IX HYDROPOWER DEVELOPMENT PLAN

SECTOR IX
HYDROPOWER DEVELOPMENT PLAN

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CHAPTER 1 BASIC CONCEPT FOR PLANNING

Indonesia's energy policy is to efficiently mobilize hydropower potential to save exportable resources such as oil, natural gas and coal, contributing to maximization of the country's foreign exchange earnings. In this sense, whenever dams are planned in projects, the possibility of hydropower development are taken into account.

Therefore, the hydropower generation plan in this study is formulated to use the residual capacity of the planned dam reservoirs or discharge flow released from dams for water supply. A single purpose dam of hydropower generation is not primarily studied, and the study on the hydropower generation plan does not aim to satisfy the future electricity demand but aims at supplemental supply.

The dams selected to be studied here are as below:

- Kampar Kiri No. 1 Dam (Kampar River Basin)
- Kampar Kiri No. 2 Dam (Kampar River Basin)
- Upper Sinamar Dam (Indragiri River Basin)
- Sukam Dam (Indragiri River Basin)
- Kuantan Dam (Indragiri River Basin)

Dams proposed in this study are in principle planned as multipurpose dams for flood control, hydropower, irrigation, municipal and industrial water supply, etc.

CHAPTER 2 PRESENT CONDITION OF ELECTRIC POWER SUPPLY AND USE IN STUDY AREA

2.1 Existing Electric Power Facilities

Power supply in West Sumatra and Riau provinces in which the study area is situated is managed by Region III Office of PLN and private sectors. The organization of PLN Region III is shown in Fig. IX.2.1. The existing electric power facilities in the region are explained hereinafter.

PLN Power Generating Facilities

The power generating facilities in the region are listed in Table IX.2.1 and summarized as follows:

Type	Hydro-power	Gas Turbine Power	Diesel Power	Total
Installed Capacity (kW)	79,100	42,700	142,300	264,100
Share (%)	30	16	54	100

More than 50% of the total installed capacity is shared by diesel power. The diesel power stations are located near the center of cities and towns and the power is distributed locally. As to major diesel power plants, the Simpang Haru Diesel Power Station (21,020 kW) is located in Padang City and the Padang Luar Diesel Power Station (4,560 kW) is in Bukittinggi City.

The major hydropower stations are Maninjau (68,000 kW) and Batang Agam (10,500 kW); the rest (600 kW) are generated by mini-hydropower stations. All hydropower stations are located in West Sumatra Province.

PLN Transmission and Distribution Systems

The transmission systems of 150 kV (Maninjau System) and 20 kV (Batang Agam system) in PLN Region III are shown in Fig. IX.2.2.

The Maninjau Transmission System (150 kV, 228 km long) is from the Maninjau Hydropower Station to Salak, through Lubukalung, Pauhlimau, Indarung, Solok and to Payakumbuh through Padangluar in West Sumatra Province. It is the first step of the high voltage interconnection program for the West Sumatra and Riau provinces.

The Batangagam Transmission System (20 kV, 151 km long) connects the Batangagam Hydropower Station and the Padangluar Diesel Power Station with the towns of Bukittinggi, Payakumbuh, Batusangkar, Padangpanjang and Lubukalung.

Riau Province and other areas in West Sumatra Province, however, have no transmission system and the power supply is provided locally by diesel power stations located near the center of cities or towns. Power distribution in Region III is being made at the 20 kV level and low voltage of 380/220 volts, 50 Hz standard.

In the past, electricity distribution in the region was made at the 6 kV level and low voltage of 220/127V, 50 Hz standard. From 1977, the voltage standard was changed from 220/127V to 380/220V and distribution facilities such as transformers and customer meters were replaced and the carrying capacity of the main feeders was increased to reduce the power losses and voltage drop.

Private Sector Power Generating Facilities

Aside from the power supply by PLN, many enterprises, commercial shops and factories have been compelled to install power generating facilities by themselves due to insufficient PLN generating capacity over the years. The capacities of private power generating facilities are as tabulated below.

Province	Capacity	Remarks
West Sumatra	32,216 kW	including Padang Cement
Riau	103,212 kW	including Pertamina, but excluding Caltex
Total	135,428 kW	

The factories with private power generating facilities are divided into two categories: pure captive power and captive power connected to the PLN system. The factories with pure captive power will be connected to the PLN power supply system whenever possible.

2.2 Present Electric Power Demand and Supply

PLN Power Generation and Sales

The power generation and sales of PLN Region III Office in the year 1993/1994 are given as follows:

Item	Unit	1993/94
(1) Generation and Sales		
(a) Sales	GWh	891
(b) Losses of Transmission and Distribution	GWh	188
(Loss Ratio to Energy Production)	(%)	(17.0)
(c) Sentout Energy	GWh	1,079
(d) Plant Use for Energy Production	%	2.5
(e) Energy Production	GWh	1,107
(f) Peak Load	MW	206.2
(g) Load Factor	%	61.3
(2) Type of Generation		
(a) Mini-Hydroelectric Power	MW	0.6
(b) Hydroelectric Power	MW	78.5
(c) Gas Turbine Power	MW	42.7
(d) Diesel Power	MW	142.3
Total	MW	264.1

The historical power production and sales in Region III are given in Table IX.2.2. The annual growth rate of sales is 13.4% in the period 1989/1990 to 1993/94.

Power Energy Consumption

Tables IX.2.3 and IX.2.4 show the historical energy consumption by customer type and area since 1986/87 and 1987/88, respectively. The share of energy consumption by area and customer type is almost constant for 7 years from 1986/87 to 1993/94. The share of energy consumption by area in the region in 1993/94 was as tabulated below:

Area	Padang	Bukittinggi	Solok	Pekanbaru	Dumai	Tj. Pinang	Total
Share (%)	48.8	9.2	2.7	22.2	7.6	9.5	100

Padang is the biggest consumption area followed by Pekanbaru, Bukittinggi, Tj. Pinang, Dumai and Solok. This tendency has been maintained for a long time. The share of energy consumption by customer type in 1993/94 is as tabulated below. Residential use was the biggest, followed by industrial and other uses.

Customer Type	Residential Use	Industrial Use	Others	Total
Share (%)	42.1	41.4	16.5	100

Number of Customers

The number of customers in the region increased from 233,931 in 1986/87 to 517,900 in 1993/94. The growth rate was 12.0% for seven years.

Electrification in Region III

The PLN is pushing through the electrification of towns and villages as one of the important goals in social and economic development. The rural electrification rate in Region III as of 1994 is as follows:

Region	Total No. of Villages	Electricity Supplied Villages (No.)	Electrification Rate (%)	No. of Houses	Electification Rate (%)
West Sumatra	2,011	1,453	72.25	147,850	20.62
Riau	983	277	28.18	66,458	11.66
Kerinci	246	169	68.70	16,258	29.48
Total			58.61		17.45

According to the PLN's data in "A Short Note on the Development of Rural Electrification in Indonesia, Nov. 1990", the electrification rate in villages and households in Region III as of 1990 were 34.6% and 15.4%, respectively. During the last 4 years, rural electrification in Region III has grown with about 24% in villages and about 2% in households.

CHAPTER 3 EXPANSION PROGRAM OF ELECTRIC POWER FACILITIES IN REGION III

3.1 PLN Generating Capacity Expansion Program

To meet the rapid growth in power demand, PLN is making efforts to increase power supply capacity taking into full use of oil resources, particularly hydropower and coal. In addition, expansion of the transmission line system is being carried out to supply economical and reliable power to the service areas.

In accordance with the power system expansion and investment plans in Region III, several projects are under construction, committed and planned as shown in Table IX.3.1. Among them, the following are the major projects.

(1) Kotapanjang Hydropower Project

Location	Desa Merangin, Kec. Bangkinang, Kab. Kampar Riau Province, 20 km from Bangkinang, 85 km from Pekanbaru, Riau Province
Water Source	Kampar Kanan River
Installed Capacity	114 MW (3 × 38 MW)
Annual Generation	542 GWh
Completion Year	1997/98

(2) Singkarak Hydropower Project

Location	Desa Tapakis, Kec. Lubukalung, Kab. Pariaman, West Sumatra Province, 32 km from Padang City
Water Source	Singkarak Lake
Installed Capacity	175 MW (4 × 43.75 MW)
Annual Generation	986 GWh
Completion Year	1998/99

(3) Ombilin Thermal Power Project

Location	Desa Sijantang, Kec. Talawi, Kab. Sawahlunto/Sijunjung, West Sumatra Province
Energy Source	Coal
Installed Capacity	200 MW (2 × 100 MW)
Completion Year	1997/98

The future share of energy production by plant type will change as follows, taking into account the commissioning of new plants.

Type of Plant	1993/94	2000/01	2008/09
Hydropower	79.1 MW (29.9 %)	375.8 MW (45.9%)	391.8 MW (48.7%)
Gas Turbine Power	42.7 MW (16.2%)	70.0 MW (8.6%)	70.0 MW (8.7%)
Coal-fired Thermal Power	-	200.0 MW (24.4%)	200.0 MW (24.9%)
Geothermal Power	-	2.4 MW (0.3%)	2.4 MW (0.3%)
Diesel Power	142.3 MW (53.9%)	169.8 MW (20.8%)	140.8 MW (17.5%)
Total	264.1 MW (100 %)	818.0 MW (100 %)	805.0 MW (100 %)

3.2 Power System Interconnection Program in PLN Region III

Table IX.3.2 shows a list of 150 kV transmission/substation facilities under construction and committed up to 1997/98 and Fig. IX.3.1 shows the connection diagram. The facilities are located as follows:

- Payakumbuh - Kotapanjang Hydropower Station, Pekanbaru
- Singkarak Hydropower Station, Lubukalung
- Singkarak Hydropower Station, Batusangkar
- Ombilin Thermal Power Station, Indarung
- Padang Gas Turbine Power Station, Simpangharu

3.3 Power System Interconnection Plan in Sumatra

The objectives of interconnection in Sumatra are to have an equal distribution of power between regions, to achieve a better inter-cultural relationship, to reduce power reserve requirements and to improve network operations. Fig. IX.3.2 shows the power system interconnection program in PLN Region III.

As shown in Table IX.3.3, the power demand in whole Sumatra could be met by interconnection up to the year 2003/04 with condition that all planned power plants are made in operation as scheduled.

Fig. IX.3.3 shows a connection plan between Region III and other regions in Sumatra. PLN Region III will have an excess of cheaper power over the considered period (1997/98 to 2003/04) and the proposed 150 kV interconnection line from Lubuk Sikaping to Padang Sidempuan will make the export of power from PLN Region III to Region II possible. A proposed 220 kV (or eventually 275 kV) interconnecting line from Ombilin to Muara Bungo will make export of power from PLN Region III to Region IV possible.

On the other hand, since the peak load demand (810 MW) in 2004/05 dominates the supply capacity (805 MW) in Region III, power in Region III may have to be imported from Region II or Region IV, through the interconnecting transmission line.

As a further long term plan, PLN is expecting networks with 500 kV extra high voltage transmission systems to interconnect with Java as shown in Fig. IX.3.4.

CHAPTER 4 ELECTRIC POWER DEMAND FORECAST

PLN renews its electric power demand forecast of the Region III every year based on the latest energy and economic records for establishment of its system expansion plan and additional investment plan.

Table IX.4.1 is an energy and power demand forecast up to 2008/09 in Region III prepared by PLN in May, 1993. Based on that forecast, the future energy and power demand up to 2018/19 is forecasted in this study as tabulated below.

Fiscal Year	Energy Consumption (GWh)	Generation (GWh)	Peak Load (MW)
1993/94	891.2	1,107.1	206.2
1998/99	2,157.9	2,599.8	452.6
2003/04	3,383.7	4,076.7	738.4
2008/09	5,000.8	5,953.4	1,112.5
2013/14	7,313.9	8,707.1	1,672.8
2018/19	10,696.9	12,734.4	2,515.3

The growth rates of power generation capacity up to the year 2018/2019 are estimated as below:

Fiscal Year	Generation (%)	Peak Load (%)
1993/94 - 1998/99	18.6	17.0
1998/99 - 2003/04	9.4	10.2
2003/04 - 2008/09	7.9	8.5
2008/09 - 2013/14	7.9	8.5
2013/14 - 2018/19	7.9	8.5

Based on the above forecast, the power demand and supply in Region III presented in Table IX.4.2 was worked out by PLN in June 1993.

CHAPTER 5 NECESSITY OF ELECTRIC POWER DEVELOPMENT IN STUDY AREA

The present electric power supply situation in Region III, especially in the study area including Pekanbaru is not sufficient, as evidenced by the frequent power supply interruption, the many enterprises with private generating equipment, the many waiting customers, and delay the rural electrification.

Since Kotapanjang Hydropower Station will be in operation from 1997/98, electric power supply will be gradually increased in both provinces, especially in Pekanbaru. The future development would be made with the Power System Interconnection Program in PLN Region III as shown in Fig. IX.5.1.

However, after the completion of the Kotapanjang, Singkarak and Ombilin projects, no other specific projects is considered in PLN Region III for medium term and long term according to the PLN office, except diesel plants for isolated areas and a small geothermal power project (Kerinci). However, due to the small size of diesel and geothermal projects, the effect of these small plants to the future interconnected networks is negligible.

For the long term, possibilities of power development in Region III will depend on large thermal power stations for base operations and hydropower stations for peak operations (3 to 4 hours operation) which may have some impact to the interconnection networks.

The dams proposed in this Study are located near 150 kV substations (25 to 70 km) in the power system interconnection program in PLN Region III, as shown in Fig. IX.5.1.

After the year 2005, the excess demand would be met by other regions through interconnection network. To reduce power supply from other regions, the development of a power generation plan for the region is necessary.

CHAPTER 6 OVERALL DEVELOPMENT PLAN OF HYDROPOWER GENERATION

6.1 Proposed Hydropower Stations

The following six dams are selected as possible dams for flood control and water resources development:

- Kampar Kiri No. 1 Dam (Kampar River Basin)
- Kampar Kiri No. 2 Dam (Kampar River Basin)
- Kapoernan Dam (Kampar River Basin)
- Upper Sinamar Dam (Indragiri River Basin)
- Sukam Dam (Indragiri River Basin)
- Kuantan Dam (Indragiri River Basin)

Since the Kapoernan Dam has a small reservoir capacity, it is not suitable for hydropower generation and is considered for flood control purposes only. Kampar Kiri No. 1 and Kampar Kiri No. 2 power stations are optimized for power generation use since the dam reservoir capacities are huge and no interventions occur in storage allocation.

On the other hand, Kuantan Dam has a huge storage capacity but effective storage is limited, so that the installed capacity of Kuantan Power Station is to be determined as a part of multipurpose development for flood control and water supply.

Since Upper Sinamar and Sukam dams have small storage capacities, they are considered to supplement the Kuantan Dam. No exclusive storage for power generation use is considered through alternative studies.

6.2 Criteria for Reservoir Operation

For the hydropower generation calculation, the following criteria for reservoir operation are established.

<u>Power Generation Pattern</u>

The power generation pattern of each power station is set as shown in Fig. IX.6.1 for the comparative study taking into account annual runoff, discharge for water supply, river maintenance flow, etc.

The Kampar Kiri No. 1, Kampar Kiri No. 2 and Sukam power stations are to be operated only for 8-hour peak operation, because the water supply demand in the downstream areas from these power stations are small and also, no influence by peak power operation is locationally expected in the downstream reaches.

On the other hand, the Upper Sinamar and Kuantan power stations are to be operated partly with 24-hour base operations and partly 8-hour peak operations, because they have rather large base flow and constant flow may be necessary for the downstream stretches from the environmental viewpoint.

The simulated reservoir water level shall be returned to Normal Water Level (NWL) at least once 5 years.

Power and Energy Calculation

The outputs of power and energy are calculated by the following equations.

$$P = 9.8 \times h \times Q \times He$$

where, P : power output (kW)
h : combined efficiency (0.85)
Q : turbine discharge (m^3/s)
He : effective head (m)

$$E = P \times T$$

where, E : energy output (kWh)
P : power output (kW)
T : time (hours)

Rated Water Level and Tail Water Level

The rated water level is set at the level of two-thirds of the water depth for effective storage. Tail water level is given by the uniform flow calculation.

Installed Capacity

The installed capacity for comparative study is taken as the capacity given by turbine discharge of three times the assumed firm discharge and head for rated water level.

Available Water for Power Generation

The water available for hydropower generation is, in principle, the water released for water supply. However, when excess water is spilled out from dams, peak power generation is extended to utilize the excess water for power generation as much as possible.

Head Loss

Head loss in waterway to determine an effective head is approximated in the simulation study by the following equation:

$$H_L = \{ L/200 + 0.5 + \alpha \} (Q/Q_{max})^2$$

where, H_L : head loss (m)

L : length of waterway (m)

α	:	0 to 0.5 m
Q_{max}	:	maximum turbine discharge (m^3/sec)
Q	:	discharge at power generation (m^3/sec)

Therefore, the effective head He is calculated as follows :

$$He = RWL - TWL - HL$$

where, He	:	effective head (m)
RWL	:	reservoir water level (EL.m)
TWL	:	tail water level (EL.m)
HL	:	head loss (m)

6.3 Optimization of Installed Capacities of Kampar Kiri No. 1 and No. 2 Power Stations

6.3.1 Criteria for Optimization

As mentioned before, the scale of Kampar Kiri No. 1 and No. 2 power stations is determined by optimum water use for hydropower generation. On the other hand, the scale of the Kuantan, Upper Sinamar and Sukam power stations depends on the flood control and water resources plans, so that they are studied following the cases studied in SECTOR VIII, WATER RESOURCES DEVELOPMENT PLAN.

Benefit and Cost

For the optimization of installed capacity of power stations, benefit-cost analysis is required.

The benefit of hydropower generation consists of power benefit and energy benefit of thermal power generation. The power benefit is obtained by multiplying kW-value by 90% dependable power output and the energy benefit is obtained by multiplying kWh-value by annual energy output. Basic economic indexes for these values are calculated in Table IX.6.1. The kW-value and kWh-value of the thermal power generation applied are summarized below:

kW-value	US$391.66/kW (< 50 MW) or US$318.14/kW (> 50 MW)
kWh-value	US$0.0178/kWh

On the other hand, costs of dam and power facilities are estimated from cost curves shown in SECTOR XII, DAM ENGINEERING. For the calculation of B-C and B/C for comparative study, the cost is converted to annual cost at the discount rate of 10%.

Selection of Optimum Installed Capacity

The optimum installed capacity of power station is in principle defined as the one which gives maximum B-C and B/C in comparative study.

6.3.2 Optimization of Kampar Kiri No. 1 Power Station

This power station is operated so as to maximize the power benefit. The optimum installed capacity of the Kampar Kiri No. 1 Power Station is found out by setting different installed capacities and normal water levels as parameters for the comparative study.

The cases studied and results of reservoir operation are presented in Table IX.6.2 and summarized as follows:

Case	NWL (El.m)	Installed Capacity (MW)	90% Dependable Power (MW)	Energy Output (GWh/year)	B-C (10^9Rp.)	B/C
A.1	115.0	98.6	95.3	355.6	27.10	1.52
A.2	115.0	113.6	102.3	349.9	29.29	1.53
A.3	115.0	119.3	99.8	340.9	26.68	1.48
A.4	120.0	105.8	101.5	378.4	28.78	1.51
A.5	120.0	122.1	111.4	373.3	31.73	1.53
A.6	120.0	128.2	107.2	373.3	27.76	1.46
A.7	125.0	112.7	110.2	401.7	30.62	1.50
A.8	125.0	130.9	121.2	398.5	35.99	1.57
A.9	125.0	137.3	115.8	388.8	28.70	1.43

NWL: Normal Water Level

As seen in the above table, the value of B-C and B/C increase with the increase of NWL and dam height. The relationship between installed capacity in each alternative and net present value (B-C) is shown in Fig. IX.6.2. Therefore, the optimum scale is determined from maximum limitation of reservoir water level due to the topographical conditions. In conclusion, Case A.8 was identified as the optimum case and the main features of Case A.8 are summarized below.

Dam Height	103.0 m
NWL	EL 125.0 m
Necessary Storage Capacity for Hydropower Generation	646 x $10^6 m^3$
Installed Capacity	131 MW

Fig. IX.6.3 shows the simulated reservoir operation for Case A.8.

6.3.3 Optimization of Kampar Kiri No. 2 Power Station

This power station is operated so as to maximize the power benefit. The optimization study on the Kampar Kiri No. 2 Power Station is made in the same manner as the Kampar Kiri No. 1 Power Station.

The cases studied and results of reservoir operation are presented in Table IX.6.3 and summarized as follows:

Case	NWL (El.m)	Installed Capacity (MW)	90% Dependable Power (MW)	Energy Output (GWh/year)	B-C (10^9Rp.)	B/C
B.1	125.0	34.7	33.1	114.3	9.12	1.39
B.2	125.0	37.5	33.9	115.5	9.74	1.41
B.3	125.0	39.1	31.8	116.1	7.77	1.33
B.4	135.0	39.9	38.2	128.3	10.30	1.38
B.5	135.0	42.8	38.9	131.2	10.91	1.40
B.6	135.0	45.2	37.6	132.8	9.54	1.35
B.7	147.0	45.9	44.1	143.9	9.16	1.27
B.8	147.0	49.4	45.0	149.2	9.60	1.28
B.9	147.0	52.5	44.5	152.9	9.11	1.26

NWL: Normal Water Level

Fig.IX.6.2 shows the relationship between installed capacity and net present value (B-C). Although Case B.5 gives the highest B-C value, the reservoir water level does not recover to NWL. Therefore, the optimum case is determined as Case B.4 which gives the second highest B-C value. The optimum installed capacity and reservoir storage volumes are determined as follows:

Dam Height	95.0m
NWL	EL 135.0 m
Necessary Storage Capacity for Hydropower Generation	$438 \times 10^6 m^3$
Installed Capacity	40 MW

Fig. IX.6.3 shows the simulated reservoir water level of Case B.4.

6.4 Power Generation of Kuantan Power Station

As mentioned before, the Lower Kuantan Dam is developed for multipurpose of flood control, water supply and power generation. The storage allocation for respective uses shall be optimized from the viewpoint of total net present value of the project.

The optimization study is made in SECTOR XI, MULTIPURPOSE DEVELOPMENT PLAN. The power generation calculation is made for 31 cases as presented in Table IX.6.4.

In the case study, the LWL is set at EL 102.0 m, which is 2.5 m above the sedimentation level of EL 99.5 m for 100 years. The reason is that some allowance (usually two times of penstock diameter) is required between the LWL and invert level of power inlet to prevent air entrance.

Finally, Case K.19 is selected as the optimum case, as mentioned in SECTOR XI, MULTIPURPOSE DEVELOPMENT PLAN. The features of the hydropower plan for the optimum case of the Kuantan Dam are as follows :

Surcharge Water Level (SWL)	EL 120.00 m
Normal Water level (NWL)	EL 115.20 m
Low Water Level (LWL)	EL 102.00 m
Effective Storage Available for Hydropower	$527 \times 10^6 m^3$
Installed Capacity	114.0 MW
90% Dependable Power	103.6 MW
Annual Energy Output	657.0 GWh/year

The simulated reservoir water level of the optimum, Case K.19, is shown in Fig. IX.6.3. Monthly energy output of the optimum scale is given in Table IX.6.5.

6.5 Power Generation of Upper Sinamar and Sukam Power Stations

6.5.1 Upper Sinamar Power Station

The Upper Sinamar Dam is considered in combination with the Lower Kuantan Dam for water supply as mentioned in SECTOR VIII, WATER RESOURCES DEVELOPMENT PLAN, and power generation of this power station is made using the water released for water supply.

The cases studied are as given below, which coincide with the study cases for water resources development planning in the abovesaid sector.

Unit: m^3/s

Case	Irrigation Water	River Maintenance Flow**	Kuantan Dam
b.1	0.00	14.22	Case a.2 (full supply)
b.2	0.00	20.00	- do -
b.3	0.00	23.00	- do -
b.4	25.46 (53%*)	14.22	
b.5	19.21 (40%*)	14.22	- do -

* Percentage indicates ratio to full supply peak demand.

** Including water for power generation.

The results of reservoir operation are presented in Table IX.6.6 and summarized below.

Case	NWL (EL.m)	Installed Capacity (MW)	90% Dependable Power (MW)	Energy Output (GWh/year)	B-C * (10^9Rp.)	B/C *
b.1	481.8	13.8	13.3	120.1	6.97	2.01
b.2	487.2	32.1	30.5	231.3	22.12	3.79
b.3	490.2	42.3	39.8	282.5	29.48	4.28
b.4	490.4	35.9	33.6	255.1	24.76	3.96
b.5	488.3	30.3	28.5	224.7	20.59	3.63

* Cost include additional cost for power generation.
NWL: Normal Water Level

The development scale is discussed in SECTOR XI, MULTIPURPOSE DEVELOPMENT PLAN, taking the flood control plan into account.

6.5.2 Sukam Power Station

The Sukam Dam is also operated in combination with the Kuantan Dam and the Sukam Power Station will generate electric power using the water released for water supply. The cases studied are as given below, which coincide with the cases for water resources development planning.

Unit: m^3/s

Case	Irrigation Water	River Maintenance Flow **	Kuantan Dam
c.1	0.00	3.24	Case a.2 (full supply)
c.2	0.00	5.00	- do -
c.3	0.00	7.00	- do -
c.4	0.00	11.00	- do -
c.5	24.26 (67%*)	3.24	- do -
c.6	18.67 (50%*)	3.24	- do -

* Percentage indicates ratio to full supply peak demand.
** Including water for power generation.

The results of reservoir operation are presented in Table IX.6.7 and summarized below.

Case	NWL (El.m)	Installed Capacity (MW)	90% Dependable Power (MW)	Energy Output (GWh/year)	B-C * (10^9Rp.)	B/C *
c.1	195.2	2.7	2.6	16.8	-1.79	0.62
c.2	199.6	4.7	4.4	24.7	-0.27	0.95
c.3	203.0	7.2	6.6	31.6	1.34	1.24
c.4	218.1	15.4	11.5	46.6	5.46	1.89
c.5	216.0	15.6	11.6	44.2	5.35	1.86
c.6	211.1	11.6	9.5	40.5	3.84	1.66

* Cost indicate additional cost for power generation only.
NWL: Normal Water Level

The development scale is discussed in SECTOR XI, MULTIPURPOSE DEVELOPMENT PLAN, taking the flood control plan into account.

CHAPTER 7 FEASIBILITY STUDY ON HYDROPOWER GENERATION

As explained in SECTOR XI, MULTIPURPOSE DEVELOPMENT PLAN, the idea of lowering the NWL of Kuantan Dam during rainy season till completion of the river improvement comes out in the feasibility study to cut the flood peak at the dam as much as possible.

The NWL set for reservoir operation are as follows:

- Apr. - Sept. : EL 115.2 m (Dry Season)
- Oct. - Mar. : EL 109.5 m (Rainy Season)

The rated water level (RWL) and low water level (LWL) are the same as Case K.19 in CHAPTER 6. They are EL 110.7 m and EL 102.0 m, respectively.

The reservoir operation has been simulated for the above conditions. Table IX.7.1 gives the monthly energy output, while Fig. IX.7.1 shows the simulated reservoir water level. The results are summarized below.

Normal Water Level (NWL)	EL 115.20 m (Dry Season) EL 109.50 m (Rainy Season)
Low Water Level (LWL)	EL. 102.0 m
Effective Storage Available for Hydropower	$527 \times 10^6 m^3$ (Dry Season) $119 \times 10^6 m^3$ (Rainy Season)
Installed Capacity	115 MW
90% Dependable Power	94.4 MW
Annual Energy Output	583.4 GWh/year

TABLES

IX HYDROPOWER DEVELOPMENT PLAN

Table IX.2.1 EXISTING MAIN ELECTRIC POWER FACILITIES IN REGION III

As of 1993/1994

Facilities	Capacity	Length	Remarks
1. Power Generating Facilities			
1) PLTA Maninjau	68,000 kW		4 Units
2) PLTA Batang Agam	10,500 kW		3 Units
3) Mini hydro power stations	600 kW		
4) PLTG Pauh Limau	42,700 kW		
5) PLTD Simpang Haru	21,020 kW		10 Units
6) PLTD Padangluar	4,560 kW		4 Units
7) Other diesel power stations	116,720 kW		52 Units
Total	264,100 kW		
2. 150 kV Transmission Line			
1) PLTA Maninjau - S/S Lubukalung		56 km	
2) S/S Lubuk Alung - PLTG Pauhlimau		33 km	
3) PLTG Pauh Limau - S/S Indarung		5 km	
4) S/S Indarung - S/S Solok		34 km	
5) S/S Solok - S/S Salak		27 km	
6) PLTA Maninjau - S/S Padangluar		42 km	
7) S/S Padang Luar - S/S Payakumbuh		31 km	
Total		228 km	
3. 150/20 kV or 150/6.3 kV Substation			
1) S/S Lubukalung	1 x 10 MVA		150/20 kV
2) S/S Indarung	2 x 30 MVA		150/6.3 kV
3) S/S Solok	1 x 20 MVA		150/20 kV
4) S/S Salak	1 x 10 MVA		150/6.3 kV
5) S/S Padangluar	1 x 20 MVA		150/20 kV
6) S/S Payakumbuh	1 x 20 MVA		150/20 kV
Total	140 MVA		

Note PLTA - Hydro Electric Power Plant
PLTG - Gas Turbine Power Plant
PLTD - Diesel Power Plant
S/S - Substation

Table IX.2.2 HISTORICAL ENERGY PRODUCTION AND SALES IN REGION III

Item	Unit	1988/89	1989/90	1990/91	1991/92	1992/93	1993/94
1. Energy Production and Sales							
1) Sales	GWh	479	523	603	670	747	891
Growth rate	%	-	(9.2)	(15.3)	(11.1)	(11.5)	(19.3)
2) Losses of transmission and distribution	GWh	138	142	153	148	135	188
Loss ratio to energy production	%	(21.8)	(20.6)	(19.8)	(17.6)	(14.9)	(17.0)
3) Sent out energy production	GWh	605	655	757	816	882	1,079
4) Plant use for energy production	%	2.5	2.8	2.7	2.8	2.8	2.5
5) Energy production	GWh	632	682	778	842	908	1,107
6) Peak load	MW	133	143	165	166	170	206
7) Load factor	%	54.2	54.4	63.8	61.5	61.1	61.3
2. Type of Generation							
1) Mini hydroelectric power	MW	0.6	0.6	0.6	0.6	0.6	0.6
2) Hydroelectric power	MW	78.5	78.5	78.5	78.5	78.5	78.5
3) Gas turbine power	MW	42.7	42.7	42.7	42.7	42.7	42.7
4) Diesel power	MW	165.2	160.2	171.4	145.3	142.7	142.3
Total	MW	287.0	282.0	293.2	267.1	264.5	264.1

Source : PLN, INVESTEMENT PROGRAM 1993-2003, RUKEN Scenario June 17, 1993
Energy & Load Demand Forecast, PLN Region III - Padan (RUKN) Mei, 1991
Feasibility study on interconnection of Region, I, II, III and IV of Sumatra, Volume II

Table IX.2.3 HISTORICAL ENERGY CONSUMPTION BY CUSTOMER TYPE IN REGION III

Unit : GWh

Category/Area	1986/87	1987/88	1988/89	1989/90	1990/91	1991/92	1992/93	1993/94
1. Residencial Use								
1) Padang	51.7	57.0	64.4	68.0	73.1	86.7	98.5	107.3
2) Bukittinggi	30.2	35.3	39.5	39.9	45.4	53.1	59.7	62.9
3) Solok	6.4	7.8	9.6	10.5	12.5	14.1	15.8	17.6
4) Pekanbaru	52.2	62.6	51.2	54.7	62.2	75.3	87.6	102.8
5) Dumai	-	-	21.1	23.7	27.1	30.7	32.3	38.9
6) Tanjungpinang	12.1	15.6	17.6	18.8	22.4	30.3	38.2	46.0
Sub - Total	152.6	178.2	203.2	215.6	242.7	290.0	332.0	375.5
Growth rate (%)		16.8	14.0	6.1	12.6	19.5	14.5	13.1
Share to total (%)	43.1	42.4	42.4	41.2	42.5	43.2	44.4	42.1
2. Industrial Use								
1) Padang	120.1	137.2	152.1	167.5	191.4	185.8	194.0	282.1
2) Bukittinggi	1.0	.1.0	1.1	1.1	1.5	2.0	3.0	2.6
3) Solok	.2	.2	.5	.5	.5	.5	.5	.9
4) Pekanbaru	8.7	19.6	26.3	31.5	43.6	46.5	48.3	47.2
5) Dumai	-	-	3.2	3.5	5.1	6.3	11.8	14.1
6) Tanjungpinang	2.9	9.0	11.5	13.0	15.5	18.9	25.2	22.0
Sub - Total	132.9	167.1	194.7	217.0	257.4	260.0	282.7	368.9
Growth rate (%)		25.7	16.5	11.5	18.6	1.0	8.7	30.5
Share to total (%)	37.6	39.7	40.6	41.5	45.1	38.8	37.8	41.4
3. Others (including Commercial and Public Use)								
1) Padang	24.0	25.9	26.5	30.3	34.2	39.3	41.6	45.7
2) Bukittinggi	8.8	9.4	10.3	11.2	13.3	15.0	15.9	16.2
3) Solok	2.5	3.1	3.8	4.0	4.2	4.6	5.4	5.7
4) Pekanbaru	26.6	29.2	24.3	27.5	32.79	38.4	42.9	48.2
5) Dumai	-	-	7.9	8.6	9.6	11.3	13.1	14.6
6) Tanjungpinang	6.4	7.6	8.4	8.5	9.3	12.0	14.0	16.4
Sub - Total	68.3	75.1	81.3	90.2	70.6	120.6	132.7	146.7
Growth rate (%)		10.0	8.1	11.0	-21.7	70.8	10.1	10.5
Share to total (%)	19.3	17.9	17.0	17.2	12.4	18.0	17.8	16.5
Total	353.8	420.4	479.1	522.7	570.6	670.6	747.4	891.0

Source : PLN Region III, Padang Office
Feasibility study on interconnection of Region I, II, III and IV of Sumatra, Volume II

Table IX.2.4 HISTORICAL ENERGY CONSUMPTION BY AREA IN REGION III

Unit : GWh

Area	1987/88	1988/89	1989/90	1990/91	1991/92	1992/93	1993/94
1. Padang	220.1	242.9	265.7	298.57	311.73	334.00	435.06
Growth Rate (%)		(10.4)	(9.4)	(12.4)	(4.4)	(7.1)	(30.0)
Share to Total (%)	(52.4)	(50.7)	(50.8)	(49.5)	(46.5)	(44.7)	(48.8)
2. Bukittinggi	45.7	50.8	52.2	60.17	69.63	78.53	81.69
Growth Rate (%)		(11.2)	(2.8)	(15.3)	(15.7)	(12.8)	(4.0)
Share to Total (%)	(10.9)	(10.6)	(10.0)	(10.0)	(10.4)	(10.5)	(9.2)
3. Solok	11.1	13.8	15	17.12	19.20	21.63	24.21
Growth Rate (%)		(24.3)	(8.7)	(14.1)	(12.1)	(12.7)	(11.9)
Share to Total (%)	(2.6)	(2.9)	(2.9)	(2.8)	(2.9)	(2.9)	(2.7)
4. Pekanbaru	111.3	101.8	113.7	138.51	160.16	178.76	198.17
Growth Rate (%)		(-8.5)	(11.7)	(21.8)	(15.6)	(11.6)	(10.9)
Share to Total (%)	(26.5)	(21.3)	(21.8)	(23.0)	(23.9)	(23.9)	(22.2)
5. Dumai	-	32.2	35.8	41.80	48.26	57.19	67.57
Growth Rate (%)		-	(11.2)	(16.8)	(15.5)	(18.5)	(18.2)
Share to Total (%)	-	(6.7)	(6.8)	(6.9)	(7.2)	(7.7)	(7.6)
6. Tanjungpinang	32.2	37.5	40.3	47.21	61.16	77.31	84.31
Growth Rate (%)		(16.5)	(7.5)	(17.1)	(29.5)	(26.4)	(9.1)
Share to Total (%)	(7.7)	(7.8)	(7.7)	(7.8)	(9.1)	(10.3)	(9.5)
Total	420.4	479.0	522.7	603.4	670.1	747.4	891.0
Growth Rate (%)		(13.9)	(9.1)	(15.4)	(11.1)	(11.5)	(19.2)

Source : PLN Region III, Padang Office
Feasibility on Interconnection of Regions I, II, III and IV of Sumatra, Volume II

Table IX.3.1 PLN GENERATING CAPACITY EXPANSION PROGRAM IN REGION III

Project	Capacity (MW)	Completion Year
1. On-going Projects		
PLTG Padang # 2	35	1994/1995
PLTA Kotapanjang # 1 - 3	114	1997/1998
PLTA Singkarak # 1 - 4	175	1998/1999
Sub-total	324	
2. Committed Projects		
PLTU Ombilin # 1	100	1996/1997
PLTU Ombilin # 2	100	1997/1998
Sub-total	200	
3. Planned Projects		
PLTP Kerinci	2.4	1997/1998
PLTA Mini (1)	2.7	1995/1996
PLTD (1)	24.0	1995/1996
Sub-total	29.1	
Total	553.1	

Source : PLN, Investment Program 1993 - 2003, RUKN Scenario June 17, 1993

Note : PLTA - Hydro Electric Power Plant
PLTU - Steam Turbine Power Plant
PLTD - Diesel Power Plant
PLTP - Geothermal Power Plant
PLTG - Gas Turbine Power Plant

Table IX.3.2 TRANSMISSION/SUBSTATION FACILITIES IN PLN POWER SYSTEM INTERCONNECTION PROGRAM

Name of Transmission Line and Substation	Length (km)	Capacity (MVA)	Complention Year
1. On-going Projects			
(1) 150 KV Transmission Line			
Payakumbuh S/S - Kotapanjang S/Y	83		1996/1997
Kotapanjang S/Y - Bangkinang S/S	15		1996/1997
Bangkinang S/S - Pekanbaru S/S	55		1996/1997
Kotapanjang S/Y - Pekanbaru S/S	50		1996/1997
Singkarak S/Y - Lubukalung S/S	12		1997/1998
Singkarak S/Y - Padangpanjang S/S			1997/1998
Singkarak S/Y - Batusangkar S/S	27		1997/1998
Padangpanjang S/S-Batusankar S/S	27		1997/1998
Pauhkimau S/Y - Simpangharu	9		
(2) 150/20 KV Substation			
Payakumbuh S/S (extension)		1 x 20	1996/1997
Bangkinang S/S		1 x 10	1996/1997
Pekanbaru S/S		2 x 50	1996/1997
Lubukalung S/S (extension)		1 x 10	1997/1998
Padangpanjang S/S		1 x 20	1995/1996
Batusangkar S/S		1 x 20	1995/1996
Sub Total	278 km	180 MVA	
2. Committed Projects			
(1) 150 KV transmission Line			
Ombilin S/Y - Salak S/S	4		1995/1996
Ombilin S/Y - Indarung S/S	68		1995/1996
(2) 150/20 KV Substation			
Simpangharu S/S (extension)		2 x 30	1994/1995
Salak S/S (extension)		1 x 50	1995/1996
Sub Total	72 km	110 MVA	
Total	350 km	290 MVA	

Note : S/Y - Switchyard in Power Station
S/S - Substation

Table IX.3.3 PEAK LOAD AND INSTALLED CAPACITY OF WHOLE SUMATRA

Unit : MW

Year	Item	Region I	Region II	Region III	Region IV	Total
1993/94	Peak Load Capacity	79 60	546 639	206 314	357 364	1,188 1,377
1998/99	Peak Load Capacity	152 575	1,338 1,387	453 819	598 797	2,541 3,578
2003/04	Peak Load Capacity	247 895	3,168 2,365	738 805	929 1,357	5,082 5,422
2008/09	Peak Load Capacity	359 -	4,517 -	1,194 -	1,386 -	7,456 -

Source : Feasibility Study on Interconnection of the Regions I, II, III and IV of Sumatra, Volume I, Eroupe Power Systems
- Data are not available

Table IX.4.1 ENERGY AND POWER DEMAND FORECAST IN REGION III BY PLN

Item	1993/94	1998/99	2003/04	2008/09
1. Residential Use				
Population (million)	7,767.4	8,733.7	9,732.5	10,690.5
Growth Rate (%)	2.6	2.3	2.1	1.8
Electrification Ratio (%)	30.4	41.8	52.0	62.8
No. of Customers (1000)	472.7	730.1	1,028.9	1,344.3
Power Contracted by Customers(VA)	632.4	638.6	641.9	643.8
Power Contracted (MVA)	299.0	466.3	660.5	865.5
Growth of GDP Sector (%)	6.8	7.0	5.0	4.6
Consumption by Customers (KWh)	829.1	1,060.5	1,309.7	1,565.0
Energy Consumption (GWh)	391.9	774.3	1,347.6	2,103.8
Growth Rate (%)	18.1	14.4	10.4	7.7
Share to Total (%)	44.0	35.9	39.8	42.1
2. Commercial Use				
No. of Customers	27,828	42,085	58,319	75,106
Customer Elasticity	1.0	1.0	1.0	1.0
Elasticity	1.8	1.8	1.8	1.8
Growth of GDP Sector (%)	7.3	8.2	6.2	5.2
Power Contracted by Customers(VA)	2,104.1	2,068.9	2,049.7	2,038.5
Power Contracted (MVA)	58.6	87.1	119.5	153.3
Consumption by Customers (KWh)	2,942.2	4,400.0	6,569.0	9,648.6
Energy Consumption (GWh)	81.9	195.2	384.3	725.5
Growth Rate (%)	18.2	18.7	14.2	11.7
Share to Total (%)	9.2	8.6	11.4	14.5
3. Public and Others				
No of Customers	16,198	22,526	29,205	35,742
Customer Elasticity	0.8	0.8	0.8	0.8
Elasticity	1.1	1.1	1.1	1.1
Power Contracted by Customers(VA)	2,920.1	2,942.5	2,955.7	2,963.8
Power Contracted(MVA)	47.3	66.3	86.3	105.9
Consumption by Customers (KWh)	4,743.3	5,906.9	7,409.7	9,211.1
Energy Consumption (GWh)	76.8	133.1	216.4	329.2
Growth Rate (%)	21.2	11.9	9.2	7.6
Share of Total (%)	8.6	5.2	6.4	6.6
4. Industrial Use				
No. of Customers	1,155	1,699	2,288	2,937
Elasticity	1.1	1.1	1.1	1.1
Growth of GDP Sector (%)	8.7	6.1	5.3	4.2
Power Contracted by Customers(VA)	118,240.0	171,374.0	175,467.0	142,098.0
Power Contracted (MVA)	136.5	291.1	401.5	417.4
Energy of Total Demand (GWh)	1,667.8	2,453.3	3,305.5	4,242.7
Captive Power (GWh)	1,327.2	1,398.0	1,870.1	2,400.3
Share of PLN to Total (%)	20.4	43.0	43.4	43.4
Energy Consump. (GWh)	340.6	1,055.3	1,435.4	1,842.4
Annual Growth Rate (%)	20.5	14.0	5.8	4.6
Share to Total (%)	38.2	49.4	42.2	36.8
5. Total				
No. of Customers (1000)	517.9	796.4	1,118.7	1,456.1
Power Contracted (MVA)	541.4	910.8	1,267.8	1,542.1
Energy Consumption (GWh)	891.2	2,157.9	3,383.7	5,000.8
Annual Growth Rate (%)	19.3	14.4	8.9	7.0
Transmission and Distribution Losses (%)	17.0	14.5	14.5	13.5
Energy Sent Out (GWh)	1,079.4	2,534.0	3,974.8	5,804.6
Plant Use (%)	2.5	2.5	2.5	2.5
Production (GWh)	1,107.1	2,599.8	4,076.7	5,953.4
Load Factor (%)	61.3	65.6	63.0	61.1
Peak Load (MW)	206.2	452.6	738.4	1,112.5

Source : Energy & Load Demand Forecast, PLN Region III-Padang (RUNK) May, 1993

Table IX.4.2 POWER DEMAND AND SUPPLY IN REGION III

Demand and Supply	Unit	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09
1. Demand																	
Sales	GWh	891	1,203	1,406	1,636	1,886	2,158	2,384	2,632	2,867	3,112	3,384	3,692	4,040	4,351	4,672	5,001
(Growth rate)	(%)	(19.3)	(35.0)	(16.8)	(16.4)	(15.3)	(14.4)	(10.5)	(10.4)	(9.0)	(8.5)	(8.7)	(9.1)	(9.4)	(7.7)	(7.4)	(7.0)
Losses of T & D	GWh	188	245	276	309	343	377	417	460	501	544	591	635	683	723	764	804
Loss to production	(%)	(17.0)	(16.5)	(16.0)	(15.5)	(15.0)	(14.5)	(14.5)	(14.5)	(14.5)	(14.5)	(14.5)	(14.3)	(14.1)	(13.9)	(13.7)	(13.5)
Sent Out Energy	GWh	1,079	1,448	1,681	1,945	2,229	2,535	2,801	3,091	3,368	3,656	3,975	4,327	4,723	507	5,436	5,805
Plant Use	%	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Energy Production	GWh	1,107	1,485	1,725	1,995	2,286	2,600	2,873	3,171	3,455	3,750	4,077	4,438	4,844	5,204	5,575	5,953
Peak Load	MW	206.2	262.4	303.1	348.7	397.7	452.6	505.2	563.2	617.8	674.7	738.4	810.0	891.7	963.1	1,036.9	1,112.5
Load Factor	%	61.3	64.6	65.0	65.3	65.6	65.6	61.9	64.3	63.8	63.4	63.0	62.5	62.0	61.7	61.4	61.1
2. Supply																	
(1) Existing																	
PLTA Mini	MW	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
PLTA	MW	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5
PLTG	MW	42.7	42.7	42.7	42.7	42.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PLTD	MW	142.3	142.1	142.1	131.8	119.9	111.6	111.6	110.6	102.8	97.9	81.6	81.6	81.6	81.6	81.6	81.6
Sub-total	MW	264.1	263.9	263.9	253.6	241.7	190.7	190.7	189.7	181.9	177.0	160.7	160.7	160.7	160.7	160.7	160.7
(2) On-going Projects																	
PLTG Padang #1-2	MW	35.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
Kotapanjang #1-3	MW	-	-	-	-	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0
Singkarak #1-4	MW	-	-	-	-	-	175.0	175.0	175.0	175.0	175.0	175.0	175.0	175.0	175.0	175.0	175.0
PLTD Pekanbaru	MW	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2
Sub - total	MW	50.2	85.2	85.2	85.2	199.2	374.2	374.2	374.2	374.2	374.2	374.2	374.2	374.2	374.2	374.2	374.2
(3) Commited Project																	
PLTU Ombilin #1-2	MW	-	-	-	100.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0
(4) Planned Project																	
PLTP Kerinci	MW	-	-	-	-	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
PLTA Mini	MW	-	-	2.7	2.7	7.7	7.7	7.7	7.7	8.7	9.5	23.7	23.7	23.7	23.7	23.7	23.7
PLTD	MW	-	-	24.0	24.0	34.5	44.0	44.0	44.0	44.0	44.0	44.0	44.0	44.0	44.0	44.0	44.0
Sub - total	MW	0.0	0.0	26.7	26.7	44.6	54.1	54.1	54.0	55.1	55.9	70.1	70.1	70.1	70.1	70.0	70.0
Total	MW	314.3	349.1	375.8	465.5	685.5	819.0	819.0	818.0	811.2	807.1	805.0	805.0	805.0	805.0	805.0	805.0

Source : PLN, Investment Program 1993-2003, RuKN Scenario, June 17, 1993

Note : PLTA - Hydroelectric Power Plant
PLTU - Steam Turbine Power Plant
PLTD - Diesel Power Plant
PLTP - Geothermal Power Plant
PLTG - Gas Turbine Power Plant
T & D - Transmission and Distribution

Table IX.6.1 KW-VALUE AND KWH-VALUE

Adjustment Factors		Hydro	Coal-fired
Auxiliary Power Use	(%)	0.3	7.0
Transmission Loss	(%)	5.0	2.0
Forced Outage	(%)	0.5	8.0
Overall & Inspection	(%)	2.0	12.0
		7.8	29.0
kW-value Adjustment Factor	=	1.2517	
kWh-value Adjustment Factor	=	1.0392	

kW-Value and kWh-Value		50 MW Class	100 MW Class
kW-value			
Discount rate	(%)	10	10
Construction cost	(US$/kW)	2,315.0	1,880.4
Service life	(year)	25	25
Capital Recovery Factor	(CRF)	0.1102	0.1102
O & M cost	(%)	2.5	2.5
Adjustment Factor (A.F.)		1.2517	1.2517
kW-value	(US$/kW)	391.66	318.14
kWh-value			
Fuel Cost	(US$/kWh)	0.0167	0.0167
Price of Coal	(US$/ton)	35.0	35.0
Heat Value	(kcal/kg)	5,300	5,300
Thermal Efficiency	(%)	34.0	34.0
Heat rate	(kcal/kWh)	2,529.4	2,529.4
O & M cost	(%)	2.5	2.5
Adjustment Factor		1.0392	1.0392
kWh-value	(US$/kW)	0.0178	0.0178

Table IX.6.2 POWER GENERATION BENEFIT AND COST OF KAMPAR KIRI NO.1 POWER STATION

Item	Unit	Case-A.1	Case-A.2	Case-A.3	Case-A.4	Case-A.5	Case-A.6	Case-A.7	Case-A.8	Case-A.9
1. NWL	EL. m	115.0	115.0	115.0	120.0	120.0	120.0	125.0	125.0	125.0
2. RWL	EL. m	112.0	110.6	108.8	117.3	115.9	114.0	122.3	121.3	119.2
3. LWL	EL. m	106.0	101.5	96.4	111.8	107.5	101.9	117.0	113.9	107.7
4. TWL	EL. m	37.5	38.0	38.0	37.5	38.0	38.0	37.0	37.5	38.0
5. Effective Storage	10^6 m^3	421.2	601.3	766.3	428.0	622.1	846.3	484.3	646.1	941.8
6. Firm Discharge	m^3/sec	55.0	65.0	70.0	55.0	65.0	70.0	55.0	65.0	70.0
7. Gross Head	m	74.5	72.6	70.8	79.8	77.9	76.0	85.3	83.8	81.2
8. Max. Turbine Discharge	m^3/sec	165.0	195.0	210.0	165.0	195.0	210.0	165.0	195.0	210.0
9. Installed Capacity	MW	98.6	113.6	119.3	105.8	122.1	128.2	112.7	130.9	137.3
10. 90 % Dependable Power	MW	95.3	102.3	99.8	101.5	111.4	107.2	110.2	121.2	115.8
11. Energy Output	GWh/year	355.6	349.9	340.9	378.4	373.3	363.2	401.7	398.5	388.8
12. Annual Power Benefit	10^9 Rp.	65.94	70.79	69.06	70.23	77.08	74.18	76.25	83.86	80.13
13. Annual Energy Benefit	10^9 Rp.	13.77	13.55	13.20	14.65	14.45	14.06	15.55	15.43	15.05
14. Total Annual Benefit (B)	10^9 Rp.	79.71	84.33	82.26	84.88	91.54	88.24	91.81	99.29	95.18
15. Total Construction Cost	10^9 Rp.	501.0	519.0	526.0	528.0	551.0	559.0	560.0	584.0	594.0
16. Annual Cost (C)	10^9 Rp.	53.04	54.94	55.68	55.89	58.33	59.18	59.28	61.82	62.88
17. Net Present Value (B-C)	10^9 Rp.	26.68	29.39	26.57	28.99	33.21	29.06	32.53	37.47	32.30
18. Benefit Cost Ratio (B/C)		1.50	1.54	1.48	1.52	1.57	1.49	1.55	1.61	1.51

Note : NWL - Normal Water Level
RWL - Reservoir Water Level
LWL - Low Water Level
TWL - Tail Water Level

Table IX.6.3 POWER GENERATION BENEFIT AND COST OF KAMPAR KIRI NO.2 POWER STATION

Item	Unit	Case-B.1	Case-B.2	Case-B.3	Case-B.4	Case-B.5	Case-B.6	Case-B.7	Case-B.8	Case-B.9
1. HWL	EL. m	125.0	125.0	125.0	135.0	135.0	135.0	147.0	147.0	147.0
2. RWL	EL. m	122.8	121.7	120.0	133.6	132.7	130.5	145.6	144.7	142.5
3. LWL	EL. m	117.3	113.6	105.4	128.0	123.0	116.3	140.6	134.9	129.2
4. TWL	EL. m	52.0	52.5	53.0	52.0	52.5	53.0	52.0	52.5	53.0
5. Effective Storage	10^6 m^3	383.7	541.2	845.1	437.6	706.3	1,025.1	508.8	893.2	1,259.6
6. Firm Discharge	m^3/sec	20.0	22.0	24.0	20.0	22.0	24.0	20.0	22.0	24.0
7. Gross Head	m	70.8	69.2	67.0	81.6	80.2	77.5	93.6	92.2	89.5
8. Max. Turbine Discharge	m^3/sec	60.0	66.0	72.0	60.0	66.0	72.0	60.0	66.0	72.0
9. Installed Capacity	MW	34.7	37.5	39.1	39.9	42.8	45.2	45.9	49.4	52.5
10. 90 % Dependable Power	MW	33.1	33.9	31.8	38.2	38.9	37.6	44.1	45.0	44.5
11. Energy Output	GWh/year	114.3	115.5	116.1	128.3	131.2	132.8	143.9	149.2	152.9
12. Annual Power Benefit	10^9 Rp.	28.20	28.88	27.09	32.54	33.14	32.03	37.57	38.33	37.91
13. Annual Energy Benefit	10^9 Rp.	4.43	4.47	4.50	4.97	5.08	5.14	5.57	5.78	5.92
14. Total Annual Benefit (B)	10^9 Rp.	32.62	33.35	31.58	37.51	38.22	37.17	43.14	44.11	43.83
15. Total Construction Cost	10^9 Rp.	245.0	248.0	250.0	285.5	288.0	291.0	342.0	346.0	352.0
16. Annual Cost (C)	10^9 Rp.	25.94	26.25	26.46	30.22	30.49	30.80	36.20	36.63	37.26
17. Net Present Value (B-C)	10^9 Rp.	6.69	7.10	5.12	7.29	7.73	6.37	6.94	7.48	6.57
18. Benefit Cost Ratio (B/C)		1.26	1.27	1.19	1.24	1.25	1.21	1.19	1.20	1.18

Note : NWL - Normal Water Level
RWL - Reservoir Water Level
LWL - Low Water Level
TWL - Tail Water Level

Table IX.6.4 POWER OUTPUT AND ENERGY OUTPUT OF KUANTAN POWER STATION

Case	SWL (EL.m)	NWL (EL.m)	RWL (EL.m)	LWL (EL.m)	Effective Storage (10^6m^3)	Base Turbine Discharge (m^3/sec)	Max Turbine Discharge (m^3/sec)	Installed Capacity (MW)	90% Dependable Power (MW)	Energy Output (GWh /year)
k.1	125.0	108.8	106.5	102.0	1,675	57.39	96.39	39.1	38.5	315.3
k.2	125.0	111.4	108.3	102.0	1,675	57.39	176.22	72.3	69.7	498.9
k.3	125.0	114.2	110.1	102.0	1,675	57.39	245.22	103.2	95.7	620.8
k.4	125.0	116.7	111.8	102.0	1,675	57.39	305.22	131.5	116.7	700.5
k.5	125.0	119.3	113.5	102.0	1,675	57.39	368.22	162.5	139.1	765.1
k.6	125.0	121.3	114.9	102.0	1,675	57.39	413.22	185.9	155.7	800.9
k.7	125.0	123.2	116.1	102.0	1,675	57.39	446.22	204.9	166.6	830.5
k.8	125.0	125.0	117.3	102.0	1,675	57.39	452.22	212.2	175.0	855.3
k.9	125.0	106.8	105.2	102.0	1,675	57.39	61.02	24.3	24.2	211.4
k.10	122.5	108.8	106.5	102.0	1,395	57.39	96.39	39.1	38.5	315.3
k.11	122.5	112.9	109.3	102.0	1,395	57.39	212.22	88.3	83.9	567.6
k.12	122.5	115.8	111.2	102.0	1,395	57.39	284.22	121.4	108.8	675.2
k.13	122.5	118.3	112.9	102.0	1,395	57.39	344.22	150.5	130.0	743.5
k.14	122.5	120.6	114.4	102.0	1,395	57.39	401.22	179.2	149.7	789.4
k.15	122.5	122.5	115.7	102.0	1,395	57.39	431.22	196.6	163.3	818.6
k.16	122.5	106.8	105.2	102.0	1,395	57.39	61.02	24.3	24.2	211.4
k.17	120.0	108.8	106.5	102.0	1,145	57.39	149.43	59.6	58.6	422.2
k.18	120.0	112.4	108.9	102.0	1,145	57.39	203.22	84.1	80.1	550.0
k.19	120.0	115.2	110.8	102.0	1,145	57.39	269.22	114.4	103.6	657.0
k.20	120.0	117.8	112.5	102.0	1,145	57.39	332.22	144.6	215.4	731.1
k.21	120.0	120.0	114.0	102.0	1,145	57.39	386.22	171.5	144.5	778.5
k.22	120.0	106.8	105.2	102.0	1,145	57.39	61.02	24.32	24.2	211.4
k.23	117.5	108.8	106.5	102.0	925	57.39	149.43	59.7	58.8	423.2
k.24	117.5	112.1	108.7	102.0	925	57.39	194.22	80.2	76.8	533.9
k.25	117.5	114.8	110.5	102.0	925	57.39	260.22	110.1	100.6	643.7
k.26	117.5	117.5	112.3	102.0	925	57.39	326.22	141.6	123.1	723.4
k.27	117.5	106.8	105.2	102.0	925	57.39	61.02	24.3	24.2	211.4
k.28	115.0	108.8	106.5	102.0	735	57.39	96.39	39.1	38.5	315.3
k.29	115.0	112.3	108.9	102.0	735	57.39	197.22	81.6	78.1	540.2
k.30	115.0	115.0	110.7	102.0	735	57.39	263.22	111.7	101.8	649.0
k.31	115.0	106.8	105.2	102.0	735	57.39	61.02	24.32	24.2	211.4

Note : SWL - Surcharge Water Level
NWL - Normal Water Level
RWL - Reservoir Water Level
LWL - Low Water Level

Table IX.6.5 MONTHLY ENERGY OUTPUT OF KUANTAN POWER STATION
(NWL : EL. 115.2 m for Jan. - Dec.)

Unit : GWh

Year\Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1981	54.3	57.8	60.5	81.9	85.1	41.0	41.6	41.0	40.0	68.1	54.1	49.7	675.1
1982	55.1	66.1	74.9	82.4	84.6	60.1	41.5	40.2	39.2	40.8	40.2	66.5	691.6
1983	84.9	70.3	57.3	55.2	66.7	40.4	40.9	38.9	38.9	41.3	40.1	40.7	615.6
1984	41.3	74.9	79.0	78.2	79.5	57.1	41.7	41.4	40.0	40.6	61.1	60.1	695.0
1985	57.9	72.6	62.9	52.7	58.3	40.2	38.5	35.0	36.2	41.2	60.1	41.9	597.5
1986	59.2	40.6	85.1	65.1	54.0	40.0	37.5	33.2	32.3	38.0	39.3	49.0	573.2
1987	52.8	38.1	74.4	82.2	76.5	40.5	40.3	37.1	36.0	39.9	55.6	42.2	615.6
1988	59.9	72.9	82.1	68.0	71.2	40.6	41.0	40.5	75.1	47.9	40.3	42.0	681.6
1989	71.3	62.5	71.2	56.4	47.5	40.1	38.2	34.0	35.7	41.5	75.4	73.1	647.0
1990	68.3	70.5	79.5	52.2	65.6	40.2	40.0	36.2	35.3	40.1	65.2	78.7	671.6
1991	80.7	61.7	65.8	71.4	60.3	44.1	41.0	38.3	36.3	35.5	51.7	85.1	671.8
1992	81.9	75.4	72.6	63.7	80.1	41.8	41.6	41.7	40.4	52.7	75.4	80.7	748.0
Average	64.0	63.6	72.1	67.4	69.1	43.9	40.3	38.1	40.5	44.0	54.9	59.1	657.0

Table IX.6.6 POWER GENERATION BENEFIT AND COST OF UPPER SINAMAR POWER STATION

Item	Unit	Case-b.1	Case-b.2	Case-b.3	Case-b.4	Case-b.5
1. NWL	EL. m	481.8	487.2	490.2	490.4	488.3
2. RWL	EL. m	476.4	480.0	482.0	482.0	480.7
3. LWL	EL. m	465.6	465.6	465.6	465.6	465.6
4. TWL	EL. m	362.0	362.0	362.0	362.0	362.0
5. Effective Storage	10^6 m^3	68.0	115.0	147.0	148.0	124.0
6. Gross Head	m	119.8	125.2	128.2	128.4	126.3
7. Base Turbine Discharge	m^3/sec	14.22	14.22	14.22	14.22	14.22
8. Max. Turbine Discharge	m^3/sec	14.22	31.56	40.56	33.90	29.07
9. Installed Capacity	MW	13.8	32.1	42.3	35.9	30.3
10. 90 % Dependable Power	MW	13.3	30.5	39.8	33.6	28.5
11. Energy Output	GWh/year	120.1	231.3	282.5	255.1	224.7
12. Annual Power Benefit	10^9 Rp.	9.20	21.10	27.54	23.25	19.72
13. Annual Energy Benefit	10^9 Rp.	4.65	8.96	10.94	9.88	8.70
14. Total Annual Benefit (B)	10^9 Rp.	13.85	30.06	38.48	33.13	28.42
15. Power Facilities	10^9 Rp.	76.0	95.0	106.0	99.0	93.0
16. Annual Cost(C)	10^9 Rp.	8.05	10.06	11.22	10.48	9.84
17. Net Present Value (B-C)	10^9 Rp.	5.81	20.00	27.26	22.65	18.58
18. Benefit Cost Ratio (B/C)		1.72	2.99	3.43	3.16	2.89

Note :
NWL - Normal Water Level
RWL - Reservoir Water Level
LWL - Low Water Level
TWL - Tail Water Level

Table IX.6.7 POWER GENERATION BENEFIT AND COST OF SUKAM POWER STATION

Item	Unit	Case-c.1	Case-c.2	Case-c.3	Case-c.4	Case-c.5	Case-c.6
1. NWL	EL. m	195.2	199.6	203.0	218.1	216.0	211.1
2. RWL	EL. m	194.5	197.5	199.7	209.8	208.4	205.1
3. LWL	EL. m	193.2	193.2	193.2	193.2	193.2	193.2
4. TWL	EL. m	161.0	161.0	161.0	161.0	161.0	161.0
5. Effective Storage	10^6 m^3	9.0	29.0	58.0	232.0	203.0	136.0
6. Gross Head	m	34.2	38.6	42.0	57.1	55.0	50.1
7. Max. Turbine Discharge	m^3/sec	9.7	15.0	21.0	33.0	34.6	28.3
8. Installed Capacity	MW	2.7	4.7	7.2	15.4	15.6	11.6
9. 90 % Dependable Power	MW	2.6	4.4	6.6	11.5	11.6	9.5
10. Energy Output	GWh/year	16.8	24.7	31.6	46.6	44.2	40.5
11. Annual Power Benefit	10^9 Rp.	2.2	3.7	5.6	9.8	9.9	8.1
12. Annual Energy Benefit	10^9 Rp.	0.65	0.96	1.22	1.80	1.71	1.57
13. Total Annual Benefit (B)	10^9 Rp.	2.87	4.70	6.85	11.60	11.59	9.66
14. Power Facilities	10^9 Rp.	54.0	59.0	64.0	72.5	73.0	69.5
15. Annual Cost (C)	10^9 Rp.	5.72	6.25	6.77	7.67	7.73	7.36
16. Net Present Value (B-C)	10^9 Rp.	-2.85	-1.54	0.07	3.93	3.87	2.30
17. Benefit Cost Ratio (B/C)		0.50	0.75	1.01	1.51	1.50	1.31

Note :

Without Base Operation

NWL - Normal Water Level

RWL - Reservoir Water Level

LWL - Low Water Level

TWL - Tail Water Level

Table IX.7.1 MONTHLY ENERGY OUTPUT OF KUANTAN POWER STATION

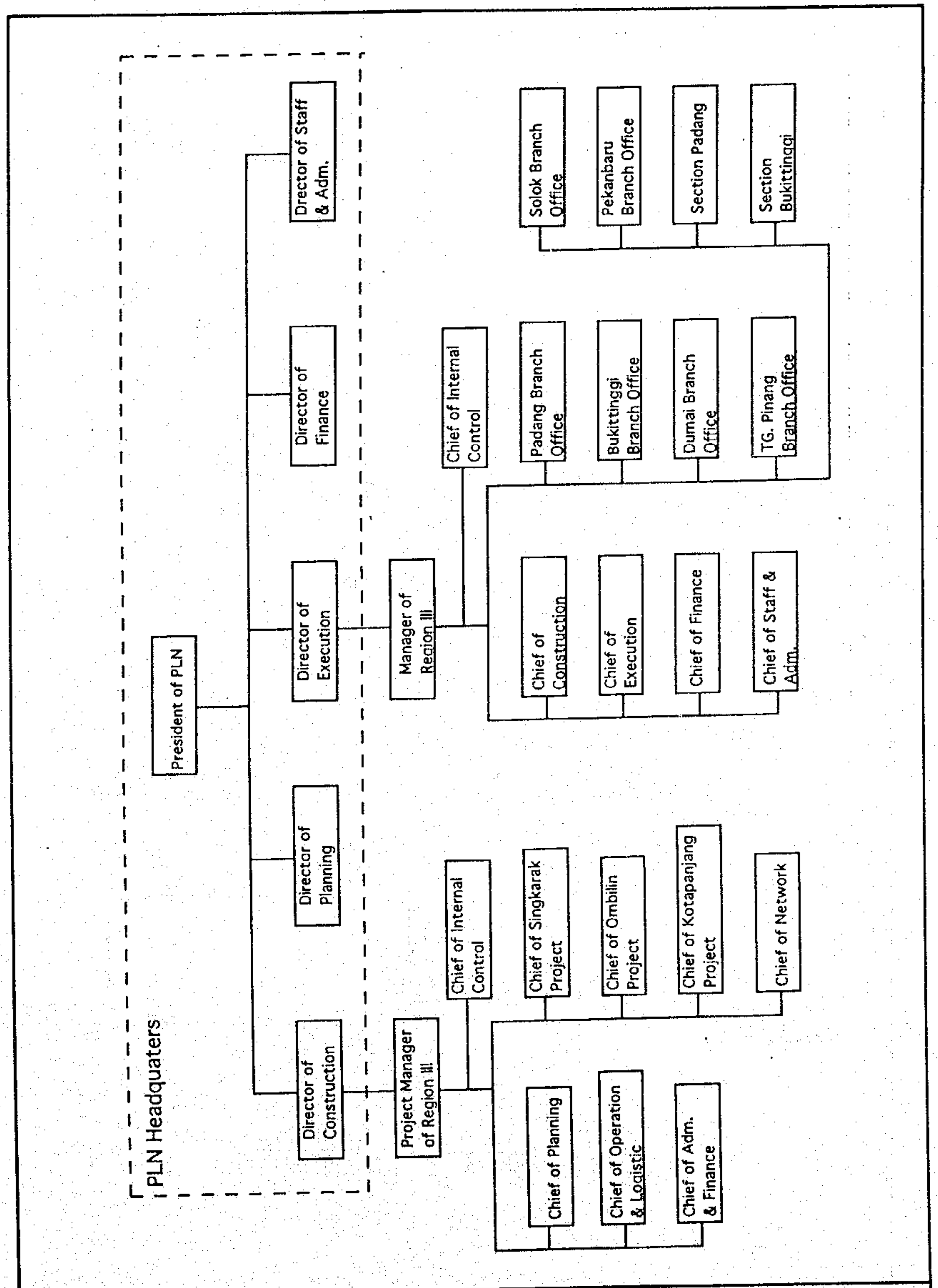
(NWL : EL. 115.2 m for Apr. - Sept., EL. 109.5 m for Oct. - Mar.)

Unit : GWh

Year\Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1981	45.9	48.5	52.4	47.0	85.1	41.0	41.6	41.0	40.0	75.4	46.6	42.0	606.5
1982	47.3	55.9	63.7	60.9	84.6	60.1	41.5	40.2	39.2	50.6	55.1	64.6	663.7
1983	74.5	60.7	49.3	36.7	41.6	40.0	39.4	36.6	37.2	59.1	34.2	30.2	539.3
1984	52.6	66.1	67.9	39.9	77.4	57.1	41.7	41.4	40.0	40.8	62.4	51.9	639.2
1985	49.3	63.6	53.8	37.0	39.6	36.6	19.6	18.1	34.6	48.4	59.0	35.2	494.9
1986	50.9	34.1	75.8	38.1	41.2	37.1	25.1	14.6	32.3	49.0	41.5	59.4	499.1
1987	44.7	32.6	64.9	39.3	76.5	40.5	40.3	37.1	36.0	60.7	51.5	36.1	560.3
1988	50.7	64.0	72.8	38.0	57.4	40.6	41.0	40.5	75.1	40.8	31.2	36.1	588.2
1989	62.4	54.5	60.7	38.3	39.8	35.1	12.2	18.1	35.5	64.9	68.7	64.1	554.2
1990	58.8	62.7	67.9	37.1	40.7	37.3	34.3	14.2	33.6	63.0	63.5	69.3	582.4
1991	71.5	52.0	55.9	50.4	60.3	44.1	41.0	38.3	36.3	35.9	53.2	74.0	612.8
1992	71.6	66.0	62.5	39.4	73.2	41.8	41.6	41.7	40.4	44.5	66.5	71.3	660.3
Average	56.7	55.0	62.3	41.8	59.8	42.6	34.9	31.8	40.0	52.8	52.8	52.8	583.4

FIGURES

IX HYDROPOWER DEVELOPMENT PLAN



THE STUDY ON
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IN THE REPUBLIC OF INDONESIA

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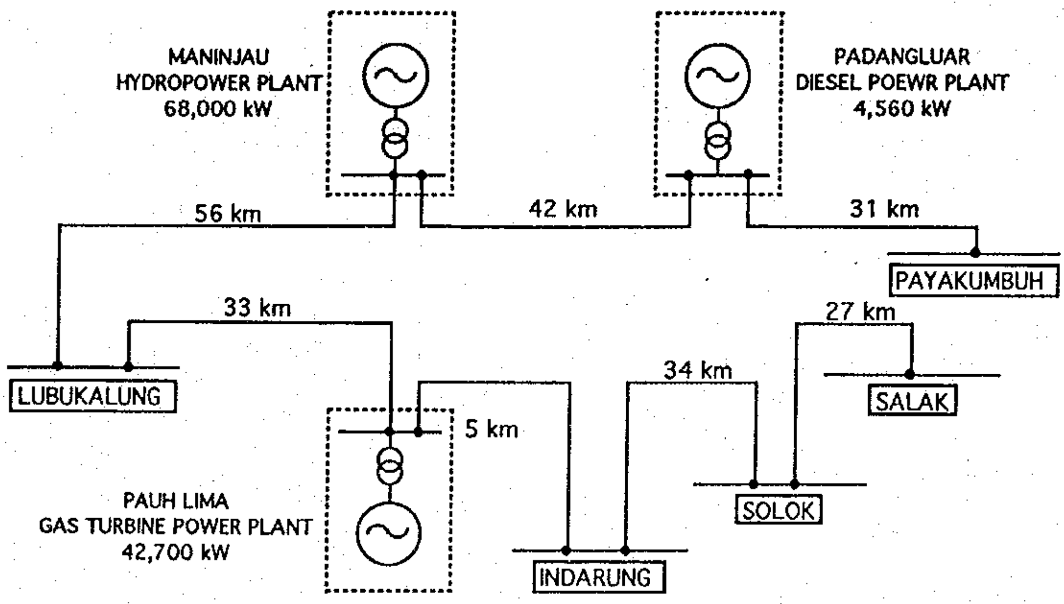
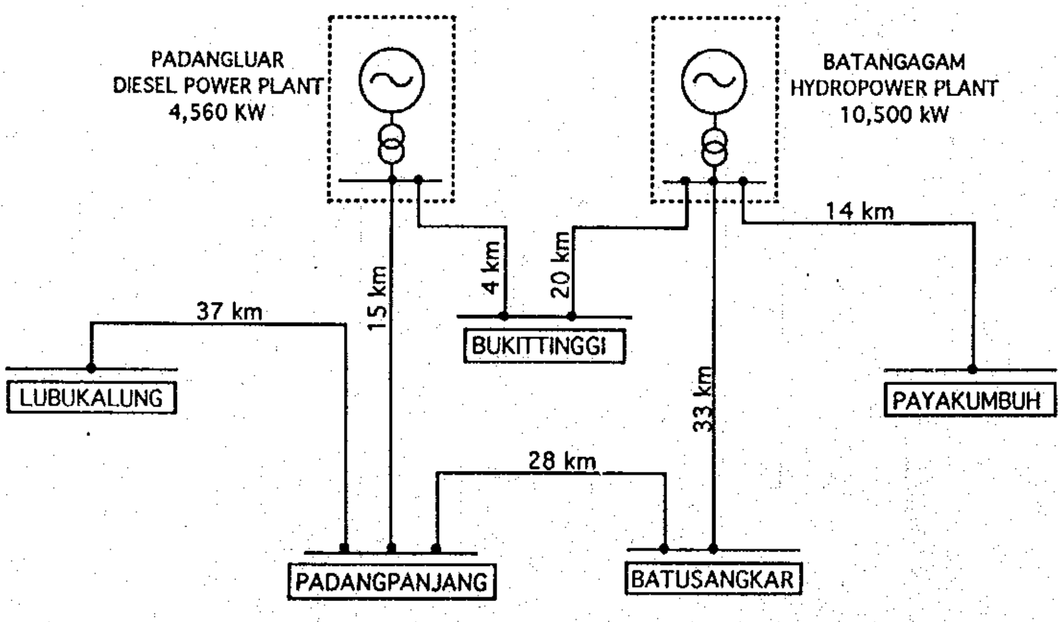
Fig. IX.2.1 ORGANIZATION CHART OF PLN REGION III



MANINJAU 150 KV LINE



BATAN AGAM 20 KV LINE

THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. IX.2.2 TRANSMISSION SYSTEM IN PLN REGION III
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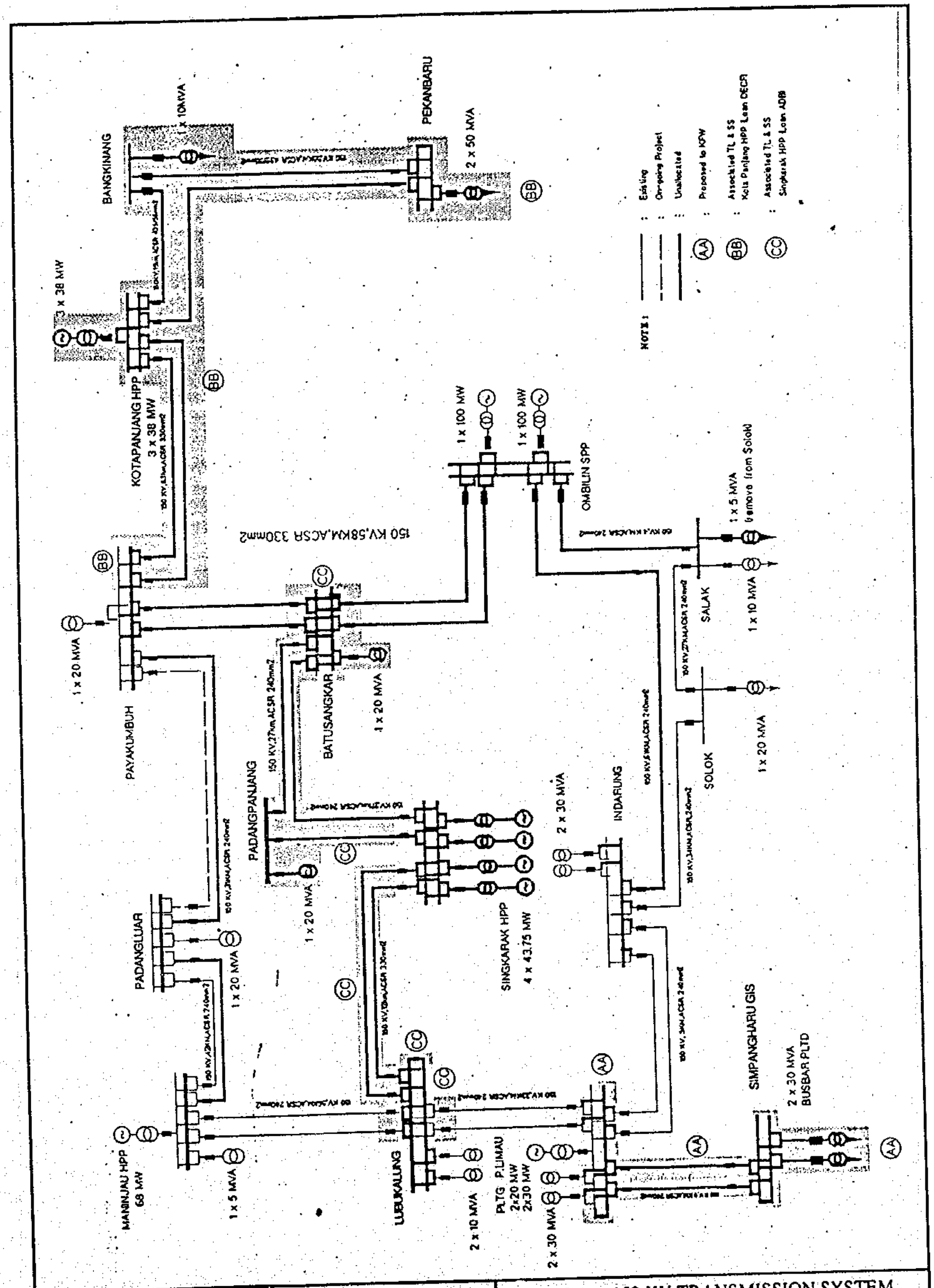

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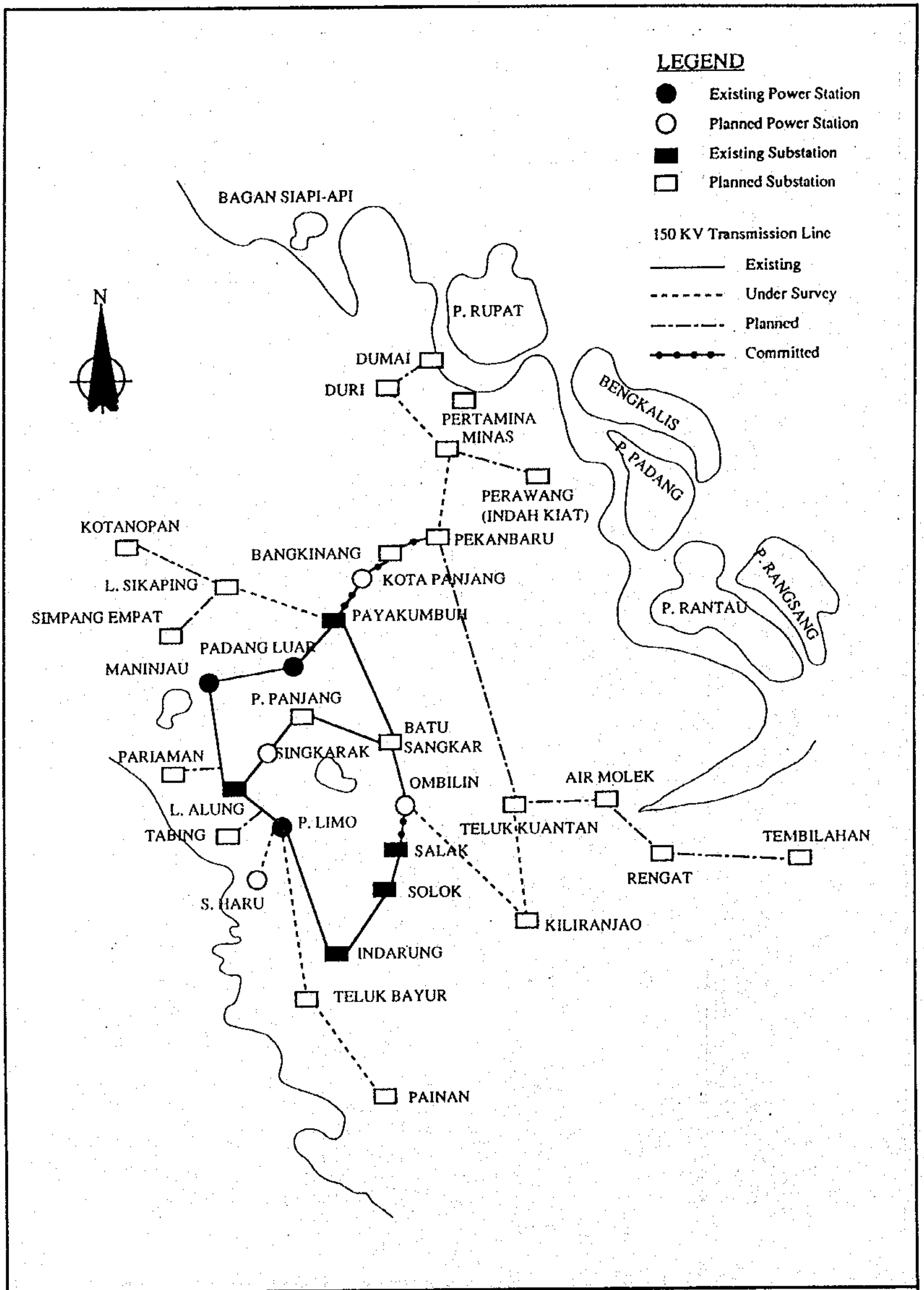

THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. IX.3.2 POWER SYSTEM INTERCONNECTION PROGRAM IN PLN REGION III
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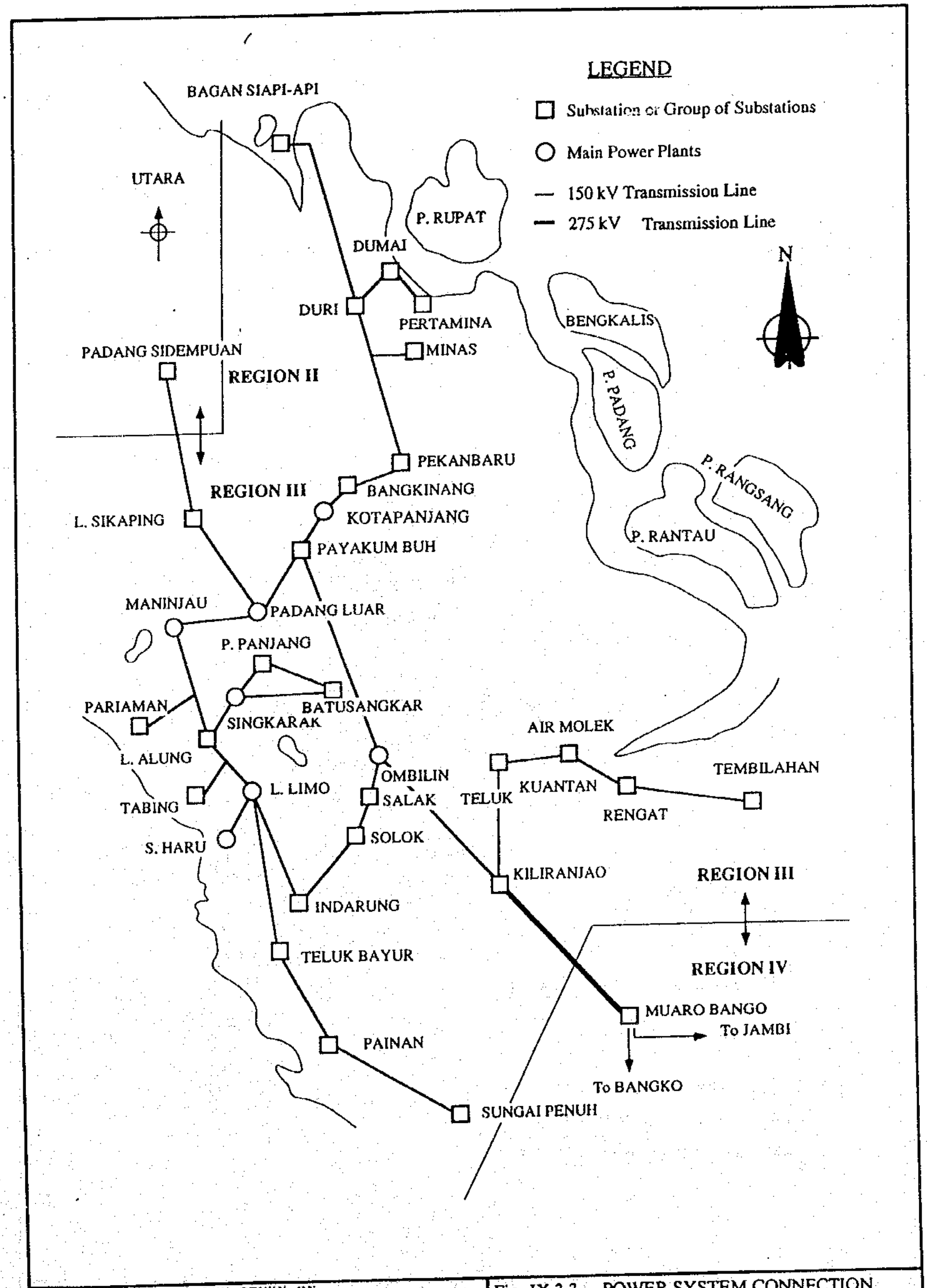

THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. IX.3.3 POWER SYSTEM CONNECTION PLAN BETWEEN PLN REGION III AND OTHER REGIONS
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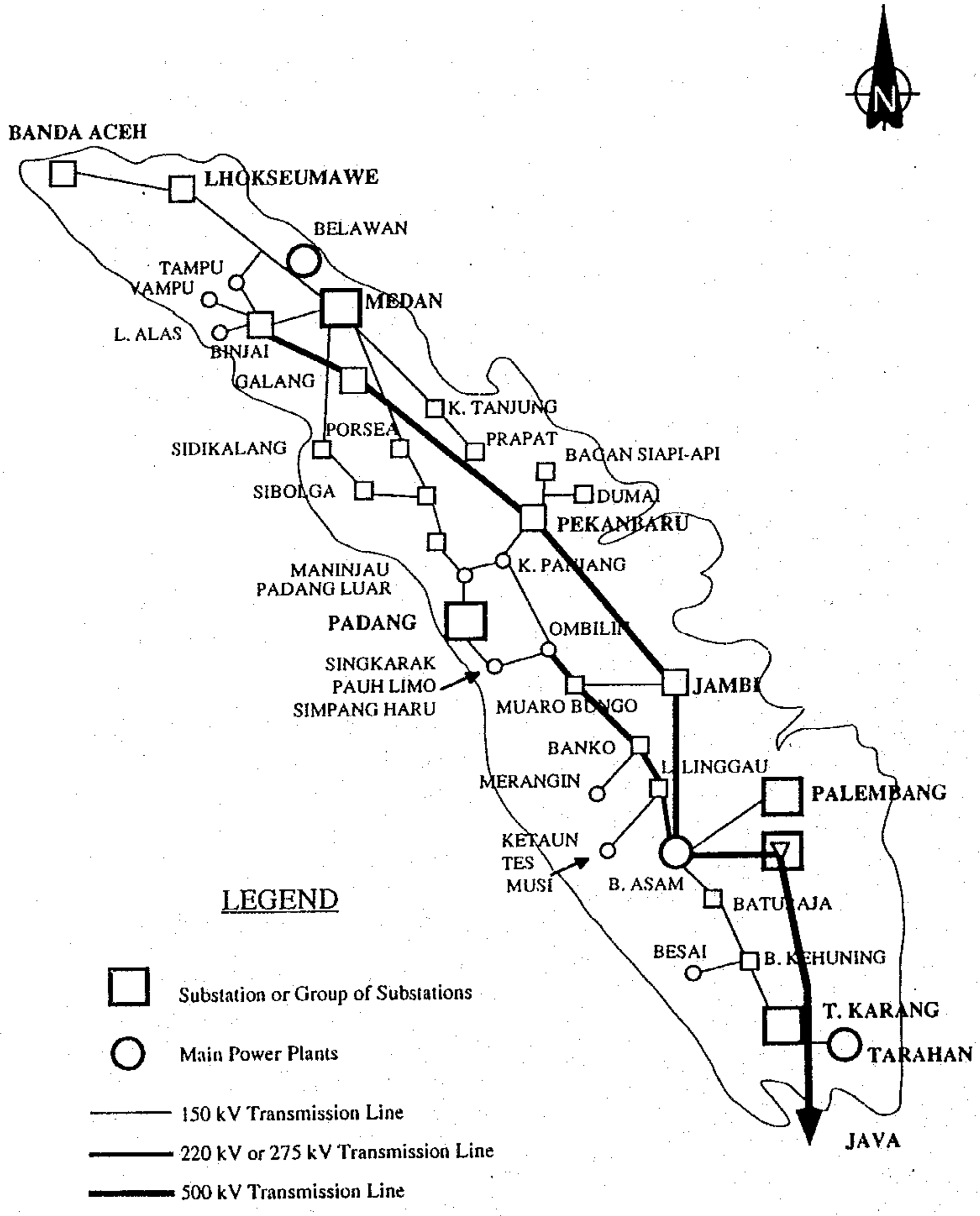

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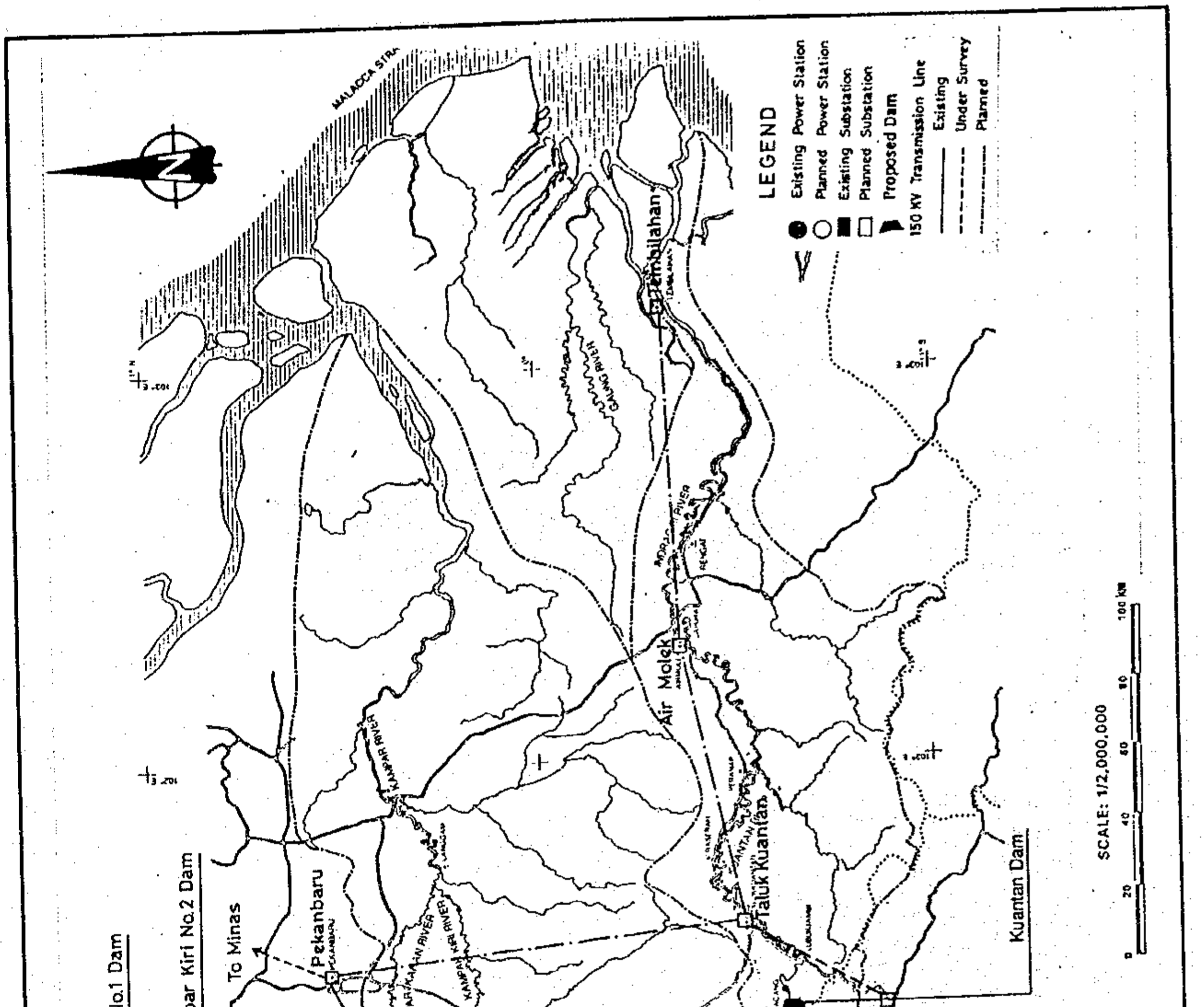
JAPAN INTERNATIONAL COOPERATION AGENCY		



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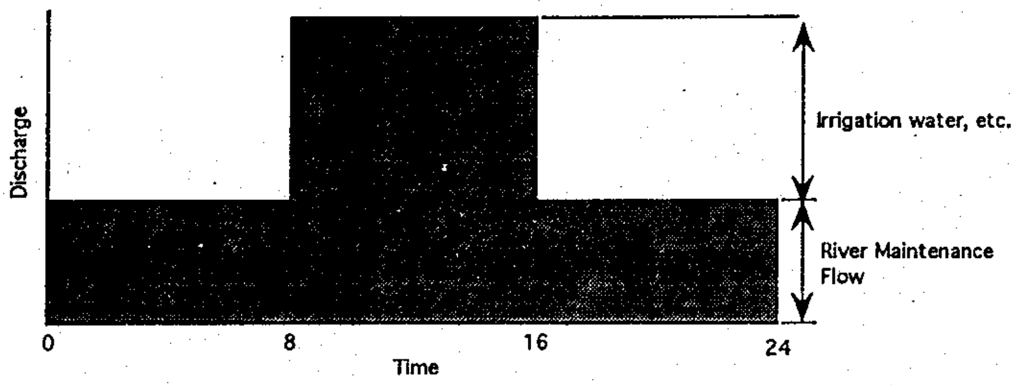
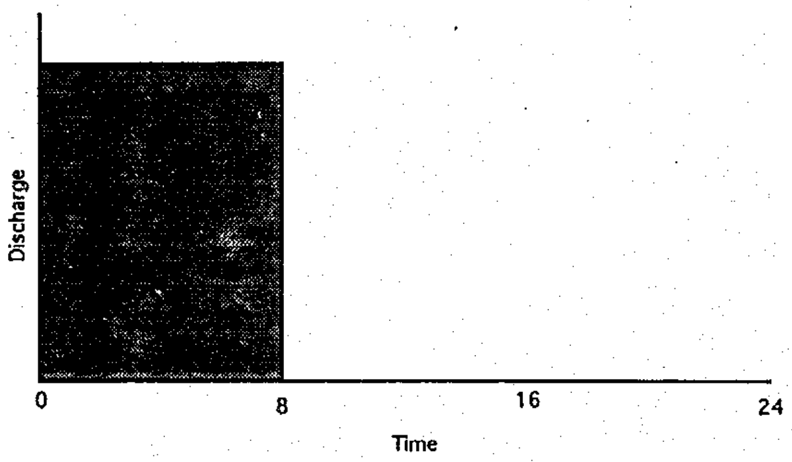


Upper Sinamar and Kuantan Power Stations



Kampar Kiri No1, Kampar Kiri No.2 and Sukam Power Stations

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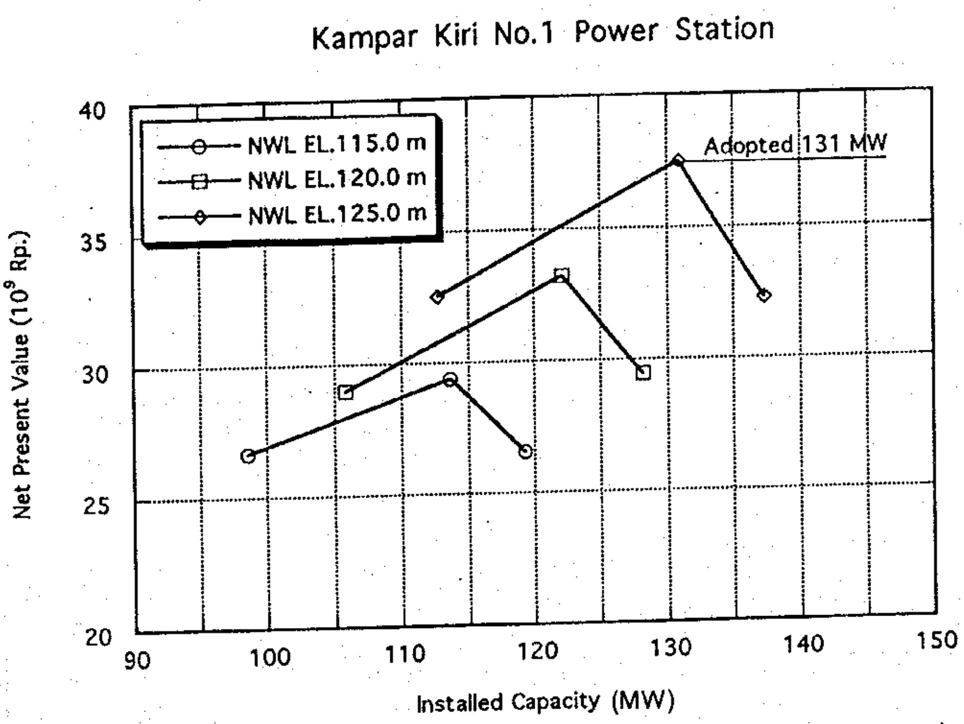

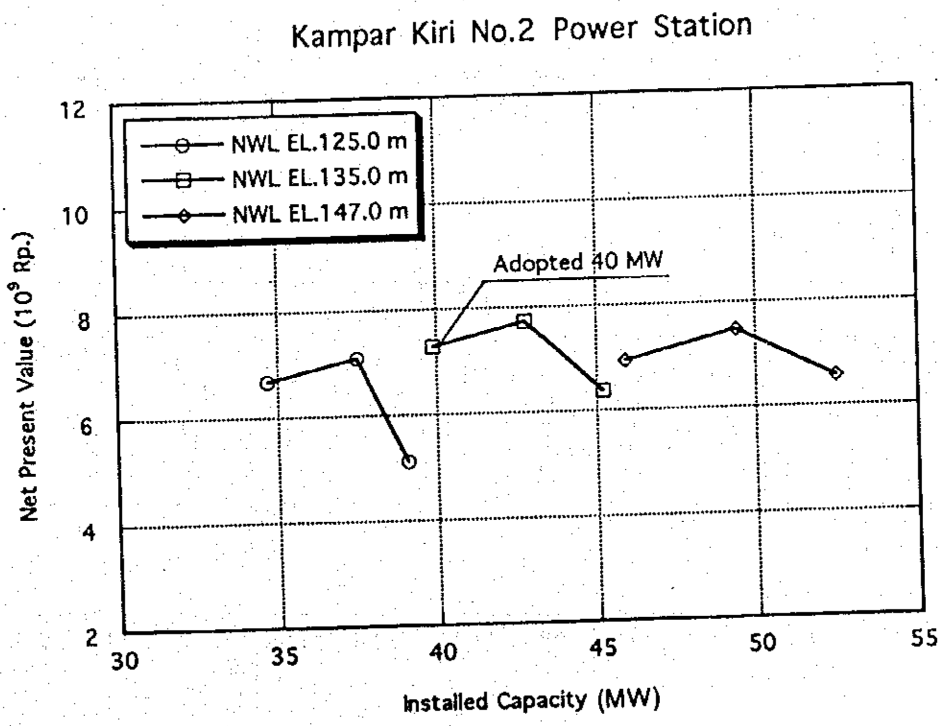

THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. IX.6.2 COMPARATIVE STUDY RESULTS OF KAMPAR KIRI NO. 1 AND NO. 2 POWER STATIONS
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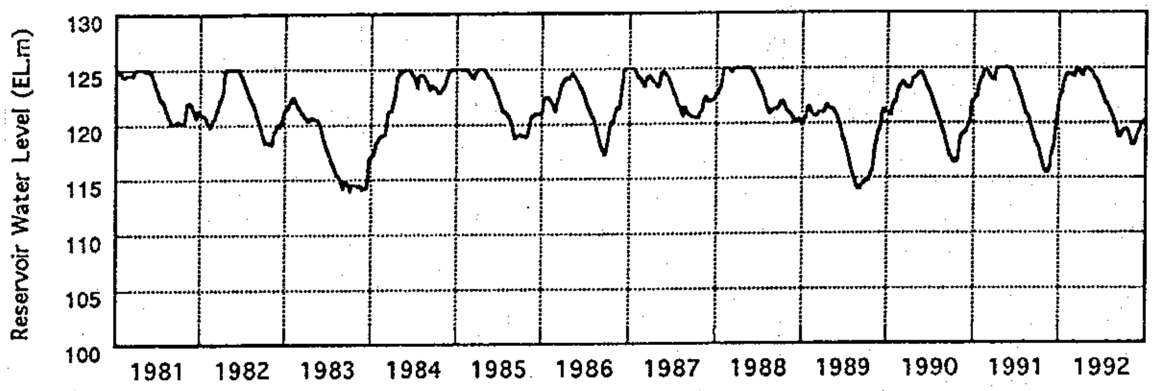
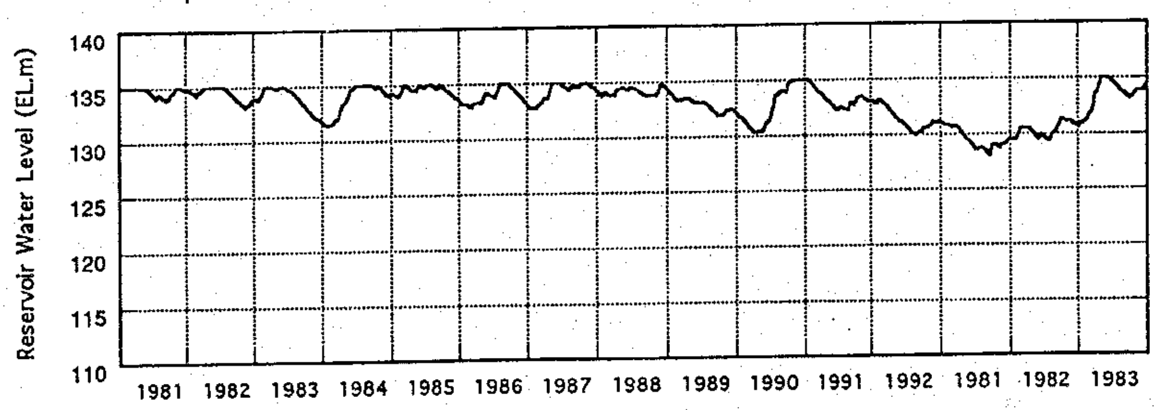
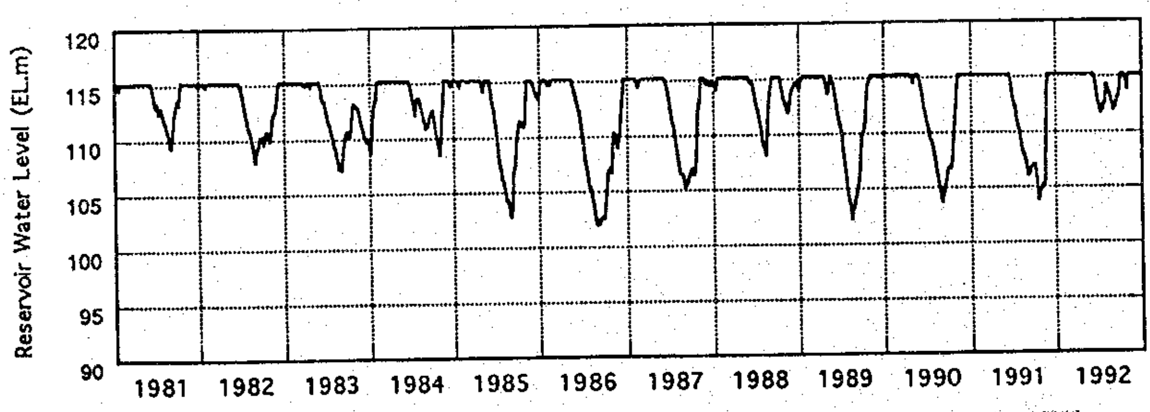
Kampar Kiri No.1 Dam (Case A.8)



Kampar Kiri No.2 Dam (Case B.4)

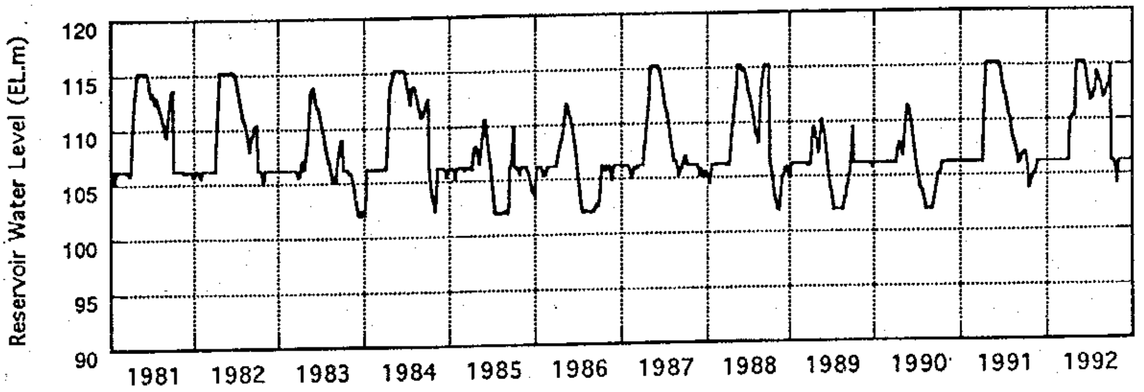


Kuantan Dam (Case K.19)



THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. IX.6.3 RESULTS OF SIMULATION OF RESERVOIR OPERATION
JAPAN INTERNATIONAL COOPERATION AGENCY	

Kuantan Dam (Low NWL in Rainy Season)



THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. IX.7.1 RESULT OF SIMULATION OF RESERVOIR OPERATION OF KUANTAN DAM
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X SEDIMENT CONTROL PLAN

SECTOR X
SEDIMENT CONTROL PLAN

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CHAPTER 1 PRESENT CONDITION

1.1 Sediment Yield

The major sources of sediment in the Kampar-Indragiri river basin are:

- sheet erosion in devastated lands; and,
- bank erosion in river channels.

Of the sheet erosion, erosion in the Lampasi and Balubus rivers of the Indragiri river basin has been identified as significant through the field reconnaissance and DPU had constructed a check dam on the Balubus River (for details, refer to SUPPORTING REPORT VI, FLOOD CONTROL PLAN). No other large sheet erosion areas have been reported.

Bank erosions are usually found along rivers especially at concave sides of meandering points. Bank erosions cause loss of land and sometimes houses.

1.2 Land Cover

A land cover analysis has been conducted by PUS-DATA during the survey period. The analysis was carried out based on the information from LANDSAT. Land in the basin was divided into 11 categories. Areas by land cover were obtained by sub-basin of the Kampar and Indragiri rivers. Four sub-basins respectively for the Kampar and Indragiri river basins and the delta in between the two were considered.

Fig. X.1.1 shows the sub-basin for the land cover analysis. Table X.1.1 tabulates areas and ratio by land cover. These are summarized in the following table.

Land Cover	Kampar River Basin		Indragiri River Basin		Delta in Between	
	ha	%	ha	%	ha	%
High Dense Vegetation	1,100,706	44.8	623,366	38.3	976,601	92.3
Low Dense Vegetation	567,439	23.1	249,318	15.3	55,437	5.2
Bush and Shrub	162,264	6.6	130,350	8.0	8,324	0.8
Mixed Garden	302,406	12.3	253,894	15.6	1,172	0.1
Estate	149,816	6.1	150,288	9.2	113	0.0
Settlement	7	0.0	660	0.0	0	0.0
Paddy Field	37,507	1.5	70,307	4.3	4,895	0.5
Upland Cultivation	23,899	1.0	40,662	2.5	6,797	0.6
Bare Land	89,637	3.7	84,947	5.2	2,784	0.3
Transmigration	3,055	0.1	3,742	0.2	0	0.0
Water	18,066	0.7	19,266	1.2	1,877	0.2
Totals *	2,454,800	100.0	1,626,800	100.0	1,058,000	100.0

* Some totals may not add up to indicated amount due to rounding.

1.3 Riverbed Material

The Study Team had conducted riverbed material survey at 20 locations in the study area. As indicated in Fig. X.1.2, there are 6 sampling sites in the Kampar river basin and 14 sites in the Indragiri river basin.

The survey consisted of sieving at the sampling site and sieving, hydrometer test (when necessary) and specific gravity test in the laboratory. The results of the tests are summarized in Table X.1.2, and gradation curves are shown in Fig. X.1.3. The present condition of riverbed material is discussed by river system as below.

1.3.1 Kampar River System

The riverbed materials in the upper and middle reaches; namely Location No. K-1 to No. K-5, are generally composed of 60 to 70% of sand (0.074 - 2 mm) and 40 to 30% of gravel (2 - 75 mm). Silty materials are found only at K-6 on the Kampar River at just the downstream point of the junction of Kampar Kanan and Kampar Kiri rivers. Almost all the materials are well-graded with uniformity coefficient (Uc) of more than 10 except K-5.

This tendency of gradation corresponds to the longitudinal gradient, as shown in the river profile in SUPPORTING REPORT VI, FLOOD CONTROL PLAN. The riverbed gradient of the Kampar Kanan and Kampar Kiri rivers become abruptly gentler after flowing out from mountainous areas to flood plains. Sand and gravel are deposited in the upper reaches of the flood plain and silty materials are transported further downstream. The sand and gravel could be transported by riverbed and bank erosions.

1.3.2 Indragiri River System

The gradation curves for the Indragiri River are clearly grouped into two, namely sandy material and silty material, as shown in Fig. X.1.3. The riverbed materials in the upper reaches, however, are not always sandy, because the upper reaches are in a relatively flat valley and silty materials are locally deposited. Accordingly, silty materials are found in relatively flat areas in the upper reaches and the middle and lower reaches, i.e., in the Kuantan-Indragiri River.

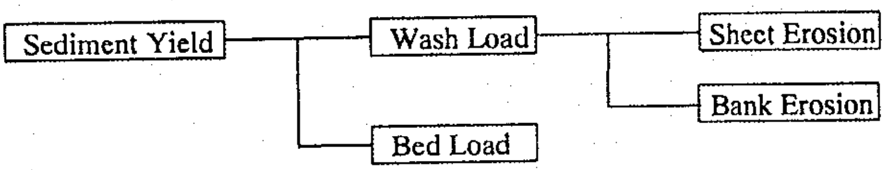
As mentioned before, the Lampasi River produces much sediment into the Indragiri River. The riverbed material of the Lampasi River is composed of sand and gravel, which are produced in the basin and deposited in the river channel causing reduction of flow capacity.

Material with much gravel is found also at Lubukkambacang (I-11), where the river flows out from mountain to flat terrain. The proposed Lower Kuantan Dam is located in the upstream reaches of this point.

CHAPTER 2 SEDIMENT YIELD ANALYSIS

2.1 Category of Sediment Yield

Sediment yield in basins can be classified into two; namely, wash load from drainage basins and bed load in river channels. Wash load is mainly produced by sheet erosion and bank erosion, and sheet erosion is a dominant source of sediment production in the study area. Sediment yield is accordingly estimated.



2.2 Sheet Erosion

The Universal Soil Loss Equation (USLE), which is used worldwide, has been adopted for the estimation of sheet erosion in the study area. The USLE formula and details of each factor are as below.

$$E = R \times K \times LS \times C \times P$$

where;

E : average annual soil loss (ton/ha)
R : rainfall factor
K : soil erodibility factor
LS : slope gradient-length factor
C : cropping management factor
P : supporting conservation practice factor

(1) Rainfall Factor (R)

Rainfall factor (R) is derived from the summation of individual storm products of kinetic energy of rainfall multiplied by the maximum 30-minute rainfall intensity, for all significant storms with a total depth of more than 13 mm. Rainfall factor and kinetic energy of rainfall are expressed as follows:

$$R = \sum EK \cdot I_{30}$$

$$EK = \left[916 + 331 \cdot \log\left(I/25.4\right)\right] \times 0.0296 \cdot r$$

where;

EK : kinetic energy (ton/ha)
I_{30} : maximum 30-min rainfall intensity (mm/hour)
I : average rainfall intensity (mm/hour)
r : rainfall amount (mm)

The rainfall factor *R* of 3,200 is employed for this project, referring to the value for other similar areas.

(2) Soil Erodibility Factor *(K)*

Soil erodibility factor has been determined referring to other similar projects, as shown in Table X.2.1, according to the land cover.

(3) Slope Gradient-Length Factor *(LS)*

The slope gradient-length factor has been derived from the following Taneda's Formula:

$$LS = L^{1/2}\left(0.067S + 0.952S^2\right)$$

where;

L : length of Slope (m)
S : land gradient measured as tangent

The length of slope of 1,000 m, the generally applied value, has been adopted in this study. The land gradient has been assumed from the topomap by land cover category, as shown in Table X.2.1.

(4) Cropping Management Factor *(C)*

Cropping management factor by land cover category has been determined referring to the value of similar projects, as shown in Table X.2.1.

(5) Management Practice Factor *(P)*

Management practice factor by land cover category has been determined referring to the value of similar projects, as shown in Table X.2.1.

(6) Sheet Erosion Amount

Sheet erosion by sub-basin has been calculated, as shown in Table X.2.1. The results are summarized below:

Unit: 1,000 ton/year

River Basin	Kampar	Indragiri
Sheet Erosion	32,471	27,056

2.3 Bank Erosion

Bank erosion which is caused mainly by collapse of river bank is generally much lesser compared to sediment yield due to sheet erosion. For this study, 2% of sheet erosion is considered as bank erosion.

2.4 Wash Load

Total wash load has been accordingly calculated by summing up sheet erosion and bank erosion, as shown in Table X.2.2. In this table, wash load in weight has been converted into capacity using the following formula:

$$Wc = Ww \times \frac{1}{Gs} \times \frac{1}{(1-P)}$$

where;

Wc	:	wash load in capacity (m^3)
Ww	:	wash load in weight (ton)
Gs	:	specific gravity of the particle (2.65)
P	:	porosity (75%)

2.5 Bed Load Transport

The bed load transport has been calculated by empirical formula. Kalinske-Brown's Formula has been employed for this study.

$$\frac{q_B}{u_* d} = 10 \cdot \left\{ \frac{u_*^2}{(\sigma / \rho - 1) \cdot g \cdot d} \right\}^2$$

where,

q_B	:	bed load ($m^3/s/m$)
u_*	:	shear velocity (m/s)
		$u_* = \sqrt{g \cdot h \cdot I}$
		h : water depth (m)
		I : river gradient
d	:	average grain size (m)
σ	:	density of sediment particle (2.65)
ρ	:	density of water (1.0)
g	:	gravity acceleration (9.8 m/s^2)

Table X.2.3 presents the process and results of bed load transport calculation by sub-basin. For the calculation, the following basic conditions have been applied for this study:

Average Discharge	Applied is the annual average discharge calculated for each sub-basin for the hydrological study discussed in SECTOR I, METEOROLOGY AND HYDROLOGY.
Average Grain Size	Applied are the results of riverbed material survey, as presented in Table X.1.2 and in Figs. X.1.2 and X.1.3.
River Width	Used are the river survey results and 1/50,000 scaled topographical maps.
Water Depth	Calculated by Manning's formula.
River Gradient	Used are the river survey results and 1/50,000 scaled topographical maps.

CHAPTER 3 SEDIMENT BALANCE ANALYSIS

Sediment balance has been studied for the Kampar and Indragiri river basins under the present condition and the with-project condition. Kotapanjang Dam, which is under construction by PLN, has been considered as the with-project condition. The sediment balance study was conducted using the amount of wash load and bed load calculated in CHAPTER 2, SEDIMENT YIELD ANALYSIS.

3.1 Study Procedure

(1) Wash Load

The volume of wash load transport has been determined considering the delivery rate to the sheet erosion yield. The delivery rate is the ratio of wash load to be delivered to the river to the yielded sheet erosion. Wash load not delivered to the river is deposited in the basin. The delivery rate of 20% is applied to the present study referring to other similar projects in Indonesia. Wash load in the sediment balance analysis is considered not to be deposited to the downstream river channel.

(2) Bed Load

Bed load balance has been calculated as the balance of inflow of sediment produced as bed load in the upstream reaches and bed load transportability. Surplus will be deposited in the objective river channel and deficit will be taken from the channel.

3.2 Sediment Balance

The results of sediment balance calculation are presented in Table X.3.1 and Fig. X.3.1.

3.2.1 Sediment Inflow to Proposed Dams

Sediment inflow to the proposed dams have been calculated, as shown in Table X.3.1 and summarized below.

River Basin	Location	Design Sediment Volume ($m^3/km^2/year$)
Kampar River Basin	Upper Reaches	500
Indragiri River Basin	Upper Reaches	585
	Middle Reaches	525

Kampar Kiri No. 1 and No. 2 dams in the Kampar river basin are proposed in the Overall Development Plan. Design sediment volume for these two dams are determined at 500 m^3/km^2/year, as obtained for the Kotapanjang Dam basin considering similarity of basin conditions.

Upper Sinamar Dam applies 585 m^3/km^2/year as the value for the upper reaches in the Indragiri River. Lower Kuantan Dam and Sukam Dam apply 525 m^3/km^2/year as the value for the middle reaches in the Indragiri River.

3.2.2 Balance under With-Project Condition

Sediment balance under the with-project condition is presented in Fig. X.3.1.

(1) Kampar River System

Before completion of Kotapanjang Dam, the riverbed of Kampar Kanan River in Bangkinang has the tendency to rise by approximately 6 mm/year (125,000 m^3/year for the stretch from Kuok to the Kampar Kiri confluence).

After construction of Kotapanjang Dam, wash load of 1,074,000 m^3/year and bed load of 192,000 m^3/year will be captured by the dam. The capture of wash load and bed load will cause decrease of sediment supply to the downstream area. Since wash load is considered to be transported further downstream, it will not affect the stretch just downstream. The decrease of bed load transport of 192,000 m^3/year will change the balance and the riverbed will lower by 2 mm/year (67,000 m^3/year for the stretch from Kuok to the Kampar Kiri confluence).

(2) Indragiri River System

The riverbed of the Indragiri River at the stretch from Lubuk Ambacang to Peranap has the tendency to degrade at approximately 10 cm/year (2,368,000 m^3/year) in the present condition. After completion of the proposed Kuantan Dam, degradation will be 13 cm/year due to the decrease of sediment supply from the upstream stretch.

CHAPTER 4 SEDIMENT CONTROL PLAN

4.1 Problems on Sedimentation

Problems on sedimentation in the basin is summarized below based on the present condition and the sediment yield and balance analyses discussed in the preceding chapters, in due consideration of the Overall Development Plan of Flood Control.

(1) Collapse of Sediment Balance by the Construction of Dam

Sediment balance will collapse if dams are constructed on rivers as discussed in CHAPTER 3, due to trapping of sediment by the dams. In the Kampar and Indragiri river basins, three dams are proposed in the Overall Development Plan; namely, the Kampar Kiri No. 1, Kampar Kiri No. 2 and Kuantan dams. In addition to these dams, the Kotapanjang Dam, which is under construction by PLN, will also create the same problem.

After construction of the dams, sediment supply will decrease in the downstream stretches. This will cause deficit of sediment and hence, erosion may occur.

Sand mining will accelerate sediment deficit. Although there is not enough data on sand mining, it is widely conducted in the middle reaches of the Kampar and Indragiri rivers. The sand mining volume is large at about several hundred thousand m^3/year, especially in the Bangkinang stretch of the Kampar Kanan River

(2) Collapse of River Morphology by Improvement Works

River improvement works will change the present alignment, longitudinal profile and cross section and may cause collapse of river morphology. Steepened longitudinal gradient may result in the erosion of riverbed and banks in the upper reaches, and aggradation of river channels in the lower reaches.

(3) Excess Sediment Inflow into Reservoirs

The design sediment volume for dam planning has been estimated on the basis of sediment production and transportation analysis. The amount of sediment inflow is, however, uncertain because of the limited information. Excess sediment inflow in dam projects has sometimes been reported.

4.2 Sediment Control Plan

The sediment control plan is as described below.

(1) Monitoring and Control of Sand Mining

As discussed in the preceding section, sand mining especially after construction of dams will cause degradation of river channels. Since the present sand mining volume is not clearly known, it should be monitored to collect basic data. Control program should be prepared based on the collected sand mining data and the river profile and cross-sectioning survey results discussed elsewhere in this report.

(2) Erosion Protection for River Channel

Flow velocity for the improved river channel has been checked and it is planned to be maintained at less than 2 m/s. However, turbulent flow often causes erosion in the riverbed and banks, especially at concave portions of meandering. Accordingly, revetments and groins are proposed bank protection in the river improvement plan.

Since sedimentation phenomenon is very complicated and difficult to be grasped in the planning stage, monitoring of riverbed gradient and cross sections after channel improvement works should be conducted. River profiling and cross-sectioning survey should be conducted to monitor the change in the improved channel. Necessary additional structural measures, e.g., check dam or groundsill to maintain river gradient may then be proposed.

(3) Forest Conservation for Reservoir Watershed

As discussed in CHAPTER 2, the dominant sediment inflow to the reservoirs consists of small particles produced by sheet erosion in the watersheds. The following non-structural measures are recommended for sediment control in the watershed area.

The forest area is effective in preventing sediment yield due to sheet erosion, as discussed in CHAPTER 2. From this point of view, the forest and plantation areas densely covered by trees shall be conserved continuously as forest reservation areas in the future. Devastated areas and bare lands should be reforested to deter sheet erosion in these areas.

It has been reported that the shifting cultivation is the major cause of the increase in barren lands in the basin. This should also be controlled by appropriate legislation.

(4) Sediment Control for Devastated Areas

The Lampasi river basin has been reported to produce much sediment in the basin. In the upper reaches of the Lampasi River, stepped gabion dams will be effective. The gabion dams have the advantage of low cost and flexibility to riverbed variation in comparison with concrete dams. Fig. X.4.1 illustrates the standard features of the proposed gabion dam.

TABLES

X SEDIMENT CONTROL PLAN

Table X.1.1 LAND COVER BY SUB-BASIN

Kampar River Basin

	Land Cover	K-1		K-2		K-3		K-4		Total	
		ha	%	ha	%	ha	%	ha	%	ha	%
1	High Dense Vegetation	81,620	32.2	47,503	17.6	282,515	40.1	689,068	56.2	1,100,707	44.8
2	Low Dense Vegetation	56,410	22.2	52,364	19.4	216,556	30.7	242,109	19.7	567,439	23.1
3	Bush and Shrub	48,270	19.0	31,843	11.8	52,872	7.5	29,279	2.4	162,264	6.6
4	Mixed Garden	43,596	17.2	68,074	25.3	88,037	12.5	102,699	8.4	302,405	12.3
5	Estate	11,865	4.7	31,206	11.6	19,492	2.8	87,253	7.1	149,815	6.1
6	Settlement	5	0.0	2	0.0	0	0.0	0	0.0	7	0.0
7	Paddy Field	3,668	1.4	13,109	4.9	5,262	0.7	15,468	1.3	37,507	1.5
8	Upland Cultivation	2,949	1.2	4,322	1.6	6,029	0.9	10,599	0.9	23,898	1.0
9	Bare Land	4,725	1.9	17,386	6.5	28,221	4.0	39,305	3.2	89,637	3.7
10	Transmigration	0	0.0	810	0.3	2,245	0.3	0	0.0	3,055	0.1
11	Water	593	0.2	2,782	1.0	4,070	0.6	10,621	0.9	18,066	0.7
	Total	253,700	100	269,400	100	705,300	100	1,226,400	100	2,454,800	100

Indragiri River Basin

	Land Cover	I-1		I-2		I-3		I-4		Total	
		ha	%	ha	%	ha	%	ha	%	ha	%
1	High Dense Vegetation	30,541	23.9	197,239	31.9	108,142	31.5	287,444	53.4	623,367	38.3
2	Low Dense Vegetation	19,088	14.9	108,799	17.6	54,558	15.9	66,873	12.4	249,319	15.3
3	Bush and Shrub	17,930	14.0	87,370	14.1	17,934	5.2	7,116	1.3	130,350	8.0
4	Mixed Garden	24,263	19.0	109,915	17.8	47,853	13.9	71,863	13.3	253,893	15.6
5	Estate	10,738	8.4	31,739	5.1	57,064	16.6	50,747	9.4	150,289	9.2
6	Settlement	307	0.2	16	0.0	0	0.0	337	0.1	659	0.0
7	Paddy Field	13,593	10.6	27,473	4.4	15,779	4.6	13,462	2.5	70,307	4.3
8	Upland Cultivation	7,772	6.1	21,577	3.5	4,909	1.4	6,404	1.2	40,662	2.5
9	Bare Land	3,487	2.7	16,000	2.6	36,538	10.6	28,922	5.4	84,947	5.2
10	Transmigration	0	0.0	0	0.0	0	0.0	3,742	0.7	3,742	0.2
11	Water	81	0.1	17,372	2.8	423	0.1	1,390	0.3	19,266	1.2
	Total	127,800	100	617,500	100	343,200	100	538,300	100	1,626,800	100

Delta in between Kampar and Indragiri

	Land Cover	Delta	
		ha	%
1	High Dense Vegetation	976,601	92.3
2	Low Dense Vegetation	55,437	5.2
3	Bush and Shrub	8,324	0.8
4	Mixed Garden	1,172	0.1
5	Estate	113	0.0
6	Settlement	0	0.0
7	Paddy Field	4,895	0.5
8	Upland Cultivation	6,797	0.6
9	Bare Land	2,784	0.3
10	Transmigration	0	0.0
11	Water	1,877	0.2
	Total	1,058,000	100

Source: Percentage of each land cover is from PUS-DATA, 1994, DPU

Table X.1.2 SUMMARY OF RIVERBED MATERIAL TESTS

No.	Site No.	River and Location	Unified Classification	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
Kampar River Basin							
1	RM-K-1	Kampar Kanan	GP	61.0	39.0	0.0	0.0
2	RM-K-2	Kampar Kanan	GP	74.0	26.0	0.0	0.0
3	RM-K-3	Sibayang (Damsite)	GP	71.0	29.0	0.0	0.0
4	RM-K-4	Singingi (Damsite)	GP	65.0	35.0	0.0	0.0
5	RM-K-5	Kampar Kiri	SP	0.0	99.5	0.5	0.0
6	RM-K-6	Kampar	F	0.0	20.0	66.0	14.0
Indragiri River Basin							
7	RM-I-1	Sinamar	GP	89.0	11.0	0.0	0.0
8	RM-I-2	Sinamar	F	0.0	28.0	58.0	14.0
9	RM-I-3	Balubus	SP	8.0	90.0	2.0	0.0
10	RM-I-4	Lampasi	SP	0.0	99.0	1.0	0.0
11	RM-I-5	Agam	GP	62.0	38.0	0.0	0.0
12	RM-I-6	Sinamar	F	0.0	14.0	72.5	13.5
13	RM-I-7	Sinamar	F	0.0	9.5	69.0	21.5
14	RM-I-8	Ombilin	F	0.0	22.0	64.0	14.0
15	RM-I-9	Sinamar	SP	7.0	92.0	1.0	0.0
16	RM-I-10	Sukam (Damsite)	F	0.0	24.0	63.0	13.0
17	RM-I-11	Kuantan	GP	80.5	19.5	0.0	0.0
18	RM-I-12	Kuantan	F	0.0	20.0	66.5	13.5
19	RM-I-13	Kuantan	F	0.0	9.0	72.0	19.0
20	RM-I-14	Indragiri	F	0.0	10.0	72.0	18.0

Note: Gravel: 2.0mm<
Sand: 0.074< <2.0mm
Silt: 0.005< <0.074mm
Clay: <0.005mm

GP: Poorly graded gravel
SP: Poorly graded sand
F: Fines

No.	Site No.	D_{10} (mm)	D_{60} (mm)	D_{50} (mm)	D_{30} (mm)	Uc	Uc'	Dm (mm)	Gp (tf/m^3)
Kampar River Basin									
1	RM-K-1	0.15	7.6	5.5	0.4	50.7	0.14	5.834	
2	RM-K-2	0.74	10.5	6.7	2.6	14.2	0.87	8.29	
3	RM-K-3	0.54	11	8.8	2.15	20.4	0.78	6.99	
4	RM-K-4	0.32	8	5.3	1.45	25.0	0.82	5.88	
5	RM-K-5	0.155	0.29	0.26	0.205	1.9	0.94	0.2	
6	RM-K-6	0.001	0.033	0.025	0.01	33.0	3.03	0.03	2.6514
Indragiri River Basin									
7	RM-I-1	1.9	7.2	5.9	3.65	3.8	0.97	6.21	
8	RM-I-2	0.001	0.041	0.029	0.013	41.0	4.12	0.05	2.6458
9	RM-I-3	0.13	0.35	0.315	0.245	2.7	1.32	0.75	
10	RM-I-4	0.135	0.285	0.25	0.285	2.1	2.11	0.21	
11	RM-I-5	0.3	7	4.1	1.1	23.3	0.58	6.82	
12	RM-I-6	0.001	0.024	0.018	0.009	24.0	3.38	0.04	2.6475
13	RM-I-7	0.001	0.011	0.008	0.004	11.0	1.46	0.02	2.6571
14	RM-I-8	0.001	0.04	0.033	0.014	40.0	4.90	0.04	2.6916
15	RM-I-9	0.16	0.44	0.385	0.285	2.8	1.15	0.68	
16	RM-I-10	0.001	0.041	0.034	0.013	41.0	4.12	0.05	2.6514
17	RM-I-11	1.25	8.8	6	3	7.0	0.82	7.74	
18	RM-I-12	0.001	0.037	0.032	0.013	37.0	4.57	0.03	2.6628
19	RM-I-13	0.001	0.014	0.01	0.004	14.0	1.14	0.017	2.6458
20	RM-I-14	0.001	0.018	0.013	0.006	18.0	2.00	0.019	2.6277

Note: $Uc=D_{60}/D_{10}$: Uniformity Coefficient
$Uc'=D_{30}^2/(D_{10}xD_{60})$: Radius Coefficient

Dm: Mean Diameter
Gp: Specific Gravity of Particles

Table X.2.1 SHEET EROSION BY SUB-BASIN

Average Annual Soil Loss by Land Cover (ton/ha)

	Land Cover	Rainfall Factor	Soil Erodibility Factor	Slope Gradient-Length Factor			Cropping Management Factor	Supporting Conservation Practice Factor	Average Annual Soil Loss (ton/ha)
		R	K	L	S	LS	C	P	A
1	High Dense Vegetation	3,200	0.200	1,000	0.25	2.41	0.001	1.00	2
2	Low Dense Vegetation	3,200	0.200	1,000	0.25	2.41	0.005	1.00	8
3	Bush and Shrub	3,200	0.200	1,000	0.15	1.00	0.020	1.00	13
4	Mixed Garden	3,200	0.200	1,000	0.10	0.51	0.200	0.40	26
5	Estate	3,200	0.200	1,000	0.03	0.09	0.200	0.75	9
6	Settlement	3,200	0.200	1,000	0.01	0.02	0.500	1.00	8
7	Paddy Field	3,200	0.200	1,000	0.02	0.05	0.010	0.25	0
8	Upland Cultivation	3,200	0.200	1,000	0.03	0.09	0.500	0.40	12
9	Bare Land	3,200	0.200	1,000	0.10	0.51	0.500	1.00	164
10	Transmigration	3,200	0.200	1,000	0.05	0.18	0.500	0.50	29
11	Water	3,200	0.200	1,000	0.00	0.00	0.000	0.00	0

Kampar River Basin

	Land Cover	K-1		K-2		K-3		K-4		Total	
		1000 t/year	%	1000 t/year	%	1000 t/year	%	1000 t/year	%	1000 t/year	%
1	High Dense Vegetation	126	3.9	73	1.2	436	4.3	1,063	8	1,699	5.2
2	Low Dense Vegetation	435	13.5	404	6.9	1,671	16.7	1,868	14.0	4,378	13.5
3	Bush and Shrub	615	19.0	406	6.9	673	6.7	373	2.8	2,067	6.4
4	Mixed Garden	1,145	35.4	1,788	30.5	2,312	23.1	2,697	20.2	7,942	24.5
5	Estate	103	3.2	272	4.6	170	1.7	759	5.7	1,304	4.0
6	Settlement	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
7	Paddy Field	0	0.0	1	0.0	0	0.0	1	0.0	3	0.0
8	Upland Cultivation	34	1.1	50	0.9	70	0.7	123	0.9	277	0.9
9	Bare Land	776	24.0	2,854	48.6	4,632	46.2	6,451	48.4	14,713	45.3
10	Transmigration	0	0.0	23	0.4	65	0.6	0	0.0	89	0.3
11	Water	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	Total	3,234	100	5,871	100	10,030	100	13,336	100	32,471	100
	Total in 1000 m^3/year	4,882		8,861		15,139		20,131		49,013	

Note: Values may not add up to totals due to rounding

Indragiri River Basin

	Land Cover	I-1		I-2		I-3		I-4		Total	
		1000 t/year	%	1000 t/year	%	1000 t/year	%	1000 t/year	%	1000 t/year	%
1	High Dense Vegetation	47	2.6	304	3.7	167	1.9	444	5.3	962	3.6
2	Low Dense Vegetation	147	8.1	839	10.1	421	4.9	516	6.2	1,924	7.1
3	Bush and Shrub	228	12.6	1,113	13.4	228	2.6	91	1.1	1,660	6.1
4	Mixed Garden	637	35.0	2,887	34.8	1,257	14.6	1,887	22.7	6,668	24.6
5	Estate	93	5.1	276	3.3	497	5.8	442	5.3	1,308	4.8
6	Settlement	2	0.1	0	0.0	0	0.0	3	0.0	5	0.0
7	Paddy Field	1	0.1	2	0.0	1	0.0	1	0.0	6	0.0
8	Upland Cultivation	90	5.0	250	3.0	57	0.7	74	0.9	472	1.7
9	Bare Land	572	31.5	2,626	31.6	5,997	69.5	4,747	57.1	13,943	51.5
10	Transmigration	0	0.0	0	0.0	0	0.0	108	1.3	108	0.4
11	Water	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	Total	1,819	100	8,299	100	8,625	100	8,313	100	27,056	100
	Total in 1000 m^3/year	2,746		12,526		13,019		12,548		40,839	

Note: Values may not add up to totals due to rounding

Table X.2.2 WASH LOAD BY SUB-BASIN

Kampar River Basin

	Land Cover	K-1	K-2	K-3	K-4	Total
		1000 m³/year	1000 m³/year	1000 m³/year	1000 m³/year	1000 m³/year
1	High Dense Vegetation	194	113	671	1,637	2,615
2	Low Dense Vegetation	670	622	2,573	2,876	6,741
3	Bush and Shrub	947	625	1,037	574	3,182
4	Mixed Garden	1,763	2,752	3,560	4,152	12,227
5	Estate	159	418	261	1,169	2,007
6	Settlement	0	0	0	0	0
7	Paddy Field	0	2	1	2	5
8	Upland Cultivation	53	77	108	189	427
9	Bare Land	1,194	4,394	7,132	9,933	22,652
10	Transmigration	0	36	100	0	136
11	Water	0	0	0	0	0
	Total	4,980	9,039	15,442	20,533	49,993

Note: Values may not add up to totals due to rounding

Indragiri River Basin

	Land Cover	I-1	I-2	I-3	I-4	Total
		1000 m³/year	1000 m³/year	1000 m³/year	1000 m³/year	1000 m³/year
1	High Dense Vegetation	73	469	257	683	1,481
2	Low Dense Vegetation	227	1,292	648	794	2,962
3	Bush and Shrub	352	1,714	352	140	2,556
4	Mixed Garden	981	4,444	1,935	2,906	10,266
5	Estate	144	425	765	680	2,014
6	Settlement	4	0	0	4	8
7	Paddy Field	2	4	2	2	9
8	Upland Cultivation	139	385	88	114	726
9	Bare Land	881	4,043	9,233	7,309	21,467
10	Transmigration	0	0	0	167	167
11	Water	0	0	0	0	0
	Total	2,801	12,777	13,279	12,799	41,656

Note: Values may not add up to totals due to rounding

Table X.2.3 CALCULATION OF BED LOAD TRANSPORT

Sub-Basin for Sediment Analysis	Sub-Basin for Hydrological Analysis	Average Discharge Q m^3/s	Average Grain Size d mm	Water Depth h m	River Width b m	River Gradient 1/I	I
K-1	K-2to3	104.8	6	1.27	70	1,100	0.00091
K-2	K-1to4	258.6	6	1.96	150	3,500	0.00029
K-3	K-5to13	352.1	0.2	2.57	130	3,500	0.00029
K-4	K-1to16	877.8	0.03	2.21	700	10,000	0.00010
I-1	I-1	31.5	6	0.56	55	500	0.00200
I-2	I-1to4	82.7	0.4	0.89	150	2,500	0.00040
I-3	I-1to14	330.7	0.1	2.12	200	5,000	0.00020
I-4	I-1to17	490.4	0.02	2.18	400	10,000	0.00010

Sub-Basin for Sediment Analysis	u_* (a) m/s	sgd (b) m^2/s^2	u_*^2/sgd	$(u_*^2/sgd)^2$	u_*d	q_B (c) m^2/s	$Q_B=bq_B$ m^3/s	$Q_B=bq_B$ $1000m^3/yr$
K-1	0.1064	9.70E-02	0.117	1.36E-02	6.38E-04	8.68E-05	0.006	192
K-2	0.0740	9.70E-02	0.056	3.19E-03	4.44E-04	1.42E-05	0.002	67
K-3	0.0848	3.23E-03	2.221	4.93E+00	1.70E-05	8.36E-04	0.109	3,428
K-4	0.0466	4.85E-04	4.473	2.00E+01	1.40E-06	2.80E-04	0.196	6,174
I-1	0.1051	9.70E-02	0.114	1.29E-02	6.30E-04	8.16E-05	0.004	142
I-2	0.0591	6.47E-03	0.541	2.92E-01	2.37E-05	6.92E-05	0.010	327
I-3	0.0645	1.62E-03	2.574	6.62E+00	6.45E-06	4.27E-04	0.085	2,695
I-4	0.0463	3.23E-04	6.620	4.38E+01	9.25E-07	4.06E-04	0.162	5,116

(a) $u_*=(g\times h\times I)^{1/2}$ (g:gravity acceleration, h:water depth, I:river gradient)

(b) $s=(\sigma/\rho-1)=2.65/1-1=1.65$ (Specific weight of sediment particle in water)

(c) $q_B=10\times u_*d\times(u_*^2/sgd)^2\times u_*d$

Table X.3.1 SEDIMENT BALANCE

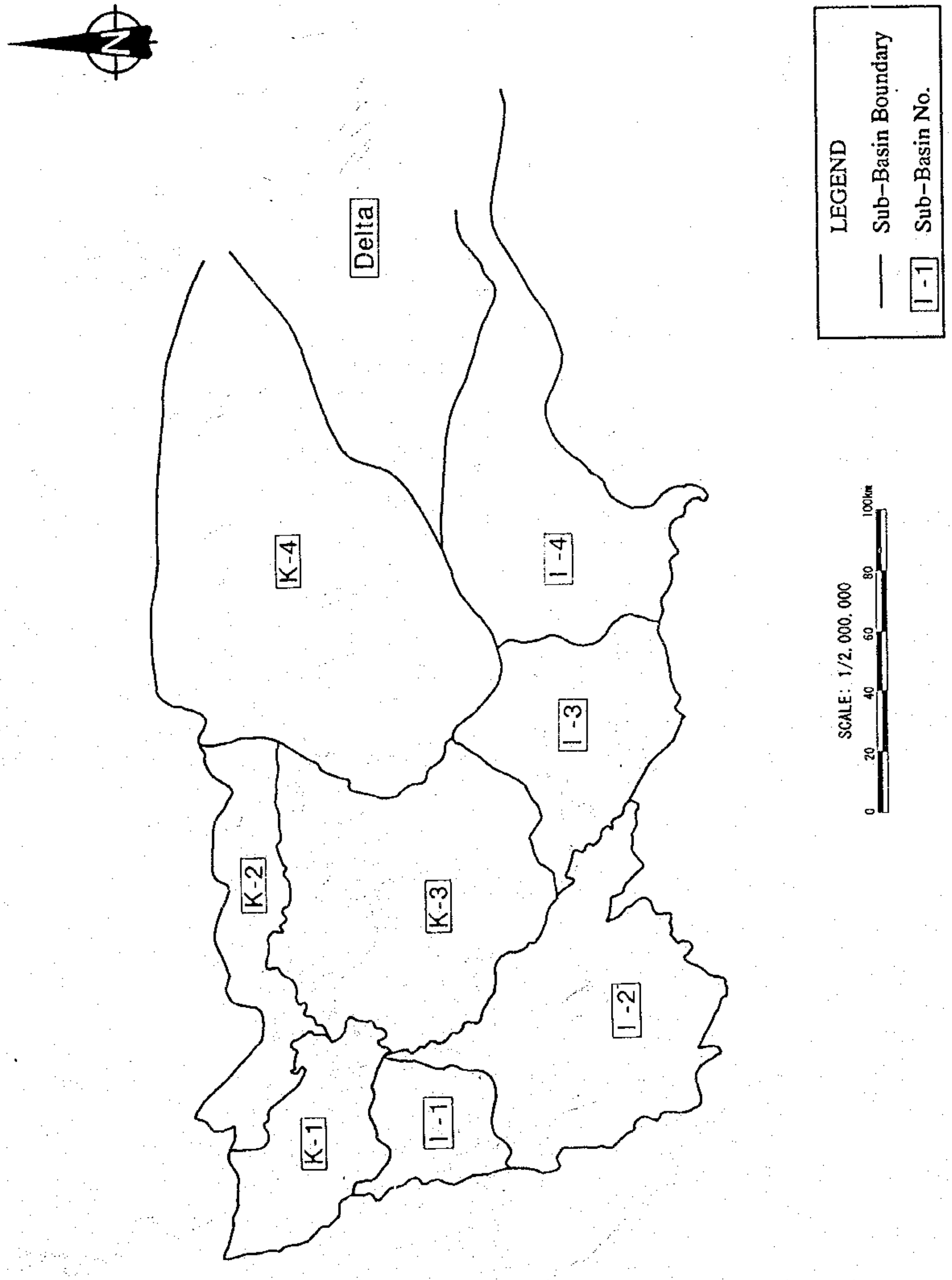
Sub-Basin for Sediment Analysis	Catchment Area	Wash Load					Bed Load			Total Sediment Discharge	
		Inflow	Yield: Sheet Erosion	Yield: Bank Erosion	Deposit in Basin	Outflow	Inflow	Deposit	Outflow		
	km²	1,000m³/yr					1,000m³/yr			1,000m³/yr	m³/km²/yr
K-1	2,537	0	4,882	98	3,906	1,074	0	-192	192	1,266	499
K-2	2,694	1,074	8,861	177	7,089	3,024	192	125	67	3,091	1,147
K-3	7,053	0	15,139	303	12,111	3,331	0	-3,428	3,428	6,758	958
K-4	12,264	6,354	20,131	403	16,104	10,783	3,495	-2,679	6,174	16,957	1,383
Total	24,548										
I-1	1,278	0	2,746	55	2,197	604	0	-142	142	746	584
I-2	6,175	604	12,526	251	10,459	2,922	142	-186	327	3,249	526
I-3	3,432	2,922	13,019	260	10,415	5,786	327	-2,368	2,695	8,481	2,471
I-4	5,383	5,786	12,548	251	10,038	8,546	2,695	-2,421	5,116	13,662	2,538
Total	16,268										

Delivery Rate of Sheet Erosion except for I-2 Basin: 0.20 (Deposit Rate is 0.80)

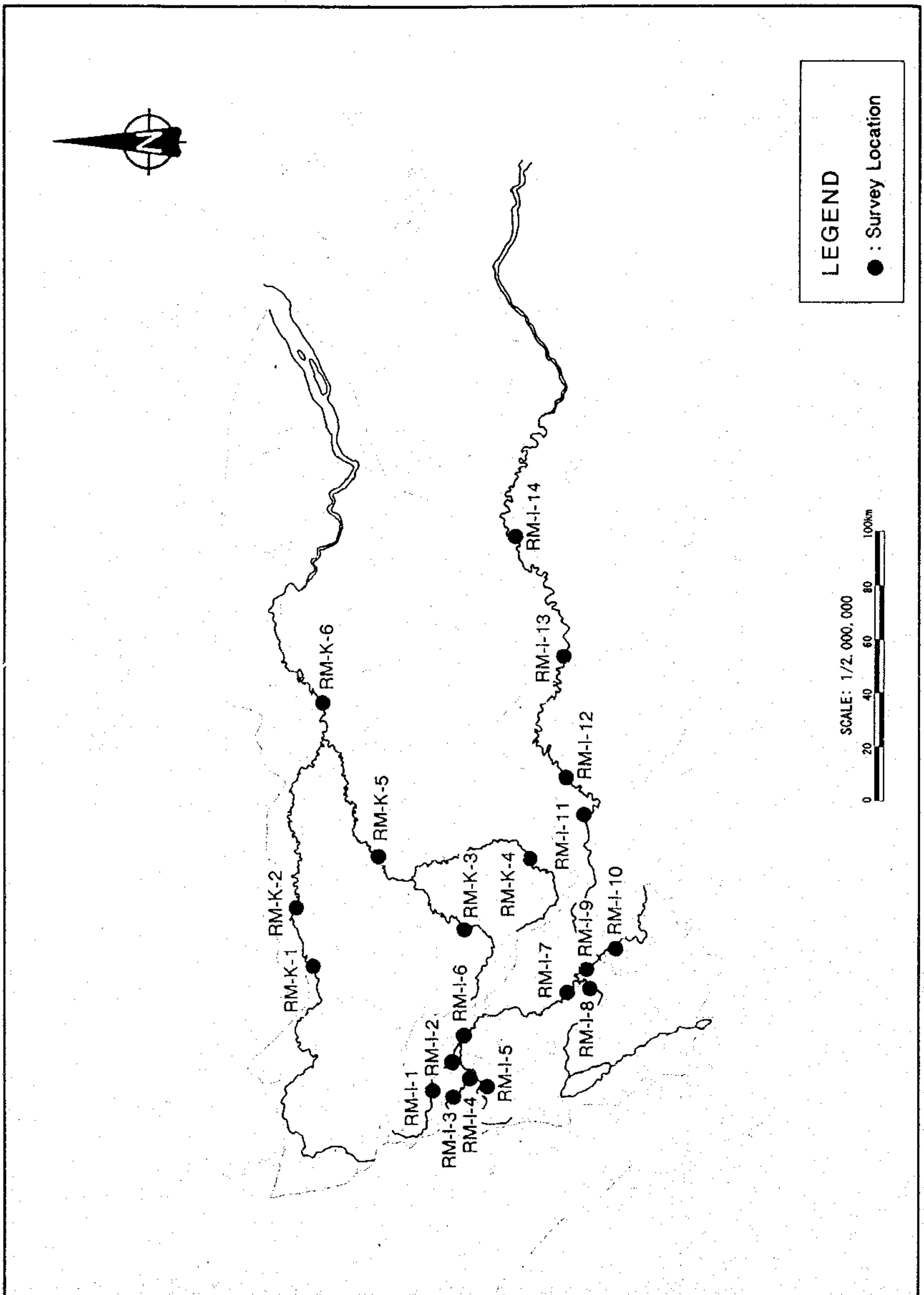
Delivery Rate of Sheet Erosion for I-2 Basin (considering Singkarak Lake): 0.165 (Deposit Rate is 0.835)

FIGURES

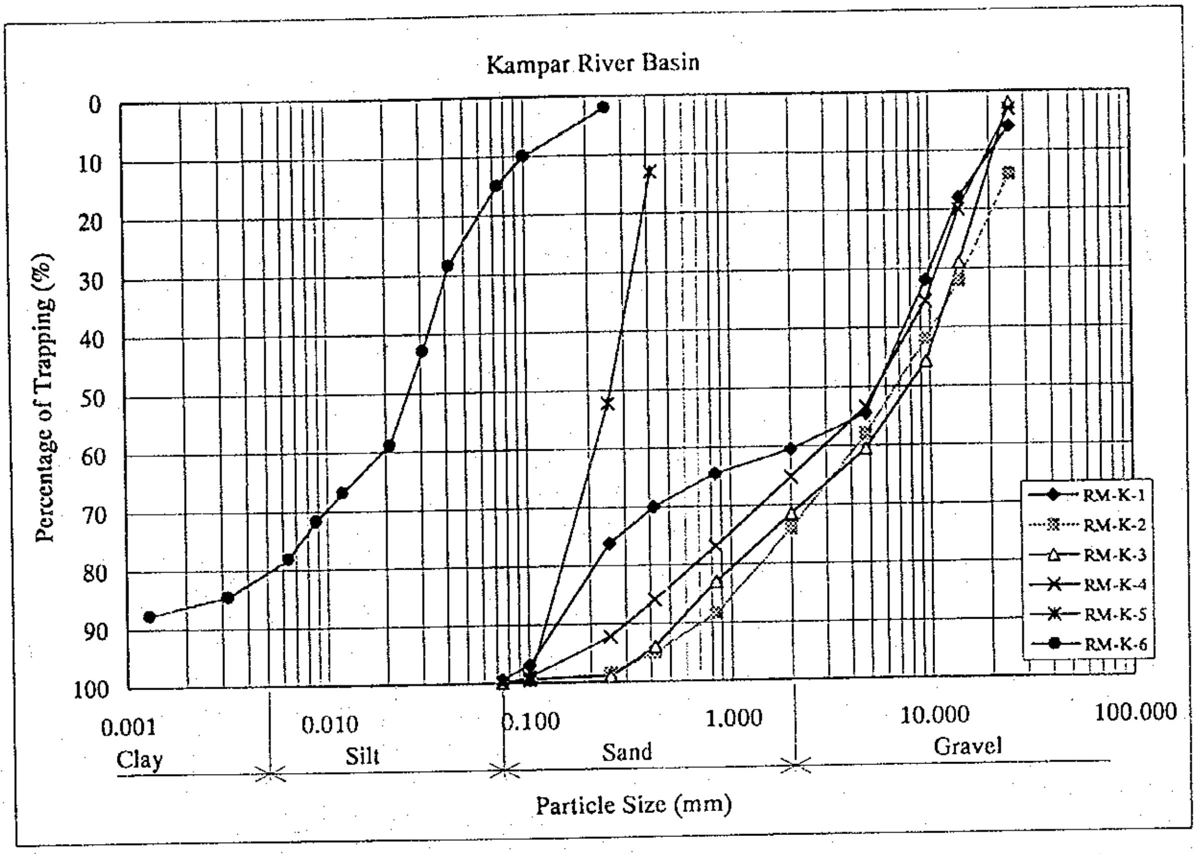
X SEDIMENT CONTROL PLAN

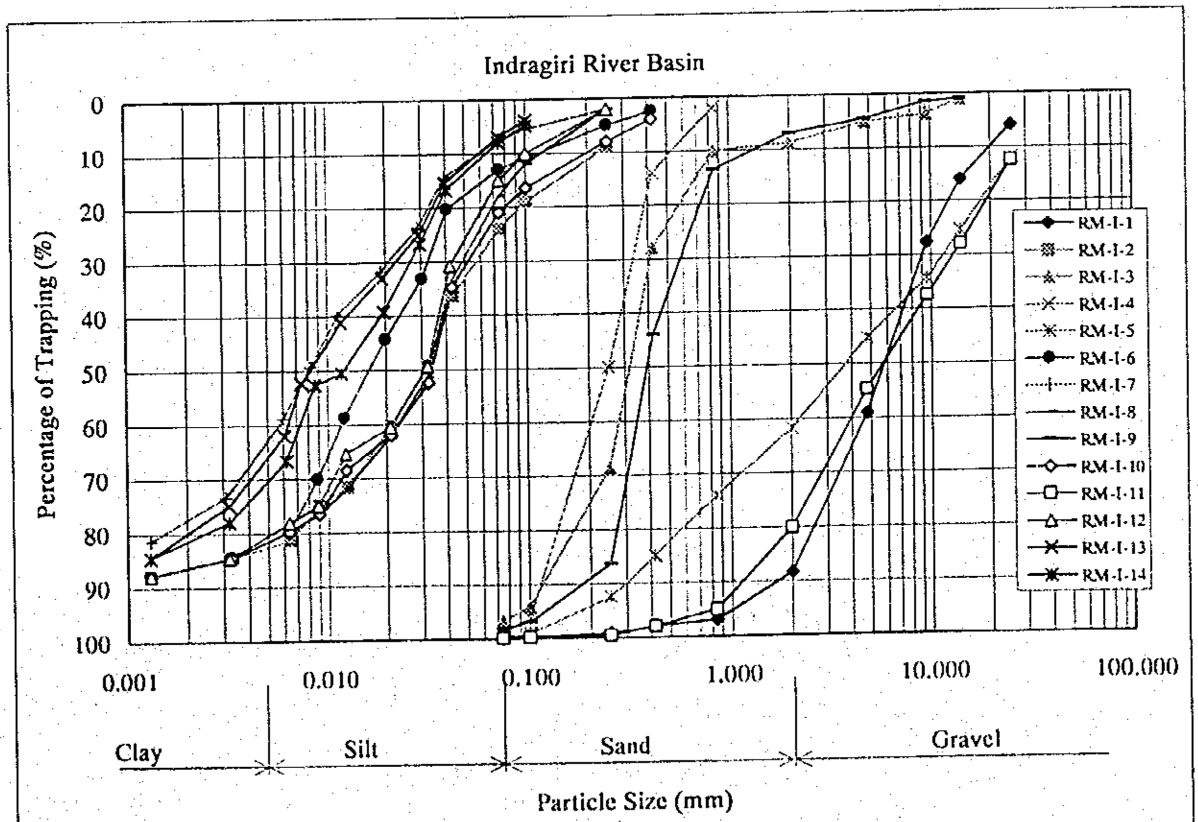


THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. X.1.1 SUB-BASIN FOR LAND COVER ANALYSIS
JAPAN INTERNATIONAL COOPERATION AGENCY	

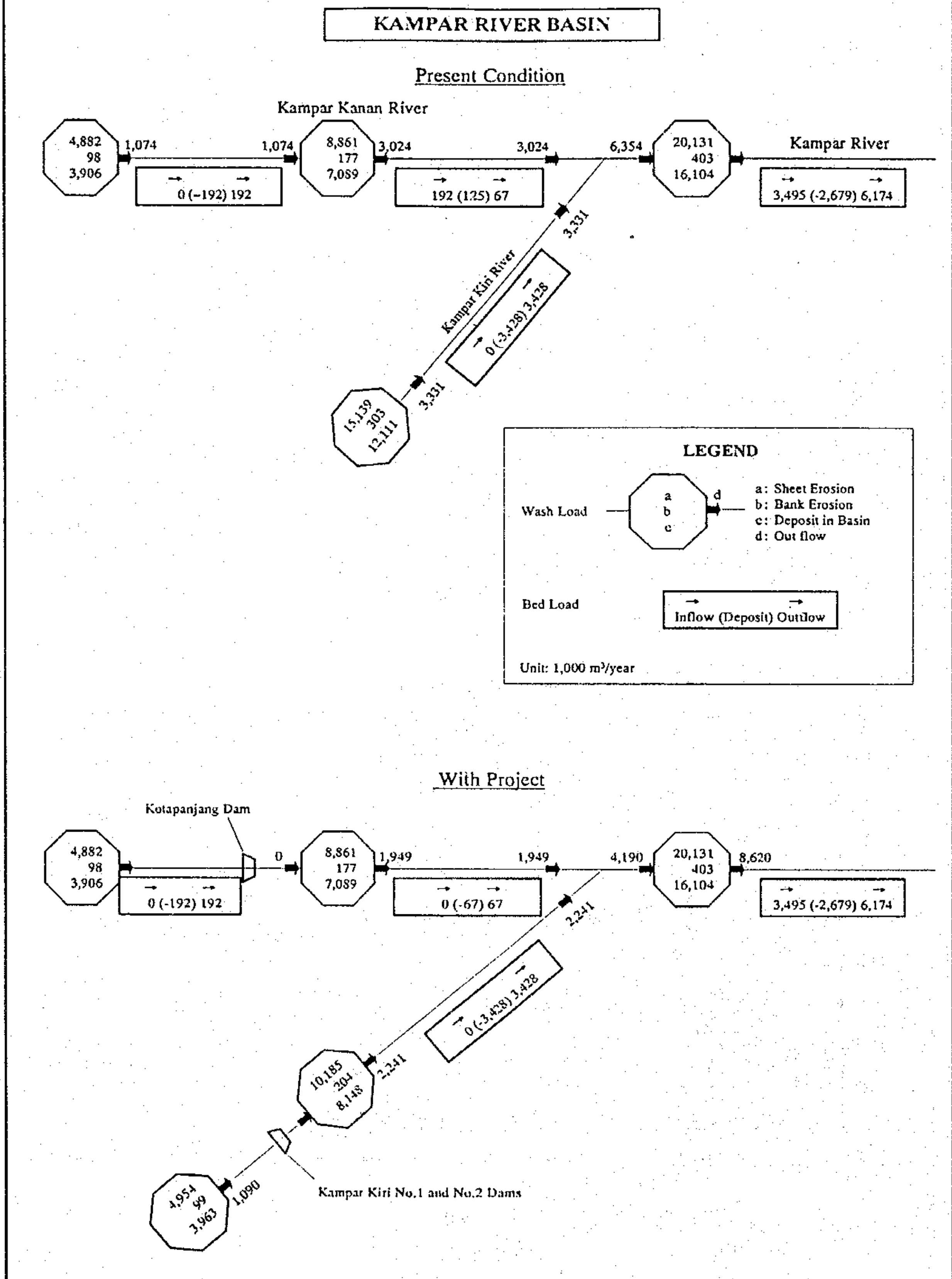


THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. X.1.2 LOCATION MAP FOR RIVERBED MATERIAL SURVEY
JAPAN INTERNATIONAL COOPERATION AGENCY	





THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. X.1.3 GRADATION CURVES OF RIVERBED MATERIAL
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY ON
KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT
IN THE REPUBLIC OF INDONESIA

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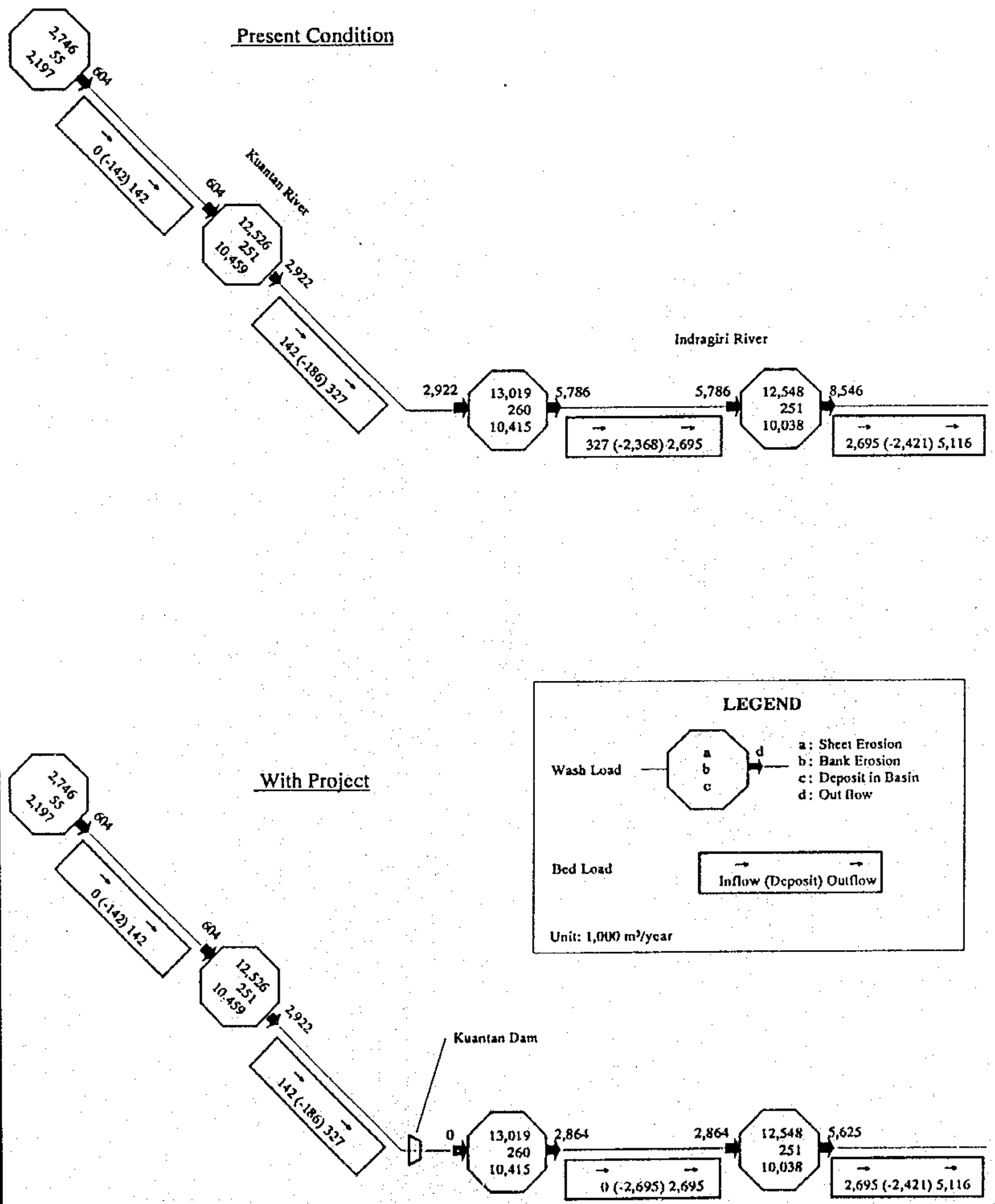
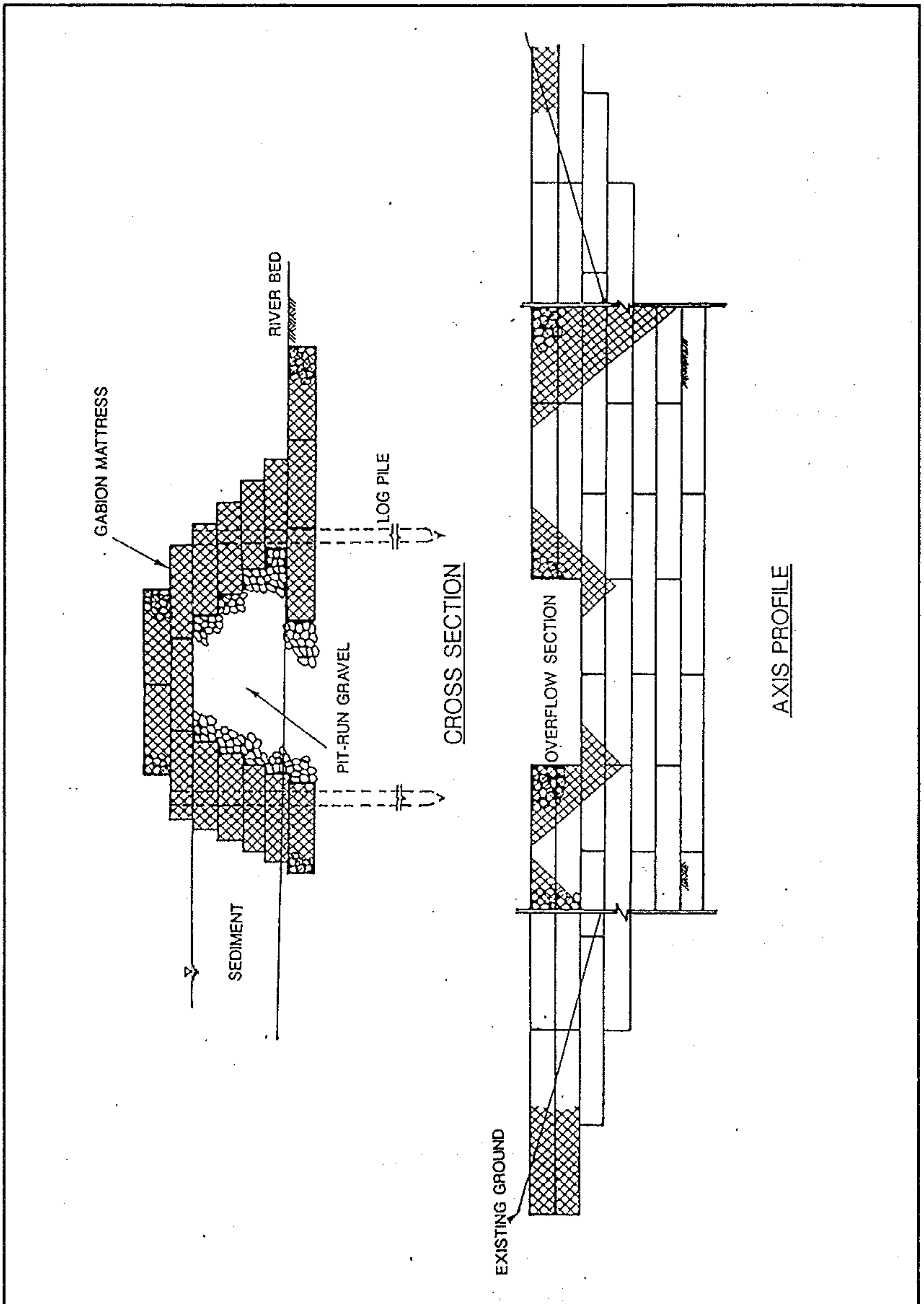
Fig. X.3.1 SEDIMENT BALANCE (1/2)

KUANTAN-INDRAGIRI RIVER BASIN



THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. X.3.1 SEDIMENT BALANCE (2/2)
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA	Fig. X.4.1 STANDARD FEATURES OF GABION DAM
JAPAN INTERNATIONAL COOPERATION AGENCY	

XI MULTIPURPOSE DEVELOPMENT PLAN

SECTOR XI
MULTIPURPOSE DEVELOPMENT PLAN

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CHAPTER 1 GENERAL

Some projects of the Flood Control Plan are considered to be more effective if they are formulated in combination with projects of the Water Resources Development Plan because of close relationship with one another. The Overall Development Plan thus formulated is primarily for flood control and water resources development, and composed of single purpose and multipurpose development projects.

This SECTOR presents the formulation of project components as well as the optimization study for multipurpose development projects of the Overall Development Plan and the feasibility study. The optimization study for single purpose development projects of flood control and water resources development plans is presented in SECTOR VI and VIII, respectively.

1.1 Project Components of Overall Development Plan

The five projects shown in the table below comprise the Overall Development Plan. Three of these projects are in the Kampar River System and two are in the Indragiri River System. They consist of single purpose and multipurpose projects and their locations are as shown in Fig. XI.1.1.

Name of Project	Purpose	Optimization Study
Kampar River System		
(1) Kampar Kanan Water Supply Project	Single	SECTOR VIII
(2) Kampar Kanan River Improvement Project	Single	SECTOR VI
(3) Kampar and Kampar Kiri River Development Project	Multiple	This SECTOR
Indragiri River System		
(1) Indragiri River Development Project	Multiple	This SECTOR
(2) Upper Indragiri River Improvement Project	Single	SECTOR VI

1.2 Multipurpose Development Plan

Among the projects comprising the Overall Development Plan, the following two projects have been considered as multipurpose projects because their sub-project components are closely related to one another. The optimization study for these two projects is carried out in succeeding chapters of this report.

- Kampar and Kampar Kiri River Development Project
- Indragiri River Development Project

CHAPTER 2 OVERALL DEVELOPMENT PLAN

2.1 Optimization of Kampar and Kampar Kiri River Development Project

2.1.1 Basic Conditions and Planning Criteria

The basic conditions and planning criteria for the formulation of Kampar and Kampar Kiri River Development Project are as described below.

(1) Purposes of the Project

The Kampar and Kampar Kiri River Development Project has the following purposes.

- Flood control of the Kampar and Kampar Kiri rivers; and
- Hydropower generation at Kampar Kiri No. 1 and No. 2 dams.

(2) Hydropower Generation

The Kampar Kiri No. 1 and No. 2 dams proposed in the Kampar river basin could be used for both flood control and water resources development. Since the future water supply for the Kampar river basin and Pekanbaru City is to be met by the water released from Kotapanjang Dam, water resources development at the above two dams focusses on hydropower generation only.

Optimization study for the single purpose of hydropower generation only for the Kampar Kiri No. 1 and No. 2 dams is presented in SECTOR IX, HYDROPOWER DEVELOPMENT PLAN. The optimum dam scales for hydropower generation shown in the table below are given as the basic condition.

Unit: $10^6 m^3$

Particulars	Kampar Kiri No. 1 Dam	Kampar Kiri No. 2 Dam
Storage Capacity for Hydropower Generation	646	438
Storage Capacity below Normal High Water Level	1,996	2,050

(3) Flood Control Measures

River improvement works, dams and a natural retarding basin in the downstream stretch of the Kampar Kiri River are taken into consideration as flood control measures (refer to SECTOR VI, FLOOD CONTROL PLAN). Floodways are not considered as alternatives due to topographic reasons.

(4) Design Scale for Flood Control

The design scale for flood control by phase and by area have been determined in SECTOR VI, FLOOD CONTROL PLAN, as follows:

Phase	Area	Design Scale (Return Period)
Final	Urban	50-year
	Rural	50-year
Initial	Urban	-
	Rural	-

(5) Standard Flood Discharge at Damsite

Standard flood discharges are set as below in accordance with the results of flood runoff analysis.

Unit: m^3/s

Damsite	Standard Flood Discharge (50-year Return Period)
Kampar Kiri No. 1 Dam	1,630
Kampar Kiri No. 2 Dam	1,240

(6) Flood Control Method at Dam

Non-gated control is considered for both Kampar Kiri No. 1 and No. 2 dams taking easier operation into account. The relation between flood control capacity and maximum release for the Kampar Kiri No. 1 and No. 2 dams is presented in Fig. XI.2.1.

2.1.2 Alternative Cases

Optimization for the flood control plan along the Kampar and Kampar Kiri rivers has been conducted comparing the combination of the following two flood control alternative cases:

- Flood control by Kampar Kiri No. 1 and No. 2 dams
- River improvement along the Kampar and Kampar Kiri rivers

A retarding basin with a fixed capacity in the downstream stretch of the Kampar Kiri River is taken into consideration in every combination.

Alternative combinations of the flood control capacity of both Kampar Kiri No.1 and No.2 dams and design discharge for river improvement of both Kampar and Kampar Kiri rivers have been set as given in Table XI.2.1.

2.1.3 Cost Comparison

Dam construction cost, river improvement cost and total cost for the above alternative cases were accordingly calculated as presented in Table XI.2.2. These costs were estimated on the following conditions: