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

### 3.8.3 Probable Flood Analysis on Kualuh and Bunut Rivers

The same analysis method was applied to the data on Kualuh and Bunut rivers, the results of which are shown below:

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

The above figures were used for flood control master plan. (The details shall be referred to APPENDIX G.)

## 3.9 Flood Damage

### 3.9.1 Flooding Characteristics

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

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

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

Fig. 3.32 shows possible flooding areas based on the data collected from DPUP, North Sumatra and the informations obtained through field survey.

The flooding conditions for each river are as follows:

Bunut river

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

Silau river

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

Asahan river

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

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

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

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

Kualuh river

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

### 3.9.2 Flooding Conditions

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

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

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

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

In order to estimate flooding conditions, a contour map of the study area is tentatively made as shown in Fig. 3.33 based on the existing data on topography. But this contour map shall be revised using a correct river survey result and 1/5,000 scale topographic maps with one meter contour along the Asahan and Silau rivers and their tributaries. Based on the contour map and results of discharge analysis in the lower area, the flooding conditions, that is, inundated area, depth and duration of the said floods were estimated as shown in Table 3.14.

The flooding conditions for probable floods of 2 yr, 10 yr, 30 yr and 100 yr were also estimated as shown in Table 3.15.

### 3.9.3 Flood Damages

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

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

#### Damages to buildings/properties

The unit values for each property were estimated as shown in Table 3.16 based on the statistic data obtained in the field. The standards of damage rates in Japan were adopted as shown in Table 3.17.

#### Damages to agricultural crops

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

Based on the paddy price predicted by World Bank (IBRD), the farm-gate price of paddy (dry stalk paddy) was estimated at Rp 188/kg as shown in Table 3.18.

The cropping pattern in the study area is as follows:

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

The area has a flood season from September to January which corresponds to the growing period of paddy. In consideration of growing stage of paddy in the flood season, yield reduction rates for different flooding conditions are presented in Table 3.19.

The upland crops were further classified into upland paddy, maize, and soybean. The unit price and damage rate are presented in Tables 3.18 and 3.19.

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

Damages to public facilities

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

Indirect damages

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

Probable flood damages in 1985 conditions

Table 3.20 shows the calculation result of probable flood damages under the present conditions. The total flood damages are summarized below:

(Rp million)

| River | 2-yr | 5-yr | 10-yr | 15-yr | 30-yr | 50-yr | 100-yr |
|---|---|---|---|---|---|---|---|
| Asahan river | 1,464 | 2,609 | 3,561 | 3,657 | 3,779 | 3,834 | 3,888 |
| Silau river | 4,729 | 5,388 | 5,965 | 8,698 | 10,463 | 11,590 | 12,717 |
| Total | 6,193 | 7,997 | 9,527 | 12,355 | 14,242 | 15,424 | 16,605 |

Probable flood damages in 2005 conditions

Probable flood damages in the year of 2005 were estimated based on the annual growth rate of GRDP in North Sumatra and consumer price index (CPI) in 1980. Unit prices of agricultural crops were estimated based on the data in "Price Prospects for Major Primary Commodities, Sept. 1984". The calculation result of probable flood damages under the future conditions are as follows:

(Rp million)

| River | 2-yr | 5-yr | 10-yr | 15-yr | 30-yr | 50-yr | 100-yr |
|---|---|---|---|---|---|---|---|
| Asahan river | 2,179 | 4,287 | 5,993 | 6,138 | 6,406 | 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 |

Average annual flood damages

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

The calculation of average annual flood damages for the years of 1985 and 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.

Among others the most significant water use in its quantitative terms in the area is for irrigation.

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

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

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

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

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

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

Annual water consumption in the study area under the present conditions is estimated as 81 million cubic meters in the whole fields, composing of 83 percent for irrigation, 9 percent for domestic water use and 8 percent for industrial uses. Present water utilization in the study area is summarized in Table 3.21. This volume corresponds to 1.2 percent of annual runoff of three rivers, Asahan, Silau and Kualuh, in 1983, which was somewhat a drought year in recent several years (see Table 3.5).

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

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

### 3.11 Saline Water Intrusion at Estuary

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

In the Strait of Malacca and Singapore the investigation of tides and tidal streams were carried out jointly by the three coastal countries, Indonesia, Malaysia and Singapore, and Japan for three years from 1977 (ref. M. 15).

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

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

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

The range of tide observed at Bagan Asahan and Tanjung Balai at the spring tide on 8 March 1985 were 4.0 meters and 2.0 meters respectively as shown in Fig. 3.34. The former coincided with the record of tidal level at Bagan Asahan stated in Sub-Paragraph 3.3.3.

The standard point for prediction of tidal heights on the coast of the north-eastern Sumatra is One Fathom Bank (2°53'N and 101°0'E, just a center of the Strait (Fig. 3.35). The spring tides at the Bank in 1985 and hourly tidal heights on 8 and 9 March 1985 at the same point are as seen in Table 3.22.

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

$$H = (HO - 244) * R + 202.7$$

where,

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

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

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

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

In the Asahan river the saline water neither intrude to Tanjung Balai nor to Tuluk Nibung even at the spring tide in low flow season as shown in Table 3.23. River runoffs of the Asahan and Silau rivers in early March 1985, when the tide level and saline water intrusion of the Asahan river were measured at the spring tide on 8 March 1985, were nearly lowest ever recorded (Asahan at Pulau Raja 147 $m^3/s$ and Silau at Kisaran 35 $m^3/s$). This assertion is endorsed by the fact that shellfish never lives in the river course beyond the point 1.5 km upstream of Bagan Asahan (see Fig. 3.35). Both the long term flood control plan and the urgent flood control plan include no dredging works downstream reaches so that no further intrusion of saline water is anticipated.

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

### 3.12 Sedimentation

(Refer to APPENDIX E, VOL. I for details)

#### 3.12.1 Present Conditions

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

It was also confirmed by the ground survey and the interpretation of false color image made from the Landsat IV data taken on June 8, 1984 that no large scale mountain break and land slide exist in the water shed. However private random cutting of trees on mountain slopes scatters in small patches. This should be prevented from the view point of soil and water conservation. Therefore the above sediment poduction 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 30 to 80 $km^2$ per annum. Even after replanted with young seedlings those areas would cause sheet erosion of 2 to 3 mm/year for about 10 years. It means that annual production will amount to 1.0 to 2.4 million $m^3$ of sediment, corresponding to 230 to 550 $m^3/km^2$ for the catchment area of study area excluding the catchment area of Lake Toba.

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

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

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

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.

### 3.12.2 Conclusion

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

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

## 3.13 Agriculture

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

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

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

As far as farming practice is concerned, about 60% of rice seed is improved varieties. Most of varieties of palawija crops are local varieties. About half of the farmers in the study area uses fertilizer and agro-chemicals for paddy cultivation under intensification programme. The estimated average dosage per ha for paddy from 1980/81 to 1983/4 is 83 kg of Urea, 28 kg of TSP, 9 kg of ZA, 5 kg of KCl, 4 liters of insecticide and 0.3 kg of rodenticide. Detail on farm input is explained in Appendix D, Agriculture and Irrigation. No application of fertilizer and agro-chemicals is practiced for palawija crops. Such low dosage of fertilizer is one of the constraints to hinder unit yield of crops. The major reasons of such low dosage are considered as follows:

(1) Farmers in the study area can't purchase fertilizers due to low capacity to pay.
(2) About 80% of paddy field is under rainfed, which hampers effective application of farm inputs. The farmers in the rainfed paddy field do not want to apply proper dosage of fertilizer.
(3) KUD, one of the agencies of farm inputs distribution, does not always function effectively.

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

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

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

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

(1) Low level of fertilizer's dosage
(2) Though about 60% of total rice seed is the improved varieties, only 6% are certified seed.
(3) Considerable infection and damage by pest, diseases and rat are found.
(4) Damages by flood and poor drainage.
(5) More than 80% of the total paddy field is under rainfed.

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

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

| | PTP | | Small holder | | |
|---|---|---|---|---|---|
| | Unit yield (t/ha) | Total production (t) | Unit yield (t/ha) | Total production (t) | Total production (t) |
| Oil palm | 18.0 | 403,600 | 1.7 | 700 | 404,300 |
| Rubber | 1.3 | 19,800 | 0.4 | 4,800 | 24,600 |
| Coconut | - | - | 0.8 | 20,300 | 20,300 |

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

## 3.14 Irrigation and Drainage

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

### (1) Present Condition of Paddy Schemes

Paddy schemes in the study area have been developed and maintained by DPU North Sumatra Province and Asahan Kabupaten Office. In the study area, paddy field covered by irrigation or control drainage schemes totals about 32,600 ha in net comprizing 25,100 ha (23 schemes) in Kabupaten Asahan and 7,500 ha (8 schemes) in Kabupaten Labuhan Batu. Of them, irrigable area is estimated to be 6,800 ha in total, or

21% of total irrigation scheme area, consisting of 2,880 ha in the lower Bunut area, 1,880 ha in the lower Silau area, and 2,040 ha in the other area. Among these irrigable areas, an area of 2,050 ha can be cultivated during dry season due to limitation of available river discharge. Irrigation canal density in the existing schemes is estimated at 19 m/ha on an average which is too low to achieve adequate water management.

(2) Problems and Constraints in the Existing Paddy Schemes

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

(a) The Padang Mahondang scheme and Sei Lebah scheme located in the Asahan river basin are suffering from flood problem.
(b) In the existing irrigation schemes in the lower Bunut area, irrigable area for dry season paddy is quite limited due to shortage of available water in the Bunut river.
(c) In the existing irrigation schemes in the lower Silau area, irrigable area for dry season paddy is limited due to insufficient river water level at the free intakes during dry season.
(d) Most of all paddy schemes in the study area, provision of canal network is insufficient. Poor drainage condition seems to be one of the reasons of low productivity of paddy.
(e) In most existing irrigation schemes, tertiary canal and measuring device are not provided yet. Lack of these facilities seems to be one of the reasons of present poor water management.
(f) Farm roads are absolutely insufficient. Especially, accessibility in and around the existing control drainage schemes is terribly poor.
(g) To achieve good O&M for existing schemes, present number of O&M staffs and budget is too small.
(h) Many existing intakes and canal tructures constructed in 1970's are partly deteriorated already, especially gates.

(3) Present Water Utilization for Irrigation

Present irrigation water requirement was provisionally estimated using present cropping pattern, existing irrigable area and calculation method proposed by PROSIDA. Assumptions and procedure of estimation are described in Appendix D. 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 |

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

(4) Possibility of Irrigation and Drainage Development

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

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

Location of these areas are shown in Fig. 3.36. Possibility of irrigation and drainage development in these areas is provisionally presumed as shown below. Possible area for future development can be determined based on the soil survey and agricultural and irrigation studies in Part II study.

(a) Upper Bunut area

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

(b) Lower Bunut area

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

(c) Upper Silau area

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

(d) Lower Silau area

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

(e) Asahan area

This area is a vast area including huge Asahan swamp. Paddy scheme areas are scattered around the Asahan swamp as shown in Fig. 3.36. Paddy fields in this area have been increased steadily. In 1985, existing paddy field is estimated to be 12,500 ha (gross). At present, 4 irrigation schemes (885 ha in total) and 2 controlled drainage schemes (6,500 ha in total) have been maintained by DPU and Asahan Kabupaten Office. Of them, the Sei Lebah controlled drainage scheme (6,550 ha in gross) is the largest scheme. To improve this scheme, provision of flood protection dikes, adequate irrigation facilities and drainage facilities will be necessary. The Padang Mahondang scheme of 2,230 ha is suffering from flood from the Asahan river. At present, irrigation facilities have been provided to the paddy field of about 560 ha. Flood protection dikes, irrigation and drainage facilities are indispensable to upgrade this scheme. For other minor paddy fields, possible measures will be considered taking the local conditions into account.

(f) Leidong area

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

(g) Upper Kualuh area

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

(h) Lower Kualuh area

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

# CHAPTER 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 of small branch streams.

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

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

## 4.2 Long-Term Flood Control Plan

### 4.2.1 General

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

### 4.2.2 Objective Area for Long-Term Plan

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

The objective rivers and their stretches are as follows :

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

### 4.2.3 Flood Control Method

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

Upper basin : flood regulation by reservoir.

Middle basin : flood retardation by retarding basin and flood prevention by channel improvement.

Lower basin : flood diversion by floodway, flood retardation by retarding basin and flood prevention by channel improvement.

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

(1) Flood control method in the upper basin

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

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

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

In calculation, the flood peak discharge from the area of 214 sq.km is estimated at about 410 cms and its total volume may be 30 mcm in the case of 30-year probable flood. If the storage capacity of 12 mcm for flood control is secured at the NO.3 intake dam, the above peak discharge will be cut down to 100 cms. The flood control effect of this intake dam will reduce about 20% of the peak flood discharge of 1360 cms at Pulau Raja which includes the maximum flood release of 400 cms from the upstream regulating dam. So that, it is recommended to take the flood control capacity at the No.3 intake dam. It seems that the decrease of annual electric energy at the No.3 power station would be as small as less than 1% or so even in case of 12 mcm of flood control capacity during the flood season, as some part of flood quantity at the intake dam will reduce the loss of power due to lower head during flood season.

(2) Flood control method in the middle basin

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

(3) Flood control method in the lower basin

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

a. Bunut river

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

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

b. Asahan and Silau rivers

Asahan mainstream:

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

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

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

iv) Combination of above methods.

Silau river:

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

c. Kualuh river

Kualuh mainstream:

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

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

Kanopan river

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

(4) Alternative Schemes

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

a. Bunut river

Alternative Scheme B-1 : Floodway.

Alternative Scheme B-2 : Channel improvement alone.

b. Asahan and Silau rivers

Alternative Scheme A-1 :

Asahan river : Channel improvement combined with floodway.

Silau river : Channel improvement alone.

Alternative Scheme A-2 :

Asahan river : Channel improvement combined with retarding basin.

Silau river : Channel improvement alone.

Alternative Scheme A-3 :

Asahan river : Channel improvement alone.

Silau river : Channel improvement alone.

c. Kualuh river

Alternative Scheme K-1 :

Kualuh river : Channel improvement combined with retarding basin.

Kanopan river: Channel improvement alone.

Alternative Scheme K-2 :

Kualuh river : Channel improvement alone.

Kanopan river: Channel improvememt alone.

### 4.2.4 Scale of Long-Term Plan

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

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

| Design flood (year) | Ave.annual benefit (Rp million) | Economic cost (Rp million) | B/C with discount rate of 14 % |
|---|---|---|---|
| 15 | 10,571 | 56,152 | 1.01 |
| 30 | 11,662 | 61,404 | 1.03 |
| 50 | 12,166 | 69,053 | 0.94 |

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

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

### 4.2.5 Comparison of Alternative Schemes

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

| Alternative scheme | Ave. annual benefit (Rp. million) | Economic const. cost (Rp. million) | B/C with discount rate of 12 % |
|---|---|---|---|
| Bunut river | | | |
| B-1. | 1,839 | 15,555 | 0.77 |
| B-2. | 1,839 | 12,074 | 0.99 |
| Asahan and Silau rivers | | | |
| A-1. | 12,444 | 103,558 | 0.78 |
| A-2. | 11,662 | 61,404 | 1.24 |
| A-3. | 11,976 | 71,323 | 1.09 |
| Kualuh river including Kanopan river | | | |
| K-1. | 3,116 | 19,715 | 1.03 |
| K-2. | 3,742 | 25,241 | 0.97 |

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

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

#### 4.2.6 Proposed Long-Term Flood Control Plan

(1) Design flood discharge

Based on the results of flood discharge analysis, the design flood discharges of the Bunut, Asahan mainstream, Silau, and Kualuh rivers for the long-term flood control plan are determined as shown in Fig.4.1. In determination of design flood discharge at Pulau Raja on the Asahan mainstream, flood regulation of 310 cms by Asahan No.3 Dam was considered and outflow from Regulating dam was estimated at 400 cms assuming that flood peak from the basin downstream from Regulating dam overlaps with the maximum outflow from Regulating dam. However, the case without Asahan No.3 Dam was also studied and compared.

(2) Proposed plan

The proposed long-term plan is composed of channel improvement by means of construction of dike and excavation of channel, construction of drainage outlet culverts, and reconstruction of irrigation free intake owing to channel improvement. The proposed alignments of dike, longitudinal profiles and cross-section are shown in Fig.4.2 to 4.4 The outline of the works of this proposed long-term plan for each river is as follows:

a. Bunut river

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

b. Asahan and Silau rivers

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

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

c. Kualuh river including Kanopan river

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

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

(3) Construction cost

Construction costs are composed of the costs of civil works, land acquisition and compensation, contingency and engineering and administration. Cost required for civil works is accounted by multiplying work quantity by unit cost. Engineering and administration cost is assumed to be 15 % of the sum of the civil works, land aquisition and compensation costs. Cost for contingency is assumed at 10 % of the above costs. The construction costs for the long-term plan for each river are estimated at Rp 12,550 million for the Bunut river, Rp 63,470 million (with Asahan No.3 dam) and Rp 69,840 million (without dam) for the Asahan and Silau rivers, and Rp 20,500 million for the Kualuh river. The breakdown of the costs is shown in Table 4.3.

(4) Economic evaluation

a. Economic construction cost

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

(Unit : Rp million)

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

b. Benefits

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

Benefit under present conditions

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

(Unit : Rp million/yr)

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

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

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

Benefits under future conditions

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

(unit : Rp million/yr)

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

c. Internal rate of return

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

| Conditions | Internal rate of return (%) | | |
|---|---|---|---|
| | Bunut R. | Asahan & Silau R. | Kualuh R. |
| Present condition | 8.3 | 8.4 | 8.1 |
| Future condition | 11.9 | 14.3 | 12.3 |

d. Priority Order

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

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

## 4.3 Water Use in Future

As clarified through the investigation and study in Part I work, water resources in the study area is far beyond the water 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, in the Bunut river basin of the northern fringe of the study area is suffering from water shortage in the dry season owing to the small catchment area and less precipatations. To conquer the water shortage of the Banut 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 southwest of Kisaran as shown in Fig. 3.19. |
| Diverting discharge: | 10 to 15 m3/s, estimated from the catchment area at the diversion site (about 500 km2) and that at Kisaren gaging site (1,050 km2) (refer to Table 3.5). |

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 km2, 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 future.

In addition the cosiderably 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. Threfore 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 stong infection.

The malaria in North Sumatra is almost infected by the mosquitoes, Anopheles Sundaicus, which live only along the coast of the Strait of Malacca, because this species has a definite characteristics of laying eggs in semi-sailing water, of which the concentration of 5,000 to 20,000 ppm of salt. Therefore malaria patients are predominant only in the belt zone about one kilometer 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 raches 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 secio-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 desease infects through foods and drinking water. From this veiwpoint also, improvement of drainage and severage will play a big role.

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

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

### 4.4.3 Water Supply and Water Quality

In North Sumatra Province, the source of water for drinking in urben area is mainly water-well (59.6%) and pipe (33.1%), while that in rural area is well (58.5%), spring (16.5%), river (14.7%) and so on, as shown in Table 4.4. As for bathing and washing, water of well and river are commonly used.

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

The urban water supply system is administrated by the Regional Water Supply Enterprise (PDAM) in each Kabupaten and Kotamaja. The water supply system of the city Kisaran was commenced in 1928, and at present about 4,000 households (corresponding to about 23% of the total) are supplied (20 hrs/day) from the Silau river with yield of 40 lit/s. However, most of inhabitants in the study area are using water of well, rain and/or river for their drinking, cooking, bathing and laundry.

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

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

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

Regarding the water quality of Lake Taba, laborious survey results of North Sumata University is available in the Final Report of Community, Toba Territory and Biology of Lake Toba published in march 1980. The physical and chemical analysis proved very clean and pure water of Lake Toba as summarized in Table 4.6. The report concluded that the physical and chemical character of the water is still normal, plankton condition is still good, floating plant is mostly eichhornia crassipes (water hyacinth) type, agriculture is developed mostly on the plain and scarcely on steep slopes, but some places have been recently contaminated by feces.

At present the waters of Asahan, Silau and Kualuh rivers are not so much polluted by artificial activities as this study area has not so 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 some press news a pulp and rayon factory is planned to set up at Porcea near the outlet of Lake Toba.

Dissolved pulp for rayon material produced by kraft pulp method requires to use much Chloric oxides. Those Chloric oxides with lignin, $\beta$-cellulose and $\gamma$-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.

The conceivable effects of those pollutants on the respective field are as follows:

- For drinking and bathing: Bad taste, smell and stained color. If the lignin content is high it causes Casimpec disease which hinders the growing of children.

- For irrigation use: Increase of BOD will affect on growing of paddy and causes root-rot.

- For fishery: Lignin, carbonic acid and resinoid matters will hinder the gathering of fish.

- For downstream hydropower structures: Sulphate would corrode and weaken concrete in a long run. Chrolic acid will increase corrosion of steel pipes, gates and trubines.

On the other hand, denudation of forest surrounding Lake Toba will increase sheet erosion of soils and evaporation from the ground. It will cause rapid flood inflow into the lake.

. The problems are summarized as follows:

i) Rayon pulp production uses much quantity of water, normally 100 to 200 $m^3$ per ton.

ii) It also produces much suspended solids in the waste.

iii) Most of chemical components in waste water can hardly be recovered by even expensive chemical purification process.

iv) Those chemical components are non-biodegradible ones, so that self-purification in downstream reaches can not be expected. Therefore when those wastes are once discharged into a river the consequent pollution of the water quality can not be recovered.

It is therefore strongly recommended that such pulp factory shall be avoided to establish at the head of river.

### 4.4.4 Probable Impact of Development

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

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

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

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

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

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

# CHAPTER V RESULT OF FEASIBILITY STUDY ON URGENT FLOOD CONTROL PLAN

## 5.1 General

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

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

## 5.2 Necessity of Urgent Flood Control Project

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

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

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

## 5.3 Design Flood

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

| Design flood (year) | Ave. annual benefit (Rp million) | Economic cost (Rp million) | B/C with discount rate of 12 % |
|---|---|---|---|
| 5 | 3,945 | 33,215 | 0.85 |
| 10 | 5,124 | 35,369 | 1.03 |
| 15 | 5,576 | 44,964 | 0.89 |

The 10-year plan has a little high economic value of B/C compared with the others, so that the 10 year flood is proposed as design flood for the urgent flood control plan from the standpoint of high economic value and socio-economic conditions in the area. The determined design flood discharge is shown in Fig.5.1.

## 5.4 Proposed Urgent Flood Control Plan

### 5.4.1 River Stretches for Proposed Urgent Plan

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

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

### 5.4.2 Improvement Plan of River Channel

The project proposes channel improvement over a total length of 57 km. The proposed river channel improvement plan such as alignment of dike, longitudinal profile and cross-sections is shown in Fig.5.2. The outline of the improvement plan of river channels is as follows:

(1) Asahan mainstream

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

(2) Silau River

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

### 5.4.3 Proposed Urgent Flood Control Works

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

(1) Asahan mainstream

(a) excavation/dredging of channel and embankment of dike

(b) Bank protection by means of crib and wet masonry

(c) Construction of drainage culverts

(2) Silau River

(a) Excavation/dredging of channel and embankment of dike

(b) Bank protection by means of crib

(c) Reconstruction of irrigation free intakes

(d) Construction of drainage culverts

The proposed work quantity is as follows:

| | | |
|---|---|---|
| Excavation/dredging works | 3,650,000 | m3 |
| Embankment works | 2,270,000 | m3 |
| Bank protection works | 2,600 | m |
| Reconstruction of irrigation free intakes | 5 | places |
| Construction of drainage culverts | 12 | places |

## 5.5 Construction Plan and Cost Estimate of the Project

### 5.5.1 Execution System

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

### 5.5.2 Construction Time Schedule

The proposed 6-year construction time schedule is given in Fig.5.3. This is planned based on the following assumptions.

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

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

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

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

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

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

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

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

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

5.5.3 Cost Estimate for the Project

(1) Basic Conditions

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

(a) The currency exchange rates are assumed at ;

US$ 1 = Rp 1,100 = Japanese ¥ 250.

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

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

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

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

(2) Unit price

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

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

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

(3) Unit construction cost

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

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

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

The estimated unit construction costs are shown in Table 5.1.

### 5.5.4 Cost Estimate

(1) Construction cost

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

The breakdown of construction cost is presented in Table 5.2.

(2) Operation and maintenance cost

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

## 5.6 Organization and Management

### 5.6.1 Present Organization

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

The present organization for flood control works in lower Asahan area is shown in Fig.5.4. The organization for the Lower Asahan River Flood Control Project is not established yet because the project is being on the study stage at present.

### 5.6.2 Organization for Implementation of Project

The Ministry of Public Works will entirely be responsible for the implementation of the project, and necessary consultations will be made by the organizations concerned. For implementing the project, establishment of a project office in Kisaran will be required. The organization for the project is recommended as shown in Fig.5.5.

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

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

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

## 5.7 Evaluation for Urgent Flood Control Project

### 5.7.1 Economic Evaluation

#### (1) Economic cost

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

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

#### (2) Benefit

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

##### a. Flood damage reduction

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

b. Enhancement benefits

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

c. Average annual benefit

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

(3) Comparison of cost and benefit

Flow of the economic costs and benefits is shown in Table 5.3. Based on this flow, cost-benefit analysis is made. The internal rate of return (IRR) is calculated at 12.4 %. The benefit-cost ratio (B/C) is calculated at 1.03 with a discount rate of 12 %.

(4) Sensitivity test

Sensitivity of IRR of the project is examined adopting increase in cost and decrease in benefit. The results of sensitivity test are summarized in Table 5.4 which shows the value of IRR of the project exceeds 10 % even if the cost goes up by 20 % or the benefit comes down by 20 %. The results of comparison of cost and benefit are also shown in Fig.5.6.

5.7.2 Financial Aspects

(1) Required funds

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

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

(2) Disbursement schedule

The schedule of annual disbursement of the fund mentioned above is planned as shown in Table 5.5.

5.7.3 Project Effect and Social Impact

(1) Stabilization of people's livelihood

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

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

(2) Incremental land for agriculuture and residence

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

(3) Employment opportunity

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

(4) Relocation of houses

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

(5) Environmental aspects

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

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

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

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

Since the flood peak from the residual basin downstream of the regulating dam up to Pulau Raja is rather significant, it would occur that the river facilities to be constructed under the urgent flood control plan would be jeopardized only by the flood out of the residual basin even though the outflow from Lake Toba would be reduced by the regulation method as proposed in Chapter VI. Therefore it is recommendable to install and operate a flood forecasting and warning system for the sake of inhabitants in the downstream area. The system would consist of four (4) robot rain gaging stations, four (4) robot river water level gages in the middle reaches of the Asahan river, a control office at Kisaran and a VHF radio wave system connecting the Kisaran control office with the DPU Medan office as shown in Figs 5.7 and 5.8. Facilities cost is estimated at ¥600 million or US$2.8 million equivalent.

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

### 5.9 Recommendation

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

# CHAPTER VI REGULATION OF WATER LEVEL OF LAKE TOBA

## 6.1 Lake Toba and Asahan River

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

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

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

## Lake Toba and Asahan Project

### Lake Toba

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

| | | Siguragura power station | Tangga power station | Total |
|---|---|---|---|---|
| **Intake dam & pondage** | | | | |
| NHWL | EL m | 735.4 | 506.0 | - |
| Incremental catchment area | $km^2$ | 50 | 97 | 147 |
| Pondage area | $km^2$ | 0.3 | 0.2 | - |
| Net storage | 1,000$m^3$ | 752 | 713 | - |
| Dam | | | | |
| Type | - | conc. gravity | conc. arch | - |
| Height | m | 46 | 82 | - |
| **Power output** | | | | |
| Max. turbine discharge | $m^3/s$ | 150.5 | 161.1 | - |
| Firm discharge | " | 105.4 | 111.9 | - |
| Gross head | m | 230.0 | 237.4 | 467.4 |
| Rated net head | m | 218.0 | 226.8 | 444.8 |
| Installed capacity | MW | 286 | 317 | 603 |
| Firm power output | " | 203 | 223 | 426 |
| Annual energy output | GWh | 1,868 | 2,054 | 3,922 |

Transmission line
275 kV 2 cct 120 km to Kuala Tanjung
150 kV 2 cct 91 km for main line
(Kuala Tanjung-Medan)
150 kV 1 cct 156 km for branch line

## 6.2 Hydrological Data

Hydrological data and analysis all over the study area are stated in Chapter III of their Report, hence here the data covering only the Lake Toba basin are cited.

Rainfall data in and around the Lake Toba basin are available at around ten (10) rain gage stations intermittently (Fig. 6.1). Data availability and reliability are much higher for the prewar days. Based on those rainfall data the basin mean monthly rainfall was calculated for the years of 1919 through 1940 and 1974 through 1980. Annual mean rainfall of the basin is 1,820 mm ranging between 1,470 mm and 2,730 mm as shown in Table 6.1. Details of the analysis are compiled in Appendix I.

Outflow from Lake Toba has been measured and recorded at two gage stations on the Asahan river, Siruar and Simorea. The Siruar gage station was located at the head of rapids of the Asahan river 14 km downstream from the outlet of the lake, and there daily discharge record is available from 1916 up to January 1981 with interruption during the wartime. Those records have been collected and accumulated in the data bank of Nippon Koei through several former investigations and during construction stage of the Asahan Project. In February 1981 and thereafter the outflow from the lake has been controlled by the regulating dam constructed at a gorge near the Siruar gage station. Daily record of lake water release out of the regulating dam up to January 1985 is now available by courtesy of INALUM.

The Simorea gage station was located below a drop of 175 m from the regulating damsite and at the head of Siguragura falls where the Siguragura intake dam was constructed. Daily discharge record at the Simorea gage station is now available from 1956 to 1984 with some interruption. Balance of the discharge at the said two gage stations gives some indications of runoff from the residual basin between the regulating dam and Siguragura intake dam. The mean runoff from that basin is around 3 to 10 $m^3/s$ according to the record. The discharge records at Siruar and Simorea gaging stations including the release record out of the regulating dam were compiled in Data Book.

Daily mean water surface level of Lake Toba is being recorded at several places along the lakeside, however, among them the record at Janji Matogu situated near the outlet of the lake is most reliable due to its long duration of the record. Daily mean lake water level record at Janji Matogu is available since May 1963. Lake water level before then was reestablished from a relation of discharge at Siruar and lake water level. Daily mean lake water level record at Janji Matogu and reestablished one are compiled in Data Book and detailed procedure of reestablishment of lake water level before April 1963 is described in Appendix I.

## 6.3 Net Inflow

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

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

where,

- I : net inflow into the lake for a specified period ($m^3/s$)
- O : discharge at Siruar averaged for the specified period ($m^3/s$)
- A : Surface area of Lake Toba, 1,100 $km^2$
- dH : rise or drop of lake water level during the specified period
- dT : number of seconds of the period

Ten (10) days mean net inflow for about 43 years from 1916 to 1932 and from 1957 to January 1985 was calculated, used for further analysis and compiled in Appendix I. Here the monthly mean net inflow is presented in Table 6.2. Net inflow mass curve based on ten (10) days mean net inflow is attached to Appendix I as a separate figure.

### 6.4 Study on Lake Operation

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

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

Current Operation Rule

| Lake Water Level | | Flood Release |
|---|---|---|
| higher than WL | 905.05 m | 186 $m^3/s$ |
| " | 905.10 | 242 |
| " | 905.15 | 315 |
| " | 905.20 | 400 |

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

| | | |
|---|---|---|
| Max. lake water level | : | WL 905.42 m |
| Flood release | : | 400 $m^3$/sec for 30 days continously |
| Spill out | : | $4.95 \times 10^9$ $m^3$ for 43.08 years |

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

| | |
|---|---|
| Q=101 $m^3/s$ | 97.2% |
| Q= 0 " | 2.8% in recent 6 years (1978 thru 1983) |

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

Opertion Method; Case I

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

and its results are as follows:

Max. lake water level : WL 905.37 m

Flood release : 300 $m^3/s$ for 40 days continuously

Spillout : $8.99 \times 10^9$ $m^3$ for 43.08 years

Lowest lake water level : WL 902.41 m

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

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

Average discharge for power generation : 94.6 $m^3/s$

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

In order to decrease the spill-out or increase the effective discharge for power generation, several test cases were examined by trial and error. Opertion methods of each test case and its results are presented in Table 6.3. Among them, Case V was superior to other cases. So that this Case V was presented in this report as One Model Operation Method of Lake Toba.

The method of Case V and its results are summarized below;

## One Model Operation Method of Lake Toba

### Restricted Seasonal Lake Water Level (RWL)

at the end of each month

(+ WL 900 m)

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

| Lake Water Level | Flood Release | Discharge for Power Generation |
|---|---|---|
| higher than WL 905.50 m | 400 $m^3/s$ max. | 101 $m^3/s$ |
| 905.50 - 905.20 | 300 | " |
| 5.20 - 5.10 | 250 | " |
| 5.10 - 5.00 | 200 | " |
| | (incld. power discharge) | |
| lower than WL 905.00, but | | |
| higher than RWL | 50 max. | 101 |
| higher than RWL + 0.20 m | 75 | " |
| | (spill-out only) | |
| higher than WL 904.50 | - | 101 |
| 904.50 - 904.25 | | 101 or 98 |
| 4.25 - 4.00 | | 98 or 95 |
| 4.00 - 3.75 | | 95 or 92 |
| 3.75 - 3.50 | | 92 or 80 |
| 3.50 - 3.25 | | 86 or 80 |
| 3.25 - 2.40 | | 80 |
| lower than WL 902.40 | | 0 |

Note: Discharge for power generation when the lake water level is lower than WL 904.50 m is chosen from both the lake water level and the discharge in the previous 10 days, for example, in a case that the discharge in the previous 10 days be 95 $m^3/s$ and if the lake water level descends below WL 903.75 m then the discharge should be 92 $m^3/s$ and if the lake water level regains above WL 904.25 m then the discharge be 98 $m^3/s$. (Fig. 6. 2)

Operation Results

Max. lake water level : WL 905.34 m

Flood release : 300 $m^3/s$ for 30 days continuously

Spill-out : $7.71 \times 10^9 m^3$ for 43.08 years

Lowest lake water level : WL 902.44 m

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

| Q | Duration | Accumulated duration |
|---|---|---|
| 101 $m^3/s$ | 42.4% | 42.4% |
| 98 | 16.8 | 59.2 |
| 95 | 14.4 | 73.6 |
| 92 | 11.0 | 84.6 |
| 86 | 2.8 | 87.4 |
| 80 | 12.6 | 100.0 |
| 0 | - | |

average discharge for power generation : 95.6 $m^3/s$

Detailed calculation sheets are compiled in Appendix I.

## 6.5 Flood and its Control in Lake Toba

Net inflow into Lake Toba usually begins to swell sharply in September or October and its flood lasts until April or May. Some major flood inflows into the lake are listed in Table 6.4. Heaviest flood recognized so far is the flood lasted from the early October 1930 to the end May 1931 and its volume was $4.74 \times 10^9$ $m^3$. Flood in 1983/1984, which lasted from the early September 1983 to the end May 1984 was the third one among the 41 records during the rainy season.

Hence the period from 1 October to 31 May of next year (8 months) would be defined as flood season. Total net inflow volume in the flood season is tabulated in the order of magnitude in Table 6.5 and probable flood for each return period is shown in Table 6.6.

The flood occurred in 1930/31 was more or less equivalent to the 100-year probable flood. Then that flood was checked under the same operation method as in Case V with one additional condition that the lake water level at the end of September 1930 was WL 904.68 m, that is, the restricted water level at the end of September (The calculated lake water level at the end of September 1930 of the through operation presented in the previous Section was WL 903.43 m. See the calculation sheets compiled in Appendix I). The check was carried out on both ten-day basis for one year and daily basis for six months from 1 October 1930 to 31 March 1931. Detailed calculation sheets are compiled in Appendix I and its results are as follows:

| | | |
|---|---|---|
| max. lake water level | : | WL 905.49 m |
| flood release | : | 300 $m^3/s$ for 44 days continuously |

## 6.6 Tentative Operation prior to Completion of Urgent Flood Control Project

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

max lake water level : WL 905.47 m
flood release : 200 $m^3/s$
spill-out : $7.71 \times 10^9$ $m^3$ for 43.08 year
lowest lake water level: WL 902.44 m
duration of discharge for power generation for 43 years and 1 month

| Q | Duration | Accumulated duration |
|---|---|---|
| 101 $m^3/s$ | 42.3% | 42.3% |
| 98 | 16.9 | 59.2 |
| 95 | 14.4 | 73.6 |
| 92 | 11.0 | 84.6 |
| 86 | 2.8 | 87.4 |
| 80 | 12.6 | 100.0 |
| 0 | - | - |

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

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

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

## 6.8 Recommendation

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

i) To establish adequate seasonal water level control
ii) To provide adequate spill-out discharge of surplus water if the seasonal water level exceeds the ristricted level
iii) To establish adequate discharge for power generation in accordance with the lake water level
iv) To establish adequate flood discharge beyond the normal high water level of EL 905.00 m.

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

# 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) Field Invstigation

(1) Topographic Servey

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

b) check survery 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,

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,

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,

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

(6) Survey on existing social infrastructure

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

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,

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,

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

(9) Survey on agricultural supporting services

a) survey on present situation of exisiting 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 the existing inland fisheries development.

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 transmigration.

(B) <u>Preliminary formulation of basic agricultural development plans</u>

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 plan
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 team 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 team for the Part II study will consist of the following specialists/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

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D.5 Inventarisasi Daerah Irigasi Sampai Akhir Tahun I Repelita IV. Dati II, Asahan, Dec.1984

D.6 Inventarisasi Lahan Rawa di Kabupaten Asahan (draft), March 1985

D.7 Inventarisasi Lahan Rawa di Kabupaten Labuhan Batu (Draft), March 1985

D.8 Inventory of Irrigation and Evaluation of Possible Projects, July 1979, North Sumatra Design Unit/Binnie & Partners, Vols.1 & 2

D.9 North Sumatra Design Unit, Annual Report May 1979
North Sumatra Design Unit, Annual Report June 1980

D.10 Daftar Usulan Rencana Proyek (Durp 1985-1986), Bahagian Pengairan DPU

D.11 Pembangunan Jaringan Irigasi di Propinsi Dati I Sumatera Utara, 1981, Design Unit PPU

D.12 Perhitungan/Penjelasan Perencanaan, Sei.Silau Ke Sei.Bunut, Asahan, March 1983, DPU

D.13 Perencanaan Teknis Tahap II, Proyek Pengembangan Rawa Daerah Rawa Sei Kualuh, July 1979, Institut Teknologi Bandung

D.14 Evapotranspirasi di Sumatera Utara, Petunjuk No.1, April 1978, Design Unit DPU/Binnie & Partners

D.15 Peta Lokasi Pengairan di Kabupaten Asahan

D.16 Peta Lokasi Pengairan di Labuhan Batu

D.17 Guideline BP2B, Studies for Water Resources Projects, Sep. 1983, Binnie & Partners/Hunting

(7) Flood Control Economy

E.1 Sumatera Utara Dalam Angka 1983; Kantor Statistik Propinsi Sumatera Utara.

E.2 Penduduk Sumatera Utara, Hosil Sensus Penduduk 1980; Biro Pusat Statistik, Jakarta.

E.3 Penduduk Kabupaten Asahan 1980; Biro Pusat Statistik, Kantor Statistik Kabupaten Asahan, Mar. 1981

E.4 Katamadya Tanjung Balai Dalam Angka 1983; Kantor Statistik Kotamadya Tanjung Balai.

E.5 Penduduk Kabupaten Labuhan Batu 1983; Kantor Statistik Kab. Labuhan Batu.

E.6 Price Prospects for Major Primary Commodities, Sep. 1984; International Bank for Reconstruction and Development.

E.7 Pedoman Perhitungan Tarip Bangkar Muat di Pelabuhan; Cabang Belawan, April 1985.

E.8 Pengadaan Palawija Dalam Negri Tahun 1984/1985; Badan Urusan Logistik, Jakarta, 1984.

E.9 Manual for River and Sabo Works in Japan; International Engineering Consultants Association, Japan, 1977.

(8) Water Quality

Q.1 Laporan Akhir Komunitas, Lingkungan Perairan dan Kehidupan Biologi Danau Toba di Sumatera Utara Tahun 1979, Pusat Kajian Lingkungan Hidup Universitas Sumatera Utara, Medan, Maret 1980

F. 13 Daftar Harga dan Upah Bahan Bangunan untuk Tahun Anggaran Pertama 1985 Daerah Tingkat II Asahan

F. 14 Rencana Pelita IV mengenai Proyek Perbaikan dan Pengamanan Sungai, Dinas PU Prop. Dati I Sum. Utara Seksi Pengairan Asahan

F. 15 Surat Perjanjian Pemborong/Perintah Pekerjaan Pengendalian dan Pengamanan Benteng S. Kualuh guna penyelamatan Areal Persawahan dari bahaya banjir seluas 8000 ha Kec. Kualuh Hulu Kab. Labuhan Batu (Dhi.: yang dikerjakan kelompok A), September 1982

F. 16 Surat Perjanjian Pemborong/Perintah Pekerjaan Pengendalian dan Pengamanan Benteng S. Kualuh guna penyelamatan Areal Persawahan dari bahaya banjir seluas 8000 ha kec. Kualuh Hulu Kab. Labuhan Batu (Dhi.: yang dikerjakan kelompok B), Sept. 1982

F. 17 Surat Perjanjian Pemborongan
Peninggian/pelebaran tanggul kiri S. Kualuh 6.350 m dan pemasangan cerocok 178 m Kec. Kualuh Hulu Kab. Labuhan Batu Dhi.: Kelompok A; antara ptk.73 s/d 104 A + 50 sepanjang 3.200 m dan pemasangan cerocok 44 m, Agustus 1983

F. 18 Surat Perjanjian Pemborongan
Peninggian/pelebaran tanggul kiri S. Kualuh 6.350 m dan pemasangan cerocok 178 m Kec. Kualuh Hulu Kab. Labuhan Batu Dhi.: Kelompok B; antara ptk. 104 A + 50 s/d ptk. 120 + 100 sepanjang 1.600 m, Agustus 1983

F. 19 Surat Perjanjian Pemborongan
Peninggian/pelebaran tanggul kiri S. Kualuh 6.350 m dan pemasangan cerocok 178 m Kec. Kualuh Hulu Kab. Labuhan Batu Dhi.: Kelompok C; antara ptk. 160 s/d ptk. 175 A sepanjang 1.550 m dan pemasangan cerocok sepanjang 134 m, Agustus 1983

F. 20 Surat Perjanjian Pemborong/Perintah Pekerjaan
Memperlebar/Mempertinggi tanggul lama S. Kualuh dari ptk. 121 s/d 160 dan ptk. 175 A s/d 181 A sepanjang 4.500 m dan pembuatan Kanal Sep. 550 m, pemasangan Cerocok/Krib Sep. 48 m, pembuatan patok beton bertulang pada tanggul Kec. Kualuh Hulu Kab. Lab. Batu, Juni 1984

Table 1.1 Member List of Advisory Committee and Study Team

| | | |
|---|---|---|
| **JICA Advisory Committee** | | |
| 1. | Dr. Kazuto Nakazawa | Chairman of Committee |
| 2. | Mr. Masakuni Kawamata | Vice-chairman |
| 3. | Mr. Hiroshi Miyai | Advisor |
| 4. | Mr. Nobuo Ando | Advisor |
| 5. | Mr. Akihiko Nunomura | Advisor |
| 6. | Mr. Shuhei Seyama | Advisor |
| 7. | Mr. Hitonori Ono | Coordinator |
| 8. | Mr. Kazuo Nakagawa | Coordinator |
| **JICA Study Team** | | |
| 1. | Mr. Makoto Tsuda | Team Leader |
| 2. | Mr. Hiroshi Ono | Deputy Leader/River Planner |
| 3. | Mr. Yasuo Iwasaki | Water Resources Engr. |
| 4. | Mr. Masao Matsumura | River Engr. |
| 5. | Mr. Toshio Terashima | Hydrologist |
| 6. | Mr. Tokio Imai | Survey Guidance Engr. |
| 7. | Mr. Nobuhiko Uchiseto | Engr. for Geology & Soil-mechanics |
| 8. | Mr. Kanetaka Gomi | Expert for Land use & Environment |
| 9. | Mr. Fumihiko Furuichi | Regional Economist |
| 10. | Mr. Kenjiro Onaka | Agriculture Engr. |
| 11. | Mr. Syuichi Sato | Irrigation & Drainage Engr. |
| 12. | Mr. Ryosaku Nagata | River Structure Engr. |
| 13. | Mr. Masatomo Watanabe | Expert for Sediment |
| 14. | Mr. Kazuhiko Takebayashi | Construction Planner |
| 15. | Mr. Yoshiaki Ishizuka | Flood Control Economist |

Table 1.2 . List of Indonesian Counterpart Personnel

| No. | Position | Name | Agency | Period |
|---|---|---|---|---|
| | Project Manager | Ir. J. Banjarnahor MSc. | DPU, North Sumatra | End of Oct. - date |
| | Deputy Project Manager | Ir. M.R. Sembiring | - do - | - do - |
| 1. | Team Leader/River Planner | Ir. Rachman Syarief | CV. SECON | Dec.24, 1984 - May 29, 1985 |
| 2. | Water Resources Engr. | Ir. Alfred Purawidjaya | - do - | Jan. 7, 1985 - Mar.25, 1985 |
| 3. | Engr. for River & Sediment | Ir. Tani Winata | - do - | Jan.19, 1985 - Jun.28, 1985 |
| 4. | Hydrologist | Drs. Eko Harsono | - do - | Dec.24, 1984 - May 25, 1985 |
| 5. | Survey Guidance Engr. | Ir. Deddi Mulyadi | - do - | Dec.24, 1984 - Jul.29, 1985 |
| 6. | Expert for Land Use & Environment | Ir. Suhardi | - do - | Mar. 4, 1985 - Mar.25, 1985 |
| 7. | Expert for Economy & Agriculture | Ir. Priyo Budi Sayoko | - do - | Dec.24, 1985 - Mar.25, 1985 &<br>Jul. 4, 1985 - Jul.25, 1985 |
| 8. | Engr. for Soil-Mechanics, Irrigation & Drainage | Ir. Trisna Sanjaya | - do - | Jan.26, 1985 - Mar.25, 1985 &<br>May 18, 1985 - Jun.28, 1985 |
| 9. | River Structure Engr. | Ir. Andrianto Wijaya | - do - | Jan.26, 1985 - May 25, 1985 |
| 10. | Construction Planner | Ir. Dinas Sebayang | - do - | May 18, 1985 - Jun.13, 1985 |
| 11. | Temporary | Ir. Ibrahim | DPU, North Sumatra | End of Oct. - End of Nov. |
| 12. | - do - | Drs. Sangap Tarigan | - do - | - do - |

Table 3.1 Average Monthly Rainfall Data (1920 - 41)

(Unit: mm)

| Month | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Medan | 157 | 65 | 128 | 127 | 158 | 133 | 123 | 152 | 205 | 291 | 223 | 171 | 1,933 |
| P. Siantar | 288 | 218 | 272 | 277 | 306 | 211 | 143 | 263 | 330 | 420 | 319 | 236 | 3,282 |
| Parapat | 174 | 124 | 189 | 214 | 137 | 68 | 61 | 100 | 168 | 236 | 245 | 189 | 1,905 |
| Sibolga | 376 | 389 | 461 | 525 | 372 | 253 | 268 | 355 | 437 | 495 | 548 | 450 | 4,929 |

Table 3.2 Climatic Conditions

(Unit : m3/s)

| Item | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Max. Temperature (oC) | | | | | | | | | | | | | |
| Sei Dadap ('66-'83) | 31.5 | 32.1 | 32.5 | 32.8 | 32.7 | 32.8 | 32.8 | 32.5 | 32.1 | 31.8 | 31.5 | 31.4 | 32.3 |
| Balige ('73-'81) | 24.8 | 25.2 | 25.1 | 26.0 | 26.2 | 25.8 | 25.5 | 25.0 | 25.0 | 25.0 | 24.8 | 24.7 | 25.1 |
| Mean Temperature (oC) | | | | | | | | | | | | | |
| Sei Dadap ('66-'83) | 25.7 | 26.0 | 26.3 | 26.7 | 26.8 | 26.8 | 26.5 | 26.3 | 26.2 | 26.2 | 26.2 | 26.0 | 26.4 |
| Balige ('73-'82) | 18.8 | 18.7 | 19.1 | 19.1 | 19.2 | 19.2 | 19.0 | 18.9 | 18.8 | 18.9 | 19.1 | 19.0 | 19.1 |
| Min. Temperature (oC) | | | | | | | | | | | | | |
| Sei Dadap ('66-'83) | 21.8 | 21.5 | 21.9 | 22.7 | 22.7 | 22.5 | 22.3 | 22.2 | 22.5 | 22.6 | 22.5 | 22.3 | 22.2 |
| Balige ('75-'81) | 15.1 | 15.1 | 15.3 | 15.7 | 16.0 | 15.6 | 15.6 | 15.3 | 15.3 | 16.3 | 16.1 | 15.8 | 15.4 |
| Relative Humidity (%) | | | | | | | | | | | | | |
| Sei Dadap ('66-'83) | 89 | 88 | 88 | 88 | 87 | 87 | 87 | 88 | 89 | 89 | 90 | 89 | 88 |
| Balige ('73-'82) | 85 | 85 | 86 | 86 | 84 | 84 | 84 | 83 | 84 | 85 | 85 | 85 | 85 |
| Rainfall (mm) | | | | | | | | | | | | | |
| Sei Dadap ('66-'83) | 72 | 53 | 87 | 111 | 129 | 113 | 140 | 145 | 229 | 225 | 175 | 139 | 1643 |
| Balige ('73-'82) | 108 | 140 | 123 | 159 | 139 | 120 | 119 | 71 | 126 | 182 | 206 | 187 | 1691 |
| Sunshine Hours (%) | | | | | | | | | | | | | |
| Sei Dadap | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Balige ('73-'75) | 34 | 23 | 41 | 31 | 34 | 33 | 30 | 31 | 32 | 19 | 27 | 23 | 32 |
| Wind Speed (m/sec) | | | | | | | | | | | | | |
| Sei Dadap ('79-'83) | 0.2 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.2 | 0.2 | 0.2 | 0.3 |
| Balige | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Evaporation (mm) | | | | | | | | | | | | | |
| Sei Dadap ('79-'83) | 102 | 104 | 109 | 111 | 112 | 111 | 115 | 115 | 108 | 105 | 90 | 99 | 1278 |
| Balige | - | - | - | - | - | - | - | - | - | - | - | - | - |

Table 3.3 One Day and Two Days Maximum Basin Rainfall (1/2)

(Unit: mm)

| Year | 1 day | | | | | | 2 day | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | P.Raja | | Kisaran | | T.Balai | | P.Raja | | Kisaran | | T.Balai | |
| 1963 | Sep.28 | 50 | Sep.28 | 47 | Oct.17 | 24 | Sep.28 | 53 | Sep.28 | 76 | Oct.18 | 33 |
| 1964 | Jan.20 | 39 | Sep.7 | 41 | Sep.30 | 37 | Mar.4 | 58 | Jan.20 | 58 | Oct.15 | 44 |
| 1965 | Dec.17 | 50 | Dec.6 | 54 | Dec.6 | 32 | Dec.17 | 56 | Dec.6 | 76 | Dec.6 | 37 |
| 1966 | Nov.9 | 29 | Mar.19 | 30 | May 20 | 24 | May 21 | 51 | Oct.8 | 57 | May 20 | 34 |
| 1967 | Nov.10 | 38 | Sep.22 | 33 | Jun.19 | 33 | Sep.22 | 68 | Nov.30 | 50 | Nov.30 | 41 |
| 1968 | Aug.28 | 42 | Jan.15 | 43 | Jan.15 | 34 | Oct.31 | 47 | Jan.16 | 68 | Jan.16 | 45 |
| 1969 | Oct.14 | 86 | Oct.14 | 50 | Oct.14 | 39 | Oct.15 | 102 | Oct.14 | 85 | Oct.14 | 54 |
| 1970 | Oct.26 | 29 | Oct.7 | 26 | Oct.26 | 25 | Oct.7 | 38 | Oct.7 | 51 | Oct.26 | 35 |
| 1971 | Jun.22 | 36 | Sep.20 | 28 | Sep.20 | 22 | Feb.23 | 71 | Jan.5 | 54 | Sep.20 | 41 |
| 1972 | Oct.9 | 33 | Sep.6 | 31 | Sep.6 | 28 | Sep.6 | 60 | Sep.6 | 58 | Sep.6 | 37 |
| 1973 | Dec.1 | 66 | Dec.1 | 77 | Dec.26 | 42 | Dec.27 | 122 | Oct.21 | 84 | Dec.27 | 60 |
| 1974 | Sep.29 | 38 | Sep.29 | 35 | Jun.24 | 26 | Dec.30 | 66 | Jun.24 | 69 | Dec.30 | 28 |
| 1975 | May 21 | 50 | Mar.22 | 38 | Apr.21 | 30 | Mar.22 | 61 | Mar.22 | 62 | Apr.22 | 35 |
| 1976 | Feb.4 | 27 | Feb.4 | 37 | Jul.6 | 27 | Feb.5 | 43 | Sep.28 | 63 | Sep.28 | 36 |
| 1977 | Sep.30 | 49 | Sep.30 | 59 | Sep.30 | 37 | Oct.2 | 73 | Sep.30 | 74 | Oct.1 | 48 |
| 1978 | Dec.21 | 48 | Dec.21 | 44 | Oct.13 | 22 | May 21 | 52 | Dec.21 | 52 | Oct.13 | 30 |
| 1979 | Dec.12 | 37 | Nov.19 | 21 | Nov.12 | 28 | Jun.12 | 41 | Nov.14 | 40 | Oct.18 | 31 |
| 1980 | Nov.3 | 33 | Mar.17 | 36 | Aug.6 | 27 | Aug.7 | 53 | Dec.10 | 47 | Aug.6 | 29 |
| 1981 | Sep.7 | 44 | Sep.10 | 34 | Nov.17 | 32 | Sep.7 | 61 | Sep.11 | 61 | Sep.11 | 38 |
| 1982 | May 22 | 35 | May 23 | 39 | Aug.24 | 29 | May 23 | 44 | Nov.1 | 41 | Oct.31 | 32 |
| 1983 | Dec.18 | 36 | Dec.18 | 47 | Sep.9 | 23 | Jun.18 | 51 | Sep.10 | 78 | Sep.10 | 28 |
| 1984 | Dec.3 | 59 | May 23 | 45 | May 11 | 24 | Jan.25 | 63 | Sep.15 | 78 | Feb.1 | 29 |

Table 3.3 One Day and Two Days Maximum Basin Rainfall (2/2)

(Unit: mm)

| Year | 1 day | | | |
|---|---|---|---|---|
| | T.Binjai (Kualuh R.) | | T.Tiram (Kiri R.) | |
| 1963 | Dec.3 | 44 | Sep.28 | 30 |
| 1964 | May 14 | 45 | Oct.14 | 22 |
| 1965 | May 21 | 42 | Dec.13 | 26 |
| 1966 | Mar.21 | 44 | Oct.3 | 22 |
| 1967 | Sep.22 | 34 | Oct.12 | 26 |
| 1968 | Jul.20 | 21 | Oct.29 | 26 |
| 1969 | Oct.14 | 40 | Oct.14 | 35 |
| 1970 | Dec.25 | 32 | Nov.5 | 15 |
| 1971 | Feb.23 | 50 | Sep.20 | 14 |
| 1972 | Dec.4 | 29 | Sep.6 | 19 |
| 1973 | Oct.21 | 57 | Dec.14 | 23 |
| 1974 | Dec.29 | 38 | Feb.4 | 28 |
| 1975 | Sep.27 | 29 | Dec.3 | 29 |
| 1976 | Nov.3 | 26 | Jul.6 | 30 |
| 1977 | Feb.8 | 29 | Oct.10 | 25 |
| 1978 | Feb.14 | 27 | Apr.16 | 30 |
| 1979 | Sep.11 | 26 | Jul.11 | 36 |
| 1980 | Oct.5 | 30 | Oct.10 | 35 |
| 1981 | Nov.23 | 38 | Oct.16 | 29 |
| 1982 | Mar.29 | 34 | Apr.28 | 25 |
| 1983 | Sep.13 | 36 | Sep.9 | 24 |
| 1984 | Jan.23 | 38 | Apr.8 | 39 |

Table 3.4 Probable One Day Rainfall

(Unit: mm)

| Return Period (yr) | P.Raja Asahan R. | Kisaran Silau R. | T.Balai Asahan R. | T.Binjai Kualuh R. | T.Tiram Kiri R. |
|---|---|---|---|---|---|
| 100 | 103 | 91 | 51 | 64 | 46 |
| 50 | 92 | 82 | 47 | 60 | 43 |
| 30 | 84 | 76 | 44 | 56 | 40 |
| 25 | 80 | 73 | 43 | 55 | 39 |
| 15 | 72 | 66 | 41 | 52 | 37 |
| 10 | 66 | 61 | 38 | 49 | 35 |
| 5 | 54 | 51 | 34 | 44 | 32 |
| 2 | 37 | 37 | 28 | 36 | 27 |

Table 3.5 Monthly Mean Discharge (1/2)

(Unit: m3/s)

| Year | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Ave. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station : Pulau Raja (Asahan R., 4486 km2) | | | | | | | | | | | | | |
| 1977 | - | - | - | 137.0 | 150.5 | 142.8 | 123.5 | 119.2 | 111.3 | 168.7 | 190.4 | 200.0 | - |
| 1978 | - | 157.4 | 148.1 | 147.0 | 152.0 | 145.7 | 119.8 | 89.3 | 98.5 | 118.9 | 131.2 | 148.4 | - |
| 1979 | 118.0 | 99.9 | 191.1 | 114.4 | 97.7 | 127.6 | 92.1 | 79.5 | 101.1 | 123.0 | 182.0 | 180.6 | 117.3 |
| 1980 | 154.9 | 145.4 | 188.7 | 162.3 | 195.0 | 157.6 | 131.4 | 161.2 | 136.1 | 149.5 | 199.9 | 165.0 | 162.3 |
| 1981 | 190.2 | - | - | - | - | - | - | - | 149.9 | 144.9 | 163.8 | 108.1 | - |
| 1982 | 88.4 | 92.2 | 106.4 | 236.3 | 338.2 | 191.7 | 107.9 | 97.2 | 142.5 | 147.6 | 169.5 | 162.2 | 156.7 |
| 1983 | 149.3 | 105.9 | 89.0 | 75.7 | 87.2 | 94.3 | 113.9 | 102.7 | 136.8 | 139.2 | 118.1 | 161.2 | 114.4 |
| 1984 | 227.5 | 323.3 | 224.8 | 271.8 | 306.3 | 199.1 | 153.4 | 141.9 | 146.7 | 168.8 | 160.0 | 176.1 | 208.3 |
| Ave. | 154.7 | 154.0 | 141.4 | 163.5 | 190.0 | 151.2 | 120.3 | 113.0 | 127.9 | 145.1 | 164.4 | 162.7 | 151.8 (149.0) |
| Station : Kisaran (Sirau R., 1050 Km2) | | | | | | | | | | | | | |
| 1973 | 61.0 | 44.7 | 63.5 | 85.9 | 60.3 | 68.3 | - | - | 77.9 | 80.3 | 71.9 | 194.2 | - |
| 1974 | 82.9 | 82.1 | 61.2 | 66.1 | 59.9 | 56.1 | 53.8 | - | 62.0 | 72.5 | 86.1 | 76.2 | - |
| 1975 | 74.7 | 67.6 | 63.8 | 100.3 | 84.1 | 56.9 | 54.3 | 44.3 | 83.7 | 84.6 | 94.6 | 89.1 | 74.8 |
| 1976 | 84.1 | 71.7 | 52.7 | 77.2 | 64.6 | 62.4 | 59.6 | 58.0 | 59.2 | 78.4 | 102.1 | 84.0 | 71.2 |
| 1977 | 62.0 | 52.6 | 45.6 | 46.3 | 50.2 | 49.6 | 33.7 | 42.9 | 55.7 | 121.8 | 94.6 | 81.8 | 61.4 |
| 1978 | 50.3 | 54.0 | 45.6 | 45.0 | 50.5 | 59.4 | 49.2 | 31.4 | 49.3 | 69.2 | 64.5 | 70.7 | 53.3 |
| 1979 | 52.7 | 44.9 | 38.7 | 61.6 | 45.0 | 59.4 | 43.1 | 34.5 | 53.2 | 59.7 | 96.4 | 69.5 | 54.9 |
| 1980 | 52.5 | 40.6 | 78.1 | 50.2 | 71.3 | 43.1 | 35.8 | 78.4 | 53.6 | 62.8 | 93.0 | 68.9 | 60.7 |
| 1981 | 72.7 | 59.7 | 41.8 | 51.7 | 85.5 | 47.6 | 46.7 | 36.3 | 79.1 | 81.7 | 73.7 | 48.9 | 60.5 |
| 1982 | 49.0 | 58.5 | 69.4 | 91.9 | 97.7 | 45.9 | 43.7 | 48.3 | 55.3 | 66.7 | 63.0 | 56.4 | 62.2 |
| 1983 | 46.4 | 35.9 | 40.0 | 28.7 | 46.1 | 41.8 | 47.1 | 43.4 | 74.8 | 88.4 | 49.8 | 82.9 | 52.1 |
| 1984 | 94.5 | 94.3 | 79.9 | 70.1 | 116.4 | 47.8 | 48.6 | - | 52.3 | 69.7 | 76.8 | 82.3 | - |
| Ave. | 65.2 | 58.9 | 56.7 | 64.6 | 69.3 | 53.2 | 46.9 | 46.4 | 63.0 | 78.0 | 80.5 | 83.7 | 61.2 (63.9) |

Table 3.5 Monthly Mean Discharge (2/2)

(Unit: m3/s)

| Year | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Ave. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station : Pulo Dogom (Kualuh R., 1116 km2) | | | | | | | | | | | | | |
| 1979 | - | - | - | - | - | - | - | - | - | - | - | 65.1 | - |
| 1980 | 54.2 | 45.5 | 79.8 | 60.3 | 74.1 | 47.4 | 29.1 | 50.6 | 45.5 | 70.6 | 85.9 | 61.3 | 58.7 |
| 1981 | 94.9 | 68.3 | 34.1 | 56.8 | 80.5 | 50.8 | 48.7 | 27.0 | 76.0 | 81.3 | 69.4 | 47.1 | 61.2 |
| 1982 | 35.5 | 56.8 | 59.8 | 82.5 | 80.9 | 43.8 | 37.6 | 44.4 | 54.3 | 80.0 | 55.3 | 64.5 | 57.9 |
| 1983 | 56.4 | 36.4 | 30.9 | 22.1 | 37.0 | 41.2 | 51.4 | 31.5 | 83.8 | 76.3 | 57.3 | 105.6 | 52.5 |
| 1984 | 112.4 | 82.2 | 88.8 | 104.4 | 117.8 | 59.4 | 48.9 | 44.1 | 51.3 | 70.1 | 61.0 | 81.9 | 76.9 |
| Ave. | 70.6 | 57.8 | 58.7 | 65.2 | 78.1 | 48.5 | 43.1 | 39.5 | 62.2 | 75.7 | 65.8 | 70.9 | 61.4 (61.3) |

Table 3.6 Estimated Monthly Mean Discharge at Pulau Raja from Remaining Area Downstream of Siruar

(Unit : m3/s)
(Catchment Area = 797 km2)

| Year | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1973 | (56.4) | (44.1) | (58.3) | (75.2) | (55.9) | (62.0) | - | - | (69.2) | (71.0) | (64.7) | (157.0) | - |
| 1974 | (72.0) | (72.4) | (56.6) | (60.3) | (55.6) | (52.8) | (51.0) | - | (57.2) | (65.1) | (75.4) | ( 67.9) | - |
| 1975 | (66.8) | (61.4) | (58.6) | (86.1) | (73.9) | (53.4) | (51.4) | (43.8) | (73.6) | (74.3) | (81.8) | ( 77.7) | 66.9 |
| 1976 | (73.9) | (64.5) | (50.2) | (68.7) | (59.2) | (57.5) | (55.4) | (54.2) | (55.1) | (69.6) | (87.5) | ( 73.8) | 64.1 |
| 1977 | (57.2) | (50.1) | (44.8) | 35.2 | 45.1 | 47.3 | 45.8 | 45.5 | 57.9 | 91.8 | 78.2 | 67.2 | 55.5 |
| 1978 | (48.4) | 55.8 | 48.7 | 45.1 | 47.1 | 53.9 | 41.7 | 23.6 | 37.1 | 45.5 | 61.9 | 75.2 | 48.7 |
| 1979 | 44.0 | 30.4 | 20.4 | 39.8 | 26.3 | 54.9 | 22.6 | 16.2 | 32.3 | 53.5 | 90.1 | 69.6 | 41.7 |
| 1980 | 47.9 | 41.5 | 72.1 | 44.8 | 76.0 | 45.0 | 33.6 | 63.4 | 44.9 | 56.9 | 103.6 | 64.7 | 57.9 |
| 1981 | (65.3) | (55.5) | (42.0) | (49.4) | (75.0) | (46.3) | (45.6) | (37.8) | 103.3 | 78.1 | 90.6 | 64.1 | 62.8 |
| 1982 | 47.4 | 53.2 | 59.4 | 63.3 | 87.4 | 54.5 | 50.5 | 44.9 | 47.9 | 71.3 | 44.5 | 53.3 | 56.5 |
| 1983 | 43.3 | 37.4 | 42.4 | 25.3 | 35.9 | 38.1 | 55.4 | 40.8 | 76.0 | 72.6 | 48.6 | 81.9 | 49.8 |
| 1984 | 98.2 | 83.5 | 80.6 | 85.5 | 94.8 | 76.7 | 55.9 | 44.2 | 52.5 | 75.0 | 68.8 | 72.5 | 74.0 |
| Ave. | 60.2 | 54.2 | 52.8 | 56.6 | 61.0 | 53.5 | 46.3 | 41.4 | 58.9 | 68.7 | 74.6 | 77.1 | 57.8 (58.8) |

Note : Data with parenthesis are estimated by use of both observed discharge at Kisaran and regression curve shown below.

$$Q_{PR} - Q_{SI} = 0.755\, Q_{k} + 10.4$$

where ; $Q_{PR}$ : discharge at Pulau Raja

$Q_{SI}$ : discharge at Siruar

$Q_{k}$ : discharge at Kisaran

Table 3.7 Tide Level at Kuala Tanjung and Bagan Asahan

(Unit : cm above datum of tide gage)

| | Year | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | AVE. | Max. or Min. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kuala Tanjung | | | | | | | | | | | | | | | |
| HHL | 1983 | - | - | - | 292 | 305 | 293 | 285 | 291 | 300 | 302 | 322 | 283 | | |
| | 1984 | 285 | 291 | 302 | 309 | 315 | 292 | 296 | 309 | 321 | 305 | - | - | | 321 |
| MHHL | 1983 | - | - | - | 233 | 245 | 271 | 228 | 238 | 242 | 249 | 256 | 231 | | |
| | 1984 | 229 | 228 | 239 | 244 | 248 | 246 | 240 | 249 | 248 | 243 | - | - | 242 | |
| MSL | 1983 | - | - | - | 148 | 160 | 177 | 148 | 151 | 150 | 158 | 169 | 150 | | |
| | 1984 | 149 | 144 | 150 | 156 | 163 | 160 | 156 | 161 | 164 | 166 | - | - | 157 | |
| MLLL | 1983 | - | - | - | 63 | 74 | 82 | 67 | 63 | 58 | 66 | 82 | 69 | | |
| | 1984 | 69 | 60 | 61 | 67 | 77 | 73 | 72 | 72 | 79 | 89 | - | - | 71 | |
| LLL | 1983 | - | - | - | 10 | 18 | 26 | -1 | -22 | -24 | -7 | 24 | -7 | | |
| | 1984 | -18 | -30 | -24 | -4 | 24 | 15 | 2 | -8 | -11 | 19 | - | - | - | -30 |
| Bagan Asahan | | | | | | | | | | | | | | | |
| HHL | 1983 | - | - | - | - | - | - | - | - | - | - | - | 390 | | |
| | 1984 | 390 | 400 | 420 | 420 | 400 | 380 | 390 | 430 | 430 | 440 | 380 | - | | 440 |
| MHHL | 1983 | - | - | - | - | - | - | - | - | - | - | - | 331 | | |
| | 1984 | 329 | 328 | 332 | 338 | 330 | 329 | 336 | 340 | 336 | 335 | 321 | - | 332 | |
| MSL | 1983 | - | - | - | - | - | - | - | - | - | - | - | 213 | | |
| | 1984 | 209 | 210 | 214 | 216 | 214 | 215 | 217 | 222 | 222 | 220 | 215 | - | 213 | |
| MLLL | 1983 | - | - | - | - | - | - | - | - | - | - | - | 95 | | |
| | 1984 | 88 | 91 | 96 | 93 | 98 | 101 | 97 | 103 | 108 | 105 | 108 | - | 99 | |
| LLL | 1983 | - | - | - | - | - | - | - | - | - | - | - | 50 | | |
| | 1984 | 40 | 40 | 40 | 40 | 50 | 50 | 50 | 40 | 40 | 40 | 40 | - | | 40 |

Note ; HHl : Higher High Level
MHHL : Mean Higher High Level
MSL : Mean Sea Level
MLLL : Mean Lower Low Level
LLL : Lower Low Level

Table 3.8 Existing River Improvement Works (1982 - 1984)

| Site | Year | Location | Budget (million Rp.) | Remarks |
|---|---|---|---|---|
| A. Asahan River | | | | |
| 1. Kec. Pulau Rakyat | 1982 | P 310 - 255<br>P 260 | 100.0 | Reconstruction for broken Dike (82 Apr. Flood)<br>Lining of river channel L = 0.415 km |
| 2. Kec. Pulau Rakyat | 1984 | P 322 - 309<br>P 323 - 324 | 50.0 | Heightening L = 1.75 km<br>and New Dike L = 0.55 km |
| 3. Kec. Pulau Rakyat | 1984 | P 276 - 275<br>P 323 - 322 | 50.0 | Reconstruction for broken Dike L = 46 m<br>and New Dike L = 0.31 km (including drainage canal L = 2.1 km) |
| 4. Kec. Pulau Rakyat | 1984 | P 321 - 278 | 50.0 | Reconstruction for broken Dike L = 62 m |
| 5. Kec. Pulau Rakyat | 1984 | P 276 - 275 | 19.84 | Rehabilitation for slidden Dike L = 1.66 km<br>Reconstruction for broken Dike L = 22 m |
| B. Silau River | | | | |
| 1. Kec. Air Joman | 1983 | P 155 - 165 | .251.1 | Rehabilitation (R); L = 605 m (L):L = 598 m |
| 2. Kec. Simpan Empat | 1984 | P 155 | 258.8 | Heightening (R); L = 1.00 km (L): L = 1.00 km |

Note : Collected from DPUP,North Sumatra

Table 3.9 Dimension of Main Bridge

| Name of Bridge | Location | Elevation of Road-face | Length (m) | Width (m) | Data Source | Remarks |
|---|---|---|---|---|---|---|
| 1. Asahan R | | | | | | |
| - Asahan Br. | P-346 | | 28.0+33.6 +28.0 =89.6 | 1.0+6.0 +1.0 | Bina Marga | Highway |
| - (Kapias kiri Br.) | Kapias.K.R. | | 42.3 | 0.65+4.0+0.65 | DPUP | |
| - (Selat Lancang Br.) | S.Lancang R. | | 69.4 | 3.65 | Site Survey | |
| 2. Silau R. | | | | | | |
| - Muara Silau Br. | P-3 | | 7.5+10.5+10x 11.0+9.0=137.0 | 1.0+5.4 +1.0 | DPUP | Reconstruction Plan is under Consideration |
| - Silau Br. | P-510 | 22.552 | 2(20.0+28.0) +33.6=129.6 | 1.0+7.0 + 1.0 | Bina Marga | Highway |
| - Silau Br. | P-460 | 19.045 | | 4.0 | Bina Marga | |
| - (Bandar Jepang Br.) | B.Jepang R. | | 19.20 | 3.20 | Site Survey | |

DPUP : Dinas P.U. Propinsi Dati I Sumatera Utara, Seksi Asahan

Table 3.10 Existing Structures along River

| Description | Location | Floor level (EL.m) | Width (m) | Remarks |
|---|---|---|---|---|
| 1. Asahan River | | | | |
| Padang Mahondang | P - 295 (R) | 11.094 | 1.3 x 2 | with gate |
| Pump Irrigation Intake | Lebah river | -0.209 | - | with gate |
| 2. Silau River | | | | |
| KLEP Intake | P - 33 (L) | - | 5.0 | open |
| Intake/Sijambi | P - 156 (R) | 3.375 | 0.6 + 1.0 + 0.8 | with gate |
| Intake/Tasik Malaya | P - 268 (L) | 7.319 | 1.2 x 4 | with gate |
| Drainage Sluice | P - 278 (L) | - | 1.0 x 2 | with gate |
| Pump Irrigation Intake | P - 301 (L) | 8.026 | 0 300 x 21.5 HP x 2 | no use since 1981 |
| KLEP Drainage Sluice | P - 308 (L) | - | 1.5 | with gate |
| KLEP Drainage Sluice | P - 347 (L) | - | 0 800 | with gate |
| Intake/Srikamah II | P - 363 (R) | 10.037 | 1.3 x 3 | with gate |
| Pump Irrigation Intake | P - 395 (L) | 10.870 | - | no use since 1982 |
| Intake/Siumbut-umbut | P - 408 (L) | 11.798 | 1.2 x 3 | with gate |

Table 3.11 Manning's Roughness Coefficient under Existing Channel Conditions adopted for Calculation of Discharge Capacity

| Channel stretch | | Manning's n |
|---|---|---|
| 1. Asahan River | | |
| River-mouth | - P 55 (0.4 km downstream from Lebah river) | 0.023 |
| P 55 | - P 160 (0.3 km downstream from Nantalu river) | 0.025 |
| P 160 | - P 245 (16.4 km upstream from Nantalu river) | 0.028 |
| P 245 | - P 360 (Tarum river) | 0.030 |
| 2. Silau River | | |
| Asahan river | - P 40 (2.75 km upstream from Bandar Jepang river) | 0.030 |
| P 40 | - P 510 (Highway bridge at Kisaran) | 0.035 |

Table 3.12 Estimated Discharge Capacity of Existing Channel

| Channel stretch | | Discharge Capacity (cms) |
|---|---|---|
| 1. Asahan River | | |
| River-mouth | - A 10 (0.4 km upstream from Silau river) | 3500 |
| A 10 | - P 20 (0.2 km downstream from Kepayang river) | 450 |
| P 20 | - P 60 (0.6 km km upstream from Lebah river) | 200 |
| P 60 | - P 135 (5 km downstream from Nantalu river) | 350 |
| P 135 | - P 215 (10.6 km upstream from Nantalu river) | 200 |
| P 215 | - P 275 (14.5 km downstream from Highway bridge at Pulau Raja) | 250 |
| P 275 | - P 348 (Highway bridge) | 350 |
| P 348 | - P 360 (Confluence of Sakur river) | 1300 |
| 2. Silau River | | |
| Asahan river | - P 100 (5.7 km downstream from Free intake, Sijambi/ Simpang Empat) | 150 |
| P 100 | - P 230 (4.1 km downstream from Free intake, Tasikmalaya/ Air Joman) | 200 |
| P 230 | - P 340 (2.6 km downstream from Free intake, Silau/Srikamah II) | 400 |
| P 340 | - P 410 (0.9 km downstream from Railway bridge) | 300 |
| P 410 | - P 460 (0.2 km upstream from Kisaran road bridge) | 700 |
| P 460 | - P 733 (Confluence of Piasa river) | 1000 |

Table 3.13 Annual Maximum Discharge Records

| Year | Pulau Raja (Asahan R.) Date | W.L. (m) | Discharge (cms) | Kisaran (Silau R.) Date | W.L. (m) | Discharge (cms) | Pulo Dogom (Kualuh R.) Date | W.L. (m) | Discharge (cms) |
|---|---|---|---|---|---|---|---|---|---|
| 1973 | - | - | - | Dec.2 | 3.30 | 590 | - | - | - |
| 1974 | - | - | - | Sep.30 | 2.25 | 292 | - | - | - |
| 1975 | - | - | - | May 20-21 | 2.00 | 236 (260) | - | - | - |
| 1976 | - | - | - | May 21 | 1.97 | 230 | - | - | - |
| 1977 | Sep.29 | 3.62 | 373 (440) | Sep.30 - Oct.3 | 2.90 | 464 (530) | - | - | - |
| 1978 | Dec.22 | 3.36 | 324 | Dec.21 | 1.75 | 187 | - | - | - |
| 1979 | Dec.13 | 3.10 | 278 | Nov.20 | 1.80 | 196 | - | - | - |
| 1980 | Nov.3 | 3.41 | 333 | Mar.17 | 1.75 | 187 | Nov.22 | 3.26 | 450 |
| 1981 | Nov.17 | 3.32 | 317 | May 29 | 2.22 | 285 | Oct.23 | 3.13 | 416 |
| 1982 | May 23 | 4.18 | 491 (460) | May 24 | 2.47 | 346 (370) | Oct.18 | 3.31 | 463 |
| 1983 | Sep.13 | 3.20 | 295 | Dec.18 | 2.00 | 236 | Dec.8 | 3.60 | 544 |
| 1984 | Jan.25 | 4.31 | 521 (510) | May 24 | 2.10 | 258 | Jan.25 | 4.02 | 674 |

Remarks ; Discharge with parentheses is estimated by runoff culculation.

Table 3.14 Estimated Flooding Conditions of Past Floods (1/2)

1. Asahan river

| I t e m | Unit | Flood | | |
| --- | --- | --- | --- | --- |
| | | Sep.1977 | May 1982 | Jan.1984 |
| 1) Inundated area | | | | |
| House/building | nos | 562 | 565 | 1249 |
| Paddy | ha | 1980 | 2010 | 2740 |
| Oil Palm | " | - | - | - |
| Rubber | " | - | - | - |
| Uplands Crops | " | 30 | 150 | 570 |
| Others(including swamp) | " | 13690 | 14340 | 22390 |
| Total | " | 15700 | 16500 | 25700 |
| 2) Average inundated depth | | | | |
| House/building | m | 0.50 | 0.50 | 0.64 |
| Paddy | " | 0.60 | 0.60 | 0.74 |
| Oil palm | " | - | - | - |
| Rubber | " | - | - | - |
| Upland Crops | " | 0.40 | 0.40 | 0.50 |
| Others | " | 0.50 | 0.50 | 0.64 |
| 3) Maximum inundated depth | | | | |
| House/building | m | 1.40 | 1.40 | 1.90 |
| Paddy | " | 1.62 | 1.65 | 2.14 |
| Oil palm | " | - | - | - |
| Rubber | " | - | - | - |
| Upland crops | " | 0.50 | 0.50 | 0.55 |
| Others | " | 1.40 | 1.40 | 1.90 |
| 4) Inundated duration | day | 5 | 81 | 69 |
| 5) Peak Discharge at Pulau Raja | cms | 450 | 486 | 512 |

Table 3.14 Estimated Flooding Conditions of Past Floods (2/2)

2. Silau river

| Item | Unit | Flood | | |
|---|---|---|---|---|
| | | Sep.1977 | May 1982 | May 1984 |
| 1) Inundated area | | | | |
| House/building | nos | 7300 | 3860 | 3405 |
| Paddy | ha | 4658 | 3036 | 1329 |
| Oil palm | " | 100 | - | - |
| Rubber | " | 101 | - | - |
| Upland Crops | " | 46 | 30 | 30 |
| Others | " | 855 | 527 | 459 |
| Total | " | 5760 | 3593 | 1818 |
| 2) Average inundated depth | | | | |
| House/building | m | 0.60 | 0.57 | 0.50 |
| Paddy | " | 0.70 | 0.60 | 0.60 |
| Oil palm | " | 0.50 | - | - |
| Rubber | " | 0.50 | - | - |
| Uplands Crops | " | 0.50 | 0.50 | 0.50 |
| Others | " | 0.60 | 0.57 | 0.50 |
| 3) Maximum inundated depth | | | | |
| House/building | m | 1.58 | 1.22 | 0.85 |
| Paddy | " | 1.83 | 1.47 | 1.10 |
| Oil palm | " | 0.50 | - | - |
| Rubber | " | 0.50 | - | - |
| Upland crops | " | 1.08 | 1.00 | 0.80 |
| Others | " | 1.58 | 1.22 | 0.85 |
| 4) Inundated duration | day | 6 | 4 | 8 |
| 5) Peak Discharge at Kisaran | cms | 570 | 420 | 310 |

Table 3.15 Estimated Flooding Conditions of Probable Floods (1/2)

1. Asahan river

| Item | Unit | Probable Flood | | | |
|---|---|---|---|---|---|
| | | 2 yr | 10 yr | 30 yr | 100 yr |
| **1) Inundated area** | | | | | |
| House/building | nos | 733 | 1387 | 1441 | 1486 |
| Paddy | ha | 2434 | 4866 | 5103 | 5467 |
| Oil Palm | " | - | - | 166 | 608 |
| Rubber | " | - | - | - | - |
| Uplands Crops | " | 160 | 876 | 966 | 1076 |
| Others(including swamp) | " | 13996 | 23675 | 28925 | 32129 |
| Total | " | 16590 | 29417 | 35160 | 39280 |
| **2) Average inundated depth** | | | | | |
| House/building | m | 0.51 | 0.65 | 0.78 | 0.80 |
| Paddy | " | 0.61 | 0.75 | 0.88 | 0.90 |
| Oil palm | " | - | - | 0.50 | 0.50 |
| Rubber | " | - | - | - | - |
| Upland Crops | " | 0.50 | 0.50 | 0.51 | 0.52 |
| Others | " | 0.51 | 0.65 | 0.78 | 0.80 |
| **3) Maximum inundated depth** | | | | | |
| House/building | m | 1.59 | 2.08 | 2.10 | 2.13 |
| Paddy | " | 1.84 | 2.33 | 2.35 | 2.38 |
| Oil palm | " | - | - | 0.50 | 0.50 |
| Rubber | " | - | - | - | - |
| Upland crops | " | 0.50 | 0.58 | 0.60 | 0.63 |
| Others | " | 1.59 | 2.08 | 2.10 | 2.13 |
| **4) Inundated duration** | day | more than 5 | more than 7 | more than 7 | more than 7 |
| **5) Peak Discharge at Pulau Raja** | cms | 625 | 1001 | 1355 | 1839 |

Table 3.15 Estimated Flooding Conditions of Probable Floods (2/2)

2. Silau river

| Item | Unit | Probable Flood | | | |
|---|---|---|---|---|---|
| | | 2 yr | 10 yr | 30 yr | 100 yr |
| 1) Inundated area | | | | | |
| House/building | nos | 6350 | 7364 | 9796 | 11809 |
| Paddy | ha | 3270 | 4686 | 4932 | 5387 |
| Oil palm | " | - | 100 | 1092 | 1300 |
| Rubber | " | - | 101 | 1598 | 1805 |
| Upland Crops | " | 33 | 47 | 49 | 54 |
| Others | " | 802 | 864 | 1754 | 3932 |
| Total | " | 4105 | 5770 | 9425 | 12478 |
| 2) Average inundated depth | | | | | |
| House/building | m | 0.57 | 0.57 | 0.68 | 0.80 |
| Paddy | " | 0.67 | 0.67 | 0.78 | 0.90 |
| Oil palm | " | - | 0.50 | 0.50 | 0.50 |
| Rubber | " | - | 0.50 | 0.50 | 0.50 |
| Uplands Crops | " | 0.50 | 0.50 | 0.50 | 0.50 |
| Others | " | 0.57 | 0.57 | 0.68 | 0.80 |
| 3) Maximum inundated depth | | | | | |
| House/building | m | 1.52 | 1.59 | 2.07 | 2.25 |
| Paddy | " | 1.77 | 1.84 | 2.32 | 2.70 |
| Oil palm | " | - | 0.50 | 0.50 | 0.50 |
| Rubber | " | - | 0.50 | 0.50 | 0.50 |
| Upland crops | " | 1.02 | 1.09 | 1.57 | 1.95 |
| Others | " | 1.54 | 1.59 | 2.07 | 2.25 |
| 4) Inundated duration | day | 5 | 6 | 6 | 6 |
| 5) Peak Discharge at Kisaran | cms | 449 | 565 | 911 | 1300 |

Table 3.16 Unit Prices of House, Effects and Goods in 1985 for the Flood Damage Estimation

(Unit : Rp $10^3$/house)

| Item | Kab. Asahan | Tanjung Balai |
|---|---|---|
| I. House/Building | | |
| (1) Residence/Farmhouse | 600 | 1,580 |
| (2) Commercial Sector | 875 | 2,000 |
| (3) Small Industry | 4,000 | 4,000 |
| (4) Others | 1,250 | 3,000 |
| II. Household Effects | 809 | 1,404 |
| III. Stored Goods, Properties | | |
| (1) Commercial Sector | 1,881 | 1,881 |
| (2) Small Industry | 10,340 | 10,340 |

Note : 1985 current price.

Table 3.17 Damage Rate of Inundation and Sedimentation for House, Effects and Goods

I. Damage Rate of Inundation

| Item | Inundation depth (cm) | | | | |
|---|---|---|---|---|---|
| | 0-59 | 60-109 | 110-209 | 210-309 | 310- |
| Residence/Farmhouse | 0.053 | 0.072 | 0.109 | 0.152 | 0.220 |
| Household effects | 0.086 | 0.191 | 0.331 | 0.499 | 0.690 |
| Stored goods | 0.180 | 0.314 | 0.419 | 0.539 | 0.630 |

II. Damage Rate of Sedimentation

| Item | Sedimentation depth (cm) | |
|---|---|---|
| | less than 60 cm | more than 60 cm |
| Residence/farmhouse | 0.43 | 0.57 |
| Household effects | 0.50 | 0.69 |
| Stored goods | 0.54 | 0.63 |

Note : (1) Rate in the "less than 60 cm" is adopted for the estimation.

(2) Floor height is assumed at 10 cm for I and II.

Table 3.18 Unit Prices of Agricultural Crops for the Flood Damage Estimation

| Item | Unit Yield (ton/ha) | (Rp $10^3$/ton) | | (Rp $10^3$/ha) | |
|---|---|---|---|---|---|
| | | 1985 | 2005 | 1985 | 2005 |
| (1) Paddy | | | | | |
| Asahan river | 2.5 | 188.0 | 257.0 | 470.0 | 642.5 |
| Silau river | 3.0 | 188.0 | 257.0 | 564.0 | 771.0 |
| (2) Upland Paddy | | | | | |
| Asahan river | 2.0 | 188.0 | 257.0 | 376.0 | 514.0 |
| Silau river | 2.0 | 188.0 | 257.0 | 376.0 | 514.0 |
| (3) Maize | | | | | |
| Asahan river | 2.0 | 191.5 | 182.5 | 383.0 | 365.0 |
| Silau river | 2.0 | 191.5 | 182.5 | 383.0 | 365.0 |
| (4) Soybean | | | | | |
| Asahan river | 0.8 | 339.0 | 342.0 | 271.0 | 273.5 |
| Silau river | 0.8 | 339.0 | 342.0 | 271.0 | 273.5 |

Table 3.19 Damage Rate of Agricultural Crops

| Item | Duration (day) | | | | | wash-away |
|---|---|---|---|---|---|---|
| | 1-2 | 3-4 | 5-6 | 7-10 | 11- | |
| <u>Wetland paddy</u> | | | | | | |
| over 1.0 m | 0.70 | 0.80 | 0.85 | 0.95 | 1.00 | 1.00 |
| 0.50 - 1.0 m | 0.40 | 0.46 | 0.49 | 0.55 | 0.70 | 1.00 |
| below 0.50 m | 0.37 | 0.42 | 0.45 | 0.50 | 0.60 | 1.00 |
| <u>Upland paddy</u> | | | | | | |
| over 1.0 m | 0.70 | 0.80 | 0.85 | 0.95 | 1.00 | 1.00 |
| 0.50 - 1.0 m | 0.40 | 0.46 | 0.49 | 0.55 | 0.70 | 1.00 |
| below 0.50 m | 0.37 | 0.42 | 0.45 | 0.50 | 0.60 | 1.00 |
| <u>Maize</u> | | | | | | |
| over 1.0 m | 0.51 | 0.67 | 0.81 | 0.91 | 1.00 | 1.00 |
| 0.50 - 1.0 m | 0.35 | 0.48 | 0.67 | 0.74 | 0.95 | 1.00 |
| below 0.5 m | 0.27 | 0.42 | 0.54 | 0.67 | 0.90 | 1.00 |
| <u>Soybean</u> | | | | | | |
| over 1.0 m | 0.40 | 0.50 | 0.68 | 0.81 | 1.00 | 1.00 |
| 0.50 - 1.0 m | 0.30 | 0.44 | 0.60 | 0.73 | 0.95 | 1.00 |
| below 0.5 m | 0.23 | 0.41 | 0.54 | 0.67 | 0.90 | 1.00 |

Note : (1) Rate for booling stage of paddy is adopted for the estimation.

Source : - Manual for River and Sabo Works in Japan ; International Engineering Consultants Association, Japan, 1977.

- Ministry of Agriculture, Forestry and Fishery, Japan for the paddy damage.

Table 3.20 Probable Flood Damage under Present Condition (1/2)

1. Asahan River

(Unit : Rp $10^6$)

| Description | 2-year | 5-year | 10-year | 15-year | 30-year | 100-year |
|---|---|---|---|---|---|---|
| I. House Properties | | | | | | |
| (1) House/Building | 66.1 | 168.9 | 259.9 | 265.1 | 272.6 | 282.5 |
| (2) Household Effects | 123.0 | 283.9 | 398.9 | 406.8 | 439.0 | 442.6 |
| (3) Stored Goods | 19.1 | 36.3 | 49.7 | 50.6 | 53.6 | 55.3 |
| Sub-total | 208.2 | 489.1 | 708.5 | 722.5 | 765.2 | 780.4 |
| II. Agricultural Products | | | | | | |
| (1) Wetland Paddy | 706.0 | 1,101.8 | 1,453.5 | 1,495.6 | 1,528.2 | 1,569.0 |
| (2) Upland Crops | 35.5 | 112.0 | 166.4 | 172.7 | 178.6 | 193.3 |
| (3) Other (1)+(2)x10% | 74.2 | 121.4 | 162.0 | 166.8 | 170.7 | 176.2 |
| Sub-total | 815.7 | 1,335.2 | 1,781.9 | 1,835.1 | 1,877.5 | 1,938.5 |
| I + II | 1,023.9 | 1,824.3 | 2,490.4 | 2,557.6 | 2,642.7 | 2,718.9 |
| III. Public Facilities 30% (I + II) | 307.2 | 547.3 | 747.1 | 767.3 | 792.8 | 815.7 |
| IV. Indirect Damage 10% (I + II + III) | 133.1 | 237.2 | 323.8 | 332.5 | 343.6 | 353.5 |
| Total (Asahan River) | 1,464.2 | 2,608.8 | 3,561.3 | 3,657.4 | 3,779.1 | 3,888.1 |

Table 3.20 Probable Flood Damage under Present Condition (2/2)

2. Silau River

(Unit : Rp $10^6$)

| Description | 2-year | 5-year | 10-year | 15-year | 30-year | 100-year |
|---|---|---|---|---|---|---|
| I. House Properties | | | | | | |
| (1) House/Building | 678.2 | 740.9 | 804.9 | 1,291.7 | 1,626.3 | 2,021.0 |
| (2) Household Effects | 1,269.3 | 1,354.4 | 1,448.2 | 2,589.3 | 3,229.0 | 4,054.9 |
| (3) Stored Goods | 475.4 | 487.6 | 509.2 | 756.3 | 944.9 | 1,176.2 |
| Sub-total | 2,422.9 | 2,582.9 | 2,762.3 | 4,637.3 | 5,800.2 | 7,252.1 |
| II. Agricultural Products | | | | | | |
| (1) Wetland Paddy | 799.3 | 1,070.7 | 1,273.7 | 1,306.0 | 1,370.8 | 1,483.3 |
| (2) Upland Crops | 4.5 | 6.3 | 7.5 | 7.8 | 8.0 | 8.6 |
| (3) Other (1)+(2)x10% | 80.4 | 107.7 | 128.1 | 131.4 | 137.9 | 149.2 |
| Sub-total | 884.2 | 1,184.7 | 1,409.3 | 1,445.2 | 1,516.7 | 1,641.1 |
| I + II | 3,307.1 | 3,767.6 | 4,171.6 | 6,082.5 | 7,316.9 | 8,893.2 |
| III. Public Facilities 30% (I + II) | 992.1 | 1,130.3 | 1,251.5 | 1,824.8 | 2,195.1 | 2,668.0 |
| IV. Indirect Damage 10%(I + II + III) | 429.9 | 489.8 | 542.3 | 790.7 | 951.2 | 1,156.1 |
| Total (Silau River) | 4,729.1 | 5,387.7 | 5,965.4 | 8,698.0 | 10,463.2 | 12,717.3 |
| Grand Total (Asahan and Silau Rivers) | 6,193.3 | 7,996.5 | 9,526.7 | 12,355.4 | 14,242.3 | 16,605.4 |

Table 3.21 Preliminary Estimate of Present Water Utilization in the Study Area

| Description | | Kabupaten Asahan /2 | Kabupaten Labuhan Batu /3 | Total |
|---|---|---|---|---|
| **Basic Indicators** | | | | |
| | Area (km²) | 4,043 | 2,357 | 6,400 |
| | Population in 1983 ($10^3$) | 603 | 167 | 770 |
| | Irrigated paddy area (ha) | 6,033 | 759 | 6,792 |
| **Present Water Utilization ($10^6$ m³/y)** | | | | |
| (1) | Water Supply | | | |
| | Urban /1 | 2.3 | - | 2.3 |
| | Rural /4 | 3.8 | 1.2 | 5.0 |
| | (Sub-total) | (6.1) | (1.2) | (7.3) |
| (2) | Factory use | | | |
| | Oil Palm | 0.9 | - | 0.9 |
| | Rubber | 4.3 | 0.9 | 5.2 |
| | (Sub-total) | (5.2) | (0.9) | (6.1) |
| (3) | Irrigation | 61.8 | 5.8 | 67.6 |
| **Total** | | 73.1 | 7.9 | 81.0 |

Remarks ; /1 = Kisaran and Tg. Balai

/2 = Including Asahan, Silau, Bunut river basins

/3 = Including Kualuh and Leidong river basins

/4 = Excluding water quantity of river water used at the spot

Table 3.22 Spring Tide at One Fathom Bank of 1985

| Date | Lowest Hour | Lowest Height | Highest Hour | Highest Height |
|---|---|---|---|---|
| Jan. 11 | 15 | 30 cm | 21 | 408 cm |
| Feb. 8 | 14 | -15 | 20 | 445 |
| Mar. 8 | 13 | -22 | 19 | 473 |
| " 9 | 13&14 | -12 | 20 | 474 |
| Apr. 6 | 12 | 6 | 19 | 491 |
| May 5 | 12 | 39 | 18 | 486 |
| June 2 | 11 | 83 | 17 | 459 |
| July 23 | 3 | 65 | 9 | 429 |
| Aug. 20 | 2 | 26 | 8 | 465 |
| Sept. 17 | 1 | 12 | 7 | 492 |
| Oct. 15 | 0 | 24 | 6 | 503 |
| Nov. 13 | 0 | 52 | 6 | 485 |
| Dec. 13 | 0 | 69 | 6 | 436 |

| Date | Hour: 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| March 8 | 55 | 41* | 89 | 186 | 293 | 380 | 431 | *434 | 383 | 288 | 179 | 79 |
| 9 | 84 | 34* | 43 | 115 | 224 | 329 | 405 | *440 | 422 | 351 | 246 | 137 |

| Date | Hour: 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| March 8 | 5 | -22* | 17 | 118 | 246 | 360 | 440 | *473 | 449 | 373 | 271 | 168 |
| 9 | 46 | -12* | -12* | 57 | 175 | 301 | 403 | 464 | *474 | 426 | 335 | 230 |

Notes :
1. Hour : 8 hE (Singapore Hour)
2. Datum level of tidal heights : 244 cm below mean sea level
3. Laction : 2° 53' 18" N, 100° 59' 48" E
4. Symbol (*) prefixed or suffixed to a tidal height denotes high or low water, respectively

Source : 1985 TABLES OF HOURLY TIDAL HEIGHTS, MALACCA AND SINGAPORE STRAITS, Maritime Safety Agency, Japan.

## Table 3.23 Electric Conductivity (EC) of Asahan River

A. Marine water of Malacca Strait at the pierhead of Kuala Tanjung Port adjacent to smelter.

| | |
|---|---|
| 13:50 25 Feb. 1985 | |
| Water Temperature | 30.4°C |
| EC | 43,200 mho/cm |

B. Asahan river on 8 March 1985

1. Teluk Nibung

| Hour | Air temp. °C | Water depth m | Water temp. °C | EC mho/cm | Remarks |
|---|---|---|---|---|---|
| 14:20 | - | 1.0 | - | - | stationing forward flow |
| 14:30 | 33.3 | 1.2 | 28.1 | 110 | backward flow |
| 15:00 | - | 1.7 | 28.3 | 98 | |
| 15:30 | - | 2.5 | 28.5 | 100 | |
| 16:00 | - | 2.93 | 28.3 | 124 | |
| 16:30 | 27.5 | 3.18 | 28.5 | 190 | |
| 17:00 | - | 3.61 | 28.5 | 224 | |
| 17:30 | - | 3.64 | 28.6 | 322 | |
| 18.00 | - | 3.48 | 28.7 | 950 | |
| Approx 18:20 | - | - | - | - | forward flow |

Note : Electric conductivity was constant at any depth at a certain hour.

2. Turning point between Teluk Nibung and Bagan Asahan

| Hour | Air temp. | Water depth | Water temp. | EC | |
|---|---|---|---|---|---|
| | | | | Surface | Bottom |
| 18:45 | - | 3.32$^m$ | 29.3°C | 35,000 | 39,000 |

3. Tanjung Balai

| Hour | Air temp. | Water depth | Water temp. | EC |
|---|---|---|---|---|
| 20:00 | - | - | 29.3°C | 70 |

Remarks : River run-off on 8 March 1985
Asahan at Pulau Raja 147 $m^3/s$ }
Silau at Kisaran 35 $m^3/s$ } Lowest in early 10 days of March 1985

C. At the same point as B.2 at 16:15 on 26 Feb. 1985
Current condition : strong backward flow

| Water depth | Water temp. | EC |
|---|---|---|
| 0.50$^m$ | 30.6°C | 1,000 mho/cm |
| 1.00 | " | 990 |
| 1.50 | " | 880 |
| 2.00 | " | 780 |
| 2.50 | " | 730 |

Table 4.1 Principal Features of Asahan No.3 Project

| Description | Feature |
|---|---|
| 1. Location | About 5 - 10 km downstream from Tangga Power station |
| 2. Reservoir area | |
| - catchment area | 4,010 $km^2$ |
| - Annual average discharge | 129.3 $m^3/s$ |
| - Effective storage capacity | 12 x $10^6$ $m^3$ |
| - Resevoir surface area | 2.4 $km^2$ |
| - HWL (FWL) | EL. 267.0 m |
| - LWL | El. 262.0 m |
| - Design flood | 1,800 $m^3/s$ |
| 3. Parhitean Dam | |
| - Type | Center core type rock fill dam |
| - Dam height | 130 m |
| - Crest length | 390 m |
| - Embankment volume | 6,800,000 $m^3$ |
| 4. Power Plant | |
| - Gross head | 177.0 m |
| - Net head | 171.0 m |
| - Plant discharge | 208.2 $m^3/s$ |
| - Installed capacity | 300,000 KW = 75,000 KW x 4 units |
| - Energy output | 1,586 x 106 KWh/year |

Source : Feasibility Report on the Asahan No.1 and No.3 Hydroelectric Power Development Project, Dec. 1982, JICA.

Table 4.2 Design Discharge and its Scale of Rivers in Indonesia

| No. | Name of River | Province | Catchment Area (sq.km) | Design Flood (cms) | Specific Discharge (cms/sq.km) | Return Period (year) |
|---|---|---|---|---|---|---|
| 1. | Cimanuk | West Java | 3,006 | 1,440 | 0.48 | 25 |
| 2. | Serang | Central Java | 937 | 900 | 0.96 | 25 |
| 3. | Citanduy | West Java | 3,680 | 1,900 | 0.52 | 25 |
| 4. | U l a r | North Sumatra | 1,080 | 800 | 0.74 | 30 |
| 5. | Pemali | Central Java | 1,228 | 1,300 | 1.06 | 25 |
| 6. | Cipanas | West Java | 220 | 385 | 1.75 | 25 |
| 7. | S o l o | Central/East Java | 3,400 | 1,500 | 0.44 | 10 *1 |
| | | | | 2,000 | 0.59 | 40 *2 |
| 8. | Madiun | East Java | 2,400 | 1,100 | 0.46 | 10 *1 |
| | | | | 2,300 | 0.96 | 40 *2 |
| 9. | Wampu | North Sumatra | 3,840 | 1,320 | 0.34 | 20 |
| 10. | Arakundo | A c e h | 5,495 | 1,800 | 0.33 | 20 |
| 11. | Kring Aceh | A c e h | 1,775 | 1,300 | 0.73 | 20 |
| 12. | Brantas | East Java | 10.000 | 1,350 | 0.135 | 10 *1 |
| | | | | 1,500 | 0.15 | 50 *2 |
| 13. | Bah Bolon | North Sumatra | 2,776 | 1,220 | 0.44 | 20 |
| 14. | Walanae | South Sulawesi | 3,190 | 2,900 | 0.91 | 20 |
| 15. | B i l a | South Sulawesi | 1.368 | 1,900 | 1.39 | 20 |
| 16. | Jeneberang | South Sulawesi | 729 | 3,700 | 5.08 | 50 |
| 17. | Ciujung | North Banten | 1,850 | 1,100 | 0.59 | 10 *1 |
| | | | | 1,600 | 0.86 | 50 *2 |
| 18. | Kuranji | West Sumatra | 213 | 870 | 4.08 | 25 *1 |
| | | | | 1,000 | 4.69 | 50 *2 |
| 19. | Air Dingin | West Sumatra | 131 | 600 | 4.58 | 25 *1 |
| | | | | 700 | 5.34 | 50 *2 |
| 20. | Marmoyo | East Java | 290 | 230 | 0.79 | 20 |
| 21. | Surabaya | East Java | 631 | 370 | 0.59 | 50 |

Note : *1 : 1st stage and/or urgent plan
*2 : 2nd stage and/or overall plan

Table 4.3 Construction Cost of Long-term Flood Control Plan (1/5)

| Description | Unit | Quantity | Local Currency Unit Cost(Rp) | Local Currency Amount (Rp million) | Foreign Currency Unit Cost($) | Foreign Currency Amount ($ thousand) | Foreign Currency Amount (Eq.Rp million) | Equivalent Total (Rp million) |
|---|---|---|---|---|---|---|---|---|
| Bunut River | | | | | | | | |
| 1. Civil Works | | | | 2,278.5 | | 6,491.6 | 7,140.8 | 9,419.3 |
| (1) Preparatory | L.S | | | 154.5 | | 440.1 | 484.1 | 638.6 |
| (2) Clearing for bush | sq m | 2,000 | 250 | 0.5 | 0.68 | 1.4 | 1.5 | 2.0 |
| (3) Embankment | cu m | 1,200,000 | 560 | 672.0 | 1.31 | 1,572.0 | 1,729.2 | 2,401.2 |
| (4) Excavation | cu m | 1,450,000 | 680 | 986.0 | 2.56 | 3,712.0 | 4,083.2 | 5,069.2 |
| (5) Bank protection | m | 1,000 | 83,400 | 83.4 | 151.45 | 151.4 | 166.6 | 250.0 |
| (6) Drainage culvert | nos. | 1 | 24,000,000 | 24.0 | 32,700.00 | 32.7 | 36.0 | 60.0 |
| (7) Bridge (b = 4 m) | m | 100 | 1,650,000 | 165.0 | 318.00 | 31.8 | 35.0 | 200.0 |
| (8) Sub-total (2)-(7) | | | | 1,930.9 | | 5,501.4 | 6,051.5 | 7,982.4 |
| (9) Miscellaneous | L.S | | | 193.1 | | 550.1 | 605.2 | 798.3 |
| 2. Acquisition & Compensation | | | | 307.9 | | - | - | 307.9 |
| (1) Land acquisition | sq m | 514,000 | | 153.1 | | | | 153.1 |
| (2) Land compensation | sq m | 1,015,000 | | 151.5 | | | | 151.5 |
| (3) House compensation | nos. | 12 | | 3.3 | | | | 3.3 |
| 3. Sum (1.+ 2.) | | | | 2,586.4 | | 6,491.6 | 7,140.8 | 9,727.2 |
| 4. Engineering & Administration | | | | 543.1 | | 1,038.7 | 1,142.5 | 1,685.6 |
| 5. Sum (3.+ 4.) | | | | 3,129.5 | | 7,530.3 | 8,283.3 | 11,412.8 |
| 6. Contingency (10 % of 5.) | | | | 313.0 | | 753.0 | 828.3 | 1,141.3 |
| 7. Grand Total | | | | 3,442.5 | | 8,283.3 | 9,111.6 | 12,554.1 |
| Asahan and Silau Rivers (with Dam) | | | | | | | | |
| 1. Civil Works | | | | 10,353.5 | | 34,390.5 | 37,829.6 | 48,183.1 |
| 1.1 Asahan River | | | | 5,890.5 | | 19,792.0 | 21,771.2 | 27,661.7 |
| (1) Preparatory:(8) x 8% | | | | 399.4 | | 1,341.8 | 1,476.0 | 1,875.4 |
| (2) Clearing for bush | sq m | 827,000 | 250 | 206.8 | 0.68 | 562.4 | 618.6 | 825.4 |

Note : (1) Price level in March 1985 is adopted.
(2) Exchange rate : US$ 1 = Rp 1,100 = Japanese ¥ 250.

Table 4.3 Construction Cost of Long-term Flood Control Plan (2/5)

| Description | Unit | Quantity | Local Currency Unit Cost (Rp) | Local Currency Amount (Rp million) | Foreign Currency Unit Cost ($) | Foreign Currency Amount ($ thousand) | Foreign Currency Amount (Eq.Rp million) | Equivalent Total (Rp million) |
|---|---|---|---|---|---|---|---|---|
| (3) Embankment | cu m | 1,560,000 | | 963.5 | | 2,385.8 | 2,624.4 | 3,587.9 |
| - mainstream | cu m | 1,270,000 | 560 | 711.2 | 1.31 | 1,663.7 | 1,830.1 | 2,541.3 |
| - Lebah river | cu m | 290,000 | 870 | 252.3 | 2.49 | 722.1 | 794.3 | 1,046.6 |
| (4) Excavation | cu m | 1,550,000 | 680 | 1,054.0 | 2.56 | 3,968.0 | 4,364.8 | 5,418.8 |
| (5) Dredging | cu m | 2,310,000 | 1,050 | 2,425.5 | 4.05 | 9,355.5 | 10,291.0 | 12,716.5 |
| (6) Bank protection | | | | 86.1 | | 152.4 | 167.7 | 253.8 |
| - wet masonry | cu m | 50 | 54,700 | 2.7 | 17.43 | 0.9 | 1.0 | 3.7 |
| - crib | m | 1,000 | 83,400 | 83.4 | 151.45 | 151.5 | 166.7 | 250.1 |
| (7) Drainage culvert | nos. | 13 | | 256.0 | | 348.8 | 383.7 | 639.7 |
| - 1.5 x 1.5 | nos. | 9 | 16,000,000 | 144.0 | 21,800.00 | 196.2 | 215.8 | 359.8 |
| - 2.0 x 2.5 | nos. | 3 | 24,000,000 | 72.0 | 32,700.00 | 98.1 | 107.9 | 179.9 |
| - 2.0 x 2.5 x 2 | nos. | 1 | 40,000,000 | 40.0 | 54,500.00 | 54.5 | 60.0 | 100.0 |
| (8) Sub-total:(2)-(7) | | | | 4,991.9 | | 16,772.9 | 18,450.2 | 23,442.1 |
| (9) Miscellaneous : (8) x 10% | | | | 499.2 | | 1,677.3 | 1,845.0 | 2,344.2 |
| 1.2 Silau River | | | | 4,463.0 | | 14,598.5 | 16,058.4 | 20,521.4 |
| (1) Preparatory:(9) x 8% | | | | 302.6 | | 989.7 | 1,088.7 | 1,391.2 |
| (2) Clearing for bush | sq m | 8,000 | 250 | 2.0 | 0.68 | 5.4 | 5.9 | 7.9 |
| (3) Embankment | cu m | 1,220,000 | 560 | 683.2 | 1.31 | 1,598.2 | 1758.0 | 2,441.2 |
| (4) Excavation | cu m | 2,840,000 | 680 | 1,931.2 | 2.56 | 7,270.4 | 7,997.5 | 9,928.7 |
| (5) Dredging | cu m | 700,000 | 1,050 | 735.0 | 4.05 | 2,835.0 | 3,118.5 | 3,853.5 |
| (6) Bank protection | m | 2,000 | 83,400 | 166.8 | 151.45 | 302.9 | 333.2 | 500.0 |
| (7) Intake structure | nos. | 5 | | 136.0 | | 185.3 | 204.0 | 340.0 |
| - 2.0 x 2.5 | nos. | 4 | 24,000,000 | 96.0 | 32,700.00 | 130.8 | 144.0 | 240.0 |
| - 2.0 x 2.5 x 2 | nos. | 1 | 40,000,000 | 40.0 | 54,500.00 | 54.5 | 60.0 | 100.0 |
| (8) Drainage culvert | nos. | 6 | | 128.0 | | 174.4 | 192.0 | 320.0 |
| - 1.5 x 2.0 | nos. | 4 | 16,000,000 | 64.0 | 21,800.00 | 87.2 | 96.0 | 160.0 |
| - 2.0 x 2.5 | nos. | 1 | 24,000,000 | 24.0 | 32,700.00 | 32.7 | 36.0 | 60.0 |
| - 2.0 x 2.5 x 2 | nos. | 1 | 40,000,000 | 40.0 | 54,500.00 | 54.5 | 60.0 | 100.0 |
| (9) Sub-total : (2)-(8) | | | | 3,782.2 | | 12,371.6 | 13,608.9 | 17,391.3 |
| (10)Miscellaneous : (9) x 10% | | | | 378.2 | | 1,237.2 | 1,360.8 | 1,738.9 |

Table 4.3 Construction Cost of Long-term Flood Control Plan (3/5)

| Description | Unit | Quantity | Local Currency | | Foreign Currency | | | Equivalent Total |
|---|---|---|---|---|---|---|---|---|
| | | | Unit Cost(Rp) | Amount (Rp million) | Unit Cost($) | Amount ($ thousand) | Amount (Eq.Rp million) | (Rp million) |
| 2. Acquisition & Compensation | | | | 1,068.0 | | - | - | 1,068.0 |
| 2.1 Asahan River | | | | 415.0 | | - | - | 415.0 |
| (1) Land acquisition | sq m | 382,000 | | 114.0 | | | | 114.0 |
| (2) Land compensation | sq m | 1,120,000 | | 162.0 | | | | 162.0 |
| (3) House compensation | nos. | 508 | | 139.0 | | | | 139.0 |
| 2.2 Silau River | | | | 653.0 | | - | - | 653.0 |
| (1) Land acquisition | sq m | 842,000 | | 251.0 | | | | 251.0 |
| (2) Land compensation | sq m | 1,650,000 | | 245.0 | | | | 245.0 |
| (3) House compensation | nos. | 336 | | 157.0 | | | | 157.0 |
| 3. Sum (1.+ 2.) | | | | 11,421.5 | | 34,390.5 | 37,829.6 | 49,251.1 |
| 4. Administration & Engineering | | | | 2,398.5 | | 5,502.5 | 6,052.7 | 8,451.2 |
| 5. Sum (3.+ 4.) | | | | 13,820.0 | | 39,893.0 | 43,882.3 | 57,702.3 |
| 6. Contingency (10% of 5.) | | | | 1,382.0 | | 3,989.3 | 4,388.2 | 5,770.2 |
| 7. Grand total | | | | 15,202.0 | | 43,882.3 | 48,270.5 | 63,472.5 |
| Asahan and Silau Rivers (without Dam) | | | | | | | | |
| 1. Civil Works | | | | 11,061.1 | | 36,677.1 | 40,345.0 | 51,406.1 |
| 1.1 Asahan River | | | | 6,598.1 | | 22,078.6 | 24,286.6 | 30,884.7 |
| (1) Preparatory:(8) x 8% | | | | 447.3 | | 1,496.9 | 1,646.5 | 2,093.9 |
| (2) Clearing for bush | sq m | 935,000 | 250 | 233.7 | 0.68 | 635.8 | 699.4 | 993.1 |
| (3) Embankment | cu m | | | 1,189.1 | | 2,919.8 | 3,211.8 | 4,400.9 |
| - mainstream | cu m | 1,651,000 | 560 | 924.6 | 1.31 | 2,162.8 | 2,379.1 | 3,303.7 |
| - Lebah river | cu m | 304,000 | 870 | 264.5 | 2.49 | 757.0 | 832.7 | 1,097.2 |
| (4) Excavation | cu m | 1,690,000 | 680 | 1,149.2 | 2.56 | 4,326.4 | 4,759.0 | 5,908.2 |
| (5) Dredging | cu m | 2,550,000 | 1,050 | 2,677.5 | 4.05 | 10,327.5 | 11,360.3 | 14,037.8 |
| (6) Bank protection | | | | 86.1 | | 152.4 | 167.7 | 253.8 |
| - wet masonry | cu m | 50 | 54,700 | 2.7 | 17.43 | 0.9 | 1.0 | 3.7 |
| - crib | m | 1,000 | 83,400 | 83.4 | 151.45 | 151.5 | 166.7 | 250.1 |

Table 4.3 Construction Cost of Long-term Flood Control Plan (4/5)

| Description | Unit | Quantity | Local Currency | | Foreign Currency | | | Equivalent Total |
|---|---|---|---|---|---|---|---|---|
| | | | Unit Cost(Rp) | Amount (Rp million) | Unit Cost($) | Amount ($ thousand) | Amount (Eq.Rp million) | (Rp million) |
| (7) Drainage culvert | nos. | 13 | | 256.0 | | 348.8 | 383.7 | 639.7 |
| - 1.5 x 1.5 | nos. | 9 | 16,000,000 | 144.0 | 21,800.00 | 196.2 | 215.8 | 359.8 |
| - 2.0 x 2.5 | nos. | 3 | 24,000,000 | 72.0 | 32,700.00 | 98.1 | 107.9 | 179.9 |
| - 2.0 x 2.5 x 2 | nos. | 1 | 40,000,000 | 40.0 | 54,500.00 | 54.5 | 60.0 | 100.0 |
| (8) Sub-total:(2)-(7) | | | | 5,591.6 | | 18,710.7 | 20,581.9 | 26,173.5 |
| (9) Miscellaneous : (8) x 10% | | | | 559.2 | | 1,871.1 | 2,058.2 | 2,617.3 |
| 1.2 Silau River (same as with dam) | | | | 4,463.0 | | 14,598.5 | 16,058.4 | 20,521.4 |
| 2. Acquisition & Compensation | | | | 1,068.0 | | - | - | 1,068.0 |
| 2.1 Asahan River | | | | 415.0 | | - | - | 415.0 |
| (1) Land acquisition | sq m | 382,000 | | 114.0 | | | | 114.0 |
| (2) Land compensation | sq m | 1,120,000 | | 162.0 | | | | 162.0 |
| (3) House compensation | nos. | 508 | | 139.0 | | | | 139.0 |
| 2.2 Silau River (same as with dam) | | | | 653.0 | | - | - | 653.0 |
| 3. Sum (1.+ 2.) | | | | 12,129.1 | | 36,677.1 | 40,345.0 | 52,474.1 |
| 4. Administration & Engineering | | | | 2,547.1 | | 7,702.2 | 8,472.5 | 11,019.6 |
| 5. Sum (3.+ 4.) | | | | 14,676.2 | | 44,379.3 | 48,817.5 | 63,493.7 |
| 6. Contingency (10% of 5.) | | | | 1,467.6 | | 4,437.9 | 4,881.7 | 6,349.4 |
| 7. Grand total | | | | 16,143.8 | | 48,817.2 | 53,699.2 | 69,843.0 |
| Kualuh River | | | | | | | | |
| 1. Civil Works | | | | 3,577.0 | | 10,416.3 | 11,453.9 | 15,030.9 |
| 1.1 Kualuh River | | | | 2,403.3 | | 7,062.8 | 7,767.1 | 10,170.4 |
| (1) Preparatory | L.S | | | 121.7 | | 357.6 | 393.4 | 515.1 |
| (2) Clearing for bush | sq m | 230,000 | 250 | 57.5 | 0.68 | 156.4 | 172.0 | 229.5 |
| (3) Embankment | cu m | 1,485,000 | 560 | 831.6 | 1.31 | 1,945.4 | 2,139.9 | 2,971.5 |
| (4) Excavation | cu m | 1,500,000 | 680 | 1,020.0 | 2.56 | 3,840.0 | 4,224.0 | 5,244.0 |
| (5) Bank protection | | | | 44.4 | | 76.6 | 84.3 | 128.7 |
| - wetmasonry | cu m | 50 | 54,700 | 2.7 | 17.43 | 0.9 | 1.0 | 3.7 |
| - krib | m | 500 | 83,400 | 41.7 | 151.45 | 75.7 | 83.3 | 125.0 |
| (6) Intake structure | nos. | 1 | 24,000,000 | 24.0 | 32,000.00 | 32.7 | 36.0 | 60.0 |

Table 4.3 Construction Cost of Long-term Flood Control Plan (5/5)

| Description | Unit | Quantity | Local Currency | | Foreign Currency | | | Equivalent Total |
|---|---|---|---|---|---|---|---|---|
| | | | Unit Cost(Rp) | Amount (Rp million) | Unit Cost($) | Amount ($ thousand) | Amount (Eq.Rp million) | (Rp million) |
| (7) Drainage culvert | nos. | 9 | | 152.0 | | 207.1 | 225.8 | 377.8 |
| - 1.5 x 1.5 | nos | 8 | 16,000,000 | 128.0 | 21,800.00 | 174.4 | 191.8 | 319.8 |
| - 2.0 x 2.5 | nos. | 1 | 24,000,000 | 24.0 | 32,700.00 | 32.7 | 36.0 | 60.0 |
| (8) Sub-total (2)-(7) | | | | 2,129.5 | | 6,258.2 | 6,882.0 | 6,882.0 |
| (9) Miscellaneous | L.S | | | 152.1 | | 447.0 | 491.7 | 643.8 |
| 1.2 Kanopan River | | | | 1,173.7 | | 3,353.5 | 3,686.8 | 4,860.5 |
| (1) Preparatory | L.S | | | 62.7 | | 179.1 | 197.0 | 259.7 |
| (2) Clearing for bush | sq m | 50,000 | 250 | 12.5 | 0.68 | 34.0 | 37.4 | 49.9 |
| (3) Embankment | cu m | 700,000 | 560 | 392.0 | 1.31 | 917.0 | 1,008.7 | 1,400.7 |
| (4) Excavation | cu m | 700,000 | 680 | 476.0 | 2.56 | 1,792.0 | 1,971.2 | 2,447.2 |
| (5) Drainage Culvert | nos. | 9 | | 152.0 | | 207.1 | 225.8 | 377.8 |
| - 1.5 x 1.5 | nos | 8 | 16,000,000 | 128.0 | 21,800.00 | 174.4 | 191.8 | 319.8 |
| - 2.0 x 2.5 | nos. | 1 | 24,000,000 | 24.0 | 32,700.00 | 32.7 | 36.0 | 60.0 |
| (6) Sub-total (2)-(5) | | | | 1,032.5 | | 2,950.1 | 3,243.1 | 4,275.6 |
| (7) Miscellaneous | L.S | | | 78.5 | | 224.3 | 246.7 | 325.2 |
| 2. Acuisition & Compensation | | | | 845.5 | | - | - | 845.5 |
| 2.1 Kualuh River | | | | 755.9 | | - | - | 755.9 |
| (1) Land acquisition | sq m | 535,000 | | 158.7 | | | | 158.7 |
| (2) Land compensation | sq m | 3,790,000 | | 564.0 | | | | 564.0 |
| (3) House compensation | nos. | 95 | | 33.2 | | | | 33.2 |
| 2.2 Kanopan River | | | | 89.6 | | - | - | 89.6 |
| (1) Land aquisition | sq m | 152,500 | | 44.8 | | | | 44.8 |
| (2) Land compensation | sq m | 264,000 | | 38.9 | | | | 38.9 |
| (3) House compensation | nos. | 16 | | 5.9 | | | | 5.9 |
| 3. Sum (1.+ 2.) | | | | 4,422.5 | | 10,416.3 | 11,453.9 | 15,876.4 |
| 4. Administration & Engineering | | | | 928.7 | | 1,666.6 | 1,833.3 | 2,762.0 |
| 5. Sum (3.+ 4.) | | | | 5,351.2 | | 12,082.9 | 13,287.2 | 18,638.4 |
| 6. Contingency (10 % of 5.) | | | | 535.1 | | 1,208.3 | 1,329.1 | 1,864.2 |
| 7. Grand total | | | | 5,886.3 | | 13,291.2 | 14,616.3 | 20,502.6 |

Table 4.4 Percentage of Households in Urban and Rural Areas by Type of Lighting in North Sumatra Province and Indonesia, 1981/1982

| Lighting | % of Households | | Total |
|---|---|---|---|
| | Urban | Rural | |
| North Sumatra Province | | | |
| Electricity | 60.6 | 12.6 | 24.4 |
| Kerosene lamp | 12.9 | 41.3 | 34.3 |
| Kerosene pressure lamp | 25.8 | 42.5 | 38.4 |
| Others | 0.7 | 3.6 | 2.9 |
| Total (%) | 100.0 | 100.0 | 100.0 |
| Indonesia /1 | | | |
| Electricity | 48.8 | 5.4 | 14.5 |
| Kerosene | 50.8 | 93.1 | 84.5 |
| Others | 0.5 | 1.5 | 1.3 |

Remarks : /1 Figures in 1980

Source : Keterangan Kesejahteraan, Sosial Anak Sumatera Utara, 1981/1982; Welfare Indicators, 1983.

Table 4.5 Water Quality Analysis of Rivers

| PARAMETER | | Unit | Sample Number | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Chemist & Physics | | | (Bunut) | | (Asahan) | | | (Silau) | | (Kualuh) | | | (Natas) | (Kualuh) |
| Conductivity | | micromhos/cm | 92 | 84 | 84 | 104 | 108 | 52 | 50 | 35 | 31 | 42 | 35 | 33 |
| pH | | | 6.7 | 6.4 | 6.9 | 7.4 | 7.3 | 6.7 | 6.6 | 6.7 | 6.7 | 6.6 | 7.2 | 6,6 |
| S.A.R. | | | 0.148 | 0.152 | 0.146 | 0.142 | 0.149 | 0.237 | 0.234 | 0.276 | 0.269 | 0.214 | 0.262 | 0.268 |
| Dissolved solid | | mg/l | 56 | 55 | 57 | 71 | 72 | 37 | 31 | 32 | 28 | 38 | 28 | 26 |
| Suspendid solid | | mg/l | 68 | 26 | 46 | 82 | 102 | 14 | 42 | 38 | 42 | 22 | 34 | 28 |
| Hardness | | mg/l | 16 | 15 | 27 | 34 | 36 | 9 | 10 | 9 | 10 | 8 | 15 | 7 |
| K | | | | | | | | | | | | | | |
| Potassium | (K) | meq/l | 0.024 | 0.023 | 0.037 | 0.032 | 0.029 | 0.131 | 0.174 | 0.189 | 0.180 | 0.171 | 0.186 | 0.188 |
| Sodium | (Na) | meq/l | 0.134 | 0.134 | 0.136 | 0.139 | 0.142 | 0.283 | 0.291 | 0.215 | 0.290 | 0.296 | 0.228 | 0.231 |
| Calcium | (Ca) | meq/l | 0.22 | 0.18 | 0.36 | 0.40 | 0.44 | 0.16 | 0.12 | 0.14 | 0.18 | 0.14 | 0.20 | 0.14 |
| Magnesium | (Mg) | meq/l | 0.10 | 0.12 | 0.18 | 0.28 | 0.28 | 0.02 | 0.08 | 0.04 | 0.02 | 0.02 | 0.10 | 0.08 |
| Iron | (Fe) | meq/l | 0.36 | 0.09 | 0.09 | 0.02 | 0.06 | 0.03 | 0.04 | 0.06 | 0.01 | 0.03 | 0.0 | 0.01 |
| Manganese | (Mn) | mg/l | 0.16 | 0.09 | 0.20 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.01 |
| Nitrogen total | | mg/l | 0.18 | 0.22 | 0.11 | 0.12 | 0.11 | 0.21 | 0.28 | 0.31 | 0.34 | 0.36 | 0.22 | 0.34 |
| A | | | | | | | | | | | | | | |
| Chloride | (Cl) | meq/l | 0.21 | 0.21 | 0.18 | 0.28 | 0.31 | 0.14 | 0.13 | 0.16 | 0.14 | 0.12 | 0.14 | 0.15 |
| Sulphate | (SO4) | meq/l | 0.08 | 0.08 | 0.13 | 0.17 | 0.19 | 0.11 | 0.08 | 0.15 | 0.13 | 0.11 | 0.13 | 0.13 |
| Phosphate | (PO4) | meq/l | - | - | - | - | - | - | - | - | - | - | - | - |
| Bicarbonate | (HCO3) | meq/l | 0.80 | 0.80 | 0.80 | 1.20 | 0.70 | 1.10 | 0.61 | 0.45 | 0.70 | 0.45 | 0.55 | 0.51 |
| Carbonate | (CO3) | meq/l | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Copper | (Cu) | mg/l | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cadmium | (Cd) | mg/l | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Chromium | (Cr) | mg/l | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lead | (Pb) | mg/l | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Zinc | (Zn) | mg/l | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Phosphor | (P) | mg/l | 0.08 | 0.08 | 0.07 | 0.07 | 0.06 | 0.11 | 0.12 | 0.07 | 0.07 | 0.06 | 0.11 | 0.10 |
| Silicon | (Si) | mg/l | 9.34 | 9.08 | 8.02 | 8.09 | 10.04 | 7.91 | 7.60 | 8.28 | 8.46 | 8.33 | 3.81 | 6.47 |

Note, -: No Analysis
As for location of sampling, refer to Fig. 3.47.

Table 4.6 Water Quality of Lake Toba

| | | Haranggaol | Parapat | Porsea |
|---|---|---|---|---|
| Air Temperature, °C | | 26.5 | 26.0 | 26.5 |
| Water Temperature, °C | | 25.6 | 26.0 | 27.0 |
| PH | | 8.2 | 8.2 | 8.2 |
| Total Dissolved Solid, mg/l | | 70 | 92 | 117 |
| $CaCO_3$, mg/l | | 58.4 | 58.8 | 59.8 |
| $MgCO_3$, " | | 15.2 | 12.5 | 15.5 |
| Conductivity, $\mu$mhos/cm | | 143 | 160 | 155 |
| DO, | ppm | 7.0 | 6.33 | 8.47 |
| BOD, | " | 0.53 | 3.08 | 1.09 |
| COD, | " | 1.90 | 1.37 | 0.81 |
| Free $CO_2$, | " | 2.36 | 2.15 | 1.37 |
| $HCO_3^-$, | " | 93.95 | 94.61 | 91.32 |
| OD, | " | 0.92 | 0.67 | 0.53 |
| $Ca^{++}$, | mg/l | 14.9 | 16.6 | 15.3 |
| $Mg^{++}$, | " | 4.38 | 3.60 | 4.47 |
| $Cl^-$, | " | 7.83 | 7.05 | 9.07 |
| $SO_4^{--}$, | " | 0.10 | 0.15 | 0.14 |
| $NO_3^-$, | " | - | - | - |
| $HCO_3^-$, | " | 139.7 | 138.8 | 114.0 |
| $Fe^{+++}$, | " | 0.08 | 0.05 | 0.19 |
| $NH_4$, | " | - | - | 0.12 |
| $PO_4^{--}$, | " | 0.33 | 0.33 | 1.20 |
| $SiO_2$, | " | 2.9 | 2.9 | 12.37 |

Source: See foot note on page 54.

Table 5.1 Estimated Unit Construction Cost

| Work Item | Unit | Local Currency (Rp) | Foreign Currency (US$) | Equivalent Total (Rp) | Remarks |
|---|---|---|---|---|---|
| Clearing (1) | sq m | 20 | 0.04 | 65 | |
| Clearing (2) | sq m | 250 | 0.68 | 1,000 | for bush area |
| Excavation | cu m | 680 | 2.56 | 3,500 | |
| Dredging | cu m | 1,050 | 4.05 | 5,500 | |
| Embankment (1) | cu m | 560 | 1.31 | 2,000 | |
| Embankment (2) | cu m | 870 | 2.49 | 3,600 | for Lebah river |
| Wet masonry | cu m | 54,700 | 17.43 | 73,870 | |
| Crib | m | 83,400 | 151.45 | 250,000 | |
| Culvert (1) | nos. | $16 \times 10^6$ | 21,800 | $40 \times 10^6$ | b x h=1.5m x1.5m |
| Culvert (2) | nos. | $24 \times 10^6$ | 32,700 | $60 \times 10^6$ | b x h=2.0m x2.5m |
| Culvert (3) | nos. | $40 \times 10^6$ | 54,500 | $100 \times 10^6$ | b x h=2.0m x2.5m x2 |
| Concrete work | cu m | 49,600 | 5.76 | 55,900 | |
| Form work | sq m | 8,200 | 4.87 | 13,560 | |
| Bar work | ton | 66,000 | 717.00 | 854,700 | |
| Excavation | cu m | 230 | 0.98 | 1,310 | for structure |
| Back fill | cu m | 280 | 1.22 | 1,620 | - do - |

Note : (1) Price level in March 1985 is adopted.

(2) Exchange rate : US$ 1 = Rp 1,100 = Japanese ¥ 250.