2.3. Improvement Plan of Irrigation and Drainage.

2.3.1. Basic Concept of the Plan.

The production of foodstuff, with emphasis on rice, is still insufficient to meet regional or national demand due to rapid increase of population and of per-capita consumption of rice. It is forecasted that shortage of rice will also occur in North Sumatra Province in the near future as described in 2.3.3.

In the project area, there are many constraints against rice production. Among them, major constraints are lack of irrigation water during dry season, poor drainage conditions, floodings and improper farm management. Plans for improvement of irrigation and drainage in this study was formulated to eliminate these constraints and to increase rice production under introduction of improved irrigation farming. This project is principally considered to be an overall plan for improvement of the Ular river in a broad sense; hence it is not taken into consideration to divert the discharge of the Ular river to any basin of other rivers and vice versa. The project area has no room to be newly reclamed and in estate lands, crop diversification to paddy faces some difficulties under the present situation. Consequently, the existing paddy fields will become the objective area for plan of irrigation, and this plan would focus its attention on a work to convert the existing paddy fields to technical irrigation area to promise double cropping of paddy per year instead of the present low rate (less than 25 %) of double cropping of paddy.

Water resources for irrigation of the objective area will entirely depend on the Ular river because the river has relatively sufficient discharge throughout the year. From this point of view, no construction of reservoir for irrigation purpose is needed as already mentioned in the Overall Plan Study.

For improvement of irrigation, two ways will be considered in this case. One is a way to provide irrigation water utilizing as many existing intakes as possible, and the other is a way to provide it through a new weir which may be constructed a little upstream of Serbajadi Bridge unifying the existing intakes.

As for the former way, most of the existing intakes have recently constructed or rehabilitated after 1970. In addition, five existing intakes out of thirteen in total have sufficient capacities if only some improvement is made in the related irrigation canals and the remaining eight intakes will be able to provide economically sufficient irrigation water if the intakes are enlarged or small intakes are supplementally installed.

On the other hand, a new unifying weir will surely be able to supply irrigation water more stably and make it easy to control sand sedimentation. However, for construction of the new weir, two major problems will be considered. One is the problem of fund and the other is the problem of influence upon the existing social condition.

If a new weir is constructed at a point upstream of Serbajadi Bridge, much amount of fund will be required, especially by reason that (1) this weir must be of a movable-type with a view of enabling it easy to flush out sands deposited upstream of the weir, (2) the treatment of foundation of the weir will need much cost by reason that this area is an alluvial fan, and, at the same time, some strong bed-protection works will be required on the river bed closely downstream of the weir by reason that the river bed is composed of five materials; furthermore, careful and incessant maintenance works will be needed after the completion of the weir, (3) new canals will have to be constructed to connect the new weir with the existing irrigation canals, and (4) the paddy fields located upstream of Serbajadi Bridge will be affected by the back-water of the weir.

For reference, rough estimation was made of construction cost of a fixed weir equipped with sand-flushing facilities and a canal connecting the weir with the existing irrigation canals. In estimating the cost,

(a) the site of the weir was located at a point about 700 m upstream of Serbajadi Bridge,

(b) the topographical map of 1/10,000 drawn by JICA in 1978 was used,

(c) river cross-section at the weir site was assumed on the basis of a cross-section measured by the Feasibility Study Team near Serbajadi Bridge, and

(d) the height of the weir was assumed at about 1.5 m above the existing river bed and 10-meter-long wooden pile foundation was assumed.

The cost roughly worked out at Rp 3,000,000,000. This cost mounts up to eight times as much as that of the improvement works of the existing intake facilities.

From the standpoint of cost mentioned above and from the viewpoint that any change in irrigation system which will accrue from construction of a new unifying weir will exert a serious influence upon the existing social condition, the plan should be made so that the existing intake facilities may be utilized as much as possible.

2.3.2. Agricultural Development Plan.

(1) Land use and cropping pattern.

The project area mentioned in the paragraph 2.1.1 of Chapter II is shown in Fig.2-3-7. The area is 45,000 ha. From among this area, as mentioned previously, an area of irrigation and drainage, which comprises technical irrigation area of 3,000 ha, semi-technical irrigation area of 1,500 ha, non-technical area of 2,500 ha and rain-fed area of 11,500 ha excluding the coastal zone which is not suitable for cultivation mainly because of complicated topography and/or salt intrusion.

In this project area, there is no room for further reclamation; however, it is expected to turn all the paddy field into technically-irrigated paddy field which enables year-round irrigation farming after the implementation of construction of irrigation and drainage facilities as well as flood control works. Under these circumstances, rice cultivation was selected as the plan for agricultural development by the following reasons.

(a) The Indonesian Government is annually importing as much rice

as one million tons. In 1977/78, however, the Government will have to import approximately 2.4 million tons of rice spending about 640 million US dollars of foreign currency. Therefore, rice production is especially required for meeting the rapidly growing demand for foodstuffs as well as for saving the foreign currency.

(b) In North Sumatra Province, 0.12 million tons of rice is either imported or shifted from other provinces annually. It is furthermore forecasted that a shortage of 1.0 million tons of rice will occur in 2000. This indicates high marketing potentiality of rice in the future.

(c) Price of rice is relatively stable at present. It is expected that this trend will continue hereafter. The benefit cost evaluation has proved that rice production will highly be profitable.

(d) As described in the paragraph 2.2.5 of Section 2.2, most of farmers in the project area strongly want to cultivate double-cropping of paddy per year. Furthermore the farmers are very familiar with paddy cultivation.

The proposed cropping pattern as double-cropping of paddy per year is shown in Fig.2-3-1. Physiologically, there is no limitation of paddy seed germination due to the constant high temperature which indicates the possibility of seedling at any time. However, special attention should be paid to the increase in photosynthetic efficiency of paddy in order to increase rice production. The critical growth period for such efficiency is about 15 days before heading and 25 days after heading. Cropping pattern of paddy, therefore, should be prepared in such a way that the said period falls on the period of long duration of sunshine; and also attention should be paid to make havesting escape from rainy month. On the other hand, it is necessary to consider effective use of natural rainfall during puddling which requires much irrigation water.

Polowijo crops will not be cultivated in the project area because all the cultivation area can be improved for more profitable use through paddy production. Multi-cropping index in the project will rise to 2.0 from the present 1.3.

(2) Anticipated yield.

Unit yield of farm crops was estimated as regards both without-project condition in future and with-project condition in future.

The review of the data on historical production in North Sumatra Province and the related 7 Subdistricts revealed that no substantial increase in unit yield of agricultural production is found under the present farming condition. Table 2-3-1 shows the summary of trend in increase of production yield. As regards paddy, increase in rice production is expected to be only 0.06 ton per year. On the contrary, unit yield of upland crops except peanuts shows a decreasing tendency.

Taking into consideration the past trend of unit yield on the basis of paddy production in North Sumatra Province and assumed increase in input, unit yield of paddy on condition of without-project was estimated at 3.3 ton/ha on rain-fed area and 4.0 ton/ha on irrigated area respectively. As for upland crops, unit yield on without-project condition in future is not expected to increase. Therefore the present unit yield shall be applied.

On the other hand, future unit yield of paddy on with-project condition is expected to increase considerably through the introduction of improved-irrigation farming as recommended in the following paragraph. The future unit yield of paddy was estimated at 4.5 ton/ha on the basis of the experimental data obtained in the Provincial Seed Center established in Tanjung Morawa, International Rice Research Institute in the Philippines and the Bogor Agricultural Experimental Station as well as the data on well-irrigated land in the project area. During interviews with farmers on this occasion, an unit yield of paddy exceeding 6 ton/ha was observed. The yield was assumed to increase gradually from year to year and to reach its maximum in and after the seventh year after the introduction of improved irrigation farming.

The future unit yield on with- and without-project conditions are sumarized in Table 2-3-2.

(3) Farm input and farming practice.

In the project area, improved high-yielding varieties such as IR-series will be introduced. Proper application of fertilizers and agricultural chemicals is essential for the full exploitation of rice production for these high-yielding varieties under irrigation farming.

On with-project condition, the estimated total fertilizer requirement for paddy is 250 kg/ha of urea and 100 kg/ha of triple super phosphate respectively. As regards fertilization, split application of urea is practiced in order to increase rice yield and its heavy top-dressing is specially done in the late period of the young panicle formation stage. The total amount of super phosphate will be applied as basic dressing. As to the damages to rice, the disease caused by grassystant virus and hopperburn was conspicuous from 1973 to 1976. In addition, damages by rice borer are principally found. In due consideration of these aspects, 4 l/ha of insecticides such as Diazinon, Sumithion, Nogos etc. should be used. It is absolutely necessary to carry out joint prevention of plant deseases at the same time. Proper water management during the growing stage of paddy is also an important factor for attaining the target yield of rice. The required technics are the drying practice and application of deep or shallow water, etc. Table 2-3-3 shows the summary of design criteria of paddy cultivation technics.

It is expected, on the other hand, there will be no substantial change in input requirement for without-project condition in

future except some increase in fertilizer input. Input requirement for each crop on the without- and with-project conditions in future were estimated as shown in Tables 2-3-4 to 2-3-9.

(4) Agricultural production.

Agricultural production estimated for future without- and with-project conditions is summarized in Table 2-3-10. On with-project condition, production of paddy will increase to 166,500 tons or about two times of the expected production on without-project condition.

(5) Marketing and price prospects.

As described previously, the Government of Indonesia is annually importing about one million tons of rice, and in 1977/78 fiscal year, 2.4 million tons of rice will have to be imported. The shortage of rice in Indonesia seems to continue to some extent due to the increase in population together with increase in rice consumption per papita induced by raised living standard in the future. North Sumatra Province is also affected by shortage of rice. About 100,000 tons of rice are imported every year.

It was assumed in this study that the rice production in the project area would be marketed in the domestic market and future prospect of demand-supply condition of rice in North Sumatra Province would be as shown in Table 2-3-11.

For the period of 1980 to 2000, eight cases shown in Table 2-3-11 were considered to study the future prospect of demand-supply condition of rice in North Sumatra Province on the assumption that the rice production in the project area will be marketed in the domestic market.

It was assumed in the calculation of supply-demand balance of rice that annual rate of population growth, area cultivated and percapita consumption will continue during the said period. With regard to rice production forecast, annual increasing rate of rice (0.04 ton/ha of paddy or 0.024 ton/ha of rice) was estimated on the basis of historical data in North Sumatra Province. The anticipated unit yield of rice in the said period is shown in Table 2-3-12.

Although these projections were made on the basis of rather simple assumptions and comprison, the results suggest that the shortage of rice will continue in the future and will reach 238,000 tons at least and 1,045,000 tons at maximum in 2000. The estimated shortage of rice which may occur during the period of 1980 to 2000 is summarized in Table 2-3-13 and 2-3-14.

An increase of about 50,600 tons of rice or 84,300 tons of paddy can be expected at the stage of full development in the project area. This amount of increase will easily find its outlet in the domestic markets.

As regards prices of farm products in the future with project, the economic farm gate price for paddy was estimated at Rp 65/kg on the basis of the international market price considering the transportation, processing and other costs and expenses. Details are shown in Table 2-3-15.

2.3.3. Irrigation Plan.

(1) General.

As described in the paragraph 2.3.1, the irrigation plan for agricultural development in the project area is mainly to improve the existing irrigation systems and expand the technical irrigation area without the construction of special structures such as dam or weir.

Based on the results of survey of the existing irrigation intakes and of calculation of water level at intakes in future after the implementation of the river improvement works, it was concluded that Pulau Gambar, Swadaya, Perbaungan, Bendang and Romania intakes have respectively sufficient capacity to provide irrigation water to their command area if the irrigation canal systems are improved. The remaining intakes of Buluh, Timbang Deli, Sumber Rejo and Singosari, however, have respectively insufficient capacity for providing irrigation water even if their irrigation canal systems were improved. Table 2-3-16 shows the sizes of these intakes and the intake capacities estimated based on the relation between discharge and water level of the Ular as shown in Fig.2-3-2. Therefore, some measures must be considered to irrigate such area as is under the command of the intakes of insufficient capacity. For this purpose, the following three means were basically considered.

a. Improve the existing intakes by enlarging.

b. Supply irrigation water as supplement through the existing intake which has a sufficient capacity in such a way that irrigation water taken from Swadaya Intake, for example, is divided into the area of Buluh Intake by connecting them with a new canal.

c. Construct a new supplementary intake at a point located upstream of the existing one to supplement irrigation water through the new intake to the area under the command of the existing one to be left as it is.

In order to find the most economical system of diversion of irrigation water, the following six alternative plans were inquired into considering the combination of the above-mentioned means. The alternative plans are outlined below.

(a) Alternative Plan A.

Buluh, Timbang Deli and Suber Rejo Intakes shall be improved,

and Singosari Intake shall be constructed newly.

(b) Alternative Plan B.

Swadaya canals shall be improved for supplying water to Buluh. Bendang Intake shall be improved for supplying water to Singosari. Timbang Deli Intake shall be improved for supplying water to Timbang Deli and Sumber Rejo.

(c) Alternative Plan C.

Swadaya canals shall be improved for supplying water to Buluh. Timbang Deli Intake shall be improved for supplying water to Timbang Deli and Sumber Rejo. Singosari Intake shall be constructed newly.

(d) Alternative Plan D.

Swadaya canals shall be improved for supplying water to Buluh. A supplementary intake shall be constructed newly for supplying water to Timbang Deli and Sumber Rejo. Singosari Intake shall be constructed newly.

(e) Alternative Plan E.

Swadaya canals shall be improved for supplying water to Buluh. Timbang Deli and Sumber Rejo Intakes shall be improved. Singosari Intake shall be constructed newly.

(f) Alternative Plan F.

Swadaya canals shall be improved for supplying water to Buluh. Timbang Deli Intake shall be improved. A supplementary intake shall be newly constructed for Sumber Rejo. Singosari Intake shall be constructed newly.

Figs.2-3-3(1) to 2-3-3(6) show the diagrams of the above-menttioned 6 alternative plans for distributing irrigation water. For these plans construction costs were estimated as shown in Table 2-3-17. The costs are summarized below.

Alternative Plan A : Rp 210,000,000

Alternative Plan B : Rp 355,200,000

Alternative Plan C : Rp 349,400,000

Alternative Plan D : Rp 302,000,000

Alternative Plan E : Rp 199,800,000

Alternative Plan F : Rp 193,900,000

It is seen from the above comparison that the alternative plans A, E and F are favorable compared with the plans B, C and D from the viewpoint of construction cost. From the view point of operation and maintenance cost, no difference is found

among the plans of A.E and F. Therefore, Alternative Plan F was selected as the proposed plan.

(2) Water resources.

Discharge at the Serbajadi gaging station located near Pulau Gambar Intake is available for study of irrigation plan. This station has a catchment area of 1,030.6 km^2. Since there is scarcely residual catchment area between Serbajadi and the river mouth of the Ular, river discharge in time of drought is regarded to decrease gradually downstream in proportion to quantity of intake discharge.

In Indonesia, irrigation plan is usually formulated on the basis of drought discharge of a probability 1 in 5 years. On the occasion of this study, however, discharges at Serbajadi are observed only for three and half years and no distinct correlation is found between the river discharge and the areal rainfall on the catchment area. It is therefore almost impossible to calculate discharge in probability. Hence ten-day discharge system was adopted to formulate the irrigation plan.

By use of the past records of discharges, comparison was made between the ten-day discharges and the total diversion requirements. This is shown in Fig.2-3-4. In all the past records shown in Fig.2-3-4, the total water requirement for diversion in every ten-day is smaller than the ten-day river discharge in the same period. The minimum difference between them was 18.7 m^3/s in the first ten-day of August in 1972, and the river discharge in this ten-day was 30.6 m^3/s which was the minimum river discharge near Pulau Gamber Intake. Though the period of past records of river discharges is still as short as only more than 3 years, the above-mentioned comparison suggests that the Ular river has comparatively sufficient discharge for supplying irrigation water.

(3) Irrigation water requirement.

Irrigation water requirement for the project was estimated based on the cropping pattern mentioned in the paragraph 2.3.2 and the proposed irrigation area. No measurement data on consumptive use of water by crops are available in the project area so far. The consumptive use of water by crops was then estimated by applying computation method using the climatological data mentioned in Table 2-1-4.

The calculation was made in accordance with the following procedures.

a. Computation of reference crop evapotranspiration, ET_o,

b. Calculation of consumptive use of water by crop.

c. Add percolation rate, water for field preparation and water

for nursery bed to the consuptive use.

d. Subtract effective rainfall from the water requirement computed above.

e. Taking account of the farm waste and conveyance losses, the irrigation water requirement can be obtained.

(i) Reference crop evapotranspiration, ET_o.

There popular methods were adopted to estimate the reference crop evapotranspiration, ET_o, defined as "the rate of evapotranspiration from an extended surface of 8 to 15 cm tall green grass cover of uniform height, actively growing, completely shading the ground and not short of water". The Blaney Criddle method and the Radiation method are extremely popular and well developed. /1 The modified Penman method is introduced in Nedeco-Prosida Series-B./2

(a) Blaney-Criddle Method.

The Blaney-Criddle equation is expressed as follows.

$$f = p(0.46t + 8.13)$$

where f : consumptive use factor (mm),

p : mean daily percentage of annual daytime hours,

t : daily mean temperature (°C).

Taking account of the general levels of climate, namely, humidity, sunshine and wind, ET_o is estimated from linear relationship between the f factor and ET_o.

$$ET_o = b \cdot f + a$$

where a,b : coefficient which depend on minimum relative humidity, ratio of actual to maximum possible sunshine hours and daytime wind velocity.

The calculation procedure and results are shown in Table 2-3-18.

(b) Radiation Method.

The relationship suggested to calculate ET_o from temperature and radiation data is as follows.

/1 "Crop water requirements" published by FAO.

/2 "Assesment of irrigation water requirements (Possibilities of standardization)", August 1972, NEDECO-PROSIDA.

$$ET_o = a + b \cdot w \cdot R_s$$

where R_s : solar radiation expressed in equivalent evaporation (mm/day),

w : weighting factor which depends on temperature and altitude,

a,b : coefficient which depand on mean relative humidity and daytime wind velocity.

The calculation procedure and results are shown in Table 2-3-19.

(c) Modified Penman Method.

The original Penman method (1948) for the calculation of evaporation from an open water surface using meteorological data is modified for the calculation of evaporation with an albedo of 0.25 for a green grass, as ET_o. The modified Penman formula is as follows.

$$E_{gr} = \frac{\Delta(H_{nt}^{sh} - H_{nt}^{lo})/L + \gamma E_a}{\Delta + \gamma/\alpha}$$

where E_{gr} : reference crop evaporation, ET_o (mm per 24 hr),

H_{nt}^{sh} : net short-wave radiation (Langleys per 24 hr).

H_{nt}^{lo} : net long-wave radiation (Langleys per 24 hr),

E_a : evaporation computed from the aerodynamic equation, assuming the surface temperature to be equal to the air temperature (mm per 24 hr),

L : latent heat of vaporization (Langleys per mm),

Δ : slope of saturated vapor pressure vs. temperature curve at temperature of the air (mm Hg per °C),

γ : a factor, called the psychrometer constant, which is defined by Bawen's dimensionless ratio (0.49 mm Hg per °C), and

α : a factor representing the stomatal diffusion resistance. A value of 0.7 has been used in the computation of the evaporation index.

Applying the climatological data to the formula, ET_o was estimated as shown in Table 2-3-20./1

(d) Determination of ET_o.

The result of calculation by the three methods are summarized as follows and shown in Fig.2-3-5 comparing with actual evaporation record.

mm/day

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Blaney-Criddle	2.8	2.9	2.9	3.1	3.1	3.1	3.1	3.1	3.0	2.9	2.8	2.8
Radiation	2.9	3.1	3.2	3.2	3.1	3.0	3.0	3.1	2.9	2.9	2.6	2.6
M. Penman	2.9	3.2	3.3	3.3	3.2	3.0	3.1	3.2	3.0	3.0	2.6	2.7
Evaporation	2.0	2.5	2.4	2.2	2.1	2.3	2.4	2.0	1.7	1.7	1.7	1.8

The modified Penman method is one of the few methods that are based on a sound physical model. The fluctuation of ET_o by the modified Penman formula has a better similar appearance of recorded evaporation than other methods. Therefore, ET_o calculated by the modified Penman methods is applied to the calculation of water requirement of the project.

mm/day

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ET_o	2.9	3.2	3.3	3.3	3.2	3.0	3.1	3.2	3.0	3.0	2.6	2.7

(ii) Consumptive use of water by crop, ET.

Consumptive use of water by crop, ET, is obtained by multiplying crop factor (K_c) by ET_o. Crop factors are well derived from the measured ET data and calculated ET_o by the modified Penman formula at several experimental stations in Indonesia. K_c as recommended value is expressed as a percentage of total growing season as shown in Fig.2-3-6.

Value of crop factor, K_c	Growing stage
1.08	at 10 % of the growing season
1.18	20 "
1.27	30 "
1.37	40 "
1.40	50 "
1.33	60 "
1.23	70 "
1.13	80 "
1.02	90 "
0.92	100 "

/1 "Computation of irrigation requirement for wet sawah paddy", September 1973, NEDECO-PROSIDA.

During the last two weeks before harvest of crop, no irrigation water is supplied, since the existing water layer and water available in the soil will meet the evapolation of the crop. For convenience, it is proposed to use a crop factor of 0 for this period.

Adopting these values, crop factor for the project is determined on each 10 days.

	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th
K_c	1.08	1.17	1.25	1.33	1.40	1.40	1.33	1.24	1.15	1.05	0

ET for the proposed paddy cultivation is summarized below and calculations are detailed in Tables 2-3-28 and 2-3-29.

ET for Paddy

mm/day

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet season	4.0	4.4	4.4	3.5							3.0	3.8
Dry season				3.6	4.3	4.2	4.3	4.4	3.5			

(iii) Rate percolation.

Some portion of irrigation water requirement is occupied by inevitable loss of water due to percolation as free water is kept on paddy fields for the greater part of the growing period of paddy. Amount of percolation in paddy fields depends on permeability of soil layer, ground water table, and water level on the fields. Taking account of the general conditions of those factors in the project area, the rate of percolation was estimated as below.

3 mm/day from January to August.

2 mm/day from September to December.

(iv) Water required for field percolation and nursery bed.

The quantity of water required for field preparation work in paddy field is theoretically assessed by soil depth to be saturated and its porosity. Field tests revealed that solid portion of soil was 38 % and its porosity was 62 %. These results were applied to water requirement for field preparation, then the porosity of soil to be saturated by field preparation work was assumed to be 37 % for dry season paddy, 33 % for wet season paddy respectively. Further, depth of soil to be saturated was assumed at about 30 cm and the

submergence depth of water after preparation was assumed at 10 cm.

Dry season paddy : 300 × 0.37 + 100 = 210 mm.

Wet season paddy : 300 × 0.3 + 100 = 200 mm.

Water needed for preparation of nursery bed is almost the same as estimated above. ET for nursery plants is similar to that for plants after transplanted. The area covered by nursery bed is approximately 5 % of the gross area. Net irrigation requirements for nursery beds are shown in Tables 2-3-21 and 2-3-22.

(v) Effective rainfall.

The following rainfall records were used in the calculation of effective rainfall. The locations of these rain-gage stations are shown in Fig.2-1-2.

Station	Calender year
Batang Kwis	1956 to 1970
Kwala Namu	1956 to 1970
Delimuda	1956 to 1970
Melati	1956 to 1970
Perdaus	1956 to 1970
Adolina III/IV	1956 to 1970

The effective rainfall available for the consumptive use of water during the growing period of crops takes different amount from month to month and from year to year. In case of paddy cultivation with flooding irrigation, rainfall will be stored in the field. The following conditions were applied to the calculation of effective rainfall.

a. Effective rainfall is calculated every ten-day period.

b. From January to August, the amount of consumptive use of water and rate of percolation was estimated at about 7 mm/day as mentioned before. Consequently, ten-day rainfall below 70 mm is all effective and the excess beyond 70 mm is all effective and the excess beyond 70 mm is ineffective for paddy.

c. From September to December, in the same way, ten-day rainfall below 50 mm is all effective and the excess beyond 50 mm is ineffective.

On the above assumption, calculations were made, of which

a sample is shown in Table 2-3-23. From the results of calculations, the efficiency of the annual rainfall is estimated at 70 % of annual rainfall. The distribution of ten-day effective rainfall is shown in Table 2-3-24.

As for effective rainfall in drought year, a probability analysis was made on annual rainfall for obtaining once-in-5-year drought rainfall. Table 2-3-25 shows annual rainfall at the seven stations mentioned before. The Gumbel method was applied for determining the frequency distribution of rainfall at each station. The results are shown in Table 2-3-26. The average of the above probable rainfall was adopted as the design rainfall.

Applying the efficiency of annual rainfall to the design rainfall, the dependable effective rainfall was estimated at 956 mm annually. Effective rainfall in each 10-day period was calculated as shown in Table 2-3-27.

(vi) Diversion irrigation requirement.

(a) Farm waste.

Farm waste on paddy field as well as a certain surface runoff and horizontal percolation was assumed at 10 % on the average of field irrigation water.

(b) Conveyance losses.

Conveyance losses primarily result from three cases; (1) seepage in canals and ditches, (2) leakage through and around head gates and other canal structure and (3) evaporation from water surface and consumptive use of phreatophytes. Large losses due to seepage will be assumed since earthen type canals are proposed for the project. Besides, certain gate-operation losses from the respective turnout should be taken into account. Considering those conditions, conveyance losses were assumed at 30 % on the average of diversion water.

Taking account of the farm waste and conveyance losses mentioned above, diversion irrigation requirement for each ten-day period was estimated as shown in Tables 2-3-28 and 2-3-29. For the cropping area of 18,500 ha, peak diversion water requirement was calculated at about 20.7 m^3/s which occurs on the first ten-day in February as shown in Table 2-3-30.

(4) Irrigation systems.

It was planned that ten intakes feed the irrigation systems in the project area totaling 18,500 ha. Based on the result of alternative study described in 2.3.3,(1), it was proposed to improve or newly construct three intakes.

Timbang Deli Intake shall be improved by only enlarging

the width of the existing intake to assure the total diversion water requirement. As for the Sumber Rejo area, for expanding the irrigation area from the existing 800 ha to 2,700 ha, it was proposed to newly construct a supplementary intake at a point 1.1 km upstream of the existing intake. As for Singosari Intake, it was proposed to construct a new intake unifying the existing five small intakes situated on the right bank of the lower reaches of the Ular. The remaining intakes of Pulau Gambar, Swadaya, Buluh, Perbaungan, Bendang and Romania have no necessity for improvement.

Fig.2-3-7 shows the proposed irrigation systems in the project area and Fig.2-3-8 shows the diagram of distribution system of irrigation water to be taken from the Ular river during the first ten days of February when the intakes will take the maximum discharge of 20.7 m^3/s in total and the river has a ten-day discharge of 44.7 m^3/s. However, as seen in Fig.2-3-4, the minimum difference between the total diversion requirement and ten-day discharge appears in the first ten-day period of August. The amount of the total diversion requirement in the first ten-day period of August in 1972 is 11.9 m^3/s, the ten-day discharge of the Ular river is 30.6 m^3/s and their difference is 18.7 m^3/s.

In planning the method for drawing irrigation water from the Ular river, it was decided, from the viewpoint that the existing intakes should be utilized as much as possible, to adopt the free-intake system with approach channel which is at present employed for almost all the existing intakes. In this case, it may be supposed that the approach canals will have some sand deposits after flood. It was planned, in this study, to remove the sediment however, on the occasion of the detailed design, it is desirable to make a precise study on a countermeasure for preventing sediment from entering into the approach canals or intakes.

2.3.4. Drainage Plan.

(1) General.

The drainage basin forms a flat alluvial plain with a relatively steep gradient of 1/600 - 1/1,200, sloping south to north. Based on the topography of the Project area and its neighborhood, the drainage basin for the project was demarcated at 55,000 ha including a south-western basin covered by S. Sialang and S. Kataran Batu. There are two different drainage conditions. One type is the plantation area and the other is non-plantation area. The plantation areas have well developed and maintained drainage system, however non-plantation areas have poor drainage system.

There are scarcely serious problems caused by sub-surface water. Hence the drainage of surface runoff caused by intensive spot rainfall should be taken into consideration as the main

part of drainage problem. From the economical viewpoint, natural rivers and the existing drainage canals must be employed as much as possible.

Most of the proposed irrigable area are higher than high tide level. However, salt intrusion may be seen in some places when an extraordinary high tide occurs. In order to prevent this salt intrusion into drainage canal, provision of flapgates is recommendable.

Inundation troubles are frequently caused especially in the eastern part of the project area by insufficient flow capacity of crossing structures of the national highway and railway and lack of collector drains. To solve this problem, it must be considered to improve and newly construct crossing structures and excavate collector drains.

(2) Drainage Water Requirement.

Surface drainage discharge is estimated by use of the PROSIDA method/1 applying estimated design rainfall to this formula.

(i) Design rainfall.

For calculation of design rainfall, annual maximum one-day rainfall and 2-day rainfall were picked out from among rainfall data obtained in the period of 1949 to 1977 at each of 22 rain-gauge stations as shown in Table 2-3-31. Using these data, probable rainfalls of 5-year return period were estimated by the Gumbel method for each station. The values are shown in Table 2-3-32.

Non-weighted mean value of these probable point rainfalls was adopted as the design rainfall for calculation of surface drainage discharge. Weighted mean was not adopted because of unevenness of distribution of rain-gauge stations. The average rainfalls are

139.6 mm for one-day rainfall,

161.7 mm for two-day rainfall.

In a similar way, average probable rainfall for 2-year, 10-year and 20-year return periods were calculated. By plotting these values, the relations between duration and rainfall were obtained as shown in Fig.2-3-9. From this figure, 1-hour rainfall and 4-day rainfall of 5-year return period were estimated at 71 mm and 187 mm, respectively.

/1 "Rehabilitation of drainage system facilities series-A projects" Part I - Requirements and criteria, prepared for Directorate of Water Resources PROSIDA

On the other hand, the PROSIDA formulas give the following rainfalls.

One hour rainfall $i = 0.6 \times R(24) = 0.6 \times 139.6 = 84$ mm

4-day rainfall $i = 1.75 \times R(24)-50 = 1.75 \times 139.6 - 50 = 194$ mm

The above values calculated by the PROSIDA formulas coincide with those estimated from Fig.2-3-9.

(ii) Surface drainage discharge.

The PROSIDA proposes that surface runoff from agricultural land can be obtained as a sum of runoffs estimated by the following two formulas.

a. Runoff from paddy field.

Rational formula is applied.

$$Q_1 = 1.25 \times \frac{C_1 \times i_m \times A_1}{T}$$

where Q_1 is runoff from paddy field (m^3/s), C_1 is coefficient of runoff, i_m is amount of design rainfall in 4 days (m), A_1 is area of paddy field (m^2), T is duration of drainage (sec) and 1.25 is peaking factor.

b. Runoff from drainage area comprising villages, roads and non-agricultural land.

Empirical formula of Mcmath is applied.

$$Q_2 = 0.023 \times C_2 \times i \times A_2^{4/5} \times S^{1/5}$$

where Q_2 is runoff from drainage area (m^3/s), C_2 is coefficient of runoff, A_2 is drainage area (ha), i is design intensity of rainfall (cm/hr) and S is average ground slope of drainage area.

c. Total surface runoff.

$$Q = 1.15 \ (Q_1 + Q_2)$$

where Q is total surface runoff (m^3/s) and 1.15 is allowance for flow capacity. In calculation total surface runoff, the following conditions were taken into consideration.

a. In general, rice plant is allowed to submerge without undue damage for a period of less than 3 or 4 days. In this case, the top of plant must be exposed by 15 cm at least above the

water surface within a period of not more than 4 days. Considering this condition, duration of drainage (T) must be 4 days at maximum.

b. Design 4-day rainfall (i_m) is estimated by the following formula.

$$i_m = (1.75 \times R_{24} - 50) \times \alpha$$

where R_{24} is maximum daily rainfall on the probability base.

c. Hourly intensity of design rainfall is estimated to be 60 % of the maximum daily rainfall.

$$i = 0.60 \times R_{24} \times \alpha$$

d. Adjustment factor between point intensity and average intensity over a large area, α in percent is shown in the following table and shown in Fig.2-3-10.

Area	% of Point rainfall
50 ha	100
100	100
500	98
1,000	96
2,000	93
5,000	90

Surface runoff was calculated applying the following values.

a. Probable one-day rainfall of 5-year return period.

$$R_{24}(1/5) = 139.6 \text{ mm}$$

b. Runoff coefficients.

$$C_1 = 0.9 \quad \text{and} \quad C_2 = 0.6$$

c. The surface gradient was assumed to be 0.0015.

d. The ratio of paddy field to other area was measured using the topographic map on a scale of 1/10,000.

Table 2-3-33 and Fig.2-3-11 show the calculated relationship between surface drainage discharge and drainage area with a parameter of ratio of paddy field.

(3) Drainage system.

Drainage system was planned on the basis of the following conditions.

a. The drainage system should have a sufficient flow capacity to protect land from 5-year storm.

b. The drainage system should have as many drainage canals as possible separately from those for irrigation so far as it is practicable.

c. In principle, it is desirable to work out a drainage plan on an unit of several hundred hectares.

Based on the above concept of planning, the whole drainage basin was divided into ten blocks, every one of which has more than several drainage units. Many natural rivers are applied to main drainage canals and most of them must be widened to secure reasonable flow area. Natural and excavated streams are used for secondary drainage canals, and also most of them must be widened. The principal features of the proposed drainage systems are shown in Table 2-3-34 and Fig.2-3-12.

2.3.5. Proposed Irrigation and Drainage Works.

(1) Intakes and settling basins.

The proposed area of 18,500 ha for irrigation improvement is divided into 8 blocks by canal networks with 10 intakes. The irrigation blocks are shown in the following table.

Irrigation Blocks in the Project Area

Block	Area(ha)	Intake
Pulau Gambar	1,200	Pulau Gambar and Swadaya
Buluh	4,600	Buluh
Timbang Deli	400	Timbang Deli (improved)
Perbaungan	5,500	Perbaungan
Sumber Rejo	2,700	Sumber Rejo and a new one
Bendang	1,700	Bendang
Singosari	700	New Singosari
Ramonia	1,700	Ramonia
Total	18,500	

Out of the ten intakes mentioned above, three are improved or newly constructed. Timbang Deli Intake shall be improved by enlarging the width. Singosari and supplementary Sumber

Rejo Intakes shall be newly constructed. The principal dimensions of the three intakes are as follows.

Intake	Timbang Deli	Singosari	Supplementary Sumber Rejo
Type	Sluice	Sluice	Sluice
Width	0.75 m × 4 bays	1 m × 2 bays	1.20 m × 3 bays
Elevation of bed	32.60 m	12.10 m	18.50 m

As mentioned in 2.2.1, considerable amount of sand sediment are found near the intakes reducing the capacities of the canals and the intakes. In order tc prevent sediments from entering into the canals, settling basins should be provided at suitable places in the upstream reaches connecting with the intakes. The grain size of sands to be settled was assumed at 0.25 mm as a grain size which will not do harm to paddy field. Velocity in the basin was assumed at 0.15 m/s. Fig.2-3-13 shows the relationship between the length and the average water depth of a settling basin and Fig.2-3-14 shows the relationship between the width of settling basin and the intake discharge. The results of hydraulic calculations for intakes and settling basins of the ten intakes are shown in Table 2-3-35 and Fig.2-3-15(1) to (10).

(2) Irrigation canals and related structures.

(a) Irrigation canals.

The design discharges for main and secondary canals were fixed based on the calculated water requirements. Figs.2-3-16(1) to (8) show the canal networks and their design discharges. The profiles of canals were determined in consideration of topographical conditions and hydraulic requirements. The preliminary design of canals was carried out on the following conditions.

a. Type of canal.

All canals were designed as unlined earthen canals except the new canals in the plantation area, where concrete lining canals were proposed to prevent seepage from canals. However, the final decision of necessity of the lining is expected on the occasion of the detailed design.

b. Inside slope.

Inside slope of a canal depends on the stability of canal materials. Considering the existing condition of canals, slope was fixed at 1 : 1.

c. Freeboard.

Freeboard of a canal is usually determined in consideration of canal size, location, velocity, flood, wind action, etc. In this study, the following standard was adopted as a minimum freeboard.

Freeboard (m)	Discharge (m^3/s)
0.4	$Q < 1.0$
0.5	$1.0 \leq Q \leq 5.0$
0.6	$5.0 < Q$

d. Velocity.

The allowable maximum and minimum velocities were fixed as follows.

	Maximum(m/s)	Minimum(m/s)
Earthen canal	0.6	0.3
Concrete lining canal	1.5	0.3

e. Mean velocity formula.

The Manning formula is usually used for calculating discharge.

$$Q = AV$$

$$V = \frac{1}{n} R^{2/3} I^{1/2}$$

where Q is design discharge (m^3/s), A is cross-sectional area (m^2), V is velocity (m/s), R is hydraulic radius (cross-sectional area divided by wetted perimeter), I is slope os water surface and n is roughness coefficient (0.03 was adopted for earth canal and 0.015 was adopted for lining canal).

f. Standard cross section.

Standard cross sections for main, secondary and concrete lining canals are shown in Fig.2-3-17.

For the purpose of smooth supply of irrigation water, some modifications of the cross sections and slopes will be needed for the canals in the existing irrigated area. The rain-fed area and non-technical area coming under the project will have to be provided with new irrigation canals. As a result, canals

totaling 20.4 km in length shall be improved out of the total existing main canals 33.9 km in length. In addition, main irrigation canals totaling 2.6 km in length shall newly be constructed. With regard to secondary canals, the length totaling 51.5 km shall be improved out of the total existing length of 168.9 km. Besides, additional secondary canals of 158.5 km shall newly be constructed. Table 2-3-36 shows the results of hydraulic calculations for irrigation canals and Table 2-3-37 shows the details for the length of canals, classifying the canals into "not to be improved", "to be improved" and "to be newly constructed".

(b) Related structures.

Main and secondary canals cross tributaries, canals, roads and the railway thereunder at some places or thereover at other places, which requires many structures such as siphons, aqueducts and bridges. Measuring devices to be installed to diversion works are among the most important structures for proper water management, which must be a major key to attain the successful development of the project area. Check gates must also be provided to secure and keep the necessary water surface of the Buluh main canal. This canal shall be left as a dual-purpose canal for the purpose of both irrigation and drainage because the canal length is large and accordingly the separation will need a large amount of cost. Provision of drop works will be needed to prevent erosion at inside slopes of the canals. The related structures proposed here are shown in Table 2-3-37.

(3) Drainage canals and related structures.

(a) Drainage canals.

Profiles of canals were determined in consideration of topographic conditions and hydraulic requirements. Preliminary designs were carried out on the following conditions.

a. Type of canal.

Drainage canals are natural rivers or excavated earthen canals.

b. Inside slope.

Inside slope of canals was fixed to be 1 : 1 considering the results of soil-mechanical tests and the conditions of the existing canals.

c. Minimum freeboard.

Minimum freeboard was fixed at 20 cm.

d. Maximum velocity.

Maximum velocity was fixed at 0.9 m/s.

e. Mean velocity formula.

The Manning formula was used to calculate mean velocity, where a value of 0.03 was adopted for coefficient of roughness.

On the above-mentioned conditions, preliminary designs were carried out of the main canals totaling 195 km including 125 km to be improved and the secondary canals totaling 136 km in length. Particulars of the proposed drainage canals are shown in Table 2-3-38 and some typical cross sections are shown in Fig.2-3-18.

(b) Related structures.

a. Bridges.

In case a canal passes under a road, a concrete bridge is proposed. The T-20 wheel loading is applied to the national highway and the T-9 loading shall be applied to other trunk roads. Respective widths shall be 7.0 m and 3.0 m. In case a canal passes under the railway, a girder bridge is recommended. The wheel loading shall be 15 ton.

b. Drops.

The upper reaches of canals are generally too steep to keep non-scouring velocity. In this case, drop structures are useful to decrease hydraulic energy.

c. Flap gates.

As mentioned in 2.3.4, (1), flap gates shall be constructed.

d. Cross syphons.

Circular concrete pipes would be adopted for small-size crossing works which will serve as secondary canals passing under farm roads.

Table 2-3-39 gives the summary of the related structures proposed here.

(4) Farm ditches and farm roads.

a. Farm ditches.

Optimal density of farm ditches was estimated at about 40 m/ha taking account of the sizes and general shapes of the farm-blocks into consideration and assuming that each farm-block will be equipped with a ditch at least on one side of it for equitable distribution of irrigation water.

b. Farm drains.

Suitable drainage facilities will serve for increasing the

productivity of soil. It can be assumed that each farm-block must have a drain at least on one side of it. From this viewpoint, the density of drains required for proper water management was estimated at 40 m/ha at minimum.

c. Farm roads.

For proper water management and effective farming practices, each farm-block must be provided with one accessible farm road. The necessary density of farm roads was estimated at about 30 m/ha.

Based on the above-mentioned principles and considering the present conditions of on-farm facilities, density of on-farm works in the project area was proposed as follows.

	Density per ha (m/ha)	
	Irrigated area	Rain-fed area
Farm ditch	20	40
Farm drain	20	40
Farm road	15	30

The total lengths of the proposed farm ditches, farm drains and farm roads are 600 km, 600 km and 450 km respectively. Table 2-3-40 shows the details in each irrigation block.

Table 2-1-1 SOIL PROFILE

SOIL PROFILE NO.1

LOCATION	Pagar Marbau II
LAND USE	Rainfed Paddy Field
Horizon	Description
I(A)(0-30 cm)	Dark brown, Sandy clay, Few, fine to medium mottles, Weak, fine to medium sub-angular blocky, Slightly plastic, Sticky
II(IIB)(30-40 cm)	Yellowish gray, Loamy clay, Few, fine to medium mottles, Weak fine to medium sub-angular blocky, Plastic, Sticky
III(IIIC)(40-50 cm)	Yellowish gray, Loamy sand, Few, medium to coarse mottles, Very weak sub-angular blocky, Non plastic, Non sticky
IV(IVC)(50-55 cm)	Yellowish gray, Clay loam to loamy clay, Few mottles, Medium to fine blocky, Plastic, Sticky
V(VC)(55-90 cm)	Yellowish gray, Clay loam to loamy clay, Prominent, fine to medium mottles, Medium to fine blocky, Plastic, Sticky
VI(VIG)(90 cm +)	Grayish blue, Loamy sand, Non mottles (G horizon), Very weak blocky

SOIL PROFILE NO.2

LOCATION	5 km north from Lubuk Pakam
LAND USE	Oil palm plantation
Horizon	Description
I(A)(0-15 cm)	Dark brown, Loamy clay, Medium to fine subangular blocky, Plastic, Sticky
II(B)(15-55 cm)	Grayish brown, Sandy clay to loam, Coarse sand spottly existed, Few, fine mottles, Medium sub-angular blocky, Plastic, Sticky
III(Bg)(55-100 cm)	Light gray, Loamy clay to Light clay, Fine to medium mottles, Weak, medium blocky, Plastic, Sticky.
IV(G)(100 cm +)	Bluish gray, Coarse sand

SOIL PROFILE NO.3

LOCATION	Kampung Sayur
LAND USE	Paddy field (Rainfed)
Horizon	Description
I(A)(0-15 cm)	Dark brown, Clay loam, Weak fine to medium sub-angular blocky, Slightly plastic, Slightly sticky
II(B)(15-25 cm)	Grayish brown, Clay loam, Many fine mottles, Medium sub-angular blocky, Slightly plastic, Slightly sticky, Mica
III(IIC)(25-75 cm)	Grayish brown, Coarse sand, Medium to coarse blocky, Non plastic, Non sticky, Mica
IV(IIIC)(75-85 cm)	Yellowish brown, Loamy sand, Prominent coarse mottles, structureless, Non plastic, Non sticky
V(G)(85 cm +)	Bluish gray, Coarse sand

SOIL PROFILE NO.4

LOCATION	Pantai Labu
LAND USE	Paddy Field (Rainfed) with Chilly cultivation
Horizon	Description
I(AG)(0-20 cm)	Dark brown, Heavy clay, Massive, Very plastic, Very sticky
II(G)(20-25 cm)	Yellowish gray, Heavy clay, Massive, Very Plastic, Very sticky.
II(G)(25-100 cm)	Grayish blue, Heavy clay, Massive, Very plastic, Very sticky

SOIL PROFILE NO.5

LOCATION	Pematang Biara
LAND USE	Paddy field (Rainfed)
Horizon	Description
I(AG)(0-20 cm)	Dark brown, Heavy clay, Massive, Very plastic, Very sticky
II(G)(60-90 cm)	Yellowish gray, Heavy clay, Massive, Very plastic, Very sticky
III(G)(90 cm +)	Bluish gray, Coarse sand (Coastal sand), Structureless

SOIL PROFILE NO.6

LOCATION	Pasar I Sidoardjo
LAND USE	Paddy Field
Horizon	Description
I(A)(0-30 cm)	Dark gray, Loam Clay, Weak sub-angular blocky, Plastic, Sticky
II(B)(30-55 cm)	Brownish gray, Loamy sand, Prominent, coarse mottles, Structureless, Non plastic, Non sticky
III(IICG)(55-100 cm)	Yellowish gray, Loam, Few mottles, Weak sub-angular blocky, Non plastic, Slightly sticky

SOIL PROFILE NO.7

LOCATION	Denai Lama
LAND USE	Upland (Sweet potatoes)
Horizon	Description
I(A)(0-15 cm)	Dark brown, Loam, Granular, Mica, Slightly plastic, Slightly sticky
II(B)(15-35 cm)	Yellowish brown, Loamy clay, Weak sub-angular blocky, Many fine mottles spotty gley mottles, Mica, Plastic, Sticky
III(Cg)(35-80 cm)	Yellowish brown, Loamy clay, Many fine mottles, Medium sub-angular blocky, Spotty gley mottles, Very plastic, Very sticky
IV(IICg)(80 cm +)	Yellowish brown, Coarse sand, Coarse prominent mottles, Structureless

SOIL PROFILE NO.8

LOCATION	Kota Pari
LAND USE	Paddy Field (Rainfed)
Horizon	Description
I(A)(0-20 cm)	Dark brown, Loamy clay
II(IIC)(20-50 cm)	Yellowish brown, Coarse sand to loamy sand, Structureless, Non Plastic, Non sticky
III(IIIC)(50-70 cm)	Grayish brown, Heavy clay, Few to many fine mottles, Massive, Very plastic, Very sticky
IV(IVC)(70-90 cm)	Grayish brown, Loam, Many medium mottles, Weak medium sub-angular blocky, Slightly plastic, Slightly sticky
V(VC)(90 cm -)	Yellowish gray, Heavy clay, Massive Very plastic, Very sticky

SOIL PROFILE NO.9

LOCATION	Kota Pari
LAND USE	Cassava Field
Horizon	Description
I(A)(0-35 cm)	Dark brown, Sandy clay, granular, Slightly plastic Slightly sticky
II(C)(35-100 cm)	Yellowish brown, Loamy sand (coastal sand), Structureless

(continued)

SOIL PROFILE NO.10

LOCATION: Sialang Bush
LAND USE: Paddy field (Swampy area)

Horizon	Description
I(AG)(0-30 cm)	Dark brown, Sandy clay, Weak subangular blocky Slightly plastic, Slightly sticky
II(G1)(30-60 cm)	Grayish blue, Heavy clay, Massive (marine deposited clay), Very plastic, Very sticky
III(IIG1)(60 cm +)	Grayish blue, Coarse sand, Structureless

SOIL PROFILE NO.11

LOCATION: Pinlaus
LAND USE: Oil palm plantation

Horizon	Description
I(A)(0-15 cm)	Dark brown, Sandy clay, Weak sub-angular blocky, Slightly plastic, Slightly sticky
II(B)(15-45 cm)	Yellowish brown, Sandy clay, (clay content increases with depth), Weak sub-angular blocky, Slightly plastic, Sticky
III(Bg)(45-110 cm)	Reddish brown, Light clay, Weak angular blocky, Very plastic, Very sticky, Coarse prominent mottles

SOIL PROFILE NO.12

LOCATION: Teluk Mengkudu
LAND USE: Paddy field (Rainfed)

Horizon	Description
I(AG)(0-30 cm)	Dark brown, Heavy clay, Massive, Very plastic, Very sticky
II(G)(30-85 cm)	Bluish gray, Heavy clay, Massive, Very plastic Very sticky
II(G1)(15-50 cm)	Yellowish gray, Sandy clay to loam, Weak sub-angular blocky, Slightly plastic, Sticky
III(G2)(50 cm +)	Grayish blue, Loamy sand, structureless, Non plastic, Non sticky

SOIL PROFILE NO.16

LOCATION: Pematang Sijonam
LAND USE: Paddy field

Horizon	Description
I(AG)(0-15 cm)	Dark brown, Loamy clay, Weak sub-angular blocky, Very plastic, Very sticky
II(B)(15-65 cm)	Yellowish brown, Loamy clay, Medium sub-angular blocky, Very plastic, Very sticky
III(B)(65-80 cm)	Yellow grayish brown, Sandy loam, Weak sub-angular blocky, Medium fine mottles, Slightly plastic, Slightly sticky
IV(G)(80 cm -)	Gray, Sandy loam, Structureless, Non plastic, Non sticky

SOIL PROFILE NO.13

LOCATION: Parit 12
LAND USE: Paddy field

Horizon	Description
I(AG)(0-20 cm)	Dark brown, Heavy clay, Massive, Very plastic Very sticky
II(G)(20-50 cm)	Bluish gray, Heavy clay, Massive, Very plastic, Very sticky

SOIL PROFILE NO.14

LOCATION: Tanah Merah
LAND USE: Paddy field

Horizon	Description
I(AG)(0-15 cm)	Dark brown, Sandy loam to loam, Weak sub-angular blocky, plastic, Sticky
II(G1)(15-30 cm)	Yellowish gray, Loamy clay to loam, Few fine mottle, Weak sub-angular blocky, Plastic, Sticky
III(IIG1)(30-65 cm)	Yellowish gray, Loamy sand, Very weak sub-angular blocky, plastic, sticky
IV(IIIG1)(65 cm -)	Yellowish gray, Loamy clay, Weak sub-angular blocky, Very plastic, Very stick

SOIL PROFILE NO.15

LOCATION: Kampong Baru
LAND USE: Paddy field

Horizon	Description
I(AG)(0-15 cm)	Dark brown, Sandy clay to loamy sand, Weak sub-angular blocky, Slightly plastic, Sticky

Table 2-1-2 Results of Soil Analysis

Analysis items / No. of Soil samples	pH (H_2O)	pH (Kcℓ)	Total carbon (%)	Total nitrogen (%)	C/N	Cation exchange capacity (me/100g)	Exchage cation (me/100g) Ca	Mg	K	Na	Total	Base saturation degree (%)
4 - II	7.5	5.8	0.61	0.07	9.3	36.5	10.0	20.8	0.84	2.62	34.3	94.0
4 - III	7.7	7.0	2.56	0.20	12.8	34.1	19.3	19.3	1.18	4.54	44.3	130.0
7 - II	6.8	4.9	0.67	0.07	9.1	19.0	7.73	1.84	0.16	1.68	11.4	60.1
7 - III	6.7	5.0	0.78	0.10	8	31.3	7.95	3.24	0.55	1.94	13.7	43.8
9 - I	6.3	4.8	0.83	0.09	9	12.9	5.21	1.23	0.33	1.03	7.8	60.5
9 - II	6.5	4.6	0.37	0.04	9	11.6	4.22	0.98	0.27	1.41	6.9	59.5
10 - I	6.4	5.1	0.74	0.06	12.2	8.38	4.18	3.36	0.06	0.61	8.2	98.0
10 - II	6.6	4.8	0.65	0.05	13	12.2	4.69	5.94	0.10	1.63	12.4	104.1
10 - III	6.8	4.9	0.59	0.04	14.3	18.2	6.22	9.95	0.20	2.50	18.9	103.8
11 - I	5.4	4.3	0.87	0.09	9.4	7.24	3.28	0.32	0.08	0.41	4.1	56.5
11 - II	5.5	4.3	0.63	0.07	8.7	8.55	2.84	0.32	0.08	0.10	3.3	39.1
11 - III	5.6	4.0	0.44	0.04	10	23.3	2.53	0.68	0.06	0.66	3.9	16.9
12 - I	6.5	4.05	1.76	0.20	8.9	32.7	9.11	9.61	0.21	2.86	21.8	66.7
12 - II	5.1	3.6	0.72	0.07	10.7	42.6	7.28	15.9	0.29	4.75	28.2	66.2
14 - I	5.5	4.0	1.36	0.14	10.1	15.6	4.78	1.64	0.20	1.46	8.1	51.8
14 - II	6.1	4.3	0.32	0.04	7.8	11.1	4.31	1.40	0.14	2.08	7.9	71.4
14 - III	5.8	3.9	0.34	0.04	8	19.6	4.83	1.84	0.20	2.73	9.6	49.0
16 - I	6.3	5.0	1.16	0.14	8.1	12.9	5.21	1.17	0.53	1.03	7.9	61.6
16 - II	6.1	3.9	0.41	0.05	8.0	12.5	6.22	1.04	0.53	2.08	9.9	79.0
16 - III	5.9	3.6	0.36	0.04	8.5	19.8	2.93	4.02	1.08	5.09	13.1	66.2

(continued)

Analysis items No. of Soil samples	Available P_2O_5 (mg/100g)	Available K_2O (mg/100g)	Free iron (Me_2O_3%)	Sulfide (Smg/100g)	Cℓ (mg/100g)	Soil texture	Soil particle distribution: Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)
4 - II	-	-	-	0.5	35.6	HC	2.5	7.7	34.6	55.2
4 - III	-	-	-	8.8	97.1	HC	1.2	9.1	38.1	51.6
7 - II	-	-	-	-	-	LiC	3.0	44.8	25.5	26.7
7 - III	-	-	-	-	-	LiC	2.4	14.0	40.6	43.0
9 - I	0.54	79.1	0.39	-	3.0	SCL	16.2	42.4	17.9	23.5
9 - II	-	-	-	-	4.1	SL	8.7	66.2	10.6	14.5
10 - I	0.83	9.7	0.09	0.5	3.1	SCL	77.3	1.6	1.6	19.5
10 - II	-	-	-	0.8	1.8	SCL	68.0	1.9	5.3	24.8
10 - III	-	-	-	2.0	2.6	LiC	46.3	2.0	10.4	41.3
11 - I	0.54	7.3	0.30	-	-	SL	56.9	13.2	10.1	19.8
11 - II	-	-	-	-	-	SC	48.1	16.0	2.3	33.6
11 - III	-	-	-	-	-	HC	29.0	10.0	13.0	48.0
12 - I	trace	15.8	0.04	1.3	2.4	HC	7.9	4.7	27.5	59.9
12 - II	-	-	-	0.3	2.7	HC	1.1	3.5	28.6	66.8
14 - I	0.33	59.9	0.09	-	-	LiC	30.6	20.7	16.5	32.2
14 - II	-	-	-	-	-	SC	25.0	31.9	13.3	29.8
14 - III	-	-	-	-	-	LiC	20.2	29.3	17.5	33.0
16 - I	3.33	61.8	0.17	-	-	LiC	5.5	40.3	22.5	31.7
16 - II	-	-	-	-	-	LiC	2.7	36.1	31.8	29.4
16 - III	-	-	-	-	-	LiC	5.4	27.9	30.7	36.0

Table 2-1-3 Results of Water Quality Test/1

No. of Sampling	Date of Sampling	Reaction* for $AgNO_3$	** EC	pH	*** Cl-	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
					ppm	
1	28th Nov.'77		0.38	8.3	55	well-water
2	do.		0.53	8.4	78	do.
3	do.		1.82	8.4	411	river water at low tide
4	do.		2.83	8.2	673	do.
5	do.		0.39	8.5	26	well-water
6	do.		0.10	8.0	84	canal water at low tide
7	do.		1.14	7.8	227	do.
8	do.	+	0.66	8.3	11	well-water
9	do.	+	0.24	8.4	14	do.
10	do.	+	0.46	7.8	100	water in paddy field
11	do.	+	0.16	7.6	24	do.
12	do.	+	0.20	7.6	28	do.
13	1st Dec.'77	+	18.98	7.8	5,891	fish pond-water
14	do.	+	0.22	7.7	31	river water at low tide
15	do.	+	0.20	7.6	30	do.
16	do.	+	0.19	7.6	20	water in paddy field
17	do.	+	0.16	7.6	25	river water at low tide
18	do.	+	2.53	8.4	74	water in paddy field
19	do.	+	0.36	7.8	74	do.
20	do.	+	8.22	8.0	2,376	river water at low tide

* 0.1 N- $AgNO_3$

** millimho/cm/25°C

*** part per million (ppm)

/1 Made by RISPA in Medan

(continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
21	1st Dec.'77	+	0.21	8.0	39	river water at low tide
22	do.	+	0.43	8.3	59	water in paddy field
23	do.	+	1.14	8.2	248	do.
24	2nd Dec.'77	+	0.30	7.1	47	river water at low tide
25	do.	+	0.31	7.6	56	do.
26	do.	+	0.21	7.7	30	well-water
27	do.	+	1.86	7.7	297	river water at low tide
28	do.	+	3.50	7.8	891	do.
29	do.	+	2.06	8.5	337	well-water
30	do.	+	0.42	8.2	96	river water at low tide
31	do.	+	1.54	7.6	376	do.
32	3rd Dec.'77	+	1.12	8.5	98	water in paddy field
33	do.	+	1.81	8.4	396	canal water
34	do.	+	3.29	8.2	792	water in swamp
35	do.	+	2.54	8.1	495	do.
36	do.	+	0.85	8.0	149	river water at low tide
37	do.	+	2.25	8.4	594	do.
38	do.	+	1.28	8.3	277	do.
39	do.	-	0.19	8.1	6	water in paddy field

Table 2-1-4 Climatological Data

Item	Unit	J	F	M	A	M	J	J	A	S	O	N	D	Year	Wet season	Dry season
Monthly rainfall	mm	145	89	117	141	156	139	140	173	220	289	251	196	2,056	1,274	782
Rainy days		8	5	7	8	9	7	8	10	12	14	13	10	111	67	44
Air temperature	°C	25.2	25.7	26.1	26.5	26.6	26.5	26.2	26.2	25.9	25.8	25.5	25.4	25.9	25.7	26.3
Relative humidity	%	87	84	84	86	86	87	86	86	88	88	89	89	87	88	86
Wind direction																
Calm	%	6	2	7	-	5	5	1	5	3	2	3	4	3.5	3.8	3.3
N	%	31	22	28	31	24	11	22	17	21	25	15	24	22.5	22.2	23.0
NE	%	47	67	56	60	58	70	58	58	64	57	62	52	59.5	57.7	61.5
E	%	-	-	1	3	4	3	6	5	9	6	-	-	3.3	3.3	2.8
SE	%	1	-	-	5	2	6	6	6	1	3	3	1	2.8	2.5	3.2
S	%	-	-	1	1	1	-	1	1		-	-	-	0.3	0.1	0.7
SW	%	-	1	4	-	4	2	2	2	-	3	-	1	1.5	1.0	2.2
W	%	6	1	-	-	-	-	1	1	-	-	-	4	1.1	1.8	0.3
NW	%	9	7	3	-	2	3	3	5	2	4	17	14	5.7	8.5	3.0
Wind velocity	m/sec	1.05	1.12	1.13	1.00	1.00	0.95	0.95	0.97	0.88	0.86	0.83	0.93	0.98	0.92	1.03
Sunshine duration	%	45	48	57	38	53	55	57	52	43	40	40	37	49	43	55
Solar radiation	cal/cm^2	367	386	398	394	380	371	382	386	366	364	332	331	371	358	385
Evaporation	mm	2.00	2.52	2.44	2.20	2.07	2.26	2.41	1.96	1.71	1.68	1.69	1.67	2.06	1.80	2.32

Remarks: Rainfall and rainy days are the average values of rainfall stations in the project area and another climatic items are applied by the data in Sampali meteorological station.

Table 2-1-5 Mean 10-Day Dsicharge at Pulau Tagor Station (Serbajadi Bridge) by DPMA

Unit: $m^3/sec.$

Month	Period	1971	1972	1973	1974	Average
	first		52.0	70.2	68.7	63.1
Jan.	middle		50.4	57.6	56.0	54.7
	last		57.5	49.8	56.7	54.7
	first		55.8	44.7	60.2	53.6
Feb.	middle		52.0	39.7	63.5	51.7
	last		48.4	39.6	57.1	48.4
	first		50.1	46.5	48.3	48.3
Mar.	middle		48.5	46.7	48.5	47.9
	last		47.5	60.3	46.7	51.5
	first		49.6	62.6	52.6	54.9
Apr.	middle		57.4	55.2	46.2	52.9
	last		63.7	56.9	45.6	55.4
	first		53.6	52.3	45.7	50.5
May	middle		61.2	48.0	54.2	54.5
	last		56.3	58.1	45.0	53.1
	first		51.3	73.6	45.2	56.7
Jun.	middle		52.8	48.4	40.3	47.2
	last		47.3	47.1	49.8	48.1
	first		40.6	45.9	40.7	42.4
Jul.	middle		38.8	44.5	47.4	43.6
	last		33.3	54.3	49.3	45.6
	first	51.0	30.6	48.6	49.1	44.8
Aug.	middle	60.1	30.4	46.4	44.6	45.4
	last	53.3	38.3	46.9	46.1	46.2
	first	52.4	38.8	48.5	55.8	48.9
Sep.	middle	69.9	46.6	57.8	64.1	59.6
	last	69.5	45.6	48.2	76.5	60.0
	first	54.2	54.8	46.5	75.8	57.8
Oct	middle	57.2	48.5	53.5	55.6	53.7
	last	58.1	58.0	79.5	52.6	62.1
	first	57.8	53.1	58.1	55.9	56.2
Nov.	middle	54.9	64.5	57.0	66.2	60.7
	last	51.8	76.6	61.0	66.5	64.0
	first	63.3	68.3	81.6	57.9	67.8
Dec.	middle	78.7	63.3	86.7	43.9	68.2
	last	66.0	55.9	96.4	45.8	66.0

Table 2-1-6 Results of Water Quality Analysis of Ular River Water

Item	Unit	Place of Sampling	
		Pulau Gamber	Bendang
PH		6.9	6.9
Total hardness	°D	1	1.4
Suspended matter	mg/L	354	351
Total solids	"	577	531
Permanganate value	"	454	414
Carbonates	"	-	-
Bicarbonate	"	37	37
Calcium	"	3.6	5.1
Magnesium	"	2.2	3.1
Sodium	"	6.0	5.0
Potassium	"	3.0	3.0
Iron	"	9	9
Manganese	"	0.1	0.2
Copper	"	-	-
Alminium	"	-	-
Silica	"	54	54
Lead	"	-	-
Arsenic	"	-	-
Ammonia	"	-	-
Albuminoid Nitrogen	"	-	-
Nitrates	"	-	-
Nitrites	"	-	-
Sulfides	"	-	-
Sulfates	"	12	12
Chlorides	"	-	-
Phosphate	"	5.4	5.4
Oxygen	"	7.8	7.6
Carbon dioxide	"	4.4	4.4
Electrical conductivity	million/cm/25°C	0.06	-

Table 2-1-7 Grain Size Distribution (Per cent by weight)

Location of Sampling	Specific Gravity	Size (mm) 2.00	0.84	0.42	0.25	0.149	0.074
Pulau Gamber							
1. Approach Canal A	2.28		99.1	96.0	91.8	73.9	46.2
2. Approach Canal B	2.27		98.7	94.4	92.0	87.2	80.6
3. After Intake	2.25		98.0	86.2	61.7	34.8	13.9
S. Buluh							
4. Approach Canal A	2.34		97.8	89.0	78.2	59.3	37.8
5. Approach Canal B	2.08		99.2	97.4	96.0	92.1	86.4
6. After Intake			64.3	20.3	10.6	1.6	0.67
Timbang Deli							
7. Approach Canal			59.4	30.6	10.1	0.85	0.46
8. After Intake		97.2	64.2	28.0	15.0	3.4	1.8
9. Main Canal		98.0	64.3	12.1	4.0	1.5	1.2
Perbaungan							
10. Approach Canal			58.1	6.9	1.1	0.08	0.03
11. After Intake			50.7	6.2	1.1	0.09	0.03
12. Main Canal A			50.6	6.6	1.3	0.15	0.07
13. Main Canal B			15.0	3.1	0.55	0.05	0.03
Sumber Rejo							
14. Approach Canal			95.9	93.7	61.5	38.7	27.5
15. After Intake		96.5	83.9	64.5	45.1	40.1	8.5
16. Main Canal A		99.6	86.2	65.9	4.7	1.7	0.75
17. Main Canal B		88.8	56.7	13.9	4.6	1.4	1.2
Bendang							
18. Approach Canal			85.1	70.7	53.1	7.9	3.6
19. After Intake			49.7	16.5	7.3	0.75	0.19
Ramonia							
20. Approach Canal	2.06						

Table 2-1-8 Population by Tribes in the Project Area in 1976

Kecamatan	Total Population	Melayu	Batak	Jawa	Banjar	Chinese	Others
Pantai Cermin	15,329	6,419	529	6,134	1.050	1.197	-
	(%)	41.9	3.4	40.0	6.9	7.8	0
Lubuk Pakam	50,470	6,583	14,749	26,598	-	1.818	721
	(%)	13.0	29.2	52.8	0	3.6	1.4
Galang	8,266	1,373	2,629	4,212	-	-	50
	(%)	16.6	31.8	51.0	0	0	0.6
Sungai Rampah	2,038	165	180	1.168	-	10	515
	(%)	8.1	8.8	57.3	0	0.5	25.3
Perbaungan	42,909	9,658	552	19,083	10,750	1.131	1.735
	(%)	22.5	1.3	44.5	25.1	2.6	4.0
Teluk Mengkudu	18,019	1.045	2,850	9,783	3,729	275	338
	(%)	5.8	15.8	54.3	20.7	1.5	1.9
Tanjung Beringin	6,516	3.231	-	2,726	239	320	-
T o t a l	143,545	28,474	21,487	69,704	15,768	4,751	3,359
	(%)	19.8	15.0	48.6	11.0	3.3	2.3

Source: * Population statistic in Deli Serdang Kabupaten in 1976.
* Data collected from each Kecamatan Office.

Table 2-1-9 Population by Religions in the Project Area in 1976

Kecamatan	Total population	Moslem	Catholic	Protestant	Buddhist	Confucian	Others
Pantai Cermin	15,329	13,705	127	638	-	-	857
	(%)	89.4	0.8	4.2	0	0	5.6
Lubuk Pakam	50,470	38,048	1,000	9,972	-	1,450	-
	(%)	75.4	2.0	19.8	0	2.9	-
Galang	8,266	7,075	15	1,176	-	-	-
	(%)	85.6	0.2	14.2	0	0	0
Sungai Rampah	2,038	1,949	-	48	41	-	-
	(%)	95.6	0	2.4	2.0	0	0
Perbaungan	42,909	41,258	-	464	1,100	-	87
	(%)	96.1	0	1.1	2.6	0	0.2
Teluk Mengkudu	18,019	15,890	53	1,801	275	-	-
	(%)	88.2	0.3	10.0	1.5	0	0
Tanjung Beringin	6,516	6,196	-	-	320	-	-
	(%)	95.1	0	0	4.9	-	-
T o t a l	143,545	124,121	1,195	14,099	1,736	1,450	944
	(%)	86.5	0.8	9.8	1.2	1.0	0.7

Source: Population statistic in Deli Serdang Kabupaten in 1976.
Data collected from each Kecamatan Office.

Table 2-2-1 Existing Intake Facilities

Name	Location	Site	Completion Year	Authorities concerned	Type	Size of intake structure (gate width×number)	Bed elevation of intake	Irrigation area		Control at gate operation	Remarks
	km					m	EL(m)	Wet season ha	Dry season ha		
Pulau Gambar	+22.5	Right	1965	P.U.Province	Free intake	Concrete 1.00×2	43.66	1,200	800	Sektor L. Pakam	
Swadaya	+19.7	Right	1976	P.U.Kabupaten	Free intake	Concrete 1.20×1	39.30			P.U.Kabupaten	Supplementary intake for Pulau Gambar area
S. Buluh	+19.0	Right	1975	P.U.Kabupaten	Free intake	Concrete 1.20×3	38.49	400	-	P.U.Kabupaten	Project INPRES (Constructed by the budget from the President)
Timbang Deli	+14.3	Left	1975	P.U.Province	Free intake	Concrete 0.75×2	32.60	400	400	Sektor L. Pakam	
Perbaungan	+ 9.6	Right	1960	P.U.Province	Free intake	Concrete 1.20×4	25.56	1,950	1,800	P.U.Province	Rehabilitated in 1975
Sumber Rejo	+ 3.1	Left	1970	P.U.Kabupaten	Free intake	Concrete 1.00×4	17.63	800	100	Sektor L. Pakam	Rehabilitated in 1975 by the Ular River Project, now under P.U.Province
Bendang	+ 0.2	Right	Before 1935	P.U.Province	Free intake	Concrete φ0.80×2	13.12	1,000	900	Sektor L. Pakam	Rehabilitated in 1974 by the Ular River Project.
Adolina	- 0.2	Right	1976	Public	Pump station	Yanmer TS 60mm pipe φ4"×2	no data	-	-	Public	Constructed by PNP VIADOLINA
Singosari (2 places)	- 2.6 - 3.2	Right	1970	P.U.Kecamatan	Syphon	(I)Steel pipe φ100×12 (II)-ditto- φ100× 8	no data	100	-	Farmer	
Ramonia	- 4.7	Left	1967	P.U.Province	Free intake	Concrete 1.20×3	7.73	1,100	500	Sektor L. Pakam	
Wonosari (3 places)	- 6.7 - 7.0	Right	1974	P.U.Kecamatan	Free intake	(I)Concrete pipe φ500×3 (II) -ditto- φ500×1 (III)-ditto- φ500×1	no data	50	-	Farmer	
Total								7,000	4,500		

Table 2-2-2 List of Existing Irrigation Facilities

Facilities	Unit	Pulau Gambar	S. Buluh	Timba-ng Deli	Perba-ungan	Sumber Rejo	Ben-dang	Singo-sari	Wono-sari	Ramo-nia	Total
1) Intake	No.	2	1	1	1	1	1	2	3	1	13
2) Canal structures											
Diversion work	No.	1	1	1	2	1	1	-	-	1	8
Secondary diversion work	No.	4	5	1	6	7	2	1	-	7	33
Drop	No.	4	6	-	6	-	-	-	-	-	16
Aqueduct	No.	1	-	-	1	1	3	-	-	7	13
Syphon	No.	1	1	-	2	1	-	-	-	1	6
Conduit	No.	-	1	-	-	1	-	-	-	-	2
Wooden bridge	No.	5	2	-	15	-	-	-	-	-	22
Spillway	No.	-	3	-	2	-	-	-	-	-	5
3) Canal length											
Main canal	Km.	5.0	20.0	2.0	2.0	0.6	4.3	-	-	-	33.9
Secondary canal	Km.	22.7	23.7	7.0	41.1	32.6	14.2	3.6	3.0	21.0	168.9
Total	Km.	27.7	43.7	9.0	43.1	33.2	18.5	3.6	3.0	21.0	202.8

Table 2-2-3 Existing Drainage System

Block No.	Name of Main Drain	Major Tributaries	Length (Km)	Catchment Area (Km^2)	Peak Discharge (m^3/sec)
I	Pantai Labu		10.5	103.6	60.6
		S. Kenang	11.3	56.2	31.3
		Paluh Labu	9.0	22.6	22.6
		Paluh Subaji	8.6	24.8	18.1
	S. Serdang			21.2	
		S, Galang	1.6	9.3	8.3
		S. Kwala Namu	4.9	11.9	9.9
II	S. Denai			39.1	27.0
		Paluh Babi	10.5	27.9	20.5
		Canal Kebun	5	11.2	8.5
III	S. Perbaungan			65.2	40.7
		Tungtung Canal	13.9	41.1	
		S. Perbaungan	22.7	12.3	
		-		11.8	
IV				42.8	
	Pematang Kasir		9.1	9.7	8.1
	Canal Palu		5.0	3.6	3.3
	Pematang Lalang		5.7	9.6	7.7
	Arapayung		5.9	6.8	6.8
	Kwala Lama		6.5	13.1	10.4
V	Lubuk Dendang			21.6	15.9
		S. Sijenggi	7.9	11.0	9.3
		S. Lidah tanah	2.3	2.7	3.0
		L. Saban	5.4	7.9	

(continued)

Block No.	Name of Main Drain	Major Tributaries	Length (Km)	Catchment Area (Km^2)	Peak Discharge (m^3/sec)
VI	S. Baru			15.3	9.9
		S. Mayang	3.1	9.2	7.4
		S. Baru	8.1	6.1	5.7
VII	Canal S. Buluh			106.9	56.3
		S. Nippah	16.0	21.2	15.9
		Canal S. Buluh	25.4	60.8	45.0
		S. Sialang	7.3	24.9	17.5
	S. Kota Bangoen		9.1	27.4	19.1
		S. Kataran Batu	5.2	27.4	
VIII	S. Buluh		12.8	17.0	13.0
IX	S. Teluk Mengkudu		12.0	38.8	25.2
X	S. Pavdo		7.7	51.8	26.3
	T o t a l		252.5	550.7	

Table 2-2-4 Number of Farmers by Type in the Project Area

Type	Number	Percent
Owner farmers	16,155	82.2
Tenant farmers	1,242	6.3
Farm labours	2,255	11.5
Total	19,652	100.0

Source: Agricultural Service Office, Deli Serdang District Data Collected from Kecamatan Office.

Table 2-2-5 Land Condition on an Average Farm

	Area	Percent	
Average farming sige	1.132 ha	100.0	
Rice field	1.063	93.90	100.0
Irrigated paddy field	0.402		37.8
Technical irrigation field	0.172		16.2
Semi-technical irrigation field	0.086		8.1
Non-technical irrigation field	0.144		13.5
Rain-fed field	0.661		62.2
Vegetable field	0.029	2.56	
Fruits field	0.040	3.54	

Table 2-2-6 Land Use in the Project Area

Item	Area (ha)
A) Rice Field	18,500
a) Technical irrigation area	3,000
b) Semi-technical irrigation area	1,500
c) Non-technical irrigation area	2,500
d) Rain-fed area	11,500
B) Estate Field (P.N.P., Private estate and samll holder farm)	17,800
a) Oil palm area	10,000
b) Rubber area	4,300
c) Coconut area	3,500
C) Other Crop Field	1,200
a) Vegetable	500
b) Fruits	700
D) Forest	1,600
E) Resident Area	4,300
F) Others	1,600
Total	45,000

Table 2-2-7 Production Cost of Paddy per Ha for Rain-fed Area at Present

Items		:	Rp.
1. Seed	(40 kg x Rp. 100/kg)		4,000
2. Fertilizer Urea	(50 kg x Rp. 70/kg)	:	3,500
3. Insecticide		:	400
4. Rodenticide		:	-
5. Labor Cost		:	46,450
A) Land preparation		:	
Land clearing	(13 man day x Rp.300)	:	3,900
Ploughing	(9 man day x Rp.450)	:	4,050
Harrowing	(5 man day x Rp.350)	:	1,750
B) Nursery			
Land preparation	(1 man day x Rp.400)	:	400
Seedling	(1 man day x Rp.400)	:	400
Spraying	(1 man day x Rp.300)	:	300
Pulling	(6 man day x Rp.350)	:	2,100
C) Cultivation			
Fertilization	(1 man day x Rp.250)	:	250
Transplanting	(30 man day x Rp.350)	:	10,500
Weeding	(30 man day x Rp.350)	:	10,500
Spraying	(1 man day x Rp.300)	:	300
D) Harvesting			
Reaping	(16 man day x Rp.400)	:	6,400
Threshing, drying & others	(14 man day x Rp.400)	:	5,600
6. Miscellaneous Cost		:	4,650
Total		:	59,000

Table 2-2-8 Production Cost of Paddy per Ha for Irrigation Area at Present

Items		:	Rp.
1. Seed	(25 kg x Rp.150)	:	3,750
2. Fertilizer			
Urea	(150kg x Rp. 70)	:	10,500
TSP	(50 kg x Rp. 70)	:	3,500
3. Insecticide	(1 1 x Rp.900)	:	900
4. Rodenticide		:	100
5. Labor Cost		:	61,900
A) Land preparation			
Land clearing	(12 man day x Rp.300)	:	3,600
Ploughing	(14 man day x Rp.450)	:	6,300
Harrowing	(17 man day x Rp.350)	:	5,950
B) Nursery			
Land preparation	(1 man day x Rp.400)	:	400
Seedling	(1 man day x Rp.400)	:	400
Spraying	(1 man day x Rp.300)	:	300
Pulling	(6 man day x Rp.350)	:	2,100
C) Cultivation			
Fertilization	(7 man day x Rp.250)	:	1,750
Transplanting	(30 man day x Rp.350)	:	10,500
Weeding	(40 man day x Rp.350)	:	14,000
Spraying	(10 man day x Rp.300)	:	3,000
D) Harvesting			
Reaping	(16 man day x Rp.400)	:	6,400
Threshing, drying & others	(18 man day x Rp.400)	:	7,200
6. Miscellaneous Cost		:	6,350
Total		:	87,000

Table 2-2-9 Production Cost of Peanuts per Ha

Items		:	Rp.
1. Seed	(100 kg x 140 Rp/kg)	:	14,000
2. Labor Cost		:	31,200
Land preparation	(20 man day x Rp.400)	:	8,000
Planting	(12 man day x Rp.350)	:	4,200
Weeding	(20 man day x Rp.350)	:	7,000
Harvesting	(30 man day x Rp.400)	:	12,000
3. Miscellaneous Cost		:	1,800
Total		:	47,000

Table 2-2-10 Production Cost of Cassava or Sweet potatoes per Ha

I t e m s		:	Rp.
1. Seed		:	2,750
2. Labor Cost		:	31,000
Land preparation	(30 man day x Rp.400)	:	12,000
Planting	(10 man day x Rp.350)	:	3,500
Weeding	(10 man day x Rp.350)	:	3,500
Harvesting	(30 man day x Rp.400)	:	12,000
3. Miscellaneous Cost		:	1,250
T o t a l		:	35,000

Table 2-2-11 Production Cost of Soy-beans or Other Beans per Ha

Items		:	Rp.
1. Seed	(35 kg x 95 Rp/kg)	:	3,325
2. Labor Cost		:	5,450
Land preparation	(20 man day x Rp.400)	:	8,000
Planting	(12 man day x Rp.350)	:	4,200
Weeding	(15 man day x Rp.350)	:	5,250
Harvesting	(20 man day x Rp.400)	:	8,000
3. Miscellaneous		:	1,225
Total		:	30,000

Table 2-2-12 Area, Production and Unit Yield of Paddy (1971 to 1976) in Irrigated Land (3 in the Kecamatan in the Project Area

	1971	1972	1973	1974	1975	1976	Total (1*	Total (2*
Planted Area	21,952	18,830	23,980	7,970	3,955	5,788	88,475	64,495
Production	16,498	55,929	37,392	19,500	17,222	22,530	269,071	231,679
Unit Yield	4.17	2.97	1.56	2,46	4.35	3.89	3.04	3.59 (≒3.6)

(1 1971 to 1976

(2 exclude value in 1973 when damages of rice production due to leaf hopper occured.

(3 Area in Bimas Inmas program.

Table 2-2-13 Harvested Area, Production and Unit Yield of Paddy (1971-1976) in Total Area of Rain-fed and Irrigated Area in the Kecamatans in the Project Area

	1971	1972	1973	1974	1975	1976	Total
Harvested Area (ha)							
P.Cermin	2,752	2,375	1,574	2,333	2,174	2,357	
Lubuk Pakam	10,699	12,128	9,451	8,893	9,418	10,349	
Galang	4,695	5,165	4,471	4,868	1,243	3,497	
S.Rempah	10,410	14,177	5,128	8,072	1,298	1,799	
Perba-ungan	15,368	20,136	21,293	9,941	3,423	10,545	
Teluk Mengkudu	4,330	3,007	2,479	2,040	2,127	2,938	
Tg. Beringin	4,320	3,950	2,855	2,319	621	3,960	
Total	52,574	60,938	47,251	38,466	20,304	41,445	260,978
Production (ton)							
P.Cermin	7,848	7,189	4,685	6,933	5,468	8,169	
Lubuk Pakam	37,895	37,388	29,734	32,193	17,125	27,665	
Galang	13,828	16,159	12,818	9,333	1,541	11,812	
S.Rampah	38,237	52,125	17,244	29,889	4,172	28,257	
Perba-ungan	58,569	83,655	62,442	29,442	7,190	27,616	
Teluk Mengkudu	10,906	8,665	8,736	6,131	5,340	7,613	
Tg. Beringin	11,264	16,340	6,260	5,630	1,133	12,356	
Total	178,547	221,521	141,919	119,353	41,965	123,488	826,793
Unit Yield (ton/ha)							
P.Cermin	2.85	3.03	2.98	2.97	2.52	3.47	
Lubuk Pakam	3.54	3.08	3.15	3.60	1.82	2.67	
Galang	2.95	3.13	2.87	1.92	1.24	3.38	
S.Rampah	3.67	3.68	3.36	3.70	3.21	3.62	
Perba-ungan	3.81	4.15	2.93	2.96	2.10	2.62	
Teluk Mengkudu	2.52	2.88	3.52	3.01	2.51	2.59	
Tg. Beringin	2.61	4.14	2.19	2.43	1.82	3.12	
Average yield	3.40	3.64	3.00	3.11	2.07	2.98	3.17≒3.2

Table 2-2-14 Unit Yeild of Upland Crops (1971 - 1976) in the Kecamatans in the Project Area

	1971	1972	1973	1974	1975	1976	Total or avarage
Cassava & Sweet Potato							
Harvested Area	702	576	1,264	1,137	2,218	1,748	7,645
Production	6,617	7,282	15,822	14,227	27,555	19,908	91,441
Unit Yield	9.43	12.64	12.52	12.51	12.42	11.39	11.9
Beans							
Harvested Area	1,228	1,340	1,243	82	269	992	5,154
Production	1,599	1,167	1,201	74	226	682	4,949
Unit Yield	1.30	0.87	0.97	0.90	0.84	0.69	0.95
Peanuts							
Harvested Area	15	14	0	19	577	1,099	1,724
Production	17	14	0	18	687	1,148	1,884
Unit Yield	1.13	1.00	-	0.95	1.19	1.04	1.09

Table 2-2-15 Summary of Present Crop Yield and Production

	Harvested Area (ha)	Unit Yield (ton/ha)	Total Production (ton)
(1) Paddy Field			
Rice			
Wet season paddy (Irrigated land)	4,500	3.6	16,200
Wet season paddy (Rain-fed area)	14,000	2.9	40,600
Dry season paddy (Irrigated land)	4,500	3.6	16,200
Sub-total	23,000		73,000
Polowijo			
Cassava & Sweet Potato	654	11.9	7,800
Peanut	170	1.09	190
Beans	80	0.95	80
Sub-total	904		8,070
(2) Upland Field (Vegetable)			
Cassava & Sweet Potato	360	11.9	4,280
Peanut	90	1.09	100
Beans	50	0.95	50
Sub-total	500		4,430
(3) Estate Field			
Oil palm	10,000	16.8	168,000
Rubber	4,300	1.4	6,000

Table 2-2-16 Standard for BIMAS Package Credit (1977/1978) per ha

	Urea	TSP	DAD	N.P.K. 15-15-15	Insecti-cide	Rodenti-cide	Seed	Sprayer	Additional Expenditure	Total
Paddy in wet field										
Package A amount	200 kg	50 kg	-	-	Z[1]	100 g	-	-	-	-
value (Rp)	14,000	3,500	-	-	2,460	230	3,750	2,000	6,000	31,940 Rp
Package B amount	100 kg	35 kg	-	-	Z[1]	100 g	-	-	-	-
value (Rp)	7,000	2,450	-	-	2,460	230	-	2,000	6,000	20,140 Rp
Package C amount	250 kg	75 kg			Z[1]	100 g	-	-	-	-
value (Rp)	17,500	5,250	-	-	2,460	230	3,750	2,000	6,000	37,190 Rp

Source: B.R.I.

Table 2-2-17 Average Retail Price of Rice in Mdean

Year	Rp/Kg
1973	84.76
1974	94.03
1975	120.83
1976	126.84

Source: Statistic Year Book, 1976, Kantor Sensus & Statistic, SUMATERA UTARA

Table 2-2-18 Monthly Average Retail Price of Rice in Medan in 1976-1977

Unit: Rp/Kg

	J	F	M	A	M	J	J	A	S	O	N	D
'76	130.75	119.50	116.75	117.50	127.00	128.00	130.00	126.00	125.00	129.10	137.78	135.16
'77	133.11	130.43	127.73	135.36	138.64	135.00	137.99	139.14	139.23	140.37	144.45	-

Source: DEPOT LOGISTIK SUMATRA UTARA.

Table 2-2-19 Monthly Average Farm Gate Price of Paddy in 1976 in North Sumatra

Unit: Rp/Kg

	J	F	M	A	M	J	J	A	S	O	N	D
Local	74.65	70.96	71.00	72.08	70.00	71.17	70.27	71.50	72.39	73.94	80.65	82.00
										average		73.38
IR	66.50	65.25	62.44	63.17	69.63	68.59	69.88	66.95	68.10	65.77	77.27	79.81
										average		68.61

Source: Agricultural Department of North Sumatra Province 1977.

Table 2-2-20 Present Annual Budget on Typical Owner Farmer

Farm size	Type I 1.45 ha (Rain-fed Paddy 1.34 ha, upland field 0.11 ha)	Type II 1,00 ha (Irrigated Paddy 0.45 ha, Rain-fed 0.5 ha, upland field 0 05 ha)
Family size	5.55 families	5.25 families
1. Gross farm income	Rp	Rp
Intensive Paddy (wet season)	-	113,400
" (dry season)	-	113,400
Non-intensive Paddy	291,450	108,750
Upland crops	22,640	12,080
Total	314,090	347,630
2. Farming expense		
Hired labours & cows	7,740	9,110
Seeds	5,900	5,610
Fertilizers	4,690	14,350
Agri chemicals	540	1,100
Miscellaneous	6,380	8,110
Total	25,250	38,280
3. Other expense		
IPEDA Tax	5,080	4,900
Interest of credit	-	1,710
Other fee	290	290
Total	5,370	6,900
4. Net farm income	283,470	302,450
5. Non farm income	29,000	-
6. Family living expense	290,270	274,580
7. Payment capacity	22,200	27,870

Table 2-2-21 Annual Living Expense of Farm Houseboulds in the Project Area

Item	per capita	Type I (5.55 families)	Type II (5.25 families)
Food	33,500	185,925	175,875
Clothing	1,700	9,435	8,925
Residence	3,400	18,870	17,850
Education	2,700	14,985	14,175
Social expense	2,500	13,875	13,125
Others	6,500	36,075	34,125
Tax and fees	2,000	11,100	10,500
Total	52,300	290,265	274,575
	(US$ 126)	(US$ 699)	(US$ 662)

Table 2-2-22 Questionnaire

Date _____
Name of village _____
Name of person _____

(I) Please select two items that you consider to be most urgently needed to be done among the following 12 items presented by the Ular River Survey Team.

1. Improvement of irrigation channels.
2. Sufficient irrigation water supply during dry season.
3. Better drainage.
4. Improvement of farm road.
5. Expantion of arable area.
6. Introduction of modern technics.
7. Obtaining more cattle or draught animals.
8. Mechanization.
9. Introduction of operational capital.
10. Elimination of labor shortage.
11. Facilitating farm product marketing.
12. Others.

(II) We make an irrigation and a drainage plan as a part of the Ular River Improvement Project. The purpose of this plan is to provide sufficient irrigation water throughout a year and to prevent flooding during wet season.

How do you think about the percentage in the future that your villagers would adopt the cropping pattern, double cropping of paddy drainage systems? Please check, one among following four items.

I more than 80%
II 80 - 60%
III 60 - 40%
IV less than 40%

Table 2-2-23 Result of Farmers' Intention Survey

Item \ Kecamatan	P. Cermin	L. Pakam	Galang	S. Rampah	Perba-ungan	Teluck Mengkudu	Tanjung Beringin	Total	Proportional extent (%)
Improvement of irrigation channels.	6	14	2	0	12	3	0	37	(26.3)
Sufficient irrigaton water supply during dry season.	9	19	2	2	19	5	3	59	(42.1)
Better drainage	0	4	1	1	0	4	2	12	(8.6)
Improvement of farm road	2	3	0	0	4	2	1	12	(8.6)
Expantion of arable area	1	1	0	0	2	1	0	5	(3.6)
Introduction of modern technics.	1	0	0	0	3	1	0	5	(3.6)
To get more cattle or draught animals.	0	0	0	0	3	1	0	4	(2.9)
Mechanization	0	0	0	0	0	0	0	0	(0)
Introduction of operational capital.	0	1	0	1	1	1	0	4	(2.9)
Elimination of labor shortage.	0	0	0	0	0	0	0	0	(0)
Facilitating farm product marketing.	0	0	1	0	0	0	0	1	(0.7)
Others	0	1	0	0	0	0	0	1	(0.7)
Total	19	43	6	4	44	18	6	140	100

Table 2-2-24 Farmers' Intention for Double Cropping Paddy per Year

Prevailing % of double cropping of paddy per year	Number	Proportional extent (%)
More than 80%	66	93.0
80 - 60%	4	5.6
60 - 40%	1	1.4
Less than 40%	0	0
T o t a l	71	100

Table 2-2-25 Number of Agricultural Co-operative in North Sumatra by Year

	North Sumatra Province		Deli Serdang Kabupaten	
	Agricultural Co-operative	No.of members	Agricultural Co-operative	No.of members
1965	754	14,513	56	Not available
1970	80	7,523	2	81
1975	43	2,114	3	100

Source: KEPALA DIREKTORAT KOPERASI PROPINSI SUM.

Table 2-2-26 Number of BUUD / KUD and members in North Sumatra Province Aug. 1975

	North Sumatra	Deli Serdang 1977
Village Unit (WUD)	304	60
Village Unit Co-operative (KUD)	265	30
No. of Members	33,738	7,367
No. of Farmers	655,995	156,960

Table 2-2-27 Present Condition of KUD in the Project Area

Kecamatan WUD	No. of Village	No. of Farmers	No. of Members	%	No. of Candidate	Rice mill Owned	Godown Owned
Kecamatan Pantai Cermin	*/	Under BIMAS				E	L3
1 Pantai Cermin	10/12	3,354	750	22,36	2,604	(x)	0
Kecamatan Lubuk Pakam							
2 Karang Anyer	13/13	6,500	382	5,88	5,999	@	0
3 Pasar Miring	8/17	6,191	57	0,92	6,134	@	0
Tumpatan	1/8						
Kecamatan Galang							
4 Pulau Tagor	1/15	6,765	89	1,32	6,676	0	OL
Pulau Gambar	2/5						
Kecamatan Sungai Rampah							
5 Sungai Rejo	2/5	5,955	206	3,46	5,749	0	OL
Kecamatan Perbaungan							
6 Kota Galuh	6/9	2,465	56	2,27	2,409	0	OL
7 Melati II	5/8	2,585	22	0,85	2,563	-	OL
8 Tanah Merah	12/15	1,303	120	9,21	1,183	0	OL
9 Petuaran	1/9	2,515	141	5,61	2,374	-	0
Kecamatan Taluk Mengkudu							
10 Pematang Setera k	7/10	3,145	480	14,63	2,685	-	OL
11 Sungai Buluh	2/2	1,268	75	5,91	1,193	-	OL
Kecamatan Tanjung Beringin							
12 Tanjung Beri- ngin	3/8	4,407	124	2,81	2,604	(x)	0
Total 14 WUD	73/136	46,453	2,482	5,34	42,173	8	12

*/: No. of Village in the Project area / in WUD (x) = will be possessed, 0= possess, @= possess with joint venture, OL= have rented Godown.

Table 2-2-28 Realization of Development of Agricultural Extension Service in North Sumatra

	1974	1975	1976	1977	1978
Agricultural Development Center	-	-	-	-	-
Rural Extension Center	-	-	37	37	37
Number of WUD	-	304	304	551	551
Number of PPS	10	15	15	20	20
Number of PPM	-	-	-	96	96
Number of PPL	172	224	257	327	536

Table 2-2-29 Realization of Development of Agricultural Extension Service in Deli Serdang

		1974	1975	1976	1977	1978
Rural Extension Center	Deli Serdang	-	-	4	7	7
	Project area	-	-	3	4	4
Number of PPS	Deli Serdang	1	1	1	2	2
	Project area	-	-	-	-	-
Number of PPM	Deli Serdang	-	-	-	3	16
	Project area	-	-	-	2	8
Number of PPL	Deli Serdang	35	35	42	60	61
	Project area	14	14	14	25	25

Table 2-2-30 BIMAS Package loan in Deli Serdang (for Paddy)

	Unit	1973	1974	1975	1976	1977
1. Number of lender		4,812	20,786	31,267	42,388	9,475
2. Amount of loan	10^3 Rp	239,779	364,488	630,249	937,018	323,965
3. Loan per capita	Rp	49,829	17,535	20,157	22,106	34,192
4. Amount of repayment	10^3 Rp	87,764	48,413	283,792	47,652	252,980
5. Repayment per capita	Rp	18,239	2,329	9,076	11,127	1,063
6. Amount of outstanding	10^3 Rp	152,015	316,075	346,457	465,366	70,986
7. Outstanding per capita	Rp	31,591	15,206	11,081	10,979	7,492
8. Rate of repayment	%	36.6	13.3	45.0	50.3	78.1
9. Rate of outstanding	%	63.4	86.7	55.0	49.7	21.9

By the end of November 1977.

Source: B.R.I. MEDAN OFFICE

Table 2-3-1 Past Trend of Unit Yield of Crops

Item of crops	Annual Increasing Rate (ton/year)
Paddy and upland paddy in North Sumatra	+ 0.043 *
Paddy excluding upland paddy in North Smatra Province	+ 0.062 *
Sweet potato in Related 7 Kecamatans	- 0.190 **
Peanuts in Related 7 Kecamatans	+ 0.023 **
Cassava in Related 7 Kecamatans	- 0.41 **
Soybean in Related 7 Kecamatans	- 0.03 **

* tendency between 1960 and 1976.

** tendency between 1967 and 1976.

Table 2-3-2 Anticipated Unit Yield of Crops in the Project Area

Kind of crops	Without Project	With Project
Paddy		
Irrigated area	4.0	4.5
Rain-fed area	3.3	4.5
Upland crops (Polowijo)		
Cassava & sweet potato	11.9	11.9
Peanuts	1.09	1.09
Soybeans	0.95	0.95

Table 2-3-3 Design Criteria of Paddy Cultivation with Project

Items	Design Criteria
1) Nursery bed	500 m^2/ha or $\frac{1}{20}$ of paddy field
2) Nursery period	20 days
3) Fertilization in Nursery bed	
Urea	12.5 g/m^2 (or 6.25 kg/ha)
Triple super phosphate	12.5 g/m^2 (or 6.25 kg/ha)
4) Seed Volume	25 kg/ha
5) Germination rate of seed	more than 80%
6) Planting density	30 x 15 cm
7) Planting depth	3 cm from surface
8) Seedling Number per hill	3
9) Fertilization in paddy field	
Urea (243.75 kg)	
Basic-dressing (transplanting time)	25% Urea
First-top-dressing (about 2 weeks after transplanting time)	25% Urea
Second top-dressing (18-20 days before heading)	50% Urea
TSP (93.75 kg)	
Basic-dressing (transplanting time)	100% Urea
10) Rodenticide	0.5 kg
11) Chemicals	41

Table 2-3-4 Production Cost of Paddy per Ha for Rain-fed Area Including Non-Technical Area (Without-Project)

1. Seed	(40 Kg x Rp 100/Kg)	4,000
2. Fertilizer		
Urea	(150 Kg x Rp 70/Kg)	10,500
T S P	(50 Kg x Rp 70/Kg)	3,500
3. Insecticide	(2 L x Rp 900/Kg)	1,800
4. Rodenticide		460
5. Labor cost		56,150
(A) Land preparation		
Land clearing	(13 man.day x Rp 300)	3,900
Ploughing	(9 man.day x Rp 450)	4,050
Harrowing	(5 man.day x Rp 350)	1,750
(B) Nursery		
Land Preparation	(1 man.day x Rp 400)	400
Seedling	(1 man.day x Rp 400)	400
Spraying	(1 man.day X Rp 300)	300
Pulling	(6 man.day x Rp 350)	2,100
(C) Cultivation		
Fertilization	(5 man.day x Rp 250)	1,250
Transplanting	(30 man.day x Rp 350)	10,500
Weeding	(40 man.day x Rp 350)	14,000
Spraying	(5 man.day x Rp 300)	1,500
(D) Harvesting		
Reaping	(20 man.day x Rp 400)	8,000
Threshing, drying & others	(20 man.day x Rp 400)	8,000
6. Miscellaneous cost		5,590
T o t a l		82,000

Table 2-3-5 Production Cost for Paddy per Ha for Irrigated Area (Double Cropping of Paddy) (Without-Project)

1. Seed	(25 Kg x Rp 150/Kg)	3,750
2. Fertilizer		
Urea	(200 Kg x Rp 70/Kg)	14,000
T S P	(75 Kg x Rp 70/Kg)	5,250
3. Insecticide	(3 L x Rp 900/Kg)	2,700
4. Rodenticide		840
5. Labor cost		70,250
(A) Land preparation		
Land clearing	(12 man.day x Rp 300)	3,600
Ploughing	(14 man.day x Rp 450)	6,300
Harrowing	(17 man.day x Rp 350)	5,590
(B) Nursery		
Land preparation	(1 man.day x Rp 400)	400
Seedling	(1 man.day x Rp 400)	400
Spraying	(1 man.day x Rp 300)	300
Pulling	(6 man.day x Rp 350)	2,100
(C) Cultivation		
Fertilization	(7 man.day x Rp 250)	1,750
Transplanting	(30 man.day x Rp 350)	10,500
Weeding	(47 man.day x Rp 350)	16,450
Spraying	(15 man.day x Rp 300)	4,500
(D) Harvesting		
Reaping	(20 man.day x Rp 450)	8,000
Threshing, drying & others	(25 man.day x Rp 400)	10,000
6. Miscellaneous cost		7,210
T o t a l		104,000

Table 2-3-6 Production Cost of Paddy per Ha
(With-Project)

1. Seed	(25 Kg x Rp 150/Kg)	3,750
2. Fertilizer		
Urea	(250 Kg x Rp 70/Kg)	17,500
T S P	(100 Kg x Rp 70/Kg)	7,000
3. Insecticide	(4 L x Rp 900/L)	3,600
4. Rodenticide	(0.5 Kg x Rp 2,300 Kg/L)	1,500
5. Labor cost		76,950
(A) Land preparation		
Land clearing	(12 man.day x Rp 300)	3,600
Ploughing	(14 man.day x Rp 450)	6,300
Horrowing	(17 man.day x Rp 350)	5,950
(B) Nursery		
Land preparation	(1 man.day x Rp 400)	400
Seedling	(1 man.day x Rp 400)	400
Spraying	(1 man.day x Rp 300)	300
Pulling	(6 man.day x Rp 350)	2,100
(C) Cultivation		
Fertilization	(10 man.day x Rp 250)	2,500
Transplanting	(30 man.day x Rp 350)	10,500
Weeding	(54 man.day x Rp 350)	18,900
Spraying	(20 man.day x Rp 300)	6,000
(D) Harvesting		
Reaping	(20 man.day x Rp 400)	8,000
Threshing, drying & others	(30 man.day x Rp 400)	12,000
6. Miscellaneous cost		7,050
T o t a l		117,000

Table 2-3-7 Production Cost of Cassava or Sweet Potatoes per Ha (Without-Project)

Items		Rp.
1. Seed		2,750
2. Labor cost		31,000
Land preparation	(30 man.day x Rp 400)	12,000
Planting	(10 man.day x Rp 350)	3,500
Weeding	(10 man.day x Rp 350)	3,500
Harvesting	(30 man.day x Rp 400)	12,000
3. Miscellaneous cost		1,250
T o t a l		35,00

Table 2-3-8 Production Cost of Peanuts per Ha (Without-Project)

Items		Rp.
1. Seed	(100 Kg x Rp 140 Rp/Kg)	14,000
2. Labor cost		31,200
Land preparation	(20 man.day x Rp 400)	8,000
Planting	(12 man.day x Rp 350)	4,200
Weeding	(20 man.day x Rp 350)	7,000
Harvesting	(30 man.day x Rp 400)	12,000
3. Miscellaneous cost		1,800
T o t a l		47,000

Table 2-3-9 Production Cost of Soy-beans or Other Beans per Ha (Without-Project)

Items		Rp.
1. Seed	(35 Kg x Rp 95/Kg)	3,325
2. Labor cost		25,4500
Land preparation	(10 man.day x Rp 400)	8,000
Planting	(12 man.day x Rp 350)	4,200
Weeding	(15 man.day x Rp 350)	5,250
Harvesting	(20 man.day x Rp 400)	8,000
3. Miscellaneous		1,225
T o t a l		30,000

Table 2-3-10 Agricultur Production in Future With and Without Project Condition

Kind of Crops	Without Project			With Project			In-crease (ton)
	Area (ha)	Unit yield (ton/ha)	Production (ton)	Area (ha)	Unit yield (ton/ha)	Production (ton)	
Paddy	(1) Rain-fed area						
	14,000	3.3	46,200				
	(wet season)						
	(2) Irrigated area			(1) Irrigated area			
	4,500	4.0	18,000	18,500	4.5	83,250	
	(Dry season)			(Wet season)			
	4,500	4.0	18,000	18,500	4.5	83,250	
	(Wet season)			(Dry season)			
	T o t a l		82,200			166,500	84,300
Cassava & Sweet Potato	654	11.9	7,800	-	-	-	-7,800
Peanuts	170	1.09	190	-	-	-	- 190
Soybean & Other Beans	80	0.95	80	-	-	-	- 80

Table 2-3-11 Parameters in Demand-Supply Prospect

Case	Annual population growth rate (%)	Annual per capita consumption (Kg)	Cultivated land (ha)
1	2.9 /1	150 /3	533,000 /5
2	2.9	150	565,000 /6
3	2.9	115.5 /4	565,000
4	2.9	115.5	533,000
5	2.4 /2	150	533,000
6	2.4	150	565,000
7	2.4	115.5	565,000
8	2.4	115.5	533,000

/1 Annual population growth estimated from Table 2-3-14.

/2 Annual population growth projected by BAPPEDA.

/3 Target annual per capita consumption proposed by North Sumatra Province.

/4 Target annual per capita consumption recommended in the final year of Pelita II.

/5 Cultivated land in 1976.

/6 Maximum cultivated land from 1960 to 1976.

Table 2-3-12 Anticipated Unit Yield of Rice /1
in North Sumatra Province

Year	Anticipated unit yield (ton/ha)	
	Paddy	Rice
1976	2.97	1.782
1980	3.13	1.878
1985	3.33	1.998
1990	3.53	2.118
1995	3.73	2.238
2000	3.93	2.358

/1 It is estimated on the basis of the historical trend of average unit yield of wet paddy and upland paddy in North Sumatra Province between 1960 and 1976.

Table 2-3-13 Forecast of Rice Shortage in North Sumatra Province

	Year	Population	Demand (ton)	Production (ton)	Balance (ton)
Case 1	1980	8,633,000	1,299,000	1,001,000	- 298,000
	1985	9,994,000	1,499,000	1,065,000	- 434,000
	1990	11,580,000	1,730,000	1,129,000	- 601,000
	1995	13,301,000	1,995,000	1,193,000	- 802,000
	2000	15,345,000	2,302,000	1,251,000	-1,045,000
Case 2	1980	8,663,000	1,229,000	1,061,000	- 238,000
	1985	9,944,000	1,499,000	1,129,000	- 370,000
	1990	11,580,000	1,730,000	1,196,000	- 534,000
	1995	13,301,000	1,995,000	1,264,000	- 371,000
	2000	15,395,000	2,302,000	2,302,000	- 970,000
Case 3	1980	8,663,000	1,001,000	1,061,000	+ 60,000
	1985	9,994,000	1,154,000	1,129,000	- 25,000
	1990	11,580,000	1,337,000	1,196,000	- 141,000
	1995	13,301,000	1,536,000	1,264,000	- 272,000
	2000	15,345,000	1,772,000	1,332,000	- 440,000
Case 4	1980	8,663,000	1,001,000	1,001,000	0
	1985	9,994,000	1,154,000	1,065,000	- 89,000
	1990	11,580,000	1,337,000	1,129,000	- 208,000
	1995	13,301,000	1,536,000	1,193,000	- 343,000
	2000	15,345,000	1,772,000	1,257,000	- 515,000

(to be continued)

	Year	Population	Demand (ton)	Production (ton)	Balance (ton)
Case 5	1980	8,496,000	1,274,000	1,001,000	-273,000
	1985	9,565,000	1,435,000	1,065,000	-370,000
	1990	10,769,000	1,615,000	1,129,000	-486,000
	1995	12,110,000	1,817,000	1,193,000	-624,000
	2000	13,652,000	2,048,000	1,257,000	-791,000
Case 6	1980	8,496,000	1,274,000	1,061,000	-213,000
	1985	9,565,000	1,435,000	1,129,000	-306,000
	1990	10,769,000	1,615,000	1,196,000	-419,000
	1995	12,110,000	1,817,000	1,214,000	-553,000
	2000	13,652,000	2,048,000	1,332,000	-716,000
Case 7	1980	8,496,000	977,000	1,061,000	+ 84,000
	1985	9,565,000	1,100,000	1,129,000	+ 29,000
	1990	10,769,000	1,238,000	1,196,000	- 42,000
	1995	12,110,000	1,393,000	1,264,000	-129,000
	2000	13,652,000	1,570,000	1,332,000	-238,000
Case 8	1980	8,496,000	977,000	1,001,000	+ 24,000
	1985	9,565,000	1,100,000	1,065,000	- 35,000
	1990	10,769,000	1,238,000	1,129,000	-109,000
	1995	12,110,000	1,393,000	1,193,000	-200,000
	2000	13,652,000	1,570,000	1,257,000	-313,000

Table 2-3-14 Population in North Sumatra Province

Year	Population	Population growth rate
1961	4,964,723	
1962	5,105,700	2.8
1963	5,321,900	4.2
1964	5,362,500	0.8
1965	5,498,300	2.5
1966	5,639,300	2.6
1967	5,785,200	2.6
1968	5,936,600	2.6
1969	6,094,000	2.6
1970	6,413,270	5.2
1971	6,690,723	4.3
1972	6,889,960	3.0
1973	7,091,866	2.9
1974	7,297,927	2.9
1975	7,509,113	2.9
1976	7,726,737	2.9

Source: Statistical Year Book of North Sumatra, 1975.

Table 2-3-15 Rice Price Estimation for Economic Evaluation of the Project

	US$/t	Rp/t	Rp/t
International market price (FOB Bangkok)	270		112,050
Transportation Cost (Bangkok-Belawan)	10	4,150	
Handling charge & Warehouse charge (handling charge Rp. 1,000, Warehouse charge 10 Rp/day x 60 days = Rp. 600)		1,600	117,800
Transportation cost (Belawan-Medan)		2,600	120,400
Processing Cost			
a. Package & handling charge		6,000	114,400
b. Milling charge		2,500	111,900
c. Selling price of paddy b x 0.6			67,140
Transportation and brokers margin		2,500	64,640
Farm gate price			64,640
			(65,000)

Table 2-3-16 Existing Intake Capacity

Name of intake	Size of intake	Bed elevation of intake	Water level of intake	Existing Intake Capacity (Without) canal improvement	(With) canal improvement	Planning irrigation area	Planning max discharge	Remarks
Pulau Gambar	1.00m x 2	EL 43.66m	EL 44.2	- m^3/s	1.12	1,200 ha	1.34 m^3/s	O.K
Swadaya	1.20 x 1	39.30	40.2	-	0.22 (0.69)*			
Buluh	1.20 x 3	38.49	39.5	1.61	4.46	4,600	5.15	(-0.69)
Timbang Deli	0.75 x 2	32.60	32.8	0.23	0.23	400	0.45	(-0.22)
Perbaungan	1.20 x 4	25.56	26.4	2.73	6.16	5,500	6.16	O.K
Sumber Rejo	1.00 x 4	17.63	17.9	0.28	0.95	2,700	3.02	(-2.07)
Bendang	¢ 0.80 x 2	13.12	14.2	0.06	1.90	1,700	1.90	O.K
Singosari	-	-	-	-	-	700	0.78	(-0.78)
Ramonia	1.20 x 3	7.73	8.4	1.05	1.90	1,700	1.90	O.K

Note: * Swadaya intake can supply the shortage water of 0.69 m^3/s the Buluh with canal improvement.

Table 2-3-17 Construction Costs of Six Alternative Plans for Providing Irrigation Water

Alternative - A		
. Buluh intake-improvement	54.7×10^6	Rp.
. Singosari intake-new construction	60.3×10^6	
. Timbang Deli intake-improvement	11.6×10^6	
. Sumber Rejo intake-improvement	83.5×10^6	
T o t a l	210.1×10^6	
Alternative - B		
. Swadaya canal-improvement for supplying water to Buluh	44.4×10^6	
. Bendang intake-improvement for supplying water to Singosari	66.1×10^6	
. Timbang Deli intake-improvement for supplying water to Timbang Deli and Sumber Rejo	244.7×10^6	
T o t a l	355.2×10^6	
Alternative - C		
. Swadaya canal-improvement for supplying water to Buluh	44.4×10^6	
. Singosari intake-new construction	60.3×10^6	
. Timbang Deli intake-improvement for supplying Water to Timbang Deli and Sumber Rejo	244.7×10^6	
T o t a l	394.4×10^6	

Alternative - D

. Swadaya canal-improvement for supplying water to Buluh	44.4×10^6
. Singosari intake-new construction	60.3×10^6
. New construction of supplementary intake for supplying water to Timbang Deli and Sumber Rejo	197.3×10^6
T o t a l	302.1×10^6

Alternative - E

. Swadaya canal-improvement for supplying water to Buluh	44.4×10^6
. Singosari intake-new construction	60.3×10^6
. Timbang Deli intake-improvement	11.6×10^6
. Sumber Rejo intake-improvement	83.5×10^6
T o t a l	199.8×10^6

Alternative - F

. Swadaya canal-improvement for supplying water to Buluh	44.4×10^6
. Singosari intake-new construction	60.3×10^6
. Timbang Deli intake-improvement	11.6×10^6
. New construction of supplementary intake for supplying water to Sumber Rejo	77.6×10^6
T o t a l	193.9×10^6

Table 2-3-18 Calculation of ETo by Blaney-Criddle Method

	P	t	f	RH min	n/N	U	a	b	ETo
Jan.	0.27	25.2	5.32	High	Low	Light	-1.45	0.80	2.8
Feb.	0.27	25.7	5.39	"	"	"	-1.45	0.80	2.9
Mar.	0.27	26.1	5.44	"	"	"	-1.45	0.80	2.9
Apr.	0.28	26.5	5.69	"	"	"	-1.45	0.80	3.1
May.	0.28	26.6	5.70	"	"	"	-1.45	0.80	3.1
Jun.	0.28	26.5	5.69	"	"	"	-1.45	0.80	3.1
Jul.	0.28	26.2	5.65	"	"	"	-1.45	0.80	3.1
Aug.	0.28	26.2	5.65	"	"	"	-1.45	0.80	3.1
Sep.	0.28	25.9	5.61	"	"	"	-1.45	0.80	3.0
Oct.	0.27	25.8	5.40	"	"	"	-1.45	0.80	2.9
Nov.	0.27	25.5	5.36	"	"	"	-1.45	0.80	2.8
Dec.	0.27	25.4	5.35	"	"	"	-1.45	0.80	2.8

$f = p(0.46^{t} + 8.13)$

$ETo = b \cdot f + a$ (mm/day)

p : Mean daily percentage of annual daytime hours at 3°30' N in percentage

t : Daily mean temperature in °C

RHmin : Class of minimum relative humidity
Low : 20%, Medium : 20-50, High : 50

n/N : Class of radiation
Low : 0.6, Medium : 0.6-0.8, High : 0.8

U : Class of daytime wind
Light : 2m/sec, Moderate : 2-5, Strong : 5-8

a,b : Coefficents

Table 2-3-19 Calculation of ETo by Radiation Method

	t	Rs cal/cm² /day	Rs mm/day	w	w.Rs	RH mean	U	a	b	ETo
Jan.	25.2	367	6.22	0.74	4.60	High	Light	-0.3	0.69	2.9
Feb.	25.7	386	6.54	0.75	4.91	"	"	-0.3	0.69	3.1
Mar.	26.1	398	6.75	0.75	5.06	"	"	-0.3	0.69	3.2
Apr.	26.5	394	6.68	0.75	5.01	"	"	-0.3	0.69	3.2
May.	26.6	380	6.44	0.76	4.89	"	"	-0.3	0.69	3.1
Jun.	26.5	371	6.29	0.76	4.78	"	"	-0.3	0.69	3.0
Jul.	26.2	382	6.47	0.75	4.85	"	"	-0.3	0.69	3.0
Aug.	26.2	386	6.54	0.75	4.91	"	"	-0.3	0.69	3.1
Sep.	25.9	366	6.20	0.75	4.65	"	"	-0.3	0.69	2.9
Oct.	25.8	364	6.17	0.75	4.63	"	"	-0.3	0.69	2.9
Nov.	25.5	332	5.63	0.75	4.22	"	"	-0.3	0.69	2.6
Dec.	25.4	331	5.61	0.74	4.15	"	"	-0.3	0.69	2.6

$ETo = a + b \cdot w \cdot Rs$ (mm/day)

t : Daily mean temperature in °C

Rs : Solar radiation measured in cal/cm /day can be converted to equivalent evaporation by dividing by 59.

w : Weighting factor for the effect of radiation on ETo at different temperature and altitude (about 2-30 m above sea level).

RHmean : Class of mean relative humidity
Low: 40%, Medium-Low: 40-55, Medium-High: 55-70, High: 70

U : Class of daytime wind
Light: 2m/sec, Moderate 2-5, Strong: 5-8, Very strong: 8

a,b : Coefficients

Table 2-3-20 Calculation of ETo by Modified Penman Method

	t mean	RH mean	U_2	n/N	Rs	ΔL^{-1} x10^2	$\Delta + \gamma/\alpha$	γEa	H^{sh}_{nt}	$H^{\ell 0}_{nt}$	ETo
Jan.	25.2	87	1.05	0.45	367	2.46	1.92	0.57	2.75	0.68	2.9
Feb.	25.7	84	1.12	0.48	386	2.52	1.96	0.75	2.90	0.72	3.2
Mar.	26.1	84	1.13	0.57	398	2.57	1.99	0.77	2.99	0.75	3.3
Apr.	26.5	86	1.00	0.58	394	2.63	2.02	0.65	2.96	0.71	3.3
May.	26.6	86	1.00	0.53	380	2.64	2.03	0.65	2.85	0.67	3.2
Jun.	26.5	87	0.95	0.55	371	2.63	2.02	0.59	2.78	0.67	3.0
Jul.	26.2	86	0.95	0.57	382	2.59	2.00	0.62	2.87	0.71	3.1
Aug.	26.2	86	0.97	0.52	386	2.59	2.00	0.63	2.90	0.68	3.2
Sep.	25.9	88	0.88	0.43	366	2.55	1.98	0.50	2.75	0.63	3.0
Oct.	25.8	88	0.86	0.40	364	2.54	1.97	0.49	2.73	0.61	3.0
Nov.	25.5	89	0.93	0.40	332	2.50	1.95	0.46	2.49	0.62	2.6
Dec.	25.4	89	0.98	0.37	331	2.49	1.94	0.47	2.48	0.60	2.7

$$ETo = \frac{\Delta\,(H^{sh}_{nt} - H^{\ell 0}_{nt})\,/\,L + \gamma Ea}{\Delta + \gamma/\alpha} \quad (mm/day)$$

t mean = Daily mean temperature (°C)

RHmean = Mean relative hunidity (%)

U_2 = Wind velocity at 2m (m/sec)

n/N = The relative duration of bright sunshine

Rs = Solar radiation (cal/cm^2/day)

Ea = $0.35\ (0.5 + 0.54U\ )(e_s - e_a)$

e_s = Saturation vapor pressure at mean air temperature in mm Hg (Fig.)

e_a = RHmean x e_s

H^{sh}_{nt} = $(1 - \gamma)\ H_A$

H_A = Rs x 10^{-2}

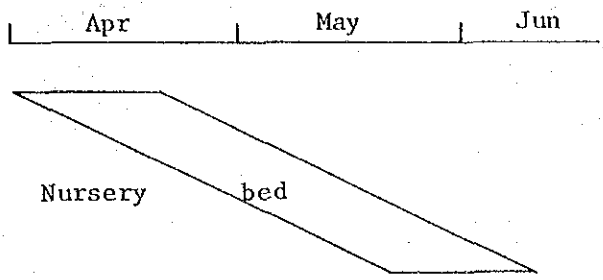
γ = The reflective coefficient of the surface, for grass a value of 0.25 has been selected

$H^{\ell 0}_{nt}$ = 0.97

σ = The stefan-Bolzmann constant equal to 0.8132×10^{-10} cal cm^{-2} min^{-1} deg^{-4}

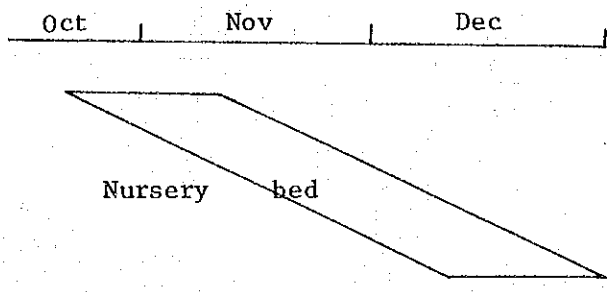
T^4_k = The fourth power of tmean in °K

Table 2-3-21 Water Requirement for Nursery Bed
(Dry Season Paddy)



(kc) Value for first 1/6 area	1.08	1.17					
" second "		1.08	1.17				
" third "			1.08	1.17			
" 4 th "				1.08	1.17		
" 5 th "					1.08	1.17	
" 6 th "						1.08	1.17
Average for 10 days	1.08	1.13	1.13	1.13	1.13	1.13	1.17
Evapotranspiration, Et	3.6	3.7	3.7	3.6	3.6	3.6	3.5
Percolation , P	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Effective rainfall	2.4	2.2	2.2	3.4	2.5	2.2	2.2
Ratio of area	0.17	0.33	0.33	0.33	0.33	0.33	0.17
Net irrigation requirement	0.71	1.49	1.49	1.06	1.35	1.45	0.73
Water req. for field preparation.	3.5	3.5	3.5	3.5	3.5	3.5	
Effective rainfall	2.4	2.2	2.2	3.4	2.5	2.2	
Net irrigation req.	1.1	1.3	1.3	0.1	1.0	1.3	
Total amount of net Irrigation req. (mm/day)	1.81	2.79	2.79	1.16	2.35	2.75	0.73

Table 2-3-22 Net Irrigation Requirement for Nursery Bed (Wet Season Paddy)



(Kc) Value for first 1/6 area	1.08	1.17					
" second "		1.08	1.17				
" third "			1.08	1.17			
" 4 th "				1.08	1.17		
" 5 th "					1.08	1.17	
" 6 th "						1.08	1.17
Average for 10 days	1.08	1.13	1.13	1.13	1.13	1.13	1.17
Everpotranspiration, ET	3.2	2.9	2.9	2.9	3.1	3.1	3.2
Percolation , P	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Effective rainfall	4.4	3.6	3.5	3.4	2.9	2.2	2.3
Ratio of area	0.17	0.33	0.33	0.33	0.33	0.33	0.17
Net irrigation req.	0.14	0.43	0.46	0.50	0.73	0.96	0.49
Water req. for field preparation	3.3	3.3	3.3	3.3	3.3	3.3	
Effective rainfall	4.4	3.6	3.5	3.4	2.9	2.2	
Net irrigation req.	0	0	0	0	0.4	1.1	
Total amount of net Irrigation req. (mm/day)	0.14	0.43	0.46	0.50	1.13	2.06	0.49

Table 2-3-23 Sample Calculation of Effective Rainfall

Station : Batang Kwis Year : 1956

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall in 10 days												
Early	63	17	3	69	31	48	0	29	88	96	84	74
Middle	27	0	7	52	43	39	45	18	51	40	78	60
Last	47	34	5	38	40	8	56	34	32	124	348	0
								Annual :			1,828	mm
Effective rainfall												
Early	63	17	3	69	31	48	0	29	50	50	50	50
Middle	27	0	7	52	43	39	45	18	50	40	50	50
Last	47	34	5	38	40	8	56	34	32	50	50	0
								Annual :			1,275	mm

Table 2-3-24 Distribution Ratio of 10-day Effective Rainfall

(in percentage)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Early	2.8	1.1	1.5	2.5	3.5	2.3	1.9	2.8	3.6	3.7	3.8	3.0
Middle	2.3	1.7	1.3	2.3	2.6	2.9	2.6	3.2	3.4	4.0	3.7	2.3
Last	1.9	1.4	2.3	2.3	2.3	3.0	3.8	3.9	3.8	4.6	3.5	2.4
								Annual : 100 %				

Table 2-3-25 Annual Rainfall

Year	Batang Kwis	Kuala Namu	Pagar Merbau	Deli Muda	Melati
1956	1,828	1,915	2,090	-	2,103
1957	1,626	1,590	2,275	1,682	1,574
1958	1,489	1,338	2,440	1,234	1,149
1959	1,638	1,808	2,071	1,985	1,681
1960	2,002	935	1,912	2,219	1,534
1961	1,841	1,702	1,720	1,818	1,880
1962	1,543	1,295	1,380	1,752	1,852
1963	1,780	1,548	1,752	1,745	1,709
1964	1,534	1,244	1,525	1,777	1,285
1965	1,323	1,378	1,802	1,753	1,903
1966	1,267	1,286	1,711	2,262	1,444
1967	1,402	1,019	1,746	1,337	1,550
1968	1,276	1,266	1,275	1,770	1,443
1969	954	1,320	1,863	2,205	2,049
1970	1,818	1,290	1,498	1,653	1,865

Year	Perdaus	Adolina III/IV
1956	1,819	2,206
1957	1,186	1,379
1958	1,316	1,279
1959	2,051	1,879
1960	1,687	1,944
1961	1,687	1,424
1962	1,469	1,716
1963	1,565	2,035
1964	1,025	-
1965	1,304	-
1966	1,418	-
1967	1,286	1,603
1968	1,412	1,697
1969	1,824	-
1970	723	1,689

Table 2-3-26 Probable Annual Rainfall in 5 Year Return Period

(in mm)

Name of station	Probable rainfall
Batang Kuis	1,293
Kwala namu	1,143
Pagar merbau	1,503
Deli Muda	1,518
Melati	1,410
Perdaus	1,257
Adolina III/IV	1,438
Average	1,366

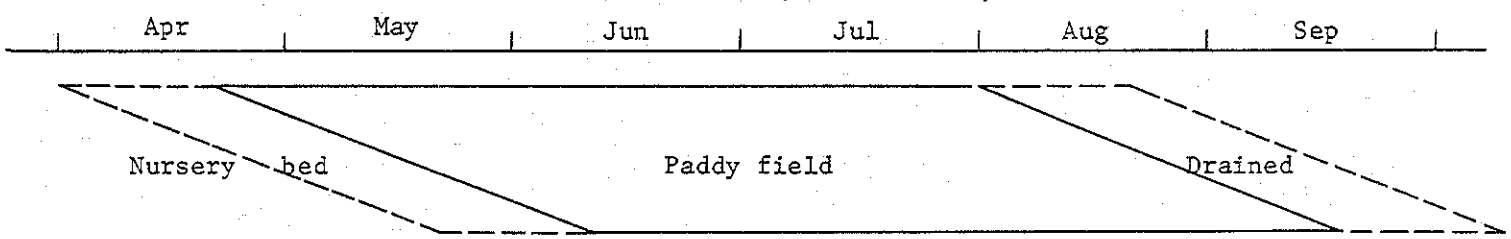
Table 2-3-27 Effective Rainfall in Each 10 Days

(in mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Early	27	11	14	24	34	22	18	27	34	35	36	29
Middle	22	16	12	22	25	28	25	31	33	38	35	22
Last	18	13	22	22	22	29	36	37	36	44	34	23
Monthly	67	40	48	68	81	79	79	95	103	117	105	74

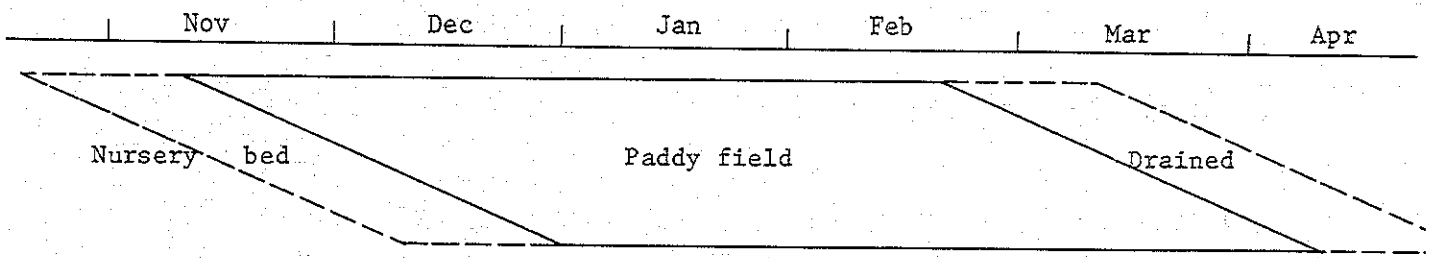
Annual = 956 mm

Table 2-3-28 Water Requirement for Dry Season Paddy



(Kc) Value for	first 1/6 area	1.08	1.17	1.25	1.33	1.39	1.39	1.33	1.24	1.15	1.05					
"	second "		1.08	1.17	1.25	1.33	1.39	1.39	1.33	1.24	1.15	1.05				
"	third "			1.08	1.17	1.25	1.33	1.39	1.39	1.33	1.24	1.15	1.05			
"	4 th "				1.08	1.17	1.25	1.33	1.39	1.39	1.33	1.24	1.15	1.05		
"	5 th "					1.08	1.17	1.25	1.33	1.39	1.39	1.33	1.24	1.15	1.05	
"	6 th "						1.08	1.17	1.25	1.33	1.39	1.39	1.33	1.24	1.15	1.05
Average for 10 days		1.08	1.13	1.17	1.21	1.24	1.27	1.31	1.32	1.31	1.26	1.23	1.19	1.15	1.1	1.05
Evapotranspiration, ET		3.6	3.6	3.7	3.9	3.7	3.8	3.9	4.1	4.1	3.9	3.9	3.8	3.7	3.3	3.2
Percolation		3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0
Effective rainfall		2.2	3.4	2.5	2.2	2.2	2.8	2.9	1.8	2.5	3.6	2.7	3.1	3.7	3.4	3.3
Ratio of area		0.17	0.33	0.5	0.67	0.83	1.0	1.0	1.0	1.0	1.0	0.83	0.67	0.5	0.33	0.17
Net irrigation requirement		0.75	1.06	2.10	3.15	3.74	4.0	4.0	5.30	4.60	3.30	3.49	2.48	1.50	0.63	0.32
Water req. for field preparation		3.5	3.5	3.5	3.5	3.5	3.5									
Effective rainfall		2.2	3.4	2.5	2.2	2.2	2.8									
Nor irrigation requirement		1.3	0.1	1.0	1.3	1.3	0.7									
Net irr. req. for nur. bed		0.09	0.14	0.14	0.06	0.12	0.14	0.04								
Net field irr. req.		0.09	0.14	2.19	1.22	3.22	4.59	5.08	4.7	4.0	5.30	4.60	3.30	3.49	2.48	1.50	0.63	0.32
Field irr. req. (mm/day)		0.10	0.16	2.43	1.36	3.58	5.10	5.64	5.22	4.44	5.89	5.11	3.67	3.88	2.76	1.67	0.70	0.36
Equivalent continuous flow (l/sec/ha)		0.01	0.02	0.28	0.16	0.41	0.59	0.65	0.60	0.51	0.68	0.59	0.42	0.45	0.32	0.19	0.08	0.04
Diversion water req. (l/sec/ha)		0.02	0.03	0.40	0.22	0.59	0.84	0.93	0.86	0.73	0.97	0.84	0.61	0.64	0.46	0.28	0.12	0.06

Table 2-3-29 Water Requirement for Wet Season Paddy



(Kc)	Value for first 1/6 area	1.08	1.17	1.25	1.33	1.39	1.39	1.33	1.24	1.15	1.05					
"	second "		1.08	1.17	1.25	1.33	1.39	1.39	1.33	1.24	1.15	1.05				
"	third "			1.08	1.17	1.25	1.33	1.39	1.39	1.33	1.24	1.15	1.05			
"	4 th "				1.08	1.17	1.25	1.33	1.39	1.39	1.33	1.24	1.15	1.05		
"	5 th "					1.08	1.17	1.25	1.33	1.39	1.39	1.33	1.24	1.15	1.05	
"	6 th "						1.08	1.17	1.25	1.33	1.39	1.39	1.33	1.24	1.15	1.05
Average for 10 days		1.08	1.13	1.17	1.21	1.24	1.27	1.31	1.32	1.31	1.26	1.23	1.19	1.15	1.1	1.05
Evapotranspiration, ET		2.8	2.9	3.2	3.3	3.3	3.7	3.8	3.8	4.2	4.0	3.9	3.9	3.8	3.6	3.5
Percolation		2.0	2.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Effective rainfall		3.5	3.4	2.9	2.2	2.3	2.7	2.2	1.8	1.1	1.6	1.3	1.4	1.2	2.2	2.4
Ratio of area		0.17	0.33	0.5	0.67	0.83	1.0	1.0	1.0	1.0	1.0	0.83	0.67	0.5	0.33	0.17
Net irrigation requirement		0.22	0.49	1.15	2.08	2.49	4.0	4.6	5.0	6.1	5.4	4.65	3.69	2.8	1.45	0.70
Water req. for field preparation		3.3	3.3	3.3	3.3	3.3	3.3									
Effective rainfall		3.5	3.4	2.9	2.2	2.3	2.7									
Net irrigation requirement		0	0	0.4	1.1	1.0	0.6									
Net irr. req. for nur. bed	0.01	0.02	0.02	0.03	0.06	0.10	0.02									
Net field irr. req.	0.01	0.02	0.24	0.52	1.61	3.28	3.51	4.6	4.6	5.0	6.1	5.4	4.65	3.69	2.8	1.45	0.70
Field irr. req. (mm/day)	0.01	0.02	0.27	0.58	1.88	3.64	3.90	5.10	5.10	5.56	6.78	6.0	5.17	4.10	3.1	1.61	0.78
Equivalent continuous flow (l/sec/ha)	0.01	0.02	0.03	0.07	0.22	0.42	0.45	0.59	0.59	0.64	0.78	0.69	0.60	0.47	0.36	0.19	0.09
Diversion water req. (l/sec/ha)	0.02	0.03	0.04	0.10	0.30	0.60	0.64	0.84	0.84	0.92	1.12	0.99	0.85	0.68	0.51	0.27	0.13

Table 2-3-30 Diversion Water Requirement

	January	February	March	April
Unit diversion requirement (l/sec/ha)	0.84 0.84 0.92	1.12 0.99 0.85	0.68 0.51 0.27	0.15 0.03 0.40
Diversion requirement for 18,500 ha (m^3/sec)	15.6 15.6 17.1	20.7 18.4 15.8	12.6 9.44 5.00	2.78 0.56 7.40
	May	June	July	August
Unit diversion requiremnt (l/sec/ha)	0.22 0.59 0.84	0.93 0.86 0.73	0.97 0.84 0.61	0.54 0.46 0.28
Diversion requirement for 18,500 ha (m^3/sec)	4.07 11.0 15.6	17.3 16.0 13.6	18.0 15.6 11.3	11.9 8.51 5.18
	September	October	November	December
Unit diversion requirement (l/sec/ha)	0.12 0.06 -	- - 0.02	0.03 0.04 0.10	0.30 0.60 0.64
Diversion requirement for 18,500 ha (m^3/sec)	2.22 1.11 -	- - 0.37	0.56 0.74 1.85	5.55 11.1 11.9

Table 2-3-31 Annual Maximum Rainfall (1)

Year	1 Batang Kwis		2 Ramonia		3 Kwala Namu		4 L.Pakam		5 T. Garbus		6 Pagar Merbau	
	R24	R48	R24	R48	R24	R48	R24	R28	R24	R48	R24	R48
1945												
46												
47												
48												
49												
1950	93	96			68	85			87	87	80	80
51	125	145			83	89			114	133	140	158
52	82	97			137	137			120	120	97	101
53	130	130			123	123			102	132	97	102
54												
55	57	61			107	112					80	89
56	283	316			215	255			169	231	125	232
57	75	90			104	114			70	71	105	113
58	78	84			114	136			83	83	177	187
59	54	69			70	89			70	96	100	109
1960	110	152			97	145			111	146	112	135
61	113	142			70	81			90	110	65	103
62	64	67			70	70			70	70	59	73
63	78	84			62	66			65	70	91	99
64	83	90			85	85			52	75	75	110
65	69	76			91	113			110	149	83	100
66	98	98			83	90			50	63	82	107
67	100	111			47	83			75	115	80	98
68	81	83			63	79			85	92	75	135
69	58	86			68	102			80	83	105	116
1970	108	143			83	83			110	125	109	112
71	120	120			65	120			77	77	100	125
72	95	110			84	89			75	75	88	117
73	70	79			96	96			68	104	100	145
74	108	108			75	87			75	75	102	102
75	135	137			100	187			90	96	114	136
76					72	79			69	89	96	96
77					74	110			100	120		

Annual Maximum Rainfall (2)

Year	8 Timbang Deli		9 K.S.Karang		11 S.Putih		13 Serbajadi		14 Bandar Kwala		15 Deli Muda	
	R24	R48	R24	R48	R24	R48	R24	R48	R24	R48	R24	R48
1945												
46												
47												
48												
49					92	92						
1950					98	118						
51					78	78						
52					96	106						
53					72	107					79	87
54					64	76						
55	62	84			124	124	104	127				
56	295	308	208	219	121	130	175	198	117	124	104	150
57	100	118	131	155	126	139	110	120	97	102	80	88
58	131	131	134	145	54	86	62	87	83	144	90	113
59	115	120	127	144	133	189	104	127	120	125	89	97
1960	70	90	87	87	101	101	95	123	75	106	102	107
61	160	170	94	94	103	109	91	95	67	94	67	84
62	75	115	106	108	72	133	38	76	69	76	70	75
63	100	115	120	134	75	105	77	91	65	96	100	113
64	100	150	117	117	84	104	117	146			130	136
65	115	125	80	105	82	91	460	485	55	95	118	118
66	70	85	78	95	80	113			68	70	100	152
67	85	100	75	80	75	81			69	106	80	80
68	85	110	98	100	60	85			59	89		
69	165	165	137	145	98	121						
1970	85	120	180	180	97	135						
71	80	95	110	132	83	96						
72	150	150			78	83			31	37	47	71
73	91	133	160	168	137	184			90	160		
74	50	58			80	80					65	70
75	59	85	110	123	62	93					72	91
76	94	100	88	111	-	-	-	-	67	112	69	71
77	55	98	71	85	-	-	-	-	91	117	85	114

Annual Maximum Rainfall (3)

Year	16 Melati		17 Tahah R.II		18 Liberia		19 Matapao		20 Bengabing		22 Perdaus		23 Pelin Tahan	
	R24	R48	R24	R48	R24	R48	R24	R48	R24	R48	R24	R48	R24	R48
1945														
46														
47														
48														
49														
1950	78	97												
51	85	99												
52	65	72												
53	95	104					78	128						
54							87	114						
55							98	100			120	122		
56	280	316					250	321	240	290	185	210		
57	69	69			275	350	71	71	70	70	52	90		
58	93	94	66	85	95	111	92	94	61	61	102	102		
59	94	98	90	132	90	90	81	89	85	113	98	98		
1960	65	65	100	102	85	70	124	184			113	128		
61	75	115	94	108	83	136	156	230			82	94		
62	71	130	100	115	300	150	232	232						
63	100	100	100	120	400	400	145	185						
64	88	88	60	107	200	325	255	140	75	81				
65	67	83	75	107			275	275	105	107				
66	65	81	125	125			242	292	84	98				
67	142	142			64	90	178	178			96	96		
68	88	101			36	59					68	89		
69	77	121	82	74			114	114	73	83	95	95		
1970	94	96					57	105	54	65	75	91		
71	172	172	85	100			117	117	76	92				
72	76	89	80	110			75	75	67	75	71	88		
73	199	199	95	99			92	113	144	153	108	108		
74	146	146	59	59	56	59	110	110	104	104	108	108		
75	92	144			117	117	117	135	105	105				
76					140	155	136	146	75	82				
77					100	130	143	147	62	62				

Annual Maximum Rainfall (4)

Year	24 Adolina II		25 Adolina III/IV		26 Rombung		27 Ram.Sialang		28 S.Parit		30 Sarang Giting	
	R24	R48	R24	R48	R24	R48	R24	R48	R24	R48	R24	R48
1945												
46												
47												
48												
49												
1950												
51												
52												
53									60	69		
54	110	124	80	98	88	116			65	118		
55	56	58	67	96	83	115	95	140	126	126	75	91
56	90	140	190	290	120	195	217	227	157	192	126	134
57	40	45	66	66	75	75	85	98	40	74	81	81
58	60	78	102	121	79	79	102	102	85	89	94	102
59	200	220	72	113	90	120	76	83	140	167	105	118
1960	78	82	126	126	94	116	120	158	332	332	70	70
61	86	86	74	74	73	92	90	110	-	-	81	81
62	98	98	109	109	66	88			-	-	75	103
63	160	160	108	108	72	108			86	130	85	99
64					75	94			68	90		
65					70	100			62	88		
66					104	104	57	73	50	84	60	83
67	137	137	92	157	110	130	70	70	300	304	65	67
68	89	125	90	110	68	72	80	110	160	163	75	104
69					80	105	150	150	58	89	48	64
1970	107	145	71	101	72	89	85	85	105	105		
71	99	134	104	144	69	88			62	80		
72	75	78	65	84	65	65	58	95	70	70		
73	118	143	210	210	100	132	81	92	115	124		
74	68	68	200	205	85	94	74	77	114	114		
75	110	119	115	163	120	120	72	85	67	82		
76	66	78	100	100			56	107			75	77
77	106	131	110	155			69	110			139	164

Table 2-3-32 Probable Rainfall of 5-Year Return Period

No.	Name of Station	Samples	One - Day	Two - Day
1	Batang Kwis	25	137.4	154.7
3	Kwala Namu	27	117.1	141.9
5	Tanjung Garbus	26	109.0	134.6
6	Pagar Merbau	26	118.6	147.6
8	Timbang Deli	23	150.2	165.7
9	K.S.Karang	20	147.8	158.4
11	S. Putih	27	109.4	134.3
13	Serbajadi	11	234.3	266.0
14	Bandar Kwala	16	97.4	130.2
15	Deli Muda	18	104.5	124.7
16	Melati	24	148.0	164.2
17	Tahan R. II	14	103.6	121.6
18	Liberia	14	247.7	283.2
19	Matapao	24	160.0	222.2
20	Bengabing	16	134.4	153.6
22	Peridaus	14	128.0	138.4
24	Adolina II	20	131.0	149.9
25	Adolina III/IV	20	146.8	179.8
26	Rambung	22	99.5	128.6
27	Ram Siarang	18	126.4	144.6
28	S. Parit	21	178.9	191.8
30	Sarang Giting	15	106.1	121.2
	Average		139.6	161.7

Table 2-3-33 Surface Draingage Discharge : Q

Unit : m^3/sec

Area	Ratio of Paddy Field %					
(ha)	100	80	60	40	20	0
50	0.36	0,52	0,62	0.69	0,77	0,82
100	0.72	0,98	1,13	1.25	1,35	1,44
200	1.45	1.86	2.08	2.25	2,39	2,51
400	2,88	3,49	3,80	4.02	4.19	4,32
600	4,25	5,03	5,38	5,61	5,77	5.89
800	5,61	6,51	6,89	7,12	7,26	7,33
1,000	6.95	7.96	8.35	8.56	8.66	8.70
2.000	13.54	14.90	15,21	15,22	15.04	14,74
4,000	26.39	28.01	27.85	27.17	26.20	25.00
6,000	38.93	40,53	39,70	38,18	36,24	34.02
8,000	51,32	52,70	51,14	48,66	45,68	42,34
10,000	63,57	64,70	62,24	58,76	54,67	50,16

Table 2-3-34 Proposed Drainage System

BLOCK No.	Name of Main Drain & Major Secondary Drain	Length (Km)	Catchment Area (Km^2)	Peak Discharge (m^3/sec)
I.	Pantai Labu	10.5	103.6	60.6
	S. Kennang	11.3	56.2	31.3
	Paluh Labu	9.0	22.6	22.6
	Paluh Sibaji	8.6	24.8	18.1
	S. Serdang		21.2	
	S. Galang	1.6	9.3	8.3
	S. Kwala Namu	7.9	11.9	9.9
II.	S. Denai		39.1	27.0
	Paluh Babi	10.5	27.9	20.5
	Canal. Kebun	5.0	11.2	8.5
III.	S. Perbaungan		65.2	40.7
	Tung Tung Canal	13.9	41.1	
	S. Perbaungan	22.7	12.3	
	-		11.8	
IV.			42.8	
	Pematang Kasih	9.1	9.7	8.1
	Canal Palu	5.0	3.6	3.3
	Pematang Lalang	5.7	9.6	7.7
	Ara Payung	5.9	6.8	6.8
	Kwala Lama	6.5	13.1	10.4
V.	Lubuk Dendang		21.6	15.9
	S. Sijenggi	7.9	11.1	9.3
	S. Lidah Tanah	2.3	2.7	3.0
	L. Sabah	5.4	7.9	
VI.	S. Baru		15.3	9.9
	S. Mayang	3.1	9.2	7.4
	S. Baru	8.1	6.1	5.7
VII.	Canal S. Buluh		106.9	56.3
	S. Nipah	16.0	21.2	15.9
	Canal S. Buluh	25.4	60.8	45.0
	S. Sialang	7.3	24.9	17.5
	S. Kotabangoen	9.1	27.4	19.1
	S.Kataran Batu	5.2	27.4	
VIII.	S. Buluh	12.8	17.0	13.0
IX.	S. Teluk Mengkudu	12.0	38.8	25.2
X.	S. Panda	7.7	51.8	26.3
		252.5	550.7	

Table 2-3-35 Results of Hydraulic Calculations for Intake, Settling Basin and Successive Canal

Name of Intake	Intake Discharge	Intake				Settling Basin				Successive Canal				
		Size of Intake	Water Level	Intake Bed Elevation	Water Depth	Effective Water Depth	Effective Length	Effective Width	Bed Elevation	Bed Width	Side Slope	Water	Gradient	Begining Canal Bed Elevation
	m^3/S	m	m	m	m	m	m	m	m	m			m	m
Pulau Gambar	1.12	1.00 x 2	44.2	43.66	0.54	2.10	16.0	3.6	41.97	2.5	1:1	0.00098	0.60	43.47
Swadaya	0.19	1.20 x 1	40.0	39.30	0.70	1.70	13.0	3.6	38.17	2.5	1:1	0.00086	0.55	39.32
Buluh	4.46	1.20 x 3	39.3	38.49	0.81	2.45	19.0	12.0	36.58	7.4	1:1	0.00047	0.90	38.13
Timbang Deli	0.45	0.75 x 4	32.8	32.60	0.20	1.60	12.0	2.2	31.13	1.8	1:1	0.00117	0.40	32.33
Perbaungan	6.16	1.20 x 4	26.4	25.56	0.84	2.50	19.0	16.4	23.62	9.5	1:1	0.00039	1.00	25.12
Sumber Rejo New	2.07	1.20 x 3	19.2	18.50	0.70	2.30	18.0	6.0	16.84	1.65	1:1	0.00102	0.70	18.44
Sumber Rejo Existing	0.95	1.00 x 4	17.9	17.63	0.27	2.00	15.0	3.2	15.81	3.0	1:1	0.00090	0.50	17.31
Bendang	1.90	ç 0.8 x 2	14.2	13.12	1.08	2.40	18.0	5.4	11.44	6.0	1:1	0.00050	0.60	13.24
Singosari	0.78	1.0 x 2	12.6	12.10	0.50	1.80	14.0	3.0	10.55	1.7	1:1	0.00035	0.55	12.00
Ramonia	1.90	1.2 x 3	8.4	7.73	0.67	2.20	17.0	5.8	6.15	2.0	1:1	0.00062	0.70	7.65
Total	20.7													

Table 2-3-36 (1) Results of Hydraulic Calculations for Irrigation Canals

Description	Canal Type	Discharge Q	Gradient I	Bed width B	Water depth H	Velocity V
		(m^3/s)		(m)	(m)	(m/s)
(1) Pulau Gambar						
Existing Main Canal	E.C/1	1.12	0.00098	2.50	0.60	0.60
" "	E.C	0.91	0.00086	2.50	0.55	0.55
(2) Buluh						
Existing Main Canal	E.C	4.46	0.00047	7.40	0.90	0.60
" "	E.C	5.15	0.0004	8.00	1.00	0.59
Existing Secondary Canal	E.C	1.98	0.00033	4.80	0.80	0.45
" "	E.C	1.41	0.00033	4.50	0.70	0.41
" "	E.C	1.07	0.001	2.50	0.60	0.60
New Secondary Canal	C.L/2	2.24	0.0004	2.00	0.90	0.92
" "	E.C	1.70	0.0005	4.30	0.70	0.51
" "	E.C	1.36	0.0005	3.30	0.70	0.49
" "	E.C	0.25	0.0005	1.50	0.40	0.33
" "	E.C	1.11	0.001	2.50	0.60	0.60
" "	E.C	0.34	0.001	1.50	0.40	0.46
" "	E.C	0.54	0.0005	2.50	0.50	0.40
" "	E.C	0.33	0.001	1.50	0.40	0.46
" "	E.C	0.13	0.001	1.00	0.30	0.37
" "	E.C	0.21	0.0008	1.00	0.40	0.39
" "	E.C	0.20	0.0008	1.00	0.40	0.39
" "	E.C	0.29	0.0008	1.40	0.40	0.41
" "	E.C	0.45	0.001	2.00	0.40	0.48
" "	E.C	0.11	0.001	0.80	0.30	0.36
" "	E.C	0.34	0.0008	1.70	0.40	0.41
" "	E.C	0.57	0.001	1.70	0.50	0.52
" "	E.C	0.22	0.001	1.00	0.40	0.44

Table 2-3-36 (2)

Description	Canal Type	Dsicharge Q	Gradient I	Bed width B	Water depth H	Velocity V
		(m^3/s)		(m)	(m)	(m/s)
New Secondary Canal	E.C	0.29	0.0008	1.40	0.40	0.41
" "	E.C	0.49	0.0005	2.00	0.50	0.38
" "	E.C	0.17	0.0005	1.00	0.40	0.31
" "	E.C	0.17	0.0008	0.80	0.40	0.38
" "	E.C	0.16	0.001	0.80	0.40	0.42
" "	E.C	0.44	0.0005	1.80	0.50	0.38
" "	E.C	0.12	0.0005	0.80	0.40	0.30
" "	E.C	0.20	0.0005	1.20	0.40	0.31
(3) Timbang Deli						
Existing Main Canal	E.C	0.45	0.00117	1.80	0.40	0.51
(4) Perbaungan						
Existing Main Canal	E.C	6.16	0.0004	9.50	1.00	0.59
Existing Secondary Canal	E.C	5.14	0.0005	8.50	0.90	0.60
" "	E.C	3.43	0.0005	7.00	0.80	0.57
" "	E.C	1.86	0.00067	4.00	0.70	0.58
" "	E.C	1.86	0.0005	4.60	0.70	0.51
" "	E.C	1.71	0.00067	4.00	0.70	0.56
" "	E.C	1.50	0.00067	3.20	0.70	0.56
" "	E.C	1.50	0.0005	3.70	0.70	0.49
" "	E.C	1.33	0.0005	3.30	0.70	0.48
" "	E.C	1.06	0.001	2.30	0.60	0.60
New Secondary Canal	C.L	1.02	0.0005	1.30	0.70	0.85
" "	C.L	0.51	0.001	1.00	0.42	0.89
" "	E.C	0.13	0.0007	0.80	0.40	0.35
" "	E.C	0.89	0.0005	2.80	0.60	0.44
" "	E.C	0.51	0.001	1.50	0.50	0.52
" "	E.C	0.38	0.0005	1.50	0.50	0.38

Table 2-3-36 (3)

Description	Canal Type	Discharge Q	Gradient I	Bed width B	Water depth H	Velocity V
		(m^3/s)		(m)	(m)	(m/s)
New Secondary Canal	E.C	0.18	0.0008	0.80	0.40	0.38
" "	E.C	0.20	0.0005	1.20	0.40	0.31
" "	E.C	0.33	0.0007	1.70	0.40	0.39
" "	E.C	0.11	0.0007	1.00	0.30	0.31
" "	E.C	0.17	0.001	0.80	0.40	0.42
" "	E.C	0.22	0.001	1.00	0.40	0.43
" "	E.C	0.71	0.001	1.50	0.60	0.57
" "	E.C	0.66	0.001	1.40	0.60	0.57
" "	E.C	0.34	0.001	1.50	0.40	0.46
" "	E.C	0.45	0.001	1.30	0.50	0.51
" "	E.C	0.39	0.001	1.10	0.50	0.49
" "	E.C	0.47	0.001	1.40	0.50	0.51
" "	E.C	0.47	0.0008	1.50	0.50	0.47
(5) Sumber Rejo						
Existing Main Canal	E.C	0.95	0.0009	3.00	0.50	0.54
" "	E.C	3.02	0.00067	6.50	0.70	0.60
Existing Secondary Canal	E.C	1.59	0.0007	3.50	0.70	0.56
" "	E.C	1.20	0.0007	3.20	0.60	0.53
" "	E.C	0.75	0.0007	2.60	0.50	0.48
" "	E.C	0.41	0.0007	1.50	0.50	0.41
" "	E.C	0.24	0.0009	1.10	0.40	0.40
New Main Canal	C.L	2.07	0.001	1.65	0.70	1.24
New Secondary Canal	E.C	0.39	0.0005	1.70	0.50	0.37
" "	E.C	0.17	0.0005	1.20	0.40	0.31

Table 2-3-36 (4)

Description	Canal Type	Discharge Q (m^3/s)	Gradient I	Bed width B (m)	Water depth H (m)	Velocity V (m/s)
New Secondary Canal	E.C	0.22	0.001	1.00	0.40	0.44
" "	E.C	0.35	0.0005	1.60	0.50	0.37
" "	E.C	0.16	0.0005	1.20	0.40	0.31
" "	E.C	0.19	0.001	0.80	0.40	0.42
" "	E.C	0.17	0.001	0.70	0.40	0.41
" "	E.C	0.24	0.001	1.00	0.40	0.43
" "	E.C	0.19	0.001	0.80	0.40	0.42
(6) Bendang						
Existing Main Canal	E.C	1.90	0.0005	6.00	0.60	0.48
Existing Secondary Canal	E.C	1.16	0.0005	2.80	0.70	0.48
" "	E.C	0.86	0.0005	2.00	0.70	0.45
" "	E.C	0.53	0.001	1.50	0.50	0.53
" "	E.C	0.28	0.001	1.20	0.40	0.44
" "	E.C	0.31	0.001	1.30	0.40	0.45
(7) Singosari						
Existing Secondary Canal	E.C	0.39	0.001	1.70	0.40	0.46
New Main Canal	C.L	0.78	0.00035	1.70	0.55	0.64
New Secondary Canal	E.C	0.50	0.0005	2.20	0.50	0.38
" "	E.C	0.28	0.001	1.20	0.40	0.44
" "	E.C	0.10	0.001	0.60	0.30	0.35
" "	E.C	0.11	0.0005	1.10	0.30	0.30
" "	E.C	0.15	0.001	1.10	0.30	0.37
(8) Ramonia						
Existing Secondary Canal	E.C	0.87	0.0005	2.00	0.70	0.45
" "	E.C	0.57	0.001	1.20	0.60	0.54
" "	E.C	0.28	0.0005	1.10	0.50	0.35

Table 2-3-36 (5)

Description	Canal Type	Discharge Q	Gradient I	Bed width B	Water depth H	Velocity V
		(m^3/s)		(m)	(m)	(m/s)
Existing Secondary Canal	E.C	0.84	0.0005	2.00	0.70	0.45
" "	E.C	0.60	0.0005	1.90	0.60	0.42
" "	E.C	0.47	0.0005	2.00	0.50	0.38
" "	E.C	0.35	0.0005	1.50	0.50	0.37
New Secondary Canal	E.C	0.28	0.001	1.20	0.40	0.44
" "	E.C	0.16	0.001	0.80	0.40	0.42
" "	E.C	0.06	0.001	0.60	0.30	0.35
" "	E.C	0.10	0.001	0.60	0.30	0.35
" "	E.C	0.08	0.001	0.60	0.30	0.35

Note ∠1 : Earth Canal

∠2 : Concrete Lining Canal

Table 2-3-37 Proposed Irrigation Facilities

Note ; A : Facilities not to be improved
B : Facilities to be improved
C : New Facilities

Facilities		Intake (No)	Settling Basin (No)	Canal length (Km)			Related Structure (No)								
				Main	Secondary	Total	Main Diversion Work	Secondary Diversion Work	Drop	Aqueduct	Syphon	Conduit	Bridge	Check Gate	Spillway
Pulau Gambar & Swadaya	A	2	-	-	22.7	22.7	1	2	3	1	-	-	5	-	-
	B	-	-	5.0	-	5.0	-	2	1	-	1	-	-	-	-
	C	-	2	-	-	-	-	-	-	-	-	-	-	-	-
	Total	2	2	5.0	22.7	27.7	1	4	4	1	1	-	5	-	-
Buluh	A	1	-	12.0	20.0	32.0	-	2	-	-	-	-	-	-	-
	B	-	-	8.0	3.7	11.7	1	3	6	-	1	1	2	-	3
	C	-	1	-	64.0	64.0	1	13	4	6	12	-	2	3	-
	Total	1	1	20.0	87.7	107.7	2	18	10	6	13	1	4	3	3
Timbang Deli	A	-	-	-	7.0	7.0	-	1	-	-	-	-	-	-	-
	B	1	-	2.0	-	2.0	1	-	-	-	-	-	-	-	-
	C	-	1	-	-	-	-	-	-	-	-	-	-	-	-
	Total	1	1	2.0	7.0	9.0	1	1	-	-	-	-	-	-	-
Perbaungan	A	1	-	-	12.0	12.0	-	-	-	-	-	-	6	-	-
	B	-	-	2.0	29.1	31.1	2	6	6	1	2	-	9	-	2
	C	-	1	-	52.9	52.9	1	10	13	10	16	-	2	2	-
	Total	1	1	2.0	94.0	96.0	3	16	19	11	18	-	17	2	2
Sumber Rejo	A	1	-	-	26.2	26.2	-	3	-	-	1	1	-	-	-
	B	-	-	0.6	6.4	7.0	-	4	-	1	-	-	-	-	-
	C	1	2	1.1	14.3	15.4	-	6	3	1	9	-	-	-	-
	Total	2	2	1.7	46.9	48.6	1	13	3	2	10	1	-	-	-
Bendang	A	1	-	1.5	11.1	12.6	-	-	-	2	-	-	-	-	-
	B	-	-	2.8	3.1	5.9	1	2	-	1	-	-	-	-	-
	C	-	1	-	11.8	11.8	-	1	1	2	3	-	-	1	-
	Total	1	1	4.3	26.0	30.3	1	3	1	5	3	-	-	1	-
Singosari	A	-	-	-	4.2	4.2	-	-	-	-	-	-	-	-	-
	B	-	-	-	2.4	2.4	-	1	-	-	-	-	-	-	-
	C	1	1	1.5	6.1	7.6	1	2	2	3	7	-	-	-	-
	Total	1	1	1.5	12.7	14.2	1	3	2	3	7	-	-	-	-
Ramonia	A	1	-	-	14.2	14.2	-	1	-	4	1	-	-	-	-
	B	-	-	-	6.8	6.8	1	6	-	3	-	-	-	-	-
	C	-	1	-	9.4	9.4	-	1	2	2	8	1	-	-	-
	Total	1	1	-	30.4	30.4	1	8	2	9	9	1	-	-	-
Grand Total	A	7	-	13.5	117.4	130.9	1	9	3	7	2	1	11	-	-
	B	1	-	20.4	51.5	71.9	7	24	13	6	4	1	11	-	5
	C	2	10	2.6	158.5	161.1	3	33	25	24	55	1	4	6	-
	Total	10	10	36.5	327.4	363.9	11	66	41	37	61	3	26	6	5

Table 2-3-38 Proposed Drainage Canal

Block No.	Name of Main Drain	Total Length (m)	Discharge (m^3/sec)	Length to be Improved (m)	Canal Type
Main Drains					
I	Pantai Labu	10,500	17.3 - 60.6	To be left as it is.	
II	S. Denai	7,300	5.41 - 20.53	7.300	III-VIII
III	S.Perbaungan	22,700	3.12 - 40.72	16,700	V,VII, VIII,XII
	-Tung Tung Canal	13,900	5.54 - 19.00	To be left as it is.	
IV	Pematang Kasir	9,100	5.66 - 8.13	4,600	III-V
	Canal Palu	5,000	3.29	2,000	III
	Pematang Lalang	5,700	5.54 - 7.69	2,700	III-V
	Arapayung	5,900	5.95	2,800	IV
	Kwala Lama	6,500	5.50 - 10.43	3,000	III-VI
V	Lubuk Dendang				
	-S.Sijenggi	7,900	7.26 - 11.08	To be left as it is.	
	-S.Lubuk Saban	8,100	11.08- 15.92	7,300	VI,VII
VI	S. Baru	8,100	5.17 - 9.9	5,300	III-V
VII	Canal S.Buluh				
	-S.Nippah	19,400	3.67 - 15.91	19,400	I-V
	-Canal S.Buluh	27,300	9.8 - 56.27	27,300	II-V,VII VIII,X
VIII	S. Buluh	18,000	2.40 - 52.2	18,000	III-VI,XI
IX	S.Teluk Mengkudu	12,000	8.03 - 25.16	4,200	VI-VIII
X	S.Pavdo	7,700	2.05 - 20.7	4,400	III,VI, VIII
	T o t a l	195,100		125,000	
Secondary Canals					
I		26,600	2.03 - 8.50		II-IV
II		7,600	3.19 - 5.41		II, III
III		18,800	2.3 -10.24		I-V
IV		3,800	3.29		I
V		12,500	3.02		I
VI		3,000	5.67		II
VII		12,200	1.44 - 7.15		I-III
VIII		3,500	2.4 - 3.5		I, II
IX		20,700	3.0 - 9.91		II, III
X		27,600	4.09 -11.78		III-Vi
	T o t a l	136,300			

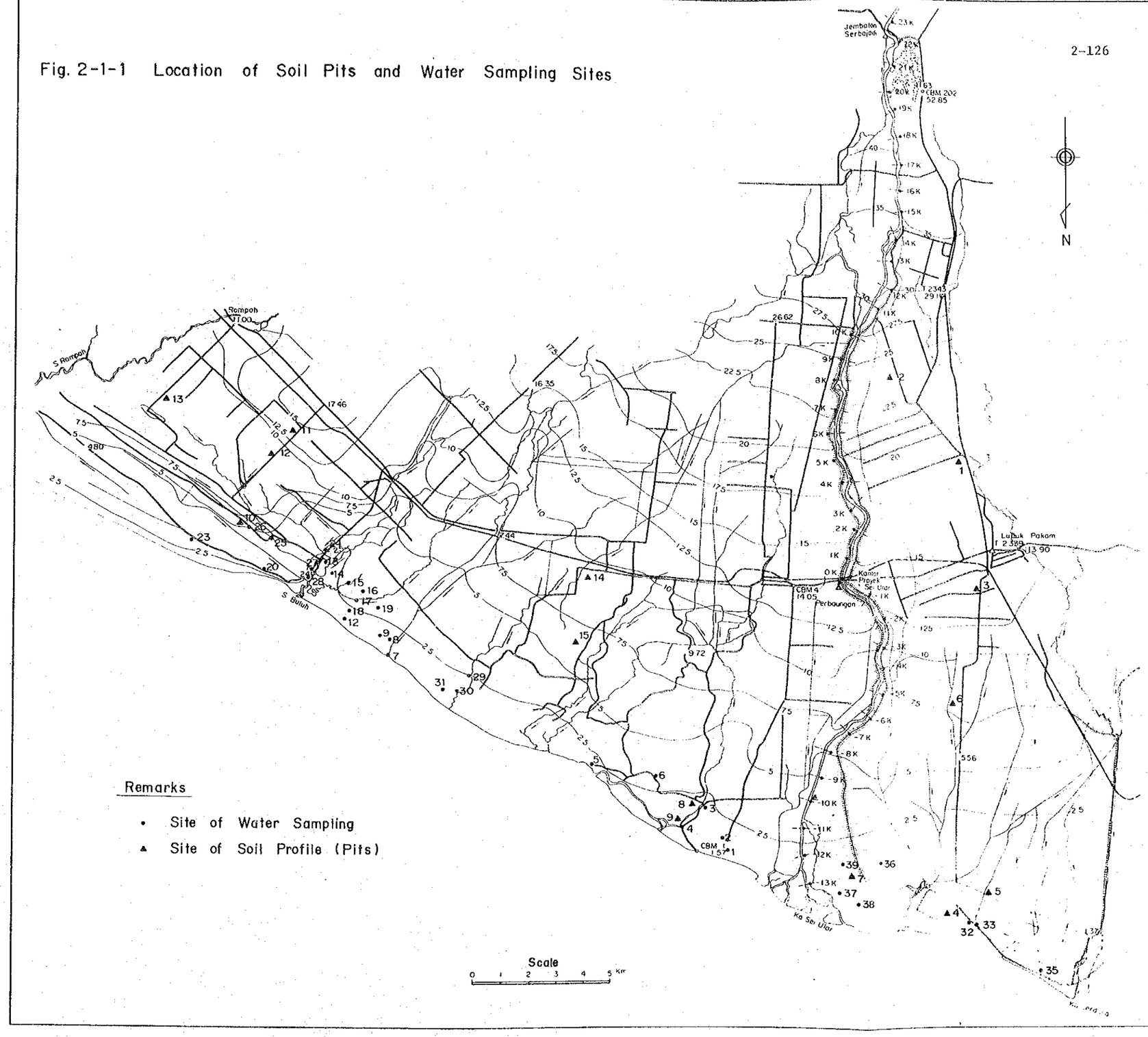
Table 2-3-39 Proposed Drainage Related Structures

Block No.	Name of Main Drain	Drop	Bridge	Flap gate
I	Pantai Labu		1	1
II	S. Denai		1	1
III	S. Perbaungan	6	1	2
VII	Canal S. Buluh & S. Nippah	24	4	
VIII	S. Buluh	6	1	2
IX	S.Teluk Mengkudu	1	3	2
X	S. Pavdo	2	5	3

Table 2-3-40 Length of Farm Ditch, Farm Drain and Farm Road

Irrigation Block	Farm ditch (m)	Drain (m)	Farm road (m)
Pulau Gambar			
Irrigated area	24,000	24,000	18,000
Rain-fed area	-	-	-
Total	24,000	24,000	18,000
Buluh			
Irrigated area	8,000	8,000	6,000
Rain-fed area	168,000	168,000	126,000
Total	176,000	176,000	132,000
Timbang Deli			
Irrigated area	8,000	8,000	8,000
Rain-fed area	-	-	-
Total	8,000	8,000	8,000
Perbaungan			
Irrigated area	39,000	39,000	29,250
Rain-fed area	142,000	142,000	106,500
Total	181,000	181,000	135,750
Sumber Rejo			
Irrigated area	16,000	16,000	12,000
Rain-fed area	76,000	76,000	57,000
Total	92,000	92,000	69,000
Bendang			
Irrigated area	20,000	20,000	15,000
Rain-fed area	28,000	28,000	21,000
Total	48,000	48,000	36,000
Singosari			
Irrigated area	3,000	3,000	2,250
Rain-fed area	22,000	22,000	16,500
Total	25,000	25,000	18,750
Ramonia			
Irrigated area	22,000	22,000	16,500
Rain-fed area	24,000	24,000	18,000
Total	46,000	46,000	34,500
Grand total	600,000	600,000	450,000

Fig. 2-1-1 Location of Soil Pits and Water Sampling Sites



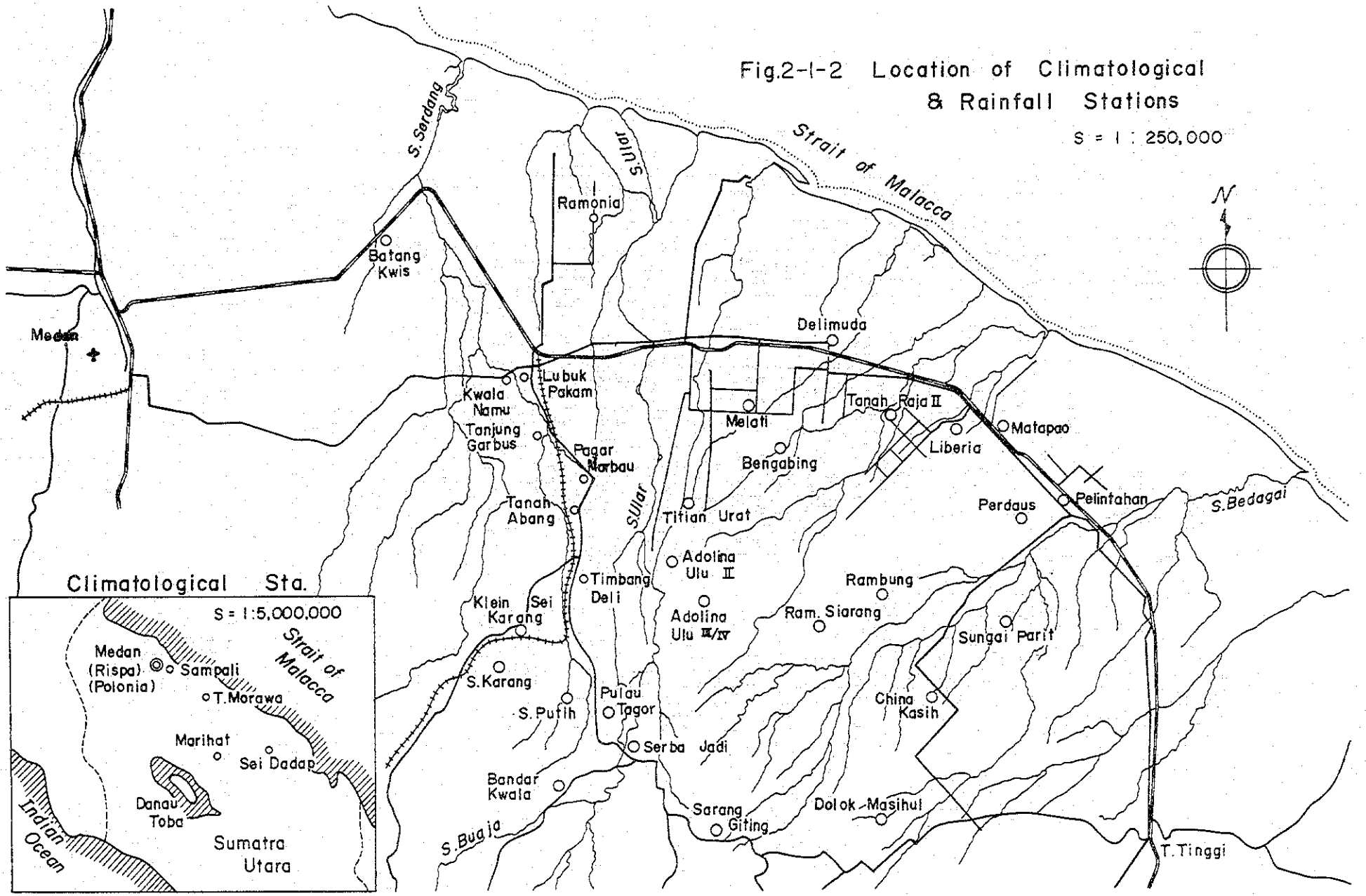


Fig.2-1-2 Location of Climatological & Rainfall Stations
S = 1 : 250,000
N
Strait of Malacca
S. Serdang
S. Ular
Ramonia
Batang Kwis
Medan
Delimuda
Lubuk Pakam
Kwala Namu
Tanjung Garbus
Pagar Merbau
Melati
Tanah Raja II
Matapao
Liberia
Bengabing
Tanah Abang
Titian Urat
Perdaus
Pelintahan
S. Bedagai
Adolina Ulu II
Timbang Deli
Rambung
Klein Sei Karang
Adolina Ulu III/IV
Ram. Siarang
Sungai Parit
S. Karang
S. Putih
Pulau Tagor
China Kasih
Serba Jadi
Bandar Kwala
Sarang Giting
Dolok Masihul
S. Bugis
T. Tinggi
Climatological Sta.
S = 1:5,000,000
Strait of Malacca
Medan (Rispa) (Polonia)
Sampali
T. Morawa
Marihat
Sei Dadap
Danau Toba
Indian Ocean
Sumatra Utara

Fig. 2-1-3 Chart of Daily Rainfall Record

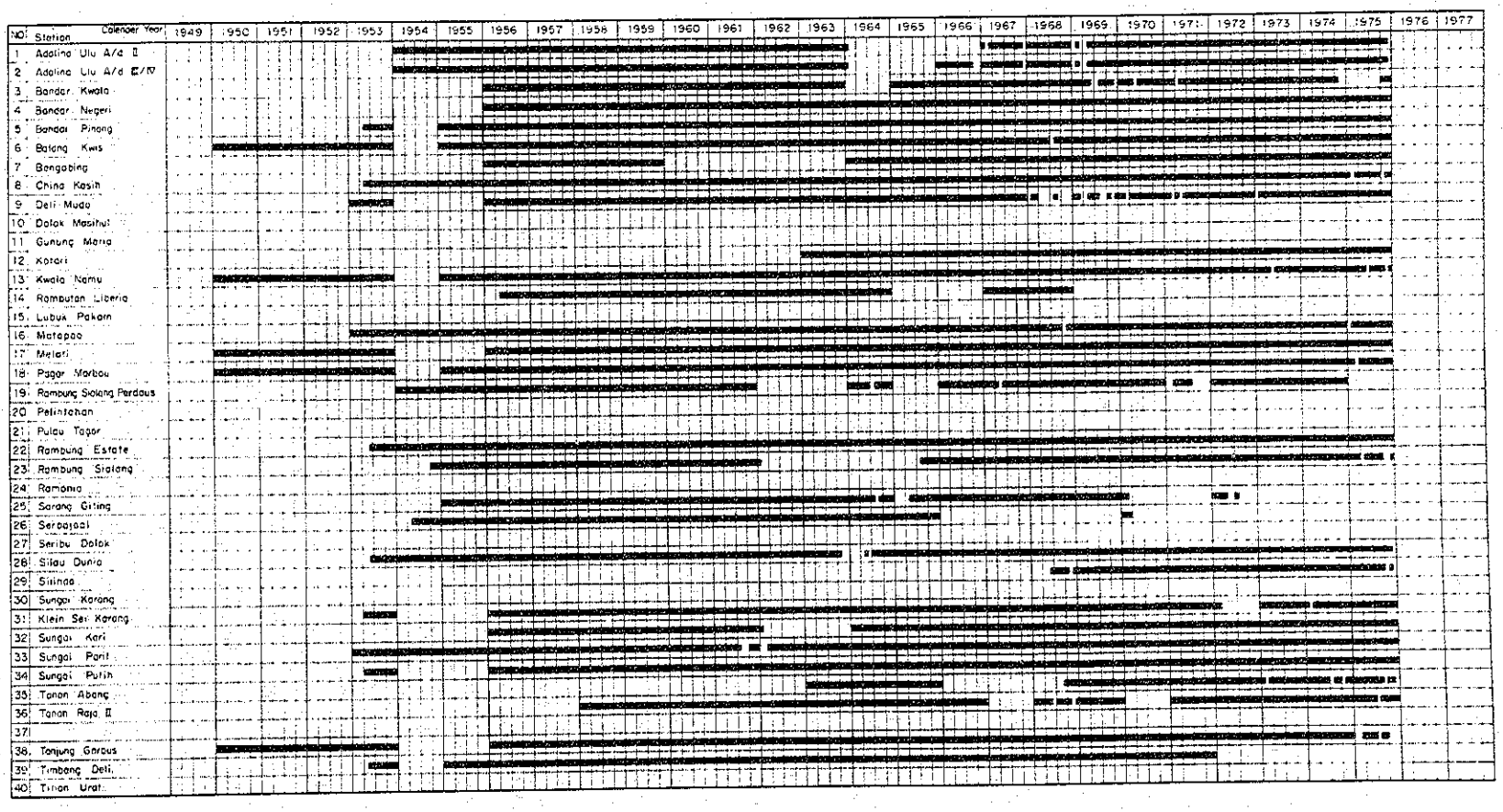


Fig. 2-1-4 Discharge Co-relation Between Pulau Tagor (Serbajadi Bridge) and Ular Bridge

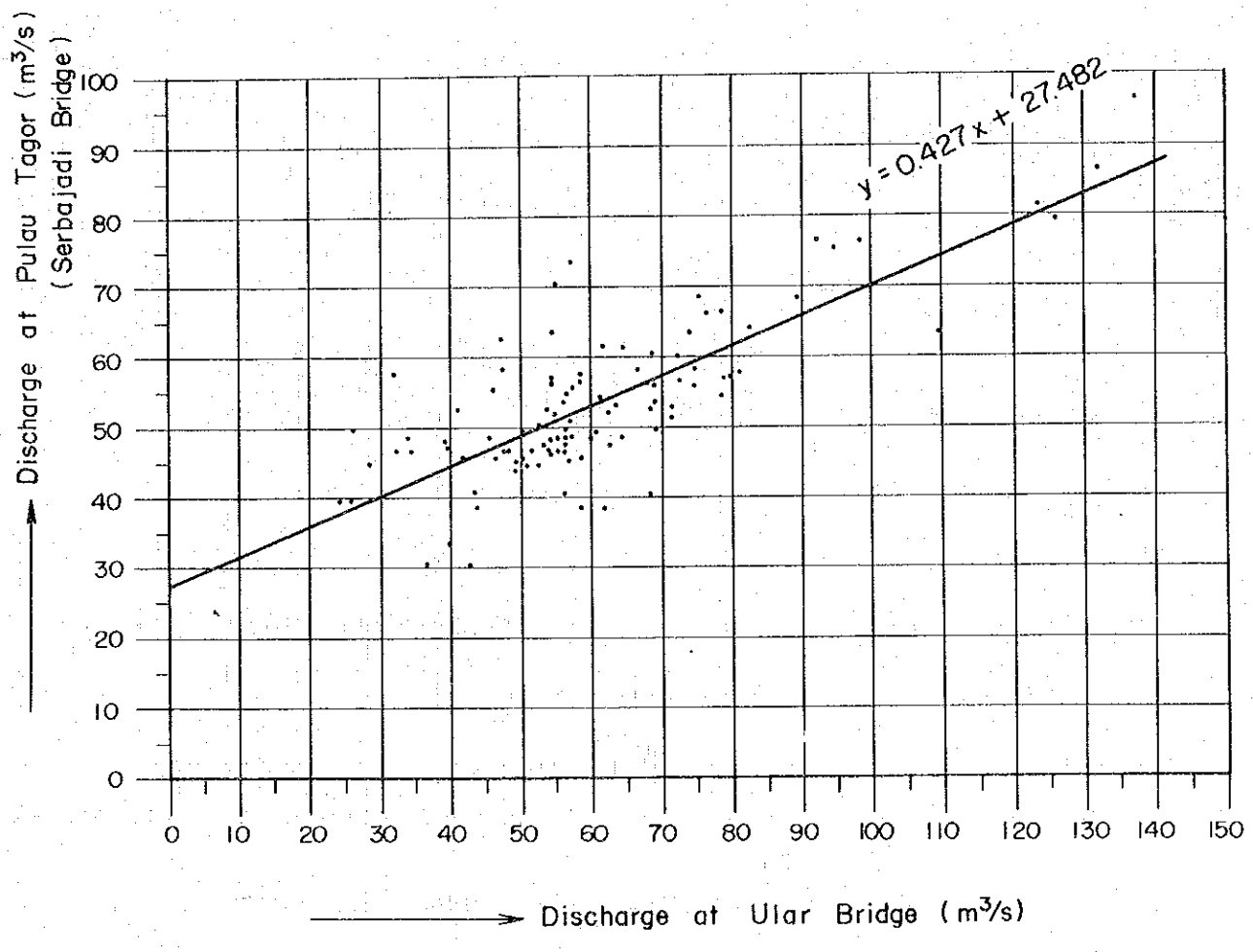
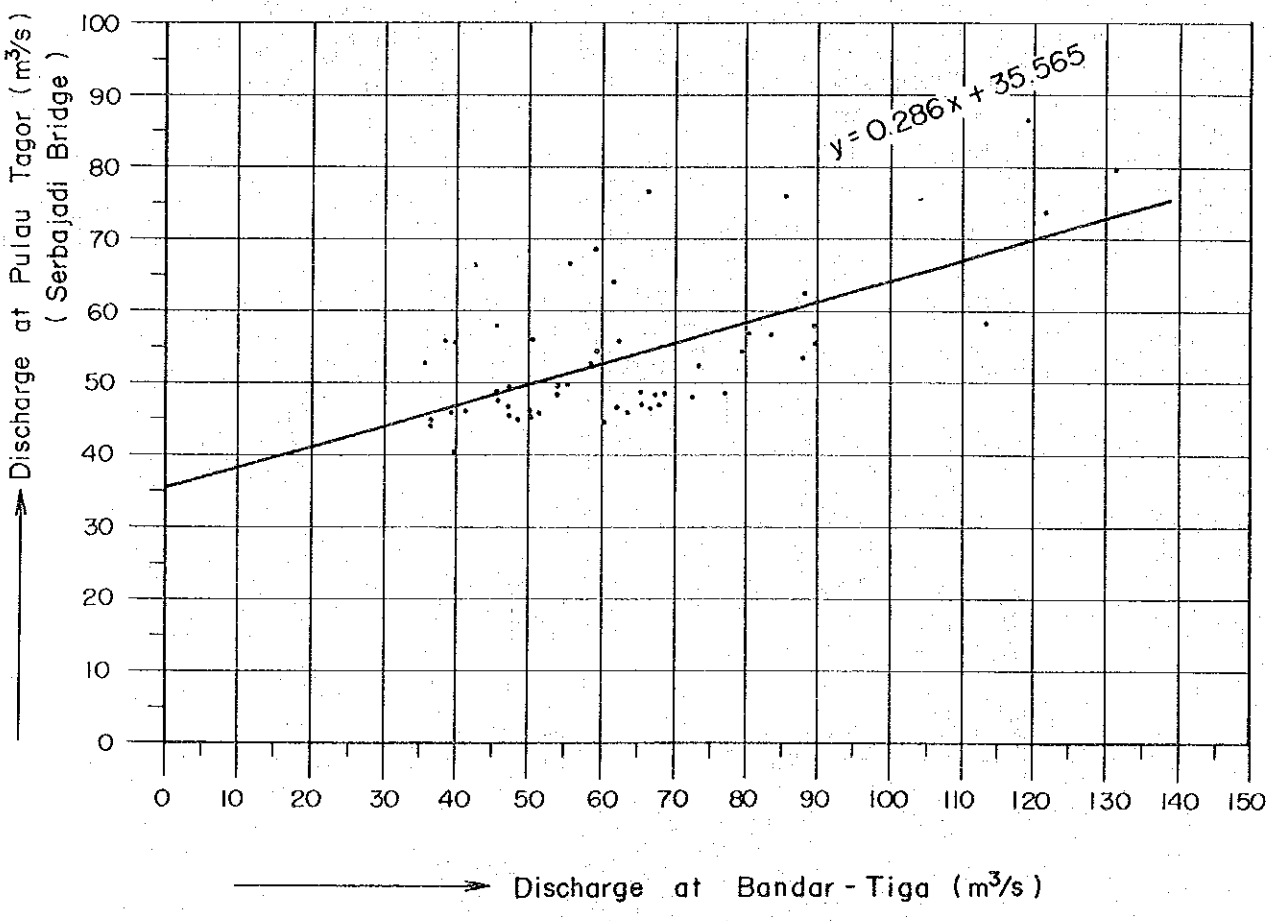


Fig. 2-1-5 Discharge Co-relation Between Pulau Tagor (Serbajadi Bridge) and Bandar Tiga



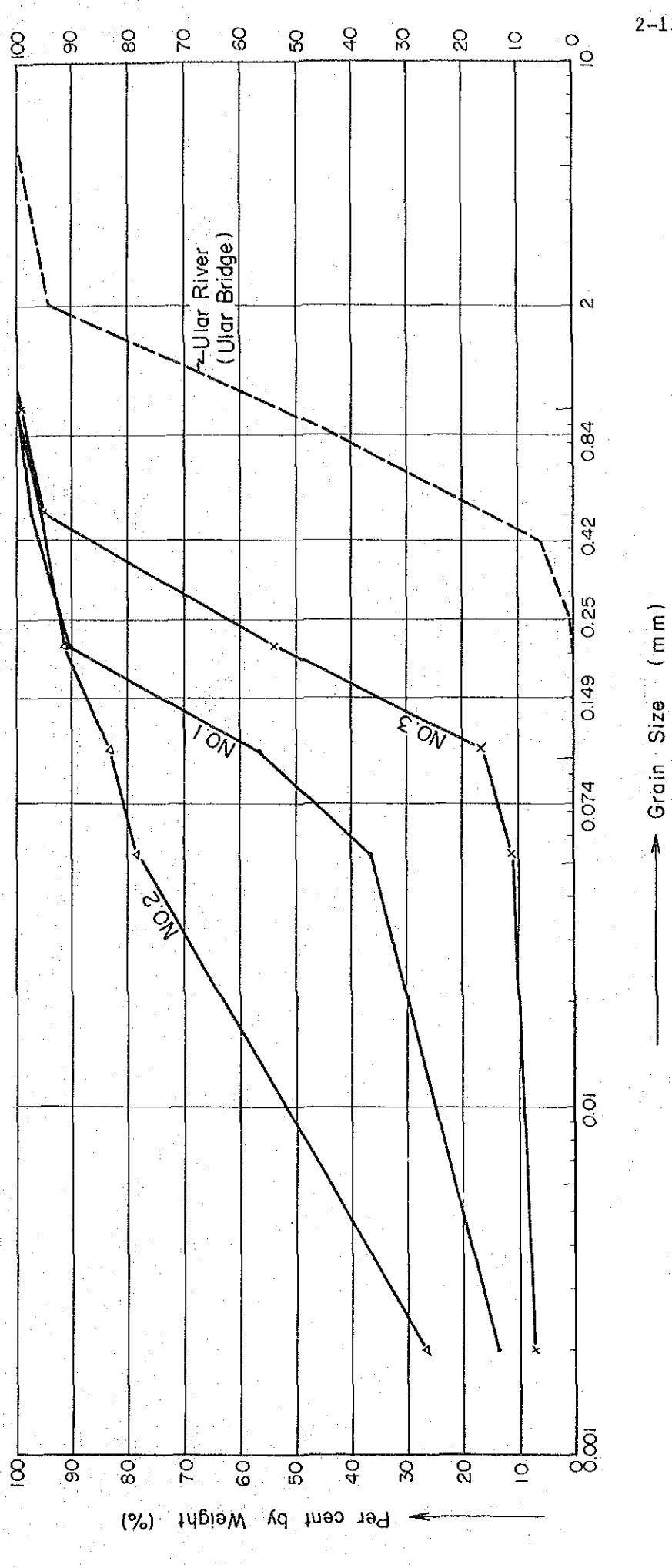


Fig. 2-1-6,(1) Grain Size Accumulation Curve
(Pulau Gambar)

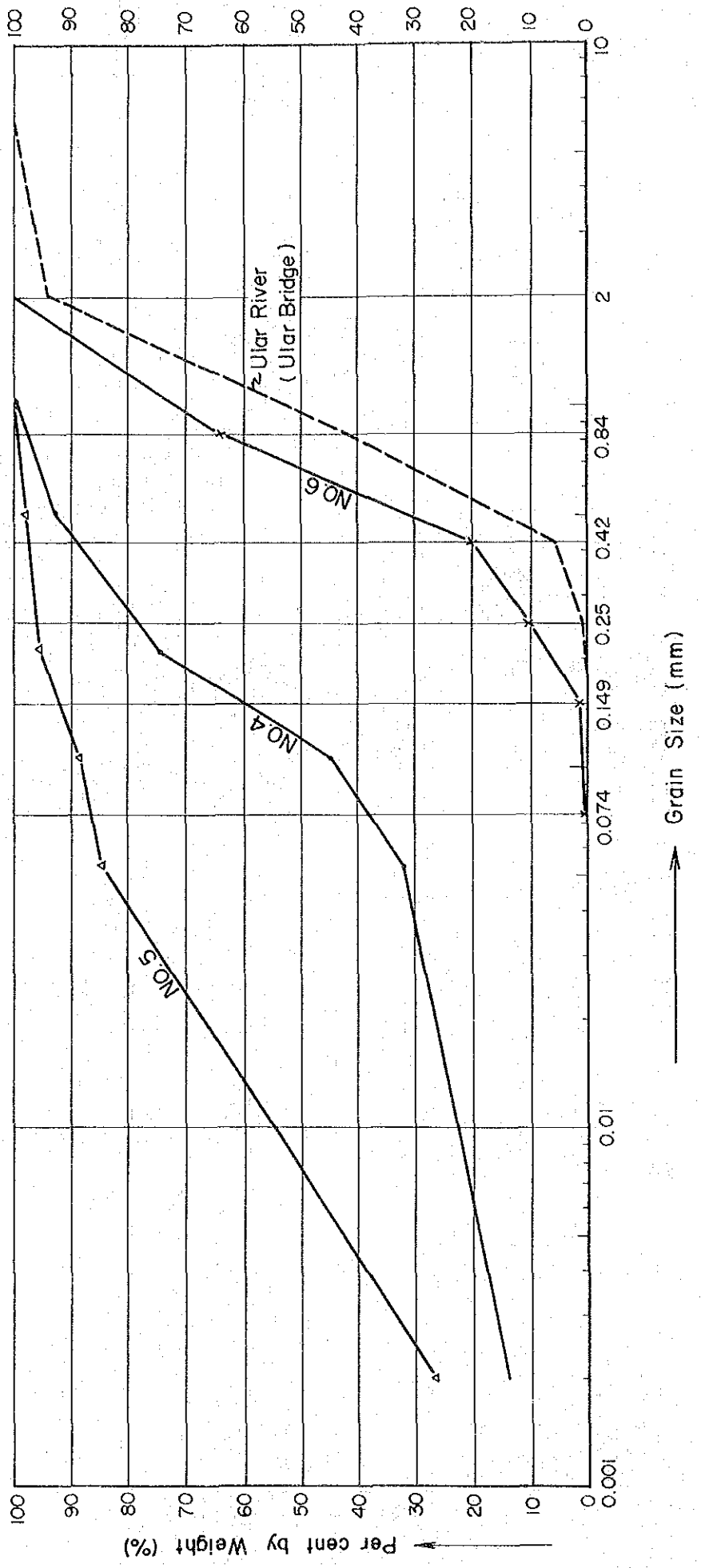


Fig.2-1-6,(2) Grain Size Accumulation Curve

(S. Buluh)