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

MASTER PLAN STUDY ON LOWER ASAHAN RIVER BASIN DEVELOPMENT

INTERIM REPORT EXECUTING SUMMARY

October 1985.

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

It is with great pleasure that I present this "Master Plan Study on the Lower Asahan River Basin Development (Interim Report)" to the Government of the Republic of Indonesia.

This study is composed of two parts, namely Part I on basic direction of the lower basin development and feasibility study on urgent flood control and Part II on development plan in the sector of agriculture.

This report embodies the result of Part I study which was carried out (in the Lower Asahan basin, Sumatra Island) from October 1984 to July 1985 by a Japanese study team commissioned by the Japan International Cooperation Agency following the request of the Government of the Republic of Indonesia to the Government of Japan.

The study team, headed by Mr. Makoto Tsuda of the Nippon Koei Co., Ltd., had a series of close discussion on the Project with officials concerned of the Government of Indonesia and conducted a wide scope of field survey and data analysis.

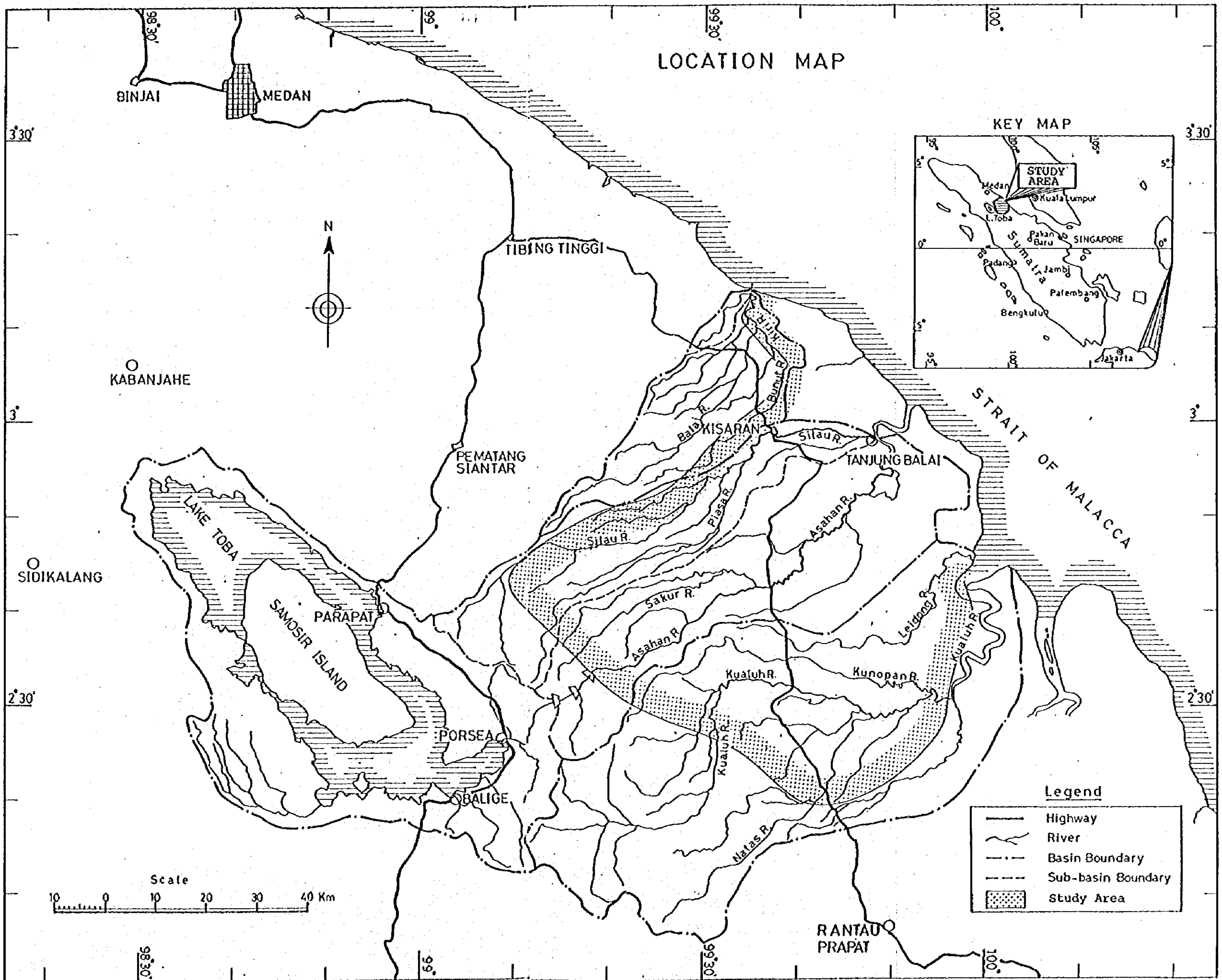
After the survey team returned to Japan, further studies were made and the present report has been formulated.

I hope that this report will be useful as a basic reference for the development of the Project.

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

October 1985

Keisuke Arita
President
Japan International
Cooperation Agency
Tokyo, Japan


LOCATION MAP
KEY MAP
STUDY AREA
Medan
Kuala Lumpur
L. Toba
Pakan Baru
SINGAPORE
Padang
Sumatra
Jambi
Palembang
Bengkulu
Jakarta
BINJAI
MEDAN
TIBING TINGGI
KABANJAHE
PEMATANG SIANTAR
SIDIKALANG
LAKE TOBA
SAMOSIR ISLAND
PARAPAT
PORSEA
BALIGE
KISARAN
TANJUNG BALAI
STRAIT OF MALACCA
RANTAU PRAPAT
Bunut R.
Bala R.
Silau R.
Piasa R.
Asahan R.
Sakur R.
Kualuh R.
Kunopan R.
Leidong R.
Natas R.
N
Scale
10 0 10 20 30 40 Km
98°30'
99°
99°30'
100°
3°30'
3°
2°30'
Legend
Highway
River
Basin Boundary
Sub-basin Boundary
Study Area

SUMMARY

1. This study entitled "Master Plan Study on Lower Asahan River Basin Development" aims to establish a Master Plan for land and water resources development in the study area of about 6,000 km^2 extending along the lower reaches of the Asahan, Silau, Bunut and Kualuh rivers. The Master Plan will envisage the development program up to the year 2005 A.D. from a viewpoint of long-range policies such as raising productivity, increasing employment opportunities, promoting of transmigration and improving the living standard in the study area.

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

i) to identify the basic direction of land and water resources development based on the socio-economic and natural conditions in the study area.

ii) to establish a master plan for flood control.

iii) to make a feasibility study of an urgent flood control project.

iv) to make a study and recommendations on water regulation of Lake Toba.

v) to report on the survey and study program required for Part II works.

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

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

3. The objective study area lies in Kabupaten Asahan and Labuhan Batu, North Sumatera 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, since long ago, been developed mainly with large estates of rubber, oil palm and coconuts. With an increasing population, now reaching about 800,000 persons, the area of paddy fields gradually increased to the present level of about 77,000 ha with supplemental upland fields of about 15,000 ha for cropping. However, the study area also suffers from frequent floods due to heavy tropical showers causing considerable damages to crops as well as to social and private properties. In spite of great effort by the Indonesian Government to construct earth dikes in recent years, the flood carrying capacity of major rivers is still far less than the peak flood discharges, resulting in frequent destruction of those dikes. Hence, this Master Plan Study for flood control is urgently needed.

4. The socio-economic survey and land use survey have revealed that the study area has been already developed into excellent land use patterns leaving almost no wasted land except swampy lands. Large estates of rubber, oil palm and coconut occupy about 32% of the study area and contribute to a fairly high income, but those estates cannot absorb the increasing population. Similarly the very small holding size of

paddy field per family, say only about 0.8 ha on an average, makes it difficult to support the ever-increasing farming population due to the low unit yields of crops. The low yields are mainly attributable to inadequate irrigation development. Hence, the raising of land productivity of cultivated lands is deemed most urgent need to mitigate the population pressure and increase the per-capita income. Present paddy production in the study area is not sufficient even for the local demand.

The above facts indicate the urgent need to establish a flood control master plan and an agricultural development master plan. Flood control measures are most urgent in the most heavily damaged areas.

5. The flood control master plan covering four major rivers, Bunut, Silau, Asahan and Kualuh rivers, is presented in this Report. Among alternative plans, the most economical flood control solution was recommended, mainly consisting of earth dikes along those rivers, except Asahan river where the combination of earth embankment and a natural retarding basin is recommended. The Master Plan aims to protect the lands along rivers from 30-year probable flood.

6. The flood damage survey showed that most, and the most frequent, damage has occurred along the Asahan river downstream reaches below Pulau Raja and Silau river below Kisaran. Therefore, the feasibility study was concentrated on those rivers. The economic comparison studies revealed that the recommendable scale for the urgent flood control plan should be for the 10-year probable flood. The feasibility study on the urgent flood control plan clarified that the internal rate of return derived from this project

would be 12.4% with the total construction cost of 36,484 million Rupiahs.

The geotechnical surveys revealed no serious obstacles to construction of earth embankments in regard to foundations and soil materials except that careful drying of soils will be required before filling embankments.

7. The water resources survey revealed that abundant fresh water is available in this area from both surface and ground water, while less than two persent of surface flow is being used at present. The chemical analysis of waters in Lake Toba, Asahan, Silau, Bunut and Kualuh rivers showed good quality for any use without recognizable contamination or pollution. However, any future large scale industrial development which might cause water pollution should be avoided or thoroughly controlled so as not to cause any deterioration in water quality.

It was observed that severe irrigation water shortage exists in the lower reaches along the Bunut river, especially in the dry season, hence a possible diversion plan from Silau river is worth study in Part II study works.

Saline water intrusion near the estuary of the Asahan river was surveyed. The result showed no adverse effect on fresh water utilization since only the lowest 6 km from the estuary has saline water underlayers even at the spring tide with almost minimum river discharge. The same survey on the Kualuh river is recommended in Part II study.

8. The sedimentation survey and study showed that the problem was not so serious although random cutting of trees in scattered patches is observed, which shall be controlled by other administrative means. The river bed between Tanjung Balai and the estuary will be gradually silted in the long term, but the port function of Tanjung Balai has been shifted by development of inland transportation and port Belawan. A little accretion in the river bed of the Silau river was observed but not so serious as to require urgent dredging at the present time. However, prolonged monitoring may be required to see what changes will happen after the urgent flood control facilities will have been completed.

9. The environmental survey showed no serious problems existing at present except the need for improvement of social health. The existence of malaria mosquitoes, in brackish water of 5,000 to 20,000 ppm of salt, suggests the undesirability of brackish water fish pond development or deep dredging of the river bed which would allow these mosquitoes to multiply. The flood control and agricultural development will not cause any environmental harm but rather improve living conditions by easing domestic water supply, increasing transportation amenities, etc.

10. The analysis and studies on water regulation of Lake Toba revealed a possible solution to satisfy requirements for both the flood control and efficient water utilization. This Report suggests the setting of seasonal water level control and discharge control together with improved operation of the existing regulating dam. According to one model (Case V) as explained in detail in this Report, the 100-year

probable flood can be regulated to less than 300 m^3/sec discharge from the regulating dam below the restricted flood high water level of EL 905.50 m, and the minimum discharge from the dam even in driest season can be kept at 80 m^3/sec even when the water level reaches near the restricted low water level of EL 902.40 m.

Even if such water regulation is applied to the past actual inflow into Lake Toba (43 years' records), out of total average inflow of 101 m^3/sec, 95.6 m^3/sec can be utilized for power generation which can assure the production of aluminium of about 95% of 225,000 t/year at full capacity.

11. In addition to the above study, a further tentative study was made for mitigating the downstream flood since the present river channel has a very low flood carrying capacity until the urgent flood control facilities along the Asahan downstream reaches are completed. It suggests that it is possible to restrict the maximum discharge from the regulating dam to 200 m^3/sec all through the flood period under the highest flood water level of EL 905.47 m, 3 cm lower than the restricted flood water level. Hence it may be recommendable to take such measures until the completion of flood control facilities in the downstream reaches of the Asahan river.

12. Even the flood discharge from the regulating dam is to be reduced less than before, still the flood derived from the remaining catchment area between the regulating dam and Pulau Raja is quite large. Therefore, it is recommended that a flood forecasting and warning system be provided in the remaining catchment area.

It may comprise a telemetered system of four robot rain gages and four robot river water level gages, with a control office at Kisaran and a wireless connection between the control office and Medan DPU office.

13. In connection with the above flood control studies it was found that the Asahan No. 3 Power Development Project under planning will have a very high intake dam with a considerable storage capacity. The intake dam, according to the Feasibility Report, will have five meters draw-down to regulate the discharge required for power generation. About 12 million m^3 of effective storage capacity is available with this draw-down. If this storage capacity is utilized also for flood control against the flood inflow from the remaining catchment area of 214 km^2 after the regulating dam, the peak flood discharge from the remaining area of 407 m^3/sec in case of 30-year probability can be reduced to only 100 m^3/sec. It will reduce the peak flood of 1,355 m^3/sec at Pulau Raja to 1,048 m^3/sec which is less than the designed flood carrying capacity of the urgent flood control plan. Thus it is strongly recommended that Asahan No. 3 Intake Dam be planned to have a flood control function. The electric energy loss thus caused by flood control operation is estimated to be less than one percent of the annual energy output expected.

14. The detailed scope of works, time schedule and survey programs required for Part II work are described in this Report. Early execution of this Part II work is recommended to achieve the maximum social and economic benefits indicated above.

EXECUTING SUMMARY
FOR
MASTER PLAN STUDY
ON
LOWER ASAHAN RIVER BASIN DEVELOPMENT

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CHAPTER I INTRODUCTION

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.

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 II 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 km^2. Owing to its high surface elevation of EL.905m, the outflow of about 100 m^3/s 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 centre 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 study 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

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 estates 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 Indonesian 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 distruction of those dikes. Hence, this Master Plan Study for flood control is urgently necessitated.

No big scale industries exist in the study area 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 III 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 terace 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. The low hilly zone is mostly planted with rubber and oil palm. Also the national highway and railway pass on the hilly area or its foothills. Major towns and villages develop along highway and secondary roads branching off normally from the highway. But those secondary roads are usually gravel paved and not jeepable in rainy season.

The low alluvial plain is mostly occupied by paddy fields or upland fields on its higher area but lower areas are almost swamps with bushes and forests. The low fields have been often suffered from frequent floods. The fringe surrounding swamps are now gradually settled by farmers under high population pressure.

Sand dunes along coast are used for coconut plantation and some fields. Sand dunes hinder the drainage from swamps to the sea, so that flood water once stagnated in swamps has to be drained through river channels.

The coast margin affected by tides 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. The annual average temperature along the coast is about 26°C with very little seasonal variation ranging from the maximum 33°C to the minimum 21°C. The temperature around Lake Toba on an elevation of about EL 905 m is about 6°C lower than the above.

The annual rainfall ranges between 4,500 mm in mountain area and 1,500 mm along coast. The average rainfall in Lake Toba basin is 1,820 mm with high rainfall of 2,000 to 2,200 mm in southern part and low value of 1,400 to 1,600 mm in northern area.

The study area is affected by northeast monsoon from China Sea in September through December and southwest monsoon from Indian Ocean in March through May. The main rainy season begins from the coast facing Malacca Strait with richest rain in October and it reaches to the coast of Indian Ocean after one or one and a half month. On the contrary, the secondary rainy season begins from Indian Ocean side and reaches to Pematan Siantar and Medan after one month. The Indian Ocean monsoon affects Medan very little. The interval between both peak rainy months in Lake Toba basin is therefore 7 months, so that only 60 to 70 mm of rainfall occurs in June and July. While, in Medan and Pematan Siantar, the interval is as 5 months resulting in no distinct dry season even in June and July.

Relative humidity is as high as 88% on an average with 92% in the highest month and 82% in the lowest. Records on wind, sunshine and evaporation are very scarce, but the general tendencies are as follows.

Wind velocity is as weak as 0.3 m/sec on annual average with very little seasonal variations. Sudden instant gales happen a few times a year. Sunshine is generally very short due to many rainy days, more than 15 days in a month during rainy season.

Evaporation around Lake Toba is presumed to be about 1,300 mm a year being estimated from incomplete observation records. The low value may be attributable to the high elevation with low temperature, many rainy days and very weak wind. The annual average evaporation from the lake surface is presumed to be about 930 mm.

3.3 Hydrology

3.3.1 Rainfall

There are 80 rainfall observatories in this study area distributing in higher density in low area but very thin in mountain area. All those data have been collected and analyzed for discharge and flood analyses. Daily maximum and 2-day maximum rainfalls and their probability analyses were also made. Continuous rainfall records measured by automatic rain gages are available for recent years at several places, according to which the rain in the first one hour occupies usually highest percentage but total rainfall is not so big due to short duration.

3.3.2 River Discharge

There are three water gaging stations, namely Kisaran on Silau river, Pulau Raja on Asahan and Pulo Dogom on Kualuh. No gage exists on Bunut river, so that the run-off of this river was estimated from the similar rivers. Of those three gaging stations, 30 to 50 times of discharge measurement records are available but very few in high water season. Therefore, JICA Study Team made supplemental measurements in high water season. Stage-discharge curves were drawn from those records and checked. Through the check on the river sections of those gaging stations it was recognized that not much change happened. So that those stage-discharge curves were applied to convert the recorded daily water levels into daily discharges.

According to the results the annual average discharge at Kisaran, Pulau Raja and Pulo Dogom are about 61 m^3/sec, 152 m^3/sec and 61 m^3/sec, respectively. The specific discharge from 100 km^2 at Kisaran is 5.83 m^3/sec and that at Pulo Dogom is 5.50 m^3/sec. It suggests the hydrological similarity between Silau and Kualuh rivers. While, that at Pulau Raja is as low as 3.29 m^3/sec. But if excluding the catchment area of Lake Toba, the specific discharge from the remaining area jumps up to 7.12 m^3/sec. It clearly proved that the discharge from Lake Toba is low due to less rainfall and enormous evaporation loss from the wide lake surface, while the remaining catchment area belongs to the highest rainfall zone, actually up to 4,500 mm a year. It suggests that the peak flood discharge from the remaining catchment area is also high.

3.3.3 Tide

The hourly tide records observed at Bagan Asahan (3°-01'N, 99°-52'N) and Kuala Tanjung (3°-22'N, 99°-28'E) were collected and analyzed. The records show a regular high and low tides twice a day each. Almost not much errors were there between both measurements. So that the average tide level at Bagan Asahan was calculated as the mean sea level being EL 0 m and this datum was used for all the levelling works. The highest tide was 2.25 m and the lowest was -1.75 m. Annual average high tide is 1.17 m and that of low tide is -1.16 m.

3.4 Geology

Basement rocks exposed in the mountain area are composed of acidic volcanic rocks, which are pyroclastic rocks derived from volcanic eruptions in the 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 the 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 sandy 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.

3.5 Land Use

3.5.1 Present Land Use

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	58,398	8.9
7.	Upland forest	158,440	23.9
8.	Bushes (Swampy)	48,592	7.3
9.	Swamp (Mostly forest)	125,851	19.1
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 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 general 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. 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.

All 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 idintified above, almost no wasted lands exist 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.

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 1981 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 Kabupaten 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 seem 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 purchase 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 for 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 floodings.

As clarified in the land use study, all the lands are well utilized under heavy population pressure except swampy areas. Although reliable information for assessment of development potential of swampy land, particularly soil and hydrological conditions, is not available at present, the field reconnaissance indicates that considerable swampy lands seem to be expected to have possibility for agricultural development. In Part II study development potential of the swampy land and its economic viability should be clarified through careful agricultural studies. In general much investment for swampy land development will be required and creation of benefit will take for longer time, however swampy land development will become one of the attractive method for increasing agricultural crop production if such development is able to be executed effectively and efficiently. It is therfore recommendable to raise the land productivity of the existing cultivated lands as well as swampy lands.

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 irrgated lands by enlargement of existing facilities or addition of facilities and also to extension of farm land by swampy land development.

Since the above development will require a considerable length of time, probably exceeding the target year of 2005 A.D. of the 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.

3.7 River Conditions

3.7.1 General

The Bunut river, with 59 km length and 621 km^2, originates in low hill area of about 300 m high. The width is as small as 15 m at the highway bridge point and gradually becomes wider to 20 or 24 m in the middle reaches and to 40 or 50 m after the confluence.

The both banks have been mostly developed into paddy fields with many small irrigation facilities. However severe water shortage is caused due to small river discharge especially in dry season. Although flood peak discharge was small, it caused frequent floods due to so narrow river channel.

In recent years, DPU constructed earth dikes in total length of 14 km, then the past flood damages become very small.

The Silau river, a major tributary of Asahan originates in high mountains and drains 1,180 km^2 catchment area with its 100 km length. The steep gradient of river in mountain area gradually becomes gentler to 1/800 near Kisaran and 1/1,500 near Tanjung Balai. The wide alluvial plain on both banks has been developed into paddy fields with many irrigation free intakes. DPU has constructed earth dikes along both banks in a total length of 28 km in recent years. But still frequent floods often overtopped those dikes and destroyed them.

The Asahan river flows from Lake Toba and drains about 3,200 km^2 of lands excluding the catchment area of the lake with its 152 km length. The water flows down in rapid through existing two hydropower stations of Sigurangura and Tangga up to Pulau Raja, from where it meanders in wide alluvial plain with gentle gradient of 1/4,000 to 1/13,000 near Tanjung Balai. Due to low flood carrying capacity of river channel, floods frequently overflow on both banks. The low area on the right bank therefore consists of wide bogging swamps.

The Kualuh river drains 3,820 km^2 of land with its 165 km length. The river condition is quite similar with Asahan having steep gradient in mountain area, very gentle slope in alluvial plain and wide swampy areas on both banks in the downstream reaches.

3.7.2 Existing Flood Control Facilities

All the four major rivers had earth dikes, namely the Bunut 14 km, Silau 28 km, Asahan 15 km and Kualuh 29 km in total length. Generally those dikes have a crest width of 2 to 3.5 m and a height of 1 to 4 m, with side slope of 1 : 1 to 1 : 2 on both sides. Those embankments have been often destroyed by floods once a year or two years due to low flood carrying capacity.

3.8 Flood Discharge

3.8.1 Recorded Major Floods

Past major floods were recorded in 1973, 1977, 1979 and 1984. Flooding season covered September to December normally with largest one in December. However the flood in 1984 occurred in January to February by overlapping of both floods from Lake Toba and the remaining catchment area. Among those floods occurred in Asahan and Silau rivers the typical largest one occurred in December 1973. Those past flood records were used for hydrological flood discharge analyses.

3.8.2 Flood Discharge Analysis

The flood discharge analysis was made by applying the storage function method on the past flood data recorded in 1973, 1977, 1979, 1982 and 1984. The entire catchment area was divided into many sub-basins according to the major tributaries and specific coefficients for those basins were calculated.

On the confirmed formula thus established, the probable rainfalls having different probability were applied and hourly flood discharges were estimated, the results of which are shown in the following table.

Probable Flood Peak Discharge

(m^3/sec)

River	Place	Probability (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
Kualuh	Pulo Dogom	661	729	880	978	1,101	1,270	1,378
Bunut	Confluence	51	63	70	73	80	88	95

The above probable flood discharges were used for the planning of flood control plans and also for the estimation of probable flood damages.

The flood reaching time between the regulating dam and Pulau Raja and that from the remaining catchment area were also scrutinized resulting in almost same time. Accordingly the overlapping of both flood peaks is judged unavoidable. So that the design flood discharge at Pulau Raja was obliged to add the maximum discharge of 400 m^3/sec to be discharged from the regulating dam.

3.9 Flood Damage

The data on past flood damages by respective flood were collected from the authorities concerned and confirmed by interview with local inhabitants. Also the levelling survey was made to clarify the inundation depth. All those data were checked on the topographic maps and the flood damages were estimated applying the price level in March 1985.

Based on the analysis on past flood damages the probable flood damages corresponding to the probable peak flood discharges were estimated in two cases, namely on the conditions of 1985 and that of 2005.

The estimated results are shown below:

Probable flood damages in 1985 conditions

(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	11,590	12,717
Total	6,193	7,997	9,527	12,355	14,242	15,424	16,605

Probable flood damages in 2005 conditions

(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	6,487	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

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 at the conditions of 1985 and 2005 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. But present total water use is less than 2% of the whole water resources, out of which irrigation water occupies a majority.

Even if water demand for any use is increased in future the given natural water resources seem to have enough surplus. Only some imbalance of demand and supply was recognized in Bunut river basin. In order to solve this shortage it was conceived to divert 10 to 15 m^3/sec of water from Silau river. Topographically no difficulty exists to excavate a diversion canal of about 6 km long. Detailed study on this plan was therefore proposed in Part II study works.

Many free intakes for irrigation exist on both banks of Silau river. Improvement of those intakes was considered in the urgent flood control plan.

In the downstream reaches of Asahan and Kualuh, the drainage shall be more important, which will be studied in Part II together with agricultural development plan.

Pipe water supply system exists at Kisaran and Tanjung Balai taking water from Silau river, but the total quantity amounts to only 7 m^3/min. Rural people depend almost on well water for their drinking water. River water is used mainly for washing and bathing. In the irrigation planning for Part II study domestic water supply will be taken into consideration for the benefit and sanitary improvement of inhabitants.

The optimum allocation plan of water resources will be studied in Part II works including the irrigation water requirement. At present the existing abundant water resources in the study area suggest no problem on water utilization. It seems rather important to improve drainage and sewerage in low-lying towns and villages. Those problems will be considered in the planning of agricultural development.

3.11 Saline Water Intrusion

Survey on saline water intrusion near the estuary of Asahan river was carried out two times on February 26th and March 8th 1985. The high tide on March 8th is the spring tide recording HWL 1.89 m at Bagan Asahan. According to the measurement by an electric conductivity meter, it was confirmed that saline water ends at the river bed at 6 km upstream from the estuary.

The discharges at Kisaran and Pulau Raja on the same day totalled only 150 m^3/sec which presents the lowest discharge. Accordingly it was judged that no further intrusion will be caused by the flood control and agricultural development in future, because no dredging works are planned.

3.12 Sedimentation

The engineering analysis on the measurements of sediment along Asahan and Silau rivers clarified that the annual total sediment yield in those basins ranged between 500 and 550 m^3/km^2, out of which the specific sediment of riverbed materials was 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 existed in the watershed. However private random cutting of trees on mountain slopes scatters in small patches. This should be prevented from the viewpoint of soil and water conservation. The above sediment production is considered to be attributable mainly to the sheet erosion of the ground surface of mountain and hill area.

One 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 the 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 riverbed 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.

Although the forestry problem in the Lake Toba catchment basin is out of scope of this study, it was observed from the Landsat IV data that considerable devastation of forest was progressed to the supercritical level. The traditional custom of the local inhabitants to burn the forest for shifting cultivation seems to accelerate it further by recent population pressure. In order to reduce such problem, the possibility of local transmigration will be surveyed in Part II works.

A little rising of riverbed 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.

Most of soils in this study area are suitable for irrigation farming except problems of peaty soils and acid sulphate soils related to swampy area.

Major food crops in the study area are paddy, followed by upland rice, maize, cassava, soy beans, 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 on a small scale throughout a year.

About 60% of paddy seed is improved varieties but the application of fertilizers and chemicals is still in low level. The major reason for low yield is the samll area under irrigation (only 20%) and also the incomplete irrigation facilities.

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

	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
Soy beans	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.

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 controlled 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.

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/s/ha)		
Dry season paddy	1.45	1.16
Wet season paddy	0.87	0.73
2. Seasonal irri. requirement (cu·m/crop)		
Dry season paddy	11,530	8,160
Wet season paddy	9,580	5,920

Those water requirement will be further studied in Part II works.

The potential lands for future irrigation and drainage development mostly extend along the major rivers. Those areas will be surveyed in detail in Part II works and future development plan will be established in accordance with the soils, topography, economy, etc.

CHAPTER IV 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 workers 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 os small branch streams.

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

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.

The results of comparative study clarified that the combination of earth dike with natural retarding basin is most economical for Asahan river and earth dikes for other three rivers with some enlarging of river width.

As for the target scale for long-term flood control plan the comparative study made clear that the case of 30 years' probability has higher economic viability than 15 or 50 years. Accordingly the design flood for long-term plan was selected at 30 year probable flood from the catchment area for four rivers.

The recommended long-term flood control plan is explained in detail in the Interim Report.

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 uses 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, 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 as follows;

Diversion site:	at the closest site of Silau and Bunut rivers, about 16 km south-west of Kisaran.
Diverting discharge:	10 to 15 m^3/s, estimated from the catchment area at the diversion site (about 500 km^2) and that at Kisaren 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 contributes 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 the future.

In additon 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-saline 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 width 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. Improvement of drainage and sewerage will play a big role in improvement of social health conditions.

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

About 70% of the people in the study area depend their drinking water on wells and washing and bathing on river water. Pipe water supply system exists in Kisaran supplying to 23% of residents and in Tanjung Balai for 50% people. Rubber and oil palm factories normally use deep wells.

Water quality of rivers has no problem for any use. The water of Lake Toba is also very clean according to the survey report published by North Sumatra University in 1981.

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 big industrial set-ups, although minor scale rubber and oil palm 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 Porsea near the outlet of Lake Toba is under planning. Dissolved pulp for rayon material product by kraft pulp method requires to use much Chloric oxides. Those Chloric oxides with lignin, β-cellulose and γ-cellulose will be the main pollutants in the waste water. This waste is stained in dark brown color with bad smell.

Those pollutants in the waste water are very difficult to recover even by chemical purification process and normally discharged into river water. Those chemical components are non-biodegradible ones, so that natural self-purification in downstream reaches can not be expected.

Such pollutants, even diluted with river water, will stain the water and air with bad smell and brown color and will give some adverse effects on the water use in downstream reaches. Therefore, establishment of such a factory at the head of river shall be avoided.

On the other hand, probable denudation of the forest surrounding Lake Toba will increase sheet erosion of soils and evaporation from the ground, resulting in a more rapid flood inflow into the lake after a long run.

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 futher intrusion of saline water by tide.

CHAPTER V RESULT OF FEASIBILITY STUDY ON URGENT FLOOD CONTROL PLAN

The economic comparative study to define the scale of the design flood revealed that the case of 10 years' probability showed the highest benefit-cost ratio among other cases. Accordingly for the urgent flood control plan of Asahan and Silau rivers, 10-year probable flood was selected as the design flood.

Based upon the preliminary design, the total length of dikes required is 43 km along Asahan and 19 km along Silau river. The total length of river channels to be improved is 57 km. Those works require excavation of 3.65 million m^3 and embankment of 2.27 million m^3. Improvement of 5 free intakes and 12 drainage culverts are also required.

The total time requirement was estimated at 6 years, including periods for detailed design, financial arrangement, tendering, land acquisition, etc. with main civil works requiring 3 years.

Based on the above time schedule and suitable construction method, the total construction cost was estimated at about Rp.36,484 million on the price level in March 1985, which includes Rp.9,292 million in local currency and US$24,750 thousand equivalent in foreign currency. The operation and maintenance cost was estimated to be Rp.136 million per annum.

The direct benefit accrued from decrease of flood damages amounts to Rp 4,610 million in value of annual average. In addition an enhancement benefit created by this project will amount to Rp 514 million. So that total annual benefit was estimated at Rp 5,124 million in monetary value.

The economic internal rate of return (IRR) was calculated under the economic life of 50 years. The result shows 12.4% and benefit-cost ratio of 1.03 with 12% annual discount rate. Further sensitivity analysis was made for various different cases. But even if the cost is increased by 20% and benefit decreased by 20% the IRR exceeds 10%, proving sound economic feasibility.

Financial estimates were made under assumption of 3% annual price escalation for foreign currency and 12% for local currency considering the trend in recent five years. The result showed total financial investment of Rp 51,420 million, which is broken down to Rp 18,727 million in local currency and US$29,721 thousand equivalent in foreign currency. Annual disbursement schedule was also prepared and shown in Table 5.5 in the Main Report.

In addition to the above direct benefit in monetary value the following intangible benefits will be created by this urgent flood control project:

(1) Among the existing cultivated lands habitually inundated about 10,600 ha will be relieved from flood damages. Also 8,700 households will be released from flood suffering. This will stabilize not only the livelihood of the inhabitants but also social psychological conditions to rely on administration.

(2) The sanitary conditions will be much improved unless otherwise the long stagnation of dirty water would generate water-borne disease. The hindrance on traffic and transportation often caused by floods will be eliminated or mitigated.

(3) Out of swampy area about 4,700 ha of lands can be cultivated and about 500 ha of lands can be utilized for residential lands.

(4) This construction project will provide employment of unskilled laborers of about 600,000 man-days. Also many employees will be trained into skillful labor or technicians, such as operators, mechanic, etc. It will make them easier than before to find jobs in future. The purchase of local materials, such as sand, gravel, timber, etc. will increase the income of local people.

However, resettlement of about 650 families will be required for this project. But those families will be able to resettle in the lands to be relieved by this project which might contribute to mitigate the compensation problem.

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.

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. Therefore it is recommendable to install and operate a flood forecasting and warning system for the safety of inhabitants in the downstream area. The system would consist of four (4) robot rain gaging stations, four (4) 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. Facilities cost is estimated at ¥600 million or US$2.8 million equivalent.

In addition, a few years' actual operation of this system will contribute to not only the safety of the inhabitants but also to clarifying the flood discharge mechanism resulting in a good model for the similar system required for other projects.

CHAPTER VI REGULATION OF WATER LEVEL OF LAKE TOBA

6.1 Lake Toba and Asahan River

The Lake Toba supplies clean and stable water to Asahan river with its vast surface area of 1,100 km^2 at an elevation of about 905 m above M.S.L. Harnessing this advantage two hydropower stations, Siguragura and Tangga, have been constructed by early 1981 and the generated power is sent to aluminium smelter at Kuala Tanjung which has annual production capacity of 225,000 ton. In order to regulate the outflow for this purpose a regulating dam was constructed at the head of rapid about 14 km downstream from the outlet of the lake.

However, the flood recorded in 1984 and the droughty years continued from 1978 to 1981 necessitated the study on this water regulation of Lake Toba from both viewpoints of flood control and water utilization. The maximum discharge before 1978 under natural condition was 207 m^3/sec and the minimum was 38 m^3/sec. Now the regulated outflow is usually in a range of 95 to 100 m^3/sec through a year for power generation except in flood season when the maximum discharge of 250 m^3/sec was released for a short period.

According to the present Master Agreement between the Indonesian Government and INALUM, INALUM keeps the right of ownership of all the structures and also the right of operation. The regulation of water level of Lake Toba was stipulated in the Agreement and operation rule as follows:

(1) INALUM has a right to use water between the normal high water level of EL.905.00 m and the low water level of EL.902.40 m for power generation, but not allowed to use water lower than the low water level.

(2) In case of floods, INALUM shall release the surplus water beyond EL.905.00 m according to the operation rule and control the flood water level not exceeding EL.905.50 m. The flood discharge specified in the operation rule is as follows:

Water Level	Flood Discharge (m^3/sec)
Beyond EL.905.05 m	186
Beyond EL.905.10 m	242
Beyond EL.905.15 m	315
Beyond EL.905.20 m	400

(3) If an abnormal flood flows into lake and can not be controled within the restricted flood water level of EL.905.50 m even by the above flood release operation, responsibility of INALUM shall be released as the Force Majeure.

No other detailed conditions were specified regarding the technical aspects.

6.2 Hydrological Data

Rainfall data are available at 10 places in and around Lake Toba basin, but lacking during the World War II and many interruptions after the war. The basin average annual rainfall was calculated by Tiessen method on records from 1919 to 1940 and from 1974 to 1980 resulting in 1,820 mm.

The water level records of Lake Toba are available at several places along the coast, among which longest and reliable one is records at Janji Matogu since May 1963.

The daily water level records at Siruar and Simorea are available for about 43 years spanning from 1916 to 1984 with several interruptions. Actual outflow measurement records at Siruar are available about 590 times between 1961 to 1980, by which the water level can be converted into discharge. Also the definite relation between the water levels at Janji Matogu and Siruar makes it possible to convert water level into discharge or vice versa. The discharge records from February 1981 to January 1985 are available at the regulating dam.

The discharge records of same period from 1956 to 1984 at Siruar and Simorea made it possible to presume the discharge from the catchment area between the regulating dam and an intake dam for Siguragura power station. Those annual discharges are averaged to about 5 m^3/sec ranging from 3 to 10 m^3/sec by year.

6.3 Net Inflow

Net inflow into Lake Toba can be calculated by the water level records of the lake and outflow at Siruar. The gross inflow and evaporation loss from the lake surface are not known. Those daily net inflows were used for detailed calculation of flood analysis. For general calculation it is not necessary to use daily records but 10 days' average values. The basic data covers 43 years and one month between 1916 to 1932 and between 1957 and January 1985 with some interruptions.

6.4 Study on Lake Operation

The minimum required power for full aluminium production is 426 MW through a year continuously. Of course surplus power beyond the above minimum can be sold to PLN up to 50 MW if so agreed.

The required outflow at the regulating dam to generate 426 MW is about 101 m^3/sec as the balance between required flow of 105.4 m^3/sec at Siguragura intake and run-off of 5 m^3/sec from the catchment area between the regulating dam and Siguragura intake.

At first the water levels of Lake Toba were calculated under the conditions that 101 m^3/sec of discharge is continuously used through the 43 years' records. Then the obtained results are as follows:

(1) Flood water level does not exceed EL.905.50 m but reaches at EL.905.42 m.

(2) The maximum flood discharge of 400 m^3/sec continues for 30 days.

(3) The full discharge of 101 m^3/sec for power generation can be used for 41 years and 10 months out of 43 years and one month.

(4) The water level descends to the low water level of EL.902.40 m for 1 year and 2 months during which no power can be generated and no water can be discharged to the downstream reaches. All the periods of zero discharge occur between 1978 and 1983.

From the above trial calculation the following matters were revealed:

a) In order to avoid 0 discharge, the power discharge shall be decreased before the water level reaches at the low water level.

b) Only about 80 m^3/sec may be discharged through the droughty years from 1978 to 1981.

c) The lake water level usually descends down to about EL.904.50 m at the end of dry season, say end of September or October. So that even the past maximum flood inflow happened in 1930/31 has been absorbed within the restricted flood water level of EL.905.50 m. This flood corresponds to about 100 years' probable flood.

Hence the idea to set up seasonal restricted water levels and to reduce the power discharge down to 80 m^3/sec from 101 m^3/sec according to the lake water level was hinted. It was also presumed that the maximum flood discharge may be decreased from 400 m^3/sec to 300 m^3/sec.

Then such a trial operation was calculated as Case I. The results showed the following matters:

a) The maximum flood release of 300 m^3/sec continues for forty days and the highest water level reaches only EL.905.37 m.

b) The lowest level descends down to EL.902.41 m and water level recovers higher. Minimum 80 m^3/sec of power discharge can be used even in heaviest droughty year.

c) The average discharge used for power generation through 43 years and one month is 94.6 m^3/sec which makes possible to produce about 210,000 ton/year of aluminium on an average.

Additional various cases were examined to find better operation method to increase average power discharge as much as possible and Case V was reached as one of the recommendable model method.

The operation method of Case V is based on the following four conditions:

(1) Restricted water levels at the end of each month are specified as follows:

(+EL.900 m)

Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb. to Jul.
5.00	4.84	4.58	4.52	4.64	4.76	4.88	5.00

The restriction shall apply in 10 days' interval in linear function.

(2) Release of flood surplus water above EL.905.00 m is made according to the following method:

Water Level	Flood discharge
905.00 to 5.10 m	200 (m^3/sec)
905.10 to 5.20 m	250
905.20 to 5.50 m	300
Above 905.50 m	400

(3) When the lake water level exceeds the restricted seasonal water levels specified in above (1) more than 0.20 m, 75 m^3/sec shall be discharged from the regulating dam in addition to the power discharge of 101 m^3/sec. When it exceeds less than 0.20 m, 50 m^3/sec shall be discharged.

(4) The power discharge is gradually reduced according to the lake water level as follows:

Range of Water Level	Power Discharge (m^3/sec) Descending	Rising
Above EL.904.50 m	101	101
904.25 to 4.50 m	101	98
904.00 to 4.25 m	98	95
903.75 to 4.00 m	95	92
903.50 to 3.75 m	92	80
903.25 to 3.50 m	86	80
902.40 to 3.25 m	80	80
Below EL. 902.40 m	0	0

The results of Case V operation are as follows:

(1) Flood water level reaches only EL.905.34 m under maximum discharge of 300 m^3/sec for 30 days.

(2) Average power discharge is 95.6 m^3/sec which can produce 213,000 ton/year of aluminium.

6.5 Flood Control by Lake Toba

In case of above Case V, the water level before inflowing of 1930/31 flood was lower than the restricted water level, so that the highest flood water level reached only EL.905.34 m.

For the sake of caution an additional calculation was made under the assumption that the water level at the end of September before 1931 flood was same as the restricted level of EL.904.68 m. The calculation was made on daily basis.

The result showed that the maximum flood water level reaches EL.905.49 m under the flood discharge of 300 m^3/sec for 44 days.

The above check calculation proved that even 100 years' probable flood could be absorbed within the present restricted flood water level of EL.905.50 m if the specified restricted seasonal water level is strictly observed.

6.6 Tentative Operation Method before Completion of Urgent Flood Control Facilities

At present the flood carrying capacity of the river channel downstream from Pulau Raja is very small until completion of the urgent flood control facilities. Therefore it is suggested to adopt some tentative method to keep the flood discharge from the regulating dam smaller than 300 m^3/sec.

The above Case V showed that maximum flood level reaches only EL.905.34 m. So that an additional calculation was made under the maximum flood discharge of 200 m^3/sec. The result showed that even if the flood discharge from the regulating dam is restricted to 200 m^3/sec the maximum flood water level does not exceed EL.905.50 m.

6.7 Recommendations

The results of all the above studies clarifed that there is a possible solution to satisfy both the requirements from the flood control and water utilization.

The above Case V is one model among various solutions. So that the figures adopted in Case V can be adjusted to some extent according to the realistic needs for power generation and aluminium production. Accordingly it is recommended that all the authorities directly concerned with this matter shall review and fully discuss the above method and reach the final best solution.

CHAPTER VII WORK PLAN OF PART II STUDY

7.1 Methodology and Sequence of Study Works

In line with the basic direction of the lower basin development recommended in the Part I study, a master planning of the lower basin from the viewpoint of agricultural development will be conducted in the Past II study. The objective of the Part II study is to formulate a long-range development policies on agriculture up to 2005 A.D. and to propose promising development projects with priority aiming at raising agricultural productivity, increasing employment opportunity, promoting transmigration and bettering living standard of the people in the study area.

The JICA study team will execute the Part II study in two steps. The first step work is (a) to conduct the field investigation, (b) to evaluate land and water resources for development, and (c) to preliminarily formulate basic agricultural development plans. All the first step works will be executed in Indonesia with Indonesian counterpart. The results of the study in the first step will be summarized in the Progress Report IV.

The second step work is (a) to establish definite agricultural development plans, and (b) to determine priority sequence of the plans. The study in the second step will be carried out in Japan.

7.2 Work Schedule

7.2.1 First step work

Prior to the formulation of the development plan for agriculture in the study area, all the necessary field investigations will be carried out. The JICA study team for the Part II study will carry out the following field investigations:

(A) <u>Field Investigation</u>

(1) Topographic survey

a) preparation of the technical specifications and scope of works for topographic survey which shall be carried out by DGWRD, and

b) check survey on the results of the above work a).

(2) Hydrological survey

a) collection of the additional data,

b) survey on tide level on the Kualuh and the Leidong rivers,

c) survey on saline water intrusion near estuary of the Kualuh river,

d) discharge measurement in the Silau and the Bunut rivers, and

e) survey on sedimentation in Silau river.

(3) Survey on water resources

a) collection of data and analysis on the low flow in the Asahan, Silau, Kualuh, Benut rivers and other major tributaries.

(4) Soil survey

a) preparation of the technical specifications and scope of works for soil survey which shall be carried out by DGWRD, and

b) supervision of the above soil survey work and judgement.

(5) Survey on irrigation and drainage

a) collection of data and drawings on the existing irrigation and drainage facilities,

b) survey on present conditions of the existing irrigation and drainage facilities, and

c) survey on present O & M works being carried out in the existing schemes.

(6) Survey on existing social infrastructure

a) inventory survey on existing social infrastructure in the study area, and

b) field survey on present conditions of existing social infrastructure.

(7) Agricultural survey

a) collection of additional data on agriculture,

b) survey on present farming method and technology, and

c) survey on unit yield of paddy.

(8) Agro-economic survey

a) collection of additional agro-economic data,

b) survey on farmers economy by interview,

c) survey on price of agricultural products and production costs,

d) survey on agricultural marketing, and

e) interview survey on farmer's intention to agriculture development.

(9) Survey on agricultural supporting services

a) survey on present situation of existing supporting services for agriculture.

(10) Environmental survey

a) survey on present condition of sewerage treatment at the existing oil palm and rubber factories and major cities/towns in the study area.

(11) Survey on construction costs

a) survey on prices of construction materials, wages and construction cost.

(12) Survey on inland fisheries

a) survey on existing inland fisheries in nearest districts

b) examination of possibility on inland fisheries development

(13) Survey on local transmigration

a) survey on present condition of local transmigration program

b) collection of data with respect to future local transmigration program, regulation and social customs of land tenure system for transmigrants.

(B) Preliminary formulation of basic agricultural development plans

a) land use plan
b) agricultural/farming plan
c) water resources utilization plan
d) irrigation and drainage plan
e) rural development plan
f) farm road improvement
g) swamp development plan
h) seeds multiplication plan
i) post-harvest improvement plan
j) agricultural industry plan
k) inland fisheries development plan if any

7.2.2 Second step work

The second step work will include the following works:

(1) Planning on agricultural infrastructure and facilities.

(2) Estimation of project costs and expected benefits.

(3) Establishment of definite agricultural development plans.

(4) Evaluation of proposed projects.

(5) Selection of the projects and determination of priority sequence of the projects.

(6) Adjustment of the proposed flood control plans to the proposed agricultural development plans, if necessary.

7.3 Reporting

The JICA study steam will prepare and submit the following reports to the Government of Indonesia.

(1)	Progress Report III	:	thirty (30) copies
(2)	Progress Report IV	:	thirty (30) copies
(3)	Draft Final Report	:	thirty (30) copies
(4)	Final Report	:	fifty (50) copies

7.4 Assignment Schedule

The JICA study steam for the Part II study will consist of the following specialists and engineers.

- Team Leader
- Agro-economist
- Agronomist/Soil expert
- Water resources engineer
- Hydrologist
- Irrigation engineer
- Drainage engineer
- Design engineer
- Rural development planner
- River engineer
- Topographic survey expert