Outside the Palembang system, there are 18 isolated systems in major towns, each consisting of one diesel power plant and town-scale distribution networks. The maximum one is at Tanjung Karang with 16,376 kW installation. The total installed capacity of these 18 isolated systems is 39,577 kW only. Table VII-2 lists the existing power plants of PLN Region IV.

Besides the above PLN utilities, Pertamina and P.T. Pusri have their own power plants of 50,000 kW and 38,500 kW respectively in Palembang. Small/medium size generators owned by other industries are also in operation, of which total installed capacity is about 233 MVA. Table VII-3 lists the existing captive power.

The power is distributed with 30 kV, 20 kV and 6/7 kV distribution lines respectively, as the standarization of distribution voltage has not been performed yet. The low tension supply is also still made with both 380/220 V (new standard) and 220/127 V (old standard).

The population in the area is said as 10,009,200, from which the number of households is estimated at about 1,850,000 by assuming 5.4 persons per household. Out of these, 85,050 households are served with power supply, that is, the region-wide electrification ratio remains at 4.6% only. In fact, the power supply service is limited in major towns and their vicinities, but most of villages are not served. Even in the electrified towns, the electrification ratio remain at 28% in Palembang and less than 21% in other towns.

2.2.2 Power Statistics

From the viewpoint of development schedule of the project, the power market is temporarily limited to the area covered by PLN's branch offices in Palembang, Lahat and Tanjung Karang, namely the South Sumatra and Lampung provinces. The survey on power statistics was therefore concentrated in the said concerned area. The installed capacities in the area is summarized in the attached Table VII-4.

Historical record of energy production and consumption in the PLN system are given in Table VII-5. Summary of them is as follows:

Power Statistics in 1980/81

	Energy Generated (10^3 kWh)	Energy Sold (10^3 kWh)	Peak Load (10^3 kW)	Nos. of Whole Customer (10^3 nos.)
Palembang	172,895 (68%)	124,355 (67%)	33,400	47.06 (55%)
Baturaja	4,610	3,622	900	2.65
Kayuagung	2,282	1,547	630	1.32
Sekayu	756	633	272	0.87
L. Linggau	4,926	3,866	1,020	2.66
Lahat	3,446	2,759	994	2.56
Muara Enim	1,524	1,285	353	1.38
Pagar Alam	1,929	1,612	680	2.25
Tg. Karang	53,710 (21%)	39,651 (21%)	11,060	20.68 (24%)
Metro	4,716	3,359	1,025	2.01
Kotabumi	4,698	3,124	965	1.91
Total	255,492 (100%)	185,813 (100%)	51,299	85.35 (100%)

From the above table, the followings are observed:

(1) Ratio of Sold Energy/Production

		Loss.
Palembang	124,355/172,859 = 71.9%	(28.1%)
Tg. Karang	39.651/53,710 = 73.8%	(26.2%)
Others	21,807/28,923 = 75.4%	(24.6%)
Total	185,813/255,492 = 72.7%	(27.3%)

(2) Consumption per Customer

Palembang	124,355/47.06 = 2,642 kWh
Tg. Karang	39,651/20.68 = 1,917 kWh
Others	21,807/17.61 = 1,238 kWh
Total	185,813/85.35 = 2,177 kWh

A considerably high value of energy loss including station use seems to mean the distribution systems becoming overloaded and deteriorated. Improvement works on distribution lines are under execution with OECF loans in Palembang.

As for the consumption per customer, the above figures show the average including household, commercial and industrial consumers. Therefore, the figures in Palembang and Tanjung Karang where economic activity is in a higher level, are remarkably high in comparison to those in the other local towns.

2.2.3 Electrification Ratio

As easily understood from the above statistics, the electrification in the area is in very low level. Comparing the registered number of consumers and the estimated number of households, the electrification ratios in each major town are estimated as follows:

	Town Population (10^3)	Assumed Size of Household (Person)	Nos. of Household (10^3)	Nos. of Residential Customer	Electrification Ratio (%)
Palembang	761	5.0	152.8	42,992	28.1
Baturaja	63	5.0	12.6	2,184	17.3
Kayuagung	49	5.0	9.8	1,217	12.4
Sekayu	109	5.0	21.8	823	3.8
L. Linggau	56	5.0	11.2	2,240	20.0
Lahat	63	5.0	12.6	2,314	18.4
Muara Enim	41	5.0	8.2	1,232	15.0
Pagar Alam	81	5.0	16.2	1,939	12.0
Tg. Karang	430	5.6	76.2	16,099	20.9
Metro	107	6.0	17.8	1,346	7.6
Kotabumi	96	5.5	17.4	1,506	8.7
Total	1,859	(5.2)	357.3	73,892	20.7

As seen in the above, the electrification ratio has not yet reached 21% in the most towns. Even in Palembang it is only 28%.

2.2.4 Growth Rate of Power Demand

The past growth records in major towns, where more than two million kWh energy was consumed in 1980/81, were analysed based on the sold energy during these 6 years as follows:

	Sold Energy (10^3 kWh)			Growth Ratio for 3 years	
	1974	1977	1980	1974-77	1977-80
Palembang	58,052	71,853	124,355	1.24 (7.4%)	1.73 (20.0%)
Baturaja	1,279	1,710	3,622	1.34 (10.2%)	2.12 (28.5%)
L. Linggau	1,174	1,532	3,866	1.30 (9.1%)	2.52 (36.1%)
Lahat	1,936	2,572	2,759	1.33 (10.0%)	1.07 (2.3%)
Tg. Karang	15,937	19,991	39,651	1.25 (7.7%)	1.98 (25.6%)
Metro	870	1,158	3,359	1.33 (10.0%)	2.90 (42.6%)
Kotabumi	1,233	1,560	3,124	1.27 (8.3%)	2.00 (26.0%)

(% in parenthesis means average increase)

As seen in the above table, the growth rates were extra-ordinarily accelerated and over 20% per annum in most towns, in these few years, during which it is noted that a lot of diesel engine generators were installed under the so-called "Isolated Diesel" electrification project.

2.3 Preliminary Demand Forecast

2.3.1 Preliminary Demand Forecast by PLN Customer

Although more analysis on detailed power statistics and surveys on expectable economic growth in the concerned area are needed to make a demand forecast, a preliminary study is hereunder made to obtain the scale of future demand.

Referring to the rural electrification policy of the Government, and taking into account the current electrification ratio, it is assumed that the electrification will be performed within coming ten years at the following level:

60% in Palembang and Tanjung Karang;
40% in other local towns already electrified; and
20% in rural area not yet electrified.

As for the population, the statistics in 1980/81 show the followings:

	Population (1980)	Growth Rate (1971-80)
South Sumatra Province	4,630	3.32
Lampung Province	4,624	5.82
Total	9,254	4.57

On the other hand, the annual population growth rate in the nation is projected at 2% in the REPELITA III. However, for the purpose of a preliminary forecast, the future population growth rate was assumed at 3% by taking an approximate inter in value among these rates.

Then, the expected numbers of PLN customers in 1990 are estimated as follows:

	Population (10^3)			Nos. of Household (10^3)	Electrif. Ratio (%)	No. of Residential Customer (10^3)
	1980	1990	per each Household			
Palembang	764	1,027	5.0	205.4	60%	123
Tg. Karang	430	578	5.0	115.6	60%	69
Local towns	665	893	5.0	178.6	40%	71
Other area	7,395	9,938	6.0	1,656.3	20%	331
Total	9,254	12,436		2,155.9		594

Further, assuming the unit consumption per customer as follows, the residential energy demand is estimated hereunder:

	Unit Consumption	No. of Residential Customer (10^3)	Residential Demand
Palembang	2,200 kWh	123	271 GWh
Tg. Karang	2,200 kWh	69	152 GWh
Local towns	1,500 kWh	71	107 GWh
Other area	600 kWh	331	199 GWh
Total		594	729 GWh

Besides the above, the energy consumed by other consumers such as commercial, industrial and social use was 40% of the total energy sold (= 67% of residential demand) in Wilayah IV. And their average growth rate during the period from 1974 to 1980 in Palembang has been 15% per annum. It is assumed that 488 GWh at 1990 (729 x 0.67 = 488 GWh) will be added to the residential demand.

Then, the total required energy production and peak load would be as follows based on the assumed loss rate of 20% and load factor of 60%:

Production = (729 + 488) x 1.20 = 1,460 GWh
Peak load = 1,460 x 10^6/(8,760 hr x 0.6) = 277 MW

These figures mean the following average rate of annual growth against actual production of 255 GWh and 51 MW in peak in 1980/81.

Production 1,460/255 = 5.73 (19.1% growth per annum)
Peak Load 277/51 = 5.43 (18.4% growth per annum)

2.3.2 Overall Demand Forecast on Preliminary Basis

Besides the aforementioned demands by PLN customers, captive power demands are to be considered, the detail is available in the attached Table-VII-3, and its total installed capacity is 198 MVA in the project area.

And also, as seen attached Table VII-6, the waiting consumers are requested to receive the power from PLN at present, and its total capacity is 106 MVA in February, 1981. From this demand, 129 MVA shall be deleted as mentioned last paragraph.

Making hold to assume the following, the demand in 1990 would become 867 GWh in production and 165 MW in peak load:

Power factor 0.8
Utilization factor (Actual load/installed cap.) 60%
Load factor 60%
Annual growth rate 7%

Peak load in 1990 = (198 + 106-129) x 0.8 x 0.6 x 1.07^{10} = 165 MW
Production in 1990 = 165 MW x 8,760 hr x 0.6 = 867 GWh

Adding these to the public demands as PLN customers, the total regional demand in 1990 would be about 2,327 GWh and 442 MW.

	PLN demand	Captive power	Total
Production	1,460 GWh	867 GWh	2,327 GWh
Peak load	277 MW	165 MW	442 MW

It should be noted that the loads shown in the above do not include:

- the oil refinery at Palembang (50 MW Captive Power)
- the fertilizer factory at Palembang (38.5 MW Captive Power)
- a new cement factory at Baturaja (18,000 kVA Captive Power)

These have or will have their own large generating plants (129 MVA in total), and would not connect to PLN within the study period.

2.3.3 Power Transmission to Java

During the site survey it was learnt that PLN was planning to construct a DC high voltage transmission line between Sumatra and Java islands in order to transmit surplus electric power to be developed in Sumatra to the Trans-Java 500 kV network, which is currently under construction and the power demand in Java is over 1,600 MW at 1987.

If this DC transmission project is implemented, any power plants to be developed in the Southern part of Sumatra island will have a practically infinite power market.

2.4 Future Activity

2.4.1 New Industries

According to the Bureau of Industrial Development (BKPM-D), an aromatic center, several pulp factories, a cement manufacturing factory and other small domestic industries will be promoted in the project area.

The followings were explanation of outline.

(1) Aromatic Center

Aromatic Center is established at Plaju for produceing the internal material from Naphtha to supply to the textile factories. Major figures are mentioned as follow.

Location : Plaju, South Sumatra

Production & Capacity

- Plat former	25,000 BPCD
- Benzene	374,000 tons/year
- Paraxylene	150,000 tons/year
- Orthoxylene	40,000 tons/year
- DMT	120,000 tons/year
- Cyclohexane (saprolactam)	60,000 tons/year

Raw Material : Naphtha 25,000 BBLD

Marketing : Domestic & Export

Participation : Government (Pertamina)

(2) Pulp and Paper

(a) Pulp for rayon

Location : South Sumatra

Capacity : 200 tons/day dissolving

Raw Material : Monoculture tropical wood

Participation: Government

(b) Pulp & Paper

Location : Around Palembang

Raw Material : Hardwoods including mangrove

Marketing : Domestic & export

2.4.2 Mining Development

In Southern Sumatra, 10 billion tons of coal are estimated to be deposited. The Government intends to develop the coal resources to use coal as the alternate energy sources instead of oil.

Bukit Asam, one of coal mining, has a schedule to produce the coal as follows:

Coal production schedule

Unit : 10^3 tons

	1981	1984	1987
PLTU Suralaya	0	1,147	2,442
PLTU Bukit Asam	0	0	320
P.T. Semen Baturaja	80	224	320
Rail way	18	35	35
others	105	258	400
(Total)	203	1,664	3,517

3. POWER DEVELOPMENT SCHEME BY PLN

3.1 Generation Plants

To meet the fast growing power demands, PLN is currently planning to develop the power plants and extend the transmission networks in the project area.

PLN's power development program in the whole Region IV between FY 1984/85 and 1993/94 is as shown in the attached Table VII-7. Summary of them is as follows (project area only):

Palembang	1 x 20 MW Gas Turbine	1982/83
Bukit Asam No.1 & No.2	2 x 65 MW Coal-fired Steam	1984/85
Banding Agung No.1	2 x 2 MW Hydro	1986/87
Batu Tegi	2 x 12 MW Hydro	"
Banding Agung No.2	4 x 4 MW Hydro	1987/88
Tarahan I	1 x 50 MW Coal-fired Steam	1988/89
Tarahan II	1 x 50 MW Coal-fired Steam	1989/90
Sumber Jaya	20 MW Hydro	"
Komering No.1	81.9 MW Hydro	1990/91

3.2 Power Transmission System

To provide the electric power from the proposed power development sites to the promising power consuming areas; Palembang and Tanjung Karang, PLN is currently planning to construct transmission lines in appropriate scale. The expansion plan of transmission line system in the whole Region IV is shown in the attached Table VII-8. Fig. VII-3 shows the proposed power transmission system and location of hydropower potential in Southern Sumatra.

3.3 Power Distribution System

Proposed expansion for the distribution system is shown in the attached Fig. VII-4.

Standard voltage will be uniformed with 70 kV, 20 kV and 380/220 V in future.

4. LONG-TERM FORECAST OF DEMAND AND SUPPLY

4.1 Demand Forecast

The future power demand in South Sumatra and Lampung Provinces from 1980/81 upto 2003/04 is forecasted through the following procedure.

(1) The demand for lower limit in 1990/91 is forecasted by using 18.4% of average annual growth rate of power demand estimated in section 2.3.1. The demand for upper limit in 1990/91 is used the same demand as estimated in section 2.3.2.

(2) The demand for lower limit in 2003/04 is estimated by assuming the average annual growth rate of power demand to be 10%, considering that the increase of power demand generally take logistical trend. The demand for upper limit in 2003/04 is considered to be the same as that estimated for the lower limit.

(3) Using the demands thus forecasted, the lower and upper demand curves are prepared as shown in Fig. VII-5. In this, the two lower demand points in 1990/91 and 2003/04 are connected with logistic curve, while, the upper demand curve is drawn applying the Logistic Curve Method between two upper demand points in 1990/91 and 2003/04.

4.2 Proposed Supply Plan

In order to satisfy the future demand forecasted in the above, the following generating plants are proposed to be installed taking into consideration the PLN's power development program as well as the development sequence of dams in the Upper Komering River Basin Development Project. The proposed generation plants are as follows:

- Palembang	1 x 20 MW	Gas Turbine	1982/83	Planned by PLN
- Bukit Asam No.1 & No.2	2 x 65 MW	Coal-fired Steam	1984/85	Planned by PLN
- Ranau	3 x 28 MW	Hydro	1987/88	Planned by JICA
- Tarahan No.1 & No.2	2 x 50 MW	Coal-fired Steam	1988/89	Planned by PLN
- Bukit Asam No.3 & No.4	2 x 65 MW	Coal-fired Steam	1989/90	Proposed by JICA

- Tarahan No.3 & No.4	2 x 50 MW	Coal-fired Steam	1991/92	Proposed by JICA
- Komering No.1	3 x 36 MW	Hydro	1993/94	Planned by JICA
- Bulu	92.6 MW	Hydro	1996/97	Proposed by JICA
- Komering No.2	2 x 18 MW	Hydro	1998/99	Planned by JICA
- Padang Binda	78.5 MW	Hydro	1999/2000	Proposed by JICA
- Muaradua	24 MW	Hydro	2001/02	Planned by JICA

Table VII-1 HYDROPOWER POTENTIAL IN LAMPUNG, SOUTH SUMATRA AND BENGKULU PROVINCES

Project Site	Dam Volume ($10^6 m^3$)	Reservoir Capacity ($10^6 m^3$)	Installed Capacity (MW)	Annual Output (GWh)
Lampung Province:				
Batu Tegi (Sekampung river)	-	-	24	50
Sumber Jaya (Besay)	-	-	20	88
Way Semangka	-	-	47	203
Semung No.1	0.6	20	20	116
Semung No.2	0.4	50	30	137
Sub-total			141	594
South Sumatra Province:				
* Ranau Lake (Banding Agung)	-	200	80.7	148
* Komering No.1	2.0	120	114.3	438
* Komering No.2	0.2	4	20.9	174
* Muaradua	1.3	150	7.7	68
Sub-total			223.6	828
Musi Hulu No.1	0.4	200	70	400
Musi Hulu No.2	Run-off-river		53	303
Musi Hulu No.3	Run-off-river		50	302
Padang Bindu (Enim river)	-	-	78.5	344
Bulu (Lematang river)	-	-	92.6	449
Tanjung Pura (saka)	-	-	26.7	116
Sub-total			370.8	1,914
Bengkule Province				
Tes I	-	-	16	101
Tes II	-	-	17	145
Mata Air Panas I (Kelaun river)	-	-	20	88
Sub-total			53	334
Total			788.4	3,670

Data Source: PLN Pusat, Power Development Program on September 1981, and others.

Remarks * : Refer to ANNEX-VIII.

Table VII-2(1) EXISTING GENERATION OWNED BY PLN

PLN WILAYAH IV

(April 1981)

PLTD - Diesel
PLTG - Gas Turbine
PLTU - Thermal
PLTA - Hydro

Source: PLN Region IV

TOWN	PRIME MOVER	RPM	YEAR INSTALLED	VOLT	p.f.	kW	TOTAL INSTALLED kW	DEPENDABLE kW
Palembang (Kramasan)	PLTG							
	W House I	4,830	1976	11,500	0.85	14,466		
	W House II	4,830	1978	11,500	0.85	14,466		
							28,932	26,000
	PLTU							
	Yugo Turbine	3,000	1974	6,300	0.8	12,500		
	Yugo Turbine	3,000	1974	6,300	0.8	12,500		
							25,000	22,500
Palembang (Boom Baru)	PLTG							
	AEG	5,100	1968	6,300	0.78	12,500		
							12,500	11,000
	PLTD							
	MAN	231	1962	7,000	0.78	2,500		
	GM	750	1968	4,160	0.8	2,100		
							4,600	3,800
Kayu Agung	PLTD							
	Waukesha	1,000	1960	220	0.8	100		
	SWD	750	1976	6,300	0.8	336		
	Daihatsu	750	1978	6,300	0.8	250		
	Caterpillar	1,500	1980	210/380	0.8	360		
							1,046	920
Baturaja	PLTD							
	SWD	750	1974	6,300	0.8	336		
	SWD	750	1976	6,300	0.8	336		
	Daihatsu	750	1978	6,300	0.8	250		
	Daihatsu	750	1978	6,300	0.8	250		
							1,172	1,075

Table VII-2(2) EXISTING GENERATION OWNED BY PLN

PLN WILAYAH IV

TOWN	PRIME MOVER	RPM	YEAR INSTALLED	VOLT	p.f.	kW	TOTAL INSTALLED kW	DEPEND-ABLE kW
Sekayu	PLTD							
	DAF	1,500	1972	220	0.8	100		
	SWD	750	1976	6,300	0.8	336		
							436	430
Lahat	PLTD							
	KVM	1,500	1975	400	0.8	200		
	Detroit Diesel	1,500	1977	400	0.8	240		
	SWD	750	1978	6,300	0.8	536		
	Caterpillar	1,500	1977	400	0.8	110		
							1,086	820
Lubuk Linggau	PLTD							
	Skoda	500	1968	6,300	0.8	256		
	SWD	750	1974	6,300	0.8	336		
	SWD	750	1977	6,300	0.8	536		
	SWD	750	1977	6,300	0.8	536		
							1,664	1,410
Muara Enim	PLTD							
	DAF	1,500	1976	220	0.8	100		
	Daihatsu	750	1979	6,300	0.8	250		
							350	315
Pagar Alam	PLTD							
	SWD	750	1977	6,300	0.8	336		
	Daihatsu	750	1978	6,300	0.8	250		
	Daihatsu	750	1978	6,300	0.8	250		
	Caterpillar		1980			500		
							1,336	1,110

Table VII-2(3) EXISTING GENERATION OWNED BY PLN

PLN WILAYAH IV

TOWN	PRIME MOVER	RPM	YEAR INSTALLED	VOLT	p.f.	kW	TOTAL INSTALLED kW	DEPEND-ABLE kW
Tanjungkarang	PLTD							
	Enterprise	600	1957	6,300	0.8	1,000		
	MAN	300	1962	6,300	0.8	1,240		
	MAN	300	1970	6,300	0.8	1,280		
	MAN	300	1970	6,300	0.8	1,280		
	Enterprise	600	1968	6,300	0.8	1,200		
	SWD	500	1977	6,300	0.8	2,296		
	SWD	500	1978	6,300	0.8	4,040		
	SWD	500	1978	6,300	0.8	4,040		
							16,376	14,450
Kotabumi	PLTD							
	Deutz	600	1966	230	0.8	220		
	Deutz	600	1966	230	0.8	220		
	SWD	750	1976	6,300	0.8	336		
	DAF	1,500	1977	200	0.8	100		
	Daihatsu	750	1978	6,300	0.8	250		
							1,126	1,086
Metro	PLTD							
	SWD	750	1974	6,300	0.8	336		
	Daihatsu	750	1978	6,300	0.8	250		
	Daihatsu	750	1978	6,300	0.8	250		
	SWD	750	1978	6,300	0.8	536		
							1,372	1,250
Jambi	PLTD							
	Worthington	375	1956	6,300	0.8	800		
	Skoda	375	1964	6,300	0.8	560		
	Skoda	375	1965	6,300	0.8	560		
	MAN	600	1968	6,300	0.8	440		
	SWD	500	1975	6,300	0.8	1,340		
	SWD	500	1975	6,300	0.8	1,340		
	SWD	500	1977	6,300	0.8	2,296		
							7,336	5,748
Muara Bungo	PLTD							
	Skoda	750	1970	231	0.8	60		
	Skoda	750	1970	231	0.8	60		
	Daihatsu	750	1979	6,300	0.8	250		
							370	370

Table VII-2(4) EXISTING GENERATION OWNED BY PLN

PLN WILAYAH IV

TOWN	PRIME MOVER	RPM	YEAR INSTALLED	VOLT	p.f.	kW	TOTAL INSTALLED kW	DEPENDABLE kW
Bangko	PLTD							
	DAF	1,500	1976	220	0.8	100		
							100	100
Bengkulu	PLTD							
	Kroshaut	750	1971	6,300	0.8	248		
	Kroshaut	750	1971	6,300	0.8	248		
	SWD	750	1977	6,300	0.8	536		
	SWD	750	1977	6,300	0.8	536		
	SWD	750	1978	6,300	0.8	536		
	MWM	0	-	-	0.8	200		
	MWM	0	-	-	0.8	100		
							2,504	2,200
Tes	PLTA							
	SPAC	1,000	1959	6,000	0.8	660		
	SPAC	1,000	1959	6,000	0.8	660		
							1,320	1,200
Manna	PLTD							
	Daimler Benz	1,000	19	230	0.8	64		
	Daimler Benz	1,000	19	230	0.8	69		
	Caterpillar	1,500	1977	400	0.8	110		
	Caterpillar		1980			200		
							443	350
T. Laning	PLTA							
	G. Gilkes	660	1977	220	0.8	100		
							100	100
Tanjung Pandan	PLTD							
	Daihatsu	750	1979	6,300	0.8	500		
	Daihatsu	750	1979	6,300	0.8	500		
	Daihatsu	750	1979	6,300	0.8	500		
							1,500	1,350
	Total						110,609	97,574

Table VII-3(1) EXISTING GENERATION OWNED BY ENTERPRISE

PRIVATE (Captive Power)

(January 1981)

TRADE NAME	BUSINESS	CAPACITY (kVA)			OPERATION SINCE (YEAR)	REMARKS
		GENERATOR		FROM PLN		
CABANG: PALEMBANG						Source: PLN Pusat
A. A. Hamid	Pabrik ES	Diesel	26	-	1952	
Bumi Swarna	Pabrik ES	"	193.75	-	1950	
Pabrik Ban	Pabrik Ban	"	2 x 720	1,000	1969	
Bakri Brothers	Remilling Karet	"	1,753	-	1970	
Waringin Kencana	Remilling Karet	"	3 x 350	-	1970	
P.N. Patal	Pabrik Pemintalan	"	5 x 1,100	2,000	1969	
P.N. Patal	Pabrik Pemintalan	"	340	-	1969	
P.T. Pusri	Pupuk	"	5 x 1,836	-	1962	
C.V. Panca Putra	Panglong Kayu	"	260	250	1954	
P.T. Raja Baru	Panglong Kayu	"	210	-	1969	
Pemancar Pantai	Pengusahaan Pelabuhan	"	50	-	1962	
Bina Marga	Perbengkelan	"	52	-	1967	
Penerbangan Sipil	Pelabuhan Udara/Telkom	"	125	300	1971	
- " -	- " -	"	30	-	1956	
- " -	- " -	"	30	-	1963	
- " -	- " -	"	50	95	1965	
Kian Guan	Panglong Kayu	"	297	-	1957/1958	
New Pioneer	Pengawetan Udang	"	125	-	1950	
RSUP. Palembang	Rumah Sakit	"	2 x 135	360	1954	
R.S. Charitas	Rumah Sakit	"	270	100	1956	
Musi Bahagia	Pabrik	"	50	-	1951	
P.L.K. Kenten	Sekolah	"	150	160	1969	
Jembatan Musi	Pemda TK.I	"	500	161.5	1964	
P.T. Lembah Agung	Penggilingan Kopi	"	85	-	1962	
Pabrik ES Sekanak	Pabrik ES	"	304	-	1954/1955	
H. Sabari	Panglong Kayu	"	25	-	1950	
Tiara Indah	Panglong Kayu	"	35	-	1960	
Alir Menjaya	Bengkel	"	66	114	1966	
P.T. Nusantara	Panglong Kayu	"	30	-	1960	
Hidayah	Panglong Kayu	"	100	-	1953/1960	
H. Ujang	Panglong Kayu	"	90	-	1970	
P.T. Wahab Sidik	Panglong Kayu	"	355	-	1962	
Studio R.R.I	Pemancar	"	60	-	1972	
S.T.M. Pakjo	Sekolah/Bengkel	"	75	- -	1950	

(Note) excluding following
- Pertamina 50,000 kW
- P.T. Pusri 38,500 kW
- P.T. Semen Baturaja 18,000 kVA

Table VII-3(2) EXISTING GENERATION OWNED BY ENTERPRISE

PRIVATE (Captive Power)

(January 1981)

TRADE NAME	BUSINESS	CAPACITY (kVA) GENERATOR		FROM PLN	OPERATION SINCE (YEAR)	REMARKS
P.U	Bengkel	Diesel	65	160	1964	
A.U.R.I	Lapangan Udara	"	69	200	1957	
	Sub Total	36-Owner	23,310.75 kVA	(18.6 MW)		

CABANG: LAHAT

Source: PLN Vilayah IV

TRADE NAME	BUSINESS	GENERATOR		FROM PLN	OPERATION SINCE (YEAR)	REMARKS
Perkebunan Teh	Pabrik Teh	Diesel	150	-	1965	
		"	138	-	1953	
		"	155	-	1970	
P J K A	Bengkel	"	250	-	1971	
		"	500	-	1973	
PT. Air Saling	Perkebunan	"	25	-	1968	
		"	45	-	1960	
PT. STANVAC	Pengolahan Minyak	"	600	-	1950	
		"	600	-	1950	
		"	600	-	1950	
		"	600	-	1950	
		"	600	-	1970	
PT. STANVAC	Pengolahan Minyak	"	185	-	1969	
		"	210	-	1969	
		"	110	-	1969	
		"	110	-	1969	
		"	500	-	1970	
		"	500	-	1970	
		"	500	-	1970	
		"	500	-	1970	
		"	110	-	1970	
		"	110	-	1970	
		"	60	-	1971	
PT. Lingga Jaya	Remiling Karet	"	60	-	1970	
		"	60	-	1970	
		"	100	-	1959	
PN. TBB. UPBA	Tambang Batubara	Steam	2,500	-	1924	
		"	2,500	-	1926	
		"	3,000	-	1930	
		"	3,000	-	1933	
		"	6,250	-	1965	
		"	6,250	-	1965	

Table VII-3(3) EXISTING GENERATION OWNED BY ENTERPRISE

PRIVATE (Captive Power)
(January 1981)

TRADE NAME	BUSINESS	CAPACITY (kVA) GENERATOR		CAPACITY (kVA) FROM PLN	OPERATION SINCE (YEAR)	REMARKS
Pabrik Es.	Pabrik Es	Diesel	160	-	1952	
Usaha Veteran	Distribusi Listrik	"	100	-	1959	
PT. Mekar Jaya	Pabrik Es	"	10	-	1977	
S.P.B.U.	Pompa Bensin	"	10	-	1978	
Sakura	Photo Studio	"	5	-	1978	
Salco	Photo Studio	"	3	2	1979	
Kota Baru	Rumah Makan	"	2	1.3	1979	
Pelangi	Photo Studio	"	3	2	1979	
Perum Telkom	Telephone	"	100	100	1979	
		"	100	-	1979	
Abd. Manaf	Penerangan	"	3	-	1979	
Nasaruddin	Penerangan	"	3	-	1979	
Zainal Arifin	Penerangan	"	5	-	1979	
Anas Tar Tar	Penerangan	"	2	-	1979	
Kosim	Penerangan	"	3	-	1979	
Badri	Penerangan	"	5	-	1979	
Basri	Penerangan	"	3	-	1979	
Jusi	Penerangan	"	3	-	1979	
Jaisi	Penerangan	"	3	-	1979	
Matari	Penerangan	"	3	-	1979	
Asir	Penerangan	"	8	-	1979	
M.Asmal	Penerangan	"	5	-	1979	
Gotong Royong	Penerangan	"	35	-	1979	
Nalo	Pabrik Es	"	10	-	1979	
S.P.B.U.	Pompa Bensin	"	10	-	1980	
Salon	Photo Studio	"	2	-	1979	
N.si	Photo Studio	"	2	-	1979	
Suka Cinta	Penerangan	"	10	-	1979	
Pandar	Penerangan	"	5	-	1979	
Kebun Pandar	Penerangan	"	5	-	1979	
Karang Anyar	Penerangan	"	3	-	1979	
Telek Gunung	Penerangan	"	3	-	1979	
Lubuk Bintak	Penerangan	"	2	-	1979	
Muara Terang	Penerangan	"	2	-	1979	
Tanjung Menang	Penerangan	"	2	-	1979	
Tanah Putih	Penerangan	"	2	-	1979	

Table VII-3(4) EXISTING GENERATION OWNED BY ENTERPRISE

PRIVATE (Captive Power)

(January 1981)

TRADE NAME	BUSINESS	CAPACITY (kVA)			OPERATION SINCE (YEAR)	REMARKS
		GENERATOR		FROM PLN		
Buana Keling	Penerangan	Diesel	2	-	1979	
Mingkik	Penerangan	"	2	-	1979	
	Sub Total	44-Over	31,514 kVA	(25.2 MW)		

CABANG: TANJUNG KARANG

Source: PLN Pusat

TRADE NAME	BUSINESS	GENERATOR		FROM PLN	OPERATION SINCE (YEAR)	REMARKS
P.T. Bakri Brothers	Pengolahan Hasil Bumi	Diesel	72	200	1963	
		"	50	-	1963	
P.T. Bumi Waras II	Pabrik Minyak Kelapa	"	240	-	1977	
		"	240	-	1977	
P.T. Gunung Semiung	Pengolahan Hasil Bumi	"	100	-	1971	
P.T. Darma Lampung Industri	Perucetaken	"	50	-	1975	
P.T. Lampung Pelletizing	Pengolahan Hasil Bumi	"	250	-	1971	
		"	250	-	1971	
		"	200	-	1971	
		"	150	-	1971	
P.T. Andatu	Galangan Kapal	"	50	-	1972	
		"	50	-	1972	
		"	50	-	1972	
		"	50	-	1972	
P.T. Indopel Raya	Pabrik Pellet	"	262	-	1975	
		"	262	-	1975	
		"	262	-	1975	
		"	15	-	1975	
P.T. Teluk Betung Pelletizing	Pabrik Pellet	"	450	-	1974	
		"	400	-	1974	
		"	50	-	1974	
		"	30	-	1974	
P.N.P. X. Nigeria	Perkebunan	"	413	-	1975	
		"	188	-	1975	
		"	16.25	-	1975	
P.T. Indra Brothers	Pengolahan Hasil Bumi	"	75	-	1964	
Pelabuhan Ferry Srengsem	Pelabuhan	"	50	-	1977	
		"	50	-	1977	
		"	50	-	1977	

Table VII-3(5) EXISTING GENERATION OWNED BY ENTERPRISE

PRIVATE (Captive Power)

(January 1981)

TRADE NAME	BUSINESS	CAPACITY (kVA)			OPERATION SINCE (YEAR)	REMARKS
		GENERATOR		FROM PLN		
P.T. Daya Sakti	Pabrik Sepeda	Diesel	270	-	1952	
		"	200	-	1952	
		"	200	-	1952	
		"	200	-	1952	
		"	200	-	1952	
		"	350	-	1952	
P.T. Garuntang	Pengolahan Hasil Bumi	"	340	40	1961	
		"	340	-	1961	
		"	340	-	1961	
P.T. Lembah Gunung	Pengolahan Hasil Bumi	"	140	-	1966	
		"	140	-	1966	
		"	50	-	1966	
P.T. Way Kandis	Pabrik Karet	"	325	-	1971	
		"	260	-	1971	
		"	313	-	1971	
		"	313	-	1971	
		"	325	-	1971	
C.V. Kota Agung	Pengolahan Hasil Bumi	"	64	-	-	
		"	120	-	-	
P.T. Nasional Sumatera Pelletizing	Pabrik Pellet	"	1,502.4	-	-	
P.T. Lembah Gunung	Pengolahan Hasil Bumi	"	264	-	-	
Work Shop P.U.	Bengkel	"	52	-	-	
Perhubungan Udara	Komunikasi Dan	"	385	-	1976	
	Penerangan	"	37.6	-	-	
P.N.P. Pewa	Crumb Rubber	"	696	-	-	
P.T. Valet Kencana	Pengolahan Hasil Bumi	"	42	-	-	
C.V. Lukman Saoi	Pengolahan Hasil Bumi	"	136	-	-	
P.J.K.A.	Pompa Air	"	30	-	-	
Edi Permata	Pengolahan Hasil Bumi	"	52.4	-	-	
Pabrik Semprong	Pabrik	"	32	-	-	
C.V. Wira Sari	Pengolahan Hasil Bumi	"	40	-	-	
King Teatre	Bioskop	"	52.4	-	-	
P.T. Sungai Budi	Pengolahan Hasil Bumi	"	64	-	-	
P.T. Sabang Jaya	Pengolahan Hasil Bumi	"	109.6	-	-	
P.T. Tri Tunggal	Pengolahan Hasil Bumi	"	62.4	-	-	
P.T. Semen Baturaja	Pengantongan Semen	"	1,900	-	1980	
	Sub Total	32-Owner	14,323.05 kVA		(11.5 MW)	

Table VII-3(6) EXISTING GENERATION OWNED BY ENTERPRISE

PRIVATE (Captive Power)
(January 1981)

TRADE NAME	BUSINESS	CAPACITY (KVA)			OPERATION SINCE (YEAR)	REMARKS
		GENERATOR		FROM PLN		
CABANG: JAMBI						Source: PLN Pusat
P.T. Angkasa Raya	Crumb Rubber	Diesel	187.5	-	1970	
		"	187.5	-	1970	
		"	187.5	-	1970	
		"	187.5	-	1970	
P.T. Merawa	Crumb Rubber	"	80	-	1964	
		"	50	-	1964	
		"	185	-	1964	
		"	156	-	1964	
		"	30	-	1964	
P.T. Batang Hari Tembesi	Crumb Rubber	"	200	-	1970	
		"	312.5	-	1970	
		"	312.5	-	1970	
		"	312.5	-	1970	
B.N.I.	Bank	"	105	100	1976	
P.T. Jambi Waras	Crumb Rubber	"	330	-	1968	
		"	220	-	1968	
		"	60	-	1968	
		"	670	-	1968	
		"	670	-	1968	
P.T. Waringin Kencana	Crumb Rubber	"	525	-	1970	
		"	525	-	1970	
		"	525	-	1970	
		"	525	-	1970	
		"	525	-	1970	
		"	525	-	1970	
P.T. Wiolu Karya Indah	Saw Mill	"	63	-	1973	
		"	50	-	1973	
D.P.R.D. Dati I. Jambi	-	"	188	33.5	1975	
P.T. Eok Tong	Crumb Rubber	"	435	-	1974	
		"	435	-	1974	
		"	294	-	1974	
		"	100	-	1974	
		"	150	-	1974	
R.R.I. Jambi	Pemancar Radio	"	38	6.1	1968	

Table VII-3(7) EXISTING GENERATION OWNED BY ENTERPRISE

PRIVATE (Captive Power)
(January 1981)

TRADE NAME	BUSINESS	CAPACITY (kVA) GENERATOR		CAPACITY (kVA) FROM PLN	OPERATION SINCE (YEAR)	REMARKS
R.R.I. Jambi	Pemancar Radio	Diesel	62.5	-	1976	
		"	62.5	-	1976	
		"	9	-	1976	
T.V.R.I.	Stasiun Relay	"	47.5	-	1976	
		"	47.5	-	1976	
		"	47.5	-	1976	
Makmur	Hotel	"	24	42.5	1971	
		"	12.5	42.5	1971	
		"	50	42.5	1971	
	Sub Total	13-Over	9,709.5 kVA	(7.8 MW)		

CABANG: BENGKULU

Source: PLN Pusat

TRADE NAME	BUSINESS	CAPACITY (kVA) GENERATOR		CAPACITY (kVA) FROM PLN	OPERATION SINCE (YEAR)	REMARKS
Perum Telekomunikasi	Penerangan/Bid. Telkom	Diesel	50	3.9	1976	
RRI Pemda Bengkulu	Penerangan & Pemancar	"	2 x 50	-	1976	
C.V. Yakin Makmur	Remilling Karet	"	63	-	1976	
P.T. Asarin	Crumb Rubber/Penerangan	"	135	-	1971	
P.T. Asarin	Crumb Rubber	"	260	-	1972	
Bank Indonesia	Penerangan	"	105	-	1971	
D.P.U. TK.I.	Work Shop/Penerangan	"	65	-	1971	
POLRI	Penerangan	"	40	-	1971	
Pelabuhan Udara	Instrument/Penerangan	"	30	-	1971	
Pemda Prop. Bengkulu	Instrument/Penerangan	"	45	-	1975	
Rakyat Setempat	Penerangan	"	105	-	1950	
S.K.S.D.	Untuk Siaran/Pemancar	"	2 x 25	-	1978	
P.A.M. Bengkulu	Perusahaan Air	"	118	-	1979	
P.A.M. Bengkulu	Perusahaan Air	"	125	-	1979	
	Sub Total	14-Over	1,291 kVA	(1.0 MW)		

CABANG: TANJUNG PANDAN

Source: PLN Pusat

TRADE NAME	BUSINESS	CAPACITY (kVA) GENERATOR		CAPACITY (kVA) FROM PLN	OPERATION SINCE (YEAR)	REMARKS
P.T. UPTB Belitung	Tambang Timah	Diesel	540	-	1943	
		"	540	-	1943	
		"	540	-	1947	
		"	540	-	1947	
		"	540	-	1947	
		"	245	-	1968	
		"	315	-	1968	

Table VII-3(8) EXISTING GENERATION OWNED BY ENTERPRISE

PRIVATE (Captive Power)

(January 1981)

TRADE NAME	BUSINESS	CAPACITY (kVA) GENERATOR		FROM PLN	OPERATION SINCE (YEAR)	REMARKS
P.T. UPTB Belitung	Tambang Timah	Diesel	75	-	1973	
		"	75	-	1973	
		"	75	-	1973	
		"	75	-	1973	
		"	75	-	1971	
		"	75	-	1971	
		"	540	-	1947	
P.T. UPTB Belitung	Tambang Timah	"	125	-	1968	
		"	125	-	1968	
		"	125	-	1968	
		"	180	-	1966	
		"	180	-	1966	
		"	125	-	1968	
P.T. UPTB Belitung	Tambang Timah	"	1,200	-	1927	
		"	2,100		1927	
		"	2,100		1927	
		"	2,200	-	1927	
		"	2,100	-	1927	
		"	2,200	-	1935	
		"	2,650	-	1974	
		"	2,650	-	1974	
P.T. Keramika Indonesia (P.T. Kerasia)	Pabrik Keramik	"	500	-	1972	
		"	570	-	1978	
		"	275	-	1957	
		"	275	-	1957	
		"	560	-	1969	
	Sub Total	5-Owner	24,490 kVA	(19.6 MW)		
	Total		104,638.3 kVA	(83.7 MW)		

Table-VII-4 INSTALLED CAPACITIES IN SOUTH SUMATRA AND LAMPUNG PROVINCES

Name of City/Town	PLN (as of April 81) Unit	Installed Capacity (KW) /1	Private (as of Jan. 81) Nos. of Owner	Installed Capacity (KVA)
South Sumatra Province				
Palembang	7	71,032 (59,500)	1 (Pertamina)	50,000(kW)
			1 (Pusri)	38,500(kW)
			36	23,310.75
Baturaja	4	1,172 (1,075)	1 (P.T. Semen Baturaja)	18,000
Kayuagung	4	1,046 (920)		
Sekayu	2	436 (420)		
Lubuk Linggau	4	1,664 (1,410)		
Lahat	4	1,086 (820)	44	31,514
Muaraenim	2	350 (315)		
Pageralam	4	1,336 (1,110)		
Sub-Total	31	78,122	50	183,449.75
Lampung Province				
Tanjung Karang	8	16,376(14,450)	32	14,323.05
Kotabumi	5	1,126 (1,086)		
Metro	4	1,372 (1,250)		
Sub-Total	17	18,874	32	14,323.05
Total	48	96,996 (82,356)	82	197,772.80

/1 : Figures in Parenthesis mean actual output.

Table-VII-5(1) HISTORICAL DATA OF ENERGY PRODUCTION AND CONSUMPTION

Year	Peak Load kW	Production 10^3 kWH	Sold 10^3 kWH	Peak Load kW	Production 10^3 kWH	Sold 10^3 kWH
		PALEMBANG			TANJUNG KARANG	
CY 68	9,200	48,801	36,970			
69	9,250	53,230	40,052			
70	9,399	54,130	40,822			
71	-	60,272	46,685		18,121	
72	-	61,726	46,819		18,644	13,960
73	-	62,718	48,086			14,949
FY 74/75	16,000	94,147	58,052	3,860	21,536	15,937
75/76	18,800	106,153	63,127	4,320	23,553	17,343
76/77	20,000	116,943	66,540	4,530	24,549	17,793*
77/78	24,500**	129,770	71,853	5,780	29,734	19,991*
78/79	25,400	137,690	84,771	7,890	36,949	24,185*
79/80	26,500	151,802	106,096*	9,500	47,330	35,215
80/81	33,400**	172,895	124,355	11,060	53,710	39,651
		KAYUAGUNG			METRO	
FY 74/75	172	566	500	336	1,051	870
75/76	185	608	504	335	1,240	972
76/77	300	910	562	370	1,303(CY)	1,052
77/78	340**	1,275	744	433	1,539	1,158*
78/79	480	1,622	1,029	730	2,660	1,641*
79/80	550**	1,875	1,300	850	4,112	2,950
80/81	630	2,282	1,547	1,025	4,716	3,359
		BATURAJA			KOTABUMI	
FY 74/75	417	1,553	1,279	-	1,598	1,233
75/76	443	1,723	1,355	388	1,592	1,210
76/77	478	1,891	1,463	388	1,686	1,252
77/78	534**	2,210	1,710	600	2,186	1,560
78/79	638	2,700	2,112	750	3,200	1,979*
79/80	765	4,088	2,920	920	4,523	2,927*
80/81	900	4,610	3,622	965	4,698	3,124

Table-VII-5(2) HISTORICAL DATA OF ENERGY PRODUCTION AND CONSUMPTION

Year	Peak Load kW	Production 10^3 kWH	Sold 10^3 kWH	Peak Load kW	Production 10^3 kWH	Sold 10^3 kWH
		SEKAYU				
FY 74/75	0	0	0			
75/76	0 (from June)	0	0			
76/77	70	99	80			
77/78	121	292	237			
78/79	159	395	314			
79/80	205	577	520*			
80/81	272	756	633			
		LAHAT			**MUARAENIM**	
FY 74/75	588	2,052	1,936	184	939	918
75/76	576	2,350	2,071	176	966	927
76/77	504	2,675	2,172	184	1,064	1,043
77/78	621**	3,020	2,572	200	1,222	1,094
78/79	679**	3,022	2,722	344	1,268	1,213
79/80	808**	4,452	3,489	308**	1,037**	1,024*
80/81	994**	3,446	2,759	353**	1,524**	1,285
		PAGERALAN			**LUBUK LINGGAU**	
FY 74/75	0		0	335	1,256	1,174
75/76	0 (from March)		0	325	1,273	1,161
76/77	-	3.7	3.4	437	1,329	1,180
77/78	196**	197	152	518	1,804	1,532*
78/79	281**	641	496	760	3,248	2,516*
79/80	585	1,364	803*	920	4,536	3,488*
80/81	680	1,929**	1,612	1,020	4,926	3,866

(source) * marked figure; from PLN Wilayah IV (proceed from others)
** marked figure; from PLN Pusat (")
no marked figure; from PLN each Branch Office and Sector

(note) CY: calendar year, FY: fiscal year

Table-VII-6 (1) LIST OF WAITING CONSUMER
(February 1981)

CABANG PALEMBANG

Source: PLN Branch Office

CONSUMER	ADDRESS	CAPACITY (kVA)
PRI	Indralaya	1,750
TVRI	Jl. Kapten A.Rivai Kampus	1,000
Sumatra Steel	Jl. Duku	800
Acid	Jl. Kolonel Barlian	500
UNSRI	Jl. R. Suprapto	1,000
Remiling	Jl. Gandus	1,000
Pabrik Es	Tanjung Raja	350
Real Estate	Jl. Kenten	300
Penerbangan Sipil	Jl. Talang Betutu	100
Sosial Indralaya	Indralaya (OKI)	50
Pabrik Textil Matratex	Jl. Jendral Sudirman	300
Pabrik Es	Jl. Suro	100
Pabrik Es	Jl. KH Azhari	100
Komplek Wai Hitam	Seberang Ulu	250
Komplek Pertokoan	Jl. KH Azhari	750
Dika Trading	Jl. Beringin Janggut	1,000
Komplek Pertokoan	15 Ilir (Bekas Kebakaran)	400
Komp. Perumahan ABRI	Jl. Sediduk Putih	150
PT. Sepakat Siantar	Banyuasin	1,000
Pabrik Ban	Jl. S. Batang	1,000
Komplek perumahan Tl. Kelapa	Jl. Sim. Talang Betutu	1,000
Perum Nas Tahap ke II	Jl. Kenten	500
Kantor P.U. Propinsi	Jl. Kpt. Anwar Sastro	100
Perumahan U.K.A.	Jl. Kenten	150
Unit Batalyon Balau	Martapura	600
Pabrik Es Martapura	Martapura	50
Kompl. Yayasan Ibnu Sutowo	Martapura	50
	TOTAL	14,350

Table-VII-6 (2) LIST OF WAITING CONSUMER
(February 1981)

CABANG TANJUNGKARANG

Source: PLN Branch Office

CONSUMER	ADDRESS	CAPACITY (kVA)
A. Large Consumer		
PT. Indopell Raya	Jln. Way Lunik Panjang	800
PT. Nasional Sumatra Pelletizing	" - Idem -	1,200
PT. Lampung Pelettizing	" Yos Sudarso Panjang	600
PT. Indofood Raya	" Kalianda	500
PT. Sumber Jaya	" Yos Sudarso	1,000
CV. BUMI WARAS I	" Yos Sudarso	400
CV. Bumi Waras II	" Yos Sudarso	1,500
PT. Daya Sakti	" Yos Sudarso	1,200
PT. Andatu	" Kalianda	450
PT. Jaka Utama	" Kalianda	1,200
PT. Gunung Madu	Palabuhan Panjang	150
Pelabuhan Panjang	- Idem -	200
PT. Gunung Seminung	Jln. Yos Sudarso	100
Pabrik Sabun Sinar Laut	- Idem -	500
CV. Kota Agung	- Idem -	120
PT. Semen Batu Raja	- Idem -	8,000
Rencana Terminal Batubara	BATU SERAMPOK	7,000
Rencana Pabrik Ban Dunlop	---	15,000
	Sub Total	39,920
B. Residencial Consumar		
Komplek perumahan Dosen Faperta Unila 40 rumah	Jln. Labuhan Ratu	100
Komplek perumahan Way Halim Permai 400 rumah	Kamp. Way Halim	400
Komplek perumahan Way Halim 1032 Rumah	- Idem -	400

Table-VII-6 (3) LIST OF WAITING CONSUMER

(February 1981)

CABANG TANJUNGKARANG

Source: PLN Branch Office

CONSUMER	ADDRESS	CAPACITY (kVA)
Komplek Perumahan Hankam 200 rumah	Kamp. Way Halim	160
Langganan siap sambung 3000 calon langganan	Tersebar	3,000
Komplek perumahan Palri 100 rumah		160
Studio RRI Pahoman	Jln. Slamet Riyadi	95
Pemancar RRI Kedaton III	Kedaton. III	66
	Sub Total	4,381
	TOTAL	44,301

Table-VII-6 (4) LIST OF WAITING CONSUMER

(July 1981)

CABANG LAHAT

Source: PLN Branch Office

Town	Use	Capacity (kVA)
Lahat	Household-Urban	987.5
	Household-Rural	369
	Industry	500
Lubuk Linggau	Hosehold-Urban	895.5
	Household-Rural	231
	Industry	250
Muaraenim	Household-Urban	1,418
	Household-Rural	450
	Industry	36,060
Pageralam	Household-Urban	2,197.8
	Household-Rural	3,714
	Industry	625
	TOTAL	47,697.8

Table-VII-7 EXPANSION PLAN OF MAJOR POWER PLANT IN SOUTHERN SUMATRA

Operation Start	Name of Plant	Capacity	Type/1	Status
FY 1984/85	Bukit Asam I, II	2 x 65 MW	U	Under construction
85/86	Tes I	4 x 4 MW, 101 GWh	A	Engineering Design
86/87	Banding Agung I	2 x 2 MW	A	Engineering Design
86/87	Batu Tegi	2 x 12 MW, 50 GWh	A	Engineering Design
87/88	Banding Agung II	4 x 4 MW	A	FS
88/89	Tarahan I	1 x 50 MW	U	Plan
88/89	Tes II	2 x 8.5 MW, 145 GWh	A	F.S
89/90	Tarahan II	1 x 50 MW	U	Plan
89/90	Sumber Jaya	20 MW, 88 GWh	A	Pre FS
90/91	Komering I	81.9 MW, 470 GWh	A	Pre FS
91/92	Komering II	52.2 MW, 326 GWh	A	Pre FS
91/92	Bukit Asam III	1 x 65 MW	U	Plan
92/93	Padang Bindu (sungai Enim)	78.5 MW, 344 GWh	A	Pre FS
93/94	Bulu (sungai Lematang)	92.6 MW, 449 GWh	A	Pre FS
Not yet decided	Ranau (Banding Agung)	48.3 MW, 129 GWh	A	Pre FS
"	Mata Air Panas I (sungai Ketaun)	20 MW, 88 GWh	A	Pre FS
"	Way Semangko	47 MW, 203 GWh	A	Pre FS
"	Muara Dua	34.2 MW, 245 GWh	A	Pre FS
"	Tanjung Pura	26.7 MW, 116 GWh	A	Pre FS
"	Suoh	86 MW	P	Plan

Source: PLN Pusat, September 1981

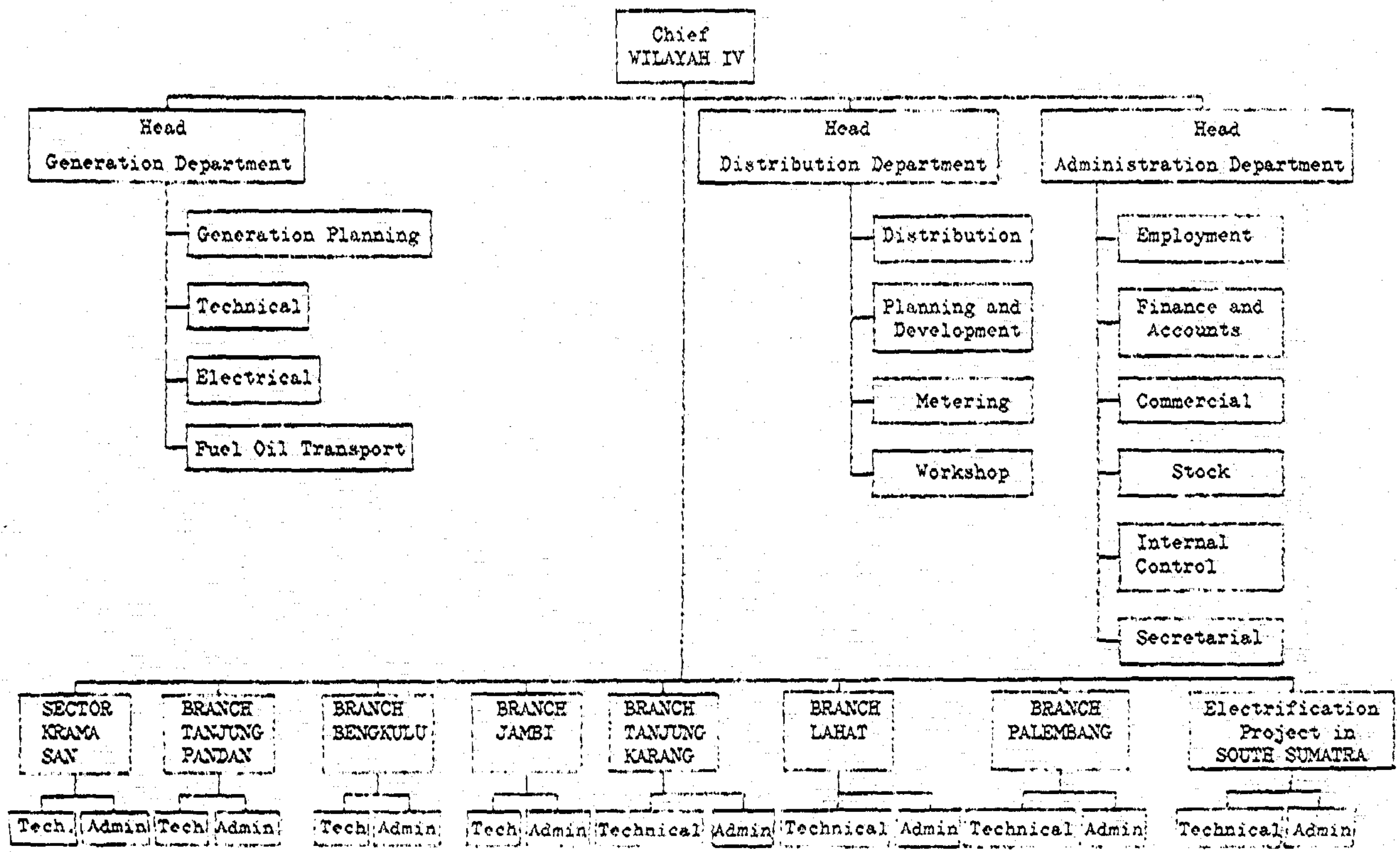
/1: U = Steam A = Hydro P = Geo Thermal

Table-VII-8 EXPANSION PLAN OF POWER TRANSMISSION SYSTEM IN SOUTHERN SUMATRA

Section	Voltage (kV)	Length (km)	No. 2 Circuit	Commissioning Year
PLTU Bukit Asam - Palembang	150	150	2	1984/85
PLTU Bukit Asam - Baturaja	150	90	2	"
Kotabumi - Metro	150	50	2	"
Metro - Tanjung Karang	150	30	2	"
PLTA Tes I - Curup	150	40	2	1985/86
Curup - Bengkule (1st)	150	60	1	"
Curup - Lubuk Linggau (1st)	150	45	1	"
PLTA Batu Tegi - Talang Padang	150	15	1	1986/87
Talang Padang - Tanjung Karang	150	50	1	"
PLTA Banding Agung - Muara Dua	150	40	1	"
Muara Dua - Baturaja	150	60	1	"
PLTU Tarahan I - Tanjung Karang	150	10	2	1988/89
PLTU Tarahan I - Kalianda (1st)	150	60	1	"
PLTA Tes I - PLTA Tes II	150	5	2	"
PLTA Sumber Jaya - Kotabumi	150	50	1	1989/90
PLTU Tarahan II - Tanjung Karang	150	10	1	"
Curup - Bengkule (2nd)	150	60	1	1990/91
Curup - Lubuk Linggau (2nd)	150	45	1	"
PLTA Komering I - Muara Dua	150	35	1	"
PLTA Komering II - Muara Dua	150	30	1	1991/92
PLTU Bukit Asam - Prabumulih	150	-	1	"
PLTA Padang Bindu (Enim) - Baturaja	150	60	2	1992/93
PLTU Tarahan I - Kalianda (2nd)	150	60	1	1993/94
PLTA Bulu (Lematang) - Tanjung Enim	150	50	2	"
PLTA Mata Air Panas I - Tes I	150	-		Under Planning
PLTA Way Semangka - Talang Padang	150	40		"
PLTA Muara Dua - Muara Dua	150	5		"
PLTA Tanjung Pura - Baturaja	150	50		"
PLTP Suoh - Talang Padang	150	40		"

Source : PLN Pusat, September 1981

Fig. VII-1 ORGANIZATION STRUCTURE OF PLN REGION IV



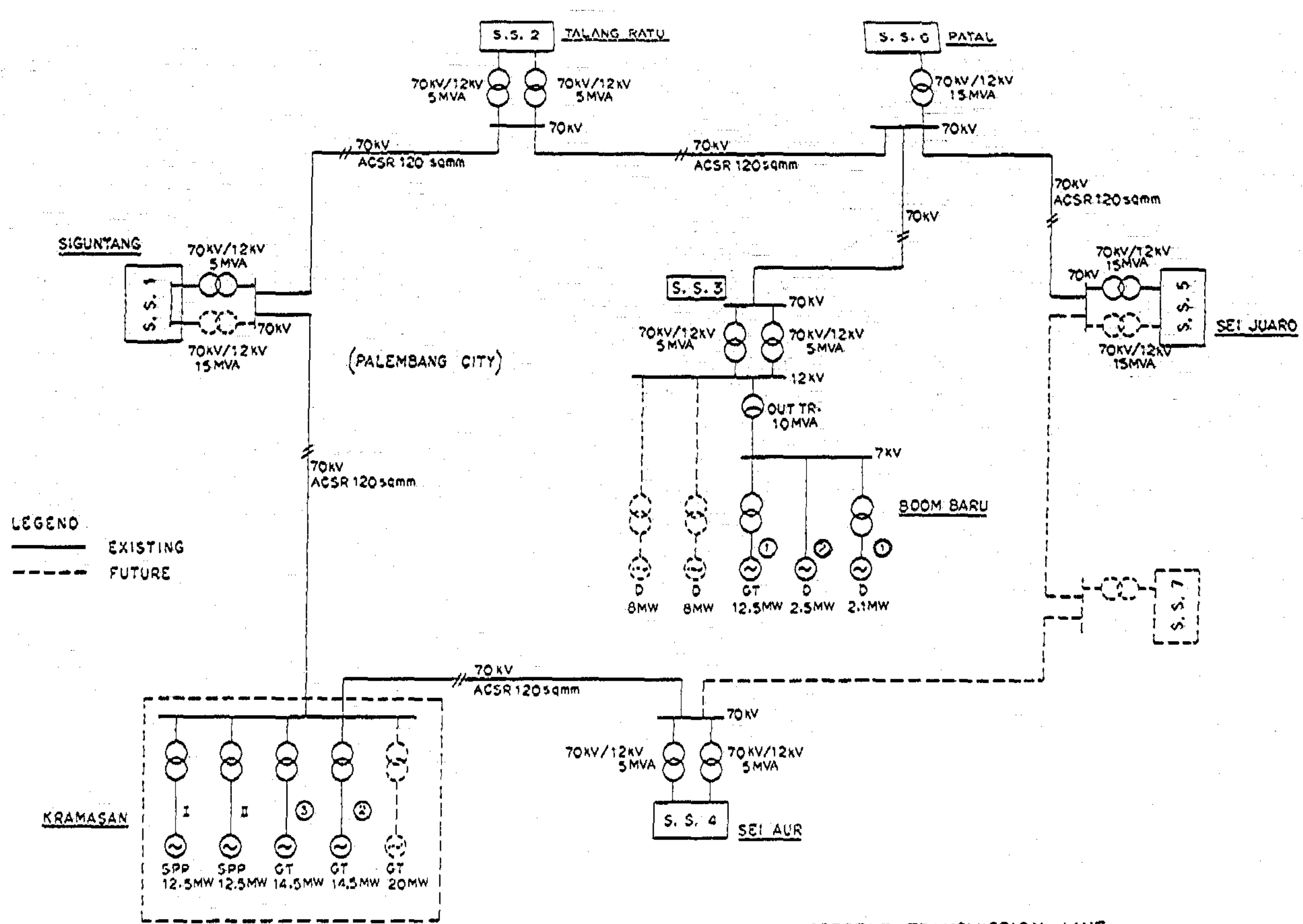
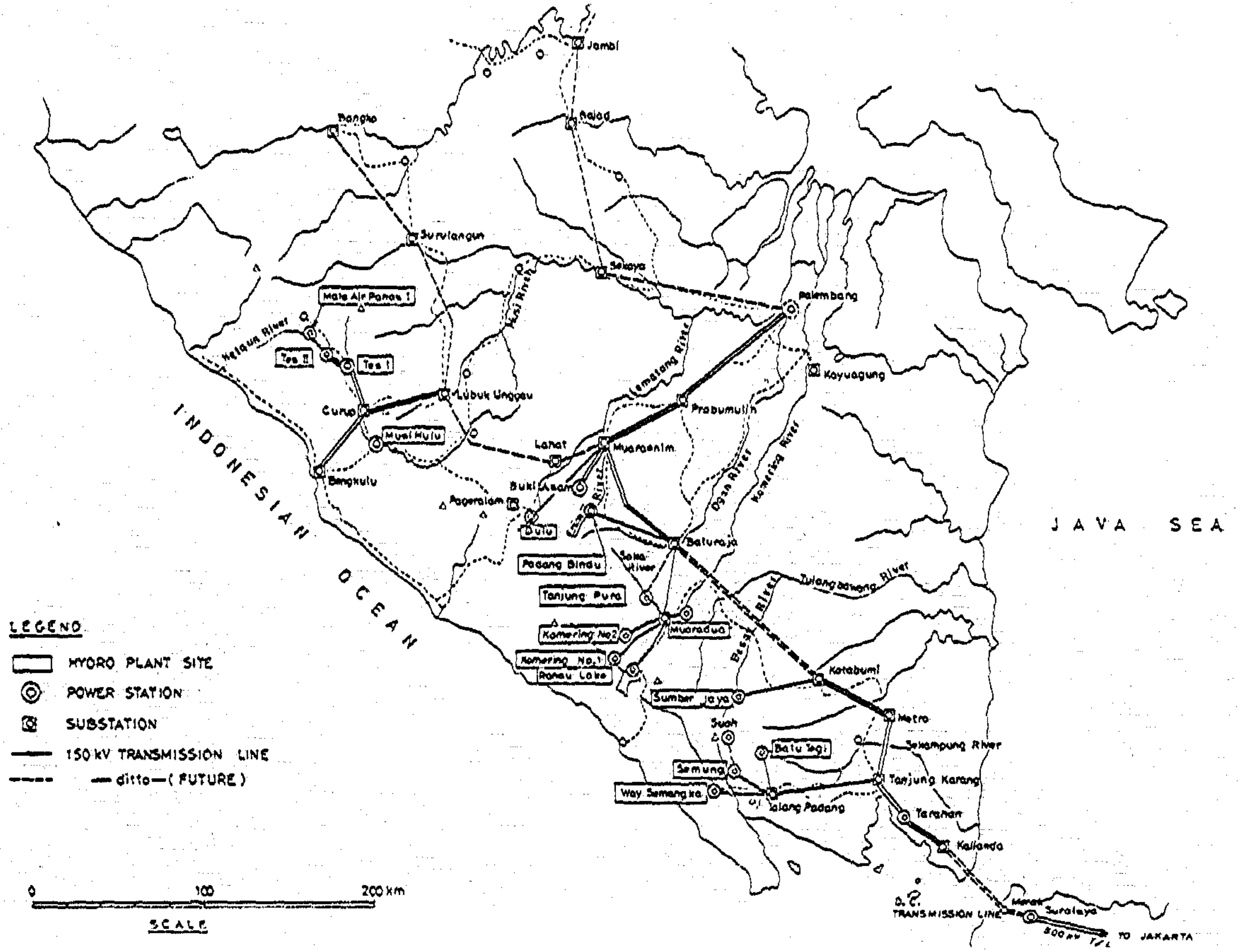


Fig. VII-2 PRESENT TRANSMISSION LINE

Fig. VII - 3 POWER TRANSMISSION SYSTEM AND LOCATION OF HYDRO PLANT SITE IN SOUTHERN SUMATRA



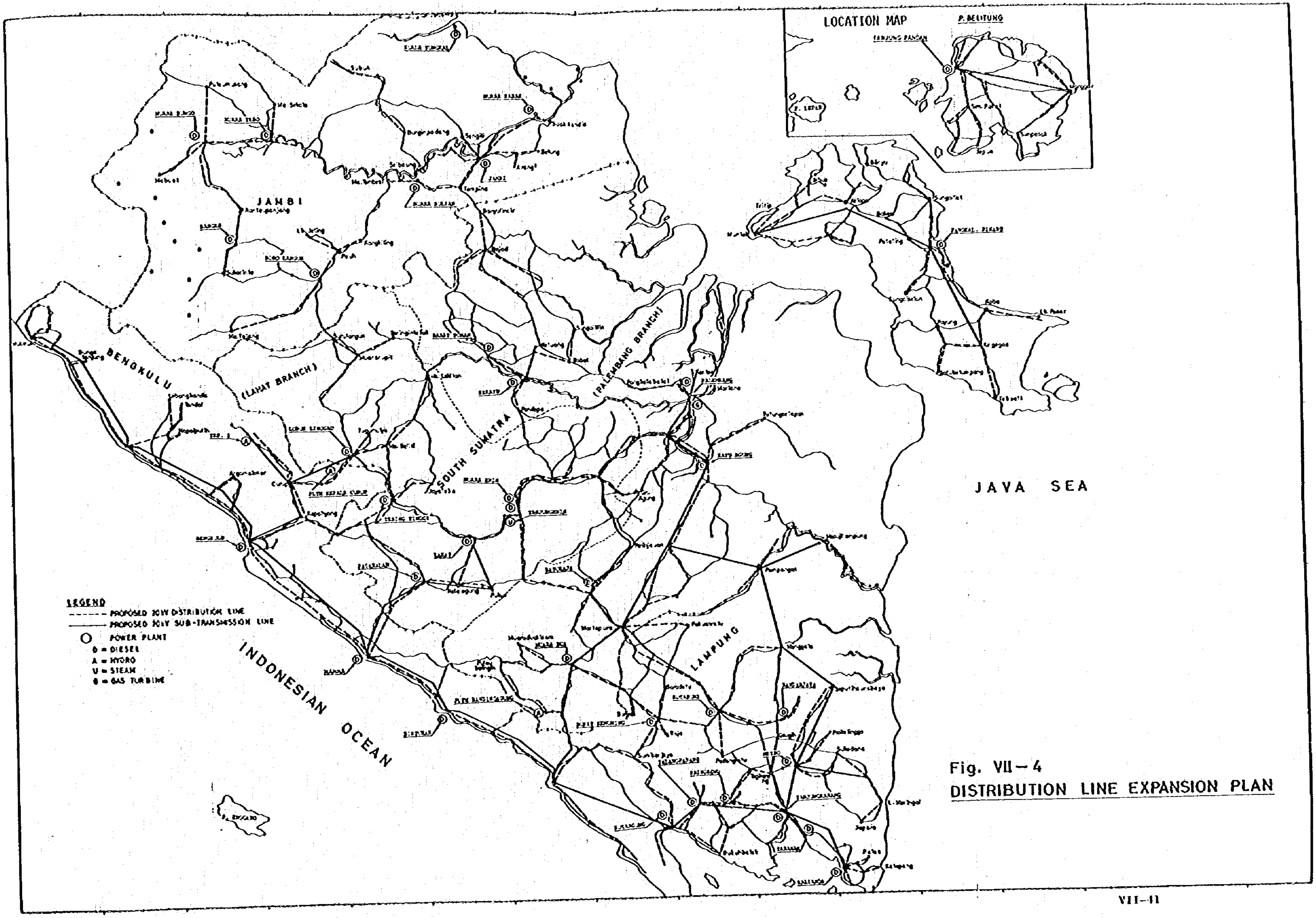
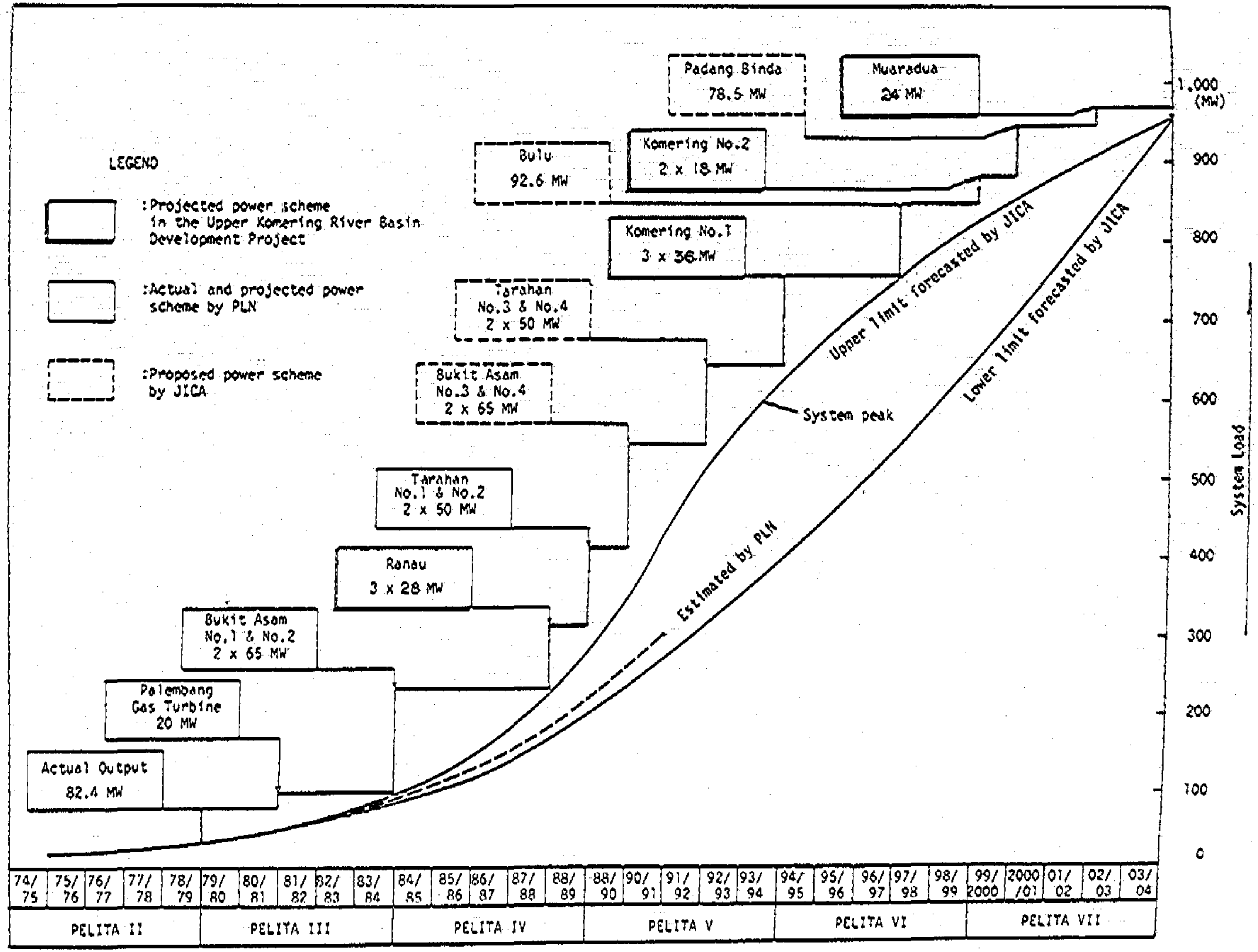


Fig. VII – 4
DISTRIBUTION LINE EXPANSION PLAN

Fig. VII-5 POWER DEMAND FORECASETED IN SOUTH AND LAMPUNG PROVINCE



ANNEX VIII

STORAGE AND HYDROPOWER DEVELOPMENT

ANNEX - VIII

STORAGE AND HYDROPOWER DEVELOPMENT

1. INTRODUCTION

A storage development by constructing dams is contemplated in order to adjust water in the Komering river to the proposed irrigation of 125,600 ha and the Lebak area of 76,000 ha in net area.

A hydropower development in the upper gorge of the Komering river is also proposed because the proposed dams can develop its potential.

Herein presented are proposed plan for the storage and hydropower development in the Komering valley.

2. BASIC DATA AND ASSUMPTIONS

2.1 Hydrological Data

The monthly run-off records at the Banding Agung gauge (508 km^2) and Martapura gauge (4,260 km^2) were estimated for the 18-year period from 1963 to 1980 as shown in ANNEX I.

The run-off at the Banding Agung gauge was regarded as that at the proposed Ranau dam site, and the run-off at the Martapura gauge was assumed to be identical with that at the proposed Perjaya headworks because of close location.

The monthly run-off record in the above-mentioned period at the proposed Komering No.1, Komering No.2 and Muaradua dam sites were estimated assuming a linear relationship between catchment area and run-off between the two gauges.

The catchment area, 18-year average annual run-off and 1,000-year flood discharge are summarized for the two gauges, proposed dam sites and headworks site in Table VIII-1.

The more detail of the estimated flood discharge is shown in ANNEX I.

Annual sediment yield was assumed to be 1,000 m^3/km^2 of catchment area.

2.2 Required Discharge at the Proposed Perjaya Headworks

The required discharge at the proposed Perjaya headworks was estimated for the proposed irrigation development as shown in Tables I-27 and I-26 in ANNEX I. It is the rate of river flow required for the existing and proposed irrigation in the upper Komering river basin, also allowing for the irrigation and other water uses in the entire area in the downstream reaches.

The required discharge in Stages II, III and IV were estimated for each month assuming the hydrological condition in the 18-year period from 1963 to 1980 as shown in Table VI-6 in ANNEX VI.

3. STORAGE DEVELOPMENT PLAN

3.1 Storage Requirement for Balancing Water Demand and Supply

The annual required discharge at the proposed Perjaya headworks is estimated to be 2.9×10^9 m^3 on an average, assuming that all the proposed irrigation is completed; Stage IV. It is high of 46% of the average annual run-off of 6.5×10^9 m^3. High water requirement usually occurs between April and July, i.e., in the later part of the wet season.

The required discharge and natural run-off at the proposed Perjaya headworks site are illustrated in Fig. VIII-1. Water deficit will occur from time to time and it will be generally highest in June. It was estimated that a water storage of 400×10^6 m^3 would be necessary to adjust the river flow to the required discharge.

3.2 Reservoir Operation

The primary objective of the proposed storage development is to balance water demand and supply in the Komering river basin. The proposed dams together should be so operated that the regulated river flow can meet the required discharge at the proposed Perjaya headworks.

Another objective is hydropower generation that requires augmentation of low flow to sustain firm continuous power output. Outflow should be sustained as much as possible, even if there is no downstream requirement.

The active storage capacity available for the above-mentioned objectives will be 474×10^6 m^3 in total consisting of 200×10^6 m^3 at the Ranau dam site, 120×10^6 m^3 at the Komering No.1 dam site, 4×10^6 m^3 at the Komering No.2 dam site and 150×10^6 m^3 at the Muaradua dam site, after the completion of the proposed storage development, as described in Chapter 6 of this ANNEX. The Komering No.2 dam will contribute a little to the water demand and supply balance, but it will only be utilized for the daily regulation of the outflow from the Komering No.1 power station, because its active storage capacity is small.

The outflow from each of the proposed dams except for the Komering No.2 dam was calculated, under the hydrological condition of the 18-year period from 1963 to 1980, assuming the following operation rules:

(1) Scheduled outflow:

Unit: m^3/sec

	June	The other months
Ranau	45	15
Komering No.1	100	30
Muaradua	Equal to water deficit, but 60 m^3/sec, if water deficit is less than 60 m^3/sec.	

(2) Outflow shall be equal to inflow, if the inflow is larger than the scheduled outflow and the reservoir water surface is at HWL.

(3) Outflow shall be equal to inflow, if the inflow is smaller than the scheduled outflow and the reservoir water surface is at LWL.

The results of calculation and shown in Fig. VIII-2 for the Ranau dam, Fig. VIII-3 for the Komering No.1 dam and Fig. VIII-4 for the Muaradua dam, in the form of inflow and outflow mass-curve.

The regulated river flow by the proposed reservoir operation at the proposed Perjaya headworks site is compared with the required discharge at the same site in Fig. VIII-5. All required discharge can be met by the regulated river flow, except that some deficit occurs in 1963, 1964, 1972 and 1976.

The duration curve of outflow from each dam is illustrated in Figs. VIII-6, VIII-7, VIII-8 and VIII-9. The firm discharge is estimated to be 15 m^3/sec at the Ranau dam site, 30 m^3/sec at the Komering No.1 dam site, 32 m^3/sec at the Komering No.2 dam site and 60 m^3/sec at the Muaradua dam site, if it is defined to be the outflow of 95-98% in probability of exceedence.

4. HYDROPOWER DEVELOPMENT PLAN

The slope of the Komering river is steep of 1/100 between the Lake Ranau and the Komering No.2 dam site. Three power stations are proposed for the cascade development of this river stretch i.e., the Ranau power station of 111.6 m in rated water head between the Ranau reservoir and Komering No.1 reservoir, the Komering No.1 power station of 144.1 m in rated water head between the Komering No.1 reservoir and Komering No.2 reservoir, and the Komering No.2 power station of 66.9 m in rated water head below the Komering No.2 reservoir. High water head cannot be developed below the Komering No.2 power station because of gentle slope of the river, but the water head created by the Muaradua dam can develop certain hydropower. The rated water head is 15.9 m.

It is proposed to design the Ranau and Komering No.1 power stations as peak-load power stations, taking advantage of the reregulating effect of reservoirs proposed just downstream. The Komering No.2 and Muaradua power stations were planned as base-load power station, because re-regulating dam sites have not been identified yet.

The installed capacity was preliminarily determined to be 83.7 MW for the Ranau power station, 108 MW for the Komering No.1 power station, 35.7 MW for the Komering No.2 power station and 23.8 MW for the Muaradua power station.

The proposed hydroelectric plan including reservoir, dams, waterways and power stations is shown in Fig. VIII-10 and the corresponding profile is as shown in Fig. VIII-11.

5. OUTLINE OF PROPOSED FACILITIES

5.1 Ranau Dam and Power Station

The Komering river bifurcates into the Selabung river and Saka river at Muaradua. The Selabung river originates from the Lake Ranau, of which surface area is 127 km^2 at the mean water surface of EL. 542 m. The Banding Agung gauge located at the lake outlet has a catchment area of 508 km^2. The run-off at the gauge of 580×10^6 m^3/year on an average is quite stable owing to the regulation effect of the lake.

The Ranau regulating dam is proposed 2.3 km downstream of the above-mentioned gauge site. The proposed plan for the Ranau reservoir is to provide an active storage capacity in the Ranau lake by dredging the river channel between the lake and the dam site and constructing a dam at the Ranau dam site. Larger storage capacity will result in better economy, because the construction cost of dam will be small compared with the other reservoirs proposed. It is estimated that the social and environmental conditions limit the possible drawdown in the reservoir between EL. 542.3 m and EL. 540.7 m; between 0.3 m above and 1.3 m below the present mean lake surface level of EL. 542 m. The corresponding active storage capacity is 200×10^6 m^3.

The dam is a concrete gravity dam of 15 m in height, 150 m in crest length and 8×10^3 m^3 in volume, having a movable spillway. A general plan of the Ranau regulating dam is as shown in Fig. VIII-12. The maximum discharge for power generation is assumed to be 90 m^3/sec, which corresponds to 1/6 in capacity factor. The headrace tunnel of 5 m in diameter is located in a distance of 9 km on the right bank of the Komering river. The surge tank at the downstream end of the headrace is a concrete lined vertical shaft. The penstock is a steel lined shaft. The underground power house is 25 m in width, 50 m in length and 30 m in height. The tailrace is a tunnel of 5.5 m diameter and 700 m in length. It opens in the Komering No.1 reservoir. The generated equipment is 83.7 MW in installed capacity with a rated water head of 112 m. Annual energy output is estimated to be 151 GWh.

5.2 Komering No.1 Dam and Power Station

The Komering No.1 dam site is located in the Selabung river at 16 km downstream of the Ranau dam site. Average annual inflow from the catchment area of 1,056 km^2 is estimated to be 1,441 x 10^6 m^3. The storage efficiency (gross storage capacity/dam volume) is approximately maximum if H.W.L. is set at EL. 420 m, which is the topographically the maximum limit. The active storage capacity is set to be, 120 x 10^6 m^3 between EL. 420 m and EL. 395 m which is the minimum reservoir water surface limited by the sedimentation in the reservoir. The reservoir surface area is 10 km^2 at H.W.L. of EL. 420 m. The area-storage curve of the Komering No.1 reservoir is as shown in Fig. VIII-13.

The dam is a rockfill dam of 85 m in height, 380 m in crest length and 2 x 10^6 m^3 in volume. A side channel spillway is provided on the left bank. General plan and sections of the proposed dam are shown in Figs. VIII-14 and VIII-15. The maximum discharge for power generation is assumed to be 90 m^3/sec which, corresponds to 1/3 in capacity factor. The headrace tunnel of 5 m is diameter is placed in a distance of 8.5 km on the left bank. A surge tank is provided at the downstream end of the headrace. The penstock is a steel lined shaft. The underground power house is 30 m in width, 50 m in length and 30 m in height. Tailrace is a concrete lined tunnel of 5.5 m in diameter and 800 m in length, opening in the Komering No.2 reservoir. The generating equipment is 108 MW in installed capacity with a rated water head of 144 m. Annual energy output is estimated to be 474 GWh.

5.3 Komering No.2 Dam and Power Station

The Komering No.2 dam site is located on the Selabung river at 12 km downstream of the Komering No.1 dam site. Average annual inflow from the catchment area of 1,165 km^2 is estimated to be 1,612 x 10^6 m^3. The physical maximum water level of the reservoir is estimated to be EL. 252.5 m. Because of large sedimentation flowing into the reservoir, the active storage capacity is only 4 x 10^6 m^3, between H.W.L. of EL. 252.5 m and L.W.L. of EL. 241 m. It is utilized only for the daily regulation of the outflow from the Komering No.1 power station. The reservoir surface area is 0.7 km^2. The area-storage curve of the Komering No.2 reservoir is shown in Fig. VIII-16.

The dam is a concrete gravity dam of 65 m in height, 135 m in crest length and 200 x 10^3 m^3 in volume. A center overflow spillway with moveable gates is provided. General plan and sections of the proposed dam are shown in Figs. VIII-17 and VIII-18. The maximum discharge for power generation is assumed to be 64 m^3/sec, approximately corresponding to 70% in plant factor. The headrace tunnel of 5 m in diameter in a distance of 2.5 km on the right bank, provided with a surge tank and the downstream end. The penstock is a steel lined shaft. The underground power house is 30 m in width, 60 m in length and 35 m in height. The tailrace tunnel is 5.5 m in diameter and 400 m in length. The installed capacity is 35.7 MW with a rated water head of 67 m. Annual energy output is estimated to be 230 GWh.

5.4 Muaradua Dam and Power Station

The Muaradua dam site is located in the Komering river just downstream of the confluence of the Selabung river and the Saka river; at 35 km downstream of the Komering No.2 dam site. Average annual inflow from the catchment area of 2,866 km^2 is estimated to be 4,285 x 10^6 m^3. The maximum storage efficiency is attained if H.W.L. is set at EL. 140 m. The active storage capacity is 150 x 10^6 m^3, between H.W.L. of EL. 140 m and L.W.L. of 132.5 m. This size appears to be physical maximum so far based on the study to date. The reservoir surface area is 24 km^2 at H.W.L. of EL. 140 m. The area-storage curve of the Muaradua reservoir is illustrated in Fig. VIII-19.

The dam is an earthfill dam of 30 m in height, 550 m in crest length and 1.3 x 10^6 m^3 in volume. A chute spillway with movable gates is provided on the left bank. General plan and sections of the proposed dam are shown in Figs. VIII-20 and VIII-21. The maximum discharge for power generation is assumed to be 180 m^3/sec, which corresponds to about 70% in plant factor. A surface power station is located on the left bank of the dam site. The installed capacity is 23.8 MW with a rated water head of 16 m. Annual energy output is estimated to be 149 GWh.

5.5 Summary

The principal features of proposed dams and power stations are summarized in Table VIII-2.

6. CONSTRUCTION SCHEDULE AND POWER BENEFIT

6.1 Construction Schedule

All the Ranau, Komering No.1 and Muaradua dams should be all completed by 2001, if the irrigation system in the upper Komering area is developed as proposed.

The power demand is growing rapidly but the existing power system lacks in hydropower. Hydropower development should be expedited from the viewpoint of power supply. The construction schedule of the Ranau and Komering No.1 dams is determined based on this requirement. It is noted that the Ranau and Komering No.1 and No.2 dams are economically viable, even if they are developed for only the purpose of hydropower generation.

The recommended completion time of dam and power station is 1988 for the Ranau, 1994 for the Komering No.1 and 2001 for the Muaradua. The Komering No.2 dam and power station does not contribute to the water demand and supply, but it is recommended to be completed in 1999 from the viewpoint of power supply. According to the recommended construction schedule, irrigation requirement in the upper Komering area and the water requirement for the other purpose can be met. The proportion of hydropower in the power supply system will be between 12 % and 25 %, if the proposed power stations are implemented.

The construction period of each dam/power facilities is assumed to be 5 years.

6.2 Power Benefit

Economic benefit to be derived from power generation is estimated as the cost of the least-costly alternative power plant. As the alternative plants, diesel thermal and coal-fired thermal plants are taken into account. All the costs used in the benefit estimate are at the price level of August 1981.

	Diesel Thermal	Coal-fired Thermal
Investment Cost ($/kW) (at discount rate of 8%)	600	750
Annual O&M Cost (% of investment)	4.0	3.0
Plant Life (years)	15	20
Thermal Efficiency (%)	35	35
Heat Value (Kcal/kg)	10,300	5,200
Station Service Factor (%)	2	7
Fuel Cost ($)	38/barrel	60/ton
kWh Cost (Calculated) (mill)	58	30
Adjustment Factor Compared with Hydropower	1.44	2.15

On the basis of the above figures listed, kW and kWh values are calculated as shown below;

	Diesel Thermal	Coal-fired Thermal
kW Value ($/kW)	113	124
kWh Value ($/kWh)	0.0835	0.0644

For all the range of possible plant factor, the coal-thermal plant shows lower value of power. Therefore, the above-mentioned values for the coal-fired thermal plant is assumed for the estimate of power benefit.

7. FURTHER STUDY

(1) Dam sizing: The dam height was preliminarily determined at the seemingly the best scale taking into account the environmental condition, topography and storage efficiency in this study. The size of dam should be reviewed in the light of economic optimization criteria in further stage.

(2) Installed capacity: The installed capacity was preliminarily determined assuming the load condition in the future, but it was rather arbitray in terms of economy. An economic analysis on the installed capacity should be carried out in further stage.

(3) Komering No.2 and Muaradua power station as peak load power station: The Komering No.2 and Muaradua power stations were planned as base load power station, because no reregulating dam site has been identified for them. If a reregulating dam site or some other measures for the safety in the downstream river channel of each the station, these power stations can be planned as peak load power stations which are move advantageous than the base load power station. It is proposed to carry out a survey to find out reregulating dam sites or other measures below these power station sites in the further study.

Table VIII-1 SUMMARY OF HYDROLOGICAL DATA AT GAUGE SITES AND PROPOSED DAM SITE

Gauge Site / Proposed Dam Site	Catchment Area (km^2)	Long-Average Annual Inflow (10^6 m^3)	1000-yr Flood Discharge (m^3/s)
Banding Agung gauge/Ranau dam	508	580	50
Komering No.1 dam	1,056	1,441	1,400
Komering No.2 dam	1,165	1,612	1,500
Muaradua dam	2,866	4,285	2,200
Martapura gauge/(Perjaya headworks)	4,260	6,476	2,500

Remarks; Long-Average Annual Inflow; for 18 years from 1963 to 1980.
The difference between figures at the Martapura gauge site and those at the proposed Perjaya headworks site is disregarded, because the two sites are closely located each other.

Table VIII-2 PRINCIPAL FEATURES OF PROPOSED FACILITIES

Items	Unit	SCHEME				
		Ranau	Komering No.1	Komering No.2	Muaradua	Total
Catchment area	(km^2)	508	1,056	1,165	2,866	
Average annual inflow	($10^6 m^3$)	580	1,441	1,612	4,285	
Reservoir						
H.W.L.	(EL.m)	542.3	420.0	252.5	140.0	
L.W.L.	(EL.m)	540.7	395.0	241.0	132.5	
Gross storage capacity	($10^6 m^3$)	200	175	15	320	710
Effective storage	($10^6 m^3$)	200	120	4	150	474
Dam						
Type		Concrete Gravity	Rockfill	Concrete Gravity	Earthfill	
Dam height	(m)	15	85	65	30	
Crest elevation	(m)	544	423	255	143	
Crest length	(m)	150	380	135	550	
Volume	($10^3 m^3$)	8	2,000	200	1,800	
Power station						
Type		Dam & waterway	Dam & waterway	Pondage & waterway	Dam	
Powerhouse		Under-ground	Under-ground	Under-ground	Surface	
Max. Discharge	(m^3/s)	90	90	64	180	
Firm Discharge	(m^3/s)	15	30	32	60	
T.W.L.	(EL.m)	415.0	252.5	180.0	120.0	
Rated water head	(m)	112	144	67	16	
Installed capacity	(MW)	83.7	108.0	35.7	23.8	251.2
Annual energy production	($10^6 kWh$)	151	474	230	149	1,004

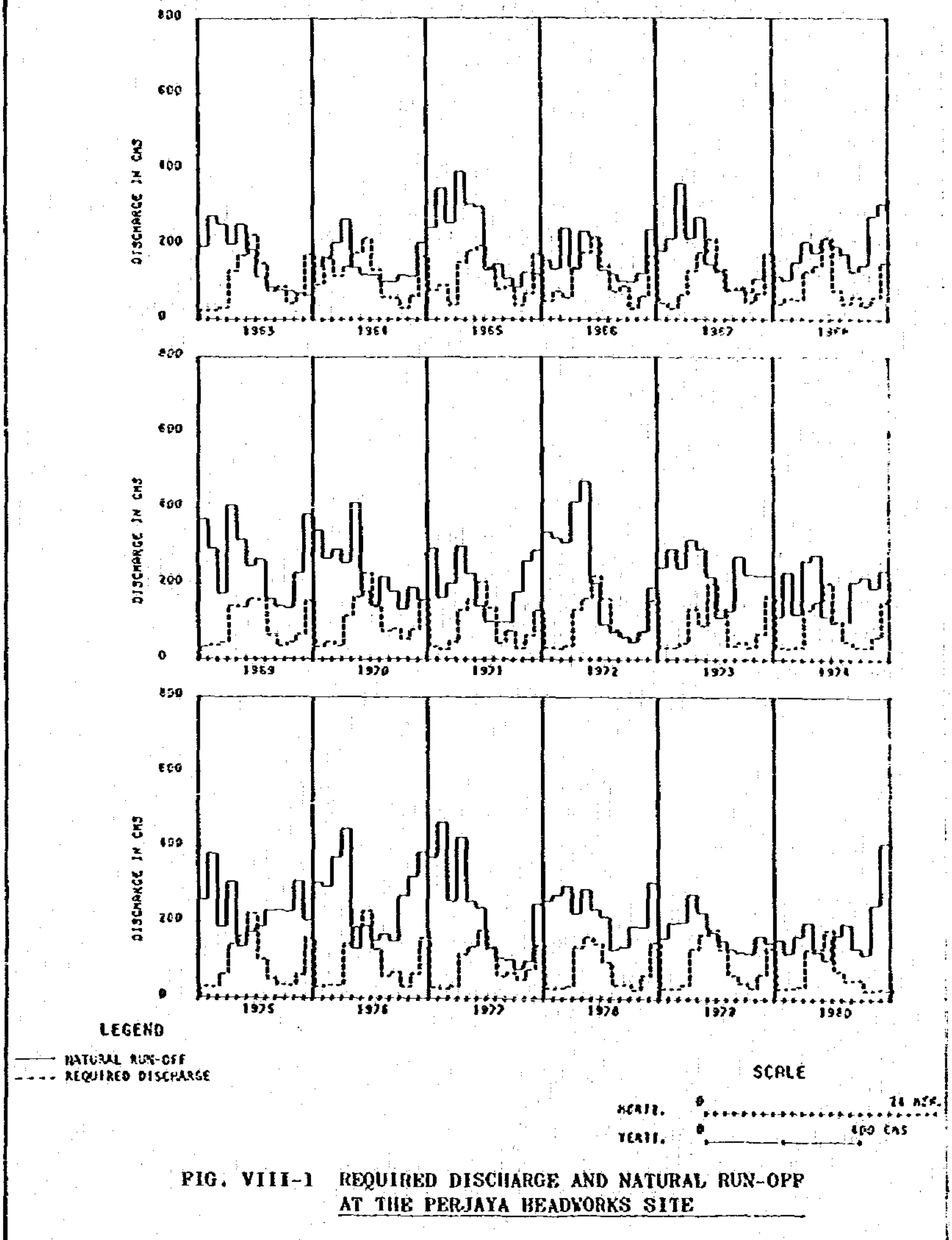


FIG. VIII-1 REQUIRED DISCHARGE AND NATURAL RUN-OFF AT THE PERJAYA HEADWORKS SITE

FIG. VIII - 2 INFLOW AND OUTFLOW MASS CURVE AT RANAU REGULATING DAM

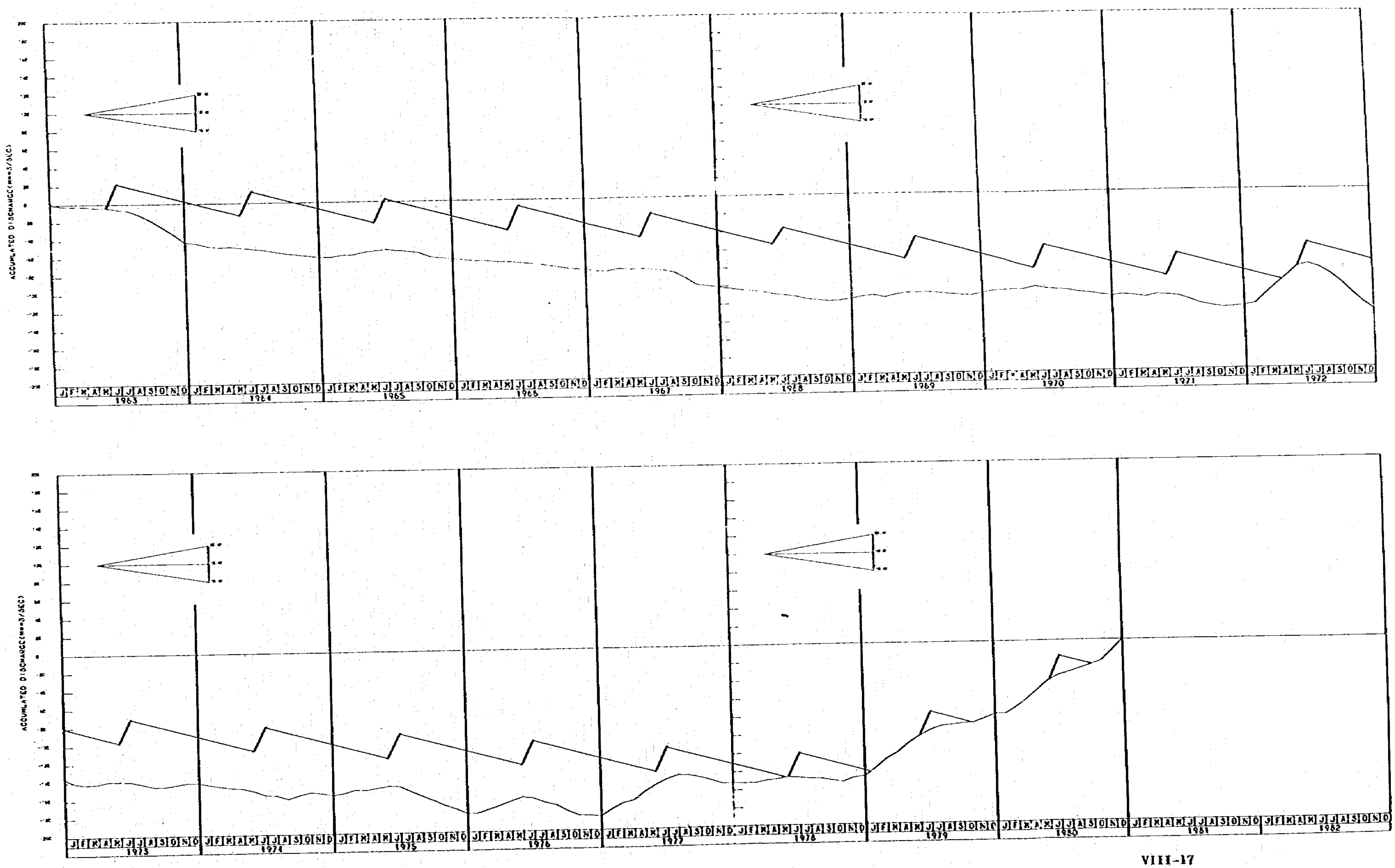
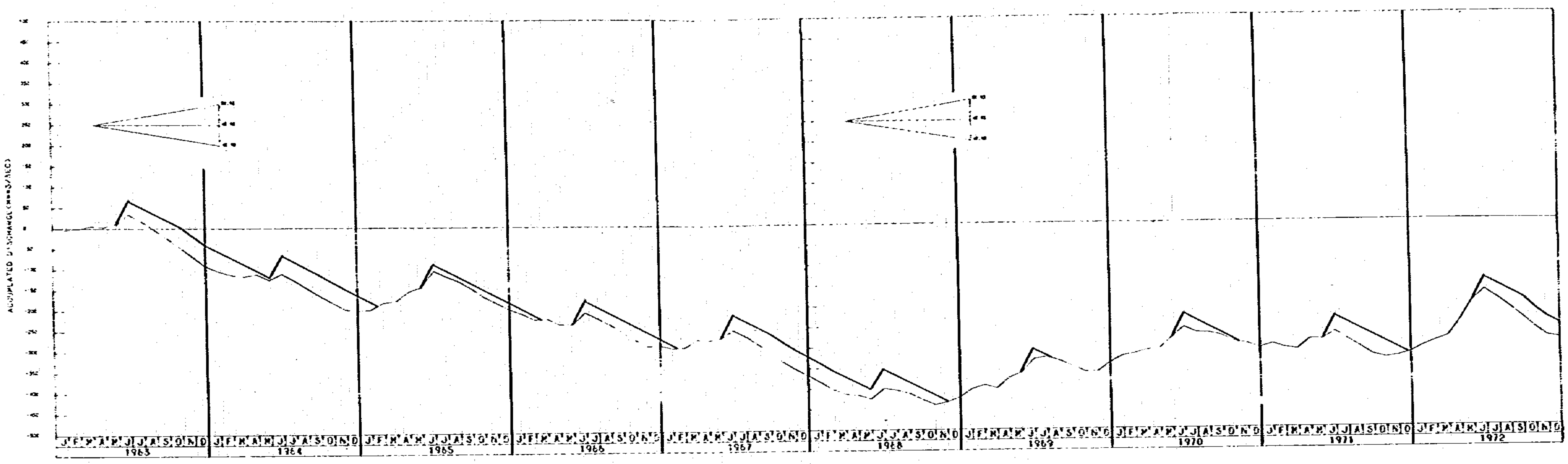


FIG. VIII-3 INFLOW AND OUTFLOW MASS CURVE AT KOMERING NO. I DAM



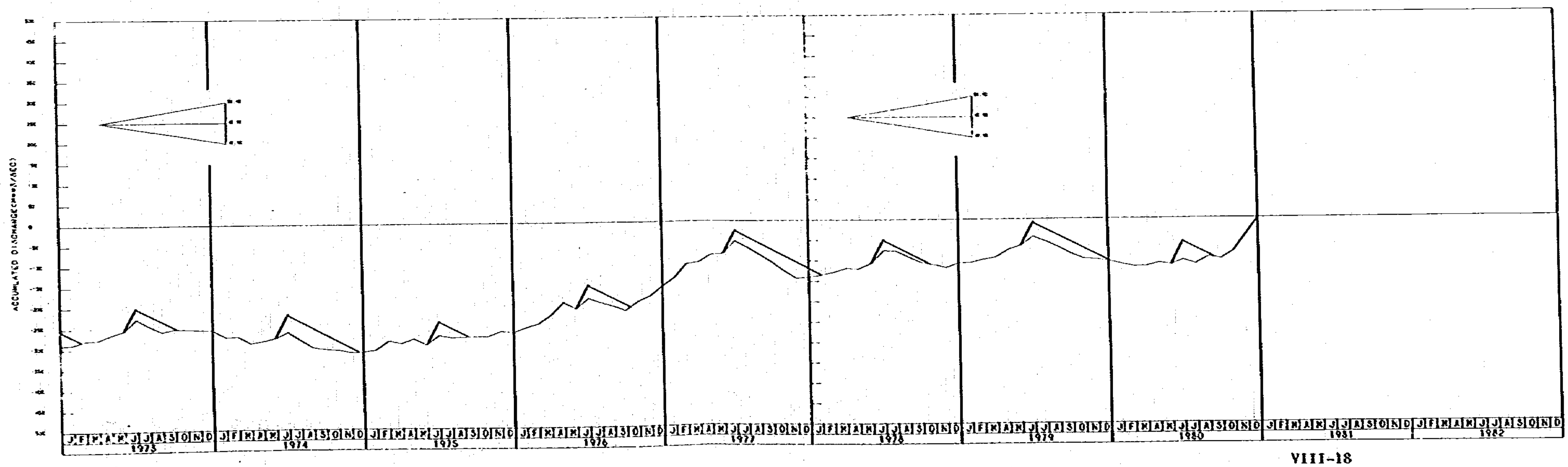
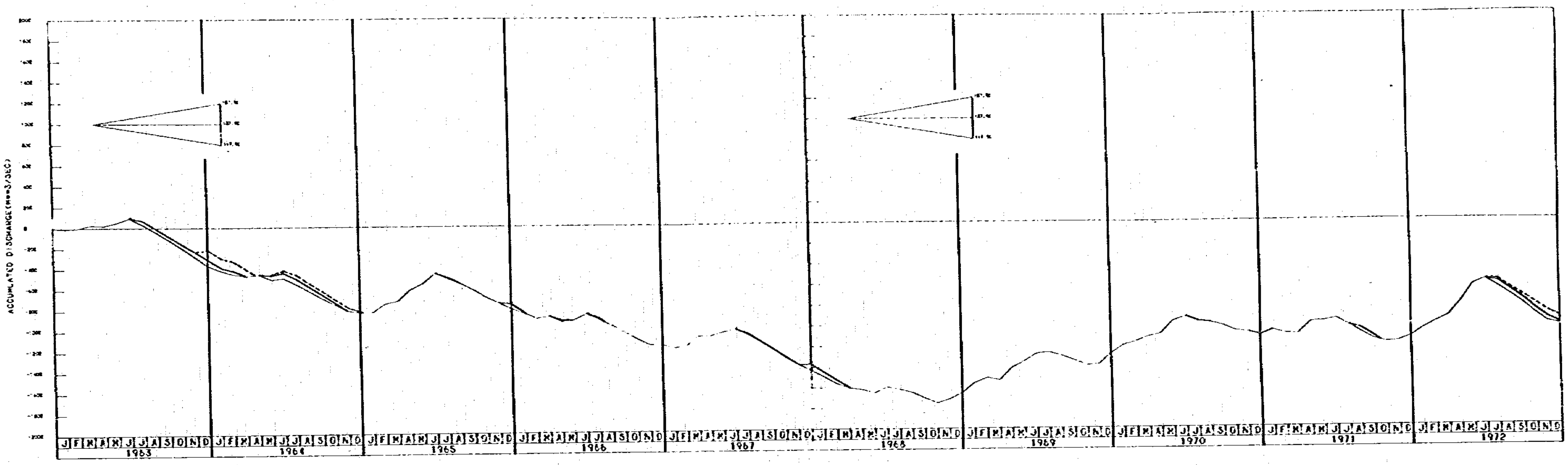
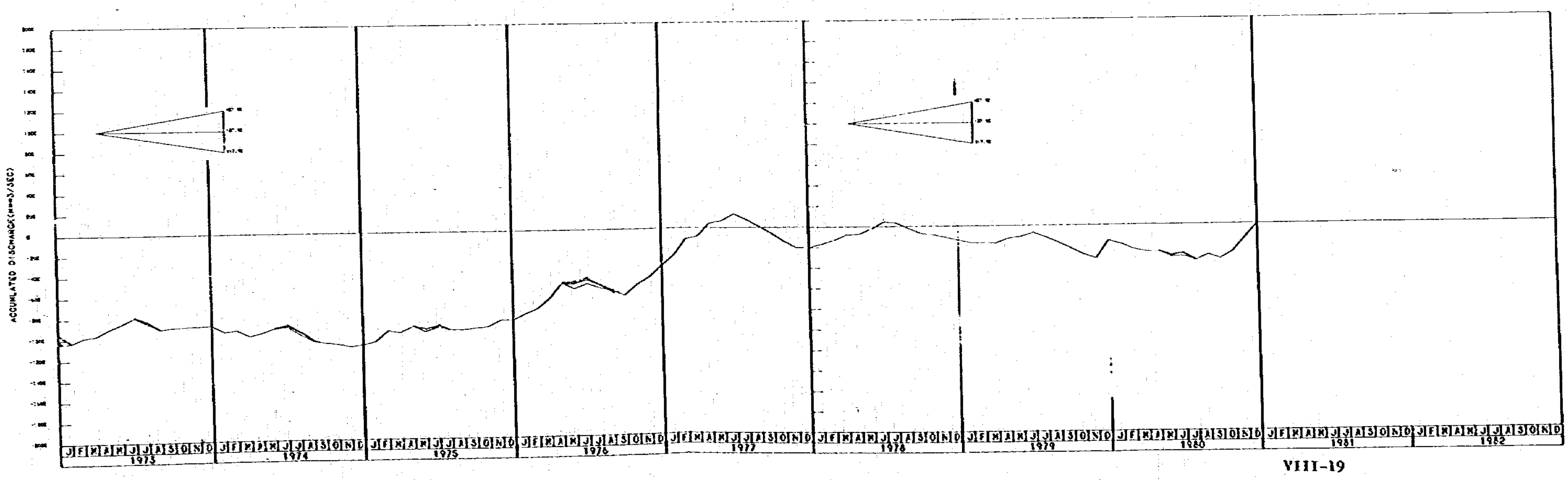


FIG. VIII-4 INFLOW AND OUTFLOW MASS CURVE AT MUARADUA DAM SITE





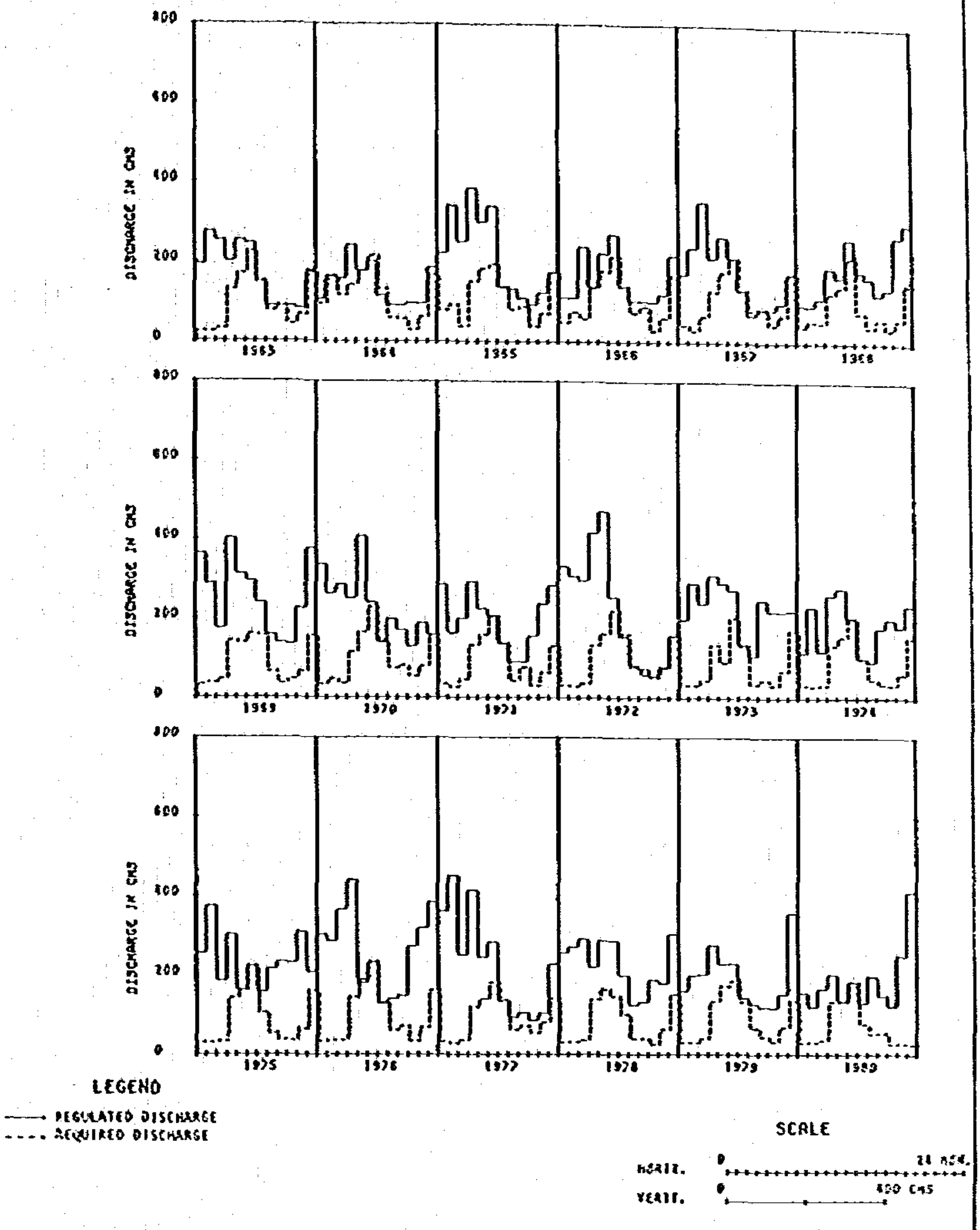
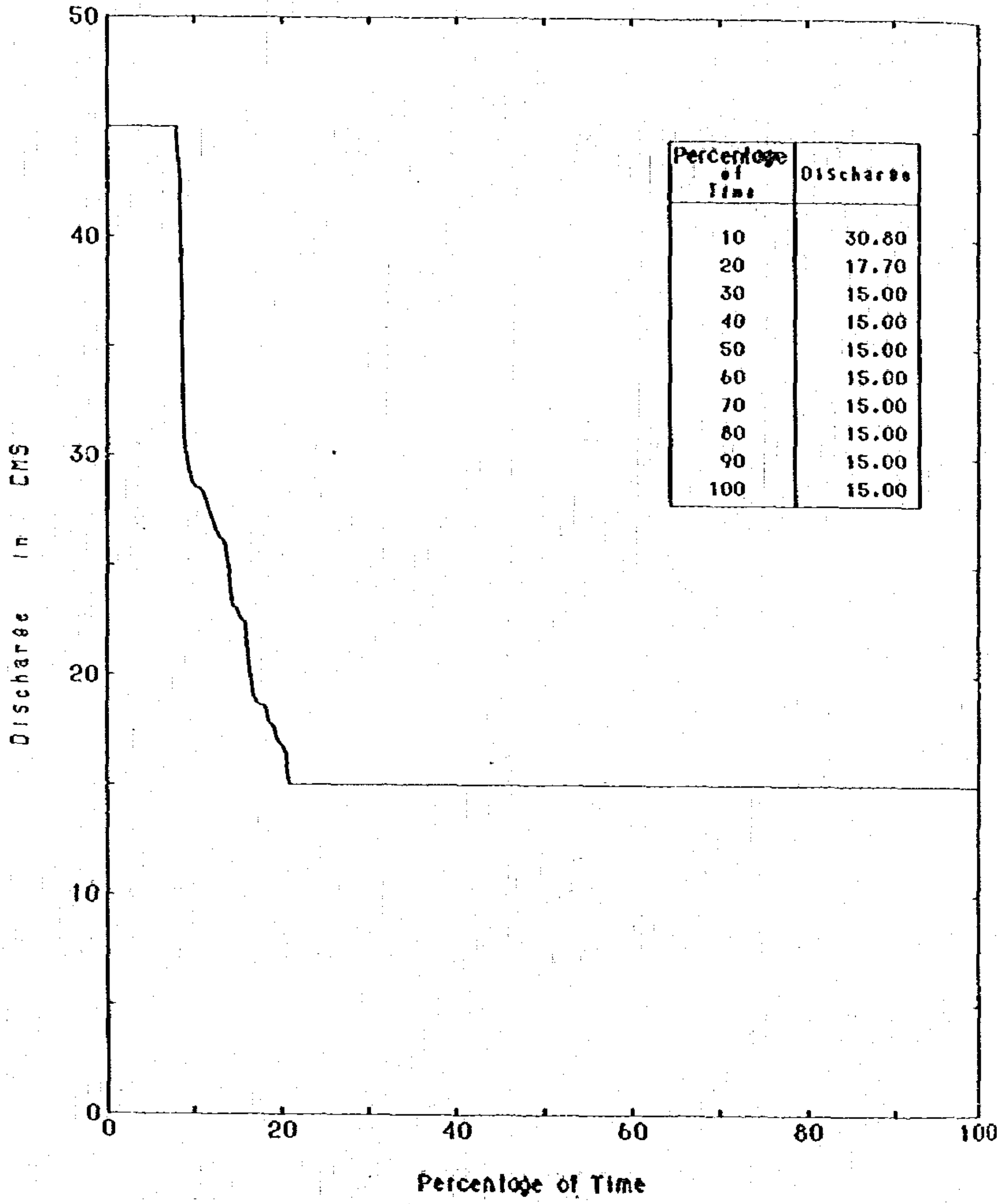


FIG. VIII-5 REQUIRED DISCHARGE AND REGULATED RIVER FLOW AT THE PERJAYA HEADWORKS SITE

Station : RANAU
Stream : SELABUNG RIVER
River System : UPPER KOMERING
Drainage Area : 508.0 Sq. km



Percentage of Time	Discharge
10	30.80
20	17.70
30	15.00
40	15.00
50	15.00
60	15.00
70	15.00
80	15.00
90	15.00
100	15.00

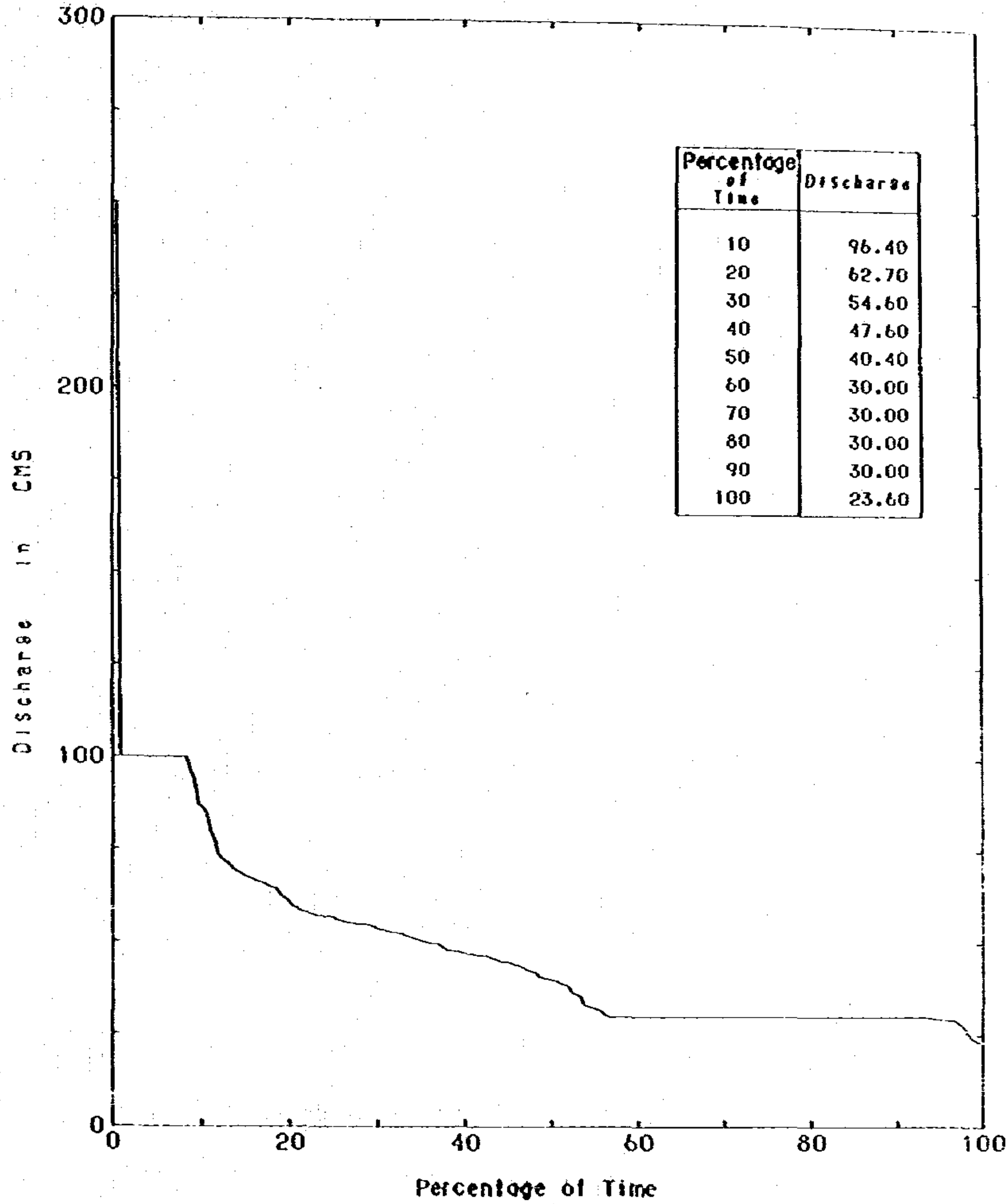
FIG.VIII-6. DURATION CURVE OF REGULATED OUTFLOW FROM RANAU DAM

Station : KOMERING NO.1 DAM

Stream : SELABUNG

River System : UPPER KOMERING

Drainage Area : 1056.0 Sq. km.



Percentage of Time	Discharge
10	96.40
20	62.70
30	54.60
40	47.60
50	40.40
60	30.00
70	30.00
80	30.00
90	30.00
100	23.60

FIG. VIII - 7 DURATION CURVE OF REGULATED OUTFLOW FROM KOMERING NO. I DAM

Station : KOMERING NO.2 River System : UPPER KOMERING

Stream : SELABUNG Drainage Area : 1165.0 sq. km.

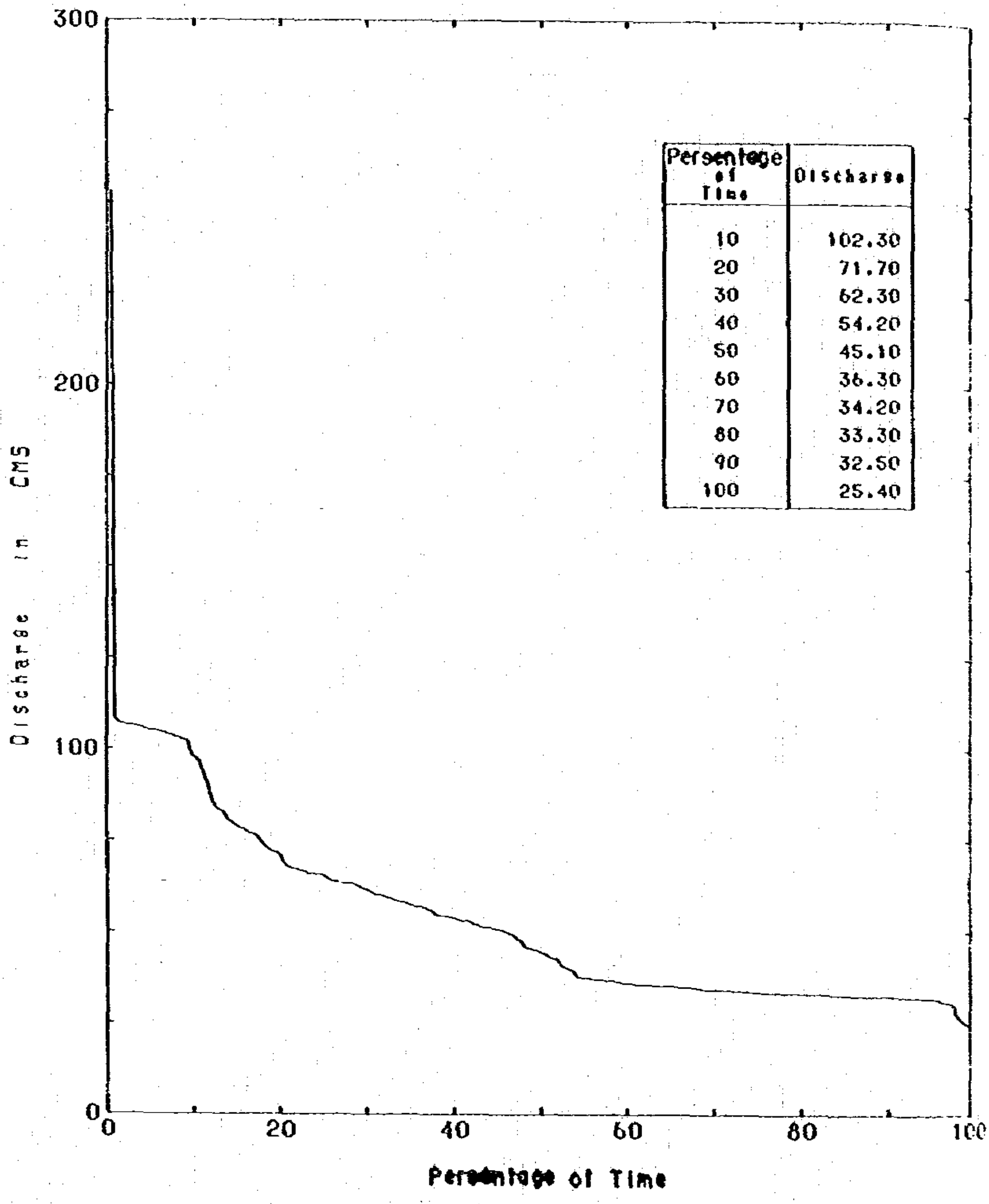


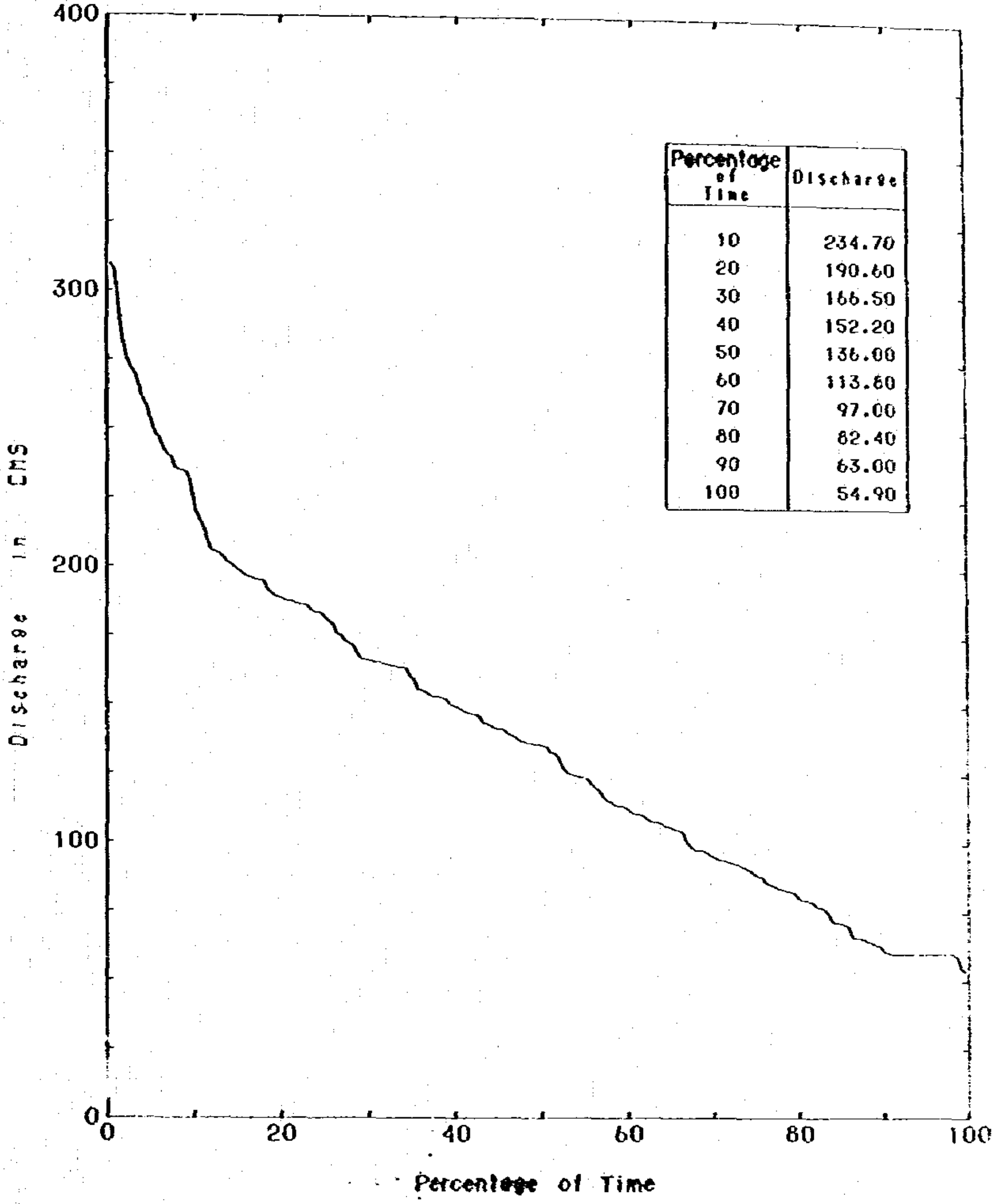
FIG. VIII - 8 DURATION CURVE OF REGULATED OUTFLOW FROM KOMERING NO. 2 DAM

Station : MUARADUA

Stream : KOMERING RIVER

River System : UPPER KOMERING

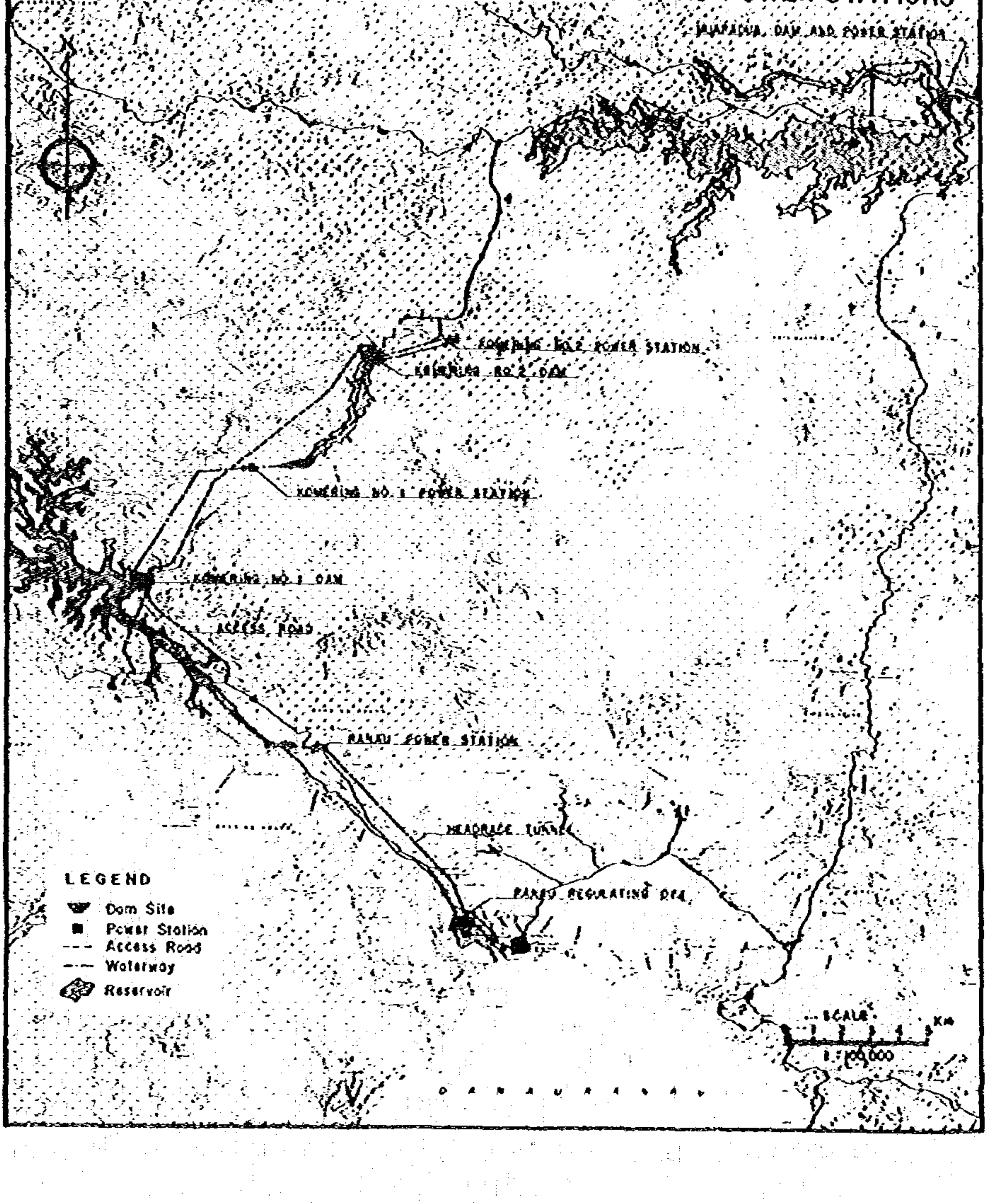
Drainage Area : 2866.0 Sq.km.



Percentage of Time	Discharge
10	234.70
20	190.60
30	166.50
40	152.20
50	136.00
60	113.80
70	97.00
80	82.40
90	63.00
100	54.90

FIG. VIII-9 DURATION CURVE OF REGULATED OUTFLOW FROM MUARADUA DAM

FIG.VIII-10 GENERAL PLAN OF PROPOSED DAMS AND POWER STATIONS



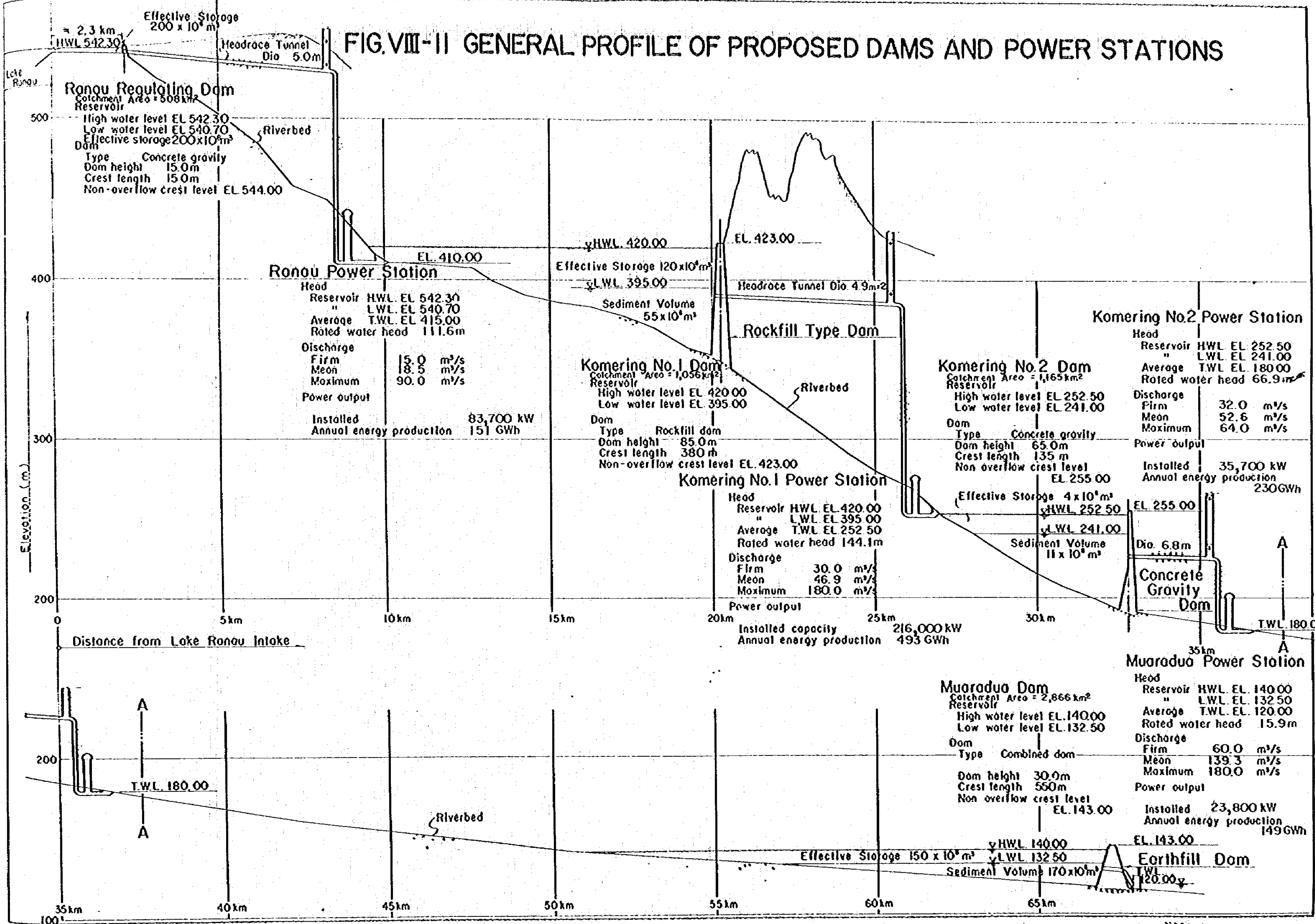


FIG. VIII-11 GENERAL PROFILE OF PROPOSED DAMS AND POWER STATIONS

FIG. VIII - 12 GENERAL PLAN OF RANAU REGULATING DAM

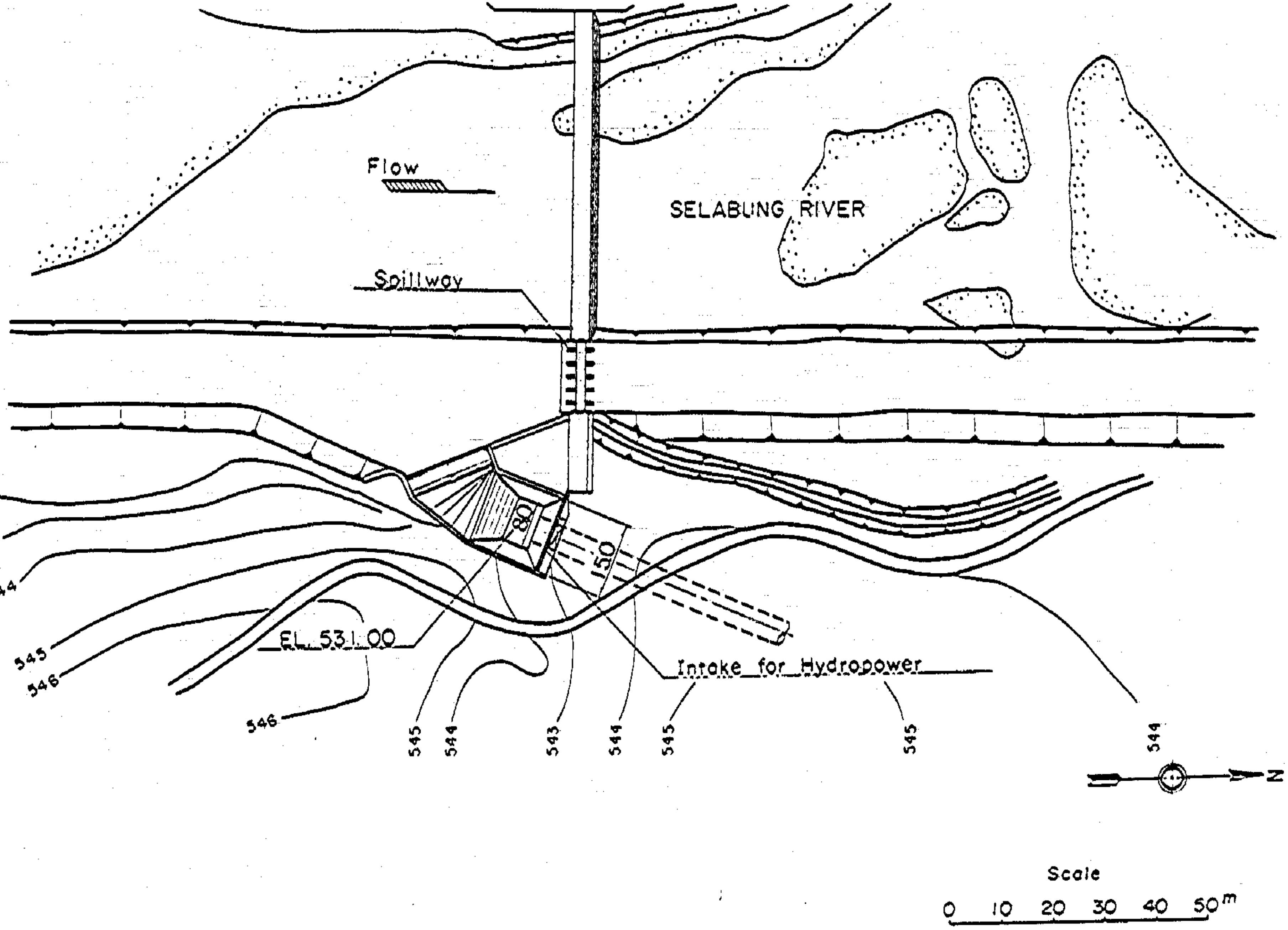


FIG.VIII-13 STORAGE CAPACITY AND RESERVOIR AREA OF KOMERING NO.1 DAM

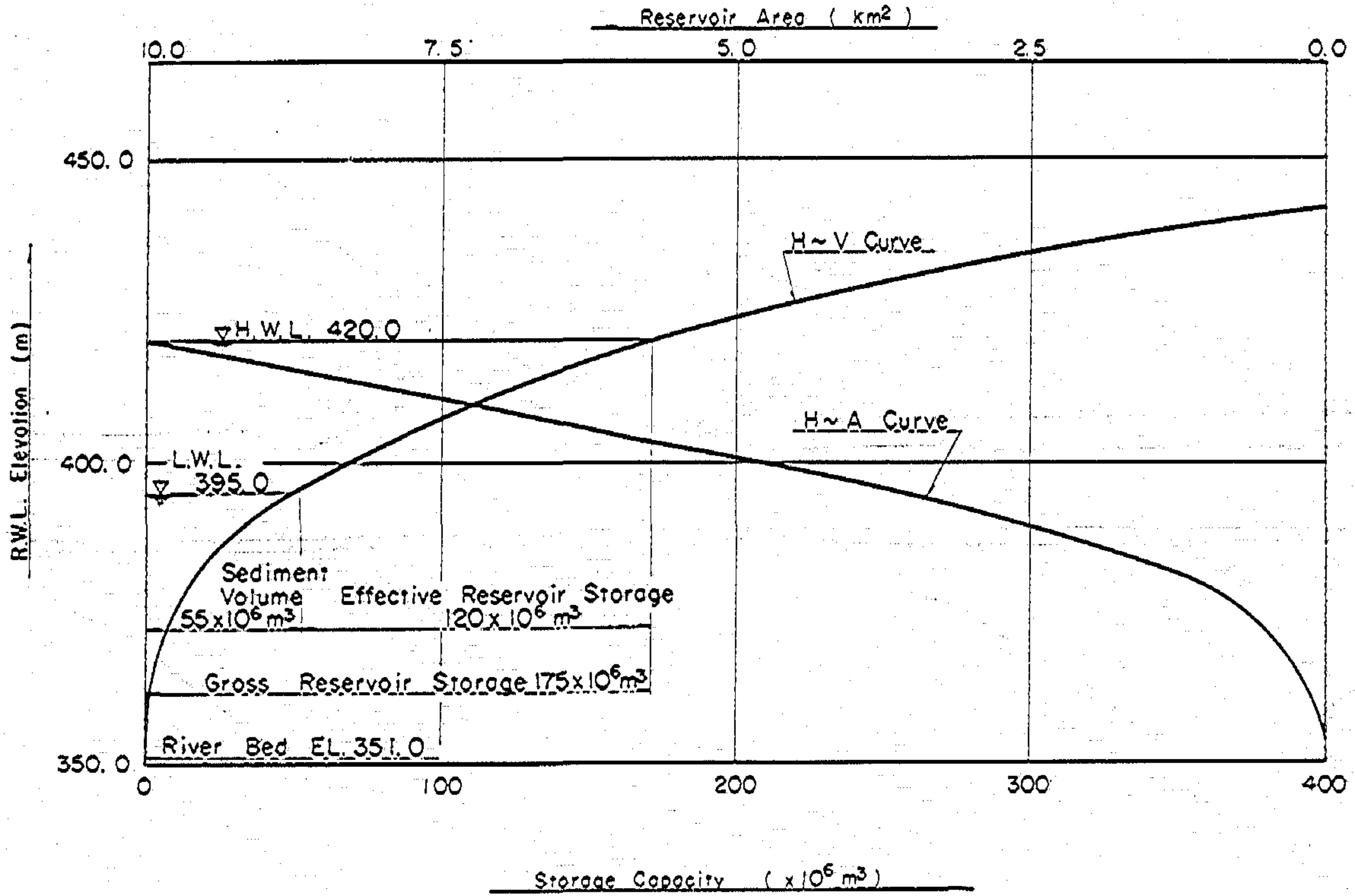


FIG. VIII-14 GENERAL PLAN OF KOMERING NO. 1 DAM

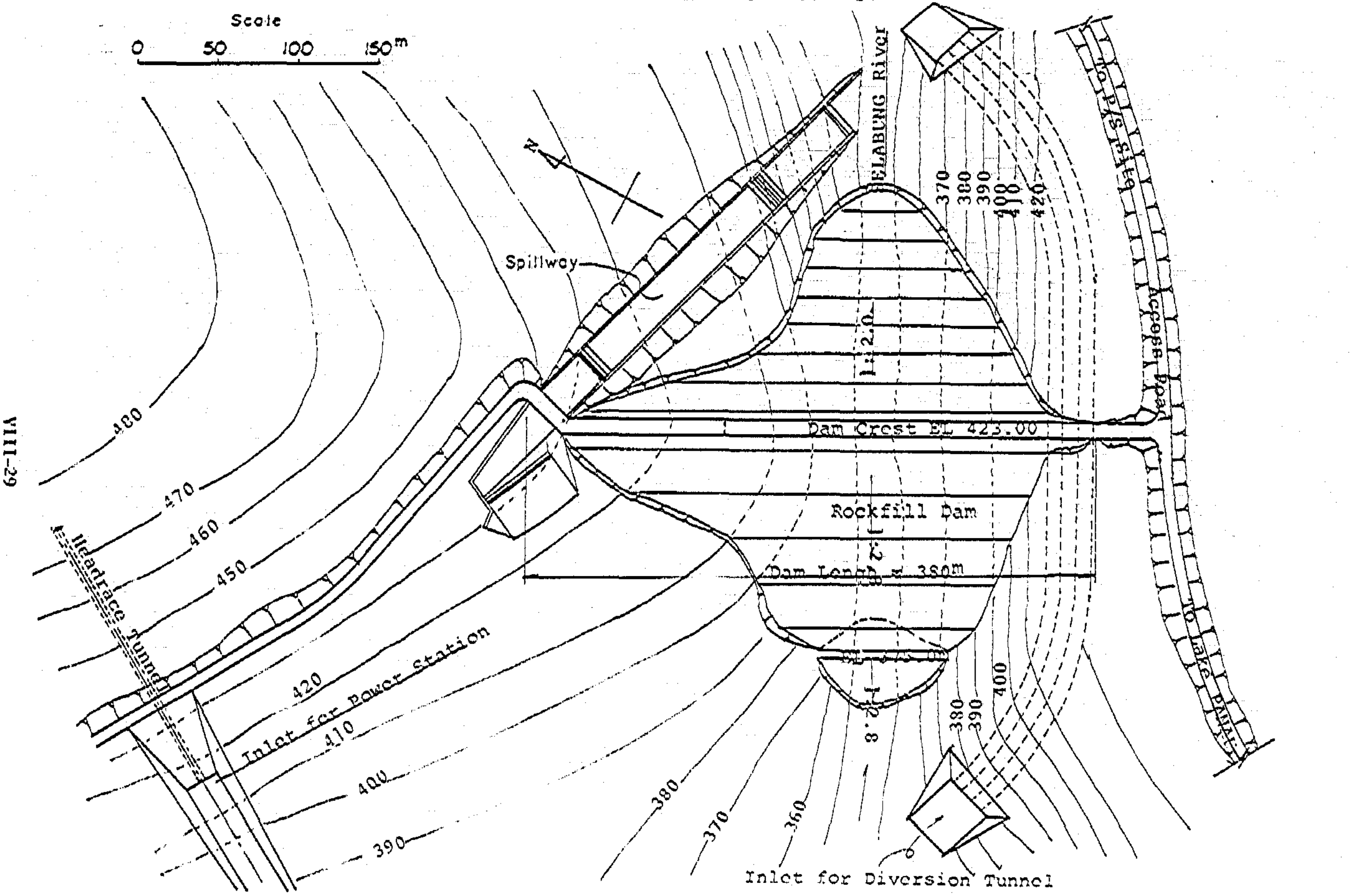


FIG. VIII-15 CROSS SECTION AND PROFILE OF KOMERING NO. 1 DAM

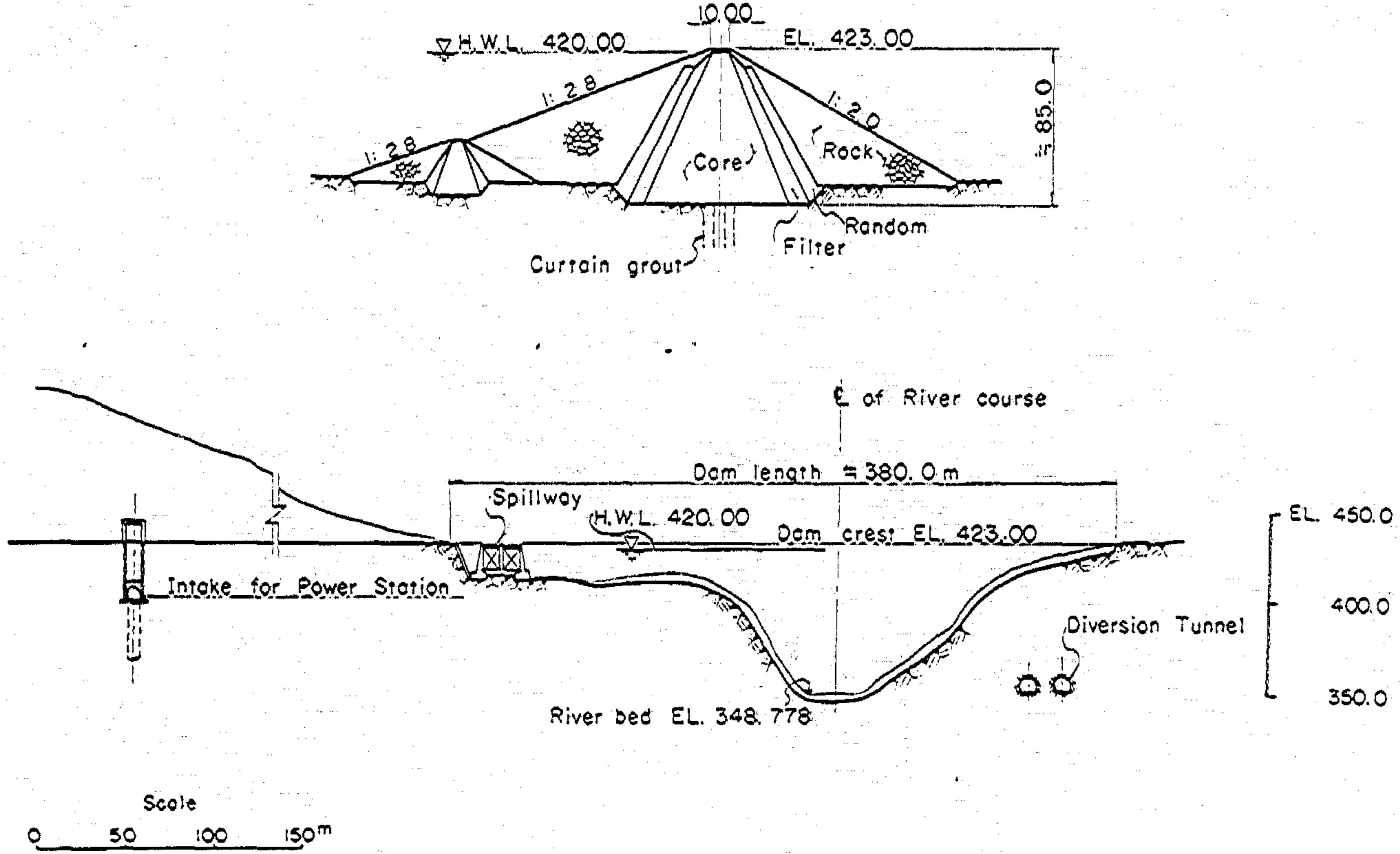


FIG. VIII - 16 STORAGE CAPACITY AND RESERVOIR AREA OF KOMERING NO.2 DAM

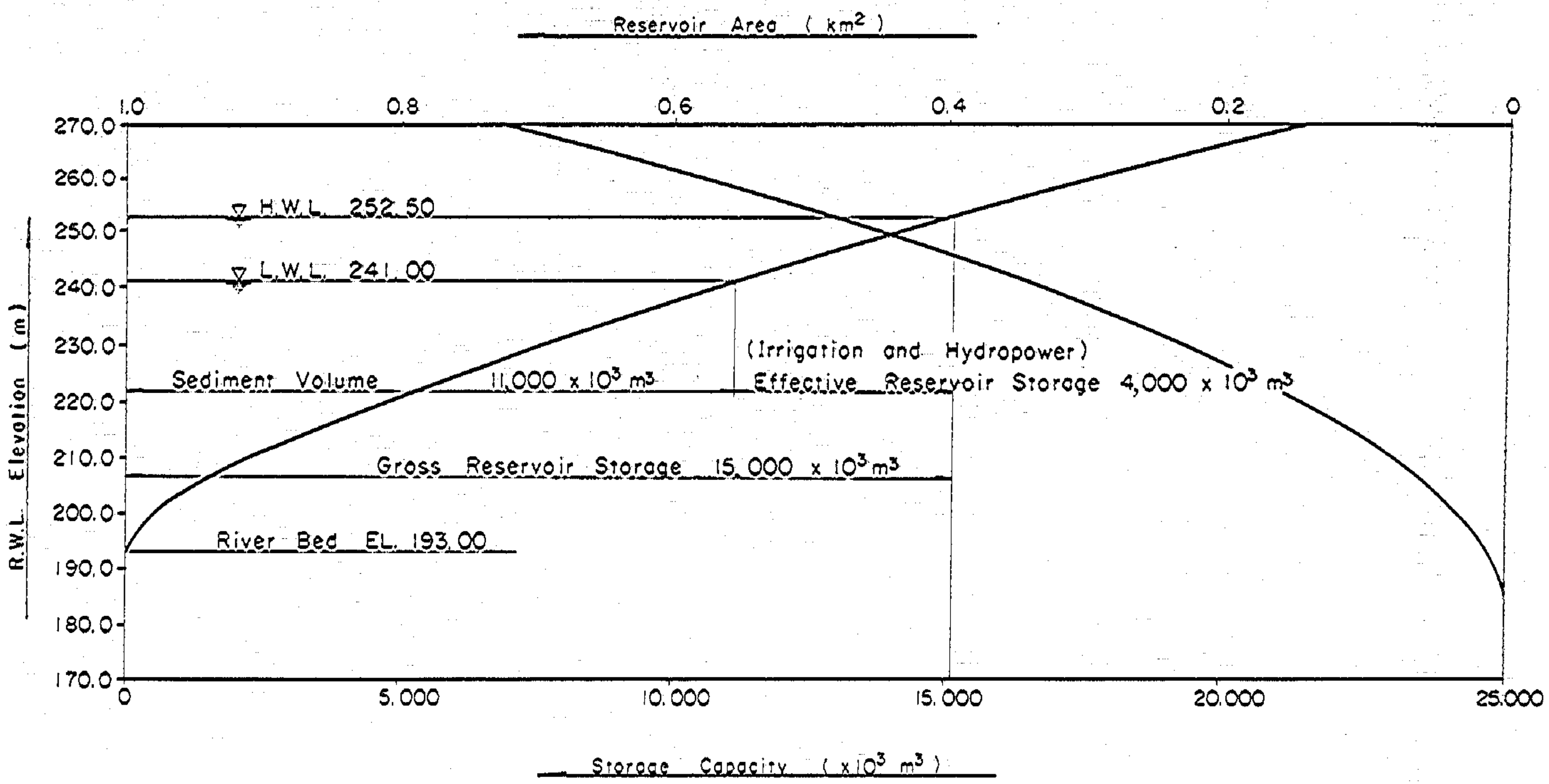


FIG. VIII-17 GENERAL PLAN OF KOMERING NO. 2 DAM

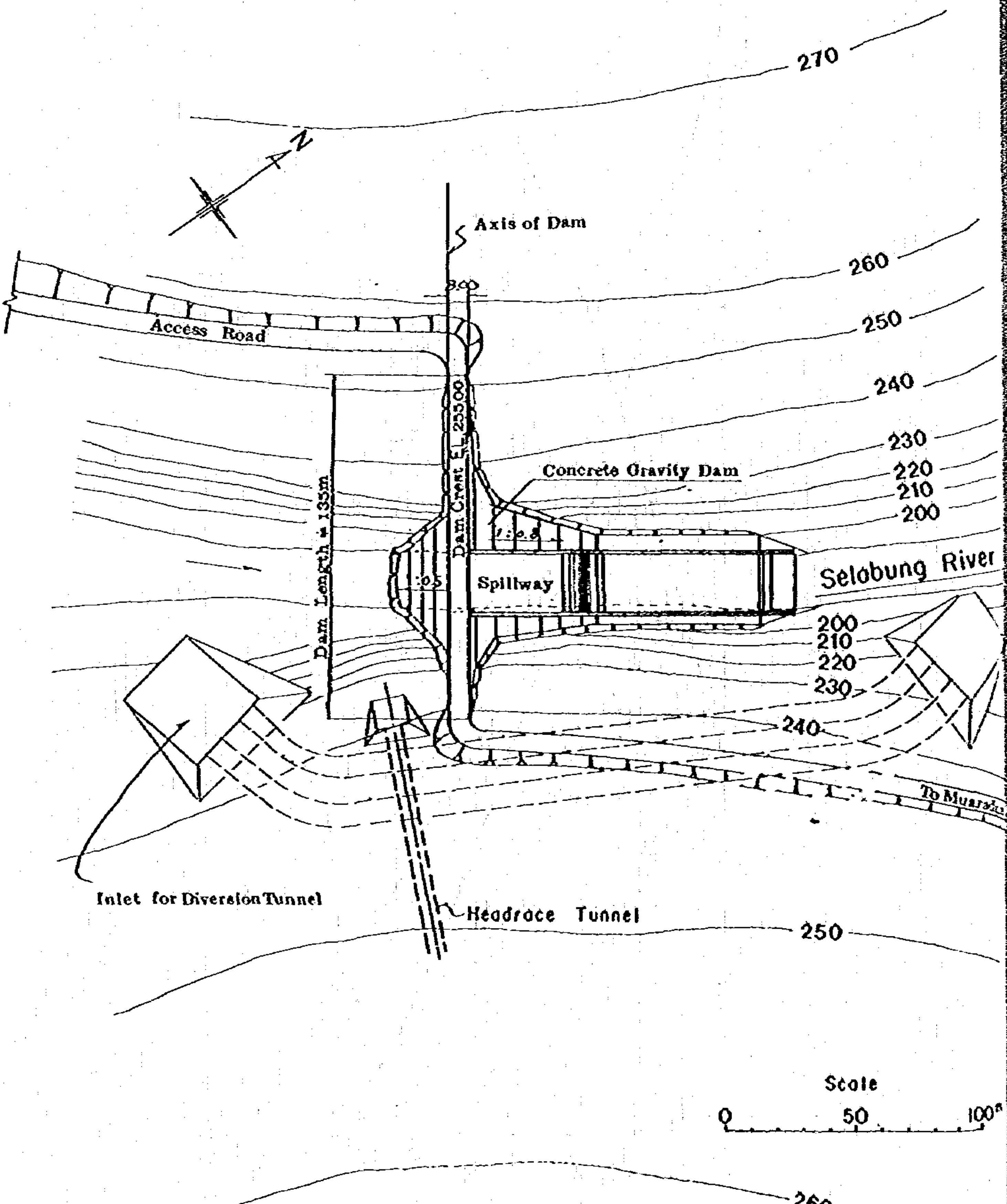


FIG. VIII-18 CROSS SECTION AND PROFILE OF KOMERING NO. 2 DAM

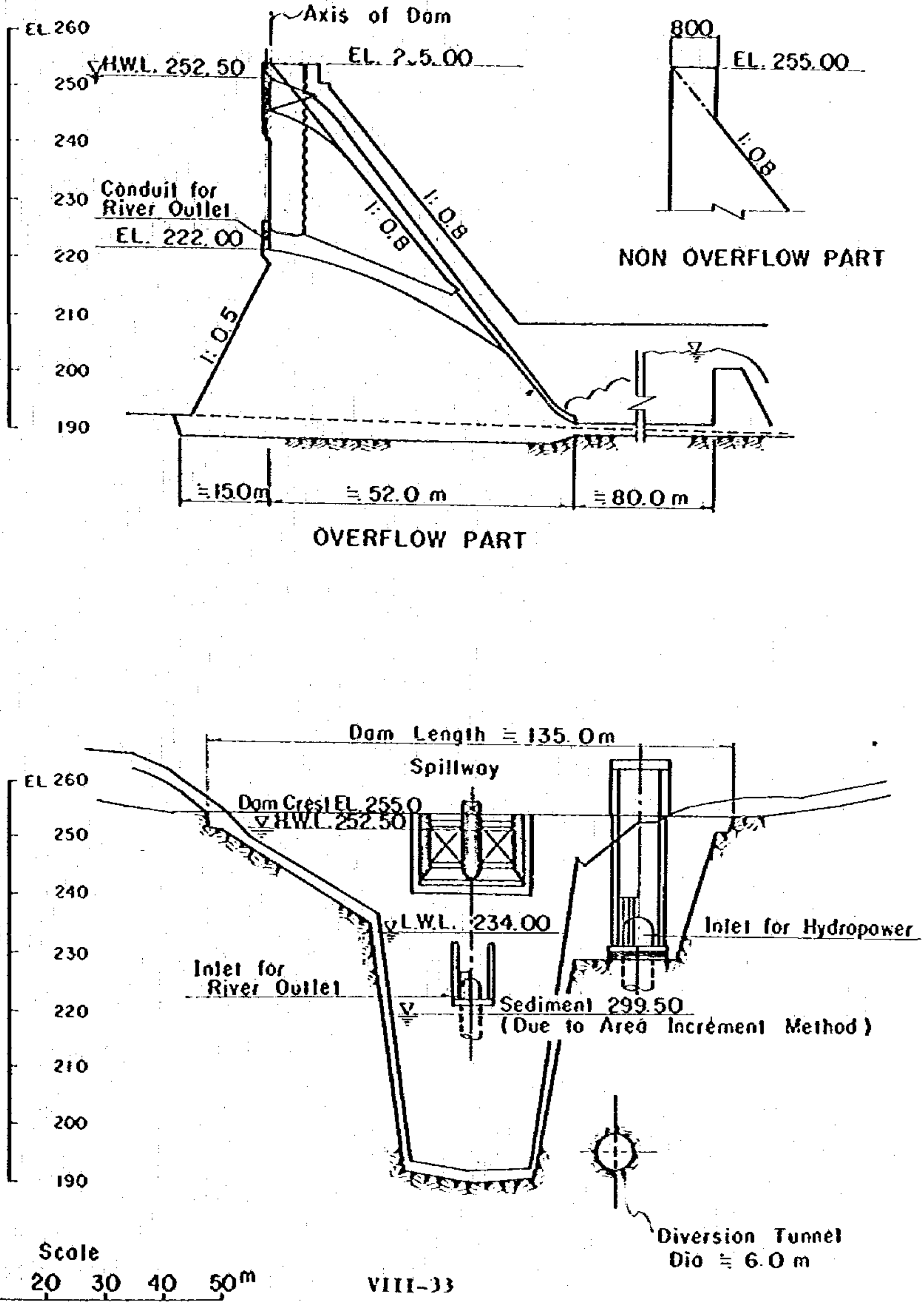


FIG. VIII-19 STORAGE CAPACITY AND RESERVOIR AREA OF MUARADUA DAM

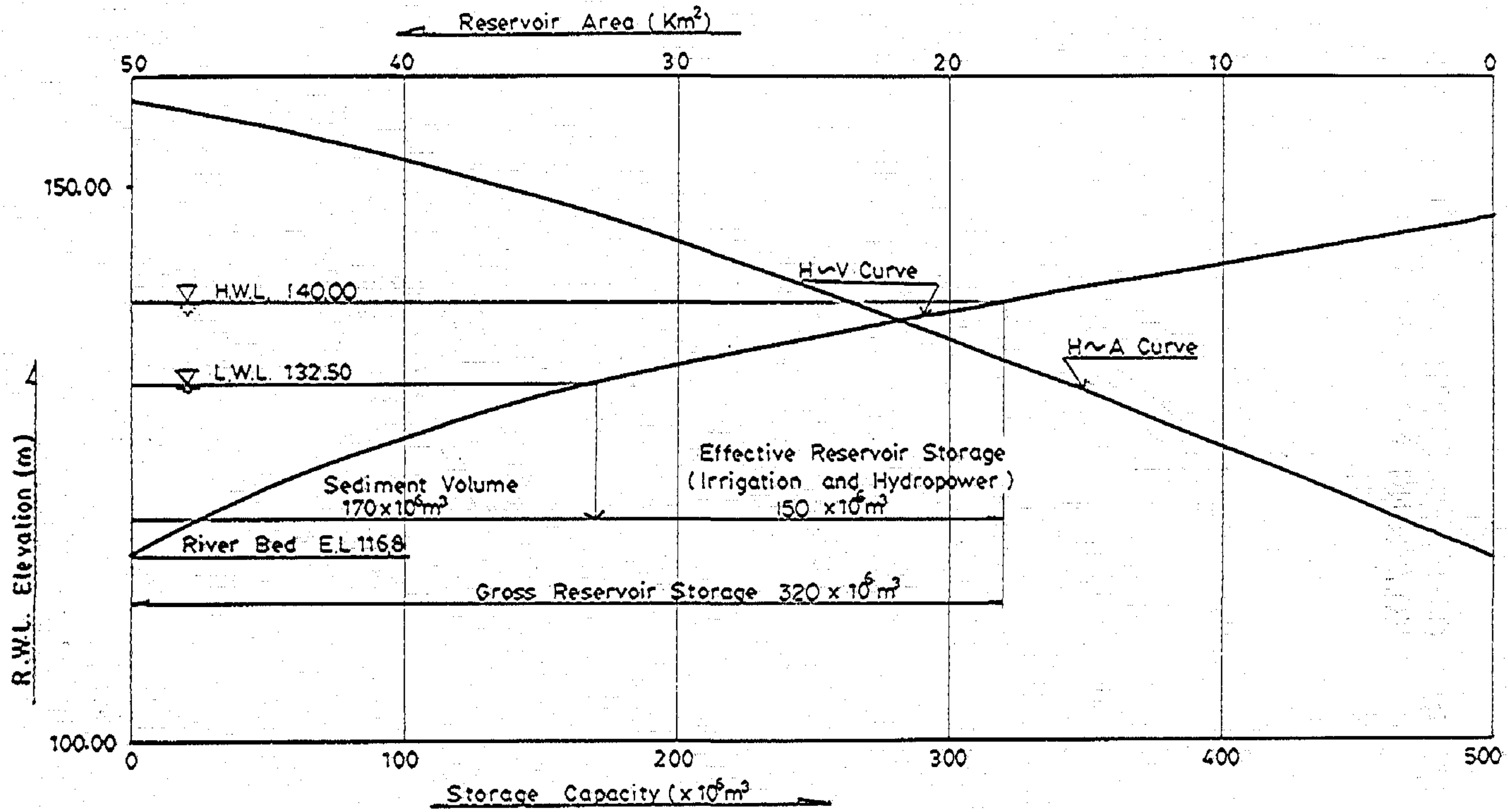


FIG. VIII-20 GENERAL PLAN OF MUARADUA DAM

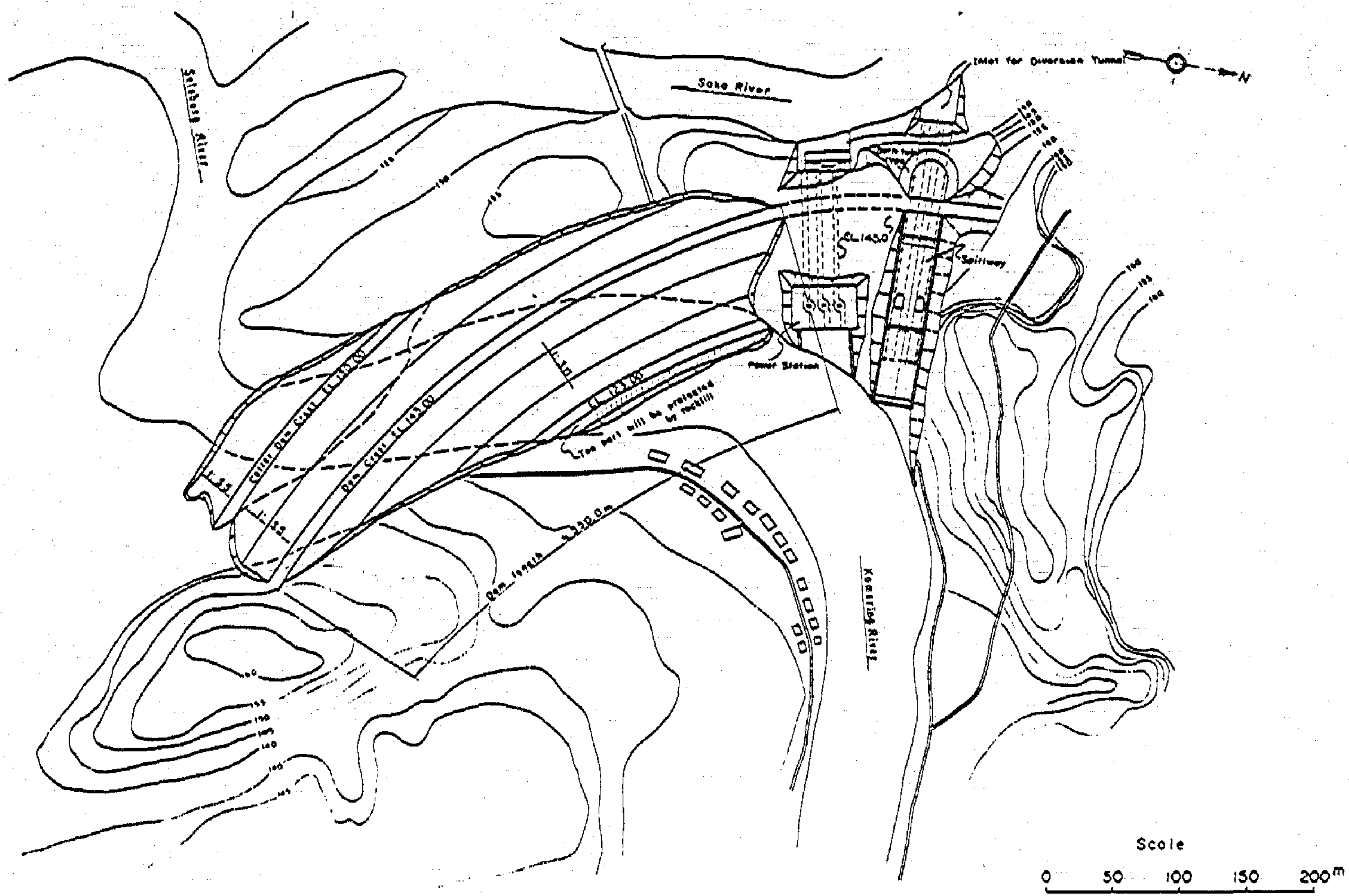
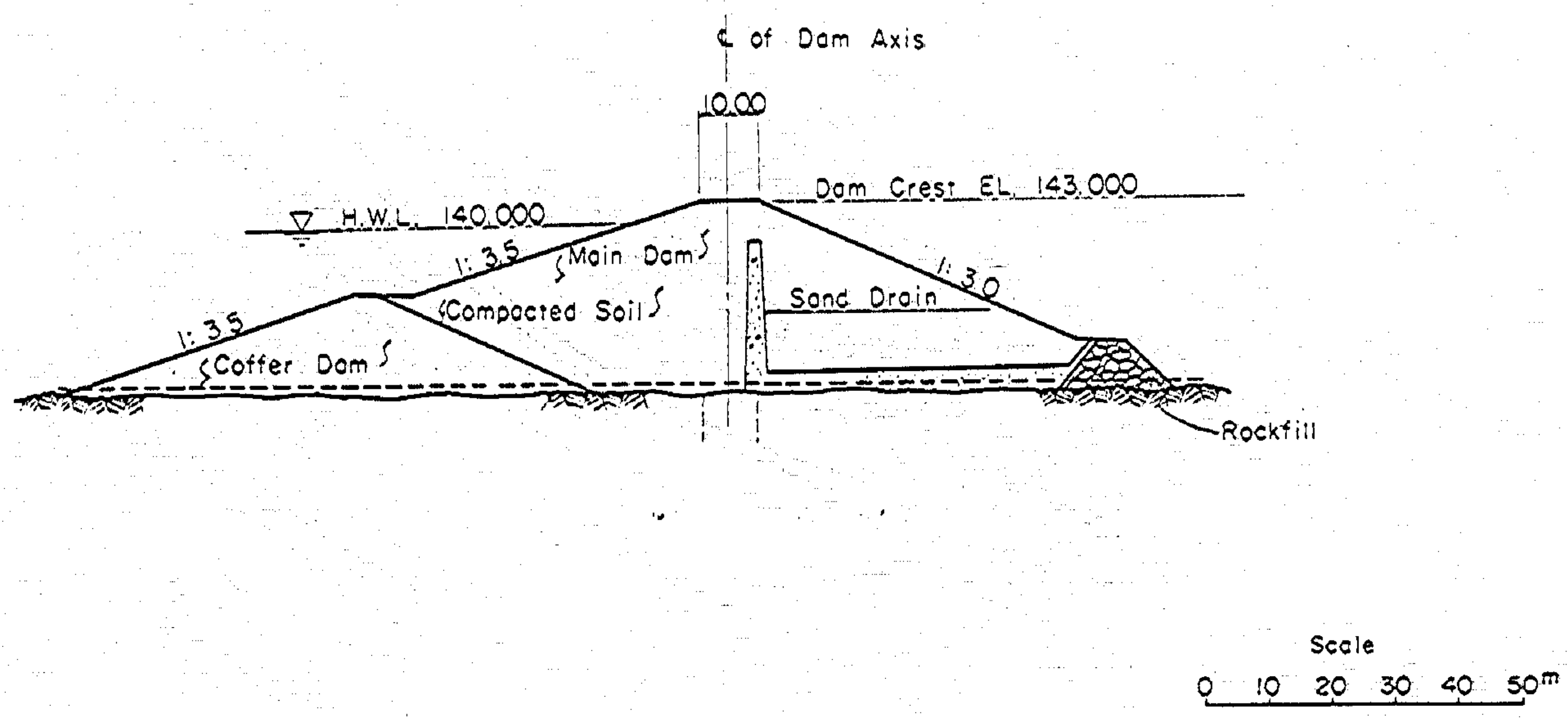


FIG. VIII - 21 CROSS SECTION OF MUARADUA DAM



ANNEX IX

WATERSHED MANAGEMENT

ANNEX - IX

WATERSHED MANAGEMENT

1. INTRODUCTION

1.1 Purposes and Scope of Study

The principal objectives of the study are to provide quantitative support to the engineering studies of the upper Komering river basin and to evaluate the effects of the project on natural environment and human life in the watershed.

This study deals with sediment transport in the river only. The erosion on the hills could not be measured, but is considered to be the natural cause of sediment transport, and gives rise to some inter-related remarks. Previous technical studies of the Komering and other projects have been utilized as essential background information.

1.2 Present Condition of Upper Komering River Basin

1.2.1 Lake Ranau

The Lake Ranau is a crater lake measuring 127 km^2 in area and 60 km in circumference, and located in the uppermost stream of the Komering river. The watershed measures 508 km^2 in area, and the altitude of the lake surface is 542.0 m. The maximum water depth of the lake is 229 m. The lake is surrounded by such parasitic cones as Seminung (1,881 m) and Pakiwang (1,531 m). Villages such as Banding Agung, Kotabatu and Sakabanjar scatter on the shores of the lake, and a considerable number of people live in these villages.

The lake exit is located in east of the Banding Agung village, and it forms a barranco of the Lake Ranau. The barranco is called the Selabung river, forming the headwaters of the Komering to flow out an average discharge of 18.5 m^3/sec.

The project aims at effective utilization of the Komering river for such purposes as irrigation and hydropower generation. The Lake Ranau, judging from its scale of regulating volume and effective head, can play an extremely important role in the project.

1.2.2 River Basin

The watershed of the Komering river is divided into upper stream mountainous headwaters areas and downstream alluvial plains, making the town of Muaradua located 150 m in altitude as a border. The upper reaches of the river are mountain districts including the Barisan Mountains which exceed 2,000 m in elevation. The upper reaches are formed by the watersheds of several tributaries, and are mostly covered with forests. Muaradua forms a contact where the Komering river starts flowing from mountain districts to plains, and the Komering river starts flowing as one river at this contact. The lower reaches of the river have the so-called alluvial plains from this contact on both sides of the river, where the land is cultivated. The Komering river meanders in these alluvial plains and flows down to its rivermouth about 300 km downstream forming very gentle grades.

1.2.3 Upper Reaches of Komering River

Study area extends over the southwest corner of the South Sumatra Province and partly in the northern part of Lampung Province having about 4,260 km^2 at Martapura. The elevation of the basin ranges from EL. 2,180 m (Mt. Pesagi) in the Barisan Mountains to EL. 80 m at Martapura. Forest covers around 60% of the basin, particularly in the mountainous region, and shifting cultivation and plantation areas cover the remaining area. Geologically the lands are composed of pleistocene formations of soft tuffaceous sandstone, sandy conglomerate and siltstone, and are dissected extensively by gullies and rivulets. The alluvial plains lie mainly along the lower reach of the upper Komering river.

The main stream of the Komering river originates from the Lake Ranau, and flows in torrents in northwest direction until it joins with the Baru river. At the confluence, it changes its cource towards northeast and flows down through steep and narrow gorge dividing the Barisan Mountains. At Muaradua, it joins with the Saka river and travels through hilly area collecting the water from other tributaries towards almost northeast up to Martapura.

Shifting cultivation in association with the uncontrolled and irresponsible fire is causing destructive havoc to the extent of creating a foreseeable ecological disaster in the Komering watershed. Soil erosion is largely accelerated by the above shifting culture with fire particularly in the steep mountainous region, and considerable sediment loads are transported from the upper basin resulting in raising of river bed in the downstream reach of the Komering river. Recognizing this serious condition of the watershed, the Government of Indonesia has put great emphasis on "Penyelamatan Hutan, Tanah dan Air" (forest, soil and water conservation).

1.2.4 Lower Reaches of Komering River

There are areas forming the so-called alluvial plains of the Komering river downstream of Muaradua. The Komering river repeats meandering in these alluvial plains at gentle grades for about 300 km until it reaches the river-mouth. Palembang with a population of 720,000, which is the capital of the South Sumatra province, is located 250 km downstream, serving as a political and economical center in the region. The water of the Komering river has a close relation with people's life such as vital water, water transportation, and fishing, in addition to the use as agricultural water. The villages primarily locate along the river.

Except for some revetment in scattered sections of the Komering river, no artificial control of the river such as dams and levees have been made, and the river is a primeval river. The river overflows in the rainy season every year, and natural levees are formed along the river. Inundations during the rainy season supply fertile soil to cultivated land in the watersheds. For those people in the area who are in extensive farming, floods are not necessarily a bad aspect. The watersheds consist of paddy fields, alang-alang, shrub areas, swamp areas, etc. Underdeveloped irrigation facilities make the land productivity low, and the proportion of unutilized areas is large.

The annual average discharge during 1963 to 1980 at Martapura, where watershed area is 4,260 km^2, is 205.6 m^3/sec. The maximum discharge is recorded in April with 291.8 m^3/sec, whereas the minimum discharge is recorded in September with 135.5 m^3/sec.

There are five rivers connecting from the Komering river to the Ogan river between Cempaka and Kayuagung. These five rivers are the Randu, the Arisan, the Jambu, the Sigonang and the Anyar from the upstream to downstream. According to the discharge data measured by the Provincial P3SA, South Sumatra, about 75% of river flow of the Komering flows into these five rivers. Recently, Kayuagung city and its surroundings have suffered from the stagnant flow of the Komering river in the dry season, which has sometimes resulted in an epidemic. It is considered that the above facts are mainly due to raise of the river bed resulted from the considerable deposits of sediment and a large diversion of water from the Komering river to the Ogan river as mentioned above. Another problem observed along the lower reaches of the Komering river is bank erosion caused by changes in meandering mode of the river, for which the gravel digging by local people for the use of construction work affects to some extents.

As future policies to cope with these problems, a determination of a more detailed state will be necessary about run-off of water to the Ogan river, and a low water discharge will have to be secured regarding deterioration of water. Regarding digging of gravel in river beds, conversion of aggregate from gravel to crushed stones, digging in deltas which cause less effects on the river meandering, and other countermeasures will be required.

1.3 Forest Administration

In Indonesia, forest administration is conducted by the respective Provincial Forestry Services Office under the supervision of Directorate General of Forestry, Ministry of Agriculture in accordance with the Law No. 5 Year 1967 for Forestry Acts (Undang-Undang No. 5 Tahun 1967 Tentang Ketentuan-Ketentuan Pokok Kehutanan).

The forest in the upper Komering river basin is administratively categorized into three groups, i.e. protection forest of 85,670 ha, production forest of 13,300 ha and reserved forest of 160,000 ha.
The protection forest is further grouped into two for its purpose, i.e. hydrological protection forest and animal protection forest. These protection forests have been selected in the elevated areas with the

elevation of more than 500 m. On the other hand, the production forest has been selected in the low-elevated area below the elevation of 500 m. For the cutting of industry-use trees, the concessions are given to the private companies through tendering. The reserved forest consists of the forest which has not been confirmed for its category, and the forest which is reserved for reclamation.

2. EROSION AND SEDIMENT TRANSPORT IN THE KOMERING RIVER BASIN

2.1 Factors Influencing Erosion and Sediment Transport

2.1.1 Vegetation

Generally, well vegetated lands are less influenced by erosion due to the following actions of vegetation.

(1) to relieve the energy of rain drops,

(2) to reduce the velocity of surface flow,

(3) to increase the percolation rate of soil resulting in the reduction of surface flow, and

(4) to increase the shearing strength of soil and to keep the clod of soil strong due to development of root network.

The following tables show the general indication of erosion by the vegetation conditions.

Relation between Magnitude of Erosion and Felling Rate /1

Felling Rate	Erosion per Year (tons/ha)
100%	3.66
50%	1.14
0%	0.35

Relation between Magnitude of Erosion and Type of Vegetation /1

(Land Slope: more than 15°)

Type of Vegetation	Erosion (mm/year)
Devastated land	10 - 100
Stripped land	1 - 10
Cultivated land	0.1 - 1
Forest land	0.01 - 0.1

/1: Function of Water and Soil Conservation in Forest Area and its Practice, 1978, Hideaki Nakano, Japan.

According to the forest Management map (Fig. IX-1) provided by BAPPEDA, South Sumatra Province, and the aerial photographs taken by JICA in 1979, the vegetation in the upper Komering river basin is broadly classified into three groups; vergin forest, secondary forest, including plantation and cultivation area including alang-alang. The vergin forest about 1,720 km^2, is mainly located in high altitude of the basin. The secondary forest and coffee or rubber plantation, about 1,830 km^2, is mainly situated in hill area along the upper Komering river. Around 710 km^2 of the cultivation area including alang-alang extends along the lower reaches of the upper Komering river as shown in Fig. IX-2.

2.1.2 Topography

The general topography of the upper Komering river basin can be explained as follows:

(1) hill area with elevation of 80 m - 120 m and land slope 0^o-10^o between Martapura and Muaradua,

(2) volcanic plain with elevation of 120 m - 540 m and land slope of 10^o-20^o between Muaradua and Ranau, and

(3) Barisan Mountains with a elevation of 540 m - 2,750 m and land slope of more than 20^o.

The following tables show the area extent for respective range of altitude and land slope (ref. Fig. IX-3 and IX-4).

2.1.3 Geology

Geologically the upper Komering river basin mainly consists of pleistocene formations underlied by the Tertiary sedimentary rocks and the Pretertiary igneous rocks, and further classified into following four geological groups:

(1) Young volcanic products

(2) Ranau tuff

(3) Upper Palembang formation

(4) Granite

The young volcanic products are mainly composed of andesite lavas and tuffs of the alluvial epoch, and occupy the Barisan Mountains, both banks of the Baru river, left bank of Selabung river and the upper basin of Saka river as shown in Fig. IX-5. This formation is not so erosive.

The Ranau tuffs are mainly distributed along the right bank of the Selabung and the Komering rivers, where the land slope ranges from 10° to 20°. The Ranau tuffs are composed of acid volcanic ash and welded tuff. The acid volcanic ash is deposited over the welded tuffs for 10 m to 15 m in depth. The Ranau tuffs, especially the acid volcanic ash, are very erosive, and accordingly a particular consideration should be paid to these areas for the erosion control.

The Upper Palembang formation mainly consists of acid pumice tuffs, tuffacous sandstone and kaolinike mudstone, practically without marine horizon and with few coal bearing horizons. This formation is observed in the patches along the upper reaches of the Saka river. The area of this formation is not so erosive.

Granite is mainly observed in the patches on both banks of the Komering river near Muaradua. The granite has been weathered and become erosive.

2.1.4 Rainfall

Annual mean rainfall in the upper Komering river basin is around 3,000 - 3,500 m in the western part of the basin and 2,000 - 2,500 m in the eastern and central parts of the basin as shown in Fig. IX-6. The following table shows the annual mean rainfall and the daily maximum rainfall at Banding Agung, Muaradua and Martapura for the period from 1972 to 1979.

Station	Rainfall (mm)	
	Annual Mean	Daily Maximum
Banding Agung	2,220	116
Muaradua	2,530	116
Martapura	2,930	207

Generally the rainfall intensity is one of the most important factors influencing the soil erosion. According to the FAO Report/1, whole upper Komering river basin is included in the 100 - 120 mm/hr zone, and it can be said that this high intensity of rainfall influences the watershed erosion to great extent.

2.2 Suspected Area for Erosion

Generally speaking, soil losses from mountain districts are caused primarily by devastated mountain districts, particularly landslides and soil erosion. Shifting cultivation is actively performed in the watershed of the Komering river. Because the history of shifting cultivation is relatively new and because the productive power of the land has not lowered very much, secondary stands immediately grow even if cultivation is abandoned. The mountain districts have not caused landslides, and landslides cannot be blamed for soil losses.

The primary causes for soil losses in the watershed are related to the geological structure of the watershed and to vertical erosion of valleys. The watershed generally consists of volcanic ejecta.
In particular, the volcanic ash plateaus centering in the right side of the Komering river are extremely vulnerable to water erosion. It is common with valleys in volcanic plateaus to have vertical erosion progressing in the form of a wave extending from foots of hillside to ridges, that is, valley peaks, which may be called valley peak erosion.
The watershed of the Komering river has exactly the same mode. For this reason, principal torrents with a high water flow rate and large erosion power have erosion reaching to their bedrocks, thus forming valleys in shapes of U or V letters. The small torrents in the upper reaches are slow in vertical erosion of valleys. Even at present, erosion is progressing towards valley peaks. These small torrents are well developed in a tree-branch shape in the watershed, primarily on the right side, chiefly responsible for the production and losses of soil in the watershed of the Komering river.

/1: Land and Water Resources Development in South Sumatra, Indonesia, "Hydrometeorological Analyses and Evaluation", Dr. Medardo Molina G, FAO, 1974.

Through the above study, it may be concluded that the areas with land slopes of 10 to 20° and V- or U-shaped valleys along the tributaries of the Komering river are in a serious condition against possible erosion. (See Fig. IX-7)

Erosion is a phenomenon caused as a result of compound action of the foregoing factors. No decisive technique has been established yet regarding judgment of an erosion danger zone as locations of heavy rainfalls, which are one incitement, cannot be determined.

However, past examples empirically tell us under which conditions (factors) erosion is liable to occur. It is possible to determine to some extent where such danger exists by combining these conditions.

The danger zones were determined for the watershed by giving marks to each factor in accordance with its danger degree and by combining these marks. (The same rainfall conditions were considered for all zones.)

(1) <u>Technique</u>

(a) Factors used in combinations: The following three factors shall be used; topography, geology and vegetation.

(b) The watershed is divided into a net of 1,154 meshes (2km x 2km)

The following marks are given to each factor.

Topography (slope) Y = 3	X	4	3	2	1
	Condition	Above 30°	20 - 30°	10 - 20°	Below 10°
Geology Y = 4	X	4	3	2	1
	Condition	Ranau Tuff	Young Volcanic Product	Granite	Upper Palembang Formation Alluvial
Vegetation Y = 5	X	3		2	
	Condition	Secondary Stand & Shifting Cultivation Area		Virgin Forest	

Topology and geology are divided into four zones each (X = 1 - 4), and vegetation, into two zones (X = 2 - 3). Each of the foregoing factors is given marks Y = 3 - 5 in the order of impacts on erosion.

(c) $\Sigma X \cdot Y$ for each mesh is considered the danger degree.

(2) Example

Topography; Y = 3, X = 3
Geology ; Y = 4, Y = 2
Vegetation; Y = 5, X = 3

Danger degree $\Sigma X \cdot Y = (3 \times 3) + (4 \times 2) + (5 \times 3)$
= 32 marks

(3) Classification of Danger Degree

The results fall within the range of $\Sigma X \cdot Y$ = 17 - 43, and this range was divided into the following three stages of danger degree:

Danger degree I	35 - 43 marks
Danger degree II	26 - 34 marks
Danger degree III	17 - 25 marks

(4) Judgment Results

Danger Degree	Meshes	Proportion (%)
I	491	43
II	568	49
III	95	8
Total	1,154	100

The erosion danger zones of the watershed were judged by using the foregoing method. As a result, 43% of the watershed is considered to be darger zones. It should be noticed that this is based on the assumption that the same rainfall condition, which is an incitement, would be applied and that the danger degree of the areas with the danger degrees II and III will increase if and when local heavy rain falls.

Fig. IX-7 only shows areas with the danger degree I.

2.3 Estimate of Sediment Loads

2.3.1 Sediment Measurement and Analyses

In the study area of the upper Komering river basin, the water sampling at the Martapura water level gauging station and the analyses for suspended load had been under taken by P3SA, South Sumatra province, for the period from January 1980 to October 1981 for 6 times.
The sampling is still being continued until now once a month, but their analyses have not been made yet.

The sampling and the analysis were made in the following manner:

(1) The same river cross section as that for the discharge measurement was used for the measurement of sediment load.

(2) The river cross section was equally divided into five observation sections.

(3) The water sample was taken at three positions, i.e. water surface, middle point of water depth and river bottom, for each observation section.

(4) The content of sediment load was measured in laboratory and expressed in mg/lit.

(5) The average content of sediment load in each observation section was calculated using the following equation:

$$q = \frac{qs + 2qm + qb}{4}$$

where, q: average content of sediment load,

qs: content of sediment load in the water sample taken at the water surface,

qm: content of sediment load in the water sample taken at the middle of water depth,

qb: content of sediment load in the water sample taken at the bottom.

(6) Just before and after the water sampling, the river water level was observed.

The result of the suspended load measurement is shown in Table IX-1.

In addition to the above measurement of the suspended sediment load, the sampling and grain size analysis were carried out on the bed load of the Komering at Muaradua, Martapura and Kurungan Nyawa during this survey period. The result of analysis is graphically shown in Fig. IX-8.

2.3.2 Estimate of Sediment Loads

The result of the suspended load measurement shows a relation between river discharge and sediment discharge as shown Fig. IX-9, and further the measured points conformed to the following equation:

$$q = 1.658 \times 10^{-4} \cdot Q^{1.252}$$

where, q: sediment discharge of suspended load (m^3/sec)
Q: river discharge (m^3/sec)

Using the above equation, the annual amount of suspended load is calculated to be $4.1 \times 10^6 m^3$ for the average year.

Floating material and bed load are of relatively minor quantity, and it is too difficult to measure them with sufficient accuracy. Then, assuming that the amount of these loads are 10% of the suspended load, the annual total sediment loads are estimated to be $4.55 \times 10^6 m^3$, which correspond to 1,068 m^3/km^2/year. This estimated result is compared with the estimated result of 880 m^3/km^2/year in the FAO/UNDP report/1 and 1,030 m^3/km^2/year estimated using the modified Einstein method. The above estimated result is further compared with the annual total sediment loads estimated for the Way Seputih and the Way Sekampung, 1,000 - 1,300 m^3/km^2/year/2, and for the Way Rarem, 750 m^3/km^2/year/3.

/1: Belitang Extension Area Agricultural Development Project, Annex-IV, FAO/UNDP, (Nippon Koei Co., Ltd.), 1974.

/2: Feasibility Study on the Way Seputih and the Way Sekampung Basins, Volume 4, Ministry of Overseas Development, London, 1978.

/3: Feasibility Study on the Way Rarem Irrigation Project, JICA, 1975.

As the result, the erosion rate of 1,000 m^3/km^2/year seems reasonable and applicable to the study of reservoir capacity.

After completion of the dams in the upper reaches of the Komering river, most of the sediment discharge will be checked by the dams and there will be less supply of sediment loads to the downstream. This would cause the degradation of the Komering river bed in the downstream, and it may affect the free intake practices at Kurungan Nyawa and Muncak Kabau.

2.4 Problems and Needs Related to Watershed Management

2.4.1 Basic Problems

For the proper watershed management in the upper Komering river basin, the following three things can be pointed out as the basic problems.

(a) About 57% of the basin has once artificially been devastated for the agricultural use, i.e., shifting cultivation, plantation or logging for the production of wood, and the forest has lost its function for soil and water conservation.

(b) At present, the Provincial Forestry Services Office administers 99,000 ha of the forest area, which corresponds to 23% of the total river basin area, which is far below the area required for the proper watershed management.

(c) Valley peak erosion in the valley erosion process can be witnessed with volcanic plateaus in the watershed, primarily causing production of soil.

2.4.2 Countermeasures Against the Watershed Erosion

The following countermeasures are proposed to maintain water and soil conservation functions of the forests and to check soil losses in response to the foregoing basic problems.

(1) For the forest lands below El. 500 m: These lands occupy around 55% of the total river basin area. Most of the lands have flat topography, and are used for the shifting cultivation. For this area, shifting cultivation should be allowed only in the area with a land slope of less than 10°, where less soil erosion is observed,

and rehabilitation of forest should be made in the area with a land slope of more than 10° through reforestation. Land reclamation works should be made in the downstream area to resettle the farmers who live in the area to be reforested.

(2) For the forest lands between EL. 500 m to EL. 1,000 m: All the area should be designated to be the hydrological protection forest, and clear cutting should not be allowed but selective cutting.

(3) For the forest lands above EL. 1,000 m: All the area should be designated to be the hydrological protection forest, and felling should not be allowed in this forest area. Regarding restoration of the land used for shifting cultivation, the land productive power has not been deteriorated so extensively at present, and secondary stands can be developed fairly certainly. Natural stands have a more effective forestry conservation function, and there is no necessity for artificial afforestation at present.

(4) For the vertical erosion in valleys: In order to protect the hydrological forest and the farmlands against the land slides to be caused by vertical erosion in U or V-shaped valleys, sabo dams should be built in parallel with the management of forests in the watershed Fig.IX-10 shows the proposed sites of the sabo dams, and Fig. IX-11 shows the typical features of the dams.

(5) For the erosion along roads: The farm roads and the access roads to be constructed in the steep-sloped area should be provided with the properly designed gutters along the shoulders and turfing on the side slopes of the road embankments to protects the gully erosion along the roads.

2.4.3 Cost Estimate for Erosion Control Works

An approximate cost required to undertake the foregoing plan particularly for the sabo dams is estimated to be about 24 million US Dollars.

3. ENVIRONMENTAL CONSEQUENCES OF THE PROJECT

3.1 Impacts of the Ranau Regulating Dam Construction

3.1.1 Fluctuation of Water Level of the Lake Ranau

In order to utilize the large water body of the Lake Ranau efficiently for irrigation and hydropower generation, the present outflow pattern of the lake will be regulated according to the requirements mentioned in ANNEX-VI "Irrigation and Drainage" and ANNEX-VIII "Hydropower Development and Dams". The regulation of the present outflow will be made by constructing a dam on the Selabung river; about 2.4-km downstream from the lake outlet.

According to the water balance study, the regulation will require about 200 million m^3 of active storage capacity which will be created using 1.6 m of the operating depth between the high water level of EL. 542.3 m and the low water level of EL. 540.7 m, while the present water level fluctuation is in the range from EL. 542.3 m to EL. 541.5 m.

Although the designed low water level will occur once in several years, the water surface fluctuation in the lake will give various affects mentioned below.

3.1.2 Land Slide

Prediction of land slide due to fluctuation of the lake water level will generally be made by stability analysis of slopes on the basis of detailed geological and rock and/or soil mechanical data. However, since these detailed data are not available so far, a preliminary study based on the general geological information is made to find the probable land slide area around the lake.

In view of geological condition, Lake Ranau is rectangular volcano tectonic basin and the southwestern border is a steep fault escarpment, rising about 1,400 m above the present floor of the lake.

Fig. IX-12 is a rough sketch map of geological structure around the lake, showing two couldron faults bordering the Barisan mountains and the lake in western and southwestern parts of the lake. These fault escarpments consist of hard and well compacted Tertiary volcanic products and, therefore, there might be very rare possibility of land slide even if the lake water level fluctuate widely upward or downward.

The southern part of the lake is bordered by a steep footslope of Seminung volcano consisting mainly of andestic lavas, and therefore the possibility of land slide in this area might also be small.

The northern and eastern parts of the lake seem to have a relatively high possibility of land slide, due to distribution of soft-mad-loose pyroclastic sediments of the Ranau tuff and due to high terrace-scarp-like slopes in the shoreline. Land slide in the Ranau tuff may take place as a slope failure but the scale of failure may be rather small, probably within 10 m as seen in excavated slopes of the road passing through the pyroclastic plateau nearby the lake. Therefore, land slide in the northern and eastern part of the lake might be a kind of slope erosion accompanying small scaled slope failure suddenly taking place.

3.1.3 Retrogressive Erosion in the Streams Flowing into the Lake Ranau

More than 40 rivers or streams flow into the Lake Ranau, among which the Way Warkuk, the Way Mengkupai, the Way Pilla and the Way Sebarek are notable. The river beds of them are stable at present without erosion. After completion of the Ranau regulating dam, however, some retrogressive erosions may occur on the river beds due to more steep hydraulic gradients in the rivers than the present ones, which will be caused by lowering the water level of the Lake Ranau. These retrogressive erosions may give damages to the foundations of the bridges crossing these rivers to some extent. In order to assess the possible damages in detail, further investigations along the rivers from both geological and hydrological viewpoints should be made before start of the Komering-I project.

3.1.4 *Change of Inhabitation Conditions for Fish*

The Lake Ranau measures 127 km^2 in area and has the maximum water depth of 229 m. Its water temperature is said to be stable throughout the year between 28 and 30°C. Except for its west shore area, littoral zones (shallow sections where hydrophytes grow thick) develop around the lake. A variety of fish live in the Lake Ranau, and the fish in an important protein supply source for the local residents.

Generally speaking, a lake can be divided into a littoral zone where plants with roots grow and into a pelagic zone which is further inside the lake than the littoral zone. A plant zone in a littoral zone is divided into an emerged plant zone, floating leaved plant zone, and submerged plant zone in the order of nearness to the lake shore.

This classification also applies to the Lake Ranau, and the littoral zone has a close relation with inhabitation of birds in many respects.

The present plan calls for regulating variations of the water level in the Ranau Regulating Dam to be 0.3 m above and 1.3 m below the present mean water level. The problem with this plan to fishery is what effects would be caused to inhabitation conditions of fish when part of the littoral zone is temporarily lost due to the lowered water level.

The following four principal environmental conditions are required for inhabitation of fish:

- Water temperature is maintained at an appropriate level.
- Dissolved oxygen is available.
- Feed is available.
- Places for reproduction and spawning are available.

(1) Effects on Water Temperature

The water temperature greatly affects respiration, growth, and multiplication of fish, and each species of fish has an endurable temperature range. Fish cannot live outside these temperature ranges. The water temperature also greatly affects the quantity of dissolved oxygen. In the equator region, variations of the sunshine quantity, temperature, etc. are low throughout the year, and the water temperature is nearly constant throughout the year. The vertical difference is also small. According to the survey in "Die Deutsche Limnologische Sunda-Expedition" undertaken by Ruttner et al. of Germany during January-May, 1929, the water temperature of the Lake Ranau was 25°C at 200 m below the water surface, with a difference of 2 to 3°C with the surface water temperature (History of Limnology by M. Ueno).

In the final analysis, it is safe to conclude that there will be no change in the water temperature caused by variations in the water level, because the temperature difference by water depth is very small, fluctuations of the water level are small compared with those for the water depth, and because variations take place over a long period of time.

(2) Effects on Dissolved Oxygen

Fish need dissolved oxygen in water for respiration. The supply source of oxygen in water is that in air contacting the water surface and that generated by optical synthesis action by submerged plants. A submerged plant zone is located the outermost of a littoral zone, and variations in water level to an extent of about 20 m does not seem to cause a great effect. There will be almost no variations in water area, and fluctuations of the dissolved oxygen quantity in the lake by this plan will nearly be none.

(3) Effects on Feed

Feeding habits of fish differ for fries and adult fish. Their feeding habits can roughly be divided into the following categories:

- Fish that eat adhesive algae.
- Fish that eat hydrophytes.
- Fish that eat vegetable planktons.
- Fish that eat animal planktons.
- Fish that eat benthos (water insects, shellfish, etc.)
- Fish that eat fish.

For all of the foregoing categories, littoral zones are an important supply source. In particular, planktons actively breed in a hydrophyte zone, and water insects also live in this zone in a large number. Thus, it seems unavoidable that some effects are caused to the food chain in the lake when part of the plant zones in the lake shores is lost even temporarily.

(4) Effects on Regeneration and Spawning

Fish spawn on hydrophytes at the waterside, on sand and gravel on lake bottoms, and in rivers flowing into lakes, depending on fish species.

The hydrophyte zones on lake shores are important for fish to spawn and for fries to grow. This is the problem that requires particular attention among effects caused to fish by this project. Fish which spawn by going upstream will no longer be able to go upstream when the lake surface and rivers are no longer continuous by the lowered lake water level.

Effects on fishery that can be considered at present are presented above. A future study will be needed to determine specifically how these effects would affect the resource quantity of fish. In any event, judging from the fluctuations of the water level, it is difficult to consider that particularly large effects will be caused. However, when the fish resource quantity clearly decreases after the completion of the dam, some countermeasures such as stocking fries in the river by artificial hatching will become necessary.