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

THE STUDY ON
[illegible] PADANG
INTEGRATED RIVER BASIN DEVELOPMENT

FINAL REPORT

(MAIN)

MARCH 19[illegible]

JAPAN INTERNATIONAL COOPERATION
AGENCY

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PREFACE

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

JICA sent to Indonesia a study team headed by Mr. Mitsuo Nakahiro, CTI Engineering Co., Ltd., three times between May 1990 and January 1992.

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

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

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

March 1992

Kensuke Yanagiya

KENSUKE YANAGIYA
President
Japan International Cooperation Agency

JICA STUDY TEAM
BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT

March 26, 1992

Mr. Kensuke Yanagiya
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Sir:

LETTER OF TRANSMITTAL

We are pleased to submit herewith, the Final Report on the Study on Belawan-Padang Integrated River Basin Development.

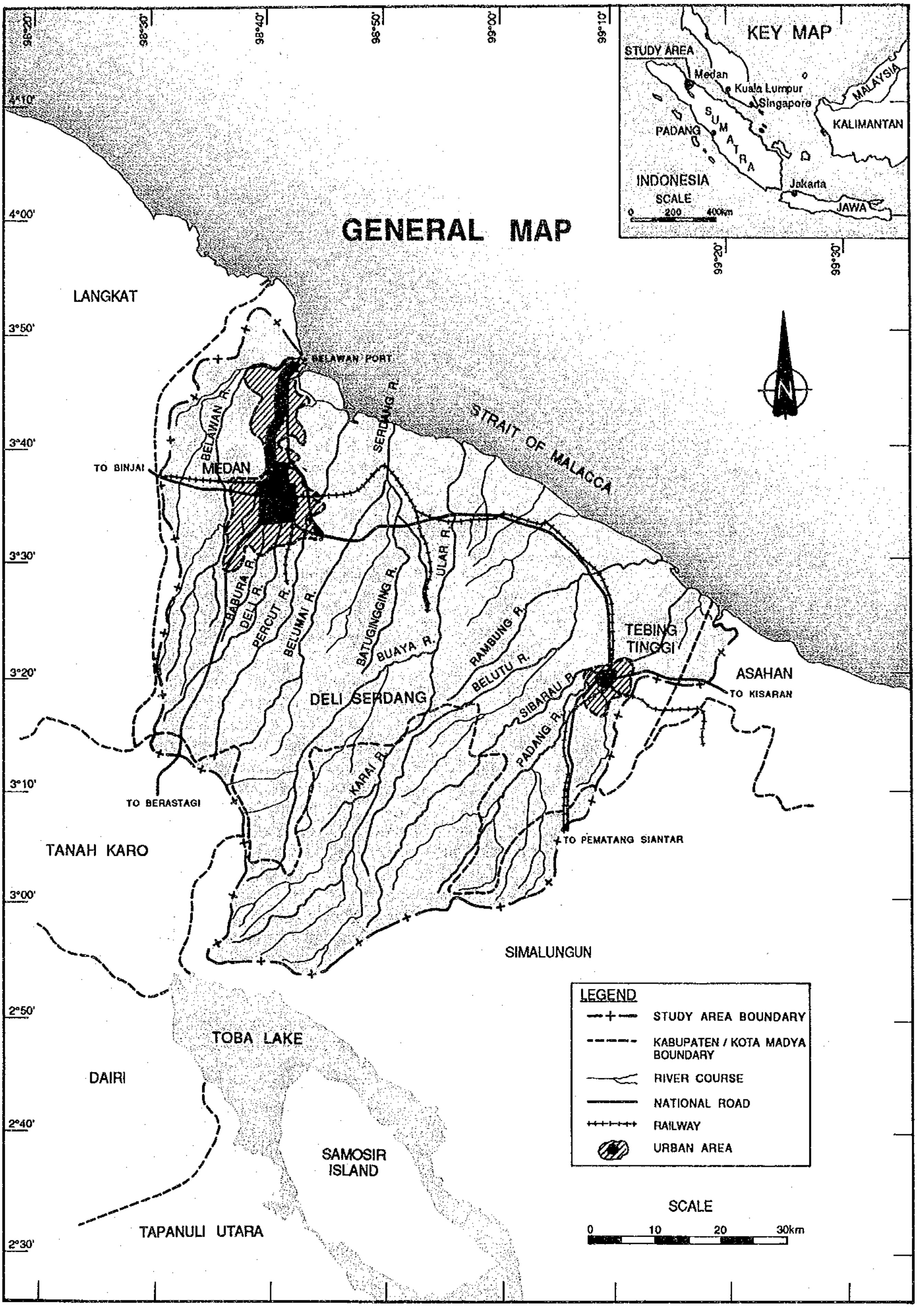
The Final Report consists of four (4) volumes; namely, (1) the Summary Report presenting the summary of all the study results, (2) the Main Report presenting the details of project formulation and recommendations, (3) the Supporting Report discussing the sectorwise technical details, and (4) the Data Book which mainly includes preliminary design drawings of the Urgent Project.

We wish to express our grateful appreciation to the officials of the Japan International Cooperation Agency, the Advisory Committee, the Ministry of Foreign Affairs, the Ministry of Construction, the Embassy of Japan in Indonesia, and the officials concerned of the Government of the Republic of Indonesia for their assistance and advice to the Study Team. We sincerely hope that the study results would be useful for the next stage of the project to work out solutions towards the socioeconomic development of the Belawan-Padang Integrated River Basin.

Very truly yours,

MITSUO NAKAHIRO
Team Leader

Encl.: a/s


GENERAL MAP
KEY MAP
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Medan
Kuala Lumpur
Singapore
MALAYSIA
KALIMANTAN
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SUMATRA
INDONESIA
Jakarta
JAWA
SCALE
0 200 400km
98°20'
98°30'
98°40'
98°50'
99°00'
99°10'
99°20'
99°30'
4°10'
4°00'
3°50'
3°40'
3°30'
3°20'
3°10'
3°00'
2°50'
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LANGKAT
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TANAH KARO
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STUDY ON BELAWAN - PADANG
INTEGRATED RIVER BASIN DEVELOPMENT

FINAL REPORT
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TERMS AND ABBREVIATIONS

1. GOVERNMENT AGENCIES AND OTHER ORGANIZATIONS

GOI	:	Government of Indonesia
BAPPENAS	:	Badan Perencanaan Pembangunan National (National Development Planning Board)
BAPPEDA	:	Badan Perencanaan Pembangunan Daerah (Provincial Development Planning Board)
DPU	:	Departemen Pekerjaan Umum (Ministry of Public Works)
DGWRD	:	Directorate General of Water Resources Development, Ministry of Public Works
DGCK	:	Directorate General of Cipta Karya (Housing, Building and Urban Development)
DOR	:	Directorate of Rivers, DGWRD
DPUP	:	Dinas Pekerjaan Umum Propinsi (Provincial Public Works Services)
P3SA	:	Proyek Pengembangan dan Penyelidikan Sumber-Sumber Air (Water Resources Development and Investigation Planning Project)
PGM	:	Pusat Meteorologi dan Geofisika (Centre of Meteorology and Geophysics)
PLN	:	Perusahaan Listrik Negara (State Electricity Corporation)
BPP	:	Balai Penyuluhan Pertanian (Agricultural Extension Centre)
RISPA	:	Research Institute of Sumatra Planter's Association
IHE	:	Institute of Hydraulic Engineering (Bandung)
ADB	:	Asian Development Bank
GOJ	:	Government of Japan
IBRD	:	International Bank for Reconstruction and Development (The World Bank)
IGGI	:	Inter-Governmental Group of Indonesia
JICA	:	Japan International Cooperation Agency
MOC	:	Ministry of Construction, Japan
OECF	:	Overseas Economic Cooperation Fund, Japan
UNDP	:	United Nations Development Programme
WHO	:	World Health Organization

2. UNITS OF MEASURE

Length

mm	:	millimeter
cm	:	centimeter
m	:	meter
km	:	kilometer

Weight

g, gr	:	gramme
kg	:	kilogramme
t, ton	:	metric ton
dwt, DWT	:	dead weight

Area

mm^2	:	square millimeter
cm^2	:	square centimeter
m^2	:	square meter
km^2	:	square kilometer
ha	:	hectare

Time

sec, s	:	second
min	:	minute
h, hr	:	hour
d, dy	:	day
y, yr	:	year

Volume

cm^3	:	cubic centimeter
m^3	:	cubic meter
l, ltr	:	litre

Derived Measures

(Speed/Velocity)

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

(Stress)

kg/cm^2	:	kilogramme per square centimeter
ton/m^2	:	ton per square meter

(Discharge)

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

3. INDONESIAN TERMS

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

CHAPTER 1. INTRODUCTION

1.1 Background of the Study

The study area, situated in the northern part of North Sumatra Province, is composed of the basins of several small rivers and those of the seven (7) major rivers; namely, Belawan, Deli, Percut, Serdang, Ular, Belutu and Padang. Medan City, the largest city in Sumatra and the third largest city in Indonesia is within the study area.

Under the Fourth Five-Year Development Plan, the Government of Indonesia had promoted development policies such as the reduction of the regional discrepancies in labor force and economic potential, water resources development and flood control in developed/developing areas. It was particularly active in promoting the development of outlying areas such as Sumatra in conjunction with the policy to promote transmigration.

The rate of resettlement due to transmigration in North Sumatra Province is high, and the province is one of the areas where development is highly expected. However, the occurrence of floods causing serious damage has been a factor impeding development.

The population of Medan City makes up over a half of the total population of approximately 3.63 million in the study area. The growth of the city population in recent years has resulted in the serious shortage of municipal water.

Under the above circumstances, a request for technical cooperation to work out solutions to the problems of flood and water shortage was made by the Government of Indonesia (GOI) to the Government of Japan (GOJ). In response to the request, the Japan International Cooperation Agency (JICA) was commissioned to conduct the Study on Belawan-Padang Integrated River Basin Development (hereinafter referred to as the Study). The Study was started in March 1990, with completion slated in March 1992.

1.2 Objectives and Scope of the Study

1.2.1 Objectives of the Study

The objectives of the Study are as follows:

(a) To formulate a Master Plan of integrated river basin development for the integrated river basins from Belawan to Padang, focusing on flood control and water utilization; and

(b) To conduct a Feasibility Study on urgent projects based on ranking of priority for implementation.

1.2.2 Scope of the Study

The Study is to be carried out in twenty-four (24) months from March 1990 to March 1992. Divided into two (2) phases, the first phase of work from March 1990 to March 1991 is to formulate the Master Plan, and the second phase of work from April 1991 to March 1992 is to carry out the Feasibility Study for urgent projects selected from the Master Plan. The scope of work in each phase is summarized as follows:

Phase I: Master Plan Study

(1) Data Collection and Review of Previous Studies

- (a) National and regional socio-economic data;
- (b) Data on meteorology and hydrology;
- (c) Soil, geological and geographical data;
- (d) Existing riparian and drainage facilities, and other relevant facilities;
- (e) Existing regional development plans and projects;
- (f) River and its water utilization;
- (g) Municipal water supply;
- (h) Present land use and assets;
- (i) Past floods and inundation, and their damages; and
- (j) Other related data and information.

(2) Field Survey

- (a) Field reconnaissance;
- (b) River survey (longitudinal and cross-section profile);
- (c) Meteorological and hydrological observation;
- (d) Flood and inundation damage survey;
- (e) Geological survey including construction materials survey;
- (f) River bed material test;
- (g) Water sources for municipal water supply;
- (h) Water quality test; and
- (i) Other related surveys (aerial photographic survey).

(3) Study and Analysis

- (a) Hydrological and hydraulic analysis;
- (b) Flood and inundation damage analysis;
- (c) Erosion and sedimentaiton study;
- (d) Water demand projection and water balance;
- (e) Water resources potential and its optimum allocation study;
- (f) Social and environmental impact; and
- (g) Others.

(4) Formulation of Master Plan

(a) Formulation of master plan on flood control and water utilization for integrated river basins.

- o Formulation of development concept
- o Basic layout of major structures for:
  - flood control including drainage
  - erosion control
  - dams
  - water supply
- o Preliminary design of major facilities
- o Construction plan
- o Rough estimation of costs for construction, operation and maintenance
- o Project evaluation
- o Socio-economic and environmental impact
- o Programme and organization for operation and maintenance

(b) Identification of priority projects to be urgently implemented.

Phase II: Feasibility Study on Urgent Projects

(1) Topographic survey for proposed structure sites;
(2) River profile and cross-section survey;
(3) Geological survey including construction materials survey;
(4) Preliminary design of the required facilities;
(5) Estimation of costs for construction, operation and maintenance;
(6) Project evaluation (cost and benefit);
(7) Social and environmental impact study; and
(8) Recommendations.

CHAPTER 2. STUDY AREA

2.1 Geography

2.1.1 Location and Topography

The study area covers the integrated river basins of approximately 5,800 km^2 situated between Belawan River and Padang River. It is located in the northern part of North Sumatra Province in Sumatra Island (2°50' to 3°50'N latitude and 98°30' to 99°20'E longitude), bounded on the northeast by the Strait of Malacca, as shown in Fig. 2-1.

Broadly, the topography of the study area is divided into four (4) zones from northwest to southeast, as follows:

(a) Steep mountainous area from EL. 500 m to EL. 1,500 m which is mostly covered with natural and secondary forest;

(b) Low undulating hills and terrace extending between EL. 50 m and EL. 500 m;

(c) Wide and flat alluvial plain lower than EL. 50 m including the lower swampy area; and

(d) Coastal sandy zone from EL. 0.00 m to EL. 10 m, 2 to 3 km wide.

2.1.2 Geology

A major part of the study area is covered with volcanic soils. These volcanic soils came from the Takur-Takur-Simbolon Centre, the Toba Centre and the Sibayak Centre, and were formed during the Plio- Pleistocene and Pleistocene-Holocene. The major component of the volcanic soils is Toba tuff consisting of pyroclastic flow deposits during the formation of the Toba caldera.

At some places on the western side of the steep mountains, Bruksah Formation is observed. Distributed next to the Bruksah Formation is Mendem Microdiorite, intrusive. The area around Medan City is diluvial upland consisting of the Pleistocene Medan Formation, while the eastern lowlands facing the Strait of Malacca is composed of Holocene alluvium. The formation of these layers is shown in Fig. 2-2.

2.1.3 River and Basin

Seven (7) major rivers originating in the steep slope of the mountains generally flow in north to northeastern direction in the study area. They are, from northwest to southeast, the Belawan, Deli, Percut, Serdang, Ular, Belutu and Padang rivers.

(1) Belawan River Basin

Belawan River with a catchment area of 647 km^2 originates in Mt. Pintau (EL. 2,200 m), flows to the north, runs at the western side of Kodya. Medan and empties into the Strait of Malacca. It is joined by the Tengah River at Pancur Batu, where the topography of the basin changes from hilly to flat lowland. At the estuary, there is the Belawan Port for import and export activities.

(2) Deli River Basin

Deli River with a catchment of 358 km^2 originates in the northern slope of Mt. Pintau, Mt. Sibayak and the surrounding mountains having the heights of from EL. 1,400 m to EL. 1,800 m. It flows through Kodya. Medan and empties into the Strait of Malacca. At around the center of Medan, it is joined by the biggest tributary, Babura River (99 km^2) and afterwards, by Sikambing River (40 km^2). At Deli Tua, Deli River Basin changes its topography from hilly to plain land and hence the river gradient also becomes small.

(3) Percut River Basin

Percut River originates in the mountains of Mt. Barus (EL. 1,905 m), Mt. Kalinjohang (EL. 1,680 m) and Mt. Takur-Takur (EL. 1,524 m), and flows down to the north at the eastern edge of Medan. The river basin with an estimated area of 186 km^2 is characterized by a long, narrow and steep slope. The topography of this basin also changes at Timbang Deli from hilly to plain land.

(4) Serdang River Basin

Two major tributaries, Belumai (262 km^2) and Batugingging (343 km^2) join together at Tanjung Morawa to become the Serdang River with the total catchment area of 671 km^2. The former originates in Mt. Takur-Takur and the latter starts from the mountain-like plateau. Belumai River flowing down the mountainous area changes to a more gentle riverbed gradient near Kampung Simpang Kawat. Batugingging River flows down over a rather gentle hilly area, gathering many small streams in the vast plantation area.

(5) Ular River Basin

Ular River, the biggest river in the study area with a catchment area of 1,081 km^2, is composed of two (2) main tributaries, Buaya (440 km^2) and Karai (573 km^2) which join together at Desa Pulau Tagor. Buaya River originates in a chain of mountains such as Mt. Kalinjohang (EL. 1,680 m) and Mt. Tenaroh (EL. 1,932 m), flows down on the eastern slopes and turns to the north-south direction at the foot of the mountain.

Karai River comes out from the northern slope of somma of Toba Caldera and flows down northeastwards through steep slopes. In the mountain slopes, it gathers water from secondary tributaries such as Pulung and Si-Udan Udan and is joined by Buaya River as it exits from the mountainous to the hilly area. Ular River, receiving water from both Buaya and Karai rivers, meanders northwards in the plain until the Strait of Malacca.

(6) Belutu River Basin

Belutu River with a catchment area of 500 km^2 originates in the mountains such as Mt. Kolai (EL. 980 m) and Mt. Sipapagus (EL. 1,004 m) and flows down northeastwards on steep slopes. The river further flows on the hilly area and is joined by the main tributary, Rambung River (166 km^2), near the national road.

(7) Padang River Basin

Padang River with a catchment area of 919 km^2 starts in mountains such as Mt. Simbolon (EL. 1,509 m), Mt. Simarite (EL. 1,306 m) and Mt. Sidermut (EL. 1,165 m) and flows down to the northeast direction passing by the eastern edge of the study area. Sirabau River, the main tributary coming out from the Raya plateau, joins Padang River near Kodya. Tebing Tinggi. After Tebing Tinggi, Padang River flows north with meandering in the low-lying alluvial plain and finally, empties into the Strait of Malacca.

2.2 Meteorology and Hydrology

2.2.1 Climatology and Rainfall

Existing Observatory

There are four (4) meteorological stations (Sampali, Polonia, Belawan and Tanjung Morawa) operated by the Center of Meteorology and Geophysics (PMG) for the observation of temperature, relative humidity, sunshine duration, wind velocity, evaporation and rainfall. The other stations are the 91 stations maintained by the Research Institute of Sumatra Planter's Association (RISPA) for the observation of daily rainfall and the 25 rainfall stations related to the Ular River Project. Although all RISPA stations are operated manually, observation has been continued for a long time and rainfall data are available from 1948. Those under the Ular River Project has been only for a short period and with incomplete records. Location and data of these rainfall stations are as shown in Figs. 2-3 and 2-4.

Climatic Characteristics

The climate of Sumatra, unlike that of other Indonesian regions south of the equator, is characterized by a little difference between the wet and dry seasons. Since Sumatra 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.

Temperature ranges between 21°C and 33°C and annual temperature averages 26°C. Humidity range is between 83% and 87% and the average is 85%. The temperature and humidity in this area is very high throughout the year with the annual pan evaporation as high as 1,566 mm. Northerly or northeasterly monsoons blow throughout the year, but the area is located outside of the region affected by tropical depressions or cyclones.

Rainfall in the southern mountainous area and the northern coastal plain are 2,900 mm and 1,700 mm, respectively. Seasonally, rainfall is low in January to March and high in September to December. The isohyetal map of annual rainfall is as shown in Fig. 2-5. The higher elevation the area is located, the more rainfall is observed.

In accordance with the length of observation periods and areal distribution, 15 rainfall stations representing two periods are selected for hydrological analyses. The first period is 15 years (1954 to 1968) and the second period is 20 years (1969 to 1988) as shown in Fig. 2-6. Their mean monthly rainfalls for 20 years from 1969 to 1988 are as presented in Table 2-1.

2.2.2 River Flow and Runoff

Existing Observatory

Water level stations under operation are the ten (10) stations (Kampung Lalang, Asam Kumbang, Helvetia, Simeme, Tembung, Kp. Serdang, Tanjung Morawa, Silau Dunia, Tebing Tinggi and Pulau Tagor) under the Hydrology Section of DPUP and the seven (7) stations related to the Ular River Project.

Records of daily water level have been collected and processed by the Hydrology Section since 1972, and data of the automatic water level stations are available from 1980. Observation under the Ular River Project was started in late 1971, but it was discontinued in 1986.

Discharge Rating Curve

Daily discharge data for low flow analysis, as well as the rating curves used for conversion from daily water level, were provided by the Institute of Hydraulic Engineering (IHE) in Bandung.

For flood runoff analysis, hourly water levels are converted into hourly discharges using the same rating curves. It is necessary, however, to study the applicable rating curve for high flows with some hydraulic analysis.

The annual maximum water level was extracted from the recording charts of automatic water level stations and converted into the maximum flood discharge. Table 2-2 shows the annual maximum flood discharges for each station.

2.2.3 Sedimentation

Sediment Production

In general, sedimentation in the river basins is described as follows:

(1) General Sediment Condition

Neither large-scale landslide nor gully erosion is observed in the upperstream area of rivers. Mountain slopes are usually covered with thick forest and hence stable without producing a big volume of sediment because they are under government regulation as "Forest Reserve Area."

Some parts of the upstream areas of Serdang, Ular, Belutu and Padang rivers have suffered from small-scale sheet erosion and surface collapse caused by shifting cultivation and related activities. However, such areas are limited to produce a considerable sediment discharge.

(2) River Sediment

The eastern rivers after the Serdang River, namely Belawan, Deli and Percut, are rather free from river bank erosion and sedimentation. The river courses are relatively stable without meandering in the middle stream.

Batugingging River, the right tributary of Serdang River, and Belutu River have high content of silt and sand in their flows. Sandbars have formed at riverbends and riverbeds have aggradated.

In the riverbed of the upper streams of Ular and Padang, downward erosion is dominant and river channels form deep valleys. Deposits of fine sands have formed also at the bend of the river channels.

Riverbed Materials and Suspended Sediment

(1) Riverbed Material Survey

The riverbed material survey consists of the grain size analysis and the specific gravity test of soil particles. There are ten (10) sampling sites located at about 10 km along the river course as indicated in Fig. 2-7.

Grain size analysis is carried out with sieve analysis (the grain diameter larger than 74 microns) and hydrometer analysis (the grain diameter smaller than 74 microns). Grain size accumulation curves are prepared for the sedimentation analysis.

(2) Suspended Load Survey

Two (2) sampling sites of suspended load survey were selected for each river basin as shown in Fig. 2-7. Sampling was executed at three (3) points along the river course at each site, the right bank side, the centre of flow and the left bank side.

To draw the relation between the volume of suspended load and the discharge, the flow discharge was also measured. The DPUP of North Sumatra had executed the suspended load survey in six (6) river basins excluding the Belutu River.

The sediment rating curves (refer to Supporting Report on Sediment Control Plan) show that suspended sediment is rather small compared with the other rivers in Indonesia.

2.3 Socio-Economy

2.3.1 Population and Land Use

Population

A population census was conducted in 1961, 1971, 1980 and 1990. According to the 1990 population census, the populations of Indonesia and North Sumatra Province were 179,322 thousand and 10,256 thousand, respectively. During the period 1980-1990, the average annual growth rates were 1.97% and 2.06%.

The 1990 population was 1,602,749 for Kab. Deli Serdang, 1,730,752 for Kodya. Medan and 116,767 for Kodya. Tebing Tinggi, and during the said period the average annual growth rates showed 2.59%, 2.30% and 2.40%, respectively (refer to Table 2-3). These average growth rates of Kab. Deli Serdang and Kodya. Medan are fairly high compared with those of the country as a whole and North Sumatra Province. Such a high growth of population suggests that urbanization is in progress in Medan City and suburbs.

Population in the study area in 1990 is composed of those of Kab. Deli Serdang, the seven (7) kecamatans of Kab. Simalungun, Kodya. Medan and Kodya. Tebing Tinggi. The population, together with the population density and the number and average size of households are summarized as follows:

Population, Density and Households in 1990

Kab./ Kodya.	Area (km2)	Popula- tion	Popula- tion Density (person/km2)	Number of Household (person/hh*)	Household Size
Deli Serdang	4,398	1,602,749	364	316,875	5.06
Simalungun**	1,553	178,254	115	36,597	4.87
Medan	265	1,730,752	6,532	324,084	5.34
T. Tinggi	38	116,767	3,079	21,896	5.33
Study Area	6,254	3,628,522	580	699,452	5.19

* hh means household; ** 7 Kecamatans only.

Source: Hasil Sensus Penduduk 1990, Kab. Deli Serdang, Kab. Simalungun, Kodya. Medan and Kodya. Tebing Tinggi.

The study area has 54 kecamatans as administrative units in 1990. They are the 33 units in Deli Serdang, 7 units in Simalungun, 11 units in Medan City and 3 units in Tebing Tinggi City.

Land Use

Land use in North Sumatra Province has shown a drastic change. More than 40% of the permanent forest area has already been converted into other land utilization such as plantation, paddy and so on.

Land use in the study area is dominated by plantation/estates of rubber, oil palm, coconut, etc., and paddy fields occupy approximately 90,000 ha which correspond to 17% of the study area. Land use in 1976 and 1985 is presented in Table 2-4 and that of 1985 is mapped out in Fig. 2-8.

In the upper reaches of the rivers, land is covered by bush, shifting cultivation, mixed cultivation, upland crop and forest designated as the National Conservation Forest. In the middle reaches, the dominant land covers are plantations of rubber, oil palm, coconut, tobacco and scrubs, and paddy. In the lowland area coming down to the coastal line, land cover consists of wetland paddy field, rubber plantation, oil palm, cacao plantation, nipah/palm forest and mangrove.

2.3.2 Economic Structure

National Economy

(1) Governmental Budget

Budget expenditure of the Central Government amounted to Rp. 38,165 billion in fiscal year 1989-1990, consisting of Rp. 24,331 billion for the routine sector and Rp. 13,834 billion for the development sector. As shown in Table 2-5, the budget expenditure indicated a high average annual growth rate of about 20% for the routine sector, while there was little growth for the development sector during the period of 1985/86 to 1989/90.

(2) Gross Domestic Product

In 1989, the Gross Domestic Product (GDP) of Indonesia grew to Rp. 116,320 billion at current market prices at an average annual rate of about 15% for the period 1985-1989, and the manufacturing industrial sector showed the highest growth rate of 24.1% per annum on average for the same period (refer to Table 2-6). On the other hand, the real annual growth rate of the GDP was about 4%, which was close to the average growth rate among the world countries.

(3) External Trade

In 1980, exports in Indonesia amounted to US$23,950 million against imports of US$10,834 million, i.e., the balance of trade indicated an export surplus of US$13,116 million which was the most favorable balance in the past. After that year the amount of exports, on the decrease due to the recession of oil market in the world, fell to US$14,805 million in 1986, though the trade balance still maintained the export surplus amounting to US$4,087 million. However, the external trade of Indonesia, indicating an upward tendency after the year 1986, amounted to the exports of US$25,800 million and the imports of US$20,100 million in 1990, i.e., an export surplus of US$5,700 million. On the other hand, the external trade balance which excluded petroleum and gas from the exports and imports was in an unfavorable situation every year during the period from 1980 to 1990 (refer to Table 2-7).

Regional Economy

(1) Gross Regional Domestic Product

At current market prices, the Gross Regional Domestic Product (GRDP) of North Sumatra Province amounted to Rp. 7,592 billion in 1988 at an average annual growth rate of 17.1% (equivalent to the real growth rate of 6.5%) since 1983. This growth rate is fairly high compared with the GDP of the country as a whole, especially the sector of electricity, gas and water supply which indicated the highest average growth rate of 25.1% per annum for the period 1983-1988. The agricultural sector, which had a large share of 36.6% in the GRDP in 1988, also achieved the high growth rate of 19.6% during the same period. (See Tables 2-8 and 2-9.)

(2) Agriculture

Typical food crops produced in North Sumatra Province and the study area are shown in Tables 2-10 and 2-11. In 1989, paddy production was 2,541 million tons with a yield rate of 3.74 ton/ha in North Sumatra Province and 567 million tons with a yield rate of 4.12 ton/ha in Kab. Deli Serdang. The yield rate in North Sumatra was rather low compared with that of the country as a whole, especially at the yield rate of wetland paddy.

North Sumatra Province is among the most developed regions in the country on the estate plantation which is represented by rubber and oil palm. Table 2-12 shows the planted area, production and yield rate of rubber and palm oil in the study area and in North Sumatra Province.

(3) Establishment and Employee

Table 2-13 shows the number of establishments and employees by industrial origin in North Sumatra Province and the study area. In 1986, North Sumatra Province had 326,839 establishments including the 141,273 establishments in the study area (except Kab. Simalungun), and the number of employees was 675,513 including the 323,932 in the study area. In either case, the study area had nearly a half of the number in North Sumatra Province.

In the same year, the distribution of establishments in the study area was 45,605 (32%) for Kab. Deli Serdang, 88,949 (63%) for Kodya. Medan and 6,719 (5%) for Kodya. Tebing Tinggi. The percent distribution for the number of employees was 30%, 66% and 4%, respectively.

(4) Budget of Regional Government

Budget expenditure of the North Sumatra Autonomous Government amounted to Rp. 290,356 million in fiscal year 1988/89 at an average annual growth rate of about 16% during the period 1980/81 to 1988/89. This expenditure is composed of Rp. 245,681 million (85%) for routine work and Rp. 44,674 million (15%) for development. Both indicated average growth rates of 18% and 10% per annum, respectively, during the said period (refer to Table 2-14).

According to the financial information from the Provincial Government of North Sumatra, budget expenditures of both sectors of flood control and water resources development were about Rp. 7,100 million and Rp. 120 million, respectively, in fiscal year 1988-89. All budgets related to flood control were maintained exclusively by the national budget including foreign loan, and the budget for water resources development was composed of both the national and provincial finances.

2.3.3 Organizational Structure

Government Organization

The Ministry of Public Works in the central government was set up under Presidential Decree No. 44/1974. The organizational structure was later modified by Presidential Decree No. 15/1984 as shown in Fig. 2-9. The Decree of the Minister No. 211/1984 covers the basic tasks and functions of the Ministry as a governmental organization to undertake development projects.

Development programs for water resources and river basins are handled by the Sub-Directorate of River Basin Development Planning in the Directorate of Planning and Programming, Directorate General of Water Resources and Development (DGWRD), which consists of a survey section and three (3) regional sections. The Directorate of Rivers is directly concerned in river development. Its specific tasks are technical planning and design, implementation, and operation and maintenance. It also carries out feasibility studies on river works, especially on flood control.

Laws and Regulations on Water

The laws and regulations concerning water use and water management are as follows:

(a) Law No. 11/1974 (Law on Water Resources Development)

(b) Government Regulation No. 22/1982 (Regulation on Water Management and River Basin Control)

(c) Government Regulation No. 14/1987 (Regulation on Irrigation and the Establishment of Water Users Association)

(d) Regulation of the Minister No. 39/1989 (Regulation on River Classification)

(e) Government Regulation (Final Draft) on Rivers

(f) Decree of the Minister No. 211/1984 (Decree on Water Supply/Drinking Water)

There is no specific law on water supply aside from joint decrees issued by the Minister of Home Affairs and the Minister of Public Works, No. 3/1984 and No. 265/1984, regarding the "Water Supply Project Proposal Procedure, Temporary Management Transfer", and the Decree of the Minister of Public Works No. 269/KPTS/ 1984 regarding "Drinking Water Management Agency Formation" or "Badan Pengelola Air Minum (BPAM)".

2.4 Regional Development

2.4.1 Water Resources Development Plans

Water Resources Development under Repelita V

Water resources development under Repelita V is still concentrated on the irrigation sector. The development policies on irrigation are specifically aimed at the enhancement of operation and maintenance activities and the increase of irrigation networks.

The expansion of irrigation networks will be carried out in areas outside of Java in order to maintain self-sufficiency and compensate for the decrease of paddies in Java. The following table shows the selected targets in the irrigation sector:

Water Resources Development Plans (1,000 ha)

Activity	Repelita IV	Repelita V
1. Improvement and Maintenance of Irrigation Networks:		
- O&M	5,400.0	5,800.0
- Rehabilitation	561.0	334.3
2. Construction of New Irrigation Networks	344.8	500.0
3. Swamp Area Development:		
- Reclamation	225.5	444.2
- Pond Improvement	9.0	60.0
- Pond Development	3.0	10.0
4. Flood Control	359.0	450.0

Source: BAPPENAS, Fifth Five-Year Development Plan, 1989/90-1993/94.

Water Resources Development in North Sumatra

The technical irrigation area was increased from 51,362 ha to 53,854 ha or 1.05% per annum from 1983 to 1987. The Semi-technical irrigation area was decreased from 63,744 ha to 59,549 ha or 1.68% per annum, but the simple irrigation area was increased and improved to upgrade it to semi-technical from 53,049 ha in 1983 to 76,845 ha in 1987 or an increase of 8.84% per annum.

2.4.2 Other Infrastructural Development Plans

Medan Urban Development Project

The study for Medan Urban Development, Housing, Water Supply and Sanitation Project was started in 1978 and completed in October 1980 under the supervision of the Directorate General of Housing, Building, Planning and Urban Development (DGCK), Ministry of Public Works. It was partly financed by the Asian Development Bank (ADB).

The study covered the whole area of Kodya. Medan with the following scope of work:

(a) Preparation of a long term urban development plan.

(b) Feasibility study for housing development projects including a kampung development programme, sites and services, and low cost housing scheme.

(c) Development of a long-range master plan for water supply, wastewater drainage and solid waste systems in Medan and its vicinity through the year 2000.

(d) First Stage Feasibility Study for water supply, wastewater, drainage and solid waste systems to meet needs through the year 1990.

(e) Detailed engineering for the First Stage sites and services scheme and the low housing scheme.

Based on the study, the first stage program was implemented starting in 1982. With technical assistance from ADB, the second stage of MUDP, namely the Second Medan Urban Development Project (MUDP II), was also started including some overall studies for flood control and water supply covering a wide area from Belawan River to Serdang River which occupies about a half of the area of this present Study.

Transportation Projects

(1) Road

The development plan for roads emphasizes the expansion of road networks in growth centers and production centers. By the end of Repelita V, national and provincial road networks are expected to cover 43,000 km, while asphalt paved roads are expected to increase to 93,900 km in length. In addition, artery/collector roads of 1,600 km, municipality roads of 344 km, and bridges totaling 4,200 m will be constructed.

(2) Railway

The development plan for railways focusses on increasing their load capacity, service quality and management efficiency. For this purpose, 1,835 km of tracks will be rehabilitated and 175 underpass and overpass bridges will be constructed to sustain a total load capacity of 2,500 tons.

The route which is presently not being operated due to its bad condition is estimated at about 68.76 km. In the long term program there are plans to build and develop new modern commuter train services for the MEBIWANTI (Medan, Binjai, Belawan, and Tebing Tinggi) area, which will be tentatively scheduled in the year 2000 to 2025 (MEBIWANTI Railway Project).

(3) Sea Port

Development of sea communication/transportation is also expected to facilitate expansion of interregional trade and to increase competitiveness of domestic products in domestic and foreign markets. During Repelita V, the national fleet capacity will be increased by 178,500 dwt, the load sailing fleet by 22,000 dwt, the small holders sailing fleet by 50,000 dwt, the special sailing fleet by 119,800 dwt, and passenger ships by 40,000 dwt.

(4) Airport

Air transport service will be extended to a greater number of regional areas. In Repelita V, the growth rate of demand per annum is expected to reach 8.6% for domestic air transport, 9.1% for international transport, and 11.2% for pioneering air transport.

Medan Polonia Airport is the biggest airport in North Sumatra and it has good facilities for either domestic or international transport with favorable conditions until the year 2005. After that year it should be moved to another area in Kab. Deli Serdang.

Electricity and Energy Projects

Domestic energy demands are to be met as much as possible through the utilization of existing non-oil energy resources such as natural gas, geothermal energy, hydropower and coal. In North Sumatra Province the target of installed capacity is 265.5 MW, and 164.3 MW or 69.9% was accomplished at the end of Repelita IV. The remaining is expected to be accomplished within Repelita V. The energy sources in the province are oil, natural gas and hydropower.

2.5 Environmental Condition

2.5.1 Environmental Policy in Indonesia

Legislation

Laws, regulations and decisions on environmental protection and management in Indonesia are based on its 1945 Constitution. This was strengthened by the "Environmental Management Act (EMA), 1982", which recognizes the right of every person to a good and healthy living environment. The Act serves as the basis for the evaluation and adjustment of all legislations containing provisions related to aspects of the living environment heretofore valid, e.g., legislation regarding irrigation, mining, energy, forestry, protection and conservation of nature, industry, settlements, land use, etc. Another provision of the EMA is the requirement for an environmental impact assessment (EIA), for projects likely to have a significant impact on the environment.

Environmental management policies and their coordination in Indonesia is handled by the Minister of State for Population and Environment principally in the areas subject to EIA, hazardous substances and waste, and environmental quality guidelines. A detailed description of an EIA will be given in the following section.

Environmental Impact Assessment

Environmental Impact Assessment (EIA) is implemented under Government Regulation 29/1986 which came into effect on June 5, 1987 on the basis of the Environmental Management Act (1982). Working procedures for EIA are given in Fig. 2-10.

The EIA in Indonesia is characterized by functioning to ensure objectivity through distinct separation of each responsibility, i.e., report preparation (Proponent), technical assistance (AGA), and evaluation (Commission) for EIA. The Ministry of Public Works (MPW) had prepared an EIA manual for conducting an effective Environmental Impact Assessment for projects with which they are concerned, under Government Regulation 29/1986, and its contents are as follows:

(a) Working Procedures in the MPW for ANDAL (EIA)
(b) Screening and Scoping
(c) Technical Guidelines
(d) ANDAL for Existing Project
(e) Evaluation of ANDAL
(f) Provincial Referral System

2.5.2 Environmental Condition of the Study Area

Natural Environment

The study area includes areas under legal regulations for nature conservation, i.e., a Nature Reserve Area (designated by the Protection Nature and Environmental Board) and a Forest Reserve Area, as illustrated in Fig. 2-11. These conservation areas are designated, centering around ranges of mangrove and lowland forest along the seashore.

Compared with Java, Sulawesi and other small islands, Sumatra as a whole has much more abundant and various vegetation. The study area, however, has a small range of vegetation since a large area is cleared for oil palm, rubber and other kinds of plantation.

Generally, Sumatra provides an excellent living environment for wild animals, and is a habitat for a number of species including 196 mammals and 580 different species of birds. In the study area, animals such as monkeys live primarily in the forests.

Social Environment

The study area has a large number of Christians compared with Indonesia as a whole; however, the proportion in this area is not unusually large for North Sumatra Province.

The study area is composed of several ethnic groups. The Javanese has the largest proportion of population at 39% and the Bataks including Karos occupy the second largest at 25%. Originally, the Melayu was dominant in number in the study area.

The study area has a number of historical and cultural structures such as mosques, cemeteries and holy places, and other cultural assets. These assets are located in the relatively lower reaches of the river basin.

Health and Hygiene

Traditionally, water for bathing, washing and toiletry is usually provided by a well in a village or by a small stream nearby. People often live along small streams, into which domestic refuse is thrown. Therefore, the water quality of rivers in the study area is affected by the population and such customs. The people seem to be not fully aware of the environment surrounding them.

2.5.3 Water Quality Survey

Water quality survey was conducted to examine the potability of river surface water and groundwater in the study area. The water sampling points are shown in Fig. 2-12.

Summarizing the results, groundwater sampled from either deep or shallow wells in Tebing Tinggi showed higher concentrations of manganese and sulfate ions than in Medan. Generally, river water and shallow well water includes a high content of coliform bacteria. Deep wells in Medan keep good water quality suitable for drinking.

CHAPTER 3. FLOOD, SEDIMENT AND WATER SUPPLY

3.1 Flood

3.1.1 Past Flood Damage

Flooding Condition

Frequent floods in the study area have been reported. Except some special study reports such as those for the Ular River Project and MUDP, however, no record and details have been compiled into a report by the DPUP. Therefore, to identify flooding conditions, an interview survey was conducted at 55 locations in flood-prone areas.

The causes of flood are classified into two (2), river overbanking and inland water drainage. Floods due to river overbanking have been reported in mainly the downstream reaches of the six (6) rivers, except Ular River, while those by inland water drainage have been observed in urban areas such as Medan and Tebing Tinggi, and also the coastal lowland areas. The latest serious river flood that hit Medan and the surrounding area on November 26, 1990 was due to the overflow from the Deli and Percut rivers and the inundation area is estimated at about 4,200 ha, as shown in Fig. 3-1 together with the inundation depths.

Except on the swampy areas in the lowest coastal shores, there is less occurrence of flood from the Belawan River. In the case of Belutu and Serdang rivers, frequent flooding has been reported in paddy fields and oil palm plantations. Flood water depth of either overbank flow or inland water has been reported mostly at 0.5 m to 1.5 m. Except in swampy areas in the lower reaches, flood duration has also been reported to be relatively short.

Flood Damage

Some records on past flood damage in Medan, Tebing Tinggi and Kab. Deli Serdang have been compiled by the Office of Social Welfare. However, records are short in Kab. Deli Serdang and inadequate in Kodya. Medan and Kodya. Tebing Tinggi, summarized as follows:

Summary of Flood Damage

Year	No. of Households Affected	No. of People Affected	No. of Casualties		No. of Houses Damaged		Area of Paddy Inundated (ha)	Estimated Damage (1,000 Rp.)	Remarks
			Dead	Injured	Full	Partial			
1981	518	3,090	0	0	4	0	179.9	35,108	Kab. Deli Serdang
1982	785	5,409	0	0	50	5	454.0	108,377	-do-
1983	289	1,854	0	0	0	5	41,534.0	39,010	-do-
1984	450	2,948	1	0	0	0	124.0	20,004	-do-
1985	113	786	0	0	0	113	15.0	49,310	-do-
1986	629	4,369	3	0	130	182	69.0	305,755	-do-
1987	629	4,684	0	0	34	92	0.0	190,775	-do-
1988	324	2,269	0	0	77	23	0.0	79,495	-do-
1987	1,256	7,592	0	0	2	1,254	n.a.	n.a.	Medan City
1988	2,083	15,655	0	0	0	1,285	n.a.	n.a.	-do-
1986	1,072	4,047	0	0	n.a.	n.a.	n.a.	n.a.	T. Tinggi City
1987	625	3,572	0	0	n.a.	n.a.	n.a.	n.a.	-do-
1988	1,594	8,502	0	0	n.a.	n.a.	n.a.	n.a.	-do-

n.a. : Data are not available.
Source: Office of Social Welfare in Medan, T. Tinggi and Kab. Deli Serdang

In Kab. Deli Serdang where records since 1981 are available, the main cause of flood damage is the overbank flow from Belutu and Padang rivers. Estimated at approximately Rp. 100 million per annum on average from 1981 to 1988, the damage is considered big, because no extraordinary flood has hit the area during that period. However, casualties were few and this is attributed to the topographic condition which does not produce any flash flood.

3.1.2 Existing Flood Control Works

Existing River Channel

River dikes have been provided for mainly the lower and middle reaches of each river (refer to Fig. 3-2). However, the dikes are inadequate to ensure safety against floods, except Ular River which had an extensive river improvement works. River sections are mostly excavated channels with single cross-sections of 20 to 50 m wide. The river channels have no bank protection works such as revetment and/or groins, except near river bridges or other river structures such as intakes and weirs.

The main river structures are the bridges. Many road bridges have been constructed across the Deli and Percut rivers because they flow through Medan City, while there are only a few bridges on the other rivers. Major road bridges crossing river channels are constructed at elevations higher than the surrounding ground, however, their abutments encroach into the river channel, decreasing the river width and forming a bottleneck.

Flow capacity was estimated for the existing river channels, except the Ular River. The flow capacities are very small, less than the flood discharge of a 2-year return period.

Improvement Works

The flood control works, which were mostly river improvement works as shown in Table 3-1, were planned by DPUP. Among them, only the Deli River Improvement Project was carried out with financial assistance from OECF and ADB.

The design scale of improvement works was set at a 10-year return period mainly due to budgetary constraint. Priority of implementation was then placed on the low-lying areas where flood damage has been serious.

3.1.3 Flood Analysis

Flood Runoff Model

Each river basin is divided into several subbasins, taking into consideration the catchment of tributaries and topographic conditions. The subbasins are as shown in Fig. 3-3.

A basin runoff model is constructed for each river according to the subbasin divisions. The model includes the possible dams which are discussed in Section 3.4 and shown in Fig. 3-4. The Storage Function Method is employed for the flood runoff analysis.

The parameters of the storage function model are calculated based on the eleven (11) actual flood records selected. The parameters presented in Fig. 3-5 are determined to be the most suitable to simulate the calculated hydrograph to the observed one.

Probable Rainfall

Less than twelve (12) hours of runoff concentration time which is governed by the catchment area, river length and topography, is justified for all river basins. Therefore, daily rainfall is adopted for the flood runoff calculation. Probable daily rainfalls for the respective river basins are estimated, using the Gumbel Method, at 143.0 mm, 206.4 mm and 177.2 mm for a 100-year return period in Deli, Ular and Padang river basins, respectively. (Refer to Table 3-2.)

There is only one (1) rainfall gauging station in the study area, namely Sampali, where hourly rainfall data have been recorded. To define a typical rainfall pattern in the study area, the biggest 20 daily rainfalls for 13 years from 1977 to 1989 are extracted from all records and superimposed putting in order the occurrence time of hourly maximum rainfall. Storms causing flood usually continue for 12 hours on average because their rainfall distribution is standardized by the hourly rate as presented in Fig. 3-6. Based on this typical rainfall pattern and the aforementioned probable daily rainfall, the design storm is prepared.

Probable Flood Discharge

The probable flood discharges of each river basin from 2-year return period to 100-year return period are calculated, applying the probable design storm to the flood runoff model. The probable flood discharges at the reference point of the respective river basins are estimated at 690 m^3/s, 1,070 m^3/s and 940 m^3/s for a 100-year return period at Helvetia (Deli), Pulau Tagor (Ular) and Brohol (Padang), respectively (refer to Table 3-3). The distribution in each river system is presented in Fig. 3-7.

3.1.4 Flood Inundation Area

Probable Inundation Area

Generally, flood inundation is classified into two (2) types, storage type and flow/diffusion type. Since the flood area is flat with a slight slope towards the sea, the overbank flow usually spreads along the river course. Furthermore, the flood is somewhat retained in the shoreline area. The flooding in the area, therefore, shows both of storage and flow/diffusion. Based on this complicated feature of flooding, the Two Dimensional Unsteady Flow Model is employed for flood inundation analysis in the study area.

In the model construction, the inundation area is divided into several cells called mesh. The size of a mesh is set at 1.0 km x 1.0 km on account of the rather flat topography and the large scale land use condition.

The probable inundation area is estimated at about 500 km^2 in total for the six (6) rivers except Ular River, as shown in Fig. 3-8. Among them, the inundation area is smallest in the Belawan River Basin, while the biggest is in the Serdang River Basin.

Assets in the Flooding Area

Most of the residential houses in either the urban or rural area are built as a one-storey single house made of tile or tile cement. The average floor area of a house is about 50 m^2, and the average construction cost of such house is estimated at approximately Rp. 5.0 million.

Table 3-4 shows the appraised value of assets such as buildings, household effects and agricultural crops. The appraised value of buildings and household effects is given as the average price as of the year 1991 for each of the farmhouses, residences, shops, offices, schools, hospitals, factories, mosques and churches, while that of agricultural crops is given as the producer price, also in 1991, for each paddy, rubber, coconut, oil palm, cacao, tobacco, maize, cassava, potato, peanut, soybean and green pea plantation.

3.1.5 Flood Damage Analysis

Flood Damage Rate

The flood damage rate to several assets is analyzed on the following assumptions and the results are summarized in Table 3-5.

(1) Damage to Buildings and Household Effects

Flood damage to buildings and household effects is considered as a function of inundation depth to buildings. Damage rate to buildings and household effects is assumed at 0.5 m of water depth above floor level, taking into account the average distribution of goods above the floor level of houses in the study area.

(2) Damage to Paddy

Flood damage to paddy is generally related to the height of planted paddy and the depth and duration of submergence.

(3) Damage to Oil Palm and Rubber

Production of palm oil (including kernel) and rubber will decrease due to flood, because of the suspension of the production activities in periods of flood and restoration of production facilities after flood. In estimating these damages, it is assumed that the restoration period is nearly equal to the flood duration and production is uniformly made all the year round.

Under the above assumption, the decrease in production per day and per hectare of palm oil (incl. kernel) and rubber caused by inundation is respectively estimated as follows, using the unit prices of these crops shown in Table 3-4.

(a) Oil Palm (incl. Kernel)

Rp. 665,000 * (1-0.4) * 2/365 = Rp. 2,150/day/ha

(b) Rubber

Rp. 143,000 * (1-0.4) * 2/365 = Rp. 470/day/ha

Where, production costs of these crops are assumed to be 40% of the producer prices in accordance with the plantation statistics in North Sumatra.

(4) Damage to Tree Crops (Cacao, Coffee, Papaya, Banana, etc.)

Tree crops such as cacao, coffee and banana bear fruit at a comparatively lower position above the ground, therefore, some fruits are directly damaged by flood.

(5) Damage to Upland Crops (Palawija)

The rate of flood damage to upland crops such as cassava, potato, peanut, soybean and green pea depends on both inundation depth and duration.

(6) Damage to Public Facilities

There are no available data required for estimating damage by flood discharge in the study area. Hence, the damage rate to public facilities such as roads, railways, bridges, and electric, water supply and drainage facilities is assumed in the present study as 34% of the damage to buildings and household effects.

<u>Flood Damage Calculation</u>

The total flood damage is firstly calculated for each river by summing up each mesh's damage for a certain scale of flood (refer to Table 3-6). The average annual flood damage is generally given using the following formula:

$$d = \int_{Q_1}^{Q_2} D(Q)P(Q)dQ$$

where,

d	:	average annual flood damage
Q	:	flood discharge
$D(Q)$	:	damage caused by flood discharge (Q)
$P(Q)$	:	probability of occurrence of flood discharge (Q)
Q_1	:	innocuous discharge
Q_2	:	design flood discharge

The average annual flood damage by return period is summarized as follows:

Average Annual Flood Damage (Million Rp.)

Return Period (Year)	Belawan River (1)	Deli River (2)	Percut River (3)	Serdang River (4)	Ular* River (5)	Belutu River (6)	Padang River (7)
10	324	32,363	2,443	10,919	-	2,019	8,961
20	711	35,687	3,059	11,909	460	2,217	9,857
30	869	36,919	3,296	12,248	1,080	2,292	10,193
50	1,001	37,968	3,491	12,527	1,520	2,354	10,469
100	-	38,795	3,647	-	-	-	-

* Source: Overall Ular River Improvement Project, JICA, 1971

3.2 Water Supply

3.2.1 Present Water Source and Water Use

Municipal/Domestic Water

(1) Medan

The water sources for the water supply system in Medan are the surface flow of Belawan River and Deli River, springs in the mountain slope, and groundwater. Intake facilities for surface flow are located at Sunggal and Deli Tua with the intake capacity of 1,500 l/s at Belawan River and 1,400 l/s at Deli Rivers.

Groundwater is drawn from deep wells by pumps and from shallow wells. Although many wells are utilized, only 22 wells are incorporated into the municipal water supply system in Medan. These are augmented by privately-owned deep wells and shallow wells supplying domestic water of approximately 5,000 m^3/day and 56,000 m^3/day, respectively.

In addition to the above, the Belawan Port Authority (BPA) independently owns a water supply system of which a small part is conveyed to Medan. Summarizing the current water use in Medan, about 183,000 m^3/day is used for municipal and domestic needs.

Municipal and Domestic Water Source

Water Source	Supply Capacity (m^3/d)
1. Sibolangit Springs	46,000 (530)
2. Sunggal (Belawan River)	90,720 (1,050)
3. Deli Tua (Deli River)	30,240 (350)
4. Deep Well	14,750 (170)
5. Transmission from BPA* (Deep Well)	1,420 (16)
Total	183,130 (2,116)

* Belawan Port Authority
Amounts in parentheses are in l/s.

Under the water supply system operated by PDAM Tirtanadi, the total number of consumers in Medan City is 97,081 and total consumption is 127,177 m^3/day as of May 1990, as presented in Table 3-7. Since the population is about 1.7 million in 1990, the service ratio is estimated at about 30%.

(2) Tebing Tinggi

The water source for the municipal water supply by PDAM Tebing Tinggi is only the surface flow of Padang River. An intake structure and a water treatment plant were constructed at Bulian in 1981, with the intake capacity of 60 l/s and production capacity of about 45 l/s. On the other hand, there exist eight (8) deep wells with a total capacity of 30 l/s for non-domestic water use.

The total number of consumers under PDAM Tebing Tinggi as of February 1990 was about 2,400 units, corresponding to about 14,400 persons. Thus, the present water supply service ratio is about 12% since the population is 117 thousand.

(3) Deli Serdang

Fourteen (14) kecamatans in Kab. Deli Serdang are at present provided with water supply system with water sources from river flow, groundwater and springs. River surface water is utilized at Tanjung Morawa and Sei Rampah from Belumai River (Serdang River) and Belutu River with intake capacities of 10 l/s and 20 l/s, respectively. Other kecamatans such as Lubuk Pakam, Batang Kuis, Perbaungan, Dolok Masihul, Hamparan Perak, Tembung, Bandar Khalipah, Dolok Merawan, Pantai Cermin, Galang and Tiga Juhar are provided by deep wells with the total capacity of about 60 l/s. According to the PDAM of Deli Serdang, about 3,000 households are supplied from the water supply service and this is only 1.1% of the total population of about 1.6 million in Kab. Deli Serdang.

On the other hand, there are seven (7) kecamatans currently receiving services under PDAM Tirtanadi. They are Pancur Batu, Namo Rambe, Deli Tua, Sunggal, Labuhan Deli, Percut Sei Tuan and Sibolangit. Data on supply volume, consumers, etc., are not available.

Irrigation Water

The major crops in the study area are wetland rice, upland rice, maize, cassava, soybean, sweet potato, peanut and other beans. Rice is planted generally from October to November and harvested during February to April.

Based on the inventory of existing paddy fields, the present condition is classified into the following four (4) categories of irrigation system.

Category of Irrigation System

Category	Area (ha)	Ratio (%)
1. Technical Irrigation Area	18,824	24.0
2. Semi-technical Irrigation Area	18,890	24.1
3. Simple Irrigation Area	25,592	33.1
4. Rainfed Area	14,700	18.8
Total	78,366	100.0

In addition to the above, there exist 10,200 ha of swampy area of which some portions are partially cultivated and the potential for paddy irrigation is high.

The technical irrigation area is well provided with irrigation facilities and achieving double cropping, i.e., a crop intensity of 200%. However, the semi-technical and simple irrigation areas may only attain the crop intensity of 120% and 100% on average, respectively.

Institutional, Commercial and Industrial Water

Records of water tariff collection of PDAM Medan in May 1990 show that about 25% of the total use was for non-domestic purposes, and unaccounted loss of water is also estimated at about 25%, as presented in Table 3-8.

Aquacultural Water

There exist three (3) types of aquacultural practice in the study area classified by the provincial fishery office (Dinas Perikanan Propinsi); namely, (a) Mina Paddy, (b) Kolam and (c) Tambak. Mina Paddy and Kolam are the freshwater aquaculture conducted in paddies or freshwater fishponds to raise fish such as Tawes, Lele, etc. Tambak is the brackish water aquaculture conducted in the lowland area along the seashore, mainly for shrimp and tiger prawn.

There are about 520 ha of Kolam and 280 ha of paddy in the study area, but the required water is mostly supplied by unused and/or circulated irrigation water. As for Tambak, out of 2,100 ha in total, about 830 ha is in operation as fresh water is supplied from rainfall.

3.2.2 Present Water Demand

Municipal Water

(1) Condition for Demand Estimation

In conformity with the Fifth Five-Year Development Plan (Repelita V), the service ratio of water supply in the urban area is upgraded to 80% from the 75% which was adopted in the previous plan (Repelita IV).

Then based on the per capita consumption and present water use condition in the study area under Repelita, the conditions for the estimation of water demand are set as follows:

(a) The target areas the water supply plan are Kodya. Medan, Tebing Tinggi and all kecamatans in Kab. Deli Serdang.

(b) For Kodya. Medan and Tebing Tinggi the per capita consumption of 130 l/c/d is adopted, while for the others they are determined with reference to Repelita V.

(c) Institutional, commercial and industrial water in Medan is consequently estimated at 40% of the domestic water and the same ratio of 40% is employed for Kodya. Tebing Tinggi. With regard to the kecamatans in Kab. Deli Serdang, the ratio of 10% is assumed for non-domestic use on the basis of the statistics of DGCK.

(2) Estimated Water Demand

The municipal water demand in the cities and of the respective river basins is estimated at approximately 372,000 m^3/d, as shown in the following table.

Municipal Water Demand in Cities and River Basins

Name of City/River	Population (person)	Water Demand (m^3/d)
1. Medan	1,731,000	315,042
2. Tebing Tinggi	117,000	21,294
3. Belawan	326,930	6,813
4. Deli	68,221	1,421
5. Percut	254,594	5,306
6. Serdang	293,365	6,114
7. Ular	381,569	7,951
8. Belutu	224,470	4,678
9. Padang	281,428	3,427
Total	3,561,577	372,046

Irrigation Water

Irrigation water requirements are estimated based on the cropping pattern and its corresponding unit diversion requirement as shown in the following tables.

Irrigation Water Requirements

Wet Season Paddy:

Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Ratio of Cultivation Area	0.17	0.67	1.00	0.94	0.50	0.06
Diversion Water Requirement (l/s/ha)	0.03	0.51	0.87	0.99	0.49	0.04

Dry Season Paddy:

Item	Apr.	May	Jun.	Jul.	Aug.	Sep.
Ratio of Cultivation Area	0.06	0.50	0.94	1.00	0.67	0.17
Diversion Water Requirement (l/s/ha)	0.03	0.55	0.84	0.81	0.46	0.06

A peak requirement arises in February for wet season paddy and in June for dry season paddy.

Aquaculture

Demand for aquaculture is not incorporated into the present study, since it is met by the water utilized for irrigation purposes and the water of swamps in the vicinity.

River Maintenance Flow

The low flow of the river shall be maintained so that no serious change from the present condition will arise. However, the river maintenance flow has not been determined for rivers in the study area.

3.2.3 Low Flow Analysis

Low Flow Runoff Model

The Tank Model Method which is the most commonly used method with a simple structure designed to calculate daily discharges over a long time, is employed as a low flow runoff model. A three-staged tank is applied since the observed flow regime is relatively flat. River flow simulation is made for a period of 20 years (1969 to 1988).

Model Calibration

The most important factor, loss in runoff in the model, is determined to be about 70% of pan evaporation, which is estimated at 1,100 mm/year. This is applied for all seven (7) river basins since their climatic conditions are quite similar with each other.

Parameters of the Tank Model are determined by trial-and-error until the calculated flow regime show good correlation with the observed flow regime. In evaluating the degree of similarity in flow regime, low flow portions (80 to 95% exceedance discharge) and annual variation patterns are justified. The flow regime by low flow runoff analysis for 20 years from 1969 to 1988 is summarized for the existing water level stations, as follows:

Flow Regime by Low Flow Runoff Analysis

Station (River)	Catchment Area (km^2)	Annual Rainfall (mm)	Flow Regime (m^3/s) Max.	95%	Min.	Mean
Kp. Lalang (Belawan)	254	2,151.6	41.50	4.75	4.40	8.59
Simeme (Deli)	158	2,508.0	33.60	3.91	3.68	7.13
Helvetia (Deli)	341	2,308.0	67.51	7.23	6.78	13.31
Tg. Marawa (Serdang)	250	2,632.0	75.78	5.93	5.61	12.19
Pulau Tagor (Ular)	1,031	2,868.7	140.47	38.71	35.70	57.82
T. Tinggi (Padang)	919	2,497.4	136.02	25.94	24.15	39.72

3.2.4 Water Supply Potential

River Surface Flow

River flow has a seasonal fluctuation depending on the rainfall in the catchment area. The water supply potential from river flow is evaluated by water use pattern; municipal water use is rather constant throughout the year and irrigation water requirement has some seasonal variations.

Generally, water shortage in municipal/domestic water supply is not allowed even in a severe drought; once in 10 years, and irrigation water shall be secured at least in the droughtest year for 5 years.

The water supply capacity of each river basin is evaluated at the possible lowest intake point of river as follows:

Water Supply Capacity of River Basin

River	Intake Point	Catchment Area (km^2)	Drought Mean Discharge (m^3/s)			
			20-yr	10-yr	5-yr	Average
Belawan	Kp. Lalang	254	5.84	7.39	7.54	8.59
Deli	Simeme	158	5.07	5.70	6.12	7.13
Percut	Tembung*	171	6.06	6.81	7.31	8.52
Serdang	Tg. Morawa	250	8.18	9.03	10.70	12.19
Ular	Pulau Tagor	1,031	35.67	43.68	45.67	57.82
Belutu	Sei Rampah**	423	12.43	13.02	13.59	15.15
Padang	T. Tinggi	919	32.60	34.13	35.64	39.72

* Specific discharge of Simeme (Deli River) is used with rainfall ratio.
** Specific discharge of T. Tinggi (Padang River) is used with rainfall ratio.

Groundwater

(1) Springs

The present water production of springs around Medan City has been reported at 107,400 m^3/day, tabulated as follows:

Water Produced from Springs

Spring	River Basin	Estimated Production (m^3/day)
Tuntungan	Belawan	8,600
Sibolangit	Deli	76,000
Tanjung Marihan	Serdang	10,800
Kampung Bantan	Serdang	13,000
Total		107,400

Only about 46,000 m^3/day from the Sibolangit spring in Deli River Basin has been utilized for the existing municipal water supply to Medan. Water from other springs passes into the rivers, so that the existing water resources of springs are already involved in the low flow runoff of the river surface flow.

(2) Deep Wells

In the study area, there are totally 27 deep wells identified to have operation records. They are geologically grouped into three (3) areas other than some scattered wells; namely Medan, Belawan and Tebing Tinggi. Their water drawing potentials by deep wells are estimated at 25.0 l/s, 72.5 l/s and 5.0 l/s for 12 hours operation per day, however, development may not be technically and economically feasible. Therefore, further development of deep wells is not applied, while the existing deep wells will be constantly operated.

3.2.5 Water Balance

Water Balance Simulation Model

The simulation model for each basin is constructed, based on land use and the location of kecamatans. Some kecamatans adjacent to each other are grouped together in a demand center and possible dams are incorporated in the model to estimate the required storage volume for water supply.

Runoff discharges from subbasins are computed by means of the Tank Model Analysis and summed up into 5-day discharges. In the computation, domestic water from the scattered kecamatans is not taken from river water but from groundwater, because the current practice of using deep well is more economical than taking water from rivers for the scattered and small demand areas. Therefore, the balance is only investigated between supply potential by river flow and demand for irrigation water required for wet paddy and municipal water in Medan and Tebing Tinggi.

Present Water Balance

Since the water volume of actual consumption could not be obtained, the present water balance is estimated on the basis of the present water use for municipal water and the estimated water demand for irrigation water. The simulation is carried out for 20 years from 1969 to 1988.

(1) Belawan River Basin

The second droughtest year in 20 years from 1969 to 1988, namely the design drought year, is assessed to be 1985 when the proposed Tembengan Dam released a maximum of 0.837 m^3/s to meet the water demand of both municipal and irrigation water. Municipal water of 1.05 m^3/s was taken at Sunggal and supplied to Medan, and shortage of irrigation water arose mainly in the irrigation areas named Medan Kris (3,016 ha, semi-technical) and Suka Raya (201 ha, simple). Therefore, the Tembengan dam reservoir shall have a water supply capacity of 1,200,000 m^3.

(2) Deli River Basin

The design drought year is 1987, which is evaluated to be a 10-year return period of drought probability. The proposed Namobatang Dam is required to have a water supply capacity of approx. 2,800,000 m^3/s to be able to discharge a maximum of 1,448 m^3/s to meet both the municipal water of 0.35 m^3/s and the irrigation requirements of Namo Rambe (3,280 ha, semi-technical) and Lausimeme (220 ha, semi-technical).

(3) Percut River Basin

The design drought year is 1987, when the required water supply capacity is estimated at only 400,000 m^3. The maximum dam release flow is 0.470 m^3/s to supply the irrigation water of Bandar Sidoras (3,457 ha, semi-technical). In February of the drought year 1987, the river flow at the estuary is estimated at zero.

(4) Serdang River Basin

This river basin has a surplus water after meeting the water demand for irrigation. In the second droughtest year 1976, the river flow at the estuary is estimated at 5.698 m^3.

(5) Ular River Basin

The Ular River Basin also has a surplus, although the irrigation system is the most highly developed among those of the river basins in the study area. Through the Ular River Project, paddy fields of 18,500 ha were upgraded to technical irrigation area with a cropping intensity of 200%. The surplus flow at the estuary is estimated at 11.208 m^3/s in the design drought year 1983.

(6) Belutu River Basin

This river basin has suffered from water shortage in almost every year. All water demands rise in the semi-technical irrigation areas scattered over the lower reaches such as Sei Belutu (5,100 ha), Pekan Dolok (625 ha), Cinta Kasih (360 ha), Bulian (300 ha), Pertambatan (145 ha) and Siromrawan (260 ha). The required water supply capacity in the design drought year 1979 is estimated at 15,000,000 m^3 to be able to release the irrigation water of 3.851 m^3/s at maximum.

(7) Padang River Basin

The Padang River Basin is also categorized as a water surplus river. The surplus water at the estuary is estimated at 18.840 m^3/s in the design drought year 1979.

Among the seven (7) rivers, Belawan, Deli, Percut and Belutu have a serious shortage of water. The other rivers of Serdang, Ular and Padang still have a surplus water supply potential.

3.3 Sediment

3.3.1 Existing Sediment Control Works

Non-structural measures have been undertaken for sediment control in the study area. However, 42,350 ha of forest zone have been designated as conservation forest; some 24,350 ha of this forest are in the Ular River Basin, while 18,100 ha are in the Padang River Basin, as shown in Fig. 3-9.

The ongoing project in and around the study area is the Wampu and Ular Watershed Reforestation and Greening Project (Project Pembinaan Reboisasi dan Penghijauan DAS Wampu/Ular) under the

Directorate General of Reforestation and Rehabilitation, Ministry of Forestry.

3.3.2 Sediment Analysis

To formulate a sediment control plan for the study area, a mean annual sediment discharge is adopted as the fundamental volume of sediment, considering the average value for a long duration.

Based on the above principle, estimation of sediment yield, sediment transport and sediment balance is conducted as follows.

<u>Volume of Sediment Yield</u>

The sediment yield in the study area is classified into two (2) modes, sheet erosion in the region of plantation or upland cultivation, and channel erosion and collapse of the river bank.

(1) Sheet Erosion

In the estimation of sheet erosion volume, the depths of annual soil erosion shown in the following table are applied.

Depth of Annual Soil Erosion (mm/yr)

Land Use	Annual Soil Erosion
1. Settlement	0.000
2. Wetland Cultivation	0.000
3. Upland Cultivation	0.800
4. Plantation	0.509
5. Shifting Cultivation	0.176
6. Bush	0.020
7. Forest	0.010

Consequently, the total amount of sediment volume due to sheet erosion in the study area is estimated at 1.72 MCM/yr.

(2) Channel Erosion and Collapse of Bank

Sediment yield due to bank erosion, riverbed erosion (including secondary erosion of deposits) and collapse of river bank are estimated based on the valley order analysis of the Horton's Law using topographic maps of 1:50,000 scale. The following sediment yield per unit length of channel erosion and collapse of bank are applied.

Sediment Yield by Horton's Law ($m^3/km.yr$)

Valley Order	Channel Erosion and Collapse
1st	15
2nd	25
3rd	30
4th	120
5th	135
6th	180

The total sediment yield due to sheet erosion and channel erosion is estimated at 1.88 MCM/year, as follows:

Sediment Yield from Sheet Erosion and Channel Erosion (1000 m^3/yr.)

River	Sheet Erosion	Channel Erosion	Total
Belawan	181.9	18.2	200.1
Deli	125.9	14.9	140.8
Percut	51.3	9.8	61.1
Serdang	360.0	23.0	383.0
Ular	470.5	47.4	517.9
Belutu	152.0	15.6	167.6
Padang	376.2	37.0	413.2
Total	1,717.8	165.9	1,883.7

Volume of Sediment Transport

The volume of sediment transport is estimated by the sediment transportability of riverbed materials consisting of bed load and suspended load. For the estimation of the volume of sediment transport, Sato, Kikkawa and Ashida's Formula is employed for the bed load and the relationship between suspended load and flow discharge obtained from the suspended load survey is applied for the suspended load.

Sediment Balance

In this study, sediment balance is analyzed from the upper stream to the downstream. The sediment balance analysis in each river basin is conducted using the values of sediment yield and sediment transport. The process of calculation is expressed by the following formula:

$$V_4 = V_1 + V_2 - V_3$$

where,

V_1 : sediment inflow from upper unit basin (m^3/yr)
V_2 : sediment yield in a unit basin (m^3/yr)
V_3 : sediment deposit in a unit basin (m^3/yr)
V_4 : sediment discharge from a unit basin (m^3/yr)

The average sediment yield of the seven (7) river basins in estimated at approx. 430 m^3/km^2/year, which is considered a usual geographical transformation. The results of sediment balance analysis are shown in Fig. 3-10, summarized as follows:

Annual Sediment Balance

River	Catchment Area (km^2)	Annual Sediment Volume (1,000 m^3/year)		
		Yield	Deposit	Discharge*
1. Belawan	618	200.1	59.9	140.2
2. Deli	358	140.8	43.4	97.4
3. Percut	186	61.1	14.2	46.9
4. Serdang	671	383.0	111.4	271.6
5. Ular	1,081	517.9	124.4	393.5
6. Belutu	500	167.6	80.3	87.3
7. Padang	919	413.2	146.5	266.7
Total	4,333	1,883.7	580.1	1,303.6

* Discharge is estimated at the lowest point of river basin.

3.3.3 Sediment Control

Erosion Control Facilities

Sediment yield in the study area is usually generated by superficial erosion like sheet erosion. Generally, sheet erosion cannot be prevented from spreading by means of structural works like the construction of a check dam, because it is difficult to pinpoint the exact location of occurrence and there are many possible places where sheet erosion may occur in a large river basin.

Forest Conservation

To keep annual sediment discharge in the river basin below the harmful volume, orderly preservation works of plants such as the designation of a forest reserve area, reforestation and re-greening should be consistently implemented. The method of felling that will minimize erosion, especially in the practice of large scale plantation, should be employed. Furthermore, shifting cultivation which brings land clearing by burning and/or changes of the present land use should be prohibited or restricted by the promulgation of laws and regulations to control erosion on the steep slope of a hilly land.

Erosion and Sediment Deposits in River Channel

Since there is no large-scale and continuous bank erosion and collapse along the river channels in the study area, large scale countermeasures may not be required. For local bank erosion and collapse affecting a residential area and/or public facilities, individual treatment works such as the installation of spurdike, bank protection works, turfing works, etc., have to be executed accordingly.

3.4 Dam Development Potential

3.4.1 Possible Dam Sites

Eight (8) possible dam sites in the study area have been identified through the field reconnaissance and by using the topographic maps on the scale of 1/50,000. Six (6) of them are located in the upper reaches of six (6) rivers, namely Belawan, Deli, Percut, Serdang, Belutu and Padang. The other two (2) are in the middle reaches of the Ular River.

The locations of dam sites are selected in consideration that dams in the lowest stream of each river will have hydrologic and economic advantages as to flood control and water resources development. At these dam sites, dam construction can be economical with conventional construction methods. The locations and topographic characteristics of the eight dam sites are presented in Table 3-9 and in Fig. 3-11.

3.4.2 Geological Condition of Dam Sites

The geological condition on each dam site is summarized as follows:

(1) Tembengan Dam Site

Tembengan is located in the upper reaches of the Belawan River and there are flat plateaus on both bank sides. There is an extensive terrace along the banks. There is a scarp on the right bank, and continuous outcrops are observed. No outcrops are observed between the riverbed and the left bank.

The geology consists of the Pleistocene Binjai Unit which is made up of alternations of tuff and tuff breccia. There is a layer of hard tuff breccia near the confluence with a tributary on the right side about 250 m upstream of the dam site. This layer is considered to be part of the Plio-Pleistocene Mentar Unit, which is likely to run under the riverbed. The left bank is highly dissected, and there is an extensive terrace made of sand and gravel along the river.

(2) Namobatang Dam Site

This dam site in the upper reaches of the Deli River is located at a U-shaped valley opening toward the left bank. Relatively hard bedrock is observed on the right bank upstream of the dam axis and on the left bank downstream of the dam axis.

The site is composed of Pleistocene Toba Tuff and pyroclastic flow deposits. Toba Tuff, which contains lens-like pumice, is composed mainly of quartz, biotite, feldspar and volcanic glass. Outcrops near the banks are welded tuffs with well-developed cooling joints.

Underlying welded layers are relatively hard but permeable due to the cooling joints. Andesite and andesitic tuff breccia which are part of the Mentar Unit, are distributed under the Toba Tuff about 1.0 km upstream of the dam site. On both banks, there are terraces composed of sand and gravel.

(3) Lausimeme Dam Site

This dam site in the upper reaches of the Percut River has a V-shaped topography. On both sides, there are residual hills projecting from plateaus made of Toba Tuff. Hard bedrock with few cracks is almost continuously observed on the left bank, while it is sparsely distributed on the right bank.

The formation of the Plio-Pleistocene Mentar Unit at the site is composed of layers of andesitic tuff and tuff breccia. These layers occur alternately and partly sandwich pumice tuff breccia. The layers are distributed downstream of the site at a small angle of about 10°.

Toba Tuff covers the Mentar Unit distributed over an area extending about 600 to 700 m upstream and downstream of the dam axis. On both banks of the river, there are some terraces composed of sand and gravel.

(4) Beranti Dam Site

There is a flat plateau on either side of the Belumai River Basin. A scarp exists on either side of the river, and outcrops of sound bedrock are observed. On the right bank there is a scarp extending up to the hill side. There is a flatland at an elevation of about 165 m. On the left bank, continuous outcrops of sound bedrock are observed next to the flat land.

The layers forming scarps on the river banks are part of the Seureula Formation and are composed of rhythmic alternations of sandstone and mudstone. On the top face of the Seureula Formation, which is at an elevation of about 165 m, there is a flatland. At this elevation and above, observed is fine and hard dacite, which is similar to the one observed at the Buaya dam site and almost the same age as the Toba Tuff.

(4) Buaya Dam Site

There is a plateau with a flat top on either side of the Ular River, and the topography is a U-shaped valley open upwards. Some scarps exist on either bank in both upstream and downstream of the dam site, and the scarps expose hard bedrock. Soft bedrock is also exposed at some places on the left riverbed downstream of the dam site. Similar soft bedrock is also observed on the riverbed about 400 to 500 m upstream and downstream of the dam site.

The geology of the dam site consists of dacite formed during the same age as that of Pleistocene Toba Tuff. Dacite overlies layers of soft tuff, which extend almost horizontally, at a level lower than the riverbed. Dacite has mineralogical composition similar to that of Toba Tuff and constitutes fine and hard bedrock. The dacite layers overlie soft layers of tuff.

(6) Karai Dam Site

Topography of this dam site is similar to that of the Buaya dam site in the middle reaches of the Ular River. There are flat plateaus on both sides of the river, and the topography is a U-shaped valley open upwards. The condition of exposed rocks is not favorable since only small scarps are observed upstream and downstream of the dam site.

The geology consists of Pleistocene Toba Tuff. There is not a sufficient number of welded parts around the dam site, and gully erosion is often observed in the unwelded sections. On both sides of the river upstream and downstream of the dam site, there are some terraces made of sand and gravel.

(7) Sibakudu Dam Site

There is a flat plateau on either side in the upper reaches of the Belutu River, and the dam site shows the topography of a U-shaped valley open upwards. Outcrops are observed sparsely along the foot of the mountains.

The geology of the dam site consists of Pleistocene Toba Tuff. Outcrops observed around the dam site are not sound. Although welded rocks are observed at some places, the properties of bedrock distributed between the hillside and the summit are unknown. Layers of unwelded rocks are thick. On both sides of the river are extensive alluvial plains composed of sand and clay.

(8) Sampanan Dam Site

There is a flat plateau on the left side of the Padang River, and there is also a highly dissected, corrugated plateau. There is a continuous expanse of relatively hard bedrock between the riverbed and the right bank, while on the left bank, one is observed upstream and downstream of the dam site.

The geology consists of Pleistocene Toba Tuff. Toba Tuff which are observed between the riverbed and both banks, are relatively hard welded tuffs and have some cooling joints. A terrace made of sand and gravel is observed on the right bank downstream of the dam site, and there is also a small terrace on the left bank downstream of the dam site.

3.4.3 Comparison of Planned Dams

Eight (8) dams are planned at the eight (8) possible dam sites mentioned before. The topographic features and economic aspect of each site have been comparatively studied, assuming that a rockfill dam is employed on account of adaptability for various geological conditions of dam foundation, although a concrete gravity type of dam may be more economical when dam height is low and the purpose is exclusively for flood control.

The results of the comparative study on condition that each dam reservoir is planned to be annually recovered to full capacity are summarized in Table 3-10. From the ratio of estimated construction cost per annually secured effective storage capacity presented in the far right column of Table 3-10, a relatively economical dam construction is expected in the river system of Ular, Belutu and Padang, although these dam sites are located far from Medan. Among the dam sites near Medan, Lausimeme in the Percut River and Namobatang in the Deli River are considered to be promising dam sites from the economical viewpoint of reservoir storage efficiency.

CHAPTER 4. MASTER PLAN

4.1 Flood Control Plan

4.1.1 Flood Control Method

Project Scale and Target Area

(1) Project Scale

The project scale for flood control is proposed to be a 50-year return period for six (6) rivers, namely Belawan, Percut, Serdang, Ular, Belutu and Padang. The project scale is bigger for the Deli River, i.e., 100-year return period, in consideration that the river passes through Medan City. However, as discussed later, a floodway which diverts a part of the flood discharge of Deli River to the Percut River is proposed to be the optimum flood control method. Therefore, the project scale of Percut River flood control shall be upgraded to a 100-year return period, since both Deli and Percut rivers are to be defined as one river system with the construction of a floodway.

(2) Target Area

The target stretch for river improvement is determined based on the inundation area caused by an overbank flow of approximately a 100-year return period flood. The present flow capacity, present land use and future development plan are considered as well. The following table shows the target river improvement stretches.

River Improvement Stretch

Stretch	River Length (km)		Improvement
1.	Belawan	15 km upstream of river mouth to crossing with national road	21.7
2.	Deli	River mouth to Titi Kuning	37.4
3.	Percut	River mouth to Tembakau	28.0
4.	Serdang		
	(a) Serdang and Belumai	River mouth to Bandar Labuhan	16.5
	(b) Batugingging	Confluence with Belumai River to crossing with national road	8.9
5.	Ular	River mouth to Pulau Tagor	31.8
6.	Belutu	River mouth to Bakaran Batu	32.7
7.	Padang	River mouth to confluence with Sibarau River	29.5

Standard Project Flood

The standard project flood to formulate the Master Plan is the discharge corresponding to the project scale, i.e., 100-year return period for Deli River and Percut River, and 50-year return period for the other five (5) rivers.

Possible Flood Control Structure

Depending upon topographical and geological conditions and the hydrology of the rivers, the following structural measures are applicable for the respective rivers.

(1) River Improvement

River improvement works such as diking and channel normalization are the direct measures for confining floods in the river channel.

(2) Floodway

A floodway or diversion channel is generally difficult to apply to the rivers in the study area, because all the rivers flow rather in parallel with each other in the north direction. However, it is possible to divert the flood discharge from a river in an urban area to a river in a rural area in consideration of economical construction and the social problems in land acquisition for river improvement.

(3) Retarding Basin

Some possible sites for the construction of a retarding basin are identified on four (4) rivers, namely Belawan, Serdang, Belutu and Padang. However, these sites are usually utilized as paddy or plantation, so that the construction of a retarding basin will be rather costly.

(4) Dam

As described in Section 3.4, eight (8) possible dam sites are identified in the upper reaches of each river (Ular River has two dam sites on its two major tributaries). Although the efficiency in controlling floods depends on the location of the dam, dam construction is more advantageous due to the possibility of multiple uses with water supply, etc.

4.1.2 Optimum Flood Control Plan

In the Master Plan Study, the optimum combination of structural measures for flood control is selected from the technical and economical aspects. River improvement is examined for all objective rivers and the application of floodway from Deli River to Percut River is investigated. Then, comparison between dam and retarding basin is made and finally, the combination of dam and river improvement is compared.

<u>River Improvement Plan</u>

River improvement to confine the standard project flood in the river channel is proposed, based on the Japanese criteria entitled "Manual for River Works in Japan (Draft)" prepared by the Ministry of Construction of Japan.

Alignment of the river course is designed to have less meandering so as to maintain the design high water level which is set at the same level as the ground elevation or the existing dike. The design riverbed longitudinal profile is fixed to the average of the existing one.

A wide and compound cross section with flood channel and low water channel is principally employed. A single cross section is adopted for river stretches in residential/urban areas.

Earth embankment is, in principle, adopted, although revetment of wet masonry is provided for meandering river sections with bank slope steeper than 1:2.

Due to the topographic condition of river basins, namely (1) the lower reaches are rather flat and rivers are shallow; and, (2) the middle and upper reaches are steep and rivers are deep, the river improvement plan is so prepared that the lower section is a wide and compound one and the middle section is a rather narrow and single one.

(1) Belawan River

The proposed dike is aligned to envelop meandering sections. Therefore, the proposed cross sections are generally compound types. A single cross section is employed for a deep channel portion in the middle reaches.

Plan and typical cross sections are shown in Fig. 4-1 and a longitudinal profile is in Fig. 4-2.

(2) Deli and Percut Rivers

Due to the difficulty of land acquisition, a single cross section is employed for the proposed improvement stretch of Deli River. For the Percut River, a compound cross section is applied from the river mouth to Bandar Setia (PE.11) and a single cross section is for the upper stretch.

Plan and typical cross sections are shown in Fig. 4-3 and a longitudinal profile is in Fig. 4-4.

(3) Serdang River

A compound cross section is employed for the mainstream of Serdang River and a tributary, Batugingging River. Belumai River, another tributary, is proposed to be a single cross section since the existing river channel is steep and deep.

Plan and typical cross sections are shown in Fig. 4-5 and a longitudinal profile is in Fig. 4-6.

(4) Ular River

Widening of low flow channel is the only practical means to increase flow capacity of the improved channel. Plan and typical cross sections are shown in Fig. 4-7 and a longitudinal profile is in Fig. 4-8.

(5) Belutu River

The proposed dike is aligned to envelop meandering sections for the lowest stretch from the river mouth to Tanjung Bringin (BE.9). Therefore, a compound cross section is applied to this stretch and the upstream stretch from the confluence with the Rambung River. Plan and typical cross sections are shown in Fig. 4-9 and a longitudinal profile is in Fig. 4-10.

(6) Padang River

From the national road (PA.24) through Tebing Tinggi, a single cross section is employed. Plan and typical cross sections are shown in Fig. 4-11 and a longitudinal profile is in Fig.4-12.

Construction of Floodway

Construction of a floodway from the Deli River to the Percut River is identified to be possible on account of the topographic condition and land use along and around the said two (2) rivers. The possible route is selected in the upstream area of Medan as plotted in Fig. 4-3. In order to justify the application of a floodway, the comparison of construction cost of river improvement only and of river improvement with floodway is carried out. The planning conditions for floodway are the same as those for the river improvement.

The construction costs for both river improvement only and river improvement with floodway are estimated, as shown in Fig. 4-13. The construction costs show that river improvement with floodway is economical when the discharge at Helvetia is more than 500 m^3/s.

Construction of Flood Control Dam

For the eight (8) dam sites identified in the upper reaches of the respective rivers, a flood control function is estimated assuming dam type to be a concrete gravity dam with gated spillway.

Flood control capacity is computed applying the maximum reduction rate of 80% to inflow discharge. Other planning conditions are as follows:

(a) Sedimentation is assumed to be horizontal level with the sediment volume for 100 years.

(b) Design discharge for a spillway is estimated based on the flood discharge of a 200-year return period.

(c) Seismic coefficient is 0.12.

The catchment area of Lausimeme Dam only occupies more than 50% of that at a flood control reference point, while Buaya and Karai dams, if they are combined, occupy more than 90%.

Optimum Flood Control Plan

(1) Comparison between Dam and Retarding Basin

The selection of appropriate flood control plan between dam and retarding basin is carried out in accordance with the index of required construction cost for unit flood mitigation effect as expressed in the following equation (refer to Table 4-1).

$$\text{Index} = \frac{\text{Required Construction Cost (Million Rp.)}}{\text{Flood Regulation Effect at Reference Point } (m^3/s)}$$

The comparative study shows that the dam is economically more advantageous than the retarding basin.

(2) Comparison between Dam and River Improvement

The construction costs of river improvement and dam applied singly or in combination with each other are compared. The results of the comparison show that the river improvement with dam construction is economical for Deli and Percut rivers, while dam construction only is economical for Ular River and river improvement only is economical for the other rivers, as shown in Fig. 4-14.

In accordance with the results of the foregoing comparative studies, the optimum flood control plans for each river are summarized as follows (refer to Fig. 4-15 for the design discharge):

Optimum Flood Control Plans

	River	Optimum Flood Control Facilities	Remarks
1.	Belawan	River Improvement (21.7 km)	
2.	Deli-Percut	River Improvement (37.4 km), Floodway (3.8 km) and Namobatang Dam	Deli River
		River Improvement (28.0 km) and Lausimeme Dam	Percut River
3.	Serdang	River Improvement (25.4 km)	
4.	Ular	Karai Dam	
5.	Belutu	River Improvement (32.7 km)	
6.	Padang	River Improvement (30.0 km)	

4.2 Water Supply Plan

4.2.1 Projection of Future Water Demand

Population Projection

Population projections are made at an interval of five (5) years for the period from 1995-2010, for each region of Kab. Deli Serdang, Kodya. Medan, Kodya. Tebing Tinggi, Kab. Simalungan (only the seven kecamatans mentioned before) and the study area as a whole. Three (3) cases are assumed, as discussed in the Supporting Report on Socioeconomy.

In accordance with the three cases, the future population in the study area is estimated at the interval of five years for the period of 1995- 2010 as shown in Table 4-2, and the population forecast in 2010 is as summarized in the following table.

Population Forecast in 2010 (thousands)

Region	Case 1	Case 2	Case 3
Study Area	5,681	5,811	5,300
Kab. Deli Serdang	2,626	2,671	2,434
Kodya. Medan	2,680	2,725	2,485
Kodya. Tebing Tinggi	173	188	171
Kab. Simalungan*	202	227	207

* Seven kecamatans in the study area.

According to Case 1, the 2010 population is estimated at 5,681 thousand for the study area as a whole, 2,627 thousand for Kab. Deli Serdang and 2,680 thousand for Kodya. Medan. These populations indicate the increase of 57%, 64% and 55% against the 1990 populations, respectively.

Municipal Water Demand

The future demand for municipal water is computed on the basis of the standards and targets of Cipta Karya in Repelita V as follows:

Future Demand for Municipal Water

Particulars	1990		2000		2010	
	Urban	Rural	Urban	Rural	Urban	Rural
Service Ratio (%)	75	60	80	70	85	80
Per Capita Consumption (l/d/p)	130	30	140	40	150	50
Ratio of Non-Domestic Use to Domestic Use (%)	40	10	40	10	40	10
Unaccounted Water Loss (%)	25	5	22	5	20	5

The future municipal/domestic water demand in both Medan and Tebing Tinggi cities and in each river basin in 2010 are computed as shown in the following table.

Municipal/Domestic Water Demand in 2010

City/River Basin	Population (person: thousand)	Water Demand (m^3/d)
Medan City	2,679	597,723
Tebing Tinggi City	173	38,639
Belawan River Basin	536	24,811
Deli River Basin	112	5,177
Percut River Basin	417	19,322
Serdang River Basin	481	22,264
Ular River Basin	586	27,117
Belutu River Basin	360	16,675
Padang River Basin	261	12,074
Total	5,605	763,802

Irrigation Water Demand

The future demand for irrigation water is estimated on the assumption that the technical level of irrigation practice is upgraded in rank, i.e., simple and rainfed irrigation area will become semi-technical and semi-technical will become technical. The swampy area is also assumed to become a semi-technical irrigation area. These changes in irrigation area and the water demand in each river basin are as follows:

Changes in Irrigation Area and Water Demand

River Basin	Irrigation Area (ha)		Water Demand (MCM/yr)	
	1990	2010	1990	2010
Belawan	8,242	14,492	35.3	149.5
Deli	4,940	4,940	44.1	63.9
Percut	5,356	6,451	30.0	59.4
Serdang	14,879	15,755	84.2	161.2
Ular	24,296	24,296	349.8	355.0
Belutu	11,398	16,368	79.9	180.5
Padang	9,255	17,655	31.8	195.7
Total	78,366	100,407	655.1	1,165.2

River Maintenance Flow

River maintenance flow is proposed at the maximum specific discharge of 0.01 $m^3/s/km^2$, or a low flow discharge in the drought year of a 10-year return period under the present condition of water use. The river maintenance flow of each river at its lowest point is determined as follows:

River Maintenance Flow

River	Catchment Area (km^2)	Maintenance Flow (m^3/s)	Remarks
Belawan	647	5.2	10-yr return period
Deli	358	2.9	10-yr return period
Percut	186	1.5	10-yr return period
Serdang	671	4.9	10-yr return period
Ular	1,081	10.8	Specific Discharge
Belutu	500	4.9	10-yr return period
Padang	919	9.2	Specific Discharge

4.2.2 Optimum Water Supply Plan

Project Scale and Target Area

(1) Project Scale

The project scale of a water supply plan is, in general, based on the recurrence probability of drought. Compared with the irrigation water supply, the allowable limit of water shortage for domestic water supply is more strict. To simplify the water balance analysis, the design drought of 10-year return period is adopted for both domestic and irrigation water supply.

(2) Target Area

As mentioned before, the target area for the water supply plan with river surface flow is limited to only Medan City and six (6) kecamatans (hereinafter called as Medan Area) under PDAM Medan (except Kec. Sibolangit), and Tebing Tinggi City. Kecamatan capitals where the demand for domestic water is small are excluded from the target area of the water supply plan since groundwater utilization by means of deep well is more economical and easier than river surface flow.

Possible Water Resource Structures

Through the water balance study, Serdang, Ular and Padang rivers have surplus water, while the other rivers are in shortage even only to fulfill the present demand. The surplus water of Serdang, Ular and Padang rivers is estimated at 5.7 m^3/s, 11.2 m^3/s and 18.0 m^3/s, respectively, at the lowest point of each river in the second droughtest year for 20 years from 1969 to 1988. Since Padang River is located farthest from Medan City, transbasin water diversion from the Padang River to Medan City is less economical compared with Ular and Serdang.

Therefore, two (2) routes of transbasin water diversion by aqueduct are planned as shown in Fig. 4-16. One route is 9.0 km from Sinembah on the Belumai River and the other is 30.5 km from Pulau Tagor on the Ular River.

As for the reservoirs, only three (3) dams; namely, Tembengan on the Belawan River, Namobatang on the Deli River and Lausimeme on the Percut River are potential sources to supply water to Medan Area. Summarizing the water resource structures such as aqueducts and dams, the following are technically and economically viable to ensure municipal water supply for Medan Area:

Feasible Water Resource Structures

Water Resources Facility	Dimension	Newly Developed Supply Capacity (m^3/s)
Tembengan Dam	Storage Capacity = 21.0 MCM	2.5 (216,000)*1
Namobatang Dam	Storage Capacity = 11.0 MCM	1.65 (142,500)*1
Lausimeme Dam	Storage Capacity = 29.5 MCM	3.7 (319,680)
Belumai Aqueduct*2	Length = 5.5 km Diameter = 1,500 mm	2.6 (224,640)
Ular Aqueduct*2	Length = 27.0 km Diameter = 2,000 mm	6.1 (527,040)

Note: Figures in parentheses are in m^3/d.
*1: Figure presents excludes the existing supply capacity.
*2: Longitudinal profiles of aqueducts are shown in Fig. 4-17.

Optimum Combination of Structures

The municipal water demand of 21,300 m^3/d in Tebing Tinggi City in the target year 2010 will be fully supplied by the surface flow of the Padang River. That in Medan Area of approx. 770,000 m^3/d will be assured mostly by new water sources such as reservoirs and aqueduct/transbasin diversion. Since about 60,000 m^3/d will be supplied from groundwater by means of springs and deep wells, 710,000 m^3/d has to come from the new water sources.

To select the appropriate facilities among the alternative water sources, cost efficiency of the facilities is examined, as follows:

Cost Efficiency Analysis

Water Resources Facility	Newly Developed Supply Capacity (MCM/yr)	Construction Cost (mil. Rp)	Cost Efficiency ($Rp/m^3/yr$)
Tembengan Dam	79	90,000	1,139
Namobatang Dam	52	46,000	885
Lausimeme Dam	117	124,700	1,066
Belumai Aqueduct	82	39,200	478
Ular Aqueduct	192	207,100	1,079

From the estimated cost efficiency of the structures, the following three (3) structures are proposed to fill the municipal water demand in Medan Area:

(a) Lausimeme Dam
(b) Namobatang Dam
(c) Belumai Aqueduct

With the said three (3) structures, the future demand for municipal water in Medan Area in the target year 2010 will be fully met. The water supply program is proposed, as shown in Fig. 4-18, taking the following conditions into consideration:

(a) Period and volume of water shortage are to be minimized.

(b) Surplus in supplying capacity is also to be minimized.

(c) Consumption of irrigation water is to be decreased in the program, since the present water supply by taking in surface water of both Belawan and Deli rivers consumes the irrigation demand in the downstream.

(d) Number of people to be affected by the project are to be minimized.

4.3 Framework of the Master Plan

4.3.1 Overall Scheme

Multipurpose Development

In Sections 4.1 and 4.2, the flood control and water supply plans are formulated at the target year of 2010. Structures and facilities are incorporated in the respective plans and there are facilities to be commonly utilized in both plans. Therefore, a multipurpose plan is considered in the master plan to achieve harmonious development for the seven (7) river basins from the economic, social and technical point of view.

Among the structures considered in both plans, the Namobatang and Lausimeme dams are to be utilized for flood control and water supply to Medan Area. The capacity and construction cost allotted for the respective purposes are estimated as follows:

Reservoir Capacity and Construction Cost

Name of Dam	Flood Control		Water Supply		Integrated Plan	
	Capacity (MCM) *1	Const. Cost (mil.Rp)	Capacity (MCM) *2	Const. Cost (mil.Rp)	Capacity (MCM) *2	Const. Cost (mil.Rp)
Namobatang	2.60	23,339	11.00	46,035	14.60	63,554
Lausimeme	2.80	21,182	29.50	124,652	33.40	141,344

Note: *1 presents the flood control capacity by applying gated spillway.
*2 presents the flood control capacity by applying non-gated spillway.

As shown in the above table, the total construction cost if both the flood control and water supply plans are integrated amounts to Rp. 63,554 million for Namobatang Dam and Rp. 141,344 million for Lausimeme Dam. Since the construction cost is reduced by 8 to 10% by integrating the plans, the proposed dams are to have the multiple functions of flood control and water supply.

Target Year

As determined for the flood control and water supply plans, the target year of completion for the master plan is proposed to be the year 2010. The project life of dams, floodway and river improvement is 50 years and that for the aqueduct is 40 years after completion.

Project Component

The master plan of integrated river basin development is composed of the following components for each river basin. Their locations are given in Fig. 4-19.

(1) Belawan River

Only river improvement on a stretch of 21.7 km will be carried out to confine the design flood discharge of 550 m^3/s at Lalang, corresponding to a 50-year return period.

(2) Deli-Percut River

A stretch of 37.4 km on the Deli River will be improved to confine the flood discharge of 460 m^3/s at Helvetia. A 3.8 km floodway (named as Medan Floodway) will be constructed to divert a part of the flood discharge of 120 m^3/s from Titi Kuning in Deli River to Tembakau in Percut River. Namobatang Dam will be constructed to regulate the flood discharge from 250 m^3/s to 50 m^3/s at the dam site and to supply municipal water of 2,000 l/s to Medan Area. Percut River will be additionally improved to confine the discharge diverted through the floodway.

River improvement on a stretch of 28.0 km of the Percut River will be carried out with the design discharge of 300 m^3/s including the diverted discharge of 120 m^3/s through the floodway. Lausimeme Dam will be constructed to regulate the flood discharge of 280 m^3/s down to 60 m^3/s and to supply municipal water of 3,700 l/s to Medan Area.

(3) Serdang River

Only river improvement on a total stretch of 25.4 km including those of the tributaries Belumai and Batugingging will be carried out to confine the design discharges of 850 m^3/s, 330 m^3/s and 480 m^3/s at Baru (Serdang River), Buntu (Belumai River) and Gang Melaya (Batugingging River), each of which corresponds to a 50-year return period flood.

A 5.5 km aqueduct, namely the Belumai Aqueduct, will be constructed starting at Sinembah on Belumai River to Deli Tua to transmit municipal water of 2,600 l/s to Medan Area.

(4) Ular River

To upgrade the flood control level, Karai Dam will be constructed to regulate the flood discharge of 500 m^3/s down to 300 m^3/s at the dam site. As a result, the flood discharge of 970 m^3/s at Pulau Tagor, which corresponds to a 50-year return period, will be controlled.

(5) Belutu River

Only river improvement on a stretch of 32.7 km will be carried out with the design discharge of 340 m^3/s at Sei Rampah corresponding to a 50-year return period.

(6) Padang River

Only river improvement on a stretch of 29.5 km will be carried out with the design discharge of 840 m^3/s at Brohol corresponding to a 50-year return period.

4.3.2 Implementation Schedule

The implementation schedule of the master plan is prepared by placing higher priority on components which can satisfy the following conditions:

(a) Urgency in implementation to mitigate the flood damage and to meet the water demand;

(b) Higher economic efficiency is expected with the implementation; and

(c) The plan will serve to continue and strengthen the existing or ongoing projects of the Indonesian Government.

Among the flood control projects covering all six river systems, the first priority is to be put on the implementation of the project components in the Deli-Percut River System. The Padang River is to be taken as the second priority, because Tebing Tinggi has been frequently hit by floods. Since rehabilitation of the dike along the Serdang River has already been carried out by DPUP, the river improvement of Serdang River is to be taken as the third priority for implementation.

Following the above three (3) priorities, the Belutu River has to be improved in consideration that the river has only a small flow capacity. The implementation of flood control works on the Belawan and Ular rivers are to have lower priority than the others, because the flow capacity of these rivers corresponds to a 10-year and a 20-year return period, respectively.

The construction of flood control works is scheduled aiming at completion in the year 2010, as follows:

Construction Schedule

Project Area	Construction Period	
	Year	Period
1. Belawan River	3	2008 - 2010
2. Deli-Percut River	10	1995 - 2004
3. Serdang River	5	2003 - 2007
4. Ular River	3	2008 - 2010
5. Belutu River	5	2006 - 2010
6. Padang River	7	1996 - 2002

A water supply project consisting of the construction of Namobatang Dam, Lausimeme Dam and Belumai Aqueduct is planned to meet the demand of domestic water in Medan Area at 2010.

Among the components of the water supply plan, the construction of Lausimeme Dam is the most urgent to meet the present demand of municipal water in Medan Area. Consecutively, the Namobatang Dam will be constructed to meet the future water demand, and the Belumai Aqueduct is to follow.

Construction of the water supply structures is scheduled as follows, where the economic life of each facility is assumed to be 50 years after completion of the construction work.

Schedule of Water Supply Structures

Project	Construction Period	
	Year	Period
1. Namobatang Dam	4	2001 - 2004
2. Lausimeme Dam	4	1995 - 1998
3. Belumai Aqueduct	5	2003 - 2007

Based on the prioritization made above, the implementation program of the master plan is proposed in consideration of the construction periods of the respective project components, as presented in Fig. 4-20.

4.3.3 Cost Estimate

Project cost is estimated under the following conditions:

(1) Price level is as of September 1991.

(2) Price escalation and physical contingency are assumed as follows:

(a) Annual Price Escalation : 8% for Local Currency Component

(b) Physical Contingency : 10% for Construction Cost and Engineering Service Cost

(3) Currency Conversion Rate is assumed at US$1.00 = ¥136 = Rp. 1,950.

(4) Compensation Cost consisting of house evacuation and land acquisition is estimated on the basis of the data obtained from Medan City.

(5) Administration Cost is estimated at 7% of the total Construction Cost.

The summary of project cost is shown in the following table. The disbursement schedule is shown in Table 4-3.

Summary of Project Cost

	Name of River/ Work Item	Const. Base Cost	Adm.	E/S	Comp.	P.Conti.	Total
1.	Belawan River						31,261
	- RiverImprovement	20,960	1,467	3,144	2,848	2,842	31,261
2.	Deli-Percut River						403,130
	- Deli Improvement	76,652	5,366	11,498	14,310	10,782	118,608
	- Namobatang Dam	42,401	2,968	10,288	2,120	5,777	63,554
	- Medan Floodway	21,380	1,497	3,207	3,039	2,912	32,035
	- Percut Improvement	29,003	2,030	4,350	7,880	4,326	47,589
	- Lausimeme Dam	102,234	7,156	16,861	2,244	12,849	141,344
3.	Serdang River						153,850
	- River Improvement	68,752	4,813	10,313	20,372	10,425	114,675
	- Belumai Aqueduct	28,782	2,015	4,317	499	3,562	39,175
4.	Ular River						16,076
	- Karai Dam	8,977	628	4,309	700	1,462	16,076
5.	Belutu River						56,401
	- River Improvement	34,897	2,443	5,235	8,699	5,127	56,401
6.	Padang River						100,544
	- River Improvement	69,792	4,885	10,469	6,257	9,141	100,544
	Total	503,830	35,268	83,991	68,968	69,205	761,262

Adm. : Administration Cost is 7% of construction base cost.
E/S : Cost for Engineering Services
Comp. : Compensation Cost
P. Conti. : Physical Contingency

4.4 Project Evaluation

4.4.1 Economic Evaluation

The economic evaluation in the master plan study aims at finding out an optimum plan for the flood control and water supply plans from the economic viewpoint. The evaluation process is as follows:

(a) To conduct economic cost-benefit analysis for each flood control plan by design-flood discharge and water supply plan;

(b) To provide some alternative plans in terms of combined projects based on result of the analysis above;

(c) To conduct the economic analysis for an optimum plan out of some alternatives in (b) above.

The evaluation is conducted by usual means of Economic Internal Rate of Return (EIRR), Net Present Value (NPV) and Benefit-Cost Ratio (B/C) by using economic cost and benefit of the project. The economic cost and benefit are converted from financial cost and benefit of the project under the following conditions and assumptions:

(a) Transfer payments such as taxes and duties are assumed to be 10% of market prices of goods and services procured locally, and to be exempted from duties for commodities imported from abroad;

(b) Standard conversion rate to be applied for local commodities and services is approximately assumed to be 90% of the local prices, based on export and import statistics in recent years;

(c) Economic wage of unskilled laborers employed for construction works of the project is assumed to be 80% of the actual market wage, taking account of the employment opportunity of laborers in Indonesia.

(d) Economic cost of land compensation is assumed to be 80% of the actual payment, taking account of the opportunity cost of land.

Project life is economically taken as 50 years after completion of the construction works, and the project benefit together with operating, maintenance and replacement cost (OMR cost) is assumed to occur throughout the project life.

Flood Control Plan

(1) Economic Cost

The project cost consists of the construction cost and the OMR cost. Annual flows of these economic costs are given in Table 4-5, under the said conditions and assumptions, and the total cost is summarized as follows:

Total Economic Construction Cost (Million Rp.)

Flood Control Project	Return Period (Year)				
	10	20	30	50	100
1. Belawan R.	17,804	22,820	26,097	29,385	-
2. Deli-Percut R.	152,302	185,910	196,644	207,997	225,297
3. Serdang R.	88,974	95,532	100,351	106,131	-
4. Ular R.	-	4,686	14,179	15,125	-
5. Belutu R.	45,047	47,768	49,589	52,376	-
6. Padang R.	69,077	80,477	86,914	94,932	-

Economic Annual OMR Cost (Million Rp.)

Flood Control Project	Return Period (Year)				
	10	20	30	50	100
1. Belawan R.	127	159	179	200	-
2. Deli-Percut R.	996	1,212	1,260	1,334	1,413
3. Serdang R.	534	582	617	657	-
4. Ular R.	-	35	79	84	-
5. Belutu R.	279	299	312	333	-
6. Padang R.	474	559	607	666	-

Where, the average annual OMR cost is assumed to be 1% of the direct construction cost and to accrue every year throughout the period of project life. The partial OMR cost before completion of the project is given in proportion to progress of the construction work.

(2) Economic Benefit

Economic benefit of the flood control project is represented as an effect of reduction in the flood damage to assets, agricultural crops, and economic activities in the river basin. Accordingly, the average annual damage shown in Section 3.1 will be given as an average annual benefit of the flood control project after completion of the construction work.

The project benefit will accrue every year throughout the period of project life. The partial benefit before completion of the project is assumed to accrue in proportion to progress of the construction and is approximately given in a ratio of the invested construction cost to the total construction cost.

(3) Cost-Benefit Analysis

Results of cost-benefit analysis by design flood discharge for each flood control project are given by means of the Economic Internal Rate of Return (EIRR), Net Present Value (NPV) and Benefit-Cost Ratio (B/C) as shown in Table 4-5, and the EIRR are summarized below:

Economic Internal Rate of Return (%)

Return Period (Year)	Belawan River (1)	Deli-Percut River (2)	Serdang River (3)	Ular River (4)	Belutu River (5)	Padang River (6)
10	-	20.03	11.02	-	2.94	11.54
20	0.84	18.49	11.20	8.79	3.14	10.82
30	1.20	18.09	10.96	6.54	3.12	10.36
50	1.33	17.66	10.59	8.92	2.95	9.66
100	-	16.80	-	-	-	-

Of six flood control projects, the three river projects of Deli- Percut, Padang and Serdang are estimated to be the EIRR of over 10% for design flood discharge with return periods from 10 years to 30 years. This shows that the said three flood control projects are feasible economically, and among them the Deli-Percut river system project has the highest economic feasibility.

An optimum plan of integrated flood control for the Deli-Percut river system and other six river basins is formulated from the technical viewpoint, taking account of the above result of economic analysis for each river.

In the above plan, the return period of design flood discharge is taken as 100 years for the Deli-Percut river system project and 50 years for other river basin projects. Estimates of the economic cost and benefit for this plan are made under the same assumptions and conditions as those of the respective river projects mentioned above. The annual flow of the cost and benefit is given in Table 4-6.

The result of cost-benefit analysis under the above-mentioned conditions indicates the EIRR of 13.92% at the discount rate of 12%, the B/C of 1.15 and the NPV of Rp. 34,455 million. This shows that this project is economically feasible. Details are given in Table 4-7.

Water Supply

Economic evaluation of the water supply project is generally made by comparing the economic benefit expected by supplying the domestic water with the total economic cost of construction and OMR of facilities required from production to supply of the domestic water. However, the present plan excludes the construction of treatment plants and distribution system. Accordingly, the economic evaluation in the present study is carried out by making a comparison between economic benefit and cost of water production at the water sources. A water supply project which consists of constructions of Namobatang Dam, Lausimeme Dam and Belumai Aqueduct is planned to meet the demand of domestic water in Medan at 2010.

(1) Economic Cost

The economic cost of construction and OMR for the water supply project is converted from the financial cost of the project under the same assumptions and conditions as those of the above-mentioned flood control project. Annual flow of the economic construction cost is given in Table 4-4, and the total construction cost together with the annual OMR cost is summarized below:

Economic Construction and OMR Costs (Million Rp.)

Project	Total Cost of Construction	Annual Cost of OMR
1. Namobatang Dam	43,683	294
2. Lausimeme Dam	118,281	890
3. Belumai Aqueduct	37,465	829
Total	199,429	2,013

(2) Economic Benefit

Economic benefit of the water supply project is given by multiplying the effective water quantity by the economic unit price of water.

The water supply project is only the construction of two dams and one aqueduct, excluding construction of water supply facilities such as water treatment plant, transmission and distribution pipes and other facilities connected to users. Therefore, the price and production of water at the water sources are adopted as the basic values for estimating the economic benefit.

According to similar water supply projects in Indonesia in recent years, the producer price of water at dam site ranges from Rp. 25/m3 to Rp. 45/m3. In the present study, the water price in the water source is assumed to be Rp. 50/m3 in 1993, in consideration of the above-mentioned water price at the existing some dam sites together with economic condition such as the growth rate of GRDP in recent years in Medan and the current water tariff of the PDAM Tirtanadi.

In estimating the future economic benefit of the water supply project, the said water price is assumed to rise in proportion to a growth rate of the GRDP in Medan under the following conditions:

(a) To set an average real growth rate of 5% per annum for the GRDP in Medan, taking the recent growth rate into account.

(b) To revise the water price at 5-year interval, taking account of time interval of change in the water supply tariff of PDAMs and BPAMs in Indonesia.

(c) To apply an average water price at interval of 5-year in estimating the water supply benefit, under the conditions (a) and (b) above.

On the other hand, the water quantities supplied at Lausimeme dam, Namobatang dam and Belumai aqueduct are estimated at 3,700 l/s, 2,000 l/s and 2,600 l/s, respectively. Under above-mentioned conditions and assumptions on the water price and quantity, an average annual benefit of the water supply project is estimated for each of the said three facilities as shown in Table 4-8. These benefits are expected to accrue every year throughout the period of project life after completion of the construction works.

(3) Cost-Benefit Analysis

A cost-benefit analysis is conducted in the same method as that of the flood control project by using the annual flows of economic cost and benefit shown in Table 4-6. The result is given in Tables 4-5 and 4-7, and the EIRR is summarized below:

EIRR of Water Supply Project

Project	EIRR (%)
1. Lausimeme Dam	9.69
2. Namobatang Dam	12.12
3. Belumai Aqueduct	14.77
4. Whole Project of Water Supply	10.70

In the estimation of EIRR, Lausimeme Dam, Namobatang Dam and Belumai Aqueduct are taken as individual projects without phasing under the whole construction schedule of the water supply project described above. As for the whole project of water supply, the construction schedule is taken into consideration.

The above results indicate fairly high figures compared with those of similar domestic water supply projects. This means that these projects are economically feasible.

Integrated Project of Flood Control and Water Supply

In case of an integrated plan where both flood control and water supply projects are combined, the integrated project cost with regard to the Deli-Percut river system will be somewhat reduced compared with a simple sum of costs of two independent projects of flood control and water supply, because it is possible to share a part of facilities with each other. The reduced economic cost is estimated at Rp. 9,310 million in the total construction cost with the return period of 100-year and Rp. 28 million in the average annual OMR cost.

As for other projects of flood control and water supply, the construction and OMR costs in case of the integrated project are the same as the respective costs of the individual projects. On the other hand, the economic benefit of the integrated project is given as a simple sum of both economic benefits of the flood control and water supply projects.

An economic analysis for the integrated project of flood control and water supply is made in regard to the design flood discharges with return period of 100-year for the Deli-Percut river system and with the return period of 50-year for other river basins. The annual flows of economic cost and benefit are provided in accordance with the said construction schedule of the whole plan (See Table 4-6). The result is given in Table 4-7, and the EIRR is as follows:

EIRR of the Integrated Project

Project	EIRR (%)
1. Deli-Percut River System	13.55
2. Whole River Basins	12.52

The above results show that both the integrated project in the Deli- Percut River System and the integrated project in the whole river basins are economically feasible.

4.4.2 Social and Environmental Impacts

All the proposed facilities and river improvement works will not affect natural conservation areas designated by the national and provincial governments. Reservoir areas of both the Lausimeme and Namobatang dams are not used for productive activities such as paddy, plantation, etc., but covered with bushes. Few residents are found in the areas. The river improvement plan is also proposed minimizing houses to be evacuated and land to be acquired.

Generally, the study area is covered with small range of vegetation and provided with few kinds of wildlife due to the widely developed plantations. Therefore, the realization of the master plan will have a little impact on natural environment in the study area.

On the other hand, the implementation of the project will have the following natural and social advantages which could not be evaluated in monetary terms:

(a) Mitigation of flood damage will enhance economic activities and bring about hygienic living conditions;

(b) Piped water supply system will prevent the outbreak of water- borne diseases; and

(c) Assurance of river maintenance flow of the rivers will improve river water quality and the scenic view around the river channels.

4.4.3 Selection of the Urgent Project

Through the priorities and implementation schedule discussed in Section 4.3, the areas or projects for the feasibility study are selected. Since it is justifiable to complete the urgent projects within the maximum expanse of 10 years, the areas or projects having the implementation period of 10 years as included in the program are selected, as follows:

(a) Deli River Improvement
(b) Percut River Improvement
(c) Construction of Floodway
(d) Construction of Lausimeme Dam
(e) Padang River Improvement

CHAPTER 5. URGENT PLAN

5.1 Project Formulation

5.1.1 Project Scale and Target Year

Flood Control

The proposed design flood discharge for the urgent project is presented in Fig. 5-1.

(1) Deli-Percut River

The urgent project is formulated at the scale of a 30-year return period in view of the following reasons.

(a) Ular River which runs through the agricultural area, has already been improved with a design discharge of 800 m^3/s which corresponds to almost a 20-year return period flood. It is then reasonable that the project scale for the Deli and Percut rivers which run in the urban area of Medan City and its vicinity with a population of more than 1,700 thousand be set greater than a 20-year return period.

(b) According to the economic analysis in the master plan study, the highest Economic Internal Rate of Return (EIRR) is expected at a 10-year return period for the Deli-Percut River. High EIRRs greater than 15% are expected even if a 30-year return period is employed as the project scale.

(2) Padang River

A 10-year return period with the highest EIRR of 11.54% is proposed for the urgent project scale. The project scale of a 10-year return period is the minimum requirement for flood control in the study area.

Water Supply

The project scale of the water supply plan is defined by the recurrence probability of drought. In the master plan, the design drought of 10-year return period is adopted for both domestic and irrigation water supply. In detail, a 5-day mean discharge for 10 years shall not fail to meet the requirement of both domestic and irrigation water demand. Therefore, water resource structures will be constructed to cope with the said requirement when existing water sources such as surface and groundwater are available.

Target Year

The target year of the urgent project is proposed as the year 2000 considering a total of 10 years for implementation.

5.1.2 Project Works

The design flood discharges of the Deli and the Percut river improvement works in the urgent plan are almost equivalent to those in the master plan. Since it is economically advantageous to pursue the improvement works with the design flood discharge of the master plan, the project works for urgent projects are proposed as follows:

(1)	Deli River Improvement	:	37.4 km in length; design discharge = 460 m^3/s at Helvetia
(2)	Percut River Improvement	:	28.0 km in length; design discharge = 300 m^3/s at Tembakau
(3)	Floodway (Titi Kuning to Tembakau)	:	3.8 km in length; design discharge = 120 m^3/s
(4)	Lausimeme Dam	:	rockfill type, 74.5 m high; gross storage capacity = 34 MCM
(5)	Padang River Improvement	:	29.5 km in length; design discharge = 630 m^3/s at Brohol

5.2 River Improvement

5.2.1 Improvement Plan

In the urgent project, the river improvement plans for the Deli, Percut and Padang rivers are generally formulated based on the planning conditions and design criteria employed for the formulation of the master plan, as stated in Section 4.1, Flood Control Plan.

On the other hand, there are some particular schemes for each river improvement plan due to topographic/geologic conditions and socioeconomic circumstances, as follows:

<u>Deli River</u>

The proposed alignment with typical cross sections are shown in Fig. 5-2, and the longitudinal profile in Fig. 5-3.

(1) Cut-off Channel

Meanderings are conspicuous in the middle reaches and they reduce the flow capacity and stability of the channel. Among six (6) stretches of extreme meandering, a cut-off channel is employed for two (2) stretches after a comparison of cost between cut-off channel and improvement of the existing channel, as follows:

Proposed Cut-off Channel

No.	Stretch	Channel Length (m)	
		Existing	Cut-off
1.	DE.27+350 - DE.27+930	580	220
2.	DE.29+30 - DE.29+760	730	140

(2) Alignment

The lower reaches (river mouth to Titi Papan) is to be widened to have a new dike, because the geological condition along this stretch requires some foundation protection such as sheet piling which will result in costly construction. The stretches of Labuhan Deli to Sikambing River (DE.5 to DE.20) should have an alignment within the area acquired by DPUP to avoid further land acquisition.

(3) Cross Section

A single cross section is employed in order to minimize house evacuation and land acquisition, especially in the center of Medan City. A side slope of 1:2 is adopted for the dike, except along the stretches of DE.12 to DE.30 (H. Juanda Bridge). For this stretch along factories, a side slope of 1:1.5 is employed due to the restriction of land acquisition. Revetment is only made for this stretch and some meandering portions in the downstream.

<u>Percut River</u>

The proposed alignment with typical cross sections are shown in Fig. 5-4 and the longitudinal profiles in Fig. 5-5.

(1) Alignment

The alignment for Percut River is planned nearly the same as the existing one which has an 80 m wide compound cross section.

(2) Cross Section

A compound cross section is employed for the stretches from the river mouth to PE.13 (Titi Bobrok Bridge), where surrounding areas are used mainly as paddy or plantation. However, the stretches from Titi Bobrok Bridge to the floodway (PE.28) will have a single cross section with some widening of channel, because the surrounding areas have been newly urbanized in the expansion of Medan City. A side slope of 1:2 is set for the dike in all improvement stretches.

<u>Padang River</u>

The proposed alignment with typical cross sections are shown in Fig. 5-6 and the longitudinal profiles in Fig. 5-7.

(1) Cut-off Channel

A cut-off channel is employed for the confluence stretch with the Sibarau River, where a conspicuous meander is formed. Through cost comparison between cut-off channel and improvement of the existing channel, the cut-off channel is more economical and ensure the stability of the channel by smoothing flood flows.

(2) Alignment

The improvement is proposed to follow the existing alignment. To avoid a high design flood water level, widening of channel and setting back of dike are applied.

To minimize the construction cost of setting back of dike, the existing dike, mostly left side dike, is proposed to be strengthened and heightened. Therefore, the setting back of dike will be made by widening the river width towards the right bank side.

(3) Cross Section

A compound cross section is applied for the stretches from the river mouth to the national road (PA.24) and a single cross section is from PA.24 to Sibarau River (PA.29). Side slope of dike is set at 1:2 for all improvement stretches, and revetment is proposed for the stretches in the urban area of Tebing Tinggi City, and some stretches with considerable meanderings.

5.2.2 Related Structures

There are totally 36 bridges, 2 intake weirs and 3 sluices to be affected by the proposed river improvement works. Many drain pipes shall also be installed along the proposed dike. Most of the bridges and weirs are to be reconstructed. Sluices are mainly relocated or newly constructed to maintain the drainage condition after the construction of dike. The relocation and new river structures are summarized as follows:

Relocation and New River Structures

River	Bridge	Weir	Sluice	Drain Pipe
Deli	19 (32)	0 (0)	5 (0)	97 (0)
Percut	13 (15)	1 (1)	5 (0)	56 (0)
Padang	6 (6)	1 (1)	4 (3)	14 (0)
Floodway	7 (1)	0 (0)	0 (0)	0 (0)
Total	45 (54)	2 (2)	14 (3)	167 (0)

Note: Figures in parentheses show the number of existing structures.

Bridge

Bridges which have a length not enough for the design river width and/or a beam height with an inadequate clearance from the design high water level are principally reconstructed.

There are three (3) bridges to be newly constructed at the proposed cut- off channel of the Deli River and six (6) bridges at the Medan Floodway. For the new bridges, not only the length and clearance but also the interval of bridge piers are designed to ease flood flow.

Weir

Reconstruction of two (2) intake weirs is justified more economical than river improvement with existing fixed weirs which require more land acquisition and house evacuation. A movable type is employed for new intake weir, which is made of rubber to assure the design flow capacity during floods.

Sluice and Drain Pipe

Sluices/water gates are proposed at junctions of drainage channels to the river, which will have new dike. The sluice is designed so as to be operated manually with a small maintenance cost. Three (3) sluices along Padang River are relocated from the existing sites due to the widening of river and the construction of new dike. Other ten (10) sluices in the Deli and Percut rivers are proposed to be newly constructed to avoid spill-out of river flood.

5.3 Floodway Construction

5.3.1 Route Selection

The three (3) routes of floodway, Titi Kuning to Tembakau (two routes) and Simeme to Sigaragara (refer to Fig. 5-8) are examined. The longitudinal profiles and cross sections of alternative routes are presented in Fig. 5-9. Route B-1 which is connected to the Percut River upstream of the national road and requires less house evacuation is proposed as the economically optimum route among five (5) alternatives as shown below. The alignment and longitudinal profile of Route B-1 are shown in Figs. 5-10 and 5-11, respectively.

Floodway Route Selection

Floodway Route			Type	Length (km)	Construction* Cost (million Rp.)	Compensation	
Name	Diversion Point	Joining Point				Land (ha)	House (unit)
A.	Titi Kuning	Tembakau (North of Nat'l Road)	Open Channel	3.69	26,031	18	196
B-1.	Titi Kuning	Tembakau (South of Nat'l Road)	Open Channel	3.84	23,860	20	97
B-2.	Titi Kuning	Tembakau (South of Nat'l Road)	Box Culvert	3.84	60,772	15	66
C-1.	Simeme	Singara-gara	Open Channel	2.65	33,149	21	17
C-2.	Simeme	Singara-gara	Tunnel	2.65	35,354	2	1

* Construction cost only includes construction base cost and compensation cost.

5.3.2 Diversion Works

The diversion works is proposed with three (3) alternatives as shown in Fig. 5-12, based on the following criteria:

(a) The design discharge of 120 m^3/s, which corresponds to about 40% of a 30-year return period flood (320 m^3/s) in the upstream of Deli River, is diverted into the floodway.

(b) In ordinary time except during flood, the whole discharge of Deli River is diverted into its downstream with no flow discharge to the floodway to maintain the current water uses in the downstream area.

Diversion Structure Selection

Applicable Plan	Combination of Structures	
	Deli River	Floodway
Type I	Fixed Weir w/ Orifice	Fixed Weir
Type II	Fixed Weir w/o Orifice	-do-
Type III	Narrowed Channel	-do-

Among three types of diversion structure, Type I is selected with its superiority to the required functions. The wide stretch upstream of the diversion structure is used as impounding area to reduce water velocity and ensure flood diversion as designed. The optimum layout and structure of the diversion works are presented in Fig. 5-13.

5.4 Dam Construction

5.4.1 Dam and Reservoir

Dam

Lausimeme Multipurpose Dam will be built at Sibiru-Biru in the upper reaches of the Percut River. A rockfill type with center core is adopted for the multipurpose dam with some 70 m in height. As for dam embankment material, it is a little difficult to obtain a sufficient volume in and around the dam site. Especially, rock material which is expected to occur in the upper reaches of the catchment area about 5.0 km away from the dam site, is not distributed abundantly, although the core material will be taken from the weathered rock mass of pyroclastics, lavas and/or Toba tuff. The principal features of the dam are as follows:

Purpose	:	Flood Control and Water Supply
Type of Dam	:	Rockfill Dam with Center Core
Height	:	74.5 m
Crest Length	:	195 m
Crest Elevation	:	EL. 256.5 m
Embankment Volume	:	1,750,000 m^3

Reservoir

The principal features of the reservoir are as follows:

Catchment Area	:	105 km^2
Impounding Surface Area	:	1.7 km^2 (at Surcharge Water Level)
Sediment Capacity	:	550,000 m^3 (for period of 50 years)

Water Supply Capacity	:	29,500,000 m^3 (Intake Rate, 3.7 m^3/s)
Flood Control Capacity	:	3,900,000 m^3 (incl. 20% allowance)
Total Storage Capacity	:	33,950,000 m^3

The allocation of reservoir capacity and its corresponding reservoir water level is presented in Fig. 5-14.

5.4.2 Related Structures

The location and feature of related structures is shown in Fig. 5-15 together with those of the proposed dam.

<u>Spillway</u>

A spillway will be installed on the left bank at the dam site. The spillway is designed to be a non-gated side overflow type to avoid human operation error, namely a man-made flood, taking account of the arrival time of flood runoff and the type of dam. The principal features of the overflow part of the spillway are mentioned below. (Refer to Fig. 5-16.)

Type	:	Non-gated side overflow weir
Dimensions	:	14.4 m wide at NWL and 30.6 mwide at SWL

Design discharge of the spillway is estimated at 360 m^3/s which corresponds to 120% of a 200-year flood discharge, while the design discharge (outflow) for flood control is computed at 60 m^3/s against the inflow discharge of 280 m^3/s. Therefore, the free flow section is proposed to have a double-deck type; a wider section with 30.6 m for the dam design discharge and a narrower section with 14.4 m for the outflow discharge of flood control.

<u>Diversion Works</u>

A temporary diversion works during dam construction is planned applying a diversion tunnel which is located below the left abutment of the dam body. The design discharge for the tunnel is 180 m^3/s which corresponds to the flood of a 20-year return period. The principal features are as follows:

Type	:	Horseshoe-shaped Section
Diameter	:	6 m
Length	:	500 m

<u>Intake Facilities</u>

The intake facilities will be designed to allow the intake volume of 3.7 m^3/s at the low water level of the reservoir. For the intake, an intake tower is provided at the mouth of the temporary diversion tunnel running through the abutment of the left bank of the dam.

Accordingly, the intake water runs through the temporary diversion tunnel. After completion of the dam, this tunnel will be used as the intake channel, and water will be released to the downstream river of the dam.

Land Acquisition and House Evacuation

Fourteen (14) hectares of land consisting of 6 ha of paddy field and 8 ha of dry field shall be acquired and 12 houses shall be evacuated for construction of the dam. These properties are mainly located at Kp. Kualasawan, about 2.0 km upstream of the dam site.

5.5 Project Cost

5.5.1 Construction Schedule

The construction schedule of the urgent project is proposed in consideration that the target year is set at 2000. Dividing the urgent project into two (2) areas; namely, the Deli-Percut River System and the Padang River Basin, a higher priority is given to the former area because it includes Medan City where flood damage and water shortage are most serious in the study area.

Among the project components of Deli-Percut River System, the Percut river improvement is to be carried out earlier than other components since this is the most critical factor to facilitate the efficient functions of the proposed structures in the urgent flood control plan. On the other hand, the construction of Lausimeme Dam shall be completed before or at the same time with Medan Floodway in order to compensate the additional flood discharge to the Percut River through the floodway.

As for the Padang River Basin, the improvement works is divided into two (2) stages. One is the urgent portion and the other is for the master plan. The urgent portion is to be implemented by the target year 2000. In consideration of the required construction periods of all project components, the construction schedules are proposed as follows:

Construction Schedule

Work Item	Schedule
1. Deli River Improvement	1995 to 2000 (6 years)
2. Percut River Improvement	1995 to 1997 (3 years)
3. Construction of Floodway	1995 to 1998 (4 years)
4. Construction of Lausimeme Dam	1995 to 1998 (4 years)
5. Padang River Improvement	1996 to 2002 (5 years)

5.5.2 Cost Estimate

Project cost of the urgent project is estimated under the condition defined in the master plan study as stated in Subsection 4.3.3.

The summary of project cost is shown in the following table. The breakdown of cost is presented in Table 5-1 and the disbursement schedule in Table 5-2.

Summary of Urgent Project Cost (Million Rp.)

	Works/Items	F.C.	L.C.	Total
1.	Construction Base Cost			
1.1	Deli River Improvement	43,924	32,915	76,839
1.2	Medan Floodway	13,233	8,118	21,351
1.3	Percut River Improvement	20,348	8,729	29,077
1.4	Lausimeme Dam	67,246	34,988	102,234
1.5	Padang River Improvement	33,503	15,955	49,458
	Sub-Total of 1	178,254	100,705	278,959
2.	Engineering Services	36,966	6,404	43,370
3.	Compensation	0	34,226	34,226
4.	Administration (7% of 1; L.C.)	0	19,527	19,527
	Sub-Total of 2 to 4	36,966	60,157	97,123
5.	Price Escalation (8%; L.C.)	0	92,470	92,470
6.	Physical Contingency (10% of 2 to 5)	21,521	25,333	46,854
7.	Value Added Tax (10% of 2 to 6; L.C.)	0	51,541	51,541
Grand Total		236,741	330,206	566,947

5.6 Economic Evaluation

5.6.1 General

The economic evaluation in the feasibility study is carried out on the urgent project of the Deli-Percut River System and the Padang River Basin. Objectives of the evaluation are flood control project with 30- year return period and water supply for the Deli-Percut River System, and flood control project with 10-year return period for the Padang river.

The evaluation is conducted by the usual means of Economic Internal Rate of Return (EIRR), Net Present Value (NPV) and Benefit-Cost Ratio (B/C) by using economic cost and benefit of the project. The economic cost and benefit are converted from financial cost and benefit of the project under the conditions and assumptions described in Section 4.4.

The project life is economically taken as 50 years after completion of the construction works. The project benefit together with operation, maintenance and replacement costs (OMR cost) is assumed to occur every year throughout the project life, and the partial benefit and OMR cost which will be brought from a partial improvement of river works before completion of the construction works are presumed to accrue in proportion to progress of the construction and to be approximately given in a ratio of the invested construction cost to the total construction cost.

5.6.2 Economic Cost

Economic costs have been evaluated as follows:

(1) Cost of Flood Control Project

The total economic construction cost of the flood control project is estimated at Rp. 203,645 million for the Deli-Percut River System and Rp. 68,988 million for the Padang River Basin, and the average annual OMR cost is estimated at Rp. 1,030 million and Rp. 404 million, respectively. Annual flows of these economic costs are given in Table 5-3.

(2) Cost of Water Supply Project

The total economic construction cost of the Lausimeme Dam water supply and the average annual economic OMR cost are estimated at Rp. 114,628 million and Rp. 715 million, respectively, and the annual flows of these costs are given in Table 5-3.

(3) Cost of the Integrated Project for the Deli-Percut River System

The integrated project of the Deli-Percut River System is given as an integrated project of both flood control and water supply. The total economic construction cost and the average annual economic OMR cost are estimated at Rp. 318,278 million and Rp. 1,745 million, respectively, and annual flows of these costs are given in Table 5-3.