Comparing the above figures with the annual poverty line of ₱ 24,792, it can be concluded that the living standard of the farmers in the Project Area is fallen on a lower level.

3.7 Social Conditions

1) Roads

According to the data prepared by the Department of Public Works and Highway in 1985, the existing length of the roads in Tarlac Province is 211 km of the national road, 561 km of the provincial road, 140 km of the municipal road, 3,627 km of the barangay road and 4,539 km in total.

The ratio of the pavement with concrete or asphalt material is 78% in the national road, 25% in the provincial road, 54% in the municipal road but less than 1% in the barangay roads.

The ratio of the gravel pavement is 65% in the provincial road, 34% in the municipal road and 54% in the barangay roads.

The Lagawa-Burgos provincial road which is the main access road to the Project Area is mostly paved with gravel materials and is planned partly to pave with concrete materials for a further traffic increase due to the implementation of the Balog-Balog Multipurpose Project.

The barangay roads inside of the Project Area are almost earth roads with partly paved by concrete or asphalt materials at dense housing area. They, therefore, become badly muddy with much appearance of small water-pool here and there and results in troubles on passing to the local populace.

The barangay roads linked in the Project Area are as follows:

Burgos	:	13 routes	9.75 km	
Iba	:	22 routes	12.52 km	
Mariones	:	10 routes	5.24 km	
Lubigan	:	5 routes	6.00 km	
Villa Agripay	:	9 routes	13.50 km	
Sula	:	6 routes	12.38 km	(Total 59.39 km)

The local populace go and back from the center of Tarlac Municipality through the above barangay roads via the Lagawa-Burgos provincial road.

2) Transportation measures

Main transportation measures are a buffalo wagon, tractor, jeepney, jeep or track. Highway bus is available between Tarlac Municipality and the other main city (Manila, Baguio, Dagupan, San Fernando, etc.). Because of bad road conditions in the Project Area, the traffic by the owned passenger car is very few.

3) Telephone and Telegram

Telephone system is conected from Tarlac Municipality to Manila and the other main cities, the telegraphic office is also situated in Tarlac Municipality. Postal services by the National Government cover all the barangay area and the private LBC cargo services are available interconnecting the main urban area of the Philippines.

4) Water supply facilities

The Tarlac Water District is serving municipal water to 2,200 households and some factories with the capacity of 69,513 m^3/day from the four deep wells. The Project Area, however, is not included in the service area of the Tarlac Water District. The local populace, therefore, use ground water lifted by the manual pumps, spring water, streams and the Bulsa River water for their living. They strongly request to provide the drinking and domestic water supply facilities.

5) Electric Power

Generally, electricity in the province is supplied by the grid system of the National Power Corporation (NPC), a network of interconnecting power stations and transmission lines which distributes electric power in all municipalities. Private franchise holders purchase power from the NPC and provide services for distribution of electricity among the household population. In Tarlac Municipality, the Tarlac Enterprise is supplying the electricity with the capacity 50,000 KVA/day with diesel generator. 55% of the barangays in the province is already electrified, and 45% is not electrified. All the barangays in the Project Area is not electrified yet.

6) Education and Medical Services

In Tarlac Municipality, there exists 89 public primary schools, 6 private primary schools, 2 public high schools, 5 private high schools and 4 colleges. Also, 10 hospitals and 24 health centers are providing medical services. The public primary school is constructed with a ratio of one per one barangay.

3.8 Relevant Development Projects

The development project which is relevant to this Project is the Balog-Balog Multipurpose Project (BBMP). The project will construct a rockfill type dam with 113.5 m dam height at Balog-Balog in Mamot Municipality, at around 10 km upstream of the Project Area and creates a reservoir having the gross storage capacity of 625 million m^3 and improve the existing Tarris diversion dam to store 1 million m^3 of water for irrigation. It has the irrigation plan for about 40 thousand hectares covering the municipalities of Conception, Gerona, La Paz, Paniqui, Pura, Ramos, Tarlac, Victoria and Magalang to provide year-round supply of irrigation water. The cropping is planned with paddy, sugarcane and diversified crops (e.g. corns). The project also includes the improvement of the irrigation canal system and the construction of hydropower plant of 3 x 11 MW and the related transmission line.

The total project cost is estimated at ₱ 3,750 million and assisted with the World Bank Loan. The feasibility survey was carried out by the ELC- Electoroconsult, Italy. This project is accompanied by the BBMP Resettlement and Rehabilitation Program for the concerned farmers with the land acquisition of the reservoir area of 18 km^2. The implementing agency is the NIA, and the BBMP office was constructed in Tarlac Municipality and the construction preparation works are on-going.

Under the BBMP,there is no plan to improve the barangay road and bridge in the Western Barrios area except the pavement plan of the Lagawa-Burgos provincial road for constructing the BBM dam.

The Western Barrios area has the existing CIS (250 ha) in Sula and Iba and the existing CIS (175 ha) in Lubigan with double cropping. The Lubigan CIS is of an earth canal structure and its improvement to the concrete lining canal is planned by the Provincial Irrigation Office of the NIA.

The other relevant project is the Diversified Crops Irrigation Engineering Center Project (DCIECP), which have started out as a Grant Aid Program of Japan in Manila. This project aims to establish the necessary irrigation technology for the diversified crops on the paddy field which is the urgent nation-wide requirement after the attainment of the self-sufficiency of rice production. The irrigation plan of the Project aims also to stabilize the wet season paddy production and to develop the diversified crops (e.g. corns) in the dry season, therefore, the established irrigation technology at the DCIECP is expected to be applied on the Western Barrios area to produce successful fruits to the local farmers as well as to the local society concerned.

The relationship between the above projects and this Project have been illustrated in the following figure :

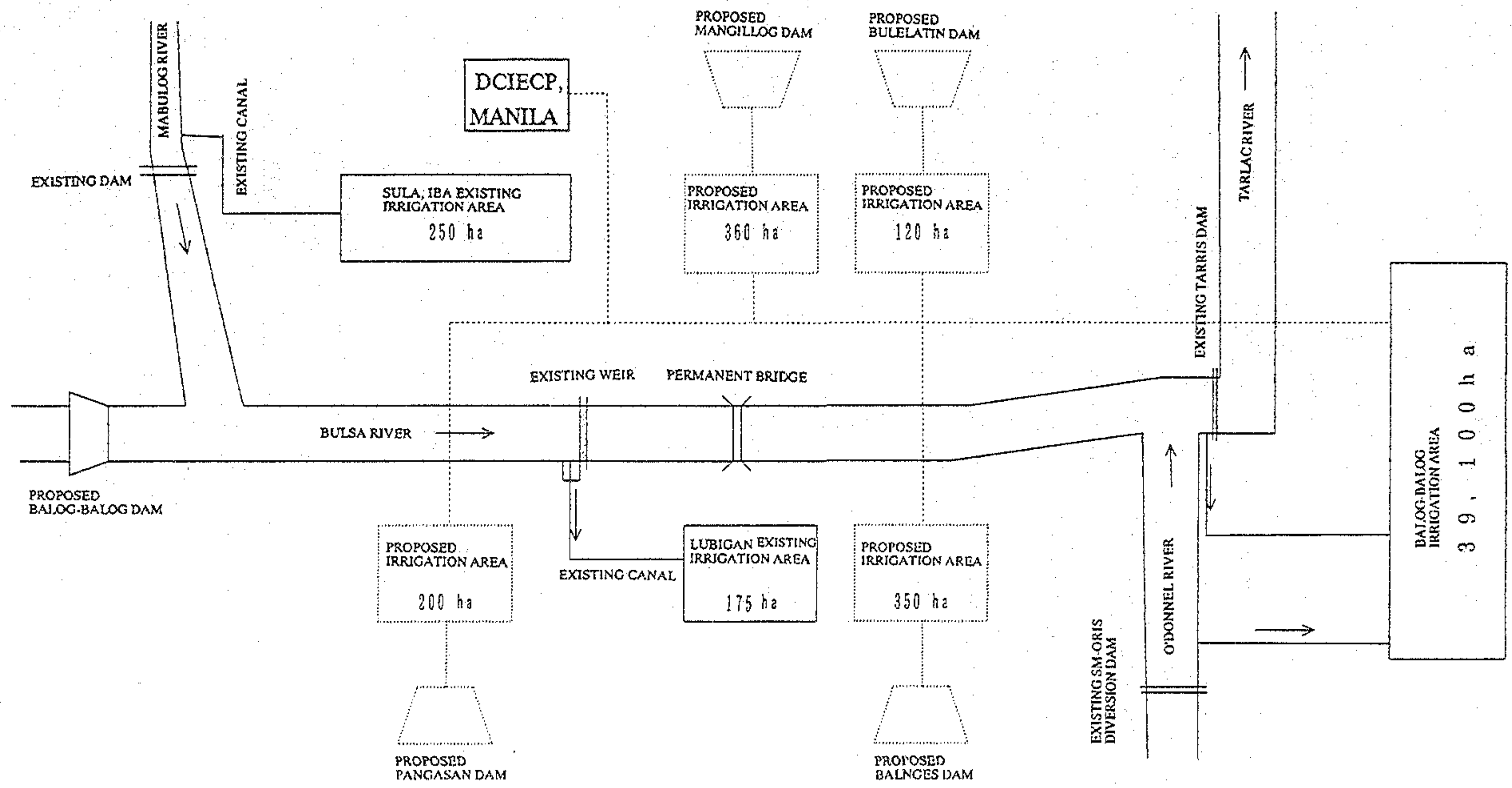


Fig.3.8.1 SCHEMATIC DIAGRAM OF DEVELOPMENT IN WESTERN BARRIOS AREA

CHAPTER 4 OUTLINE OF THE PROJECT

4.1 Objectives

The purpose of this Project is to construct dams, reservoirs, irrigation facilities, operation and maintenance roads including a bridge in the Western Barrios area, and to contribute to increasing agricultural productivity and income, stabilizing farm management, uplifting living standard of farmers, strengthening farmers irrigators' association, enhancing rural communication and consensus, and finally direct to the activation of rural economy and the prosperity of rural society.

The Government of the Philippines is now encouraging the implementation of the Small Water Impounding Management Project (SWIM) all over the country as an important national project since 1981. The dams and reservoirs planned for this Project are expected to present a good preceding example to the SWIM Project.

4.2 Review of the Request

(1) Irrigation systems

a. Necessity

The Project Area has been developed mainly as a rainfed paddy field and paddy is cropped during the wet season. The paddy production remains in the level of 2 ton/ha because of lack of water sources and irrigation systems by which crop water requirements can be met adequately with crop growth in addition to uneven distribution of rainfall during the wet season. As a result, the income of local farmers is very low and, in the dry season, the farmers are forced to give up any crop cultivation owing to lack of water and thus the field is left dry. Farmers are suffering from unstable income and either work away from home for daily wages or to hunting in the mountain, breeding sheep or livestock, or fishing in the river. For farmers to settle in the area and to secure the stable income, it is necessary to realize irrigation development including the construction of water sources, irrigation and drainage facilities. The farmers desire those development and express willingness for participation to the Project and cooperation in future operation and maintenance activities.

The surface water source in the Project Area belongs to the Bulsa River system. The rainfed paddy field in the area does not have any water right of the Bulsa River. On the other hand, the Balog-Balog multipurpose dam is under construction in the upper reach of the Bulsa River, and all water from the Bulsa River have been allocated to the beneficial area of BBMP. Since new establishment of water right on the main Bulsa River for the Project area is difficult, available water sources for the Project area are limited to the tributaries of the Bulsa River system.

As the climate of this area is characterized by the distinguished wet and dry season, reservoirs are essentially required as the water source facilities of the Project area so as to store run off water in the wet season and release in the dry season for irrigation.

Despite the small distance (only 20 km) from the center of Tarlac Municipality, the development is left untouched due to shortage of infrastructure fund. The administrative authorities also acknowledge the necessity of breaking out from this poverty-stricken state.

b. Technical feasibility

The result of the field surveys and the home studies have proved the technical feasibility of constructing structures at the proposed dam and reservoir sites in terms of geology and topography .

The areas to be irrigated from reservoirs were studied and delineated with the layout of the canal system on the 1/4,000 topographic maps and the canal routes were selected at the sites. As a result, it has been identified that the area of gravity irrigation is 1,030 ha. The operation and maintenance road shall be constructed along the irrigation canals and the construction road shall be also built. These road network may be used not only by the irrigation beneficiaries but also by farmers of neighboring existing fields. These areas were estimated to be 640 ha in the minimum. Consequently, it has been confirmed that the beneficial area of the Project is 1,670 ha in total (1,030 ha plus 640 ha),the same as the request.

(2) Bridge

There are farmland of about 800 ha and farmers with population of about 3,000 (Iba 1,000, Lubigan 600, Moriones 1,400) in the right bank area of the Bulsa River. Those people ford the Bulsa River at around four sites of selected shallow using a carabao-cart or a vehicle (jeepny) for rural communication, attending school and transportation of everyday goods, agricultural materials and production during low water in the dry season.

When the river depth become more than around 70 cm, people cross the river by small ferry instead of vehicle transportation. It, however, becomes dangerous in accordance with the increase of river flow velocity and the ferry operation is to be canceled, so that no transportation is available to the opposite river bank side during high water season. In such conditions, about half of the year, people can not cross the Bulsa River. Based on the topo-map of 1 : 50,000 scale, there is a mark of the bridge connecting Villa Aglipay and Moriones, but it was confirmed at the field survey that the bridge had been completely washed away by floods.

Two temporary or submersible bridges on the request have been understood as the irreducible minimum demand of Municipality of Tarlac. Balnges and Pangasan dams are planned to be constructed on the right bank area of the Bulsa River. Those dams have large catchment areas, so that careful activities concerning watching overflow condition of dam spillways, adequate operation on water release, inspection of dams, transportation of temporary construction materials and keeping an eye on flood protection should be carried out during and after heavy rain. Therefore, it is judged that the construction of one permanent bridge is necessarily required for the Project, because temporary bridges cannot make to cross the river possible during and after heavy rain to perform the above mentioned activities.

It is also reported that the Provincial Government gives a preference to the construction of one permanent bridge rather than two temporary bridges.

As regards to the temporary (submergible) bridges, the candidate sites were selected through field reconnaissance and the following river survey with an objective of comparative studies.

The river, however, is very wide at the both selected sites and its flood is estimated at 2,529 m^3/s in the maximum of the past nine years. The design flood from the Balog-Balog dam is taken at 3,250 m^3/s. According to the NIA design criteria, the design flood discharge of the submersible bridges is the normal floods, and thus about 500 m^3/s for this design. applying this criteria, the temporary bridges were designed to be 17-barrel box culverts with 5 m width and 3 m height (reinforced concrete structure).

The suitable site for the permanent bridge was selected by field surveys at the place where the river is narrow and the flow line is relatively stable. The bridge site connecting Villa Aglipay and Lubigan was chosen as a proposed bridge site based on the technical and economical studies.

(3) Conclusion

The farmers in the Project Area are the poorest within Municipality of Tarlac. To break out from such poverty, enhancement of the agricultural productivity, as well as increase and stabilization of farm income are requisite among other things. These are also in line with the national development plan and regional development programs.

As a result of field surveys and subsequent home studies in Japan, necessity and technical feasibility of reservoir irrigation development in the request is justified and the Project has adequacy for an object of the Grant Aid Program of Japan.

The concluded components of the Project are as follows :

		Dam Height	Crest Length	Reservoir Capacity	Canal Length
1.	Mangillog dam and irrigation facilities	19.3(m),	704.5(m),	3.21(MCM),	10.32(km)
2.	Bulelatin dam and irrigation facilities	10.0(m),	215.0(m),	0.73(MCM),	1.58(km)
3.	Pangasan dam and irrigation facilities	17.3(m),	195.0(m),	1.14(MCM),	3.13(km)
4.	Balnges dam and irrigation facilities	24.2(m),	208.0(m),	1.82(MCM),	8.80(km)
5.	Operation and maintenance road	Total length : 23,83 km, total width : 4.5 m, effective width : 3.5 m			
6.	Bulsa river bridge (permanent bridge)	One place : effective width 3.6 m, length 225 m			

The Comparison of major points between the Basic Design Study and the Feasibility Study prepared by the NIA has been illustrated as shown in Table 4.2.1.

Table 4.2.1 Comparison of Major Points between B/D and F/S

Item	Feasibility Study (F/S)	Basic Design Study (B/D)	Main Reason
1. Irrigation facilities and plan			
1) Irrigation area	Wet season (rice) 1,670 ha	1,030 ha	Heightened accuracy of fundamental data used for analysis of land and water resources. Exclusion of existing Lubigan irrigation area in B/D because Lubigan CIS has the water right from the Bulsa River.
	Dry season (corn) 1,010 ha	842.5 ha	
2) Dam design			
a. Dam type	(Bulelatin Dam) Zone type	Homogeneous type	To reduce the dam construction cost.
b. Dam spillway Type	(Mangillog Dam) Morning Glory type	Overflow weir type	To increase hydraulic stability.
	(Bulelatin Dam) Morning Glory type	Overflow weir type	
c. Dam foundation	(Pangasan Dam) Shallow core trench	Deep core trench	To reduce seepage water through the dam foundation.
3) Canal design	Total length 15 km	23.83 km	For layout and design of the canal system, F/S used the 1/50,000 topographical map while B/D used the 1/4,000 map prepared by topographic survey.
2. Bridge planning and design	Two temporary submergible bridges	One permanent bridge	When the temporary bridges are submerged during flood, O&M and inspection of the dams and irrigation facilities on the right bank of Bursa River become impossible. So, construction of one permanent bridge is essencially required.

4.3 Project Description

4.3.1 Water Resources Plan

The water resources for securing the irrigation development of the Project area are planned to be stream water of the Mangillog, the Bulelatin, the Pangasan and the Balnges tributaries of the Bulsa River system and each stream water will be stored in each reservoir formed by the construction of Mangillog dam, Bulelatin dam, Pangasan dam and Balnges dam.

Since the record of discharge of each tributary is not available, the run-off discharge to each reservoir has been estimated for a period of 20 years through the analysis on rainfall, evaporation of a bench mark station, observed discharge of the Bulsa river and watershed characteristic of each tributaries and the Bulsa river.

The bench mark station is decided at the PAGASA Hacienda Luisita station which is located at 25 km east of and about 50 m lower elevation than the Project area. Those rainfall and evaporation data and the observed discharge records of the Bulsa River for a period of 1975 to 1984 at the Villa Agripay site having the water shed of 405 km^2 have been used for the tank model analysis.

The run-off discharge of each tributary has been estimated for a period of 20 years : 1968 to 1987 on the basis of the specific discharge calculated by the tank model method as shown in Table H-2. Those discharges are deemed as the water resources available in this development plan.

4.3.2 Irrigation and Drainage Plan

(1) Proposed land use and cropping pattern

The present land use in the proposed irrigation area is single rice cropping during the wet season. As for the proposed land use, rice cropping during the wet season and upland cropping during the dry season will be introduced.

The introduction of upland cropping is in line with the Central Luzon Region Development Plan, and Tarlac Province has been specified as a diversified-cropping area of corn, beans and peanut in this plan. Corn has been selected as the representative upland crop in this irrigation plan of the Project, because corn is prevailing crop during the dry season in the Municipality of Tarlac and farmers in the Project area also have a high willingness to cultivate corn. Cropping season of rice is planned to 130 days and that of corn is 120 days.

As a result of reservoir operation study to analyze the optimum scale of the irrigation area in the dry season, it has been proved that the cropping intensity increases from 100% at present to 182% in future as shown in the table below :

Cropping intensity

	Name of Reservoir	Irrigation Area (ha)			Cropping Intensity (%)
		Wet Season (Rice)	Dry Season (Corn)	Total	
1.	Mangillog				
	Upper Intake	255	127.5	382.5	150
	Lower Intake	105	105	210	200
	Sub-Total	360	232.5	592.5	165
2.	Bulelatin	120	60	180	150
3.	Pangasan	200	200	400	200
4.	Balnges	350	350	700	200
	Total	1,030	842.5	1,872.5	182

Cropping area, cropping pattern and cropping season are the major factors to determine the water resources demand and its reasonable distribution in a year round irrigation plan. The required water storage capacity of each reservoir is determined through the water balance analysis between the available water resources at the reservoir site and the irrigation water demand of the respective irrigation area.

On the other hand, the maximum possible storage capacity of each reservoir is constrained by topographical and geological conditions. The designed capacity of each reservoir in this plan is approximated to the maximum possible storage capacity.

Under those situation, the importance will be to find out a suitable cropping pattern and cropping season which enable to irrigate the largest area in the dry season with the designed reservoir capacity. The future cropping pattern, thus, has been proposed on the basis of above consideration as shown in fig. 4.3.1. Tentative cropping pattern, however, could be introduced for several years until the beneficial farmers add to their experience in newly introduced water management. As for a tentative crop during the dry season, beans or vegetables could be introduced instead of corn.

What should be noted here is the cropping plan for the Mangillog irrigation system, which may be characterized as follows:

i. Intake facilities

Two intake facilities are designed for this dam, the intake levels are designed at EL 104.5 m for the upper and EL 99.0 m for the lower. The available capacity allocation according to the elevation is about 1.9 million m^3 above the upper intake level and 1.2 million m^3 between upper and lower intake levels.

ii. Irrigation area

The irrigation area commanded by the upper intake facilities is 255 ha while that by the lower intake is 105 ha. those commanded irrigation systems are independent each other and no water transaction is made between them.

iii. Intake control and cropping plan

To secure 100% rice cropping, it must be cultivated during the wet season. Since the lower intake facilities are naturally possible to release reservoir water without any constraint at any time, it is necessary to control to release reservoir water through the lower intake facilities as possible while the water is released through the upper intake facilities for corn cultivation during the dry season. In this context, the cropping plan employed is basically to prevent the cropping season of corns from the overlapping during the dry season.

(2) Irrigation method

In the paddy fields, continuous 24 hours irrigation will be introduced during the crop vegetative stage, and 30 days rotational irrigation will be adapted in each rotation block at the stage of land preparation. On the other hand, the upland fields will be irrigated with furrow irrigation in an intermittent irrigation manner so as to meet these field capacities.

(3) Effective rainfall

a) The expected effective rainfall during the rice vegetative stage was calculated as follows based on the daily rainfall record of the past 21 years at Hacienda Luisita :

i. The effective rainfall for paddy by decade is firstly aggregated by assuming the rainfall depth of 5 mm or less and 80 mm or more as ineffective, then, 80 % of each total is considered as effective rainfall. Note that, in addition, the allowable storage depth limit on the paddy field is 180 mm and the average daily evapotranspiration is assumed at 6 mm/day. The upper limit of the effective rainfall for each decade is assumed at 240 mm.

ii. From the above effective rainfall data by decade for each year, the average, standard deviation, skewness and the dependable rainfall with 50%, 68% and 80% probability of occurrence are determined.

iii. The effective rainfall is designed to be expected in two years of three years from a viewpoint of saving water. In other words, the 68% probability of occurrence is used.

b) For the effective rainfall during the land preparation stages, the 68 % probability of occurrence of whole rainfall is used as a design effective rainfall.

c) The upland cropping is introduced mainly during the dry season when the effective rainfall cannot be expected. Note that the effective rainfall on paddy field was applied for upland crop during the transition period between the dry and the wet seasons.

(4) Irrigation efficiency

The design criteria of NIA consider the following three components of efficiency in overall irrigation efficiency. Overall irrigation efficiency of 55% was applied to rice cropping during the wet season and 50% for upland cropping.

Irrigation Efficiency (unit: %)

Efficiency	Paddy	Upland
1. Field application efficiency	85	72
2. Conveyance efficiency	77	77
3. Operational efficiency	85	90
Overall efficiency	55	50

(5) Irrigation water requirements

Irrigation water requirements were calculated by subtracting the above effective rainfall from crop evapotranspiration, land preparation water and paddy field percolation, then, by taking overall irrigation efficiency into consideration. The calculation procedures and results are shown in Table 4.3.1. The basic contents is described below :

a) Crop evapotranspiration

Crop evapotranspiration (ETcrop) is determined from reference crop evapotranspiration (ETo) and crop coefficient (KC):

$$ETcrop = KC \times ETo$$

Reference crop evapotranspiration is calculated according to the pan evaporation method as shown below:

$$ETo = Kp \times Epan$$

where, Kp = Pan coefficient,
Epan = Pan evaporation in mm/day. (Hacienda Luisita)

Crop evapotranspiration was calculated on rice and corn for each decade.

b) Land preparation water

For necessary water for land preparation and paddling of paddy field, rainfall is stored in the field for effective and maximum utilization. At the same time, the reservoirs start impounding of water to secure water resources for subsequent irrigation and the nursery bed is prepared also to nurse rice seedlings. Accordingly, the land preparation water is taken at a total of 120 mm including resaturation water for 30 cm soil depth of 90 mm and standing water after transplanting of 30 mm.

c) Paddy field percolation

Percolation rate of paddy field was assumed to be 2 mm/day based on the Feasibility Study Report (NIA).

(6) Design drainage discharge

a) Farm drain

Design drainage modus of farm drain was derived from the 5-year return period 3-day rainfall of 320 mm. It was estimated at 8 l/sec/ha on condition that 65 % amount of the rainfall will be drained within three days.

b) Cross drain

Design drainage discharges for crossing structures related to the irrigation canals will be estimated with the peak discharge having 10-year return period. Probable rainfall intensity-duration curves having 10-year return period were studied by rainfall analysis as follows :

$5 \leq T < 50$; $I = Exp(5.9762 - 0.3755 \times Ln\ T)$,

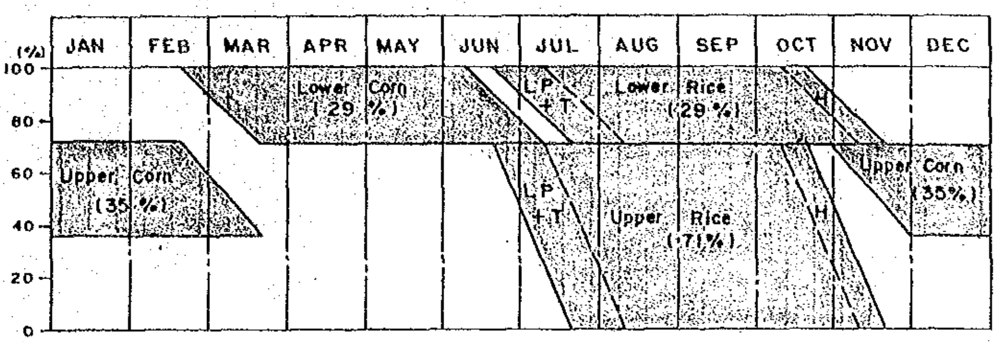
$50 \leq T \leq 1{,}440$; $I = Exp(7.0817 - 0.6592 \times Ln\ T)$,

Where, T = Time of concentration in min,

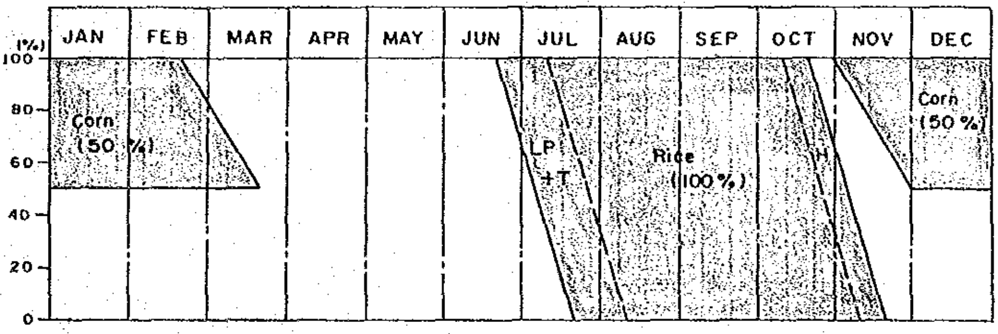
I = Rainfall intensity in mm/hr.

Refer to Table M-6

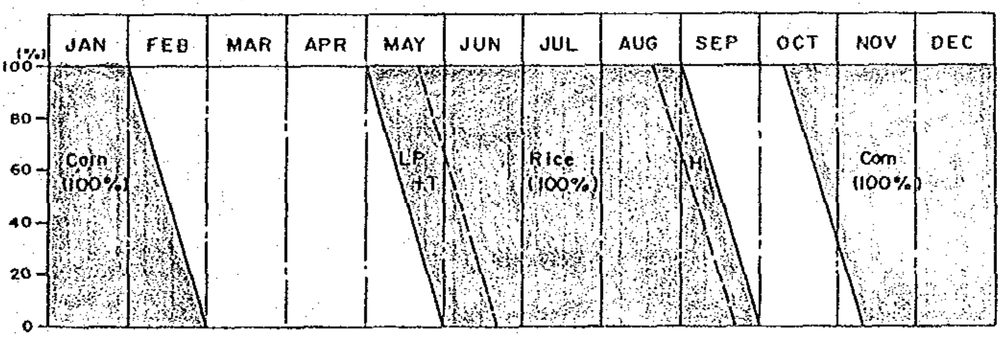
Mangillog Irrigation System (Net 360 ha)



Bulelatin Irrigation System (Net 120 ha)



Pangasan (Net 200 ha) & Balnges (Net 350 ha) Irrigation System



LEGEND:
LP = Land Preparation
T = Transplant
H = Harvest

Fig 4.3.1 Proposed Cropping Pattern

Table 4. 3. 1 Irrigation Water Requirement (Mangillog, Bulelatin Area)

MONTH	DECADE	ETo (mm)	KC Upper Intake (1)	KC Upper Intake (2)	KC Upper Intake (3)	KC Lower Intake (1)	KC Lower Intake (2)	KC Lower Intake (3)	ETcrop (mm) Upper Intake (1)	ETcrop Upper Intake (2)	ETcrop Upper Intake (3)	ETcrop Lower Intake (1)	ETcrop Lower Intake (2)	ETcrop Lower Intake (3)	Percolation (mm)	Effective Rainfall (mm) Land Prep.	Effective Rainfall Growing Stage	Crop Irrg. Reqt. (mm) Upper Intake	Crop Irrg. Reqt. Lower Intake	Overall Eff. (%)	Diversion Reqt. (mm) Upper Intake	Diversion Reqt. Lower Intake
Jan.	1	116.3	1.05	1.05	1.05				39	39	39							39			78	
	2		1.05	1.05	1.05				39	39	39							39			78	
	3		1.05	1.05	1.05				43	43	43							43			86	
Feb.	1	126	0.6	1.05	1.05				27	47	47							40.3			80.6	
	2		0.6	0.6	1.05				27	27	47							33.7			67.4	
	3		0.6	0.6	0.6	1.05			22	22	22	38						22	12.7		44	25.4
Mar.	1	162.8		0.6	0.6	1.05	1.05			32	32	55	55					21.3	36.7		42.6	73.4
	2				0.6	1.05	1.05	1.05			32	55	55	55				10.7	55	50	21.4	110
	3					1.05	1.05	1.05				61	61	61					61	(Corn)		122
Apr.	1	173.3				1.05	1.05	1.05				61	61	61					61			122
	2					1.05	1.05	1.05				61	61	61					61			122
	3					1.05	1.05	1.05				61	61	61					61			122
May.	1	137.3				1.05	1.05	1.05				47	47	47		22	0		47			94
	2					1.05	1.05	1.05				47	47	47		30	23		24			48
	3					0.6	1.05	1.05				29	51	51		45	35		10.7			21.4
Jun.	1	114.8				0.6	0.6	1.05				23	23	40		34	24		5.3			10.6
	2					0.6	0.6	0.6				23	23	23		39	24		0			0
	3						0.6	0.6	(40)			(40)	23	23		44	31	0	0	↑	0	0
Jul.	1	102.9						0.6	(40)	(40)		(40)	(40)	20		54	41	0	0	↓	0	0
	2								(40)	(40)	(40)	(40)	(40)	(40)		66	49	0	0		0	0
	3		1.1			1.1			40	(40)	(40)	40	(40)	(40)	22	100	69	0	0		0	0
Aug.	1	79.1	1.1	1.1		1.1	1.1		28	28	(40)	28	28	(40)	20	80	59	0	0		0	0
	2		1.1	1.1	1.1	1.1	1.1	1.1	28	28	28	28	28	28	20	81	59	0	0	55	0	0
	3		1.1	1.1	1.1	1.1	1.1	1.1	31	31	31	31	31	31	22	55	38	15	15	(Rice)	27.3	27.3
Sep.	1	99.5	1.1	1.1	1.1	1.1	1.1	1.1	36	36	36	36	33	36	20	84	55	1	1		1.8	1.8
	2		1.1	1.1	1.1	1.1	1.1	1.1	36	36	36	36	33	36	20	56	42	14	14		25.5	25.5
	3		1.0	1.1	1.1	1.0	1.1	1.1	33	36	36	33	36	36	20	84	61	0	0		0	0
Oct.	1	108.0	1.0	1.0	1.1	1.0	1.0	1.1	35	35	38	35	35	38	20	19	10	46	46		83.6	82.6
	2		1.0	1.0	1.0	1.0	1.0	1.0	35	35	35	35	35	35	20	36	24	31	31		56.4	56.4
	3		0.95	1.0	1.0	0.95	1.0	1.0	36	38	38	36	38	38	22	0	0	59.3	59.3		107.8	107.8
Nov.	1	99.0	1.05	0.95	1.0		0.95	1.0	35	31	33		31	33	20			34.7 (Rice) 11.7 (Corn)	34.7	↑	63.1 (Rice) 23.4 (Corn)	63.1
	2		1.05	1.05	0.95			0.95	35	35	31			31	20			17.0 (Rice) 23.3 (Corn)	17.0	↓	30.9 (Rice) 46.6 (Corn)	30.9
	3		1.05	1.05	1.05				35	35	35							35			70	
Dec.	1	114.0	1.05	1.05	1.05				39	39	39							39		50	78	
	2		1.05	1.05	1.05				39	39	39							39		(Corn)	78	
	3		1.05	1.05	1.05				42	42	42							42			84	

Note) Irrigation water requirement for upper intake of Mangillog area is applied for Bulelatin area.

Table 4. 3. 1 Irrigation Water Requirement (Pangasan, Balnges Area)

MONTH	DECADE	Evaporation Mean (mm)	S. D.	S K.	Epan [1] (mm)	Kp	ETo (mm)	KC (1)	KC (2)	KC (3)	ETcrop [2] (mm) (1)	(2)	(3)	Percolation (mm)	Effective Rainfall (mm) Land prep.	Growing Stage	Crop Irrg. Reqt. (mm)	Overall Eff. (%)	Deversion Reqt. (mm)
Jan.	1	145.0	13.8	-0.46	155	0.75	116.3	1.05	1.05	1.05	39	39	39				39		78
	2							0.6	1.05	1.05	23	39	39				33.7		67.4
	3							0.6	0.6	1.05	25	25	41				30.3	50	60.6
Feb.	1	163.3	14.6	-0.02	168	0.75	126	0.6	0.6	0.6	27	27	27				27	(Corn)	54
	2								0.6	0.6		27	27				18		36
	3									0.6			22				7.3	↓	14.6
Mar.	1	211.5	19.1	0.21	217	0.75	162.8												
	2																		
	3																		
Apr.	1	219.1	21.2	-0.52	231	0.75	173.3												
	2																		
	3																		
May.	1	175.7	28.1	0.58	183	0.75	137.3				(40)				22	0	6	↑	10.9
	2										(40)	(40)			30	23	6.7		12.2
	3										(40)	(40)	(40)		45	35	0		0
Jun.	1	128.9	21.1	0.07	135	0.85	114.8	1.1			42	(40)	(40)	20	34	24	15.7		30.4
	2							1.1	1.1		42	42	(40)	20	39	24	25.7		46.7
	3							1.1	1.1	1.1	42	42	42	20	44	31	31		56.4
Jul.	1	111.2	23.6	-0.00	121	0.85	102.9	1.1	1.1	1.1	37	37	37	20	54	41	16	55	29.1
	2							1.1	1.1	1.1	37	37	37	20	66	49	8	(Rice)	14.5
	3							1.1	1.1	1.1	40	40	40	20	100	69	0		0
Aug.	1	91.9	19.7	0.74	93	0.85	79.1	1.0	1.1	1.1	26	28	28	20	80	59	0		0
	2							1.0	1.0	1.1	26	26	28	20	19	59	0		0
	3							1.0	1.0	1.0	28	28	28	20	55	38	12		21.8
Sep.	1	103.2	21.0	-0.73	117	0.85	99.5	0.95	1.0	1.0	32	33	33	20	84	55	0		0
	2								0.95	1.1		32	33	20	56	42	7		12.7
	3									0.95			32	20	84	61	0	↓	0
Oct.	1	118.5	23.4	0.13	127	0.85	108.0								19	10			
	2							1.05			37				36	24	4.3	↑	8.6
	3							1.05	1.05		40	40			0	0	26.7		53.4
Nov.	1	127.7	14.2	0.80	132	0.75	99.0	1.05	1.05	1.05	35	35	35				35		70
	2							1.05	1.05	1.05	35	35	35				35		70
	3							1.05	1.05	1.05	35	35	35				35		70
Dec.	1	138.5	19.4	0.42	152	0.75	114.0	1.05	1.05	1.05	39	39	39				39		78
	2							1.05	1.05	1.05	39	39	39				39	(Corn)	78
	3							1.05	1.05	1.05	40	40	40				40	50	80

Note) 1) Dependability : 67%

2) Figures in parentheses indicate land preparation water requirement.

4.3.3 Reservoir Operation Study

The climatic conditions of the area are characterized by clear classification into the wet season from May to October and the dry season of the rest. In this situation, there is no other way for introduction of the upland cropping (e.g. corn) in the dry season but to store the surface water as much as possible during the wet season for utilization in the dry season. In this plan, all the storage will be used fully for irrigation during the subsequent dry season.

About 90% of annual rainfall is concentrated to the wet season and the demand on water resources is expected to grow in the future. Accordingly, the reservoir as water resources should have the capacity as large as possible. The proposed storage capacity of four reservoirs in this Project is nearly equivalent to the maximum possible capacity in view of topographical and geological aspects.

In this context, the reservoir operation study was executed to confirm the reliability of reservoirs and the extent of irrigable area in the dry season on the irrigation plan. Under the condition that the storage volume dose not reache the total irrigation water demand of the subsequent dry season crops, the water level of the reservoir tends to decrease rapidly as increasing the assumed irrigation area in the dry season, and it results in deficiency of irrigation water supply to the crops. This in turn causes reduction of the crop yield, with degradation of the quality of product. Since the reservoir cannot demonstrate the soundness in this situation, it is necessary to reduce the assumed irrigation area to the level ensuring stable irrigation water supply every year. For the degree of reliability, the frequency of water shortage in terms of probability is generally applied.

(1) Calculation conditions

The calculation conditions roughly include (i) inflow to the reservoir, (ii) water demand on the reservoir and (iii) physical conditions of the reservoir. These were considered as follows:

i. Inflow to the reservoir is estimated by runoff analysis as described before. The existing water right in the downstream area of each tributary isn't necessary to be taken into consideration for the calculation.

ii. The water demand on the reservoir is determined from the maximum utilization of the land resources (Table 4.3.2) and the irrigation water requirements (Table 4.3.1). If the reservoir cannot secure the irrigation water supply, the assumed irrigation area should be decreased.

iii. Fig.D-1 to D-4 show the area-capacity-elevation curve of each reservoir. The evaporation from the reservoir surface was assumed to be 60% of the pan evaporation at Hacienda Luisita.

(2) Irrigable area

Table R-1 to R-6 show the result of reservoir operation study and Fig. R-1 to R-4 show the water level fluctuation diagram. As a result of studies, the irrigable areas for upland cropping (corn) during the dry season under the control of the upper intake of Mangillog dam and of the Bulelatin dam have been estimated at the 50% of the command area respectively. For other intake facilities of the dams, the 100% can be irrigated in the dry season. The irrigable area under the given conditions of the each reservoir is shown in the table below :

Table 4.3.2 Irrigable Area

(unit: ha)

	Name of Reservoir	Command Area	Irrigable Area	
			Wet Season (Rice)	Dry Season (Corn)
1.	Mangillog			
	Upper intake	255	255	127.5
	Lower intake	105	105	105
	Sub-Total	360	360	232.5
2.	Bulelatin	120	120	60
3.	Pangasan	200	200	200
4.	Balnges	350	350	350
	Total	1,030	1,030	842.5

(3) Reliability of reservoir

The NIA has established the criteria on reservoir operation study as follows :

[1] Maximum shortage per year should be less than 50 % of the average annual demand.

[2] Maximum cumulative shortage for any successive 10 years should be less than the average annual demand.

[3] The carry over period should be less than 12 months for small reservoir.

[4] The reliability of the reservoir should be above 80 % to 85 % on a monthly basis for irrigation only
(Reliability on a monthly basis = Number of months that have no water shortage / Number of calculated months).

The other criteria on the reservoir operation study for a irrigation purpose are as follows :

[5] The reservoir should be able to supply irrigation water in a draught year of 5 to 10-year return period. In other words, the reliability of the reservoir should be above 80 % to 90 % on a yearly basis (Reliability on a yearly basis = Number of years that have no water shortage / Number of calculated years).

The reliability of each reservoir is described below based on the above criteria :

a. Pangasan and Balnges reservoir

Pangasan and Balnges reservoirs satisfy above criteria with irrigation area of maximum land resources. As for Pangasan reservoir, the reliability has been calculated at 75 % on a yearly basis, however, the periods of shortage occur during the corn harvest stage. This will not cause substantial reduction of the crop yield nor degradation of the quality of product. The reliability of Balnges reservoir has been calculated at 80 % on a yearly basis.

b. Bulelatin reservoir

In the case of irrigation area of the maximum land resources (case 1), only criteria [1] and [3] can be satisfied. With the upland cropping area of 50 % of land resources (case 2), every criteria can be satisfied. Therefore, the irrigation plan and reservoir operation study of the Bulelatin reservoir have been decided based on the case 2.

c. Mangillog reservoir

The reservoir operation study of this reservoir has been controlled by the upper intake facilities, because there is no water shortage in the command area of the lower intake facilities. In the case of irrigation area of the maximum land resources (case 1), only criteria [1], [3] and

[4] can be statisfied. With the upland cropping area of 50 % of the command area of the upper intake facilities (case 2), every criteria can be satisfied. The reliability of the reservoir in case 2 has been calculated at 75 % on a yearly basis, however, periods of shortage occur during the corn harvest stage. This will not cause substantial reduction of the crop yield nor degradation of the quality of products. Therefore, the irrigation plan and reservoir operation study of the Mangillog reservoir have been decided based on case 2.

Reliabilities of reservoirs estimated by reservoir operation study are summarized in the table below :

Reliabilities of Reservoirs

Name of Reservoir	Irrigable Area (ha)			Reliability (%)	
	Wet Season (Rice)	Dry Season (Corn)	Total	Yearly Basis	Monthly Basis
1. Mangillog					
Case 1					
Upper intake	255	255	510	10.0	80.4
Lower intake	105	105	210	100.0	100.0
Sub-Total	360	360	720		
Case 2					
Upper intake	255	127.5	382.5	75.0	96.3
Lower intake	105	105	210	100.0	100.0
Sub-Total	360	232.5	592.5		
2. Bulelatin					
Case 1	120	120	240	0.0	76.7
Case 2	120	60	180	80.0	96.7
3. Pangasan	200	200	400	75.0	97.5
4. Balnges	350	350	700	80.0	98.3

4.3.4 Bridge Plan

The Bulsa River can not be crossed during the wet season and people are indeed isolated for about 6 months every year. Moreover, the construction of a permanent bridge is necessary for operation and maintenance of the Project facilities ; Pangasan dam and its irrigation system and Balnges dam and its irrigation system proposed on the right bank area of the Bulsa River. On this background, one permanent bridge has been planned.

4.3.5 Outline of Facilities

Principal facilities to be constructed by the Project are shown below :

a. Dams and reservoirs

Name of Dam and Reservoir	Dam Height (m)	Crest Length (m)	Storage Capacity (MCM)
Mangillog	19.3	704.5	3.21
Bulelatin	10.0	215.0	0.73
Pangasan	17.3	195.0	1.14
Balnges	24.2	208.0	1.82
Total	-	-	6.90

(For details, see Table 4.3.3)

b. Irrigation canal (Including O&M road with effective width of 3.5 m along the canal)

Name of System	Length (km)
Mangillog	10.32
Bulelatin	1.58
Pangasan	3.13
Balnges	8.80
Total	23.83

c. Bridge

Bridge length 225 m
Bridge width 3.6 m

Table 4.3.3 Salient Features of Dam and Reservoir

Items		Mangillog	Bulelatin	Pangasan Main	Pangasan Saddle	Balnges Main	Balnges Saddle
Watershed at Dam site	(km^2)	8.1	2.0	12.9		27.9	
Height of Dam	(m)	19.3	10.0	17.3	5.8	24.2	5.7
Crest EL.	(m)	111.3	98.0	130.8	130.8	98.2	98.2
Crest Length	(m)	704.5	215.0	195.0	50.0	208.0	44.0
Crest Width	(m)	6.0	6.0	6.0	6.0	6.0	6.0
Volume of Embankment	(m^3)	363,000	37,000	78,000	3,800	155,000	3,200
Type of Spillway		Ungated chute	Ungated chute	Ungated chute		Ungated chute	
Design Capacity	(m^3/sec)	127	26	210		266	
Crest Width	(m)	25.0	18.0	25.0		40.0	
Crest EL.	(m)	108.0	96.0	126.5		94.0	
Max. Water Surface EL.	(m)	109.2	96.5	128.6		96.3	
Normal Water surface EL.	(m)	108.0	96.0	126.5		94.0	
Min. Water Surface EL.	(m)	99.0	91.3	120.1		84.3	
Reservoir Area (N.W.S.)	(ha)	85.3	38.4	28.6		31.4	
Reservoir Area (M.W.S.)	(ha)	71.2	34.3	22.3		25.4	
Total Reservoir Capacity	(MCM)	3.21	0.73	1.14		1.82	
Active Reservoir Capacity	(MCM)	3.11	0.70	0.98		1.47	

4.3.6 Operation and Maintenance Plan

The operation and maintenance of dams and reservoirs, irrigation facilities and O&M road will be under the responsibility of the NIA with the support of the Governments of Tarlac Province and Tarlac Municipality. After transfer to the Government of Tarlac Province, the NIA shall assist O & M in technical aspects. The operation and maintenance of terminal facilities will be done principally by the farmers irrigators' organization with support from the NIA and the Governments of Tarlac Province and Tarlac Municipality. The maintenance of the bridge will be executed by the Municipality of Tarlac immediately after completion of the bridge construction. Proposed organization charts are shown in Fig. 4.3.2 and Fig. 4.3.3.

Operation and maintenance of the Project facilities will be done as follows :

(1) Dams and reservoirs

The operation and monitoring works for reservoirs and intake valves shall be carried out in accordance with the O&M manual which will be prepared in advance before completion of such facilities. Such manual shall include the O&M criteria for dams and related structures. The inspection and maintenance works of dams, related structures and reservoir areas shall be conducted on the basis of the manual in order to ensure the safety of the facilities. Initial ponding test should be done mainly by the NIA. The careful observation of the leakage water, pore water pressure, etc. as well as required maintenance will be conducted during the test.

(2) Irrigation facilities

In order to implement proper distribution and intake of water, water management rules and O&M manual should be established in advance. Supervision and operation of the irrigation facilities shall be carried out smoothly and regularly on the basis of these formulated rules and the manual.

(3) O & M Road

In order to fulfill its function, constant inspection and maintenance should be implemented.

(4) Bridge

In order to keep its function and outside appearance, constant inspection and maintenance should be implemented.

The annual expenses for operation and maintenance of dams and reservoirs, irrigation facilities and O&M road are estimated at ₱ 250,000. These expenses will be accommodated by the irrigation fee collected from members of the farmers irrigators' organization. The annual irrigation fee would be about ₱ 350 per one farm household. This irrigation fee is less than 5 % of the average farm income after the Project and its payment will not present problem. It is expected that the annual expenses for maintenance of the bridge are negligilibly small, owing to a rust stabilization coat treatment on all the surface of the structures.

Project Facilities		Annual Expenses
1. Dams and reservoirs	₱	47,000
2. Irrigation facilities	₱	80,000
3. O&M road	₱	123,000
Total	₱	250,000

The annual expenses for operation and maintenance of the Project facilities are itemized below :

1) Dams and Reservoirs
One (1) chief operator and one (1) assistant operator should be employed for operation and management of the facilities. The maintenance works like weeding etc. will be carried out twice a year.

Personnel expenses

Chief operator	₱ 2,000/Month x 12Months =	₱ 24,000
Assistant operator	₱ 1,600/Month x 8Months =	₱ 12,800
Labour	10 man•day/site x 4sites x 2 x ₱ 75/d=	₱ 6,000
Overhead expenses	(10 % of above total)	₱ 4,280
Total		₱ 47,080

2) Irrigation Facilities

Maintenance works should be carried out along the canals twice a year. The required amount of labour for this works has been estimated as ;

23.83 km x 2 ÷ 0.5 km/man•day = 96 man•day

A replacement costs of concrete lining and slide gates at turnout etc. have been considered in the expenses. The annual replacement costs have been estimated at 5 % of the construction costs concerned of these works based on the assumption of durable period of 20 years.

Personnel expenses	96 man•day x ₱ 75/d =	₱ 7,200
Replacement costs	₱ 1,303,000 x 0.05 =	₱ 65,150
Overhead expenses	(10 % of above total)	₱ 7,235
Total		₱ 79,585

3) O & M Road

Based on the Equivalent Maintenance Kilometer (E.M.K.) of ₱ 17,104/year/km in the Philippines, the maintenance expenses of the O/M road have been estimated with adjustment factors of 0.55 (gravel pavement) and 0.5 (one-lane road).

Personnel expenses etc.	23.83 km x 17,104 x 0.55 x 0.50 =	₱112,087
Overhead expenses	(10 % of above total)	₱ 11,209
Total		₱123,296

FIG. 4.3.2 WESTERN BARRIOS IMPOUNDING IRRIGATION PROJECT OPERATION AND MAINTENANCE ORGANIZATION

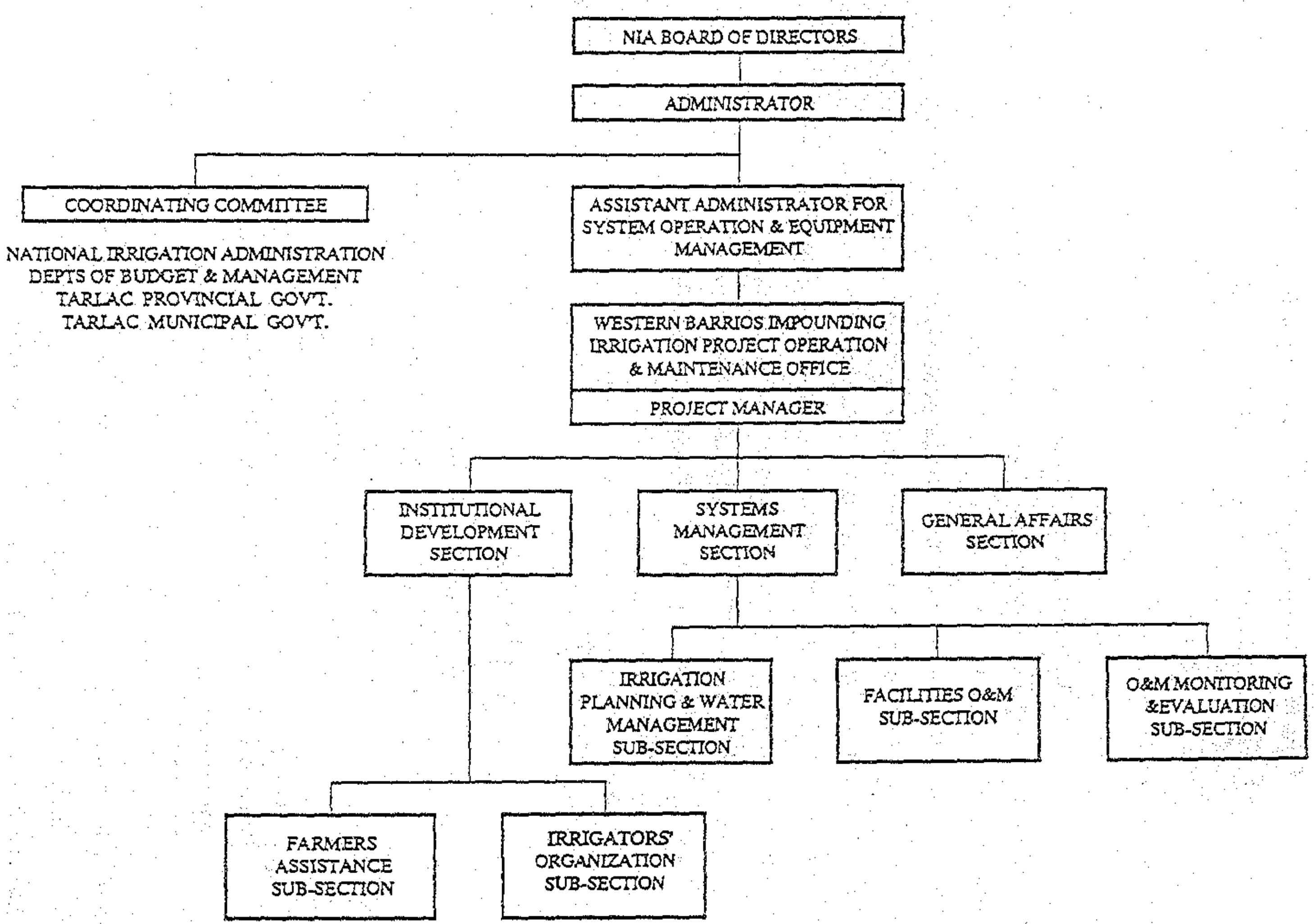
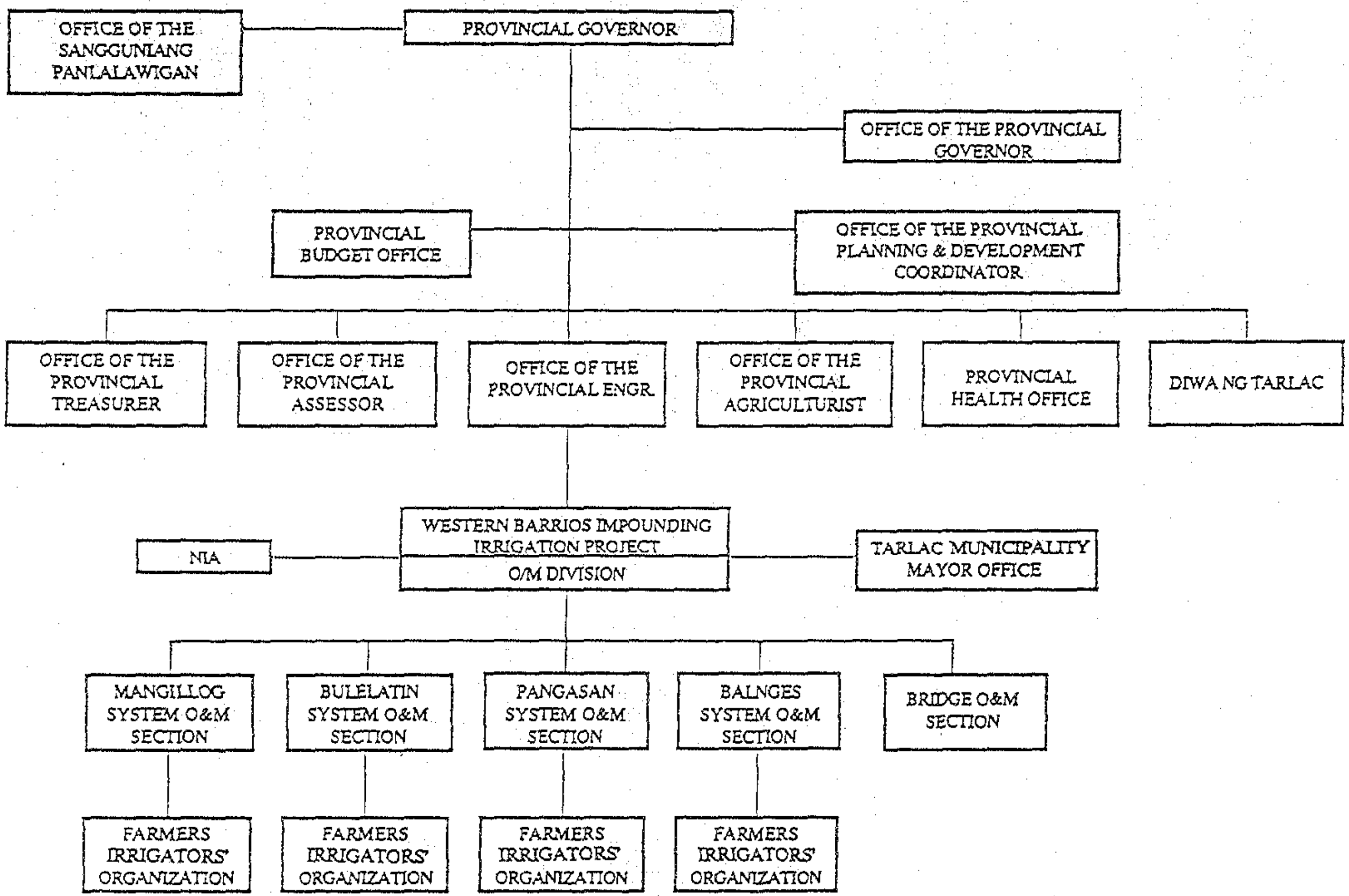


FIG.4.3.3 WESTERN BARRIOS IMPOUNDING IRRIGATION PROJECT
OPERATION AND MAINTENANCE ORGANIZATION (PROPOSE)



CHAPTER 5 BASIC DESIGN

5.1 Outline of the Basic Design

Fig. 5.1.1 is a schematic diagram of the principal facilities such as dams, irrigation facilities and bridge.

5.2 Design of Dam

5.2.1 Basic Consideration in Design

The basic principles for dam design are to ensure the necessary functions and safety with economically acceptable facilities under the natural conditions of rainfall, earthquake and geology.

Annual rainfall in this district is about 1,900 mm on the average, of which about 90% is distributed in the wet season from May to October. Failures of dam by overtopping will be prevented by sufficient free board and installation of spillway which has sufficient capacity to discharge flood due to concentrated rainfall.

During the period from 1907 to 1985, 121 occurrence of earthquakes exceeding magnitude of 5, with a epicenter within 200 km from the proposed dam sites, were reported. Accordingly, consideration against earthquake will be paid for dam design .

There are many small water impoundings and irrigation facilities in the neighboring area. Since the farmers are familiar with these facilities and the proposed dams are relatively small in scale, there is no particular problem which requires specialized technique on the operation and management for the proposed dams and canals.

National Irrigation Administration (NIA) is conducting a large scale dam construction in Balog-Balog area neighboring the Project Area and it has many experience in dam construction, operation and management. Consequently, the NIA is considered to be a competent authority with sufficient capability for supervision of dam construction, operation and management.

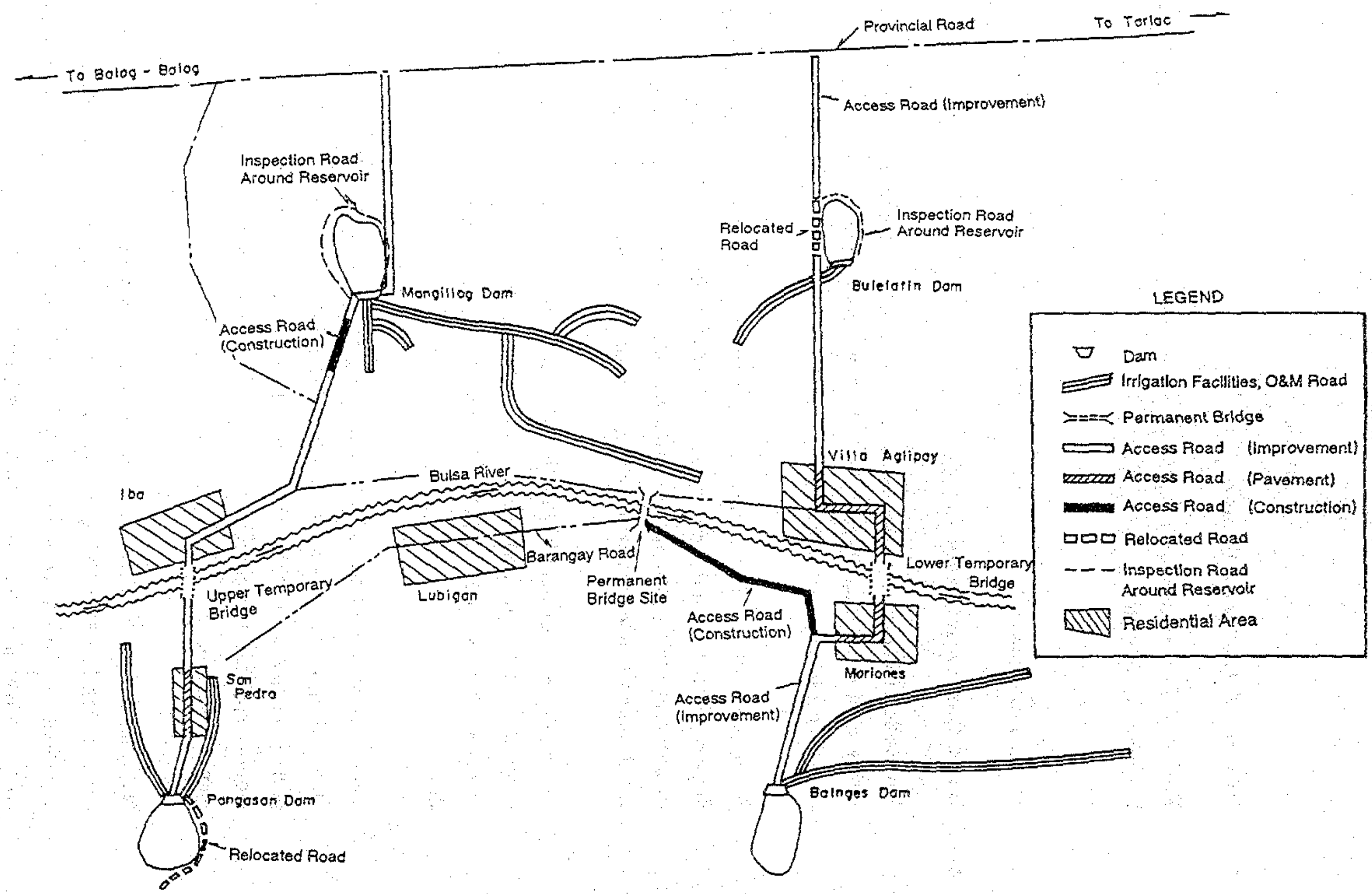


Fig. 5.1.1 SCHEMATIC DIAGRAM OF BASIC DESIGN

The design of dams has been made in consideration of local conditions, such as rainfall, intensity of earthquakes and other natural and physical conditions, and limited construction period with only one dry season.

5.2.2 Design Conditions

(1) Geology

This Basic Design Study involves drilling for geological surveys and in-situ tests. The results show the following geologic features in each dam site.

Mangillog dam site

The proposed dam site has gentle slope on both abutments and its topography is almost flat. The bedrock of dam foundation consists of alternation of strata of mudstone, siltstone, and sandstone which belong to the Moriones Formation. Thickness of each stratum ranges 0.3 to 1.0 m and the strike ranges N 20° - 60° E with the dip of 2 - 10° NE. The rocks are tuffaceous, slightly weathered and moderately hard. Standard Penetration Test (SPT) is unsuccessful since the rocks are hard ($N > 40$). The weathered layer is thin and limited to a depth of 1.0 to 2.4 m from the surface. The core recovery rate for the deeper portion under the weathered layer was 90% or more, with high Rock Quality Designation (RQD) and no weathering. Permeability is mostly in the order of 10^{-5} cm/sec, but in the order of 10^{-4} cm/sec for a part of the portion near the surface.

Bulelatin dam site

The topography of the proposed dam site is generally flat with gentle slope on both abutments. The bedrock in the dam site consists of alternation of strata of mudstone, siltstone, and sandstone which belong to the Moriones Formation. Thickness of each stratum varies with intervals of 10 to 40 cm and the strike ranges N 50° - 70° W with the dip of 28° - 30° NE. Joints in the surface layer are oxidized. Permeability of bedrock is in the order of 10^{-4} cm/sec in the surface layer, and it becomes lower as the depth increases. Weathered bedrock of 2 m in thickness is underlying the river deposit of 2 to 4 m in thickness along the river portion.

Pangasan dam site

The slopes of the both banks on both abutments of the proposed dam site is relatively steep. Bedrock of the site consists of alternation of strata of siltstone and sandstone which belong to the Akskitero Formation. These strata are metamorphosed by intrusion of nearby igneous rock. The metamorphosed hard sandstone and siltstone are exposed in the river bed of dam site. Strike ranges N 0° W with the dip of 50° E. Dike of andesite can be locally observed in the upstream of the dam axis. Top soil is distributed over with a thickness of 1 to 3 m, and underlying weathered layer extends to a depth of 2 to 9 m. Permeability is in the order of 10^{-4} cm/sec in the weathered layer and in the order of 10^{-5} cm/sec in the fresh layer.

Balnges dam sites

River bed in the proposed dam site is flat, with the gradient of about 30° at the both abutments. Bedrock is exposed at about 100 m upstream from the dam axis. The bedrock in the dam site consists of alternation strata of slightly hard siltstone and sandstone. The strike ranges N 10° - 20° W with the dip of 20° - 30° NE.

The river bed, is covered by the river deposit mainly constituted sands and gravels with thickness of about 6 m, and its bedrock is slightly weathered, but hard. The surface layer on both abutments has a highly weathered bedrock layer of about 3 m in thickness and slightly weathered bedrock layer of 9 to 14 m in thickness. In this slightly weathered bedrock layer, cracks are oxidized which means the underground water level fluctuates in this layer. Permeability is in the order of 10^{-4} cm/sec for the slightly weathered portion and in the order of 10^{-5} cm/sec for the deeper portion.

(2) Construction materials

Test pitting and laboratory soil testing were made in the Basic Design Study. The results of the laboratory tests are shown in Table D-1 and characteristics of the materials for each dam are summarized as follows :

Mangillog dam

Investigation for construction materials has been conducted in the potential spots in the Mangillog reservoir area. Clayey materials are distributed over the flat portion and weathered rock materials are distributed on the slope. The available depth of clayey materials is about 1.5 m, with an area of about 80,000 m^2, and its available volume is estimated to be more than 120,000 m^3. Weathered rock materials of approximately 200,000 m^3 or more will be available at the slope portion. The clayey materials show a slightly high moisture content, and the residual soil deposits derived from in - situ weathered rock at about 4 km upstream of the dam may be usable as a substitute core material.

Bulelatin dam

Investigation for construction materials has been conducted in the potential spots in the Bulelatin reservoir area. Due to high ground water level in the test pits dug in this investigation, the upstream spot in the Bulelatin reservoir is proposed for the borrow area. Available volume of impervious materials is expected more than 100,000 m^3, which is three times of the required volume of 32,000 m^3. The soil texture is classified as clay, which is suitable to use as the material of the low dam embankment.

Pangasan dam

Investigation for construction materials has been conducted in the potential spots in the Pangasan reservoir area. The soil is clayey, and distributes over an area of 50,000 m^2 or more which is proposed as the borrow area A volume of about 70,000 m^3 or more will be available as the clayey material. Excavated materials in the course of the spillway construction will be used as the rock material. Materials at the remaining higher portion at the upstream spot in the Pangasan reservoir area will be used as the random fill materials. Sufficient quantity of materials may be existing for a required volume of 102,000 m^3.

Balnges dam

The Balnges reservoir area of this dam is of a narrow and long shape. The deposit volume of clayey soil in this area is small, and only about 30,000 m^3 will be obtained. Accordingly, additional borrow area is provided on the left bank in the downstream of the dam. A volume of about 40,000 m^3 will be obtained from this borrow area. Weathered sandstone and siltstone are available for random fill materials, on the slope at 500 m upstream of the dam.

(3) Capacity of reservoir

Storage capacity of four dams which has been determined on the basis of the irrigation plan in the Project is shown in Table 4.3.3. Fig. D-1 to D-4 show the area-capacity-elevation curves of the respective reservoirs.

(4) Quantity of sediment

Erodibility of the reservoir watershed which affects the quantity of sediment inflow varies depending on the rainfall intensity, rainfall duration, kinds of soils, surface gradient of the watershed, vegetation and soil moisture conditions before and during rainfall. According to the result of surveys, the vegetation of the watershed is mainly grasses and low shrubs. Besides, the gradient of the surface is gentle, and the terraced rainfed paddy fields are partly existing, so that erodibility of the reservoir watershed may be very low.

No measurement of the sediment load has been made on tributaries on which dams are to be constructed, but the measured value of the sediment load per year of the nearby Rio Chico River has been applied. The measured value for this river is 125.2 $m^3/km^2/year$. Quantity of sediment for each reservoir has been estimated as follows : Those sedimentation volumes are regarded as a dead storage in the reservoir plan, respectively.

Name of Dam	Watershed (km^2)	Sediment volume (m^3/100 years)
Mangillog	8.1	102,000
Bulelatin	2.0	25,000
Pangasan	12.9	163,000
Balnges	27.9	352,000

(5) Design flood

The F/S report by the NIA, design floods and spillway capacities were decided on the basis of 50-year flood or 100-year flood as follows :

	Design Flood (m^3/sec)	Flood Surcharge (x 10^6 m^3)	Spillway Capacity (m^3/sec)	Remarks
Mangillog	105.50	1.173	56.31	100-year flood
Bulelatin	17.50	0.201	9.36	50-year flood
Pangasan	174.20	0.618	149.58	100-year flood
Balnges	221.52	0.609	214.52	100-year flood

Design criteria on dam and spillway of the NIA are based on the standard of the United States Bureau of Reclamation, entitled " Design of Small Dams " and modified in consideration of scales, importance and other factors of dams.

The dams in this Project have the following features :

i) Dimensions of each dam are small scales with height of less than 30 meters,
ii) Each dam is constructed on a small tributary of which catchment area ranges 2 to 28 km^2 and there is no densely populated area in the down stream of each dam.

In such situation, it is reasonable that the NIA has adopted 50-year flood or 100-year flood for spillway design.

It, however, is a fact that many failures of dam have been caused by deficiency of spillway capacity or by inadequate spillway design. The design flood of the spillway in this Basic Design Study, therefore, has been determined to a 20 percent increased value of 100-year flood in consideration of the increase of the safety of the fill type dam structure and resulting construction cost. Extraordinary flood of a 20 percent increased value of design flood is also adopted into the check of free board. The flood routing has been analyzed by applying the same heavy rainfall distribution as the Feasibility Study by NIA. Design flood is also checked by Rational Formula (See Table D-4) through the probable rainfall intensity analysis (See Fig. M-4).

The maximum inflow and outflow at each dam during the design flood and the extraordinary flood have been summarized below :

	Design Flood		Extraordinary Flood	
	Inflow (m^3/sec)	outflow Spillway Discharge (m^3/sec)	Inflow (m^3/sec)	outflow Spillway Discharge (m^3/sec)
Mangillog	126.60	81.52	151.92	99.13
Bulelatin	25.20	18.24	30.24	22.34
Pangasan	209.04	183.38	250.85	221.08
Balnges	265.82	256.47	318.99	307.80

5.2.3 Basic Design

(1) Dam site

Each dam site proposed in the Feasibility Study was reviewed in consideration of the irrigation area, water storage capacity, topographical features and elevation. This Basic Design Study involves detailed investigation on the location of spillway, topographical features and geology, in order to review the dam position.

Mangillog dam

The dam site is the same as the Feasibility Study, but the dam axis has been modified to the most suitable direction. In the initial plan, the axis of the right half of the dam was bent to the downstream. Because of change of the spillway type, the modification of the direction from the original dam axis has been needed so that the inflow direction into the spillway intersects with the dam axis at a right angle and the dam axis has been changed to a straight line to avoid the complicated plane shape.

Bulelatin dam

The dam site is the same as the Feasibility Study. As in the case of above Mangillog dam, the direction of dam axis has been adjusted so that the inflow direction into the spillway may intersects with the dam axis at a right angle and the location on the left abutment has been shifted to about 100 m upstream because of change of the spillway type.

Pangasan dam

As for the dam site determined in the Feasibility Study, it was found that the topographical features of the left bank for about 200 m upstream of the dam axis is different from the average ones around the reservoir and erosion is heavy in this portion due to a topographical features of concentrated small valleys. The spillway also located in the saddle on the right bank of the reservoir and needs a long channel from the stilling basin to the Pangasan tributary. To avoid these problems, the Basic Design Study has proposed shifting of the dam axis on the left bank for about 250 m upstream. The spillway location has been proposed to be shifted to the right bank of the dam. A saddle dam of 50 m in length and 6 m in height has been designed at the spillway location planned at the Feasibility Study.

Balnges dam

The river bed at the dam site determined by the Feasibility Study is covered with river deposits consisting mainly of sands and gravels of 6 m or more in thickness. Although this thick gravel layer presents the greatest obstacle for completion of the construction works of the dam within a short period, it has proved through the field investigation that this site is the best among the possible alternative sites.

(2) Selection of dam type

The dam type is selected in due consideration of the following features :

- Height of dam,
- Quality and quantity of available materials,
- Topography conditions,
- Site geology,
- Climate,
- Purpose of the reservoir,
- Construction cost.

The type of each dam is described below :

Mangillog dam

The dam site has gentle topographical features. Dam height of about 19 m and crest length of about 700 m are necessary to obtain the required water storage (about 3 million m^3) because of gentle slope topography at the dam site. The shape factor obtained by dividing the dam length by the dam height is 36.5 and it shows that the fill dam is suitable for this site.

Geology of the dam foundation is sedimentary rock consisting of siltstone and sandstone, which is appropriate as the foundation for the fill dam of about 20 m in its height. Clayey soils for impervious core are available abundantly in the reservoir area and about 4 km upstream of the dam. Random fill materials are available within the reservoir area though they are weak rocks.

This dam is largest among four proposed dams, with an embankment volume exceeding 300,000 m^3. But its wide construction site with 700 m of the long crest length makes simultaneous works possible, and the construction period can be reduced by increasing the transport capacity of materials. Zone type earthfill dam with vertical core is selected for this dam so that its work period can be cut down with ease.

Bulelatin dam

The dam site has gentle topographical features. Dam height of about 10 m and crest length of about 200 m are necessary to obtain the required water storage (about 700,000 m^3). The shape factor is 21.5 and the suitable dam type is a fill dam.

Geology of the dam foundation is sedimentary rock consisting of siltstone and sandstone, which is similar to Mangillog dam and appropriate as foundation of a fill dam with the height of about 10 m. Impervious clayey soils for embankment dam are available at the upstream spot within the reservoir. Since this dam is smallest among proposed dams with its embankment volume of about 37,000 m^3, simple dam section is better for efficient execution of construction works. Consequently, homogeneous earthfill dam is selected for this dam.

Pangasan dam

As compared with Mangillog and Bulelatin dams located at the northern bank of the Bulsa River, the abutment slope of this dam site is rather steeper. Dam height of about 17 m and crest length of about 200 m are necessary to obtain the required water storage (about 1 million m^3). The shape factor is 11.3 and fill dam is suitable for this site.

Geology of the dam foundation is relatively hard bedrock consisting of metamorphosed siltstone and sandstone. The metamorphism is thought to have been caused by the intrusion of igneous rock near the dam site. For the low dam height of less than 20 m, there will be no foundation problem. Clayey soil for impervious core is available abundantly within the reservoir area. Relatively hard rock will be obtained from the right abutment of the dam for a rock fill materials.

Rockfill dam with vertical clay core is chosen for this dam so that the work period can be shortened and good quality construction materials can be available in the vicinity of the dam for an embankment volume of less than 100,000 m^3.

Balnges dam

The slope gradient of both banks on both abutments is about 30° and the river bed is flat. Dam height of about 24 m and crest length of about 200 m are necessary to obtain the required water storage (about 1.5 million m^3). The shape factor is 8.6.

The geology of the dam foundation is hard sedimentary rock consisting of siltstone and sandstone, with alluvial deposits mainly gravels covering the river bed. Both gravel and sedimentary rock layers have sufficient bearing capacity as the foundation for a fill dam of less than 30 m high. Impervious clayey soil for core are available within the reservoir area and about 1 km downstream of the dam. Random fill materials are available within the reservoir area but they are weak rock materials.

Both fill and concrete dam types are possible topographically and geologically at this site. Fill dam may be more appropriate because construction works from excavation of river deposit to banking of embankment must be completed within a short construction period and the construction cost of fill dam is lower than that of concrete dam.

Though the embankment volume is around 150,000 m^3, the construction period is expected to be longer because of necessity of refilling the excavated portion of the river bed with impervious clayey soil. Consequently, zone type earthfill dam with vertical core is selected to enable reduction of the construction period.

(3) Embankment Design

a) Height of dam

Height of dam is determined from active storage, dead storage and surcharge storage, plus wave height, free board and excavation depth of core trench.

Some flood flow is stored in the reservoir during the flood because the spillway of each dam is without crest gate. The water level is calculated at a design flood and at an extraordinary flood.

Dead storage of these dams is derived from estimated sediment volume during 100 years. (Refer to 5.2.2) Wave height is estimated by S.W.B. method and Saville method. Results are shown as follows :

	Fetch (m)	Slope	Slope Protection	Wind Veloeity (m/sec)	Wave Height (m)
Mangillog	1,100	1 : 3.0	Riprap	30	0.50
Bulelatin	400	1 : 3.0	Riprap	30	0.27
Pangasan	400	1 : 3.0	Riprap	30	0.27
Balnges	550	1 : 3.0	Riprap	30	0.32

Free board is calculated by following equation :

$$\text{Free board} = 0.05 \times (H_h - H_b) + 1.0 \quad \text{(in meter)}$$

Where, H_h : Maximum water level in meter,

H_b : Elevation of dam basement in meter.

Results are shown as follows :

	Max. Water Level (m)	Elevation of Dam Basement (m)	Free Board (m)	Elevation of Top of Dam (m)
Mangillog	109.57	95.00	1.73	111.29
Bulelatin	96.71	90.50	1.30	98.02
Pangasan	128.70	114.50	1.71	130.41
Balnges	96.47	81.00	1.77	98.24

Free Board is also checked by using the following equation :

$$H_f = dh + h_w + h_a + h_i$$

where, H_f = Free board in meter,
dh = Height of extraordinary flood water surface from design flood level in meter,

h_w = Wave height from reservoir surface in meter,

h_a = Height of water surface by mis-operation of gate in meter,

h_i = Added height of importance and type of dam, 1.0 meter for all dams.

	dh (m)	h_w (m)	h_a (m)	h_i (m)	H_f (m)	Elevation of top of dam (m)
Mangillog	0.19	0.50	0.00	1.00	1.69	111.07
Bulelatin	0.09	0.27	0.00	1.00	1.36	97.98
Pangasan	0.32	0.27	0.00	1.00	1.59	129.97
Balnges	0.29	0.32	0.00	1.00	1.61	97.79

Excavation depth of core trench for each dam is determined on the basis of the result of foundation drilling. Base rock will be excavated with 3 meters depth from the surface at Mangillog and Bulelatin dam. Modification of surface irregularities will be needed at Pangasan dam but is not necessary at the river section because of exposure of hard base rock. At Balnges dam, about one (1) meter of the baserock underlying the river deposits will be removed because of the influence of weathering.

According to the above discussion, elevation of the tops of dams and height of dams are determined as below :

	Elevation of Top of Dam (m)	Height of Dam (m)
Mangillog	111.30	19.3
Bulelatin	98.00	10.0
Pangasan	130.50	17.3
Balnges	98.20	24.2

b) Construction materials

As a rule, soils and rocks around each dam will be used as construction materials. Sand and gravel for filters and drains are available at the Bulsa River for all dams. At this Basic Design Study, test pitting and auger boring were made in the proposed borrow area to investigate the available thickness of the soil layer and samples were taken from each test pit for the necessary laboratory tests. On the basis of this study and the NIA Feasibility Study results, design values were determined for each dam materials. Design values and characteristics of the materials for each dam are shown in Table D - 1 and Table D - 2.

c) Type of dam section

Zoning for dam section was determined on the basis of embankment materials and construction conditions to secure the required functions and to achieve at minimal cost.

Basic dam section of each dam in this Project was determined mainly from the embankment materials and construction conditions: that is, availability of large quantity of soils and rocks around the proposed dam site, completion of dam within the shortest construction period using these soils and rocks, and no hindrance to the work progress, such as slide of the embankment under the rapid filling. Zoning of each dam is described as follows :

<u>Mangillog dam</u>

Dam type is zone type earthfill dam with vertical core. Clayey soils in the reservoir and in the area about 4 km upstream of dam are available for impervious zone. For upstream and downstream shell zones, weak rock materials will be taken from the reservoir area. These shell zones may possibly become semi-permeable or impervious by compacting works, and seepage water shall be drained from the embankment. The drain and filter materials for this purpose may be gathered from the Bulsa River around the fording point between Iba and San Pedro.

Bulclatin dam

Dam type is homogeneous earth dam. Clayey soils for embankment will be obtained from the upstream portion of the reservoir . The drainage materials to discharge seepage water from the embankment are to be gathered from the Bulsa River around the fording point between Villa Aglipay and Moriones.

Pangasan dam

Dam type is rockfill dam with vertical clay core. Clayey soils in the reservoir will be used for impervious zone, while relatively hard rocks excavated at a hillock on the right abutment will be used for upstream and downstream shell zones. The filter materials are to be gathered from the Bulsa River around the fording point between Iba and San Pedro.

Balnges dam

Dam type is zone type earth fill dam with vertical clay core. Clayey soils in the reservoir area and from the downstream area of dam are available for impervious zone. For upstream and downstream shell zones, weak rock materials are found in the reservoir area. These shell zones may possibly become semi-permeable or impervious, and seepage water shall be drained from the embankment. The drain and filter materials for this purpose may be gathered from the Bulsa River around the fording point between Villa Aglipay and Moriones.

d) Shape of dam section

Top width of dam is set at 6 m in view of safety against erosion by wave, heavy rainfall, piping and internal erosion by seepage water and collapse and sliding induced by earthquake.

In view of the property of embankment material, the gradient of slope is set 3.0:1 for the upstream slope and 2.5:1 for the downstream slope.

Filter is provided for preventing washout of soil particles by seepage water. Drainage blanket to discharge seepage water from embankment is also provided for dams excluding Pangasan dam. Since the Bulelatin dam is a homogeneous earth dam, interceptor drain is provided in addition to the drainage blanket in order to collect seepage water effectively.

Upstream slope of dam is subject to various actions causing its damage, such as erosion with wave, washout of soil particles due to seepage water from embankment when the reservoir water become low, cracks due to drying when the water level has dropped, and thus it is less resistive against weathering and erosion. To reduce adverse effects of these actions, upstream slope of these dams will be covered with a layer of large size gravels. Thickness of this layer is 70 cm, with a 30 cm thick filter layer provided under this layer to prevent washout of small particles. Downstream slope of dam is subject to erosion by rainfall. Since the embankment materials of downstream slope of Mangillog, Bulelatin and Balnges dams are mainly soils or weak rocks, erosion by rainfall may cause deep gully. Sodding, seeding of grasses, etc., will be provided as a protection of the downstream slope. The dam top should also be protected by laying gravels.

e) Seepage control

The following items must be reviewed in the design of embankment dams with regards to seepage :

(1) Seepage quantity through embankment and foundation,

(2) Influence of seepage on the stability of embankment and foundation,

(3) Seepage control methods.

Allowable daily seepage quantity is commonly limited to about less than 0.05% of the active reservoir capacity from the viewpoint of storage efficiency of irrigation reservoir.

Review of the influence of seepage water on the stabilities of embankment and foundation involves the analysis of the stability against piping and boiling and of the determination of a flow net. The following methods are considered for seepage control :

(1) Installation of filter zone to prevent piping and boiling,

(2) Installation of impervious blanket and grouting to reduce seepage water,

(3) Installation of drain to discharge seepage water safely from the embankment.

The above items were studied for the four proposed dams.

i. Quantity of seepage through embankment

Quantity of seepage through impervious zone of each dam is estimated by flow net method at steady state with normal water level (See Fig. D-9 to D-12). The following formula is adopted for calculation :

$$Q = \sum \Delta q = \sum k \, (H/L) \, \Delta x$$

where, Q : Seepage quantity (m^3/sec),

Δq : Seepage quantity per unit width (m^3/sec),

k : Coefficient of permeability (m/sec),

H : Difference of head between upstream and downstream of impervious zone (m),

L : Length of flow line in impervious zone (m).

Results are shown below :

	Elevation of N.W.L. (m)	Coefficient of Permeability (m/sec)	Seepage Quantity (m^3/day)
Mangillog	108.00	1×10^{-5}	43.9
Bulelatin	96.00	1×10^{-5}	7.6
Pangasan	126.50	1×10^{-5}	7.2
Balnges	94.00	1×10^{-5}	20.0

ii. Quantity of seepage through foundation

Grouting is designed at the baserock under the embankment so as to reduce seepage, so that the seepage through the bedrock may be scarcely occurred. However, checking of seepage through the natural ground extended from the both abutment of the each dam is required because the surface layer on both banks is weathered and cracked except the Mangillog dam. At Mangillog dam site, path length of seepage through natural ground is assumed long and seepage quantity will be small. On other dam sites, more seepage through natural ground is expected and seepage amount is estimated by applying same method in the case of embankment as follows :

	Elevation of N.W.L. (m)	Water Level at Downstream (m)	Coefficient of Permeability (m/day)	Seepage Quantity (m^3/day)
Bulelatin	96.00	92.00	1×10^{-3}	34.6
Pangasan	126.50	115.00	5×10^{-4}	45.6
Balnges	94.00	92.00	5×10^{-4}	35.0

iii. Seepage control method.

Mangillog dam

This dam is designed as a zone type dam and provided with filter zone in boundary between impervious core and semi-permeable random zone to prevent washout of fine soil particles and occurrence of piping. Since the random zone is less permeable, drainage blanket is provided to ensure discharge of seepage water safely from the embankment. To reduce seepage through the foundation, grouting shall be made with a hole interval of 3 m and depth of 10 m in the permeable portion of the core foundation.

Bulelatin dam

This dam is a homogeneous earth dam, occurrence of leakage by high seepage line on the downstream slope is not favorable for its stability.

An interceptor drain is provided in the embankment for the collection of seepage water and drainage blanket for its safe discharge. To reduce the seepage through the foundation, grouting shall be made with a hole interval of 3 m and depth of 10 m in the permeable portion along the foundation of dam axis and permeable portion due to weathering in natural ground on the right bank up to 90 m upstream from the dam axis.

Pangasan dam

This dam is designed as a rockfill dam and has a filter zone in the boundary between impervious core and permeable rock zone to prevent washout of fine soil particles and occurrence of piping. To reduce seepage through the foundation, grouting shall be made with a hole interval of 3 m and depth of 10 m in permeable portion of the core foundation and permeable portion of quarry site on the right bank.

Balnges dam

This dam is designed as a zoned earth dam and has a filter zone in the boundary between impervious core and semi-permeable random zone to prevent washout of fine soil particles and occurrence of piping. Since the random zone is less permeable, drainage blanket is provided to ensure discharge of seepage water safely from the embankment. To reduce seepage through the foundation, grouting shall be made with a hole interval of 3 m and depth of 10 m for permeable portion in the foundation along the dam axis and the weathered permeable portion on both banks up to about 75 m upstream from the dam axis.

f) Stability of embankment and foundation

Stability of embankment and foundation against sliding is examined by slip circle method. The review was made on following two cases:

(1) End of construction,
(2) Steady seepage with normal full water level.

The design values for calculation of stability are shown in Table D-2 and Fig. D-13 to D-16. The results of stability calculation are shown as follows for each dam, where the coefficient of seismicity is 0.15.

		End of Construction		Steady seepage with N.W.L.	
		Nomal	w/ earthquake	Nomal	w/ earthquake
Mangillog	upstream	2.240	1.390	2.346	1.165
	downstream	1.915	1.266	2.013	1.349
Bulelatin	upstream	2.027	1.240	3.225	1.598
	downstream	2.197	1.504	2.197	1.504
Pangasan	upstream	2.288	1.494	2.100	1.138
	downstream	1.907	1.300	1.907	1.300
Balnges	upstream	2.219	1.388	2.147	1.114
	downstream	1.871	1.227	1.938	1.302

(4) Design of spillway

A spillway is a facility provided to ensure the safety of a dam against flood. Therefore, a spillway should be a structure such that outflow capacity of a spillway is sufficient to release the design flood discharge safely. Spillways of proposed dams are ungated crest type to be free from mis-operation.

Mangillog dam

Feasibility Study report describes the spillway as a morning glory type inlet connected to a bottom conduit. But the morning glory type inlet is functionally unsatisfactory, because it may be blocked with driftwoods and/or debris during flood. Thus, inlet portion is changed to straight crest type and guide portion to the chute type to avoid fear of failure caused by erosion in embankment or foundation and leakage from the conduit.

Spillway is selected on the higher portion near mid point of the dam after consideration of the topographical and geological features and construction conditions such as meandering of the Mangillog tributary, suitability of excavated soils as embankment materials, required volume of concrete, etc. Crest length of inlet portion is 25 m and head on crest is 1.38 m.

Bulelatin dam

Feasibility Study report describes a morning glory type inlet and a conduit type guide as in the case of Mangillog dam. A morning glory inlet is to be changed to straight type and guide to chute type. Location of the spillway is selected at the right abutment due to topographical and geological features. Crest length of inlet portion is 18 m and head on crest is 0.62 m.

Pangasan dam

Feasibility Study proposes the spillway on the saddle distanced from embankment on the right bank to reduce excavation. Additional drilling in this study made it clear that the excavated rocks from the higher portion on the right bank are suitable as rockfill materials. Consequently, locating the spillway at the site of the quarry will be more economical by using excavated rocks from spillway to embankment materials and shortening the channel to the downstream of the tributary. Spillway is located on the right abutment in this view and a saddle dam is set on the saddle. The type of spillway is not changed and inlet is straight type with chute type guide. Crest length of inlet is 25 m and head on crest is 1.88 m.

Balnges dam

Location of spillway is on a saddle on the left bank distanced from the embankment positioned as described in the Feasibility Study Report due to topographical and geological features. Flood discharge through spillway flows into the Sudit tributary. Type of spillway is not changed with a straight type inlet and a chute type guide. Crest length of inlet is 40 m and head on crest is 2.18 m.

(5) Design of intake works

All four proposed dams take water only for irrigation. Intake facilities will be used for intake of irrigation water after completion of dam but they will be used for diversion during construction period. Intake facilities consist of inlet portion, regulating portion and guide portion, and each component is designed as follows :

Inlet structure is planned at the place 10 to 15 m apart from the end of upstream slope with a trash rack structure to prevent debris or drift.

Guide portion consists of conduit and energy dissipator. Since the conduit will be used also for drainage diversion during construction, steel pipe of 1,000 mm diameter is to be used. Impact stilling basin will be adopted as an energy dissipator and positioned at 10 to 15 m from the end of the downstream slope.

Regulating portion is located between downstream end of conduit and energy dissipater. Control valves should have a diameter of 400 to 600 mm according to the respective intake volume requirements. Two valves are installed in series to facilitate repair in case of impossibility of control due to being choked by debris.

Slide gate is also provided at the upstream end of the conduit for inspection and repair of the conduit and valves. Details of intake facilities of each dam are described as follows and summarized in Table D-3.

Mangillog dam

In view of the area to be irrigated, the dam will have two intake facilities. Intake capacity is 0.51 m^3/s for the upper inlet at an elevation of EL. 104.5 m and with a control valve having diameter of 600 mm and 0.21 m^3/s for the lower inlet at an elevation of 99 m and with a control valve having diameter of 400 mm. Since the reservoir is also planned to be used for fish farming, the lower intake works will be used to drain the reservoir. This lower intake works will also be used for drainage diversion during construction with a slide gate on the side wall of inlet structure.

Bulelatin dam

Inlet of this dam is designed at an elevation of EL. 91.3 m with an intake capacity of 0.20 m^3/sec and control valve having diameter of 500 mm. This facility will be used also for diversion during construction and in draining the reservoir for fish farming. Consequently, a slide gate will be provided on the side wall of inlet structure to enable discharge of storage water as much as possible.

Pangasan dam

Inlet of this dam is designed at an elevation of EL. 120.1 m, with an intake capacity of 0.40 m^3/sec and a control valve having diameter of 500 mm.

Balnges dam

Inlet of this dam is designed at an elevation of EL. 84.3 m with an intake capacity of 0.70 m^3/sec and a control valve having diameter of 600 mm.

(6) Safety around the reservoir

There is scarce possibility of landslide or slope failure around the reservoir as the slopes are covered by cohesive residual soil materials. But timely patrol along the surrounding road for watching and inspecting the reservoir's surroundings shall be carried out.

(7) Operation and maintenance of dam

To monitor the behavior of the dam after completion, the following monitoring and observation facilities shall be installed:

(1) Leakage measuring system,
(2) Deformation measuring system,
(3) Pore pressure measuring system.

Cracking due to abnormal deformation of the embankment or foundation, or water paths due to piping or hydraulic fracturing cause sudden increase of water leakage and the turbidity of leaking water. Consequently, abnormality of the dam can be identified by observing the leaking water. To meet this purpose, a leakage measuring system shall be installed.

Embankment and foundation develop deformation due to their own weight and due to water pressure during and after construction. A deformation measuring system shall be installed to measure the deformation in horizontal and vertical directions.

After the storage of water, pore water pressure develops in the embankment due to seepage water. Pore pressure measuring system shall be provided to observe and check pore water pressure with seepage water.

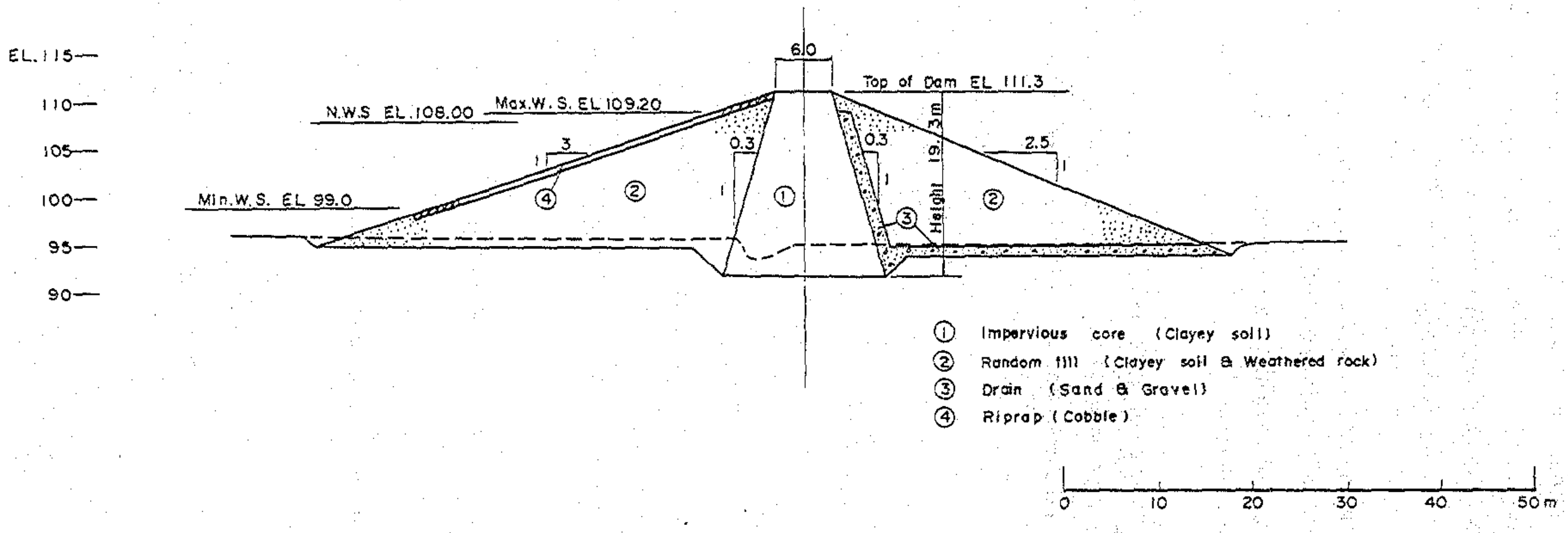


Fig.5.2.1 TYPICAL SECTION OF MANGILLOG DAM

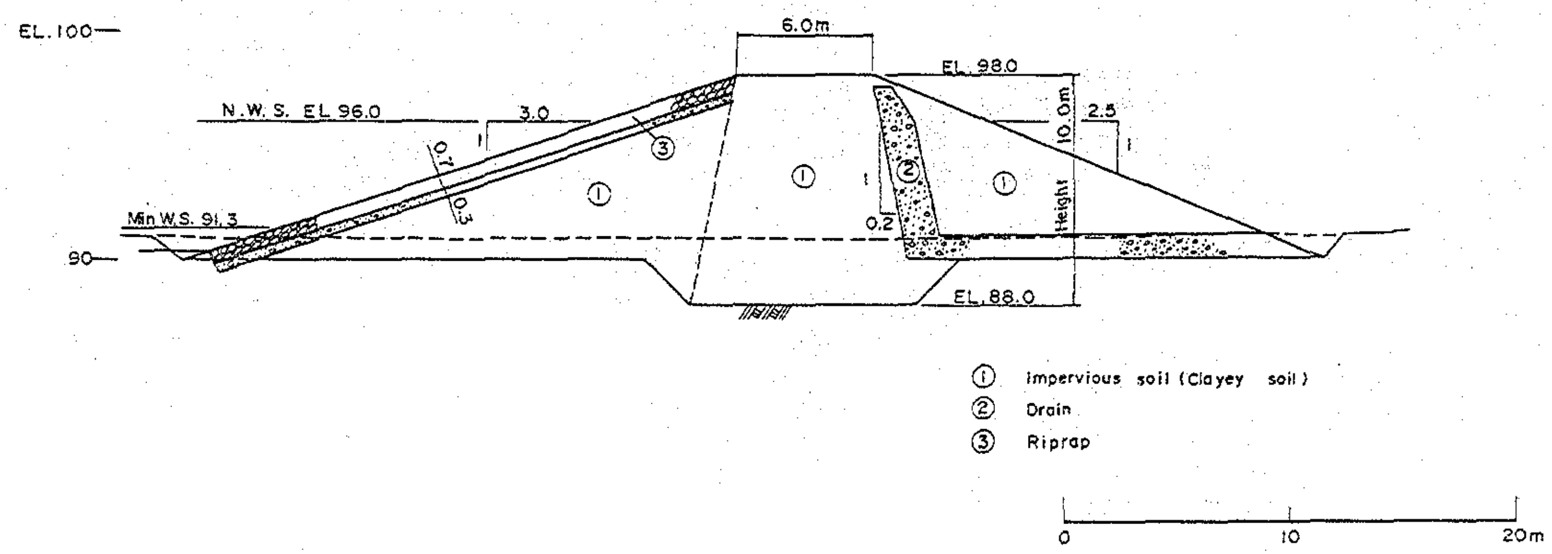


Fig.5.2.2 TYPICAL SECTION OF BULELATIN DAM

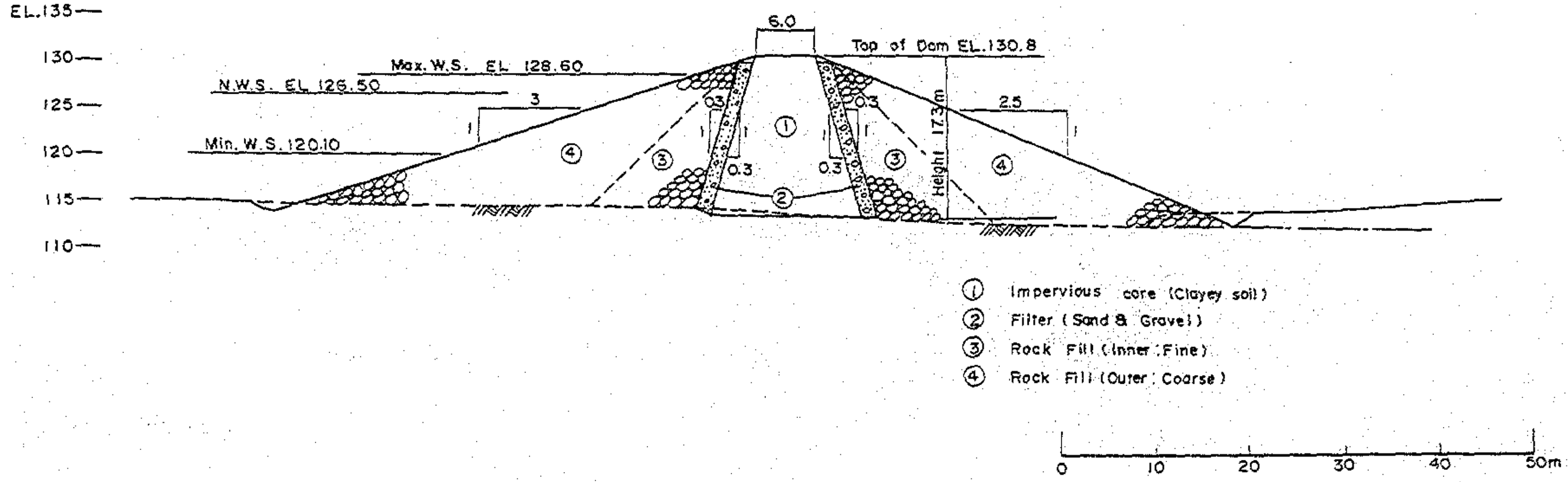


Fig.5.2.3 TYPICAL SECTION OF PANGASAN DAM

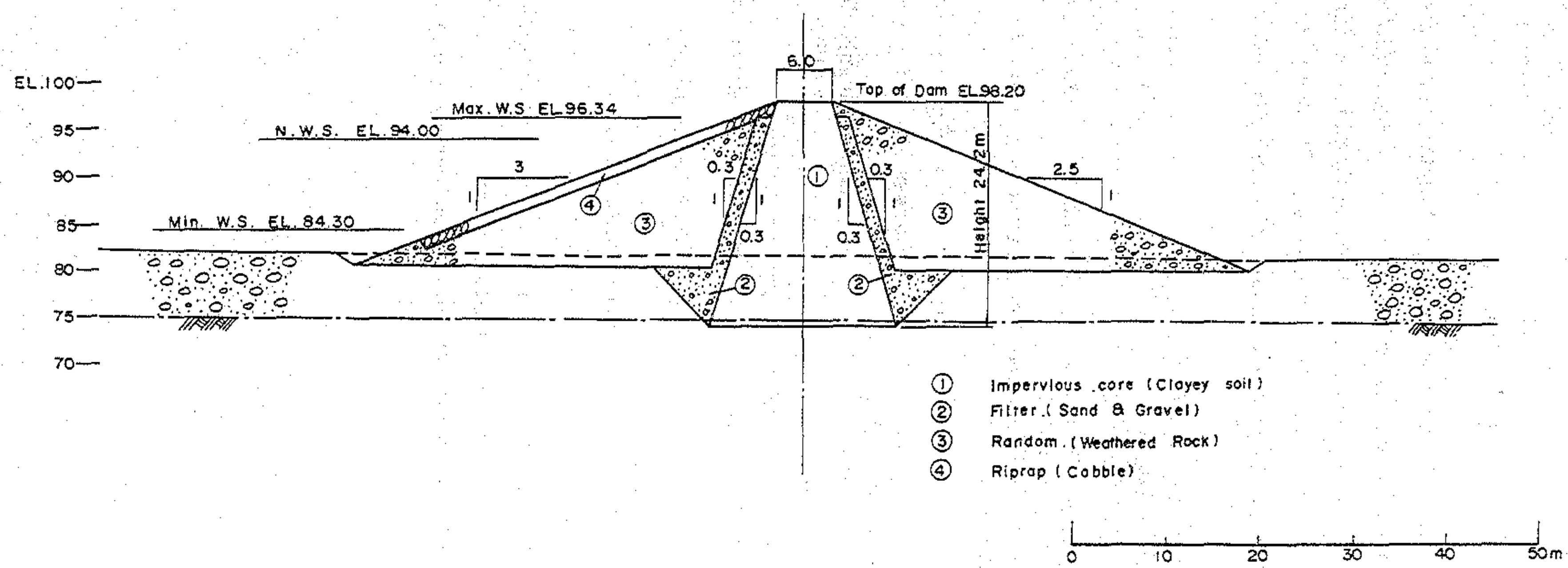


Fig.5.2.4 TYPICAL SECTION OF BALNGES DAM

5.3 Canal Design

5.3.1 Basic Consideration in Design

The soil conditions along the proposed canal routes are outlined as shown below. It is expected that there is no serious problems for the construction of proposed canal routes. Unlined canal type has been designed in consideration of the little flow capacity and economic construction cost. However, sharp curved portions of canals will be lined by concrete to prevent scouring and erosion.

	Canal Section	Soils property (thickness)	
1)	Downstream portion of South Lateral Canal of Mangillog system and Downstream portion of Main Canal on left bank of Balnges system	Surface: Substratum:	silt or clay (0.2 - 1.0 m) gravel
2)	Upstream portion of Main Canal on left bank of Pangasan system	Surface: Substratum:	silt or clay (0.1 - 0.5 m) highly/slightly weathered rock
3)	Section other than the above	Surface: Substratum:	silt or clay (0.1 - 0.2 m) highly weathered rock

The irrigation canals consist of various related structures which are combined organically to make up the canal systems and to function as a whole system.

The following canal related structures have been taken into consideration at the canal design.

Facility			Classification
1)	Conveyance	a.	Open channel
		b.	Pipe line
		c.	Syphon
		d.	Drop
2)	Diversion measuring devices	a.	Diversion works
		b.	Turnout
		c.	Parshall flume
3)	Regulation	a.	Check and drop
		b.	Spillway
4)	Protection	a.	Cross drain
5)	Maintenance	a.	O&M road
6)	Appurtenant	a.	Bridge
		b.	Foot bridge
		c.	Road crossing

The scope of the design includes head reach, main canal and lateral canal. The proposed irrigation systems consist of the following four canal systems, and the total length is 23.83 km.

Main Irrigation System (Length)	Name of Water source	Name of Canal		
(1) Mangillog system (10.32 km)	(Mangillog reservoir)	Head reach (200m)	Right bank main canal (1,160m)	
			Central main canal (880m)	
		Left bank main canal (3,600 m)	North lateral canal (1,880m)	
			South lateral canal (2,600m)	
(2) Bulelatin system (1.58 km)	(Bulelatin reservoir)	Head reach (380m)	Main canal (1,200m)	
(3) Pangasan system (3.13 km)	(Pangasan reservoir)	Head reach (100m)	Left bank main canal (1,630m)	
			Right bank main canal (1,400m)	
(4) Balnges system (8.80 km)	(Balnges reservoir)	Head reach (250m)	Left bank main canal (2,950m)	
			Right bank main canal (5,600m)	
Total 23.83 km				

5.3.2 Design Conditions

The basic design is in principle in compliance with the NIA design criteria.

(1) Design discharge

Maximum unit water requirement is 1.41 lit/sec/ha according to the irrigation water requirement study. As the unit design capacity, 2.0 lit/sec/ha has been adopted over the whole canal system in consideration of some allowance for future increase of irrigation water requirements due to changes in the cropping pattern and farming practice (e.g. partly introduction of dry season paddy) in the command area concerned.

This value is considered reasonable, because as for the unit design capacity for irrigation canals in the Philippines, generally 1.7 - 2.3 lit/sec/ha is used actually.
The irrigation system of the Project is outlined in Fig. 5.3.1 to Fig. 5.3.4.

(2) Hydraulic design

Canals are designed by the following given conditions :

	Item	Hydraulic Design
1)	Applied mean velocity formula	Manning's formula (coefficient of roughness= 0.03, standard value for small canal)
2)	Min. allowable velocity	0.45 m/sec (prevention of silting of suspended sediment)
3)	Max. allowable velocity	0.6 m/sec (based on canal materials : clay or loam)
4)	Free board	0.3 m (determined to be the minimum value)

(3) Farm ditch

Farm ditches are included in the scope of works undertaken by the Philippine side and consist of the followings :

- A turnout will irrigate a rotation block of about 40 ha through main farm ditch,

- Four or five diversion boxes will be provided for each main farm ditch. Each box will irrigate about 10 ha rotation unit through supplementary farm ditch.

(4) O&M road

O&M roads will be constructed along the main and lateral canals, and will be used not only for operation and maintenance of canals but also as farm roads. Thus, these roads are expected to have other derivative benefit than that of O & M.

The total road width is 4.5 m of which 3.5 m is the effective width with both side shoulders of 0.5 m wide. One lane width is secured for vehicle traffic. Gravel pavement is planned on the road surface.

5.3.3 Basic Design

The basic design of canals is attached at Plates of this Report. The plan is based on the terms below :

(1) Alignment of canal

Alignment of canal systems has been planned to enable the gravity irrigation of the largest possible area with reference to the elevation of the dam and reservoir concerned.

(2) Canal length and number of facilities

Length and numbers of facilities of each canal system are as follows :

Table 5.3.1 Outline of Irrigation Facilities Designed

	Items		Mangillog	Bulelatin	Pangasan	Balnges	Total
1)	Conveyance Structure						
	a.	Open Channel(m)	9,810	1,490	2,980	8,580	22,860
	b.	Pipe line(m)	0	0	100	0	100
	c.	Syphon(m)	510	90	50	220	870
		(nos.)	(6)	(2)	(1)	(3)	(12)
	d.	Drop(nos.)	13	0	0	0	13
2)	Diversion Works and Measuring Devices						
	a.	Diversion works(nos.)	3	1	1	1	6
	b.	Turnout(nos.)	9	4	7	11	41
	c.	Measuring devices(nos.)	18	2	3	3	16
3)	Regulating Works						
	a.	Check and drop(nos.)	17	4	6	8	35
	b.	Spillway(nos.)	7	2	2	3	14
4)	Protective Works						
	a.	Cross drain (nos.)	6	1	5	7	19
5)	Maintenance Works						
	a.	O&M road (m)	10,320	1,580	3,130	8,800	23,830
6)	Appurtenant Works						
	a.	Bridge (nos.)	9	2	2	7	20
	b.	Foot bridge (nos.)	9	2	2	7	20
	c.	Road crossing (nos.)	2	1	1	3	7

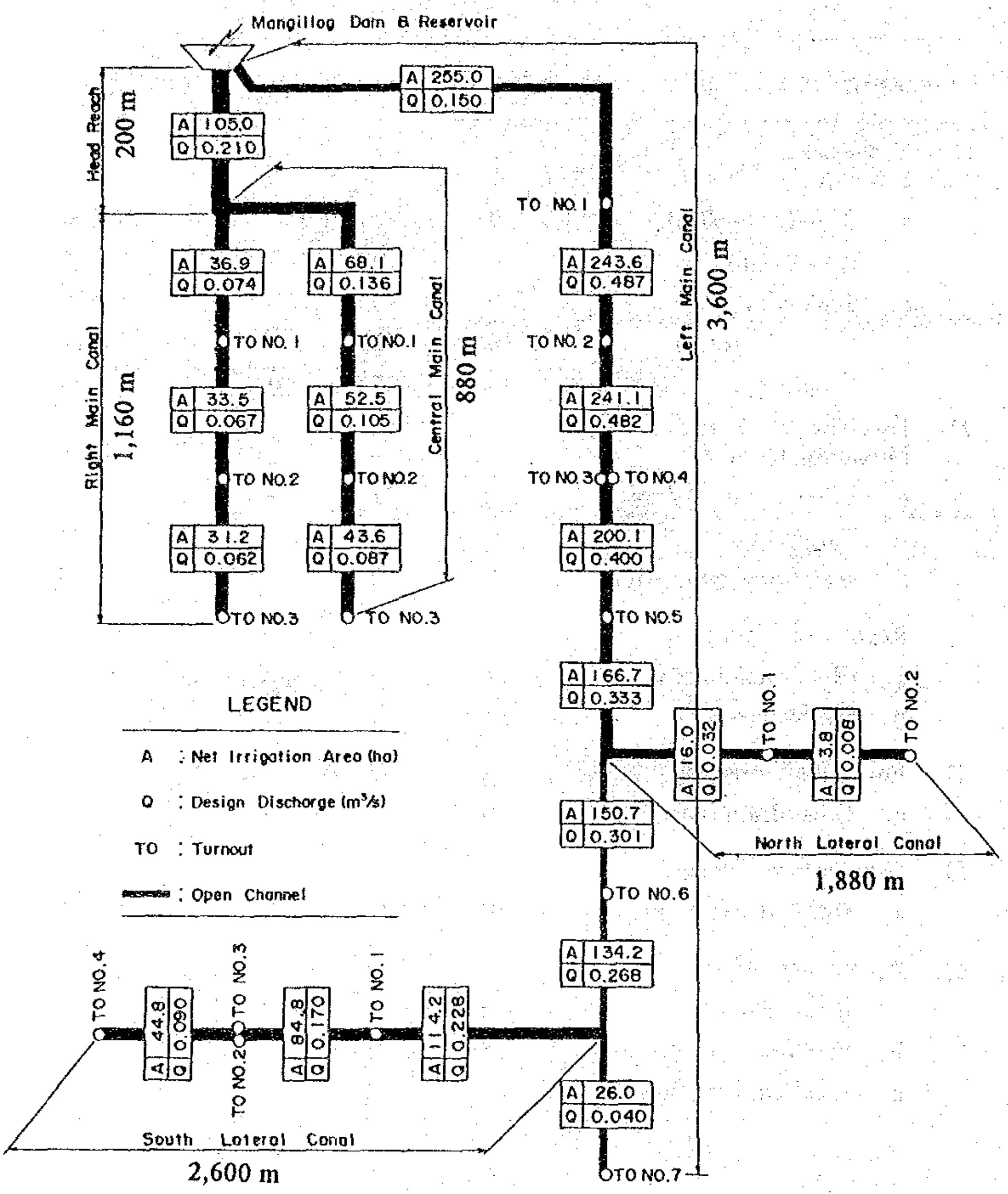


Fig. 5.3.1 SCHEMATIC DIAGRAM OF MANGILLOG IRRIGATION SYSTEM

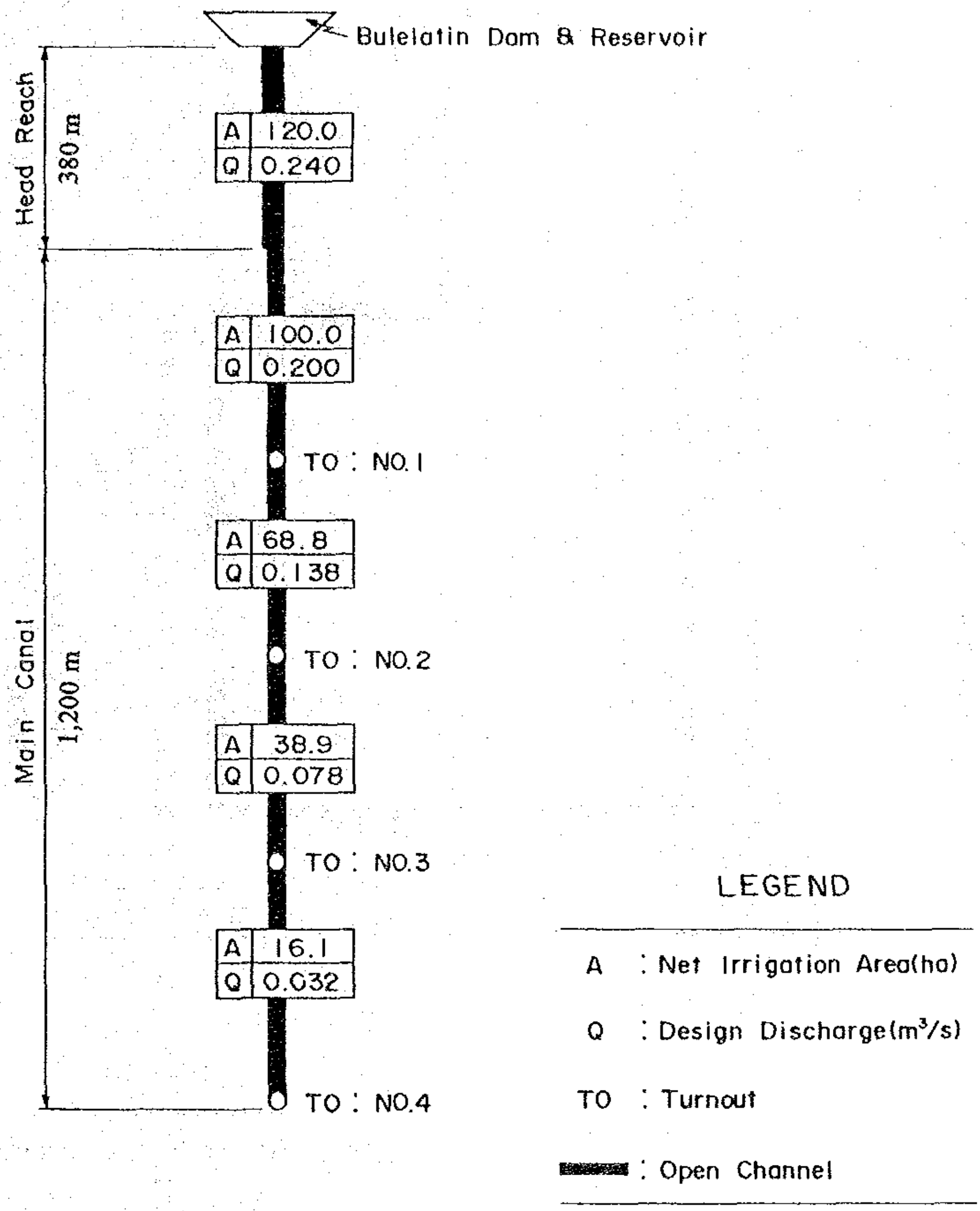


Fig. 5.3.2 SCHEMATIC DIAGRAM OF BULELATIN IRRIGATION SYSTEM

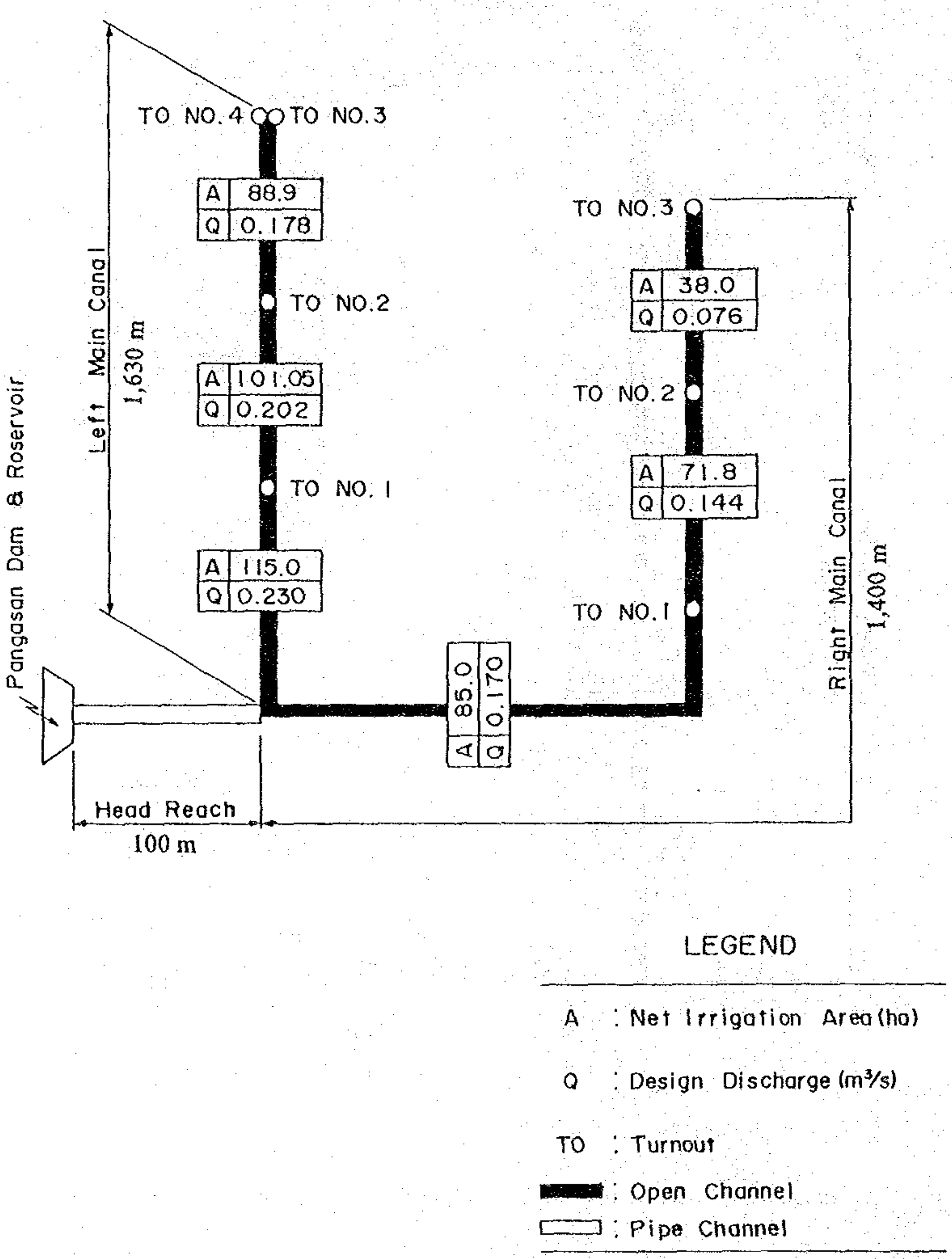


Fig. 5.3.3 SCHEMATIC DIAGRAM OF PANGASAN IRRIGATION SYSTEM

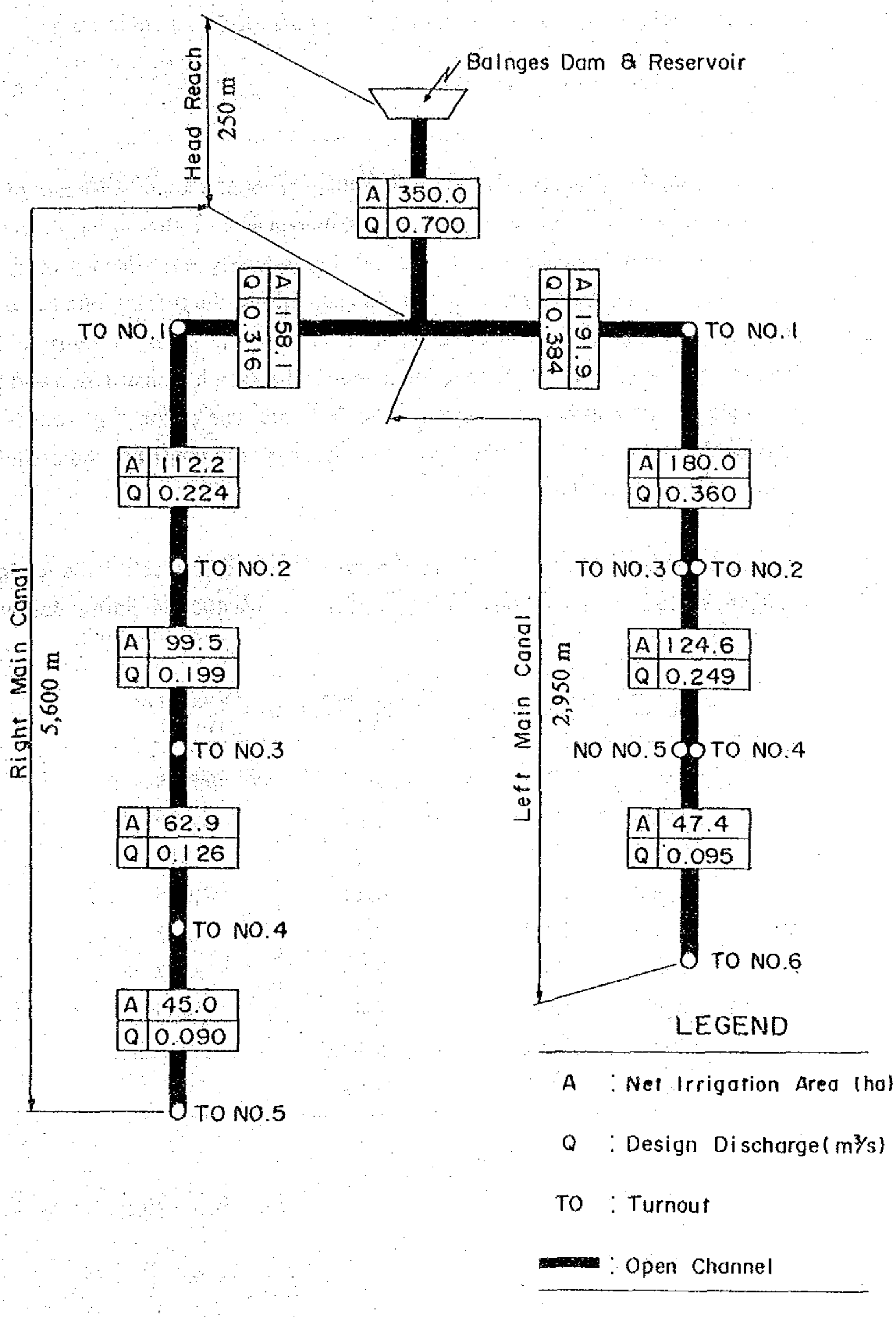


Fig. 5.3.4 SCHEMATIC DIAGRAM OF BALNGES IRRIGATION SYSTEM

5.4 Bridge Design

5.4.1 Basic Consideration in Design

Judging from the data obtained from core drilling at about 2 km downstream of the proposed bridge site, the underlying materials consists of alternating layers of slightly weathered sandstone and mudstone and gravelly river deposit of about 10 m in thickness. Under above foundation conditions, the bearing pile has been designed to support the load of piers, abutment and the super structure of the bridge. H-shaped steel pile foundation is practically easy in construction and has sufficient strength after construction. The desirable type of the super-structure may be the H-shaped steel beam bridge which is easier to construct and earlier to complete than the reinforced concrete one.

The annual records of the maximum discharge of the Bulsa River at Villa Agripay gauging station near the proposed bridge site (basin area 405 km^2) are as follows :

Month	Year	Water Level (m)	Discharge (m^3/s)
May	1976	4.42	2,529
November	1977	4.22	2,196
August	1978	2.78	613
August	1979	4.11	2,025
September	1980	2.81	633
August	1981	2.48	432
August	1982	2.88	683
August	1983	3.19	933
August	1984	2.90	697

Probable flood discharges calculated by Iwai's method and Gunbel's method are shown below :

(Unit ;m^3/sec)

Return period (year)	Iwai's method	Gunbel's method
2	981	1,085
5	1,698	2,077
10	2,263	2,734
20	2,868	3,364
50	3,745	4,179
100	4,475	4,790

10-year flood of 2,500 m^3/sec was considered as the design flood discharge at the bridge site. The clearance under beam of bridge must be more than the value shown below :

Clearance under beam of bridge crossing the river

Design Flood Discharge (m^3/sec)	Clearance under Girder (m)
below 200	0.6
200 to 500	0.8
500 to 2,000	1.0
2,000 to 5,000	1.2
5,000 to 10,000	1.5
10,000 or above	2.0

5.4.2 Design Conditions

(1) Design Flood Stage

Design flood stage at the discharge of 2,500 m^3/sec is estimated at 5.0 m in flow depth. This means that the clearance under beam of bridge is 1.2 m.

(2) Design load

The approaching road width is less than 5.0 m, therefore, live load of 14 tons has been taken into the design.

(3) Width

Width of the bridge is designed to be 3.6 m with one lane.

5.4.3 Basic Design

The basic design of the bridge is shown in the Plate attached to this Report. Basic conditions of design are described below :

(1) Selection of the bridge site

At present, the Bulsa River is crossed through fords with ferry, truck, jeepney and carabao-cart only when the Bulsa River depth is shallow during the dry season. When the river is deep, river crossing becomes actually troublesome and difficult.

This plan intends to construct the permanent bridge for releasing about 3,000 farmers and 800 ha farmland from being isolated on the right bank of the Bulsa River during the flood season. The following points have been taken into account for selecting the bridge site :

i. To be a location well coordinated with existing rural roads and convenient for use of local populace,

ii. To avoid the river branch, confluence and curve from the view point of hydraulic stability,

iii. To be a straight stream line and narrow river width from the viewpoint of economy,

iv. To have a good geologic foundation, and especially to have a shallow water depth.

Field surveys show that there are three principal fording points used frequently by local populace. These points are found to satisfy above requirements. (see Fig. 5.4.1)

Principal fording Points

	Location
Point 1	Iba - San Pedro
Point 2	Villa Agripay - Lubigan
Point 3	Villa Agripay - Moriones

Among these three points, point 2 site is located at the central part of the right bank of the Bulsa River and has convenient connection to the existing road networks for use by local populace. This site is also stable in hydraulic aspects and the river is relatively narrow at this site. As a result, this site was judged most suitable and selected as the proposed bridge site.

(2) Outline of bridge

The outline of the designed bridge is as follows :

Item	Outline
1. Substructure	
Abutment	2 nos. (reversed T-type)
Pier	8 nos. (reversed T-type)
Foundation method	H-shaped steel pile (bearing pile)
2. Superstructure	
Bridge length	225 m (span length 25 m x 9 spans)
Width	Total width 4.8 m (effective width 3.6 m)

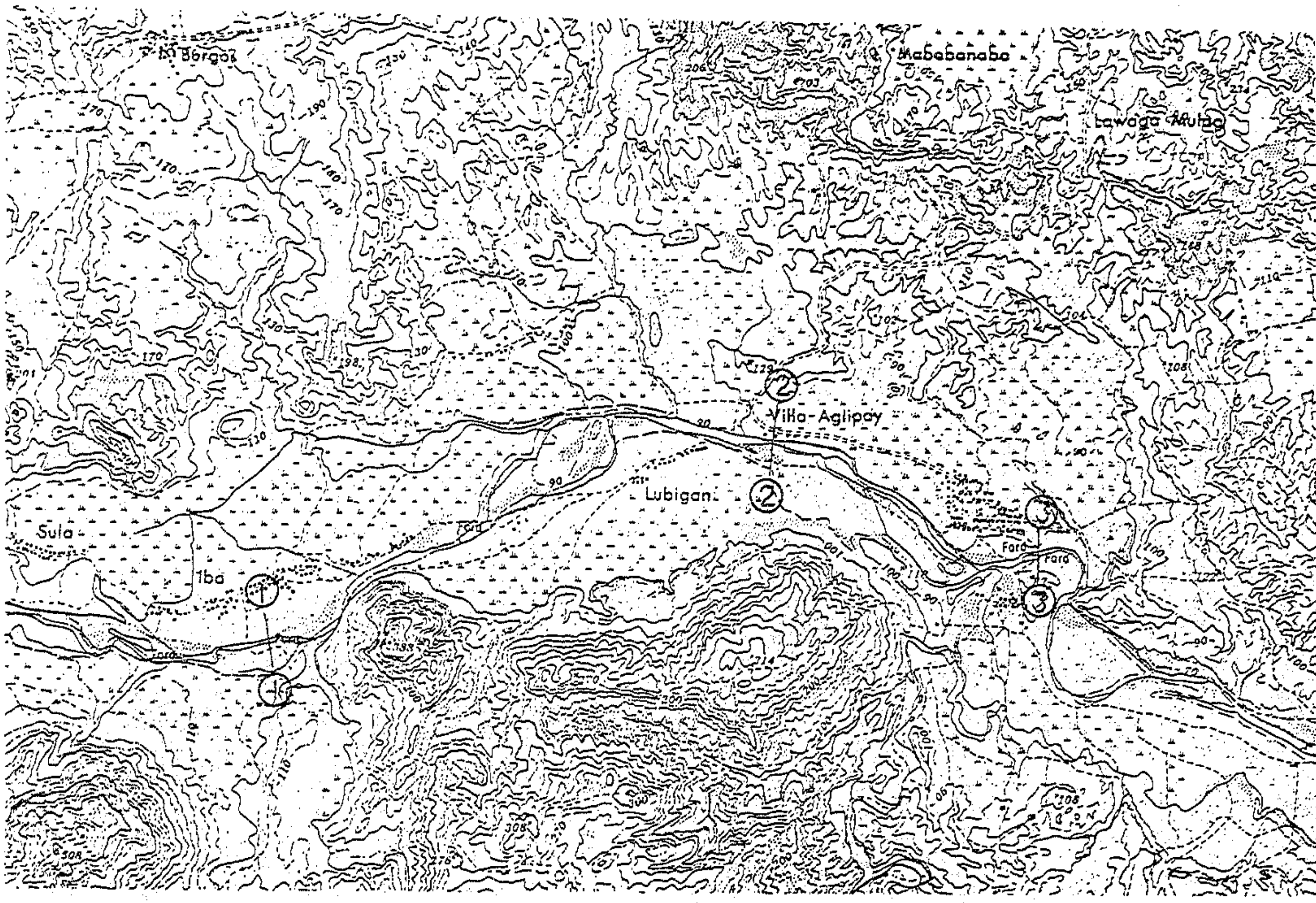
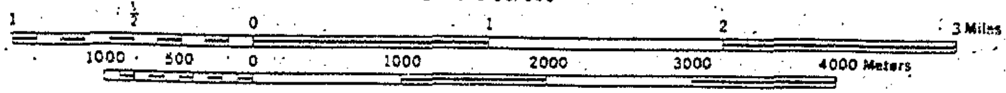


FIG. 5.4.1 FORDING SITE

Scale 1:50,000



CHAPTER 6 PROJECT IMPLEMENTATION PROGRAM

Project implementation has been envisaged to be under the Grant Aid Program of Japan. The basic line of the implementation program is as follows.

6.1 Executing Agency of the Project

Executing agency of the Project is the National Irrigation Administration (NIA), which undertakes responsibility to the contract procedures (consultant service agreement, construction contract, banking arrangements (B/A), etc.), the approval of tender documents for the construction works and the issuance of certification related to authorization to pay (A/P).

During the construction period, the Construction Management Department of NIA will take the leadership to form a Project execution team to cover all execution jobs. At the same time, the Coordinating Committee and the Technical Committee, which were organized at the start of the Basic Design Study, will be further developed to strengthen the Project execution system to ensure smooth realization of the Project. (See Fig. 6.1.1)

6.2 Proposed Construction Work

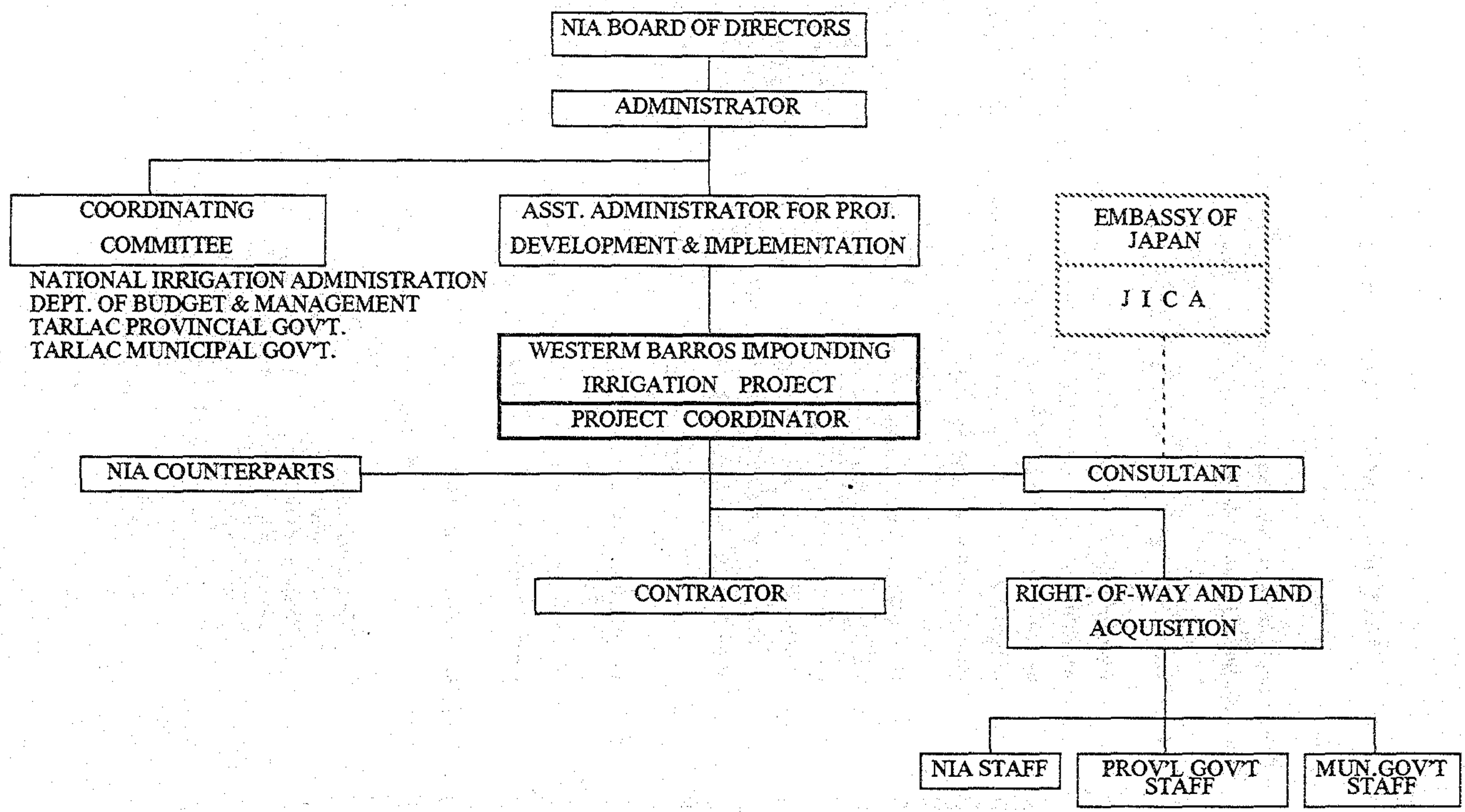
The scope of work of this Project includes construction of following facilities and related temporary works of access roads necessary for execution of the work :

a. Dam construction work

	Dam Height	Crest Length	Storage Capacity
Mangillog dam	19.3 m	704.5 m	3,210,000 m^3
Bulelatin dam	10.0 m	215.0 m	730,000 m^3
Pangasan dam	17.3 m	195.0 m	1,140,000 m^3
Balnges dam	24.2 m	208.0 m	1,820,000 m^3

FIG. 6.1.1

IMPLEMENTATION ORGANIZATION
WESTERN BARRIOS IMPOUNDING IRRIGATION PROJECT



b. Canal construction work

Mangillog system	10.32 km
Bulelatin system	1.58 km
Pangasan system	3.13 km
Balnges system	8.80 km

c. Bridge

Bulsa bridge	1 place	L= 225 m	W= 3.6 m

6.3 Construction Planing

6.3.1 Opening Formalities

After signing of the Exchange of Notes (E/N) for the Project, an agreement on the banking arrangements (B/A) between the Government of the Philippines (GOP) and an authorized Japanese foreign exchange bank will be concluded as early as possible. The Project shall be implemented using a Japanese consulting firm (the Consultant) and a Japanese contractor (the Contractor).

6.3.2 Construction Planning

The annual rainfall of the Project Area is about 1,900 mm, of which more than 90% is concentrated in the wet season from the middle of May to October. Consequently, execution of large scale earth work during the wet season is considered impossible and is basically scheduled to be concentrated in the dry season. The dam work of this Project contains a large earth work which will be carried out by heavy machinery on concentrated work sites, and improvement of the access road may help the efficient execution of the work. Since operating, excavating and compacting works with heavy machinery are mostly impossible during the wet season, the dam work period should be concentrated on the dry season.

The canal work, on the other hand, involves ballanced earth cutting and banking work, O & M road, canal , and various concrete structures. The work site extends linearly, to long distance, therefore, the machinery construction of the O & M road is better to preceed the construction of canals. On the progress of road construction the canal work will be followed by utilizing mainly manpower, it may be executed even during the wet season.

For the Bulsa bridge work, the substructure and a part of the upper structure shall be completed during the dry season, and the remaining portion of the upper structure during the wet season.

6.3.3 Consultant Service

Detailed design and construction supervision shall be carried out by a Japanese consultant firm under the agreement between the NIA and the said Consultant firm. Contents of the supervision are : to assist the NIA to conclude justifiable Contract for the Construction with a Japanese Contractor, to realize the intention of detailed design, to give the constactor technical guidance from the fair standpoint so that the construction may agree with the contract. The Consultant services includs the followings :

1) Assistance in Construction Contract

   Preparation of detailed design and tender documents, examination of bill of quantity, witnessing to tendering of the construction, awarding the Contract, etc.

2) Approval of construction drawings, etc.

   Approval of construction drawing by the Contractor and examination of materials, finishing specimen, and procured equipments, etc.

3) Advice for construction

   Examination of construction schedule, advice to Contractor for technical aspects, reporting construction progress to NIA and JICA, etc.

4) Cooperation for arrangement of approval to pay

   Examination of request for payment by the Contractor during and after the construction, cooperation for arrangement of the payment, etc.

5) Inspection of completed work

Inspection of the work completed during the prior period of time (from initiation to completion of the construction period).

After confirming the complete execution of the construction, and witnessing the transfer of the implemented facilities, the consultant will make their services complete with the approval of NIA at the receipt of the said facilities.

6.4 Implementation Program

This Project will be completed after undertaking the processes described below :

Consultant Contract
The NIA will conclude the consultant service agreement with a Japanese consulting firm. The consultant will proceed upon the verification of the agreement by the Government of Japan.

Design
Design documents and tender documents are prepared in 3 months on the basis of the B/D Study Report. Such documents will be submited for approval by the NIA at the end of the design stage.

Tendering
After the approval by the NIA, the Consultant will explain the contract documents and the bidding to the Japanese contractor firms. Tendering is composed of public notice, pre-qualification of contractor, assessment of tenders, and awarding the Contract. Period required is about 1.5 months.

Construction
As soon as the Contract is concluded, the construction will commence with the verification of GOJ. The construction of the Project will be completed in 12 months.

Implementation and construction schedules are shown on Fig. 6.4.1 and Fig. 6.4.2, respectively.

Fig. 6.4.1 Implementation Schedule

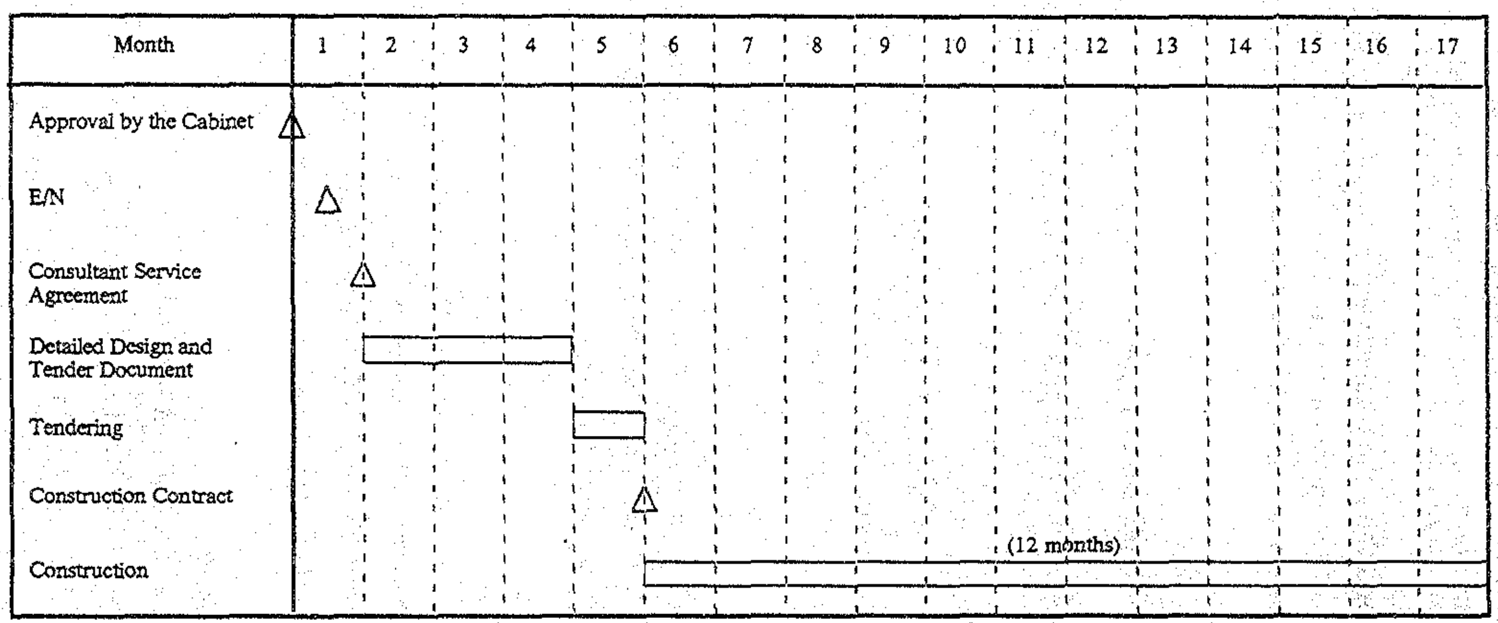
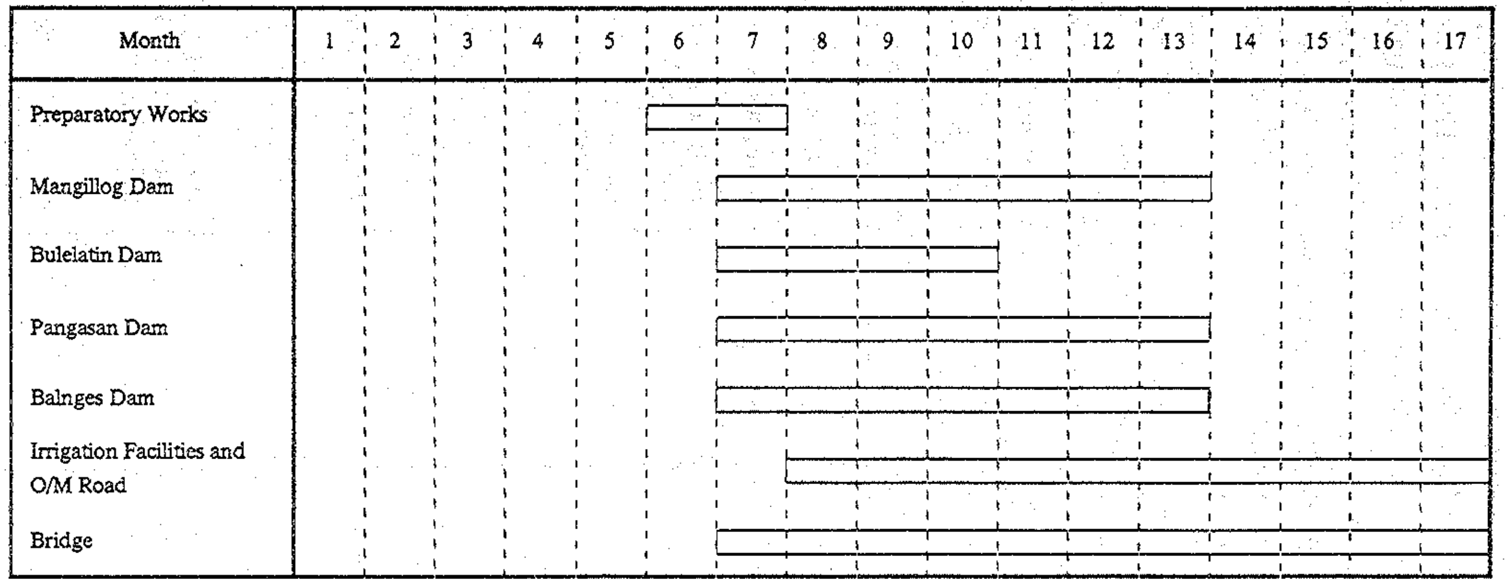


Fig. 6.4.2 Construction Schedule



6.5 Procurement of Equipments and Materials

Principal construction materials and common equipments can be procured in the Philippines. About half of the heavy machinery would be procured from Japan, because the number of available heavy machinery is insufficient for the proposed construction work. Steel materials for bridge, gates, valves and steel pipes for dams would be also procured from Japan. Procurement plan of equipments and materials is summarized below :

Items	Philip-pines	Japan	Reasons Selected
1) Construc. Materials			
Cement	O		The quality varies a little, but sufficient in compressive strength.
Sand, Gravel	O		Sand and gravel of the Bulsa River are in good quality in general, but quantities insufficient.
Reinforcing bars	O		The quality varies a little, but sufficient in strength.
Wooden frames	O		Locally available, with good quality.
Lumber	O		Plenty of good lumber is available. Woodcraft skills are high.
Concrete blocks	O		The quality varies a little, selection of producers is required.
H-Beam, I-Beam for bridge		O	Not produced in the Philippines.
Gates, Valves and Steel pipes for dams		O	Not produced in the Philippines.
Gates for canal	O		Locally available, sufficient in quality.
Scaffolding pipes		O	Not produced in the Philippines.
2) Construc. Machinery			
Bulldozer, Backhoe, Tractor shovel, Dump truck, Tamping roller, Vibrating roller, Truck crane	O		About half of bulldozers, backhoes and tractor shovels and other kinds of machinery are available in the Philippines.
Bulldozer, Backhoe, Tractor shovel		O	About half of the machinery shall be procured in Japan to complete the Project on time according to the construction schedule.
Batching plant	O		Plant is available in the Philippines.

6.6 Undertaking by the Philippine Government for the Project Implementaion

Necessary amounts of the Project cost to be undertaken by the Governement of the Philippines have been estimated as shown below :

1.	Land aquisition for the facilities (dams, reservoirs and irrigation canals) under the Grant Aid Program of Japan	₱	7,500,000
2.	Project cost for the construction of the terminal facilities including right-of-way, construction, survey, engineering administration	₱	4,500,000
3.	Head office and project office expenses	₱	3,000,000
	Total	₱	15,000,000

CHAPTER 7 PROJECT EVALUATION

7.1 Outline

The purpose of this Project is to construct the dams, canals, operation and maintenance road and bridge by the national investment, thereby to improve the infrastructure for the agricultural sector of the area concerned and to enhance the agricultural productivity to increase steadily the income of farmers. This Project is expected to act as initiator on a micro level to the Medium-Term Philippine Development Plan for 1987 - 1992.

The economic benefit realized by this Project is the increase in the production of the agricultural sector as indicated in the National Development Plan. Additionally, social benefit is also expected. The transfer of technology realized in the Project and economic and social benefit achieved in the Project Area will further exert a preceeded favorable impact and effect to the nation-wide Small Water Impounding Management Project (SWIM).

7.2 Project Effects

The effects expected from this Project may be classified as follows:

Type	Item
1) Economic benefit	• Increased crop production
2) Social benefit	• Improvement of living environment • Improvement of settling conditions, etc.

Table 7.2.1 summarizes the scope, scale and contents of the effects to be realized by the Project. The unit yields used for calculation of the irrigation benefits are as

shown below. Other basic data were also taken from the Feasibility Study Report prepared by NIA.

Crop Unit Yield (Unit : ton/ha)

	Rice		Corn	
	Rainfed	Irrigation	Rainfed	Irrigation
Present 1)	2.0	2.5	1.0	-
Future				
Without project 2)	2.4	3.0	1.3	-
With project 3)	-	4.5	-	4.0

1) at the study
2) in the case the project will not be implemented increase in future is expected through general improvement of farming technique
3 in the case the project will be implemented

7.3 Project Evaluation

The effects of this Project cover the population of 11,000, which is about 7% of the population of 167,249 (1990) in the rural area of the Municipality of Tarlac. Once the Project is executed, production increase of 2,163 tons for rice and 3,370 tons for corns are expected. This is evaluated at ₱ 13,577,000 economically. In addition, the improvement of road network resulting from the Project realize a road benefit from rainfed paddy fields of 640 ha along the improved and constructed roads. The road benefit is evaluated at ₱ 217,000 economically.

Though the Philippines has achieved self-supply of rice in 1970s, the corns are considered essential as food and forage crop and about 10% (about 300,000 tons) of the corns consumption is imported annually. The success of the Project will contribute to saving foreign currency.

Farmers benefited by the irrigation have the mean income of about ₱ 800 monthly, which is far below the poverty line of ₱ 2,066 per month of the farm households in the Philippines. This Project will cause increase of about ₱ 13,000 in annual net crop income for full owner and about ₱ 8,000 for lessee farmers, respectively. The financial state of farm households will be improved up to a level slightly below the poverty line. The number of those benefited by irrigation will run up to 4,200 persons.

The operation and maintenance of the Project facilities will be undertaken by the NIA until the Government of Tarlac Province obtains the capability on O & M work. After transfer to the Government of Tarlac Province, it is confirmed that the technical cooperation will be given by the NIA.

The NIA is implementing operation and maintenance of existing Tarlac Irrigation Systems while engaging with numerous similar projects with sufficient number of experts. On the other hand, in the Office of the Tarlac Provincial Engr. , about 140 staffs are working under the Provincial Engineer to perform numerous works on civil engineering plan, construction supervision and operation and maintenance. Based on the above, the NIA and Government of Tarlac Province are judged to be competent authorities with sufficient capability for operation and maintenance of the Project facilities.

Table 7.2.1 Summary Table of Project Effects

Kind	Contents	Scope	Scale
1. Economic a) Irrigation benefit	a) Increased and stabilized rice production in the wet season, and increased corn production in the dry season.	a-1) Beneficial area 1,030 ha • Wet season 1,030 ha (Rice) • Dry season 842.5 ha (Corn) a-2) Beneficiaries • Farm households 800 • Population 4,200	a-1) Irrigation Benefit (See Table E-2) i Increased crop production (W/-W/O) • Rice 2,163 ton • Corn 3,370 ton ii Net incremental value of production in economic price • ₱ 13,577,000 a-2) Farm budget (See Table E-4) Net crop income (₱/year) Owner / Leaseholder Present 6,050 / 3,940 With Project 19,360 / 11,754 Note) Representative farm size ; 1.5ha
b) Road and bridge benefit	b) Farm labor cost saving, transportation cost saving and decreased crop spoilage.	b-1) Beneficial area • Rainfed paddy field 640ha b-2) Beneficiaries • Farm households 420 • Population 2,200	b) Road and bridge venefit • ₱ 217,600 in economic price
2. Social a) Improvement of living Emvironment	a) Improvement of road network resulted from the Project, and solution to the isolation of right bank area of the Bulsa River.	a,b) Beneficiaries • Farm household 2,100 • Population 11,000	

CHAPTER 8 CONCLUSION AND RECOMMENDATION

As described above, this Project is expected to create substantial effects and contribute greatly to the enhancement on the life of inhabitants over a wide range. In this context, this Project is worth executing under the Grant Aid Program of Japan. Besides, on the recipient country's side organization is satisfactory without problem in terms of personnel and fund for operation and management of the Project. More smooth and effective execution of the Project may be promissing with the following activities.

1) Construction of terminal irrigation systems for dams and irrigation facilities to fulfill their function firmly as early as possible

2) Establishment of a cooperative body consisting of the NIA, the Government of Tarlac Province and Tarlac Municipality, which will encourage to organize the farmers irrigators' organization for beneficial farmers to operate and maintain dams and irrigation facilities and manage water use

3) To give the farmers irrigators' organization technical guidance on the operation and maintenance of the irrigation facilities including fair and effective water management by the NIA, the Government of Tarlac Province and Tarlac Municipality.

Technical Analysis & Data

Contents of Technical Analisis & Data

Technical Data :

1. Rainfall Analysis

LIST OF TABLES

LIST OF FIGURE

Table M-1 Annual Maximum Daily Rainfall (mm/day)

LOC.	Clark A. B		Dagupan C.		H. Luisita		Sta. C. Porac		Camiling	
LAT.	15°11'N		16°03'N		15°26'N		15°05'N		15°41'N	
LONG.	120°33'E		120°20'E		120°38'E		120°33'E		120°25'E	
ALT.	144m		2m		37.5m		75m		16m	
Year	mm	Date	mm	Date	mm	Date	mm	Date	mm	Date
1946	136.4	6/22	-	-	-	-	-	-	-	-
1947	88.1	8/31	-	-	-	-	-	-	-	-
1948	108.7	7/26	-	-	-	-	-	-	-	-
1949	96.0	6/19	142.0	9/3	-	-	-	-	-	-
1950	145.5	8/3	134.4	10/2	-	-	-	-	-	-
1951	146.3	5/7	148.1	7/30	-	-	-	-	-	-
1952	178.3	8/7	498.0	8/5	-	-	-	-	-	-
1953	185.9	8/21	151.1	7/3	-	-	-	-	-	-
1954	89.7	8/30	171.7	8/30	-	-	-	-	-	-
1955	109.7	9/24	135.4	9/23	-	-	-	-	-	-
1956	87.9	9/21	68.3	11/4	-	-	-	-	-	-
1957	83.3	7/15	203.4	9/20	-	-	-	-	-	-
1958	127.5	7/13	129.5	9/3	-	-	-	-	-	-
1959	61.5	8/12	73.7	5/16	-	-	-	-	-	-
1960	204.7	6/27	177.8	8/13	-	-	-	-	-	-
1961	318.0	6/27	-	-	-	-	-	-	-	-
1962	178.8	9/6	319.5	6/20	-	-	-	-	-	-
1963	160.0	6/28	212.1	6/28	-	-	-	-	-	-
1964	-	-	205.5	8/6	-	-	-	-	-	-
1965	-	-	115.1	7/13	-	-	-	-	-	-
1966	-	-	332.0	5/19	-	-	-	-	-	-
1967	-	-	125.3	8/28	-	-	-	-	-	-
1968	324.4	8/28	280.3	8/29	180.1	8/28	-	-	-	-
1969	108.0	8/6	144.6	8/5	73.2	8/5	125.5	7/30	-	-
1970	223.0	9/1	139.4	8/31	178.6	8/31	159.0	9/1	122.7	8/31
1971	113.3	10/12	144.1	6/15	68.8	9/17	139.2	7/25	79.0	7/6
1972	291.6	7/19	203.0	8/16	171.7	7/18	272.8	7/18	187.2	7/18
1973	134.6	10/16	99.9	10/7	207.0	10/15	122.5	10/15	55.4	6/3
1974	173.0	8/16	260.0	8/16	240.8	8/16	154.7	8/10	276.6	8/16
1975	113.5	10/20	70.6	5/7	86.6	10/20	140.5	10/20	78.7	8/10
1976	-	-	368.0	5/25	172.5	6/25	245.4	5/23	191.8	5/24
1977	-	-	158.8	7/20	170.2	11/14	207.0	11/14	245.9	11/14
1978	-	-	169.7	8/23	93.5	7/24	116.4	8/12	80.6	10/26
1979	-	-	162.5	8/25	173.2	8/15	204.6	8/15	153.9	8/15
1980	-	-	167.4	7/25	141.2	11/5	-	-	-	-
1981	-	-	149.4	11/24	74.7	7/4	-	-	-	-
1982	-	-	135.0	8/7	95.0	7/16	-	-	-	-
1983	-	-	141.0	8/14	83.3	8/14	-	-	-	-
1984	-	-	232.2	8/28	157.0	10/28	-	-	-	-
1985	-	-	256.4	6/28	230.1	6/28	-	-	-	-
1986	-	-	376.8	7/8	113.8	7/9	-	-	-	-
1987	-	-	-	-	235.0	8/18	-	-	-	-
n	26		37		20		11		10	

Table M-2 Heavy Rainfall Patterns Observed at the Hacienda Luisita

in mm

One hour / Date	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24	Σ
17 Jul. 1972	0	0.5	0.5	0	0	0	0.5	1.4	0.5	7.9	6.9	5.4	3.4	2.9	0.5	1.5	1.5	1.0	0	1.5	2.9	5.4	3.9	2.5	50.6
18 Jul. 1972	4.9	9.3	4.9	5.9	4.9	17.6	14.2	5.4	3.4	1.9	9.1	13.3	14.4	4.8	1.0	1.0	4.3	0.5	5.8	6.7	5.3	3.8	3.4	1.9	147.7
19 Jul. 1972	9.6	10.4	13.0	5.8	11.0	8.6	22.1	13.9	21.0	12.0	6.0	16.0	12.0	1.5	3.5	3.5	5.0	5.5	2.0	4.5	5.5	5.0	1.5	6.0	204.9
20 Jul.1972	2.0	1.0	1.0	0.5	0	0	1.0	2.5	1.0	0	0	0	0	1.5	2.0	3.9	8.3	5.4	2.0	5.4	1.5	2.9	4.9	5.9	52.7
15 Oct.1973														1.0	1.6	3.6	0.5	1.0	2.1	0.5	2.1	1.6	1.0	10.9	25.9
16 Oct.1973	84.2	21.8	13.5	6.2	4.2	15.6	28.1	8.3	6.1	2.0	2.0	0.5	0.5	4.1	0.5	0.5	4.6	0	0	0	0	0	0	0	202.7
26 Jul.1974																			32.6	37.7	23.4	0	0	0	93.7
15 Aug.1974									0.6	0	0.6	0	0.6	3.6	1.2	4.9	5.5	12.2	3.1	6.1	10.4	6.1	14.0	7.9	76.8
16 Aug.1974	5.5	2.4	0	2.4	24.4	14.0	9.8	6.7	0.5	8.6	11.9	11.3	5.4	17.3	7.6	2.7	0.5	4.3	10.3	5.9	21.6	6.5	10.8	15.1	205.5
17 Aug.1974	8.6	11.3	9.7	12.4	8.1	16.7	15.1	18.4	10.8	5.9	4.9	7.0	3.8	10.8	7.0	2.7	1.6	0	0	0.5	1.1	0	0.5	0	156.9
24 May.1975	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.9	58.2	12.1	0.5	0	0	0	0	74.7
20 Oct.1975	0	2.7	0.5	2.7	2.7	6.3	2.7	1.5	2.4	6.8	3.4	5.3	4.4	6.8	2.9	1.0	0	0.5	1.9	10.2	9.2	4.9	6.3	6.3	91.4
10 Aug.1976	2.4	0.5	0	0	0	0	0	0	0	0	2.5	2.9	2.0	2.9	1.5	2.9	2.9	0.5	1.5	0	9.3	23.0	3.9	22.5	81.2
2 Jul.1977	0	0	0	0	0	0	0	0	0	0	0	0	0	0	39.2	23.5	1.5	0	5.4	11.8	9.8	2.0	0.5	0	93.7
31 Jul.1977	0	0	0	0	0	0	0	0	0	0	0	0	24.5	35.8	0.5	0	0.5	0	0	0.5	0	0	0	1.0	62.8

Table M-3 Annual Maximum Rainfall Amount for Different Duration at Hacienda Luisita

Unit : mm

Year	5 min	10 min	15 min	20 min	30 min	45 min	60 min	80 min	100 min	120 min	150 min	3 hr	6 hr	12 hr	24 hr
1967	14.7	21.4	31.6	40.7	51.4	57.0	67.2	68.3	68.3	69.4	69.4	69.4	69.4	69.4	76.2
1968	4.9	9.7	15.5	19.4	27.5	37.2	40.5	40.5	40.5	40.5	51.8	71.2	93.9	125.2	180.1
1969	10.9	18.8	25.8	26.7	36.6	39.6	43.2	49.0	49.4	50.0	52.8	52.8	54.4	62.5	64.8
1970	8.0	14.0	19.0	22.0	32.0	46.0	54.0	57.5	58.0	62.0	86.1	94.6	104.2	123.7	178.5
1971	12.0	18.5	32.0	33.0	37.0	40.0	41.7	43.0	49.0	51.0	52.4	54.0	68.9	68.9	68.9
1972	11.8	21.4	26.8	32.1	42.8	53.5	57.8	57.8	57.8	66.6	96.0	96.0	96.8	108.9	171.7
1973	11.4	20.8	31.6	37.4	52.0	68.6	84.2	98.8	107.1	111.3	117.5	124.8	145.6	197.6	207.0
1974	9.8	17.6	25.5	29.4	34.3	38.2	39.2	45.6	45.6	45.6	47.5	51.3	81.5	154.4	240.8
1975	17.2	26.5	31.8	37.1	46.0	54.6	60.1	73.2	74.2	74.2	74.2	74.9	74.9	74.9	86.6
1981	12.1	21.9	26.4	30.2	40.0	57.4	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	74.6

Source : Maximum Rainfall Amount for Different Durations
Volume II, 1979, PAGASA, and Collected data at Pagasa

Table M-4 Rainfall Intensity of One Series Rainfall at Hacienda Luisita

Unit : mm

Year	5 min	10 min	15 min	20 min	30 min	45 min	60 min	80 min	100 min	120 min	150 min	3 hr	6 hr	12 hr	24 hr
15, Oct. 1973	11.4	20.8	31.2	37.4	52.0	68.6	84.2	98.8	107.1	111.3	117.5	124.8	145.6	197.6	207.0
15, Aug. 1974	6.1	9.8	12.8	15.9	18.9	25.7	28.1	31.7	35.4	38.4	45.1	48.7	58.0	109.8	142.5
16, Aug. 1974	7.6	10.8	14.0	15.7	16.2	19.5	21.6	24.8	35.6	42.1	47.5	51.3	81.5	154.4	240.8
2, Jul. 1977	14.7	22.5	29.4	39.2	46.1	51.9	52.9	62.7	63.2	63.7	64.2	64.2	87.3	95.0	95.0
26, Oct. 1978	4.0	6.0	7.5	8.5	10.5	12.5	14.5	19.0	25.5	28.5	36.0	48.5	73.0	87.0	87.1
2, May. 1981	9.5	16.7	22.4	26.2	33.3	40.5	47.0	47.0	47.0	47.0	48.8	49.9	49.9	50.4	50.4
4, Jul. 1981	3.8	4.5	5.3	6.0	6.8	7.6	8.7	10.6	13.2	14.5	18.1	19.5	24.0	43.4	74.6
27, Sep. 1981	12.1	21.9	26.4	30.2	40.0	57.4	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0

Table M-5 Probability of Exceedance of Rainfall Amount by Gamble Method at Hacienda Luisita

Unit : mm

Return Period	5 min	10 min	15 min	20 min	30 min	45 min	60 min	80 min	100 min	120 min	150 min	3 hr	6 hr	12 hr	24 hr	1 Day	2Days	3Days
	number of data (year) 10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	20	20	20
2	10.8	18.4	25.8	29.9	38.9	47.8	53.0	57.2	58.6	60.5	67.9	71.9	81.6	98.5	125.8	138.8	188.5	215.7
4	13.9	22.7	31.1	36.2	46.4	57.6	66.4	73.4	76.3	79.2	89.0	93.8	106.1	141.0	187.9	186.4	251.5	297.1
5	14.8	24.0	32.6	38.0	48.5	60.4	70.2	78.1	81.5	84.5	95.2	100.1	113.2	153.3	205.8	200.2	269.7	320.6
10	17.5	27.6	37.1	43.3	54.9	68.7	81.6	91.9	96.6	100.4	113.2	118.7	134.2	189.5	258.8	240.8	325.5	390.1
25	20.9	32.3	42.7	50.1	63.0	79.3	95.9	109.4	115.8	120.5	136.1	142.3	160.7	235.3	325.7	292.2	391.4	477.8
50	23.4	35.7	46.9	55.1	69.0	87.1	106.6	122.4	130.0	135.4	153.0	159.8	180.4	269.2	375.3	330.2	441.8	542.9
100	25.9	39.1	51.1	60.1	75.0	94.9	117.1	135.3	144.1	150.2	169.8	177.1	199.9	302.9	424.6	368.1	491.9	607.6
200	28.3	42.5	55.3	65.1	80.9	102.6	127.7	148.1	158.1	164.9	186.6	194.4	219.3	336.5	473.7	405.7	541.7	671.9
1000	34.0	50.4	64.9	76.6	94.7	120.5	152.1	177.8	190.6	199.0	225.4	234.5	264.4	414.3	587.4	493.0	657.2	821.1

Table M-6 Computed Rainfall Intensity Curves and Tables at Hacienda Luisita (1)

LN I=A*LN T + B
I:RAINFALL INTENSITY (MM/HOUR)
T:RAINFALL DURATION (MIN.)

N-YEAR PROBABILITY=5.
RANGE OF TIME
T1=5. T2= -
A=-0.358
B=5.7903

LN I=-0.358*LN T+5.7903

T	I
5	183.85
6	172.23
7	162.99
8	155.38
9	148.96
10	143.45
11	138.64
12	134.38
13	130.59
14	127.17
15	124.07
16	121.23
17	118.63
18	116.23
19	114.00
20	111.92
21	109.99
22	108.17
23	106.46
24	104.85
25	103.33
26	101.89
27	100.52
28	99.22
29	97.98
30	96.80
31	95.67
32	94.59
33	93.56
34	92.56
35	91.60
36	90.69
37	89.80
38	88.95
39	88.12
40	87.33
41	86.56
42	85.82
43	85.10
44	84.40
45	83.72
46	83.[illegible]
47	82.43
49	81.[illegible]

LN I=A*LN T + B
I:RAINFALL INTENSITY (MM/HOUR)
T:RAINFALL DURATION (MIN.)

N-YEAR PROBABILITY=10.
RANGE OF TIME
T1=5. T2=50
A=-0.3755
B=5.9762

LN I=-0.3755*LN T+5.9762

T	I
5	215.26
6	201.02
7	189.71
8	180.43
9	172.63
10	165.93
11	160.10
12	154.95
13	150.36
14	146.24
15	142.50
16	139.09
17	135.96
18	133.07
19	130.39
20	127.91
21	125.58
22	123.41
23	121.37
24	119.44
25	117.63
26	115.91
27	114.28
28	112.73
29	111.25
30	109.84
31	108.50
32	107.21
33	105.98
34	104.80
35	103.67
36	102.57
37	101.52
38	100.51
39	99.54
40	98.60
41	97.69
42	96.81
43	95.95
44	95.13
45	94.33
46	93.55
47	92.86
48	92.07
49	91.36
50	90.67

LN I=A*LN T + B
I:RAINFALL INTENSITY (MM/HOUR)
T:RAINFALL DURATION (MIN.)

N-YEAR PROBABILITY=25.
RANGE OF TIME
T1=5. T2=60.
A=-0.393
B=6.1752

LN I=-0.393*LN T+6.1752

T	I
5	255.36
6	237.71
7	223.73
8	212.30
9	202.69
10	194.47
11	187.32
12	181.02
13	175.42
14	170.38
15	165.83
16	161.67
17	157.87
18	154.36
19	151.11
20	148.10
21	145.29
22	142.65
23	140.18
24	137.86
25	135.66
26	133.59
27	131.62
28	129.75
29	127.98
30	126.28
31	124.67
32	123.12
33	121.64
34	120.22
35	118.86
36	117.55
37	116.29
38	115.08
39	113.91
40	112.78
41	111.69
42	110.64
43	109.62
44	108.64
45	107.68
46	106.76
47	105.86
48	104.99
49	104.14
50	103.31
51	102.51
52	101.73
53	100.98
54	100.24
55	99.52
56	98.81
57	98.13
58	97.46
59	96.81
60	96.17

Table M-7 Computed Rainfall Intensity Curves and Tables at Hacienda Luisita (2)

LN I=A*LN T + B
I:RAINFALL INTENSITY
(MM/HOUR)
T:RAINFALL DURATION
(MIN.)

N-YEAR PROBABILITY=5.
RANGE OF TIME
T1= [illegible] T2=1440.
A=-0.683
B=7.0508

LN I=-0.683*LN T+7.0508

T	I
[illegible]	82.[illegible]
90	53.38
120	43.86
150	37.66
180	33.25
210	29.93
240	27.32
270	25.21
300	23.46
330	21.98
360	20.71
390	19.61
420	18.64
450	17.78
480	17.02
510	16.32
540	15.70
570	15.13
600	14.61
630	14.13
660	13.69
690	13.28
720	12.90
750	12.54
780	12.21
810	11.90
840	11.61
870	11.34
900	11.08
930	10.83
960	10.60
990	10.38
1020	10.17
1050	9.97
1080	9.78
1110	9.60
1140	9.42
1170	9.26
1200	9.10
1230	8.95
1260	8.80
1290	8.66
1320	8.53
1350	8.40
1380	8.27
1410	8.15
1440	8.03

LN I=A*LN T + B
I:RAINFALL INTENSITY
(MM/HOUR)
T:RAINFALL DURATION
(MIN.)

N-YEAR PROBABILITY=10.
RANGE OF TIME
T1=50 T2=1440.
A=-0.6592
B=7.0817

LN I=-0.6592*LN T+7.0817

T	I
50	90.28
90	61.28
120	50.69
150	43.76
180	38.80
210	35.05
240	32.10
270	29.70
300	27.71
330	26.02
360	24.57
390	23.31
420	22.20
450	21.21
480	20.33
510	19.53
540	18.81
570	18.15
600	17.55
630	16.99
660	16.48
690	16.00
720	15.56
750	15.15
780	14.76
810	14.40
840	14.06
870	13.73
900	13.43
930	13.14
960	12.87
990	12.61
1020	12.37
1050	12.13
1080	11.91
1110	11.70
1140	11.49
1170	11.30
1200	11.11
1230	10.93
1260	10.76
1290	10.59
1320	10.43
1350	10.28
1380	10.13
1410	9.99
1440	9.85

LN I=A*LN T + B
I:RAINFALL INTENSITY
(MM/HOUR)
T:RAINFALL DURATION
(MIN.)

N-YEAR PROBABILITY=25.
RANGE OF TIME
T1=60. T2=1440.
A=-0.6567
B=7.2587

LN I=-0.6567*LN T+7.2587

T	I
60	96.54
90	73.97
120	61.24
150	52.89
180	46.92
210	42.40
240	38.84
270	35.95
300	33.55
330	31.51
360	29.76
390	28.24
420	26.90
450	25.71
480	24.64
510	23.68
540	22.81
570	22.01
600	21.28
630	20.61
660	19.99
690	19.42
720	18.88
750	18.38
780	17.91
810	17.47
840	17.06
870	16.67
900	16.31
930	15.96
960	15.63
990	15.32
1020	15.02
1050	14.74
1080	14.47
1110	14.21
1140	13.96
1170	13.73
1200	13.50
1230	13.28
1260	13.07
1290	12.87
1320	12.68
1350	12.49
1380	12.32
1410	12.14
1440	11.98

Table M-8 Computed Rainfall Intensity Curves and Tables at Hacienda Luisita (3)

LN I=A*LN T + B
I:RAINFALL INTENSITY
(MM/HOUR)
T:RAINFALL DURATION
(MIN.)

N-YEAR PROBABILITY=50.
RANGE OF TIME
T1=4. T2=
A=-0.3972
B=6.2865

LN I=-0.3972*LN T+6.2865

LN I=A*LN T + B
I:RAINFALL INTENSITY
(MM/HOUR)
T:RAINFALL DURATION
(MIN.)

N-YEAR PROBABILITY=100.
RANGE OF TIME
T1=4. T2= 7[illegible]
A=-0.403
B=6.3928

LN I=-0.403*LN T+6.3928

LN I=A*LN T + B
I:RAINFALL INTENSITY
(MM/HOUR)
T:RAINFALL DURATION
(MIN.)

N-YEAR PROBABILITY=200.
RANGE OF TIME
T1=4. T2=
A=-0.4029
B=6.4751

LN I=-0.4029*LN T+6.4751

T	I	T	I	T	I
4	309.78	4	341.77	4	371.13
6	263.70	6	290.24	6	315.20
8	235.23	8	258.47	8	280.70
10	215.27	10	236.24	10	256.57
12	200.24	12	219.51	12	238.40
14	188.34	14	206.29	14	224.04
16	178.61	16	195.48	16	212.31
18	170.45	18	186.42	18	202.47
20	163.46	20	178.67	20	194.05
22	157.39	22	171.93	22	186.74
24	152.05	24	166.01	24	180.31
26	147.29	26	160.74	26	174.59
28	143.01	28	156.01	28	169.45
30	139.15	30	151.73	30	164.80
32	135.63	32	147.84	32	160.57
34	132.40	34	144.27	34	156.70
36	129.43	36	140.98	36	153.13
38	126.68	38	137.94	38	149.83
40	124.12	40	135.12	40	146.77
42	121.74	42	132.49	42	143.91
44	119.51	44	130.03	44	141.24
46	117.42	46	127.72	46	138.73
48	115.45	48	125.55	48	136.37
50	113.60	50	123.50	50	134.15
52	111.84	52	121.56	52	132.05
54	110.18	54	119.73	54	130.05
56	108.60	56	117.99	56	128.16
58	107.09	58	116.33	58	126.36
60	105.66	60	114.75	60	124.65
62	104.29	62	113.25	62	123.01
64	102.99	64	111.81	64	121.45
65	102.5[illegible]	66	110.43	66	119.95
		68	109.11	68	118.52
		70	107.84	70	117.14

Table M-9 Computed Rainfall Intensity Curves and Tables at Hacienda Luisita (4)

LN I=A*LN T + B
I:RAINFALL INTENSITY
(MM/HOUR)
T:RAINFALL DURATION
(MIN.)

N-YEAR PROBABILITY=50.
RANGE OF TIME
T1= 65 T2=1440.
A=-0.6508
B=7.3446

LN I=-0.6508*LN T+7.3446

T	I
65.	102.30
90	82.77
120	68.64
150	59.36
180	52.72
210	47.69
240	43.72
270	40.49
300	37.81
330	35.54
360	33.58
390	31.88
420	30.37
450	29.04
480	27.85
510	26.77
540	25.79
570	24.90
600	24.08
630	23.33
660	22.63
690	21.99
720	21.39
750	20.83
780	20.30
810	19.81
840	19.35
870	18.91
900	18.50
930	18.11
960	17.74
990	17.38
1020	17.05
1050	16.73
1080	16.43
1110	16.14
1140	15.86
1170	15.59
1200	15.34
1230	15.09
1260	14.86
1290	14.63
1320	14.42
1350	14.21
1380	14.01
1410	13.81
1440	13.62

LN I=A*LN T + B
I:RAINFALL INTENSITY
(MM/HOUR)
T:RAINFALL DURATION
(MIN.)

N-YEAR PROBABILITY=100.
RANGE OF TIME
T1= [illegible] T2=1440.
A=-0.646
B=7.4234

LN I=-0.646*LN T+7.4234

T	I
[illegible]	[illegible]
90	91.52
120	76.00
150	65.79
180	58.48
210	52.94
240	48.57
270	45.01
300	42.05
330	39.53
360	37.37
390	35.49
420	33.83
450	32.36
480	31.04
510	29.84
540	28.76
570	27.77
600	26.87
630	26.04
660	25.26
690	24.55
720	23.88
750	23.26
780	22.68
810	22.13
840	21.62
870	21.14
900	20.68
930	20.24
960	19.83
990	19.44
1020	19.07
1050	18.72
1080	18.38
1110	18.06
1140	17.75
1170	17.45
1200	17.17
1230	16.90
1260	16.64
1290	16.39
1320	16.15
1350	15.91
1380	15.69
1410	15.47
1440	15.26

LN I=A*LN T + B
I:RAINFALL INTENSITY
(MM/HOUR)
T:RAINFALL DURATION
(MIN.)

N-YEAR PROBABILITY=200.
RANGE OF TIME
T1= [illegible] T2=1440.
A=-0.6408
B=7.4903

LN I=-0.6408*LN T+7.4903

T	I
	[illegible]
90	100.17
120	83.30
150	72.20
180	64.24
210	58.20
240	53.43
270	49.54
300	46.31
330	43.56
360	41.20
390	39.14
420	37.33
450	35.71
480	34.27
510	32.96
540	31.77
570	30.69
600	29.70
630	28.79
660	27.94
690	27.16
720	26.43
750	25.74
780	25.10
810	24.50
840	23.94
870	23.41
900	22.90
930	22.43
960	21.98
990	21.55
1020	21.14
1050	20.75
1080	20.38
1110	20.02
1140	19.68
1170	19.36
1200	19.05
1230	18.75
1260	18.46
1290	18.19
1320	17.92
1350	17.66
1380	17.42
1410	17.18
1440	16.95

Table M-10 Probability of Exceedance 1-day Max. Rainfall by Gamble Method

Unit : mm

	Hacienda Luisita	Dagupan City	Sta. Cruz Proc	Camiling	Clark Air Base
Data No. n =	20	37	11	10	26
Return Period					
2	133.3	174.9	164.3	136.8	142.7
4	182.6	247.0	212.5	207.8	199.5
5	196.8	267.9	226.4	228.3	215.9
10	238.8	329.4	267.5	288.9	264.5
25	291.9	407.2	319.4	365.5	325.8
50	331.3	464.9	357.9	422.3	371.2
100	370.3	522.2	396.1	478.7	416.4
200	409.3	579.2	434.2	534.9	461.3
1000	499.5	711.4	522.2	665.0	565.5