27	62.24
1978	216.08	128.14	88.47	55.15	25.80	13.33	11.72	64.07
1979	175.33	106.53	67.08	42.03	28.06	13.65	11.83	53.11
1980	153.94	92.56	62.89	42.46	27.31	17.74	15.16	50.10
1981	178.13	109.87	64.29	38.59	21.39	10.86	9.78	50.53
Total	3,202.31	1,360.31	766.05	488.27	323.04	195.22	171.77	657.36
Average	291.11	123.63	69.66	44.40	29.35	17.74	15.59	59.77

(2) Design Flood Discharge

Upon determination of the Dam design flood discharge, runoff analysis and investigations on design flood discharges of existing dams in Indonesia were carried out, and the probable flood discharge for 200 years of occurrence was employed as the design flood discharge.

(a) Runoff Analysis

The 200-year flood discharge was obtained by following three methods.

(i) The 200-year rainfall was determined based on the data for the period between 1902 and 1975 (there were no measurements for 23 years of this period) at the Kota-Baru Rain-Gauge Station, this being station near the Dam site having the longest rainfall data record. The design flood discharge was then determined by using Rational Formula.

(ii) As in the case of (i) above, rational formula was used, but the rainfall intensity set was according to the rainfall intensity formula at Jakarta.

(iii) The representing hourly rainfall data was selected out of the data obtained at the Pasar Kampar Rain-gauge Station near the Dam site and the design flood discharge was determined by means of Storage Function Method. It was decided, however, that if the rainfall was smaller than that of the probable 200 years of occurrence, an extension would be so given that the 200-year rainfall would become equal to the daily rainfall.

1) Estimation by means of Rational formula

The maximum annual rainfall observed at the Kota-Baru Rain-Gauge Station is analyzed by the Hazen Method and shown in Table 4.3 and Fig. 4.1.

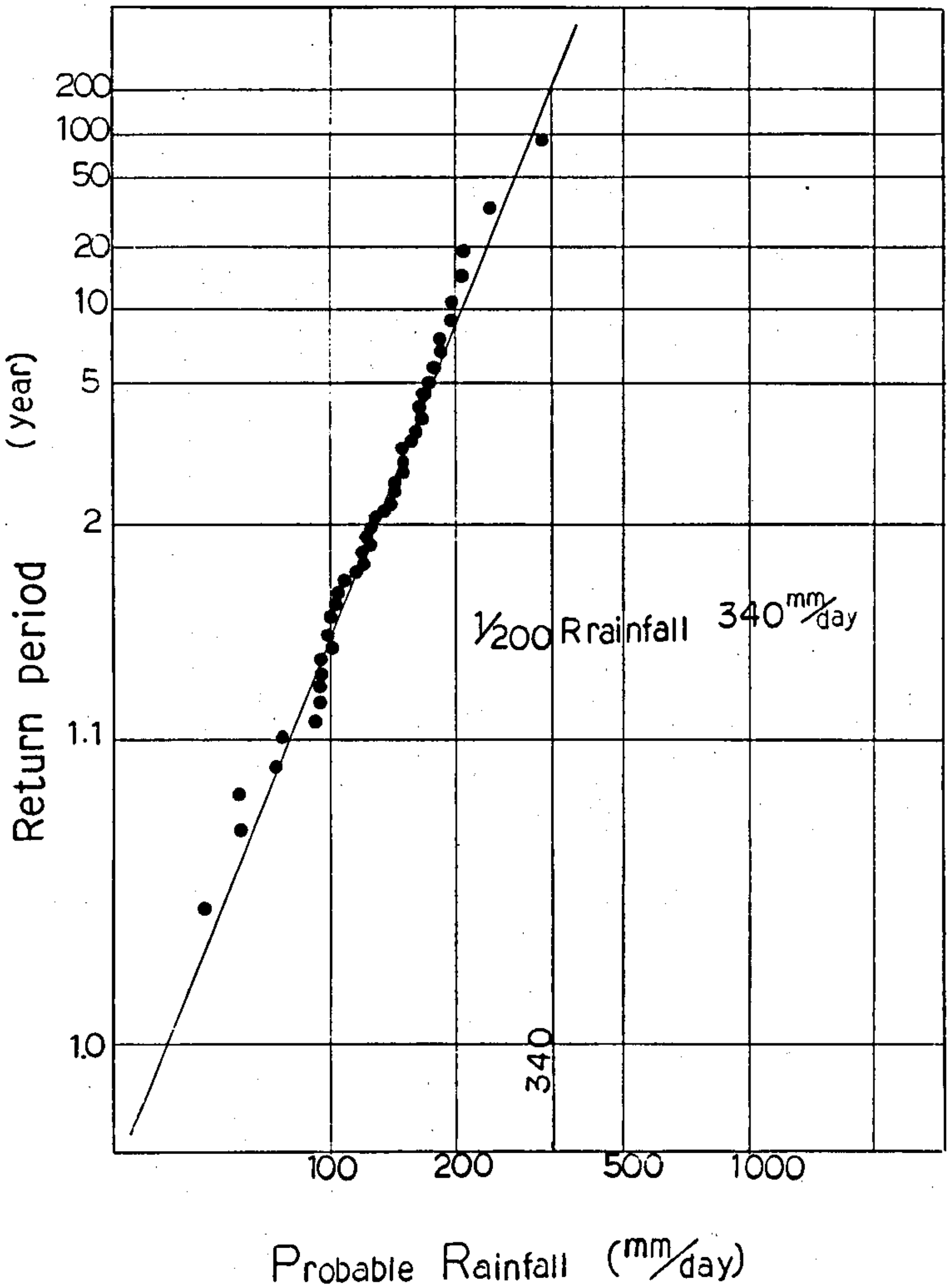
Table 4.3 Frequency Analysis by Hazen Method

Order (i)	Probable Year of Occurrence	Annual Max. Rainfall (mm/day)	$\frac{2i - 1}{2N}$	Order (i)	Probable Year of Occurrence	Annual Max. Rainfall (mm/day)	$\frac{2i - 1}{2N}$
1	1914	318	0.011	26	1927	125	0.554
2	1925	239	0.033	27	1916	120	0.576
3	1940	209	0.054	28	1902	120	0.598
4	1917	208	0.076	29	1941	116	0.620
5	1920	199	0.098	30	1919	108	0.641
6	1906	195	0.120	31	1933	105	0.663
7	1922	186	0.141	31	1907	102	0.685
8	1912	185	0.163	33	1911	101	0.707
9	1931	179	0.185	34	1930	100	0.728
10	1913	174	0.207	35	1928	100	0.750
11	1918	169	0.228	36	1970	100	0.772
12	1908	167	0.250	37	1957	96	0.794
13	1904	165	0.272	38	1929	96	0.815
14	1935	160	0.294	39	1939	95	0.837
15	1955	155	0.315	40	1936	95	0.859
16	1932	150	0.337	41	1938	93	0.880
17	1924	150	0.359	42	1903	77	0.902
18	1923	150	0.380	43	1905	75	0.924
19	1909	145	0.402	44	1975	61	0.946
20	1915	143	0.424	45	1974	61	0.967
21	1937	141	0.446	46	1973	50	0.989
22	1921	137	0.467				
23	1954	130	0.489				
24	1956	127	0.511				
25	1934	125	0.533				

. Rain-gauge Station : Kota Baru

. Gauging Period : 1902 - 1925 (24 years)
1927 - 1941 (15 years)
1954 - 1957 (4 years)
1973 - 1975 (3 years)
N = 46

Fig. 4.1 Frequency Analysis of Rainfall



The 200-year rainfall thus becomes 340 mm/day, hence, design flood discharge Q is as expressed by the following formula.

$$Q = \frac{1}{3.6} f \cdot A \cdot \gamma$$

$$\gamma = \gamma o \left(\frac{24}{T}\right)^{2/3}$$

$$T = \frac{\ell}{\omega}$$

$$\omega = 72 \left(\frac{H}{\ell}\right)^{0.6}$$

where, H : head from the upmost stream (km) = 635 m - 85 m = 0.55 km

ℓ : horizontal length from the upmost stream (km) = 75 km

ω : velocity of concentration (km/hr)

T : period of concentration (hr)

γ_o: daily rainfall (mm/hr) = 340/24 = 14.2 mm/hr

γ : rainfall intensity (mm/hr)

A : catchment area (km^2) = 3,337 km^2

f : runoff coefficient = 0.6

1 Velocity of concentration

$$\omega = 72 \times \left(\frac{0.55}{75}\right)^{0.6} = 3.77 \text{ km/hr}$$

2 Period of concentration

$$T = \frac{15}{3.77} = 19.9 \text{ hr}$$

3 Rainfall intensity

$$\gamma = 14.2 \times \left(\frac{24}{19.9}\right)^{2/3} = 16.1 \text{ mm/hr}$$

4 Peak discharge

$$Q = \frac{1}{3.6} \times 0.6 \times 3,337 \times 16.1 = 8,954 \doteqdot 9,000 \text{ m}^3/\text{s}$$

The runoff coefficient f is, however, approximate to the center value of those (0.5 to 0.75) indicated for "a large river with more than the half of the catchment area being flat" as listed in the table below.

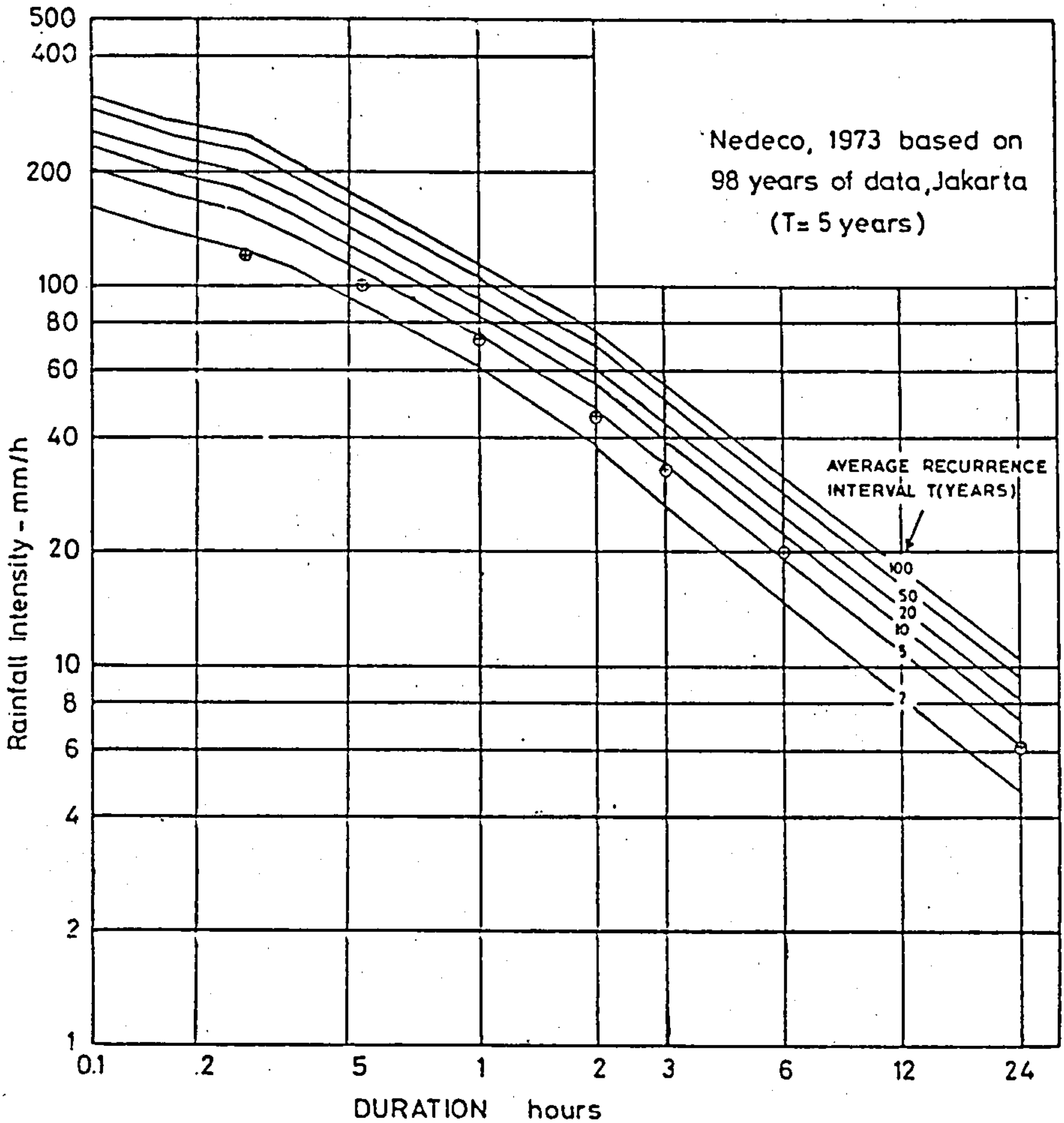
River Runoff Coefficients

Steep mountain region	0.75 - 0.90
Tertiary stratum mountains	0.70 - 0.80
Land and forest with flat & steep portions	0.50 - 0.75
Flat cultivated area	0.45 - 0.60
Paddy field during irrigation	0.70 - 0.80
River in mountainous region	0.75 - 0.85
Stream in mountainous region	0.45 - 0.75
Large river with more than half of the catchment area being flat	0.50 - 0.75

2) Estimation by means of Rational formula applied to the rainfall intensity in Jakarta

The relationship between the daily rainfall intensity and the continuous hours (duration) in Jakarta is as shown in Fig. 4.2. Design flood discharge obtained by rational formula, assuming that the duration of rain is 18 (hr) based on rainfalls between December 18 and 19, 1976 the rainfall intensity of each probable year is estimated as described in 3), c). According to the above, the design flood discharge Q of the 200-year flood becomes 8,200 m^3/sec.

Fig.4.2 Correlation of Rainfall Intensity and Duration Hours

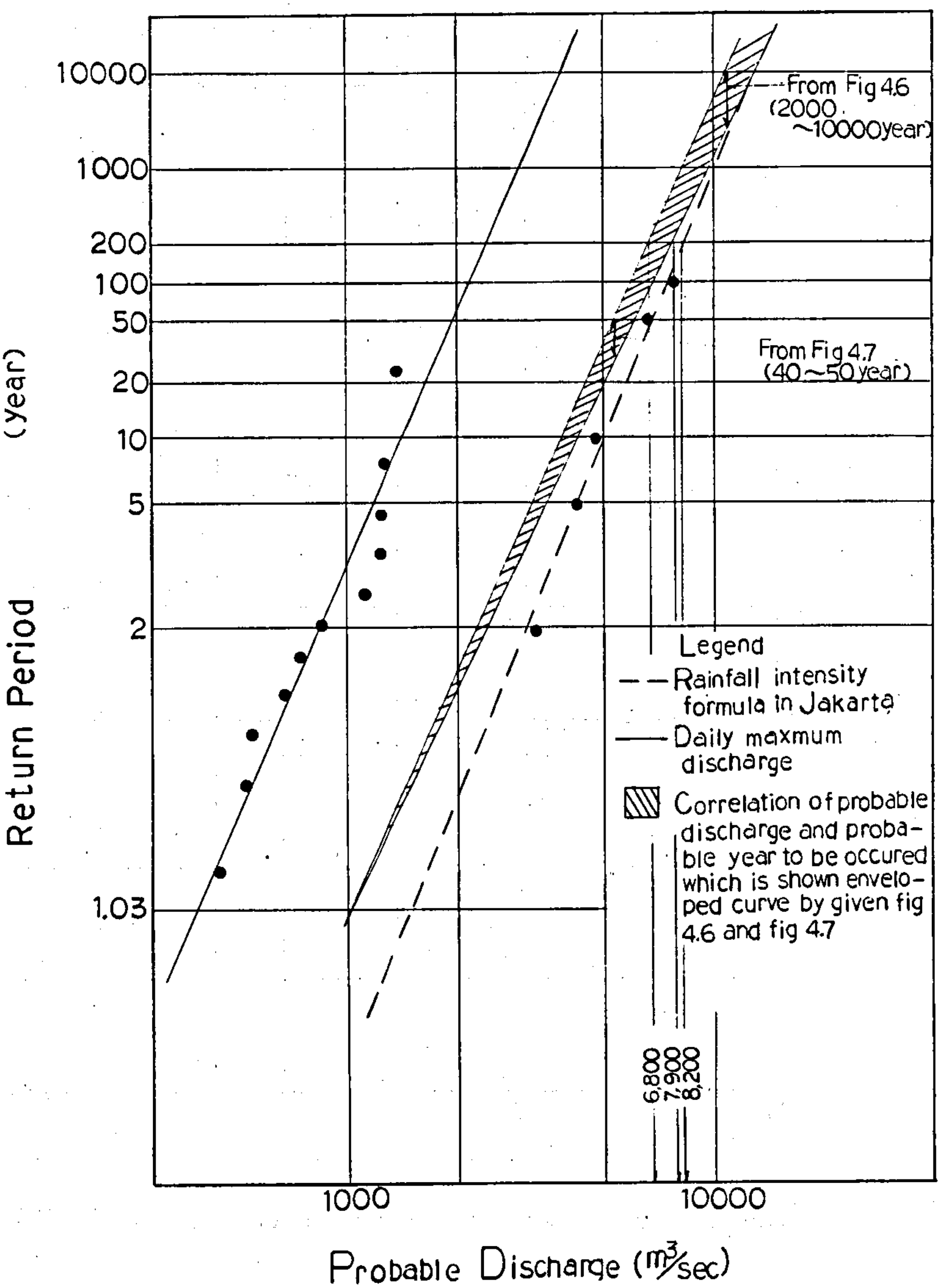


RAINFALL INTENSITY DURATION - FREQUENCY CURVES FOR JAKARTA

Note : The frequency curves have been converted to unrestricted time intervals

Source : Irish 1978

Fig.4.3 Frequency Analysis of Discharge



3) Estimation by Storage Function Method

a) Division of catchment area

The total catchment area (C.A. = 3,337 km^2) was divided into 4 sub-areas as shown in Fig. 4.4. Specifications of each sub-area are as shown in the table below.

		Catchment Area (km)	Length of River Course (km)	Gradient
Sub-area	1	628.5	43.3	0.0033
	2	728.3	58.6	0.0100
	3	1,142.2	83.0	0.0100
	4	838.0	82.8	0.0125
River course	I		82.8	0.0125

b) Constant coefficients used in Storage Function Method

Constant coefficients used in the Storage Function Method are saturation rainfall (Rsa), initial runoff rate (f), recession time (Te) and storage constants (K, P). They should be set for each sub-catchment area by dividing major tributaries within the basin, but the Japanese Method proposed by the River Bureau of the Ministry of Construction are used, due to the absence of adequate data at the site.

① Saturation rainfall, Ra and initial runoff factor, f

Some data are available on the saturation rainfall as given in the table below:

Geology \ Parameter	Saturation Rainfall Rsa
Quarternary volcanic rock	300 (280 - 430)
Geology other than above	100 (0 - 200)

The initial runoff rate, on the other hand, is generally considered to be 0.5. It is thus set here as: $f_1 = 0.5$ and Rsa = 100 mm.

② Recession time, Te

For the partial catchment area, the recession time is established by the following equation:

$$Te = 0.047 \cdot L - 0.56$$

where L : length of river course

For the river course, the following equation is used:

$$Te = (7.36 \times 10^{-4}) \cdot L \cdot i^{-0.5}$$

where i : mean gradient of river course

③ Constants, K and P expressing storage function

For the partial catchment area, constants are set according to the following equations.

$$K = 43.4 \cdot C \cdot L^{1/3} \cdot i^{(-1/3)}$$

$$P = 1/3$$

For the river course, constants are set according to the following equation.

$$K = 0.166 \cdot L \cdot i^{(-0.5)}$$

$$P = 0.6$$

④ Base flow

Base flow is set at 10 m^3/sec/100 km^2, according to the mean daily discharge.

The constants used for the Storage Function Method are as listed in the table below.

Constants Used for Storage Function Method

		Constant Course		Recession Time	Others
		K	P	Ti	
Catchment Area	1 2 3 4	122.8 93.9 105.4 97.8	0.33 0.33 0.33 0.33	1.48 2.19 3.34 3.33	Initial runoff rate f_1 = 0.5 Saturation rainfall Rsa = 100 mm
River Course	I	122.94	0.60	0.545	Base flow 10 (m^3/sec/100km^2)

c) Typical rainfall

Typical rainfall is selected from those of Pasar Kampar Rain-gauge Station in December, 1976, out of the presently available data.

The rainfall is those on December 18 and 19 of the said year, which were relatively small as 50.7 mm on the 18th and 56.5 mm on the 19th, as rainfall data.

The extension rate (daily total of the rainfall extended to the 200-year rainfall) of the rainfalls is set as 3.238, which is obtained by extending the total rainfall of 105 mm over 24 hours from 11 o'clock on December 18 to 10 o'clock on December 19, to the rainfall of 340 mm of the 200-year rainfall.

Typical hourly rainfalls are as in the table below.

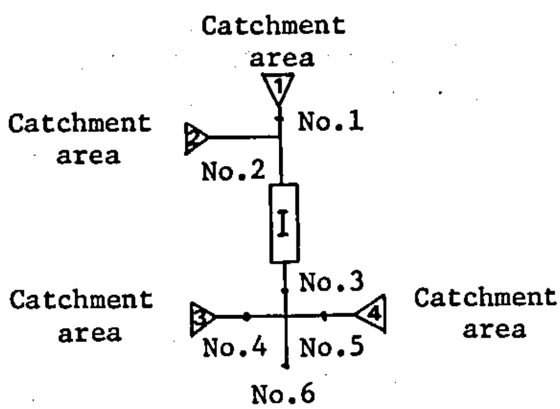
Probable Hourly Rainfalls of 200-years

Dec. 18	13°	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°
	0.0	0.3	0.0	0.	0.0	0.0	85.8	1.6	0.0	0.0	37.2	32.4
Dec. 19	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°
	67.4	42.1	16.2	16.2	11.3	2.6	0.0	13.6	11.3	2.3	0.0	0.0

d) Catchment area model

The modeling of the basin for the analysis is shown below.

Catchment Area Model



Discharge calculated area

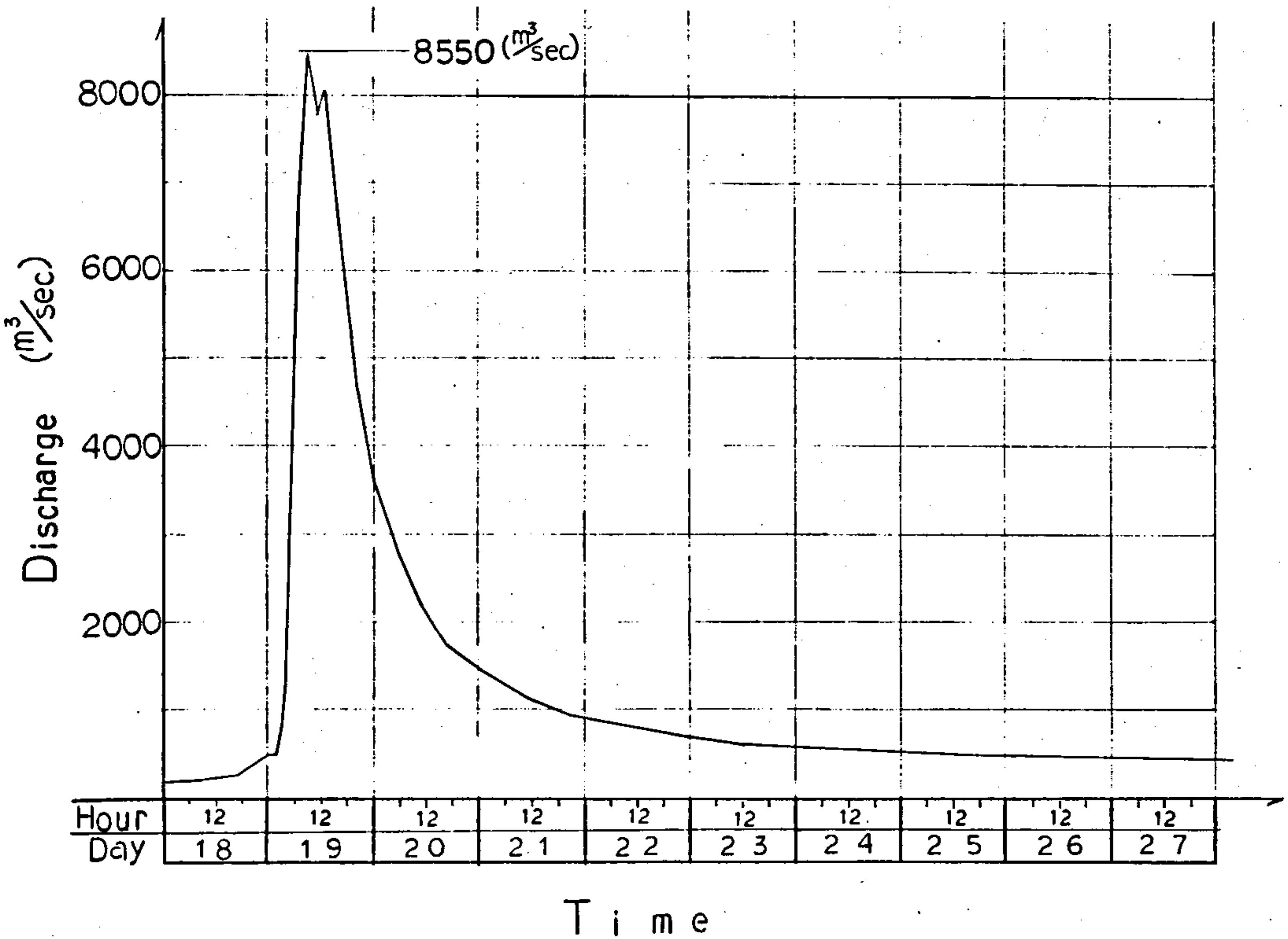
No. 1	Catchment Area 1
No. 2	Catchment Area 2
No. 3	River Course I
No. 4	Catchment Aera 3
No. 5	Catchment Area 4
No. 6	Catchment Area 3 + 4 + River Course (Dam site)

e) Calculation results

The calculation results are shown in Fig. 4.5. The design flood discharge Q is expressed as follows, according to the results.

$$Q = 8{,}550 \ m^3/sec$$

Fig.4.5 Analysis of Flood Discharge



(b) Design Flood Data of the Existing Dams in Indonesia

Fig. 4.6 gives the relationship between the design flood discharge and the catchment area of fill type dams already constructed or under construction in Java Island. Values in the figure represent respective probable years of occurrence, which cover a range of 200 years to 10,000 years. Taking account of the linear line representing each design flood discharge, the 2000 to 10,000-year discharge corresponding to a catchment area of 3,337 km^2 for the Kotapanjang Dam will become 11,000 m^3/sec.

Fig. 4.7, on the other hand, gives the relationship between the specific discharge used in Indonesia and the catchment area. Taking account of the linear line enveloping specific discharge, the 40 to 50-year discharge corresponding to the catchment area of the Kotapanjang Dam may be expressed as follows:

$$1.6\ m^3/sec/km^2 \times 3,337 = 5,300\ m^3/sec$$

Estimation of the 200-year discharge, by plotting the actual data on Fig. 4.3, will become as follows:

$$6,800 \leqq Q \leqq 7,900\ (m^3/sec)$$

(c) Flood Recorded at the Gauging Station

Among the peak flood recorded at the Danau Bingkuang Gauging Station (C.A. = 4,035 km^2) located downstream of the Dam site, the largest 7 (seven) data are listed on the following table.

No.	Water Level H (m)	Discharge Q (m^3/s)	Day of Gauging	Remarks
1	6.90	2,084.3	Dec. 15, 1978	- Rating Curve
2	5.73	1,586.7	Feb. 10, 1979	$Q = 26.306 H^2 + 181.985 + 12.164$
3	5.27	1,407.4	Nov. 27, 1979	
4	5.02	1,313.8	Nov. 25, 1980	Q : Discharge (m^3/s) H : Water level (m)
5	4.92	1,277.2	Dec. 8, 1977	
6	4.83	1,244.5	Mar. 24, 1978	- Discharges were converted to the catchment of
7	4.73	1,208.7	Jan. 10, 1979	3,337 km^2

From the recorded data, the maximum peak discharge at Dam site in 5 years, is 2,084 m^3/sec.

Fig.4.6 Correlation of Design Flood Discharge and Catchment Area

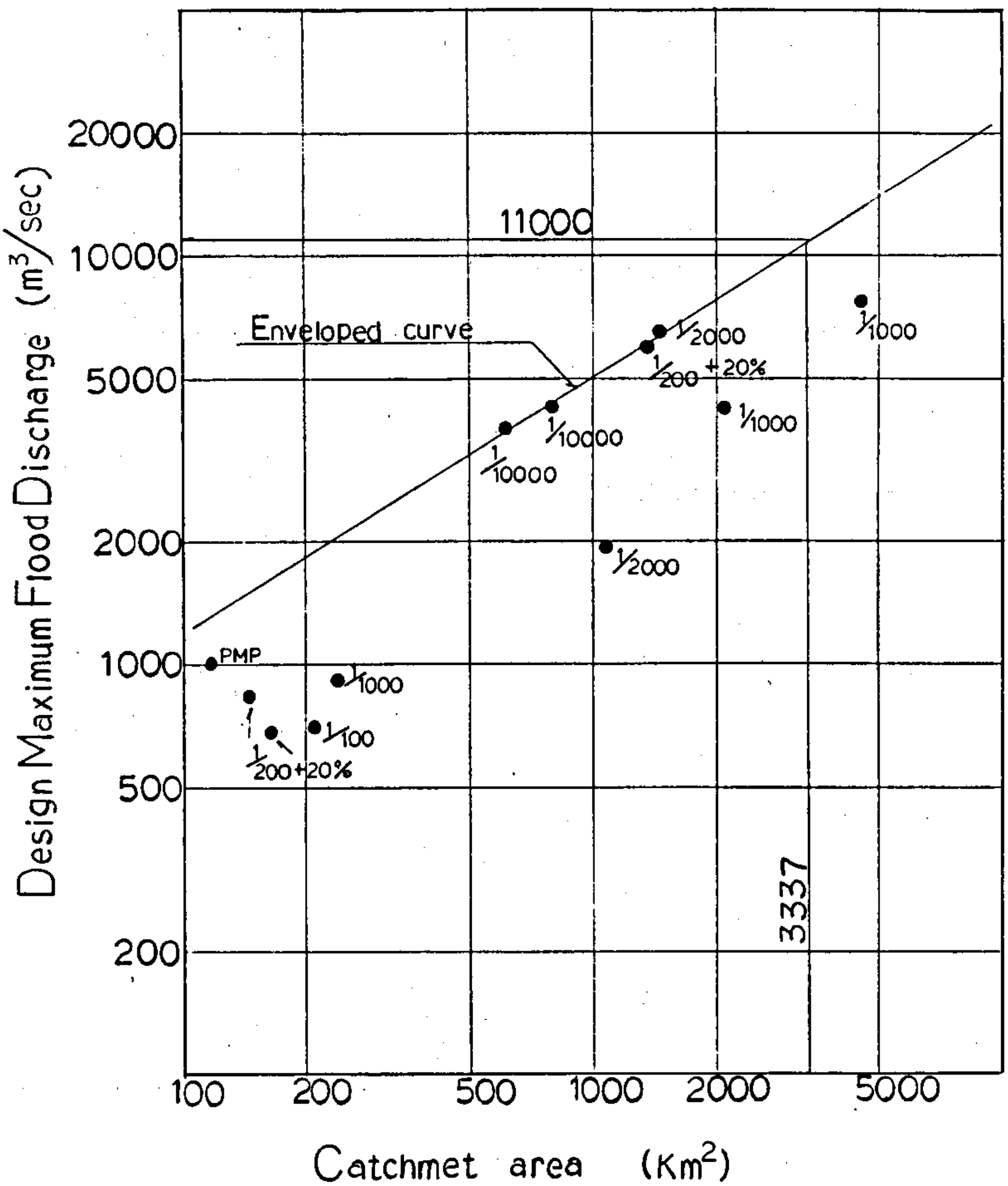
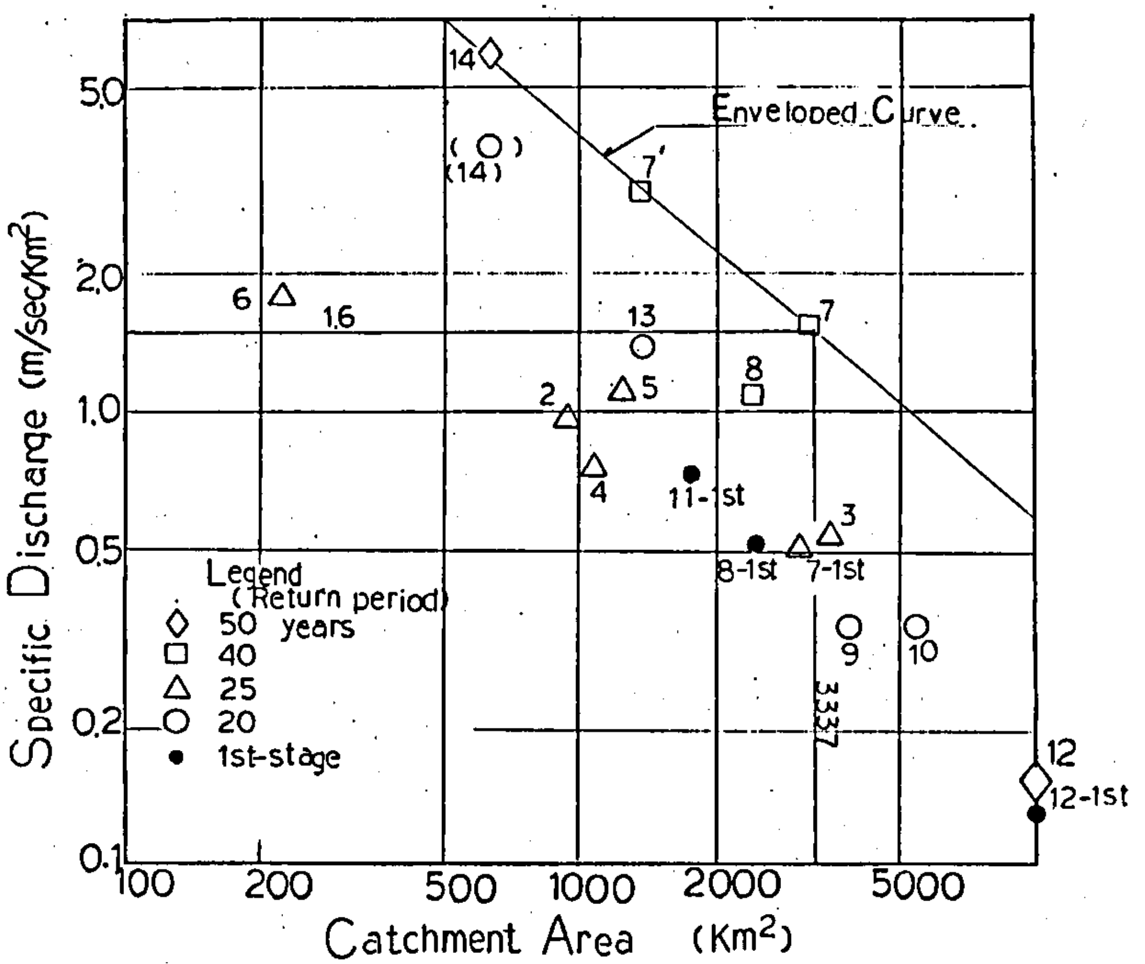


Fig.4.7 Correlation of Specific Discharge and Catchment Area



No.	Name of River	Province	Catchment Area (km^2)	Design Flood (m^3/s)	Specific Discharge	Return Period (Year)	1st-stage
1.	Sungai Cimanuk	West Jawa	3,006	1,440	0.48	25	
2.	Kali Serang	Central Jawa	937	900	0.96	25	
3.	Sungai Citanduy	West Jawa	3,680	1,900	0.52	25	
4.	Sungai Ular	North Sumatra	1,080	800	0.74	25	
5.	Kali Pemali	Central Jawa	1,228	1,300	1.06	25	
6.	Sungai Cipanas	West Jawa	220	385	1.75	25	
7.	Bengawan Solo	Central/East	3,320	5,240 (2,000)	1.58 (0.60)	40	1,500(10y)
8.	Kali Mndium	East Jawa	2,400	2,600	1.08	40	1,200(17y)
9.	Sungai Wanps	North Sumatra	3,840	1,320	0.34	20	
10.	Sungai Arakundo	Aceh	5,495	1,800	0.33	20	
11.	Sungai Kring Aceh	Aceh	1,775			20	1,300(5y)
12.	Kali Brantas	East Jawa	10,000	1,500	0.15	50	1,300(10y)
13.	Sungai Bila	South Surawesi	1,368	1,900	1.39	20	
14.	Jeneberang	South Surawesi	624	3,700 (2,300)	5.39 (3.69)	50 20	

(d) Establishment of Design Flood Discharge

The estimated values of the design flood discharge of the Kotapanjang Dam obtained by formulae and actual data are as listed in the table below.

Method		Estimated Value of Design Flood Discharge (m^3/sec)	Remark
1	Rational formula	8,954	200-year discharge
	Rational formula (Rainfall intensity is actual data in Jakarta)	8,200	do
2	Storage function method	8,550	do
3	Actual data of other dams	$6,800 < Q < 7,900$	do

Thus, the design flood discharge is set at $Q = 9,000$ m^3/sec. And design flood discharge for the diversion is set presently at 1,000 m^3/sec. This value, 1.03-year discharge, was calculated based on the actual data at other dams shown in Fig. 4.7.

(3) Design Sedimentation

In determining the design sedimentation, investigation of existing data in Indonesia, measuring of sedimented soils in the Kampar River and the Mahat River were executed. And various estimation formulae were used based upon the data collected.

(a) Sedimentation of Dam Projects

Name of Dam	Specific Sedimentation ($m^3/km^2/year$)	Type of Dam (Dam height m)	C.A. (km^2)	Location & Name of River
CIRATA	1,430	Concrete gravity (114)	4,119	Java Island Citarum River
WONOGIRI	1,170	Rockfill (37.5)	1,020	Java Island (Bengawan Solo)
RIAM KIWA	246	Earthfill (50)	1,420	Kalimantan Island Riam Kiwa River

(b) Estimation from Soil Sedimentation

Through the current investigation, it was found that the sedimented soils in the Kampar Kanan River (at Muara Mahat) were as listed in Table 4.4. The sedimentation of the soils will be studied using the maximum value of 143.66 (mg/ℓ) listed in Table 4.4, taking account of safety side. Assuming that the average flow into the reservoir is 185.77 m^3/sec, and the density of the soils is the general value of 1.5 t/m^3, the following equation is established.

$$qs = 143.66 \times 10^{-9} \times 185.77 \times 10^{3} \times 60 \times 60 \times 24 \times 365/1.5$$
$$= 561{,}082\ m^3/year$$

Assuming further that the rate of the transported soils is approximately 20 percent of the sedimented soils, the sedimentation will be as follows:

$$Q = 1.2 \times qs = 673{,}298\ m^3/year$$

The specific sedimentation Qs will be as follows: according to C.A. = 3,337 km^2.

$$Qs = 197\ m^3/km^2/year$$

Table 4.4 Measured Results of Soil Sedimentation

River	Location	Soil Sedimentation (mg/ℓ)	Investigation Date	Remarks
Kampar Kanan River	Muara Paiti	6.63	Sept. 9, 1977	- All data represent means of 3 measurements
		7.33	Feb. 24, 1980	
		18.00	Aug. 9, 1980	
		12.67	Oct. 10, 1980	
		23.33	Feb. 1, 1981	
		42.33	Apr. 1, 1981	
		24.00	Dec. 9, 1981	
		27.33	Feb. 1, 1982	
		108.00	Feb. 18, 1982	
		17.67	Apr. 26, 1982	
	Mean	28.70	-	
Mahat River	Lubuk Sipopay	10.60	Sept. 8, 1977	
		17.00	Feb. 25, 1980	
		21.00	Aug. 10, 1980	
		6.67	Oct. 8, 1980	
		10.67	Dec. 30, 1980	
		18.33	Mar. 30, 1981	
		14.33	Aug. 12, 1981	
		143.66	Feb. 17, 1982	
		16.67	Apr. 25, 1982	
		22.00	May 31, 1982	
	Mean	28.09	-	
Total Mean		28.40	-	

(c) Estimation by the Other Formula

To assume the sedimentation, the following formula, Kira formula, Tanaka formula, Ishigai formula are widely used in Japan. The estimations for reference are as follows.

- Kira formula Qs = 170 m^3/km^2/year
- Tanaka formula Qs = 134 " (76 ≦ Qs ≦ 193)
- Ishigai formula Qs = 640 " (346 ≦ Qs ≦ 933)

(d) Determination of Design Sedimentation

Estimated values of the specific sedimentation of existing dams and estimation by the formula based on the soil sedimentation are as shown below.

Method		Estimated Value of Specific Sedimentation	Remarks
1	Actual data of existing dams	1,430 ≦ Qs ≦ 246 (838)	Values in parentheses indicate mean value.
2	Estimation from the soil sedimentation	197	
3	Kira formula	170	
4	Tanaka formula	76 ≦ Qs ≦ 193 (134)	
5	Ishigai formula	346 ≦ Qs ≦ 933 (640)	

Thus, the investigation should be continued furthermore. At present, the specific sedimentation value remains at 500 m^3/km^2/year for the time being, taking into account the estimated values mentioned above.

4.1.3 Study on Development Method

In formulation of the Kotapanjang Development Project, two alternative plans, i.e. one-dam plan and two-dam development plan were studied.

The one-dam alternative plan was to build a dam of 58 m height (H.W.L. 85 m) at kotapanjang site approximately 10 km downstream of the confluence of the Kampar Kanan River and its tributary, the Mahat River, and to construct a power station of 111 MW with a reservoir of effective water storage capacity of 900 million m^3 (the proposed Dam site is on the Dam axis 4 mentioned in 4.1.4). This plan permits effective utilization of the rivers by means of large-scale power development, and the agricultural irrigation and flood control at the downstream area. On the other hand, about 2,650 houses, roughly 9,000 ha cultivated land and provincial road of 35 km would be submerged.

The two-dam alternative plan is to build regulating reservoir by two steps as a measure to reduce compensation costs for land and houses to be inundated. Specifically, the downstream dam of 30.5 m height (H.W.L. 58 m), an regulating reservoir with an effective water storage capacity of 20 million m^3 and power generation plant of 41 MW are to be constructed at aforementioned Kotapanjang Dam site and to build another upstream 38 meter high dam (H.W.L. 85 m) to create a regulating reservoir of effective storage capacity of 20 million m^3 and Mahat power plant of 23 MW at Tanjung Pauh on the Mahat River. According to this plan, about 390 houses, 1,860 ha agricultural land and 16 km provincial road would be submerged.

Locations and profiles of the two alternative plans are as shown in Fig. 4.8. Results of comparative studies of development methods are as listed in Table 4.5, indicating that the one-dam development plan is verified to be better. Therefore, in this report is for the one-dam development plan. Design drawings for the comparative studies are as shown in Figs. 4.9, 4.10 and 4.11.

Table 4.5 Comparative Study on Development Method between One-Dam Plan and Two-Dam Plan

Item \ Development method		One-dam plan	Two-dam plan		
		Kotapanjang	Kotapanjang	Mahat	Total
Catchment area	(km^2)	3,337	3,337	1,075	
Annual average inflow	(m^3/s)	185.8	185.8	59.9	
High water level	(m)	85	58	85	
Low water level	(m)	73.5	54	81	
Effective water storage capacity	($10^6 m^3$)	900	20	20	
Power generation type		Reservoir type	Pondage type	Pondage type	
Dam height	(m)	58	30.5	38	
Type of dam		Concrete gravity type	Concrete gravity type	Concrete gravity type	
Max. output	(kW)	111,000	41,000	23,000	64,000
Max. discharge	(m^3/s)	342	342	110	
Effective head	(m)	38.7	14.2	24.5	
Annual generated energy	(10^6kWh)	532	173	96	269
Construction cost	(10^3US$)	176,541	112,900	55,000	167,900
B/C		1.84	0.97	1.11	1.02
B-C	(10^3US$)	21,080	-498	838	340
Facility utilization rate	(%)	55	48	48	
Construction cost per kW	(US$)	1,590	2,753	2,391	2,623
Construction cost per kWh	(US$)	0.33	0.65	0.57	0.62

4.1.4 Selection of Dam Site and Dam Type

Upon selection of the Dam site, comparative studies were carried out on Dam axes 1, 2, 3 and 4, using existing topographic maps of 1:25,000 scale. As axis 2 was found to be relatively close to axis 3, it was excluded from further study. Field investigations including boring investigation are also applied to these axes (see Fig. 2.1).

Concrete gravity type dam on the Dam axis 1, 3, 4 are studied to select the optimum site for concrete dam. For fill-type dam, on the other hand, Dam axis 3 was selected topographically and carefully studied for two types of center core and concrete facing.

Such studies were carried out using the following procedure; the optimum layout was drawn for each case and the total construction costs were compared for main dam structure, spillway, diversion work and powerhouse excluding common work costs.

As a result, it was revealed that the construction of a concrete gravity dam on the Dam axis 4 would be the optimum one, as shown in Table 4.6, because of the high cost of countermeasures against large flood discharge during and after construction.

Table 4.6 Selection of Dam Sites and Dam Types

(10[3] US$)

Item		Concrete gravity type dam			Fill type dam	
Item (Dam type / Dam Axis)		Axis 1	Axis 3	Axis 4	Axis 3 (Spillway at right bank)	Axis 3 (Spillway at left bank)
Dam	Dam	25,158	18,715	18,140	9,867	6,480
	Spillway	8,857	9,113	8,821	21,325	31,000
	Diversion	7,046	7,488	5,879	11,779	14,383
	Concrete plug work	377	377	377	533	533
	Others	8,288	7,139	6,637	8,701	10,479
	Total	49,726	42,832	39,854	52,205	62,875
Power house		10,179	11,804	10,012	15,572	16,042
Gate, etc.	Gate	8,842	8,842	8,842	10,513	9,250
	Penstock	1,291	1,291	1,291	1,883	1,900
	Total	10,133	10,133	10,133	12,346	11,150
Grand Total		70,038	64,769	59,999	80,123	90,067

4.1.5 Preliminary Study on Dam Scale

For preliminary optimization study on the scale of the proposed Dam, annual power generation outputs and construction costs by three cases were calculated, taking into account the height of the Dam, operating hours, effective water storage capacity and effective depth, and, then, evaluated on the basis of cost-benefit analysis. According to the results, the case of H.W.L. 85 m is the optimum.

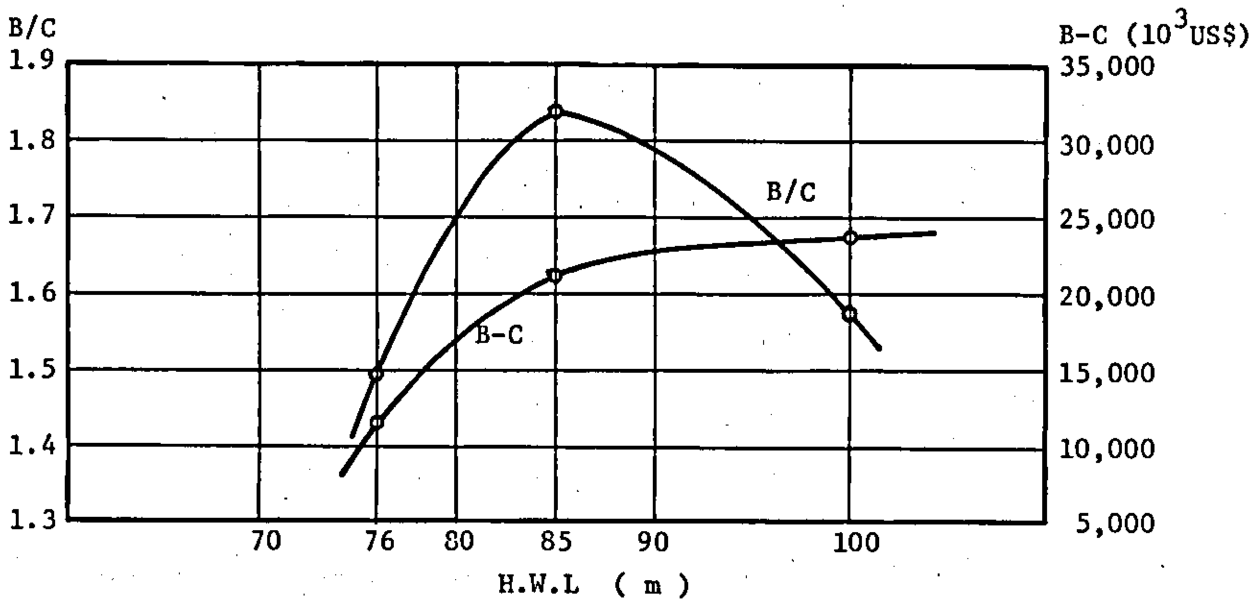
In view of the facts that Pangkalan Kota Baru, the upstream of the Mahat River, is located at an elevation of 87 m (population 8,600) and that Buddhist remains (Muara Takus) lie at an elevation of 86.4 m for which rehabilitation works are being restored at present, the proposed high water level (H.W.L.) was set at 85 m.

Results of studies are as listed in Table 4.7 and Fig. 4.12.

Table 4.7 Comparison of Dam Scales

Item \ H.W.L.		100m	85m	76m
Max. output	(kW)	155,000	111,000	85,000
Max. discharge	(m^3/s)	342	342	342
Effective head	(m)	53.7	38.7	29.7
Annual generated energy	(kWh)	738×10^6	532×10^6	388×10^6
Construction cost	(10^3US$)	285,900	176,500	161,300
B/C		1.58	1.84	1.49
B-C	(10^3US$)	23,525	21,080	11,190
Construction cost per kW	(US$)	1,845	1,590	1,898
Construction cost per kWh	(US$)	0.37	0.33	0.42

Fig.4.12 B/C and B-C Curve of Dam Scale



4.1.6 Preliminary Evaluation of Installed Capacity

Determination of the installed capacity was made by comparing nine cases, assuming that the effective depth 11.5 m and effective water storage capacity 900 million m^3. Results of these studies are as shown in Table 4.8 and Fig. 4.14.

Basic conditions for calculation of power generation are as follows:

Water Intake Level :	Water level at the center of gravity of the reservoir (EL 81.00 m)
Tailwater Level :	EL 41.00 m
Maximum Output :	$P\ max = 9.8 \times Q\ max \times h \times \eta$
where, Q max :	maximum discharge (m^3/s)
h :	effective head (= 38.7 m)
η :	comprehensive efficiency of turbine generator (= 0.86)

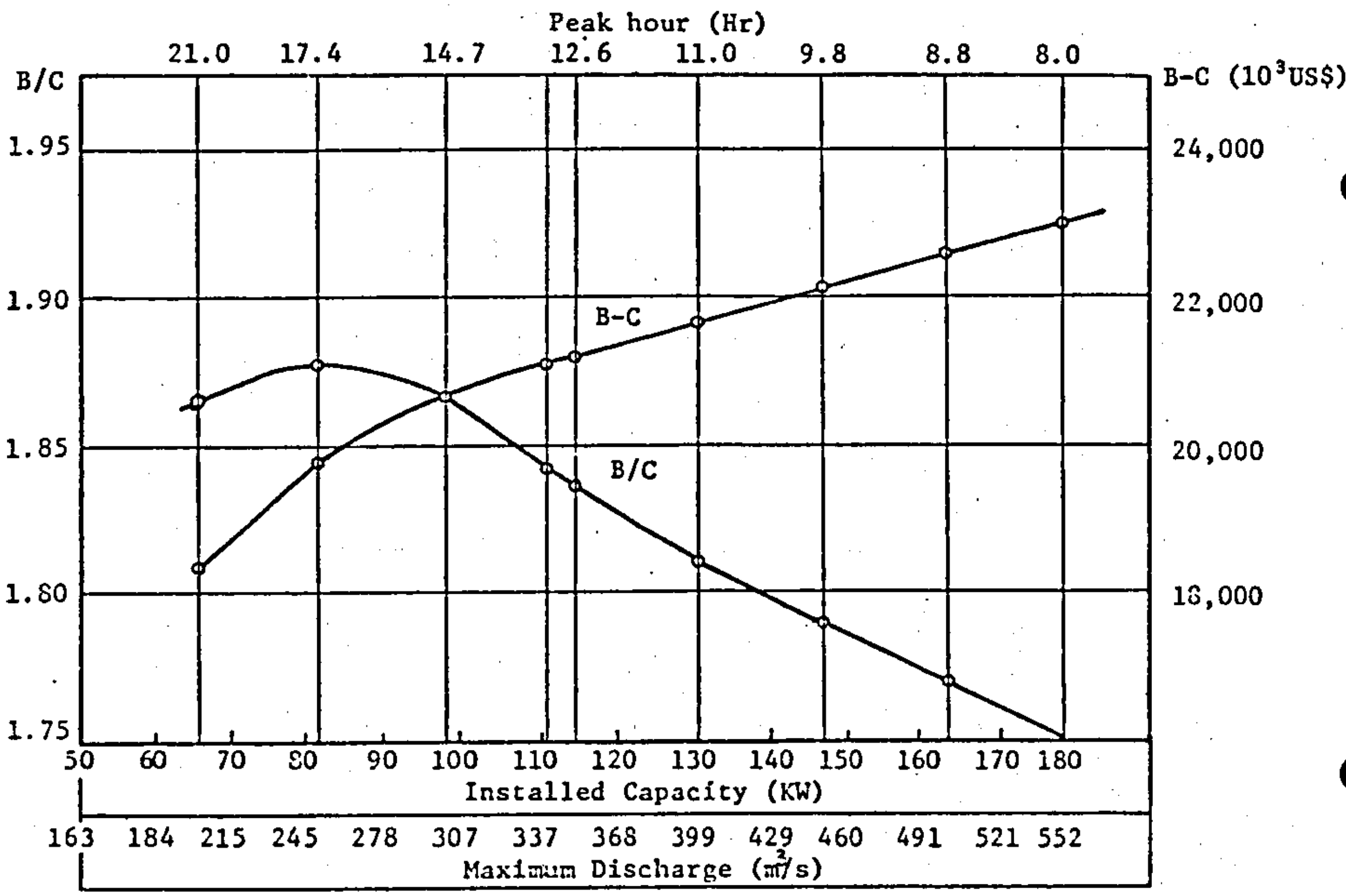
Judging from the outcomes of different cases compared it was indicated that B/C reaches the maximum around 80 to 90 MW, but tends to decrease as the scale becomes greater. B-C tends to increase gradually as maximum output increases.

The load factor in the Province of Riau is estimated at 0.3 to 0.4 at present, as the majority of current demand is for residential use, while it is estimated 0.5 in Padang where the industrial development is relatively advanced in the Province of West Sumatra. However, taking into consideration, peak demand and the change in the demand structure accompanying the future industrial development and future demand growth, the installed capacity was determined to be 111 MW.

Table 4.8 Comparison of the Installed Capacity

Max. output (MW)	Max. discharge (m^3/s)	Annual generated energy (10^6kWh)	Annual benefit B(10^3US$)	Total construction cost (10^3US$)	Annual cost C(10^3US$)	B/C	B-C (10^3US$)
65.2	200	507	39,574	149,221	21,216	1.865	18,358
81.5	250	524	42,444	158,942	22,598	1.878	19,846
97.8	300	532	44,738	168,550	23,964	1.867	20,774
111	342	532	46,180	176,541	25,100	1.840	21,080
114	350	532	46,508	178,063	25,316	1.837	21,192
130	400	532	48,257	187,500	26,658	1.810	21,599
147	450	532	50,115	196,879	27,991	1.790	22,124
163	500	532	51,864	206,225	29,320	1.769	22,544
179	550	532	53,613	215,508	30,640	1.750	22,973

Fig.4.14 B/C and B-C Curve of Power Generation Plant



4.2 Transmission Line and Sub-station Plan

4.2.1 Transmission Line

The following points were confirmed at the last meeting held with PLN staff.

(1) Transmission line will be constructed from the switchyard of the power station to Pekanbaru, where the Pekanbaru sub-station (tentative name) is to be built.

(2) The route of the transmission line is determined as shown in the attached drawing (Fig. 4.15).

(3) The outline of the transmission line is as follows:
150 kV, double circuits with a length of approximately 70 km

Based upon the transmission line plan given above, it is recommendable to complete the transmission line extention program between Pekanbaru and the major power consumption areas simultaneous with the completion of the proposed Project, taking into account future energy demands.

4.2.2 Sub-station Plan

An outline of the switchyard and sub-station to be constructed under this Project is as described below.

(1) Kotapanjang Switchyard

Major equipment scheduled to be installed in the Station is as follows:

Transformer	150 kV/20 kV	3-phase	1 set
Circuit breaker	150 kV	"	7 sets
Disconnecting switch	150 kV	"	16 sets
Potential transformer	150 kV/$\sqrt{3}$/110 V/$\sqrt{3}$	1-phase	8 pcs
Lightening arrestor	150 kV	3-phase	
Power line carrier equipment	For double circuit T/L use		2 sets
Control panel			1 set
Conductor			1 set
Structure			1 set
Control cable			1 set
Miscellaneous			1 set

(2) Pekanbaru Sub-station

Major equipment scheduled to be installed in the Station is as follows:

Transformer	150 kV/20 kV	3-phase	2 sets
Circuit breaker	150 kV	"	7 sets
Disconnecting switch	150 kV	"	18 sets
Potential transformer	150 kV/$\sqrt{3}$/110 V/$\sqrt{3}$	1-phase	10 pcs
Lightening arrestor	150 kV	3-phase	
Power line carrier equipment	For double circuit T/L use		2 sets
Control panel			1 set
Conductor			1 set
Structure			1 set
Control cable			1 set
Miscellaneous			1 set

4.3 Estimation of Construction Cost

4.3.1 Total Construction Cost

It is estimated that a construction cost for the Kotapanjang Hydro Electric Power Development amounts to 176,541 x 10^3 US dollars with foreign currency portion of 93,433 x 10^3 US dollars and local currency portion of 83,108 x 10^3 US dollars. Of the above, however, an interest during the construction and price contingency are not included. All the cost estimates were made at the price level as of November, 1982, applying exchange rates of 680 Rupia and 240 Yen and US dollar. The detailed breakdown of the proposed Project construction cost is shown in Table 4.9.

4.3.2 Prerequisites for Estimation

The Project construction cost is estimated on the basis of a preliminary optimum design determined through a comparative studies. The unit prices are estimated referring to current construction works on the similar projects in Indonesia. The total construction cost comprises civil works, metal works, generating equipment, transmitting equipment, engineering and administration, compensation and physical contingency. The basic conditions made for cost estimation are as presented below.

(1) Civil Works

Civil work costs include all civil works of dam, powerhouse, temporary facilities for consturction, power facilities, road relocation and sub-stations, whereas other necessary equipment and facilities costs are included in the respective cost items.

(2) Metal Works

This cost item involves gate, screen, penstock, hoisting equipment and other necessary metal equipment costs.

(3) Generating Equipment

The generating equipment costs consist of turbines, generator, transformer and other necessary generating equipment including cranes.

(4) Transmitting Equipment

Transmission line of 70 km between the proposed Dam site and Pekanbaru, one switchyard and one sub-station construction costs including civil work are included.

(5) Engineering Service and Administration

Engineering service comprises the detailed design and field investigation, preparation of tender document and its evaluation, and supervisory service during construction works. Engineering cost is, then, estimated on the basis of the total man-month to be required for the services said above. For PLN administration cost it is estimated at 2.0 percent of the sum of (1) to through (4) above.

(6) Compensation

The compensation is estimated for acquisition cost of those cultivated land and houses to be submerged due to the proposed Dam construction.

(7) Physical Contingency

For unpredictable changes in physical conditions, physical contingency is estimated at 10.0 percent of the sum of (1) and (6) above plus 5.0 percent of the sum of (2), (3) and (4) above.

Table 4.9 Breakdown of Construction Cost

(10^3 US$)

Cost Item	Foreign	Local	Total
1. Civil Works	29,116	39,338	68,454
2. Metal Works	9,121	1,012	10,133
3. Generating Equipment	26,487	2,942	29,429
4. Transmitting Equipment	14,150	6,475	20,625
5. Engineering Service and Administration	9,142	5,008	14,150
6. Compensation	-	21,721	21,721
7. Physical Contingency	5,417	6,612	12,029
Total	93,433	83,108	176,541

4.4 Preliminary Cost-Benefit Analysis

In order to ascertain the viability of the proposed Kotapanjang Hydro Electric Power Development Project, the preliminary cost-benefit analysis[1/] was performed as follows:

(1) Cost

It is estimated, from the above, that the total construction cost amounts to 176,541 x 10^3 US dollars. An interest cost (8.0 %) during construction period of five years is then calculated, whereas operation and maintenance cost is estimated at 1.5 percent of the construction cost. Economic life of the generating, metal and transmitting equipment being assumed at 40 years after installation, replacement cost of them is computed by adding up the sum of the above equipment cost and the cost for the civil works (10.0 %) necessary for replacement operation.

Consequently, the annual cost of the Project is worked out at 25.1 x 10^6 US dollars assuming the discount rate of 8.0 percent and the project life of 50 years.

(2) Benefit

Benefit of the proposed Project is evaluated for power value (kW-value) and energy (KWh-value) on the basis of the most competitive oil-fired thermal plant (750 US dollar/kW) of 100 MW. As a result, power value is estimated at 109.3 US dollar per kW while energy value 0.064 US dollar per kWh.

1/ For gross criteria the construction cost per kW and the cost per kWh were calculated. The outcome shows that the former becomes 1,590 US Dollar and the latter 0.33 US Dollar, indicating sufficiently competitive in comparison with other hydro electric power projects in Indonesia.

The proposed installed capacity of the Kotapanjang power plant is 111,000 kW and the annual average energy production amounts to 532 x 10^6 kWh. Accordingly, the annual benefit is computed at 46.2 x 10^6 US dollars.

(3) Cost-Benefit Ratio (B/C)

Hence, the cost-benefit ratio of the Project is calculated at 1.84 from the above annual cost and benefit.

4.5 Transportation Plan

4.5.1 Transportation Conditions in the Project Area

The Province of Riau is surrounded by a moist belt facing the Straits of Malacca and a mountainous belt running along the Barisan Mountains. It is divided by four rivers, as shown in Fig. 4.16. Within this vast area there are only small population and a few cities, and transportation conditions cannot be said favorable.

The present condition of the road system is that the trunk route passing through Dumai, Pekanbaru and Padang and connecting Riau and the Province of West Sumatra is paved with asphalt, and maintenance of the road is in good conditions. Presently, 11-ton trucks and large buses are using the road frequently, with the maximum load being 15 tons.

Other major roads include those connecting Pekanbaru - Kirilanjao, Taluk Kuantan - Rengat and Rantau Berangin - Pasir Pengaraian with portions being unpaved.

In addition, there are roads connecting towns and villages, most of which are oiled roads or unpaved roads. Paths extend into the wilderness to considerable depth. Road improvement in Riau is being actively carried out in recent years and road conditions are showing rapid improvement. On the other hand, a route constituting part of the Sumatra Highway and connecting West Sumatra and the Province of Jambi, has already been put through, therefore, access from Padang - Solok - Kirilanjao - Muara Bungo to the Province of Riau has become more convenient. As for ports, the Dumai Port facilities are of the largest scale, followed by Pekanbaru Port on the Siak River and Rengat Port on the Inderagiri River. These provide bases for the sea transport. Further, rivers in Riau represent a transportation medium indispensable to the daily life of regional residents.

Dumai Port is the largest port in Riau as mentioned in the above, and is equipped with public unloading equipments in addition to petroleum loading equipment. The facilities are capable of accommodating ships of the 10,000 ton class and expansion of the facilities to accommodate 20,000 ton class ships is being contemplated. Pekanbaru Port is located midstream of the Siak River and is capable of accommodating 500 ton ships from the river mouth. It is surrounded by concrete bank walls. Padang Port is the largest port in Sumatra and is also the point of origin of the trunk route across Sumatra. It is also capable of accommodating ships of 50,000 to 70,000 tons. The bank structure is firm and the port is capable of loading/unloading heavy goods.

4.5.2 Method of Transportation of the Construction Materials

(1) Transportation Routes

There are four routes for transportation of the construction materials, machinery and equipment to the Project site (see Fig. 4.16).

- Route I : Dumai - Duri - Kandis - Minas - Pekanbaru - Bangkinang - Dam site
- Route II : Sungaisiak (Pekanbaru) - Bankinang - Dam site
- Route III : Padang - Bukittinggi - Dam site
- Route IV : Dumai - Duri - Kandis - Tandun - Dam site

(2) Conditions of the Routes

(a) Route I

The transportation of the construction materials, machinery and equipment in general is easy in this route, because the topography from the port to the Dam site is flat.

There is an road (so-called oil-road) of approximately 20 km between Dumai Port and Duri, and an asphalt-paved road with width of approximately 5 to 6.5 m between Duri and the Dam site. The distance between Dumai Port to the Dam site is approximately 299 km and there are approximately 42 bridges of various sizes on this route. There is no wooden bridge and even the small ones are constructed with H section steel, and accordingly the traffic of heavy goods of the 20 ton class is possible.

(b) Route II

The distance by land from the port to the Dam site is relatively short, of approximately 80 km. The transportation of construction materials, machinery and equipment in general and heavy goods is easy. On the other hand, the capacity of the Siak River (Pekanbaru Port) is limited to ships of the 1,000 ton class, and accordingly the equipment and materials transported from Jawa Island or imported from foreign countries shall be transhipped from the large-sized ship to a small-sized one in Dumai, Singapore, Jakarta, etc.

(c) Route III

The transportation of the construction materials, machinery and equipment through this route seems to be difficult, because the Barisan Mountains are located between the port and the Dam site, therefore being to cross area with steep slopes and curves. Nevertheless, there is a cement plant in Padang, and the cement produced therein is supplied to Pekanbaru and to the Dam site by land route.

(d) Route IV

The topography from the port to the Dam site is flat, and the section between Dumai and Duri is the same as the Route I. Nevertheless, the section between Kandis and Tandun is unpaved and part of this section consists of oil-road. The course of the Tandun and Dam site is asphalt-paved with width of the order of 3.5 m to 4.0 m, and consequently large vehicles must use the shoulders of the road when passing.

The distance from the Dumai Port to the Dam site is approximately 296 km, and there are 44 bridges of various sizes, including 25 wooden bridges, in this section. The wooden bridges are concentrated in the Tandun and Dam site section.

From the foregoing findings, the Route IV seems to be inadequate for transportation of the construction materials because it is narrow and contains many wooden bridges. Consequently it is eliminated from the study of the transportation routes.

(3) Conditions of Transportation

The following conditions can be considered for transportation of the construction materials and equipments.

1) Cement will be transported from Padang and Jakarta.

2) Reinforcing bars, structural steel and the like will be transported from Jakarta.

3) Turbines, generators, transformers, gates, penstock, power transmission and transforming equipment, etc., shall be imported from overseas.

(4) Method of Transportation

The following methods for transportation of construction materials seem to be appropriate, by taking into consideration the foregoing findings referring to the transportation routes, the state of things, conditions and other peculiarities of the said routes.

1) As for the cement, material originary of Padang will be transported by land from Padang to the Dam site by using the existing provincial road. The Routes I and II can be taken into consideration for transportation of cement originary of Jakarta.

2) The Routes I and II can be considered for transportation of the reinforcing bars, structural steel and the like.

3) Heavy goods such as turbines, generators, transformers, etc., will be transshipped to small ships (maximum capacity 1,000 tons) in the ports of Dumai, Singapore, Jakarta, etc., and will be transported by land via Route II after being landed in Pekanbaru. The bridges may be an obstacle against the land transportation of the heavy goods. There are 32 bridges between Pekanbaru and the Dam site, but the transportation of heavy goods is possible by providing reinforcing in approximately 16 of the aforesaid bridges. Such being the case, it is presumed that there is no problem for transportation of heavy goods in this route.

4) There are two alternatives for transportation of the imported materials excluding the heavy ones such as turbines, generators, transformers, etc. In the first alternative, they will be unloaded in the Dumai Port and will be transported by land via Route I. In the second alternative, they will be transshipped to small size ships in Dumai, Singapore and Jakarta and will be transported to the Dam site via Route II.

The methods of transportation to be adopted shall be decided by carrying out an economical study and by taking into consideration the relevant factors and circumstances.

4.6 Compensation and Road Relocation Survey

4.6.1 Land Acquisition and Compensation

From the Village Survey within the Project area, it was determined that there would be ten villages directly affected in Riau and West Sumatra Province due to creation of a dam reservoir. With the proposed high-water-level (H.W.L.) of 85 m, this reservoir area would become 120 km^2, resulting in a total of 2,644 houses (2,990 families) and a total cultivated land area of 8,989 ha being submerged.

For public facilities to be submerged the summary is given below:

Facilities / River	Market	Ferry	Offices	Police Station	Schools	Mosques	Total
Kampar Kanan River	6	6	20	5	34	68	139
Mahat River	-	1	9	1	4	8	23
Total	6	7	29	6	38	76	162

The inundated land and population distribution by Desa are summarized tentatively in the following table.

Table 4.10 Tentative Figures for Inundated Land and Population Distribution by Desa (H.W.L. = 85 m)

River	Name of Desa	Population	Family	Houses	Cultivated Land (ha)		
					Paddy Crop	Perennial Crop	Total
Kampar Kanan River	Gunung Bungusu	748	166	165	460	25	485
	Muara Takus1/	686	176	166 2/	105	331	436
	Koto Tuo	1,659	364	330	727	616	1,343
	Ponkai	1,122	267	250	687	647	1,334
	Batu Bursurat	3,531	810	722	673	1,907	2,580
	Tanjung Alai	940	199	173	311	103	414
	Muara Mahat	1,128	208	170	202	331	533
	Pulau Gadang	1,446	318	294	175	183	358
	Sub-Total	11,260	2,508	2,270	3,340	4,143	7,483
Mahat River	Tanjung Balit	1,622	288	195 2/	340	860	1,200
	Tanjung Pauh	1,025	194	179	184	122	306
	Sub-Total	2,647	482	374	524	982	1,506
	Total	13,907	2,990	2,644	3,864	5,125	8,989

Notes: 1/ CANDI (Buddhist Remains) of which elevation is 86.4 m would not be submerged.

2/ This figures are not the same as the total number of houses since some of them are above 85 m.

Source: For population "Penduduk Propinsi Daerah Tingkat I Riau Hasil Registras: Penduduk, 1981" Biro Pusat Statistik and for land "Land Use Map" provided by Dinas Agraria, Pekanbaru and Padang and then updated by the information of CAMAT office.

For these families to be submerged, there was a joint meeting between the Bappeda and the JICA Team for their resettlement. The outcomes of the meeting reveals that the following location would be alternative sites appropriate for their resettlement.

For the families in Riau Province,

- Bangkinang Transmigration Project
- Rokan IV Koto Transmigration Project, Ujungbatu
- Koto Tengh Transmigration Project
- Sungai Pagar Transmigration Project
- UPP Rubber Replanting and Plantation Project, Muara Mahat
- PTP II Rubber Plantation Project
- PTP VI Rubber Plantation Project

for those in West Sumatra Province,

- Pangkalan Koto Baru Transmigration Project
- PTP III Rubber Plantation Project, Koto Kampar

It is anticipated, therefore, that the programing and coordination for resettlement shall be duly made among the responsible organizations, such as Bappeda, PLN, Dinas Transmigrasi and PU.

4.6.2 Roads

(1) Roads to be Submerged

As the result of the creation of the reservoir, the existing provincial road of extended length of about 35 km from the Dam site to Tanjung Balit along the Kampar Kanan River and the Mahat River will be submerged.

Also the road of extended length of 32 km from Muara Mahat to Muara Takus along the Kampar Kanan River will be submerged, but houses located upstream of Muara Takus will remain intact, for which regular boat transportation should be planned. Since there is a gravel road going up to Ujung Batu through Bandar Picak located upstream, some improvements should be made in future to utilize this road.

(2) Relocation of Road

As regard relocated road to be submerged, following three alternative plans will be compared and studied (see Fig. 4.19):

(a) Route I (L ≒ 68 km)

A route passing through Korapadang, utilizing the existing small road.

(b) Route II (L ≒ 45 km)

This is a plan to construct a route at the left bank of the proposed Dam using some of existing roads, but necessiating the construction of a bridge over the reservoir.

(c) Route III (L ≒ 36 km)

This is a plan to construct the route at the right bank of the Dam with a comparatively short distance going through mountains, using some of existing roads.

Of the above mentioned three plans for the alternative route, the Route III with the shortest distance appears to be the most appropriate, when lakeside sightseeing potential, operation and maintenance of the reservoir area are taken into account. Nevertheless, the P.U. is now undertaking own studies of this alternative route separately, and the final decision will be made taking into account the opinion of the P.U.

Upon initiation of the Dam construction, access roads are to be provided at the left bank of the Dam for the public use, since the use of existing provincial roads would become impossible due to the works of dam excavation.

4.6.3 Mining Rights

There has been three mines development sites identified within the reservoir area. These are two lead mines and one fluorite mine, the both being given prospecting right only at present. However, at the stage of this Interim Report, their exact locations and production data except the information below have not yet been given by the Ministry of Mines and Energy. It is expected that detailed information would be provided in due course since the questionnaire was already sent to the Department concerned.

No./Location	Mineral	Owner
176/Sumbar	Lead (Pb)	P.T Harir Jaya Raya
164/Sumbar	Lead (Pb)	SU Sinar Timur Mining Corp.
212/Sumbar	Fluorite (F)	in process

4.7 Socio-Economic and Environmental Survey

This survey aims at identifying and assessing the primary impact of the proposed Dam Project upon adjacent areas. For this purpose, socio-economic and environmental surveys were undertaken as follows: Population and family data were derived from National Census Statistics and broken down by Kabupaten (Regency), Kecamatan (Sub District) and Desa (village). For detailed analysis of the social situation in the proposed Project site and its neighborhood, a comprehensive village survey was carried out in cooperation with CAMAT (Head of Kecamatan) and KEPALA DESA (Village Head). This survey focused on such major elements as area, demography, housing, educational and religious facilities, economic activities, infrastructure and agricultural cultivation. It is envisaged that results will lead to an overall picture of the Project area and thus to a valid assessment of social conditions. Transmigration data under REPELITA I, II and III were also obtained to examine policies and performance and to estimate the future potential for receiving migrants in the vicinity of the Project area and Riau.

Environmental information was collected and scrutinized on natural, physical and biological conditions in order to assess the impact of the proposed dam scheme upon adjacent areas. It comprises population distribution and density, land use and farm land distribution, forestry, animal and fishery resource data. Environmental consideration was also given to reservoir, downstream and rural area after completion of the proposed Dam Project. A tentative plan for resettlement was considered for the people from inundated areas to neighboring alternative areas.

Survey works were carried out by JICA expert from 5 September to 19 October, 1982 in collaboration with PLN counterparts.

For data collection, PLN issued letters to organizations concerned requesting cooperation in providing the JICA expert with the necessary data and information. Detailed discussions were then held with relevant personnel of institutes and organizations in Jakarta and

Pekanbaru. The JICA expert also undertook field investigations by visiting local offices, villages and the Project site and, in particular, carried out the Village Survey in the form of a questionnaire sent to respective CAMAT and KEPALA DESA concerned..

Data and information obtained are being analyzed and processed. Some of the findings derived are tentatively given hereunder, however.

4.7.1 Social Aspect of the Project Area

The proposed Project area consists administratively of two Kecamatans, namely Kecamatan XIII Koto Kampar of Riau Province and Kecamatan Pangkalan Koto Baru of West Sumatra Province. The former is located along the Kampar Kanan River and the latter the Mahat River. The following is to summarize the overall situation of each of the two Kecamatans:

(1) Kec. XIII Koto Kampar

Kecamatan XIII Koto Kampar lies at the far end of the western part of the Riau Province, bordering West Sumatra province. It belongs to Kabupaten Kampar, and is comprised of thirteen administrative Desa with a total area of 1,750 km^2.

The central part of the Kecamatan are cut through from west to east by the Kampar Kanan River, along which capitals of all villages are located. The Mahat River, another tributary of the Kampar River, runs through the Kecamatan and meets at Desa Muara Mahat with the Kampar Kanan River.

As of 1981, the total population of the Kecamatan was 17,976. Compared to the total population in 1978 of 15,528 persons, the annual growth rate is 5.0 percent. The total number of households is 3,891, with an average 4.1 members per family. The density of the population is 10 people per km^2, making the region manpower scarce.

Because of this labor shortages in Kabupaten Kampar transmigration from Java has been encouraged. Between 1979 and 1981 there were 10,000 families settled in transmigration projects at Tanjung Medan, Pasir Pengarayan, Rokan IV Koto and Siabu. Although there has been no transmigration project in Kecamatan Kampar yet, migration impact including local migration has never been negligible.

The majority of the population are engaged in agricultural farming. Although production data are not available Kecamatan wise, the most important food crop is rice (paddy) in this region. Commercial commodities which are significant to this Kecamatan are rubber, orange, cloves and coffee of which the total area amounts to only 10.0 percent of the whole Kecamatan region.

In respect to religion, the overwhelming majority of the population are Islamic whereas Buddhist and Catholic account for minimal proportion.

(2) Kec. Pangkalan Kota Baru

Kecamatan Pangkalan Kota Baru is located in the north-eastern part of West Sumatra, facing the boundary of Riau Province. The Mahat River, on which most capitals of Desas reside, flows through the Kecamatan and meets the Kampar Kanan River. The road network in the Kecamatan is relatively upgraded, linking Padang, Bukitinggi of West Sumatra and Pekanbaru and Dumai of Riau. Goods and population mobility are of extremely high strongly supporting the economic and commercial activities of two provinces.

The Kecamatan Pangkalan Koto Baru has six administrative Desa with twenty-six sub-Desa. The total population is 18,270 persons distributed over 1,021 km^2, for an average of 18 people per km^2. Pangkalan Kota Baru, the capital of the Kecamatan, accounts for about 50.0 percent of the total population indicating rapid urbanization phenomenon in recent years.

Agricultural cultivation is a major economic activity in this region. Rice, rubber, coconut and cloves are the main crops.

The total cultivated land accounts only for 2.0 percent in the Kecamatan leaving remaining area untapped. The farmers are small land-holders with an average area of two hectares.

Social factors regarding the number of residences, shops, offices, schools, and mosques in Kecamatan XIII Koto Kampar and Kecamatan Pangkalan Kota Baru are summarized as follows:

Table 4.11 Social Investigation of Project Area

Desa	Residence		Commercial Activities			Governmental Facilities		Education	Religious Facilities
	Families	Houses	Market	Shops	Ferry	Offices	Police/Army	Schools	Mosques
Kec. XIII Kota Kampar, Riau									
1. Pulau Gadang	318	294	1	61	2	1	-	6	8
2. Muara Mahat	208	170	2	45	-	4	2	7	2
3. Tanjung Alai	199	173	-	17	1	2	-	2	5
4. Batu Bersurat	810	722	1	50	1	7	2	9	24
5. Ponkai	267	250	-	9	-	2	-	2	8
6. Kota Tuo	364	330	1	98	1	1	-	4	12
7. Muara Takus	176	171	1	30	1	2	1	2	5
8. Gunung Bungsu	166	165	-	6	-	1	-	2	4
9. Tanjung	450	360	1	50	3	1	-	3	9
10. Tabing	224	262	1	10	1	1	-	1	5
11. Gunung Malelo	226	173	1	14	1	1	-	2	4
12. Siberuang	443	425	1	20	1	1	-	4	10
13. Balung	112	121	-	8	-	1	-	1	4
Total	3,963	3,616	10	418	12	25	5	45	100
Kec. Pangkalan Kota Baru, West Sumatra									
1. Pangkalan	2,052	1,639	1	170	-	15	3	13	22
2. Manggilang	449	392	N.A.	58	N.A.	4	-	4	4
3. Kota Alam	452	391	N.A.	51	N.A.	3	-	3	6
4. Tanjung Balit	288	219	1	49	1	4	-	2	4
5. Tanjung Pauh	194	179	-	34	-	5	1	2	4
6. Gunung Malintang	791	709	N.A.	71	N.A.	5	4	3	7
Total	4,401	3,529	-	433	-	36	4	27	47

Note: N.A.: Not available
Source: Data provided by the CAMAT office and the Kepala Desa.

(3) CANDI (Muara Takus Temple)

The historical remains of an old temple have been discovered near Muara Takus Desa in Kecamatan XIII Koto Kampar. It is located at 0°21' north latitude to 100°39' east longitude, approximately 3 km from Muara Takus along the Kampar Kanan River.

The temple remains were first observed in 1900 and through successive studies it was identified as having been built in the eleventh and twelfth centuries. The present inference about the temple read that in those days Muara Takus was the center of Buddhist culture as well as commercial trade activities of the Sriwijaya Kingdom, which then extended its territory toward the Jambi and Palembang of today. The remains consist of a complex of a few structures, stupa, candi tua and others features. Mehligai Stupa, one of the highest 14.45 m, has already been rehabilitated with the assistance of the Government and seven more are expected to be reconstructed by 1988.

Details of the location of CANDI and its elevation were surveyed by the JICA Team and the results are shown below.

According to results of the topographic survey, the elevation of CANDI is 86.4 m above sea level, which is well above the high-water-level (H.W.L.) of the proposed dam reservoir.

The Provincial Government envisages that CANDI and related structures will play a central role in tourism development; absorbing not only local people but also tourists from abroad.

4.7.2 Environmental Aspect

Forestry

The forest resource of Riau consist of Tropical Rain Forest categorized by three basic types: hill forest, peat swamp forest and mangrove. There is no adequate overall forest inventory for Riau.

Nevertheless, a recent study of the total forest resource estimates hill forest to be 1,661,100 ha or 49,833,000 m^3 and peat swamp forest to be 3,053,000 ha or 76,325,000 m^3 resulting in a total of 4,714,100 ha or 126,158,000 m^3 respectively. Annual log production in 1980/81 is recorded 1,620,701 m^3.

The local government has been undertaking afforestation schemes to cope with forest exploitation practices and to replant more valuable species, particularly Meranti, Ramin and Darian Burong. These schemes completed an area of 550 ha as of 1981/82.

According to an officer of Dinas Kehutanan (Forestry Department), the forests along the Kampar Kanan River and Mahat River are registered as conservation areas with only limited areas concessioned for survey practices. Thus, there will be no compensation for forestry resources after creation of the Dam reservoir in this region.

Aquaculture

Fishing in Riau is comprised of marine fishing, freshwater fishing and fishpond farming, of which marine fish production accounted for 93 percent in 1981. River fishing has been practiced to a limited degree mainly due to scarce manpower available. Fishpond farming is a recent attempt still at the experimental stage.

For Kabupaten Kampar, fish production during 1977 and 1981 is given below:

(ton)

	1977	1978	1979	1980	1981
Freshwater	1,900.4	2,247.5	2,264.9	2,815.2	2,832.8
Fishpond	33.3	29.3	23.0	81.2	91.1
Total	1,933.7	2,276.8	2,287.9	2,896.4	2,923.9

According to Dinas Perikanan, fish production on the Kampar Kanan River and Mahat River is estimated to be 40 percent of the freshwater production above or 1,120 tons in 1981. The major fish species are Ikan Gabus, Ikan Lais, Ikan Sepat Siam, Ikan Tambakan, Ikan Lainnya and Udang Tawar (shrimp), all of which are not so called "excursion" fish. Although there are few pure fishermen in Kabupaten Kampar, it is reported that there are about 3,000 fish farmers operating along the two rivers.

With the aim of intensifying freshwater fish culture development, Dinas Perikanan expressed a plan to make use of the dam reservoir to be created by the proposed project as a fish farming pond of large scale. It is envisaged the dam reservoir would be used for valuable fish species such as Tawes, Sepat Siam, Nila, Gurame, Tambakan and Udang Galah. It is strongly expected that the dam project would have an immense positive impact upon fish production and the cash income of fish in this area.

Flood Control and Irrigation

Potential water resources in Riau await prompt exploitation. However, frequent flooding in major rivers causes serious disruption of economic and social activities in the Province. Taking Kampar Kanan River as an example, its downstream areas have suffered greatly from repeated floodings over the year. According to recent land and water study, the flood area of Kampar Kanan River is estimated at approximately 40,000 ha, most of which is of high agricultural potential.

Urgent flood control measures are of a vital for regional development. On this connection, the proposed Dam Project appears to be a good solution to flooding in the region.

Another use of abundant water resources in Project area is for irrigation purposes. At present, riceland occupies about 140,000 ha (1.5 %) of the Province, of which around 86,000 ha is used for rice grown under sawah conditions. Although the majority of sawah land is in tidal and swamp areas, a total of about 20,000 ha of riceland is irrigated from small streams.

In case of Kampar Kanan River, the government plans to implement a 2,500 ha irrigation project at Rumbio Panalongan and a 5,000 ha project at Kuamany, within which thirty-five existing simple irrigation projects are operation. For this purpose the proposed Kotopanjang Project would provide the benefit of supplying an additional volume of water to meet irrigation demand during the dry season.

Wildlife

It is revealed that there are four constituted wildlife reserves in Riau province. These are the reserves in Kerumutan (120,000 ha), Pulan Berkah (500 ha), Pulau Burong (200 ha) and Pulau Laut (400 ha) protecting major wildlife such as elephants, tapir and rhinocerous. In connection with the proposed Project, it has been confirmed that no wildlife reserve is located in the reservoir to be created and that dam construction would not have any effect on wildlife.

CHAPTER 5

HOME WORK PLAN

Chapter 5 Home Work Plan

5.1 Work Schedule

After completion of the Interim Report, home work in Japan is scheduled to be implemented.

According to the Scope of Work, a draft of the final report is scheduled to be completed within four months of completion of the detailed field investigation, and the final report is scheduled to be completed within two months of completion of deliberations on the draft of the final report discussions between the PLN and the JICA Mission, and amendments thereto.

However in view of the delay in mapping of the aerial photographs, the completion date for the final report will be substantially delayed.

Major items of home work in Japan scheduled to be covered are as follows.

(1) Mapping of Aerial Photogrammetry

After completion of aerial photography, an expert of the JICA Mission is scheduled to be sent to Indonesia.

(2) Geological Study

- Analysis of drilling investigation results
- Analysis of permeability test results
- Analysis of grouting test results
- Analysis of seismic prospecting results
- Preparation of geological maps for proposed Project area (scale 1:10,000)

- Geological evaluation of foundation for structures
- Evaluation of quarry sites and borrow sites
- Study on dam foundation excavation line
- Earthquake investigation

(3) Material Study

- Sorting and analysis of material test results data (borrow site material tests and rock microscopic tests)
- Evaluation of quality and quantity of aggregates

(4) Meteorological and Hydrological Study

Integration and sorting of meteorological and hydrological data

(5) Economic Study

Evaluation of economic data obtained for Riau

(6) Power Supply/Forecast Study

- Detailed forecast based on collected data and information
- Study on detailed development plan and timing for the proposed Project based on PLN's data
- Assessment on future schemes for transmission line routes

(7) Determination of Optimum Development Plan

- Comparative evaluation for high water levels and scale of installed capacity at the proposed site selected.
- Preparation of preliminary design for optimum power development plan; and estimation of construction costs.

(8) Economic and Financial Analysis

Economic evaluation and financial analysis for optimum power development plan.

5.2 Editing and Preparation of Final Report

The feasibility survey results will be compiled into two volumes consisting of a "Main Report" and "Appendix."

The Main Report will comprehensively describe on the findings of the investigation and study. The Appendix will summarize supporting data and detailed topography, geology, material and hydrology evaluation results for the proposed Project site.

Summary, Conclusions and Recommendation

Principal Dimensions of the Kotapanjang Project

CHAPTER 1 INTRODUCTION

CHAPTER 2 ECONOMY IN RIAU

CHAPTER 3 POWER SUPPLY AND DEMAND

CHAPTER 4 SITE CONDITIONS

CHAPTER 5 SCHEME OF DEVELOPMENT

CHAPTER 6 FEASIBILITY DESIGN OF STRUCTURE

CHAPTER 7 CONSTRUCTION SCHEDULE AND PROCEDURE

CHAPTER 8 COST ESTIMATE

CHAPTER 9 ECONOMIC AND FINANCIAL ANALYSIS

APPENDIX

Table 2.1 List of Main Bench Marks

No.	Name	Elevation	Location
1	△ 636	141.0	Muara Mahat
2	△ 368	146.1	Pangkalan Kota Baru
3	△ 479	225.3	Pulaugadang
4	TBM-5	55.542	In the Rotary in Rantau Berangin (concrete post)
5	TBM-4	50.830	BINA MARGA No.265, left bank of downstream of the Dam site
6	BM-D	55.099	Left bank of upstream of the Dam site (JICA setup)
7	TMB-3	65.064	BINA MARGA, upstream of the Kampar Kanan river bridge (concrete post)
8	TBM-2	68.785	BINA MARGA, downstream of the Mahat river bridge (concrete post)
9	PKB-23	66.114	Tanjungpauh (Kilo-post PKB 105 km)
10	PKB-9-12	82.261	Tanjungbalih (Kilo-post PKB 121 km)
11	PKB-4	89.828	Abutment of the private house at left side bank of Bangkalan Kota Baru bridge
12	TP-1	98.722	Abutment of the flag pole of Maggilang Wali Nagari
13	TP-2	87.500	CANDI Muala Takus

Table 2.4 Quality Classification of Foundation Rock

Classification	Characteristics
A	Rock-forming minerals are fresh and not weathered or altered. Joints and cracks are very closely adhered with no weathering along their planes. A clear sound is emitted when hammered.
B	Rock-forming minerals are weathered slightly or partially altered, the rock being hard. Joints and cracks are closely adhered. A clear sound is emitted when hammered.
C_H	Rock-forming minerals are weathered but the rock is fairly hard. The bond between rock blocks is slightly reduced and each block is apt to be exfoliated along joints and cracks by strong hammering. Joints and cracks sometimes contain clay and other material which may be coloured by limonite. A slightly dull sound is emitted when hammered.
C_M	Rock-forming minerals are weathered and the rock is comparatively hard. Exfoliation of the rock occurs along joints and cracks by normal hammering. Joints and cracks sometimes contain clay and other material. A somewhat dull sound is emitted when hammered.
C_L	Rock-forming minerals are weathered and the rock is slightly soft. Exfoliation of the rock occurs along joints and cracks by light hammering. Joints and cracks contain clay. A dull sound is emitted when hammered.
D	Rock-forming minerals are weathered, and rock is very soft. There is virtually no bond between rock blocks, and collapse occurs at the slightest hammering. Joints and cracks contain clay. A very dull sound is emitted when hammered.

Table 2.7 Water Quality of the Kampar Kanan River

Substances	Unit	No. 1	No. 2
Sampling Date	-	Oct.7,'82	Oct.31,'82
Air Temperature	°C	27.5	30.4
Water Temperature	°C	25.5	26.1
Discharge	m^3/s	177.0	524.0
pH Value	-	6.7	6.2
Suspended Sediment	mg/l	16.0	19.0
Calcium VI (Cr VI)	"	0.05	0.09
Copper (Cu)	"	0.04	0.03
Zinc (Zn)	"	0.35	0.07
Iron (Fe)	"	0.02	0.33
Lead (Pb)	"	0.22	0.26
Phosphate (Po)	"	5.10	7.10
Nickel (Ni)	"	0.01	0.03
Phenols	"	0.08	1.83
Fluoride (F)	"	0.01	0.36

Table 2.8 Suspended Sediment of the Kampar Kanan River

No.	Date	Discharge	Suspended Sediment (ppm)	Sampling Sites
1	Oct.7,'82	177	8	Left Dx20%
	"	"	16	Left Dx50%
	"	"	8	Center Dx20%
	"	"	16	Center Dx50%
	"	"	6	Right Dx20%
	"	"	12	Right Dx50%
2	Oct.11,'82	344	10	Left Dx20%
	"	"	6	Left Dx50%
	"	"	10	Center Dx20%
	"	"	8	Center Dx50%
	"	"	10	Right Dx20%
	"	"	8	Right Dx50%
3	Oct.16,'82	215	3	Left Dx20%
	"	"	4	Left Dx50%
	"	"	4	Center Dx20%
	"	"	6	Center Dx50%
	"	"	2	Right Dx20%
	"	"	6	Right Dx20%
4	"	224	4	Left Dx20%
	"	"	2	Left Dx50%
	"	"	4	Center Dx20%
	"	"	4	Center Dx50%
	"	"	5	Right Dx20%
	"	"	2	Right Dx50%
5	Oct.31,'82	524	20	Left Dx20%
	"	"	19	Center Dx20%
	"	"	12	Right Dx20%
6	"	405	10	Left Dx20%
	"	"	8	Left Dx50%
	"	"	8	Center Dx20%
	"	"	7	Center Dx50%
	"	"	7	Right Dx20%
	"	"	8	Right Dx50%
7	Nov.1,'82	264	4	Left Dx20%
	"	"	7	Left Dx50%
	"	"	6	Center Dx20%
	"	"	7	Center Dx50%
	"	"	2	Right Dx20%
	"	"	4	Right Dx50%
8	Nov.2,'82	424	39	Left Dx20%
	"	"	36	Center Dx20%
	"	"	38	Right Dx20%

Table 2.9 Results of River Discharge Gauged (1)

River : Kampar Kanan River
Gauging Station: Rantau Berangin
Catchment Area :

No.	Date	Water Level (m)	Section (m^2)	Velocity (m/s)	Discharge (m^3/s)
1	Oct.4,'82	0.78	291.02	0.354	103.18
2	"	1.02	319.86	0.522	167.12
3	Oct.7,'82	1.14	317.39	0.565	179.22
4	"	1.55	368.33	0.845	312.25
5	"	1.57	376.50	0.831	312.72
6	Oct.11,'82	1.82	398.37	0.898	357.64
7	"	1.72	376.55	0.847	318.86
8	Oct.12,'82	1.10	292.95	0.472	138.22
9	"	0.97	284.66	0.445	126.54
10	"	1.03	294.74	0.481	141.83
11	Oct.27,'82	0.69	270.50	0.292	78.90
12	Oct.28,'82	0.72	271.30	0.327	88.62
13	Oct.29,'82	0.76	258.90	0.384	99.30
14	Oct.30,'82	0.67	257.10	0.362	92.98
15	"	2.35	438.60	1.335	505.61
16	"	2.09	395.80	1.014	401.47
17	Oct.31,'82	1.91	373.70	0.967	361.44
18	Nov.1,'82	1.51	339.40	0.825	280.10
19	"	1.64	348.00	0.880	306.30
20	Nov.2,'82	2.06	392.70	1.092	428.81
21	"	2.24	409.90	1.201	492.20

(to be cont'd)

Table 2.10 Results of River Discharge Gauged (2)

River : Kampar Kanan River
Gauging Station: Danau Bingkuang
Catchment Area : 4,035 km^2

No.	Date	Water Level (m)	Section (m^2)	Velocity (m/s)	Discharge (m^3/s)
1	Nov.11,'82	1.55	264.2	1.015	268.029
2	"	1.55	264.7	0.902	264.700

Table 2.11 Results of River Discharge Gauged (3)

River : Mahat River
Gauging Station: Lubuk Sipopay
Catchment Area : 879.3 km^2

No.	Date	Water Level (m)	Section (m^2)	Velocity (m/s)	Discharge (m^3/s)
1	Nov.10,'82	1.37	72.8	0.869	63.234

Table 2.12 Results of River Discharge Gauged (4)

River : Kampar Kanan River
Gauging Station: Kotapanjang Dam Axis 4
Catchment Area : 3,337 km^2

No.	Date	Water Level (m)	Section (m^2)	Velocity (m/s)	Discharge (m^3/s)
1	Oct.13,'82	1.28	233.400	0.476	111.075
2	"	1.29	227.030	0.488	110.847
3	Oct.29,'82	1.31	228.975	0.477	109.174
4	Oct.30,'82	1.25	232.270	0.441	102.409
5	"	1.09	224.440	0.407	91.369
6	Nov.12,'82	1.08	229.280	0.415	95.257
7	"	1.95	283.900	0.835	236.990
8	Nov.13,'82	1.90	271.100	0.824	223.260
9	"	1.50	259.800	0.621	161.262
10	Nov.15,'82	1.59	157.640	0.667	171.787
11	"	2.55	330.300	1.000	330.500
12	"	2.73	347.100	1.014	351.900
13	"	3.04	370.100	1.131	418.700
14	Nov.14,'82	2.61	294.900	0.868	256.100

Table 2.9 (cont.)

No.	Date	Water Level (m)	Section (m^2)	Velocity (m/s)	Discharge (m^3/s)
22	Nov.2,'82	2.23	393.20	1.146	450.71
23	Nov.3,'82	1.46	332.70	0.768	255.63
24	"	1.50	337.70	0.790	266.70
25	Nov.4,'82	1.18	299.00	0.622	185.97
26	"	1.17	298.10	0.613	182.80
27	"	1.21	303.70	0.629	190.97
28	Nov.5,'82	1.29	316.25	0.725	229.32
29	"	1.45	319.10	0.841	268.21
30	"	1.57	337.60	0.889	300.02
31	"	1.74	358.90	0.979	351.52
32	"	1.87	356.50	0.976	347.93
33	"	1.73	357.10	0.937	334.58
34	"	1.64	347.30	0.882	306.44
35	Nov.6,'82	1.59	337.80	0.829	280.19
36	Nov.7,'82	1.45	333.20	0.772	257.09
37	"	1.37	313.25	0.697	218.43
38	Nov.8,'82	2.19	388.40	1.190	462.17
39	"	2.25	408.50	1.193	487.47
40	"	2.12	392.40	1.127	442.20

Table 3.2 Installed Capacity of PLN in Riau Province, 1981

Power Station	Installed Capacity (kW)	District (Kebupaten)
Pekan Baru	12,630	- Pekan Baru
Dumai	1,637	- Dumai
Bangkinang	520	Kampar
Air Tris	40	
Rengat	656	Indragiri Hulu
Air Molek	110	
Teluk Kuantan	300	
Tembilahan	672	- Indragiri Hilir
Duri	110	Bengkalis
Bagan Siapiapi	1,042	
Bengkalis	787	
Selat Panjang	220	
Total	18,724	

Table 3.3 Installed Capacity of Private Power Plant in Riau Province, 1980/81

District	Installed Cap. (kVA)	Available Cap. (kW)	Nos. of Private Power Plant
Pekanbaru	196,669	157,335	24
Dumai	79,060	63,248	6
Kampar	554	443	3
Indragiri Hulu	1,367	1,094	8
Indragiri Hilir	967	773	10
Bengkalis	545	436	9
Total	279,162	223,329	60

Table 3.4 Installed Capacity of PLN in West Sumatra Province, 1981

Power Station	Installed Capacity (kW)
Padang	21,090
Solok	1,042
Sijunjung	320
Sungai Penuh	1,102
Painan	806
Pariaman	706
Surantih I,II	80
Sulit Air	120
Tapan	40
Koto Anau	160
Lempu	80
Sub-Total (1)	25,546
Batang Agam	10,500
Lubuk Sikaping	210
Padang Luar	4,560
Panti	40
Talu	40
Sub-Total (2)	15,350
Total (1)+(2)	40,896

Table 3.5 Installed Capacity of Private Power Plant in West Sumatra Province, 1980/81

District	Installed Cap. (kVA)	Available Cap. (kW)	Nos. of Private Power Plant
Padang	22,302	17,841	32
Solok	15,906	12,724	3
Bukit Tinggi	946	756	15
Total	39,154	31,321	50

Table 3. 6 Historical Record in Riau Province (excluding Kepulauan Riau)

(1) Riau Province

Year	1973	1974	1975	1976	1977	1978	1979	1980	1981	Annual Average Growth Rate (%)
Sold Energy (MWh)	12,248	13,814	15,589	16,659	18,232	22,177	25,407	35,110	45,800	18
Peak Load (kW)	2,766	5,460	4,164	4,443	5,218	6,259	7,435	10,655	12,351	20
Generated Energy (MWh)	15,079	16,146	20,363	22,201	24,149	29,578	31,374	45,424	56,200	18
Loss (MWh)	2,831	2,332	4,774	5,542	5,917	7,401	5,967	10,314	10,400	—
Loss (%)	19	14	23	25	25	25	19	23	19	—
Load Factor (%)	50.5	28.9	42.7	42.8	39.9	40.0	39.0	37.6	42.3	—
Installed Capacity (kW)	4,396	6,912	7,036	9,772	10,285	18,954	19,164	18,985	18,724	20
Available Capacity (kW)	*	*	*	*	9,160	14,410	14,410	14,410	17,224	17

Date Source: PLN Wilayah III Head Quarter Office in Padang & Proyek Head Quarter Office in Bukit Tinggi

Note : * Data is not available

Table 3.7 Historical Record in West Sumatra Province

Year	1973	1974	1975	1976	1977	1978	1979	1980	1981	Annual Average Growth Rate (%)
Sold Energy (MWh)	22,327	25,784	28,324	31,002	35,598	38,988	48,361	53,097	70,921	16
Peak Load (kW)	6,225	7,772	7,896	8,353	10,279	12,414	15,553	19,708	23,992	18
Generated Energy (MWh)	29,444	35,705	40,737	44,682	52,894	60,421	71,566	91,140	95,861	16
Loss (MWh)	7,117	9,921	12,413	13,682	17,296	21,433	23,205	38,043	24,940	—
Loss (%)	24	28	30	31	33	35	32	42	26	—
Load Factor (%)	0.41	0.38	0.41	0.42	0.40	0.36	0.35	0.31	0.33	—
Installed Capacity (kW)	11,017	12,488	12,368	22,678	28,754	36,201	36,201	37,416	40,896	18
Available Capacity (kW)	*	*	*	15,040	19,166	25,766	25,766	33,070	34,542	18

Note: * Data is not available

Fig. 2.2 Location Map of Ground Surveying of the Dam Sites

S=1 : 12,500

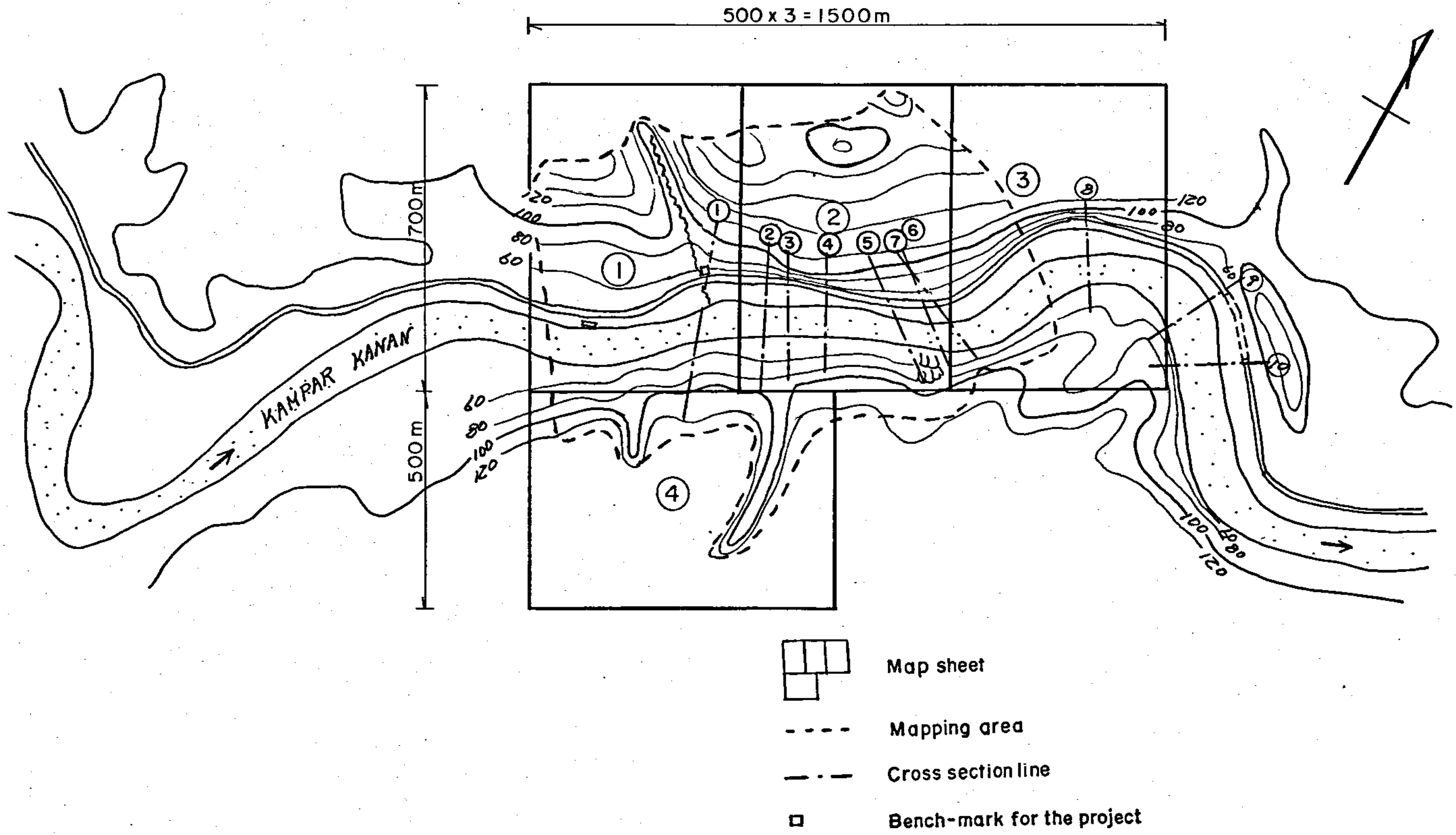
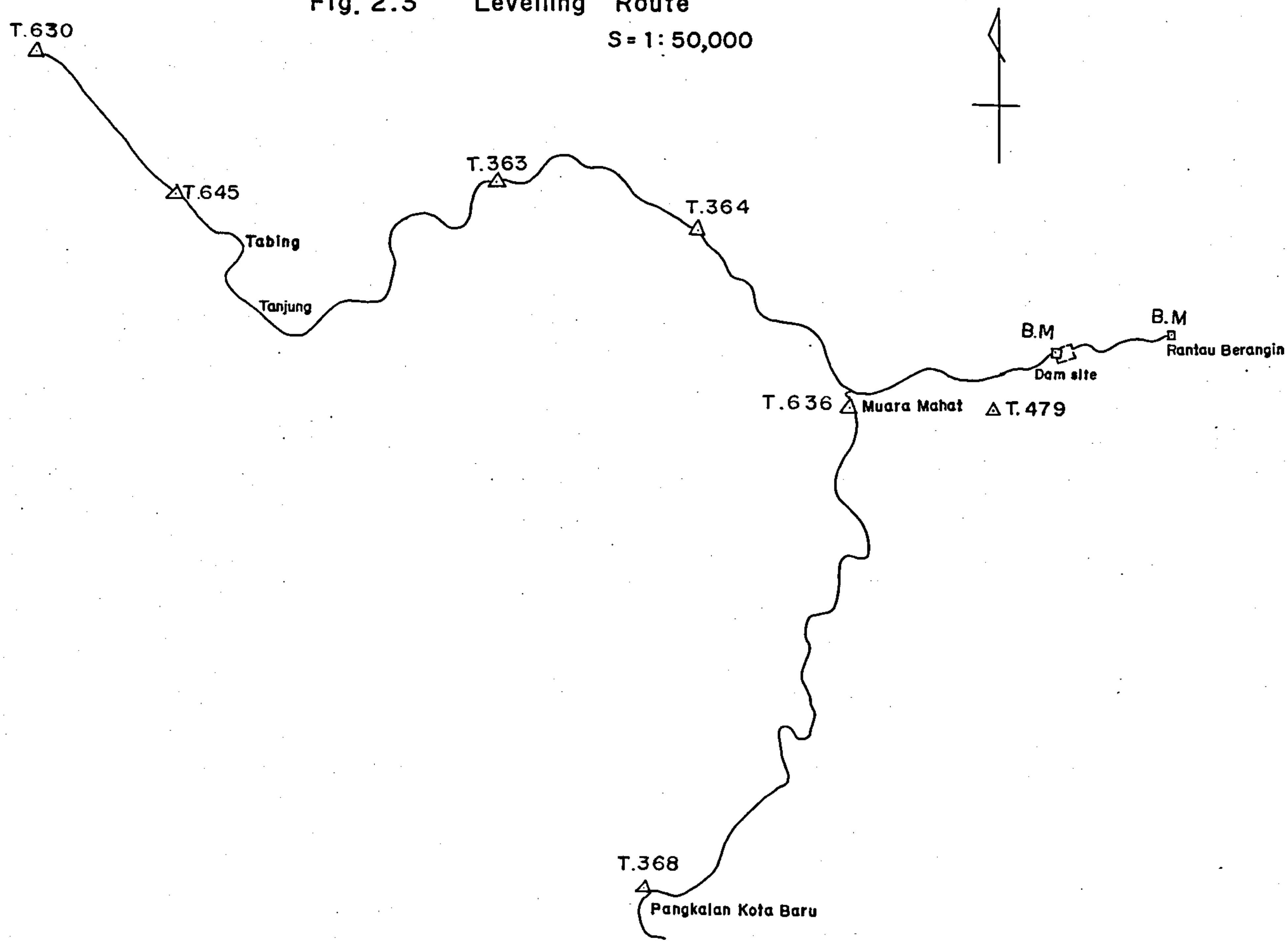


Fig. 2.3 Levelling Route
S = 1:50,000



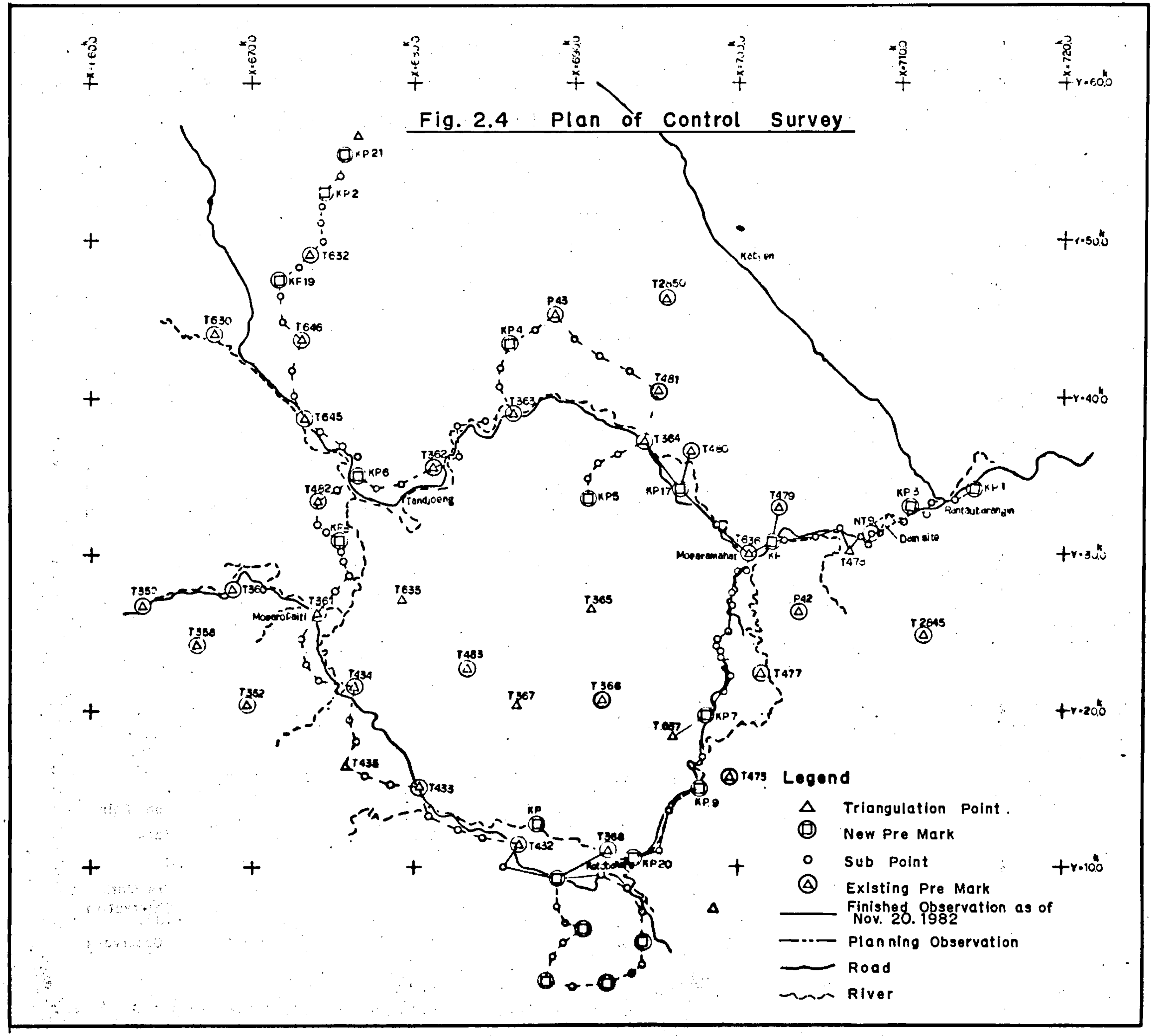


Fig.2.4 Plan of Control Survey

Fig. 2.5 OUTLINE OF GEOLOGY IN PROJECT SITE (S = 1/25.000)

17

Fig. 2.6 EXTEND FIGURE OF TEST ADIT

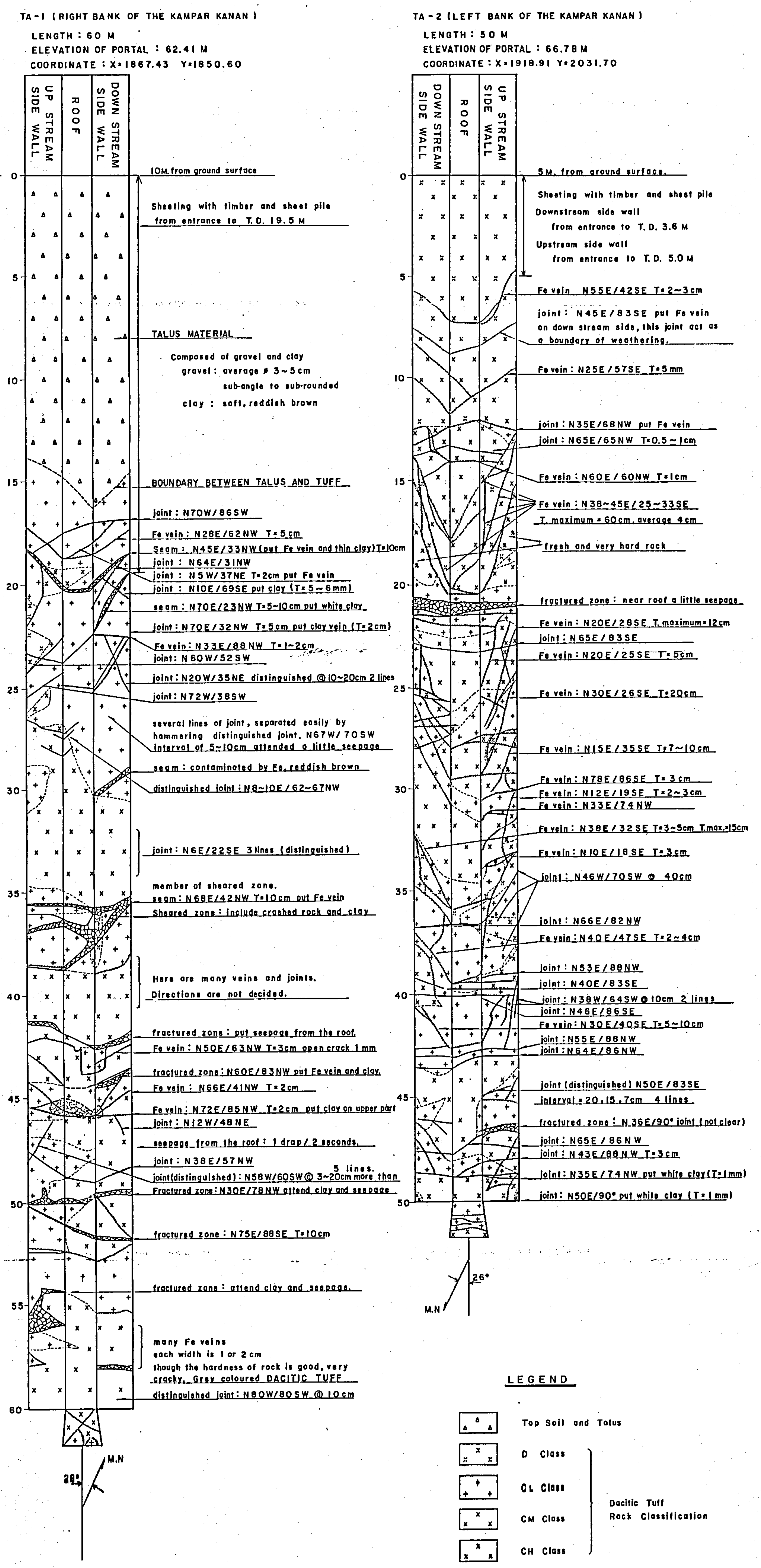


Fig. 2.7 : GEOLOGICAL PROFILE OF AXIS I

Fig.2.7 Geological Profile of Axis 1

Fig. 2.8 GEOLOGICAL PROFILE OF AXIS 3

Fig.2.8 Geological Profile of Axis 3

2

Fig. 2.9 GEOLOGICAL PROFILE OF AXIS 4

Fig. 2.10 LOCATION MAP OF QUARRY SITES (S=1/25,000)

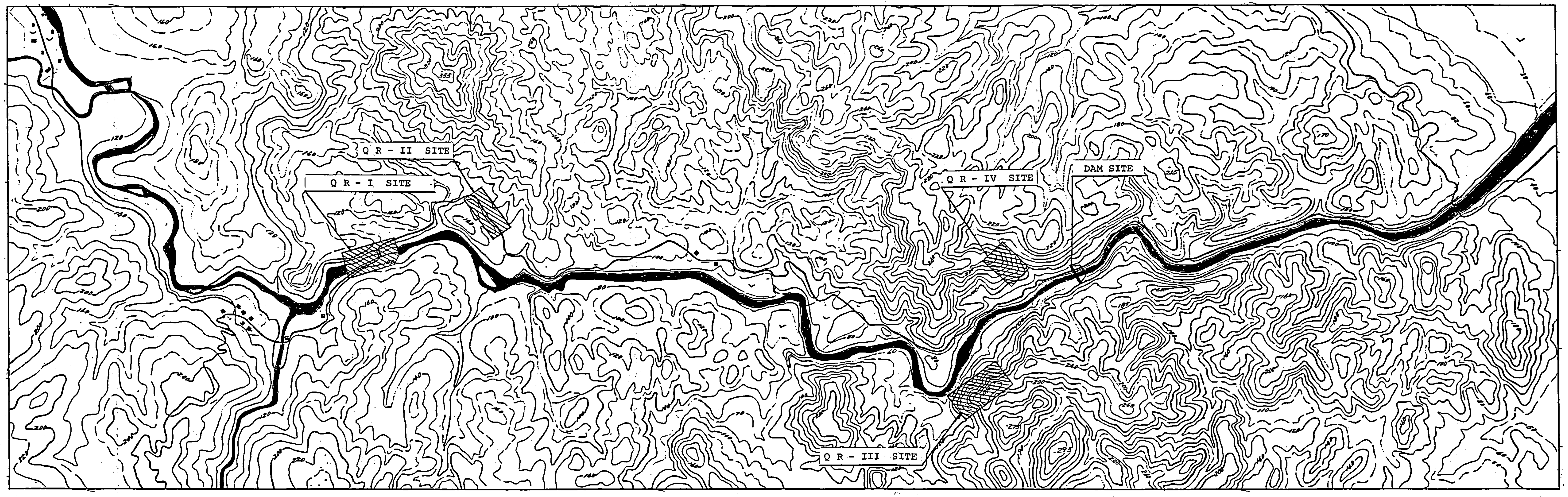
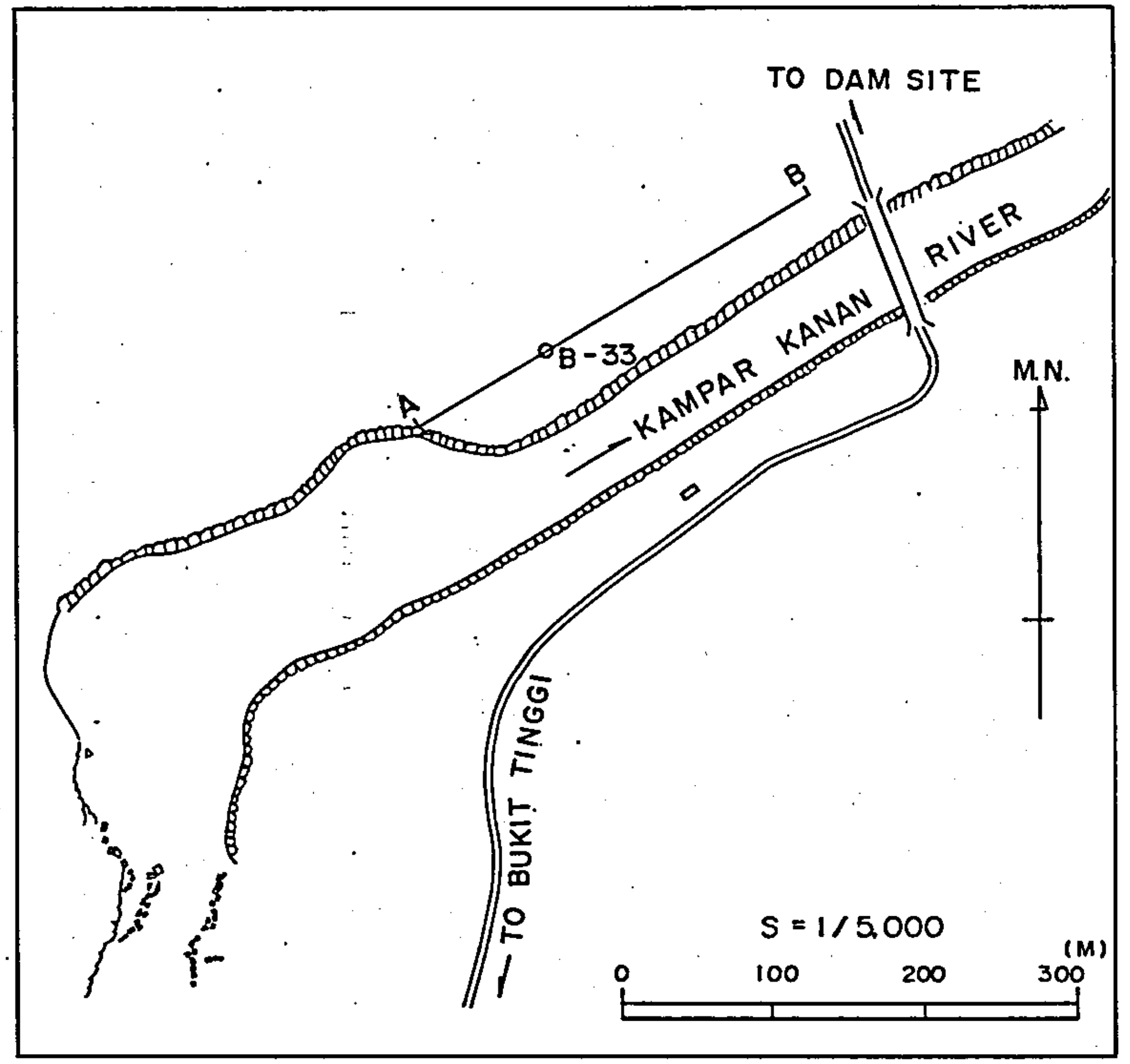


Fig.2.10 Location Map of Quarry Sites

Fig. 2.11a LOCATION MAP OF GEOLOGICAL SURVEY QUARRY SITE (QR - I SITE)

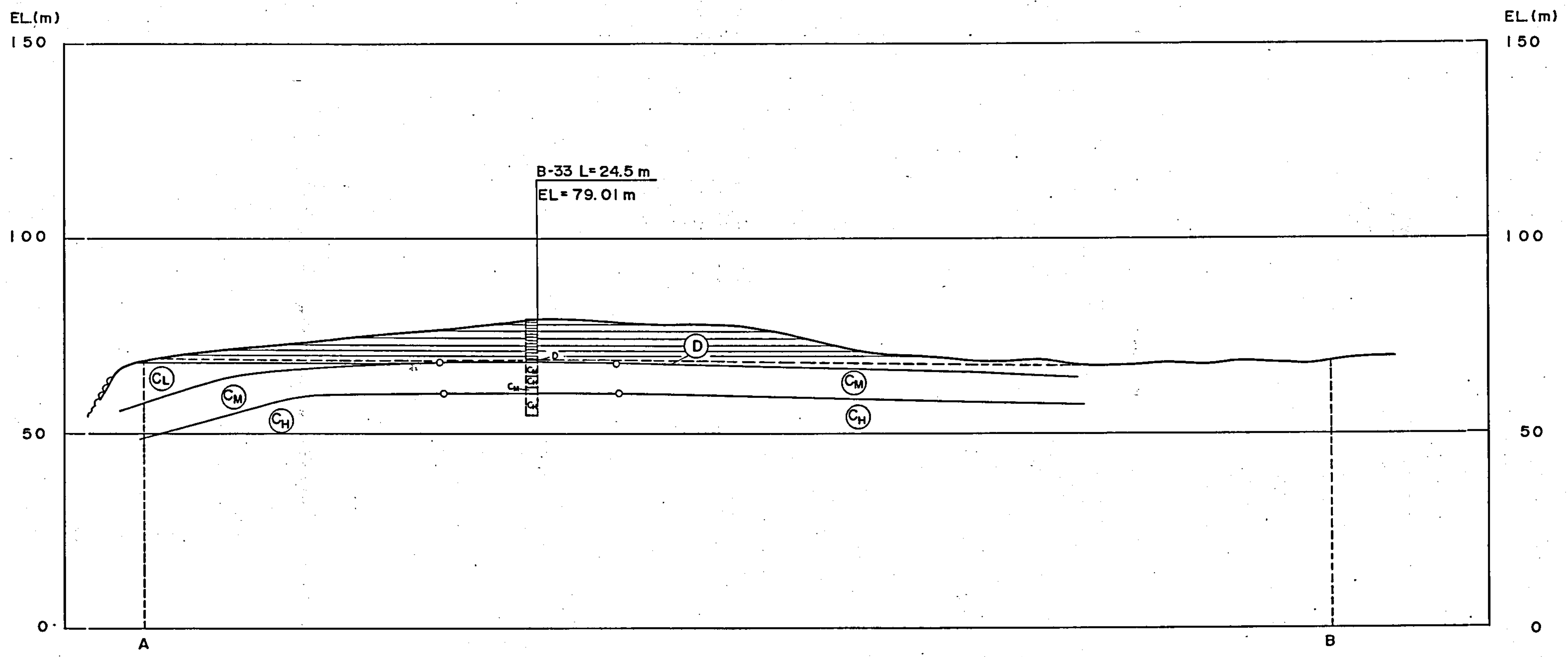


LEGEND

o B-33 Boring

A—B Topographic section

Fig. 2.11b GEOLOGICAL PROFILE OF QUARRY SITE (QR - I SITE)



LEGEND
(S = 1/1,000)

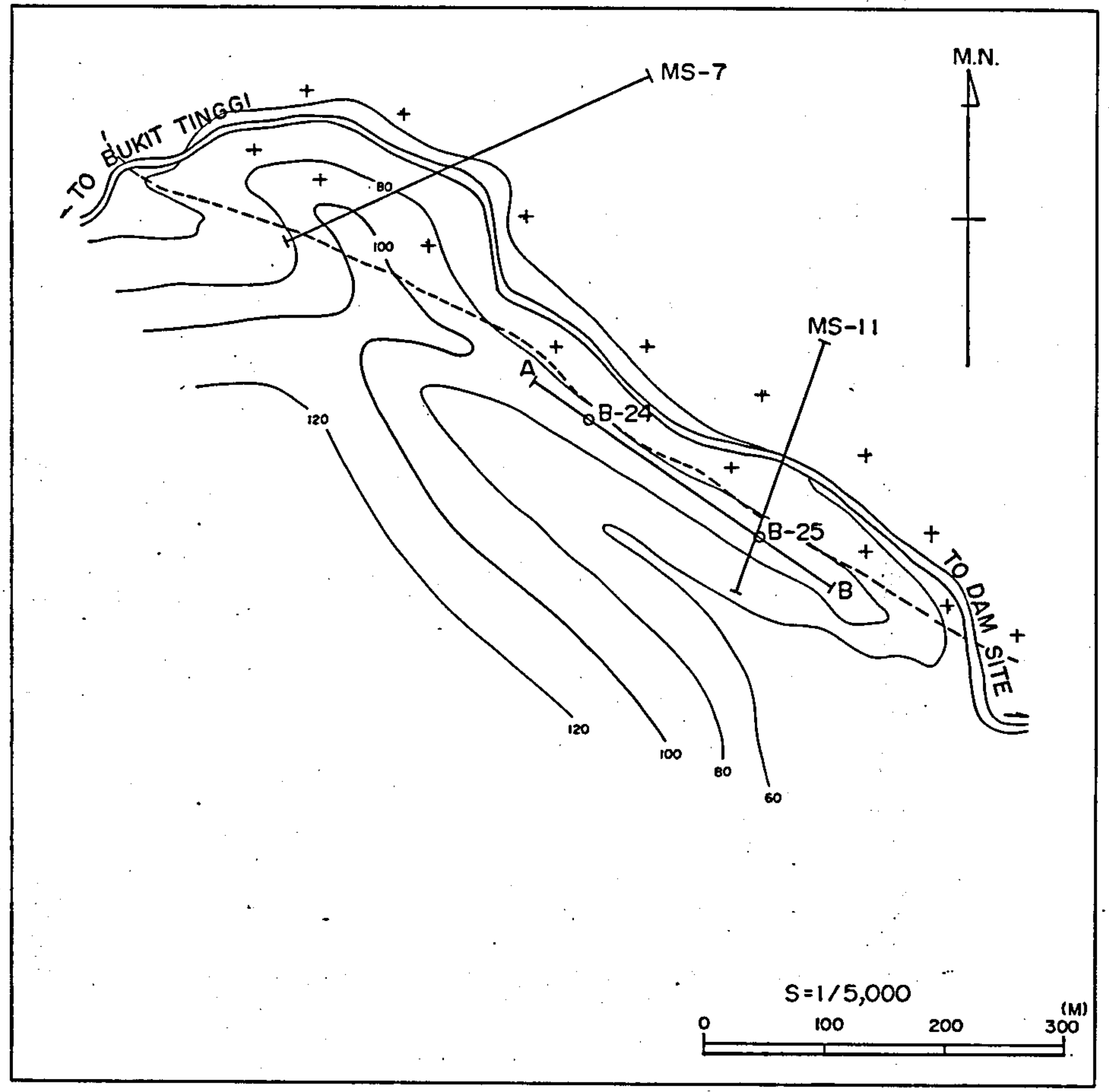
Top soil, Silty Clay and Silty Sand

Sandstone

D, CL, CM, CH — Rock Classification

Fig.2.11 Location Map of Geological
(a) Survey Quarry Site (QR-I SITE)
Fig.2.11 Geological Profile of Quarry
(b) Site (QR-I SITE)

Fig. 2.12a LOCATION MAP OF GEOLOGICAL SURVEY QUARRY SITE (QR - II SITE)



LEGEND

A——B	Topographic section	☐	Shale
——MS-7	Seismic prospecting	+ +	Granite
o B-24	Boring		

Fig. 2.12b GEOLOGICAL PROFILE OF QUARRY SITE (QR - II SITE)

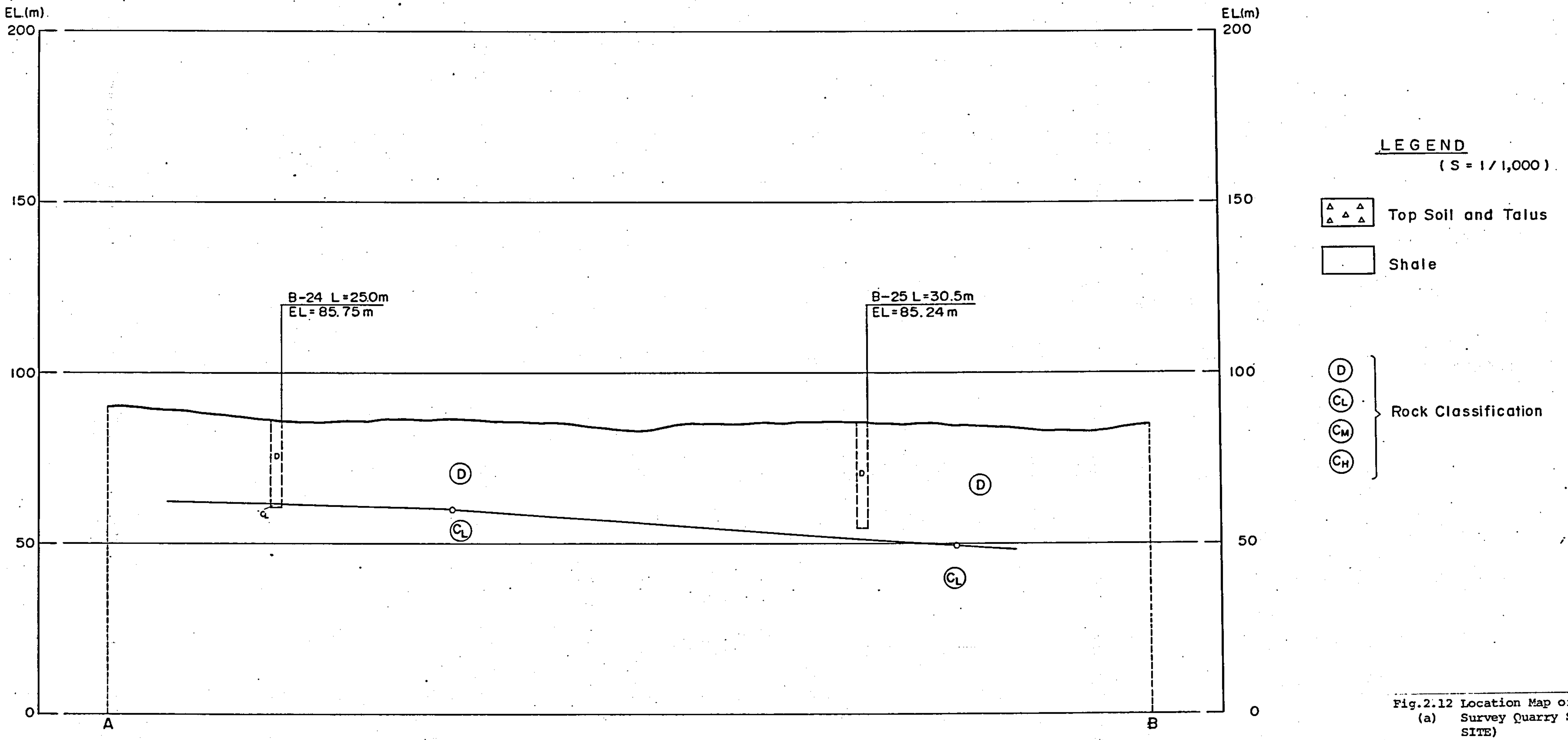
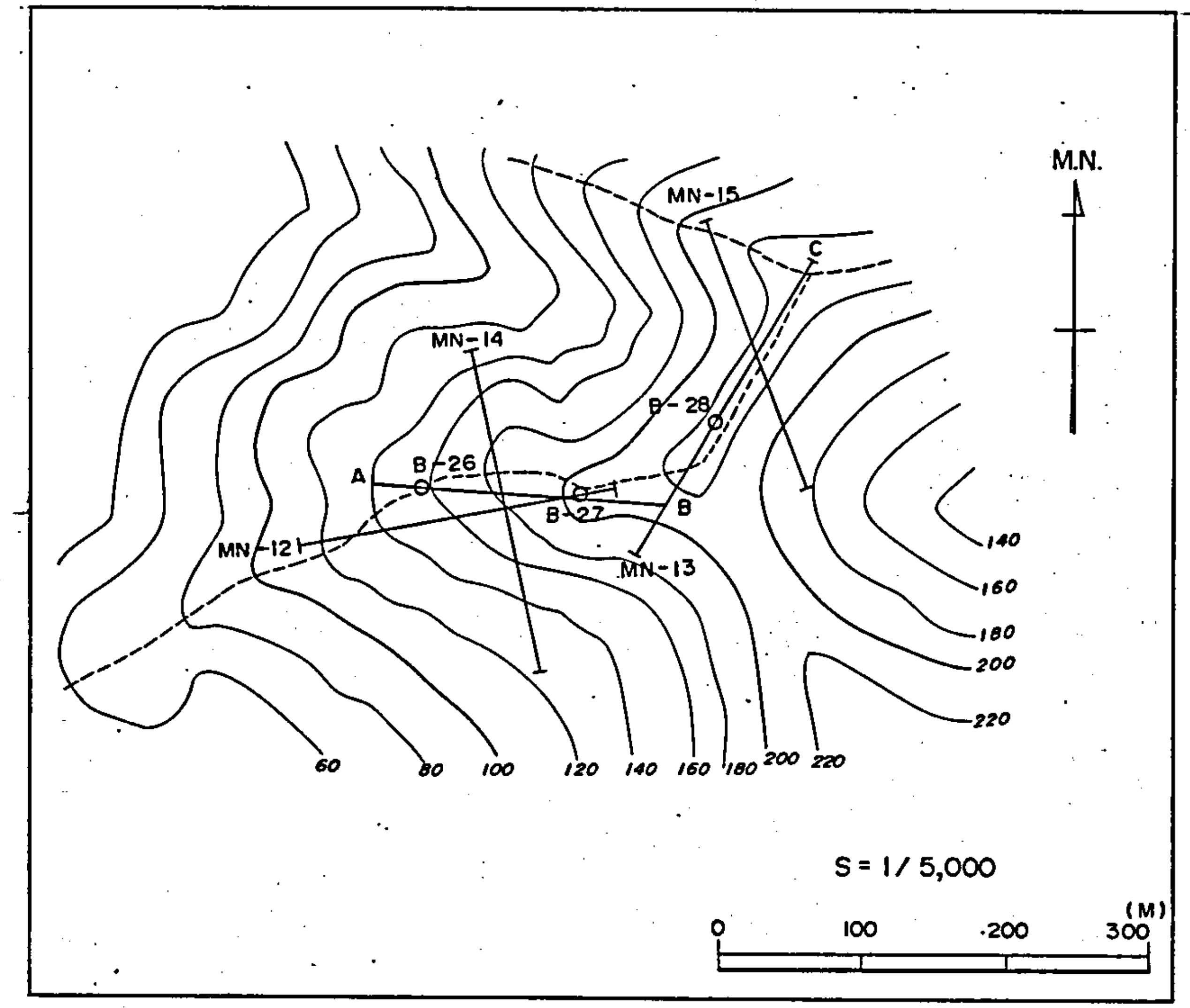


Fig.2.12 (a) Location Map of Geological Survey Quarry Site (QR-II SITE)
Fig.2.12 (b) Geological Profile of Quarry Site (QR-II SITE)

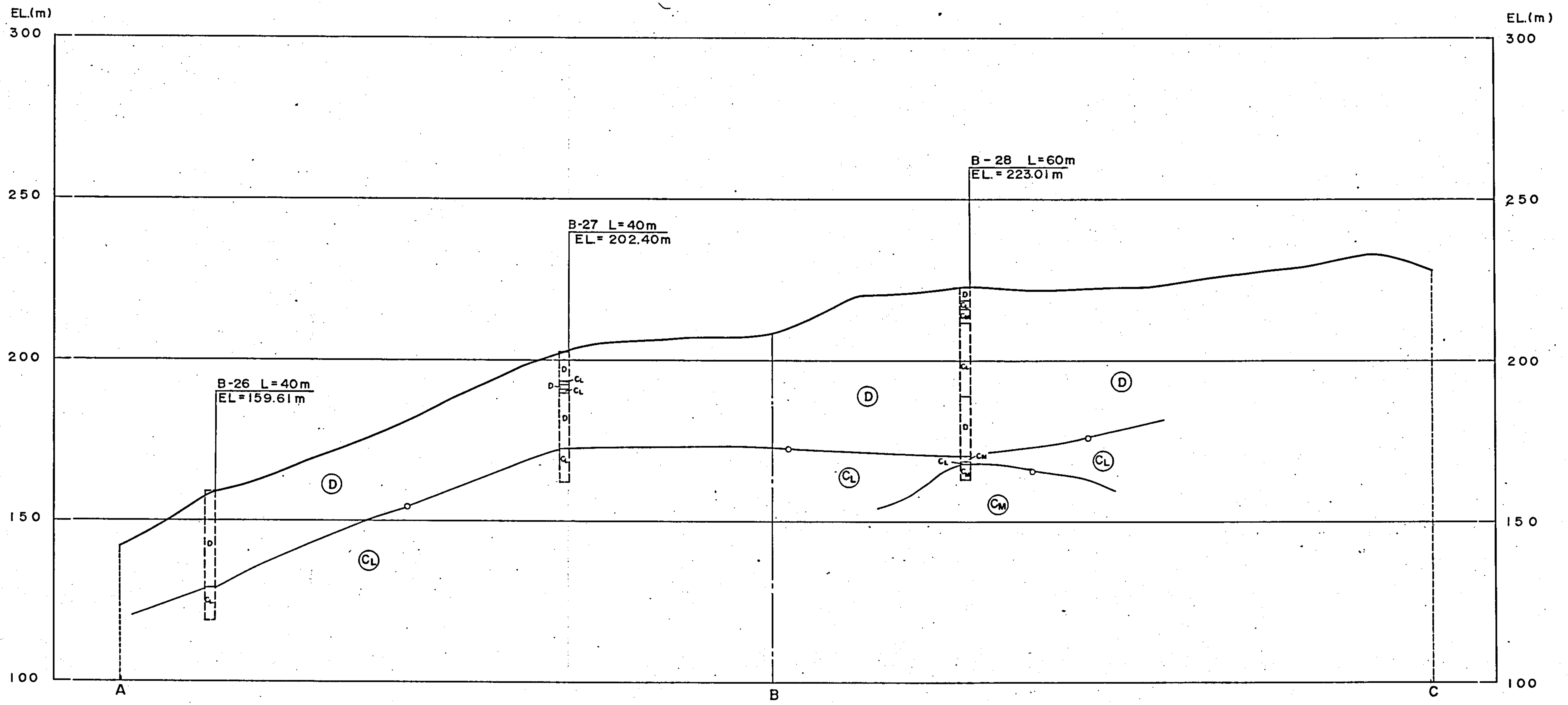
Fig. 2.13a LOCATION MAP OF GEOLOGICAL SURVEY QUARRY SITE (Q R - III SITE)



LEGEND

A B C	Topographic section
MN-5	Seismic prospecting
o B-26	Boring

Fig. 2.13b GEOLOGICAL PROFILE OF QUARRY SITE (Q R - III SITE)



LEGEND
(S = 1/1,000)

Top soil and Talus

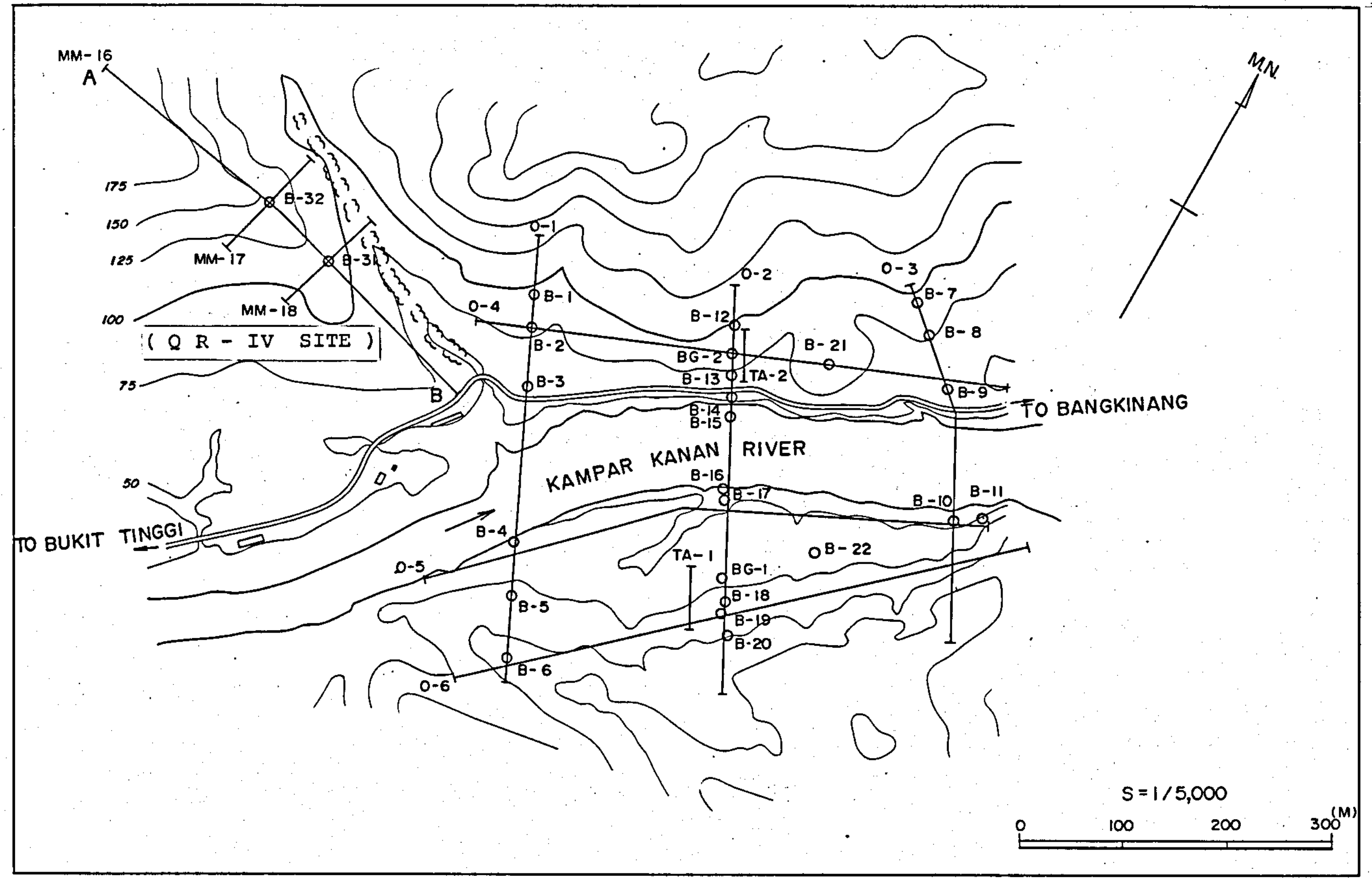
Dacitic Tuff

D, CL, CM, CH — Rock Classification

Fig.2.13 Location Map of Geological Survey
(a) Quarry Site (QR-III SITE)
Fig.2.13 Geological Profile of Quarry Site
(b) (QR-III SITE)

Fig. 2.14a LOCATION MAP OF GEOLOGICAL SURVEY

QUARRY SITE (Q R - IV SITE)



LEGEND

O-2	Seismic prospecting	o B-5	Boring
TA-1	Test adit	o BG-2	Grouting test
A B	Topographic section		Out crop

Fig. 2.14b GEOLOGICAL PROFILE OF QUARRY SITE (Q R - IV SITE)

Fig.2.14 Location Map of Geological Survey
(a) Quarry Site (QR-IV SITE)
Fig.2.14 Geological Profile of Quarry Site
(b) (QR-IV SITE)

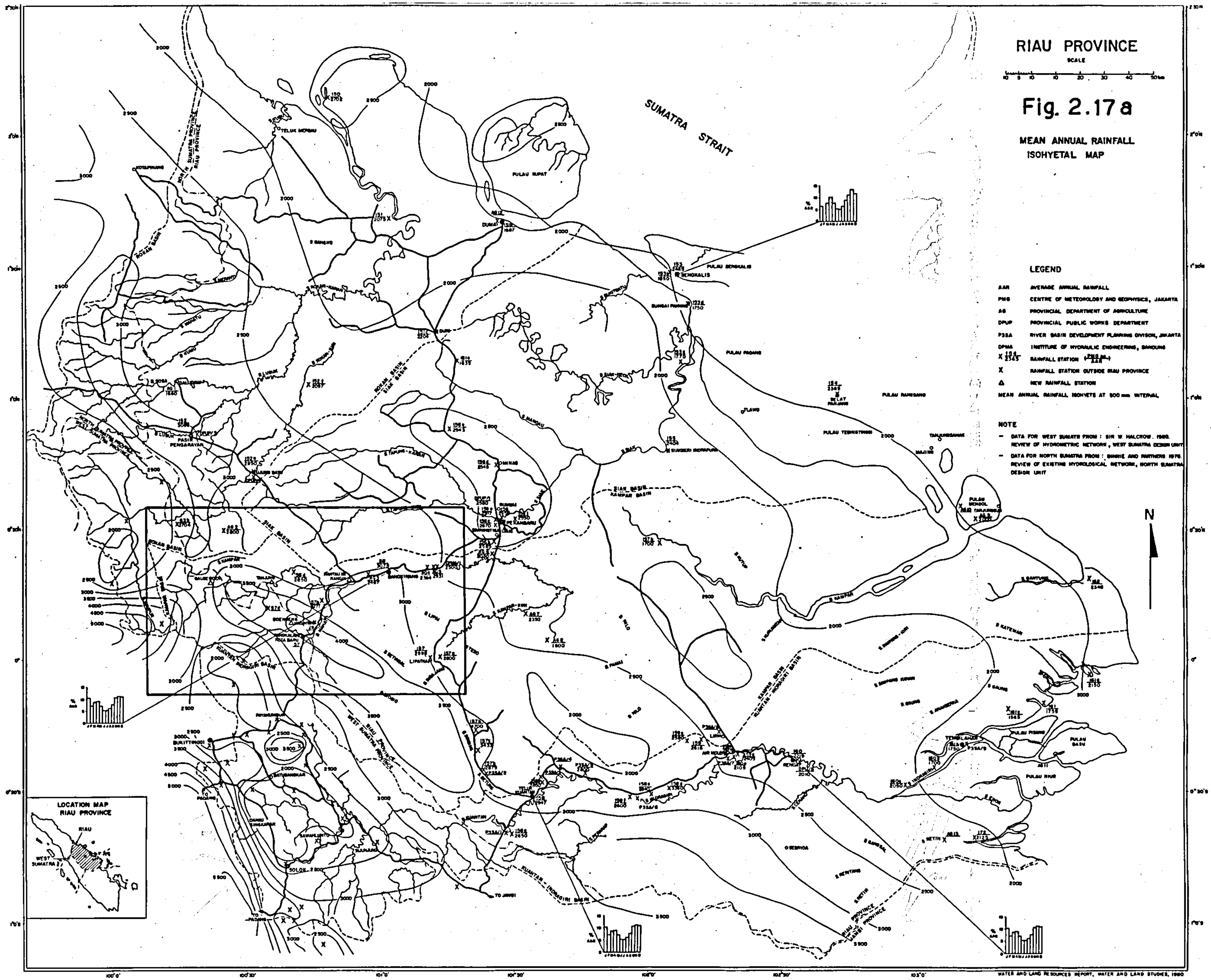
Fig. 2.15 LOCATION MAP OF BORROW SITES (S=1/25,000)

Fig.2.15 Location Map of Borrow Site

Fig. 2.16 COLLECTED METEO-HYDROLOGICAL DATA

28

Fig.2.16 Collected Meteo-Hydrological Data


RIAU PROVINCE
SCALE
Fig. 2.17 a
MEAN ANNUAL RAINFALL
ISOHYETAL MAP
SUMATRA STRAIT
PULAU RUPAT
PULAU BENGKALIS
BENGKALIS
DUMAI
PEKANBARU
LEGEND
AAR AVERAGE ANNUAL RAINFALL
PMG CENTRE OF METEOROLOGY AND GEOPHYSICS, JAKARTA
AG PROVINCIAL DEPARTMENT OF AGRICULTURE
DPUP PROVINCIAL PUBLIC WORKS DEPARTMENT
P3SA RIVER BASIN DEVELOPMENT PLANNING DIVISON, JAKARTA
DPMA INSTITUTE OF HYDRAULIC ENGINEERING, BANDUNG
RAINFALL STATION
X RAINFALL STATION OUTSIDE RIAU PROVINCE
△ NEW RAINFALL STATION
MEAN ANNUAL RAINFALL ISOHYETS AT 500 mm INTERVAL
NOTE
– DATA FOR WEST SUMATR FROM : SIR W. HALCROW. REVIEW OF HYDROMETRIC NETWORK, WEST SUMATRA DESIGN UNIT
– DATA FOR NORTH SUMATRA FROM : BINNIE AND PARTNERS. REVIEW OF EXISTING HYDROLOGICAL NETWORK, NORTH SUMATRA DESIGN UNIT
N
LOCATION MAP
RIAU PROVINCE
RIAU
WEST SUMATRA
WATER AND LAND RESOURCES REPORT, WATER AND LAND STUDIES, 1980

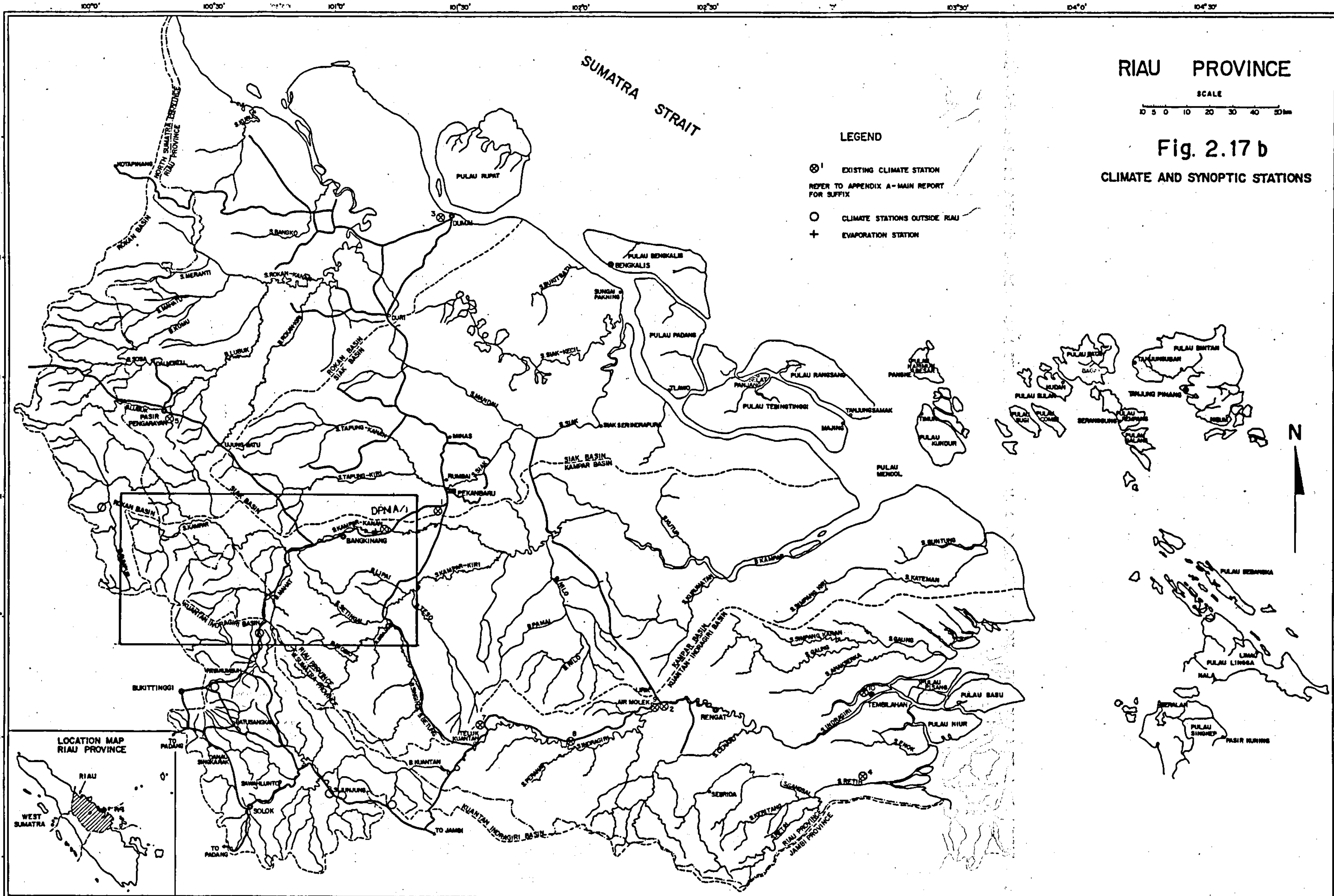
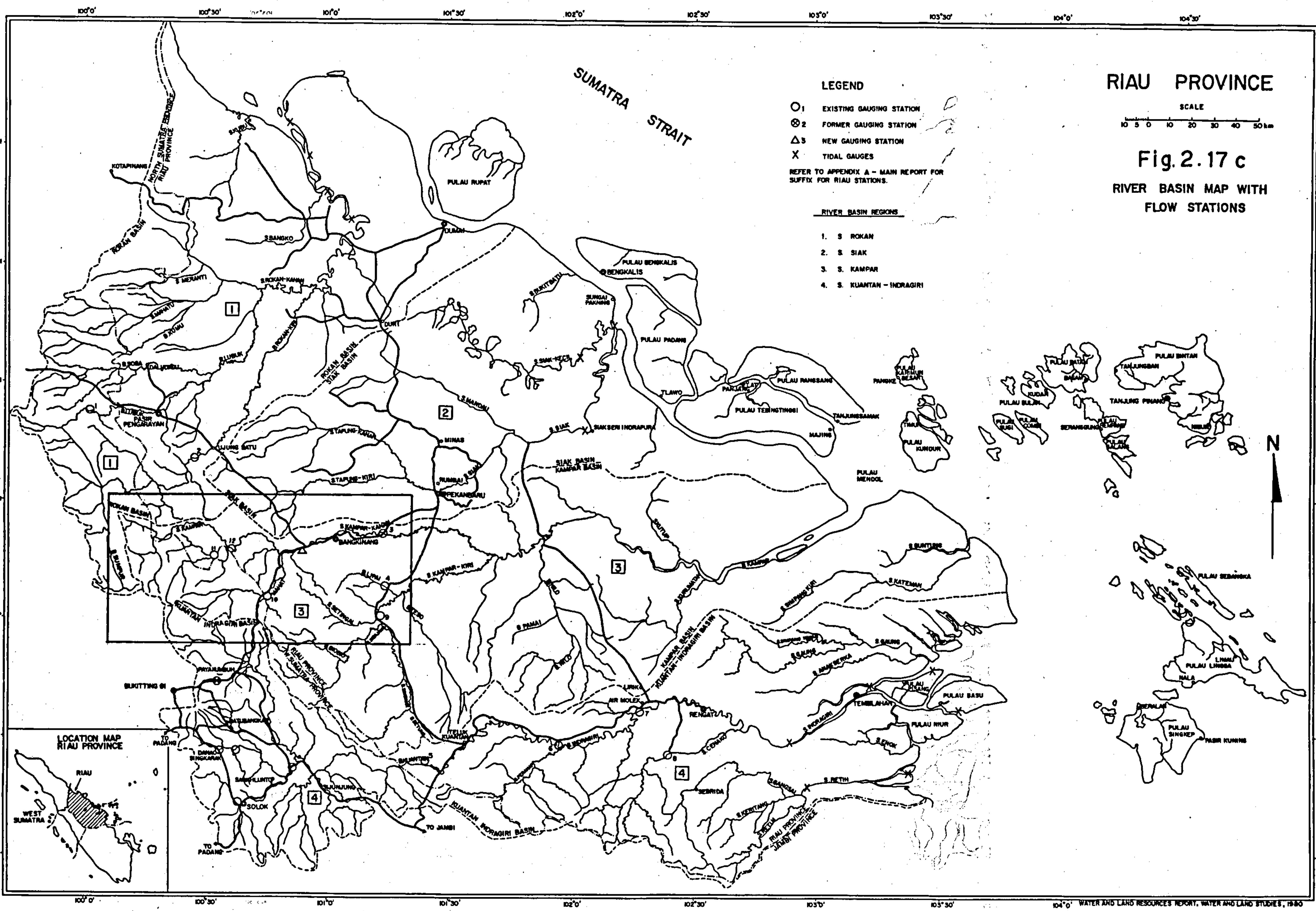


Fig. 2.17 b

CLIMATE AND SYNOPTIC STATIONS



RIAU PROVINCE

Fig. 2.17 c

RIVER BASIN MAP WITH FLOW STATIONS

Fig. 2.18 Rating Curve for Rantau Berangin Gauging Station

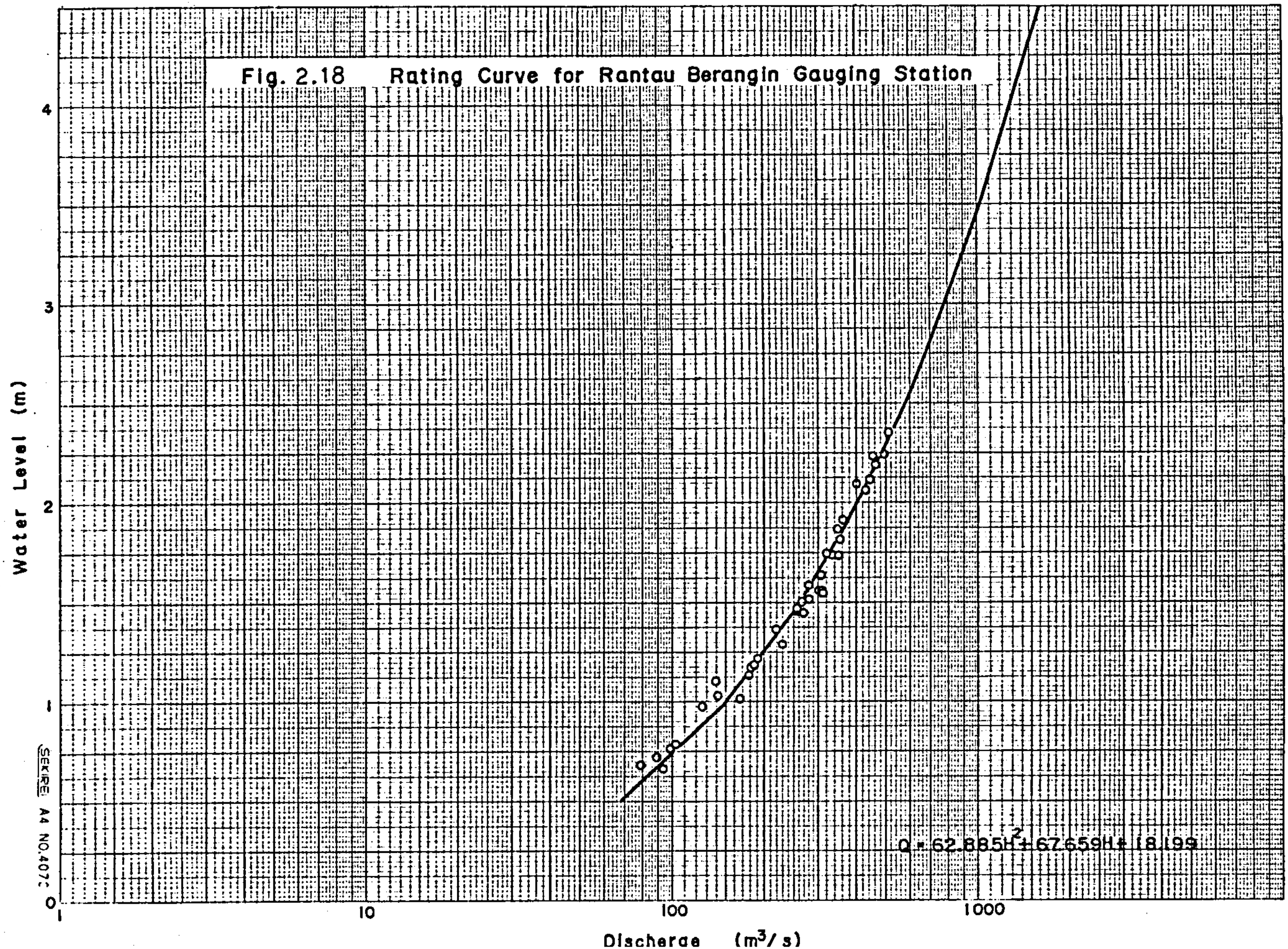


Fig. 2.19 Rating Curve for Danan Bingkuang Gauging Station

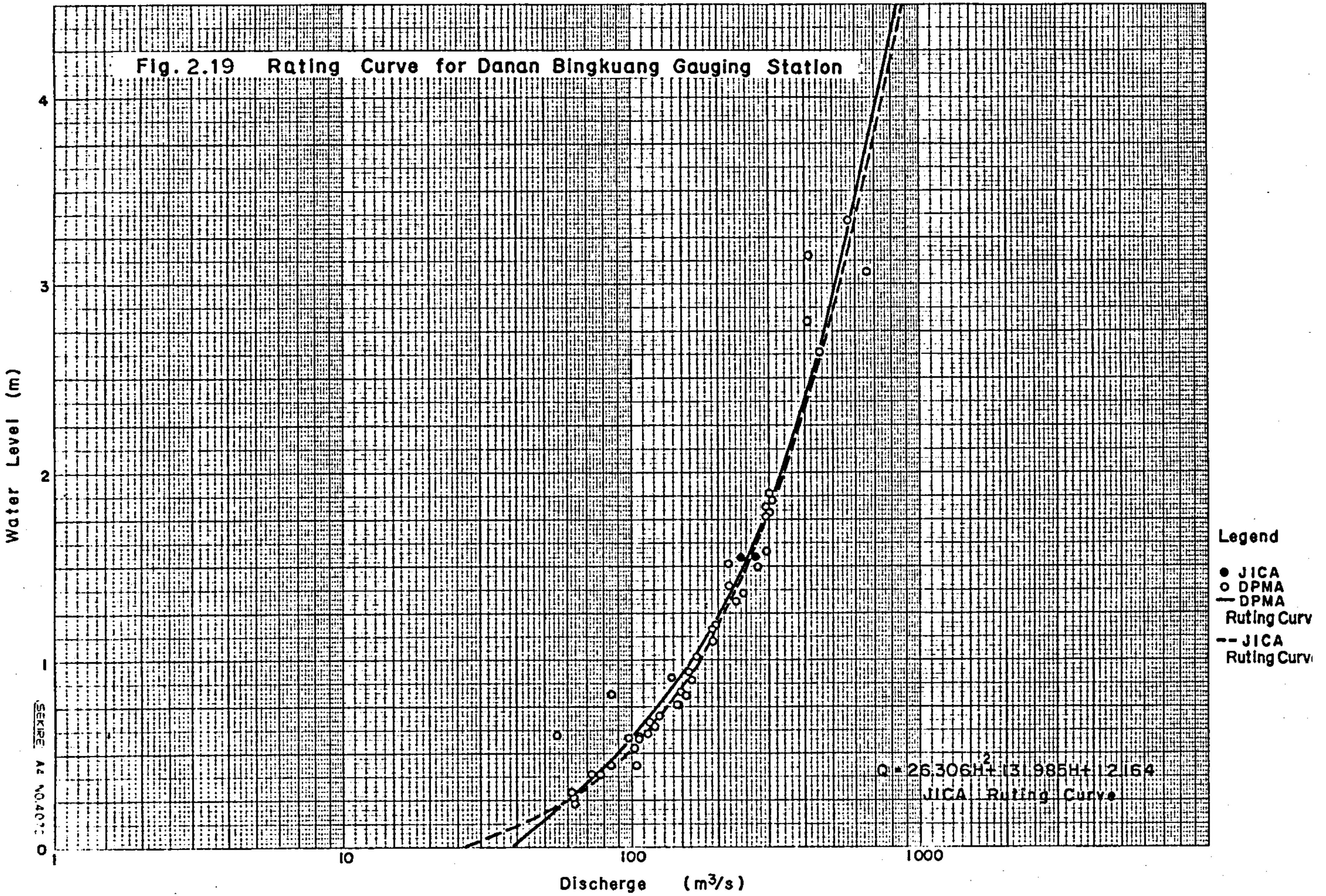
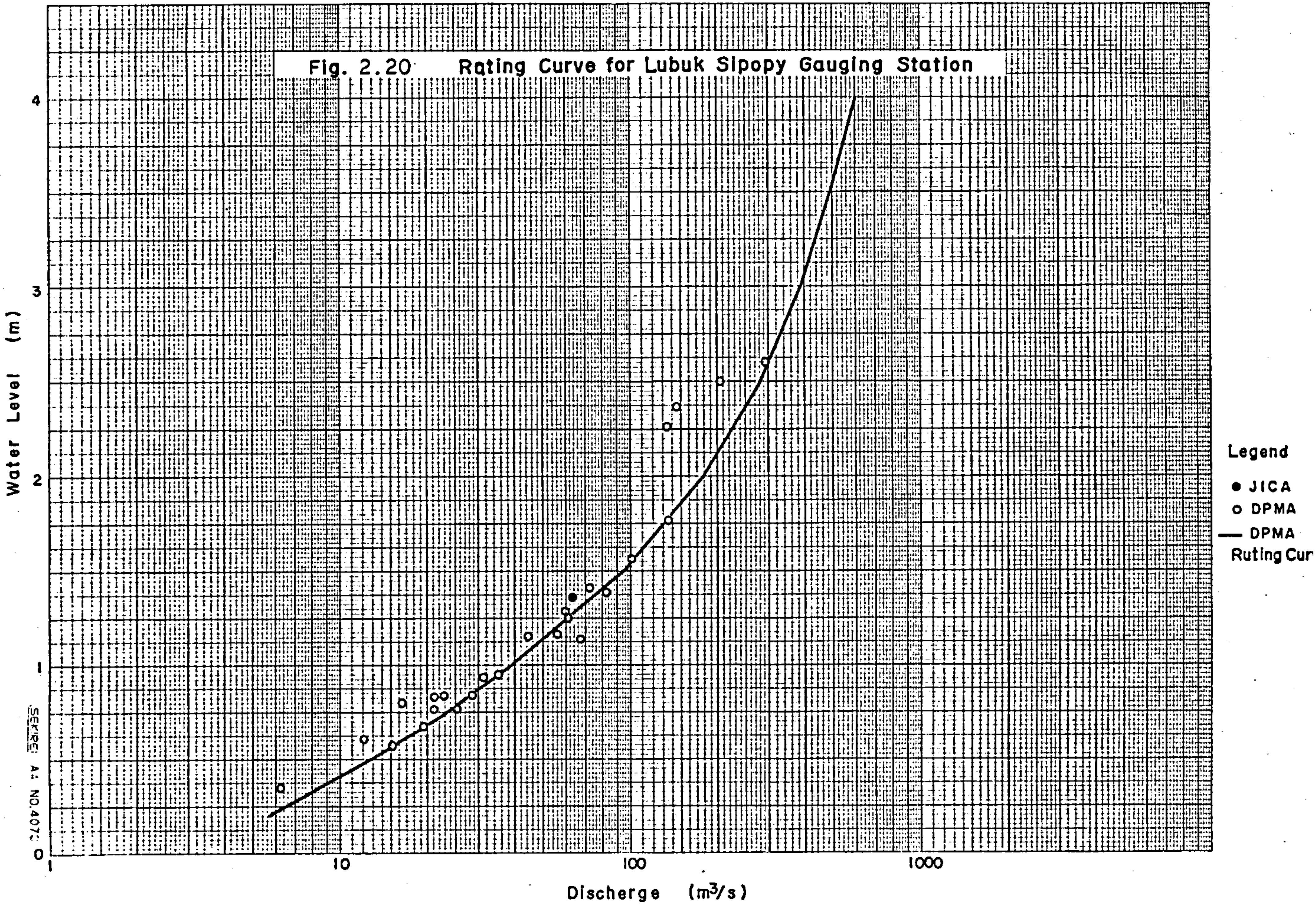


Fig. 2.20 Rating Curve for Lubuk Sipopy Gauging Station



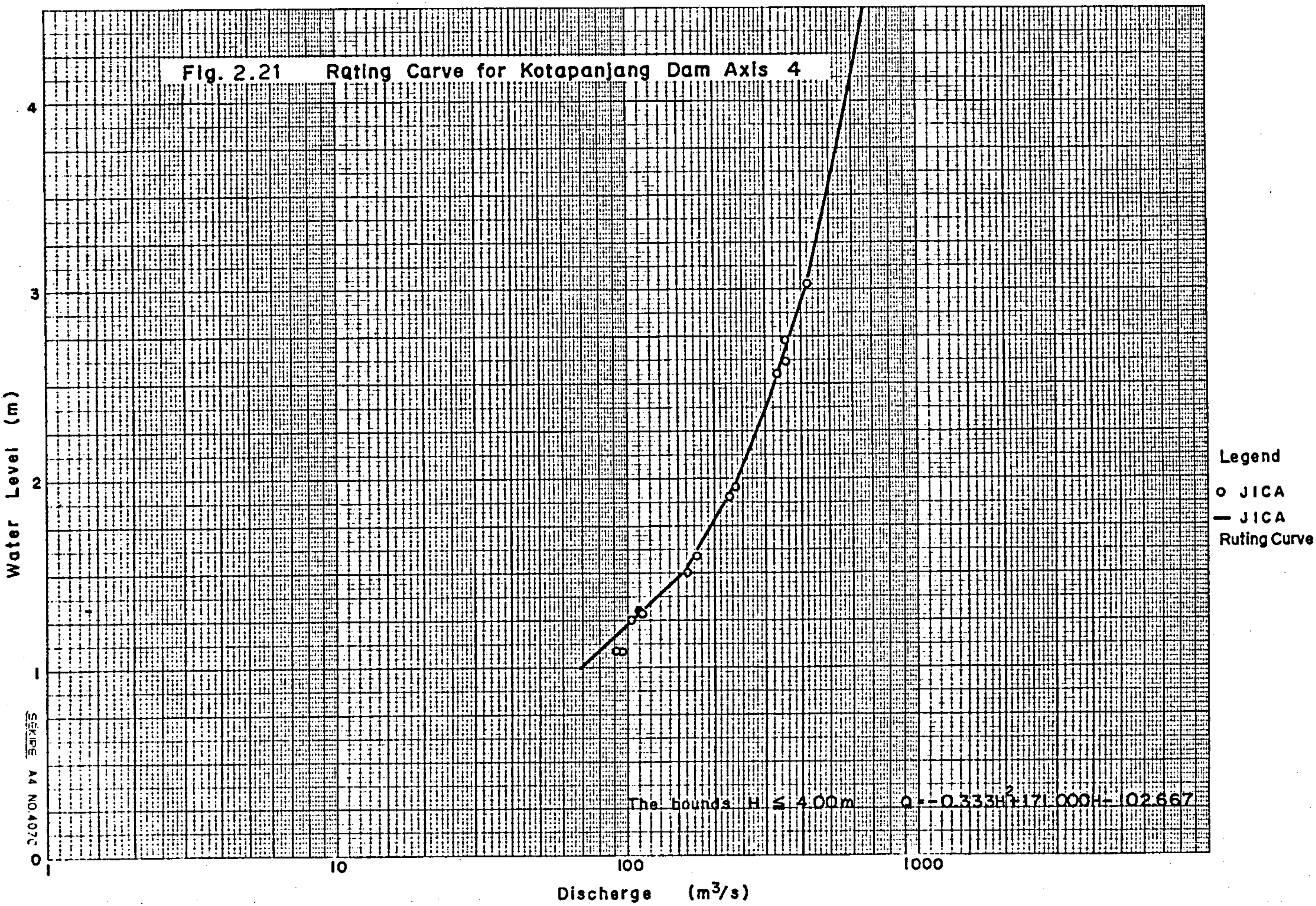


Fig. 2.21 Rating Carve for Kotapanjang Dam Axis 4
Water Level (m)
0
1
2
3
4
Discharge (m3/s)
1
10
100
1000
Legend
o JICA
— JICA
Ruting Curve
The bounds H ≦ 4.00m
Q=-0.333H2+171.000H-102.667
SEKIPE A4 NO.407C

FIG. 4.4 DIVISIONAL BASIN FOR THE STORAGE FUNCTION METHOD

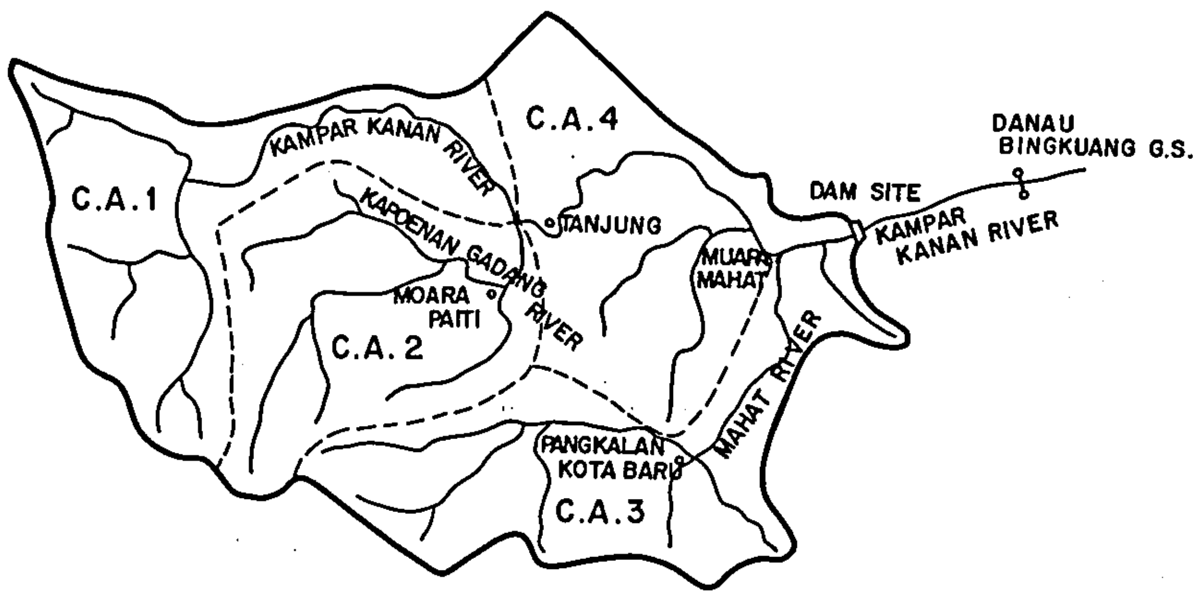


Fig. 4.8 PROFILE FOR ONE - DAM PLAN AND TWO - DAM PLAN

SH - 1 : 100.000
SV - 1 : 500

Item			1-STAGE	2-STAGE	
			Kota Panjang	Kota Panjang	Mahat
	Catchment Area	km²	3.337	3.337	1.075
DAM	High	m	60	32.5	37
DAM	Volume	m³	272.000		
RESERVE	Nor. H.W.S.	m	85	58	80
RESERVE	Reservoir Area	km²	108		
RESERVE	Gross Capacity	10⁶m³	1.550		
RESERVE	Effective Capacity	10⁶m³	850		
POWER STATION	Maximum Discharge	m³/s	330	250	145
POWER STATION	Firm Discharge	m³/s	160.3		
POWER STATION	Maximum Output	MW	110	32	23
POWER STATION	Firm Output	MW	87.9		
POWER STATION	Annual Energy	MWH	511		
POWER STATION	Gross Head	m	40.7	18.0	22.0

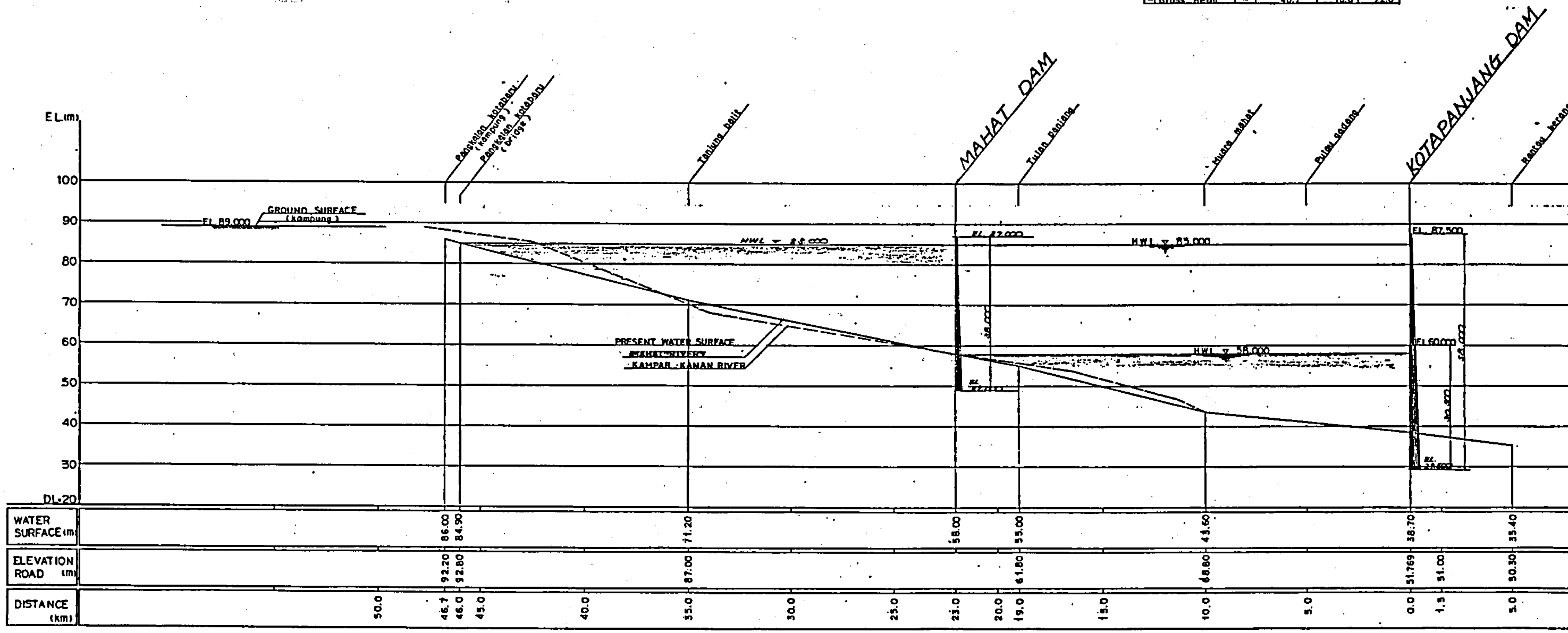
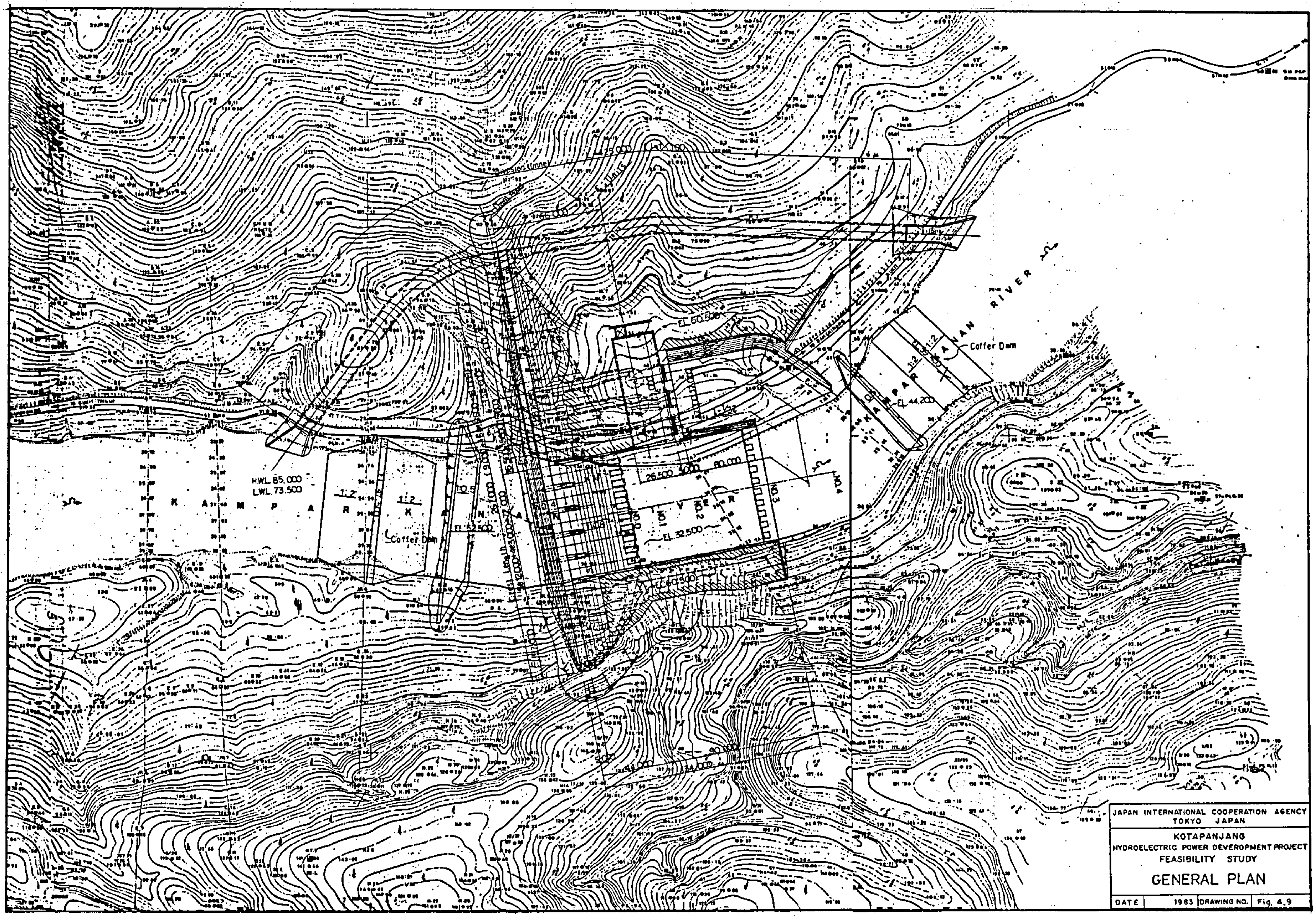


Fig.4.8 Profile for One-Dam Plan and Tow-Dam Plan

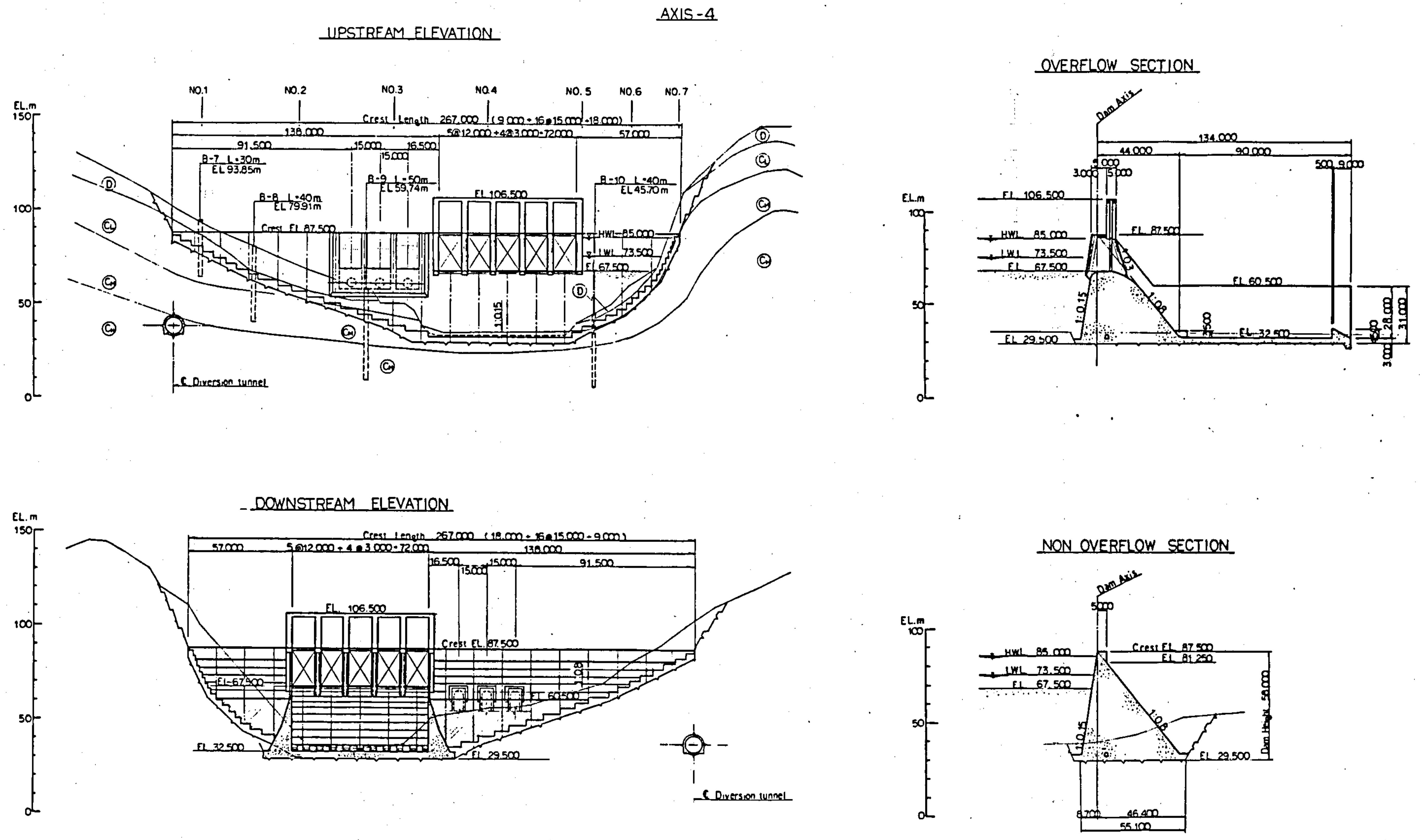


JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO JAPAN

KOTAPANJANG
HYDROELECTRIC POWER DEVEROPMENT PROJECT
FEASIBILITY STUDY

GENERAL PLAN

DATE	1983	DRAWING NO.	Fig. 4.9



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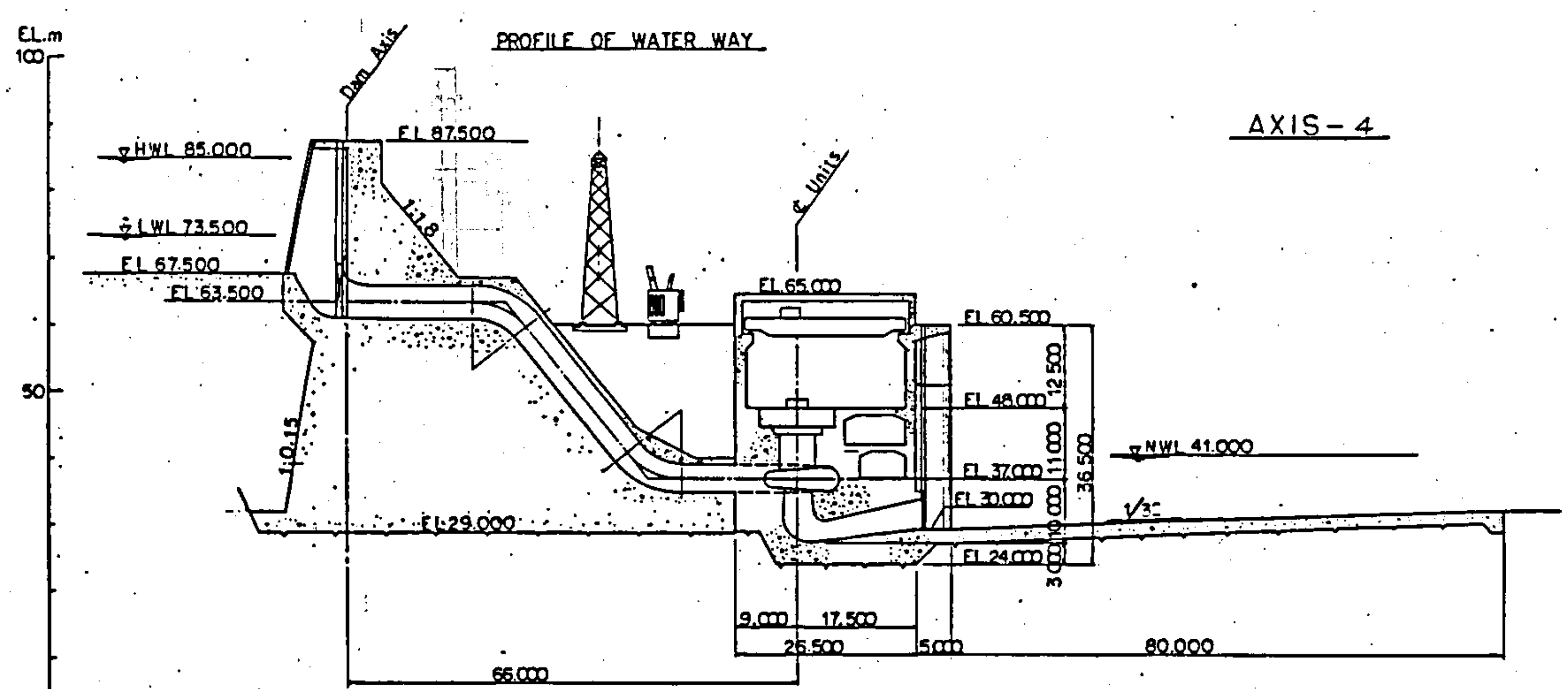
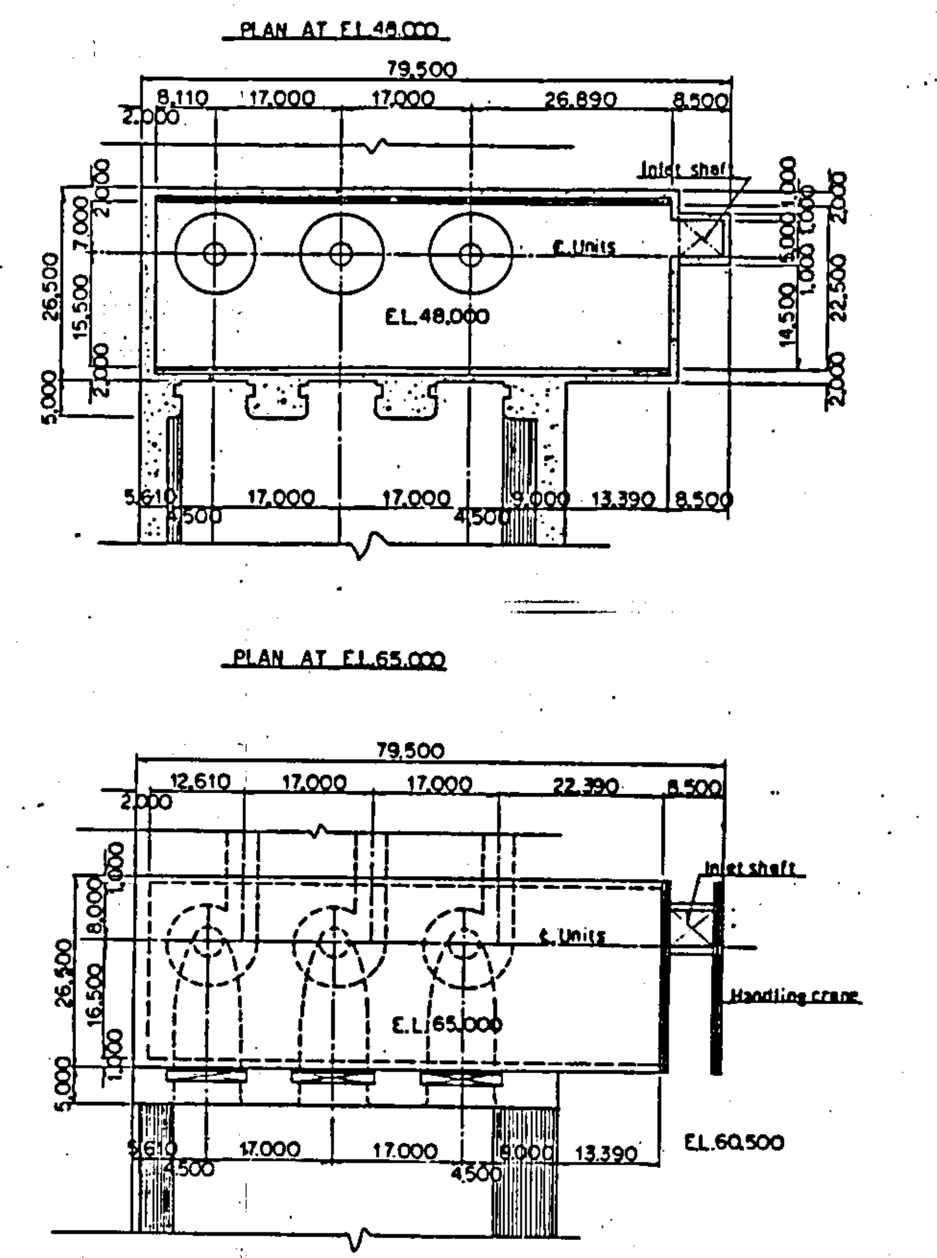
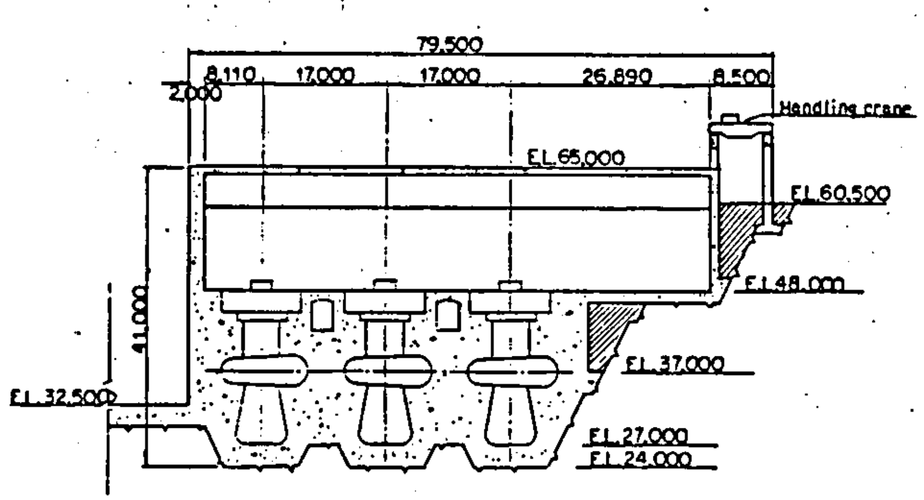
KOTAPANJANG
HYDROELECTRIC POWER DEVEROPMENT PROJECT
FEASIBILITY STUDY

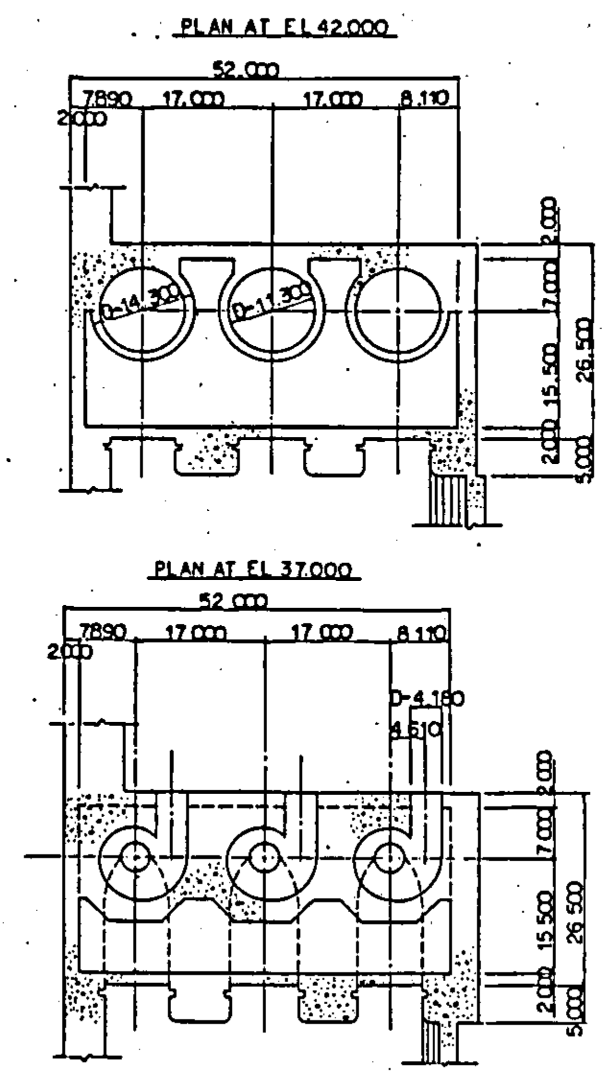
DAM PROFILE AND SECTIONS

DATE	1983	DRAWING NO.	Fig. 4.10









JAPAN INTERNATIONAL COOPERATION AGENCY
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KOTAPANJANG
HYDROELECTRIC POWER DEVEROPMENT PROJECT
FEASIBILITY STUDY

POWERHOUSE
PLAN AND SECTIONS

DATE	1983	DRAWING NO.	Fig. 4.11

Fig.4.13 KOTAPANJANG RESERVOIR SURFACE AREA AND CAPACITY CURVES

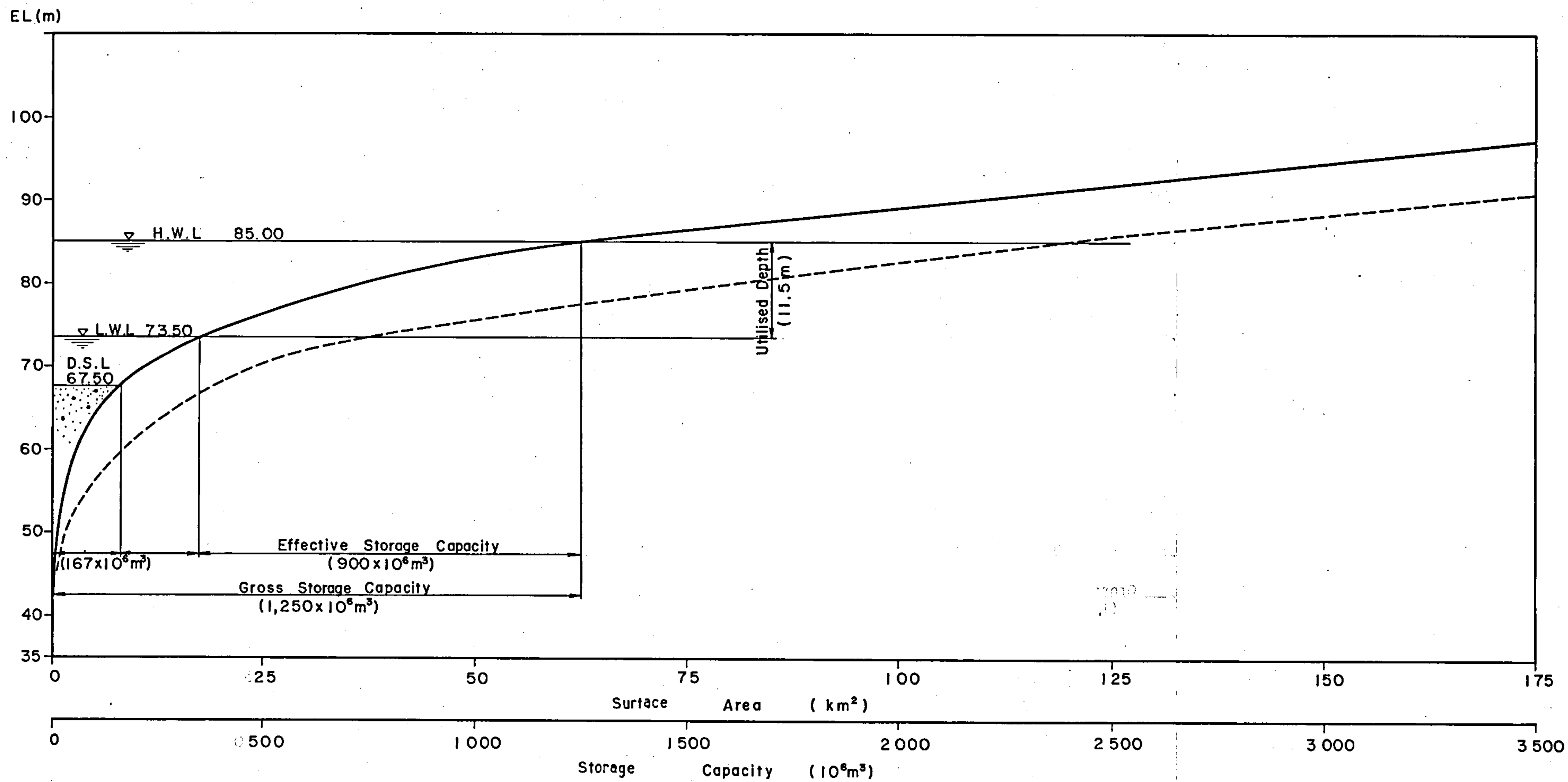


Fig.4.13 Kotapanjang Reservoir Surface Area and Capacity Curves

Fig. 4.15 Transmission Line Route Scale 1:100,000

42

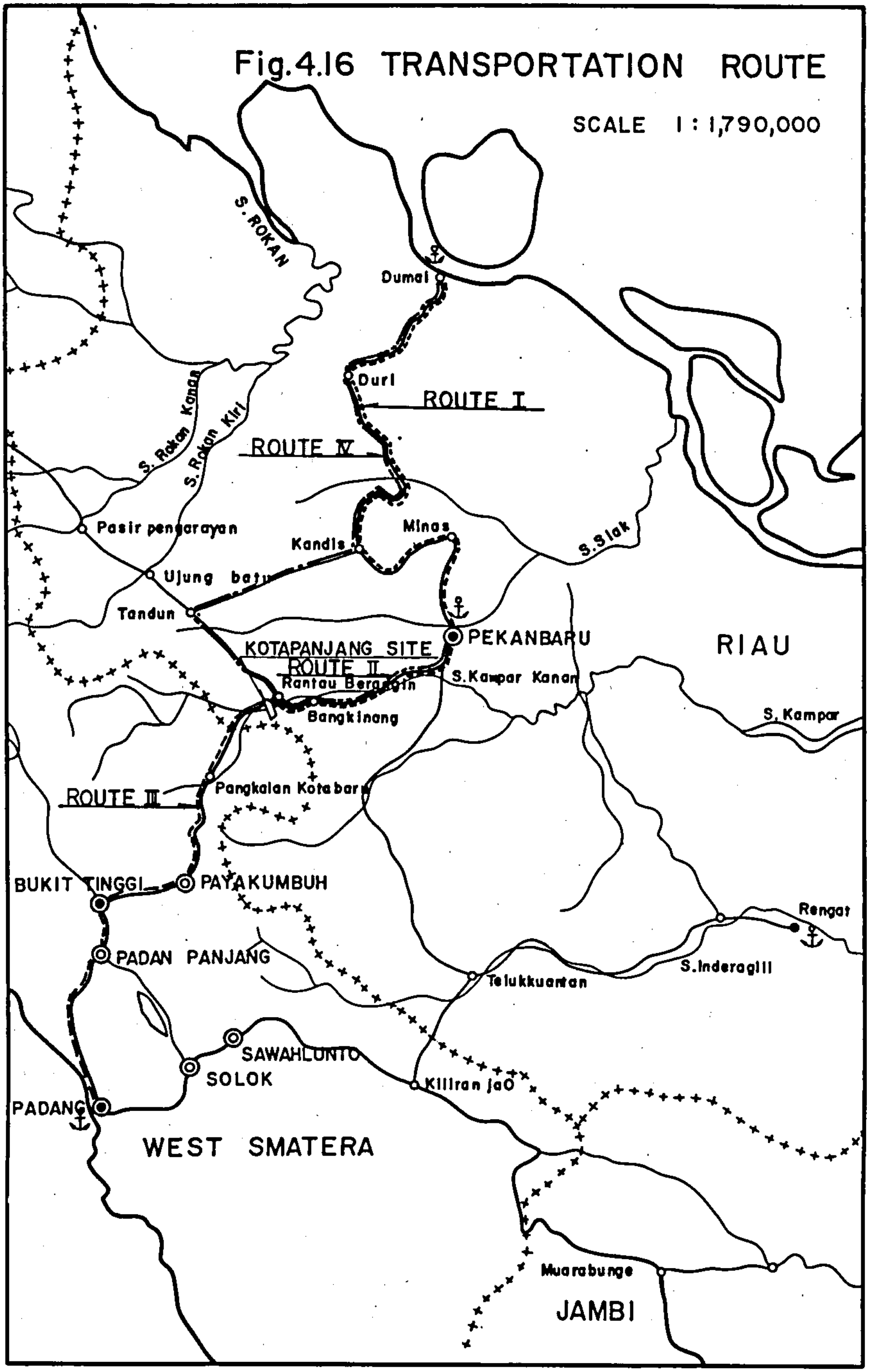


Fig.4.16 TRANSPORTATION ROUTE

43

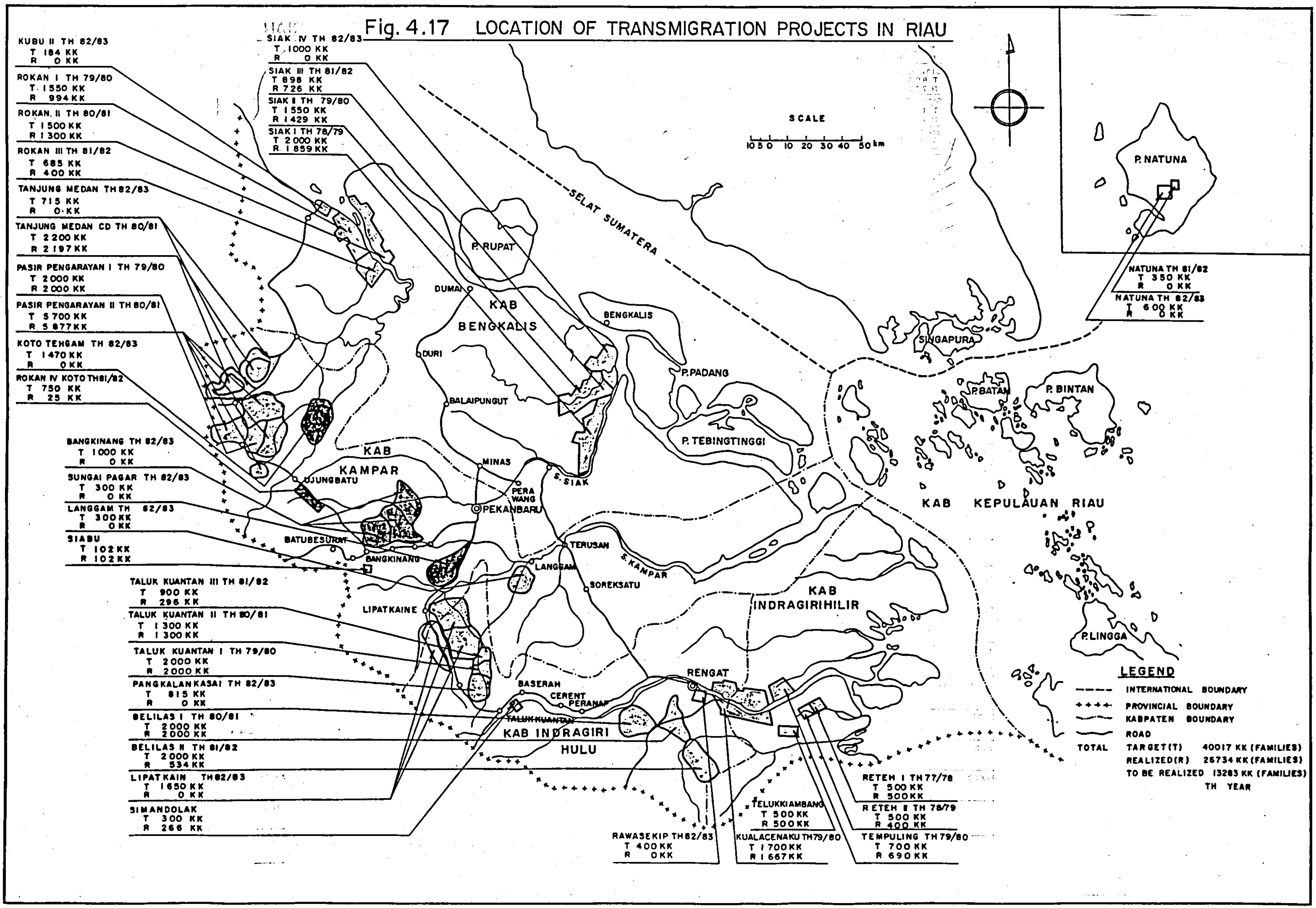


Fig.4.17 Location of Transmigration Projects in Riau

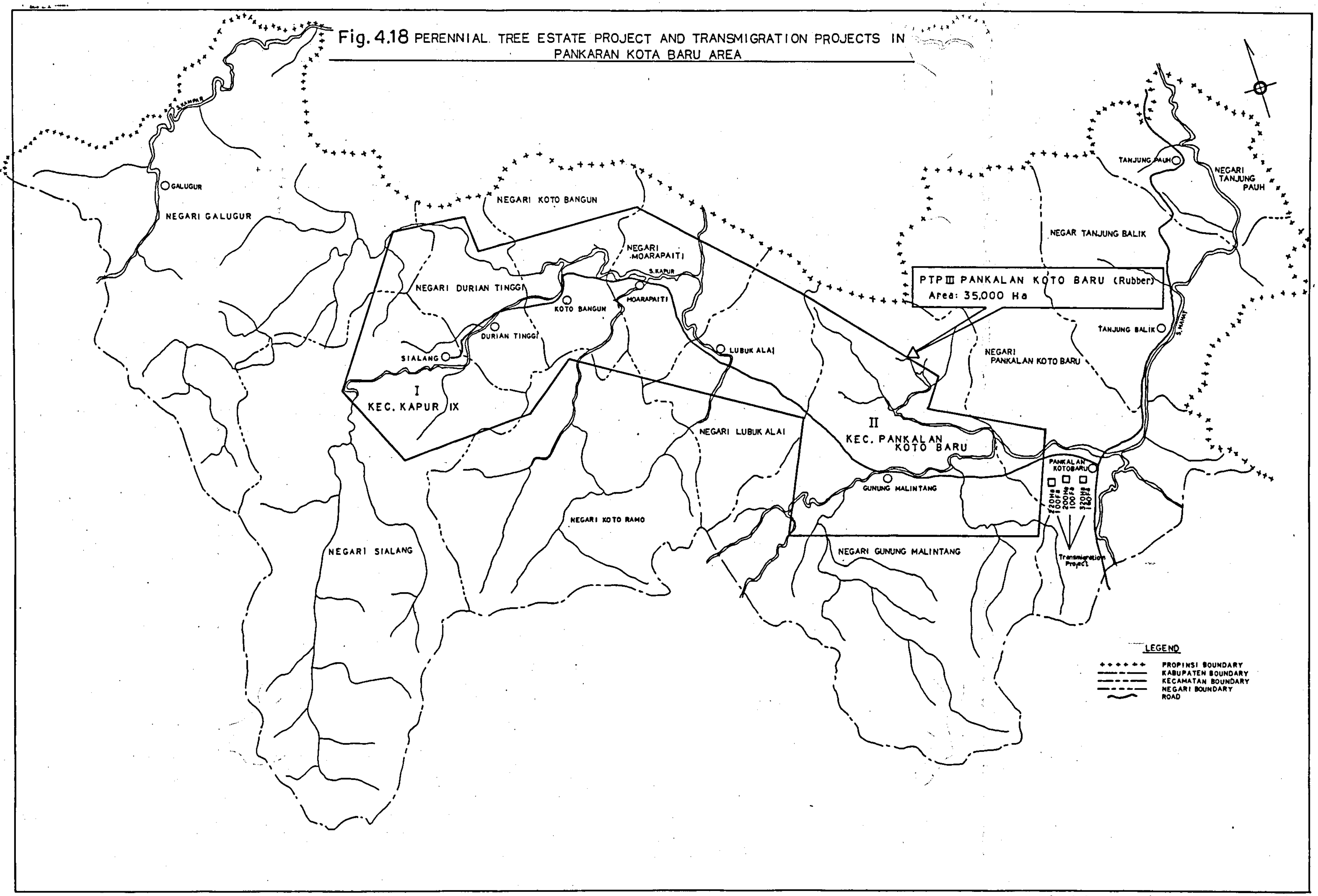
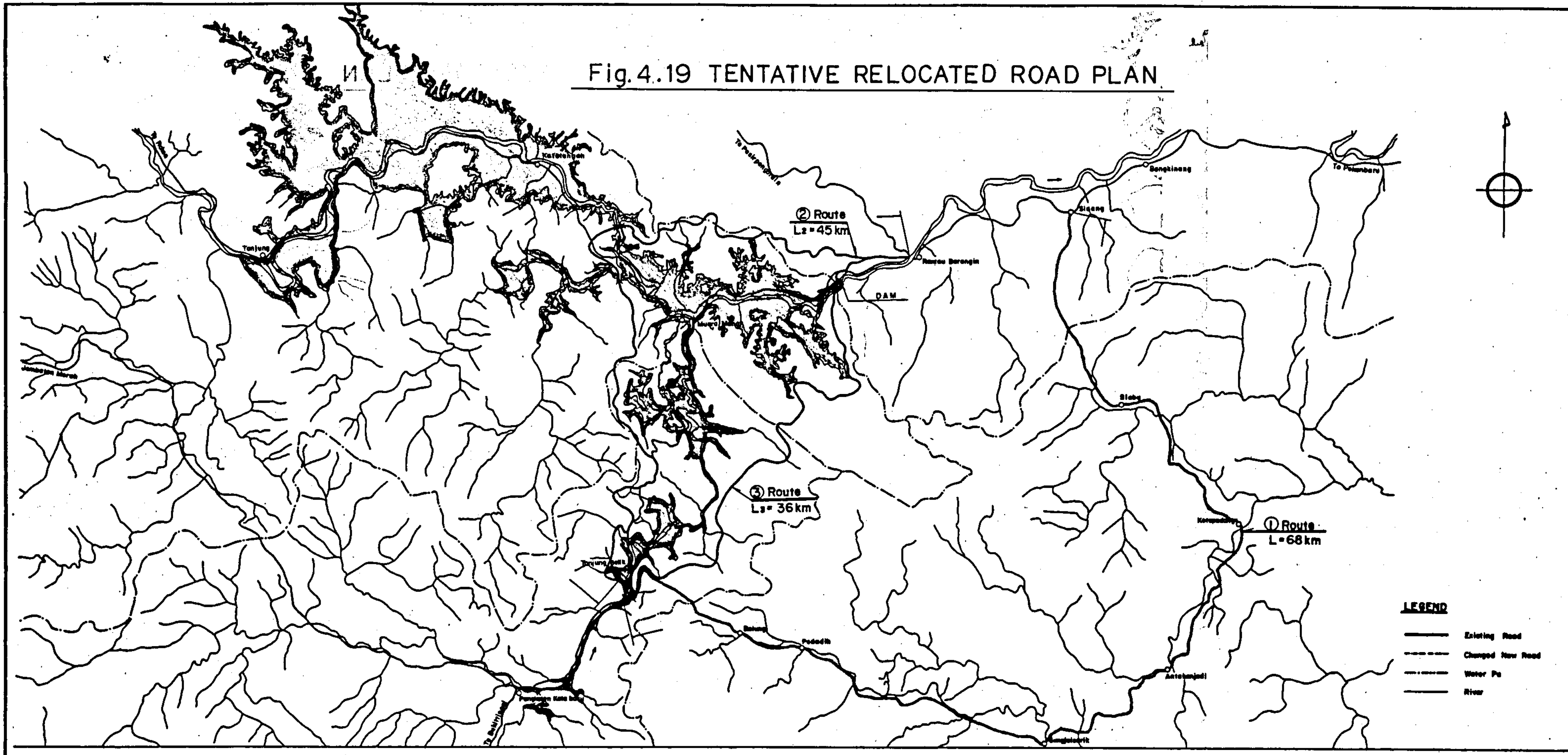
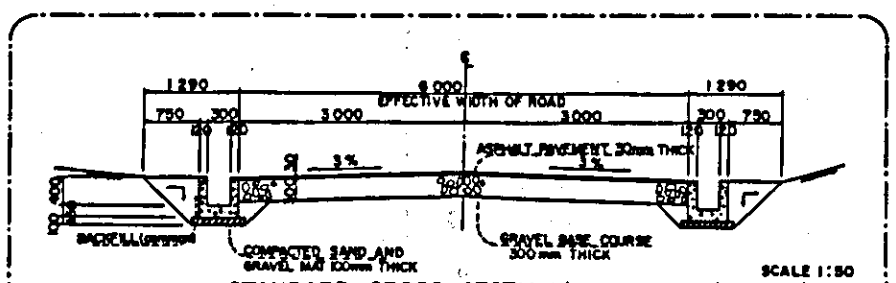


Fig.4.18 Perennial Tree Estate Project and Transmigration Projects in Pankaran Kota Baru Area

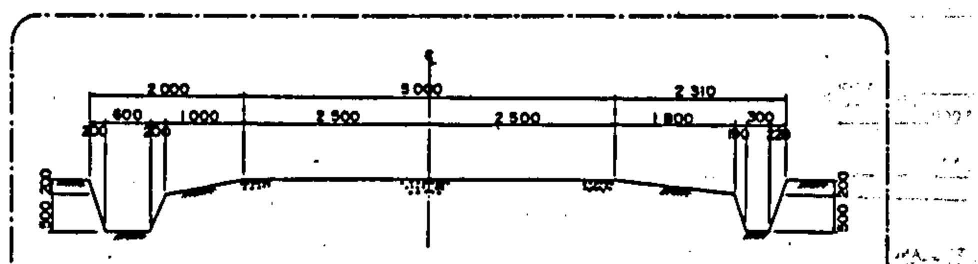
Fig.4.19 TENTATIVE RELOCATED ROAD PLAN



LONGITUDINAL SECTION



STANDARD CROSS SECTION (new constraction part)



STANDARD CROSS SECTION (reconstraction part)

Fig.4.19 Tentative Relocated Road Plan

Fig. 4.20 MINING RIGHT

SCALE 1 : 200,000