No. 2

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

MASTER PLAN STUDY ON LOWER ASAHAN RIVER BASIN DEVELOPMENT

Volume 2

Flood Control Plan

July 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

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Master Plan Study on Lower Asahan River Basin Development Vol. 2 Flood Control Plan 19

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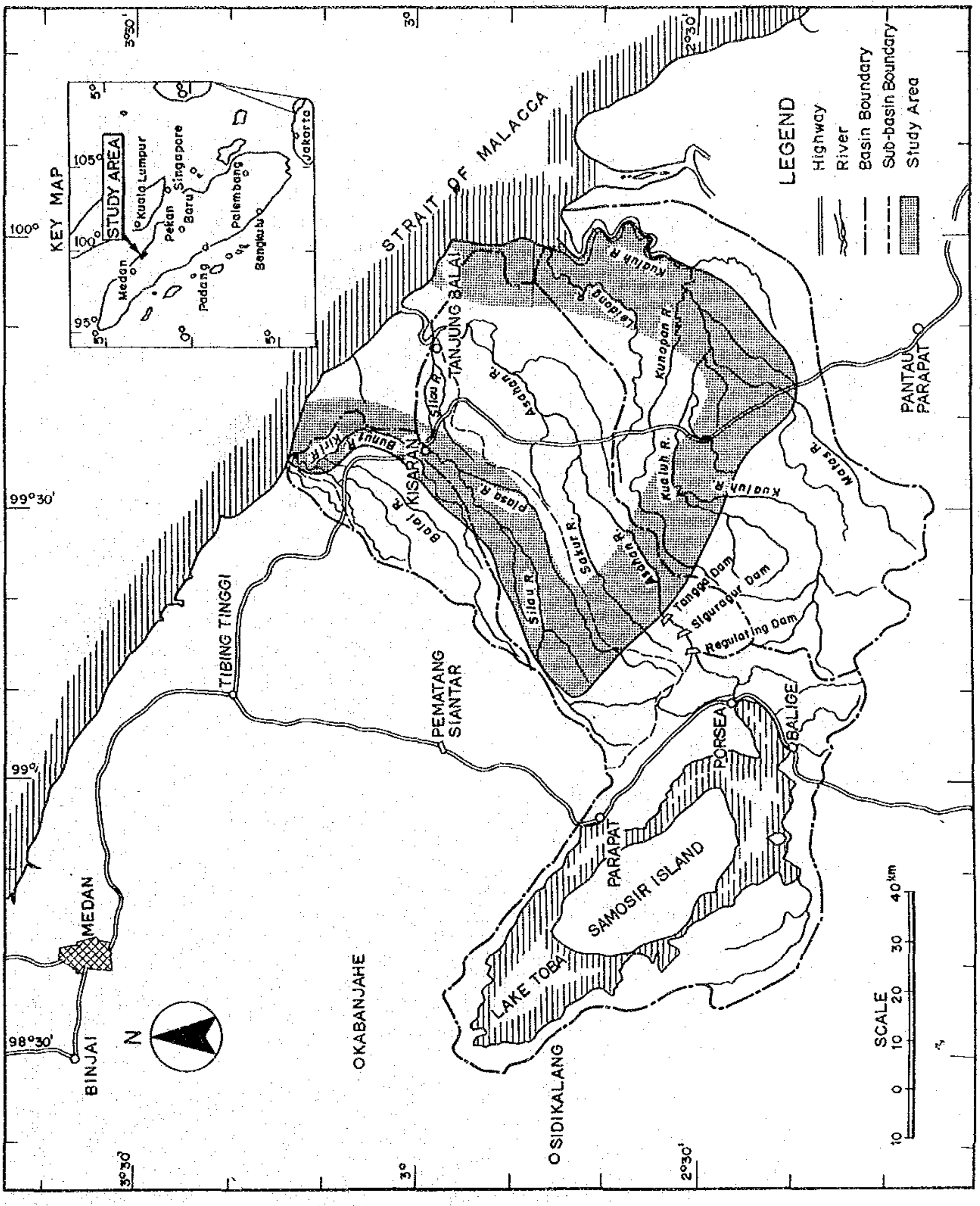
NOTICE

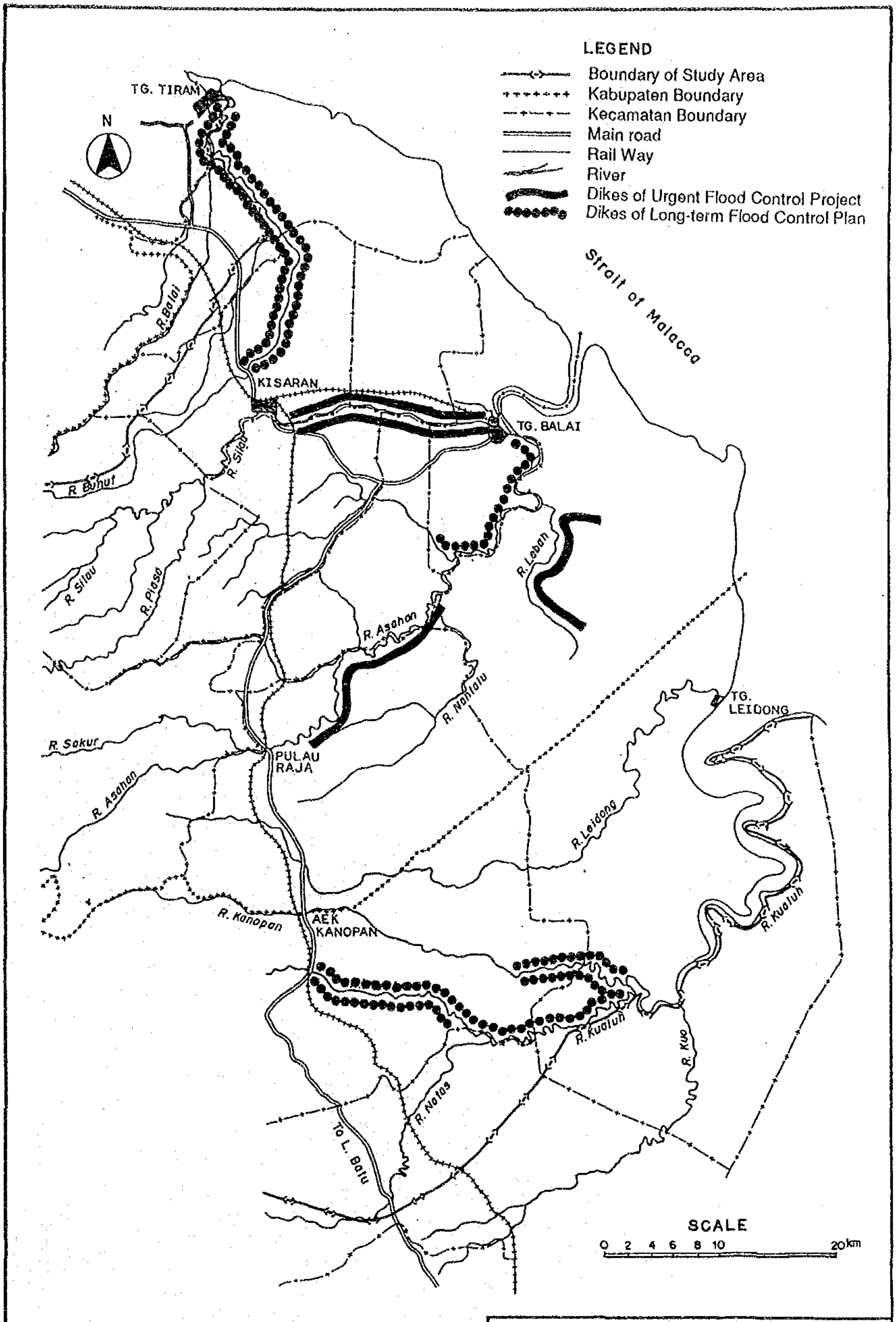
This Volume 2 is a reprinting of the Interim Report for Master Plan Study on Lower Asahan River Basin Development submitted in October 1985, but revised and simplified to avoid duplication between main text and appendices, and references modified accordingly.



Location of the Study Area

Republic of Indonesia
MASTER PLAN STUDY ON
LOWER ASAHAN RIVER BASIN DEVELOPMENT

Japan International Cooperation Agency



Proposed Flood Control Plan

Republic of Indonesia
MASTER PLAN STUDY ON
LOWER ASAHAN RIVER BASIN DEVELOPMENT
Japan International Cooperation Agency

MASTER PLAN STUDY
ON
LOWER ASAHAN RIVER BASIN DEVELOPMENT

(VOLUME 2)

FLOOD CONTROL PLAN
(Part - I Study)

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CHAPTER 1 INTRODUCTION

"This Volume 2 is the duplicate copy of the Main Report and Appendices of the Interim Report for the Study submitted in October 1985."

1.1 Purpose of the Report

This Interim Report for Master Plan Study on Lower Asahan River Basin Development Project was prepared in accordance with the Scope of Works agreed on July 27, 1984 between the Japan International Cooperation Agency (JICA) and the Directorate General of Water Resources Development (DGWRD) Ministry of Public Works, the Government of the Republic of Indonesia.

This Interim Report is prepared to report all the results of surveys and studies made for the Part I works which aims i) to find the basic direction of land and water resources development, ii) to establish a flood control master plan, iii) to make a feasibility study on an urgent flood control project selected from the master plan, iv) to make studies and recommendations on water regulation of Lake Toba, and v) to recommend a detailed survey and study program required for Part II works which mainly aims at establishment of master plan for agricultural development.

1.2 Progress of the Study

The surveys and studies for the Part I works were commenced from October 1984 and almost all the field works were completed by the end of July 1985. Since then the remaining analyses and studies were carried out in Japan and completed by the end of September 1985. Thus this Interim Report was compiled by the middle of October, 1985.

During the survey period until the end of July 1985 the JICA Study Team submitted the following four reports to DGWRD.

1.	Inception Report	December 5, 1984
2.	Progress Report I	January 29, 1985
3.	Progress Report II	March 23, 1985
4.	Discussion Note	July 26, 1985

Official meeting between both parties including the Advisory Committee of the Japanese Government and Indonesian Authorities concerned were held every time to discuss the above reports and the views and comments were confirmed by both parties in the Minutes of Meeting respectively.

All the comments from DGWRD made through an official letter dated August 19, 1985 were answered in this Interim Report.

1.3 Personnel Assigned

The JICA organized and sent a study team consisting of 15 specialists headed by Mr. M. TSUDA, Team Leader and Mr. H. ONO, Deputy Team Leader to carry out the required works in their respective field. In addition JICA assigned six members of Advisory Committee headed by Dr. K. NAKAZAWA, Director of JICA to advise the Study Team and inspect the results of study.

The members of the Advisory Committee attended all the official meetings with DGWRD and exchanged their views each other for successful execution of the study works.

The DGWRD assigned Indonesian counterpart personnel to achieve transfer of knowledge as deep as possible. The twelve persons were selected from a consulting firm in Bandung from the end of December 1984. They have worked together with JICA team members in the same field.

The lists showing all the above members assigned are shown in Tables 1.1 and 1.2 with their itinerary as shown in Fig. 1.1.

1.4 Transfer of Knowledge

The above 12 counterpart personnel were trained through on -the-job training system mainly about the following works.

a) Actual field surveys including ground reconnaissance, sampling of materials, required field tests at the spot, collection of data from various organizations, interview survey with local people, etc.

b) Analyses on the data collected including statistical analysis, engineering analyses by calculations or graphical analyses, hydrological analyses, hydraulic calculations, probability analyses, land use mapping, etc.

Especially for flood control planning the use of electronic computers was trained regarding the calculations of flood patterns, flood carrying capacity of river channels, probable flood analyses by storage function method, etc.

c) Engineering judgement on the results of surveys, tests and analyses was transferred in the fields of hydrology, hydraulics, soil property related to the structural design, socio-economy, land use, etc.

However the period of training was limited less than five months due to short time of field works and the delay of assignment. Although short in time most of those trainings were very fruitful for the counterparts as the knowledge was transferred through actual jobs immediately understandable at the respective spot.

CHAPTER 2 BACKGROUND AND OBJECTIVE OF THE STUDY

2.1 Background of the Study

The study area is located in the central part of North Sumatra Province facing to the Strait of Malacca and blessed with rich water and land resources implying the high development potential. Especially Lake Toba, the origin of the Asahan river, offers favorable stable water source through its vast regulating capacity by its large surface area of 1,100 m^2. Owing to its high surface elevation of El. 905 m, the outflow of about 100 m^3/sec of annual average discharge IS now being utilized for hydropower generation at Siguragura and Tangga power stations (603 MW in total) to supply the power to the aluminium smelter with annual production capacity of 225,000 tons at Kuala Tanjung.

Owing to the rich rainfall, this study area is also suffered from frequent floods due to insufficient flood control facilities. Major rivers running in the study area are Bunut in the north, Silau and Asahan in the center and Kualuh river in the south. The annual rainfall more than 4,500 mm precipitates on the slope of mountain divide from which those rivers originate except the Asahan main stream. The rainfall gradually decreases toward the coast of the Strait of Malacca as little as 1,300 mm. However the heavy rainfall in the mountains causes rapid flood flow often inundating the plain along the lower reaches of the rivers. Due to such flooding and insufficient infra-facilities, the study area has been constrained to the low socio-economic development stage compared with Medan and its vicinities.

The above circumstances imply the strong need of raising the land productivity by means of development of water resources. The ever-increasing population pressure, not only by the natural increase but also due to transmigration, urges the needs to increase job opportunities and to secure the stable living conditions as well.

2.2 Objective of the Study

The objective of the Study is, therefore, to conduct a master plan study for water and land resources development in the Lower Asahan River Basin, covering the period up to 2005 A.D. from the viewpoint of long-range policies as raising the productivity, increasing employment opportunities, promoting transmigration and bettering the living conditions in this region.

The actual program for the whole survey and study works was divided into two stages from the viewpoint of efficient and orderly execution, namely Part I and Part II. Part I works aimed to carry out the required surveys and studies mainly for the following five objectives:

- i) to find the basic direction of land and water resources development based on the socio-economic and natural conditions given in the project area,
- ii) to establish a master plan for flood control,
- iii) to make a feasibility study on an urgent flood control project,
- iv) to make a study and recommendations on water regulation of Lake Toba, and
- v) to report a survey and study program required for Part II works.

In continuation to the Part I works, the Part II works will be carried out mainly for establishment of the agricultural development master plan well coincided with the flood control master plan.

This Interim Report describes all the results of studies for the Part I works.

2.3 Study Area

The study area covers the lower Asahan basin (about 6,000 km^2) including Bunut river and a part of Kualuh river basin as the objective area for the master plan. The upper basin of the Asahan river including Lake Toba is considered in its plan as the external conditions in relation with the downstream flood problems and optimum utilization of water resources.

Administratively the objective study area lies in Kabupaten Asahan and Labuhan Batu, North Sumatra Province, about 160 km south-east of Medan, capital of the Province. Being blessed with rich water and land resources under the tropical monsoons the study area has been developed mainly with large estate of rubber, oil palm and coconut since long ago. With a population increase, now reaching about 800,000 persons, area of paddy field gradually increased to the present level of about 77,000 ha with supplemental upland field of about 15,000 ha for cropping. However the study area is also suffered from frequent floods due to heavy tropical shower causing considerable damages on crops as well as on social and private properties. In spite of much effort of the Indonesia Government to construct earth dikes in recent years, still the flood carrying capacity of major rivers is far less than the flood peak discharges resulting in frequent distraction of those dikes. Hence, this Master Plan Study for flood control is urgently necessitateD.

No big scale industries exist in the study rea due to poor electricity supply condition and non-existence of underground mineral resources except coal reserve in extreme southern hills. The major towns, such as Kisaran, Tanjung Balai, etc. have been electrified with isolated diesel generators, although a transmission line connecting Kisaran with Medan Network is under construction at present.

CHAPTER 3 PRESENT CONDITIONS

3.1 Topography

The study area lies in the central part of North Sumatra Province facing the Strait of Malacca running in the direction from northwest to southeast. The topography of the study area is broadly divided into four zones almost in parallel to the coast line, namely i) steep mountain area ranging from El. 1,500 m to approximately El. 100 m in elevation mostly covered by natural and secondary forests, ii) low undulating hills or terrace extending between elevations of about 100 m and 15 m, iii) wide and flat alluvial plain lower than El. 15 m including lower swampy area, and iv) coastal sand dune or coastal sand bar in width of 2 or 3 km along the coast line having the maximum elevations of 10 to 14 m.

Four major rivers dissecting this study area rise in the steep mountain area and flow down generally in northeast direction with remarkable meanders in the lowermost alluvial plain lower than 10 m in elevation.

The low hilly area, having a good natural drainage with many small streams, is mostly utilized for rubber and oil palm estates with dotted small paddy fields. Since long ago the national railway and the main highway have been constructed on this hills or along the foothills utilizing the good drainage conditions. Therefore, most of the major towns and villages are developed along this zone too. Also many small hamlets are mainly developed on or along the natural levees stretched on the both banks of main and branch streams. Numerous secondary roads branch off from the highway in both directions to mountain area and coast area.

The wide alluvial plain is classified into two areas, namely comparatively higher area than El. 4 m and the lower swampy area. The higher alluvial area has been mostly developed into estates of rubber, oil palm and coconut and considerably large size paddy fields. The easy topography to take irrigation water made this alluvial plain suitable for irrigated farming. The silty soils having less infiltration and rich humus are well suited for submerged paddy cropping. But the high groundwater table and less drainable condition prevailing in this alluvial area make the flood damages larger when inundated.

The lowermost alluvial plain lower than El. 4 m forms wide swampy area, especially between Asahan and Kualuh rivers and the right bank of the Kualuh. The Landsat false color composite image clearly shows the boundaries of those swampy areas and the vegetation cover. The ground reconnaissance with this Landsat photograph made clear that most of the swamp are covered by bushes and shrubs but some areas covered by thick swampy forests with high trees more than 10 m. The water in those swamps is obstructed their drainage way to the sea by the high coastal sand dunes, being obliged to drain into the lowest reaches of the main streams of Asahan and Kualuh through small streams. The drainage capacity is so small resulting in water logging and stagnation in long duration. The bogging swamps in deeper areas do not accept human access, but the fringes of those swamps were gradually developed into paddy fields or coconut plantation recently by planned settlement or random settlement under the heavy population pressure.

The coastal sand dunes are mostly utilized for coconut plantation, small patches of paddy fields and upland fields. The coast margin affected by high tide is mostly occupied by mangrove.

3.2 Climate

The study area lies in the tropical monsoon zone between 2 and 3 degrees in North Latitude and 99 and 100 degrees in East Longitude.

Annual average temperature on low alluvial plain along the coast is approximately 26°C with very little seasonal variation. Absolute maximum temperature is around 33°C and the minimum is around 21°C. All those temperatures around Lake Toba at the elevation of El. 910 m are about 6°C lower than those values at the coast plain.

Annual rainfall depth differs almost in parallel with the coast line up to the mountain divide to the catchment area of Lake Toba. The mountain ridge around at an elevation of 1,500 m above M.S.L. has about 4,500 mm annual rainfall, while it decreases with elevation toward the coast where only 1,500 mm average annual rainfall is observed.

The catchment area of Lake Toba is about 3,700 km^2 surrounded by mountain ranges of about 1,500 m and has an average annual rainfall of approximately 1,820 mm. It is observed that southern area has a little higher rainfall ranging from 2,000 to 2,200 mm, while the northern area has less rainfall ranging from 1,400 to 1,600 mm.

Monthly distribution of rainfall is different by the location from east to west. North Sumatra has a narrow width of about 200 km between the Strait of Malacca and the Indian Ocean, hence the monthly rainfall distribution pattern at a certain place is much affected by its location because of prevailing monsoons from both seas. In the main rainy season from October to December the north-east monsoon is predominant in this region. The onset of the rainy season begins from the coast along the Strait of Malacca and gradually moves into the inland area with one or one and a half month time lag.

While the secondary rainy season covering March through May is caused by south-west monsoon from the Indian Ocean. Therefore the secondary rainy season begins from the coast of Indian Ocean and proceeds to inland with about one month time lag.

The above fact is clearly analyzed by comparison of the monthly rainfall records at Medan, Pematang Siantar, Parapat and Sibolga. The average monthly rainfalls are converted into the share ratios against the annual average rainfall and those monthly ratios are graphically shown on Fig. 3.1. From this Figure the following characteristics of the rainfall distribution are clearly observed:

1) The maximum rainfall peaks at Medan and Pematang Siantar occur in October, while those at Parapat and Sibolga occur in November.

2) On the contrary, the secondary rainfall peaks at Sibolga and Parapat occur in April, one month earlier than those at Pematang Siantar and Medan.

3) The influence of the secondary rainy season, caused by the south-west monsoon from the Indian Ocean is very little at Medan, especially is February. The influence on Pematang Siantar is also moderate.

4) The period between the both peak months at Medan and Pematang Siantar is therefore only five months. It naturally makes not so heavy shortage of rainfall during this transit period. On the contrary, the period between the both peak rainfall months at Parapat and Sibolga is seven months, two months longer than that of Medan and Siantar. At Parapat, therefore, considerably less rainfall months happen in June and July.

The above characteristics of rainfall depth and seasonal distribution naturally affect on the seasonal runoff of rivers and also inflow into Lake Toba. So that the discharge analysis was carefully carried out by checking with the monthly rainfalls observed at nearby observatories.

Relative humidity is fairly high through a year. Monthly variation ranges between 83 and 92 percent resulting in annual average of around 88 percent.

Records of wind, sunshine and evaporation are so few that clear seasonal tendency can hardly be analyzed. But general tendency is observed as follows:

1) Wind velocity is generally very small through a year except sudden instant gales occurred a few times a year. Annual average wind velocity is a little less than 0.3 m/sec.

2) Sunshine hours in the main and secondary rainy seasons are very short as the number of rainy days reaches more than 15 days per month. Considerably long sunshine hours were recorded in June, July, August and September.

3) Evaporation records are available only at two places but the observation has incomplete with many lacking days. It was however estimated from those records that the annual average evaporation may be around 1,300 mm in the study area. This fairly small evaporation may be justified by the facts of considerably high humidity, large number of rainy days (normally 190 to 220 days a year), weak wind velocity and not so high air temperature. Trial estimations suggested that the annual average evaporation from the surface of Lake Toba may be around 930 mm per annum ranging from 1 mm/day to 7 mm/day at the maximum.

As the climatic conditions of coastal area and highlands around Lake Toba, climatic record at Sei Dadap near Kisaran and Balige is shown in Table A-1.

3.3 Hydrology

3.3.1 Rainfall

There are about 80 rainfall gaging stations in the study area mostly established by PMG, RISPA and DPU as shown in Fig. A-1. The periods of available records at those stations are shown in Figs. A-2 and A-3. Some of daily rainfall records have been already lost even though monthly records at the same period is still available.

In order to know the aerial distribution of annual rainfall, an areawise isohyetal map of annual mean rainfall depths covering the study area was prepared as shown in Fig. A-4. It shows the general trend in the study area that rainfall depth increases gradually from coastal area of about 1,500 mm towards mountainous area near the Tangga dam of about 4,000 mm. It decreases in reverse to 1,500 mm through 2,000 mm around Lake Toba. Although it is recognized that the maximum value is recorded at the eastern side of mountain outside Lake Toba, range of the heavy rainfall is still uncertain because of thin observation net-work compared with that in the lower area. Aerial distribution of annual rainfall seems to be the same as that of heavy rainfall during flood times. Monthly rainfall patterns of eight stations are also shown in Fig. A-5.

Probable one day rainfall were calculated by the Gumbel method on the basis of the estimated one day maximum basin rainfall every year, which is shown in Table A-2, with regard to upper reaches of Pulau Raja, Kisaran, Tanjung Balai, Teluk Binjai and Tanjung Tiram stations. The results are shown in Table A-3 and Fig. A-6. The maximum two day rainfall is also shown in Table A-2 and Fig. A-6 for reference.

3.3.2 Streamflow

There are water level gaging stations along the Asahan, Silau and Kualuh rivers, and also at Lake Toba. Their locations are shown in Fig. A-7. At present 9 gaging stations are being operated by both DPU and INALUM on an hourly-basis except Kisaran station where thrice-daily staff gage readings at every 7:00 A.M., 12:00 A.M. and 5:00 P.M. are executed. Availability of water level records is shown in Fig. A-8.

Collection of water level records at Pulau Raja, Kisaran and Pulo Dogom stations of the Asahan, Silau and Kualuh river basins were completed by the end of 1984. In addition discharge measurement was carried out by the Study Team at Pulau Raja from the end of January through the beginning of February 1985 to supplement the high water range of the discharge rating curve. The results are shown below:

Date	Water Level (Gauge Height) (m)	Discharge (cm)
Jan. 31, 1985	2.73	202
Feb. 1, 1985	2.5	230
Feb. 1, 1985	2.52	212
Feb. 2, 1985	2.28	201
Feb. 2, 1985	2.20	171

Discharge rating curves at the stations were revised by use of both the measurement records and hydraulic calculations based on the river cross sections surveyed by DPU. The cross-sections of the said three stations during discharge measurements since 1980 were compared to check the changes as shown in Fig. A-9. It revealed that they have not experienced so much changes. Therefore, the discharge rating curves shown in Fig. A-10 were used for conversion of daily water levels into daily stream flows. The monthly mean discharges at those stations are shown in Table A-4 and Fig. A-11. Usually high water flow is observed in September through January or February, and also in May or June. In August in general, the discharge decreases to the minimum, being about a half of that in May or June.

Monthly mean discharge at Pulau Raja from residual area excluding upstream catchment area of Lake Toba was also estimated as shown in Table A-5, which was supplemented by the correlation between discharges of the Silau river at Kisaran and the residual area as shown in Fig. A-12.

According to this analysis the annual average discharge after 1979 at Pulau Raja (4,608 km^2) is approximately 150 m^3/sec (4.7 billion m^3 per year), out of which 90 m^3/sec (60%) flows from Lake Toba and 60 m^3/sec (40%) flows from the remaining catchment area of 812 km^2.

The specific discharges per 100 km^2 of catchment area for Asahan, Silau and Kualuh rivers are shown below:

River	Station	Catchment (km²)	Annual Mean Discharge (m^3/sec)	Specific Discharge (m/sec/100 km²)
Asahan	Pulau Raja	4,608	151.8	3.29
	Regulating Dam	3,796	94.0	2.48
	Remaining area	812	57.8	7.12
Silau	Kisaran	1,050	61.2	5.83
Kualuh	Pulo Dogom	1,116	61.4	5.50

The lowest specific discharge from the catchment area of Lake Toba is mainly attributable to the considerably less rainfall and the high evaporation loss from the Lake surface. The very high specific discharge for the remaining area of Asahan river is mostly due to heavy rainfall in the mountain area. Silau and Kualuh rivers have comparatively moderate rainfall in the upstream reaches.

3.3.3 Tide

Records of tide level at Kuala Tanjung and Bagan Asahan, which are located in 3°-22'N and 99°-28'E, and 3°-01'N and 99°-52'E facing to the Strait of Malacca respectively, were collected. The records demonstrate regular two cycles a day. They were arranged in Table A-6 and Fig. A-13 being summarized below:

(El. m)

Section	HHL	MHHL	MSL	MLLL	LLL
Kuala Tanjung	1.64	0.85	0.0	-0.86	-1.87
Bagan Asahan	2.25	1.17	0.0	-1.16	-1.75

where,
- HHL : Higher High Level
- MHHL : Mean Higher High Level
- MSL : Mean Sea Level
- MLLL : Mean Lower Low Level
- LLL : Lower Low Level

3.4 Geology

The geological formation of the study area concurs to the four topographical zones. The schematic topography and geology are shown in Fig. 3.2 and the general stratigraphy is as follows:

General Stratigraphy of Study Area

Geological Age	Stratigraphy	Composition
Quarternary	Sand Dune or Bar Alluvial Plain Deposit Alluvial Terrace Deposit Tuff Volcanic Rocks	Sand, silt Sand, silt, clay, organic soil Sand, silt White tuff, laterite Lava, ignimbrite, Volcanic breccia, etc.
Tertiary	Sandstone and Shale	Sandstone, shale, Conglomerate
Pre-Tertiary (Paleozoic)	Pre-Tertiary Rocks	Sandstone, shale Quartzite, Mylonite

Those rocks and deposits are generally developed in parallel to the coastal line, well coinciding with the topographic characteristics.

Basement rocks exposed in the mountain area are composed of acidic volcanic rocks, which are pyroclastic rocks derived from volcanic eruptions in early Quarternary, such as rhyolites or liparitic pyroclastic product, so-called ignimbrite or welded tuff. Those rocks are generally very hard, if not weathered, offering good foundations for any heavy structures.

The ignimbrite is overlain by several layers of tuff sand, consolidated tuff and top overburden consisting of loamy lateritic soils. Pre-tertiary sedimentary rocks intercalated coal bed are overlain in the vicinity of the village Perlaoian located upstream about 25 km from the crossing of highway and Kualuh river.

The low hilly area is widely covered by thick laterite ranging from 5 to 10 m underlain by soft white tuff which probably belongs to Quarternary and is characterized by the presence of pumice fragments. This formation is also derived from the Toba volcanic eruptions and partially interbedded with thin sand and gravel layers dipping slightly northeastward.

The lower ends of the hilly area at the elevation of 10 to 15 m have terrace deposits mainly composed of sand and silt forming belts, projected low ridges and isolated islands. This formation seems coastal terrace deposits formed in early Alluvial period.

Alluvial plain deposit (I) mostly consists of fine silty to clayey soils interbedded by thin sand soil layers and organic soil layers. Those were transported from the hinterland composed of acidic volcanic rocks, tuff and laterite. Even now the sedimentation is progressing continuously.

Alluvial plain deposit (II) in the vast swampy areas between the lower Asahan river and Kualuh river is made of fine silty to clayey soils and organic soil.

The coastal sand dunes or sand bars are mostly composed of coarse to fine sand of volcanic native glass or hard quartz particles originated from ignimbrite.

All the above geological and geomorphological observations are shown in Fig. 3-3.

3.5 Land Use

3.5.1 Present land use

The results of land use survey covering 6,600 km^2 were compiled in two maps on a scale of 1/200,000, one the Present Land Use Map and another existing Paddy Field and Potential Land for Future Agricultural Development. The present land use in the lower Asahan river is shown in Fig. 3-4.

The whole land area was classified into ten (10) categories of land use as shown below:

	Land Use Category	Area (ha)	Percentage (%)
1.	Settlement land	9,079	1.4
2.	Paddy field	90,832	13.7
3.	Upland cultivated land	15,442	2.4
4.	Coconut estate	43,230	6.5
5.	Rubber estate	107,607	16.3
6.	Oil palm estate	53,398	8.9
7.	Upland forest	158,440	23.9
8.	Bushes (Swampy)	48,592	7.3
9.	Swamp (Mostly forest)	125,851	19.0
10.	Others	4,100	0.6
	Total	661,571	100.0

The upland forest includes both the natural forest and secondary forest. The secondary forest consists of rubber trees, oil palm, clove trees, coffee, etc. but those trees are planted mixed with natural forest trees, so that detailed demarcation is almost impossible. Anyway it shall be noticed that such cash crops are planted in the upland forest on a small scale private basis. The upland forest is being well maintained causing no big scale land slide or wide denuded land.

The paddy field occupies only about 14% of the total land area and mostly lies in low lands. Upland cultivated lands are planted with cassava, maize, various kinds of pulses and legumes and vegetables.

The three major estate crops, namely, rubber, oil palm and coconut, occupy about 32% of the whole area, rubber estate still occupies 16.3% but the area is gradually decreasing and mostly changed into oil palm estate due to economic reason. The coconut estate also gradually is being shifted to paddy field.

The swamp forest and bushes occupy about 26% of the whole area. The difficult access and living conditions reject human settlement by their bogging ground and frequent floods. However the recent high population pressure is obliging local people to intrude into the fringes of those swamps.

3.5.2 Adaptability of present land use

In this study area it was identified to utilize the lands in a good coincidence of topography. In other words, the genera land use in the study area is well adapted to the natural given conditions. The land use characteristics were easily confirmed by overlapping the geological map and the land use map as identified below:

a) Rubber estates amounting to 107,600 ha are developed in two major areas, one on hilly area along the Silau river and another on hilly area along the Kualuh river. Those areas have a good drainage topographically and also geologically as being underlain by tuff sand layer. The terrace deposits mainly composed of sand and silt at the lower end of hilly areas are also utilized.

b) Oil palm estates amounting to 58,400 ha mainly concentrate on the hilly area along the Asahan river.

c) Coconut estates mostly extend on the sand dune belt along the coast of Malacca Strait utilizing high chlorine content in water.

d) Most of paddy fields are developed on the alluvial plain along the streams or the fringe of swampy areas, utilizing the high water holding capacity of silty or clayey soils and easy topography to take water from streams.

e) The highway and railway have been constructed on the hilly area or the foothills where good drainage and solid foundation are secured. The lateral or secondary roads were developed along the natural levees along many streams. Major towns and villages have developed along those highway and lateral roads.

f) Upland fields scatter on hilly area mostly not irrigated due to higher elevation than stream flows.

AIL the above land use patterns are well characterized by excellent utilization of the given natural conditions, such as topography, drainability, soils, etc. with the wisdom accumulated in long history. It suggests no necessity to change the present land use patterns except improvement to higher land productivity, some crop diversification by future economic trend and demand and national or social requirement.

3.5.3 Desirable future development

As identified above, almost no wasted land exists in the study area due to ever-increasing population pressure. Or in other words there is no more physical land space to accommodate the increasing population. It is therefore prerequisite to raise the land productivity of the present cultivated land intensively. The development of swampy areas shall be examined in depth as for their soil conditions and economy.

The upland forest of about 24% shall be reserved as it is for the land and water conservation as well as necessary supply sources of cattle feed and fire wood for local inhabitants.

Three major recent changes of land use were observed by comparison of land use maps of 1974 and the latest one prepared this time as shown below:

(1) Rubber estates with old trees were changed into oil palm estates due to low international market price of rubber.

(2) Paddy field is gradually extended into coconut estates or swamp areas due to shortage of rice supply in this area.

(3) The fringe areas surrounding swamps are changed into estates or paddy field by random settlement of individuals.

From a view point of economy it seems that the agricultural development, particularly the irrigation development on the existing cultivated land, has the highest priority to raise the land productivity as well as to achieve self-sufficiency of rice in this area.

3.6 Socio-Economy

3.6.1 Present socio-economic conditions

The objective areas for the master plan study covers about 6,000 km^2 including 13 Kecamatans in Kabupaten Asahan, 3 Kecamatans in Kabupaten Labuhan Batu and Kotamaja Kisaran and Tanjung Balai.

Population in this study area is 798,900 in 1983 increasing with annual growth rate of 1.2%.

Traditionally this area has been developed by plantations of rubber, coconut and oil palm since long ago. So that those estates still occupy about two-thirds areas in the whole arable lands, leaving one-third for cultivated lands. About 65% of the population is engaged in the agricultural sector.

The share of agricultural sector in the Gross Regional Domestic Product (GRDP) in the study area also occupies a majority of about 64% in 1980.

The per capita incomes in 1981 for Kab. Asahan, Labuhan Batu and Kotamaja Kisaran and Tanjung Balai were approximately Rp. 331,000, Rp. 314,000 and Rp. 372,000 respectively at the current prices. Those amounts are higher than Rp. 283,000 of North Sumatra Province, but lower than Rp. 386,000 of Kotamaja Medan. The average figures seems at a comparatively high level due to higher incomes derived from the estate crop production.

However the average land holding size of the farmers in this area is as small as 0.8 ha per family. In addition the average unit yield of paddy is also as low as 2.9 ton per ha. Those farmers have far lower incomes than the above average.

Out of total labor force of about 419,000 in the study area, 212,900 are those farmers accounting for 51% of total labor force. Thus numerous low income level farmers can hardly purchases enough fertilizers, chemicals, improved seeds, buffaloes, etc. required for their paddy production.

The irrigated land occupies only about 20% of the total paddy field of about 74,000 ha net. The existing irrigation facilities are not so complete to keep high efficiency and even distribution of water. Due to those incomplete facilities the annual paddy production is not stable, for example, at a severe drought in 1981 the paddy production in this area reduced to about a half of normal production. Those cultivated lands normally extending along the rivers and streams are frequently suffered from floods too.

Social infrastructures, such as transportation, communication, power and water supply, etc. are comparatively developed in major cities of Kisaran and Tanjung Balai. But the secondary networks have not well developed yet, leaving fairly wide gap between urban and rural areas.

It is recognized in recent years that some younger generation leaves this region to other towns and districts to find jobs.

3.6.2 Basic direction of socio-economic development

Natural conditions of this region are good on the whole and there are no major constraints for the regional development except frequent damages caused by floods.

As the land use study clarified, all the lands were well utilized under heavy population pressure except swampy areas. Although those wide swamps are worthy to examine their future development potential and its economy, it is easily understood that much investment will be required and creation of benefit will take far longer time. It is therefore recommendable to raise the land productivity of the existing cultivated lands at first.

Among many measures to raise land productivity of cultivated lands, the first priority shall be given to prevent frequent inundation by floods. This implies the urgent need of flood control of major rivers, particularly Asahan and Silau rivers in consideration of the extent of damages.

The second priority shall be given to the rehabilitation and improvement of the existing irrigation and drainage facilities because of early generation of benefit with smaller investment.

The improvement of irrigation facilities shall be carried out even small irrigation projects along small streams.

The third priority will be given to extension of irrigated lands by enlargement of existing facilities or addition of facilities. New irrigation projects will follow the above.

The above development will require a considerable length of time, probably exceeding the target year of 2005 A.D. of the master plan. The development of swampy area shall be considered in a far long range plan, or some area will be developed as a model case for future reference.

3.7 River conditions

3.7.1 General

There are four major rivers in the study area, namely Bunut, Silau, Asahan and Kualuh from the north to south.

The Bunut river is a southernmost tributary of Kiri river originating in low hills of about 300 m in elevation. It has 621 km^2 of catchment with its 50 km length. It flows northeastward in parallel with the Silau river up to near Kisaran, after which it flows northward through rubber and oil palm estates and paddy fields. Finally it joins with Kiri river about 15 km upstream from the estuary where small port of Tanjung Tiram lies at the coast. The width of river channel at the highway bridge is only 15 m. It gradually widens to the middle reaches but only 20 to 25 m, while it becomes about 40 to 50 m along Kiri river. In the downstream reaches, the both banks have been developed into paddy fields, some areas of which are under irrigation. But this area often suffers from shortage of water due to little discharge of the river. Flood peak discharge is also not so big, but sometimes it causes inundation over paddy field.

In recent years about 14 km long low dikes were constructed on both banks and not so much flood damages happen now.

The Silau river, large tributary of the Asahan river, has a catchment area of 1,180 km^2 with a total length of about 100 km.

The river originates on the eastern slopes of Mt. Parparean and flows northeastward along steep and narrow valleys. At Samba Huta, it joins the Ambalutu river. Downstream from the confluence, the topography changes from hill to plain and the land has been developed by estates of rubber, coconut and oil palm. Afterwards, the river flows eastward and joins the Piasa river at Jati Sari. From Jati Sari to Kisaran, the river flows northward with meandering on the plain. The river slope becomes gentler gradually toward downstream from 1/800 to 1/1,500. In the downstream reaches from Kisaran, the river flows eastward and finally joins to the Asahan river at Tanjung Balai. In this stretch, there are some irrigation intakes and drainage sluices. The land on the both banks of the river has been developed for paddy field. The continuous dike has been built on both the banks to protect the land from floodings in a total length of 28 km.

The Asahan river has a catchment area of 6,863 km^2 including Lake Toba catchment of 3,796 km^2, with 152 km length. The Asahan river originates from Lake Toba. The lake has vast natural regulating capacity by its wide water surface area of 1,100 km^2. The water level of the lake is being controlled at about El. 905 m by Regulating dam located at 14 km downstream from the outlet of Lake Toba.

The Asahan river flows down northeastward on steep slopes of mountain along deep and narrow gorges up to Bandar Pulau, about 65 km from Lake Toba through Siguragura and Tangga dams for hydropower generation. Downstream from Bandar Pulau, the river flows eastward and the river slope decreases gradually and the surrounding topography changes from hill to plain. The land on both the banks of the river has been developed by rubber and oil palm estates. At a point about 3 km upstream from highway bridge at Pulau Raja, the river joins the Sakur river.

Downstream from Pulau Raja, the river flows northeastward with meandering on the alluvial plain. The river slope decreases gradually toward downstream, being 1/4,000 and 1/13,000 respectively in the vicinity of Pulau Raja and Tanjung Balai. The dike of about 11 km in length is built on the right bank to protect the area of Padang Mahondang. In the downstream reaches from Pulau Raja, the swamp area extends widely to the right bank and partly to the left bank.

At Tanjung Balai, the Asahan river joins the Silau river and finally empties into the Strait of Malacca. Downstream from Tanjung Balai the river widens gradually toward the sea, being 200 m and 1,500 m respectively in the vicinity of Tanjung Balai and the river-mouth.

The Kualuh river has a catchment area of 3,820 km^2 of wide area with its total length of 165 km. The Kualuh river originates on the northeastern slopes of Mt. Sihabuhabu and flows northeastward along steep and narrow valleys. Near Pulodogom, the river joins the Harimau river. Downstream from Pulodogom, the river flows eastward and the surrounding topography changes from hill to plain. The river slope decreases gradually toward downstream. At Kileng Sandala, the river joins the Natas river. In the stretch between Pulodogom and the confluence of the Natas river, estates of rubber and oil palm and paddy field extend to the both banks of the river. To protect the paddy field, the dike has been built on the left bank in the downstream reaches of highway bridge. Afterwards, the river flows with meandering on the alluvial plain and joins the Kanopan river at Teluk Binjai and the Kuo river at Kuala Bangka. The swamp area extends widely to the right bank downstream from the confluence of the Natas river and the left bank downstream from the confluence of the Kanopan river. Afterwards, the Kualuh river flows northward and finally empties into the Strait of Malacca at Tanjung Leidong. Downstream from the confluence of the Kuo river, the Kualuh river widens gradually toward the sea, being 200 m and 4,000 m respectively in the vicinity of Kualuh Bangka and the estuary.

General features of those rivers are illustrated in Fig. F-1.

3.7.2 Existing flood control facilities

In the study area, the river dikes of 86 km in total length have been constructed in the middle and lower reaches. The dike length for each river is as follows:

River	Dike Length (km)		
	Mainstream	Tributary	Total
Bunut river	14	-	14
Silau river	28	-	28
Asahan river	11	4	15
Kualuh river	22	7	29
Total	75	11	86

The location of those existing dikes is shown in Fig. F-5. Almost all the dikes were constructed in the form of the cross-section with crown width of 2-3.5 m, side slope of 1:1 - 1:1.2 and height of 1-4 m as illustrated in Fig. F-6. River improvement and rehabilitation works during 1982 to 1984 are listed in Table F-6.

Any other flood control facilities such as diversion channel, artificial retarding basin, etc., are not found in the study area.

The related structures of the river such as bridge, drainage outlet, irrigation intake exist along the river courses. The location and dimension of bridges are listed in Table F-8 and the profile of major bridges are shown in Fig. F-7. The dimension of drainage outlets and irrigation intakes are shown in Table F-9

3.7.3 Discharge capacity of existing channels

The discharge capacity of the existing river channel was estimated based on water level calculation by the non-uniform flow method in the stretch from the river-mouth to Pulau Raja for the Asahan river and from Tanjung Balai to the confluence of the Piasa river for the Silau river. In the calculation, the values of Manning's roughness coefficient shown in Table F-4 were adopted in this study considering the existing channel conditions.

The estimated discharge capacities are shown in Table F-5 and Fig. F-4. From the figure, the following facts are recognized.

(1) Bunut river

a) The channel upstream from highway bridge at Bunut has comparatively high discharge capacity of 80 m^3/sec.

b) Downstream from the bridge, the capacity decreases to 50 m^3/sec near the confluence with the Beluru river.

c) Downstream rom the confluence with Silau Tua river, the capacities increase toward the river-mouth of the Kiri river from 100 to 50 m^3/sec.

(2) Asahan river

a) The channel upstream from highway bridge at Pulau Raja has comparatively high discharge capacity of 1,300 m^3/sec.

b) Downstream from the bridge, the discharge capacities decrease gradually toward downstream. Near the confluence of the Nantalu river the capacity decreases to extremely low value of 200 m^3/sec.

c) Downstream from the confluence of the Lebah river, the capacities increase toward the river-mouth from 200 to 3,500 m^3/sec

(3) Silau river

a) The channel upstream from Kisaran has comparatively high discharge capacity of 80 m^3/sec.

b) In the vicinity of Kisaran, the capacity is 700 m^3/sec. Downstream from Kisaran, the capacity decreases from 600 to 150 m^3/sec.

(4) Kualuh river

a) The channel upstream from highway bridge at Gunting Saga has comparatively high discharge capacity of 1,100 m^3/sec.

b) Downstream from the bridge, the capacities decrease gradually toward downstream. Near the confluence with the Pamengke river, the capacity decreases to low of 200 m^3/sec.

c) Downstream from the confluence, the capacities increase toward the river-mouth from 350 to 1,500 m^3/sec.

d) The discharge capacities of the downstream reaches of the Kanopan river are from 50 to 100 m^3/sec.

3.8 Flood Discharge

3.8.1 Recorded major floods

Water level data of the lower Asahan, Silau and Kualuh rivers at Pulau Raja, Kisaran and Pulo Dogom are available from 1977, 1973 and 1979 respectively. There is no record of the Bunut river. Gaging stations at Pulau Raja and Pulo Dogom are automatic, but at Kisaran staff gage reading at 7 o'clock in the morning, 12 o'clock noon and 5 o'clock in the evening. Since then there are some apprehensions that the flood peak of the Silau river be not recorded. The annual maximum flood peak of each river is shown in Table G-1.

It is recognized that the flood in January 1984 was the most remarkable in the lower Asahan and in the Kualuh rivers, and in the Silau river the biggest flood occurred in

December 1973. Big floods occur usually in September through January and also in May in this area. It should be noticed that the runoff in the lower Asahan river had been influenced by the artificial control of outflow from Lake Toba since February 1981.

The Asahan and Silau river basins might be suffered from most severe damage by the flood in December 1973 according to the verbal information from the site. The peak discharge of the flood was roughly estimated to be 800 m^3/sec on the basis of discontinuous hydrograph at Kisaran. It was confirmed from the fact that the basin rainfall of Pulau Raja and Kisaran on Dec. 1, 1973 was ranked in the first since 1963.

3.8.2 Flood discharge analysis of Asahan and Silau rivers

(1) Flood runoff in Asahan and Silau river basins

The Asahan and Silau river basins were divided into sub-basins as shown in Fig. G-1. The flood simulation model to analyze flood runoff mechanism of the Asahan and Silau river should simulate hydraulic behavior in the basin for the various flow conditions. It incorporates river basin components such as sub-basins, channels, dams and retarding basins as shown in Fig. G-2. The storage function method was applied to calculate flood runoff from each sub-basin and channel. All the coefficients were calculated from the typical past floods in May 1975, September/October 1977, May 1982 and January 1984. After establishing the model, a check was made by comparison of the calculated hydrographs with the actually recorded ones as shown in Fig. G-3, which shows a good coincidence. So that this selected storage function model was applied to estimate the probable flood peak discharges from the probable maximum daily rainfalls.

(2) Flood overlapping

Major floods in the past of which daily discharge was bigger than 170 m^3/sec for the residual area of Pulau Raja and also 200 m^3/sec for Kisaran were picked up in due consideration of discharge capacity of the existing channel. Seasonal frequency of flood is shown in Fig. G-5. The following flood characteristics were recognized from the frequency analysis:

a) Flood is often appeared during September through January and also in May,

b) Bigger floods occur in September through January.

From the rainfall records since 1963 when the most of rainfall gaging stations started their operations, it is recognized that the residual area received much rainfall during three months from October to December in 1963 and 1969 as shown in Fig. G-6. In that season the Regulating dam might have to spill out surplus water in considerable length of time.

The flood outflow from the Regulating dam of Lake Toba is 400 m^3/sec at the maximum under the present operation rule. The hydraulic study showed that the flood reaching time from the dam to Pulau Raja and that of the remaining catchment area to Pulau Raja are nearly same. So that there is almost no possibility to avoid the overlapping of both floods. Therefore the probable flood peak discharge at Pulau Raja is estimated by adding 400 m^3/sec to the flood peak discharge from the remaining catchment area, except for case of 2-year probability when only 315 m^3/sec will be discharged from the dam.

(3) Probable floods estimated for Asahan and Silau

The results of calculations are summarized below.

River	Site	Return Period (Year)						
		2	5	10	15	30	50	100
Asahan	Pulau Raja	625	826	1,001	1,106	1,355	1,523	1,839
Silau	Kisaran	449	457	565	670	911	1,055	1,300

All the flood control plans and probable flood damages were estimated based on the above figures.

3.8.3 Probable flood analysis on Kualuh and Bunut rivers

The same analysis method was applied to the data on Kualuh and Bunut rivers. The following results were used for flood control master plan.

River	Site	Return Period (Year)						
		2	5	10	15	30	50	100
Kualuh	Pulo Dogom	661	729	880	978	1,101	1,270	1,378
Bunut	Confluence	51	63	70	73	80	88	95

3.9 Flood Damage

3.9.1 Flooding characteristics

The river basins are situated in heavy rainfall zone of the monsoons and the river profiles are characterized with steep slope. Such heavy rainfall often brings about inundation in the low-lying area of the lower basin.

After heavy rain in the mountain areas, the river stage rises shortly after the rain in the middle reaches and the flow overtops the banks exceeding the channel capacity. Flooding in the plain thus may be caused by the following two factors:

(a) Over-bank flow of flood owing to small flow capacity of channel.
(b) Insufficient drainage capacity in low-lying area.

Figure G-10 shows possible flooding areas based on the data collected from DPUP, North Sumatra and the informations obtained through field survey.

The flooding conditions for each river are as follows:

Bunut river

As the drainage area of the Bunut river is small of 120 km^2 at Serbangan irrigation weir, flood discharge and inundated area were comparatively small even in the September 1983 flood. After construction of dikes of 14 km in total length, flood damage has been eliminated.

Silau river

The Silau river has continuous dikes on the both banks in the stretch between Kisaran and near Tanjung Balai. But those dikes have been often destroyed, especially in the downstream reaches, even by small flood less than its channel capacity. It seems that those dikes are rather weak and the maintenance is not sufficient.

Asahan river

The Asahan river also has dikes of 11 km long on the right bank in the downstream reaches of Pulau Raja. Those dikes have been occasionally destroyed by floods due to insufficient capacity of the river channel.

The overtopped excess flow runs eastward and inundates the low land on the right bank. The duration of inundation is long as two or three months.

In the downstream reaches from the existing dikes, the discharge capacity is smaller than that of upstream so that the excess water above its capacity intrudes into the undeveloped broad swamps on the right bank through various small tributaries, and the whole swamp area becomes a huge flood plain.

In the swamp area, several small streams and channel networks are intricate and their capacity is inadequate to evacuate the inundated water. Then this area is inundated for long time.

Kualuh river

Most floods overflow to the left bank area in the middle reaches downstream from highway bridge due to the topography. The area which consists of paddy fields had often suffered from floodings before the present dikes were constructed in total length of 29 km. Since then flooding have been reduced remarkably.

3.9.2 Flooding conditions

According to the data on the past floods collected from DPUP, North Sumatra and the informations obtained through the field survey, the floods in the last eight years from 1977 to 1984 are as follows:

Bunut river	:	Sept. 1983
Silau river	:	Sept. 1977, Apr. 1983, May 1983, Feb. 1984, Apr. 1984, May 1984 and Sept. 1984
Asahan river	:	Oct. 1977, Dec. 1978, Mar. 1980, Apr. 1982, May 1982 and Jan. 1984

Kualuh river : Sept. 1983, Oct. 1983 and Jan. 1984

Out of them, the following floods are selected for the estimation of damages.

Asahan river : Sept. 1977, May 1982 and Jan. 1984

Silau river : Sept. 1977, May 1982 and May 1984

In order to estimate flooding conditions, a contour map of the study area is tentatively made as shown in Fig. G-11 based on the existing data on topography. But this contour map shall be revised using a correct river survey result and 1/5,000 scale topographic maps with one meter contour along the Asahan and Silau rivers and their tributaries. Based on the contour map and results of discharge analysis in the lower area, the flooding conditions, that is, inundated area, depth and duration of the said floods were estimated as shown in Table G-22.

The flooding conditions for probable floods of 2 yr, 10 yr, 30 yr and 100 yr were also estimated as shown in Table G-25.

3.9.3 Flood damages

Flood damages are estimated in principle from properties in flooding area multiplied by the damage rate depending on the following conditions. The damages were estimated for respective properties such as house/building, household effects, stored goods, agricultural crops, public facilities and others.

All the monetary values are counted by use of the economic prices as of March 1985. The conversion rates of foreign and local currencies are assumed at US$1 = Rp. 1,100 = ¥ 250.

Damages to buildings/properties

The unit values for each property were estimated as shown in Table G-25 based on the statistic data obtained in the field. The standards of damage rates in Japan were adopted as shown in Table G-28.

Damages to agricultural crops

The agricultural crops were classified into three categories such as wet land paddy, upland crops and others.

Based on the paddy price predicted by World Bank (IBRD), the farm-gate price of paddy (dry stalk paddy) was estimated at Rp. 188/kg as shown in Table G-38.

The cropping pattern in the study area is as follows:

Stage :	Transplanting	Tillering	Booting	Heading	Ripening
Month :	Oct.	Nov.	Dec.	Dec.-Jan.	Jan.

The area has a flood season from September to January which corresponds to the growing period of paddy. In consideration of growing stage of paddy in the flood season, yield reduction rates for different flooding conditions are presented in Table G-35.

The upland crops were further classified into upland paddy, maize, and soybean. The unit price and damage rate are presented in Table G-38.

Flood damages to other crops such as cassava, sweet potato, peanut, and estate products of rubber and oil palm were assumed at 10% of sum of the wet land paddy and upland crops.

Damages to public facilities

Damages to public facilities such as river dike, road, bridge, irrigation intake, drainage outlet and canal were assumed at 30% of direct damages.

Indirect damages

The indirect damages which suffers from the losses due to interruption of smooth traffic and other economic activities in the flooding area was assumed at 10% of the total direct flood damages.

Probable flood damages in 1985 conditions

Table G-39 shows the calculation result of probable flood damages under the present conditions. The total flood damages are summarized below:

(Rp. million)

River	2-yr	5-yr	10-yr	15-yr	30-yr	50-yr	100-yr
Asahan river	1,464	2,609	3,561	3,657	3,779	3,834	3,888
Silau river	4,729	5,388	5,965	8,698	10,463	11,580	12,717
Total	6,193	7,997	9,527	12,355	14,242	15,424	16,605

Probable flood damages in 2000 conditions

Probable flood damages in the year of 2000 were estimated based on the annual growth rate of GRDP in North Sumatra and consumer price index (CPI) in 1980. Unit prices of agricultural crops were estimated based on the data in "Price Prospects for Major Primary Commodities, Sept. 1984". The calculation result of probable flood damages under the future conditions are as follows:

(Rp. million)

River	2-yr	5-yr	10-yr	15-yr	30-yr	50-yr	100-yr
Asahan river	2,179	4,287	5,993	6,138	6,406	6487	6,567
Silau river	13,045	14,253	15,445	24,614	30,370	33,988	37,606
Total	15,224	18,540	21,438	30,752	36,776	40,475	44,173

Average annual flood damages

The average annual flood damages were estimated as a cumulus of flood damage segments derived from probable flood damages multiplied by the corresponding probability of flood occurrence, with regard to probable floods.

The calculation of average annual flood damages for the years of 1985 and 2000 are Rp. 4,943 million and Rp. 11,879 million respectively.

3.10 Water Utilization

Peoples and industries in the study area for their water rely on the river surface and ground water. Among others the most significant water use in its quantitative terms in the area is for irrigation.

As clarified through the investigation and study on irrigation and drainage, the river runoff of the Bunut river has been most efficiently utilized for irrigation. Planted paddy field in the dry season in the Bunut basin, however, has been restrained to about 30 percent of the total paddy field of the basin owing to the absolute shortage of the dry season runoff.

The irrigation area in the Silau and Asahan river basins in the dry season also shrinks to about 30 percent owing to mainly drop of the river water level even though the river runoff is much more than the requirement since the intake facilities for the irrigation are all free inflow types in the said two rivers.

Especially in the Asahan river basin it is likely that the drainage is much significant factor for the regional development.

Piped domestic water supply in the study area is operated now in two cities, Kisaran and Tanjung Balai. Both the systems rely on the Silau river as their sources, and raw water taking of the both systems totals 7.0 m^3 per minute at most.

Peoples living the conducting business in towns and villages other than the said two cities, as their water supply, rely on deep wells, such as the case in Tanjung Tiram, Bagan Asahan and Teluk Nibung, raw water of the river, shallow wells and rain water.

Industrial water uses in the study area are mainly consisting of uses for processing of oil palm and rubber.

Annual water consumption in the study area under the present conditions is estimated at 81 MCM in the whole fields, composing of 83% for irrigation, 9% for domestic water use and 8% for industrial uses. This volume corresponds to 1.2% of annual runoff of three rivers, Asahan, Silau and Kualuh, in 1983, which was somewhat a drought year in recent several years (see Table A-4).

As a whole, water resource in the study area is abundant compared with the water utilization at present. One exception, however, is for the Bunut river basin and water diversion from other rivers, for example, from the Silau river, to the Bunut basin would be worthy to be studied in Part II Study.

The final plan of water resources allocation will be established after the agricultural master plan is established through the Part II works. However from the above studies it may be sure that no difficulty is there to make water utilization to all the purposes, such as irrigation, water supply, river maintaining, etc. It seems rather important to improve drainage and sewerage in low-lying area through flood control and agricultural development.

3.11 Saline Water Intrusion at Estuary

In the Strait of Malacca both the high and low tides repeat regularly twice a day and the inequality is small. The tidal movement in the Straight usually precedes from the Andaman sea toward the south China sea.

In the Straits of Malacca and Singapore the investigation of tides and tidal streams were carried out jointly by the three coastal countries, Indonesia, Malaysia and Singapore, and Japan for three years from 1977.

Tide levels at Began Asahan and Tanjung Balai and saline water intrusion into the Asahan river were checked on 26 February and 8 March 1985. The former measurement was rather preliminary and latter one was proper at a chance of the spring tide (the moon's age 16.7).

Began Asahan is a small village at the estuary of the Asahan river located at 2.5 km upstream of its mouth and also a check point for numerous fishing boats operating on the Strait of Malacca.

Tidal heights at Began Asahan and Tanjung Balai were observed by staffs temporarily installed and salt concentration of the river water was measured in terms of electric conductivity by an electric conductivity meter, EST-3, at several points. At Teluk Nibung, lying halfway from Tanjung Balai to Bagan Asahan and also facing with the Asahan river, hourly variations of the electric conductivity of the river water were measured from 14:20 Hr to 18:00 Hr of 8 march 1985 on rising of the tide. Datum levels of the staffs were checked by leveling.

The range of tide observed at Bagan Asahan and Tanjung Balai at the spring tide on 8 March 1985 were 4.0 meters and 2.0 meters respectively. The former coincided with the record of tidal level at Bagan Asahan stated in Sub-Paragraph 3.3.3.

The standard point for prediction of tidal heights on the coast of the north-eastern Sumatra is One Fathom Bank (2°53'N and 101°N0'E, just a center of the Strait. In 1985 the highest and lowest hight of spring tides are 503 cm in October and -22 cm in March.

From the tidal heights at Bagan Asahan observed on 8 March 1985 and the predicted ones at One Fathom Bank on the same day, the height ratio appeared in the formula for prediction of approximate tidal height at secondary point (Began Asahan) from those at standard point (One Fathom Bank) was found out to be R=0.793. The formula is as follows:

$$H = (HO - 244) \times R + 202.7$$

where,	H	:	tidal height at Bagan Asahan (cm),
	HO	:	tidal height at One Fathom Bank (cm),
	R	:	height ratio,
	244	:	datum level of tidal heights (cam, below mean sea level) at One Fathom Bank, and
	202.7	:	ditto at Bagan Asahan.

Time difference for tides between One Fathom Bank and Bagan Asahan is about 30 minutes, tides at Bagan Asahan go ahead of those at One Fathom Bank.

As shown in the Sub-Paragraph 3.3.3, the amplitude of the tide level at Kuala Tanjung is smaller than that of Bagan Asahan. This is due to the width of the straight of Malacca, which becomes narrower from the Andaman Sea toward the strait of Singapore.

This implies that the amplitude of the tide level at the river mouth of Kualuh river is larger than that of Bagan Asahan. In fact according to the tide table for the north-eastern shore of Sumatra Island the high ratio for Tanjung Tiram, Asahan river entrance and Labuhan Bilik of the Panai river to the amplitude of tide level at One Fathom Bank is 0.55, 0.80 and 1.00 respectively.

In the Asahan river the saline water neither intrude to Tanjung Balai nor to Tuluk Nibung even at the spring tide in low flow season. River runoffs of the Asahan and Silau rivers in early March 1985, when the tide level and saline water intrusion of the Asahan river were measured at the spring tide on 8 March 1985, were nearly lowest ever recorded (Asahan at Pulau Raja 147 m^3/sec and Silau at Kisaran 35 m^3/sec). This assertion is endorsed by the fact that shellfish never lives in the river course beyond the point 1.5 km upstream of Bagan Asahan. Both the long term flood control plan and the urgent flood control plan include no dredging works downstream reaches so that no further intrusion of saline water is anticipated.

Tidal level and saline water intrusion into the river course of the Kualuh shall be checked in an early stage of Part II Study.

3.12 Sedimentation

3.12.1 Present conditions

The engineering analysis on the measurements of sediment along Asahan and Silau rivers clarified that the annual total sediment yield in those basins ranges between 500 and 550 m^3/km^2, out of which the specific sediment of river bed materials is about 260 m^3/km^2 for Asahan and about 400 m^3/km^2 for Silau river.

It was also confirmed by the ground survey and the interpretation of false color image made from the Landsat IV data taken on June 8, 1984 that no large scale mountain break and land slide exist in the water shed. The Landsat photograph also proved that the natural upland forest is kept in good vegetation cover without any large denuded lands. Therefore the above sediment production is considered to be attributable mainly to the sheet erosion of the ground surface of mountain and hill area.

On of the big sediment production sources may be the renewal operation of rubber and oil palm estates. The cutting of old trees and replanting are required in 20 to 30 years' interval for those estates.

It means that 3 to 5 percent of the total planted area of 166,000 ha would be denuded annually and planted with young seedlings. This area is so that estimated to be 50 to 80 km^2 per annum. Even after replanted with young seedlings those areas would cause sheet erosion of 2 to 3 mm/year for about 10 years. It means that annual production will amount to 1.0 to 2.4 million m^3 of sediment, corresponding to 230 to 550 m^3/km^2 for the catchment area of study area excluding the catchment area of Lake Toba.

Most of the estates take much care about the soil conservation employing such measures to construct small dikes (locally called as "Tanggul" or "Benteng"), to make contour ploughing and to plant grasses under trees. However it is inevitable to remove all vegetation by machines when replanting of young seedlings. So that it is strongly recommended that the denuded estates shall be planted as soon as possible with seedlings and grasses.

Regarding the sediment transportation regime it is judged that almost all sediment materials are being transported as bed-load and suspended load. The grain size distribution of the river bed materials, river gradient and flow depth suggest that there seems no such high density sediment flow as debris flow or mud flow.

The Lake Toba is playing a very big role not only for flood control but also sediment control as the sediment study proves very low sediment transport in Asahan. Almost all sediment materials from the surrounding area (about 2,500 km^2 of land) deposit themselves into the lake and very pure water outflows from the outlet. Therefore about 65 percent of the total catchment area of the Asahan river is not concerned to the supply of sediment.

3.12.2 Conclusion

The above sedimentation survey and study revealed not so serious problem existing in those basins since the upland forest is still well maintained. The river bed between Tanjung Balai and the estuary of Asahan is gradually silted in a long run of years. But the port function of Tanjung Balai has been already much shifted to Belawan by development of the Belawan and inland transportation.

A little rising of river bed of Silau was observed but still not so serious as to require urgent dredging at present. However, future continuous monitoring may be required to observe what changes will happen after the urgent flood control facilities are to be completed.

3.13 Agriculture

Total population and total household in the study area as of 1983 are estimated at 828,000 and 155,000 respectively. Total farm households are about 88,500 or 57% of the total households. Available labor force in agricultural sector is about 213,000 people or 51% of total available labor force in the study area. However 60 to 80% of available labor force in agricultural sector are surplus throughout the year due to low cropping intensity and less job opportunity. With respect to land tenurial status, more than 70% of total farm households are owner operators. An average farm size is roughly estimated at about 0.8 ha per family.

According to "Soil Map of The World" prepared by FAO-UNESCO in 1979, there exist five major soil groups in the study area: (1) Dystric Histosols, (2) Dystric Fluvisols, (3) Humic Gleysols, (4) Ferric Acrisols and (5) Orthic Acrisols. Soils of (2), (4) and (5) are extensively used as farm lands at present. Most of District Histosols and Humic Gleysols extend over the swamp lands which remain unused. The development of these swamp lands should be carefully executed, taking account of (1) distribution of organic soils and their peat depth, (2) distribution of potential acid sulphate soils and depth to the acid sulphate soils, (3) soil salinity, (4) stage of physical ripening of soils and (5) mineral soils under organic/peat layer.

Major food crops in the study area are paddy, followed by upland rice, maize, cassava, soybeans, sweet potato, mongo beans and peanuts. Paddy is planted at the onset of monsoon, generally September to December. Harvest is carried out from February to April. Upland rice is planted during the period of four months from July to October and harvested from December to March. Other crops are planted throughout year on a small scale.

As far as farming practice is concerned, about 60% of rice seed is improved varieties. Most of varieties of palawija crops are local varieties. About half of the farmers in the study area uses fertilizer and agro-chemicals for paddy cultivation under intensification programme. The estimated average dosage per ha for paddy from 1980/81 to 1983/84 is 83 kg of Urea, 28 kg of TSP, 9 kg of ZA, 5 kg of KCl, 3 liters of insecticide and 0.3 kg of redenticide. No application of fertilizer and agro-chemicals is practiced for palawija crops. Such low dosage of fertilizer is one of the constraints to hinder unit yield of crops. The major reasons of such low dosage are considered as follows:

(1) Farmers in the study area can't purchase fertilizers due to low capacity to pay.

(2) About 80% of paddy field is under rainfed, which hampers effective application of farm inputs. The farmers in the rainfed paddy field do not want to apply proper dosage of fertilizer.

(3) KUD, one of the agencies of farm inputs distribution, does not always function effectively.

An average unit yield and crop production in the study area are estimated as follows:

Crop	Unit Yield (ton/ha)	Production (ton)
Paddy	2.9	184,000
Upland rice	1.8	27,000
Maize	1.9	5,000
Cassava	12.3	12,000
Sweet potato	12.2	3,000
Peanuts	1.0	300
Soybeans	1.1	800
Mongo beans	1.2	400

As shown in the above table, unit yield of paddy is quite low. Unit yield of paddy has not increased for recent five years. Furthermore harvested areas of paddy have been seriously affected by natural disasters. Total annual production of paddy, therefore, has fluctuated largely, ranging from 131,000 tons to 212,000 tons during the period of recent six years.

Constraints which have hampered unit yield of paddy and its production are considered from the technical viewpoint as follows:

(1) Low level of fertilizer's dosage

(2) Though about 60% of total rice seed is the improved varieties, only 6% are certified seed.

(3) Considerable infection and damage by pest, diseases and rat are found.

(4) Damages by flood and poor drainage.

(5) More than 80% of the total paddy field is under rainfed.

Unit yields of crops other than paddy are also low due to no application of fertilizer and improved varieties in general.

In addition to major food crops, estate crops such as oil palm, coconut, rubber, coffee, clove and sugarcane are grown under PTP and/or small holder systems. The unit yield and productions of major crops are shown below:

Crop	PTP		Small Holder		Total Production (t)
	Unit Yield (t/ha)	Total Production (t)	Unit Yield (t/ha)	Total Production (t)	
Oil palm	18.0	403,600	1.7	700	404,300
Rubber	1.3	19,800	0.4	4,800	24,600
Coconut	-	-	0.8	20,300	20,300

Under smaller holder system, application of fertilizer and chemicals is not practiced in general. On the other hand PTP has carried out careful management.

3.14 Irrigation and Drainage

Study on irrigation and drainage has been made aiming (i) to clarify the present condition of paddy schemes in the study area, (ii) to reveal existing problems and constraints in the paddy schemes, (iii) to estimate the present water utilization for irrigation, and (iv) to presume the possibility of irrigation and drainage development in the future.

(1) Present condition of paddy schemes

Paddy schemes in the study area have been developed and maintained by DPU North Sumatra Province and Asahan Kabupaten Office. In the study area, paddy field covered by irrigation or control drainage schemes totals about 32,600 ha in net comprizing 25,100 ha (23 schemes) in Kabupaten Asahan and 7,500 ha (8 schemes) in Kabupaten Labuhan Batu. Of them, irrigable area is estimated to be 6,800 ha in total, or 21% of total irrigation scheme area, consisting of 2,880 ha in the lower Bunut area, 1,880 ha in the lower Silau area, and 2,040 ha in the other area. Among these irrigable areas, an area of 2,050 ha can be cultivated during dry season due to limitation of available river discharge. Irrigation canal density in the existing schemes is estimated at 19 m/ha on an average which is too low to achieve adequate water management.

(2) Problems and constraints in the existing paddy schemes

Problems and constraints in the existing paddy schemes found through the field reconnaissance, data analysis and discussions with DPU officials are summarized below:

(a) The Padang Mahondang scheme and Sei Lebah scheme located in the Asahan river basin are suffering from flood problem.

(b) In the existing irrigation schemes in the lower Bunut area, irrigable area for dry season paddy is quite limited due to shortage of available water in the Bunut river.

(c) In the existing irrigation schemes in the lower Silau area, irrigable area for dry season paddy is limited due to insufficient river water level at the free intakes during dry season.

(d) Most of all paddy schemes in the study area, provision of canal network is insufficient. Poor drainage condition seems to be one of the reasons of low productivity of paddy.

(e) In most existing irrigation schemes, tertiary canal and measuring device are not provided yet. Lack of these facilities seems to be one of the reasons of present poor water management.

(f) Farm roads are absolutely insufficient. Especially, accessibility in and around the existing control drainage schemes is terribly poor.

(g) To achieve good O&M for existing schemes, present number of O&M staffs and budget is too small.

(h) Many existing intakes and canal structures constructed in 1970's are partly deteriorated already, especially gates.

(3) Present water utilization for irrigation

Present irrigation water requirement was provisionally estimated using present cropping pattern, existing irrigable area and calculation method proposed by PROSIDA. Unit irrigation requirement was estimated as tabulated below:

Unit Irrigation Requirement	Kabupaten Asahan	kabupaten Labuhan Batu
1. Peak irri. requirement (lit/sec/ha)		
Dry season paddy	1.45	1.16
Wet season paddy	0.87	0.73
2. Seasonal irr. requirement (m^3/crop)		
Dry season paddy	11,530	8,160
Wet season paddy	9,580	5,920

Present annual water utilization for irrigation purpose in the study area was estimated at 77 MCM per year in the year of 1 in 5 year low rainfall and 68 MCM per year in the year of average rainfall.

(4) Possibility of irrigation and drainage development

The study area can be divided into eight (8) areas from the viewpoint of (i) boundary of river basin, (ii) location and characteristics of existing paddy areas, and topography. These areas are:

a) Upper Bunut area
b) Lower Bunut area (downstream of the highway)
c) Upper Silau area
d) Lower Silau area (east of Kisaran)
e) Asahan area
f) Leidong area (coastal)
g) Upper Kualuh
h) Lower Kualuh

Location of these areas are shown in Fig. 3-5. Possibility of irrigation and drainage development in these areas is provisionally presumed as shown below. Possible area for future development can be determined based on the soil survey and agricultural and irrigation studies in Part II study.

(a) Upper Bunut area

Minor paddy fields are scattered mainly along the Bunut river and its tributaries. At present, no irrigation scheme exists in this area. If river diversion plan from the Silau river to the Bunut river is implemented, about 500 ha of existing paddy fields along the Bunut river will be possible to be irrigated,

(b) Lower Bunut area

Paddy fields locating eastward of the Medan-Kisaran highway in the Bunut river basin are recognized as the lower Bunut area having 17,100 ha (gross) of paddy field. At present 4 irrigation schemes (2,882 ha in total) and 3 controlled drainage schemes (8,150 ha in total) have been maintained in this area by DPU. The major problem is the shortage of available water in the Bunut river during dry season. To upgrade the present situation of paddy fields in this area, the river diversion plan from the Silau river to the Bunut river should be considered.

(c) Upper Silau area

In the upper Silau area, or elevated area in the Silau river basin, about 2,100 ha of paddy field are scattered along the Silau river and its tributaries. At present, only one irrigation scheme, Tinggi Raja, is in operation taking irrigation water from the Piasa river. According to the map study, nearly 1,000 ha of paddy field will be possible to be irrigated. In order to realize these schemes, careful cost-benefit analysis is required.

(d) Lower Silau area

There are 7 irrigation schemes (1,882 ha in total). Among 6,800 ha (gross) of existing paddy fields in this area, about 4,000 ha (net) of paddy areas may be able to be developed into irrigation area. The biggest problem for irrigation development is inadequate water level at free intakes on the Silau river during dry season. In Part II study, possible measures to solve this problem will be considered based on field investigation and preliminary study.

(e) Asahan area

This area is a vast area including huge Asahan swamp. Paddy scheme areas are scattered around the Asahan swamp. Paddy fields in this area have been increased steadily. In 1985, existing paddy field is estimated to be 12,500 ha (gross). At present, 4 irrigation schemes (885 ha in total) and 2 controlled drainage schemes (6,500 ha in total) have been maintained by DPU and Asahan Kabupaten Office. Of them, the Sei Lebah controlled drainage scheme (6,550 ha in gross) is the largest scheme. To improve this scheme, provision of flood protection dikes, adequate irrigation facilities and drainage facilities will be necessary. The Padang Mahondang scheme of 2,230 ha is suffering from flood from the Asahan river. At present, irrigation facilities have been provided to the paddy field of about 560 ha. Flood protection dikes, irrigation and drainage facilities are indispensable to upgrade this scheme. For other minor paddy fields, possible measures will be considered taking the local conditions into account.

(f) Leidong area

Vast rainfed paddy fields are extended in the eastern side of Asahan swamp along the coast. The existing paddy fields in this area are presumed to be 14,300 ha in total. At present, no investment to improve paddy cultivation has been introduced into this area. Therefore, this area still remains as one of the poorest area in the study area. Access to this area is quite poor. To improve the present situation, an integrated development measure should be considered. It will include (1) provision of tidal band and drainage facilities, (2) improvement of existing rural roads, and (3) provision of social facilities.

(g) Upper Kualuh area

In the upper Kualuh area, about 2,500 ha of paddy field are scattered along the tributaries of the Kualuh river. Among this, irrigation facilities have been provided to 3 schemes (759 ha in total). In future, about 1,500 ha (net) of paddy field will be possible to be irrigated.

(h) Lower Kualuh area

In the low-lying area extended along the Kualuh river and its tributaries such as the Kanopan and the Natas rivers, about 22,900 ha of rainfed paddy fields have been cultivated. The major problem in this area is poor drainage. By 1985, 5 controlled drainage schemes covering 7,300 ha have been developed by means of provision of flood protection dikes, gate structures and drainage canal system. In this area, drainage system should first be completed and, then, possible measure for positive irrigation will be considered.

CHAPTER 4 MASTER PLAN FOR LAND AND WATER RESOURCES DEVELOPMENT

4.1 Basic Direction of Land and Water Resources Development

According to the socio-economic survey, this study area is blessed with tropical climate and rich land and water resources but no mineral resources except some coal reserve in the extremely southern hill area. Present meager infrastructures, such as transportation, communication, power and water supply, etc. imply much difficulty for immediate industrial development in this area. From the viewpoint of efficiency of investment and its social and economic effect it is strongly recommended to develop given land and water resources for agricultural development. As the land use survey revealed, the land of study area has mostly been developed already into plantation and cultivated lands except swamps. The present land use is well fitted to the given natural conditions suggesting no need of changes.

The socio-economic survey clarified that the estate works and merchants enjoy comparatively high incomes, while the small farming families, depending on mainly paddy cropping on their small lands, are much suffered from low incomes due to low unit yield of paddy. In order to absorb future increasing population the land productivity of those paddy fields shall first be raised. It will naturally contribute to raise family income level and to achieve the self-sufficiency of rice in this area as well.

From the economic viewpoint, the first priority shall be given to protect those existing paddy fields from frequent damage by floods. Hence the flood control plan shall be established first taking into consideration the potential land development area.

The second priority shall be put on the rehabilitation or improvement of the existing irrigation and drainage facilities. The small irrigation projects covering 100 to 500 hectares shall be also studied for utilization of small branch streams.

The third priority will be given to extension of irrigated lands by enlargement of existing facilities or additional facilities and also extension of farm land by swampy land development.

Since the above development will require considerable length of time, probably exceeding the target year of 2005 A.D. of master plan, it is essential that practical realization of project development should be formulated through careful study of project evaluation and priority sequence of project development.

4.2 Long-Term Flood Control Plan

4.2.1 General

On the basis of the results of field investigation and study on the present conditions of the study area, conceivable alternative schemes for long-term flood control plan are studied by a comparative study of the alternative schemes, and the final plan is formulated aiming at prevention of flood damage not only in the existing developed lands but also in adjoining lands for future development.

4.2.2 Objective area for long-term plan

The long-term flood control plan aims at prevention of flood damage in the study area, from viewpoint of long-range policies as raising the productivity, promoting development and bettering the living standard in the area.

The objective rivers and their stretches are as follows:

River	Stretch	Length (km)
Bunut river	River-mouth of Kiri river - Highway bridge at Bunut including a part of Kiri river	36.7
Asahan river	River-mouth - Highway bridge at Pulau Raja	61.5
Silau river	Confluence to Asahan river - Road bridge at Kisaran	21.7
Kualuh river	River-mouth - Highway bridge at Gunting Saga	84.2
Kanopan river	Confluence to Kualuh river - Road bridge at Pulo Gambut	13.0
Total		217.1

4.2.3 Flood control method

In general, the following methods are considered for flood control planning.

Upper basin	:	flood regulation by reservoir.
Middle basin	:	flood retardation by retarding basin and flood prevention by channel improvement.
Lower basin	:	flood diversion by floodway, flood retardation by retarding basin and flood prevention by channel improvement.

For selecting the flood control method, it is necessary to consider regional characteristics of the river basin such as topography, scale of catchment area, shape of flood hydrograph, flooding conditions, construction cost, etc.

(1) Flood control method in the upper basin

The river slopes upstream of the Asahan, Silau and Kualuh rivers are very steep more than 1/40. The flood runoff is therefore of the flash type with time concentration of about 7 hours. The effective measures of flood control for such rivers are to store a flood runoff by reservoir in the upper basin. However, the rivers have very steep slopes of deep and narrow gorges. Appropriate dam site with reservoir is found only at Parhitean (8 km downstream from Tangga power station) in the upstream reaches of the Asahan river.

This dam site is taken up by PLN as hydropower project namely Asahan No.3 project. The feasibility study was made by JICA in 1982. The detailed design of the project is being carried out by PLN. According to the feasibility study report, the principal features of the project are shown in Table 4.1.

The proposed intake dam for the Asahan No.3 power station will have considerably large storage capacity. It suggests a possibility of flood regulation to cut off the peak flood discharge coming from the remaining catchment area of 214 km^2 downstream from the existing regulating dam although the flood release from the regulating dam can not be regulated because the release from Lake Toba continues as long as 30 to 90 days.

In calculation, the flood peak discharge from the area of 214 km^2 is estimated at about 410 m^3/sec and its total volume may be 30 mcm in the case of 30-year probable flood. If the storage capacity of 12 mcm for flood control is secured at the No.3 intake dam, the above peak discharge will be cut down to 100 m^3/sec. The flood control effect of this intake dam will reduce about 20% of the peak flood discharge of 1,360 m^3/sec at Pulau Raja which includes the maximum flood release of 400 m^3/sec from the upstream regulating dam. So that, it is recommended to take the flood control capacity at the No.3 intake dam. It seems that the decrease of annual electric energy at the No.3 power station would be as small as less than 1% or so even in case of 12 mcm of flood control capacity during the flood season, as some part of flood quantity at the intake dam will reduce the loss of power due to lower head during flood season.

(2) Flood control method in the middle basin

In the middle basin of the said four rivers, most of the flat area along the rivers has been developed for rubber and oil palm estates. The possible areas for retarding basin are not found. In the middle reaches from Sumber Agung to Bunut of the Bunut river, from Bandar Pulau to Pulau Raja of the Asahan river, from Samba Huta to Kisaran of the Silau river, and from Pulo Dogom to Gunting Saga of the Kualuh river, the existing river channel has adequate discharge capacity due to sufficient bank height, so that no flood control measures is necessary.

(3) Flood control method in the lower basin

In the lower reaches of the rivers, the existing river channel has not enough discharge capacity in most stretches except in the stretches from Tanjung Balai to the river-mouth of the Asahan river and Teluk Binjai to the river-mouth of the Kualuh river. Conceivable alternative flood control methods in those reaches are as follows:

a. Bunut river

i) A floodway to divert the excess flood water from the Bunut river by enlarge a drainage canal over a length of 22 km from Serbangan intake to the Strait of Malacca.

ii) Channel improvement to increase the discharge capacity by means of construction of dike and excavation of channel.

b. Asahan and Silau rivers

Asahan mainstream

i) A floodway to divert the excess flood water from the Asahan mainstream by construction of 30 km channel from a point downstream of Pulau Raja to the estuary of the Kualuh river.

ii) Channel improvement to increase the discharge capacity by means of construction of dike and excavation of the channel.

iii) Channel improvement combined with a retarding basin to retard the flood water in the right bank area between the confluences of the Nantalu and Lebah rivers.

iv) Combination of above methods.

Silau river

Channel improvement is only conceivable method in the lower reaches of the Silau river owing to the topographic conditions.

c. Kualuh river

Kualuh mainstream

i) Channel improvement to protect the lands developed and to be developed in the future by means of diking system.

ii) Channel improvement combined with a retarding basin to retard the flood water in the right bank area between the confluences of the Natas and Kanopan rivers.

Kanopan river

Channel improvement is the only conceivable method in the lower reaches of the Kanopan river owing to the topographic conditions.

(4) Alternative schemes

The following alternative schemes are set up fo the present study.

a. Bunut river

Alternative Scheme B-1 : Floodway

Alternative Scheme B-2 : Channel improvement alone

b. Asahan and Silau rivers

Alternative Scheme A-1

Asahan river : Channel improvement combined with floodway

Silau river : Channel improvement alone

Alternative Scheme A-2

Asahan river : Channel improvement combined with retarding basin

Silau river : Channel improvement alone

Alternative Scheme A-3

Asahan river : Channel improvement alone

Silau river : Channel improvement alone

c Kualuh river

Alternative Scheme K-1

Kualuh river : Channel improvement combined with retarding basin

Kanopan river : Channel improvement alone

Alternative Scheme K-2

Kualuh river : Channel improvement alone

Kanopan river : channel improvement alone

4.2.4 Scale of long-term plan

At present, a level of 20-year to 50-year flood is actually selected for the flood control plan for major rivers in Indonesia as shown in Table 4.2.

In order to determine a scale of design flood for long-term plan, a comparative study is made selecting three design flood levels of 15 year, 30 year and 50 year for the Scheme A-2. The results of comparative study are summarized below:

Design Flood (year)	Ave. Annual Benefit (Rp. million)	Economic Cost (Rp. million)	B/C with Discount Rate of 14%
15	10,571	56,152	1.01
30	11,662	61,404	1.03
50	12,166	69,053	0.94

The above table shows that the 30-year design flood level is most attractive because of a little high economic value of B/C compared with the others.

Taking into consideration the design flood levels of other rivers in Indonesia, result of comparison of economic value and possibility of future realistic development in the study area, the 30-year flood is proposed as design flood for the long-term flood control plan.

4.2.5 Comparison of alternative schemes

Adopting design flood of 30-year, the seven alternative schemes described in the foregoing section are studied. The schemes comprise two alternatives for the Bunut river, three alternatives for the Asahan and Silau rivers, and two alternatives for the Kualuh river. The most optimum scheme for long-term plan is selected on the basis of the comparative study. The results of comparative study on economic value are shown below:

Alternative Scheme	Ave. Annual Benefit (Rp. million)	Economic Const. Cost (Rp. million)	B/C with Discount Rate of 12%
Bunut river			
B-1	1,839	15,555	0.77
B-2	1,839	12,074	0.99
Asahan and Silau rivers			
A-1	12,444	103,558	0.78
A-2	11,662	61,404	1.24
A-3	11,976	71,822	1.09
Kualuh river including Kanopan river			
K-1	3,116	19,715	1.03
K-2	3,742	25,241	0.97

The comparative study on economic value of B/C makes it clear that for the Bunut river and the Asahan and Silau rivers, Scheme B-2 and Scheme A-2 indicate higher economic values than the other Schemes, while for the Kualuh river, Scheme K-1 indicates a little higher economic value than Scheme K-2.

Therefore, it is considered reasonable to select the Schemes of B-2, A-2 and K-1 for the long-term flood control plan.

4.2.6 Proposed long-term flood control plan

(1) Design flood discharge

Based o the results of flood discharge analysis, the design flood discharges of the Bunut, Asahan mainstream, Silau, and Kualuh rivers for the long-term flood control plan are determined as shown in Fig. 4-1. In determination of design flood discharge at Pulau Raja on the Asahan mainstream, flood regulation of 310 m^3/sec by Asahan No.3 Dam was considered and outflow from Regulating dam was estimated at 400 m^3/sec assuming that flood peak from the basin downstream from Regulating dam overlaps with the maximum outflow from Regulating dam.

(2) Proposed plan

The proposed long-term plan is composed of channel improvement by means of construction of dike and excavation of channel, construction of drainage outlet culverts, and reconstruction of irrigation free intake owing to channel improvement. The proposed alignments of dike, longitudinal profiles and cross-section are shown in Figs. H-3 to H-5. The outline of the works of the proposed long-term plan for each river is shown in Table 4-4 and are explained below.

a. Bunut river

The long-term plan of the Bunut river proposes the works of channel improvement over a length of 33.7 km which includes a part of the Kiri river of 7 km in the stretch between highway bridge at Bunut and road bridge at Tanjung Tiram, construction of a drainage culvert, and also reconstruction of a road bridge.

b. Asahan and Silau rivers

The long-term plan of the Asahan river proposes the works of channel improvement by diking system over a length of 39.7 km in the downstream reach from Pulau Raja in addition to construction of dike for a retarding area over a length of 17.8 km on the right side bank of the Lebah river, and also construction of 13 drainage culverts.

The long-term plan of the Silau river proposes the works of channel improvement over a length of 21.7 km in the stretch between the confluence to the Asahan mainstream and road bridge at Kisaran, construction of 6 drainage culverts, and reconstruction of 5 irrigation intakes.

c. Kualuh river including Kanopan river

The long-term plan of the Kualuh river proposes the works of channel improvement by diking system over a length of 33.3 km in the stretch between the confluence with the Kanopan river and highway bridge at Gunting Saga, construction of 9 drainage culverts and reconstruction of an irrigation intake.

For the Kanopan river, the proposed works are channel improvement by diking system over a length of 13.0 km in the downstream reaches from the confluence to the Kualuh mainstream to road bridge at Pulo Gambut, and construction of 8 drainage culverts.

(3) Construction cost

Construction costs are composed of the costs of civil works, land acquisition and compensation, contingency and engineering and administration. Cost required for civil works is accounted by multiplying work quantity by unit cost. Engineering and administration cost is assumed to be 15% of the sum of the civil works, land acquisition and compensation costs. Cost for contingency is assumed at 10% of the above costs. The construction costs for the long-term plan for each river are estimated at Rp. 12,550 million for the Bunut river, Rp. 63,470 million for the Asahan and Silau rivers, and Rp. 20,500 million for the Kualuh river.

(4) Economic evaluation

a. Economic construction cost

The economic construction cost for the long-term plan is estimated by deducting tax and contractor's profit from the Rupiah currency portion of the construction cost. The tax and contractor's profit to be deducted are assumed to be 4% and 10% respectively. The land acquisition and compensation costs are evaluated as a part of construction cost. The economic construction cost for the long-term flood control plan is estimated as shown below:

(Unit: Rp. million)

River	Bunut R.	Asahan & Silau R.	Kualuh R.
Economic Construction Cost	12,074	61,404	19,715

b. Benefits

Benefits are the expected reduction of flood damages to private properties, farm crops, public facilities, etc., and also expected development effect for the land which has not been utilized during the wet season. For evaluation of long-term plan, the benefits are estimated under two conditions, i.e., the present conditions in 1985 and the future development conditions in 2005.

<u>Benefit under present conditions</u>

Based on the estimated flood damages under the present conditions, the expected reduction of flood damages by implementation of the proposed long-term plan is estimated as shown below:

(Unit: Rp. million/yr)

River	Bunut R.	Asahan & Silau R.	Kualuh R.
Reduction of average annual damage	1,224	5,547	1,768

In addition to the above benefits, the expected development effect for the land which has not been utilized during the wet season is estimated. Such development effects by the long-term plan may be counted as enhancement benefit. They are estimated as shown below:

River	Bunut R.	Asahan & Silau R.	Kualuh R.
Area to be enhanced (ha)	-	6,519	4,800
Enhancement benefit (Rp. million/yr)	-	751	200

Benefits under future conditions

The flood damages under the future conditions are estimated based on projected increase in population and GRDP in each sector. The expected benefits under the future development conditions by implementation of the proposed long-term plan is estimated as shown below:

(Unit: Rp. million/yr)

River	Bunut R.	Asahan & Silau R.	Kualuh R.
Reduction of damages	1,839	10,332	2,740
Enhancement benefit	-	1,330	376
Total benefits	1,839	11,662	3,116

c. Internal rate of return

Based on the economic construction cost and benefits mentioned above, internal rate of return for long-term plan is calculated assuming the project life of 50 years. The results show that the project is expected to yield the following internal rate of return.

Conditions	Internal Rate of Return (%)		
	Bunut R.	Asahan & Silau R.	Kualuh R.
Present condition	8.3	8.4	8.1
Future condition	11.9	14.3	12.3

d. Priority order

The priority of project implementation of the three plans is concluded from a standpoint of economic and social aspects of the study area. The priority order is as follows:

Priority Order	Long-term Flood Control Plan
1	Asahan and Silau Rivers
2	Kualuh and Kanopan Rivers
3	Bunut River

4.3 Water Use in Future

As clarified through the investigation and study in Part I work, water resources in the study area is far beyond the water use at present. It may be less than one thousandth that the water shortage becomes a serious social problem in this area even in the 21 century. Such statement will be true in the Asahan and Kualuh river basins, however, in the Bunut river basin of the northern fringe of the study area is suffering from water shortage in the dry season owing to the small catchment area and less precipitations. To conquer the water shortage of the Bunut basin, water diversion from the Silau river is conceivable. Though the details should be carefully studied in Part II work, a basic idea is a follows:

Diversion site	:	at the closest site of Silau and Bunut rivers, about 16 km southwest of Kisaran as shown in Fig. D-3.
Diverting discharge	:	10 to 15 m^3/sec, estimated from the catchment area at the diversion site (about 500 km^2) and that at Kisaran gaging site (1,050 km^2).

The final plan of water resources allocation will be established after the agricultural master plan is established through the Part II works. However from the above studies it may be sure that no difficulty is there to make water utilization to all the purposes, such as irrigation, water supply, river maintaining, etc.

4.4 Environmental Study

4.4.1 Given natural conditions

In the entire study area of about 6,000 km^2, upland forest covering about 24 percent is still well maintained without serious denuded area, which is contributing to good water and soil conservation, to keep air clean and to supply cattle feed and fuel wood to the local inhabitants. This extent of forest shall be reserved as it is in future.

In addition the considerably large estates of rubber, oil palm and coconut covering about 32 percent of the study area are serving to the people not only for the economic activities but also for human amenity with full of greens.

Only the problem of natural condition may be the existence of swampy areas even near the villages in low-lying areas. Due to the very gentle land gradient and lacking of drainage and sewerage system, such towns and villages are suffered from logging water in heavy rainy season. Hence future drainage improvement will be very important.

Fortunately enough the malaria mosquitoes living in this area belong to the special species, called as Anopheles Sundaicus, which lays their eggs only to the semi-saline water. Therefore the malaria infection does not be increased by such logging water but only narrow belt along the coast has much infection.

4.4.2 Social health conditions

The predominant diseases in the study area are malaria and tuberculosis, with occasional cholera, tetanus, rabies, etc. Among those diseases, the most serious diseases from the viewpoint of social health are malaria, tuberculosis and cholera because of strong infection.

The malaria in North Sumatra is almost infected by the mosquitoes, Anopheles Sundaicus, which live only along the coast of the Strait of Malacca, because this species has a definite characteristics of laying eggs in semi-sailing water, of which the concentration of 5,000 to 20,000 ppm of salt. Therefore malaria patients are predominant only in the belt zone about one kilometer with along coast.

If saline water area having the above range of salt content becomes wider, the number of mosquitoes will be increased. From the characteristics in this area, it is not recommendable to develop fish ponds with mixed water of fresh and sea water. Also the project has to be taken into consideration not to accelerate the saline water intrusion into the upstream reaches of the river. According to the survey made by JICA Malaria Eradication Team, the present rate of malaria carriers is about 20% at the maximum.

The tuberculosis shall be prevented by improved nourishment first. In this connection the increase of family income by socio-economic development in this area will contribute for that, in addition to the effort of extension service of social health. Cholera requires improvement of sanitary conditions of private life for its prevention as the disease infects through foods and drinking water. From this viewpoint also, improvement of drainage and sewerage will play a big role.

In this project such improvement will be carefully taken into consideration, such as, irrigation water taken from fresh river water will include supply of domestic water as much as possible, especially in low-lying area, where the stagnant water is normally contaminated by natural and artificial sources.

From the above viewpoint, the swamp development by drainage improvement will contribute to improve the environmental conditions for human life without any harm.

4.4.3 Water supply and water quality

In North Sumatra Province, the source of water for drinking in urban area is mainly water-well (59.6%) and pipe (33.1%), while that in rural area is well (58.5%), spring (16.5%), river (14.7%) and so on. As for bathing and washing, water of well and river are commonly used.

In 1981/1982, the percentage of households using piped water for drinking accounted for 9.7% of the whole Province. About 33% of households in urban area are using piped water, wile this percentage in rural area is only 2%.

The urban water supply system is administrated by the Regional Water Supply Enterprise (PDAM) in each Kabupaten and Kotamaja. The water supply system of the city Kisaran was commenced in 1928, and at present about 4,0000 households (corresponding to about 23% of the total) are supplied (20 hrs/day) from the Silau river with yield of

40 lit/sec. However, most of inhabitants in the study area are using water of well, rain and/or river for their drinking, cooking, bathing and laundry.

The water supply system of Kotamaja Tanjung Balai was started in 1917, using also water of the Silau river. Its actual yield is 70 lit/sec and about 4,300 households (about 50% of the total) depend on the PDAM for supply of water.

In other main towns in the study area, such as the case in Tanjung Tiram, the drinking water is supplied only for 480 households by deep well. Besides, in the large and medium industries and estates which are managed with an autonomous and autarky, water supply facilities are equipped for their self-use mostly from wells.

The JICA study team made the water quality analysis on the river water, namely two places along the Bunut river, two places along Silau, three places along Asahan and five places along Kualuh. The results of chemical analysis made by courtesy of the Laboratory of Health Department of Medan are also shown in Table 4.5. From those results it was judged that no problem exists for any use as far as the quality of river water.

Regarding the water quality of Lake Toba, laborious survey results of North Sumatra University is available in the Final Report of Community, Toba Territory and Biology of Lake Toba published in March 1980. The physical and chemical analysis proved that the quality of water of Lake Toba was very clean and pure. The report concluded that the physical and chemical character of the water is still normal, plankton condition is still good, floating plant is mostly eichhornia crassipes (water hyacinth) type, agriculture is developed mostly on the plain and scarcely on steep slopes, but some places have been recently contaminated by feces.

At present the waters of Asahan, Silau and Kualuh rivers are not so much polluted by artificial activities as this study area has not so processing are being done. It seems there is almost no possibility of enlarging the capacity of those rubber and oil palm factories due to limited supply of raw materials. However if in future any enlargement is planned, it is recommended to purify the waste water. According to the press news a pulp and rayon factory at Porcea near the outlet of Lake Toba is under planning. In any case the waste water from this factory should not be drained into Lake Toba or Asahan river, because water pollution will affect the irrigation and drinking water for the inhabitants in downstream reaches. Complete purification facilities shall be provided before draining at least.

4.4.4 Probable impact of development

As the basic development policies recommended, this study area will be developed first by the flood control with earth dikes to prevent the inundation along the rivers and secondly by the agricultural development.

The influence of flood control project will reduce the inundation area and duration of inundation, hence it may naturally contribute to reduce the infection of water-based diseases. The required roads along the dikes to be constructed will serve local inhabitants for easy traffic and transportation.

Especially the flood control of Silau river will mitigate the inundation of down-town of Tanjung Balai which will reduce the suffering of town residents.

In future agricultural development, most studies of which will be made in Part II works, planning will be directed to make use of irrigation water for domestic water supply. It will make a good effect on the people to improve sanitary conditions.

Also the agricultural roads to be provided will improve the traffic and transportation. For the planning of those road networks, it is also taken into consideration to provide drainage canals along the roads. It will mitigate the suffering of the people by lacking of drainage at present.

Fortunately in this area, no malaria mosquitoes live in fresh water, so that irrigation networks will have no problem at all. In the flood control master plan and urgent flood control plan, no deep dredging of river bed in downstream reaches are planned. It will make no influence on the further intrusion of saline water by tide.

CHAPTER 5 RESULT OF FEASIBILITY STUDY ON URGENT FLOOD CONTROL PLAN

5.1 General

The long-term flood control plan aims at prevention of the flood damage not only in the existing developed lands but also in adjoin lands for future development. However, the economic benefit accrued from the plan at the present state of development is not so high, and a large fund is required to implement such a big project. Therefore, the time has not come yet to implement the long-term plan at present.

While, the existing developed lands along the Asahan and Silau rivers suffer from habitual flood damage which can not be overlooked any longer. Realization of an urgent flood control measures is required aiming at mitigation of flood damage in the lands along the Asahan and Silau rivers. For this reason, urgent flood control plan of the Asahan and Silau rivers is studied based on the long-term plan to formulate a project to be implemented immediately in consideration of urgency as well as technical and economical effectiveness of the project under the present conditions. The urgent flood control plan aims at mitigation of the flood damage in the existing developed lands and adjoining potential lands to be developed in the near future.

5.2 Necessity of Urgent Flood Control Project

The lower basins of the Asahan, Silau, Bunut and Kualuh rivers have frequently suffered from flood damage. As a means of flood control in the areas, river dikes have been constructed for protecting the developed lands from flooding of the rivers. With regard to the Bunut and Kualuh rivers, the flood damage is considerably reduced at present after construction of the present dikes.

However, the capacity of the existing flood control facilities in the area is not adequate yet. The lower areas of the Asahan and Silau rivers have often suffered from damage 6 times for the Asahan river and 8 times for the Silau river in the last 8 years. To make matters worse, the cultivated land is expanding even in low-lying lands surrounding the existing swamps. The social and economic damage due to floodings is increasing in these areas.

In order to prevent the area from repeated flood of the Asahan and Silau rivers, implementation of the flood control project is urgently needed.

5.3 Design Flood

In order to select the level of design flood for the urgent plan, the urgent plan is examined by the design floods of 5 years, 10 year and 15 year. The results of comparative study are as follows:

Design Flood (year)	Ave. Annual Benefit (Rp. million)	Economic Cost (Rp. million)	B/C with Discount Rate of 12%
5	3,945	33,215	0.85
10	5,124	35,369	1.03
15	5,576	44,964	0.89

The 10-year plan has a little high economic value of B/C compared with the others, so that the 10 year flood is proposed as design flood for the urgent flood control plan from the standpoint of high economic value and socio-economic conditions in the area. The determined design flood discharge is shown in Fig. H-6.

5.4 Proposed Urgent Flood Control Plan

5.4.1 River stretches for proposed urgent plan

Taking into consideration the present flooding area and discharge capacity of the existing river channel, the river stretches taken for planning the urgent flood control plan are determined. The river stretches of the proposed urgent flood control plan are as follows:

River	Stretches to be Improved	Length (km)
Asahan mainstream	Confluence of Nantalu river - Highway bridge at Pulau Raja and Lebah river	43
Silau river	Confluence to mainstream at Tanjung Balai - Railway bridge at Kisaran	19
Total		62

5.4.2 Improvement plan of river channel

The project proposes channel improvement over a total length of 57 km. The proposed river channel improvement plan such as alignment of dike, longitudinal profile and cross-sections is shown in Fig. H-7. The outline of the improvement plan of river channels is as follows:

(1) Asahan mainstream

The proposed improvement of river channel comprises: (i) construction of dike over a length of 19.3 km on the right bank in the stretches from Padang Mahondang intake to the confluence of the Nantalu river and (ii) construction of dike for a retarding basin over a length of 17.8 km on the right side of the Lebah river. The bulk of the works is construction of dike to protect the land from flooding.

(2) Silau river

The proposed plan of the Silau river is channel improvement over a length of 19 km by means of excavation of the low-water channel and construction of dike on both banks to secure adequate discharge capacity.

5.4.3 Proposed urgent flood control works

The following major works are proposed for the urgent flood control project in this study.

(1) Asahan mainstream

(a) Excavation/dredging of channel and embankment of dike
(b) Bank protection by means of crib and wet masonry
(c) Construction of drainage culverts

(2) Silau river

(a) Excavation/dredging of channel and embankment of dike
(b) Bank protection by means of crib
(c) Reconstruction of irrigation free intakes

(d) Construction of drainage culverts

The proposed work quantity is as follows:

Excavation/dredging works	3,650,000 m^3
Embankment works	2,270,000 m^3
Bank protection works	2,600 m
Reconstruction of irrigation free intakes	5 places
Construction of drainage culverts	12 places

5.5 Construction Plan and Cost Estimate of the Project

5.5.1 Execution system

The execution system is generally classified into three methods: full-contracting basis, force account basis, and combination of them. Considering the scale of the project and the past experiences in Indonesia, all the construction works will be executed by contractors selected through international competitive bidding.

5.5.2 Construction time schedule

The proposed 6-year construction time schedule is given in Fig.5.1. This is planned based on the following assumptions.

(a) The construction period to be required is minimized as practical as possible for the efficient execution and acquiring the expected benefit soon.

(b) Detailed design will be commenced at the beginning of November in 1987 and completed by the end of January in 1989, having a total period of 15 months.

(c) Immediately after completion of the detailed design, tendering will be started, and it will be completed by October in 1990.

(d) Land acquisition and compensation will be commenced in February 1988.

(e) Civil works will be executed for about 3 years from November in 1990 to November, 1993.

The outline of the proposed sequence of execution works is described below:

(a) Dredging works of the Asahan and Silau rivers are to be commenced in February 1991 and completed by January 1993.

(b) Embankment works for both rivers will start in June 1991 and complete by the end of November in 1991.

(c) Construction of dike for the Lebah river is to be carried out for 34 months from February in 1991 to November 1993. Though the work quantity is small, construction period expands for about 3 years considering the conditions of foundation.

5.5.3 Cost estimate for the Project

(1) Basic conditions

The investment cost consists of construction cost for civil works, cost for land acquisition and compensation, administration cost of executive agency, cost for engineering service and contingency. It is estimated based on the end of March, 1985-price level. The followings are the basic conditions for cost estimate.

(a) The currency exchange rates are assumed at;
US$1 = Rp. 1,100 = Japanese ¥250

(b) All the construction works will be executed by contractors selected through international competitive bidding.

(c) All equipments and their spare parts required for the works are to be provided by the contractor.

The cost required for civil works consists of costs for preparatory works, main civil works and miscellaneous. The cost for civil works is estimated by multiplying work quantity by unit cost. The cost for preparatory works and miscellaneous works are assumed to be 8% and 10% respectively of the total cost of the main civil works.

Engineering cost is estimated based on the required expertise. Administration cost is assumed at 5% of the total local components costs for civil works, land acquisition and compensation. The physical contingency is assumed to be 10% of the sum of the above costs.

(2) Unit price

For estimating the unit construction cost, the unit price of labor wages, materials and equipment expenses are surveyed about the practical unit prices which are currently applied to the similar projects in Indonesia. The unit prices of the construction materials are divided into foreign currency portion and local currency portion.

The construction equipment including their spare parts are to be provided by the contractor. The operation cost of the construction equipments required for the works is estimated based on the costs for depreciation, repair and maintenance, fuel, and costs for labor and guidance.

The costs of land acquisition and compensation are estimated based on the data obtained from the offices concerned. The costs on the proposed high-water channel is to be compensated with a half value of the acquisition.

(3) Unit construction cost

The unit construction cost is estimated by applying the unit prices of labor, construction materials and equipment expenses.

In estimating the unit cost, contract prices including site expenses, contractor's overhead and profit, and tax are assumed in the following conditions.

a.	Site expenses	:	20% of direct cost
b.	Contractor's overhead & profit	:	15% of the sum of direct cost and site expenses
c.	Tax	:	2.5% of total cost

The estimated unit construction costs are shown in Table H-25.

5.5.4 Cost estimate

(1) Construction cost

The construction cost of the project is estimated at Rp. 36,484 million, consisted of Rp. 9,292 million of local currency portion and US$ 24,750 thousand of foreign currency portion.

The breakdown of construction cost is presented in Table H-27.

(2) Operation and maintenance cost

The operation and maintenance cost at full operation stage for the facilities after completion of the project is estimated at Rp. 136 million per annum.

5.6 Organization and Management

5.6.1 Present organization

The Asahan and Silau rivers are at present administrated and managed by DPU North Sumatra. All flood control works of the above mentioned rivers are being implemented by the Water Resources Division of DPU North Sumatra. Also the existing river facilities are operated and maintained by DPU.

The present organization for flood control works in Lower Asahan area is shown in Fig. H-9. The organization for the Lower Asahan River Flood Control Project is not established yet because the project is being on the study stage at present.

5.6.2 Organization for implementation of Project

The Ministry of Public Works will entirely be responsible for the implementation of the project, and necessary consultations will be made by the organizations concerned. For implementing the project, establishment of a project office in Kisaran will be required. The organization for the project is recommended as shown in Fig. H-10.

The Directorate General of Water Resources Development will be the executing agency for the project. The Directorate of Rivers under the control of the Directorate General of Water Resources Development will take charge of coordination with all the relevant governmental agencies and regional administrative organizations in implementing the project.

The project manager is to be appointed by the Ministry to take all the responsibility to the Ministry for the proper implementation of the project. The staffs of the project will be also appointed to support the project manager. They will support execution of detailed survey, design and planning, preparation of tender documents and specifications for civil works, equipment including materials and spare parts if necessary and land acquisition.

Foreign consultants will have to be employed to assist the implementation of the project including the field work of the detailed design and supervision.

5.7 Evaluation for Urgent Flood Control Project

5.7.1 Economic evaluation

(1) Economic cost

The economic construction cost for the urgent flood control project was estimated by deducting tax and contractor's profit from the local currency portion of the construction cost. This tax and contractor's profit to be deducted are assumed to be 4% and 10% respectively. The estimated economic construction cost is estimated at Rp. 35,369 million.

The annual economic cost for operation and maintenance is assumed at Rp. 132 million which is 0.5% of the total economic cost of civil works.

(2) Benefit

Benefit is the expected reduction of flood damage for private properties, farm crops, public facilities, etc., and the expected development effect for the land which has not been utilized during the wet season is also defined as enhancement benefit.

a. Flood damage reduction

Flood damage reduction is expressed as difference between with and without project. The reduction of the flood damage with project is estimated at Rp. 4,610 million in the value of annual average.

b. Enhancement benefits

The urgent flood control project will provide an effect for land development in the area to be protected from floods, so that the area may be used as agricultural land and residential quarter in the future with the project. The estimated average annual enhancement benefit with project is estimated at Rp. 514 million.

c. Average annual benefit

The average annual benefit from the urgent flood control project is estimated at Rp. 5,124 million which is a sum of flood damage reduction and enhancement benefit mentioned above.

(3) Comparison of cost and benefit

Flow of the economic costs and benefits is shown in Table H-32. Based on this flow, cost-benefit analysis is made. The internal rate of return (IRR) is calculated at 12.4%. The benefit-cost ratio (B/C) is calculated at 1.03 with a discount rate of 12%.

(4) Sensitivity test

Sensitivity of IRR of the project is examined adopting increase in cost and decrease in benefit. The results of sensitivity test are summarized in Table H-33, which shows the value of IRR of the project exceeds 10% even if the cost goes up by 20% or the benefit comes down by 20%. The results of comparison of cost and benefit are also shown in Fig. H-11.

5.7.2 Financial aspects

(1) Required funds

The funds required for the implementation of the project were estimated on the following assumptions. The price contingency is assumed at 12% per year for the local currency portion and 3% per year for the foreign currency portion taking into account the rate of rise in prices for the last 5 years.

The funds needed for the project were estimated at Rp. 51,420 million, which consists of Rp. 18,727 million in the local currency portion and US$ 29,721 thousand (equivalent to Rp. 32,693 million) in the foreign currency portion including price contingency during the construction period.

(2) Disbursement schedule

The schedule of annual disbursement of the fund mentioned above is planned as shown in Table H-35.

5.7.3 Project effect and social impact

(1) Stabilization of people's livelihood

At present, flood damage occurs every year. Many houses and farm lands in the project area suffer extensive damage from floods. After the proposed project is completed, about 10,600 ha of land and 8,700 houses in the project area will be relieved from flooding.

The other intangible benefits such as environmental improvement for living, stabilization of people's livelihood and so on can be expected by the implementation of the project.

(2) Incremental land for agriculture and residence

The increase of residential quarter by the project is expected from the reduction in flood damage and improved land condition. Increase of the lands for agriculture and residence are expected to be 4,695 ha and 500 ha respectively.

(3) Employment opportunity

The implementation of the project will provide employment opportunities to workers and landless farmers in and around the project area. The unskilled labor requirement for the project is estimated at 600 thousand man-days during the construction periods.

(4) Relocation of houses

There exist about 650 houses in the location of the proposed channel which will have to be relocated. About 20 ha of residential land will be required. The required land will be created by the implementation of the project.

(5) Environmental aspects

Generally, it is expected that the natural environmental conditions in the neighboring area of such a large scale project be worsened. In the case of the lower Asahan area flood control project, the works are to improve the existing river channel only. Therefore, this project will not provide any detrimental impact on the environment.

With regard to salt water intrusion into rivers, no problem is occurred at present and some groundwater is being used by inhabitants near the river mouth. It seems that the salt water intrusion into rivers is limited to the lowest reaches owing to comparatively abundant river water during the dry season. Therefore, the implementation of the project will not produce any adverse effects of salt water intrusion.

Accordingly it seems that the present environmental situation will not change due to the implementation of the project.

5.8 Flood Forecasting and Warning System in the Middle Reach of Asahan River

Since the flood peak from the residual basin downstream of the regulating dam up to Pulau Raja is rather significant, it would occur that the river facilities to be constructed under the urgent flood control plan would be jeopardized only by the flood out of the residual basin even though the outflow from Lake Toba would be reduced by the regulation method as proposed in Chapter VI. Therefore it is recommendable to install and operate a flood forecasting and warning system for the sake of inhabitants in the downstream area.

The system would consist of four (4) robot rain gaging stations, four (4) robot river water level gages in the middle reaches of the Asahan river, a control office at Kisaran and a VHF radio wave system connecting the Kisaran control office with the DPU Medan office as shown in Fig. 5-2. Facilities cost is estimated at ¥ 600 million or US$ 2.8 million equivalent.

By this facilities the rainfall intensity and runoff mechanism in the residual basin will be clarified. If the time lag between the flood from the residual basin and the outflow from the regulating dam up to Pulau Raja is somewhat considerable, that is, if the former is behind the latter by two or three hours, it would become possible to control the outflow from the regulating dam for several hours to avoid the overlapping of both the floods by connecting the system with the control office of regulating dam, which is now under the management of INALUM.

5.9 Recommendation

The feasibility study has conclusively proved that the Urgent Flood Control Project of the Asahan and Silau rivers is inevitably necessary for securing and promoting the regional economic development and the public welfare, and also the project is technically sound and economically feasible. It is therefore recommended that the project will be implemented as soon as possible.

CHAPTER 6 REGULATION OF WATER LEVEL OF LAKE TOBA

6.1 Lake Toba and Asahan River

Lake Toba situated in the Batak Highlands of the North Sumatra blesses people there with splendid scenery, comfortable circumstances and rich and clean water resources. Lake Toba was formed by eruption and collapse caldera in Tertiary Period. A partial upheaval after that created the Samosir Island with high cliffs on its eastern edge.

Only one river flows out of Lake Toba, that is the Asahan river. Owing to the inherent regulating capacity of the lake, the discharge of the river is quite stable, ranging between 38 m^3/sec and 207 m^3/sec at the former gaging station of Siruar, nearby where the regulating dam has been constructed. Owing to the high elevation of the lake and rushing rapids of the upper reaches of the Asahan river, their potentials have been developed as the Siguragura and Tangga power stations as well as the regulating dam. The outflow from the lake has been and will be controlled by the operation of regulating dam since February 1981.

Natural features of Lake Toba, developed properties of the Asahan Hydroelectric Development Project and limits of lake surface stipulated in the Master Agreement which INALUM is obliged to follow are summarized below:

<u>Lake Toba and Asahan Project</u>

<u>Lake Toba</u>

Catchment area at regulating dam	:	3,796 km^2
Lake surface area	:	1,100 km^2
Lake surface elevation		
Permitted Flood Level	:	WL 905.50 m
Normal High Water Level	:	WL 905.00 m
Permitted Lowest Water Level	:	WL 902.40 m

		Siguragura Power Station	Tangga Power Station	Total
Intake Dam & Pondage				
NHWL	El. m	735.4	506.0	-
Incremental catchment area	km^2	50	97	147
Pondage area	km^2	0.3	0.2	-
Net storage	1,000 m^3	752	713	-
Dam				
Type	-	conc. gravity	conc. arch	-
Height	m	46	82	-
Power Output				
Max. turbine discharge	m^3/sec	150.5	161.1	-
Firm discharge	m^3/sec	105.4	111.9	-
Gross head	m	230.0	237.4	467.4
Rated net head	m	218.0	226.8	444.8
Installed capacity	MW	286	317	603
Firm power output	MW	203	223	426
Annual energy output	GWh	1,868	2,054	3,922
Transmission line	275 kV, 2 cct, 120 km to Kuala Tanjung 150 kV, 2 cct, 91 km for main line (Kuala Tanjung-Medan) 150 kV, 1 cct, 156 km for branch line			

6.2 Hydrological Data

Rainfall data in and around the Lake Toba basin are available at around ten (10) rain gage stations intermittently (see Fig. I-1). Data availability are shown in Table I-1. Reliability of rainfall data is much higher for the pre-war days. Based on those rainfall data the basin mean monthly rainfall was calculated for the years of 1919 through 1940 and 1974 through 1980. Annual mean rainfall of the basin is 1,820 mm ranging between 1,470 mm and 2,730 mm as shown in Table I-2.

Outflow from Lake Toba has been measured and recorded at two gage stations on the Asahan river, Siruar and Simorea. The Siruar gage station was located at the head of rapids of the Asahan river 14 km downstream from the outlet of the lake, and there daily discharge record is available from 1916 up to January 1981 with interruption during the wartime.

Those records have been collected and accumulated in the data bank of Nippon Koei through several former investigations and during construction stage of the Asahan Project. In February 1981 and thereafter the outflow from the lake has been controlled by the regulating dam constructed at a gorge near the Siruar gage station. Daily record of lake water release out of the regulating dam up to January 1985 is now available by courtesy of INALUM.

The Simorea gage station was located below a drop of 175 m from the regulating dam site and at the head of Siguragura falls where the Siguragura intake dam was constructed. Daily discharge record at the Simorea gage station is now available from 1956 to 1984 with some interruption. Balance of the discharge at the said two gage stations gives some indications of runoff from the residual basin between the regulating dam and Siguragura intake dam. The mean runoff from that basin is around 3 to 10 m^3/sec according to the record.

Daily mean water surface level of Lake Toba is being recorded at several places along the lake side, however, among them the record at Janji Matogu situated near the outlet of the lake is most reliable due to its long duration of the record. Daily mean lake water level record at Janji Matogu is available since May 1963. Lake water level before then was reestablished from a relation of discharge at Siruar and lake water level.

6.3 Net Inflow

As well known, the discharge at Siruar is an outflow from Lake Toba regulated by its inherent regulating capacity. Lake operation simulation both for flood control and water utilization, however, should be based on an inflow into the lake. The gross inflow into Lake Toba composed of direct precipitation on to the lake surface and streams from the surrounding areas is not known. As there is no record of evaporation from the lake surface, so-called net inflow is calculated from the discharge at Siruar and lake surface level by the following simple formula:

$$I = O + A\ dH/dT$$

where,

I	:	Net inflow into the lake for a specified period (m^3/sec)
O	:	Discharge at Siruar averaged for the specified period (m^3/sec)
A	:	Surface area of Lake Toba, 1,100 km^2
dH	:	Rise or drop of lake water level during the specified period
dT	:	Number of seconds of the period

Ten-day mean net inflow for about 43 years from 1916 to 1932 and from 1957 to January 1985 was calculated. The monthly mean net inflow into Lake Toba is calculated as shown in Table I-3

6.4 Study on Lake Operation

In order to assure power generation for firm output of 426 MW in two power stations, which corresponds to the annual production of 225,000 tons of aluminium, a discharge of 105.4 m^3/sec is required at the Siguragura intake. Since about 5 m^3/sec is available on an average from the residual basin, it is assumed that the discharge to be released from the regulating dam for the firm power generation be 101 m^3/sec.

As first, it was checked what happened under the current operation rule of regulating dam for the newly estimated net inflow. In the current operation rule there is no stipulation of water utilization for power generation, but flood release in relation to the lake water level beyond the normal high water level (NHWL) 905.00 m is prescribed as briefed below:

Current Operation Rule

Lake Water Level	Flood Release
higher than WL. 905.05 m	186 m^3/sec
higher than WL. 905.10 m	242 m^3/sec
higher than WL. 905.15 m	315 m^3/sec
higher than WL. 905.20 m	400 m^3/sec

Since there is no stipulation regarding the water utilization in the current operation rule, it was assumed that the discharge for power generation be 101 m^3/sec regardless of lake water level unless the lake water level descends below the permitted lowest water level of 902.40 m, and if so the discharge should be zero. Applying such operation rule on the ten (10) days mean net inflow at 43 years and one month drew the following conclusions:

Max. lake water level	:	WL. 905.42 m
Flood release	:	400 m3/sec for 30 days continuously
Spill out	:	4.95 x 10^9 m^3 for 43.08 years

Duration of discharge for power generation for 43 years and 1 month

Q = 101 m^3/sec	97.2%
Q = 0 m^3/sec	2.8% in recent 6 years (1978 thru 1983)

Aforesaid simulation suggests that some operation methods will have to be applied on the discharge for power generation under the recent drought conditions in order to avoid the occurrence of zero discharge. And also in order to mitigate the flood peak discharge from the lake, the following operation method was first studies as Case I:

Operation Method, Case I

Lake Water Level		Flood Release (m^3/sec)	Discharge for Power Generation (m^3/sec)
Higher than WL. 905.00 m		300 max. (Spill out : 199 m^3/sec)	101
905.00 -	904.50	-	101
4.50 -	4.20	-	95
4.20 -	3.90	-	90
3.90 -	3.60	-	87.5
3.60 -	3.30	-	85
3.30 -	3.00	-	82.5
3.00 -	2.40	-	80
Lower than	902.40	-	0

and its results are as follows:

Max. lake water level	:	WL. 905.37 m
Flood release	:	300 m^3/sec for 40 days continuously
Spillout	:	8.99 x 10^9 m^3 for 43.08 years
Lowest lake water level	:	WL. 902.41 m

Duration of discharge for power generation for 43 years & 1 month.

Q	Duration	Accumulated Duration
101 m^3/sec	42.2%	42.2%
95	21.5	63.7
90	16.3	80.0
87.5	8.4	88.4
85	3.7	92.1
82.5	4.4	96.5
80	3.5	100.0
0	-	-

Average discharge for power generation : 94.6 m^3/sec

Through these trial calculations it becomes clear that the lake water level at the end of dry season, say in September or October, usually drops to WL. 904.50 m or so. Hence, the idea of introducing a seasonal restriction of lake water level was hinted aiming at mitigation of flood peak discharge without much hindrance of water utilization.

In order to decrease the spill-out or increase the effective discharge for power generation, several test cases were examined by trial and error. Operation methods of each test case and its results are presented in Table I-4. Among them, Case V was superior to other cases. So that this Case V was presented in this report as One Model Operation Method of Lake Toba.

The operation method of Case V and its results are illustrated in Fig. I-3 and summarized below:

One Model Operation Method of Lake Toba
Restricted Seasonal Lake Water Level (RWL)
at the end of each month

(+ WL. 900 m)

July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar. thru July
5.00	4.84	4.58	4.52	4.64	4.76	4.88	5.00	5.00

Lake Water Level	Flood Release	Discharge for Power Generation
Higher than WL. 905.00 m	400 m^3/sec max.	101 m^3/sec
905.00 - 904.20	300	101
5.20 - 5.10	250	101
5.10 - 5.00	200	101
	(incld. power discharge)	
Lower than WL. 905.00, but		
Higher than RWL	50 max.	101
Higher than RWL + 0.20 m	75	101
	(spill-out only)	
Higher than WL. 904.50 -	101	
904.50 - 904.25		101 or 98
4.25 - 4.00		98 or 95
4.00 - 3.75		95 or 92
3.75 - 3.50		92 or 80
3.50 - 3.25		86 or 80
3.25 - 2.40		80
Lower than WL. 902.40		0

Note: Discharge for power generation when the lake water level is lower than WL. 904.50 m is chosen from both the lake water level and the discharge in the previous 10 days, for example, in a case that the discharge in the previous 10 days be 95 m^3/sec and if the lake water level descends below WL. 903.75 m then the discharge should be 92 m^3/sec and if the lake water level regains above WL 903.75 m then the discharge should be 92 m^3/sec and if the lake water level regains above WL. 904.25 m then the discharge be 98 m^3/sec.

Operation Results

Max. lake water level	:	WL. 905.34 m
Flood release	:	300 m^3/sec for 30 days continuously
Spill-out	:	7.71 x 10^9 m^3 for 43.08 years
Lowest lake water level	:	WL. 902.44 m

Duration of discharge for power generation for 43 years & 1 month

Q	Duration	Accumulated Duration
101 m^3/sec	42.2%	42.2%
98	16.8	59.2
95	14.4	73.6
92	11.0	84.6
86	2.8	87.4
80	12.6	100.0
0	-	

Average discharge for power generation : 95.6 m^3/sec

6.5 Flood and Its Control in Lake Toba

Net inflow into Lake Toba usually begins to swell sharply in September or October and its flood lasts until April or May. Some major flood inflows into the lake are listed in Table I-5. Heaviest flood recognized so far is the flood lasted from the early October 1930 to the end May 1931 and its volume was 4.74 x 10^9 m^3. Flood in 1983/1984, which lasted from the early September 1983 to the end May 1984 was the third one among the 41 records during the rainy season.

Hence the period from 1 October to 31 May of next year (8 months) would be defined as flood season. Total net inflow volume in the flood season is tabulated in the order of magnitude in Table I-7. The probable flood for each return period is shown in Table I-6.

The flood occurred in 1930/31 was more or less equivalent to the 100-year probable flood. Then that flood was checked under the same operation method as in Case V with one additional condition that the lake water level at the end of September 1930 was WL. 904.88 m, that is, the restricted water level at the end of September (The calculated lake water level at the end of September 1930 of the through operation presented in the previous Section was WL. 903.43 m.). The check was carried out on both ten-day basis for one year and daily basis for six months from 1 October 1930 to 31 March 1931 its results are as follows:

Max. lake water level	:	WL. 905.49 m
Flood release	:	300 m^3/sec for 44 days continuously

6.6 Tentative Operation prior to Completion of Urgent Flood Control Project

In order to mitigate the flood magnitude at the lower reaches of the Asahan river under its present conditions and during implementation of the urgent flood control project, an additional case of lake operation was studied. The operation method is just same as in Case V except flood discharge to be released from the regulating dam when the lake water level is beyond the normal high water level of WL. 905.00 m. It is presumed that the flood release is limited to 200 m^3/sec including the discharge for power generation for the time being. The calculation results are shown in Table I-8 and summarized below:

Max lake water level	:	WL. 905.47 m
Flood release	:	200 m^3/sec
Spill-out	:	7.71 x 10^9 m^3 for 43.08 year
Lowest lake water level	:	WL. 902.44 m

Duration of discharge for power generation for 43 years and 1 month

Q	Duration	Accumulated Duration
101 m^3/sec	42.2%	42.2%
98	16.8	59.2
95	14.4	73.6
92	11.0	84.6
86	2.8	87.4
80	12.6	100.0
0	-	-

6.7 Flood Control by Siguragura, Tangga and No.3 Dams

The basic function of the Siguragura and Tangga intake dams are only intake dam for power generation by catching mainly the discharge released from the regulating dam and a small amount of runoff from the remaining catchments. Though both the intake dams are large dams, the storage capacities are quite small less than one million m^3 each (refer to Table in Section 6.1) because the dams have been built at narrow gorges in the rapids. Then the flood control function can not be borne by both the intake dams.

The No.3 dam, which is now under investigation for its detailed design, could function as flood control against the flood runoff only from the residual basin of regulating dam with the project features proposed in its feasibility study. The effect of flood control by No.3 dam is stated in Section 4.2.3(1).

6.8 Recommendation

The above studies on various cases proved that there is possibility to satisfy the requirements from both flood control and optimum water utilization of Lake Toba by the following four conditions:

i) To establish adequate seasonal water level control

ii) To provide adequate spill-out discharge of surplus water if the seasonal water level exceeds the ristricted level

iii) To establish adequate discharge for power generation in accordance with the lake water level

iv) To establish adequate flood discharge beyond the normal high water level of EL. 905.00 m.

The study on Case V is presented in this report as one of such possible model cases, but those detailed figures can be adjusted according to the realistic needs for power generation and aluminium production. It is, therefore, recommended that all the organizations directly concerned with this matter will make detailed review and discussions and reach a final best solution.