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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

DEPARTMENT OF IRRIGATION AND DRAINAGE
MINISTRY OF AGRICULTURE
MALAYSIA

COMPREHENSIVE MANAGEMENT PLAN OF MUDA RIVER BASIN

VOLUME 1
SUMMARY
(FINAL REPORT)

DECEMBER 1995

CTI ENGINEERING CO., LTD.
IN ASSOCIATION WITH
INA CORPORATION

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

DEPARTMENT OF IRRIGATION AND DRAINAGE
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COST ESTIMATE IS BASED

ON THE PRICE LEVEL OF DECEMBER 1994

AND EXPRESSED IN MALAYSIAN RINGGIT (RM)

ACCORDING TO THE FOLLOWING EXCHANGE RATES:

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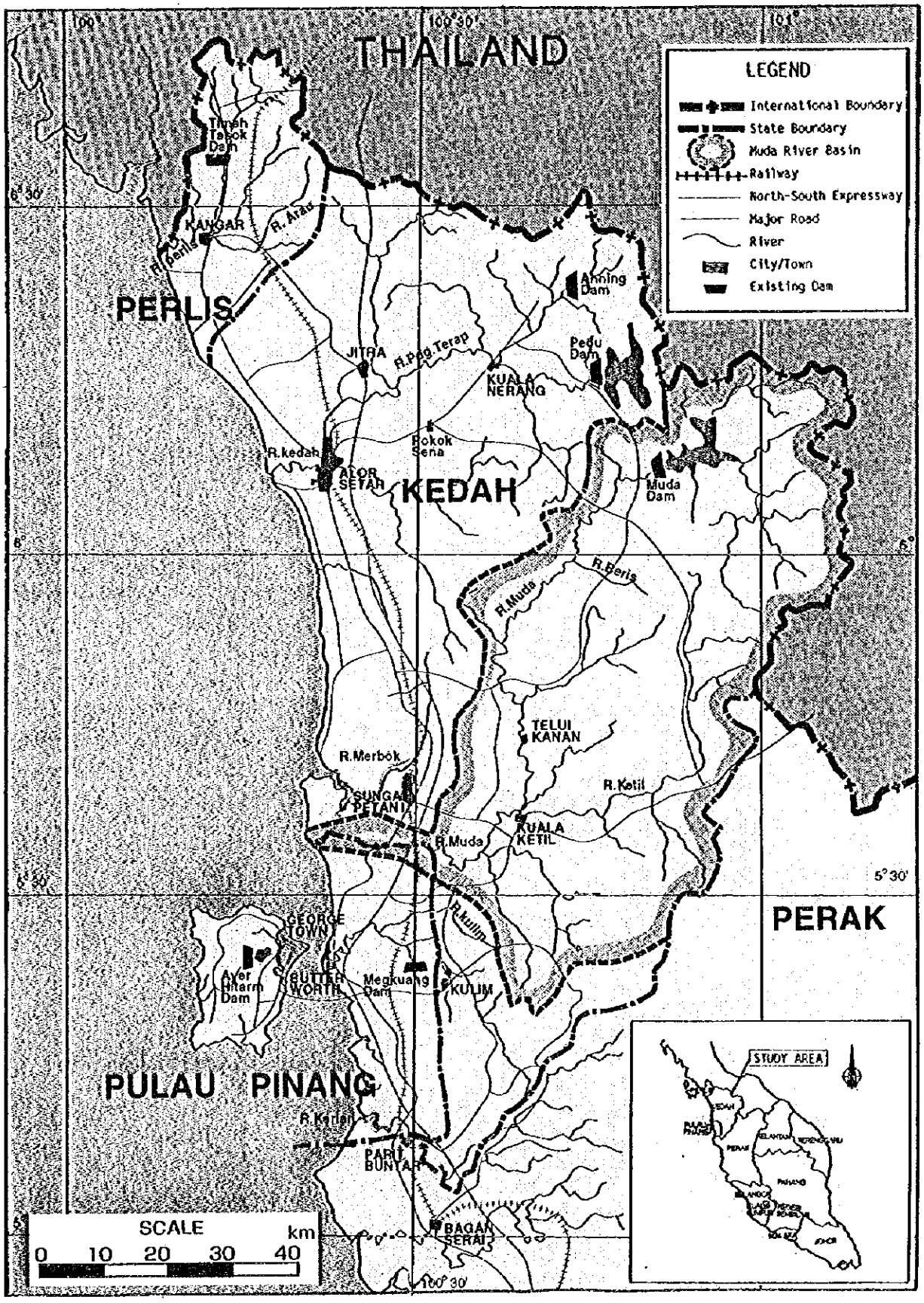
THAILAND
LEGEND
International Boundary
State Boundary
Muda River Basin
Railway
North-South Expressway
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PULAU PINANG
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PARIT BUNTAR
BAGAN SERAI
SCALE
km
0 10 20 30 40
STUDY AREA

GENERAL MAP

PREFACE

In response to a request from the Government of Malaysia, the Government of Japan decided to conduct the Study on Comprehensive Management Plan of Muda River Basin and entrusted the Study to the Japan International Cooperation Agency (JICA).

JICA sent to Malaysia a study team headed by Mr. Katsuhisa Abe, CTI Engineering Co., Ltd., and composed of members from CTI Engineering Co., Ltd. and INA Corporation, four times between March, 1993 and October, 1995.

The team held discussions with the officials concerned of the Government of Malaysia, and conducted 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 Malaysia for the close cooperation extended to the Team.

December 1995

KIMIO FUJITA
President
Japan International Cooperation Agency

December 1995

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Sir:

LETTER OF TRANSMITTAL

We are pleased to submit herewith the Final Report on the Study on Comprehensive Management Plan of Muda River Basin, Malaysia. The report contains the advice and suggestions of authorities concerned of the Government of Japan and the Japan International Cooperation Agency (JICA), as well as the formulation of comprehensive river basin management projects. Also included are the comments made by the Economic Planning Unit, the Department of Irrigation and Drainage and other authorities concerned of the Government of Malaysia during the technical discussions on the Draft Final Report in Malaysia.

The Final Report presents the Master Plan covering the entire Muda river basin and the whole states of Kedah and Pulau Pinang as well as a part of Perlis in the aspect of the water resources management plan proposed for the Study.

In view of the urgency and necessity of socio-economic development, we recommend that the Government of Malaysia shall adopt all means possible to promote the comprehensive river basin management projects to the next stage of project implementation at the earliest possible time.

Finally, we wish to take this opportunity to express our sincere gratitude to the Government of Japan, particularly, JICA, the Ministry of Foreign Affairs, the Ministry of Construction and other offices concerned. We also wish to express our deep appreciation to the Economic Planning Unit, the Department of Irrigation and Drainage and other authorities concerned of the Government of Malaysia for the close cooperation and assistance extended to the JICA Study Team during the Study.

Very truly yours,

KATSUHISA ABE
Team Leader
JICA Study Team

Encl.: a/s

EXECUTIVE SUMMARY

1. BACKGROUND

The Muda River has been developed as one of the important water resources for both the states of Kedah and Pulau Pinang. Riverbed sand is also extensively mined for use as construction materials. Thus, the river is now being used for various purposes, but intensive basin development in the future will also pose a potential problem to the river environment and hinder a well-balanced river development unless a comprehensive management plan is introduced.

In Malaysia, no comprehensive river basin management plan has ever been implemented and the Government of Malaysia expects that the Comprehensive Management Plan of Muda River Basin to be formulated in this present Study is to be used as a model case to serve as guide and reference for other river basins in the country.

2. OBJECTIVES OF THE STUDY

The Study is to formulate a comprehensive management plan for the Muda river basin with the integration of the following four components: (a) flood mitigation plan, (b) water resources management plan, (c) river environmental management plan, and (d) watershed management and monitoring plans.

3. OUTLINE OF PROPOSED PLAN

3.1 Basic Policy

The river management plan integrates all structural plans as well as non-structural plans required for (a) prevention of recurrent flood damage, (b) water resources development and water allocation among interstate and inter-agency water users and (c) enhancement of river environment. In formulating the river management plan, particular attention was given to consistency with hydrological conditions of the entire river stretch and appropriate coordination among all concerned parties for river management. The target completion year of all proposed plans is set at the year 2010

allocating the implementation period for each plan component from the 7th to the 9th 5-year Malaysia Plan.

3.2 Proposed Structural and Non-Structural Plans

3.2.1 Structural Plan

The proposed structural plans are as summarized below.

(1) Flood Mitigation Plan

Work Item	Unit	Work Volume			
		Lower Muda	Kuala Ketil	Baling	Sik
Improvement Length	km	40.30	2.79	0.75	0.8
Excavation/Dredging	10^3 m^3	10,400	522	37.5	6.2
Embankment	10^3 m^3	1,100	22.4	12.8	14.4
Revetment	10^3m^2	83	23.100	12.1	13.6
Barrage Reconstructed	place	1	0	0	0
Bridges Reconstructed	place	2	1	3	0
Land Acquisition	ha	510	11.8	2.3	1.5
Resettlement	house	189	9	28	12

(2) Water Resources Management Plan

(a) Dams

Item	Unit	Beris Dam	Naok Dam	Reman Dam
Main Dam Type		Rockfill	Earthfill	Zoned Rolled-fill
Main Dam Height	m	40	18	40
Catchment Area	km^2	116	15	32
Effective Capacity	10^6m^3	114.0	27.4	240
Land Acquisition	ha	1,600	6.5	35
Resettlement	house	500	5	200

(b) Jeniang Transfer System

Item	Unit	Transfer	Conveyance
Length	km	8	22
Maximum Capacity	(m^3/s)	40	40
Bed Width	m	12	10
Depth	m	3.7	3
Bed Gradient		1 : 12,000	3 : 10,000
Length of barrage	m	-	29
Land Acquisition	ha	34	98
Resettlement	house	0	0

(3) River Environmental Management Plan

Item	Quantity
1. Number and Size of Development Area	
1.1 Along River Corridor	
Type A (Land Development for Nature Reserve)	5 (39 ha)
Type B (Land Development for Nature-oriented Recreation)	4 (25 ha)
Type C (Land Development for Agriculture)	3 (73 ha)
Type D (Land Development for Recreation).	21 (166 ha)
1.2 Around Dam Reservoir	
Type D for Muda Dam Reservoir	1 (2 ha)
Type D for Beris Dam Reservoir	2 (277 ha)
2. Compensation	
3.1 Resettlement	40 houses
3.2 Land Acquisition	45 ha

3.2.2 Non-Structural Plan

The proposed non-structural measures are as summarized below.

(1) Optimum Dam Operation Rule for Water Resources Development

Dam Storage Volume Storage (10^6 m^3)		Dam to Supply Kedah River System		Dam to Supply Muda River System	Curtailed Ratio of Dam Water Supply
Pedu and Muda Dam	Naok and Reman Dam	Northern Part	Southern Part		
> 400	Full	Pedu	Pedu	Beris, Naok, Reman*2	0%
300 - 400	> 150	Pedu, Ahning *1	Naok, Reman*1	Beris, Naok, Reman*2	0%
	< 150	Pedu, Ahning *1	Naok, Reman, Ahning*3	Beris, Naok, Reman*2	0%
200 - 300	> 150	Pedu, Ahning*1	Naok, Reman, Beris*1	Beris, Naok, Reman*2	10%
	< 150	Pedu, Ahning*1	Naok, Reman, Ahning, Beris *1	Beris, Naok, Reman*2	10%
100 - 200	> 150	Pedu, Ahning*1	Naok, Reman, Beris*1	Beris, Naok, Reman*2	30%
	< 150	Pedu, Ahning*1	Naok, Reman, Ahning, Beris *1	Beris, Naok, Reman*2	30%
< 100	> 150	Pedu, Ahning*1	Naok, Reman, Beris*1	Beris, Naok, Reman*2	50%
	< 150	Pedu, Ahning*1	Naok, Reman, Ahning, Beris *1	Beris, Naok, Reman*2	50%

*1: Necessary water supply is allocated to each dam in accordance with the rations of their residual reservoir volume.

*2: After residual storage volume of Beris Dam falls to zero, Naok and Reman dams start water supply.

*3: When necessary water supply from Naok and Reman dams is deficient, Ahning dam starts to supplement the deficiency.

(2) Zoning for River Management

Classified Zone	Extent	Purpose
Water Source Reserve Area	2,259 km^2 in the upper reaches covering all dam catchment areas.	(1) To preserve the appropriate basin runoff discharge and sediment yield. (2) To restrain polluted water loads flowing into the dam reservoir. (3) To protect morphology of dam reservoir.
River Reserve Area	5.6 km^2 along river corridor in the lower reaches.	(1) To facilitate river improvement works. (2) To preserve the space for operation and maintenance works of the improved river channel.
River Controlled Area	51.6 km^2 along river corridor in the middle reaches.	(1) To preserve the natural flood retarding effects (2) To protect the river from the undesirable activities. (3) To minimize the damage caused by flood inundation and channel erosion and/or meandering.

(3) Number of Hydrological Monitoring Network

Monitoring Items	Existing	Newly Proposed
(1) Rainfall	15	10
(2) River Hydrology		
Class 1: Water Level, Discharge, Sediment Load and Water Quality	6*	6
Class 2: Water Level, Discharge and Water Quality	1	5
Class 3: Flood Water Level	4	4

* Existing gauging station is not available to monitor sediment load.

(4) Institutional Setup for River Management

Tier of Organization	Member	Function
Muda River Basin Management Council	Federal and State departments from Kedah and P. Pinang	(1) To approve polices as well as long-term and 5-year plans for basin development and management. (2) To approve emergency actions for extreme droughts and floods.
Technical Committee	State departments from Kedah and P. Pinang	(1) To coordinate and integrate basin development and management plans prepared by various departments and agencies. (2) To formulate policies as well as long-term and 5-year plans for basin development and management plan.
Technical Secretariat	Federal DID established in the office of Kedah State DID.	(1) To monitor natural river conditions and basin development conditions. (2) To propose to Technical Committee the counter measures for issues related to basin development and management.

4. PROJECT COST

The project cost is estimated at about RM 871 million to be disbursed in three (3) terms of the 7th to 9th Five-Year Malaysia Plan (from 1996 to 2010). The average estimated project cost per one term of Five-Year Malaysia Plan is RM 290 million corresponding to about 8% of the actual investment for flood control and domestic water supply projects in the 6th Malaysia Plan. Judging from this percentage, it is

thoroughly possible to implement the proposed project. The breakdown of project cost divided into foreign currency (F.C.) and local currency (L.C.) portions is as summarized below.

Unit: RM 1,000

Work Item	F.C.	L.C.	Total
(1) Flood Mitigation Plan (River Improvement)	183,380	175,630	359,010
(2) Water Resources Management Plan	181,831	288,371	470,203
(3) River Environment Management Plan	10,977	31,224	42,201
Grand Total	376,188	495,225	871,414

Note: Estimated at the price as of December 1994 (Exchange Rate: US$1.00 = RM 2.51 = ¥100.30

5. PROJECT EVALUATION

5.1 Economic Evaluation

The economic evaluation was made for the proposed structural plans in the sectors of flood mitigation, water resources management and river environmental improvement. The economic internal rate of return (EIRR) for proposed structural plans are as summarized below

Economic Evaluation

Sector	Proposed Structural Plan	EIRR (%)
Flood Mitigation	River improvement of 4 target river stretches.	8.3
Water Resources Management	Construction of Beris Dam, Naok Dam, Reman Dam and Jeniang Transfer Canal.	14.6
River Environmental Management	Land development of river corridor and lakeshore around reservoirs of Muda and Beris dams	23.8
Overall		13.6

According to analysis of international agencies, the opportunity cost of capital is estimated at 10 to 12%. Among the proposed structural plans, those for water resources management and river environmental management exceed the opportunity cost , and therefore could be economically justifiable.

On the other hand, the EIRR of the structural plans for flood mitigation is somewhat low as compared with the opportunity cost of capital. The flood mitigation project is, however, essential to ensure an stable social environment and promote an economic development of the region. Accordingly, implementation of the flood mitigation project is recommended, not necessarily being tied down to the economic viability.

5.2 Environmental Impact Assessment

A preliminary environmental impact assessment was carried out for the following major proposed structures for water resources development, flood mitigation and river environmental improvement.

Sector	Objective Structures
Flood Mitigation	Lower Muda River Improvement Works
Water Resources Management	Beris Dam Jeniang Transfer System including Naok and Reman dams
River Environmental Management	Beris Dam Reservoir Recreation Park Muda Barrage Recreation Park Bumbong Lima Recreation Park

The results of environmental impact assessment are summarized into assessment matrices as shown in Tables 12.2 1 to 12.2.6. According to the assessment matrices, the significant impacts by the proposed structures are seen in the following four (4) issues: (a) resettlement, (b) disruption of community, (c) soil erosion and (d) water pollution. The countermeasures and necessary monitoring items for these issues are proposed as below:

Issues	Causes	Countermeasures	Necessary Monitoring Items
Resettlement	(1) Beris Dam (2) Jeniang Transfer System (3) River channel improvement (4) Bumbong Lima recreation park	(1) Coordination with inhabitant. (2) Reasonable compensation for resettlement. (3) Assistance and guidance for suitable income of inhabitant to be resettled. (4) Preparation of resettlement land based on the desire of inhabitant.	(1) Living conditions of inhabitant to be resettled. (2) Regional socio economy (3) Precedents of resettlement of similar projects. (4) Conditions of resettlement land.
Disruption of community	Beris Dam	(1) Compensation to non-resettled inhabitant. (2) Construction of new transportation network. (3) Reorganization of administrative division. (4) Establishment of new telecommunication service.	(1) Regional socio economy (2) New transportation system (3) Living conditions of inhabitants including non-settled people.
Soil erosion	(1) Beris Dam (2) Jeniang Transfer System	(1) Dredging works (2) Plantation (3) Land use control	(1) Topography, geology and soil. (2) Vegetation
Water pollution	(1) Beris Dam (2) Jeniang Transfer System (3) Beris Dam Reservoir Recreation Park	(1) Control and treatment of pollution loads. (2) Removal of vegetation before dam impounding.	(1) Pollution source (2) Water use in dam reservoir and river channel. (3) Water quality survey.

6. RECOMMENDATION

The following items are recommended in connection with the proposed plans:

(1) Gradual Reduction in Riversand Mining and Alternative Source for Construction Sand

The riverbed will continue to be lowered as long as sand mining operations are pursued, therefore, gradual reduction and finally freezing of sand mining from the riverbed is strongly recommended. The gradual reduction of sand mining should be executed on the premises that further allowable sand mining volume should be limited to about 1.2 million m^3 that is almost equivalent to the actual annual mining volume in 1993. At the same time, it is indispensable to locate a new mining source, and ocean sand is regarded as the most probable alternative source for sand mining. However, the mining of ocean sand will require additional treatment to remove the salt as well as higher mining cost compared with river sand. When ocean sand is employed, detailed sampling test will be required beforehand and the appropriate location for ocean sand mining will need to be selected.

(2) Coordination between Basin Development and River Management

A considerable part of the urban development area as well as the industrial development area tend to be placed nearby the river channel and within the possible flood inundation area. In this connection, appropriate coordination will be required between the basin development and the river management so as to minimize the flood damage potential and the possible pollution of river water.

(3) Proposed Institutional Setup

An interstate and inter-agency coordination body is essential for the comprehensive river management, and it is recommended that a 3-tier institutional structure comprising of related government agencies from the states of Kedah, Pulau Pinang and Perlis be setup.

(4) Establishment of Nationwide River Information System

A nationwide river monitoring system is essential for the purpose of planning and design, development, and regular management for rivers, so that prompt action can be taken whenever necessary. The river information to be monitored by the system will be voluminous and dynamic in nature, requiring frequent updating and systematic storage. A computerized information system is therefore essential to improve efficiency and effectiveness in the management of rivers.

The Government of Malaysia is keen to establish the nationwide river information system. This nationwide river information system will be useful for the aforesaid comprehensive river basin management and, therefore, its early implementation is strongly recommended.

(5) Construction of Proposed Water Resources Development Facilities

The proposed water resources development facilities include Beris dam, Jeniang Transfer Canal, Naok Dam and Reman Dam. These facilities are essential to guarantee the full water supply for the projected water demand by the year 2010 in the drought level of 10-year return period. In order to minimize the present chronic water shortage and cope with the future incremental water demand, it is strongly recommended to complete Beris dam by the year 2000, Jeniang Transfer Canal together with Naok dam by the year 2005 and Remand Dam by the year 2010.

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ABBREVIATIONS AND GLOSSARY

GOVERNMENT OFFICES

DID	:	Department of Irrigation and Drainage
DOC	:	Department of Chemistry
DOE	:	Department of Environment
DOF	:	Department of Fisheries
DOH	:	Department of Health
DOS	:	Department of Statistics
DSM	:	Department of Survey and Mapping
DWNP	:	Department of Wildlife and National Parks
EPU	:	Economic Planning Unit
EXCO	:	State Executive Council
FDHPM	:	Forest Department Headquarters Peninsular Malaysia
JICA	:	Japan International Cooperation Agency
JKR	:	Jabatan Kerja Raya (= PWD)
JPS	:	Jabatan Pengairan dan Saliran (= DID)
JPT	:	Jabatan Pengairan dan Taliair (= DID)
LKIM	:	Lembaga Kemajuan Ikan Malaysia (= Malaysian Fisheries Development Authority)
MD	:	Marine Department
MMS	:	Malaysia Meteorological Service
MOA	:	Ministry of Agriculture
MOF	:	Ministry of Finance
PWD	:	Public Works Department
MADA	:	Muda Agricultural Development Authority
IADP	:	Integrated Agricultural Development Project
PWA	:	Penang Water Authority
KEDA	:	Kedah Regional Development Authority
KSDC	:	Kedah State Economic Development Corporation
PDC	:	Penang Development Corporation
SPC	:	State Planning Committee
SEPU	:	State Economic Planning Unit

WATER QUALITY TEST/ELEMENTS

As	:	Arsenic	Mg	:	Magnesium
BOD	:	Biological Oxygen Demand	N	:	Nitrogen
Ca	:	Calcium	Na	:	Sodium
Cd	:	Cadmium	NH4-N	:	Ammonia Nitrogen
Cl	:	Chlorine	P	:	Phosphorus
Cn	:	Cyanide	Pb	:	Lead
Cr	:	Chromium	PCB	:	Polychlorinate Biphenyl
COD	:	Chemical Oxygen Demand	Ra	:	Radium
DO	:	Dissolved Oxygen	Sr	:	Strontium

F	:	Flouride	SS	:	Suspended Solids
Fe	:	Iron	T-N	:	Total Nitogen
Hg	:	Mercury	T-P		Total Phosphorus
K	:	Potassium			

UNITS OF MEASUREMENT

(Area)

Ha, ha	:	hectare
m^2	:	square meter
km^2	:	square kilometer

(Weight)

Kg, kg	:	kilogram
ton	:	1,000 kg

(Volume)

GRT	:	Gross Relative Tonnage
L, l, ltr	:	liter
m^3	:	cubic meter
MCM	:	million cubic meters

(Other Measurements)

cusec	:	cubic feet per second
dia.	:	diameter
H	:	hertz
kW	:	kilowatt
m^3/s	:	cubic meter per second
V	:	volt, voltage
Sq., sq.	:	square
Cu., cu.	:	cubic
Km, km	:	kilometer
sec, s	:	second

MALAYSIAN TERMS

Kg.	:	kampong (village)
P., Pulau	:	island
Sg.	:	sungai (river)

CURRENCY

RM	:	Malaysian Ringgit
US$	:	United States Dollar
¥	:	Japanese Yen

OTHERS

EIA	:	Environmental Impact Assessment
GDP	:	Gross Domestic Product
GNP	:	Gross National Product
LSD	:	Land and Survey Datum
NDP	:	National Development Policy
VSB	:	Very Short Band
PMF	:	Probable Maximum Flood
TWL	:	Tail Water Level
PKP	:	Perlis, Kedah and Penang

355-day discharge : the discharge to exceed river flow discharge 355 days a year

1. INTRODUCTION

1.1 Background

The Muda River is located in the northwestern part of Peninsular Malaysia. It has been developed as one of the important water resources for agriculture as well as domestic/industrial water supply source for both the states of Kedah and Pulau Pinang. Riverbed sand is extensively mined for use as construction material and the river is used as navigation channel for local fishing boats, particularly, around the river mouth.

Intensive basin development in the future will pose a potential problem to the water quality of Muda River. Such problem will possibly aggravate and hinder a well-balanced river basin development unless a comprehensive river basin management plan is introduced.

No comprehensive river basin management plan has ever been implemented in the country and the Government of Malaysia is expecting to use the comprehensive management plan for the Muda river basin as a model case to serve as a guide and reference for other river basins in the country. A request for technical cooperation to carry out the Study on Comprehensive Management Plan of Muda River Basin (referred to as the Study) was therefore made to the Government of Japan.

1.2 Objectives of the Study

The Study is to formulate a comprehensive management plan for the Muda river basin by integrating four components and setting 2010 as the target year. The four components are (a) flood mitigation plan; (b) water resources management plan; (c) river environmental management plan; and (d) watershed management and monitoring plan.

1.3 Study Area

The study area for components of the comprehensive plan except the water resources management plan is within the limits of the Muda river basin. Since the water source of the Muda River extends beyond the Muda river basin covering the whole states of Kedah and Pulau Pinang as well as a part of the State of Perlis, the study on the water resources management plan is made for the whole water supply area of Muda River.

Each of the above three states is administratively divided into several districts, and each district is further divided into parishes called *mukim* in Malaysian term. The three states cover 17 districts and 239 mukims, out of which the Muda river basin covers 6 districts and 28 mukims.

2. PRESENT CONDITION OF THE STUDY AREA

2.1 Physical Features of Study Area

2.1.1 Catchment Area of Muda River

Muda River has a catchment area of 4,210 km^2 and a length of about 180 km with a slope of 1/2,300 from the river mouth to Muda Dam. The major tributaries of Muda River are Ketil River, Sedim River and Chepil River. Among them Ketil River is the largest tributary with a catchment area of 868 km^2 and a channel length of about 70 km.

2.1.2 River Morphology

The upstream of Muda Barrage tends to be eroded due to sand mining operations, aggravating channel meandering, bank erosion and degradation of the riverbed. The average riverbed has lowered by 2 to 5 m in the recent 10 years, which causes difficulty in abstracting water from the river and affecting safety of river structures (refer to Figs. 2.1.1 and 2.1.2). On the other hand, the river mouth tends to be affected by sedimentation causing aggravation of the riverbed and development of a sand bar. The shallowest riverbed surveyed in 1994 is about 2 m below LSD, causing difficulty to navigation during low tide. Judging from the sand mining operations on the river as well as the bed materials, the main cause of sediment accumulation

around the river mouth could be either ocean sand drift or the suspended sediment/wash load supplied from the Muda River.

2.1.3 Flood Condition

The lower stretches of Muda River tends to have a smaller flow capacity than the upper stretches. At many points downstream of the confluence with Sedim River, the flow capacity is to accommodate the discharge of less than a 2-year flood discharge. Moreover, low-lying areas are scattered along the Ketil and Chepir rivers where flood inundation of even a 2-year return period occur. In the upper stretches of Muda River from the confluence with Chepir River, however, the river forms a valley, and the elevation of river banks is high enough to accommodate a flood discharge of 10-year return period.

Due to the above poor channel flow capacity and the lesser flow capacity of the downstream than the upstream, flooding occurs almost every year and affects the low-lying residential and agricultural areas (refer to Fig. 2.1.3). The largest flood recorded occurred in 1988, submerging vast low-lying areas of about 78 km^2 along the Muda River and affecting about 6,100 houses and buildings. In September 1995, floods caused by Tropical Storm Ryan also occurred in the Muda river basin and many people living along rivers were reported to have evacuated to relief centers. The September 1995 flood seems to be a little smaller than the 1988 flood judging from the water level records obtained.

2.1.4 Water Quality of River

Muda River is generally evaluated to be clean or slightly polluted and suitable for public water supply, aquatic recreation, and existence of aquatic life. Some problematic results are, however, found in the test items of NH4-N, Cr (VI), Fe and P through water sampling/test carried out by the JICA Study Team in 1994. Furthermore, when the river flow discharge falls to the level of 355-day discharge, the present water quality will exceed the allowable level for drinking water.

2.1.5 Fauna and Flora

There are various species of animals in the Muda river basin. However, the forest area for wildlife has been reduced due to land clearing and other human activities. Muda River had also been well known as a habitat of freshwater turtles but the number of turtles has remarkably decreased since sand mining operations have been intensively made.

2.2 River Use Condition

2.2.1 River Structures

In the upper reaches of Muda River, there exists Muda Dam which has a catchment area of 984 km^2 and principally used for irrigation of the Muda irrigation scheme. Muda Barrage is also located about 10 km upstream from the river mouth to supply domestic and industrial water as well as irrigation water for the State of Pulau Pinang and the southern part of the State of Kedah. Moreover, there are 12 intake facilities for domestic/industrial water supply and 28 intake facilities for irrigation water supply. All major intake facilities are located along the impounding extent of Muda Barrage, abstracting about 80% of the total intake volume.

2.2.2 Water Supply

The present water demand to be supplied from Muda and Kedah River is estimated at about 2,026 million m^3/year which is divided into about 339 million m^3/year for domestic and industrial water and 1,687 million m^3/year for irrigation water as discussed below.

The domestic/industrial water is supplied to the states of Kedah, Pulau Pinang and Perlis. Among the three states, the State of Pulau Pinang is the largest domestic/industrial water user abstracting 194 million m^3/year solely from the downstream of Muda River. The State of Kedah is the second largest, abstracting about 136 million m^3/year. The remaining volume of about 9 million m^3/year is supplied to the State of Perlis from both the Muda and Kedah rivers.

The irrigation water is supplied to 60 schemes. Among them, the Muda irrigation scheme is the largest water user occupying 97,000 ha over the State of Kedah to the State of Perlis. The irrigation water demand from Muda and Kedah rivers to the Muda irrigation scheme is about 1,391 million m3/year (about 70% of the total water demand). The Seberang Perai irrigation scheme of 8,000 ha is the second largest user and located in State of Pulau Pinang having the water demand of about 80 million m^3/year (about 4% of the total demand) to be abstracted from Muda River.

In addition to the above two main granary areas, there are 58 secondary and minor irrigation schemes of 18,800 ha in total. The water demand from the rivers to these schemes is estimated at 220 million m^3/year (about 11% of the total demand).

According to the interview survey, Muda and the other existing irrigation schemes have been suffering from the chronic shortage of irrigation water supply, and reduction in paddy plantation has often been required due to the water shortage. The serious water shortage tends to occur in the least rainfall months of January to March, and even domestic and industrial water supply was curtailed for the months in the drought year of 1978.

The present water use ratio of the annual average intake water volume to the annual average natural runoff discharge volume is estimated at about 64% for the Kedah river system. Such high water use ratio indicates that the present water resources development for Kedah River has reached the critical level and it is virtually difficult to induce further water resources development. In contrast, the water use ratio of the Muda river system is estimated at 14%; hence, the future water resources development for the study area could be made only in the Muda river basin. In fact, all ongoing water resources development projects such as the Beris dam project and the Jeniang transfer system project placed their projected water sources on the Muda river system.

2.2.3 Navigation

The Muda river mouth is being used as a port by about 200 fishing boats, and all of the boats are smaller than 10 GRT. However, navigation for fishing boats has to be suspended during low tide due to siltation of the river mouth.

2.2.4 Sand Mining Operations

There are about 100 permit holders for mining operations between Muda Barrage and the proposed Jeniang Barrage (refer to Fig. 2.2.1). A big volume of sand of as much as 0.5 to 1.0 million m^3 has been removed annually from the Muda river channel for the last 10 or more years. This mining volume is much greater than the sand supply volume of 1 to 10 thousand m^3 and, therefore, cause degradation of the riverbed.

2.3 Ongoing Basin Development Condition

2.3.1 Population and Urban Area

The population of the three states of Kedah, Perlis and Pulau Pinang will increase from about 2.6 million in 1991 to 4 million in 2010 on the premise of an average annual growth rate of 2.15% for 1991-2000 and 2.63% for 2000-2010.

As for the Muda river basin, the population will reach 0.61 million in 2010. The corresponding average population density is, however, 146 persons/km^2 in 2010 which is less than the average for the entire State of Kedah (215 persons/km^2) as shown in Fig. 2.3.1. To redress the smaller population in the Muda river basin, the Kedah Regional Development Authority (KEDA) has proposed the development of six urban centers which will have the urban population of about 2,000 to 10,000, (a) Baling, (b) Kuala Ketil, (c) Kupang, (d) Bukit Selambau, (e) Jeniang, and (f) Sik (refer to Fig. 2.3.2).

2.3.2 Gross Domestic Product

The Gross Domestic Product (GDP) of the states of Kedah, Pulau Pinang and Perlis is expected to increase from about RM 13,000 million in 1993 (at the 1978 price) to RM 20,000 million in 2000, and the average annual growth rate is to be 7.5% for 1990-2000, which is almost equivalent to the national average. A notable growth of around 10%/year of GDP is expected in the secondary sector (industry sector), while the growth in the primary sector (agricultural sector) will diminish to less than 5%.

2.3.3 Industrial Area

The industrial area in operation in the states of Kedah and Pulau Pinang will expand from about 1,530 ha in 1993 to about 3,000 ha in 2000. In the Muda river basin, the three presently existing industrial areas of Baling, Sik and Jeniang covered only an area of 14.52 ha in 1993. However, three other industrial areas will be newly developed and the total industrial area will reach about 1,000 ha in 2000. Among the industrial areas in the Muda river basin, Kuala Ketil will have a noteworthy industrial area of about 740 ha in 2000 due to easier access to the present intensive industrial areas in and around Sungai Petani, Kulim and Butterworth. The area is placed along the left bank of the Muda main stream between the confluence of Ketil River and Sedim River covering a substantial part of the probable flood inundation area of 100-year return period, as shown in Fig. 2.3.3. Thus, the proposed industrial area in Kuala Ketil contains a flood damage risk, and certain coordination will be required between industrial development and the river management for flood mitigation.

2.3.4 Agricultural Land

About 177,100 ha or 42% of the Muda river basin has been developed as agricultural land, particularly, along the Muda River and its tributaries in the lower and middle reaches which rely on the water resources of Muda River (refer to Table 2.3.1 and Fig. 2.3.4). In addition, about 104,000 ha having the Muda River as water source are used for the extensive irrigation schemes managed by MADA and DID. The future expansion of agricultural land is, however, predicted to be nil because of transfer of labor to non-agricultural activities.

2.3.5 Forest Reserve

The present forest area of about 236,100 ha spreads out in the upper reaches of the Muda River, and the area except the northwestern part is delineated as forest reserve under control of the Forest Department (Fig. 2.3.5). In the delineated forest reserve area, however, logging is being made in most parts of the present forest area without any coordination with river management works. The latest aerial photograph presents the numerous newly cleared lands scattered in the previous forest area. Such present

logging works could cause various adverse effects such as increment of flood runoff discharge and reduction of basin runoff discharge during dry seasons.

2.4 Present River Management Framework

2.4.1 River Management and Monitoring System

The present monitoring system for Muda River cover three (3) territories which are independently managed by the State of Kedah, the State of Pulau Pinang and MADA (refer to Fig. 2.4.1). Monitoring by the State of Kedah and the State of Pulau Pinang is respectively made within the limits of each state boundary. The catchment area of Muda Dam is, however, not included in the monitoring coverage of the State of Kedah although the area is located in the state. Instead, the catchment is under the monitoring of MADA for the sake of irrigation supply from Muda Dam to the Muda irrigation scheme.

Thus, there does not exist any integrated monitoring system for the entire river basin. Furthermore, the existing system is available to monitor the river but not available to monitor sediment load, the indispensable information to control river channel erosion caused by the present excessive sand mining operations. There also exists no system to monitor the river environments such as river biology (fauna and flora), river scenery, and also to monitor the basin land development conditions as well as the forest reserve conditions that are the dominant factors on the basin runoff conditions and the basin sediment yield. Moreover, the number of existing hydrological monitoring stations are not necessarily sufficient.

2.4.2 Institutional Setup for River Management

The activities related to river management work in both the states of Kedah and Pulau Pinang are managed by various government and/or semi-government agencies under the supervision of the State Executive Council (EXCO), the State Planning Committee (SPC) and the State Economic Planning Committee (SEPC), which are all chaired by Menteri Besar of the State of Kedah or the Chief Minister in the case of the State of Pulau Pinang.

The principal task of EXCO is to finally approve the state development policies, while SPC is responsible for the physical planning of land use in the state, and SEPC acts as the coordinating body for the development policy established by EXCO, and the development projects proposed by each agency in charge. The Secretariat to SEPC is the State Economic Planning Unit (SEPU), the lead developing planning agency at state level.

Through the interview survey on the above institutional setup, two (2) major problems were recognized. The first problem is the lack of a state inter-agency coordinating body to implement a comprehensive management work. SPC is apparently having a function to coordinate the inter-related agencies and to determine/approve rather general and/or broad directions of waterworks. However, the function of SPC does not extend to the formulation of a detailed and well-coordinated implementation plan for river management.

The second problem is the lack of an interstate coordinating body for the river management works among the states of Kedah, Pulau Pinang and Perlis. The present water resources of Muda River is used for the states; however, there does not exist any integrated coordinating body as well as any agreement among the states to allocate the water supply for each state. This problem is currently rather latent as the extensive water shortage of Muda River has been seldom experienced. However, the future more intensive use of the water resources of Muda River would induce a serious argument between the states.

An interstate committee for the development of the Northern Region has been organized by four (4) states, that is, Perlis, Kedah, Perak and Pulau Pinang. The chief minister of each state is a major member of the committee, and the secretariat office is placed in the State of Pulau Pinang. The committee is likely to have a function to discuss/coordinate the development policy for Muda River, but the detailed implementation plan for the river management works for Muda River could not be made through the committee.

3. FLOOD MITIGATION PLAN

3.1 Structural Plan

3.1.1 Design Level

The design return period was determined as 50 years, in due consideration of the recurrence probability of the recorded maximum flood in 1988, the guidelines for design flood level prepared by DID and the design discharges applied in the recent flood mitigation plans on the strategic rivers.

3.1.2 Target River Stretch and Design Discharge

Four (4) river stretches were selected as target of the flood mitigation plan considering land use, population, assets and severity of flood damage. The selected target stretches and their design discharge are as summarized below (refer to Fig. 3.1.1).

Target River Stretch for Structural Flood Mitigation Works

River	Stretch	Length (km)	Reference Point	Design Discharge (m^3/s)
Muda River	Lower Muda River	40.3	Ldg. Victoria	1,300 *
	Kuala Ketil Town	3.5	Jam. Syed Omar	1,100 *
Ketil River	Kuala Ketil Town	1.9	Confluence with Muda River	700
	Baling Town	0.8	Pulai	500
Chepir River	Sik Town	0.8	Sik Town	130

* Regulated discharge by Muda Dam Reservoir

It is herein noted that the existing Muda Dam has a significant natural flood regulation effect by its retention volume and, therefore, such natural regulation effect is incorporated into the design discharge listed above.

3.1.3 Menu of Structural Measures

In due consideration of topographic conditions, the proposed structural measures include river channel improvement and flood bunds. The river channel improvement is applied particularly to the downstream stretch of Muda River. The river bund is

also selected to protect small local areas where damage potential is comparatively high.

3.1.4 Preliminary Design

The preliminary design for the four (4) target river stretches was made as discussed below.

(1) River Alignment

The proposed river alignment is, in principle, to follow the existing alignment so as to minimize construction cost, land acquisition, resettlement and relocation of the existing structures. As for the target stretch for the Kuala Ketil Town Improvement Works, however, a cut-off channel is proposed to reform an excessive meandering stretch that tends to decrease flow capacity and cause bank erosion.

(2) Longitudinal Profile

The existing average riverbed profile is applied as the longitudinal profile considering that the existing riverbed has been formed as the result of long-term natural phenomena and could be stable should the present excessive sand mining be suspended. The design high water level is also set below the ground level of the hinterland so as to minimize the flood damage potential.

(3) Cross Section

Among the target river stretches, the stretch for the Lower Muda River Improvement Works adopts the compound cross section composed of a low water channel and a high water channel to minimize embankment height and to assure channel stability. The cross section of the low water channel is determined to confine the existing flow capacity of 600 m^3/s. As for other target river stretches, however, the single cross section is adopted in due consideration of difficulty of land acquisition, smaller design discharge and the present shape of the single cross section.

(4) River Mouth Treatment

Treatment of the river mouth is required to avoid the present siltation and to facilitate navigation around the river mouth. In this connection, a comparative study between maintenance dredging and construction of submerged jetty was examined based on the results of the "National River Mouths Study by JICA in 1994." As a result, the capital and maintenance dredging is proposed as the optimum measure.

(5) Principal Features of River Improvement

Based on the aforesaid design discharge as well as design criteria, the preliminary design of river improvement works was made for each of the target river stretch (refer to Figs. 3.1.2 to 3.1.9). The principal features of river improvement works are as summarized below.

Principal Features of River Improvement Works

Description	Unit	Lower Muda River	Kuala Ketil Town		Baling Town	Sik Town
			Muda River	Ketil River		
Stretch Length	m	40,300	1,870	920	750	800
Design Discharge	m^3/s	1,300	1,100	700	500	130
River Width	m	180 to 1,000	100	70	53	30
Excavation/Dredging	$10^3 m^3$	10,400	522		37.5	6.2
Embankment	$10^3 m^3$	1,100	22.4		12.8	14.4
Revetment	$10^3 m^2$	83	23.1		12.1	13.6
Sluices to be Constructed	location	28	3		2	2
Barrage to be Reconstructed	location	1	0	0	0	0
Drops to be Reconstructed	location	0	1	1	0	0
Pump stations to be Relocated	location	3	0	0	0	0
Bridges to be Reconstructed	location	2	0	1	3	0
Bridges to be Reinforced	location	3	0	0	0	0
Land Acquisition	ha	510	11.8		2.3	1.5
House Evacuation	house	189	9		28	12

The proposed river improvement works for Lower Muda River include the reconstruction of Muda Barrage which was constructed in 1972. The new Muda Barrage is placed on the new cut-off channel of 1,300 m in length (refer to Fig. 3.1.10). The present state boundary is, however, set up along the center line of the Muda river channel and, therefore, the proposed cut-off channel may change the state boundary between the states of Kedah and Pulau Pinang. The center line of the cut-off channel moves towards the Kedah side by a maximum of 350 m, and some 30 ha of land could shift to the territory of the State of

Pulau Pinang. Nevertheless, the alignment of the cut-off channel is proposed as the optimum plan from the engineering viewpoint, and a certain agreement between the states will be required to delineate the new state boundary in connection with the construction of the new cut-off channel.

3.2 Non-Structural Plan

Various land development activities such as urban, industrial and agricultural development are now expanding to the riverside area. In line with such land development, land acquisition for the river improvement works tends to be difficult. At the same time, the flood damage potential is going to increase, and the river morphology is seriously affected by the land development activities. In due consideration of the ongoing land development conditions, a river reserved area and/or a river controlled area is proposed in a certain extent of the river. The river reserved area and the river controlled area is to be under the jurisdiction of the river management body newly proposed in section 7, and having the following public purposes and conditions on the land acquisition, respectively:

Area	Purpose	Land Acquisition
River Reserve Area	1. To facilitate river improvement works 2. To preserve the space for river operation and maintenance works	Entire land in the area is subject to land acquisition by the government, and any private land development works are frozen under jurisdiction of the river management body.
River Controlled Area	1. To preserve the natural flood retarding effects and protect the river from the undesirable activities. 2. To minimize the damage caused by flood inundation and channel erosion and/or meandering. 3. To be a buffer of a belt area with a width of 20 m along a river dike to protect the dike from undesirable activities.	The present private land located in the designated area is not subject to land acquisition by the government, but all land development therein is to be controlled through evaluation and approval by the river management body.

The river reserved area for Muda River is proposed in due consideration of the necessary space for the proposed river improvement works as well as the necessary river operation and maintenance works. While, the river controlled area is proposed

as the extent of the possible flood inundation area of 100-year return period, the possible extent of the river erosion and meandering and a belt area of 20 m in width along the proposed river dike. The proposed river reserve area and river controlled area cover an area of about 57 km^2 in total along a stretch of 113 km of the main stream from the river mouth to the proposed Jeniang Barrage and a stretch of 41 km long of Ketil River from the confluence with the main stream to Kg. Tg. Merbau, as shown in Figs. 3.2.1 to 3.2.2. The average width of river reserve area and river controlled area is about 69 m and 167 m, respectively both for right and left banks, as listed below:

Proposed River Reserve Area and River Controlled Area

River	Stretch	Stretch Length (km)	River Reserve Area		River Controlled Area	
			Area (km^2)	Width* (m)	Area (km^2)	Width* (m)
Muda	Lower Muda River (River Mouth to Ldg. Victoria	40.3	5.6	69	1.6	20
	Ldg. Victoria to Proposed Jeniang Barrage	72.9	Nil	Nil	33.1	227
Ketil	Muda River to Kg. Tg. Merbau	41.0	Nil	Nil	16.9	206
	Total (or Average)	154.2	5.6	69 (Ave.)	51.6	167 (Ave.)

* Average width on one side.

4. WATER RESOURCES MANAGEMENT PLAN

4.1 Projection of Water Demand

The domestic/industrial water demand taken from the river source will increase from 339 million m^3/year at present to 640 million m^3/year or 1.9 times of the present value in the year 2010. This remarkable increment is attributed to the population growth, the increment of per capita water consumption and the intensive industrial development. In contrast, the future irrigation area and its corresponding water demand tend to slightly decrease. The projected water demand for each state as well as the irrigation scheme is as summarized below.

Projected Water Demand

Demand Items	Present				Projected in 2010			
	Gross Demand		Required from River		Gross Demand		Required from River	
	($10^6m^3/yr$)	(%)	($10^6m^3/yr$)	(%)	($10^6m^3/yr$)	(%)	($10^6m^3/yr$)	(%)
1. Domestic/Industrial								
(a) Kedah State	129	4.5	136	6.7	271	9.0	281	13.1
(b) Pulau Pinang State	166	5.8	194	9.6	300	9.9	350	16.2
(c) Perlis	9	0.3	9	0.4	9	0.3	9	0.4
Sub-Total	304	10.6	339	16.7	580	19.2	640	29.7
2. Irrigation Water								
(a) Muda Scheme	1,977	68.9	1,391	68.6	2,010	66.6	1,230	57.2
(b) Balik/Seberang	156	5.4	80	4.0	170	5.6	100	4.4
(c) Others	433	15.1	216	10.7	260	8.6	180	8.4
Sub-Total	2,566	89.4	1,687	83.3	2,440	80.8	1,510	70.3
Grand Total	2,870	100.0	2,026	100.0	3,020	100.0	2,150	100.0

4.2 Necessary Water Resources Development Facilities

A water demand and supply balance simulation was made to scrutinize the necessary water resources development facilities that can meet future water demand and the river maintenance flow in case of the proposed drought level of 10-year return period. In the simulation, future water demand was assumed as the value projected in the year 2010, while river maintenance flow was estimated as the value to correspond to the specific discharge of 0.01 $m^3/s/km^2$, as described in Section 6.

From the results of simulation, it was evident that the new water resources development facilities of Beris Dam, Jeniang Transfer Canal, Naok Dam and Reman Dam are required to guarantee the full water supply for the projected water demand in the proposed drought level. There exist three (3) dams in the study area; namely, Pedu, Muda and Ahning. The active storage capacity and available supply area for these existing and proposed dams are as summarized below (refer to Fig. 4.2.1).

Existing and Proposed Dam Reservoirs for Water Resources Development

Water Supply Area	Available Dam Supply Source	Catchment Area (km^2)	Active Storage Capacity ($10^6 m^3$)
Northern and southern part of Muda Irrigation scheme	Pedu (Existing)*	171	1,049
	Muda (Existing)*	941	160
	Ahning (Existing)	120	200
Southern part of Muda Irrigation scheme and the whole supply area for Muda river system	Beris (Proposed)	116	114
	Naok (Proposed)	15	27
	Reman Proposed)	32	240

4.3 Optimum Dam Operation Rule

Trial simulation was made to select the optimum rule assuming various timing for starting the water supply from each of the existing and proposed dams. As the result, the following rule is provisionally selected to minimize the period of water deficit for all objective water supply areas including the northern part of Muda irrigation scheme.

Dam Operation Rule to Minimize Period of Water Deficit

Dam Storage Volume Storage ($10^6 m^3$)		Dam to Supply Kedah River System		Dam to Supply Muda River System
Pedu and Muda Dam	Naok and Reman Dam	Northern Part	Southern Part	
> 400	Full	Pedu	Pedu	Beris, Naok, Reman*2
300 - 400	> 150	Pedu, Ahning*1	Naok, Reman*1	Beris, Naok, Reman*2
	< 150	Pedu, Ahning*1	Naok, Reman, Ahning*3	Beris, Naok, Reman*2
< 300	> 150	Pedu, Ahning*1	Naok, Reman, Beris*1	Beris, Naok, Reman*2
	< 150	Pedu, Ahning*1	Naok, Reman, Ahning, Beris*1	Beris, Naok, Reman*2

*1: Necessary water supply is allocated to each dam in accordance with the ratio of their residual reservoir volume.
*2: After residual storage volume of Beris Dam falls to zero, Naok and Reman dams start water supply.
*3: When necessary water supply from Naok and Reman dams is deficient, Ahning Dam starts to supplement the deficiency.

When the above dam operation rule is applied, the annual minimum storage volume of all existing dams as well as Naok and Reman dams falls to zero for only two years among the 30 years of simulation period (refer to Table 4.3.1). This condition indicates that the design drought level of a 10-year return period in drought recurrence probability can be guaranteed for all objective water supply areas including the northern part of the Muda irrigation scheme.

The dam operation rule mentioned above is, however, not to contain any factor to adjust dam water supply volume corresponding to the drought conditions. Due to non-adjustment of water supply corresponding to the drought conditions, the dams need to continue full water supply until their storage volumes fall to zero. Such operation rule could minimize the water deficit period, but also cause an extremely large shortage of water supply during the zero period of dam storage volume. To avoid such undesirable condition, an attempt was made to improve the aforesaid dam operation rule and the following optimum rule is finally selected to minimize the drought damage.

Optimum Dam Operation Rule

Dam Storage Volume Storage ($10^6 m^3$)		Dam to Supply Kedah River System		Dam to Supply Muda River System	Curtailed Ratio of Dam Water Supply
Pedu and Muda Dam	Naok and Reman Dam	Northern Part	Southern Part		
> 400	Full	Pedu	Pedu	Beris, Naok, Reman*2	0%
300 - 400	> 150	Pedu, Ahning *1	Naok, Reman*1	Beris, Naok, Reman*2	0%
	< 150	Pedu, Ahning *1	Naok, Reman, Ahning*3	Beris, Naok, Reman*2	0%
200 - 300	> 150	Pedu, Ahning*1	Naok, Reman, Beris*1	Beris, Naok, Reman*2	10%
	< 150	Pedu, Ahning*1	Naok, Reman, Ahning, Beris *1	Beris, Naok, Reman*2	10%
100 - 200	> 150	Pedu, Ahning*1	Naok, Reman, Beris*1	Beris, Naok, Reman*2	30%
	< 150	Pedu, Ahning*1	Naok, Reman, Ahning, Beris *1	Beris, Naok, Reman*2	30%
< 100	> 150	Pedu, Ahning*1	Naok, Reman, Beris*1	Beris, Naok, Reman*2	50%
	< 150	Pedu, Ahning*1	Naok, Reman, Ahning, Beris *1	Beris, Naok, Reman*2	50%

*1: Necessary water supply is allocated to each dam in accordance with the ratio of their residual reservoir volume.
*2: After residual storage volume of Beris Dam falls to zero, Naok and Reman dams start water supply.
*3: When necessary water supply from Naok and Reman dams is deficient, Ahning Dam starts to supplement the deficiency.

The optimum dam operation rule indisputably causes a longer water deficit period than the first rule to minimize the period of water deficit due to the curtailment of dam water supply. However, when the optimum dam operation is applied, the annual minimum storage volume of the existing dams as well as Beris Dam never falls to zero as shown in Table 4.3.2, and the average deficit volume during the deficit days could be reduced minimizing the drought damage, as shown below.

Water Deficit in Extraordinary Drought Year

Dam Operation Rule	Deficit Year	Basic Demand from River ($10^6 m^3$/year)	Annual Deficit Volume ($10^6 m^3$/year)	Number of Deficit Days in a year	Average Curtailed Ratio for Deficit Days (%/year)
Operation Rule to Minimize Deficit Period	1982	1,922	179	37	54
	1983	2,061	125	21	43
Optimum Rule	1980	2,031	2	52	8
	1982	1,922	80	89	11
	1983	2,061	158	51	23
	1985	2,199	11	40	3
	1987	2,170	23	86	3

5. RIVER ENVIRONMENTAL MANAGEMENT PLAN

5.1 River Maintenance Flow

As described in Section 4, the proposed water resources development plan for the Muda river basin contains the construction of Beris Dam, Jeniang Transfer Canal, Naok Dam and Reman Dam, which may cause a substantial change on the natural river flow regime. On the other hand, there does not exist any standard or regulation to set up the river maintenance flow which is defined as the minimum requirement of the river flow discharge and to be guaranteed by the release from the proposed dam reservoirs.

The river maintenance flow is essential for maintaining the appropriate river environment, particularly, the river water quality during the period of low flow regime. From this point of view, the necessary river maintenance flow is determined in due consideration of the following four (4) dominant factors:

(a) Necessary Discharge to Maintain the Appropriate River Water Quality;
(b) Necessary Discharge to Conserve Natural Low Flow Regime;
(c) Necessary Discharge to Conserve River Ecology; and
(d) Necessary Discharge to Maintain River Scenery.

As a result, the discharge to maintain the appropriate river water quality is evaluated as the most dominant factor to determine the minimum requirement for river maintenance flow. Based on the evaluation, the river maintenance flow was determined to correspond to the specific discharge of 0.01 m^3/s. This river

maintenance flow is to be guaranteed by the water released from the proposed dams and its supply plan is incorporated into the integrated dam operation rule described in Section 4.

5.2 River Corridor Management Plan

5.2.1 Extent of Zoning Plan

The delineation of river reserve area and river controlled area is proposed along the river corridor to reserve the land for river improvement works and at the same time to preserve the natural flood retarding effect (refer to Section 3). To facilitate these public, zoning plan of the river reserve area and river controlled area is essential. The zoning plan around the dam reservoirs is also indispensable to preserve the natural features of the dam reservoirs and to promote inland agro-tourism. From these viewpoints, the zoning plan was applied to the following four (4) blocks which are located within the limits of the proposed river reserve area and the lakeshore areas around the reservoirs of Muda and Beris dams (refer to Fig. 5.2.1).

River Corridor Zoning Plan

Name of Block	Extent
(1) Lower Reach Block	River improvement stretch from the river mouth up to about 40 km upstream.
(2) Middle Reach Block	(a) River corridor along Muda main stream starting from the upstream end of the above river improvement section up to the proposed site of Jeniang Barrage. (b) River corridor along Ketil River starting from the confluence of Muda River up to the confluence of Kepang River.
(3) Muda Dam Reservoir Block	Lakeshore around Muda dam reservoir
(4) Beris Dam Reservoir Block	Lakeshore around Beris dam reservoir

5.2.2 Zoning Plan in Each Block

The proposed zoning plan is subject to the following four (4) types of land development:

Type A	Land for Nature Reserve (refer to Fig. 5.2.2)
Type B	Land for Nature Use (refer to Fig. 5.2.3)
Type C	Land for Agriculture (refer to in Fig. 5.2.4)
Type D	Land for Recreation Development (refer to Fig. 5.2.5)

On the premise of the above land development types, the zoning plan is proposed for each of the aforesaid four (4) blocks as described below.

(1) Zoning in Lower Reach Block

The zoning is made, in principle, for the space of the high water channel proposed in the river improvement plan (refer to Fig. 5.2.6). In due consideration of easy accessibility from the urban areas, the principal purpose of zoning is set in developing the recreation space along the river as well as the scenery of the river. Among the proposed recreation development areas, those around Muda Barrage and Bumbung Lima are proposed as large-scale development areas containing the recreation complex as shown in Figs. 5.2.7 to 5.2.9.

(2) Zoning in Middle Reach Block

The land development for recreation purpose is proposed to the limited spots currently owned by the Government. The principal purpose of development is to provide a riverside park for the neighboring local residents in particular (refer to Fig. 5.2.10).

(3) Zoning in Muda Dam Reservoir Block

The lakeshore has a steep slope, and any large-scale resort development is judged to cause serious aggravation to the morphology of the dam reservoir. From this viewpoint, a nature use zone such as a lake park and campsite is proposed on a small scale along the left bank about 2 km downstream from Muda Dam (refer to Fig. 5.2.11). The development zone as recreational area is also proposed on a small scale around the dam site. Aside from the above nature use zone and development zone, the entire lakeshore area is proposed as a nature reserve area.

(4) Zoning in Beris Dam Reservoir Block

An extensive plain land of about 222 ha is located along the southern part of the lakeshore (refer to Fig. 5.2.12). The land will have easy accessibility via a proposed connection road and, further, an island located in front of the land could be used as a part of the resort spot. From this viewpoint, a large recreational park is proposed along the southern part of the lakeshore (refer to Fig. 5.2.13). There exist the international resort area called Pedu Resort along the shoreline of the Pedu dam reservoir. In this connection, the park proposed for Beris dam reservoir is expected to promote inland aquatic tourism development for the State of Kedah together with the Pedu Resort.

5.3 Management Plan for Sand Mining Operations

As described in Subsection 2.1.2, the riverbed subsidence due to sand mining is so serious that river structures or their functions are threatened to be damaged. To minimize such aggravation, the following items are proposed as major issues for controlling future sand mining operations.

5.3.1 Environmental Impact Assessment and Monitoring Work

According to the present regulation, Environmental Impact Assessment (EIA) is made for development activities with a land size of more than 50 ha. All of the present sand mining operations is, however, made within the limits of less than 50 ha and are, therefore, not subject to EIA. In consideration of the present various adverse effects of sand mining operations, the present regulation on EIA shall have to be amended and EIA should be required for all proposed mining works. EIA for sand mining operations and the control of sand mining volume shall be made in the following manners:

(a) All river sand mining operations in one river basin shall be integrated into one package, and EIA on the basin-wide mining operation in the past one year shall be annually made for every river basin regardless of the mining size.

(b) An increment of basin-wide mining volume shall be permitted when EIA evaluates that the mining operations in the past one year could not affect any significant river environment. However, the maximum annual increment of basin-wide mining volume shall be limited to 10% of the present volume in order to avoid the drastic alternation on the river environments.

(c) Should EIA evaluate that the basin-wide mining volume in the past one year could cause the significant adverse effects on the river biology, morphology and other related environment aspects, any issue of further license for mining shall be frozen.

The monitoring of mining works is also quite insufficient due to lack of manpower at the related government agencies, and should be improved with particular attention on the benefits to inhabitants. The periodical river channel survey should be also carried out to monitor the effect of the mining works on the river channel. Moreover, a consistent gauging system on the basin sediment yield is urgently required to be established to clarify the relationship between the sand mining volume and the available sand supplied from the basin. Details of the proposed gauging system is described in Section 6.

5.3.2 Gradual Reduction in Riversand Mining

The design riverbed profile proposed in Section 2 is to stabilize the riverbed and to increase the river channel flow capacity. To avoid any further adverse effects on the design riverbed profile, the future sand mining volume shall be taken from the layer between the original riverbed and the design riverbed. The available sand deposit in the allowable mining layer is estimated on the basis of the proposed design riverbed profile and the results of the river channel survey undertaken by JICA in 1994. As the results, the following volumes are proposed as the allowable sand deposit for mining operations.

Sand Deposit Allowable for Mining

River System	Stretch	Length (km)	Sand Deposit (m3)
Main Stream	River Mouth to Muda Barrage	10.4	620,000
Main Stream	Muda Barrage to Merdeka Bridge	2.7	160,000
Main Stream	43 to 50 km upstream from River Mouth	6.7	310,000
Main River	63 to 68 km upstream from River Mouth	2.0	130,000
Total		21.8	1,220,000

The above estimated sand deposit is almost equivalent only to the actual annual mining volume in 1993, and out of the total deposit, about 50% (620,000 m^3) is located downstream from Muda Barrage containing the salinity. Moreover, the annual basin sediment yield is estimated at about 10,000 m^3 which is much less than the actual mining volume in 1993.

Since the sand deposit for allowable mining is quite limited, and sand supply from the upstream is hardly expected, the riverbed will be lowered as long as sand mining operations are pursued. In due consideration of these conditions, gradual reduction and finally freezing of sand mining from the riverbed is strongly recommended.

5.3.3 Alternative Source for Construction Sand

It is indispensable to locate a new mining source aside from the riverbed. In this connection, ocean sand is regarded as the most probable alternative source for sand mining. In Japan, the present major source for sand mining is either the mountains or the ocean, and mining from rivers is less made because of erosion of the river channel. The ratio of sand mining volume from each source in Japan recorded in 1992 are as summarized below.

Sand from the Ocean	36.7%
Sand from the Mountain	36.2%
Sand from the River and Others	27.1%

The sand mined from the ocean contains salt that must be removed. According to the Japanese Standard (JIS A5308), the sand after removal of salt must contain salinity (NaCl) of less than 0.04% for use of concrete material. The shells and other deposits in sand must be segregated from the sand. When the mined sand is too fine and its

particle size is rather uniform, crushed rock is mixed with the sand to make the appropriate distribution of particle size.

Thus, mining from ocean sand will require additional treatment as well as mining cost as compared with river sand. Moreover, the material of the ocean sand is not always applicable to the construction material. Accordingly, detailed sampling test will be required in advance, and the appropriate area for mining will need to be selected, when the ocean sand is applied.

6. WATERSHED MANAGEMENT AND MONITORING PLAN

6.1 Zoning Plan for Water Source Reserve Area

A river reserve and controlled area is proposed to facilitate the river improvement works, to preserve the natural flood retarding effects and to minimize the damage caused by flood inundation and channel erosion (refer to Chapter 6). In this Study, a water source reserve area is further proposed with the following objectives (refer to Tables 6.1.1 to 6.1.2 and Fig. 6.1.1):

(a) To preserve the appropriate basin runoff discharge and sediment load;

(b) To restrain polluted water loads flowing out from the basin; and

(c) To protect the morphology of the dam reservoir from the undesirable activities along the lakeshore.

The proposed water source reserve area shall cover the catchment area of the existing Muda Dam, the proposed Beris Dam, and the Jeniang Barrage. The present major forest reserve area located in the upper reaches is also added to the water source reserve area. Hence, the water source reserve area comes to about 2,529 km^2 or 60.1% of the entire Muda river basin. The water source reserve area is further divided into the present forest reserve area of 2,211 km^2 and agricultural area of 318 km^2 corresponding to about 52.5% and 7.6% of the basin total, respectively.

The water source reserve area overlaps with the forest reserve area and the agricultural land. The State Authority appointed the Department of Forest as a legal

controller for the forest reserve area and the Department of Land and Mining for the agricultural land. The overlapping area is rather extensive, and it is deemed difficult to transfer such present jurisdiction to the proposed river management body; details of the river management body are described in the following section 7. Due to this situation, it is proposed that the river management body will not directly control the reserve area. Instead, the body will monitor the logging and/or agricultural activities and will provide the technical reference related to the river conditions to the present legal controllers and/or the State Authority.

6.2 Objectives of Watershed Management and Monitoring

As described in the following section 7, a river management body is proposed with a three tier structure composed of the Muda Council at the top supported by a Technical Committee at the second level and a Technical Secretariat at the third level. The river management body will integrate the various monitoring items related both to the river conditions and the land development activities in the water source reserve area and the river reserve area (refer to Table 6.2.1). Based on the integrated monitoring data, the river management body will execute the short-term actions for flood mitigation works, water allocation, and river environmental improvement works. The body will also formulate the long-term basin development and management plans. The proposed river management works are carried out on the basis of the monitoring results as shown in Fig. 6.2.1.

6.3 Proposed Hydrological Monitoring Network

Among the monitoring items, the hydrological data requires major gauging facilities, so that integrated hydrological gauging networks are newly proposed as described in the following subsections. All management works for the proposed hydrological gauging networks are to be undertaken by the Technical Secretariat under an integrated river management body (refer to section 7).

6.3.1 Reference Point

The integrated reference points are first of all proposed to consistently monitor the river hydrology. The location of the reference points are selected considering the

locations of the existing gauging stations, the confluence of the major tributaries and the major river structures, as summarized below (refer to Fig. 6.3.1).

Proposed Reference Points in Muda River System

Principal Reference Point (Class 1)			Sub-Reference Point (Class 2)		
Name	River	Catchment Area (km^2)	Name	River	Catchment Area (km^2)
(1) Muda Dam	Muda	984	(1) Telui Timor	Muda	2,377
(2) Jeniang	Muda	1,740	(2) Reman Dam	Reman	32
(3) Jam. Syed Omar	Muda	3,330	(3) Batu Rima	Chepir	233
(4) Ldg. Victoria	Muda	4,010	(4) Muda Barrage	Muda	4,201
(5) Beris Dam	Beris	116	(5) Merbau Pulas	Sedim	219
(6) Kuala Pegang	Ketil	704			

The principal reference points (Class 1) are placed along the main stream of Muda River and/or downstream of the major tributaries to provide the principal information for all river management works. Priority of on-line system is given to the data transmittal of runoff discharge monitored at the principal reference point. The sub-reference points (Class 2) are placed to supplement the information for water allocation and/or flood mitigation works. In addition, the reference for Class 3 are proposed at four (4) sites of the existing gauging stations controlled by DID for the purpose of flood forecasting.

6.3.2 Rainfall Gauging Network

The existing 15 gauging stations are unevenly distributed in the lower reaches of the basin and, therefore, it is difficult to evaluate the basin runoff discharge in the water source reserve area located in the upper reaches (refer to Fig. 6.3.2). In this context, 10 rainfall gauging stations are newly proposed to monitor the rainfall conditions principally for the water source reserve area (refer to Fig. 6.3.2). All proposed rainfall gauging stations are accessible via the existing road or the waterway.

6.3.3 River Gauging Network

Gauging stations are proposed for each reference point. The total number of proposed gauging stations is 15, composed of 6 for Class 1 station, 5 for Class 2 station, and 4 for Class 3 station. All stations for Class 1 are converted from the existing gauging stations, therefore, their hydrological data so far recorded could be incorporated into

the further monitoring works. On the other hand, the Class 2 gauging stations are newly proposed, except the station at Muda Barrage, to supplement the present hydrological gauging network. The gauging items for each of proposed stations are as summarized below.

Proposed River Gauging Network

Class of Gauging Station	Number of Stations	Location	Gauging Items
Class 1	6	Principal reference points	Water level, discharge, sediment load and water quality.
Class 2	5	Sub-reference points	Same as Class 1 but excluding sediment load
Class 3	4	Present water level gauging stations for flood forecasting	Water level

6.3.4 Necessity of Nationwide River Information System

In the country, there are more than 1,500 rivers experiencing habitual flood inundation and the recurrent shortage of water supply. Deterioration of river conditions could be attributed specially to the lack of non-structural river management measures. In this connection, the first step for the comprehensive river basin management must be given to such non-structural measures including establishment of a river monitoring system on a nationwide scale.

The nationwide river monitoring system is essential for the purpose of planning and design, development and regular management for the rivers, so that prompt action can be taken whenever necessary. The river information to be monitored by the system will be voluminous and dynamic in nature, requiring frequent updating and systematic storage. A computerized information system is therefore essential to improve efficiency and effectiveness in the management of rivers.

The Government of Malaysia is keen to establish the nationwide river information system. This nationwide river information system is a new attempt for the hydrological monitoring activities, and will be useful for the aforesaid comprehensive river basin management. Accordingly, an early implementation of the study on the

strongly recommended including the study on the optimum institutional setup for the system management.

7. INSTITUTIONAL SETUP FOR RIVER MANAGEMENT

In due consideration of consistency with the existing government structure, the following three-tier structure is proposed to organize the river management body including the Muda River Basin Management Council at the top supported by a Technical Committee at the second level, and a Technical Secretariat.

Composition	Members	Functions/Scope of Works
Muda River Basin Management Council	1. EPU of Kedah and Penang 2. DID of Kedah and Penang 3. MADA 4. PWA 5. Department of Lands and Mines of Kedah and Penang 6. Forestry Department of Kedah 7. Water Supply Division of Kedah PWD	1. To approve Long-Term and Five-Year Basin Water Resources Development and Management Master Plan 2. To approve basin policies on water use priorities and allocation, flood mitigation measures, river reserves, river environment management, etc 3. To approve emergency actions to be taken during extreme droughts and floods 4. To approve water pricing policies both for the water abstraction from and water discharges into the Muda River.
Technical Committee	1. DID of Kedah and Penang 2. MADA 3. P WA 4. Water Supply Division of Kedah PWD 5. Forestry Department of Kedah 6. Town and Country Planning Department of Kedah 7. Lands and Mines Department of Kedah and Penang	1. To promote and implement rational management of water resources of the Muda River Basin through integrated and coordinated planning of water resources development 2. To prepare the Long-Term and the Five-Year Basin Water Resources Development and Management Master Plan of the Muda river basin 3. To establish procedures to determine water use priorities during periods of inadequate water supplies due to drought or other causes 4. To establish guidelines and procedures for the prevention and control of flooding, soil erosion and damage to catchment areas and water causes 5. To formulate policies and legal provisions for the management of the Muda River Basin for consideration and endorsement by the Muda River Basin Management Council 6. To coordinate and integrate the different development and management plans and projects of the various department and agencies within the Basin; and 7. To coordinate land use planning and land use changes with water resources planning, development and management of the Basin.
Technical Secretariat	Federal Unit of DID	1. To collate all the hydrological data, water extraction data, water use data, water pollution data, etc., from the existing government departments and agencies in the states of Kedah and Pulau Pinang 2. To collate all development plans, management plans, design standards, etc., for the preparation of the preliminary Long-Term and the Five-Year Basin Development and Management Master Plan; 3. To monitor all activities related to the Muda River Basin which have major negative impacts on the water resources of the Basin; 4. To submit proposals to the Technical Committee on resolving issues and problems encountered in the implementation of the Master Plan; 5. To prepare procedures for the consideration of the Technical Committee on proper management of sand mining, designation of river reserves, and issues related to the management of the Basin; 6. To act as the River Administrator of the Muda River where appropriate, and with endorsement of the Muda River Management Council 7. To enforce the emergency actions to be taken during droughts and floods as and when directed by the Muda River basin Management Council.

Through a series of discussion with and agreements from the officials concerned to the State Governments of Kedah and Penang, the following arrangements for the above organization are provisionally proposed:

(a) The Muda River Basin Management Council shall be chaired by an appropriate Executive Council Member of the State of Kedah and the Secretariat to the Council shall be the Kedah State Economic Planning Unit;

(b) The Chairman of Technical Committee shall be the Director of the River Division of the Federal Department of Irrigation and Drainage; and

(c) The Technical Secretariat shall be a Federal Unit under the Director of River Engineering Division of the Department of Irrigation and Drainage and shall be established in the office of the Kedah State Department of Irrigation and Drainage.

To offset part of the cost for the integrated management of Muda river basin, the Muda River Basin Management Council could consider charging fees for the direct abstraction of water from Muda River from the main water suppliers. The charge to be levied will be based on the quantity and usage of the water suppliers. A fee could also be levied on the discharge of water from point sources, and the charge will be based on the quantity and level of pollution of the water being discharged at each point.

The proposed institutional setup can be established with the existing government departments and agencies . There will only be one new unit, the Technical Secretariat, which will be seconded from the Federal Department of Irrigation and Drainage, to the Kedah State Department of Irrigation and Drainage. Thus, the proposed institutional setup can be established almost immediately with minimal additional costs.

As a start, the Technical Secretariat will be the central collating organization for the monitoring system of Muda river basin. It will not immediately take over the existing monitoring activities of the various government departments and agencies, but will complement and enhance the existing monitoring system by advising on additional monitoring required and providing some funds from the Federal Government for the purchase of new equipment. The Technical Secretariat will also collate and integrate all existing monitoring data collected and carry out studies and analysis on the data

when necessary. As the Technical Secretariat becomes better established, it can and should slowly take over the operation and management of the whole monitoring system of Muda river basin in an integrated manner.

8. CONSTRUCTION PLAN

The implementation schedule and project cost estimate are prepared for the structures proposed for the three (3) major sectors, mitigation plan, water resources management plan and river environmental management plan.

8.1 Implementation Schedule

In due consideration of the aforesaid basic conditions for construction works as well as work quantities of the proposed structures, the implementation schedule is proposed as summarized below (refer to Fig. 8.1.1).

Implementation Schedule

Work Item	Implementation Period Allocated to 5-Year Malaysia Plans					
	Preparatory/Engineering Works			Construction Works		
	7th (1996 - 2000)	8th (2001 - 2005)	9th (2006 - 2010)	7th (1996 - 2000)	8th (2001 - 2005)	9th (2006 - 2010)
1. Flood Mitigation						
1.1 Downstream of Muda River		O				O
1.2 Others		O			O	
2. Water Resources Management						
2.1 Beris Dam	O			O		
2.2 Jeniang Transfer System	O	O			O	
2.3 Naok Dam	O	O			O	
2.4 Reman Dam	O	O			O	O
3. River Environmental management						
3.1 River Corridor Development		O			O	O
3.2 Dam Lakeshore Development	O			O		

To facilitate the successful implementation of the structural plans and the integrated operation of the structures, the watershed management and monitoring plans are further scheduled to be completed in the following 5-year Malaysia plans (M.P.).

Implementation Schedule of Watershed Management and Monitoring Plan

Work Item	Target Completion
(1) Institutional Setup for River Management Body	7th M.P.
(2) Zoning (River Reserve Area and Water Source Reserve Area)	7th M.P.
(3) Monitoring System for : Hydrological Data	7th M.P.
: Water Abstraction Volume	8th M.P.
: Others	9th M.P.

8.2 Project Cost

The project cost is estimated on the basis of the design, construction plan and schedule, and the following assumptions and conditions:

(a) All unit costs are expressed based on the price level at the end of 1994.

(b) The exchange rate of currency is US$1.00 = RM 2.51.

(c) Project cost is composed of construction cost and contingencies. The construction cost is further divided into direct and indirect costs that includes the following items:

(i) Administration Cost = 5% of direct cost and compensation cost;

(ii) Engineering Cost = 10% of direct cost;

(iii) Physical Contingencies = 10% of direct cost, compensation cost and administration cost.

Based on the above premises, the project cost is estimated as below.

Project Cost

Unit: RM 1,000

Work Item	F.C.	L.C.	Total
1 Flood Mitigation Plan (River Improvement)			
1.1 Downstream of Muda River	171,143	152,443	323,586
1.2 Kuala Ketil Town Stretch	6,994	11,270	18,264
1.3 Baling Town Stretch	3,031	6,779	9,810
1.4 Sik Town Stretch	2,212	5,138	7,350
Sub-Total	183,380	175,630	359,010
2. Water Resources Management Plan			
2.1 Beris Dam	75,505	100,056	175,561
2.2 Jeniang Transfer System	56,576	109,509	166,086
2.3 Reman Dam	49,750	78,806	128,556
Sub-Total	181,831	288,371	470,203
3. River Environment management	10,977	31,224	42,201
Grand Total	376,188	496,225	871,414

Note: Cost for price escalation is excluded from the above project cost.

9. PROJECT EVALUATION

9.1 Economic Evaluation

The economic evaluation was made for the proposed structural plans in the sectors of flood mitigation, water resources management and river environmental improvement. Summarized below is the economic internal rate of return (EIRR) for proposed structural plans.

Economic Evaluation

Sector	Proposed Structural Plan	EIRR (%)
Flood Mitigation	River improvement of 4 target river stretches.	8.3
Water Resources Management	Construction of Beris Dam, Naok Dam, Reman Dam and Jeniang Transfer Canal.	14.6
River Environmental Management	Land development of river corridor and lakeshore around reservoirs of Muda and Beris dams	23.8
Overall		13.6

According to analysis of international agencies, the opportunity cost of capital is estimated at 10 to 12%. Among the proposed structural plans, those for water resources management and river environmental management exceed the opportunity cost , and therefore could be economically justifiable.

On the other hand, the EIRR of the structural plans for flood mitigation is somewhat low as compared with the opportunity cost of capital. The flood mitigation project is, however, essential to ensure an stable social environment and promote an economic

development of the region. Accordingly, implementation of the flood mitigation project is recommended, not necessarily being tied down to the economic viability.

9.2 Environmental Impact Assessment

A preliminary environmental impact assessment has been carried out for the following major proposed structures for water resources development, flood mitigation and river environmental improvement.

Sector	Objective Structures
Flood Mitigation	River Improvement of Lower Muda
Water Resources Management	Beris dam Jeniang transfer system including Naok and Reman dams
River Environmental Management	Beris dam reservoir recreational park Muda barrage recreational park Bumbong Lima recreational park

The results of environmental impact assessment are summarized into assessment matrixes as shown in Tables 12.2 1 to 12.2.6. According to the assessment matrixes, the significant impacts by the proposed structures are seen in the following four (4) issues: (a) resettlement, (b) disruption of community, (c) soil erosion and (d) water pollution. The countermeasures and necessary monitoring items for these issues are proposed as below.

Issues	Causes	Countermeasures	Necessary Monitoring Items
Resettlement	(1) Beris Dam (2) Jeniang Transfer System (3) River channel Improvement (4) Bumbong Lima recreation park	(1) Coordination with inhabitant. (2) Reasonable compensation for resettlement. (3) Assistance and guidance for suitable income of inhabitant to be resettled. (4) Preparation of resettlement land based on the desire of inhabitant.	(1) Living conditions of inhabitant to be resettled. (2) Regional socio economy (3) Precedents of resettlement of similar projects. (4) Conditions of resettlement land.
Disruption of community	Beris Dam	(1) Compensation to non-resettled inhabitant. (2) Construction of new transportation network. (3) Reorganization of administrative division. (4) Establishment of new telecommunication service.	(1) Regional socio economy (2) New transportation system (3) Living conditions of inhabitants including non-settled people.
Soil erosion	(1) Beris Dam (2) Jeniang Transfer System	(1) Dredging works (2) Plantation (3) Land use control	(1) Topography, geology and soil. (2) Vegetation
Water pollution	(1) Beris Dam (2) Jeniang Transfer System (3) Beris Dam Reservoir Recreation Park	(1) Control and treatment of pollution loads. (2) Removal of vegetation before dam impounding.	(1) Pollution source (2) Water use in dam reservoir and river channel. (3) Water quality survey.

TABLES

VOLUME I

SUMMARY

TABLE 2.3.1 PRESENT LAND USE IN MUDA RIVER BASIN AND KEDAH STATE

Item	Muda River Basin		Kedah State	
	(km2)	(%)	(km2)	(%)
1. Agricultural land	1,771	42.06	4,756	51.22
(1) Mixed Horticulture	163	3.88	426	4.59
(2) Rubber	1,393	33.09	2,504	26.96
(3) Oil Palm	76	1.80	219	2.36
(4) Paddy	131	3.11	1,448	15.60
(5) Others	8	0.18	158	1.70
2. Non-Agricultural Land	2,439	57.94	4,530	48.78
(1) Urban and Associated Area	2	0.05	122	1.31
(2) Forest	2,361	56.09	3,944	42.47
(a) Forest	2,251	53.46	3,483	37.51
(b) Scrub Forest	109	2.59	334	3.60
(c) Scrub Grass	2	0.04	127	1.37
(3) Newly Cleared Land	62	1.48	129	1.39
(4) Lake & Swamp	14	0.33	162	1.75
(5) Others	Nil	0.00	172	0.00
Grand Total	4,210	100.00	9,285	100.00

Source : Land use map from Ministry of Agriculture
Development Statistics of Kedah Darul Aman

TABLE 4.3.1 ANNUAL MINIMUM STORAGE VOLUME OF DAM RESERVOIR
(UNDER OPERATION RULE TO MINIMIZE PERIOD OF WATER DEFICIT)

(unit : 1,000 cum)

YEAR	MUDA & PEDU	AHNING	BERIS	NAOK & REMAN
1962	624223.0	200000.0	103248.9	267400.0
1963	287147.8	200000.0	75563.0	215923.7
1964	278996.3	200000.0	68798.3	150420.9
1965	293876.3	200000.0	85888.4	190875.9
1966	597117.0	200000.0	108456.1	267400.0
1967	787351.9	200000.0	101440.8	267400.0
1968	594455.5	200000.0	89542.9	267400.0
1969	620740.6	200000.0	100808.2	267400.0
1970	519093.4	200000.0	95799.3	267400.0
1971	743949.0	200000.0	105582.5	267400.0
1972	736923.1	200000.0	96455.6	267400.0
1973	963170.9	200000.0	105435.4	267400.0
1974	783514.1	200000.0	101982.2	267400.0
1975	700277.5	200000.0	101889.4	267400.0
1976	789776.6	200000.0	96531.3	267400.0
1977	571171.5	200000.0	53826.1	267400.0
1978	369350.2	200000.0	57689.3	236520.2
1979	131262.5	117453.3	.0	53741.5
1980	32190.9	40251.5	.0	1960.6
1981	137943.4	63082.2	.0	108542.3
1982	.0	.0	.0	.0
1983	.0	.0	.0	.0
1984	100817.8	50968.5	11018.2	137816.4
1985	40368.5	21459.1	23538.7	68117.5
1986	37122.0	34090.2	41397.8	110946.4
1987	.0	2295.4	42334.0	57430.8
1988	416646.3	88984.5	96885.6	267400.0
1989	795413.1	180796.0	107331.4	267400.0
1990	585031.0	199540.8	100599.1	267400.0
1991	387034.6	199680.2	91097.0	253044.7

TABLE 4.3.2 ANNUAL MINIMUM STORAGE VOLUME OF DAM RESERVOIR (UNDER OPTIMUM OPERATION RULE)

(unit : 1,000 cum)

YEAR	MUDA & PEDU	AHNING	BERIS	NAOK & REMAN
1962	624223.0	200000.0	103248.9	267400.0
1963	287147.8	200000.0	75563.0	215923.7
1964	278996.3	200000.0	68798.3	150420.9
1965	293876.3	200000.0	85888.4	190875.9
1966	597117.0	200000.0	108456.1	267400.0
1967	787351.9	200000.0	101440.8	267400.0
1968	594455.5	200000.0	89542.9	267400.0
1969	620740.6	200000.0	100808.2	267400.0
1970	519093.4	200000.0	95799.3	267400.0
1971	743949.0	200000.0	105582.5	267400.0
1972	736923.1	200000.0	96455.6	267400.0
1973	963170.9	200000.0	105435.4	267400.0
1974	783514.1	200000.0	101982.2	267400.0
1975	700277.5	200000.0	101889.4	267400.0
1976	789776.6	200000.0	96531.3	267400.0
1977	571171.5	200000.0	53826.1	267400.0
1978	369350.2	200000.0	57689.3	236520.2
1979	131262.5	117453.3	.0	53741.5
1980	57911.3	57029.5	.0	11315.6
1981	154100.4	82312.9	.0	118784.8
1982	.1	602.5	.0	7129.3
1983	55366.5	.0	.0	12.6
1984	132504.4	68725.2	11159.1	154839.2
1985	80139.9	33433.8	23850.9	80870.0
1986	67929.9	47860.1	41756.0	120688.8
1987	17996.1	36335.2	42884.4	70555.6
1988	435681.6	123757.6	97483.2	267400.0
1989	795761.0	199861.5	107331.4	267400.0
1990	585031.0	199540.8	100599.1	267400.0
1991	387034.6	199680.2	91097.0	253044.7

TABLE 6.1.1 EXTENT AND PURPOSE OF PROPOSED WATERSHED ZONING

Classified Zone		Extent	Size (km^2)	Size (%)	Purpose
Water Source Reserve Area	Zone 1	Present forest reserve area surrounding dam reservoir *1	240 *2	5.7	• Preserve the water quality, beatification/ morphology of the dam reservoir • Restrain the basin sediment yield, and polluted runoff discharge to dam reservoir. • Preserve the basin waster storage capacity.
	Zone 2	Present forest reserve area in dam catchment area other than Zone 1.	849 *3	20.1	
	Zone 3	Present cultivation area in the proposed dam catchment area	63 *4	1.5	
	Zone 4	Present forest reserve area in non-dam catchment area	1,142	27.1	• Preserve the water quality, beatification/ morphology of the river. • Restrain the polluted runoff discharge to the natural river flow. • Preserve the basin water storage capacity.
	Zone 5	Present cultivation area to critically effect river water quality and basin runoff condition	255	6.1	
	Sub-total (Present Forest Reserve Area:) (Present Cultivation Area :)		2,529 (2,211) (318)	60.0 (52.5) (7.5)	
River Reserve and Controlled Area	Zone 6	Probable flood inundation area (100-year return period) and shore belt of dam reservoirs	57	1.4	Facilitate river improvement, preserve flood retarding effect; protect river from undesirable activities, and minimize damages caused by flood and channel erosion/ meandering
Potential Land Development Area	Zone 7	Area other than those belonged to above classifications.	1,624	38.6	Use as the potential urban, industrial and agricultural development land.
Grand Total			4,210	100.0	

Note *1 Exclude the shore belt where the detailed zoning plan will be formulated as a part of river reserve area (Zone 6).

*2 Composed of 155 km^2 for Muda dam and 85 km^2 for the proposed Beris dam.

*3: Applied solely to the catchment area of Muda dam.

*4: Composed of 31 km^2 for the proposed Beris dam and 32 km^2 for the proposed Reman dam.

TABLE .6.1.2 MONITORING ITEMS AND REQUIRED ACTIVITIES FOR PROPOSED WATERSHED ZONING

Classified Zone		Required Activities	Monitoring Items	
			River Basin and Corridor	River and Dam Reservoir
Water Source Reserve Area	Zone 1	• Freeze any logging activities	• Logging activities	• Dam inflow and out flow discharge • Dam inflow and outflow sediment volume • Water quality of dam reservoir • Fauna and flora in dam reservoir
	Zone 2	• Provide technical reference on the logging activities, if necessary.	• Logging activities	
	Zone 3	• Provide technical reference on the agricultural activities, if necessary.	• Agricultural activities • Alienation or temporary occupation of the land	• Basin run-off discharge • Basin run-off sediment load • River water quality • Fauna and flora
	Zone 4	• Provide technical reference on the logging activities, if necessary.	• Logging activities	
	Zone 5	• Provide technical reference on the agricultural activities, if necessary.	• Agricultural activities • Alienation or temporary occupation of the land	
River Reserve and Controlled Area	Zone 6	• Control the excessive land development activities • Control the illegal sand mining and other water works.	• Agro-tourism/resort development • Agricultural activities • Conversion of land • Land development • Flood damage potential	• River flow discharge • Scenery of river channel • Morphology of river channel • Water quality of river flow • Sand mining activities • Fauna and flora

TABLE 6.2.1 PROPSED MONITORING ITEMS AND PURPOSE

Monitoring Item	Monitoring Measure	Monitoring Purpose											
		Flood Management				Water Resources Management				River Environment Management			
		(1) Flood Forecasting & Warning (2) Control of Flood Flow Discharge (3) Retention of Flood Runoff from Catchment Area (4) Reduction of Flood Damage Potential				(1) Increment of Low Water Runoff from Catchment Area (2) Control of Low Flow Regime of the River (3) Water Allocation 1 (for Irrigation) (4) Water Allocation 2 (for Domestic & Industrial)				(1) Agro-tourism/Resort Development (2) Nature Preserve (3) Improvement of River Scenery (4) Navigation			
		(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
1. Monitoring of River													
1.1 River Hydrology 1 (Water Level & Discharge)	Gauging	●*	○*	○		○	●*	●*	●*		○		
1.2 River Hydrology 2 (Suspended Sediment & River Bed Material)	Sampling & Laboratory Test												○
1.3 River Hydrology 3 (Water Quality & Pollutant Source)	Sampling & Laboratory Test							○	○	○	○		
1.4 River Hydrology 4 (Inflow & Outflow of Dam & Barrage)	Gauging		○*				●*	●*	●*				
1.5 River Morphology (Erosion/Sedimentation/Meandering)	Channel Survey & On-site Inspection				○					○	○	○	○
1.6 Water Abstraction Volume at Intake Point	Gauging							●*	●*				
1.7 Sand Mining (Location/Mining Volume/Mining Measure)	Notification & On-site Inspection				○					○		○	○
1.8 Construction of River Structure (Bridge, Water Pipe, River Bank, etc.)	Notification & On-site Inspection									○	○	○	
1.9 Fauna and Flora	On-site Inspection									○	○	○	
1.10 Damages caused by Actual Flood	On-site Inspection				○								
1.11 Navigation	Notification & On-site Inspection												○
2. Monitoring of Watershed and River Corridor													
2.1 Watershed Hydrology (Rainfall and Evaporation)	Gauging	●*	○*	○		○	●*	●*					
2.2 Land Use of Watershed and River Corridor (Vegetation/Land Development)	Survey on Aero-photograph			○	○	○		○	○	○	○	○	
2.3 Infrastructure (Road Network, Water Supply Network, etc.)	Notification & On-site Inspection							○	○	○		○	

Note : ● = Existing ○ = Proposed * = Real Time Monitoring

TABLE 12.2.1 ASSESSMENT MATRIX OF ENVIRONMENTAL IMPACT FOR BERIS DAM PROJECT

Environment Factors	Breakdown of Project / Scheme				Remarks
	Activities			Existance of Structures	
	Site Invest.	Construction	O & M		
1. Social Environment					
1.1 Resettlement	N	U1	N	A3	Some villages submerged
1.2 Economic Activities	N	B2	B1	B2	Increase of income/job
1.3 Transportation / Public Facilities	N	A1	N	B1	More convenient by the project
1.4 Division of Communities	N	A2	N	A2	Due to resettlement
1.5 Archaelogical / Cultural Heritage	U1	U1	U1	U1	No significant site
1.6 Vested Right	U1	U1	U1	U1	No definite right now
1.7 Health and Hygene	N	A1	N	U1	Generally not significant
1.8 Waste Disposal	A1	A1	A1	N	Increase of waste
1.9 Accident	N	A1	N	N	Only during construction
2. Natural Environment					
2.1 Topography and Geology	A1	U1	N	A1	Effect not significant
2.2 Soil Erosion	A1	A2	N	A2	By logging & land clearing
2.3 Ground Water	N	N	N	U1	
2.4 River and Reservoir / pond	N	N	N	A1	
2.5 Coastal Zone	N	N	N	A1	Far to the coast
2.6 Fauna (Wildlife)	N	A1	N	U1	No valuable speices
2.7 Flora (Vegetation)	N	A1	N	U1	Forest logging
2.8 Climate	N	N	N	N	
2.9 Landscape	N	A1	N	B2	Beautiful water front
3. Public Nuisanse					
3.1 Air Pollution	N	N	N	N	
3.2 Water Pollution	N	A2	N	U1	Reservoir nutrification
3.3 Soil Contamination	N	A1	N	N	
3.4 Noise and Vibration	A1	A1	N	N	
3.5 Ground Subsidence	N	N	N	N	
3.6 Odour	N	A1	N	U1	

Assessment Clasification

A1 : Adverse impact - minor

A2 : Adverse impact - medium / moderate

A3 : Adverse impact - major / significant

U1 : Unknow due to insufficent data but probably minor impact (A1) or no adverse impact

U2 : Unknow due to insufficent data but probably adverse impact (A2 or A3)

N : No adverse impact

B1 : Beneficial / positive impact - minor

B2 : Beneficial / positive impact - major

TABLE 12.2.2 ASSESSMENT MATRIX OF ENVIRONMENTAL IMPACT FOR JENIANG TRANSFER PROJECT

Environment Factors	Breakdown of Project / Scheme				Remarks
	Activities			Existance of Structures	
	Site Invest.	Construction	O & M		
1. Social Environment					
1.1 Resettlement	N	U1	N	A2	Some houses submerged
1.2 Economic Activities	N	B2	B1	B1	Increase of income/job
1.3 Transportation / Public Facilities	N	A1	N	B1	More convenient by the project
1.4 Division of Communities	N	A1	N	A1	
1.5 Archaelogical / Cultural Heritage	U1	U1	U1	U1	No significant site
1.6 Vested Right	U1	U1	U1	U1	No definite right now
1.7 Health and Hygene	N	A1	N	U1	Generally not significant
1.8 Waste Disposal	A1	A1	A1	N	Increase of waste
1.9 Accident	N	A1	N	N	Only during construction
2. Natural Environment					
2.1 Topography and Geology	A1	U1	N	A1	Effect not significant
2.2 Soil Erosion	A1	A2	N	A1	By logging & land clearing
2.3 Ground Water	N	N	N	U1	
2.4 River and Reservoir / pond	N	N	N	A1	
2.5 Coastal Zone	N	N	N	A1	Far to the coast
2.6 Fauna (Wildlife)	N	U1	N	U1	No valuable speices
2.7 Flora (Vegetation)	N	U1	N	U1	Forest logging
2.8 Climate	N	N	N	N	
2.9 Landscape	N	A1	N	B2	Beautiful water front
3. Public Nuisanse					
3.1 Air Pollution	N	N	N	N	
3.2 Water Pollution	N	A2	N	U1	Reservoir nutrification
3.3 Soil Contamination	N	A1	N	N	
3.4 Noise and Vibration	A1	A1	N	N	
3.5 Ground Subsidence	N	N	N	N	
3.6 Odour	N	A1	N	U1	

Assessment Clasification

A1 : Adverse impact - minor

A2 : Adverse impact - medium / moderate

A3 : Adverse impact - major / significant

U1 : Unknow due to insufficent data but probably minor impact (A1) or no adverse impact

U2 : Unknow due to insufficent data but probably adverse impact (A2 or A3)

N : No adverse impact

B1 : Beneficial / positive impact - minor

B2 : Beneficial / positive impact - major

TABLE 12.2.3 ASSESSMENT MATRIX OF ENVIRONMENTAL IMPACT FOR LOWER REACH RIVER IMPROVEMENT WORKS

Environment Factors	Breakdown of Project / Scheme				Remarks
	Activities			Existance of Structures	
	Site Invest.	Construction	O & M		
1. Social Environment					
1.1 Resettlement	N	U1	N	A2	Some houses relocated
1.2 Economic Activities	N	B2	B1	N	Increase of income/job
1.3 Transportation / Public Facilities	N	N	N	N	
1.4 Division of Communities	N	A1	N	N	
1.5 Archaelogical / Cultural Heritage	U1	U1	U1	U1	No significant site
1.6 Vested Right	U1	U1	U1	U1	No definite right now
1.7 Health and Hygene	N	A1	N	U1	
1.8 Waste Disposal	A1	A1	A1	N	
1.9 Accident	N	A1	N	N	
2. Natural Environment					
2.1 Topography and Geology	N	U1	N	A1	
2.2 Soil Erosion	A1	A1	N	N	
2.3 Ground Water	N	N	N	U1	
2.4 River and Reservoir / pond	N	A1	N	A1	
2.5 Coastal Zone	N	N	N	B1	River mouth improved
2.6 Fauna (Wildlife)	N	U1	N	U1	No valuable speices
2.7 Flora (Vegetation)	N	A1	N	U1	
2.8 Climate	N	N	N	N	
2.9 Landscape	N	A1	N	B1	
3. Public Nuisanse					
3.1 Air Pollution	N	N	N	N	
3.2 Water Pollution	N	A1	N	N	
3.3 Soil Contamination	N	A1	N	N	
3.4 Noise and Vibration	A1	A1	N	N	
3.5 Ground Subsidence	N	N	N	N	
3.6 Odour	N	A1	N	U1	

Assessment Clasification

A1 : Adverse impact - minor

A2 : Adverse impact - medium / moderate

A3 : Adverse impact - major / significant

U1 : Unknow due to insufficent data but probably minor impact (A1) or no adverse impact

U2 : Unknow due to insufficent data but probably adverse impact (A2 or A3)

N : No adverse impact

B1 : Beneficial / positive impact - minor

B2 : Beneficial / positive impact - major

TABLE 12.2.4 ASSESSMENT MATRIX OF ENVIRONMENTAL IMPACT FOR BERIS RESERVOIR RECREATIONAL PARK SCHEME

Environment Factors	Breakdown of Project / Scheme				Remarks
	Activities			Existance of Structures	
	Site Invest.	Construction	O & M		
1. Social Environment					
1.1 Resettlement	N	U1	N	U1	
1.2 Economic Activities	N	B2	B1	B2	Increase of income/job
1.3 Transportation / Public Facilities	N	A1	N	B1	More convenient
1.4 Division of Communities	N	N	N	N	
1.5 Archaelogical / Cultural Heritage	U1	U1	U1	U1	No significant site
1.6 Vested Right	U1	U1	U1	U1	No definite right now
1.7 Health and Hygene	N	A1	N	U1	
1.8 Waste Disposal	A1	A1	A1	A1	Depend on management
1.9 Accident	N	A1	N	N	
2. Natural Environment					
2.1 Topography and Geology	N	U1	N	A1	
2.2 Soil Erosion	A1	A1	N	A1	
2.3 Ground Water	N	N	N	U1	
2.4 River and Reservoir / pond	N	N	N	N	
2.5 Coastal Zone	N	N	N	N	
2.6 Fauna (Wildlife)	N	U1	N	U1	
2.7 Flora (Vegetation)	N	A1	N	A1	
2.8 Climate	N	N	N	N	
2.9 Landscape	N	A1	N	B2	Beautiful park
3. Public Nuisanse					
3.1 Air Pollution	N	N	N	N	
3.2 Water Pollution	N	A1	N	A2	Drainage from park
3.3 Soil Contamination	N	A1	N	N	
3.4 Noise and Vibration	N	A1	N	N	
3.5 Ground Subsidence	N	N	N	N	
3.6 Odour	N	A1	N	U1	

Assessment Clasification

A1 : Adverse impact - minor

A2 : Adverse impact - medium / moderate

A3 : Adverse impact - major / significant

U1 : Unknow due to insufficent data but probably minor impact (A1) or no adverse impact

U2 : Unknow due to insufficent data but probably adverse impact (A2 or A3)

N : No adverse impact

B1 : Beneficial / positive impact - minor

B2 : Beneficial / positive impact - major

TABLE 12.2.5 ASSESSMENT MATRIX OF ENVIRONMENTAL IMPACT FOR MUDA BARRAGE RECREATIONAL PARK SCHEME

Environment Factors	Breakdown of Project / Scheme				Remarks
	Activities			Existance of Structures	
	Site Invest.	Construction	O & M		
1. Social Environment					
1.1 Resettlement	N	U1	N	N	
1.2 Economic Activities	N	B2	B1	B1	Increase of income/job
1.3 Transportation / Public Facilities	N	A1	N	B1	
1.4 Division of Communities	N	N	N	N	
1.5 Archaelogical / Cultural Heritage	N	U1	N	U1	Existing Muda barrage
1.6 Vested Right	N	U1	N	U1	No definite right now
1.7 Health and Hygene	N	A1	N	U1	
1.8 Waste Disposal	A1	A1	A1	A1	Depend on management
1.9 Accident	N	A1	N	N	
2. Natural Environment					
2.1 Topography and Geology	N	U1	N	U1	
2.2 Soil Erosion	A1	A1	N	N	
2.3 Ground Water	N	N	N	U1	
2.4 River and Reservoir / pond	N	A1	N	A1	Cut off of river
2.5 Coastal Zone	N	N	N	N	
2.6 Fauna (Wildlife)	N	N	N	N	No valuable species
2.7 Flora (Vegetation)	A1	N	N	N	
2.8 Climate	N	N	N	N	
2.9 Landscape	N	A1	N	B2	Beautiful park & water front
3. Public Nuisanse					
3.1 Air Pollution	N	N	N	N	
3.2 Water Pollution	N	A1	N	U1	
3.3 Soil Contamination	N	A1	N	N	
3.4 Noise and Vibration	N	A1	N	N	
3.5 Ground Subsidence	N	N	N	N	
3.6 Odour	N	A1	N	N	

Assessment Clasification

A1 : Adverse impact - minor

A2 : Adverse impact - medium / moderate

A3 : Adverse impact - major / significant

U1 : Unknow due to insufficent data but probably minor impact (A1) or no adverse impact

U2 : Unknow due to insufficent data but probably adverse impact (A2 or A3)

N : No adverse impact

B1 : Beneficial / positive impact - minor

B2 : Beneficial / positive impact - major

TABLE 12.2.6 ASSESSMENT MATRIX OF ENVIRONMENTAL IMPACT FOR BUMBONG LIMA RECREATIONAL PARK SCHEME

Environment Factors	Breakdown of Project / Scheme				Remarks
	Activities			Existance of Structures	
	Site Invest.	Construction	O & M		
1. Social Environment					
1.1 Resettlement	N	U1	N	A2	Some houses relocated
1.2 Economic Activities	N	B2	B1	B1	Increase of income/job
1.3 Transportation / Public Facilities	N	A1	N	B1	
1.4 Division of Communities	N	N	N	N	
1.5 Archaelogical / Cultural Heritage	N	U1	N	U1	Existing Muda barrage
1.6 Vested Right	N	U1	N	U1	No definite right now
1.7 Health and Hygene	N	A1	N	U1	
1.8 Waste Disposal	A1	A1	A1	A1	Depend on management
1.9 Accident	N	A1	N	N	
2. Natural Environment					
2.1 Topography and Geology	N	U1	N	U1	
2.2 Soil Erosion	A1	A1	N	N	
2.3 Ground Water	N	N	N	U1	
2.4 River and Reservoir / pond	N	A1	N	A1	Cut off of river
2.5 Coastal Zone	N	N	N	N	
2.6 Fauna (Wildlife)	N	N	N	U1	No valuable species
2.7 Flora (Vegetation)	N	N	N	N	
2.8 Climate	N	N	N	N	
2.9 Landscape	N	A1	N	B2	Beautiful park & water front
3. Public Nuisanse					
3.1 Air Pollution	N	N	N	N	
3.2 Water Pollution	N	A1	N	U1	
3.3 Soil Contamination	N	A1	N	N	
3.4 Noise and Vibration	N	A1	N	N	
3.5 Ground Subsidence	N	N	N	N	
3.6 Odour	N	A1	N	N	

Assessment Clasification

A1 : Adverse impact - minor

A2 : Adverse impact - medium / moderate

A3 : Adverse impact - major / significant

U1 : Unknow due to insufficent data but probably minor impact (A1) or no adverse impact

U2 : Unknow due to insufficent data but probably adverse impact (A2 or A3)

N : No adverse impact

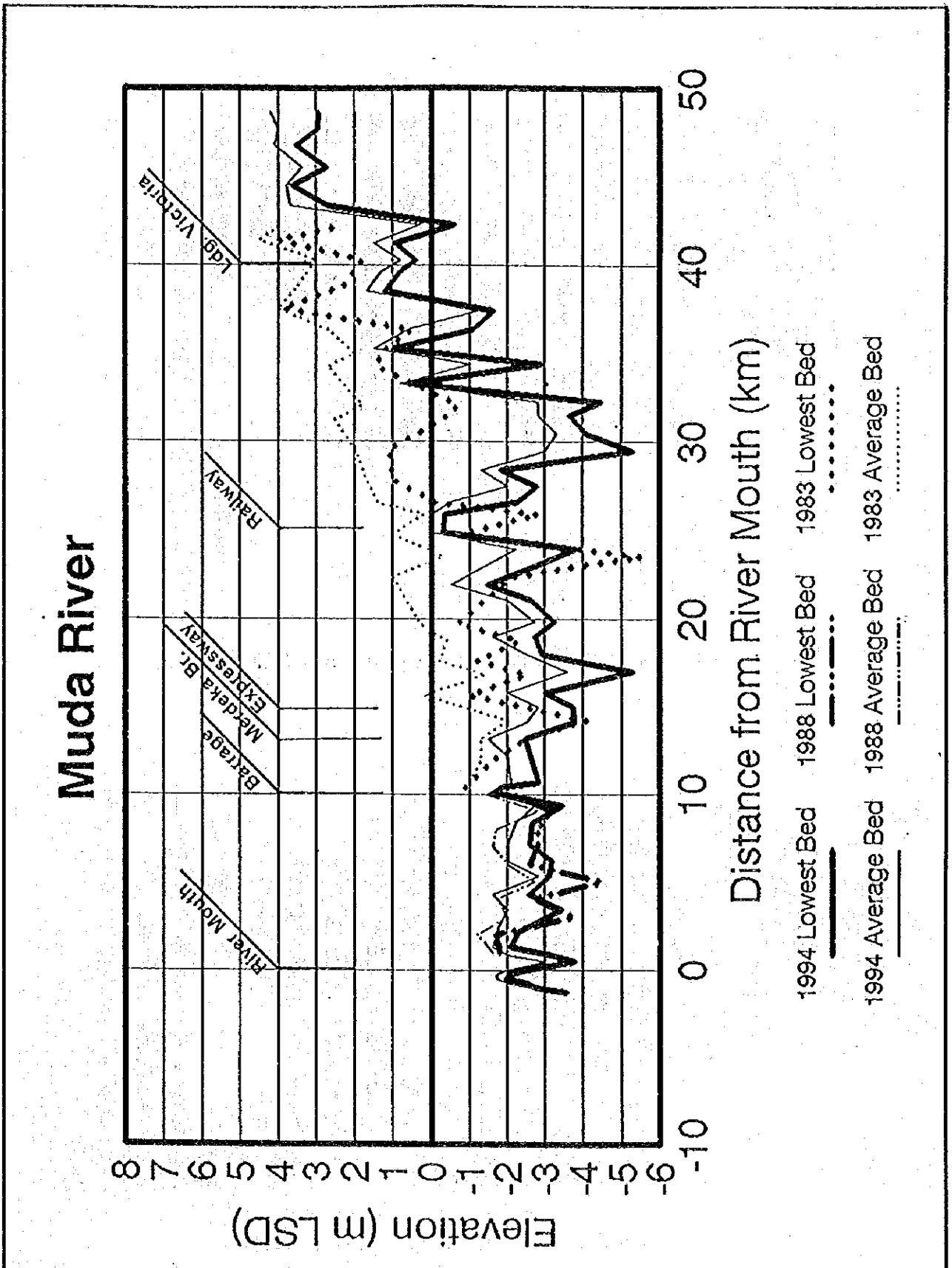
B1 : Beneficial / positive impact - minor

B2 : Beneficial / positive impact - major

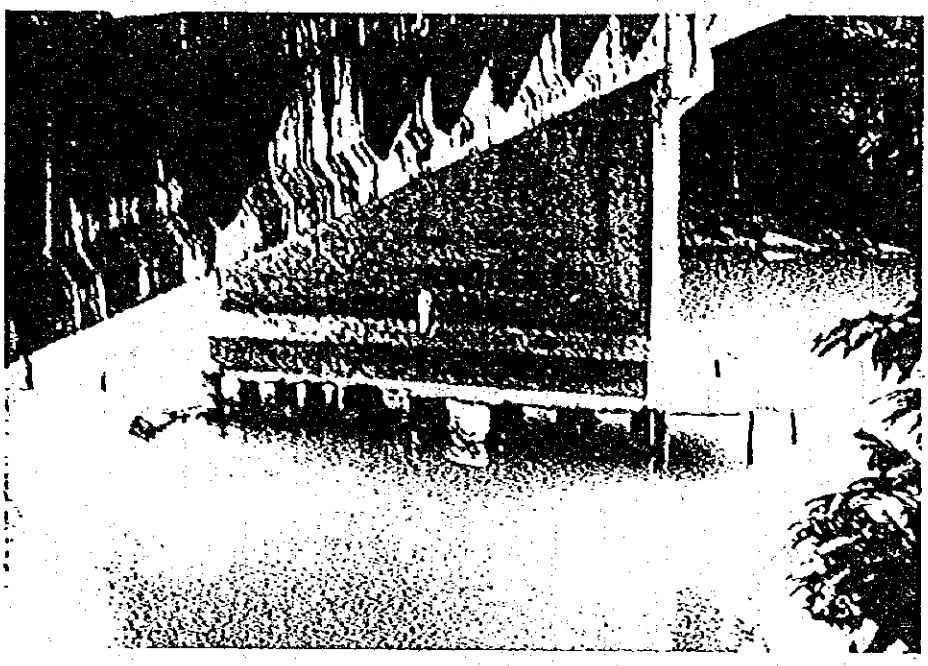
FIGURES

VOLUME 1

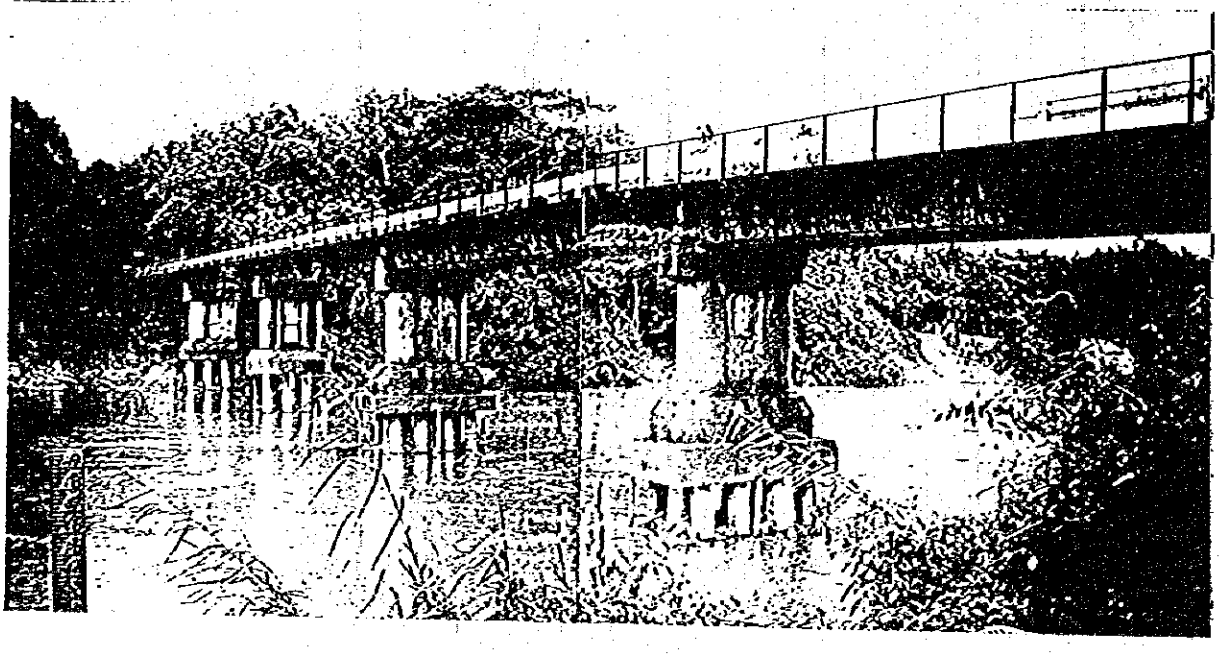
SUMMARY



COMPREHENSIVE MANAGEMENT PLAN OF MUDA RIVER BASIN	FIG. 2.1.1
JAPAN INTERNATIONAL COOPERATION AGENCY	CHANGE OF LONGITUDINAL PROFILE OF MUDA RIVER

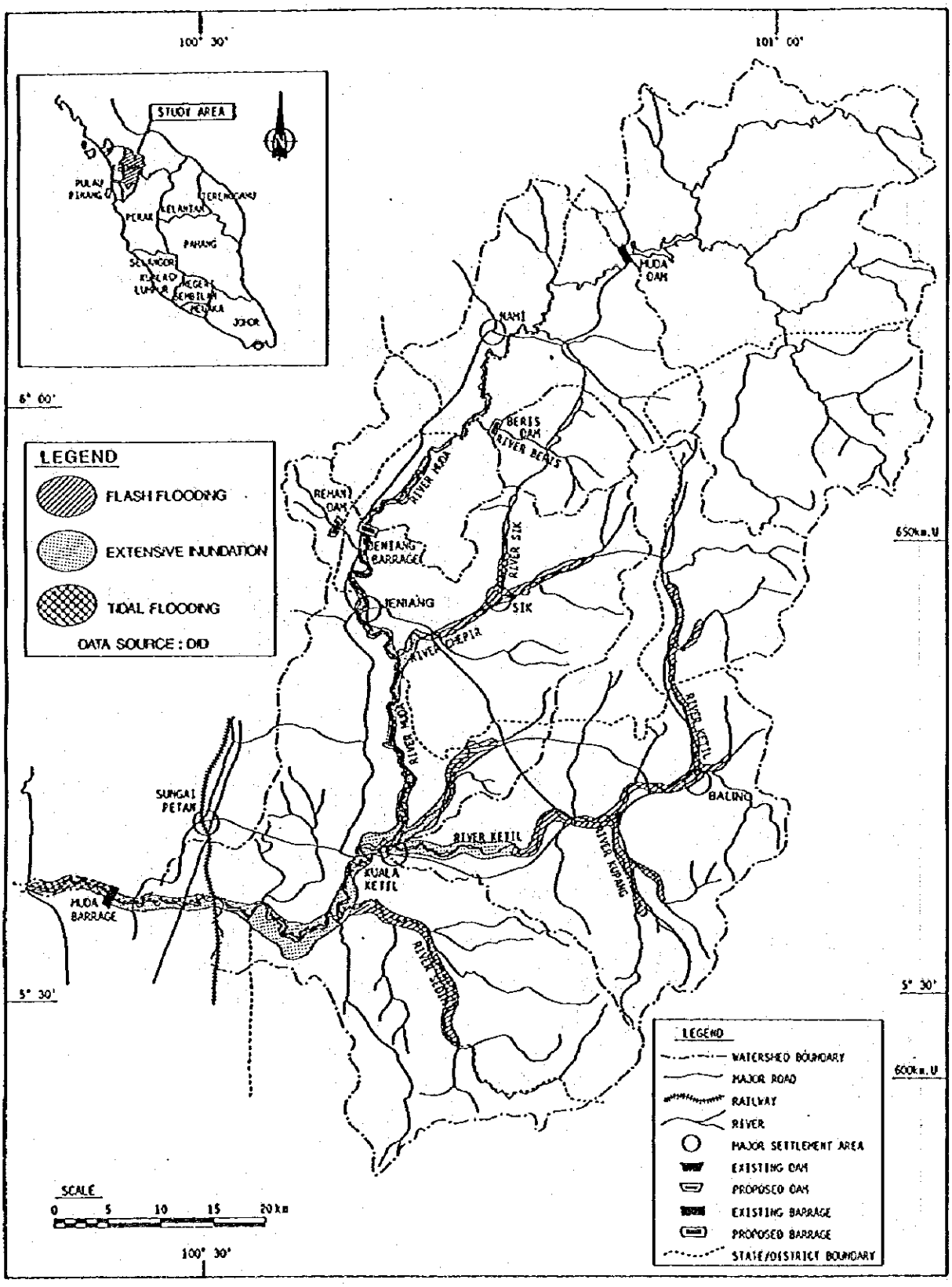


(1) Bridge Crossing Ketil River 1km Upstream of Muda River

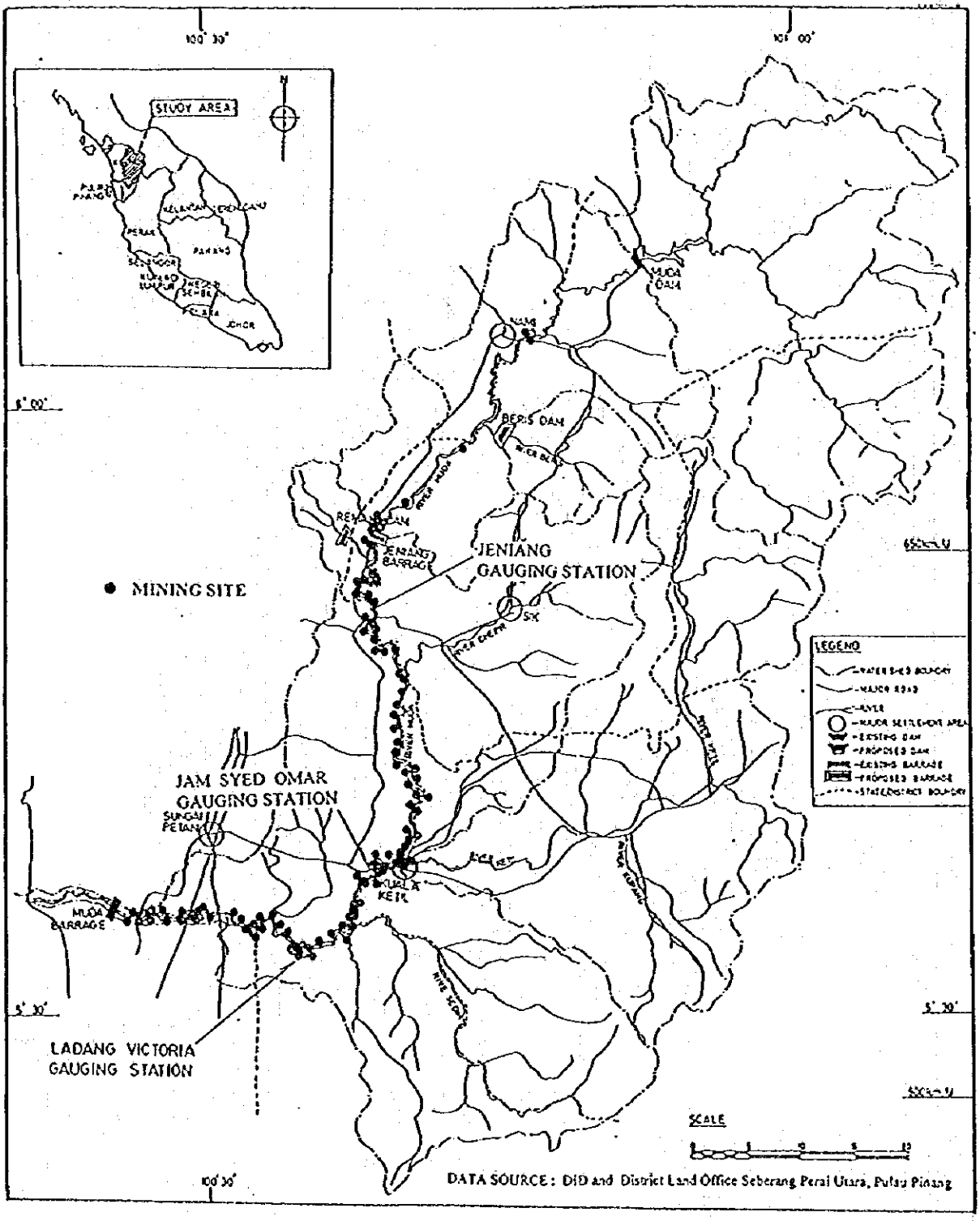


(2) Bridge Crossing Muda River at Ldg. Victória

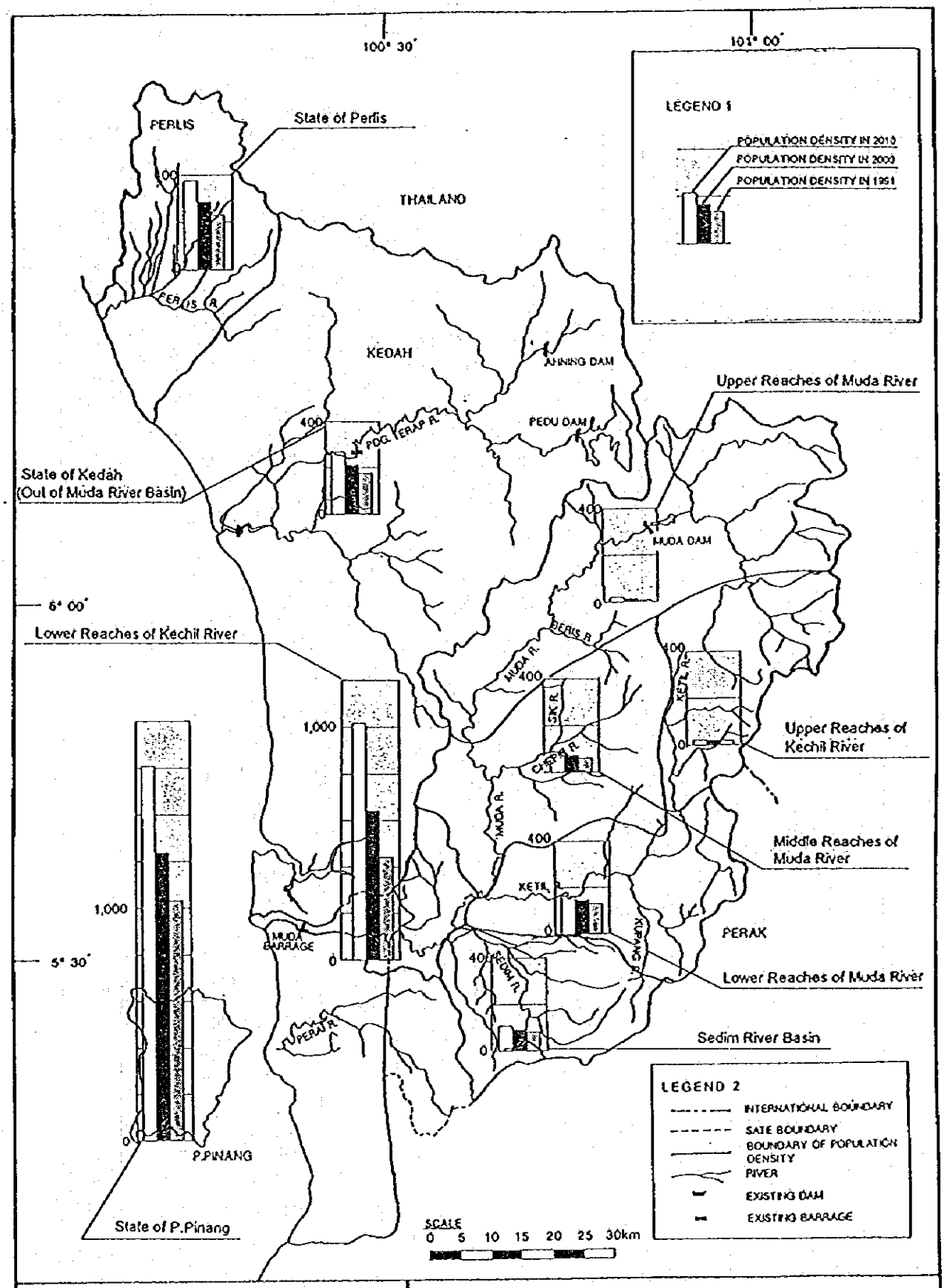
COMPREHENSIVE MANAGEMENT PLAN OF MUDA RIVER BASIN	FIG. 2.1.2
JAPAN INTERNATIONAL COOPERATION AGENCY	PHOTOGRAPH OF BRIDGE AFFECTED BY RIVER BED SUBSIDENCE



COMPREHENSIVE MANAGEMENT PLAN OF MUDA RIVER BASIN	FIG. 2.1.3 : FLOOD PRONE AREA IN MUDA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY	



COMPREHENSIVE MANAGEMENT PLAN OF MUDA RIVER BASIN	FIG. 2.2.1 LOCATION OF SAND MINING SITES
JAPAN INTERNATIONAL COOPERATION AGENCY	

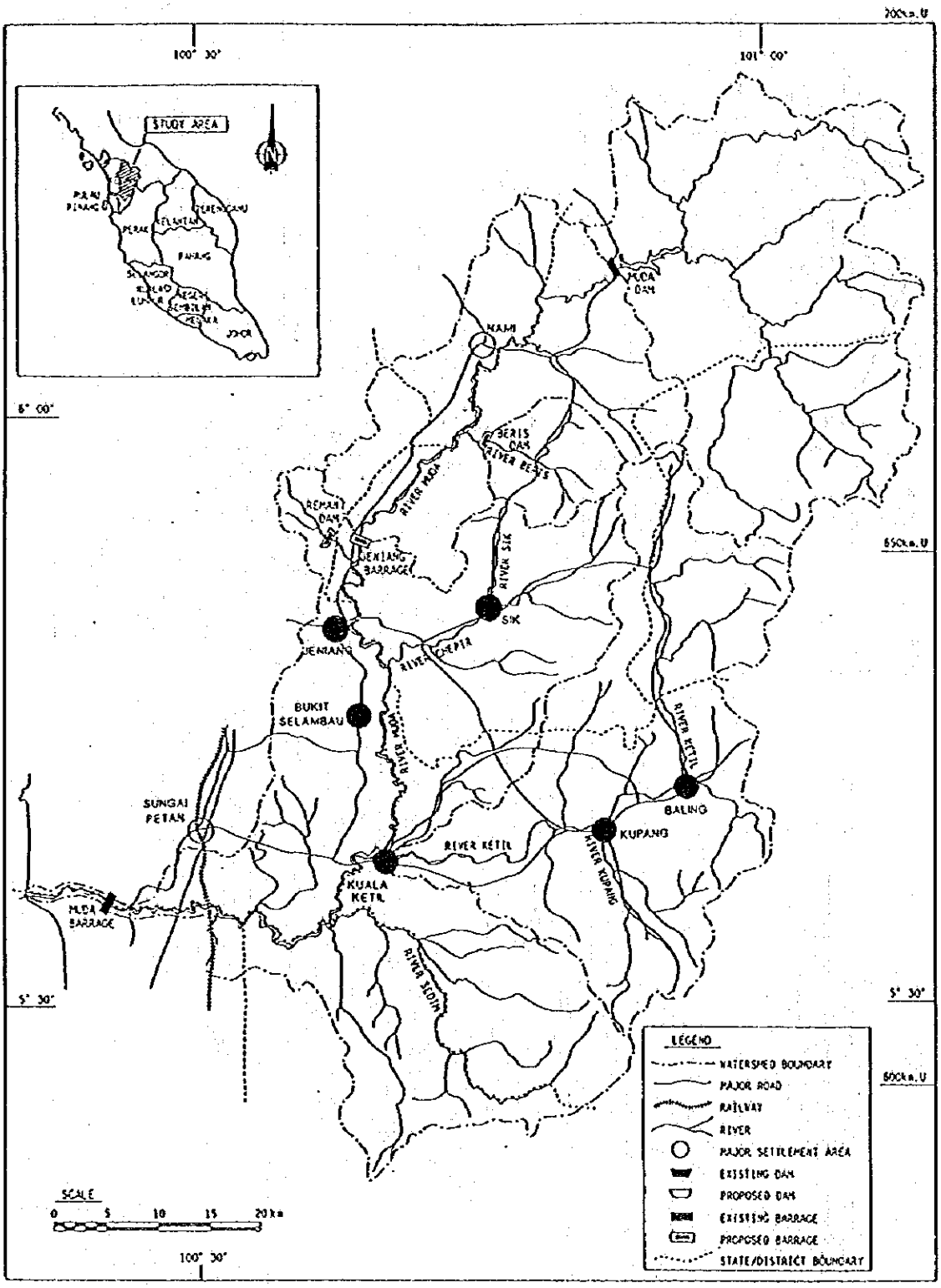


COMPREHENSIVE MANAGEMENT PLAN OF MUDA RIVER BASIN

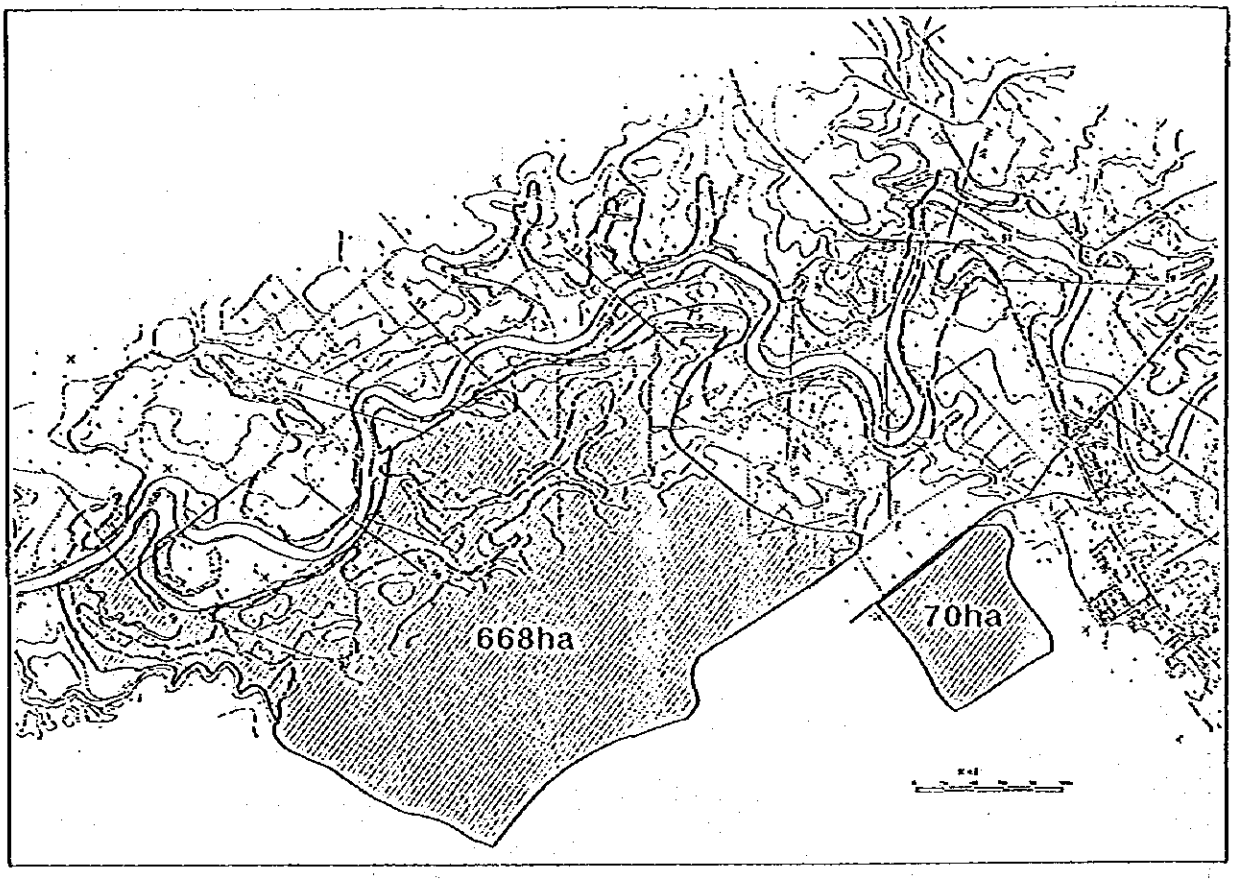
JAPAN INTERNATIONAL COOPERATION AGENCY

FIG. 2.3.1

POPULATION DENSITY IN AND AROUND MUDA RIVER BASIN



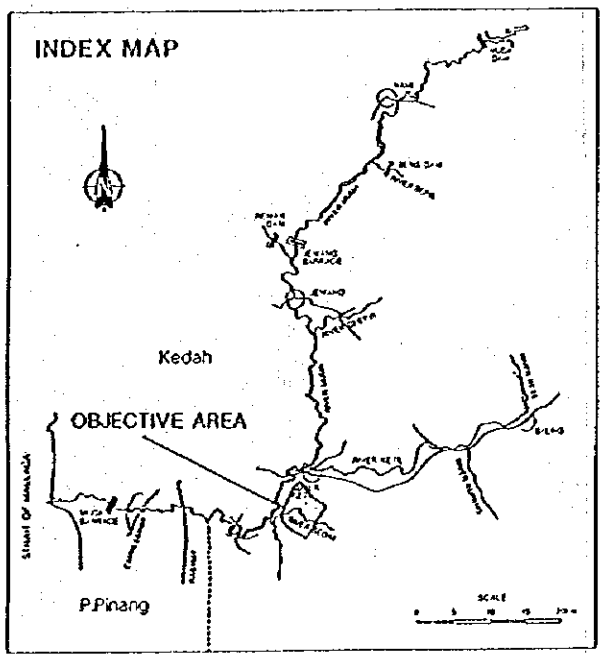
COMPREHENSIVE MANAGEMENT PLAN OF MUDA RIVER BASIN	FIG. 2.3.2
JAPAN INTERNATIONAL COOPERATION AGENCY	PROJECTED URBAN CENTERS IN MUDA RIVER BASIN



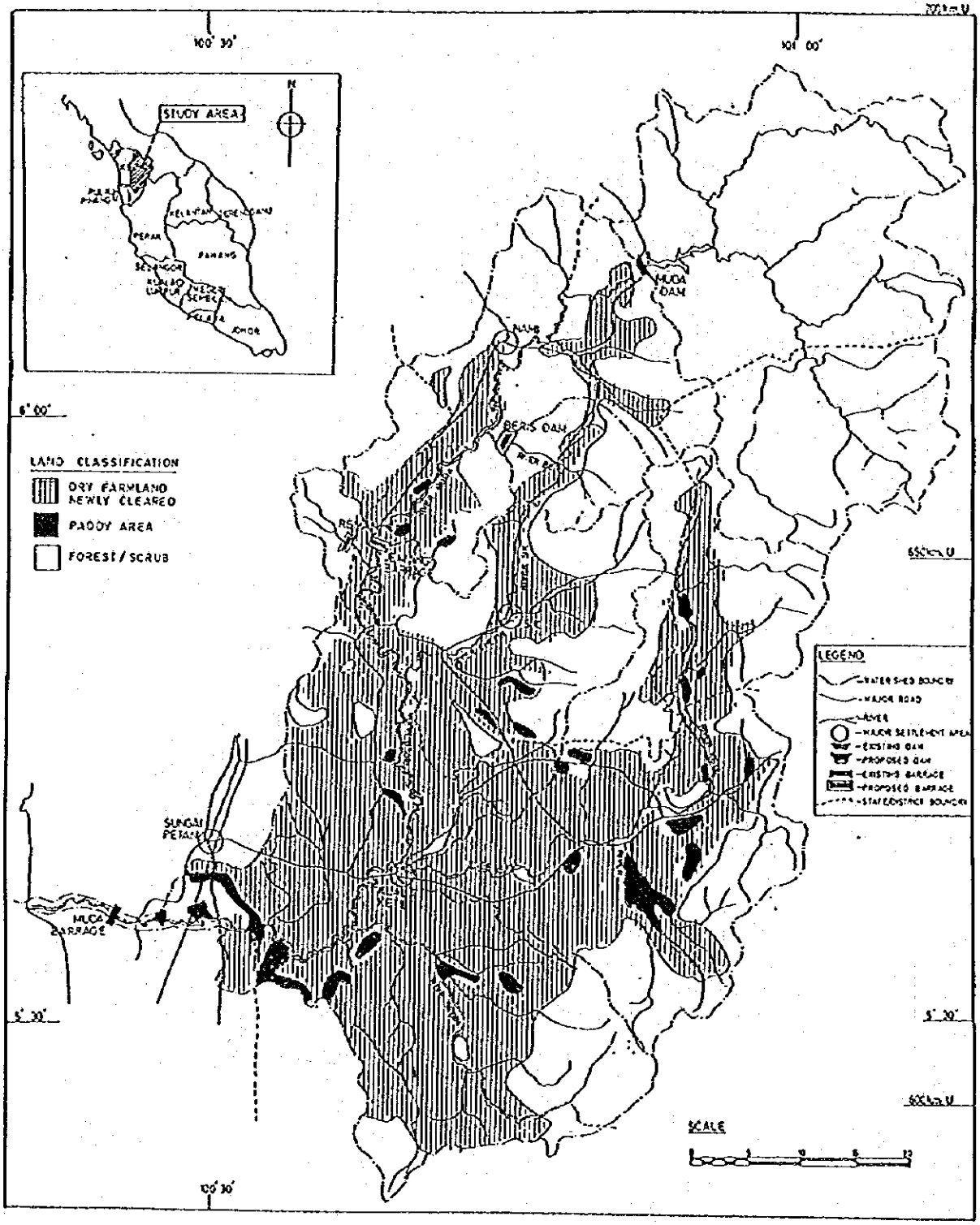
LEGEND

INDUSTRIAL DEVELOPMENT AREA

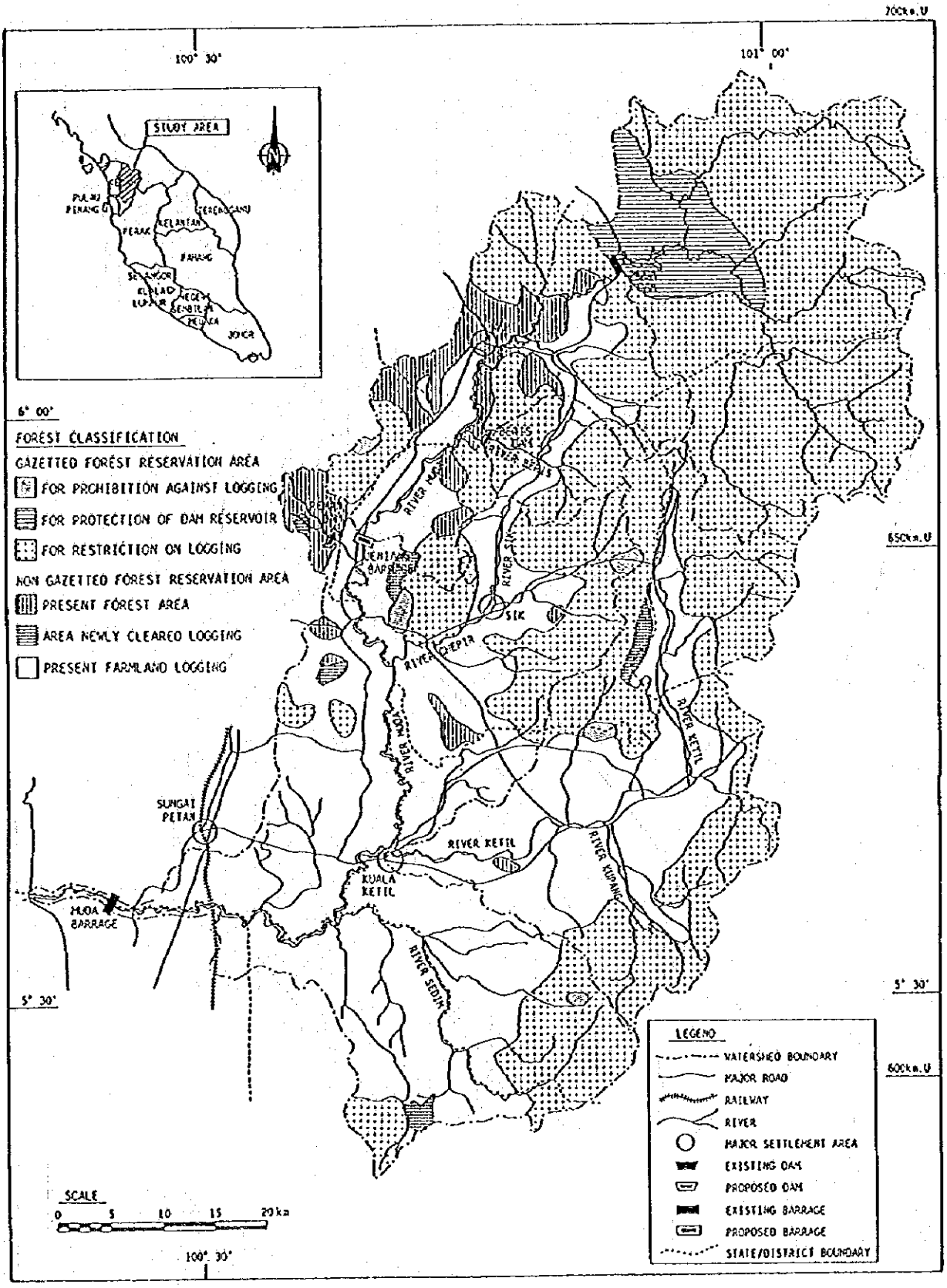
BOUNDARY OF RIVER RESERVED AREA (Approximate Extent of Flood Inundation for 100-year Return Period)



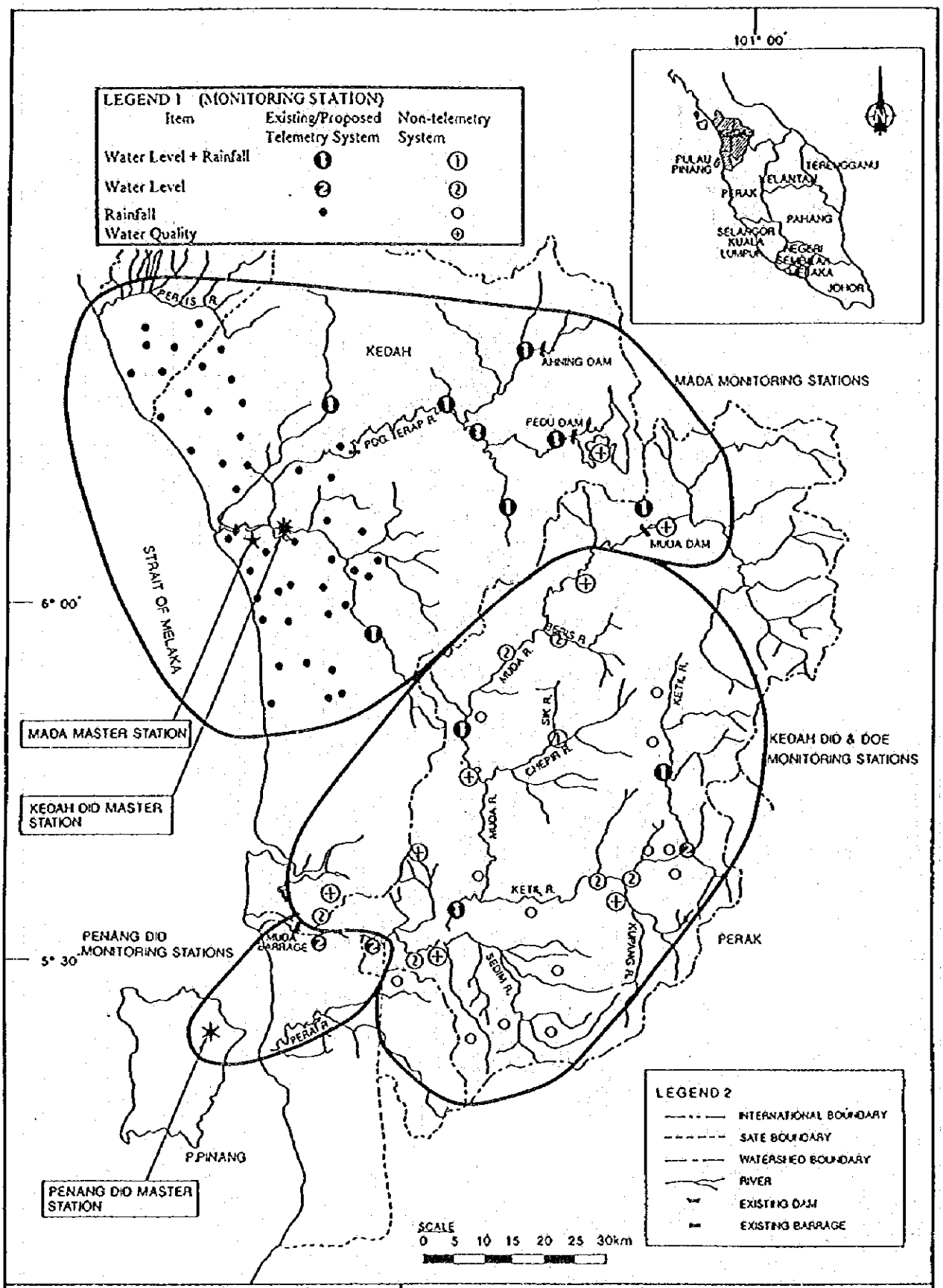
COMPREHENSIVE MANAGEMENT PLAN OF MUDA RIVER BASIN	FIG. 2.3.3 INDUSTRIAL DEVELOPMENT AREA IN KUALA KETIL
JAPAN INTERNATIONAL COOPERATION AGENCY	



COMPREHENSIVE MANAGEMENT PLAN OF MUDA RIVER BASIN	FIG. 2.3.4 PRESENT LAND USE IN MUDA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY	



COMPREHENSIVE MANAGEMENT PLAN OF MUDA RIVER BASIN	FIG. 2.3.5 PRESENT FOREST AREA IN MUDA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY	

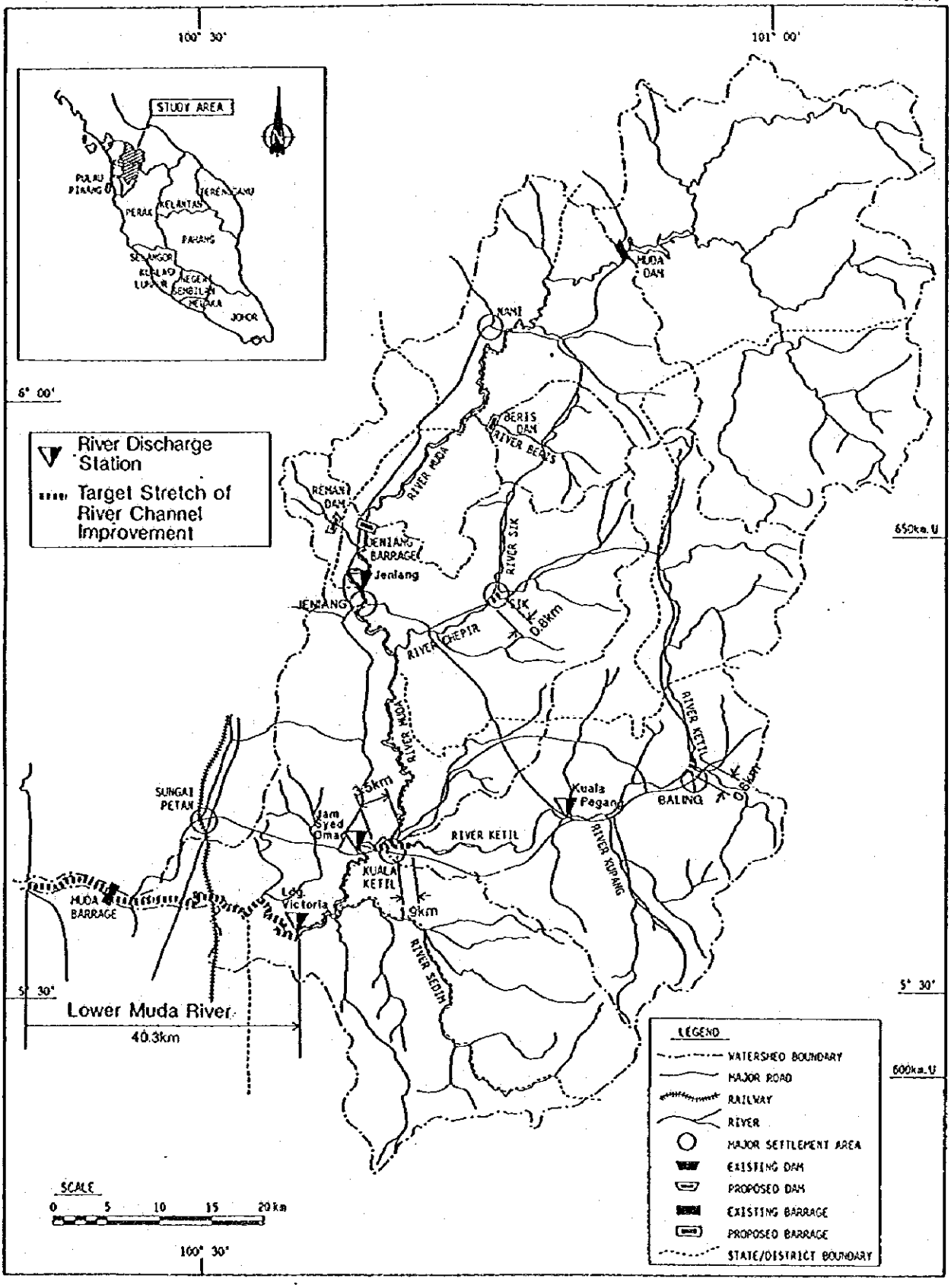


COMPREHENSIVE MANAGEMENT PLAN OF MUDA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

FIG. 2.4.1

PRESENT MONITORING SYSTEM OF MUDA RIVER AND MADA IRRIGATION AREA



COMPREHENSIVE MANAGEMENT PLAN OF MUDA RIVER BASIN	FIG. 3.1.1
JAPAN INTERNATIONAL COOPERATION AGENCY	TARGET STRETCH FOR STRUCTURAL FLOOD MITIGATION PLAN