JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
MINISTRY OF PUBLIC WORKS
THE REPUBLIC OF INDONESIA

THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT

VOLUME 1

SUMMARY

(FINAL REPORT)

DECEMBER 1995

CTI ENGINEERING CO., LTD.
IN ASSOCIATION WITH
NIPPON KOEI CO., LTD.

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PREFACE

In response to a request from the Government of the Republic of Indonesia, the Government of Japan decided to conduct the study on Kampar-Indragiri River Basin Development Project and entrusted the study to the Japan International Cooperation Agency (JICA).

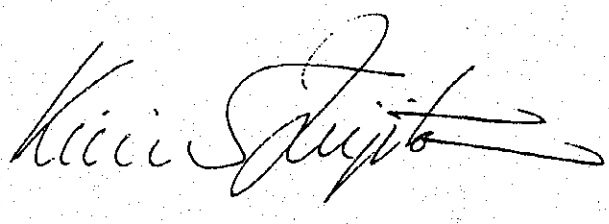
JICA sent to Indonesia a study team headed by Mr. Yoshiyuki Tomioka, CTI Engineering Co., Ltd., from January 1993 to November 1995.

The team held discussions with the officials concerned of the Government of Indonesia, and conducted four field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Indonesia for their close cooperation extended to the team.

December 1995



Kimio Fujita
President
Japan International Cooperation Agency

LIST OF REPORTS

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VOLUME 3	*SUPPORTING REPORT (1)*
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VOLUME 5	*DATA BOOK*
VOLUME 6	*APPENDIX*

COST ESTIMATE IS BASED

ON THE PRICE LEVEL OF JULY 1994

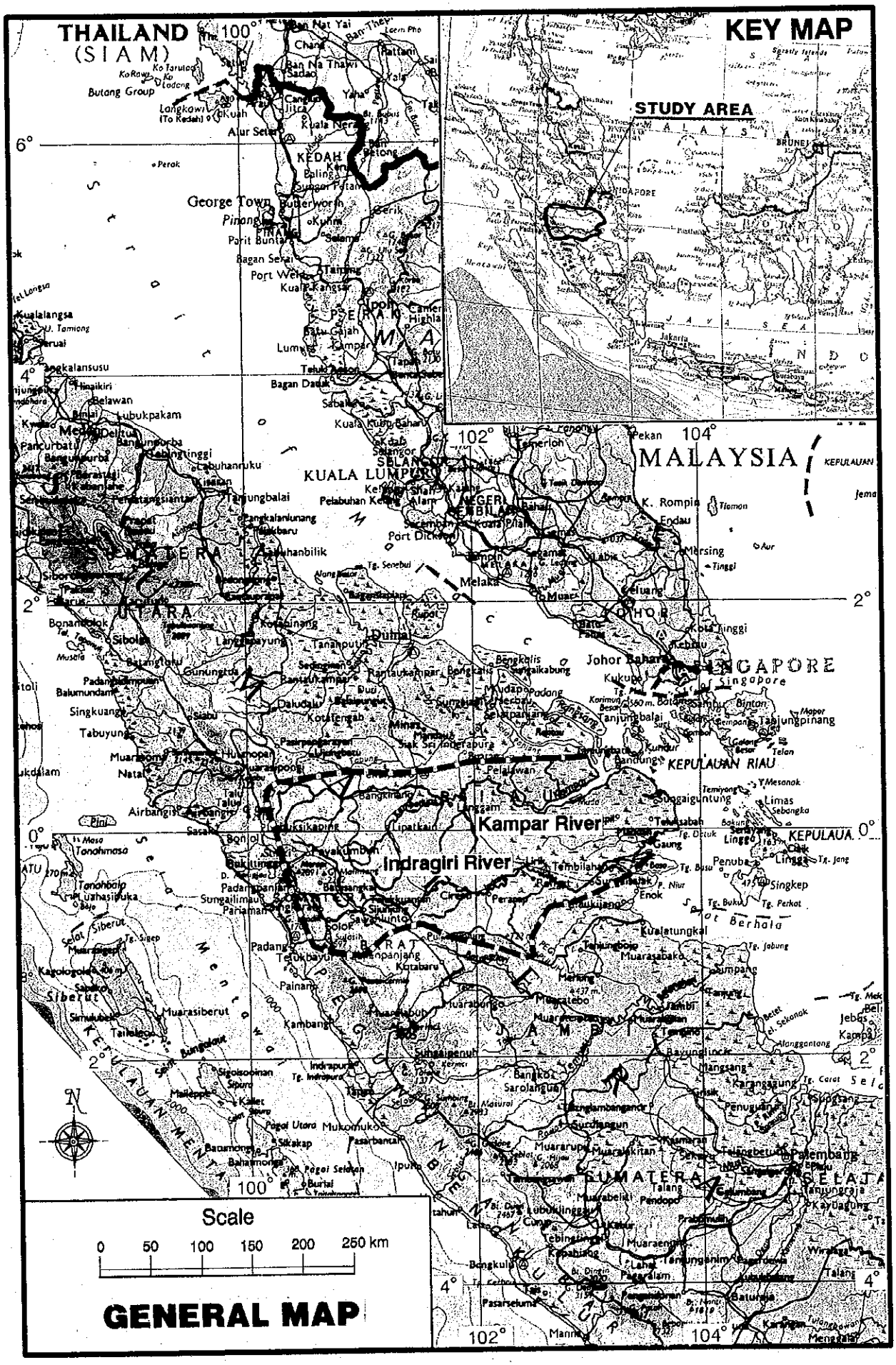
AND EXPRESSED IN INDONESIAN RUPIAH (Rp.)

ACCORDING TO THE FOLLOWING EXCHANGE RATES:

US$1.00 = Rp. 2,175

AND ¥ 1.00 = Rp. 21.90

(AS OF JULY 1994)


THAILAND
(SIAM)
KEY MAP
STUDY AREA
MALAYSIA
SINGAPORE
KUALA LUMPUR
SELANGOR
KEDAH
PERAK
PINANG
George Town
Butterworth
Pinang
Kampar River
Indragiri River
KEPULAUAN RIAU
SUMATERA
SELAT MALAKA
Scale
0 50 100 150 200 250 km
GENERAL MAP

OUTLINE OF THE PROJECT

1. OBJECTIVES OF THE STUDY

The Study has the following three objectives:

(1) To formulate the Overall Development Plan for the Kampar-Indragiri River Basin in which priority projects will be selected;

(2) To carry out a Feasibility Study for the priority projects selected through the study on the Overall Development Plan as the objectives requiring urgent solution; and,

(3) To transfer technology to government counterpart personnel concerned through the studies in Indonesia and in Japan.

2. STUDY AREA

The Study Area is within the watershed boundaries of the Kampar and Indragiri rivers, covering about 50,000 km^2 which include parts of the West Sumatra and Riau provinces as tabulated below. Pekanbaru City, the capital of Riau Province, is included in the study area for the study on a water resources development plan to supply municipal, industrial and flushing water for drainage canals in the city.

3. TARGET YEAR

The target year is set at 2019 which corresponds to the last year of the Second Long Term Development Plan (PJP II).

4. FORMULATION OF OVERALL DEVELOPMENT PLAN

The Overall Development Plan has the following components:

(1) Flood Control Plan
(2) Irrigation Development Plan

(3) Water Resources Development Plan

(4) Hydropower Development Plan

4.1 Flood Control Plan

4.1.1 Objective River Stretch

(1) Kampar River Basin

- Middle and lower reaches of the Kampar Kanan River
- Middle and lower reaches of the Kampar Kiri River
- Kampar River

(2) Indragiri River Basin

- Middle and lower reaches of the Kuantan-Indragiri River
- Payakumbuh, Solok and Sijunjung/Muara areas in the upper reaches of the Indragiri River

4.1.2 Design Scale

The following table shows the design scales adopted to this project.

Unit: Year return period

Particulars	Initial Phase (Urban/Rural)	Final Phase
Kampar River System		
Kampar Kanan River	5 / 5	50
Kampar Kiri River	-	50
Kampar River after confluence	-	50
Indragiri River System		
Sinamar/Lampasi/Agam Rivers	10 / 10	50
Lembang River	10 / 10	50
Sukam/Palangki Rivers	10 / 10	50
Kuantan-Indragiri River	10 / 5	50

4.1.3 Identification of Flood Control Project

The following component projects of the Overall Flood Control Plan have been formulated:

Component Project	Purpose	Note
Kampar River System		
Kampar Kanan River Improvement Works	Single	
Kampar and Kampar Kiri River Improvement Works	Multiple	Kampar Kiri No. 1 & No. 2 dams will be multipurpose dams.
Indragiri River System		
Kuantan-Indragiri River Improvement Works	Multiple	Kuantan Dam will be a multipurpose dam.
Upper Indragiri River Improvement Works		
- Payakumbuh Area	Single	
- Solok Area	Single	
- Sijunjung/Muara Area	Single	

4.1.4 Optimum Flood Control Plan

(1) Kampar Kanan River Improvement Works

River improvement works only is employed as the optimum measure. The improvement stretch was identified as the reaches between the proposed Kuok Intake Weir and the confluence with the Kampar Kiri River with the design discharge of 4,000 m^3/s.

(2) Kampar and Kampar Kiri River Improvement Works

The following measures are employed as the optimum flood protection plan:

- Kampar Kiri No. 1 Multipurpose Dam;
- Kampar Kiri No. 2 Multipurpose Dam;
- Retarding basin in the downstream stretch of the Kampar Kiri River; and
- River improvement of the Kampar and Kampar Kiri Rivers with the design discharge of 4,850 - 5,100 m^3/s for Kampar River and 1,450 m^3/s for Kampar Kiri River.

(3) Kuantan-Indragiri River Improvement Works

The following measures are employed as the optimum flood control plan:

- Kuantan Dam with flood control capacity of $400 \times 10^6 m^3$;
- Retarding basin in the stretch downstream from Japura of the Indragiri River; and

- River improvement works for the stretch between the Lubukjambi Intake Weir and the downstream of Rengat of the Kuantan and Indragiri rivers with the design discharge of 3,200 to 5,050 m^3/s.

(4) Upper Indragiri River Improvement Works

River improvement works only is employed as the optimum flood protection plan for the Payakumbuh, Solok and Sijunjung/Muara areas. The design discharges are 490 to 2,100 m^3/s for Payakumbuh area, 700 to 1,000 m^3/s for Solok area, and 1,050 to 5,450 m^3/s for Sijunjung/Muara area.

4.2 Irrigation Development Plan

The irrigation development plan is formulated to grasp the future irrigation water demand in the Water Resources Development Plan.

4.2.1 Identification of Objective Development Areas

The Rantauberangin Irrigation Area with 20,303 ha in the Kampar river basin and the Lubukjambi Irrigation Area with 30,149 ha in the Indragiri river basin were identified as the objective irrigation areas.

4.2.2 Proposed Facilities for Irrigation Development Plan

(1) Intake Weir

The Kuok and Lubukjambi intake weirs are proposed for the Rantauberangin and Lubukjambi irrigation areas, respectively.

(2) Main Irrigation Canal

Main irrigation canals with total lengths of 124 km and 242 km for Rantauberangin and Lubukjambi irrigation areas are proposed, respectively.

4.2.3 Irrigation Water Requirement

The future irrigation water requirements in 2019 are estimated under double-cropping conditions at 25.49 m^3/s for the Rantauberangin Irrigation Area and 36.93 m^3/s for the Lubukjambi Irrigation Area.

4.3 Water Resources Development Plan

4.3.1 Water Source

Development of river water by construction of dams is evaluated to have enough supply capacity for the future water demand in the study area.

In the Kampar river basin, water released from the Kotapanjang Dam which is under construction by PLN for the purpose of hydropower generation can be utilized as water source.

In the Indragiri river basin, the Kuantan Dam is proposed for both flood control and water resources development purposes.

4.3.2 Future Water Demand

The future water demand in the study area was studied for the following ten sectors with 2019 as the target year:

- Irrigation
- Domestic Water
- Industry
- Inland Fishery
- Livestock
- Tourism
- Urban Area Flushing
- Hydropower Generation
- River Navigation
- River Maintenance Flow

The estimated future peak water demands in 2019 are 367.35 m^3/s for the Kampar river basin and 359.95 m^3/s for the Indragiri river basin including river maintenance flow.

4.3.3 Identification of Water Resources Development Project

The following component projects of the Overall Water Resources Development Plan are formulated:

Water Resources Development Plan	Purpose
Kampar Kanan Water Supply Project	Irrigation water supply to Rantauberangin Irrigation Project and supply of domestic water, etc., to Pekanbaru City. (Single Purpose)
Kampar Kiri No. 1 Dam Construction Works	Flood control and hydropower generation. (Multipurpose)
Kampar Kiri No. 2 Dam Construction Works	Flood control and hydropower generation. (Multipurpose)
Kuantan River Multipurpose Development Project	Flood control, irrigation water supply and hydropower generation. (Mutipurpose)

4.3.4 Optimum Water Resources Development Plan

(1) Kampar Kanan Water Supply Project

Kuok Intake Weir is proposed to regulate water from the Kotapanjang Dam and to intake water to main irrigation canals. The weir is planned at the downstream of the Bangkinang Bridge to be a movable weir with rubber gates (3.7 m high × 30.0 m long × 5 units).

(2) Kampar Kiri No. 1 and No. 2 Dam Construction Works

Since both dams have multiple purposes of flood control and hydropower generation, the optimum scales of the dams are discussed in Section 4.5.

(3) Kuantan River Multipurpose Development Project

As water resources development facilities, Kuantan Dam and Lubukjambi Intake Weir are proposed. Since the Kuantan Dam is proposed as a

multipurpose dam for flood control, water resources development and hydropower generation, the optimum scale of the dam is discussed in Section 4.5.

The Lubukjambi Intake Weir is located at the downstream of the Kuantan Dam to regulate water released from the dam and to intake water to the Lubukjambi irrigation canals. The weir is planned to be a movable weir with roller gates (4.7 m high × 29.4 m long × 4 units).

4.4 Hydropower Development Plan

In general, when dam construction is planned for flood control or water resources development purpose in Indonesia, a study on hydropower development is incorporated to save exportable resources such as oil, gas and coal. In the Overall Development Plan, three dams are proposed for flood control and water resources development. Accordingly, hydropower development is planned for the following dams:

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

Since the proposed three dams have multiple purposes, the optimum scales of the dams are discussed in Section 4.5.

4.5 Formulation of Multipurpose Development Projects

Among the components of the Overall Development Plan, the following are multipurpose development projects:

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

4.5.1 Kampar and Kampar Kiri River Development Project

(1) Purposes of the Project

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

(2) Major Facilities to be Studied

- Kampar Kiri No. 1 Dam
- Kampar Kiri No. 2 Dam

(3) Optimum Scale

The optimum scale and hydropower generation capacities of the Kampar Kiri No. 1 and No. 2 dams were decided through a study on alternatives, as shown in the table below.

Description	Unit	Kampar Kiri No. 1 Dam	Kampar Kiri No. 2 Dam
Dam Height	m	103	95
Flood Control Capacity	10^6m^3	250	150
Hydropower Capacity	10^6m^3	646	438
Dead Storage Capacity	10^6m^3	1,350	1,612
Gross Storage Capacity	10^6m^3	2,246	2,200
Installed Capacity	MW	131	40

4.5.2 Indragiri River Development Project

(1) Purposes of the Project

- Flood control of the middle and lower reaches of the Kuantan-Indragiri River;
- Irrigation water supply to Lubukjambi Irrigation Project; and
- Hydropower generation at proposed dams.

(2) Major Facilities to be Studied

- Kuantan Dam

(3) Optimum Scale

The optimum scale of the Kuantan Dam was decided through a study on alternatives, as shown in the table below:

Dam Height	73 m
Capacity Allocation	
Flood Control	$400 \times 10^6 m^3$
Hydropower Generation	$415 \times 10^6 m^3$
Irrigation	$117 \times 10^6 m^3$
River Maintenance	$213 \times 10^6 m^3$
Dead Storage Capacity	$425 \times 10^6 m^3$
Gross Storage Capacity	$1,570 \times 10^6 m^3$
Installed Capacity	114 MW

4.6 Possible Maximum Development Amount of Water Resources

The governments of both Indonesia and Singapore executed a Memorandum of Understanding in August 1990 on the export of water from Indonesia to Singapore. The export amounts agreed so far are as follows:

- 31.25 m^3/s from Riau Province by the year 2010.
- 52.6 m^3/s from Sumatra by the year 2090.

The possible maximum development amount of water in the study area by the three proposed dams and the Kotapanjang Dam is calculated at 103 m^3/s.

4.7 Project Cost Estimate

Project cost has been estimated based on the following concept:

- All unit costs are based on the price level as of July 1994.
- Currency conversion rates are assumed at US$1.00 = Rp. 2,175 and ¥1.00 = Rp. 21.90 as of July 1994.
- Project cost is composed of construction base cost, compensation cost, administration cost, engineering cost, price contingency, physical contingency and value added tax.

The estimated financial project costs of the five project components are summarized in the table below.

Unit: Rp. 10^6

Project	F.C.	L.C.	Total
(1) Kampar Kanan Water Supply Project	155,256	127,068	282,324
(2) Kampar Kanan River Improvement Project	444,751	423,859	868,610
(3) Kampar and Kampar Kiri River Development Project	1,018,100	793,692	1,811,792
(4) Indragiri River Development Project	1,328,732	1,172,919	2,501,651
(5) Upper Indragiri River Improvement Project	360,022	307,215	667,237
Grand Total	3,306,861	2,824,753	6,131,6141

Note: Price Contingency is not included.

4.8 Economic Evaluation

The economic viability of the Overall Development Plan was assessed by means of Economic Internal Rate of Return (EIRR), Benefit-Cost ratio (B/C) and Net Present Value (NPV). The discount rate of 10% was applied for the calculation of B/C and NPV. The evaluation results are as shown in the table below.

Project	EIRR (%)	B/C	NPV (Rp. 10^6)
(1) Kampar Kanan Water Supply Project	9.82	0.98	- 2,300
(2) Kampar Kanan River Improvement Project	10.30	1.03	7,592
(3) Kampar and Kampar Kiri River Development Project	12.46	1.23	71,146
(4) Indragiri River Development Project	13.19	1.33	222,775
(5) Upper Indragiri River Improvement Project	10.55	1.07	15,851
(6) All Overall Development Projects	11.90	1.20	314,967

5. FEASIBILITY STUDY

5.1 Objective Priority Projects

The following four priority projects were selected from the Overall Development Plan for further study in the Feasibility Study:

- Kampar Kanan Water Supply Project (Kampar River Basin)
- Bangkinang Area River Improvement Works (Kampar River Basin)
- Kuantan River Multipurpose Development Project (Indragiri River Basin)
- Rengat Area Flood Protection Works (Indragiri River Basin)

5.2 Basic Conditions

The target year for planning is set at 2019, and the target completion year of priority projects is 2004. Cost estimate for priority projects has been made under the same conditions as the Overall Development Plan.

5.3 Kampar Kanan Water Supply Project

5.3.1 Purpose of Project

The purposes of the project are as follows:

- To supply irrigation water to priority areas of Rantauberangin Irrigation Development Project; and
- To develop water resources and ensure the required urban water demand (domestic, industry, tourism, urban area flushing uses) of Pekanbaru City.

5.3.2 Proposed Structures

The proposed structures for the project are:

- Kuok Intake Weir; and
- Main irrigation canals and other irrigation facilities for the Rantauberangin Irrigation area.

5.3.3 Water Demand

The peak water demand until 2004 is estimated as below.

Unit: m^3/s

Purpose	Peak Water Demand
Irrigation Water	16.11
Urban Water	10.90
Total	27.01

5.3.4 Main Features of Proposed Structures

The main features of proposed structures are as given below.

(1) Kuok Intake Weir

Weir Crest	EL 40.0 m
Storage Capacity	$1.6\times10^6 m^3$
Design Flood Discharge	4,000 m^3/s
Gate Type	Rubber Gate
Length × Height × No. of Units	30.0 m × 3.7 m × 5 units

(2) Main Irrigation Canal and Irrigation Area

Description	Left Bank	Right Bank
Main Canal Length	44.00 km	40.00 km
Design Discharge	11.31 m^3/s	4.80 m^3/s
Irrigation Area	9,600 ha	4,615 ha

5.3.5 Land Acquisition and House Evacuation

The necessary area of land acquisition and number of house evacuation for the project are estimated at 220 ha and 430 units, respectively.

5.4 Bangkinang Area River Improvement Works

5.4.1 Purpose of the Project

The purpose of the Bangkinang Area River Improvement Works is to mitigate flood damages along the Kampar Kanan River in Bangkinang Area by the implementation of river improvement.

5.4.2 Major Work Items

The major work items are estimated as follows:

River Improvement	49 km
Construction of Sluice	33 units
Construction of Groin	57 units
Reconstruction of Bridges	2 bridges

5.4.3 Design Scale and Design Flood Discharge

Design scale for the feasibility study stage is set at 5-year return period considering that the area consists mainly of agricultural lands. Structures difficult for upgrading in the future, e.g., bridges and sluice gates, are to be designed for 50-year return period scale.

The design flood discharges have been determined as follows:

5-year Return Period	2,800 m^3/s
50-year Return Period	4,000 m^3/s

5.4.4 Land Acquisition and House Evacuation

The necessary area of land acquisition and number of house evacuation for the project are estimated at 197 ha and 300 units, respectively.

5.5 Kuantan River Multipurpose Development Project

5.5.1 Purpose of the Project

The purposes of the project are as follows:

- To protect the Lubukjambi Irrigation Area from floods;
- To supply irrigation water to the priority area of Lubukjambi Irrigation Area; and
- To execute hydropower generation at Kuantan Dam.

5.5.2 Proposed Structures

The following structures are proposed for the project:

- Kuantan Dam;
- Lubukjambi Intake Weir; and
- Main irrigation canals and other irrigation facilities for the Lubukjambi Irrigation Area.

5.5.3 Water Demand

The peak water demand for the project is estimated as follows:

Unit: m^3/s

Purpose	Peak Water Demand
Left Bank Irrigation	7.85
River Maintenance Flow (Constant Release)	57.39
River Maintenance Flow (Supplementation of Deficit in Downstream Area)	24.64
Total	89.88

5.5.4 Main Features of Proposed Structures

The main features of proposed structures are as given below.

(1) Kuantan Dam

Dam Type	Concrete Gravity Dam
Crest Elevation	EL 123.0 m
Dam Height	73.0 m
Reservoir Capacity	
Effective Storage Capacity	$1,145\times10^6m^3$
Dead Storage Capacity	$425\times10^6m^3$
Gross Storage Capacity	$1,570\times10^6m^3$
Installed Capacity	114 MW

(2) Lubukjambi Intake Weir

Gate Type	Steel Roller Gate
Length x Height x No. of Units	29.4 m × 4.7 m × 4 units
Crest Elevation	EL 60.0 m
Design Flood Discharge	3,200 m^3/s
Storage Capacity	$2.2 \times 10^6 m^3$

(3) Main Irrigation Canal and Irrigation Area

The main features of the irrigation canal and irrigation area are as follows:

Description	Left Bank	Right Bank
Main Canal Length	76.0 km	-
Design Discharge	7.85 m^3/s	-
Irrigation Area	9,376 ha	-

5.5.5 Land Acquisition and House Evacuation

The necessary area of land acquisition and number of house evacuation in the project are estimated at 2,700 ha and 1,700 units, respectively.

5.6 Rengat Area Flood Protection Works

5.6.1 Purpose of the Project

The purpose of the project is to protect Rengat Area from flooding.

5.6.2 Proposed Structures

The proposed structures in the project are a ring dike, a drainage pumping station and other related structures.

5.6.3 Design Scale

Design scale of 10-year return period is applied for flood control in the area. The design scale for the interior drainage is determined at 5-year return period.

5.6.4 Main Features of Proposed Structures

The main features of proposed structures are as follows:

Ring Dike	24 km
Drainage Pumping Station	1 station, 3.0 m^3/s
Related Structures	
Movable Steel Wall (10.0 m long x 1.2 m high)	3 units
Control Gate	5 units
Concrete Wall	1,400 m
Sluice	1 unit
Groin	8 units

5.6.5 Land Acquisition and House Evacuation

The necessary area of land acquisition and number of house evacuation for the project are estimated at 40 ha and 20 units, respectively.

5.7 Cost Estimate

Costs of priority projects have been estimated on the same conditions as the Overall Development Plan, as summarized below.

Unit: Rp. 10^6

Description	Kampar Kanan Water Supply Project	Bangkinang Area River Improvement Works	Kuantan River Multipurpose Development Project	Rengat Area Flood Protection Works
Construction Base Cost	137,067	176,070	507,371	28,817
Compensation Cost	4,620	2,591	29,335	280
Administration and Engineering Cost	20,790	26,540	77,573	4,336
Price Contingency	76,752	116,133	282,717	8,568
Physical Contingency	22,783	30,586	85,351	4,006
Sub-Total	262,012	351,920	982,347	46,007
Value Added Tax	26,201	35,192	98,235	4,601
Total	288,213	387,112	1,080,582	50,608

5.8 Project Evaluation

Based on the estimated economic benefits and economic costs, the priority projects have been evaluated in terms of Economic Internal Rate of Return (EIRR), Benefit-

Cost ration (B/C) and Net Present Value (NPV). The evaluation results are as summarized below.

Priority Projects	EIRR (%)	B/C	NPV (Rp. 10^6)
Kampar Kanan Water Supply Project	10.14	1.02	1,524
Bangkinang Area River Improvement Works	10.19	1.02	2,216
Kuantan River Development Project	15.27	1.74	256,670
Rengat Area Flood Protection Works	11.00	1.11	2,815
All Priority Projects	13.59	1.46	263,182

6. ENVIRONMENTAL STUDY

Environmental Impact Analysis (ANDAL) has been made for the priority projects and concluded as follows:

(1) Natural Environment

Impacts on the natural environment by the construction of proposed facilities are judged to be little.

(2) Social Environment

No important historical assets and cultural properties were found in the project area.

The area of land acquisition for priority projects is 3,157 ha and the number of house evacuation is 2,450 units. According to the interview survey, there was no strong objection among the inhabitants in the project site. Therefore, land acquisition and house evacuation can proceed with reasonable compensation for inhabitants' losses and assurance of firm countermeasures for the resettlement of people.

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ABBREVIATIONS

1. INDONESIAN GOVERNMENT AGENCIES

GOI	:	Government of Indonesia
BAPPENAS	:	Badan Perencanaan Pembangunan Nasional (National Development Planning Board)
BAPPEDA	:	Badan Perencanaan Pembangunan Daerah (Provincial Development Planning Board)
DPU	:	Departemen Pekerjaan Umum (Ministry of Public Works)
DGWRD	:	Directorate General of Water Resources Development
DJCK	:	Directorat Jenderal Cipta Karya (Directorate General of Human Settlement)
DOR	:	Directorate of Rivers
DPUP	:	Dinas Pekerjaan Umum Propinsi (Provincial Public Works Services)
P3SA	:	Proyek Pengembangan dan Penyelidikan Sumber-Sumber Air (Water Resources Development and Investigation Planning Project)
PGM	:	Pusat Meteorologi dan Geofisika (Meteorology and Geophysics Center)
PLN	:	Perusahaan Umum Listrik Negara (State Electricity Corporation)
IHE	:	Institute of Hydraulic Engineering
PDAM	:	Perusahaan Daerah Air Minum (Water Supply Public Corporation)

2. JAPANESE GOVERNMENT & INTERNATIONAL ORGANIZATIONS

GOJ	:	Government of Japan
JICA	:	Japan International Cooperation Agency
MOC	:	Ministry of Construction, Japan
ADB	:	Asian Development Bank
IBRD	:	International Bank for Reconstruction and Development (World Bank)

3. MEASUREMENT UNITS

(Length)			*(Weight)*		
mm	:	millimeter(s)	g, gr	:	gram(s)
cm	:	centimeter(s)	kg	:	kilogram(s)
m	:	meter(s)	ton	:	tonne(s)
km	:	kilometer(s)			
(Area)			*(Time)*		
mm^2	:	square millimeter(s)	s, sec	:	second(s)
cm^2	:	square centimeter(s)	min	:	minute(s)
m^2	:	square meter(s)	h, (hr)	:	hour(s)
km^2	:	square kilometer(s)	d, (dy)	:	day(s)
ha	:	hectare(s)	y, (yr)	:	year(s)

(Volume)

cm^3	:	cubic centimeter(s)
m^3	:	cubic meter(s)
ℓ, l, ltr	:	litter(s)
mcm	:	million cubic meter(s)

(Electrical Unit)

W	:	watt(s)
kW	:	kilowatt(s)
MW	:	megawatt(s)
kWh	:	kilowatt-hour
MWh	:	megawatt-hour
GWh	:	gigawatt-hour
V	:	volt(s)
kV	:	kilovolt(s)
Hz	:	Hertz

(Speed/Velocity)

cm/sec, cm/s	:	centimeter per second
m/sec, m/s	:	meter per second
km/hr, km/h	:	kilometer per hour

(Stress)

kg/cm^2	:	kilogram per square centimeter
t/m^2 (ton/m^2)	:	ton per square meter

(Discharge)

ℓ/sec, ℓ/s, ltr/s	:	litter per second
m^3/sec, m^3/s	:	cubic meter per second
m^3/yr, m^3/y	:	cubic meter per year

(Note: Other combined units may be constructed similarly as above)

4. MONETARY TERMS

¥	:	Japanese Yen
US$	:	United States Dollar
Rp.	:	Indonesian Rupiah

5. INDONESIAN TERMS

Jawa	:	Java
Propinsi	:	Province
Kabupaten, Kab.	:	District (Regency)
Kotamadya, Kodya.	:	Municipality
Kecamatan, Kec.	:	Sub-District
Desa, Kampung or Kp.	:	Village (Rural Area)
Kelurahan	:	Village (Urban Area)
Sungai, Sei, Batang	:	River
Gunung	:	Mountain
Rawa	:	Swamp
Danau	:	Lake
Laut	:	Sea

1 INTRODUCTION

1.1 Background

The Kampar-Indragiri river basin, the study area, is located in the central part of Sumatra Island, occupying approximately 50,000 km^2 of the West Sumatra and Riau provinces. Due to the insufficient flow capacity of river channels in the upper reaches and the low and flat topography of the middle and lower reaches, areas along both the Kampar and Indragiri rivers suffer from habitual inundation during rainy seasons.

Pekanbaru City, the capital of Riau Province, and other cities in the study area also suffer from the chronic shortage of water supply during dry seasons, particularly, municipal and industrial water supply. The problem on water shortage is further aggravated by the concentration of population in the urban areas and transmigration from Java Island.

Appropriate measures for flood damage and shortage of water supply in the study area including Pekanbaru City are indispensable to the economic development and stabilization of people's livelihood leading to the further economic development of not only the West Sumatra and Riau provinces but the whole of Indonesia as well. To this end, the Government of Indonesia had requested technical cooperation from the Government of Japan to carry out the Study on Kampar-Indragiri River Basin Development Project, hereinafter referred to as the Study.

1.2 Objectives of the Study

The Study has the following three objectives:

(1) To formulate the Overall Development Plan for the Kampar-Indragiri River Basin in which priority projects will be selected;

(2) To carry out a Feasibility Study for the priority projects selected through the study on the Overall Development Plan as the objectives requiring urgent solution; and,

(3) To transfer technology to government counterpart personnel concerned through the studies in Indonesia and in Japan.

1.3 Study Area

The Study Area is within the watershed boundaries of the Kampar and Indragiri rivers, covering about 50,000 km^2 which include parts of the West Sumatra and Riau provinces as tabulated below. Pekanbaru City, the capital of Riau Province, is included in the study area for the study on a water resources development plan to supply municipal, industrial and flushing water for drainage canals in the city (refer to Fig. S.1.1).

Unit: km^2

River Basin	West Sumatra Province	Riau Province	Total
Kampar	3,462	21,086	24,548
Indragiri	7,459	8,809	16,268
In-between Area	0	10,580	10,580
Total	10,921	40,475	51,396

2 PHYSICAL CHARACTERISTICS OF STUDY AREA

2.1 Topography

The study area of about 50,000 km^2 is situated in the central part of Sumatra Island and belongs to both the Riau and West Sumatra provinces. About five-sixths of the area belongs to Riau Province and the rest belongs to West Sumatra Province.

The Barisan range which is the backbone of Sumatra Island occupies the western part of the study area belonging to West Sumatra Province. The highest peak of the Barisan range in the study area is Mt. Merapi with elevation of 2,891 m above MSL (mean sea level).

The western slope of the Barisan range which is the outside boundary of the study area reaches the Indian Ocean with very steep slope. On the other hand, the eastern slope in the study area is rather gentle and extends eastward to the swamp area which had developed in the eastern part of the study area until the Malacca Strait.

The study area is divided into three areas: the western mountainous area with elevation above 100 m MSL which occupies one-third of the study area, the central hilly area with elevation between 100 m and 10 m MSL which occupies another one-third of the study area, and the eastern swamp area with elevation below 10 m MSL which occupies the rest.

2.2 Geology

The geology of the study area is as summarized below.

Sedimentation started in the Carboniferous-Permian times, with the deposition of clastic sediments (shale, quartzite, sandstone) and some limestone of the Kuantan formation. The formation is supposed to be 5,000 m thick. During the Upper Mesozoic these rocks have been subjected to folding, faulting and metamorphism, accompanied by granite and diorite intrusions. This activity was probably related to the Thai-Malayan orogenesis. The rocks of the Kuantan formation have been deformed and slightly metamorphosed (greenschist facies) at that time.

There are no Jurassic or Cretaceous rocks in this area. Therefore the idea of a long period of non-deposition has to be considered.

The Tertiary deformation is controlled by basement block faulting and wrenching (Sumatra Fault System). The development of a dextral wrench fault is consequent with the oblique subduction of the Indian Ocean Plate. The general result of the Tertiary to Quaternary period of faulting was the uplift of the Barisan volcanic arch and the development of the basin and range topography in the Barisan foothills. In the foothills, the grabens are filled by Tertiary sediments while the horsts expose pre-Tertiary basement. Examples can be seen in the Pekanbaru Quadrangle.

The oldest Tertiary formation in the study area is exposed only in the Barisan mountains. The sedimentation intensified during early Miocene, evidenced by large exposures of the Ombilin formation in the Barisan range and the Telisa formation in the foothills area, both consisting of marl, limestone and sandstone. Basalt and andesite flows in the Barisan range mark a new phase of tectonic activity during the Middle Miocene. At this time, the sedimentation stopped in the Barisan range.

Outcrops of the Pliocene Palembang formation, consisting of claystone, sandstone and tuff, can be found only in the foothills and the Central Basin.

The last major period of uplift and block faulting occurred during the Plio-Pleistocene. In the Barisan range, the volcanic activity is evidenced by the andesitic-basaltic breccias of the Malintang, Talong and Marapi mountains and the deposition of pumice tuff and volcanic ash, exposed in the area of Payakumbuh.

The uplift and subsidence continue to the present day in the foothills area. Further east, the subsidence results in large areas of alluvium, deep swamps and coastal deposits.

2.3 Meteorology

The study area is located in the Riau and West Sumatra provinces in the central part of Sumatra Island which lies along the Malayan Peninsula. This region is in the southern part of Southeast Asia and is in the Intertropical Zone. The climate of Southeast Asia is controlled by the Asian monsoons; hence, the climate of the study area is under the monsoon's influence.

Asian monsoons principally consist of four seasons, i.e., the two seasons named northeast monsoon season and southwest monsoon season and the two inter-monsoon periods of the above two seasons.

The northeast monsoon season, the wet season, lasts approximately from November to March and winds are in very constant direction. The average monthly rainfall in this season ranges from 200 mm to 500 mm in the mountainous areas and 200 mm to 300 mm in the middle reaches.

The period of southwest monsoon season is dry season which lasts from about June to September. The southwest monsoon is generally weaker than the northeast monsoon. The southwest wind is humidified by the Indian Ocean and causes rainfall on the western slope of the Barisan range which is outside the study area, but the weaker winds will not cause heavy rainfall. The average monthly rainfall in this season ranges from 100 mm to 200 mm both in the mountainous areas and the middle reaches.

2.4 Land Use

2.4.1 Present Land Use

The present land use in the study area is classified into seven categories, as summarized below.

Unit: %

Category	Kampar River Basin	Indragiri River Basin	In-between Area	Study Area
Forest	67.5	55.0	97.7	69.8
Bush and Grassland	7.0	7.9	0.8	6.0
Shifting Cultivation	3.8	4.9	0.3	3.4
Wetland Cultivation	1.6	4.4	0.5	2.3
Upland Cultivation	1.0	2.6	0.6	1.4
Tree Crops/ Estate	19.0	24.8	0.1	16.9
Settlement	0.1	0.4	0.0	0.2
Total	100.0	100.0	100.0	100.0

2.4.2 Future Land Use

The future land use plan (draft) has been prepared by the Regional Development Planning Bureau (BAPPEDA) in Riau and West Sumatra provinces, as summarized below.

Category	Total	
	Area (ha)	Ratio (%)
(1) Area to be Protected for Future Use	922,600	17.9
(2) Food Crop Farming, Animal Husbandry, Agro Industry Area	186,800	3.6
(3) Plantation Development Area	1,792,100	34.8
(4) Forestry Development Area	1,196,000	23.2
(5) Urban Development and Transmigration Settlement Area	71,300	1.4
(6) Area to be Developed in Accordance with Central Government Policy	31,400	0.6
(7) City Development Area	24,400	0.6
(8) Other Purpose Development Area	480,900	9.3
(9) Conservation Area	443,200	8.6
(a) Conservation Forest, Wildlife, Natural Resources	-	-
(b) Erosion Area	-	-
Total	5,148,700	100.0

3 SOCIO-ECONOMY

3.1 Development Policy

3.1.1 National Development Policy

In Indonesia, two national development plans are presently being implemented, the Second Long Term Development Plan and the Sixth Five-Year Development Plan.

(1) Second Long Term Development Plan

The Second Long Term Development Plan (PJP II) of 25 years from 1994 to 2019 is a continuing process aiming to create and develop a physically and mentally self-reliant nation. When these objectives are attained, GNP per capita will become around US$2,600 in 2019 which is almost four times the present, US$650.

(2) Sixth Five-Year Development Plan

The Sixth Five-Year Development Plan (REPELITA VI) is to be implemented from 1994 to 1999. Economic growth is projected at 6.2% per annum on average.

3.1.2 Regional Development Policy

The regional development policy is as described below.

(1) Second Long Term Development Plan

The target of the regional development plan in PJP II is a stable, real, dynamic, harmonious and responsible regional autonomy, as well as a more even development distribution along with its outputs in the frame of increasing public prosperity.

The target of economic development is to attain a speedy growth of the gross regional domestic product (GRDP) for the non-oil and -gas sector, which is estimated on annual average at approx. 3.7% for Riau Province and 7.6% for West Sumatra Province.

The social development targets are (1) to increase the degree of public health and nutrition; (2) to decrease the population growth rate; and, (3) to attain a steady distribution and increase of basic and vocational education quality.

(2) Sixth Five-Year Development Plan

The priority of the regional economic growth is put on the non-oil and -gas sector. The target of growth of the non-oil and -gas industry is set at 7.0% and 6.5% per annum for Riau and West Sumatra provinces, respectively.

3.2 Population

3.2.1 Present Population

The present population in Indonesia and the study area is described as below.

(1) Indonesia

The total population of Indonesia has increased from 119,208 thousand in 1971 to 179,379 thousand in 1990 with an average growth rate of 2.17% per annum.

(2) Study Area

The population of the study area was about 3,500,000 in 1982 and about 4,400,000 in 1991. The average growth rate in this period was 2.59% per annum.

3.2.2 Population Projection of Study Area

The future population in the study area is projected based on past statistical data and the national and regional development plans, PJP II and REPELITA VI. Projection is made for 25 years at five-year intervals from 1994 to 2019. The results of population projection are as summarized in the table below.

Unit: person

River Basin	1994	1999	2004	2009	2014	2019
Kampar	1,018,950	1,245,799	1,532,341	1,895,697	2,314,705	2,811,499
Indragiri	2,335,479	2,547,980	2,759,616	3,005,185	3,246,077	3,500,579
Total	3,354,429	3,793,779	4,291,957	4,900,882	5,560,782	6,312,078

4 OVERALL DEVELOPMENT PLAN

4.1 Basic Considerations

The basic considerations to formulate the Overall Development Plan are as follows:

- Target year is set at 2019 in accordance with the agreement between the Preparatory Study Team of JICA and the DGWRD, DPU;
- Future land use proposed in REPELITA VI is a basis for planning; and
- The proposed land use is to be realized by the year 2019.

4.2 Objective Area

(1) Flood Protection Areas

The areas considered for flood protection in the Kampar and Indragiri river basins are outlined below.

(a) Kampar River Basin

- Bangkinang and surrounding agricultural areas along the Kampar Kanan River.
- Agricultural areas and towns scattered along the Kampar Kiri River.
- Areas along the Kampar River.

(b) Indragiri River Basin

- Areas along the middle to lower reaches of Kuantan-Indragiri River.
- Payakumbuh, Solok and Sijunjung/Muara areas in the upper reaches.

(2) Water Demand Areas

The major demand areas for water resources development are outlined below.

(a) Kampar River Basin

- Irrigation water demand area proposed by DPU in Rantauberangin Irrigation Development Project.
- Domestic water demand area in Pekanbaru City.

(b) Indragiri River Basin

- Irrigation water demand area proposed by DPU in Lubukjambi Irrigation Development Project.

(3) Hydropower Generation Areas

Hydropower generation is basically considered to be subsidiary to flood control and water resources development. Hydropower generation is possible at the following dams:

(a) Kampar River Basin

- Kampar Kiri No. 1 Dam
- Kampar Kiri No. 2 Dam

(b) Indragiri River Basin

- Kuantan Dam
- Upper Sinamar Dam
- Sukam Dam

4.3 Selection of Possible Damsites

Through the study on potential water sources, the development of river surface water by construction of dams was identified as a possible water source in the study area. In addition, employment of dams as one of the countermeasures of flood control is considered.

From these considerations, construction of dams for flood control and water resources development is incorporated into the planning of facilities. As the first step for the

formulation of the Overall Development Plan, the following six dams are selected as possible dams. Their locations are as indicated on Fig. S.4.1.

- Kapoernan Dam
- Kampar Kiri No. 1 Dam
- Kampar Kiri No. 2 Dam
- Upper Sinamar Dam
- Sukam Dam
- Kuantan Dam

4.4 Flood Control Plan

4.4.1 Planning Criteria for Overall Development Plan

Target Year

For this project the target year is set at 2019.

Design Scale

The following table shows the design scales adopted to this project.

Unit: Year return period

Particulars	Initial Phase (Urban/Rural)	Final Phase
Kampar River System		
Kampar Kanan River	5 / 5	50
Kampar Kiri River	-	50
Kampar River after confluence	-	50
Indragiri River System		
Sinamar/Lampasi/Agam Rivers	10 / 10	50
Lembang River	10 / 10	50
Sukam/Palangki Rivers	10 / 10	50
Kuantan-Indragiri River	10 / 5	50

Standard Flood Discharge

Standard flood discharges which correspond to the design scales determined above are as follows.

River	Catchment Area (km^2)	Initial Phase		Final Phase	
		Return Period (Year)	Standard Flood Discharge (m^3/s)	Return Period (Year)	Standard Flood Discharge (m^3/s)
Kampar River System					
Kampar River at Bangkinang	3,337	5	2,800	50	4,000
Sibayang River	1,187	5	1,050	50	1,650
Singingi River	552	5	550	50	950
Kampar Kiri River	3,284	-	-	50	3,100
Kampar River at Langgam	12,284	-	-	50	6,800
Indragiri River System					
Kuantan River at Lubukjambi	7,453	5	3,900	50	6,550
Kuantan River at Peranap	10,885	5	4,300	50	6,800
Kuantan River at Japura	12,320	5	4,500	50	7,000
Sinamar River	1,278	10	1,550	50	2,100
Lembang River	359	10	500	50	1,000
Sukam River	360	10	700	50	1,050
Kuantan River at Muara	6,169	10	3,950	50	5,450

4.4.2 Premises for Flood Control Planning

Flood Control Effect of Kotapanjang Dam

The reservoir operation simulation for Kotapanjang Dam which is presently under construction by PLN was carried out for floods from 1971 to 1992. The simulation results show that the flood control effect of the Kotapanjang Dam cannot always be expected.

Indragiri-Gaung Floodway

DPU had conducted a feasibility study for the Kampar-Indragiri Zone for the canalization in the east coast of Sumatra. The floodway is proposed in this plan to divert a maximum discharge of 500 m^3/s from the Indragiri River to the Gaung River. Detail design has also been started for this floodway. Accordingly, this floodway is considered as a prerequisite for the present study.

4.4.3 Applicable Alternative Measures

For flood control, the following four measures are considered as applicable countermeasures:

- Construction of flood control dam;
- Improvement of existing river channel;
- Establishment of retarding basins; and,
- Construction of floodways.

4.4.4 Identification of Flood Control Plan

The following component projects of the Overall Development Plan have been formulated:

Component Project	Purpose	Note
Kampar River System		
Kampar Kanan River Flood Control Works	Single	
Kampar and Kampar Kiri River Flood Control Works	Multiple	Kampar Kiri No. 1 & No. 2 dams will be multipurpose dams.
Indragiri River System		
Kuantan-Indragiri River Flood Control Works	Multiple	Kuantan Dam will be a multipurpose dam.
Upper Indragiri River Flood Control Works		
- Payakumbuh Area	Single	
- Solok Area	Single	
- Sijunjung/Muara Area	Single	

4.4.5 Optimization of Flood Control Plan

The optimization of the single purpose flood control plans given in the table above has been studied as below.

Optimization of Kampar Kanan River Improvement Works

(1) Optimum Plan

The study on alternatives by employing the Kapoernan Flood Control Dam and the Kampar Kanan River Improvement as applicable measures has selected the Kampar River Improvement without Kapoernan Dam as the optimum flood control plan.

(2) Design Discharge

The design discharge of the Kampar Kanan River with a 50-year return period was estimated at 4,000 m^3/s.

(3) Optimum Alignment and Longitudinal Profile

The case with shortcut at heavily meandering portions was identified as the optimum case because of the least cost. In the optimum case, the average riverbed gradient is 1/2,820 and flow velocity is 1.6 to 2.5 m/s.

(4) Optimum Cross Section

The case that could assure flow capacity mainly by embankment, with excavation at only extremely narrow sections, is selected as the optimum cross section. The river width and height of high water level from the present land elevation of the case are 300 m and 2.6 m, respectively.

Optimization of Kampar and Kampar Kiri River Improvement Works

(1) Alternative Measures

In this project, the following facilities are considered as applicable measures.

- Kampar Kiri No. 1 Multipurpose Dam
- Kampar Kiri No. 2 Multipurpose Dam
- Retarding Basin in the downstream stretch of the Kampar Kiri River
- River improvement of the Kampar and Kampar Kiri Rivers

(2) Optimum Plan

Since the Kampar Kiri No. 1 and No. 2 dams are employed for both flood control and hydropower generation purposes, the optimum flood control plan was selected through a study on alternative cases with the above measures.

(a) Optimum Plan of Dam

The optimum capacity allocation for the Kampar Kiri No. 1 and No. 2 dams was determined, as tabulated below.

Unit: $10^6 m^3$

Capacity	Kampar Kiri No. 1 Dam	Kampar Kiri No. 2 Dam
Flood Control	250	150
Hydropower Generation	646	438
Dead Storage	1,350	1,612
Gross Storage	2,246	2,200

(b) Retarding Basin

In accordance with the land use plan of REPELITA VI, the area along the Kampar Kiri River in the stretch upstream from the confluence with the Kampar Kanan River is designated as forest area. The flow capacity of the present channel in this section is very small and this area is always inundated. Accordingly, this area has been considered as a natural retarding basin.

(3) Design Discharge

The design discharges of 50-year return period for the river improvement works are estimated as below.

Sibayang River (Kiri No. 1 Dam)	500 m^3/s
Singingi River (Kiri No. 2 Dam)	150 m^3/s
Kampar Kiri River	1,450 m^3/s
Kampar River	4,850 - 5,100 m^3/s

(4) Optimum Alignment and Longitudinal Profile

The following stretches are considered for river improvement.

- Sibayang River
- Singingi River
- Kampar Kiri River
- Kampar River

River improvement works are not required for both the Sibayang and Singingi rivers because the Sibayang River has enough flow capacity at present and a forest area exists along the Singingi River.

The optimum alignment and longitudinal profile under the design discharges mentioned above are selected through a study on alternative cases as below.

(a) Kampar Kiri River

Alignment	The present alignment has been basically maintained since wider channel can be considered by application of one side bank.
Longitudinal Profile	Basically follow the present profile.

(b) Kampar River

Alignment	To create smoother channels by shortcut at heavily meandering points.
Longitudinal Profile	Determined on the basis of the new alignment: 1/5,500 - 1/17,000 (Average: 1/11,000).

(5) Optimum Cross Section

The following cross sections are selected:

Kampar Kiri River	
Lipat Kain - Kampung Dalam	Left bank only
Kampar River	
Langgam - Kerinci	B = 600 m
Kerinci - downstream	Right bank only

<u>Optimization of Flood Control Facilities for Middle and Lower Reaches of Indragiri River</u>

The optimization of flood control facilities for the middle and lower reaches of the Indragiri River is described below.

(1) Applicable Measures

The following facilities are considered as applicable measures.

- Kuantan Dam
- Upper Sinamar Dam

- Sukam Dam
- Retarding Basin in the stretch downstream from Japura of the Indragiri River
- River Improvement of Kuantan and Indragiri Rivers

(2) Optimum Scale of Dam

In a study on alternative cases with the combination of the above three dams, only the Kuantan Dam is employed for flood control purpose. Since the Kuantan Dam is developed as a multipurpose dam, the optimization study has been conducted as presented in the latter part and the optimum allocation of reservoir capacity is decided as below.

Capacity Allocation of Kuantan Dam

Flood Control	$400 \times 10^6 m^3$
Hydropower Generation	$415 \times 10^6 m^3$
Irrigation	$117 \times 10^6 m^3$
River Maintenance	$213 \times 10^6 m^3$
Dead Storage	$425 \times 10^6 m^3$
Gross Storage	$1,570 \times 10^6 m^3$

(3) Retarding Basin

In accordance with the land use plan of REPELITA VI, the left bank area along the Indragiri River in the stretch downstream from Japura is designated as forest area and non-designated area. Accordingly, this area can be considered as a retarding basin. The design discharge of this section can be decreased by 500 m^3/s, by applying this area as the retarding basin.

Since the future land use in this area is forest, no benefit is obtained even if the area is not considered as a retarding basin and protected from floods. Accordingly, this retarding basin is taken into consideration.

(4) Design Discharge

The design discharges for river improvement works of the Kuantan-Indragiri River are as follows:

Kuantan Dam - Peranap	3,200 m^3/s
Peranap - Japura	5,400 m^3/s
Japura - River Mouth	5,050 m^3/s

(5) Optimum Alignment and Longitudinal Profile

Alignment and longitudinal profile are as follows:

Alignment	To create smoother channels by shortcut at heavily meandering points.
Longitudinal Profile	Determined on the basis of the new alignment: 1/2,400 - 1/5,000 (Average: 1/3,400).

(6) Optimum Cross Section

The following cross sections are selected.

Lubukjambi - Peranap	B = 300 m
Peranap - Japura	B = 600 m
Japura - Downstream	Right bank only (Left bank is proposed as a retarding basin)

Optimization of Flood Control Structure for Payakumbuh Area

The following three rivers in Payakumbuh Area have been studied:

- Sinamar River
- Agam River
- Lampasi River

(1) Applicable Measures

Since there is no suitable site for dams, retarding basins and floodways in the Payakumbuh area, river improvement only is the applicable measure.

(2) Design Discharge

The design discharges for river improvement works are as follows:

Sinamar River	490 - 2,100 m^3/s
Agam River	1,100 m^3/s
Lampasi River	650 m^3/s

(3) Optimum Alignment and Longitudinal Profile

The optimum alignment has been determined to basically follow the present alignment and shortcut on the heavily meandering part. The proposed longitudinal gradients are as follows:

Sinamar River	1/450 - 1/2,050
Agam River	1/1,000
Lampasi River	1/600

(4) Optimum Cross Section

The case that assures flow capacity by a combination of excavation and embankment is selected as the optimum case.

Optimization of Flood Control Structure for Solok Area

The following two rivers in Solok Area have been studied:

- Lembang River
- Sumani River

(1) Applicable Measures

Since there is no suitable site for dam construction and retarding basin, river improvement and floodway are applied as alternatives. After a comparative study, river improvement without floodway is selected as the optimum case.

(2) Design Discharge

The design discharges for river improvement works are as follows:

Lembang River	1,000 m^3/s
Sumani River	700 m^3/s

(3) Optimum Alignment and Longitudinal Profile

The optimum alignment has been determined to basically follow the present alignment and shortcut on the heavily meandering part. The proposed longitudinal gradients are as follows:

Lembang River	1/140 - 1/1,480
Sumani River	1/800

(4) Optimum Cross Section

The excavated channel is applied to the Lembang River for the upstream stretch from the 11 km point from Singkarak Lake. For the stretch downstream from the same point, normal section with embankment and channelization as determined for the Sinamar River is applied.

Optimization of Flood Control Facilities for Sijunjung/Muara Area

The following three rivers in Sijunjung/Muara Area have been studied:

- Sukam River
- Palangki River
- Kuantan River

(1) Applicable Measures

The following works are considered as applicable for the Sijunjung/Muara area. There is no suitable site for retarding basin and floodway.

- Sukam Dam
- River Improvement

Through a comparative study, river improvement without Sukam Dam is selected.

(2) Design Discharge

The design discharges based on the standard flood discharge of 50-year return period have been determined as follows:

Sukam River	1,050 m^3/s
Palangki River	2,060 m^3/s
Kuantan River	5,450 m^3/s

(3) Optimum Longitudinal Profile

The proposed longitudinal gradients are as follows:

Sukam River	1/650 - 1/1,400
Palangki River	approx. 1/1,500

(4) Optimum Cross Section

Normal section with embankment and channelization of low water channel as determined for the Sinamar River is applied.

4.5 Irrigation Development Plan

4.5.1 Basic Concept for Planning

The Irrigation Development Plan is formulated to grasp future irrigation water demand for objective irrigation areas and to plan irrigation facilities for areas already developed as farmland but have water deficit and areas with newly established development plans but with no irrigation facilities constructed yet. Planning for new farmland development is not included in this study.

4.5.2 Identification of Objective Development Areas

Out of the existing development plans, the areas of the Rantauberangin Irrigation Development Project in the Kampar river basin (total irrigable area is 40,000 ha) and the Lubukjambi Irrigation Development Project in the Indragiri river basin (total irrigable area is 50,000 ha) are selected as the objective development areas. Among these areas, the objective irrigable areas where irrigation water is to be supplied are as follows:

(1) Rantauberangin Irrigation Area

Unit: ha

Area	Left Bank	Right Bank	Total
Existing Irrigation Scheme Area	5,171	4,338	9,509
Net Additional Area	10,517	277	10,794
Total	15,688	4,615	20,303

(2) Lubukjambi Irrigation Area

Unit: ha

Area	Left Bank	Right Bank	Total
Existing Irrigation Scheme Area	4,142	2,230	6,372
Net Additional Area	12,875	10,902	23,777
Total	17,017	13,132	30,149

4.5.3 Necessary Facilities for Irrigation Development Plan

(1) Intake Weir

(a) Rantauberangin Irrigation Area

Water released from the Kotapanjang Dam is used for the Rantauberangin Irrigation Area. To regulate the released water and to intake water to irrigation canals, the Kuok Intake Weir is proposed.

(b) Lubukjambi Irrigation Area

Water developed by the proposed Kuantan Dam is used for the Lubukjambi Irrigation Area. To regulate the released water and to intake water to irrigation canals, the Lubukjambi Intake Weir is proposed.

(2) Main Irrigation Canal

The main irrigation canals proposed for the two irrigation areas are as summarized below.

Unit: km

Irrigation Area	Left Bank	Right Bank	Total
Rantauberangin	84	40	124
Lubukjambi	119	123	242

4.5.4 Irrigation Water Requirement

The future irrigation water requirement in both irrigation areas was estimated under double-cropping condition and through the optimization study of cropping pattern. The optimum cropping pattern with minimum water requirement has been identified, as shown below.

Unit: m^3/s

Irrigation Area	Left Bank	Right Bank	Total
Rantauberangin	20.69	4.80	25.49
Lubukjambi	19.31	17.62	36.93

4.5.5 Selection of Irrigation Area for Priority Projects

Among the irrigation areas proposed for the Overall Development Plan, priority project areas have been selected in consideration of higher economic viability. The selected priority project areas are summarized below.

(1) Rantauberangin Irrigation Area

Unit: ha

Area	Left Bank	Right Bank	Total
Existing Irrigation Scheme Area	5,171	4,338	9,509
Net Additional Area	4,429	277	4,706
Total	9,600	4,615	14,215

(2) Lubukjambi Irrigation Area

Unit: ha

Area	Left Bank	Right Bank	Total
Existing Irrigation Scheme Area	4,142	-	4,142
Net Additional Area	5,234	-	5,234
Total	9,376	-	9,376

4.6 Water Resources Development Plan

4.6.1 Water Source

River water, groundwater, spring water and lake water in the study area are considered as the water supply sources. Development of river water by the construction of dam only is evaluated to have enough supply capacity for the future water demand in the study area.

4.6.2 Future Water Demand

The future water demand in the study area was studied for the following ten sectors with 2019 as the target year.

- Irrigation
- Domestic Water
- Industry
- Inland Fishery
- Livestock
- Tourism
- Urban Area Flushing
- Hydropower Generation
- River Navigation
- River Maintenance Flow

The future peak water demand forecasted by sector is summarized below. The average annual growth rate of total water demand excluding the river maintenance flow is 7.6% in the Kampar river basin and 3.2% in the Indragiri river basin.

Unit: m^3/sec

River Basin	1994	1999	2004	2009	2014	2019
Kampar	308.32 (13.74)	321.92 (27.34)	332.94 (38.36)	344.19 (49.61)	356.10 (61.52)	367.35 (72.77)
Indragiri	297.34 (150.93)	318.24 (171.83)	328.88 (182.47)	339.29 (192.88)	349.94 (203.53)	359.95 (213.54)

Note: Figures in parentheses indicate water demand excluding river maintenance flow.

4.6.3 Water Balance Analysis

The maximum annual deficit obtained for the simulation period from 1981 to 1992 is summarized below. The sub-basins not given in the table have no water deficit.

Unit: $10^6 m^3$

Kampar River Basin		Indragiri River Basin	
Sub-basin	Max. Annual Deficit Volume	Sub-basin	Max. Annual Deficit Volume
K-2	89.1	I-1	57.2
		I-2	13.1
		I-3	13.3
		I-5	11.0
		I-6	272.8

4.6.4 Overall Water Resources Development Plan

Kampar River Basin

(1) Major Water Demand Areas

Major water demand areas were identified at the Rantauberangin Irrigation Development Project area which requires a maximum of 25.49 m^3/s in 2019 and Pekanbaru City which requires 10.90 m^3/s in 2019. No water deficits appear in the other sub-basins.

(2) Formulation of Water Resources Development Plan

Since the major demand areas of Rantauberangin Irrigation Development Project and Pekanbaru City are situated downstream of the Kotapanjang Dam which is presently under construction by PLN, water released from the dam could be utilized for water supply to these areas by construction of the Kuok Intake Weir on the Kampar Kanan River at the uppermost reaches of the Rantauberangin area.

On the other hand, it is difficult to use the Kampar Kiri No. 1 and No. 2 dams for water supply to the above water demand areas due to their far location. Therefore, they should be independently developed. The expected benefit by these dams is of flood control and hydropower generation because the water demand downstream from these dams is as small as 1 m^3/s.

Therefore, the water resources development plan in the Kampar river basin is formulated as follows:

Water Resources Development Plan	Purpose
Kampar Kanan Water Supply Project	Irrigation water supply to Rantauberangin Irrigation Project and supply of domestic water, etc., to Pekanbaru City. (Single Purpose)
Kampar Kiri No. 1 Dam Construction Works	Flood control and hydropower generation. (Multiple Purpose)
Kampar Kiri No. 2 Dam Construction Works	Flood control and hydropower generation. (Multiple Purpose)

Indragiri River Basin

(1) Major Water Demand Area

The major water demand area is identified at Lubukjambi Irrigation Development Project area which requires a maximum of 48.03 m^3/s in 2019.

(2) Formulation of Water Resources Development Plan

Since only the Kuantan Dam has enough reservoir capacity for water supply to the Lubukjambi Irrigation Development Project area and maintenance flow for the downstream of the dam, it is selected as a water source dam for the Indragiri river basin.

Since the flood control and water resources development plans are formulated as multipurpose projects by using the Kuantan Dam, the optimum scale of the dam as a multipurpose development project has been studied. The optimization study has been conducted as presented in the latter part and the optimum storage capacity of the Kuantan Dam and the allocation for each purpose are determined as follows:

Flood Control	$400 \times 10^6 m^3$
Hydropower Generation	$415 \times 10^6 m^3$
Irrigation	$117 \times 10^6 m^3$
River Maintenance Flow	$213 \times 10^6 m^3$
Dead Storage	$425 \times 10^6 m^3$
Total	$1{,}570 \times 10^6 m^3$

4.7 Hydropower Development Plan

4.7.1 Basic Planning Concept

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 development projects, the possibility of hydropower development are taken into account.

Hydropower development is planned for the following three dams employed in the Overall Development Plan:

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

4.7.2 Necessity of Electric Power Development in Study Area

Presently, the power supply capacity cannot meet the demand in Region III, especially Pekanbaru City. Even though PLN is constructing three major power stations in the study area, demand will exceed the supply capacity in 2005. After 2005, the additional demand shall have to be met from other regions through interconnection network. To reduce power supply from other regions, development of a power generation plan for the region is necessary.

4.7.3 Overall Development Plan of Hydropower Generation

A study on development scale alternatives has been carried out and the optimum development plan has been decided. The results of the study are summarized below.

Particulars	Unit	Kampar Kiri No. 1 Dam	Kampar Kiri No. 2 Dam	Kuantan Dam
Dam Height	m	103	95	73
Necessary Storage Capacity for Hydropower Generation	$10^6 m^3$	646	438	527
Installed Capacity	MW	131	40	114

4.8 Formulation of Multipurpose Development Projects

4.8.1 Project Components

The Overall Development Plan has five project components, three in the Kampar River System and two in the Indragiri River System. The projects consist of three single purpose and two multipurpose projects of flood control and water resources development as shown in the table below (refer to Fig. S.4.2).

Name of Project	Purpose
Kampar River System	
(1) Kampar Kanan Water Supply Project	Single
(2) Kampar Kanan River Improvement Project	Single
(3) Kampar and Kampar Kiri River Development Project	Multiple
Indragiri River System	
(1) Indragiri River Development Project	Multiple
(2) Upper Indragiri River Improvement Project	Single

As shown in the table above, the following two projects are multipurpose development projects of flood control and water resources development.

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

4.8.2 Optimization for Kampar and Kampar Kiri River Development Project

Optimization for Kampar and Kampar Kiri River Development Project has been carried out as discussed below.

(1) Purposes of the Project

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

(2) Major Facilities to be Studied

- Kampar Kiri No. 1 Dam
- Kampar Kiri No. 2 Dam
- River improvement of Kampar and Kampar Kiri rivers

(3) Alternative Cases

Alternative cases are established by the combination of reservoir capacity of the two dams and the design discharges for the improvement of the Kampar and Kampar Kiri rivers. A natural retarding basin at the downstream of Kampar Kiri River is taken into consideration in all alternative cases.

(4) Optimum Plan

The alternative case in which the Kampar Kiri No. 1 and No. 2 dams have the reservoir capacity of $2,246\times10^6m^3$ and $2,200\times10^6m^3$, respectively, has been identified to have the minimum cost.

The major features of the optimum plan are summarized below.

(1) Kampar Kiri No. 1 Dam	
(a) Capacity Allocation	
Flood Control	$250 \times 10^6m^3$
Hydropower Generation	$646 \times 10^6m^3$
Dead Storage	$1,350 \times 10^6m^3$
Total	$2,246 \times 10^6m^3$
(b) Water Level	
Surcharge Water Level	EL 128.5 m
Normal Water Level	EL 125.0 m
Low Water Level	EL 113.9 m
(c) Flood Control	
Control Method	Non-gated Control
(2) Kampar Kiri No. 2 Dam	
(a) Capacity Allocation	
Flood Control	$150 \times 10^6m^3$
Hydropower Generation	$438 \times 10^6m^3$
Dead Storage	$1,612 \times 10^6m^3$
Total	$2,200 \times 10^6m^3$
(b) Water Level	
Surcharge Water Level	EL 136.9 m
Normal Water Level	EL 135.0 m
Low Water Level	EL 128.0 m
(c) Flood Control	
Control Method	Non-gated Control
(3) Design Discharge	
(a) Kampar Kiri River	
Lipat Kain	$1,450\ m^3/s$
(b) Kampar River	
Langgam - Kerinci	$4,850\ m^3/s$
Kerinci - River Mouth	$5,100\ m^3/s$

4.8.3 Optimization for Indragiri River Development Project

The optimization for Indragiri River Development Project is as discussed below.

(1) Purposes of the Project

- Flood control of the middle and lower reaches of the Kuantan-Indragiri River;
- Irrigation water supply to Lubukjambi Irrigation Project; and
- Hydropower generation at proposed dams.

(2) Major Facilities to be Studied

- Kuantan Dam
- Upper Sinamar Dam
- Sukam Dam
- Improvement of the Kuantan-Indragiri River

(3) Alternative Cases

Alternative cases are established by the combination of reservoir capacity of the three dams proposed and design discharges for the Indragiri River. In allocating the reservoir capacity of the three dams for flood control, water resources development and hydropower generation, the Upper Sinamar and Sukam dams are not allocated any flood control capacity because of the little effect of flood control by their small catchment areas and reservoir capacities. The Kuantan Dam only is allocated a flood control capacity.

(4) Optimum Plan

The alternative case in which the Kuantan Dam only is employed and the other two dams are excluded, is selected as the optimum plan in due consideration of cost and benefit and number of houses to be evacuated.

The major features of the Kuantan Dam and design discharge of Indragiri River are as summarized in the tables below.

(a) Major Features of Kuantan Dam

Capacity Allocation	
Flood Control	$400 \times 10^6 m^3$
Hydropower Generation	$415 \times 10^6 m^3$
Irrigation	$117 \times 10^6 m^3$
River Maintenance	$213 \times 10^6 m^3$
Dead Storage	$425 \times 10^6 m^3$
Gross Storage	$1,570 \times 10^6 m^3$
Water Level	
Surcharge Water Level	EL 120.0 m
Normal Water Level	EL 115.2 m
Low Water Level	EL 102.0 m
Flood Control	
Control Method	Constant Rate Discharging Method
Control Starting Discharge	500 m^3/s
Constant Rate	0.440

(b) Design Discharge of Indragiri River

Kuantan Dam - Peranap	3,200 m^3/s
Peranap - Japura	5,400 m^3/s
Japura - River Mouth	5,050 m^3/s (Indragiri Retarding Basin and Gaung Floodway are considered.)

4.9 Possible Maximum Development Amount of Water Resources

The governments of both Indonesia and Singapore executed a Memorandum of Understanding in August 1990 on the export of water from Indonesia to Singapore. The export amounts agreed so far are as follows:

- 31.25 m^3/s from Riau Province by the year 2010.
- 52.6 m^3/s from Sumatra by the year 2090.

Three dams are proposed in the Overall Development Plan in this Study, as follows:

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

To study the possibility of water export to Singapore from the study area, the possible maximum development amount of water resources is estimated by employing the

above three dams together with the Kotapanjang Dam which is presently under construction by PLN. The results of estimation show that 103 m^3/s of the possible maximum development amount of water resources is expected from the study area. Of the 103 m^3/s from the study area, 81 m^3/s is expected from the Kampar river basin, and 22 m^3/s from the Indragiri river basin.

As mentioned before, six possible damsites have been identified in this Study and the three dams mentioned above have been taken up for the Overall Development Plan of the study area from the economical point of view. However, if economical, environmental and social matters are put aside, about 25 m^3/s could be additionally obtained although the development cost may be high.

4.10 Project Cost Estimate

Conditions for Cost Estimate

Project cost has been estimated based on the following concept:

- All unit costs are based on the price level as of July 1994.
- Currency conversion rates are assumed at US$1.00 = Rp. 2,175 and ¥1.00 = Rp. 21.90 as of July 1994.
- Project cost is composed of construction base cost, compensation cost, administration cost, engineering cost, price contingency, physical contingency and value added tax.

The estimated financial project costs of the five project components are summarized in the table below.

Unit: Rp. 10^6

Project	F.C.	L.C.	Total
(1) Kampar Kanan Water Supply Project	155,256	127,068	282,324
1-1 Kuok Intake Weir/Rantauberangin Irrigation System Construction Works (Initial Phase)	107,874	87,942	195,816
1-2 Rantauberangin Irrigation System Construction Works (Final Phase)	47,382	39,126	86,508

(2) Kampar Kanan River Improvement Project	444,751	423,859	868,610
2-1 Bangkinang Area River Improvement Works (Initial Phase)	126,915	120,397	247,312
2-2 Bangkinang Area River Improvement Works (Final Phase)	45,135	59,125	104,260
2-3 Lower Kampar Kanan River Improvement Works (Initial Phase)	216,755	181,406	398,161
2-4 Lower Kampar Kanan River Improvement Works (Final Phase)	55,946	62,931	118,877
(3) Kampar and Kampar Kiri River Development Project	1,018,100	793,692	1,811,792
3-1 Kampar Kiri No. 1 Dam Construction Works	379,796	274,195	653,991
3-2 Kampar Kiri No. 2 Dam Construction Works	158,568	143,113	301,681
3-3 Kampar Kiri River Improvement Works	50,113	33,800	83,913
3-4 Kampar River Improvement Works	429,623	342,584	772,207
(4) Indragiri River Development Project	1,328,732	1,172,919	2,501,651
4-1 Kuantan River Multipurpose Development Project	503,705	422,283	925,988
4-1-1 Kuantan Dam Construction Works	256,976	210,292	467,268
4-1-2 Lubukjambi Intake Weir / Irrigation System Construction Works (Initial Phase)	100,591	85,693	186,284
4-1-3 Lubukjambi Intake Weir / Irrigation System Construction Works (Final Phase)	146,138	126,298	272,436
4-2 Kuantan-Indragiri River Improvement Project	825,027	750,636	1,575,663
4-2-1 Lubukjambi-Peranap Area River Improvement Works	275,053	290,878	565,931
4-2-2 Peranap-Japura Area River Improvement Works	338,925	304,315	643,240
4-2-3 Rengat Area Flood Protection Works (Initial Phase)	21,704	17,932	39,636
4-2-4 Rengat Area Flood Protection Works (Final Phase)	189,345	137,511	326,856

(5) Upper Indragiri River Improvement Project	360,022	307,215	667,237
5-1 Payakumbuh Area River Improvement Works (Initial Phase)	131,335	99,581	230,916
5-2 Payakumbuh Area River Improvement Works (Final Phase)	63,799	63,523	127,322
5-3 Solok Area River Improvement Works (Initial Phase)	52,499	41,410	93,909
5-4 Solok Area River Improvement Works (Final Phase)	16,793	26,489	43,282
5-5 Sijunjung/Muara Area River Improvement Works (Initial Phase)	72,077	54,586	126,663
5-6 Sijunjung/Muara Area River Improvement Works (Final Phase)	23,519	21,626	45,145
Grand Total	3,306,861	2,824,753	6,131,614

Note: Price Contingency is not included.

4.11 Implementation Schedule

Based on the construction schedule of each project, the implementation schedule of the Overall Development Plan has been prepared by placing higher priority on projects that satisfy the following conditions (refer to Fig. S.4.3):

- Urgency in implementation to mitigate flood damage;
- Higher economic efficiency and less negative social impact to be expected with the implementation; and
- Contribution to existing or other ongoing projects of the Indonesian Government.

4.12 Economic Evaluation

4.12.1 Basic Conditions for Evaluation

Flood Control Plan

The basic conditions for the economic evaluation of the Flood Control Plan are as follows:

- Design scale is 50-year return period.
- Annual average benefit or potential flood damage is calculated by the mesh unit based on LANDSATanalysis data;
- Final completion year is fixed at the year 2019 which is the final year of the Second Long Term Development Plan (PJP II), and project life is assumed at 50 years, considering the durable life of facilities to be installed and other similar projects in Indonesia;
- Project benefit is estimated on the projected development stage in 2019 in accordance with the final completion year; and
- Currency conversion rates are assumed at US$1.00 = Rp. 2,175 and ¥1.00 = Rp. 21.90 as of July 1994.

Water Resources Development Plan

The water demand in 2019 are forecasted for ten categories. Four out of the ten categories; namely, (1) domestic water, (2) industrial water, (3) tourism, and (4) urban area flushing water are called public water, and the benefits of public water and irrigation water are estimated. The benefit of hydropower use are estimated separately, and the remaining four categories are not included in the estimation of benefit because they are not expected to bring any monetary benefit.

Basic conditions for economic evaluation of the Water Resources Development Plan are the same as those of the Flood Control Plan above except the second condition.

Hydropower Development Plan

The economic evaluation on the Hydropower Development Plan is conducted for Kampar Kiri No. 1 Dam, Kampar Kiri No. 2 Dam and Kuantan Dam which are proposed as multipurpose dams.

Basic conditions for economic evaluation of the Hydropower Development Plan are the same as those of the Water Resources Development Plan mentioned above.

4.12.2 Economic Benefit

Flood Control Plan

Flood control benefit is defined as the reduction of inundation damage attributed to the proposed works. The reduction is obtained as the difference between the estimated inundation damage under the with- and the without-the-project situations.

Inundation damage consists of direct and indirect damages. Direct damages concern the following items:

- Agricultural and aquacultural products;
- Residential, industrial and business houses and buildings; and
- Public facilities.

Damage is calculated for five cases of floods, 2-, 5-, 10-, 25- and 50-year return periods of with- and without-the-project situations. The estimated benefit of the Flood Control Plan is summarized in the table below.

Flood Control Project	Average Annual Benefit (Rp. 10^6)
(1) Kampar Kanan River Improvement Project	
- Bangkinang Area River Improvement Works	38,342
- Lower Kampar Kanan River Improvement Works	51,846
(2) Kampar and Kampar Kiri River Improvement Project	
- Kampar Kiri River Improvement Works	7,250
- Kampar Kiri No. 1 Dam	3,259
- Kampar Kiri No. 2 Dam	480
- Kampar River Improvement Works	35,298
(3) Indragiri River Development Project / Kuantan-Indragiri River Improvement Project	
- Lubukjambi-Peranap Area River Improvement Works	69,763
- Peranap-Japura Area River Improvement Works	58,833
- Rengat Area Flood Protection Works	36,536
(4) Upper Indragiri River Improvement Project	
- Payakumbuh Area River Improvement Works	43,556
- Solok Area River Improvement Works	34,453
- Sijunjung/Muara Area River Improvement Works	12,420

Water Resources Development Plan

The benefit of the Water Resources Development Plan consists of the following:

(1) Public Water

The benefit of public water is estimated as the economic price of raw water at intake points. The unit price of raw water is assumed at Rp. 46.3 /m^3. However, the unit price of raw water for urban area flushing is 60% of Rp. 46.3/m^3.

Kuok Intake Weir will start to supply public water at 4.78 m^3/s in 2004 and gradually increases as the demand increases until 10.90 m^3/s in 2019, and generate the average annual benefit of Rp. 5,075×10^6 at 4.78 m^3/s and Rp. 12,230×10^6 at 10.90 m^3/s.

(2) Irrigation Water

The annual benefit of Rantauberangin Irrigation Area are estimated at Rp. 17,723×10^6, as follows:

Kind of Paddy Field	Unit Benefit (Rp. 1,000/ha)	Initial Phase (Start from 2005)		Final Phase (Start from 2010)	
		Area (ha)	Average Annual Benefit (Rp. 10^6)	Area (ha)	Average Annual Benefit (Rp. 10^6)
Existing	306.1 (30%)	3,659	1,120.0	0	0
Existing (Rainfed)	612.2 (60%)	928	568.1	0	0
Existing (Undeveloped)	1,020.3 (100%)	4,922	5,021.9	0	0
Incremental	1,020.3 (100%)	4,706	4,801.5	6,088	6,211.6
Total		14,215	11,511.5	6,088	6,211.6

The annual benefit of Lubukjambi Irrigation Area has been estimated at Rp. 28,306×10^6, as shown in the table below.

Kind of Paddy Field	Unit Benefit (Rp. 1,000/ha)	Initial Phase (Start from 2005)		Final Phase (Start from 2015)	
		Area (ha)	Average Annual Benefit (Rp. 10^6)	Area (ha)	Average Annual Benefit (Rp. 10^6)
Existing	306.1 (30%)	1,670	511.2	1,515	463.7
Existing (Rainfed)	612.2 (60%)	376	230.2	65	39.8
Existing (Undeveloped)	1,020.3 (100%)	2,096	2,138.5	650	663.2
Incremental	1,020.3 (100%)	5,234	5,340.3	18,543	18,919.4
Total		9,376	8,220.2	20,773	20,086.1

Hydropower Development Plan

The benefit of the Hydropower Development Plan is the cost of alternative facilities. The alternative facilities are assumed as a hypothetical thermal power plant with the same capacity as the hydropower plant.

The cost of a thermal power plant is estimated as the sum of kWh value and kW value. The unit kWh and kW values have been assumed as follows based on actual past records of thermal power plants in Sumatra Island and through the discussion with PLN officials.

kWh value	US$0.0178/kWh	Rp. 38.715
kW value	US$318.14/kW (> 50,000 kW)	Rp. 691,955
	US$391.66/kW (< 50,000 kW)	Rp. 851,861

The estimated benefit of hydropower is summarized below.

Project	Starting Year	Energy Value		Power Value		Annual Benefit (Rp. 10^6)
		Energy Output (GWh)	kWh Value (Rp. 10^6)	Installed Capacity (MW)	kW Value (Rp. 10^6)	
Kampar Kiri No. 1 Dam	2010	398.5	15,428	121.2	83,865	99,293
Kampar Kiri No. 2 Dam	2016	128.3	4,967	38.2	32,541	37,508
Kuantan Dam	2005	583.4	22,586	94.4	65,321	87,907
	2015	657.0	25,436	103.6	71,687	97,123

4.12.3 Economic Cost

The economic costs of projects of the Overall Development Plan are as follows:

Project	Economic Cost (Rp. 10^6)
(1) Kampar Kanan Water Supply Project	234,606
(2) Kampar Kanan River Improvement Project	719,397
(3) Kampar and Kampar Kiri River Improvement Project	1,501,603
(4) Indragiri River Development Project	2,073,459
(5) Upper Indragiri River Improvement Project	553,387

4.12.4 Economic Evaluation on Overall Development Plan

The EIRR, B/C and NPV have been estimated as below.

Project	EIRR (%)	B/C	NPV (Rp. 10^6)
(1) Kampar Kanan Water Supply Project	9.82	0.98	- 2,300
(2) Kampar Kanan River Improvement Project	10.30	1.03	7,592
(3) Kampar and Kampar Kiri River Development Project	12.46	1.23	71,146
(4) Indragiri River Development Project	13.19	1.33	222,775
(5) Upper Indragiri River Improvement Project	10.55	1.07	15,851
(6) All Overall Development Projects	11.90	1.20	314,967

4.13 Selection of Priority Projects

4.13.1 Criteria for Selection

The priority projects to be studied further in the Feasibility Study were selected from the Overall Development Plan under the following criteria.

- High Economic Viability
- Urgent Requirement
- Less Social and Environmental Impacts

4.13.2 Identification of Priority Projects

Based on the criteria for selection mentioned in the preceding section, the following have been identified as priority projects.

Kampar River Basin

- Kampar Kanan Water Supply Project
- Bangkinang Area River Improvement Works

Indragiri River Basin

- Kuantan River Multipurpose Development Project
- Rengat Area Flood Protection Works

4.13.3 Cost for Priority Projects

The financial costs of priority projects are as summarized in the following table.

Priority Projects	Financial Cost (Rp. 10^6)
(1) Kampar Kanan Water Supply Project (Initial Phase)	195,816
(2) Bangkinang Area River Improvement Works (Initial Phase)	247,312
(3) Kuantan River Multipurpose Development Project (Initial Phase)	740,325
(4) Rengat Area Flood Protection Works	40,295
Total	1,223,748
(in ¥10^6) (¥1.00 = Rp. 21.90)	55,879
(in US$$10^6$) (US$1.00 = Rp. 2,175)	563

Note: Financial costs include Physical Contingency and Value Added Tax. Price Contingency is excluded.

5 FEASIBILITY STUDY

5.1 General

5.1.1 Objective Priority Projects

The objective priority projects for feasibility study are as follows:

- Kampar Kanan Water Supply Project
- Bangkinang Area River Improvement Works
- Kuantan River Multipurpose Development Project
- Rengat Area Flood Protection Works

5.1.2 Basic Conditions

Target Year for Planning

The target year for planning is set at 2019, same as the Overall Development Plan. This target year is used to determine water demand in the future.

Target Completion Year

The target year for completion of priority projects is set at 2004. The year 2004 is the last year of the Seventh Five-Year Development Plan (REPELITA VII). The

implementation period of nine years (1996-2004) is deemed appropriate by the feasibility study.

Cost Estimate

Cost estimate has been conducted on the same conditions as the Overall Development Plan, i.e., the cost is as of July, 1994 and currency conversion rates are assumed at US$1.00 = Rp. 2,175 and ¥1.00 = Rp. 21.90.

5.2 Kampar Kanan Water Supply Project

5.2.1 Planning Criteria

Purpose and Major Components of the Project

The purposes of the project are as follows:

- To supply irrigation water to priority areas of Rantauberangin Irrigation Development Project; and
- To develop water resources and ensure the required urban water demand (domestic, industry, tourism, urban area flushing uses) of Pekanbaru City.

The proposed structures consist of the Kuok Intake Weir, main irrigation canals and on-farm development structures of Rantauberangin Irrigation Project.

Objective Area

The objective areas for irrigation development in priority projects are as tabulated below. The objective area for urban water supply is Pekanbaru City.

Unit: ha

Rantauberangin Irrigation Development Area	Left Bank Area	Right Bank Area
Existing Irrigation Area	5,171	4,338
Presently Irrigated	1,837	1,822
Presently Rainfed	553	375
Presently Undeveloped	2,781	2,141
Net Additional Area	4,429	277
Total	9,600	4,615

Design Scale

The design scale for the determination of irrigation water requirement is set at 5-year return period. The target year for the determination of future water demand for urban water of Pekanbaru City is set at the year 2019.

5.2.2 Water Demand

(1) Irrigation Water Requirement

The irrigation water requirement of the priority project area in the Rantauberangin Irrigation Area is estimated based on the optimum cropping pattern with double cropping. The estimated peak water requirement is summarized below.

Unit: m^3/s

Area	Peak Water Requirement
Left Bank	11.31
Right Bank	4.80
Total	16.11

(2) Urban Water of Pekanbaru City

The water demand of Pekanbaru City as estimated in the Overall Development Plan has been applied for the feasibility study. Water demand is as follows:

Unit: m^3/s

Purpose	Peak Water Requirement
Domestic	3.80
Industry	0.78
Tourism	0.01
Urban Area Flushing	6.31
Total	10.90

(3) Total Water Demand

Based on the above, the peak water demand in the Feasibility Study was determined, as follows:

Unit: m^3/s

Purpose	Peak Water Demand
Irrigation Water	16.11
Urban Water	10.90
Total	27.01

5.2.3 Preliminary Design of Proposed Facilities

(1) Kuok Intake Weir

The Kuok Intake Weir is proposed to regulated the water released from the Kotapanjang Dam and to intake water to main irrigation canals. The movable type wier with rubber gates is selected considering technical and economical aspects. The main structural features of the weir are shown in Fig. S.5.1 and summarized below.

Particulars	Value
Afterbay Reservoir	
Normal Water Level	EL 40.0 m
Low Water Level	EL 38.0 m
Required Storage Capacity	$1.6 \times 10^6 m^3$
Intake Discharge (for Overall Plan)	
Left Bank	$20.69\ m^3/s$ *
Right Bank	$4.80\ m^3/s$
Design Flood	
Design Scale (Return Period)	50 year
Design Flood Discharge	$4{,}000\ m^3/s$
High Water Level	EL 45.24 m
Dike Crest Elevation	EL 46.44 m
Riverbed Elevation	EL 36.30 m
Structural Dimensions of Weir	
Gate Type	Rubber Gate
Sill Elevation	EL 36.3 m
Crest Elevation	EL 40.0 m
Length×Height×Unit	30.0 m × 3.7 m × 5 units
Structural Dimensions of Flushing Gate	
Gate Type	Steel Roller Gate
Sill Elevation	EL 35.3 m
Crest Elevation	EL 40.0 m
Length×Height×Unit	5.0 m × 4.7 m × 2 units

* Design discharge for the whole irrigation area on the left bank; does not include diversion water to Pekanbaru City.

(2) Main Irrigation Canal

The main features of irrigation canals are as follows:

Particulars	Unit	Irrigation Canal	
		Left Bank	Right Bank
Canal Length	km	44.00	40.00
Design Discharge*	m^3/s	11.31	4.80
Gradient		1/3,000	1/3,000
Max. Velocity	m/s	1.02	0.79
Lining		10-cm thick concrete lining side slopes with stone wet masonry footing and compacted earth on bottom.	

* The design discharge of 11.31 m^3/s for the left bank is for the initial phase.

5.2.4 Cost Estimate

Project cost have been estimated as summarized in the following table.

Unit: Rp. 10^6

Item	Value
Construction Base Cost	137,067
Compensation Cost	4,620
Administration and Engineering Cost	20,790
Price Contingency	76,752
Physical Contingency	22,783
Sub-Total	262,012
Value Added Tax	26,201
Total	288,213

5.2.5 Project Evaluation

(1) Economic Benefit

The economic benefits of the irrigation water and urban water are estimated at Rp. $11,512 \times 10^6$ and Rp. $12,234 \times 10^6$, respectively.

(2) Economic Cost

The economic project cost is estimated at Rp. $162,695 \times 10^6$.

(3) Economic Evaluation

Based on the economic benefit and cost, EIRR, B/C and NPV are calculated as shown below.

EIRR	10.14%
B/C	1.02
NPV	Rp. $1,524 \times 10^6$

Sensitivity analysis has been carried out for the project on several cases of changes in the benefit or cost, as summarized below.

CASE	EIRR (%)	B/C	NPV (Rp. 10^6)
Benefit, 5% down	9.91	0.99	- 920
Benefit, 10% down	9.45	0.94	- 5,561
Cost, 5% up	9.93	0.99	- 734
Cost, 10% up	9.54	0.95	- 5,189

5.3 Bangkinang Area River Improvement Works

5.3.1 Planning Criteria

Purpose and Major Component of the Project

The purpose of the Bangkinang Area River Improvement Works is to mitigate flood damages along the Kampar Kanan River in Bangkinang Area by the implementation of river improvement. Major work items are embankment of dikes, excavation of shortcut channels and construction of related structures.

Objective River Stretch

The objective river stretch is the Kampar Kanan River from Rantauberangin Bridge (just upstream of Kuok Intake Weir) down to Danaubingkuang Bridge with a total length of approximately 49 km. This stretch corresponds to the irrigation development area for the priority project of Kampar Kanan Water Supply Project.