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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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

THE DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT

FINAL REPORT

VOL. I

SUMMARY

OCTOBER 1996

CTI ENGINEERING CO., LTD.

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LIST OF REPORTS

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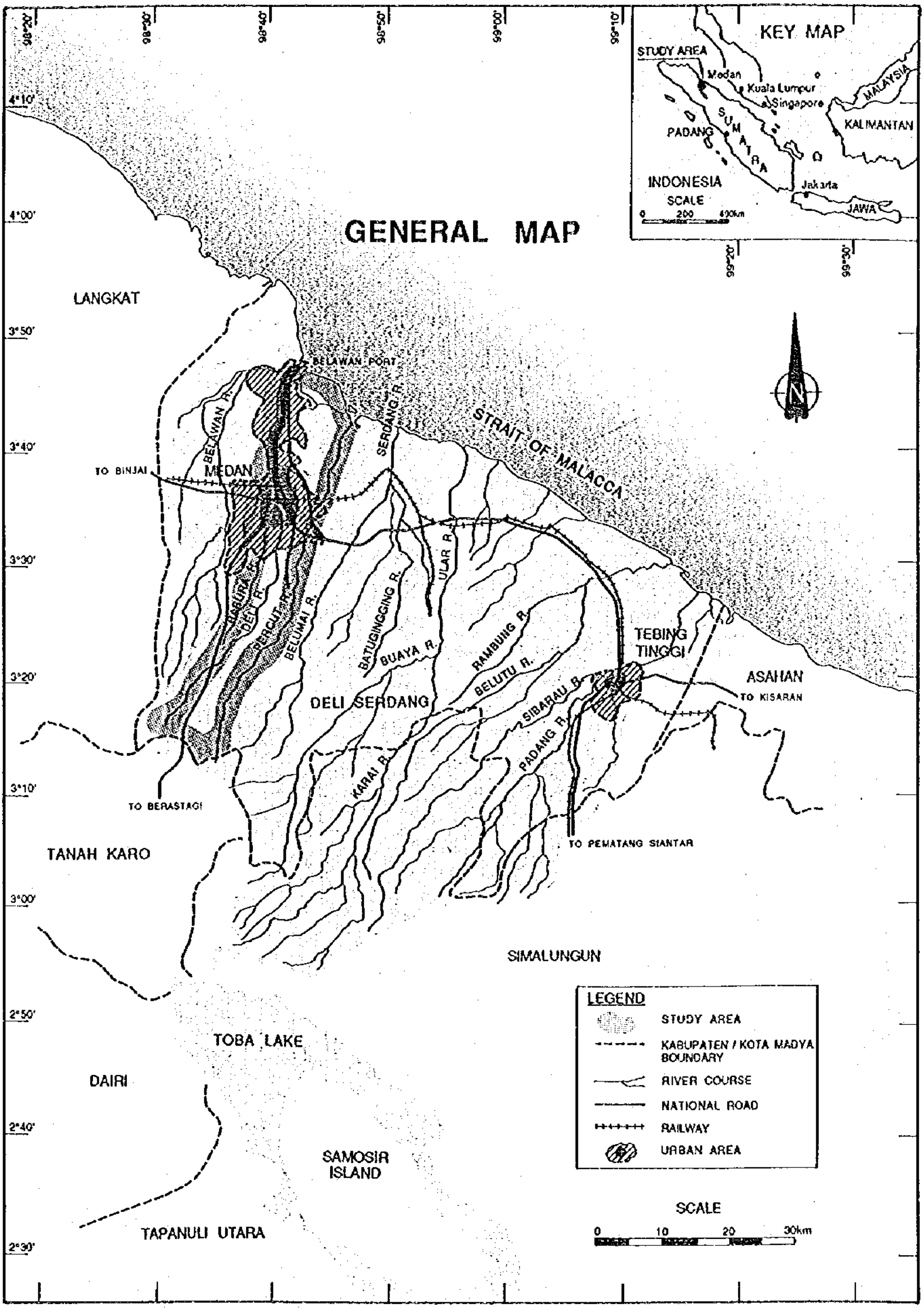
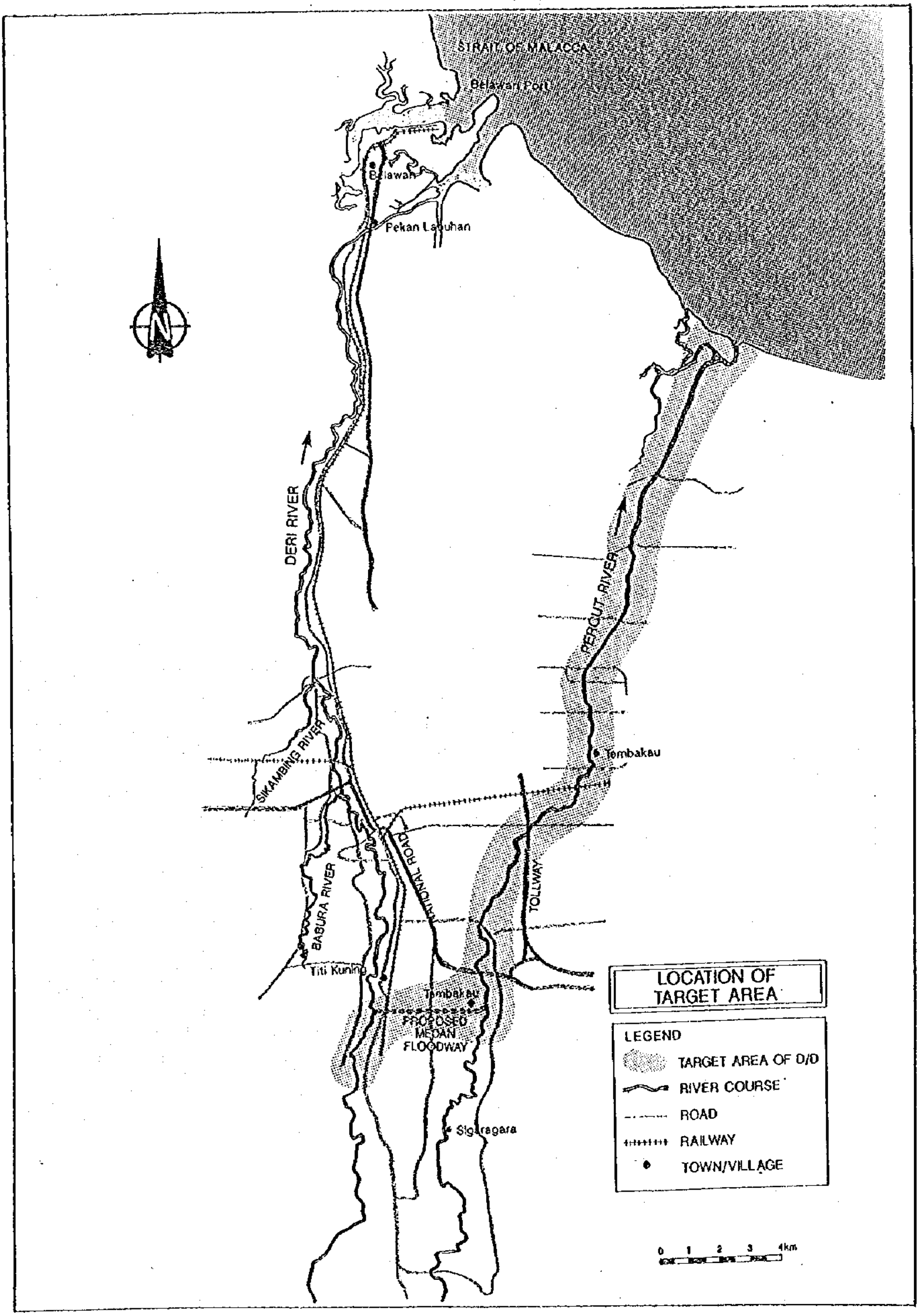
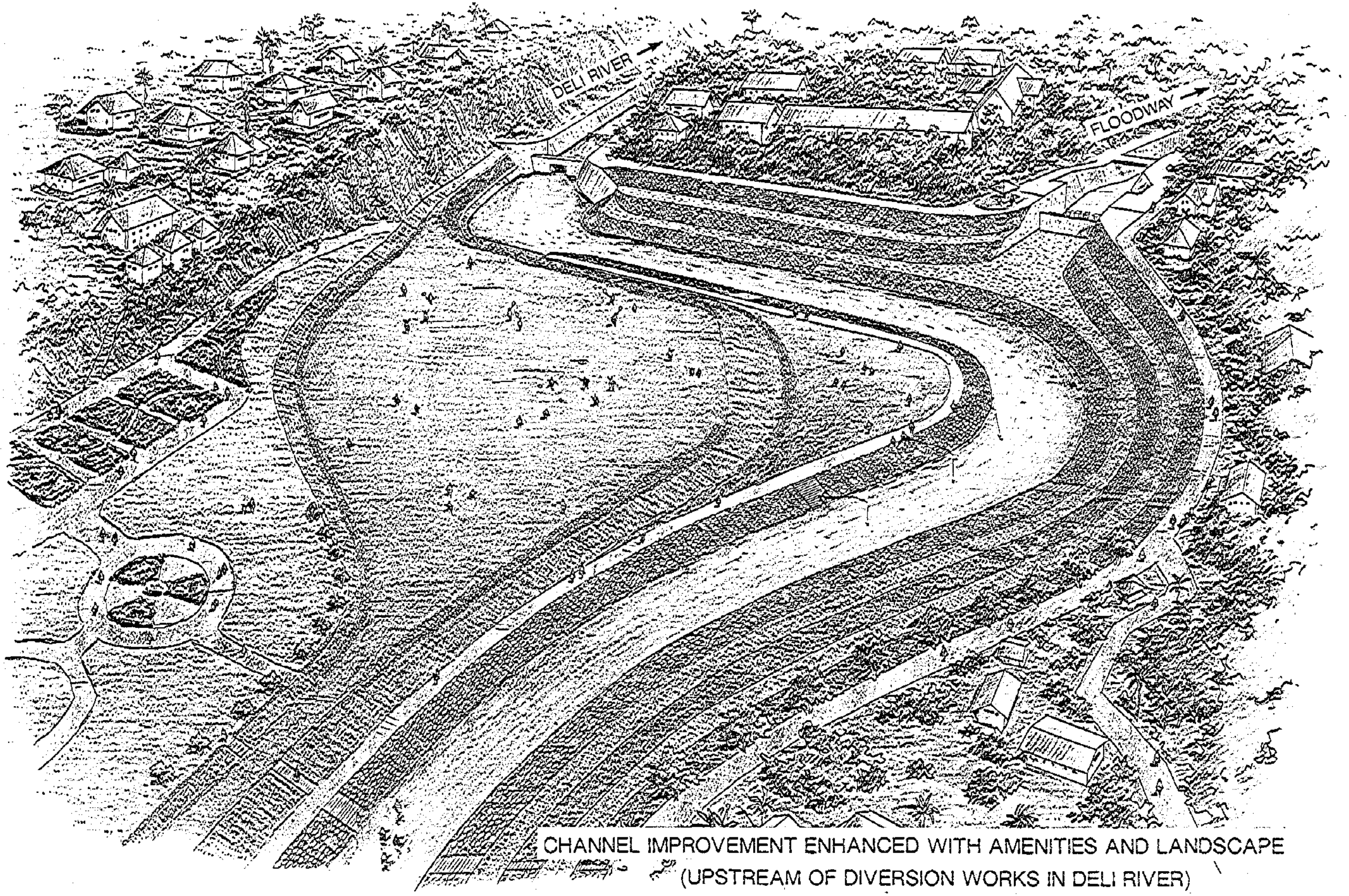


GENERAL MAP
KEY MAP
STUDY AREA
Medan
Kuala Lumpur
Singapore
PADANG
SUMATRA
MALAYSIA
KALIMANTAN
Jakarta
JAWA
INDONESIA
SCALE
0 200 400km
LANGKAT
BELAWAN PORT
STRAIT OF MALACCA
MEDAN
TO BINJAI
BELAWAN R.
SERDANG R.
BABURA R.
DELI R.
PERCUT R.
BELUMAI R.
BATUSINGGING R.
ULAR R.
BUAYA R.
RAMBUNG R.
BELUTU R.
SIBARAU R.
PADANG R.
KARAI R.
TEBING TINGGI
ASAHAN
TO KISARAN
DELI SERDANG
TO BERASTAGI
TANAH KARO
TO PEMATANG SIANTAR
SIMALUNGUN
TOBA LAKE
DAIRI
SAMOSIR ISLAND
TAPANULI UTARA
LEGEND
STUDY AREA
KABUPATEN / KOTA MADYA BOUNDARY
RIVER COURSE
NATIONAL ROAD
RAILWAY
URBAN AREA
SCALE
0 10 20 30km


STRAIT OF MALACCA
Belawan Port
Belawan
Pekan Labuhan
DERI RIVER
PERCUT RIVER
SIKAMBING RIVER
BABURA RIVER
NATIONAL ROAD
TOLLWAY
Tembakau
Titi Kuning
PROPOSED MEDAN FLOODWAY
LOCATION OF TARGET AREA
LEGEND
TARGET AREA OF D/D
RIVER COURSE
ROAD
RAILWAY
TOWN/VILLAGE
0 1 2 3 4km



CHANNEL IMPROVEMENT ENHANCED WITH AMENITIES AND LANDSCAPE
(UPSTREAM OF DIVERSION WORKS IN DELI RIVER)

PREFACE

In response to a request from the Government of the Republic of Indonesia, the Government of Japan decided to conduct a Detailed Design study on Medan Flood Control Project, and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Indonesia a study team headed by Mr. Hitoshi Kin, CTI Engineering Co., Ltd., three times between April 1995 and August 1996.

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

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

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

October 1996

Kimio Fujita
President
Japan International Cooperation Agency

October 1996

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

Sir:

LETTER OF TRANSMITTAL

We are pleased to submit herewith, the Final Report of the Detailed Design Study on Medan Flood Control Project in North Sumatra, Indonesia.

The Study was completed through the discussions with the officials of the Government of Indonesia, field investigations and surveys during the two visits from April 1995 to March 1996, and the studies at the home office thereafter.

The Final Report consists of the following reports and documents:

Design Reports

Vol. I	Summary
Vol. II	Main Report
Vol. III	Design Notes
Vol. IV	Work Quantities
Vol. V	Cost Estimate
Vol. VI	Data Book

Prequalification Documents

Tender Documents

Vol. I	Invitation to Tender, Instruction to Tenderers, Particular Instructions to Tenderers, Form of Tender and Appendices, Form of Contract Agreement, Bond Specimens, and Bill of Quantities
Vol. II	General and Special Conditions of Contract
Vol. III	General and Technical Specifications
Vol. IV	Drawings

Taking this opportunity, we wish to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs and the Ministry of Construction, and also to convey our appreciation to the officials of the Directorate General of Water Resources Development (DGWRD), Ministry of Public Works and the Embassy of Japan in Indonesia for their kind cooperation and assistance throughout our field study.

Very truly yours

Hitoshi Kin
Team Leader
The Detailed Design Study on Medan Flood Control Project

EXECUTIVE SUMMARY

1. Background

The Deli and Percut rivers pass through Medan City, the largest city and the center of social and economic development in Sumatra. Since the urban area of Medan City has been expanding every year due to rapid urbanization, damage inflicted by the frequent floods has also been more seriously hampering development, giving adverse environmental impacts to the region.

A flood control project in the Deli-Percut River Basin is urgently required as figured out in the Study on Belawan-Padang Integrated River Basin Development* (JICA, 1990-92). Inasmuch as flood control effects of river improvement works are more immediate than those of dam construction (namely, Lausimeme Multipurpose Dam), the improvement of Percut River and the construction of Medan Floodway are given higher priority for implementation, since some improvement works of the Deli River are already being executed under the Second Medan Urban Development (MUDP II). On this concept, the project is called the Medan Flood Control Project (herein referred to as "the Project"), composed of the improvement of Percut River and the construction of Medan Floodway. The detailed design study on the Project is undertaken by JICA to accelerate the implementation of the Project.

2. Objective

The objective of the study is to carry out the detailed engineering design of the Medan Flood Control Project consisting of the improvement works of Percut River and the construction of Medan Floodway.

3. Study Area

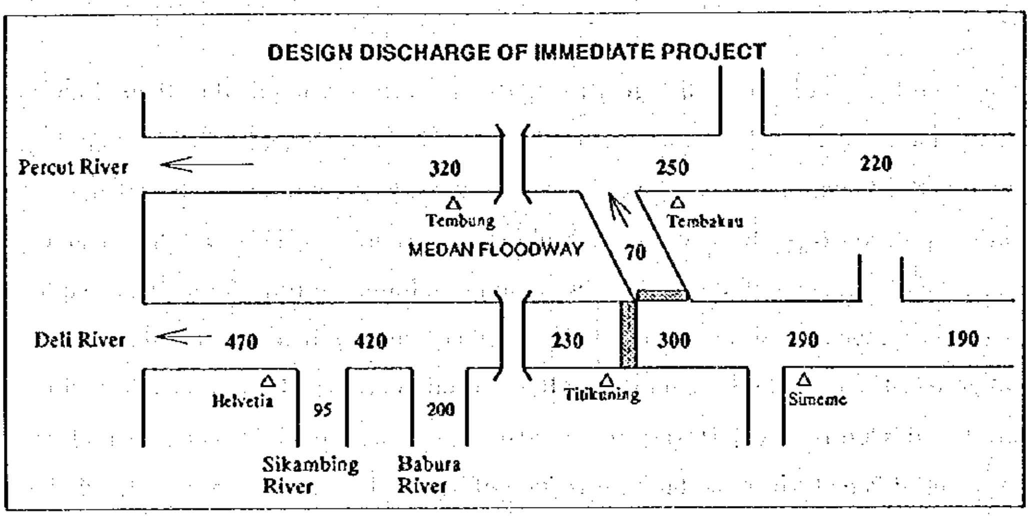
The Study Area (3°10' to 3°45' N latitude and 98°35' to 98°50' E longitude) consists of two river basins, namely Percut and Deli which have the catchment area of about 195 km^2 and 350 km^2, respectively, and is administratively covered by Medan City and Deli Serdang District in North Sumatra Province. The Medan Floodway with a length of 3.9 km is to be located from Titi Kuning at Deli River to Tembakau at Percut River, and the river improvement works of Percut River are to be undertaken for 28 km from the estuary.

4. Project Works

4.1 Design Discharge

The Project is formulated with the flood control scale of a 25-year return period, named as the Immediate Plan, which is composed of the Percut river improvement and the floodway construction without the Lausimeme Dam in the upstream of Percut River.

The design discharges for the Immediate Plan are estimated, as graphically shown below:



4.2 Major Works

The Percut river improvement and the Medan Floodway are designed to conform with the existing alignment, longitudinal profile and cross section as well as to minimize land acquisition and house evacuation to the possible extent. The proposed floodway is aligned smoothly to divert the flood from Deli River and to join to Percut River.

Slope and riverbed protection works are provided at the river sections where riparian structures are constructed, and harmful scouring/sedimentation are anticipated. Diversion weirs are designed as concrete gravity type and Bandar Sidoras Intake Weir of inflatable rubber-made type is relocated. A prestressed concrete girder is employed for the superstructures of road, railway and pedestrian bridges. Further, some waterfront facilities are introduced to facilitate the environmental improvement of river and adjacent areas.

Summarizing all works required, they are divided into three (3) components, as follows: (a) Percut River Improvement Works; (b) Construction of Medan Floodway; and (c) Diversion and Improvement Works of Upper Deli River.

(1) Percut River Improvement Works

Project Works	Quantity
Channel Works	
- Dike Construction including Reinforcement of Existing Dikes	13,150 m
- Channel Excavation and Dredging	13,150 m
- Channel Widening and Straightening	15,100 m
Slope and Riverbed Protection Works	
- Riverbed Protection	3,300 m
- Low Water Revetment	2,320 m
- Parapet Wall	1,915 m
- Groin	9 sites
- Groundsill	1 site
- Approach Step	118 sites
- Jetty and Landing	1 site
Riparian Structures	
- Reinstallation/Reconstruction of Existing Drainage Outlet	37 sites
- Relocation of Drainage Channel	710 m
- Relocation of Bandar Sidoras Intake Weir	1 site
- Reconstruction of Bridge and Approach Road	9 sites
- Reconstruction of Water Pipe Bridge	1 site
Relocation of Kabupaten Road	1,985 m
Relocation of Farm Road	2,170 m
Relocation of Water Level Gauging Station	1 site
Installation of Intake Gate for Fishpond	2 sites

(2) Construction of Medan Floodway

Project Works	Quantity
Excavation of Floodway	3,920 m
Revetment (Wet Stone Masonry)	2,585 m
Revetment (Retaining Wall)	1,035 m
Construction of Groundsill (at junction)	1 site
Construction of Drainage Channel/Ditch	7,020 m
Construction of Drainage Outlet	7 sites
Construction of Bridges (Road / Railway / Water Pipe / Pedestrian)	10 sites
Construction of Inspection Road and Tree Planting	7,600 m
Partial Improvement of Batuan River	100 m

(3) Diversion and Improvement Works of Upper Deli River

Project Works	Quantity
Construction of Deli River Weir	1 site
Construction of Floodway Weir	1 site
Excavation of Embankment of Retarding Channel	830 m
Revetment	700 m
Construction of Pedestrian Bridge	1 site
Construction of Walkway	2,100 m
Tree Planting	650 m
Approach Step	7 sites

5. Construction Plan and Cost Estimates

5.1 Construction Plan

The construction works of the Project are divided into seven (7) portions, as tabulated below, and all construction works could be completed within three (3) years.

Work Portion	Station No.	Object Distance	Construction Period (Months)
MFC-1	PE0-200 ~ PE46	5,040 m	20
MFC-2	PE46 ~ PE129	8,270 m	20
MFC-3	PE129 ~ PE210	8,100 m	27
MFC-4	PE210 ~ PE274	6.500 m	27
MFC-5	FW0 ~ FW24 & PE274 ~ PE274+320	2,680 m	20
MFC-6	FW24 ~ FW34	1,010 m	27
MFC-7	FW34 ~ FW39+50 & UD12-85.0 ~ UD23	1,500 m	27

5.2 Cost Estimate

The total project cost is estimated at Rp. 263,119 million, excluding value added tax, at the price level as of November 1995, on the basis of the design and the construction plan.

6. Project Evaluation

6.1 Economic Evaluation

The economic evaluation for the Immediate and Urgent plans is made in terms of Economic Internal Rate of Return (EIRR), as summarized below:

Plan	Return Period	EIRR (%)
Immediate Plan	25-Year	14.42
Urgent Plan	40-Year	15.43

6.2 Environmental and Social Impacts

The Environmental Impact Study (ANDAL), as well as the Environmental Management Plan (RKL) and the Environmental Monitoring Plan (RPL), was finally approved by the Minister of Public Works on January 10, 1996 based on the recommendation of the Central Commission (KOMPUS).

About 136 ha of land need to be acquired for the implementation of the Project and the number of project-affected houses/buildings will amount to 990, including public facilities such as schools, mosques, factories, etc., of which 970 units are privately owned, and the number of project-affected families is estimated at 1,584. The social impact study shows that no one is opposed to the project and, basically, 100% of all respondents agree to the implementation.

7. Conclusion

7.1 Project Benefit

The Project is evaluated as economically justifiable and technically sound, and the environmental condition after implementation is superior to the existing conditions. This is made possible especially with the provision of some waterfront facilities which will bring preferable river environments and betterment of living standards for the people in the project area.

7.2 Recommendation

Aiming at the early implementation of the Project, the preparation of funds and the formation of the execution body for compensation works should be started soon after completion of this Study. An organization for management and monitoring, based on the Environmental and Social Management/Monitoring plans, should also be created to smoothen project implementation.

Note *: The Study on Belawan-Padang Integrated River Basin Development was conducted under the JICA Development Program from March 1990 to March 1992 to formulate a master plan of integrated river basins from Belawan to Padang in North Sumatra Province. The Deli-Percut River Basin was selected to conduct the feasibility study which conceived the urgent project consisting of (a) Deli River Improvement, (b) Percut River Improvement, (c) Construction of Medan Floodway, and (d) Construction of Lausimeme Dam.

THE DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT

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TERMS AND ABBREVIATIONS

1. GOVERNMENT AGENCIES AND ORGANIZATIONS

ADB	:	Asian Development Bank
BAPEDAL	:	Badam Pengendalian Dampak Lingkungan
BAPPENAS	:	Badan Perencanaan Pembangunan National (National Development Planning Board)
BAPPEDA	:	Badan Perencanaan Pembangunan Daerah (Provincial Development Planning Board)
BPN	:	Badan Pertanahan Nasional (National Land Agency)
BPP	:	Balai Penyuluhan Pertanian (Agricultural Extension Centre)
CIDA	:	Canadian International Development Agency
DPU	:	Departmen Pekerjaan Umum (Ministry of Public Works)
DGWRD	:	Directorate General of Water Resources Development, Ministry of Public Works
DGCK	:	Directorate General of Cipta Karya (Housing, Building and Urban Development)
DPUP	:	Dinas Pekerjaan Umum Propinsi (Provincial Public Works Services)
GOI	:	Government of Indonesia
GOJ	:	Government of Japan
IBRD	:	International Bank for Reconstruction and Development (World Bank)
IHE	:	Institute of Hydraulic Engineering (Bandung)
IGGI	:	Inter-Governmental Group of Indonesia (Demolished)
JICA	:	Japan International Cooperation Agency
MOC	:	Ministry of Construction, Japan
OECF	:	Overseas Economic Cooperation Fund, Japan
P3SA	:	Proyek Pengembangan dan Penyelidikan
PDAM	:	Perusahaan Daerah Air Minum (Water Works Company)
PJKA	:	Perusahaan Jawatan Kereta Api (Railway Company)
PMG	:	Pusat Meteorologi dan Geofisika (Centre of Meteorology and Geophysics)
PLN	:	Perusahaan Listrik Negara (State Electricity Corporation)
RISPA	:	Research Institute of Sumatra Planter's Association
RIWRD	:	Research Institute of Water Resources Development
UNDP	:	United Nations Development Programme
WHO	:	World Health Organization

2. OTHERS

MUDP	:	Medan Urban Development Project
MMUDP	:	Metropolitan Mebidang Urban Development Project

3. UNITS OF MEASURE

Length			Weight		
mm	:	millimeter	g, gr	:	gram
cm	:	centimeter	kg	:	kilogram
m	:	meter	t, ton	:	metric ton
km	:	kilometer	dwt	:	dead weight

Area			Time		
mm^2	:	square millimeter	sec., s	:	second
cm^2	:	square centimeter	min	:	minute
m^2	:	square meter	h, hr	:	hour
km^2	:	square kilometer	d, dy	:	day
ha	:	hectare	y, yr	:	year

Volume			Discharge		
cm^3	:	cubic centimeter	ltr/sec, l/s	:	liter per second
m^3	:	cubic meter	m^3/sec, m^3/s	:	cubic meter per second
l, ltr	:	liter	m^3/yr, m^3/y	:	cubic meter per year

4. DERIVED MEASURES

Speed/Velocity			Stress		
cm/sec, cm/s	:	centimeter per second	kg/cm^2	:	kilogram per square centimeter
m/sec, m/s	:	meter per second	ton/m^2	:	ton per square meter
km/hr	:	kilometer per hour			

5. INDONESIAN TERMS

Propinsi	:	province
Kabupaten, Kab.	:	district (regency)
Kotamadya, Kodya.	:	city (municipality)
Kecamatan, Kec.	:	subdistrict
Desa	:	village (rural)
Kampung, Kp.	:	village (rural)
Kelurahan	:	village (urban)
Sungai, Sei	:	river
Gunung	:	mountain
Sawah	:	paddy field
Rawa	:	swamp
Danau	:	lake
Laut	:	sea

1. INTRODUCTION

1.1 Background

The background of the Project is traced to the **Study on Belawan-Padang Integrated River Basin Development** (herein referred to as "the B-P Study") which was carried out with technical cooperation by the Japan International Cooperation Agency (JICA) from March 1990 to March 1992. The Master Plan was formulated in March 1991, and some high priority or urgent projects were selected for the Feasibility Study which was completed in March 1992.

Through prioritization and the implementation program developed in the Master Plan Study, areas or projects for the Feasibility Study were selected focusing on two (2) river basins, the Deli-Percut River Basin and the Padang River Basin. The project components in each basin are as listed below.

River Basin	Project Component
Deli-Percut River Basin	(1) Deli River Improvement (2) Percut River Improvement (3) Construction of Medan Floodway (4) Construction of Lausimeme Dam
Padang River Basin	(1) Padang River Improvement

The Deli and Percut rivers pass through Medan City, the largest city and the center of social and economic development in Sumatra. Since the urban area of Medan City has been expanding every year due to rapid urbanization, damage inflicted by the frequent floods has also been more seriously hampering development, giving adverse environmental impacts to the region.

A flood control project in the Deli-Percut River Basin is urgently required as figured out in the B-P Study. Inasmuch as flood control effects of river improvement works are more immediate than those of dam construction (namely, Lausimeme Multipurpose Dam), the improvement of Percut River and the construction of Medan Floodway are given higher priority for implementation. On this concept, some improvement works of the Deli River are already being executed under the Second Medan Urban Development (MUDP II). For the purpose of this present undertaking by JICA, the project is called the **Medan Flood Control Project** (herein referred to as "the Project"), and the design work is named the **Detailed Design Study on Medan Flood Control Project** (herein called "the D/D Study").

1.2 Objectives

The objective of the D/D Study is to carry out the detailed engineering design of the Medan Flood Control Project, consisting of the improvement works of Percut River and the construction of Medan Floodway.

1.3 Study Area

The Study Area (3°10' to 3°45' N latitude and 98°35' to 98°50' E longitude) consists of two river basins, namely Percut and Deli, which have the catchment area of about 195 km^2 and 350 km^2, respectively, and is administratively covered by Medan City and Deli Serdang District in North Sumatra Province. The Medan Floodway with a length of 3.9 km is to be located from Titi Kuning at Deli River to Tembakau at Percut River, and the river improvement works of Percut River are to be undertaken for 28 km from the estuary.

2. PRESENT CONDITION OF THE STUDY AREA

2.1 Natural Condition

2.1.1 Climatic Characteristics

The climate of the Study Area is characterized by a little difference between wet and dry seasons. Since Sumatra Island is located near the southern side of the continent across the Strait of Malacca, the Study Area is not greatly affected by northeasterly monsoons and trade winds. Further, the area is located outside of the region affected by tropical depressions or cyclones.

Climatic data at Sampali Station are summarized in Table 2.1. Temperature ranges between 21°C and 33°C and the average annual temperature is 26°C. Relative humidity ranges between 83% and 87%, and the average is 85%. The temperature and relative humidity in the Study Area are rather high throughout the year with the annual pan evaporation as high as 1,566 mm.

Rainfalls in the southern mountainous area and the northern coastal plain are estimated at 2,800 mm/yr and 1,700 mm/yr, respectively. Rainfall records throughout the year are low in February and high in September, as shown in Fig. 2.1. The higher elevation the area is located, the more rainfall is observed. Mean annual rainfall is estimated at 2,337 mm/yr for the Deli river basin and 2,402 mm/yr for the Percut river basin, as shown in Table 2.2.

2.1.2 Geography

The upper stream of the Deli-Percut River runs on the northern slopes of a series of volcanoes, while the lower stream area consists of an outwash plain of volcanic material and alluvial deposits. The geography of the area is described as:

(1) Eastern lowland in the northern part of the area, consisting of volcanic outwash surface, sloping gently northward from about EL 100 m to the sea. Percut and Deli rivers run in parallel in the northern direction through this lowland and flow out into the sea; and

(2) Highland located south of the above eastern lowland, where land slopes steeply northward from about EL 1,000 m.

The southern part of the Study Area, formed by the Kabanjahe Plateau, is relatively flat and sloping westward. The geology of the area is primarily determined by Tertiary and Quaternary volcanic activity, and the morphology is a direct result of this volcanic activity.

The geologic structure is a result of the succession of several phases of volcanism, phases of erosion, and changes of the sea water level, possibly in combination with vertical differential movements of the land. (refer to Fig. 2.2)

Pre-Cenozoic rocks, as well as Tertiary deposits are encountered only in small isolated pockets in the upstream part of the area. Almost all Pre-Quaternary rocks are covered by products of recent Pleistocene and even more recent volcanism and their erosion products.

In chronological order, the following volcanic units are discerned in the area:

(1) Mentar unit is related to the activity of Takur-Takur Volcano during the Pliocene and consists of andesitic to dacitic pumiceous pyroclastics. The unit is exposed along the western border of the area, south of Pancurbatu and around Sibolangit.

(2) Toba Tuff is related to the activity of Toba Volcano during the early Pleistocene and consists of rhyodacitic tuff. The entire southeastern quarter of the Study Area is underlain by these deposits.

(3) Sinkut unit is related to the activity of Sibayak Volcano in the Pleistocene. It consists of andesites, dacites, microdiorites and tuffs.

The Medan Formation, consisting of eroded products of volcanic deposits, spreads over the entire width of the northern side of the area, and Medan City is located in the middle of this zone. This formation is overlain and intercalated with young fluviatile and paralic deposits known as alluvium, which consists of gravel, sand and clay.

2.1.3 River

(1) River System

The major river system and its catchment area is as shown in Fig. 2.3. Both of the Percut and Deli rivers originate in the Barisan mountain range, flow down northeastward and out into the Strait of Malacca after passing through Medan City. Except for the urban areas, almost all areas are covered with verdant vegetation with no remarkable gully erosion. The upstream river basin is covered with dense forest without any trace of local landslide. The basic characteristics of the Deli and Percut rivers are summarized as follows:

River	Elevation at Origin (EL m)	Length of Mainstream (km)	Mean Slope (m/km)
Percut River	1,700	81	5.71
Deli River	1,725	86	6.11

Source: 1/50,000 scaled map

(2) Flow Regime

The annual maximum flood discharges at three (3) sites, Helvetia and Simeme in Deli River and Tembung in Percut River, are given in Table 2.3. Flow regimes of observed discharges at the three sites in the last ten years are presented in Table 2.4 to 2.6. Comparing the specific discharges, similar flow regimes are estimated at the Simeme and Helvetia stations. On the other hand, discharge fluctuations are slightly bigger in Percut River. However, flow regimes in two rivers are stable that the annual minimum specific discharge is about 0.02 $m^3/s/km^2$.

2.2 Socio-Economic Condition

2.2.1 Population

The Study Area covers the whole of Medan City and seven (7) sub-districts (kecamatans); Pancur Batu, Namo Rambe, Patumbak, Deli Tua, Labuhan Deli, Percut Sei Tuan and Pantai Labu in Deli Serdang District (Kabupaten), of which total area is estimated at 906 km^2. In 1990, the Study Area indicated a population of 2.13 million, consisting of 1.73 million in Medan City and 0.40 million in the seven kecamatans. During the intercensal period from 1980 to 1990, the population growth rate of the Study Area was 2.78% per annum on average, composed of 2.33% for Medan City and 5.02% for the seven kecamatans. These population growth rates are fairly high compared with that of the country as a whole due to the rapid urbanization of Medan and its surrounding areas. Area, census population, growth rate, population density, and the number of households and household sizes of Indonesia, North Sumatra Province and the Study Area are given in Table 2.7.

According to the Metropolitan Mebidang Urban Development Project (MMUDP) Report, the number of households in the Mebidang (Medan, Binjai and Deli-Serdang) region is projected to be 0.771 million in 2000, consisting of 0.170 million in the Medan inner core and 0.601 million in the other area, and the average annual growth rate for the period 1990-2000 shows 3.80%, 1.83% and 4.40%, respectively. Furthermore, the number of households in 2010 is expected to reach 1.079 million in the Mebidang region as a whole, 0.204 million in the Medan inner core and 0.875 million in the other area, at the average annual growth rate of 3.42%, 1.85% and 3.82%, respectively, for the period 2000-2010.

2.2.2 Land Use

The Study Area consists summarily of urban areas, wet paddy fields, plantations, swampy lands and open spaces. The urban areas contain residential, commercial/official and industrial areas, and concentrate in the Medan inner core and along two (2) trunk roads; National Road and Toll Road, which run north to south and east to west from the Medan inner core. Besides, new settlements are being constructed in some places outside of the core.

A majority of the wet paddy fields together with swampy areas spread over the lower reaches of the Deli and Percut rivers, and other wet paddy fields exist in the southwestern part of Medan City. Major plantations spread in the lower and middle reaches from the river mouth to 28 km upstream of Percut River. The plantation crops are represented by rubber, oil palm, tabacco, sugarcane, coconut and coffee. Open spaces are scattered all over the Study Area, except the Medan inner core.

The land use areas are summarized as follows:

Classification of Land Use	Area (km^2)	Ratio (%)
Wet Paddy Field	200	22.1
Plantation	182	20.1
Residential	173	19.1
Commercial/Office	19	2.1
Factory	10	1.1
Swamp	42	4.6
Open Space	280	30.9
Total	906	100.0

2.2.3 Regional Economy

Gross Regional Domestic Product (GRDP) of North Sumatra Province amounted to Rp. 13,834 billion in 1992 at current prices, an average annual growth rate of 17.4% (nominal rate) during the period from 1987 to 1992, and the real annual growth for the same period also indicated a fairly high rate of 9.0%. Nominal and real growth rates of North Sumatra Province are fairly high compared to those of the country as a whole.

The GRDP in the Study Area amounted to Rp. 1,792 billion for Deli Serdang District and Rp. 3,447 billion for Medan City. During the same period, the nominal annual growth rates were 18.3% and 17.6% on average, respectively. On the other hand, the respective real growth rates indicated 9.1% and 9.9%, which were more rapid than those of the whole country and North Sumatra Province.

In 1992, the GRDP per capita of North Sumatra Province and Deli Serdang District grew to Rp. 1,283.000 and Rp. 1,077,000, respectively, at the nominal average annual growth rates of 14.7% and 15.6% (or real rate of 6.4% and 6.5%) during the said period. Despite such a rapid growth, these growth rates were somewhat lower than the GDP per capita of the whole country. On the other hand, the GRDP per capita of Medan City achieved higher than the per capita GDP, i.e., Rp. 1,926,000 in 1992, at the real average growth rate of 7.6% per annum.

2.2.4 Medan Urban Development Project

The study on the master plan for Medan Urban Development Project (MUDP) was conducted in 1978 with financial assistance from ADB as a part of the Integrated Urban Development Program of the Directorate General of Human Settlement (DGCK), Ministry of Public Works, and completed in October 1980. Based on the study, the project was implemented in 1982 with ADB funds. It covered a relatively small area focusing on only Medan City consisting of 21 sub-districts.

Since flooding has been occurring frequently in the city due to the insufficient flow capacity of the river channel and the inadequate drainage system, a further study has been conducted in the second stage of the project, namely MUDP II. Deli River and its tributaries, Sikambing and Putih, have been improved together with urban drainage works in August 1995. The number of project-affected families by the improvement of Deli River is estimated at 2,100, and the total area of expropriated lands is approximately 161 ha consisting of 3,584 parcels.

The MMUDP is planned to be undertaken as MUDP III from fiscal year 1997/98. The main objectives are to establish a long-term development strategy up to the year 2015 for the Mebidang area, and also to provide a mid-term plan for the next five to seven years aiming at preparing the detailed work approach for each development scheme such as flood control and drainage, water supply, transportation, sanitation, housing and solid waste management. The number of sub-districts involved in MMUDP will amount to 40, which include two cities (Medan, Binjai) and 14 sub-districts of Deli Serdang. The river improvement on the Deli River for a length of about 6 km from the confluence with the Babura to Titi Kuning is to be planned under MMUDP.

2.3 Flood and Flood Control Works

2.3.1 Major Floods and Flood Damage

The records of annual maximum flood discharge at Simeme Station in Deli River, although only for 14 years from 1980 to 1993, show floods of more than a 10-year return period were experienced three times: October 1985, December 1986 and November 1990. On the other hand, Percut River had experienced floods of more than a 5-year return period three times, and the biggest in the same period was recorded in December 1992.

The flood of November 26, 1990 with the peak discharge of 240 m^3/s at Simeme Station caused a vast inundation along the Deli River. The records of flood damage show that the flooding area was approx. 45 km^2 with the maximum depth of 1.5 m and 8,309 households were evacuated due to the flooding and 2 people died as reported. Direct and indirect flood damages were estimated at Rp. 38 billion and Rp. 16 billion, respectively.

2.3.2 Flood Control Works

(1) Flow Capacity

The bankfull flow capacity of Percut River has been estimated, as shown in Fig. 2.4, to be only 40 m^3/s in the lowest stretch and 150 m^3/s on average for the whole stretch, while there are some sections with smaller flow capacity of 100 m^3/s at about 9 km and 112 m^3/s at 28 km from the river mouth.

For Deli River, the lower stretch from Toll Belmera to the confluence with Babura River has been improved under MUDP II with the design discharge of 464 m^3/s to 427 m^3/s. However, the actual flow capacity is estimated at only 400 m^3/s to 370 m^3/s since the "Flood Control Manual" was applied to this stretch as presented in Fig. 2.5.

In the upper stretch of the existing channel from the confluence with Babura River, the flow capacity has been estimated, as shown in Fig. 2.6, to be about 200 m^3/s to 300 m^3/s for the whole stretch, while there are some sections with only about 30 m^3/s due to of the low bank elevation.

(2) Previous and Ongoing Flood Control Works

Since the 1980's the Deli River Improvement Works, which include Sikambing River (tributary of Deli River) and Kera River, has been undertaken by DPUP-SU, while those under MUDP II commenced in 1990. The main works of these river improvements are new dike construction, deepening and widening of existing river channel, reconstruction of bridges and installation of drainage facilities.

Under MUDP II, Deli River Improvement Works, from the estuary (cross point of Toll Belmera) to the confluence point of Babura River for a total stretch of about 24 km, is being implemented.

In addition, the project office proposed river improvement for the stretch of about 6 km from the confluence with Babura River to Titi Kuning. The project is expected to be carried out under MUDP III.

3. DEFINITIVE PLAN

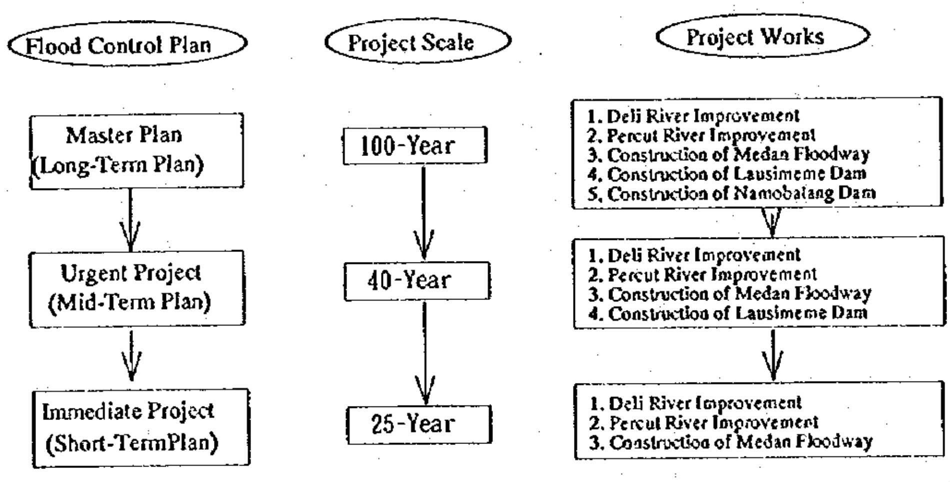
3.1 Basic Plan

3.1.1 Flood Control Scale

As figured out in the B-P Study, the flood control scheme for Deli-Percut River Basin is composed of the Master Plan and the Urgent Plan. The Urgent Plan is further divided into two stages. The first phase, named as the Immediate Plan, is composed of the project works of the Urgent Plan without the Lausimeme Dam in the upstream of Percut River, and the second phase consists of the construction of Lausimeme Dam.

Through the review and analysis of hydrology and flood control works, the project scales proposed are 100-year return period for the Master Plan and 40-year return period for the Urgent Plan. The flood control scale of the Immediate Plan is proposed to be a 25-year return period. The configuration of the flood control scheme for the Deli-Percut River is as shown below.

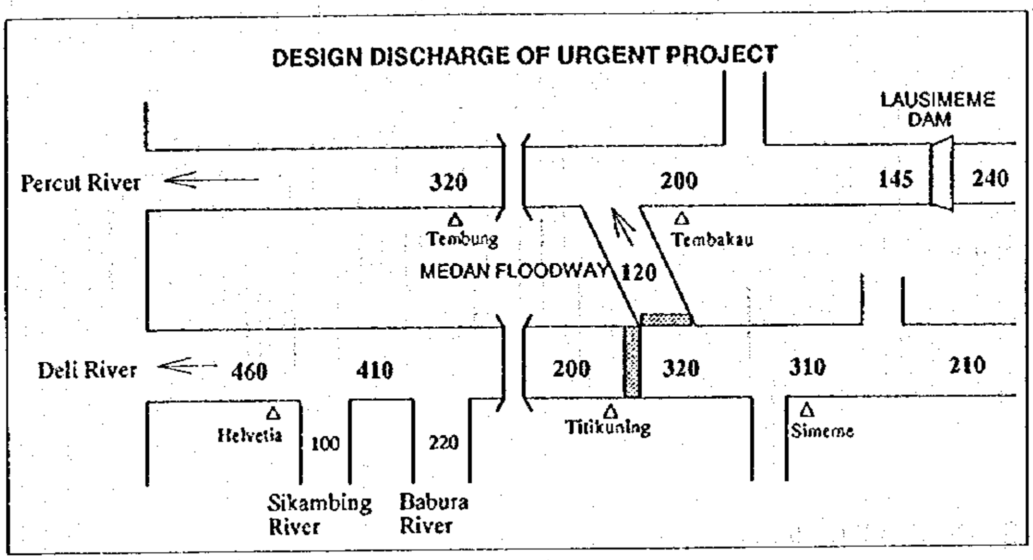
FLOOD CONTROL SCHEME



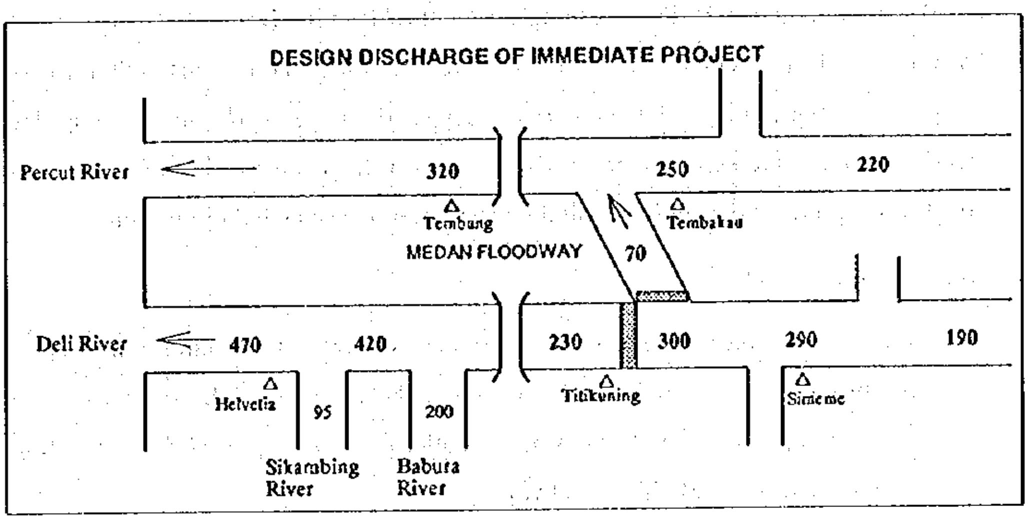
3.1.2 Design Discharge

In accordance with the newly proposed flood control scale as well as the updated probable flood discharges, the design discharges for the Urgent and Immediate projects have been estimated as graphically shown in the following:

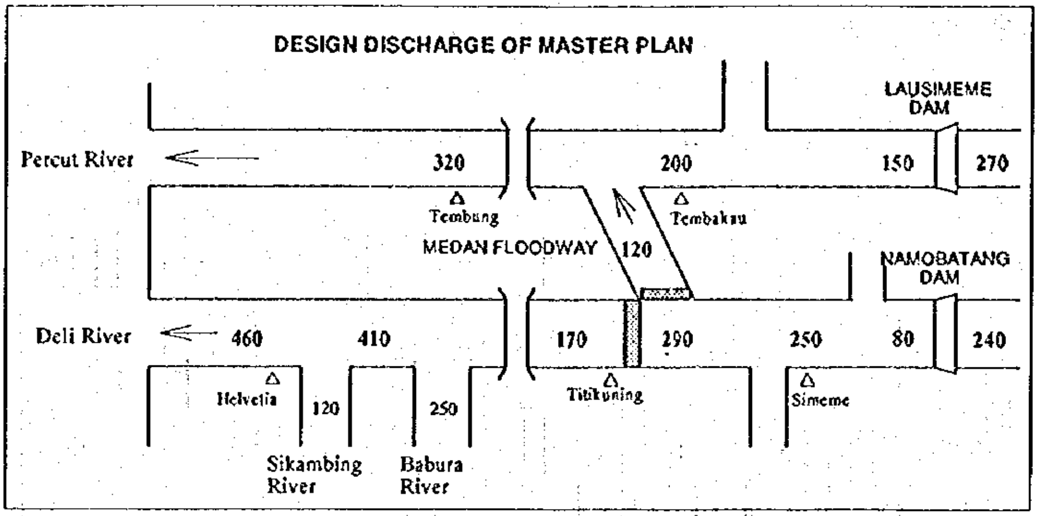
For the Urgent Project:



For the Immediate Project:



Based on the design discharges for the Urgent Project, the design discharges for the Master Plan have also been figured out as shown below to attain a smooth development of the flood control plan in the area.



3.1.3 Project Works

(1) Major Works

To attain the safety against the floods less than a 25-year return period, the main works are proposed to be the river improvement of Percut River and construction of Medan Floodway. On the other hand, there are some major construction works associated with pursuing the main works. They are drainage improvement and bridge works related to the Percut river improvement as well as construction of water front facilities to promote the environmental betterment of the river and its environs.

(a) Drainage Outlet

River improvement works such as channel excavation, widening and diking usually affect the drainage system around the river channel. Therefore, the drainage improvement will focus on the outlet portion, i.e., the sluice connecting to Percut River and Medan Floodway.

(b) Bridge Work

There are 17 bridges to be affected by the implementation of the Project; namely, 16 bridges along Percut River and 1 bridge upstream of the proposed Deli River Weir on the Upper Deli River. Of the 17 bridges, 11 are road bridges, 1 is a railway bridge, 3 are pedestrian bridges and 2 are waterpipe bridges. Through the evaluation on whether or not the dimensions and structures of the existing bridges would meet the requirements of the proposed river improvement plan, reconstruction, new construction or modification works are proposed, as presented in Table 3.1.

(c) Waterfront Facilities

The Deli and Percut rivers are featured as urban rivers which serve not only the flood control purpose in flood events but also the purpose of water supply for irrigation, fishponds, and factories as well as for daily water use of local residents living in the adjacent areas. River improvements could produce good effects in promoting or developing the environmental functions such as the realization of hygienic living environment, the improvement of river water quality, and the creation of better scenic view and pleasant open space.

The retarding channel in the Upper Deli River which is located upstream of the proposed diversion weir, is utilized for waterfront activities, sports and/or other recreational purposes during the non-flooding period. On the basis of inundation conditions in the retarding channel, the utilization and zoning plan (Fig. 3.1) is proposed as follows:

Zoning	Inundation Occurrence	Area (ha)	Utilization Plan
Zone A	1 time/year	1.84	Park Area & Sports
Zone B	10 times/year	2.71	Free Open Park Space
Zone C	Frequent	0.90	Waterfront / Walking

The high water channel of Percut River is considered usable as a park, pedestrian path, sports field and other activities. The newly created area by expanding the wide water channel at the meandering stretch will be utilized as free/open park space.

(2) Work Items and Quantities

Summarizing all works required, they are divided into three (3) components, as follows: (a) Percut River Improvement Works; (b) Construction of Medan Floodway; and (c) Diversion and Improvement Works of Upper Deli River.

The work items and their quantities are shown in Fig. 3.2 and described below.

(a) Percut River Improvement Works

The river improvement works for the of about 28.0 km is divided into two (2) portions: the downstream stretch from the existing Titi Runtuh Bridge to the river mouth, and the upper reaches from the bridge to the confluence with Medan Floodway. The river improvement shall include the following works.

Downstream Stretch from Titi Runtuh Bridge

Project Works	Quantity
Dike Construction including Reinforcement of Existing Dikes	13,150 m
Channel Excavation and Dredging	13,150 m
Improvement of Lalang River	1,241 m
Construction of River Structures	
- Low Water Revetment	2,320 m
- Parapet Wall	1,915 m
- Groin	9 sites
- Groundsill	1 site
- Approach Step	65 sites
- Jetty and Landing	1 site
Reinstallation/Reconstruction of Existing Drainage Outlet	2 sites
Relocation of Drainage Channel	710 m
Relocation of Bandar Sidoras Intake Weir	1 site
Reconstruction of Bridge and Approach Road	3 sites
Relocation of Kabupaten Road	1,985 m
Relocation of Farm Road	2,170 m
Installation of Intake Gate for Fishpond	2 sites

Upstream Stretch from Titi Runtuh Bridge

Project Works	Quantity
Channel Widening and Straightening	15,100 m
Riverbank Protection (Wet Masonry Revetment)	3,300 m
Construction of River Structures (Approach Step)	53 sites
Bridge Protection Works	4 sites
Reinstallation of Existing Drainage Outlet	35 sites
Reconstruction of Bridge and Approach Road	6 sites
Reconstruction of Water Pipe Bridge	1 site
Relocation of Water Level Gauging Station	1 site

(b) Construction of Medan Floodway

The floodway shall convey a part of the flood of Upper Deli River into Percut River. The floodway is designed as an open channel with a total length of about 3,900 m connecting Deli River and Percut River. The related works are as follows:

Project Works	Quantity
Excavation of Floodway	3,920 m
Revetment (Wet Stone Masonry)	2,585 m
Revetment (Retaining Wall)	1,035 m
Construction of Groundsill (at junction)	1 site
Construction of Drainage Channel/Ditch	7,020 m
Construction of Drainage Outlet	7 sites
Construction of Bridges (Road / Railway / Water Pipe / Pedestrian)	10 sites
Construction of Inspection Road and Tree Planting	7,600 m
Partial Improvement of Batuan River	100 m

(c) Diversion and Improvement Works of Upper Deli River

To control the flood discharge in the downstream of Deli River and to divert a part of the flood into the floodway, diversion weirs are constructed at the Deli River (Deli River Weir) and at the entrance of the floodway (Floodway Weir). Simultaneously, the retarding channel situated upstream of Deli River Weir will be improved to smoothen flood flows for the effective diversion of discharge and to create a space with better scenery and amenity for inhabitants therearound. The related works are as follows:

Project Works	Quantity
Construction of Deli River Weir	1 site
Construction of Floodway Weir	1 site
Excavation of Embankment of Retarding Channel	830 m
Revetment	700 m
Construction of Pedestrian Bridge	1 site
Construction of Walkway	2,100 m
Tree Planting	650 m
Approach Step	7 sites

3.2 Project Evaluation

3.2.1 Economic Cost

The comparison between financial cost and economic cost of the Project is made as below:

Financial Cost		Economic Cost	
Project Cost	Annual O&M Cost	Project Cost	Annual O&M Cost
204,061	1,496	178,149	1,319

In the table above, the annual O&M cost is assumed to be 1% of the direct construction cost, and partial annual O&M cost, which is required under the construction, is assumed to be proportional to the progress of construction works.

3.2.2 Economic Benefit

The economic benefit is classified into three: (1) direct effect of reduction in flood damage to assets, (2) reduction effect of flood damage to economic activities and public facilities, and (3) other socio-economic effects. Firstly, a flood damage analysis is made to assets, which are composed of general assets (buildings and household effects) and agricultural field crops. Next, flood damage to public facilities and economic activities is estimated as a function of the flood damage to general assets.

(1) Summary of Flood Damage

The total damage amounts are as summarized below:

Unit: Rp. Million

Return Period (Year)	Deli River	Percut River	Total
5	-	18,989	18,989
12	-	20,995	20,995
25	144,442	27,893	172,335
40	153,794	28,749	182,543
70	163,969	29,536	193,505
110	170,320	32,388	202,708

(2) Average Annual Flood Damage

Average annual flood damage is estimated by using the total flood damage above, taking the occurrence probability of flood into account. The results are summarized as follows:

(Unit: Rp. Million)

Return Period (Year)	Deli River	Percut River	Total
5	-	7,596	7,596
12	-	9,928	9,928
25	5,813	10,987	16,800
40	8,050	11,412	19,462
70	9,752	11.724	21,476
110	10,620	11,885	22,505

The average annual flood damage which corresponds to the Immediate and Urgent plans (25-year and 40-year return periods) is estimated at Rp. 16,800 million and Rp. 19,462 million, respectively.

(3) Average Annual Benefit

After completion of the construction works for the Immediate and Urgent projects, the average annual flood damage corresponding to the respective projects is expected to be eliminated, i.e., it would be given as an average annual benefit of the projects.

The partial annual benefit expected to accrue before completion of the construction works is assumed to be proportional to the progress of construction works by the same means as the O&M cost, i.e., the partial benefit would be approximately estimated by a ratio of the invested construction cost to the total construction cost.

Further, the average annual benefit is expected to increase at the annual rate of 3.5% for the period 1990-2000, and 3.0% after that year during project life, because of the increased number of general assets year by year.

3.2.3 Economic Evaluation

(1) Estimate of EIRR

The economic evaluation for the Immediate and Urgent plans is made by comparing both present values of economic cost and benefit using the annual flows of the cost and benefit given in Table 3.2. As a result, EIRR is as summarized below:

Plan	Return Period	EIRR (%)
Immediate Plan	25-Year	14.42
Urgent Plan	40-Year	15.43

The percentage of EIRR above shows that the project is economically justifiable, because the opportunity cost of capital is estimated to be 10 to 12% in Indonesia.

(2) Sensitivity Test

A sensitivity test for the EIRR above is made for the 10% increase in economic cost and the 10% decrease in economic benefit. The results are given as follows:

(Unit: %)

Plan	10% Increase in Cost (1)	10% Decrease in Benefit (1)	Combination of (1) and (2)
Immediate Plan	13.39	13.23	12.30
Urgent Plan	14.30	14.12	13.50

(3) Economic Effect of Recreation Park

A recreation park is planned in the retarding channel immediately upstream of the diversion weirs in the Upper Deli River. The retarding area is approximately 5 ha, 1.2 ha (24%) of which is provided as a recreation park with such facilities as flower garden, parking area, tennis court, soccer ground, etc.

The construction cost of this park is estimated at approximately Rp. 290 million, composed of Rp. 151 million (52%) for land preparation and Rp. 139 million (48%) for recreation facilities. In the present plan, only the land preparation work is included in the project cost. Annual O&M cost is assumed to be approximately 1% of the total construction cost.

The benefit could be roughly estimated by using (1) the number of visitors, (2) the time spent by them (including time spent for going to and from the park), and (3) the transportation costs. In general, the number of visitors is given as a function of distance from the park and population in the surrounding areas. The spent time is presented in monetary term, under the concept of consumer surplus.

Under the conditions above, the annual economic benefit of the park is estimated at Rp. 22.5 million for 15,000 visitors (person-day) in total, based on the concept of "willingness to pay" and "consumer surplus" of the visitors. As a result, the economic benefit of land preparation work is estimated to be Rp. 11.7 million per annum in accordance with the allocation based on both construction costs of land preparation and recreation facilities. This benefit is evaluated as an additional effect of the river improvement works.

EIRR of land preparation for the park is estimated at approximately 6%.

3.3 Environmental and Social Impacts

3.3.1 Environmental Impacts

The Environmental Impact Study (ANDAL) was carried out in August 1991 as part of the B-P Study by JICA. However, the study results have to be reviewed in accordance with the new Government Regulation No. 51 of 1993 regarding environmental impact assessment, and official approval of the Central Committee on Environment (KOMPUS) is required prior to project implementation. The ANDAL should provide analytical information on what environmental impact could be brought by the project to the river and its surrounding areas, and serve for the preparation of the Environmental Management Plan (RKL) and the Environmental Monitoring Plan (RPL).

(1) Environmental Management Plan

Based on the impact study, the environmental management plan was formulated with a view of preventing and mitigating negative impacts as well as enhancing positive strategic impacts. The issues as enumerated below were discussed as basic approach to the establishment of a proper management plan. All fundamental issues on environmental management are summarized in Table 3.3.

(2) Environmental Monitoring Plan

The monitoring work has to be performed periodically for a certain period of time depending on the subject parameter. The impact source varies according to the project stage. There are a number of parameters to be monitored in each stage as tabulated below.

Project Stage	Parameter
(1) Pre-Construction	(a) Any issue arising from land expropriation
(2) Construction	(a) Noise level, dust content level, traffic congestion (b) River water quality (c) Sedimentation (volume and treatment of soil mixed with toxic substances) (d) Groundwater level along the floodway (e) Irrigation water for the paddy field at Bandar Sidoras (f) Aquatic biology (plant and biota)
(3) Post-Construction	(a) Illegal use of expropriated land (b) River water quality (c) Sedimentation by erosion (d) Groundwater level along the floodway (e) Solid waste and refuse in the riverbank (f) Project effect and evaluation

Basically, there are four methods to collect relevant data and information: (1) field observation, (2) interview survey, (3) field measurement, and (4) sample analysis. The monitoring method is decided in accordance with the subject matter.

Fundamental issues and methods on the monitoring plan are compiled and summarized in Table 3.4.

3.3.2 Social Impacts

(1) Project Area

The project area comprises part of Medan urban area and Deli Serdang consisting of six (6) kecamatans or sub-districts: Medan Johor, Medan Amplas, Medan Denai, Medan Tembung, Percut Sei Tuan and Patumbak. The number of villages involved, called kelurahan, is supposed to be 25 altogether.

Fig. 3.3 shows the sub-districts concerned in the social study area. According to the topographic map at 1/1,000 prepared in October 1995 covering the whole target area, the total area to be required for the land expropriation is estimated at 188.6 ha including public properties. Above all, the river improvement works of Percut River need to acquire about 136 ha of land which accounts for 83% of the total required area. Although the occupancy rate of residential area is more or less 10% as a whole, it turns up to 17% for the floodway area and 56% for the upstream of Percut River.

Table 3.5 shows details on the basis of identified land use and project-affected houses. The number of project-affected houses/buildings will amount to 990 including public facilities such as schools, mosques, factories, etc., out of which 970 units are privately owned. However, the number of project-affected families is estimated at 1,584.

(2) People's Perception

The interview survey conducted in the project area indicates that no one is opposed to the project and, basically, 100% of all respondents agree to the implementation of the project for the following reasons:

(1) To enhance village development by mitigating flood damage	36.0%
(2) To improve the living environment	22.5%
(3) To expect compensation for land and house	21.3%
(4) To create job opportunities	20.2%

(3) Prediction and Evaluation

Social impacts will possibly accrue during the pre-construction, construction and post construction stages of project implementation. The impacts predicted in each stage are presented below as summarized in Table 3.6.

(4) Impact Management Plan

Several important as well as not important negative impacts will arise during the three stages of project implementation. A management plan for the social impacts is therefore necessary, as presented in Table 3.7.

In the framework of social impact management, the Project Office conducted extension meetings in the villages to be affected from March 8 to March 27, 1996. The results of these meetings show that more than 85% of the total number of project affected people or all of those who attended the meetings agree to the implementation of the project.

4. DETAILED DESIGN

4.1 River Improvement and Floodway

4.1.1 Percut River

Based on the river longitudinal profiles, the target river stretch is divided into two segments, the lower and upper stretches bounded by PE129+50.

(1) Standard Cross Section (refer to DWG. 4.1)

(a) Type of Cross Section

(i) Lower Stretch

A wide compound cross section is employed in the stretch between PE14 and PE129+40 to ensure channel stability and to protect the dike slope from erosion by strong current. The width of the channel bed ranges from 8 to 13 m in the stretch from PE129+40 to PE47. As for the lowest stretch from PE47 to the river mouth where the flow capacity is extremely low, the width of the channel bed is expanded to 40 m.

Leveling/excavation of the flood channel is executed only when the elevation of the existing channel is higher than that of the proposed channel. Filling/embankment is not performed for the flood channel with elevation lower than that of the proposed, except a counterweight fill for the dike in the stretch from the river mouth to PE14.

(ii) Upper Stretch

Based on river characteristics such as flood flow condition, channel meandering and erosion on the channel, and land use in the neighboring urban area, single trapezoidal section without diking is employed. The riverbed width is designed at 8 m, which is a little wider than the average width of the existing channel. For slope stability, a small berm with a width of 1.5 m is provided in the middle of the slope.

(b) Side Slope

A side slope of 1 : 2 (vertical to horizontal) is adopted for the low water channel to ensure bank stability. A gentle side slope will provide inhabitants with easy access to the water surface as well as maintenance of the dike slope.

(c) Cross Section at Bends

At bending section of river, rises in water level and sediment deposit are unavoidable phenomena. To cope with them, the bending section is widened by 10 to 60% of the width of the standard cross section. Open spaces in concave sides of flood channel, which are newly formed by the widening, may serve for river utilization such as recreation, sports, small park and so on. For these purposes, gravel pavement and sodding are provided on the flood channel.

(d) Right-of-Way

The right-of-ways is delineated 5 m away from the toe of dike or edge of inspection road in accordance with the government regulation for river administration. The government may acquire and control all lands to a distance of 5 m beyond the outside toe of dike or inspection road. This area will serve as access road to the site during construction.

(2) Alignment (refer to DWG 4.2)

(a) Lower Water Channel

(i) Lower Stretch

Most parts of the low water channel in this stretch has less meandering. Therefore, the channel widening is made with a smooth alignment conforming to the existing one except the following stretches.

Since the existing right dike is built close to the channel bank for the stretch of PE129 to PE110, channel excavation is made on the left side bank so that the right riverbank can maintain its slope stability. The minimum distance between the right channel bank and the dike is 5 m.

Channel widening is made only in the right bank of the stretch of PE33 to PE14 to reduce compensation works in the congested residential area in the left bank. Besides, the left riverbank forms a water colliding front and is prone to erosion during floods. Therefore, the whole stretch of the left bank is provided with slope and foot protection works.

(ii) Upper Stretch

The alignment in this stretch is in principle designed by conforming to the existing one to minimize land acquisition and house evacuation as well as construction cost. A cut-off channel is not employed.

Instead, smoothing and widening of the meandering portion is made to provide a smooth flood flow based on the condition that the maximum allowable degree of curvature of the channel (curve radius from centerline) is at least five times the average river surface width. This criterion is not applied to bending sections.

(b) Dike

Both right and left dikes are in principle smoothly aligned almost in parallel with the low water channel, with a bigger distance than that of the standard channel cross section. The following conditions are also employed in the dike alignment.

(i) Existing dikes in the stretch between PE33 and PE129+40 are raised and enlarged. The alignment of dike shall conform to the existing one. In the stretch where the distance between the existing right and left dikes is smaller than the proposed one, new dikes are provided backward.

(ii) The dike is aligned throughout the whole stretch, at least 5 m away from the low water channel (distance between the channel bank and the toe of dike slope) to protect the dike from scouring by floods.

(iii) In the non-diking downstream stretch from PE33, the dike is aligned in parallel with the proposed low water channel. The left dike is aligned in the area sandwiched by the existing riverbank and the paved village road to save on compensation cost.

(iv) Aiming at protecting the fishpond area along the right riverbank from flooding, and at leading floods and sediment smoothly into the sea, a river mouth dike is provided on the right side bank of the channel downstream of PE14. The dike is aligned in parallel with the low water channel, keeping a distance of more than 15 m from the channel bank. On the other hand, no dike is provided along the left riverbank in the downstream stretch from the river mouth to PE14. An earth dike is provided along the branch channel joining Percut River from the left at PE14 in order to protect the village therearound from floods of Percut River and high tide.

(3) Longitudinal Profile (refer to DWG 4.3)

(a) Design Riverbed

The design riverbed profile primarily conforms to the existing average riverbed profile to avoid imbalance causing scour and sedimentation, as well as to minimize relocation and modification of the existing river structures. The rate of altering the riverbed gradient of the upper stretch to the lower stretch shall be basically set at less than 0.5 to ensure the stability of the river channel. The riverbed profile is designed as follows:

(b) Design High Water Level

The design high water level is determined by non-uniform steady flow calculation for the downstream of PE46 and by uniform steady flow calculation for the upstream of PE46. In addition to the calculation results, the following items are taken into account:

(i) In the upstream stretch from Bandar Sidoras Intake Weir to the junction with the Floodway, the design high water level is to be nearly equivalent to the average elevation of the adjoining ground or the existing dike.

(ii) In the downstream stretch, the design high water level is set at around 2.0 m above the ground elevation so that the dike height is lower than 3.5 m.

(c) Elevation of Dike Crown

The design elevation of dike crown is higher than the design high water level by a freeboard of 0.8 m.

4.1.2 Medan Floodway

(1) Standard Cross Section (refer to DWG 4.4)

Two types of cross section are applied; the single trapezoidal section having a bottom width of 5.0 m and a side slope of 1 : 1.5 protected by a wet stone masonry for the downstream from FW28+50 to the confluence point and the double trapezoidal cross section with leaning walls for the upstream from FW28+50 to the Floodway Weir.

(2) Alignment (refer to DWG 4.5)

The Floodway starts at around UD13 of Deli Retarding Channel and joins Percut River at 27 m upstream of PE274 having a total channel length of 3,920 m. The main part of the Floodway is aligned as straight as possible and to avoid the difficulty of compensation.

(3) Longitudinal Profile (refer to DWG 4.6)

Basically the design channel bed elevation and high water level of the Floodway is delineated by connecting the channel beds and water levels of the Percut and Deli rivers. In addition, dimensions of diversion such as overflow depth, height and length of weir are essential in determining the channel bed elevation of Floodway.

4.1.3 Upper Deli River

(1) Alignment (refer to DWG 4.7)

The design alignment of low water channel and each zone terrace conforms with the existing topographic condition of the inundation channel which could attain a smooth flood flow to both the Deli River Weir and the Floodway Weir.

Two flood protection dikes are provided: one along the river bank between Deli River Weir and Floodway Weir and the other along the right bank in the bending stretch approaching the Floodway Weir. The former dike is aligned in a straight line between the two weirs, and the latter dike is aligned with a smooth curve conforming to the existing topography.

(2) Longitudinal Profile (refer to DWG 4.8)

Based on the geological condition, the design elevation of the weir bed is EL 24.200 m, and the bed elevation of the outlet orifice is set at EL 24.700 m to prevent sediment deposits in the orifice. For the upstream stretch from UD12, the design riverbed is determined according to the existing bed profile. A riverbed gradient of 1/170 is employed only in the stretch from Deli River Weir to the Floodway Weir (UD12 to UD13) to smoothly connect both structures.

The design high water level is set at EL 34.00 m for the section between the Deli River and Floodway weirs (UD12 to UD13) under both the Immediate and Urgent plans.

The elevation of the flood channel terrace with zoning is determined depending on the frequency of inundation, as follows:

Location	Zone Classification	Elevation	Inundation Occurrence
Top of Low Water Channel	C	EL 28.000 - 29.000 m	20 times/year
Channel Terrace (I)	A	EL 32.600 m	1 time/year
Channel Terrace (II)	B	EL 31.500 m	10 times/year
Dike Crown	D	EL 35.000 m	No inundation

(3) Standard Cross Section (refer to DWG 4.9)

The design cross section of the retarding channel is the compound trapezoidal section. The low water channel is improved by channel excavation with a riverbed width of 10 m and a side slope of 1 : 2. For the river utilization plan, an embankment is provided on the existing flood channel in accordance with the land zoning plan. A high embankment along the right bank is designed to be safe against slope failure and flowing force. A berm with a width of 3.0 m is provided on the slope at a vertical interval of around 3.0 m.

4.2 Riparian Structures

4.2.1 Dike

A river dike including small embankment for inspection road is provided in the following stretches:

Classification	Location
Existing Dike to be reinforced or relocated backward (Setback Dike)	PE33 to PE129+40 (Right bank) PE33 to PE129+40 (Left bank)
New Dike	
- Percut River	PE0 to PE14 (Right Bank)
	PE14 to PE33 (Right Bank)
	PE14 to PE33 (Left Bank)
- Deli Retarding Channel	Between Deli River and Floodway Weirs
- Left Channel at River Mouth	Along Right Bank (L=1,000m)
Embankment for Inspection Road	
- Percut River	PE129+40 to PE274 (Right and Left Banks)
- Floodway	FW4 to FW7 (Left Bank)

(1) Earth Dike (refer to DWG 4.10)

The materials excavated in Percut River and the Floodway, except those in the downstream from the Bandar Sidoras Intake Weir, are found suitable for embankment from the geotechnical survey results. In heightening and enlarging the existing dike, an embankment is made on the land-side slope of dike of which surface is stripped by 25 cm thick.

A dike composed of a combination of earth embankment and parapet wall is employed in the housing area along the left bank downstream of PE14 to PE33 to minimize land acquisition. Since the top elevation of embankment is set at the same as that of the design high water level, the height of embankment could be less than 2.0 m. A parapet wall is provided on this embankment covering the freeboard of the dike.

(a) Crown Width

The river dike should have an adequate crown width to ensure stability against seepage and piping failure, and to serve as maintenance road for flood fighting activities and daily inspection. A crown width of 3.0 m is applied to the dike of river whose design discharge is less than 500 m^3/s.

(b) Side Slope

A slope gradient of 1 : 2 (vertical to horizontal) is adopted for both landside and riverside slopes to attain slope stability during flood events and to prevent erosion of slope surface by rainfall. Approach roads/steps are provided on both land and river sides at an interval of about 1.0 km for the purpose of maintenance work on dikes, flood fighting activities and daily passage of nearby residents.

(c) Freeboard

Freeboard is provided to offset overtopping of floods caused by wave run-up or set-up, super-elevation of flow at a bend, potential dike settlement, crown deterioration and so on. A freeboard of 0.8 m is employed for the dike of Percut River and the retarding channel upstream of Deli River Weir. This freeboard corresponds to the discharges of between 200 m^3/s and 500 m^3/s according to the "Flood Control Manual," while it is 0.5 m for less than 200 m^3/s.

(d) Stability of Embankment

Seepage through the embankment shall be controlled to prevent excessive uplift, piping, instability, sloughing and erosion. Extra embankment to increase the height of dike by 10% shall be provided to cope with the settlement of earth dike body and consolidation of subsurface layer after construction so as to keep the design dike crown elevation.

(2) Flood Retaining Wall (refer to DWG 4.11)

A flood retaining wall is employed for the left bank of stretch PE17-6.5 to PE18+20 which is subject to water colliding and diking is difficult due to the limited area between the riverbank and the village road. This flood retaining wall is made of concrete with prestressed concrete sheet piles and wooden foundation piles. An embankment is provided in the backside wall, connecting the upstream and downstream earth dikes.

4.2.2 Slope and Riverbed Protection Works

(1) Revetment

Revetments are provided to protect riverbanks from erosion and scouring due to water flow and wave wash. The locations to be provided with revetment are along the concave sides of meander bends of channels; at the downstream and upstream sides of riparian structures including bridges; on the side slopes of the floodway channel; and at the water colliding fronts of riverbanks which are prone to erosion.

The revetment of wet stone masonry type is basically adopted in this river improvement works. In addition, gabion cylinder, riprap and concrete wall types are employed independently or in combination with the wet stone masonry type, as shown in the table below.

Type of Revetment	Location
Wet Stone Masonry	(1) Dike/bank slope at bend and at the water colliding front in the lower Percut River (2) At down and upstream sides of river structures and bridge (3) Floodway (FW0 to FW28+50)
Concrete Wall	
- Flood Retaining Wall	(1) PE17-6.5 to PE18+20, Left Bank
- Leaning Wall	(1) Floodway (FW28+50 to FW38+95) (2) Side wall at diversion weirs and protection for bridge foundation
Gabion Cylinder	(1) Low water channel slope at bend in lower Percut River (2) On the side slope of wet masonry type revetment
Riprap	(1) At the water colliding front in lower Percut River (2) On the slopes of the river mouth dike

(2) Groin (refer to DWG 4.12)

The lower reaches of Percut River has a gentle riverbed slope of 1/8,000, and riverbed materials are mostly silt or clay. The permeable type of groin consisting of piles is used to facilitate sedimentation therearound by controlling the flow velocity and, consequently, assure the stability of the low water channel bank.

Tops of concrete piles are connected by concrete frames to stabilize the structure. Riprap with thickness of at least 0.6 m is provided around the foot of concrete piles to prevent scouring.

(3) Groundsill (refer to DWG 4.13)

The groundsill is to be located 100 m downstream from the Titi Beshi Bridge which exists in the river section suffering degradation, to stabilize the substructures of the and the revetments. The groundsill is of 1.0 m high concrete gravity type with an apron which should prevent scouring at the foot or foundation during flood time. As for the foundation of the groundsill, prestressed concrete piles, 300 mm in diameter and 9 m long, are driven to increase the bearing capacity of the subsurface. Gabion mattress for riverbed protection is placed on the riverbeds upstream and downstream of the groundsill with appropriate lengths of 6.0 m and 12.0 m, respectively.

(4) Junction Works

To obtain a steady flow after the confluence, the transition channel of 120 m which is about three times the total width of the two channels are provided at the junction of the Floodway to Percut River. The channel section at the confluence gradually conforms to the standard cross section of Percut River within the transition channel.

The bed elevation of the Floodway is 36 cm higher than that of Percut River at the junction. To connect both channel beds smoothly, a chuteway with a length of 30 m and a slope of 1/80.4 is provided at FW3+30. A groundsill is provided at 220 m upstream from the junction (FW3+00) to protect the channel bed.

(5) Jetty: Landing Stage and Mooring Facilities (refer to DWG 4.14)

A landing stage for fishing boats exists at the lower section (PE14+57) of Percut River. This landing stage is reconstructed at the same location in the Percut River improvement works.

The landing stage is designed to keep more than 75 cm draft depth under all tide levels. Since the MHWL is EL. 1.190 m and MLWL is EL. -0.937 m, four (4) stages are provided alternately with the retaining wall height of 1.50 m in total. The elevation of each landing stage is set at EL -0.819 m, EL -0.069 m, EL 0.681 m and EL 1.431 m. The surface of each stage is paved with concrete blocks.

4.2.3 Bridge Protection Works

(1) Titi Runtuh Bridge (refer to DWG 4.15)

Protection works are carried out for the abutment of Titi Runtuh Bridge as well as the riverbanks and riverbed in the stretch for a total length of 70 m. This stretch forms a transition from a single trapezoidal section in the upper stream to a double trapezoidal section in the lower stream.

The side slopes are covered with concrete retaining walls for a length of 31 m in the central portion of the stretch and wet stone masonry with the lengths of 14 m and 21 m in the up and downstream sides. The riverbed is protected with gabion mattress.

(2) Railway Bridge (refer to DWG 4.16)

The stretch of about 70 m up and downstream of the existing railway (Mean-Deli Tua Line) is provided with bridge protection works. The river stretch covers the proposed drainage outlets (SL-5, SL-6 and SR-2).

To meet the design cross section, leaning walls with the length of 42 m are employed for the side slope protection in the central portion of the stretch. The up and downstream sides are covered with wet masonry revetments for 14 m each at up and down portions to form a smooth channel alignment. For riverbed protection, gabion mattresses are placed.

(3) National Road Bridge (refer to DWG 4.17)

The stretch to be protected is estimated at 96 m which corresponds to the width of the bridge and the river including water pipe bridge. The low flow channel side slopes are protected by concrete retaining wall built on the foundation log piles for the central portion of 60 m. At the toe of bottom slab, concrete cutoff wall is provided to protect the riverbed from scouring. Wet stone masonry with the lengths of 18 m each in up and downstream, plastered on the surface, is used for the upper side slopes between pier and abutment. For riverbed protection, concrete blocks with a weight of 1.25 ton each are placed with a flat surface.

4.2.4 Drainage Outlet

(1) Urban Drainage

Gravity flow is principally employed to avoid the big O&M cost to be brought by a pumping station. Where the design high water level is higher than the ground elevation of the drainage area, a control gate is employed for the sluice to stop the reverse flow from the river/floodway. No gate is provided for the sluice where the design high water level is lower than the ground elevation.

Either type of sluice, box culvert or pipe, could be classified according to the drainage discharge having a flow velocity of 2.5 m/s to 3.0 m/s, as below:

Type	Dia./Width (m)	Height (m)	Number	Flow Area (m^2)	Design Discharge (m^3/s)
Pipe Culvert	0.600	-	1	0.283	0.707 - 0.989
	0.800	-	1	0.502	0.989 - 1.748
	1.000	-	1	0.785	1.758 - 2.748
	0.800	-	2	1.005	2.748 - 3.517
	1.000	-	2	1.570	3.517 - 5.495
Box Culvert	1.500	1.500	1	2.250	5.495 - 7.875
	2.000	1.500	1	3.000	7.875 - 10.500
	2.000	2.000	1	4.000	10.500 - 14.000
	2.000	2.000	2	8.000	14.000 - 28.000

Through the basic design conditions, the structural dimensions of all the 42 sluices are estimated, as shown in Table 4.1.

For the box culvert of SL 2 with sluice gate, the plan of structure is given in DWG 4. As well the standard design of single pipe culvert is given in DWG 4.19.

(2) Confluence Treatment of Batuan River (refer to DWG 4.20)

Batuan River, a small tributary of Deli River, crosses the proposed floodway at FW25+24. The improvement of Batuan River is carried out for a stretch of 85 m from the confluence with the floodway to the upstream. The design discharge for the improvement is 16 m^3/s corresponding to a 10-year return period flood. Since the riverbed elevation of Batuan River is about 5.1 m higher than the channel bed of the floodway, a stepwise fall structure is provided at the confluence to dissipate the energy of river flow.

4.2.5 Bandar Sidoras Intake Weir (refer to DWG 4.21)

An inflatable rubber-made dam is employed for the intake weir. The weir is constructed on the flood channel 150 m upstream of the existing weir. Structural details of the proposed weir and related irrigation structures through the hydraulic design are summarized below:

Work Item	Dimensions	
Main Rubber Dam		
- Crest Elevation	EL. 4.06 m	
- Bottom Elevation	EL. 0.92 m	
- Auto-deflation Water Level	EL. 4.87 m	
- Height of Rubber Body	3.14 m	
- Width of Rubber Body	13.00 m at bottom	
- Maximum Water Head	3.95 m at auto-deflation water level	
- Design Overflow Depth	0.81 m	
Spillway	Upstream	Downstream
- Apron	8.0 m	16.0 m
- Protection Works	10.0 m	20.0 m
Control House (floor area)	$33.0m^2$	
Flood Channel Protection Works	$300\ m^2$	
Maintenance Bridg	1.5 m wide, I-Beam Steel Girder	
- Span	29.0 m+33.0 m	
- Steel Girder	60 cm high, 30 cm wide	
Intake Facilities	Right	Left
- Intake Gates (2 steel slide gates)	1.00×1.25m	1.00×1.00m
- Size of Box Culvert	1.50×1.50×37.3m	1.50×1.25×73.3m
Irrigation Channel (wet masonry type)	Right	Left
- Channel Size (Trapezoid-section)	B=3.3m, L=257m	B=2.8m, L=218m

4.2.6 Diversion Weirs

(1) Foundation of Weirs

An outcrop of stiff Toba Tuff stratum is observed at the riverbed of Deli River Weir, and the stratum having a high bearing capacity (N-value is mostly more than 40) is confirmed at EL 22.0 m to EL 23.0 m. The base elevation of the weir is set at EL 21.700 m which is 2.5 m below the surface of apron.

For the Floodway Weir, the foundation geology show that a stiff and uncemented Toba Tuff as supporting layer (N-value is more than 40) appears at EL 20.0 m to EL 23.0 m. Therefore, neither a spread foundation with an embedment depth of 5 m nor a pile foundation with only 3 to 4 m long piles are not employed for the Floodway Weir due to disadvantages in construction cost. To ensure the strength of the foundation, some foundation improvement works by cement-treated material is employed from the economical point of view. The improvement depth is 3 m and the area is 2 m wider than the weir base.

(2) Hydraulic Design

Hydraulic analyses were made to verify the results of the hydraulic model test and served for the hydraulic designs of weirs for Immediate and Urgent plans.

(a) Deli River Weir

Dimension of Deli River Weir	Immediate Plan	Urgent Plan
Crest Elevation	EL 31.000 m	EL 31.500 m
Overflow Depth	3.00 m	2.50 m
Weir Length	17.5 m	17.5 m
Discharge from Orifice	68.9 m^3/s	78.5 m^3/s
Discharge from Overflow Section	161.1 m^3/s	121.5 m^3/s

(b) Floodway Weir

Dimension of Floodway Weir	Immediate Plan	Urgent Plan
Crest Elevation	EL 32.500 m	EL 32.500 m
Overflow Depth	1.50 m	2.00 m
Weir Length	17.5 m	25.0 m

In designing the weir, therefore, the crest length is fixed, then the height is adjusted to assure the design diversion discharge. Correspondingly, the modification of the weirs, resulting from the change of diversion discharges between the Immediate and Urgent plans, is made by adjusting the crest height of weirs. The method of raising/cutting the weir crest for the Urgent Plan is also changed, as shown in Fig. 4.1.

(3) Structural Dimensions

The dimensions prepared through the hydraulic design calculation are as follows:

(a) Deli River Weir

Item	Dimensions
Structural Type	Gravity, Trapezoid-Shaped Weir
Design Water Level	EL 34.000 m
Elevation of Crest	EL 31.000 m (EL 31.500 m)
Elevation of Apron	EL 24.200 m
Elevation of Foundation	EL 21.700 m
Length of Overflow Weir Crest	17.5 m
Width of Overflow Weir Crest	3.0 m (2.5 m)
Height of Overflow Weir Crest	6.8 m (7.3 m)
Orifice for Low Water	3.0 m x 2.0 m
Number of Orifice	2
Bottom Elevation of Orifice	EL 24.700 m
Overflow Depth	3.00 m (2.50 m)
Inclination of Weir Face	Vertical (up) and 1 : 1 (down)
Modification of Weir from Immediate to Urgent Plan	0.5 m (Raising weir crest)

(Note) Figures in parentheses are for the Urgent Plan.

(b) Floodway Weir

Item	Dimensions
Structural Type	Gravity, Trapezoid-Shaped Weir
Design Water Level	EL 34.000 m
Elevation of Crest	EL 32.500 m (EL 32.000 m)
Elevation of Apron	EL 26.500 m
Elevation of Foundation	EL 24.000 m
Length of Overflow Weir Crest	25.0 m
Width of Overflow Weir Crest	2.0 m (2.5 m)
Height of Overflow Weir Crest	6.0 m (5.5 m)
Overflow Depth	1.50 m (2.00 m)
Inclination of Weir Face	Vertical (up) and 1 : 1 (down)
Modification of Weir from Immediate to Urgent Plan	0.5 m (Lowering weir crest)

(Note) Figures in parentheses are for the Urgent Plan.

(4) Structural Details

(a) Deli River Weir (refer to DWG 4.22)

The Deli River Weir consists of major structures such as main weir body, apron, breast wall, wing wall, riverbed protection and revetments.

(b) Floodway Weir (refer to DWG. 4.23)

The main structures are almost the same as those of the Deli River Weir.

4.2.7 Waterfront Facilities

(1) Environmental Improvement Works

To facilitate the effects and functions of environmental improvement in the Project, the following works are proposed to be carried out:

(a) Walkways and tree plantings in Floodway and Retarding Channel, and along inspection road in the Upstream of Percut River

(b) Sodding, boulder pitching construction of roofed benches in Deli Retarding Channel

(2) Reconstruction of Road

In connection with the dike construction along the right bank of the stretch from PE15 to PE34, the existing kabupaten road is reconstructed behind the new dike as Class III according to the standards of the Directorate General of Highways. The road is designed with a total road width of 5.0 m, a pavement width of 4.0 m and a total length of 1,985 m. As for the pavement, asphalt treated base (ATB) is provided.

The existing farm road in the stretch from PE84 to PE95 is also relocated and reconstructed due to the construction of the dike nearby. The road is 5.0 m wide with a gravel pavement of 3.0 m wide.

4.3 Bridges

For the 10 existing bridges requiring reconstruction, modification and protection works and the 11 new bridges to be constructed across the proposed floodway, the design is prepared with type selection of superstructure, substructure and foundation.

Along Percut River

No.	Bridge No.	Name of Bridge	Span Length (m)			Total Length (m)	Width of Roadway (m)
			Left	Center	Right		
1	Br.P1	Titi Besi	25.6	31.6	25.6	82.8	7.0
2	Br.P2	Perkebunan	31.6	40.8	31.6	104.0	7.0
3	Br.P3	Titi Gantumg	16.6	-	40.8	57.4	7.0
4	Br.P5	Payung	-	40.8	-	40.8	7.0
5	Br.P6	Pedestrian	-	40.8	-	40.8	2.0
6	Br.P7	Medan-Tembung	-	40.8	-	40.8	9.0
7	Br.P9	Medan -Denai	-	40.8	-	40.8	16.0
8	Br.P11	Binjei	-	40.8	-	40.8	16.0
9	Br.P13	Amplas	-	40.8	-	40.8	16.0
10	WBr.1	Water Pipe	-	40.8	-	40.8	-

Along Floodway

No.	Bridge No.	Name of Bridge	Span Length (m)			Total Length (m)	Width of Roadway (m)
			Left	Center	Right		
11	Br.F1	Jl. Bajak	-	31.6	-	31.6	7.0
12	Br.F2	PTP IX	-	31.6	-	31.6	9.0
13	WBr.2	Water Pipe	-	31.6	-	31.6	-
14	WBr.3	Water Pipe	-	31.6	-	31.6	-
15	Br.F3	Jl. STM Ujung	-	31.6	-	31.6	9.0
16	Br.F4	Railway	-	31.6	-	31.6	7.0
17	WBr.4	Water Pipe (Batuan)	-	31.6	-	31.6	-
18	Br.F5	Jl. Deli Tua	-	31.6	-	31.6	16.0
19	Br.F6	Pedestrian	-	31.6	-	31.6	7.0
20	Br.F7	Jl. SMA-12	-	16.6	-	16.6	5.0
21	Br.F8	Gg. Seksama	13.6	31.6	13.6	58.8	2.0

4.3.1 Road Bridge

Thirteen road bridges could be categorized into five typical types based on number of spans and bridge length, so that general plans are presented for (1) Br.P1: Titi Besi,

(2) Br.P2: Perkebunan, (3) Br.P3: Titin Gantung, (4) Br.P5: Payung, (5) Br.PF1: Jalan Bajak in DWG 4.24 to 4.28.

(1) Superstructure

The design of superstructure is proposed to be prestressed concrete I-girder beam for road, railway and pedestrian, and warren truss for water pipe bridge. The design conditions of bridge superstructure are as follows:

(a) Deck Slab (refer to DWG 4.29)

The deck slab spans in one direction and the bending moment of live and dead loads is computed as in continuous slab over the longitudinal beams. For concentrated load the bending moment per unit width of slab is computed using the effective width.

(b) Prestressed Concrete Beam (refer to DWG 4.30)

Beams are precast prestressed concrete and constructed with deck slab as composite beam. In the design of prestressed concrete members, loading is taken as not only external load such as dead load and live load but often a combination of these loads acting with the prestressing force on the concrete section. Two PC girder beams for the lengths of 31.6 m and 40.8 m are employed.

(2) Substructure

(a) Abutment (refer to DWG. 4.31)

An abutment is the substructure which supports one terminus of the superstructure of a bridge and at the same time, laterally supports the embankment which serves as an approach to the bridge. For a river bridge, the abutment also protects the river bank/slope from scouring, and abutment is made of reinforced concrete in the design. An abutment generally consists of the breast wall, wing wall and back wall. For a river bridge, the abutment type is selected to be a Spill-through Pile Trestle (or Dual Bored Piles), because the abutment shall be embedded in the riverside slope provided with wet masonry revetments.

(b) Pier (refer to DWG 4.32)

The Hammerhead Type is selected because of less restriction to the river channel. In pier design, stability of pier and stresses working on base footing are checked in four conditions as the same as for abutment, as below:

(i) Normal condition in high water level;

(ii) Normal condition in low water level;

(iii) Earthquake condition in high water level; and

(iv) Earthquake condition in low water level.

(c) Foundation

Generally, the pile foundation would be suitable when a thick stratum of soft soil overlays a hard soil. A point bearing pile is selected to transfer practically all its load by end bearing to the hard stratum on which it rests. In various calculation methods of the pile top reactions, the "Displacement Method" is used on assumption of distributing loads on footing as axial load, lateral load and moment to each pile.

4.3.2 Railway Bridge (refer to DWG 4.33)

The prestressed concrete I-girder beam is selected as the same for road bridges. The superstructure is composed of PC girders and concrete track bed on which the ballast is lain. The length of the girder and the width of concrete track bed are 31.6 m and 3.5 m, respectively.

The abutment is designed with a width of 7.5 m and a height of 4.3 m. The pile foundation is employed to convey the loads from the superstructure to the bearing layer below EL +16.5 m.

4.3.3 Pedestrian Bridge (refer to DWG 4.34)

The pedestrian bridge on Percut River is 2.0 m wide with a span length of 40.8 m. The pedestrian bridge on Medan Floodway has a span length of 31.6 m, while that on the Deli River upstream of the diversion weir has three spans of 58.8 m in total. All of these pedestrian bridges are prestressed concrete bridge structures. The detail design for pedestrian bridges is the same as that of road bridges, but a different live load of 500 kg/m^2 is applied.

4.3.4 Water Pipe Bridge

(1) Municipal Water Supply (refer to DWG 4.35)

In the course of project construction, all water pipes shall be replaced or reinstalled. For the replacement or reinstallation of water pipes, water pipe bridges shall be constructed for water pipes with a diameter of more than ϕ400 mm, while the water pipe with a diameter of less than ϕ400 mm will be installed only under the sidewalks of reconstructed or newly constructed bridges, enumerated as below:.

(a) Percut River

Bridge	Station	Location	Pipe Diameter (mm)	Crossing System
Br. P7	PE 169+59	M. Tembung	100	under sidewalk
Br. P9	PE 200+25	Medan Denai	150	under sidewalk
			100	under sidewalk
Br. P11	PE 222+00	Binjai	150	under sidewalk
			400	under sidewalk
Br. P13	PE 246+57.5	Amplas	300	under sidewalk
			150	under sidewalk
			125×4	under sidewalk
New (WB1)	PE 255+10	Amplas	600+600	new truss bridge

(b) Medan Floodway

Bridge	Station	Location	Pipe Diameter (mm)	Crossing System
New (WB2)	FW 20+50	-	800	new truss bridge
New (WB3)	FW 24+70	-	300	under sidewalk
New (WB4)	FW 32+10	-	600+300	new truss bridge
Br. F5	FW 33+65	-	350	under sidewalk

A warren truss type is selected for the water pipe bridges which is reconstructed or newly constructed in the Project.

(2) Irrigation Water (refer to DWG 4.36)

A new water bridge is constructed to convey the irrigation water over the Medan Floodway. The design discharge of the water pipe is estimated to be 0.025 m^3/s and the pipe diameter is estimated to be 0.300 m. Cost comparison of several types of water bridges such as pipe beam type and stiffened type of either truss, flange, tie rod or longer, the pipe beam type is found to be most economical and easiest to construct. Further, a continuous support type is selected as the optimum on account of the length and diameter of the pipe with the structural dimension as below:

Structural Item	Dimension
Bridge Length	3-span (16 m and 5.7 m × 2)
Pier	PC Pile ϕ300 mm, 12 m long × 2
Pipe	
- Length	55.0 m
- Diameter	300 mm
- Thickness	6.9 mm

4.3.5 Approach Road

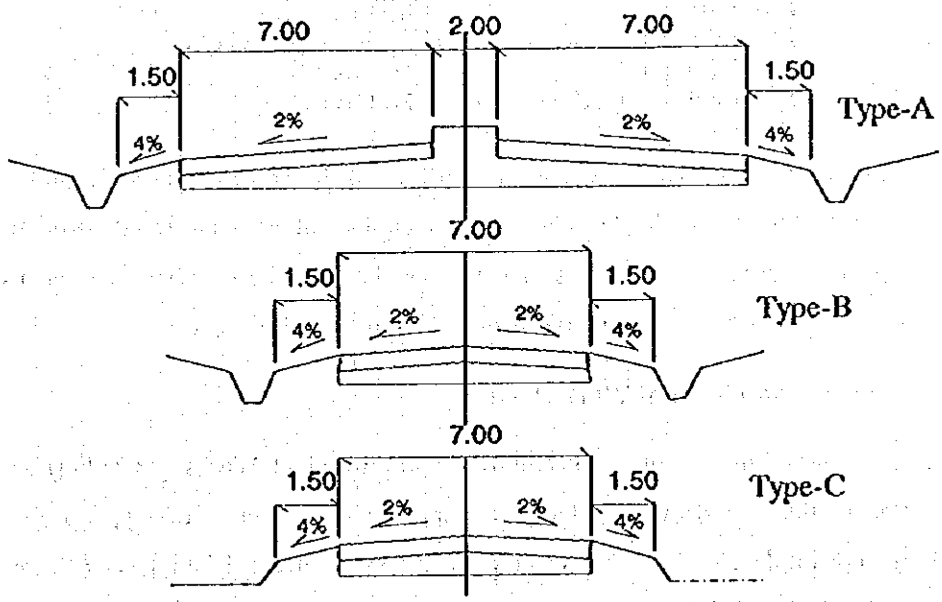
In accordance with the change of road bridge centerline, new approach road shall be constructed with the standard design of 10 m or 19 m in width and 10% of road surface slope.

(1) Percut River

Bridge	Station (m)	Total Width (m)	Total Length (m)	Type
Br. P1	PE 57+05	7.0	60.0	Type B
Br. P2	PE 84+28	7.0	60.0	Type B
Br. P3	PE 115+06	7.0	50.0	Type B
Br. P5	PE 137+49	7.0	36.0	Type B
Br. P7	PE 169+59	9.0	20.0	Type B
Br. P9	PE 200+25	16.0	20.0	Type A
Br. P11	PE 222+00	16.0	20.0	Type A
Br. P13	PE 246+57.5	16.0	20.0	Type A

(2) Medan Floodway

Bridge	Station	Total Width (m)	Total Length (m)	Type
Br. F1	FW 06+90	7.0	10.0	Type C
Br. F2	FW 20+45	9.0	10.0	Type C
Br. F3	FW 28+22	9.0	10.0	Type C
Br. F5	FW 33+65	16.0	15.0	Type A
Br. F7	FW 38+78	3.5	10.0	Gravel Pavem't



5. CONSTRUCTION PLAN AND COST ESTIMATE

5.1 Construction Plan

5.1.1 Planning Condition

(1) Working Days

The annual workable days for each work item are estimated as follows:

Civil Works Item	Workable Days
Embankment	187 days
River Channel Excavation, Groundsill and Revetment	215 days
Bridge Substructure/Foundation and Protection Works	215 days
Common Excavation	245 days
Bridge Superstructure and Drainage Outlet	245 days
Dredging	300 days

(2) Construction Materials, Labor and Equipment

The construction materials can be obtained mostly in the domestic market in Indonesia. The promising supply sources of construction materials are shown below.

Material	Source
Aggregate/Stone	Rivers in Medan and Binjai City
Cement/Asphalt	Medan City
Ready-Mixed Concrete	Medan City
Lumber/Timber	Medan City
Steel Bar	Medan City
Steel Sheet Pile	Jakarta or Surabaya City
PC Pile/Girder	Medan City
Combustibles (Oil, Grease, etc.)	Medan City

Common labor is easily recruited in and around the construction sites, and skilled labor is abundant in Medan City. Major equipment with the standard or average capacity required for construction works available in the domestic market, usually used in similar construction projects in and around the project area.

5.1.2 Construction Plan of Work Portions

The Project consists mainly of the Percut River Improvement Works (28.23 km) and the construction of the Floodway (3.92 km) including the improvement of Upper Deli River (0.95 km). For implementation, the construction works are divided into seven (7) portions, as tabulated below and delineated in Fig. 5.1. The apportioning of construction works is made in consideration of the suitable and practical volume of civil works contracts as practiced and experienced in similar projects in Indonesia.

Work Portion	Station No.	Object Distance
MFC-1	PE0-200 ~ PE46	5,040 m
MFC-2	PE46 ~ PE129	8,270 m
MFC-3	PE129 ~ PE210	8,100 m
MFC-4	PE210 ~ PE274	6.500 m
MFC-5	FW0 ~ FW24 & PE274 ~ PE274+320	2,680 m
MFC-6	FW24 ~ FW34	1,010 m
MFC-7	FW34 ~ FW39+50 & UD12-85.0 ~ UD23	1,500 m

The construction works of portion MFC-1 to MFC-7 are scheduled to commence within three years. River improvement is generally executed from the downstream to upstream, but some embankment works upstream may be conducted before excavation works of the downstream on condition that the work shall not bring an imbalance of the flow capacities between the up and downstream stretches.

Based on the examination of the aforementioned conditions, the overall construction schedule is prepared, as shown in Fig. 5.2.

5.1.3 Soil Balance

The estimation of available volume for embankment of each portion shows that MFC-1 and MFC-7 do not have enough volume for embankment works (refer to Table 5.1). Embankment materials for MFC-1 are brought from MFC-2 and MFC-3 and their quantities are estimated at 2,050 m^3 and 189,450m^3, respectively. The embankment materials for MFC-7 is provided by 94,830 m^3 from MFC-6.

In the balance calculation of embankment volume among portions, the surplus soil volume will be hauled to the spoil area. The surplus soil is mostly brought by dredging, stripping and excess soil from embankment. The materials produced by clearing and grubbing works will be arranged at the site. The surplus soil volume for each portion is calculated as shown in Table 5.2. Consequently, the total volume for the spoil area is estimated at 2,373,600 m^3.

5.2 Cost Estimate

Project cost is estimated on the basis of the design, the construction plan, and the following assumptions and conditions.

(1) Price Level

Price level is as of November 1995.

(2) Currency Conversion Rate

Currency conversion rates among U.S. Dollar (US$), Indonesian Rupiah (Rp.) and Japanese Yen (¥) are: US$1.00 = Rp 2,285 = ¥103.6.

(3) Currency of Cost Estimate

Construction cost is estimated in foreign and local currencies. Both of the estimated costs are expressed in Indonesian Rupiah using the currency conversion rates stated above.

Details of the cost estimation and the project cost are prepared and submitted as a separate volume in a sealed envelope for "Cost Estimate". The total construction cost of the Project is estimated at 176,913 million Rupiah.

6. OPERATION AND MAINTENANCE

6.1 Institutional Setup

6.1.1 Law and Regulation

Among laws, presidential decrees and government/ministerial regulations for the proper operation and maintenance (O&M) of rivers, the following regulations are particularly relevant to the formulation of an O&M organization:

(1) Government Regulation No. 22 (1982)

Direct beneficiaries are to pay their share; works for general welfare are to be covered by the Local Government; and the Central Government may assist local entities.

(2) Government Regulation No. 35 (1991)

River administration may be delegated to local government or state-owned companies; and rivers may be administered by a system of co-administration, which implies that the financing will be provided by the Central Government but the implementation will be undertaken by the Provincial Government.

The present budgeting procedure is not geared towards O&M. The Ministry of Pubic Works prepares its project budget as part of the Proposed Development Budget, under seven headings; namely, Salaries, Land, Materials, Equipment and Machinery, Official Travel, Construction, and Others.

Construction accounts for a major portion of the budget. Since there is no separate heading for O&M, the allocation for O&M is made under the construction heading which implies that an O&M project must be justified as a construction project. The amounts reflected as O&M expenses were, essentially, amounts spent on rehabilitation and other construction works.

6.1.2 Organization for O&M

In accordance with the current practice of O&M for rivers in North Sumatra, the O&M organization for Percut River and Medan Floodway will be incorporated in an overall river O&M system for the Deli and Percut rivers. This concept may be advantageous from the viewpoint of not only engineering soundness but also financial through the avoidance of duplication of functions or immobility of the organization if it is established independently from other systems.

An organization for O&M is proposed for the Project, although the organization is set up for all rivers in North Sumatra Province. Under the Sub-Project Office for Rivers and Swamps, on the presumption of the existing organization and regulation, an O&M unit can be created to exclusively carry out the operation and maintenance work for all flood control and water resources works in North Sumatra Province after their construction.

The operation of road, railway and pedestrian bridges, as well as drainage facilities will be transferred to the local government entity to which they belong. Therefore, the organizational structure for O&M is proposed to cover river and river structures not only of the Project but also of the Deli River Improvement Works when completed under MUDP, as presented in Fig. 6.1.

O&M work is considered to cover (1) the integrated operation of all major river structures and river improvement, and (2) river monitoring and comprehensive flood management for river structures, flood control works such as river dike and channel, flood plain management such as flood warning/fighting and zoning, low flow discharge, water quality, sand mining, river mouth condition of sedimentation, and environmental matters.

6.2 Operation Plan

6.2.1 Bandar Sidoras Intake Weir

(1) Operation Requirement

The new weir is a kind of rising weir made of rubber with bag shaped to be inflated by air. When overflow depth exceeds a certain level at flood time, the dam body shrinks and falls down automatically by water pressure. Therefore, floods bigger than a certain discharge may flow down safely without obstruction. After flood, the dam body will be inflated and raised by the air compressor in short time, and the function as intake weir is recovered.

Present condition of water use related to the Bandar Sidoras Intake Weir is as shown in Fig. 6.2. In accordance with the data and plan of the Irrigation Section, Branch Office of Kab. Deli-Serdang North Sumatra Provincial Office of Water Resources Development, the existing irrigation area on the right bank side is estimated at 2,090 ha and that of the left bank side is 1,360 ha. In the future irrigation plan, the irrigation area of the left bank side will increase by 320 ha to 1,680 ha. Accordingly, the water requirement of the right intake is estimated at 2.09 m^3/s, and that of the left intake is 1.36 m^3/s at present, 1.68 m^3/s in future.

The cropping yield is currently performed at 130%. As a standard cropping pattern, puddling is carried out in April and October, planting in May and November, and harvesting in August and February. However, this cropping pattern is not uniformly practiced; some farmers shift their activities by one or two months.

(2) Operation Procedure

(a) Inflatable Rubber-Made Dam

The main futures of the inflatable rubber-made dam to be newly constructed are given below.

Height of Rubber Body	3.14 m
Length of Bottom	13.00 m
Datum Level of Rubber Body	EL 0.920 m
Reservoir Water Level (Dam Crest)	EL 4.06 m
Auto-Deflation Water Level	EL 4.87 m
Medium of Inflation	Air
Rubber Sheet Size	6.315 m × 32.330 m
Thickness of Rubber Body	15.8 mm
Internal Air Volume of Rubber Body	198.7 m^3

Manual operation to deflate the rubber body is not needed as a rule. When water level in the river rises higher than 1.2 times the dam height (i.e., EL 4.870 m), the air inside the rubber body will be automatically exhausted by water pressure and the dam shrinks and falls down.

As required for irrigation water after flood, the rubber body shall be inflated to raise the river water level. The inflation could be started by pressing a switch on a control board which is installed in a control house at the right bank.

(b) Intake Gate

The main features of intake sluices, which are installed at both right and left bank sides immediately upstream of the inflatable rubber-made dam, are as follows.

Left Intake Sluice	
- Orifice Size	B1.0 m × H1.0 m × 2 sets
- Sill Elevation	EL 2.900 m
- Gate Type	steel slide gate
- Hoisting System	manually driven spindle
Right Intake Sluice	
- Orifice Size	B1.25m × H1.0 m × 2 sets
- Sill Elevation	EL 2.900 m
- Gate Type	steel slide gate
- Hoisting System	manually driven spindle

The operation of intake gates and conditions of water balance in dry season (95% discharge in annual flow regime) and usual time (50% discharge) are shown in Fig. 6.3. At 95% discharge time, the gate opening should be 74% at the right bank and 73% at the left bank. At 50% discharge time, the gate opening should be 45% at both banks. Since the gate opening in usual time at present is set at 50% with the existing structure, almost the same operation will be required for the new gate with the inflatable rubber-made dam. The proposed operation scheme is illustrated in the form of a flow diagram in Fig. 8.2.8.

The operation of intake gates will almost be similar as the existing ones except the small work of inflating the rubber body, because the sizes of new inlets will be almost the same as the existing ones. Conversely, the operation of spillway slide gates on head works, which used to be operated in flood time, will be not necessary.

6.2.2 Deli Retarding Channel

The upstream section of the Deli River Weir will become a retarding channel to be inundated in flood time by the diversion weirs; while, in usual time, the retarding channel area can be utilized as a wide open space for multipurpose uses such as park and sports facility.

The left side slope of the retarding channel will be reclaimed into staged terraces and divided into four zones, as presented in the following, on account of the frequency of inundation. Among them, three zones, Zone A to Zone C, will be multipurpose utilization zones and Zone D will be a residential area after raising work of the ground.

Zone	Area (m^2)	Ground Elevation (EL m)	Frequency of Inundation	Utilization Plan
Zone A	18,400	32.6	1 time/year	Park Area and Sports
Zone B	27,140	31.5	10 times/year	Free Open Park Space
Zone C	9,040	28.0~29.0	20 times/year	Waterfront and Walking
Zone D	33,760	35.0	No inundation	Residential

The frequency of inundation at Zone A is once a year, ten times a year at Zone B, and 20 times a year at Zone C. Zone A is recommended for use as sports ground, tennis court, recreation park or parking lot; Zone B for cycling road, walkway, picnic spot, or free open space for sports; and Zone C for waterfront activities, fishing space or walkway.

(1) Safety for Users

The basic conditions for the multipurpose utilization of the retarding channel are to assure the safety of facility users and to facilitate restoration after inundation by flood, because the rising speed of water level is high. Therefore, it is necessary to set up warning signboards at appropriate places in each zone in order to disseminate information and warning to people in and around the retarding channel in flood time and lead them for prompt evacuation.

(2) Reminder on Facilities

The park facilities to be constructed in the retarding channel shall not be obstacles to sanitation or maintenance. Facilities such as lavatory or stall which may cause sanitary problems, or such management office that may cause maintenance problems in flood time shall not be built in the retarding channel.

6.2.3 Drainage Outlet

At three (3) sites of drainage outlets with steel slide gates, manual operation of gates will be necessary to prevent back-flow from the river and protect the lowland.

(1) Main Features of Sluice

The main features of the three sluice are as given below. The hoisting system of gates is a kind of manually driven spindle.

Drainage Number	SL2	SL3	SL4
Location	PE 95+35 Left Bank	PE 138+55 Left Bank	PE 155+90 Left Bank
Box Culvert Size (B×H×Set)	2.0m×1.5m×2	1.5m×1.5m×1	2.0m×1.5m×1
Sill Elevation	EL 5.300 m	EL 11.000 m	EL 12.500 m
Riverbed of Percut River	EL 2.925m	EL 7.694m	EL 9.855m
DHWL of Percut River	EL 8.63m	EL 13.80m	EL 15.97m
Ground Level	EL 7.000 m	EL 12.800 m	EL 15.400 m
Flow Capacity at GL	149 m^3/s	215 m^3/s	259 m^3/s
Corresponding Probability	2-year	5-year	10-year
Gate			
- Type	Steel Slide Gate		
- Hoisting System	Manually Driven Spindle		
- Hoisting Speed	More than 20 cm/min		
- Manual Force	Less than 15 kg		

(2) Gate Operation Rule

Sluice gates are usually opened to drain inland water behind dike. The flow capacity at each river section where the sluice is installed is estimated for the ground height shown in the table above. Therefore, the sluice gate shall be closed for floods larger than the flow capacity.

6.3 Maintenance Plan

In order to accomplish an effective maintenance work, it is indispensable to carry out periodical and routine inspections over the river channel and river structures, as well as bridge foundations and drainage outlets. Although the maintenance works for bridges and drainage facilities will be conducted by Medan City and/or Deli Serdang District, the inspection could be carried out by the proposed O&M organization. The objectives of inspection are not only to locate trouble spots and/or obstacles which may cause deterioration of the project works but also to grasp the actual conditions such as channel flow, illegal occupancy or utilization of the project works and to monitor environmental conditions including sand mining and water quality. The items of inspection are given in Table 6.1.