The Batac Procoma (Producers' Cooperative Marketing Association) Inc. has been established more than 20 years before by tobacco growers and engaged in many works but collecting tobacco leaves, such as procurement, sales, financing, operation of restaurantes as well as gas stations, and tractor cultivation on rental basis.

The Samahang Nayon Consumers' Association at Sinait, developed on the basis of Samahang Nayon, has run a retail shop of the daily necessities.

3) Others

Besides the above farmers' organization, there are 87 Farmers' Associations, 26 Rural Youth Clubs, and 50 Rural/Home Improvement Clubs existing in the municipalities in the Project Area as shown in Table 3D-49, Appendix 3D-5. All of these organizations are under administration of the BAEx, and the Farmers' Associations have been funtioning as farmers' representatives to receive the extension services, etc. rendered by BAEx.

E. Electric Conditions

1. Introduction

In March, 1977, the NIA originated a power supply plan for the Project Area as the Palsiguan River Multipurpose Project, which involves agricultural development scheme, aimed at about 60,000 KW Power generation - annually 143 GWh to be supplied to meet the requirements in the northwestern Luzon - by the use of about 200 m total water head available from the Proposed Palsiguan dam.

The northwestern Luzon, composed of those provinces of Ilocos Norte, Ilocos Sur and Abra, is populated by some 938,000 people, most of whom are engaged in agriculture as a major industry in the area, and has been currently covered by the Luzon Grid of the National Power Cooperation (NPC) in its power supply. A new power supply plan, however, has been eagerly required for meeting sharply increasing power demand in the region as well as for reducing transmission losses caused from long distance transmission from the source.

On top of the above, hydropower generation has come to be high-lighted again with price hike of crude oil; particularly, the power generation scheme in multipurpose project plays a vitally important role in contributing to national economy. On the other hand, the Greater Manila area, the largest power consumer in Luzon, has been supplied with power generated in various power plants through the so-called Luzon

Grid, which covers a great deal of small power demand in the course to the Manila as well. The power supply plan to be discussed herein is different from the existing one in pattern to aim at regional self-sufficiency in power, and would give a significant impact to the development of the country. The proposed plan, serving to reducing oil consumption and effectively utilizing precious water resources, will provide a plant for supplemental power supply to medium-scaled power market in the hinterland of the Project, but not to the Greater Manila. The new power plant will favourably affect the government's policy for the regional energy supply program.

The plan, however, should be taken up as a chainlink of the total Luzon Grid and formulated as a part of the total development program of the power in Luzon Island, and not as an independent project in an isolated areas.

2. Present Demand and Supply

2) Luzon Island

The Philippines containing some 42 million population (1975) with its growth rate of 2.7 percent per annum, gained the Gross Domestic Product (GDP) of about 172.8 billion pesos on the 1978 price basis, in which agriculture and fisheries occupied about 27.3 percent, mining and manufacturing industries about 34.7 percent and services about 38.0 percent. Among the above three sectors, the mining and manufacturing industries have marked a sharp increase in growth rate by about 13 percent per annum.

The recent rising trend in living standard as well as in growth rate of mining and manufacturing industries has been spurring on the increase in power demand. The total national power production reached some 17,000 GWh in 1978. The Luzon Island, involving the Greater Manila as the largest consumer in the national, has consumed as much as 87 percent of the total production, and in 1978 the energy request of the Luzon Island was estimated at 15,000 GWh and the peak demand at 2,400 MW.

The major power suppliers in the Philippines are the NPC (National Power Corporation), the Meralco (Manila Electric Cooperative, Inc.) and some other organizations such as the NEA (National Electrification Administration), and those owned by provinces, municipalities and privates have taken part in power supply services. The Meralco is the largest power supplier in the country, having about 6.15 million client consumers in Manila and the annual sales amount by about 650 GWh.

The NPC, established in 1936 under the Commonwealth Act 120 enacted in 1935, has been in a position to develop the power sources to supply at the reasonable rate the energy as the base of the development in economy and industries of the nation.

The installed capacity of the NPC in the Luzon Island in 1979 was 2,991 MW in total, including 541 MW for hydropower, 220 MW for geo-thermal and 2,230 MW for oil-thermal, and the total amount in its supply reached 11,965 GWh in the same year. The sales of electric power has been carried out usually by regional Electric Cooperatives financed by regional NEA, and the regional Cooperatives are in charge of the power sales and the construction of the power distribution facilities.

The total consumption of the sold power can be brokendown into 21.6 percent for home use, 62.7 percent for industrial use and 15.0 percent for commercial use, and the relevant load factor is about 70.0 percent. The transmission lines that the NPC has been maintained so far are about 1,158 km in total length by 230 KV in single and double circuit, about 420 km by 115 KW and about 1,280 km by 69 KV, respectively. The electric cycle now applied in the Philippines is AC.60 Hz, and the distribution voltage by 110/220 V is used for the urban areas, while 240/470 V for the others (see Tables 3E-1 to 3E-4, Appendix 3E-1).

Ilocos Region

Those provinces of Ilocos Norte, Ilocos Sur and Abra are the objective consumer regions of this power supply plan. The national census held in 1975 revealed that these provinces are populated by some 372,000 people, 417,000 and 149,000, respectively. Agriculture is the major industry in these provinces, and the provincial capitals are Laoag, Vigan and Bangued, all of which function as commercial cities. Tobacco processing, ceramic manufacturing, rice milling and soft drink bottling, which are medium/small scaled industries for processing and manufacturing of farm products and consumer goods, are the major manufacturing industries in the Project Area. Recently, the copper mining has been resumed in production in the region.

The NEDA has proposed in the report of "Regional Development Investment Program" that a cigarette factory, a pig-iron smelting plant, a ceramic factory, a charcoal briquette factory and a copper mining plant (on-going) are to be provided in this Areas. Furthermore, a rice mill with 200 ton/day capacity is expected to be constructed to meet the need for processing incremental paddy under the Project.

Laoag, the commercial city, has a plan to establish a university in order to substantially provide functions as a nucleus municipality in the northwestern Luzon.

The Project Area, backed by the Cordillera Central Range, is promising in mining industry and its related industries through developing the abundant mining resources of iron, manganese, copper, etc. available in the above mountainous area.

The Ilocos region has gradually been under the service network of the NPC through 115 KV transmission lines starting from the Ambuklao Power Station by the successive installation of transmission lines, Bantay-Laoag in 1966, Bantay-Narvacan and Narvacan-San Esteban both in 1971, etc., although had been supplied with power generated by diesel generators operated by the local small-scaled enterprises. Following these developments in power supply, NEA-financing provisional Electric Cooperative, Incs. have been established to merge various local small power companies for promoting the full-scaled electrification of the Area. The Ilocos Norte Electric Cooperative Inc. (INECO), for instance, successfully and remarkably increased its connected consumers in number from 10,620 houses in 1975 to 37,732 houses in 1979 that occupies about 57.3 percent of the target consumers of 65,800 houses, and similarly, the Ilocos Sur Electric Cooperative Inc. and the Abra Electric Cooperative Inc. has been promoting electrification works at their utmost. Hence, the electrification rate of the region has reached, as a whole, about 55 percent of the target.

The total power consumption of the region in 1979 was 52,810 MWh, including 26,921 MWh in Ilocos Norte province, 25,376 MWh in Ilocos Sur and 513 MWh in Abra province, respectively, while the total demand was 22,050 KW, including 10,500 KW, 9,700 KW and 1,850 KW, respectively. The load factor for the case is estimated at 39 percent. This indicates the growth rate of electrification is about 13 percent to the consumption of 41,372 MWh in 1977.

The breakdown of such demand is shown by 84.9 percent for residential use, 11.0 percent for industrial use, 2.1 percent for commercial use, 0.4 percent for public building use, 0.1 percent for irrigation use and 1.5 percent for street lights. A greater part of consumption is occupied by residential use and the power rate per connection is estimated at 50 KWh/month. The monthly load factor ranges from 30.3 percent to 44.5 percent with the highest seasonal load factor taking place in April and May.

The electric power is distributed by transmission lines through the respective substation at Laoag, Abra and San Esteban, and major municipalities in the region have been satisfactorily electrified with completion of installation of the main transmission lines; however, there have been some parts in barrios fround unelectrified yet. Each Cooperative of every province has been trying to consolidate the transmission networks in its own service areas, and the rate of accomplishment so far made is estimated at 55 percent as a whole in the Project Area.

The monthly and the daily fluctuation in power demand observed at Laoag substation and Bantay substation are shown in Table 3E-5 to 3E-7 and Figure 3E-1 to 3E-2, Appendix 3E-2.

3. Load Demand Estimation

Luzon Island

The NPC's forecast made in 1979 suggests that while the energy request in the past ten years has grown at the rate of 7.6 percent per annum, the growth rate up to 1983 from 1980 is expected to remain by 6.8 percent with necessary electric energy of 15,500 GWh and from 1984 to 1990 it is forecasted to keep 7.0 percent growth rate level to require the elecrric energy of about 24,900 GWh in 1990.

On the other hand, while the peak load recorded in the past ten years has grown at the rate of 7.0 percent, the growth rate up to 1983 from 1980 is expected to increase to 7.6 percent with necessary load of 2,569 MW in 1983 and from 1984 and onward it is forecasted to remain at the level of annual 7.0 percent in growth rate with necessary load of about 24,130 MW in 1990. In 1990, the load factor to be required is forecasted by 68.8 percent.

The power supply program to cope with the situation is contemplated by securing about 3,000 MW (installed capacity) by hydropower in 1990, which is six times as much as at present, 880 MW by geo-thermal power, being four times as much as at present, 600 MW by coal-thermal power which will be started in operation in 1984 and 620 MW by nuclear power which will be started in operation in 1986. Contrarily, the oil-thermal power generation is planned to be levelled down from 2,230 MW at present to 875 MW in 1990. As a result, the electric power will be developed to reach 6,000 MW (installed capacity) in 1990, which is almost double as much as at present (see Table 3E-8 and 3E-9, Appendix 3E-3).

A thorough consolidation of the transmission networks is also under contemplation, and the 500 KV double circuit trunk lines will be provided running through the central part of Luzon Island from north to south, and the 230 KV branch lines will be provided and furthermore 115 KV and/or 69 KV branch lines laid down as well (see Table 3E-1, Appendix 3E-1 and Figure 3E-3 to 3E-4, Appendix 3E-4).

Ilocos Region

In 1967, the power demand of the Ilocos region was only 1,985 KW (installed capacity) and the energy request was as small as some 6,400 MWh. The Region, however, has been rapidly electrified, according to the power development plan, to the remarkable extent that the growth of electrification rate was 25.4 percent on the peak demand basis and 19.5 percent per annum on the energy request basis, respectively. In view of such rapid progress of electrification in the Region, the NPC has estimated the load factor by 39.3 percent on the basis of the Demand and Sales Forecast that was derived from the forecast of the average annual growth rate of peak demand by 14.4 percent for 10 years up to 1990, as well as the energy request by 18.2 percent (see Table 3E-10 and Figure 3E-5, Appendix 3E-5). The forecast of the power development has seemed to be made on consideration of such factors as copper mining development and industrialization of the Region. This is suggested from the fact that the proposed 230 KV transmission line laying between the Ambuklao power station and the Narvacan Substation (on-going project), located in the center of the Region, will meet a sharp increase in energy request brought about by mining development and industrialization.

Practically, however, it is rather difficult to forecast the demand and supply of the power in a limited small region, because a new plant, for instance, to be constructed in the small region will considerably change the relationship of demand and supply of the power. Actually, the forecast made in 1977 on the demand and the energy in 1987 indicates 34.5 MW and 169.5 GWh, respectively, whereas the latest forecast on the same shows a large change to 72.26 MW and 247.7 GWh, respectively. The latest forecast accordingly, has been made in taking to a large extent into account the development of mining and industries in the Region.

4. Power Rates

The NPC has taken the pricing system for the entire Luzon Island that the power is sold to the local Cooperatives at the fixed wholesale price (utilities charge) and to the large-scaled industries at the fixed retail prices (industries charge) under the direct contract with consumers.

The local Cooperatives, which are responsible for construction of distribution lines in needs, sell the power to the consumers at their own retail prices in adding their managerial cost to the NPC's wholesale price. That is to say, the Cooperative take their own retail pricing system with different classification of consumers.

The NPC sells the power at ₱0.31 KWh for utilities use and ₱0.33 per KWh for industries use, while the Cooperatives retail the power commonly at ₱0.48 ∿ 0.75 per KWh for residential and commercial use and at ₱10.0 ∿ 12.0 per KW as demand charge with ₱0.33 ∿ 0.57 KWh as energy charge for small-scaled industries (see Table 3E-11 to 3E-15, Appendix 3E-6).

CHAPTER IV. THE PROJECT

CHAPTER IV. THE PROJECT

A. Objectives and Components of the Project

1. Objectives and Scope

The Project Area is one of the regions that is left behind in economic development. The average per capita income of 780 pesos in this region is much lower than the national average of 895 pesos.

There might be many reasons to be counted in this regard, but the major reason might be the absence of water resources available for irrigation under the existing conditions. Under the status, stabilized water supply for the paddy cultivation can not be realized even in the wet season. And also, paddy cultivation in the dry season is quite limited due to the shortage of water.

In addition to the shortage of irrigation water mentioned above, the Project Area has neither rationalized irrigation and drainage systems nor farm roads. Especially, transportation to and in the Project Area is difficult during the wet season.

Under the conditions, the agricultural productivity has remained low, which results in poor farm income, mostly, due to the shortage of agricultural facilities required for rationalized agricultural production inclusive of water source facilities, irrigation and drainage canals and farm road networks.

Since the Project Area is blessed with favorable natural conditions such as soil, climate and topography for paddy and diversified crop cultivation, the potentiality of the Project Area for agricultural development could be surely exploited by means of constructing adequate facilities.

The project aims to increase agricultural production, to generate hydropower, to create the employment opportunities throughout the year and to improve the living environment through the rural development focusing on assured irrigation water supply supported by improved agricultural supporting services and farm road systems. In order to achieve the above-mentioned objectives and to get quick benefit in the whole Project Area, the following should be realized in accordance with the proposed work schedule.

i) Provision of irrigation and drainage systems for double cropping of high yield varieties of rice and for cultivation of tobacco, garlic and other profitable crops;

ii) On-farm development for irrigated agriculture as well as for modernized agricultural practices;

iii) Institutional arrangement and strengthening of agricultural supporting services for full development of the Project Area; and,

iv) Rural community development posterior to the implementation of on-farm development.

2. Components of the Project

The components of the project are irrigation and hydropower;

Irrigation: to plan the irrigated agriculture provided with water resources facilities, rationalized irrigation and drainage systems, on-farm development, road networks and agricultural supporting services.

Hydropower: to generate the hydropower by releasing Palsiguan reservoir water in Abra province through the headrace tunnel.

B. Project Formulation

1. Proposed Scheme of Development

The preliminary studies of the proposed scheme of development for Ilocos Norte Irrigation Project have been made in the overall plan, aiming at year-round irrigation for potential acreage, from technical and economic view points, based upon various alternative plans focusing upon the utilization of water resources, their associated benefits and costs. As the most optimum plan for the project development through the studies, single reservoir plan of the Palsiguan dam, trans-basin plan, has been proposed.

The development of the proposed area of ahout 22,600 ha is planned in the phasing manner, Phase I and Phase II. Phase I development areas are about 10,200 ha located on the right bank of the Bonga river, and their water resources for irrigation are river waters diverted by the diversion dams constructed across the rivers such as Labugaon, Solsona, Madongan, Papa and Bonga. The detailed description of the Phase I project has been given in the report of Ilocos Norte Irrigation Project (Phase I) prepared in 1979.

The proposed irrigable areas of the Phase II development are estimated at about 12,400 ha and their major water resources for irrigation are the stored water in the Palsiguan dam in the Abra Province as well as the river waters diverted by diversion dams to be provided across the Madupayas and Tibangran rivers. The stored water in the dam will be led through trans-basin tunnel (headrace tunnel) to the upstream of the Bonga river in the Ilocos Norte Province and diverted by the Nueva Era dam, to the service areas of the Phase I and Phase II through link canals, which will be connected with each diversion dam and its main canals.

In the service areas, irrigation and drainage canals will be newly constructed and/or repaired to separate irrigation and drainage systems, and terminal facilities will be rearranged and reinforced.

Furthermore, hydropower generation is planned in the project by using the effective water head between the Palsiguan reservoir and Bonga river bed (Bonga power station) and also water head at the Nueva Era dam (Nueva Era power station).

2. Irrigation Plan

a) Proposed Cropping Area and Cropping Pattern

The proposed beneficial area in the Phase II development, which will be served by the stored water in Palsiguan dam, is described as follows. Figure 4-1 shows the proposed irrigation networks including Phase I area.

Proposed Beneficial Area

(Unit: ha)

Item	Phase II Development	Phase I Development1/	Total
Wet season	12,400	2,120	14,520
Dry season	12,400	7,240	19,640

Note: 1/ Due to the shortage of dependable flow in each river basin, no cultivation for crops was possible from the results of water balance study for Phase I Project.

The proposed cropping pattern in the Phase II development is summarized as shown below;

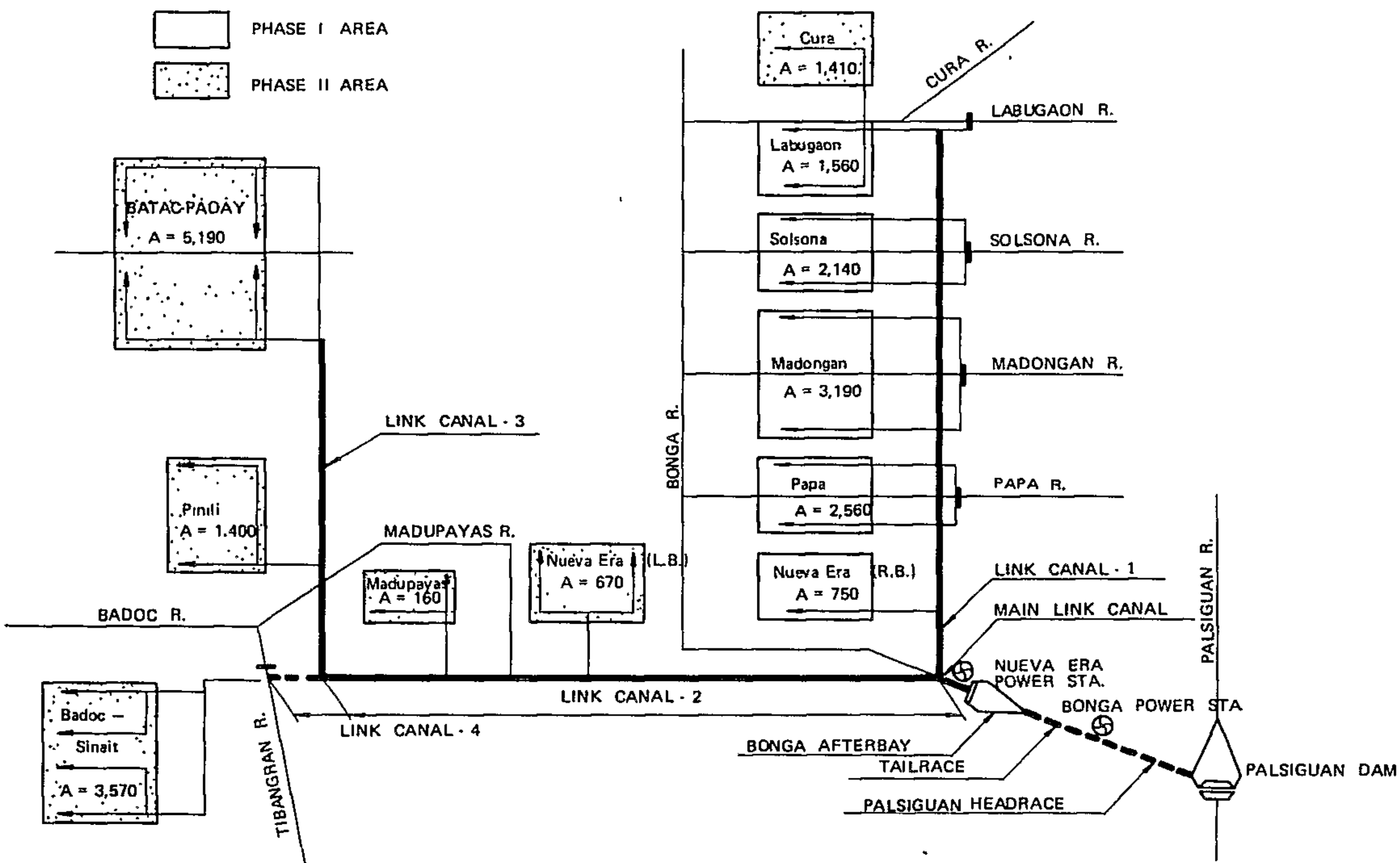


FIGURE 4-1. SCHEMATIC DIAGRAM OF PROPOSED IRRIGATION NETWORKS

Batac-Badoc Areas

Wet season		Dry season	
Paddy	+	Paddy	30%
Paddy	+	Garlic	20%
Paddy	+	Garlic & Mungbeans	20%
Paddy	+	Tobacco	20%
Paddy	+	Cotton	10%

Cura-Nueva Era Areas

Paddy	+	Paddy	90%
Paddy	+	Upland Crops	10%

b) Irrigation Water Requirement

1) Potential Evapotranspiration

Potential evapotranspiration (ETp), generally recognized as fairly reliable index in calculating consumptive use, can be determined by a number of methods, such as the evaporation measurement with evaporation pan and the application of empirical formula based on the climatological data. In the Project, the evapotranspiration of the proposed crops is estimated by applying the Penman Method[1/], based on the climatological data observed in Vigan, Ilocos Sur (see Table 3B-8, Appendix 3B-2).

2) Consumptive Use

Paddy

The consumptive use of paddy (actual evapotranspiration, ETa), which is assumed to be equal to evaporation, can be estimated by multiplying the estimated ETp values by crop coefficients which express the relationship between potential and actual evapotranspiration during distinct vegetative stages of the crops.

No data on such coefficient, however, are available in the Project Area and its vicinity, so that the ETp values estimated by the Penman Method is adjusted by the ratio of an actual evaporation observed at Vigan and Laoag.

Upland Crops

Crop diversification is planned during the dry season in the Project. The upland crops are tobacco, garlic, mungbeans and cotton for the Batac-Badoc area and garlic, tobacco and onion for Cura-Nueva Era areas.

1/ Penman Method: This is the most complete theoretical method for the rather humid area not far from ocean and essentially covered with growing vegetation.

In determining the consumptive use for these upland crops, the following crop coefficients are applied to the estimated ETp.

Crop Coefficient for Upland Crops

Month	Tobacco	Garlic	Mungbeans	Cotton	Onion
Oct.		0.30		0.30	
Nov.	0.70	0.35		0.50	0.70
Dec.	0.80	0.50		0.95	0.75
Jan.	0.70	0.25		0.90	0.65
Feb.				0.50	
Mar.			0.50		
Apr.			0.75		
May			0.40		
Jun.					
Average	0.73	0.35	0.55	0.63	0.70

The following table gives the consumptive use of crops estimated by the above procedure on the daily basis.

Estimated Consumptive Use

(Unit: mm)

Month	Paddy	Tobacco	Garlic	Mungbeans	Cotton	Onion
May	6.5			2.6		
Jun.	6.5					
Jul.	5.4					
Aug.	5.9					
Sep.	5.7					
Oct.	6.9		2.1		2.7	
Nov.	6.1	4.3	2.1		3.0	4.3
Dec.	6.7	5.4	3.4		6.4	5.0
Jan.	6.4	4.5	1.6		5.8	4.2
Feb.	6.0				3.0	
Mar.	6.6			3.3		
Apr.	6.7			5.0		
Average	6.3	4.7	2.3	3.6	4.2	4.5

3) Crop Water Requirement

Crop water requirement on the 10-day basis is estimated based on the proposed cropping pattern. In this estimation, the following values are accounted;

- Percolation rates in the paddy field are two millimeters per day throughout the growing period of paddy in the project. Percolation rates were measured at several sites in the existing paddy fields in the Phase I stage and it was found that the percolation rates, ranging from one to seven millimeters in the Phase I area, are relatively larger than those observed in the Phase II area, in which the paddy fields have impervious nature with low percolation rate around one millimeter.
- Additional water supply for land soaking and land preparation of the paddy field is decided as shown below:

Water Requirement for Land Preparation

Item	Wet Season Paddy (mm)	Dry Season Paddy (mm)
1st irrigation for land soaking	175	150
2nd and 3rd irrigation	75	80

Note: Detailed description is given in Table 4B-1, Appendix 4B-1.

On the other hand, an additional water supply for land preparation of the upland fields after October (tobacco and mungbeans) is decided at 40 mm, taking into account the dried soil conditions. However, necessary water supply for land preparation in and before October is not accounted in the amount, because of sufficient soil moisture immediately after the wet season.

The estimated crop water requirement of each crop is shown in Table 4B-2 and Figure 4B-1, of Appendix 4B-1, and the following table shows the estimated total crop water requirement.

Crop Water Requirement

	Crops				Water Requirement (mm)
a)	Wet Season				
	Paddy-1	(Jun. 1	–	Nov. 6)	1,028
	Paddy-2	(May 21	–	Oct. 26)	1,031
	Paddy-3	(May 11	–	Oct. 16)	1,035

b) Dry Season

Paddy-4	(Oct. 14 –	Mar. 21)	1,073
Tobacco	(Oct. 14 –	Apr. 25)	319
Garlic	(Sep. 28 –	Mar. 5)	223
Mungbeans	(Feb. 5 –	Jun. 18)	318
Cotton	(Sep. 23 –	Apr. 9)	579
Onion	(Oct. 13 –	Mar. 10)	385

4) Diversion Water Requirement

Diversion water requirement will be calculated by adding effective rainfalls and water losses to the crop water requirement. The criteria of the effective rainfalls and irrigation efficiency used for the Project are as follows:

Effective Rainfall

The effective rainfall during land soaking period of the paddy fields is estimated at 250 mm considering the land soaking capacity. The maximum effective rainfall during the growing stage of the paddy is estimated at 60 mm. Therefore, the maximum allowable flooding depth is 80 mm.

The effective rainfall for upland crops, on the other hand, is decided as follows: The rainfall less than 3.7 millimeter, which is equivalent to the average daily consumptive use during the growing periods of upland crops, is considered to be zero and the rainfall more than the total readily available moisture (TRAM) of 49.8 millimeter which will be described subsequently is considered to be waste water. Consequently, the effective rainfall for upland crops are those rainfalls more than 3.7 millimeter and less than 49.8 millimeter.

Irrigation Efficiency

In the estimation of diversion water requirement for paddy cultivation, the following are adopted: i) farm efficiency of 65 percent and 75 percent for the wet and dry seasons respectively, ii) conveyance efficiency in canals of 80 percent for both seasons, and iii) operation efficiency of 90 percent for both seasons. On the basis of above criteria, the overall irrigation efficiency for paddy cultivation is estimated to be 46.8 percent in the wet season, and 54.0 percent in the dry season (see Appendix 4B-1).

The irrigation efficiency for upland crops is decided at 60 percent, after making reference to the NISIS I Project.

The diversion water requirement of crops in the design year corresponding to about 10-year probability is given below;

Diversion Water Requirement

(Unit: mm)

	Batac-Badoc Area			Cura-Nueva Era Area		
Season	Paddy	Upland Crops	Average	Paddy	Upland Crops	Average
Wet Season	983.4	–	983.4	611.7	–	611.7
Dry Season	2,036.8	728.5	1,121.0 1/	1,923.0	806.5	1,837.6 1/
Total	3,020.2	728.5	2,104.4	2,534.7	806.5	2,449.3

Note. **Detailed estimate is referred in Tables 4B-3 to 4B-4, Appendix 4B-1.**

1/ Average diversion requirement in the dry season on the basis of the following diversification ratio;

Batac-Badoc Area
- Paddy : 30%
- Upland crops : 70%

Cura-Nueva Era Area
- Paddy : 90%
- Upland crops : 10%

c) Design Discharge for Planning of Irrigation Facilities

1) Terminal Irrigation Canal

The design discharge of terminal irrigation canals such as main and supplementary farm ditches is decided by the following procedures: supply of water from the main farm ditch to the supplementary farm ditch is planned to be simultaneously made, while the distribution of water from the supplementary farm ditch to the farm lots is rotationally done, during the land soaking and land preparation periods. Consequently, each supplementary farm ditch covering about eight to six hectares, one rotational unit, will have same canal capacity in one rotational area, however, the canal capacity of main farm ditch will be decreased in proportion to the number of rotational units.

The main and supplementary farm ditches are designed based on the maximum irrigation water requirement during the crop maintenance stage, and convey the maximum irrigation water requirement during the land preparation stage with the total canal depth including free board.

The maximum irrigation water requirement in both stages is summarized as follows;

Maximum Irrigation Water Requirement

Item	Batac-Badoc Area C.W.R.[1] (mm/day)	Batac-Badoc Area I.W.R.[2] (ℓ/sec/ha)	Cura-Nueva Era Area C.W.R. (mm/day)	Cura-Nueva Era Area I.W.R. (ℓ/sec/ha)
Land Preparation Stage	9.2	1.64	10.0	1.78
Crop Maintenance Stage	8.2	1.46	7.9	1.40

Note: 1/ Crop water requirement
2/ Irrigation water requirement
Detailed descriptions are given in Appendix 4B-2.

From the results of above calculation, in case of Batac-Badoc area the design discharge of the supplementary farm ditch is calculated at 13.12 lit/sec, which is equivalent to 1.64 lit/sec/ha inclusive of 35 percent of application losses, while that of main farm ditch will vary ranging from 65.60 lit/sec to 13.12 lit/sec. On the other hand, in case of Cura-Nueva Era area, the design discharge of the supplementary farm ditch is 10.68 lit/sec, equivalent to 1.78 lit/sec/ha, and that of main farm ditch ranges from 53.40 lit/sec to 10.68 lit/sec.

2) Design Discharge of Lateral Irrigation Canals

According to the proposed cropping pattern and cultivation schedule, the maximum water requirement of lateral irrigation canals for Batac-Badoc area is estimated at 2.16 lit/sec/ha as shown in Table 4B-5, Appendix 4B-2, and 2.33 lit/sec/ha for Cura and Nueva Era (L.B.) area, which has been referred to in Phase I study. The canal capacity of lateral canals in the project ranges from 3.29 cu.m/sec to 0.09 cu.m/sec.

3) Water to be Released from Palsiguan Dam to Existing Communal Irrigation Systems in Abra Province

There exists 323 ha of three communal irrigation systems located in the downstream of proposed Palsiguan Dam in the Abra Province, that is, Lagayan CIS (255 ha), Calambat CIS (29 ha) and Collago CIS (39 ha). These communal areas are irrigated by the river water at present. Under the conditions, the stored water in the Palsiguan dam should be released from the dam after the completion of the project, and the 0.814 cu.m/sec of water is estimated for this purpose.

d) Depth and Interval of Irrigation Application for Upland Crops

1) Measurement of Intake Rate

During the field survey, the intake rate measurements were made at four points, two points in Batac-Paoay area and two points in Badoc-Pinili-Sinait area, under dry and wet conditions, in order to find out an adequate irrigation method suitable for the Project. The dry conditions mean existing conditions of the field without any water supply and the wet ones mean the field keeping the water holding capacity after 24 hours of soil saturation.

To measure the intake rate, a cylinder infiltrometer was used and the reading of the water depth within the cylinder was made at the interval of every 5 to 10 minutes at the initial stage and 30 minutes after one hour.

Results of intake rate measurements are plotted on a logarithmic paper (see Figure 4B-2 to 4B-5, Appendix 4B-3). Usually, the intake rate plotted against time on logarithmic scale shows a straight line, and therefore, can be presented by the equation of $D = CT^n$. When the observation of intake rate extends over long periods, a better representation of the data can usually be obtained by using the equation of $D = CT^n + b$. Since n is negative, an accumulative intake rate (ΣD) decreases with an increase in time of T. Therefore, the intake rate (D) will approach a constant value of b as time increase. Generally, the intake does approach a constant rate, which will be referred to as basic intake rate (IBi). Caution should be observed in using the basic intake rate for irrigation design such as irrigation method.

The following table gives the calculated basic intake rate, based upon each observation of intake rate..

Obtained Basic Intake Rates (Wet condition)

Observation	Location	IBi (mm/hr)
No.1	Barrio Aracua, Batac	4.2
No.2	Barrio Linang, Paoay	12.6
No.3	Barrio Napo, Badoc	5.8
No.4	Barrio Pactit, Badoc	20.9
Average		10.9

From the above figures, it could be considered in this stage that the furrow irrigation method would be suitable for water supply to the upland crops during the growing season of them, although further studies on upland irrigation will be needed.

In parallel with such measurements of the intake rate, soil samples in the depth of 50 cm with an interval of 10 cm depth were taken to analyze the physical properties of soil in the field, such as specific gravity, porosity, field capacity, and wilting point.

The analysis results of soils under the wet condition are summarized as follows:

Physical Properties of Soils[1/]

Depth (cm)	Real Specific Gravity (Sr) (g/cm^3)	Apparent Specific Gravity (Sa) (g/cm^3)	Porosity[2/] (P) (%)	Field Capacity (Fc) (%)	Wilting Point[3/] (Wp) (%)
10	2.61	1.21	53.9	42.7	20.8
20	2.63	1.22	53.8	39.4	19.0
30	2.64	1.18	54.9	38.7	18.7
40	2.62	1.19	54.9	40.4	19.6
50	2.62	1.17	55.4	41.1	19.9

Note 1/ Average of four samples (see Table 4B-6, Appendix 4B-3)

2/ $p = (Sr - Sa) \times 100/Sr$

3/ $Wp = 0.36\ Fc^{1.08}$

2) Depth and Interval of Irrigation Application

Depth and interval of irrigation application are determined in accordance with the following procedures:

i) Determination of effective root zone

ii) Determination of moisture extraction pattern

iii) Calculation of available moisture of each soil layer within effective root zone

iv) Calculation of total readily available moisture (TRAM)

v) Determination of depth and interval of irrigation application

i) Depth of Effective Root Zone

The depth of effective root zone was determined on the basis of field investigations on root zone as shown below;

Upland Crops	Depth of Effective Root Zone (cm)
Tobacco	50
Garlic	30
Mungbeans	50
Cotton	50

ii) Moisture Extraction Pattern

Consumptive use of soil moisture by crop evapotranspiration will vary depending on the depth of soil. This consumptive rate of soil moisture is so called "moisture extraction pattern", which will be determined based upon the field investigations.

Due to the lack of such data concerned, the following pattern was applied.

Depth of Effective Root Zone (cm)	Ratio of Moisture Extraction (%)
1 – 10	40
10 – 20	30
20 – 30	20
30 – 40	10

iii) Available Moisture in Each Soil Layer within Effective Root Zone

Available moisture (A.M) is obtained from the following equation.

$$A.M. = \frac{1}{100} \cdot \Sigma(Fc - Wp).Sa.d \text{ (mm)}$$

where, Fc: *Water holding capacity after 24 hours of soil saturation (%)*

Wp: Moisture ratio at wilting point (%)

Sa: Apparent specific gravity (g/cm^3)

d: Depth of soil in each soil layer (mm)

iv) Total Readily Available Moisture (TRAM)

Total readily available moisture (TRAM) is calculated by the following:

In the soil layer concerned,

$$\text{Consumed Moisture} = \frac{\text{Available Moisture}}{\text{Ratio of Moisture Extraction}}$$

The layer presenting the minimum value obtained from the above equation is the restricting layer of moisture and its value becomes total readily available moisture (TRAM). According to the above calculation, the value of TRAM, i.e., net amount of water to be replaced, becomes 49.8 mm for each crops (see Tables 4B-7 to 4B-8, Appendix 4B-3).

v) Interval of Irrigation Application

The interval of irrigation application is obtained by dividing the TRAM by the maximum crop evapotranspiration.

Upland Crop	TRAM (mm)	Maximum Evapo-transpiration (mm/day)	Irrigation Interval (days)
Tobacco	49.8	5.4	9
Barlic	49.8	3.4	15
Mungbeans	49.8	5.0	10
Cotton	49.8	6.4	8

From a view point of water management, the same interval of irrigation application is favorable, therefore, 10-day irrigation interval is adopted for the project.

3. Reservoir Plan

a) Water Balance Study

The Ilocos Norte Irrigation Project is planned under the phasing development. In phase II plan, water resources to meet the irrigation water requirements covering the proposed area of 22,600 ha are only limited to four rivers within the Ilocos Norte Province. Out of four rivers, run-off of the Labugaon and the Bonga (Nueva Era) river is already utilized for the irrigation to the Phase I area. Therefore, the Cura and the left bank of Nueva Era sub-area covering 2,080 ha of irrigation area involved in the Phase II are only possible to receive the surplus water of the river run-off after taking required water for the Phase I. The Madupayas and the Tibangran river flows are not taken for the Phase I Area, accordingly the whole amount is available for irrigation in Madupayas, Batac-Paoay, Pinili and Badoc-Sinait areas covering 10,320 ha. However, as mentioned in Chapter III, B.2. "Water Resources for the Phase II Area", potential amount of water in both rivers in insufficient to meet the irrigation demand.

Under such conditions, in order to attain the entire development over the whole area including Phase I remaining area under the Phase II project, delivery of irrigation water inevitably depends upon the Palsiguan river discharge to be stored in the reservoir.

As studied in the Phase I project, difficiency of irrigation water occur even after diversion dams are provided. To relieve the Phase I area from the water shortage, the link canal systems are proposed to supply the irrigation water from the Palsiguan reservoir.

As the first step in process of the water balance studies, computation was so made as to grasp the amount of water shortage in case of only utilizing the natural river flows by diversion dams.

As the second step, inflow and outflow balances on the Palsiguan reservoir were studied to determine the required storage volume taking into consideration the compensation water released to the lower reaches of the Palsiguan Dam.

Design Year

The drought year with a 10-year return period is selected as a design year for the irrigation plan in consideration of the reservoir plan.

Such year falls in the water year 1968 (May 1968 to April 1969) based on probability analysis and water balance studies.

Alternative Studies

Two alternatives have been studied depending upon the proposed cropping pattern, i.e., introduction of double and triple cropping in the area.

Proposed Area to be Studied

(Unit: ha)

Item	Phase I	Phase II	Phase I + II
a) Double Cropping			
Wet Season	10,200	12,400	22,600
Dry Season	10,200	12.400	22,600
Total	20,400	24,800	45,200
b) Triple Cropping			
Wet Season	10,200	12,400	22,600
Dry Season	10,200	14,465 1/	24.665
Total	20,400	26,865	47,265

Note: 1/ In dry season, the cropped area of mungbeans is given at 2,065 ha.

On the basis of water balance studies during the period of water years, 1960 - 1969, the result of alternative studies in the design year, 1968 is summarized in the following table.

Irrigation water demand dependent upon the Palsiguan water amounts to 278 MCM in double cropping, 284 MCM in triple cropping per annum. Regarding the storage volume, 169 MCM in double cropping and 175 MCM in triple cropping are required for irrigation including evaporation from the surface of the reservoir. On the other hand, peak irrigation water delivered through the Palsiguan headrace is 26.2 cu.m/sec in double cropping and 28.2 cu.m/sec in triple cropping.

Taking into consideration the low water level of EL 275.0 m determined in the hydropower plan, the full water level becomes EL 330.0 m and 332.0 m respectively. From a view point of construction cost, both alternatives have no big difference considering the above mentioned factors. Therefore, triple cropping has been selected for the project plan.

Summary of Alternatives Studies

(Unit: MCM)

Item	Double Cropping			Triple Cropping		
	Wet Season (May-Oct.)	Dry Season (Nov.-Apr.)	Annual	Wet Season (May-Oct.)	Dry Season (Nov.-Apr.)	Annual
Utilization of Natural River Flows 1/						
1. River Run-off	455	10	465	455	10	465
2. Irrigation Requirement	123	138	261	123	144	267
3. Water Utilization						
Supplied River Water	70	3	73	70	3	73
Surplus Water	385	7	392	385	7	392
Shortage Water	53	135	188	53	141	194
Palsiguan Reservoir Plan						
1. Inflow to Reservoir						
River Run-off	291	75	366	291	75	366
Compensation Water	3	6	9	3	6	9
Available Run-off	288	69	357	288	69	357
2. Irrigation Water Demand Dependent upon Reservoir	54	224	278	54	230	284
Phase II Area	53	135	188	53	141	194
Phase I Area	1	89	90	1	89	90
3. Effective Storage for Irrigation			169			175
Net Required Volume	–	–	166	–	–	172
Evaporation	–	–	3	–	–	3
4. Maximum Delivery of Water (cu.m/sec)			26.2			28.2

Note: 1/ Including surplus river water after taking irrigation water for Phase I Area, i.e., from the Labugaon and the Bonga (Nueva Era)

b) Reservoir Operation

Storage capacity for the selected alternative including the water supply for the hydropower generation is determined as follows;

o Effective reservoir capacity including evaporation losses from the reservoir surface		189 MCM
o Dead water volume at the low water level, EL 275.0 m		43 MCM
o Storage capacity		232 MCM
o Full water level	EL	334.5 m

The reservoir operation is primarily made so as to deliver the required irrigation water and to generate effectively hydropower under the following conditions.

i) In case the reservoir has surplus water exceeding full storage volume even if the required irrigation water is taken.

- o Surplus water above the full water level is taken for the power generation.
- o Minimum intake water is taken in order to keep 4.70 cu.m/sec/day of water required for peak demand of power generation, in Nueva Era Dam.

ii) If the reservoir is impossible to keep the low water level when the required water is taken, only inflow into the reservoir is taken.

iii) Other conditions
In order to maintain the full water level at the end of October and to avoid surplus water which is not used for power generation, the reservoir is operated under the following water level, i.e., storage volume.

- o Upper Limit
  When the reservoir water exceeds the upper limit shown in Table 4B-9, Appendix 4B-4, the reservoir water above the upper limit of storage volume is released with the restriction that the released water does not exceed the maximum design discharge of 29.273 cu.m/sec at the Nueva Era Dam.

- o Lower Limit
  When the storage volume exceeds the lower limit shown in Table 4B-9, Appendix 4B-4, the reservoir water is taken so as to keep 8.00 cu.m/sec of the minimum requirement for power generation at the Nueva Era Dam. In case the reservoir becomes lower than the lower limit, 4.70 cu.m/sec/day of water required for peak demand of power generation is taken.

Depending upon the above mentioned operation rules, the reservoir operation studies have been made for the period of November 1959 to October 1969 to yield annual power-generation effectively (see Figure 4N-6, Appendixe 4B-4). Figure 4B-7 and 4B-8 in Appendix 4B-4 show the area-capacity curve used for reservoir operation study of the Palsiguan dam and Nueva Era dam.

c) Water Supply through Link Canal System

Water supply to the Phase I and Phase II areas from the Palsiguan dam by provisions of link canal systems fluctuates yearly. To determine the design discharge of link canals, the amount of shortage water in case of only utilizing the natural river flows by diversion dams is computed on the 10-day basis.

Annual peak shortage of irrigation water is obtained as follows:

Peak Shortage of Irrigation Water

(Unit: cu.m/sec)

Water Year[1/]	Period	Discharge
1960	1961 Jan. 3[2/]	28.225
1961	1962 Jan. 2	22.972
1962	1962 Dec. 3	28.188
1963	1964 Jan. 2	26.421
1964	1964 Jun. 3	17.166
1965	1966 Jan. 2	28.611
1966	1966 Jun. 3	18.889
1967	1968 Jan. 3	25.973
1968	1968 Nov. 2	27.094
1969	1970 Jan. 3	26.614

Note: 1/ e.g. 1960 means May 1960 to April 1961
2/ Jan. 3 means the period of the third 10-day in January

The water years 1965 and 1966 are continuous drought years as understood from water balance studies, specially the year 1965 is thought to be the exceeding drought year.

Therefore, as seen in the above table, the second peak water shortage of 28.225 cu.m/sec in 1960 which will be covered by the Palsiguan water is taken up as the design discharge of water supply through the Palsiguan headrace.

Concerning the Nueva Era dam, design intake amount becomes as follows:

Peak water supply from the *Palsiguan reservoir*	28.225 cu.m/sec
Inflow into the Nueva Era dam from the own catchment area	1.048 cu.m/sec
Total	29.273 cu.m/sec

As for the design discharge of the link canal systems, water shortage of each sub-area does not appear in a period due to the different cropping pattern and utilized amount of natural river flows within the Project Area.

On the basis of water balance studies for the period of 1960 to 1969, the peak water shortage during the dry season is selected as a design discharge of the link canal systems shown in Figure 4-2, which is supplied from the Palsiguan reservoir.

4. Draiange Plan

a) Design Modulus for Designing Drainage Canals in the Paddy Fields

1) Design Rainfall

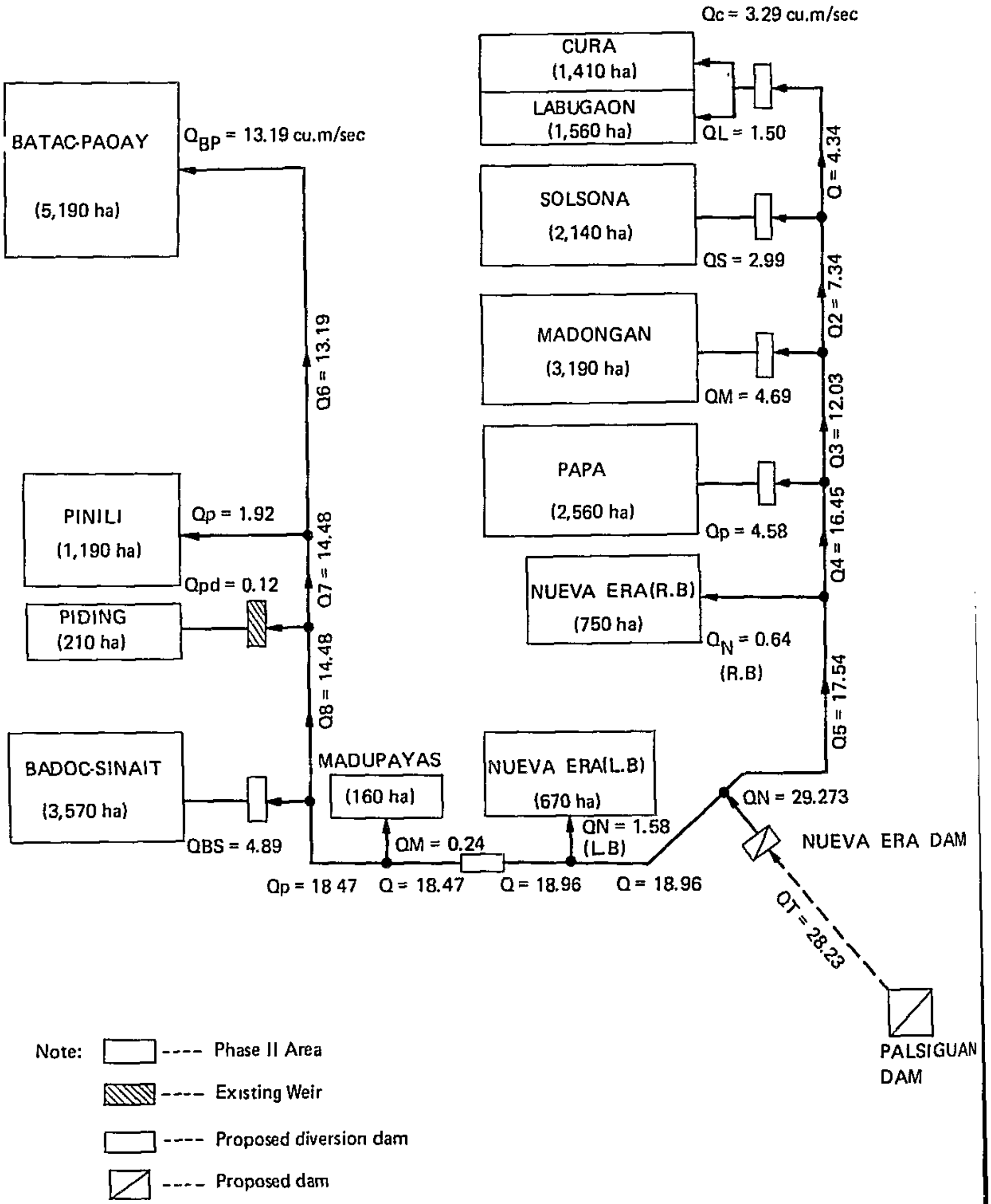
On the basis of the long term rainfall data (1951 to 1979) observed at Laoag station, probability analysis was made in order to estimate the return periods and corresponding magnitude of rainfall, and the three-day consecutive rainfall of 493.3 mm in the return period of five-year is decided as the design rainfall. The daily and hourly distribution of the selected rainfall was estimated based upon predominant rainfall characteristics in the Ilocos Norte region, that is, 122.6 mm in 1st day, 313.5 mm in 2nd day and 57.2 mm in 3rd day (see Appendix 4B-5).

2) Method for Estimation of Drainage Modulus

In the Phase I feasibility study, the Project Area is located on the alluvial fan with a gentle slope, so that the drainage analysis in the paddy fields has been made based on the simplified principles and assumptions of hydraulic phenomena (see IV, B.3 in Phase I main report). However, on the contrary, the Project Area in Phase II ks located on relatively lowlying area with flat topography. In such a flat area, paddy field plays a function to store rainy water.

The drainage mechanism in such flat paddy fields can be explained as follows; the stored water in the paddy field is discharged through notches provided at each plot to a terminal drainage canal of farm drain. The farm drain is connected to a main farm drain by drain inlet which is facilitated by means of pipes. The notch will control the run-off discharge from the paddy fields, and the drain inlet at the end of farm drain will also control the discharge to the main farm drain.

FIGURE 4-2. DESIGN DISCHARGE OF LINK CANAL SYSTEM



The run-off discharge from paddy fields with above-mentioned drainage mechanism can be estimated based on the unit hydrograph developed by the Ekdahl's method (see Appendix 4B-6). This is a method to calculate the water balance between inner and outer water levels, and the basic equation is expressed as follows.

$$1/2(I_1 + I_2)\Delta t - 1/2(O_1 + O_2)\Delta t = S_2 - S_1 \quad \ldots\ldots \quad (1)$$

where;

- I_1 : Inflow at time t_1
- I_2 : Inflow at time t_2
- O_1 : Outflow at time t_1
- O_2 : Outflow at time t_2
- S_1 : Field storage at time t_1
- S_2 : Field storage at time t_2

In accordance with aforementioned drainage mechanism and system in the paddy field, the obtained hourly rainfall for five-year return period was adopted to estimate the run-off discharge q (mm/hr) and flooding water depth H (mm), together with the duration of water stagnation in paddy fields.

In general, even if a paddy field is submerged by excess water of more than 25 cm of standing water depth, paddy grown in the field does not suffer from it in case that its duration is less than three days. In order to satisfy these standards, trial drainage analysis was made by means of varying the dimensions of notch and drain inlet which is the facilities to control the run-off capacity from the field.

Figure 4B-15 in Appendix 4B-6 indicates the analyzed drainage conditions in accordance with the procedure mentioned above in case of drainage area of 100 ha, and the following shows the results of drainage analysis.

	Item	Dimension
1)	Maximum run-off discharge	
	q (mm/hr)	4.44
	Q_0 (cu.m/sec/sq.km)	1.233
2)	Design capacity	
	$Q_1 = Q_0 \times 0.686$ 1/ (cu.m/sec/sq.km)	0.846
3)	Base flow, Qb (cu.m/sec/sq.km)	0.020
4)	Total design capacity	
	$QT = Q_1 + Qb$ (cu.m/sec/sq.km)	0.866
5)	Maximum water depth, H (cm)	38.6
6)	Duration of water stagnation depth above 25 cm in paddy fields, T (hr)	59

1/ ratio of average run-off by areal rainfall to the peak run-off by spot rainfall, which was referred to the report on hydrological study of NISIS-I, prepared by NIA, 1976.

In the above estimation, the base flow of 0.020 cu.m/sec/sq.km is adopted. As a result, the design drainage modulus of 0.866 cu.m/sec/sq.km (8.66 lit/sec/ha) is computed. The modulus of 8.66 lit/sec/ha could be applied to the area smaller than 400 ha, but a smaller modulus should be applied to a larger area than the above-mentioned because the rainfall intensity becomes low in a larger area than 400 ha. Figure 4B-16 in Appendix 4B-6 shows an approximate linear double logarithmic relation between a reduction factor and area.

When such reduction factor (F) is applied to the areas larger than 400 ha, the discharge criteria for drainage are obtained as shown below;

Discharge Criteria for Drainage

Area	Drainage Modulus (lit/sec/ha)
0 – 400	8.66
400 – 1,000	8.33
1,000 – 3,000	7.60
3,000 – 5,000	7.10

b) Drainage Discharge from Hilly Land

Many small rivers and creeks of which catchment area is less than 100 sq.km flow into the Project Area at its upper portions. This paragraph will discuss about the storm run-off from such hilly land.

Several procedures, in general, have been applied to estimate the storm run-off from hilly land, but the procedures through Mcmath or Rational methods have been usually used for the purpose in the NIA's Projects. Out of these methods, Mcmath method is applicable for the river basin having the time of concentration of more than one hour with catchment area more than 100 sq.km, so that storm discharge from the hilly land related to the Project will be analyzed by applying the Rational method.

Rational formula is expressed as follows:

$$Q = 0.2778 \cdot f \cdot \gamma t \cdot A$$

Where;
- Q: peak discharge of storm run-off (cu.m/sec)
- f: run-off coefficient
- γt: area hourly peak rainfall intensity (mm/hr)
- A: catchment area (sq.km)

In the above estimation, run-off coefficient (f) and areal hourly rainfall intensity (γt) are decided at $f = 0.269$ and $\gamma t = 41.0$ mm/hr (five-year return period) respectively, which are referred to the report on hydrological study of NISIS, Package I. As a result, specific discharge of storm run-off from the hilly land is estimated at 3.06 cu.m/sec sq.km (see Appendix 4B-7).

5. Road Plan

The proposed roads in the project are classified as follows;

Service Road

The service roads are to be provided along the link, main and lateral canals in order to carry out the operation and maintenance of irrigation and drainage facilities as well as to transport the input and output materials. The proposed roads have two types of width, six meters along link and main canals and four meters along lateral canals, and these roads will be paved by coarse materials.

The proposed cross-section of the above two types of roads has a surfacing of 15 cm thick of base coarse and selected borrow of 20 cm thick.

On-farm Road

On-farm roads, which are terminal roads in the cultivated area for farming, are planned along main farm ditches, and no pavement is planned. The width of the roads is two meters.

6. Farm Land Development (On-Farm Level)

The provision of terminal on-farm facilities such as farm ditch, farm drain and farm road is essential works to execute the irrigated agriculture including farm mechanization, and in this work, farmers' eagerness for agriculture will act as the prime mover. With their support, the rationalized land parcelling will be materialized, which are the prerequisite for upgrading the agriculture. Thus, modernized irrigation and drainage systems as well as new organization for farm management will be established at an early stage.

a) *Premise in Farm Land Development*

Farm Management

An average cultivation area per farm household to be allocated in the Project Area is 1.7 ha for Cura-Nueva Era area and 1.0 ha for Batac-Badoc area. Irrigators' Group (one rotational area) will be organized by the farm households in the cultivation area served by one turn-out under main or lateral canal. Namely, this cultivation area is 30 ha in Cura-Nueva Era area, and 40 ha in Batac-Badoc area, on an average. Operation and maintenance of on-farm facilities will be made by this Irrigators' Group, specially, the distribution of irrigation water will be performed intentionally at each rotation area.

Crops

The proposed crops in the Project are paddy of high yield varieties for wet and dry seasons, or paddy of high yield varieties for wet season and single or double cropping of upland crops for dry season. This Project will increase the cropping intensity as follows:

Sub-Project Area	Cropping Intensity
Cura-Nueva Era Area	200%
Batac-Badoc Area	240%
Overall	233%

Farm Practices

For the farm practices to grow paddy, an integrated farm mechanization system will be established with hand tractor, thresher and dryer which will be introduced for land preparation, threshing and drying works respectively, and the other works will mostly be made by a combination of manpower and carabao for the time-being.

For the farm practices to grow upland crops, on the other hand, the hand tractor will be used for land preparation works, and the other works will be made by a combination of manpower and carabao, as same as paddy cultivation.

b) Land Parcelling

1) Principle for Land Parcelling

In order to materialize the farm land parcelling satisfying all the requirements mentioned above in the Project Area, in which there are many existing communal canals, due attentions should be paid to the following:

i) to plan it in close relation with the farm management plan;

ii) to plan it for materializing rationalized irrigation and drainage water control; and,

iii) to plan it for rationalized farm management for paddy cultivation.

Further details on the above-mentioned facts are as follows:

i) to determine the location of main service and access roads as the bone of land parcelling on the basis of the proposed formation of Irrigators' Association, unit farm management group serving the area of about 60 ha to 300 ha, as well as rural community development and public facility construction plan.

ii) to dermine the location of irrigation and drainage canals taking into consideration topographic conditions, separation of irrigation and drainage canals, lengths of terminal canals, and rotational irrigation. In order to systematize and simplify the water supplying systems at terminal on-farm level, each rotational area should have one turn-out.

iii) to secure uniformity of plots in size as much as possible to simplify the extension of new technique for paddy cultivation to farmers. If all the farm plots are uniform in size, a certain quantity of agricultural chemicals can be sprayed to each farm plot to control diseases and insects. The same can be said in fertilizer application. Furthermore, planning and execution of both puddling works by tractors and management of irrigation water for puddling will be simple and easy.

2) Design of Rotation Area

Location of Farm Ditches

Following two alternative plans are considered in determining the location of farm ditches in the Project;

i) The main farm ditch is aligned across the contour lines, so that the supplementary farm ditch would be located along the contour lines.

ii) The main farm ditch is located along the contour lines.

Taking into consideration the direction and density of existing canals, the latter scheme should be basically adopted. However, the former scheme would still be applicable to some areas depending on their topographic conditions.

Rotation Area and Units

Each rotational area and unit has been planned as mentioned below in consideration of the existing communal irrigation systems, their topographic conditions and so on (see Appendix 4E-9).

Rotation Area and Rotation Unit

Sub-Project Area	Rotation Area	Rotation Unit
Cura-Nueva Era Area	30 ha	6 ha
Batac-Badoc Area	40 ha	8 ha

c) Terminal Water Management Systems

Irrigation System

Terminal irrigation system consists of main farm ditches, supplemental farm ditches and their related structures. Rotation of irrigation water supply will be made within the rotational unit which is commanded by one supplemental farm ditch, but the rotational water supply in the one rotational unit will not be performed as a rule. Namely, water supply from the main farm ditch to the supplementary farm ditch is planned to be simultaneously made, whereas distribution of water from the supplementary farm ditch to each farm lot is planned to be rotationally made. Hence, the required cross-section of the main farm ditch becomes small towards the downstream reaches and its terminal section corresponds with the supplementary farm ditch section. Irrigation water supply during land soaking and land preparation will be carried out within 25 days for Cura-Nueva Era area and within 35 days for Batac-Badoc area.

The seasonal design discharge of the terminal canals based on the premise mentioned above was computed as shown in previous paragraph IV, B.2, "Irrigation Plan", and the determined design discharges are summarized as follows:

Design Discharge of the Terminal Canal

Sub-Project Area	Land Soaking & Land Preparation Stage	Crop Maintenance Stage
Cura-Nueva Era Area	1.78 lit/sec/ha	1.40 lit/sec/ha
Batac-Badoc Area	1.64 lit/sec/ha	1.41 lit/sec/ha

Drainage System

Excess water in each farm plot is drained through a notch with a width of about 30 cm to a farm drain which is aligned along the supplementary farm dtich. Farm drain is the terminal drainage canal made of earth and constructed in each rotation unit. The design capacity for drainage is 8.72 lit/sec/ha for Cura-Nueva Era area and 8.66 lit/sec/ha for Batac-Badoc area.

d) Irrigation and Drainage Facilities and Farm Road

Irrigation Facilities

In consideration of the terminal irrigation facilities, the design discharge of a turn-out, which is the facility to divert the irrigation water from main canal or lateral canal to main farm ditch should be considered. However, turn-out is a structure of main or lateral canal composition, so this will not be included in the terminal irrigation system.

The terminal irrigation facilities are enumerated below:

Main farm ditch:	the irrigation canal, which is made of earth, to convey water from the turn-out to the supplementary farm ditches. The section of ditch becomes small towards the downstream and terminal section of the canal corresponds with that of supplementary farm ditch in size.
Division box:	the facility to check water level in the main farm ditch and divert it to the supplementary farm ditch.
Supplementary farm ditch:	the terminal irrigation canal to convey water to the paddy field in a rotation unit.
End check:	the facility to prevent discharge of irrigation water in the supplementary farm ditch from flowing out to the farm drain.
Farm ditch crossing:	the facility to provide access of farm machinery from farm road to the farm lot. In the Project, one rotation area has one farm ditch crossing.
Road crossing:	the facility to convey water under farm roads. Water in the farm ditch or farm drain can flow through road crossing without being intercepted by the farm roads.

Drainage System

The terminal drainage facilities are enumerated below:

Farm drain:	the terminal drainage canal to convey the excess water in the paddy field to the main or lateral drainage canal. This canal will be made of earth.
Farm drain crossing:	the facility to provide access of farm machinery from farm road to the farm lot.

Farm Road

Farm road is the facility for easy transportation of agricultural machine and will be located along main farm ditches. The farm road should not have a blind alley. The width of farm road will be two meters.

7. Hydropower Generation

a) General

Palsiguan dam and headrace for trans-basin have been planned for the dual purpose of irrigation and hydropower generation. The hydropower generation will be topographically very effective at this site.

The dam site has a catchment area of about 153 sq.km. The averaged daily run-off at the dam site is about 13.64 cu.m/sec with the mean annual rainfall of 2,600 mm. Nueva Era dam site has an averaged daily run-off of 4.37 cu.m/sec from its own catchment area of about 52.4 sq.m. After trans-basin, the total discharge available at Nueva Era dam site inclusive of discharge from the Palsiguan basin will amount at 18.01 cu.m/sec.

The irrigation study has revealed that a required storage capacity of Palsiguan dam for irrigation and hydropower is about 189 MCM. To store this volume of water, the Palsiguan river will be dammed up to a height of about 139.5 m from the present river bed. The river bed elevation at the dam site is EL 195 m, therefore, the full water level of this dam will be EL 334.50 m. The intake facilities for irrigation will be located at the immediately downstream of Nueva Era power station, which is on the other side of Palsiguan dam site across the Ilocos mountains. The intake water level will be 120.50 m. Therefore, the total water head available for hydropower generation is 214.00 m.

Palsiguan dam site is about 12 km from the intake facilities for irrigation of which about 9.1 km will be tunneled.

It is a peculiar characteristic of the area that 73 percent of the total run-off appears in the wet season, six months from May to October. The averaged run-off during this season is 260.5 MCM, however, the run-off widely fluctuates from the maximum of 338.6 MCM to the minimum of 160.9 MCM according to the 11 years' data from 1960 to 1970.

In principle, Palsiguan dam water will be utilized not for wet season irrigation but for dry season irrigation. The same can be said on hydropower generation. However, the dam water will be available for hydropower generation during wet seasons except drought years with the restriction that irrigation water for dry seasons can be guaranteed.

The hydropower generation plan has been formulated based on the above-mentioned principle taking into consideration the recent sharp escalation of oil price as follows;

i) Taking into account economic construction and power generation, the high and low water levels of Palsiguan dam have been determined at 334.50 m and 275.0 m, respectively. The proposed dam height is by 3.16 m higher than the actually required for irrigation, however, this dam height results to save the construction cost since the headrace can be shortened by 1,250 m long.

ii) Palsiguan headrace tunnel has been planned in consideration of geological and topographical conditions of the Bonga river basin. Its economic diameter is 3.6 m with the length of about 6,150 m. A pressure tunnel has been proposed for this headrace.

iii) Bonga power station of an underground type will be constructed at 50 m downstream of the surge tank which will be located at the downstream most of the headrace tunnel. The depth of this power station from ground surface will be about 70 m which corresponds to the difference of elevation between the Bonga river bed running near the surge tank and the high water level of Nueva Era dam. The tailrace tunnel from Bonga power station will be 2,950 m long.

iv) The maximum discharge of Bonga power station has been determined at 28.225 cu.m/sec, which corresponds to the maximum irrigation requirement in dry seasons.

v) With the effective water head of 149.30 m, Bonga power station will have the installed capacity of 36,000 KW, resulting in the annual power generation of about 159.66 GWh.

vi) The afterbay will be given a sufficient regulation capacity to cope with the maximum discharge of 28.225 cu.m/sec from Bonga power station for six hours, which is equivalent to the total volume of about 0.5 MCM In consideration of sediment accumulation during a 50-year period, the total storage capacity of this afterbay will be about 4.99 MCM with the crest elevation of 250.0 m and the effective depth of 1.50 m.

vii) A dam-type power station has been planned at Nueva Era site taking into consideration the required intake water level for irrigation. Therefore, the power station will be located at the immediately downstream of the dam body. Nueva Era power station will have the maximum discharge of 29.273 cu.m/sec inclusive of the run-off from its own catchment area.

viii) With the effective water head of 27.92 m, Nueva Era power station will have the installed capacity of 6,800 KW, resulting in the annual power generation of about 39.54 GWh.

ix) Nueva Era dam afterbay will require a considerably high and long dam body with the height of 45.50 m and the crest length of 220.0 m since the dam site is thickly covered by river deposits. A concrete dam has been proposed for the safety of the dam body and economic construction in consideration of the construction method of its temporary diversion channel through the dam body and easy supply of construction materials to be utilized.

Unit prices as of January 1980 have been employed in construction cost estimate. In economic evaluation of an alternative plan, the KW value of 700 ₱/KW/year has been applied on the assumption of a 100,000 KW class thermal power station requiring some counter-measures against air pollution. In consideration of the recent price escalation of oil, the electric power value per KWh has been evaluated at 0.429 ₱/KWh.

b) Preliminary Design

The major dimensions of Bonga and Nueva Era power stations are shown in Table 4-1.

c) Low Water Level Study

A careful topographic survey was conducted. The survey has revealed that the intake has to be located near Palsiguan dam site if the dam water is diverted at the sedimentationlevel of EL 259.00 m. In this case, a headrace with 7,400 m long will be required. However, if the dam is heightened by 3.16 m, the intake can be located at the elevation of 275.00 m which is near the center portion of Palsiguan reservoir, and the headrace length can be shortened to 6,150 m. Furthermore, the averaged water level of the reservoir will increase to a degree, resulting in an increase of power to be generated. The latter plan is also advantageous in the construction cost.

In this connection, the relationship between the power generation efficiency and construction cost involved in further dam heightening should be discussed. Therefore, a comparative study has been performed setting up the two low water levels of

Table 4 - 1 Major Dimensions of Hydropower

Description	Unit	Bonga P/S	Nueva Era P/S
1) Output			
Installed Capacity	KW	36,000	6,800
Firm Capacity	KW	–	1,830
Firm Peak Capacity	KW	30,510	–
Annual Generation	GWh	159.660	39.540
Effective Output	KW	33,776	4,514
2) Discharge and Head			
Maximum Discharge	cu.m/sec	28.225	29.273
Minimum Discharge	cu.m/sec	9.500	8.000
Average Discharge	cu.m/sec	13.640	18.000
Maximum Head	m	184.500	29.500
Average Head	m	163.150	28.750
Effective Head	m	149.300	27.915
3) Water Level and Reservoir			
High Water Level	m	334.50	150.00
Low Water Level	m	275.00	148.50
Tail Water Level	m	150.00	120.50
Drawdown	m	59.50	1.50
Reservoir Area	sq.km	5.07	0.37
Total Reservoir Volume	MCM	232.00	4.99
Effective Reservoir Volume	MCM	189.00	0.50
4) Water-Way and Powerhouse			
Headrace (Pressure Tunnel)	m	ϕ3.6 x 6,150	–
Tailrace Tunnel	m	ϕ3.8 x 2,950	–
Powerhouse		Underground type	Dam type
5) Machine Equipment			
Turbine	set	1	1
Type		Deriaz	Kaplan
Revolution	r.p.m.	450	327.5
Generator	KVA	39,600	7,480
Transformer	KV	115	115

285.0 and 295.0 m in addition to the above-mentioned. As a result, it has been found out that the efficiency does not increase in comparison with the increase of construction cost in both cases. Under the situations, the low water level of this dam has been determined at 275.00 m.

d) Headrace Plan

The headrace will be constructed connecting the intake and the surge tank. The intake site is geologically composed of dacite. Weathered layers seem to be about 20 m deep. The headrace route is mostly composed of dacite and basalt with the intrusive rock of diorite, and favorable for constructing a pressure tunnel. Taking into consideration the relatively long tunnel, necessary ventilation and smooth progress of construction works, the internal diameter of this tunnel has been determined at 3.60 m mainly in the power generation aspect by employing the economic cross section for the maximum discharge. In general, a smaller cross section than the ecnomic cross section makes the construction works difficult, resulting in a high construction cost. Taking it into consideration, a similar tunnel diameter to the above-mentioned would be most appropriate even if the tunnel is only for irrigation purpose.

As an alternative plan, it is considered to locate the power station near the intake, and change its headrace to the tailrace since this power station is of the underground type, however, this plan requires a long tailrace. If the downstream most of this tailrace is located below the afterbay water level, an additional surge tank will be required and the tailrace will be what is called the pressure tunnel. Furthermore, the power station has to be located deeper from ground surface in the alternative plan in comparison with the proposed plan in order to secure the similar water head. In addition, excavation of the tunnel can be made only from the downstream side in this plan. Under the circumstances, the proposed plan to locate the power station at the central portion of the tunnel will be the most adequate from the view points of economic construction and easy tunneling.

e) High Water Level Study

Palsiguan reservoir will be operated for the dual purpose of irrigation and hydropower generation. However, the priority in water use of the reservoir will be given to irrigation. Under the situations, the storage capacity of this reservoir has been basically determined to meet the irrigation requirement. Out of the effective storage water of 189 MCM, the water quantity of 32.5 MCM will be utilized to obtain the firm peak. The minimum discharge to be released for this purpose is 4.7 cu.m/sec/day. The storage capacity is excessive in comparison with the inflow discharge if the reservoir is excessive in comparison with the inflow discharge if the reservoir is exclusively for hydropower generatoin as proved by the fact that the storage water cannot be recovered in some drought year, according to computations.

Under the situations, the reservoir should be operated to keep the water level as high as possible for easy recovery of the reservoir water. Furthermore, a high KWh cannot be obtained even if the reservoir has a bigger storage capacity than the proposed for power generation since inflow discharge is limited. As discussed in the subsequent paragraph of "Operation Study of Reservoir", the effective storage volume of 189 MCM is the upper limit expectable from the inflow discharge.

On the contrary, a smaller storage capacity than the proposed will inevitably decrease the irrigation area to an extent resulting in a decrease of benefit in the agricultural sector. Furthermore, the construction cost of the headrace tunnel and Nueva Era dam cannot be saved, which leads to the decrease of benefits to a great extent though the construction cost of the dam itself is slightly small. Taking into consideration the above-mentioned, the water level or the dam height has been determined to store 189 MCM of water.

f) Operation Plan of Dam

In principle, the operation plan of dam has been formulated to meet the irrigation requirement. Based on hydrological data observed from November 1959 to October 1969, the dam operation study has been made to cover the following;

i) In order to secure a necessary effective water head for power generation, the reservoir water level should be kept as high as possible, at least, higher than the designed low water level by satisfying the irrigation requirement though it happens that the water level is lowered to the low water level in severe drought seasons.

ii) Effort should be made to recover the reservoir water level to the full water level by the end of October every year by avoiding ineffective release of the stored water.

iii) The maximum discharge of Bonga power station is 28.225 cu.m/sec, so the water from Palsiguan dam should be controlled within this restriction. Moreover, since the maximum discharge of Nueva Era power station is 29.273 cu.m/sec, the turbine discharge of Bonga power station will be controlled to make the discharge of Nueva Era power station inclusive of the run-off from its own catchment area smaller than the above-mentioned maximum discharge.

vi) The minimum discharge of Nueva Era power station is 8.00 cu.m/sec. Therefore, the Bonga river discharge and released water from Bonga power station are controlled to be 8.00 cu.m/sec in total.

v) The minimum discharge of Bonga power station is 9.50 cu.m/sec. This volume of water shall be secured throughout the year.

In order to meet the irrigation requirement and to generate the hydropower effectively by making use of sharply varying inflow discharge into the reservoir, the following operation rules have been set up through trial computation for the reservoir operation.

a) Two standard reservoir volumes have been determined for each 10-year period, that is, the upper limit reservoir volume (URV) and the lower limit reservoir volume (LRV).

b) The dam shall be operated to keep the reservoir water level within the URV and the LRV.

c) When the reservoir water volume exceeds to URV due to a small irrigation requirement, the reservoir water is released, within the above-mentioned limit in iii).

d) When the reservoir water level is lower than the LRV, the water is released to meet the irrigation requirement only within the restriction that the water quantity to be released for irrigation can meet the requirement mentioned in v). Otherwise, it would become difficult to raise the reservoir water to the full water surface by the end of October, resulting in a shortage of irrigation water to meet the requirement mentioned in iv).

g) Plant Factor Study

The load factor in the hydropower generation plan is small at 39 percent, approximately. This small load factor suggests that electric power is mostly consumed in night time. About 50 percent of houses has been electrified. This electrification condition would last in future, too, if the Project Area remains not industrialized. This small load factor is one of the problems involved in the power generation plan aiming at regional electric power supply in the Project.

Bonga power station has a high effective head of 149.3 m. Furthermore, the afterbay site is also favorable. The sites could be said to have the best condition for constructing power stations. A high output is expected accordingly. Furthermore, the dam and headrace could be economically utilized not only for power generation but also for irrigation.

However, a higher firm peak than the above-mentioned cannot be obtained by means of increasing discharge since, if more water is released, the reservoir water cannot recover to meet the irrigation requirement as already mentioned in the paragraph on "Reservoir Operation Plan". The most appropriate discharge for power generation is computed at 28.225 cu.m/sec, which is equal to the maximum irrigation requirement.

If the turbine discharge of more than the above-mentioned is selected, the pressure tunnel of about 6,150 m long and the tailrace of 2,950 m long should have larger cross sections than the proposed. To secure the firm peak, more discharge than 4.70 cu.m/sec/day which is equivalent to the four hours' maximum discharge of 28.225 cu.m/sec is required.

To obtain this discharge, it is required to construct a larger reservoir than the proposed in spite that the proposed reservoir itself has been planned to utilize all inflow discharge. A larger reservoir is required only to obtain the firm peak, and together with enlargement of the tunnel cross section, it needs an enormous additional construction cost.

Furthermore, if a larger reservoir is constructed, inflow discharge during wet seasons is not sufficient to recover the reservoir water by October. Through these studies, the maximum discharge has been determined at 28.225 cu.m/sec.

The designed standard turbine water level has been determined at 313.15 m which is equal to the averaged water level in the 10-year operation study. A trial computation has been made assuming the case to increase the maximum output to 40,000 KW (with the same operation efficiency of water wheel and generator). The computation has revealed that the output increases by 2.6 GWh/year on an average in the 10-year period. The increased output is equivalent to 1.6 percent of the total output whereas the increase in construction cost is 2.5 percent, which indicates that this plan is not economically advantageous. In this case, the firm peak increases by 574 KW, however, it is also not economical. Since the plan brings out the drawdown of 59.5 m, the operation efficiency of water wheels decrease of KWh. Under the situations, it can be concluded that the output of 36,000 KW is the most appropriate in case of the designed standard water level.

On the contrary, if the turbine discharge is determined less than the maximum irrigation requirement, diversion works are required on the pressure tunnel upstream of the surge tank. Assuming the maximum capacity of 40,000 KW (the maximum discharge: 26.63 cu.m/sec), a trial computation of output has been made. The computation indicates that the output decreases by 2.4 GWh on an average for the 10-year period though the construction cost does not increase. This loss is quite large. Furthermore, the operation of dam becomes complicate, and the power station cannot well function as a peak load station. The computation indicates that the most appropriate capacity arrives at 36,000 KW.

NPC forecasts that the power demand in the Project Area and neighborhood will be 81.63 MW in 1988, that is, one year after the completion of the Project, with the energy of 247.24 GWh and the load factor of 34.5 percent. On the other hand, the total plant factor per year of Bonga and Nueva Era power stations will be 53.1 percent. This plant factor is apparently too high, however, this power generation plan has a defect that power generation cannot sufficiently meet the load demand due to the seasonally fluctuating water release from Palsiguan dam. The power plants will have a plant factor of about 30 percent during April and May when discharge from the dam is small. Actually, the power stations will cover the total local demand with supplemental power supply from the other power sources through NPC's transmission gride when the plant factor of more than 30 percent is required.

At present, the electric power has been sent to the Project Area from power sources far from it. Therefore, it will be meaningful that power sources with a high firm peak is developed near the Project Area.

h) Function of Bonga Afterbay (Nueva Era dam)

Bonga afterbay has been planned to keep high the firm peak of Bonga power station, and concurrently to serve as a diversion dam for irrigation. As already mentioned above, a concrete dam with the height of 45.5 m and the crest length of 220 m has been planned. This dam will be equipped with five units of gate (7m x 6m) to cope with the design flood discharge of 970 cu.m/sec. If this dam is only a diversion dam for irrigation, a smaller one can meet the requirement. However, since the major function of this dam is to secure the firm peak of Bonga power station, the above-mentioned scale of dam has been planned. This dam has its own catchment area of about 52.4 sq.km, and abundant run-off from the catchment area occurs from May to October when discharge from Bonga power station is controlled small. Therefore, a constant discharge is available at Nueva Era power station. The dam is advantageous in this aspect though its effective head is not so high.

The firm peak value of Bonga power station and the power generation value of Nueva Era power station make the economic benefits very high. Bonga power station with the afterbay is much more economical than the without the afterbay. Furthermore, Bonga power station cannot generate the firm peak without this afterbay, so it cannot meet the local demand, resulting in the fact that the hydropower generation plant itself is already meaningless (see Appendix 4B-9).

i) Output Study

A computerized output study has been made based on 10-year period data from November 1959 to October 1969 for each power station (see Appendix 4B-10).

Bonga Power Station:

Bonga power station is a firm peak load power station, and the minimum discharge of 4.70 cu.m/sec/day has been secured for this station. This water quantity is equivalent to the four hours' maximum discharge of 28.225 cu.m/sec. The drawdown of Palsiguan reservoir water is so large as 59.50 m with the averaged head of 163.150 m. Taking it into account, one unit of the Deriaz type turbine is considered the most appropriate. So, the minimum discharge of 9.50 cu.m/sec is selected from the efficiency of this type of turbine. Discharge to be released fluctuates from 9.50 cu.m/sec to 28.225 cu.m/sec. Through the discharge modeling, these discharges have been allocated on hourly basis to meet the required discharge per day.

The intake water level is determined by the reservoir water level whereas the trailrace water level is determined by the afterbay water level to be regulated. However, the trailrace water level of EL 150.0 has been employed in this study because the flucuation of water level in Bonga afterbay cannot be utilized from the view point of the structure of this tailrace.

Nueva Era Power Station:

Runoff-from the catchment area of Bonga river and discharge from Bonga power station are regulated constantly by Bonga afterbay in order to generate hydropower and to supply irrigation water. Therefore, the intake water level for Nueva Era power station has a daily fluctuation. However, the averaged daily regulation water level has been determined at 149.25 m at the maximum. A large inflow discharge such as floods will cause to raise the water level. When the averaged daily inflow discharge is 29.279 cu.m/sec, which is equivalent to the maximum discharge, the water level arrives at the maximum water level of 150.0 m. The water level in the downstream canal (releasing water level) varies depending on the turbine discharge. Since the power station has a low water head, the intake and releasing water levels bring about a great influence on output.

The minimum discharge of 8.00 cu.m/sec will be secured by the daily run-off discharge from the catchment area of Bonga river and discharge from Bonga power station. However, it will happen in drought years that the above-mentioned minimum discharge cannot be secured for all day long due to the drawdown of Palsiguan reservoir water. Even if such difficulty arises, irrigation requirement discharge can be supplied, for instance, by 12 hours' operation, or such time falls in non-irrigation seasons. Therefore, a discharge of more than 8.00 cu.m/sec can be released for power generation. The turbine efficiency varies from 0.8 to 0.895 in accordance with a discharge volume as shown by the efficiency curve.

C. Proposed Agricultural Development

1. Proposed Land Use

The Project has the gross area of about 21,900 ha out of which the arable land is about 12,400 ha, and the remainder of about 9,500 ha is non arable land such as residential area, right of ways inclusive of proposed sites for the Project facilities, etc. (see Table 4-2).

The whole arable land will be fully irrigated by gravity in both wet and dry seasons. The above-mentioned 12,400 ha include 68 ha of reclaimable land of which 68 ha and 10 ha are presently marshy land and brush area, respectively.

Taking into consideration the limited land and water resources and a relatively high population density in the Project Area, the land use plan has been formulated to satisfy the following two requirements;

i) To make high the cropping intensity with irrigation through the intensification of farming and enlargement of farm management scale; and,

ii) To increase the upland cropping ratio in dry seasons rather than paddy cropping ratio in order to irrigate the maximum possible area with limited water resources.

Table 4 - 2 Proposed Land Use 1/

(Unit: ha)

Sub-Project	Arable Lands	Right of ways 2/	Residential Areas	Others	Total
Cura	1,410	120	75	65	1,670
Nueva Era	670	55	15	1,390	2,130
Sub-total	2,080	175	90	1,455	3,800
Madupayas	160	15	15	330	520
Batac-Paoay	5,190	415	565	2,130	8,300
Pinili	1,400	110	85	1,175	2,770
Badoc-Sinait	3,570	295	175	2,470	6,510
Sub-total	10,320	835	840	6,105	18,100
Total	12,400	1,010	930	7,560	21,900

Note: 1/ Excluding the Phase I remaining area.

2/ Including the right of ways for proposed facilities in the Project.

2. Agricultural Production Plan

a) Selection of Crops

The five major crops of paddy rice, tobacco, garlic, mungbeans and cotton have been selected in the Project in consideration of the natural conditions like climate and soils as well as the profitability of crops, Governmental agricultural production policy and farmers' opinion, etc.

Paddy rice will be grown covering the whole paddy fields in the Project Area in wet seasons. As for dry season crops, both paddy rice and upland crops have been selected. Upland crops will be preferentially cropped so far as soil and drainage conditions are suited to such crops, mainly in the following reasons;

i) A small farm size in the Project Area makes it inevitable to select profitable crops promising a high income per unit area. The cost and benefit analysis regarding the selected crops has revealed that the selected upland crops are more profitable than paddy rice.

ii) Not only in Ilocos Norte province but also in the whole Philippines, the demand and supply of paddy have tended to be balanced.

iii) The Project Area has the most distinct dry seasons with a relatively long duration among areas in Type I climate zone. This climatic condition is favorable for cultivation of upland crops followed by wet season paddy cropping specially in paddy fields where quick drawdown of groundwater takes place in land preparation periods.

The following are the major reasons for selecting the respective upland crops;

Virginia tobacco:	This is one of the major crops in the Project Area at present. All the municipalities in the Project Area, except Solsona, are situated in the Virginia tobacco cropping zone specified under the Presidental Letter of Instruction concerned.
Garlic:	The Project Area is advantageous in garlic production with a low temperature during the early half of its growth period.
Mungbean:	Belonging to the leguminous crops, this crop is suitable for multiple cropping, and has a wide-ranged soil adaptability. Furthermore, its growing period is short.
Cotton:	The climate in the Project Area is suited for cotton production because this crop needs sufficient cropping duration in dry seasons. In the Cotton Production Development Project, about four thousand hectares are identified as cotton potential area in Ilocos Norte province.
Other crops:	The cropping area of onion and other vegetables is expected to be expanded to a degree after the completion of the Project. However, their cropping scale will be not so large as these of the above-mentioned four upland crops, therefore, onion and other vegetables are dealt with as minor crops in this study.

b) Forecasted Marketability

To forecast the marketability of the selected major crops, the analysis of demand and supply has been made in the three levels of the whole country, Ilocos region and Ilocos Norte province for the latest five years (1975 to 1979). The demand of respective crops in 1990 has been forecasted based on the NEDA forecasted population (medium assumption) and the estimated food consumption per capita. Results of forecasting are as follows;

Rice:	The rice demand inclusive of the estimated buffer at 15 percent of the total demand in the year of 1990 is forecasted about 150 percent of the averaged total rice production in the three-year period for 1977 to 1979 in Ilocos Norte province. It is considered

that the above-mentioned demand will be easily attained. Furthermore, the rice production will probably exceed the demand in case that only rice cultivation is made in irrigated paddy fields which will increase by 1990 since many irrigation projects are under construction or planning including this Project. In this aspect, the rice production in the Project Area should be carefully planned so that over-production will not take place.

Virginia tobacco: In the Five-year Development Plan, the increasing rate of the Virginia tobacco production is estimated at 2.4 percent per year for the period of 1978 to 1987. Based on this increasing rate, the production increase in the Project Area for the year of 1990 can be set up, at least, at 30 percent of the total production as of 1978.

Garlic: The share of garlic production in the Project Area inclusive of its vicinity is estimated about 75 percent of the total production in the whole country. The comparison of the forecasted total demand of garlic in 1990 and the total production in 1978 at the national level suggests that garlic production in the Project Area would increase to about 1.8 times the total production in 1978.

Mungbeans: The mungbeans production at the national level should increase to about four times the total production at present to meet the forecasted total demand in 1990. Therefore, it is considered that the mungbeans production in the Project Area should also increase at least to four times the total production in 1978.

Cotton: The target production in the whole country in set up at 138 thousand tons (seed cotton) in the National Cotton Production Development Program (1979 to 1987) for self-sufficiency of cotton by 1987. In this program, 3.7 thousand tons of cotton is planned to be produced in about four thousand hectares of the cropped area in Ilocos Norte Province. For the Project Area, about one thousand hectares of cotton cropping area are proportionally allocated on the basis of the acreage of paddy field in the Project Area to the total in the Ilocos Norte province. Further details on the above forecast are given in Appendix 4C-1.

c) Proposed Cropping Pattern

The following six major cropping patterns are proposed in due consideration of various combinations of the double cropping or triple cropping a year by the previously selected crops and the proposed cropping acreages by each cropping pattern is summarized in the table shown below.

Proposed Cropping Pattern[1/]

(Unit: ha)

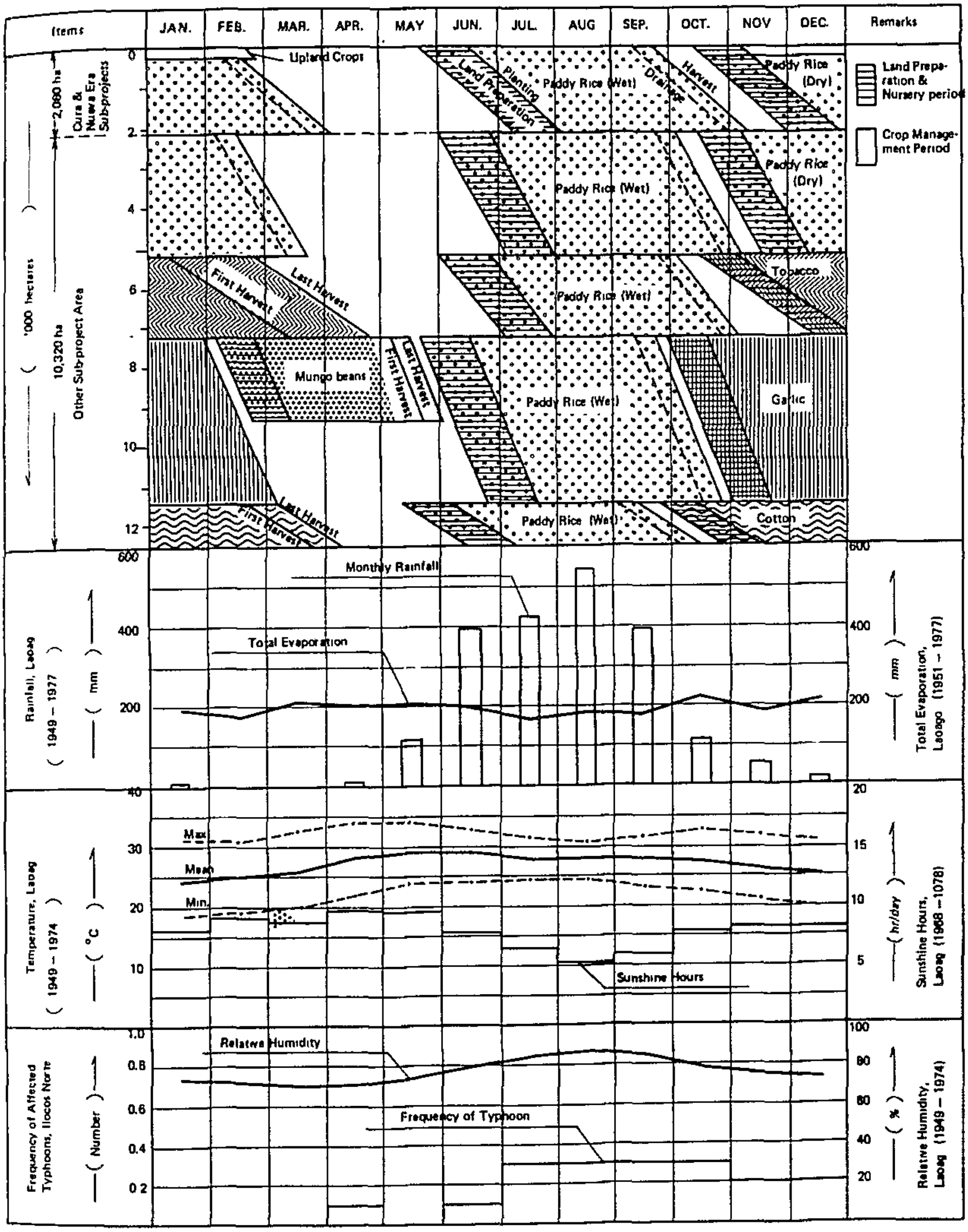
Cropping Pattern (Wet Season)	(Dry Season)	Sub-project Area: Cura & Nueva Era	Others[2/]	Total
1. Paddy +	Paddy	1,870	3,100	4,970
2. Paddy +	Upland Crops			
a) Paddy +	Tobacco	70	2,060	2,130
b) Paddy +	Garlic	140[3/]	2,065	2,205
c) Paddy +	Garlic + Mungbean	–	2,065	2,065
d) Paddy +	Cotton	–	1,030	1,030
	Sub-total	210	7,220	7,430
Total (Pnysical Area)		2,080	10,320	12,400
(Cropping Area)		4,160	22,705	26,865
Cropping Intensity (%)		200	220	217

Note: 1/ Excluding Phase I remaining area
2/ Madupayas-Batac-Badoc area
3/ Including 70 hectares of onion
Detailed descriptions are referred in Table 4C-4, Appendix 4C-2

The physical cultivated area in the Project Area is 26,865 ha out of which the total cropping area is 12,400 ha. The Project will increase the cropping intensity by 55 percent from present 162 percent to 217 percent. The cropping patterns have been prepared taking into consideration the three major factors of the land classification, selected crops and crop marketability specially paying attention to the following;

i) In Cura sub-project area, upland cropping after harvesting the wet season paddy is considered unsuitable due to a high groundwater table which lasts up to October and relatively low soil fertility. In general, soils in Nueva Era sub-project area is judged unsuitable for upland cropping, thereby, about 90 percent of the both sub-project areas is planned to be cultivated with paddy in the way of "double cropping a year". This plan will satisfy farmers requirements informed during the interview survey.

FIGURE 4-3. PROPOSED CROPPING PATTERN



ii) In the area other than the above-mentioned two sub-project areas, "dual class land" suitable for both paddy and upland crops occupies about 60 percent, and the soil fertility is relatively high. The land classified as "rice land" is mostly composed of clayey-loam soils in which crops with high soil adaptability such as garlic and mungbeans can grow. Consequently, 70 percent of the areas including a part of "dual class land" will be cultivated with "paddy + upland crops" whereas 30 percent of the rest with "paddy double cropping a year".

iii) The interview with farmers on future cropping plan in the Project Area except Cura and Nueva Era sub-project areas has revealed that about 70 percent of the interviewees prefer the pattern of "paddy + upland crops (one or two cropping)", and about 30 percent the pattern of "double cropping of paddy" or "two cropping of paddy + other crops." (see Appendix 4C-3)

The cropping calendar for the respective cropping patterns is illustrated in Figure 4-3, and the lag period in cropping calendar has been set up at 50-day period for the two sub-projects and 35-day period for the other areas. In preparing the calendar, a special consideration has been given to effective use of rainy water, weather conditions in harvesting seasons of paddy and suitable sowing time of the respective upland crops.

In the above-mentioned plan, a slack period of about one month from the middle of April to the beginning of May has been proposed for maintenance and repair of irrigation facilities and other related structures.

d) Farming Techniques and Necessary Agricultural Inputs

1) Paddy

After the completion of the Project, the full-scaled irrigation and drainage systems will ensure stabilized and intensive paddy cropping in the area. The proposed crop varieties, cultivation methods and agricultural inputs to be required are listed in Figure 4C-1, Appendix 4C-4. Prerequisite for successful paddy cropping will be functional irrigation and drainage system and effective water management to secure necessary water with optimal water depth in paddy fields in a suitable time for paddy growth.

2) Upland Crops

Upland crops will be grown in paddy fields in dry seasons after harvesting paddy, and irrigation water will be supplied in the farrow method. The proposed crop varieties, cultivation methods and agricultural inputs to be required are listed in Figure 4C-2 to 4C-5, Appendix 4C-4. As for upland irrigation, special attention should be paid to a quantity of irrigation water to be supplied. Over irrigation should be strictly avoided.

In this connection, a great care should be exercised in allotment of cropping areas and irrigation operation.

- Upland crops should be grown in the lots having soils suitable to the respecrive crops, and allotment of cropping areas should be made in the manner that upland crops will be trown in high areas whereas paddy in lowlying areas. Such area allotment will protect upland crops from damageds caused by water lodging brought about by paddy cultivation in high areas.

- Effective operation and maintenance services should be performed to prevent the excessive water supply and leakage of irrigation water from canals. To simplify the terminal water management for cropping with "pady + upland crops" which requires more complicated works than cropping with paddy double cropping, it is necessary to grow upland crops according to the cropping programs prepared every year based on the criteria of the above-mentioned area allotment.

The total agricultural inputs to be required per year are estimated as follows (ref. to Table 4C-6, Appendix 4C-5).

Agricultural Inputs Required

i)	Seeds	
	- Paddy	869 ton
	- Tobacco	64 ton
	- Garlic	1,793 ton
	- Mungbean	52 ton
	- Cotton	26 ton
ii)	Various chemical fertilizers	8,285 ton
iii)	Pesticides	
	- Liquid	65,700 quart
	- Wettable Powder	45 ton
	- Granular	35 ton
iv)	Herbicides	
	- Liquid	34,700 quart

Among many inputs, seeds of garlic and mungbean, fertilizers and pesticides will increase to a considerable extent in comparison with the present quantities.

e) Target Agricultural Production

In case of "Without Project", yield of the crops in this area will increase at the rate estimated in the previous chapter whereas in case of "With Project", it is expected to obtain the following forecast cropping acreages by crops, yield and total production after five years from the completion of the Project.

Target Agricultural Production

Crops	Cropping Acreage (ha) Phase II	Phase I[1/]	Forecasted Yield (ton/ha) Phase II	Phase I[1/]	Production (ton)
Paddy	17,370	8,650	4.29	4.11	109,959
- Wet	12,400	2,120	4.2	3.9 (3.7[2/])	60,168
- Dry	4,970	6,530	4.5	4.2	49,791
Tobacco	2,130	210	1.7	1.3	3,894
Garlic	4,270	250	2.6	2.7	11,777
Mungbean	2,065	–	1.1	–	2,272
Cotton	1,030	–	2.5	–	2,575
Onion	–	250	–	12.5	3,125
Total	26,865	9,360			133,602

Note: 1/ Phase I remaining area
2/ Yield in the Madongan sub-project area

The respective target yields are the weighted average of the target yields set up by each classification and corresponding cropping acreages (see Appendix 4C-6). It is planned that the Project will attain its target within five years after the completion of construction in due consideration of the fact that more than a half of farmers in the Project Area have experience in irrigated farming of either paddy or upland crops.

In parallel with the progress of the Project, agricultural extension and supporting services both in the technical and financial aspects should be properly rendered to the farmers concerned.

The production increment and rate of increment forecasted based on the present production data and target are indicated in the following table;

Forecasted Production Increment and Rate of Increment

Crops	Present (1) (ton)	Target (2) (ton)	Increment (3)=(2) – (1) (ton)	Rate of Increment (2)/(1) x 100 (%)
Paddy	27,513	109,959	82,446	400
Tobacco	2,345	3,894	1,549	166
Garlic	5,358	11,777	6,419	220
Mungbean	415	2,272	1,857	547
Cotton	–	2,575	2,575	–

The expected production increment of the respective crops is considered to meeting the forecasted demand expansion in view of the market forecast previously made.

3. Proposed Farm Management

a) Number of Farm Households and Farm Labor

The forecasted farm households in the full development year (1992) will be 11,342 households, and the available working population in the same year is estimated about 524,000 man-days per month (see Appendix 6C-1).

b) Farm Size and Land Tenure

The average farm size in 1992 is forecasted, based on the above-mentioned number of farm households and the projected farm land, as follows;

Sub-Project	Area (ha)	No. of Farm Household	Average Farm Size (ha)
Cura & Nueva Era	2,080	1,203	1.7
Others	10,320	10,139	1.0
Total	12,400	11,342	1.1

As already mentioned, the agrarian reform has been under way in the Project Area, although the objective areas are not so large, to realize some land transfer to the tenant farmers, and then all share tenants will be converted to lease holders in future.

c) Pattern of Farm Management

Realization of the Project will allow to increase the average cropping area per farmer through expansion of multiple cropping system. The representative patterns of farm management in the area are specified below in terms of the average farm size previously mentioned.

Representative Patterns of Farm Management

	Pattern	Farm Size (ha)	Cropping Acreage (ha)	
1.	Paddy only	1.7	Paddy (Wet)	1.7
			Paddy (Dry)	1.7
			Total	3.4
2.	Paddy + Mungbean	1.7	Paddy (Wet)	1.7
			Paddy (Dry)	1.1
			Mungbean	0.6
			Total	3.4
3.	Paddy + Tobacco + Garlic	1.0	Paddy (Wet)	1.0
			Tobacco	0.5
			Garlic	0.5
			Total	2.0
4.	Paddy + Garlic + Mungbean	1.0	Paddy (Wet)	1.0
			Garlic	1.0
			Mungbean	0.5
			Total	2.5
5.	Paddy + Cotton	1.0	Paddy (Wet)	1.0
			Paddy (Dry)	0.5
			Cotton	0.5
			Total	2.0

Note. Pattern (1) and (2) will be applied to the sub-projects areas of Cura and Nueva Era, while (3) and onward to the other areas than the above.

d) Proposed Farm Mechanization and Forecasted Balance of Farming Labor

After completion of the Project, the minimum farm mechanization described below will be required for attaining the target (see Appendix 4C-7);

The area ratio of the proposed farm mechanization can be estimated at 40 percent in land preparation, 100 percent in paddy threshing (including 50 percent by pedal-thresher) and 50 percent in paddy drying, respectively. The objectively selected farming machines and the necessary number of machines per one unit of compact farm (about 40 ha) are illustrated as follows. All the selected machines are the Philippine-made available at present or in future, and the number of machines to be introduced in one compact farm are minimized by way of the joint use.

Selected Farm Machines and Required Units per Compact Farm

Operation	Selected Machine	Nos. of Unit per Compact Farm
Land preparation	- Hand tractor (7 - 8 HP, diesel engine)	1

Threshing	- Powered thresher (7 - 8 HP diesel, throw-in-type)	1
	- Pedal thresher	5
Drying	- Dryer (Flat-bed type, 2.0 ton bin)	1/2

When the farm mechanization is applied in the above scale, crop-wise labor requirements are estimated at 103.1 man-days/ha for paddy, 273.5 man-days/ha for tobacco, 165 man-days/ha for garlic, 86.3 man-days/ha for mungbean and 139.3 man-days/ha for cotton, respectively (see Table 4C-9 to 4C-13, Appendix 4C-7).

The relationship between the estimated labor requirements in 1992, the target year, taking into account the proposed farm mechanization and the estimated total labor available in the same year in the Project Area is illustrated in Figure 4C-8, Appendix 4C-7. As learnt from the data concerned, the peak of labor requirement will appear in October when approximately eight percent of the necessary labor is short. However, the demand and supply of labor will balance almost throughout the year in the area "*with Project*".

4. Supporting Services

a) Research and Extension

There are few national irrigation projects which have such large scaled irrigation areas for upland-crops cultivation in paddy fields as this Project has, because almost all of the national irrigation projects, which implemented until now, were solely for the irrigation in paddy rice cultivation. Therefore it is considered that few research and extension activities have been made for such large scaled upland-crops cultivation area. In connection with this, the Project emphasizes strongly the necessity of the research and extension activities for the establishment of the production and water management techniques which will be applied for the large-scaled upland crops cultivation in the Project Area. Especially, the research and extension activities will be required to cover the establishment of technology in the following three items;

i) The irrigation method and comprehensive production technology in upland crops cultivation in the paddy field.

ii) The water management techniques, especially at on-farm level, in the large-scaled upland crops cultivation in paddy fields.

iii) The possible crop diversification in the upland crops cultivation in paddy fields and the establishment of crop rotation.

Although it is desirable that the existing research organizations will undertake the required activities in the Project, these organizations are not in a position to concentrate their activities to the very specific tasks. Therefore, it is necessary to establish a Pilot Farm to undertake the required research activities and to demonstrate the production technology.

Sufficient extension services have to be provided in the Project by the authorities concerned in accordance with the implementation schedule of the Project. But it will be difficult that the related governmental agencies concentrate their effort to extension activities to farmers in the Project Area. On the other hand, it is essential that farming activities and water management will be simultaneously carried out on schedule. For this purpose, in the proposed O & M organization of the Project, "agriculture division" should be set up for smooth development of crop production in the Project Area. One Water Management Technician (W.M.T.) in each of about 400 hectares is proposed to be assigned.

b) Farmers' Organizations

Aiming at the effective farming practices after the completion of the Project, a functional farmers' organizations shall be established in the Project Area.

As mentioned previously, there are some existing organizations in the Project Area such as Communal Irrigation System (CIS) for irrigation, Samahang Nayon for cooperative activities and Farmers' Association to cooperate with the extension services. However, these existing organs cannot properly function as promoting bodies for the Project, and it will be necessary to rearrange them to improve their functions.

The proposed farmers' organizations shall be fully functionable in the following;

i) O & M for irrigation/drainage facilities and a rational water distribution at on-farm level together with control of farm machineries and collection of O & M cost all of which shall be made by farmers themselves.

ii) Cooperative activities for supply of seeds, fertilizers, insecticides, pesticides, farm machineries and daily commodities, collective selling of products and credit services which shall be positively practised.

iii) New farming techniques as promoted by the BPI and BAEx which shall be extensively introduced.

Considering the above, establishment of farmers' organizations is proposed as shown below;

Farmers Irrigators' Group (FIG)

For O & M of irrigation facilities at on-farm level, a Farmers Irrigators' Group (FIB) shall be established in each rotational area.

Farmers Irrigators' Association (FIA)

At Barangay level, Farmers Irrigators' Association (FIA) which has the following functions shall be established:

i) Following the NIA's plan for O & M of irrigation systems, related Farmers Irrigators Association shall make arrangement so as to realize a fair water distribution among members.

ii) Under the guidances/supervision by the BPI and BAEx, introducing of new farming techniques and farm machineries shall be realized and joint use of the machineries and collective works shall be actively promoted by Farmers Irrigators' Associations.

iii) O & M and repair of terminal ditches and farm roads downstream of turn-out structures shall be made by farmers.

iv) In case there happens to be any changes in the NIA's water distribution program depending on the weather conditions and so on, the FIA has to secure a full coordination among the related FIG, and the most reasonable water distribution shall be carried out through close cooperation with the NIA's Water Master, Water Management Technician and Ditch Tender.

v) As the members of Samahang Nayon and Kilusang Bayan, collective selling of farm products and procurement of various farm inputs shall be realized.

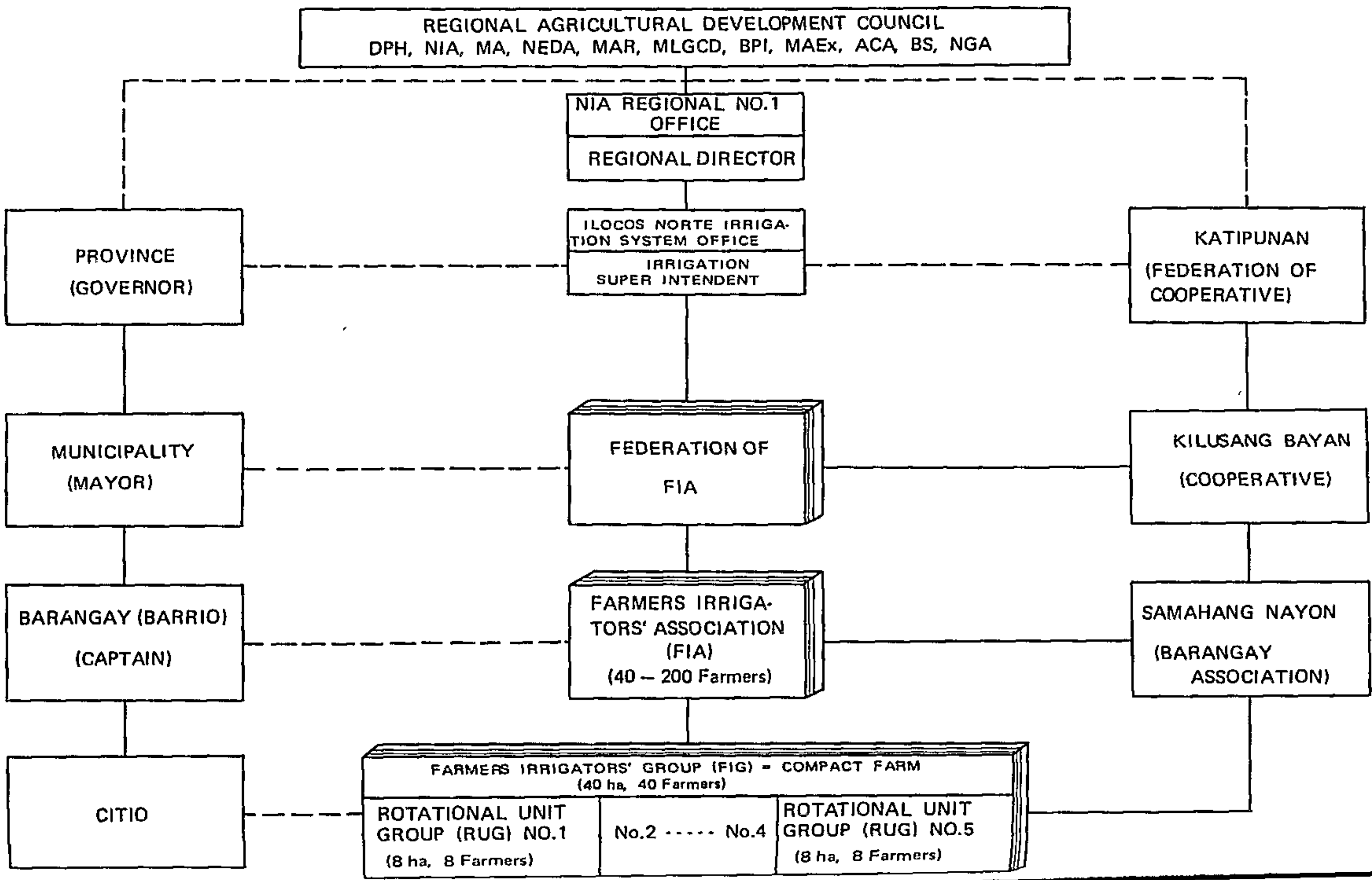
vi) Cooperating with Samahang Nayon, promotion of savings and rural development shall be made actively.

vii) Not only cooperating with the NIA in collecting irrigation fee, but also collection of repayment of project cost and O & M fee for the FIA Management.

viii) The FIA shall actively participate in the training program to be carried out by the NIA and the other governmental agencies, and provide farmers with training programs for O & M of irrigation facilities.

ix) Obtaining a full cooperation by the administrative organizations at Barangay level, irrigated agriculture shall be actively promoted.

FIGURE 4 - 4. ORGANIZATION CHART OF FARMERS' ORGANIZATION



It is necessary that the proposed farmers' organizations will be fully functionable keeping pace with the progress of the Project construction. For this purpose, in the item of the Project cost for agriculture development, the cost for the following items is covered (see Appendix 4C-8).

i) Preparation in establishment of the FIA

ii) Construction of the FIA offices

iii) O & M cost of the FIA during three years after management of the project.

D. Proposed Facilities

1. Palsiguan Dam

a) Geological Conditions of the Dam Site

The proposed Palsiguan dam site is located in mountainous Ginataran area with steep slopes about seven kilometers upstream of Baybaytin in Abra province. The Palsiguan river flows through the dam site to the south-west nearly as the crow flies, and joins the Tineg river near Polot village which is situated about 11 km downstream of the dam site.

Topographically the left bank at the proposed dam site has a slope of about 45 degrees whereas the right abutment around 35 degrees. The river bed width is about 30 m. The length-height cord at the proposed dam axis with the elevation of 340 m is 3.5. The valley shows the V-shape of which high portions unfold to a degree.

The catchment area of Palsiguan dam is underlain by volcanic rock such as dacite and basalt into which diorite has intruded. The Cordillera Central Mountains of northern Luzon are mainly comprised of dacite and basalt. Their ages are is not clear. The intrusion of diorite into them occurred in the Neogene period.

The bed rock of the proposed dam site is mainly comprised of dacite. Diorite is distributed about three kilometers upstream of the dam site whereas limestone is widely distributed about three kilometers downstream of the dam site. The access road will be constructed across the limestone area.

According to the field investigation and core-boring conducted at the proposed dam site, decite and basalt forming the base rock of the site have deeply-developed joints and cracks. However, the rock itself is hard and compact and has a sufficient bearing capacity for rockfill dam.

As the results of core-boring and seismic prospecting, the bed rock of the dam site is classified, based on its weathered conditions, into the following three zones.

i) Moderately weathered zone
Elastic wave velocity of this zone is 1.0 - 1.5 km/sec. This zone has been partially weathered to a great degree resulting in soil formation. The rock itself is a little soft, and has open cracks.

ii) Slightly weathered zone
This zone has elastic wave velocity of 2.0 - 2.5 km/sec. The rock itself is hard and compact, however, its crack plane has been contaminated due to oxidization, and is brown in color.

iii) Fresh zone
Elastic wave velocity of this zone is 3.0 - 3.4 km/sec. This zone has several cracks. Therefore, bore-hole materials broken to pieces were sampled since the rock was mechanically shocked during core boring. The cracks show a closed condition.

The sheard zone running across the right saddle will directly affect the dam. The outcrops show that soft layer such as fault clay is not intercalated in the sheared zone, however, the rock is sheared to a considerable degree and fine-grained.

The permeability test of the bed rock of the dam site conducted at bore-holes shows the following:

i) The deeper is the depth of base rock, the smaller is the permeability.

ii) The permeability coefficient of weathered zones ranges in 1 to 2×10^{-4} cm/sec.

iii) The permeability coefficient of the fresh zone to a depth of about 50 m from the ground surface also ranges in 1 to 2×10^{-4} cm/sec.

iv) The permeability coefficient of the fresh zone deeper than 50 m ranges in 2 to 5×10^{-5} cm/sec.

The bed rock of the dam site falls in the category of "the semipermeable rock."

b) Embankment Materials

Since the Palsiguan dam has been planned to have a dam height of 143.5 m, the material mixed with gravel in clay is considered suitable for impervious material. The clay and gravel which are sampled in Polot area are used for material test.

The qualities of this mixed material are as follows;

Gradation:	clay 11%, silt 23%, sand 26%, gravel 40%
Natural moisture content:	14%
Dry density:	1.873 g/cm^3
Permeability coefficient:	2.22×10^{-7} cm/sec

The spillway site and a part of the mountain connected with this site are considered to be suitable for quarry of embankment material for the Palsiguan dam. The quarry is mainly comprised of dacite with the small-scaled dike of basalt. This rock material has good qualities as shown below;

Specific gravity:	2.95
Absorption:	1.9%
Soundness:	4.2%
Compressive strength:	418 kg/cm^2

Therefore, the shearing strength of 45 degrees in internal friction angle and void ratio of 0.4 will be secured, since the compaction with high energy is practicable.

c) Topographic Condition

1) Access Road

It was informed in the initial stage of study that a road from Nueva Era would be available for the access road to Palsiguan dam site. This is a plan to utilize the national road to be constructed by the Ministry of Public Highways (MPH) from Nueva Era in Ilocos Norte province (more than EL 120 m) to Nagapran in Abra province (more than EL 380 m). However, the construction of the road has not yet completed. Furthermore, its construction is considered not easy since this road has to go across the Ilocos mountains of which the lowest elevation is EL 860 m. Under the circumstances, it is not clear when the whole line of this road could be opened for traffic. Provided that this road has been opened, the access road diverging from this national road will be required exclusively for the Project. The length of this access road to be constructed for the Project is estimated at least about ten kilometers, which means that the total road length from Nueva Era to the dam site will be about 30 km.

Instead of the above mentioned plan, it is proposed to construct the access road of about 7.2 km from Baybaytin in Abra province (more than EL 150 m) to the dam site along the Palsiguan river, and in addition, to widen the existing road with

6.3 km long from Lagayan to Baybaytin so that the dam site will be directly connected to Polot (Lagayan) where the quarry of impervious materials to be proposed for the dam embankment is located.

2) Dam Site

The dam axis has been determined about 500 m upstream of Ginataran (direction: about N 72°W). This is the same dam axis that is previously selected by NIA. Core-boring has already been conducted at five points nearly along this dam axis. Geological conditions of the dam site have been already mentioned in the previous paragraph.

Also in the topographic aspect, the dam site has no weak point except the low and thin ridge adjoining the right abutment. This ridge is considered to bring forward considerably severe problems if the storage water level is determined higher than about EL 350 m (The ridge width at EL 350 m is about 100 m). Fortunately, the full water level of this dam has been determined at EL 334.50 m.

3) Location of Appurtenant Works

In determining the location of diversion tunnel, due attention should be paid to the two requirements to minimize the tunnel length and to make smooth diversion of water to the tunnel. In the aspects, the right bank of the Palsiguan river is much more favorable than the left bank in construction of the diversion tunnel. The right bank requires the tunnel length of about 740 m, whereas the left bank about 880 m. Cellophill Resources Cooperation has utilized the river flows to transport wood from the Palsiguan upstream reaches to Baybaytin[1/]. Therefore, the diversion structure should not hinder this type of wood transportation. This is the major reason why smooth diversion of water is specially noted hereinabove.

The location of spillway should also be determined to reduce its excavation volume as much as possible and to smooth the diversion of flood discharged from the reservoir to the downstream reaches through spillway. In this aspect, the right abutment is more advantageous than the left one. If the mountain adjoining the right abutment is verified favorable for the quarry site of rock materials for dam embankment, the excavation required for the spillway will be economized to a great extent.

The spillway crest foundation should be, in general, grouted. At this dam site, the grouting for the spillway crest foundation will conveniently function to connect the grouting for dam axis to that for the leakage prvention through the low ridge located behind the right abutment.

1/ Without rafting, each of life-size wood pieces is thrown into the river flow in order to let it float down the river, and collected at Baybaytin to reduce it to pulp.

d) Layout of the Dam and Appurtenant Works

1) Access Road

The access road to connect Bangued in Abra Province and to Palsiguan dam site (Ginataran) would be as follows:

Station	Class	Elevation (m)	Distance (m)	Condition	Road Width (m)
Bangued (409 km)1/		EL 40			
	National road		10.6 2/	Existing	7.0
Kanan (419 km)		EL 60			
	Provincial road		8.3	Existing	7.0
Lagayan (452 km)		EL 105			
			4.3	Widening	14.0
Kiwas		EL 140			
			2.0	Newly constructed	14.0
Baybaytin		EL 160			
			14.0 3/	Newly constructed	14.0
Ginataran		EL 205			

Note: 1/ distance from Manila according to milepost on the map of road system in Abra province.

2/ measured section distance by jeep in February 1980.

3/ actual distance is 7.2 km. The distance of 14.0 km will includes some branch roads.

Location of the road is indicated in Figure 4D-1, Appendix 4D-1.

The access road from Lagayan to the dam site will be used for the transportation of impervious materials of dam embankment. Therefore, the road of more than 14 m wide has been planned, and it will be paved with well graded and compacted materials for the high speed transportation of embankment materials by dump truck of more than 32 ton-class which will result in good progress in construction as well as in saving of the construction cost.

This portion of the access road will be routed along the Palsiguan river, so it will be a river side road. In case of a river side road, the excavation required for its construction is small, and river bed materials are easily utilized for its embankment. The road surface elevation should be determined higher than the maximum water level of this river so far recorded in past, but it is meaningless to keep the road surface elevation higher than the probable maximum water level since during such flooding, the dam construction will be stopped. Along this route the steep rock cliff slope closely faces the river at a few places where the river course is concaved with a small angle.

At these places the embankment will be impossible, and the excavation of a big volume of rock and/or application of the special construction methods, for instance, the cantilever bridge, etc. will be required.

2) Diversion Works

Layout of the diversion works of open flow type has been made in order to release the designed flood discharge of Q = 950 cu.m/sec of which detail has been discussed in III, B.2. The open flow type requires a little bigger tunnel in comparison with the pressure flow type. On the contrary, the open flow type needs a smaller coffer dam than the pressure flow type. Therefore, the total construction cost is, as a whole, not much different in the both types. The open flow type tunnel has been proposed so that the structure will not hinder the transportation of pulpwood by the Palsiguan river flow.

The major dimension of diversion works are as follows;

Diversion Tunnel

Location	: right abutment of the dam
Type	: standard horseshoes type
Slope	: 7/740 = 1/105.71
Tunnel length	: 740 m
Water depth	: 7.74 m (discharge: 950 cu.m/sec)
Velocity	: 14.3 m/sec (discharge: 950 cu.m/sec)
Elevation of tunnel entrance	: EL 207.00 m
Water level of approach flow	: WL 222.60 m

Coffer Dam

River water depth (discharge: 950 cu.m/sec)	
Before damming-up	: more than 4 m
After damming-up	: more than 15.6 m
River Velocity	
Before damming-up	: 4.6 m/sec
After damming-up	: 0.7 m/sec
Top elevation of coffer dam	: EL 225.00 m

The detailed description of the diversion works are given in Appendix 4D-4.

3) Dam

In determining the Palsiguan dam height, careful studies were conducted to select the most appropriate low and high storage water levels to store the effective storage requirement of 189 MCM, in consideration of the headrace length, the effect in power generation and the construction cost of dam itself.

The major dimensions of dam are as follows:

Catchment area	: 153 sq.km
Dam type	: earth and rock-fill dam
Effective capacity	: 189 MCM
Capacity at F.W.L. 334.5 m	: 232 MCM
Capacity at D.W.L. 275.0 m	: 43 MCM
Sediment volume at 259.0 m	: 23.3 MCM
Freeboard	: 4.0 m
Dam height (bed rock EL 195.0 m)	: 143.5 m
Crest width (top of dam EL 338.5 m)	: 10.0 m
Crest length	: 480 m
Slope, upstream	: 1 : 2.8
downstream	: 1 : 1.9
Embankment volume,	
Core material	: 1,724 x 10^3 cu.m
Filter	: 600 x 10^3 cu.m
Rock	: 5,364 x 10^3 cu.m
Coffer dam	: 1,390 x 10^3 cu.m
Total	: 9,078 x 10^3 cu.m
Excavation (Stripping)	: 936 x 10^3 cu.m

In order to determine the type of Palsiguan dam, alternative studies were conducted on the three dam types, that is, the earth and rock-fill, concrete gravity and concrete arch types. The dam body volume rate in the above-mentioned three types is roughly expressed at 100, 24 and 7, respectively, which suggests that the arch dam is relatively advantageous among them, however, the geological conditions of the dam site do not assure that the dam site will be able to put up with an arch dam (see Table 4D-1, Appendix 4D-2).

The upstream and downstream dam body slopes are determined based on a stability analysis of the dam body against the stored water pressure and the seismic force, based on the PAGASA data. In this study the dam body slopes have been determined to be 1 : 2.8 for upstream and 1 : 1.9 for downstream, based on the seismic coefficient of K = 0.2, which has also been applied to the design of Magat dam (see Figure 4D-3, Appendix 4D-3).

Zoning of the dam cross section should be determined based on further detailed and sufficient studies and tests of embankment materials.

4) Foundation Treatment

In constructing the rock-fill dam with the dam height of 143.5 m, the following foundation treatment will be required.

i) Excavation of impervious zone foundation
Impervious zone should be put on the slightly weathered zone on fresh zone for safety.

ii) Excavation of the dam body foundation
The soft layer such as top soil and terrace deposits at the dam site is relatively thin, therefore, it should be excavated and removed.

iii) Cut-off treatment
The grouting curtain will be provided under the impervious zone of dam and spillway foundation up to the right saddle where sheared zone is observed. Thick blanket grouting zone will be required for the foundation of impervious zone to control the leakage velocity. The grouting depth will be designed as shown below;

	Location	Grouting Depth (m)
Grouting curtain	Left abutment	20 – 60
	Right abutment	60
	River bed	40 – 60
Blanket grouting		uniformly 15

5) Spillway

Layout of the spillway has been made in order to release smoothly from the right abutment the designed flood discharge of Q = 3,070 cu.m/sec of which detail is described in III. B.2. The spillway type will be "the gated chute with flip-bucket," which has been adopted to the spillways of all existing large dams in the Philippines.

A wide and deep approach canal should be constructed to make water streams smoothly approach to the spillway. Furthermore, the gated over flow weir should have a sufficient relative height at the both upstream and downstream sides.

These measures will be taken to keep the coefficient of weir discharge at the highest possible so that a small gate will meet the requirement. The flip angle of flip-bucket has been determined as 30 degree to let water jets reach the furthest point possible. With this flip angle, the flood discharge of 3,070 cu.m/sec is estimated to fly to the distance of about 140 m from the flip-bucket and finally dig by itself the water cushion with about 60 m deep though it takes a long time to do it.

The major dimensions of the spillway are as follows:

Location	:	right abutment of the dam
Type	:	gated chute with flip-bucket
Designed discharge	:	3,070 cu.m/sec
Water head	:	12.0 m (designed discharge)
Gate size:	:	H = 12.5 m, B = 11.5 m
Gate number	:	3 units
Width of chute	:	39.5 m
Slope of chute	:	1 : 3.70
Elevations	:	
Full water surface:	:	WL 334.5 m
High water surface	:	WL 334.5 m
Top of the spillway crest	:	EL 322.5 m
Approach canal	:	EL 315.0 m
Flip-bucket	:	EL 230.0 m
River bed	:	EL 200.0 m
Discharge velocity		
Approach canal	:	less than 4.0 m/sec
Crest	:	11.1 m/sec
Bucket	:	35.9 m/sec

6) Outlet Work

When the construction of dam and appurtenant works is completed, the diversion tunnel will be plugged. Therefore, the Palsiguan river flow will be cut here. However, there are irrigated lands on the Palsiguan downstream reaches of the dam site to which the Palsiguan water is supplied as mentioned in III. C.1. Furthermore, the Palsiguan river itself should maintain its functions as a river as it had before the construction of Palsiguan dam.

To cope with the above-mentioned, a pipe with a diameter of about 1.0 m will be laid through the tunnel plug. This pipe will be equipped with a control valve and an emergency valve, so that it will function as outlet work. A concrete wall with a certain height will be constructed at the middle of tunnel and a half of the tunnel cross section will be filled with soils to a height so that this platform will be passable to approach to the outlet work.

A vertical shaft will be erected at the tunnel upper most. Its uppermost will be located at the sediment elevation of dam, that is, at the elevation of 259 m. The capacity of this outlet work will be about 30 cu.m/sec at the full water level whereas about 22 cu.m/sec at the low water level.

The outlet capacity is much bigger than the water quantity to be required in the downstream irrigated area (less than 1 cu.m/sec), however, this capacity is required to drain the reservoir water lower than the designed low water level for the maintenance of the dam.

The layout drawings of the Palsiguan dam are attached hereto as Drawing No.001 to No.003.

2. Headrace Tunnel and Power Plant

a) Geology of Tunnel

The proposed Palsiguan headrace tunnel route is aligned starting from a point at the tributary of the Dogot river running through the proposed reservoir area to reach straight in the Nueva Era in crossing the Cordiella Central of Luzon. The geological survey for the new tunnel route was made by one core boring at the inlet of the original tunnel route, and the field investigation has revealed that almost of whole route is geologically composed of dacite and basalt with penetration of diorite.

The geology around the tunnel inlet is dominant by dacite, and boring at the weathered zone found the thickness of its layer to reach as deep as about 20 m. The field investigation also found outcropping of fresh dacite on the river bed with about three meters thick terrace deposits distributed.

As a result of the core boring and observation on the outcropped rocks, geological composition of the proposed route is assumed to be with fresh, hard and compacted rocks; however, a great care should be exercised in excavation of the site at the tunel inlet where the earth coverage is considerably thin because there have been some joints and cracks observed around there.

The proposed tunnel route is laid out to cross the geological formation line developing along the Cordiella Central of the Luzon. Therefore, it is essential to take measures for expecting spring water from faults or fractured zones, and loosening of rocks by mineralization.

There is dacite found as a major rock around the proposed power station site, and particularly, fresh dacite outcrops on the river bed. Under the conditions, the power station is planned to be constructed on the sound rock foundation about 70 m below the ground surface.

The upstream site of the tailrace tunnel is composed of dacite, while the downstream site of conglomerate. A fault fructured zone can be observed at the contact portion of these two kinds of rocks as clearly as the boring survey made could find out.

b) Design of the Headrace Tunnel

The headrace is the facility to serve to drive the water from the Palsiguan reservoir to the Bonga river by means of transbasin for the dual purposes of irrigation and hydropower generation. The maximum design discharge is 28.225 cu.m/sec. The proposed route has been determined in this plan in terms of economy after making comparative study of the alternative tunnel route. The length of the route is 6,150 m, and 60 m of the intake portion is added to make the total length by 6,210 m, which functions as the pressure tunnel serving for the power generation as well. When taking the standard horseshoe shape as typical section, therefore, the economic radius suitable as the pressure tunnel was estimated at 1.80 m.

The design tunnel lining thickness is 0.40 m and the steel bar required for tunneling is estimated at 60 kg/m^3 (in concrete) taking the water pressure into account. The section so designed can be said to be the minimum section in terms of construction works with the total length of 6,105 m.

Typical design of headrace tunnel is shown in the attached Drawing No.004.

c) Power Plant

1) Bonga Power Station

Surge Tank

A differential type surge tank has been adopted in planning the Bonga power plant. The said surge tank is designed with 12.0 m in tank diameter, 90 m in tank height w.6 m in riser diameter and 3.6 m in port diameter, as a result of necessary surging computation. However, chamber surge tank, which might be suited to the proposed plant with considerably long tunnel and heavy drawdown expected, should be taken into consideration in the detailed design stage.

Penstock

Penstock being connected with the underground power plant, will be provided in the ground with average bore diameter of 3.0 m, total length of 208.0 m including 116.8 m of vertical portion. The penstock, having 11.0 mm thickness on an average, should be placed on the 80 cm reinforced concrete to transfer internal pipe load on the bed rocks.

Power House

The underground power house is designed with 16.5 m span of arch and 1.2 m crown thickness. The power house will have 33.0 m in height and 20.0 m in length. The center of the turbine will be set at EL 145.0 m. Geologically, the proposed site is expected to provide good foundation rock with sufficient bearing capacity for power house.

Afterbay Chamber

An afterbay chamber with a large section will be provided immediately downstream of the draft tube for surging control of the downstream tailrace. An air duct will be installed at the afterbay chamber with its outlet open outside through the duct provided for surge tank construction works.

Tailrace and Outlet

The tailrace of non-pressure type tunnel (2,950 m in length) with 3.80 m diameter is so designed that it has the maximum discharge of 28.225 cu.m/sec with a slope of 1/1,000. The tunnel lining will be made in 0.40 m thickness with reinforcing steel bar against expected flood pressure.

The designed water level of the outlet is EL 150.0 m and the outlet should be located at the place where the sediment will not develop easily in the Bonga river for facilitating to flush sands from the outlet.

Turbine and Generator

The Deriaz type turbine with variable pitched blades is recommended in this power plant that provides various conditions such as water level drawdown as large as 59.5 m, maximum effective water head of 170.65 m and discharge fluctuation from maximum 28.225 cu.m/sec to 9.50 cu.m/sec. The diamter of the runner inlet and the number of revolution are economically determined by 2,100 mm and 450 rpm respectively. And the rated output is 36,000 KW. One set of the turbine of this type will be installed together with a set of generator with capacity of 39,600 KVA.

The regular maintenance of the power plant will be made in every August when no irrigation requirement is expected, and the specific facilities for discharging irrigation water will not be provided.

This power plant will be operated by the remote control system from the Nueva Era Power Station, so that managerial cost can be reduced as much as possible.

The effective water head was obtained at 149.30 m from computation on the basis of 10-year average water balance in the reservoir. The layout of the Bonga power plant is illustrated in the attached Drawing No.005.

2) Nueva Era Power Station

Penstock

The penstock, welded steel pipe embeded to the dam body, will link the intake tower attached to dam and the power station located at immediate downstream of dam. The penstock has 3.0 m in diameter, 11.0 mm in thickness and 30.0 m in length, providing gate at its inlet and expansion joint at its outlet.

Power House

The power house is designed in steel-frame reinforced concrete structure with 16.00 m in width, 18.0 m in length, 13.5 m in building height and 12.0 m in foundation height. The generator room provided in the house will equip a crane with 9.0 m span for mounting and maintenance works of the main body of the generator. An afterbay with 6.0 m in width and 16.0 m in length will be constructed at immediate downstream of the draft tube, linking with an irrigation canal. And the floor elevation of the generator room is designed as EL 126.00 m in considering the floodings.

Turbine and Generator

The Nueva Era power plant will function to regulate, in the reservoir, the discharge from the Bonga power plant and to release the stored water to meet the irrigation requirements through the gates. The regulation at the Nueva Era reservoir will range from 29.273 cu.m/sec to 8.00 cu.m/sec in the discharge. The effective water head is as small as only 27.92 m. Hence, the vertical Kaplan type turbine is adopted for this power plant. The diameter of the runner inlet and the number of revolution are 2,050 mm and 327.5 rpm, respectively. One set of the turbine with 6,800 KW output capacity in this type will be installed in the power house together with a set of generator with 7,480 KVA capacity.

The regular maintenance works for the power equipment will be made in time when no irrigation requirements arise, and the specific facilities for irrigation will not be provided. The layout drawings of the Nueva Era power plant are attached hereto as Drawing No.006.

Transmission Lines

The NPC's power transmission program in 1979 defines that the existing 115 KV transmission line between the Narvacan sub-station and the Laoag sub-station will be converted in use as 69 KV when the new transmission line of 230 KV is connected to the Narvacan sub-station. The transmission plan in this Project should be formulated in accordance with the above mentioned NPC's program, but since, the NPC's program has not actually defined its schedule of implementation, the plan in this Project was made up on the premise that the 115 KV line would be laid down between the both sub-stations in future.

The two lines, one by the NPC's Luzon Grid (115 KV) and the other by this Project, are designed to be connected at Badoc. Furthermore, 115 KV line will be installed with wooden poles in single circuit between Badoc and the Nueva Era power station (about 22.0 km) as well as between the Nueva Era power station and the Bonga power station (about 3.8 km). The conductor size, in that case, will be taken by 336.4 MCM, ACSR.

3. Nueva Era Dam

a) Geology of Nueva Era Dam Site

This dam site is located about 1.5 km south of Nueva Era town where the mountainous area meets the plain. Terrace deposits are observed from the immediately downstream of the dam site toward the downstream reaches. Specially, the terrace deposits are thickly accumulated on the downstream reaches of Nueva Era town.

The Bonga river running through the dam site comes from the Cordillera Central Mountains of the Northern Luzon, meanders to the north, and flowing down along the western boundary of the Phase I Project Area, pours itself into the South China Sea. The downstream portion of this big river is called the Laoag river.

The reservoir area is located on the plateau-like mountainous zone with an elevation of 200 to 300 m. The left mountain slope at the dam site is about 45° whereas the right slope is about 30°. The river bed is about 150 m wide at the dam site. The length-height cord (form factor) of the dam site at the elevation of 50 m upon the dam axis is 6.1 (190/31). The valley shows an adverse trapezoid with a long bottom side.

The dam site and its surrounding area are mainly underlain by agglomerate ino which shale and sandstone layers partially intrude. On excavated surfaces along the road on the left bank, outcrops of this rock are continuously observed though they have been mostly weathered to a great extent. The gravels have onion structures, and the matrix has been laterized. However, very massive and fresh rocks are continuously observed on the river bed.

Bore-hole drilling and the seismic prospecting were conducted in the geological study of this dam site. Details of the surveys are tabulated below, and survey results are shown in Figures 3B-23 to 3B-31 in Appendix 3B-3.

The above-mentioned study has revealed that the dam site is mainly underlain by agglomerate as already mentioned above, river deposit is distributed to the depth of about 15 m on the river bed, and terrace deposit with about 18 m thick exists on the right abutment portion.

Bore-hole Drilling Works

Bore-hole No.	Location	Depth
DDH-1	Left abutment	30.0 m
DDH-2	River bed	30.0
DDH-3	River bed	30.0
DDH-4	Right abutment	31.6
DDH-5	Right abutment	32.5
DDH-6	Left abutment	50.0
Total:	6 Bore-holes	204.6

Seismic Prospecting Works

Seismic Line	Location	Length
No.1	Dam axis	400 m
No.2	Downstream of the dam axis	400
No.3	Left bank	300
No.4	Right nank	300
No.5	Left abutment	200
No.6	Right abutment	200
No.7	Left abutment	100
No.8	Right abutment	200
No.9	Upstream of the dam axis	400
Total:	9 seismic lines	2,500 m

The bore-hole drilling has revealed that the base rock is weathered to five to ten meters deep only on the both abutment portions. On the contrary, no weathered layers are distributed on the river bed. The terrace deposit on the right abutment portion is mainly composed of sandy layers, and soft to a considerable degree. The rock test of the agglomerate, base rock of this dam site, was conducted, and results are tabulated below;

Rock Test Result, (Nueva Era Dam)

Sample No.	Bore Hole No.	Bore Hole Depth (m)	Compressive Strength (kg/cm^2)	Specifc Gravity	Absorption (%)
No.1	DDH-1	10.37 – 10.87	251.9	2.94	4.0
No.2	DDH-2	7.68 – 7.91	292.2	2.74	5.7
No.3	DDH-3	15.50 – 16.13	272.9	2.72	3.6
No.4	DDH-4	21.60 – 21.93	206.9	2.79	8.2
No.5	DDH-5	21.60 – 21.80	227.1	3.03	8.4
No.6	DDH-6	3.17 – 4.50	256.2	2.79	5.1
Average			251.2	2.84	5.8

Having the unconfined compressive strength of 251 kg/sq.cm, the specific gravity of 2.84 and the absorption of 5.8 percent on an average, this agglomerate falls in the category of medium compact rock.

The seismic prospecting shows that the velocity layer of this dam site is subdivided into four layers as follows;

Distrivution of Velocity Layers

Velocity Layer	Velocity	Geological Condition
No.1 layer	0.4 to 0.5	Surface soil, talus deposit and soft river deposit
No.2 layer	1.0 to 1.5	Terrace deposit and weathered layers (Earth and sand or gravel cores)
No.3 layer	2.0 to 3.0	River deposit and fresh rocks
No.4 layer	4.0 to 4.4	Fresh rock
Low velocity layer	2.0	Not existing

At this dam site, a gravity concrete dam with a dam height of 45.5 m has been planned. No crushed zones, which hinder the construction of a concrete dam, have been found in the geological surveys so far conducted. As for foundation treatment, river deposit as well as terrace deposit distributed on the right abutment portion shall be excavated to remove. Furthermore, out of the weathered base rocks, a part of the medium weathered rocks shall be removed since it has already become a kind of soil, and has insufficient bearing capacity. Cracks have been developed in the weakly weathered rocks. Though their bearing capacity might be sufficient for the dam, these rocks should be removed in consideration of the safety of the dam body since the layer is considerably thick.

b) Selection of Dam Type

Nueva Era dam will regulate discharge for hydropower generation. To meet this requirement, a concrete gravity dam with the height of 45.5 m from the base rock has been planned. This type of dam has been selected for the following reasons;

i) The drawdown of water level of this regulating reservoir is so small as 1.5 m. The water level shall be controlled near the full water surface almost throughout the year, and yet this reservoir shall regulate both discharge from Bonga power station and run-off from its own catchment area of about 52.4 sq.km. Therefore, gate operation of this reservoir will be very complicated. Under the situations, it can be said that this dam might be sometimes jeopardised by over flow. To secure the safety of dam body under such conditions, a concrete dam has been selected.

ii) In case of a concrete gravity dam, an over flow type spillway can be constructed on the dam body to release flood discharge. This way of construction of the spillway saves much its construction cost.

iii) Furthermore, no temporary diversion tunnel is required since such facility is economically constructed across the dam body under the topographic conditions of this dam site.

iv) Base foundation rock having sufficient bearing capacity is favorable for construction of concrete gravity dam at the site, and also the site is suitable for concrete gravity dam from topography.

v) Concrete aggregate of a high quality can be obtained about 3.5 km downstream reaches of the dam site.

vi) Since the power station site can be located immediately downstream of the dam body, its intake and penstock can be constructed directly on the dam body, resulting in very economical construction.

As mentioned above, a concrete dam has been selected to save the construction cost of the spillway and temporary diversion channel, etc., paying attention to the required dam height and narrow valley width.

It can be said that, in planning this dam, attention should be paid, with the first priority, to the safety of dam since a complete run-off analysis has not been made due to the shortage of data, and moreover, this dam has to deal with flood discharge, keeping the reservoir water level near at the full water surface almost throughout the year.

c) Major Dimensions of Nueva Era Dam

The major dimensions of this dam are shown below;

Major Dimension of Nueva Era

Reservoir			
Catchment area		52.40	sq.km
Storage capacity		4.99	MCM
Effective capacity		0.50	MCM
Full reservoir area		0.272	sq.km
High water level	EL	150.00	m
Low water level	EL	148.50	m
Drawdown		1.50	m
Design flood discharge		970.00	cu.m/sec
Dam			
Dam type		Roller-compacted concrete gravity dam	
Dam height		45.50	m
Crest length		220.0	m
Dam volume		141,000	cu.m
Slope, upstream		Vertical	
downstream		1 : 0.88	
Overflow crest	EL	144.30	cu.m
Overflow dimension	Width 45.0 m, depth 5.70 m		
Apron dimension	Width 45.0 m, length 35.0 m		
Gate	Five, 6 m high x 7 m wide		
Diversion Channel			
Type	Open canal and tunnel in dam		
Dimension	10 m wide x 7 m high		
Canal length		466.0	m
Design flood discharge		320.0	cu.m/sec

d) Dam Type and Construction Method

From the view point of construction method, the roller-compacted dam has been selected for this dam, taking into consideration the following;

i) The cement quantity per cubic meter amounting to 120 to 130 kg required for a roller-compacted dam (RCD) is much smaller than that of 170 to 180 kg for the other general gravity dams.

ii) The compaction is made by vibrating roller. Therefore, a small water-cement ratio will secure a sufficient strength of the dam body.

iii) One lift in concrete placing is made in two stages. Therefore, the height of concrete to be placed in one stage is so low as 0.75 to 0.80 m. Because of this low height of concrete and a small quantity of cement per cubic meter, the heating value of concrete becomes low. Cooling after concrete placing is not necessary, accordingly.

iv) One of the advantages of the RCD is that a costly cable way system is not necessary for hauling since concrete can be transported by truck to the placing point, resulting in easy and economical construction.

v) The dam height is low, and the maximum designed vertical strength in earthquake is about 91.5 ton/sq.m. Under the situations, no high strength of concrete is necessary.

vi) Concrete hauling is made by truck, so the access road can be routed as may be required. The construction period can be shortened to a considerable degree, accordingly.

Taking into account the above-mentioned items, the RCD is considered the most appropriate and economic, specially in the Philippines where the price of cement is high.

e) Stability Analysis of Dam

A computerized stability analysis of dam has been made to determine the slopes of this concrete dam. The analysis has revealed that the upstream surface of this dam can be constructed vertically, whereas the downstream surface will have the slope of 0.88. This downstream slope is larger than that of general concrete dams because of deep sedimentation at the dam site. The major designed dimensions of this dam are shown below;

Design Dimension of Dam

Designed seismic coefficient:	0.15
Designed safety ratio:	5.0
Unit weight:	2.35
Shearing strength of base rock:	180.0 ton/sq.m

Dam height:	45.5 m
Free board:	2.0 m
Dam height from the upstream slope:	27.0 m (from the dam crest)
Upper slope of the upstream surface:	0.0
Lower slope of the upstream surface:	0.2
Earth pressure coefficient:	0.5
Lifting pressure coefficient:	0.2
Sedimentation depth:	7.7 m (from the dam crest)

Details of the stability analysis are shown on Table 4D-3 in Appendix 4D-5. Typical design of Nueva Era dam is shown in the attached Drawing Nos. 007 to No.009.

f) Concrete Aggregate

Concrete aggregate is available on the Bonga river bed about 3.5 km downstream of the dam site. The grain size distribution is shown on Figure 3B-42-1 in Appendix 3B-4. The fine materials at the quarry have favorable grain sizes whereas the coarse materials with a large diameter are short. However, such materials are obtainable at the immediately downstream reaches of the dam site. Under the situations, aggregate materials covering all necessary grain sizes are available as a whole.

g) Temporary Diversion Channel

The design flood discharge during the construction period is determined at 320 cu.m/sec. To deal with this flood discharge, a diversion channel will be excavated on the right bank, and a tunnel with 10.0 m wide and 7.0 m high will be constructed across the dam body. Therefore, this portion of dam concrete should be completed early so that the tunnel can play its role in the dry season.

Taking into account the high permeability of the gravel layers on the river bed and the deep excavation of about 15.0 m, the canal will be so long as about 470 m to avoid piping.

4. Diversion Dam

a) Madupayas Diversion Dam

1) Dam Sites

The location of Madupayas diversion dam has been determined at a little downstream portion of a bend of the river where the river water route is stabilized in consideration of the elevation requirements to divert irrigation water to service areas in Batac and to make the canal routing easy. The foundation rock of the site is comprised of agglomerate, and the site is covered relatively thick river deposite ranging from 7 m to 13 m. However, these deposits consisting of sand and gravel have sufficient bearing capacity for the construction of the diversion dam. Therefore, there is no problems about the stability of structures.

Under these conditions, the selected dam site (hereinafter referred to as the dam site) has advantages in its river conditions as follows.

i) The river water route is stabilized near the left bank where intake facilities will be provided;

ii) Short length of cofferdam is reasonable for saving construction cost of the dam;

iii) Foundation condition is favorable; and,

iv) No adverse effects which might be brought about on the river system by damming-up of the discharge will be occurred.

2) Type of Head Works Adopted

Taking into consideration the thick river deposit as already mentioned above, floating type of head works has been planned. The head works will be equipped with a diversion dam (with the scouring slice, fixed weir and cut-off wall), intake and appurtenant facilities for safe and stabilized diversion of water and also for the utilization of all the river discharges during the dry season.

3) Design of Diversion Dam

Scouring Sluice

A big volume of sediment transportation is anticipated at the dam site during flood seasons. The scouring sluice has been planned to keep always the water route as it is expected and to flush away sand and gravel being accumulated during diversion periods. This scouring sluice will also play a role of the sedimentation basin. For a high velocity scouring sluice way, a jet-flow has been planned to strengthen the capacity of flashing away and flowing down the sand and gravel as far as possible. To increase the said capacity, guide walls have been planned for both upstream and downstream reaches.

Fixed Weir

It is hardly anticipated that the damming-up at the site will give adverse effects to the other portion of the river systems, so fixed weir type has been proposed. In general, the dam height is determined to meet the required water level for irrigation and also based on the functional capacities of head works.

The dam site elevation is high enough to supply water to the service area, so the crest elevation is determined at EL 86.15 m (dam height 3.00 m) based on the functional capacity aspect of the head works. The floating type of dam has been planned as the dam will be constructed on the river deposit.

Cut-off Wall

Except flooding periods, river water will flow over the fixed weir, but to cope with flood discharges, the high water channel with cut-off wall has been planned.

4) Intake Facilities

The intake should meet the requirements of smooth diversion of water and also prevention of sediment intrusion. So, i) the elevation of the intake sill is designed one meter higher than the scouring sluice and ii) the intake width is designed to keep the intake velocity as low as 0.6 m/sec. The scouring sluice way located in front of the intake plays a role of sedimentation basin. Therefore, intrusion of sediment to the intake is hardly anticipated during the normal water levels. On the other hand, during flood discharges, sediment of small diameter comes into the intake though big ones can not come into because a spiral flow of water is formed in front of the intake when the scouring sluice gate is open. The small particles do not harm irrigation canals and paddy fields. So, no sedimentation basin has been planned on the downstream of the intake. For easy operation, the gate span is determined at three meters.

b) Tibangran Diversion Dam

1) Dam Sites

Taking into account the necessary elevation to divert irrigation water to service areas in Badoc and also the river conditions, the location of diversion dam has been determined at the portion where the river water route is stabilized. The foundation rock of the site is comprised of agglomerate, and the lock is exposed at a part of river bed located on the left bank, however, river deposit gets considerable deep with its maximum depth of 42.0 m toward the right bank of the river. Under the situations, the intake and scouring sluice, etc., would be constructed on the rock foundation at this site, however, fixed weir would be constructed on the river deposit with floating type.

The deposit consists mainly of sand and gravel, although shale is partially distributed, therefore, the site has sufficient bearing capacity for the construction of the diversion dam.

2) Design of Diversion Dam

Same idea and procedures as taken in the designing of Madupayas diversion dam have been adopted for the design of Tibangran diversion dam. The hydraulic calculation for determining major dimensions of the facilities are given in Appendix 4D-6.

The following table indicates the major dimensions of above two diversion dams. The geological conditions of the proposed dam sites are given in Appendix 3B-4.

Major Dimensions of Diversion Dam

Item	Madupayas	Tibangran
1. Catchment Area (sq.m)	24.3	72.7
2. Estimated High-Water Discharge (cu.m/sec)	320.0	950.0
3. Necessary Intake Discharge (cu.m/sec)	4.00	7.71
4. Necessary Intake Water Surface, N.W.L. (m)	86.00	36.50
5. Dam Crest Elevation (m)	86.15	36.65
6. Dam-up Height (m)	3.00	2.50
7. Location of Intake	Left bank	Left bank
8. Dam		
Scouring Sluice	5.0m x 1set	7.0m x 1set
Fixed Weir Length (m)	44.00	73.00
Cut-off Wall Length (m)	32.00	46.00
Intake Facilities	3.00mx1.70mx2sets	3.00mx1.60mx4set
Dam Type	Floating type	Floating type

Typical design of two diversoin dams mentioned above is shown in the attached Drawing Nos. 010 to No.013.

5. Irrigation Canals

Irrigation canals in the project except on-farm canals are classified into link canals, main irrigation canals, and lateral irrigation canals.

a) *Link Canal*

The main link canal having the design discharge of 28.225 cu.m/sec will function to convey released water in the outlet of Nueva Era power station to Nueva Era diversion works, from which two link canals (Link Canal-1 and Link Canal-2) will be extended the west and east to supply water to main irrigation canals. The Link Canal-1 will convey irrigation water for the areas of Nueva Era (R.B.), Papa, Madongan, Solsona and Labugaon in the Phase I Project and Cura area in the Phase II Project. The Link Canal-2 will convey the water to Batac-Badoc areas in the Phase II Project and is furthermore divided into two link canals, Link Canal-3 for Pinili and Batac areas and Link Canal-4 for Badoc area respectively, by Madupayas diversion works.

1) Canal Alignment

Based on the 1/10,000 and 1/50,000 topographic maps, canal routes have been determined to meet the elevation requirements to supply irrigation water to the whole service areas and to minimize the canal construction cost.

2) Canal Section

In principle, the earth canal has been planned, but thin concrete lining or flume type canals will be partially provided where topographically and geologically required. Tunnels, siphons, culvert and aqueducts have been also planned where necessary. The canal cross section will be tropezoidal with the side slope of 1 : 1.5. The discharge velocity in the earth canal portions is limited around 0.6 m/sec to prevent deposition of silt or growth of aquatic plants and moss and also to prevent scouring. The design is made based on the Manning's formula in consideration of the topographic conditions. It will have a base-depth ratio of 2.5, side slope of 1 : 1.5 and coefficient of roughness "n" of 0.025. Design criteria of irrigation canal are shown in Appendix 4D-7.

3) Related Structures

Canal Structures

Various structures related to the irrigation canal will be needed to convey irrigation water from the outlet of Nueva Era Power Station to the end checks. An inverted siphon will be used where a canal goes across river and creek whose maximum flood elevations are close to or above the canal grade line.

When the maximum flood elevation has 0.9 meter allowance or more from the side grade line of canals, an aqueduct may be used. Road crossings will be provided when canals pass across the existing or proposed roads. Bench flumes and chutes/drops may be needed for water to flow safely to a lower part. Thresher crossing will be placed at convenient points where there is no road crossings.

Diversion Structures

Two types of diversion works are planned in order to divert irrigation water, that is, separating type diversion works in the link canals and culvert type diversion works to divert water from the link canals to main and lateral canals.

Regulating Structures

In some points along the canal system, especially at the headgates of main and lateral canals, regulating structures will be provided to raise the canal water elevation higher than normal one when water is less than the designed discharge. An example of this is a check structure constructed across the main or lateral canals, in order to raise the water surface elevation and allow the desired amount of irrigation water to enter into the main and lateral canals.

Protective Structures

The protective structures are to be provided in canals in order to prevent excess water from flowing into the canal and also to prevent canal waters from flowing out, which causes destruction of canal embankment. Spillway will be provided to release excess water in the canal to a drainage canal. The optimum protective structures should be selected in consideration of the canal water level. When the water level of waterway is lower than the canal bottom elevation, a culvert will be needed. When the water level of waterway is higher than the canal bottom elevation but more than 30 cm lower than the canal water level, a siphon will be used.

b) Main Canals

The alignment of main canals has been determined to irrigate the maximum area with the shortest canal length. The unlined earth canal will be mostly adopted and small portions will be lined with thin concrete where the leakage of water is anticipated. Its section will be trapezoidal with the side slope of 1 : 1.5. The discharge velocity in main irrigation canals will vary from 0.6 to 1.0 m/sec. The incidental facilities have been planned where main irrigation canals go across rivers and roads, etc.

c) Lateral Irrigation Canals

Lateral irrigation canals have been planned based on the proposed development plan of on-farm facilities. Most of them will be of earth though thin concrete lining will be provided where the leakage of water is geologically anticipated. Necessary related facilities, especially shute and drop works have been planned based on the topographic conditions.

The estimated total length of irrigation canals are as follows, and canal intensity excluding link canals is estimated at 27.2 m/ha as a whole.

Link canals	:	96.0 km
Main canals	:	96.6 km
Lateral canals	:	240.2 km
Total		432.8 km

Typical design of irrigation canals and their appurtenant structures is shown in the attached Drawing Nos. 014 to No.035.

6. Drainage Canals

a) Allocation of Canals

On the both basins of Badoc and Batac rivers which are main rivers in the Project Area, the river improvement has been planned by Ministry of Public Works. The said Project includes the rechecking unit design drainage modulus, construction of sea dike and revetment and river mouth excavation, etc. Accordingly, these rivers are excluded from the Project in this time.

After making survey on the existing drainage systems in the Project Area, the drainage canal systems were plotted on the topographical map of 1 : 10,000 in scale. Existing waterway like river, creek, etc. will be utilized as main or lateral drainage canals as much as possible, considering the economical and topographical conditions. However, most of existing waterways have to be dredged and widened to cope with the designed discharges.

The estimated length of proposed drainage canals are estimated as follows;

Length of Proposed Drainage Canal

Description	Length of Drainage Canal
Main drainage canal	75.3 km
Lateral drainage canal	47.8 km
Total	123.1 km

The intensity of drainage canal in the Project Area will be about 10 m/ha. This value does not satisfy the NIA's criteria, but it is considered that the length above-mentioned seems to be enough for the following reasons; i) about 40 km of rivers to be improved under the River Improvement Project by Ministry of Public Works is not included in the above-mentioned drainage canal length, and ii) existing small rivers and creeks can be utilized as drainage canals in the Project.

b) Canal Section

Based on the topographic map with a scale of 1 : 10,000 and 1 : 50,000, drainage areas of each canal are estimated, and the design drainage discharge of canal is computed by the drainage areas and drainage modulus. As the result, the maximum drainage area of main drainage canal is about 7,835 ha (paddy field: 2,315 ha, hilly land: 6,520 ha) and its drainage discharge is 217.11 cu.m/sec (= 2,315 ha x 0.00760 cu.m/sec/ha + 6,520 x 0.0306). The design discharge of drainage canal ranges from 2.05 cu.m/sec to 217.11 cu.m/sec, but 80 percent of the total length of drainage canal is of less than 50 cu.m/sec in discharge.

To decide the canal section, the following criteria were adopted (ref. to Appendix 4D-8 in detail)

- o Drainage canal is trapezoidal earth canal based on the NIA design criteria.
- o Side slope of drainage canal is 1 : 1
- o Manning's formula is applied (n = 0.025)
- o Maximum permissible velocity is 1.0 m/sec, considering the prevention of scouring of drainage canal
- o Ratio of bottom width and depth is 1 : 1.25 using the most hydraulically efficient section, but the maximum depth of canal is three meters.

c) Related Structure

To prevent the scouring of drainage canal, the drainage drop will be needed. This structure is made with grouted riprap.

Design of drainage canals is shown in Appendix 4D-8, and standard sections of drainage canals and related structures are shown in Drawing Nos. 036 and No.037.

7. Roads

The two types of roads would be provided in the Project Area; namely, i) services roads to be constructed along the link and main canals and ii) those along the lateral canals.

Service roads to be constructed along link and main canals will have the surface width of six meters whereas those to be constructed along lateral canals are four meters. The proposed cross section of above two type of roads have a surfacing of 15 cm thick of base coarse and selected borrow of 20 cm thick.

The total length of the proposed service road is as follows;

Type A	(along link canals)	94.8 km
	(along main canals)	96.6 km
Type B	(along lateral canals)	240.2 km
	Total	431.6 km

Road intensity in the project is estimated at 27.2 m/ha excluding those along link canals. Typical design of the proposed section is shown in Drawing No.038.

8. On-farm Facilities

a) General Description

As mentioned in the Chapter IV, B.6. Farm Land Development (On-farm Level), the terminal facilities are main and supplementary farm ditches, diversion boxes, end checks, farm drains, various canal crossing structures and farm roads. These facilities should be designed according to the criteria of on-farm water management proposed by NIA on September, 1978. For the facilities which are not provided in the design criteria, the design of them are made according to the intensions of the said design criteria.

There are many existing communal irrigation canals in the Project Area and these existing canals work as irrigation and drainage canal systems. Consequently, this existing canal should be used as irrigation or drainage canal as much as possible after completion of the Project from the view points of economy.

Main and supplemental farm ditches, farm drains and farm roads shall be made by the earth, and surface of farm roads will not be paved by gravel or other materials.

The construction and operation and maintenance of on-farm facilities, excluding field ditches and field drains of which construction will be made by farmers, will be undertaken by the NIA.

b) Model Design at Sample Area

In order to give the shape to the concept of the proposed terminal facilities, the model design of roads and irrigation & drainage canals as well as land parcelling were actually carried out at the three sample areas. Furthermore, the required costs for on-farm development were estimated and their results were applied to the design of on-farm development works in the whole Project Area.

Site Selection for Sample Area

Two sites for sample area for designing on-farm facilities were selected in the Project Area in this stage. Sample Area No.1 was selected for the representative of the area with considerable flat topographic condition, and its area is about 175 ha. Sample Area No.2 was the representative of shifting land from sloping topographic to flat land, and its area is about 120 ha.

The feature of sample areas is as follows:

Sample Area No. 1 : located north of the national road between Batac and Paoay and in the eastern part of Paoay municipality. Existing communal irrigation canal in the sample area will be utilized in the Project.

Sample Area No. 2 : extended west along the National road No.3 and in the southern part of Badoc municipality. The communal irrigation canals is developed considerably.

In addition to the above two sample areas, the Solsona sample area which was selected at Phase I study was used as the representative area for Cura-Nueva Era area and the design of on-farm facilities for the Cura-Nueva Era area, will be performed by the sample area, which is named as Sample Area No.3.

Land Parcelling and Typical Design

The land parcelling in the sample areas was made based on the topographic map with scale of 1 : 2,000 surveyed by the NIA. In designing the land parcelling and on-farm facilities in the sample areas, the existing facilities such as canals were considered to be used after completion of the Project. And in designing on-farm facilities in sample areas, the rotation area is ranged from 30 ha to 50 ha and its average acreage is about 40 ha in the Sample Area No. 1 and No. 2, and 30 ha in the Sample Area No.3. The land parcelling and typical drawings of on-farm facilities in the sample area are shown in the attached Drawing Nos.039 to No.044. The areas and quantities of the on-farm facilities area summarized below.

Quantities of Sample Area

Description	Unit	Sample Area No. 1 (Paoay) Q'ty	per ha	Sample Area No. 2 (Badoc) Q'ty	per ha	Sample Area No. 3 (Slsona) Q'ty	per ha
Area							
Gross Area	ha	174.7		112.2		72.0	
Net Area	ha	167.4		106.8		69.4	
On-Farm Facilities							
Main Farm Ditch	m	2,720	16	720	7	170	2
		(1,180)	(7)	(1,430)	(13)	(750)	(11)
Supplemental Farm Ditch	m	8,290	50	6,000	56	3,460	50
		(1,740)	(10)	(800)	(7)	(1,870)	(27)
Farm Drain	m	10,770	64	9,730	91	4,240	61
Farm Road	m	4,270	26	3,600	34	1,600	23
Diversion Box	place	20		15		10	
End Check	place	20		15		10	
Cross Structure	place	42		26		17	

Note: Figures in parenthesis show the length of existing canal which is utilized even after completion of the Project.
Detailed estimates are given in Appendix 4D-9.

c) On-farm Facilities in the Whole Project Area

As mentioned previously, the sample areas are representative lands for flat topographic land and shifting land from sloping land to flat land, therefore, the results of sample estimation at the selected three areas are applied to estimate the required on-farm facilities and costs in the whole Project Area.

The whole Project Area of 12,400 ha is classified into following four categories based on the topographic map of 1 : 10,000 in scale:

Batac-Badoc Area:			
Flat area	(Sample Area No. 1)	----------	7,910 ha
Shifting area	(Sample Area No.2)	----------	2,410 ha
Nura-Nueva Era Area:			
Whole area	(Sample Area No.3)	----------	2,080 ha
Total			12,400 ha

E. Cost Estimate

The total investment cost, excluding the cost for price escalation during the construction period, is estimated at about 2,449.9 million Pesos (US$331.1 million) of which 1,557.6 million Pesos (US$210.5 million) will be foreign currency component and 892.3 million Pesos (US$120.6 million) will be an equivalent to local currency component.

Table 4-3 shows the breakdown of the investment costs by major items, and their detail estimation is given in Appendix 4E-1.

The irrigation project cost per hectare is estimated at 60,132 Pesos/ha[1/] (8,130 US$/ha), based upon the following conditions; i) depreciation costs of construction equipment are involved in the unit cost of civil works instead of cost for construction equipment, and ii) price escalation is not included (see Table 6C-61, Appendix 6C-4).

The annual disbursement schedule for the investment cost is shown in the Table 4E-3 in Appendix 4E-2. The cost estimates of the Project were made in the following manners:

1/ ₱ 1,358,991 x 10^3/22,600 ha = 60,132 ₱/ha

Table 4 - 3 Investment Cost of the Project

	Description	Total ₱'000	Total (US$'000)	Foreign Currency ₱'000	Foreign Currency (US$'000)	Local Currency ₱'000	Local Currency (US$'000)
1.	Civil Works[1/]						
	1-1. Preparation	52,131	7,045	19,511	2,637	32,620	4,408
	1-2. Palsiguan Dam	694,474	93,848	466,337	63,018	228,137	30,829
	1-3. Headrace	104,516	14,124	49,941	6,749	54,575	7,375
	1-4. Power Plants & Tailrace	173,715	23,475	123,938	16,749	49,777	6,726
	1-5. Nueva Era Dam	84,619	11,435	42,736	5,775	41,883	5,660
	1-6. Diversion Dam	21,219	2,867	11,521	1,557	9,698	1,311
	1-7. Irrigation Canal	323,466	43,712	133,245	18,006	190,221	25,706
	1-8. Drainage Canal	31,762	4,292	12,250	1,655	19,512	2,637
	1-9. On-Farm	23,112	3,123	2,472	334	20,640	2,789
	1-10. Road	23,918	3,232	9,716	1,313	14,202	1,919
	1-11. Pre-Engineering	5,156	697	0	0	5,156	697
	Sub-total	1,538,088	207,850	871,667	117,793	666,421	90,057
2.	Land Acquisition & Compensation	31,337	4,235	0	0	31,337	4,235
3.	Construction Equipments	466,000	62,973	465,000	62,838	1,000	135
4.	Agricultural Development	4,340	586	0	0	4,340	586
5.	Operation & Maintenance Cost	7,321	989	557	75	6,764	914
6.	Project Facilities	7,738	1,046	949	128	6,789	918
7.	Project Administration	57,340	7,748	0	0	57,340	7,748
8.	Consulting Services	18,157	2,454	16,269	2,199	1,888	255
	Sub-total (1 to 8)	2,130,321	287,881	1,354,442	183,033	775,879	104,848
9.	Contingency	319,550	43,182	203,167	27,454	116,383	15,728
	Sub-total (1 to 9)	2,449,871	331,063	1,557,609	210,487	892,262	120,576
10.	Price Escalation	1,193,336	161,262	670,487	90,606	522,849	70,656
	Total	3,643,207	492,325	2,228,096	301,094	1,415,111	191,231

Note: 1/ Exclusive of depreciation cost of construction equipments.

1) Civil Works

The cost of civil works consists of the construction cost on engineering works for the Project, which are estimated on the basis of unit cost including construction materials, fuel and oil, and repair of equipment and labor cost. The depreciation costs of the imported construction equipment and workshop equipment are not included in the item of civil works.

The major items of engineering works are as follows:

Preparation	:	to include necessary preparation works for the construction of Palsiguan dam, headrace inlet and outlet and diversion dams.
Palsiguan dam	:	to include the costs for diversion tunnel, dam foundation, dam embankment, spillway, and plug & outlet works.
Headrace	:	to include the cost for intake and pressure tunnel.
Power plant and tailrace	:	to include the costs for Bonga and Nueva Era power plants and related transmission lines.
Nueva Era dam	:	to include the costs for diversion works, dam body and gates.
Diversion dam	:	to include the costs for weir, gates and intake facilities of Madupayas and Tibangran diversion dams.
Irrigation Canal	:	to include earth works of main and lateral canals and related structures.
Drainage Canal	:	to include earth works of existing rivers, creeks, main and lateral canals and drop structures.
On-farm	:	to include on-farm facilities such as farm ditch, farm drain and farm road.
Road	:	to include the construction of service and access roads
Pre-Engineering	:	to include survey works for major facilities such as dam, tunnel, diversion dam, and irrigation and drainage facilities, hydrological observation and geological investigation. Descriptions on the required items are given in Appendix 5B-2.

2) Land Acquisition and Compensation

Land acquisition and compensation costs for project facilities are estimated.

3) Construction Equipment

The construction equipment and spare parts are purchased by the Government in the lump except small equipment which is available in the Philippines. The cost of construction equipment and spare parts are estimated on the basis of CIF San Fernando in La Union Province, exclusive of the custom duties and the other local taxes to be imposed in the Philippines.

Unloading cost at San Fernando port and transportation cost from the port to construction site are added to above purchase cost.

4) Agricultural Development

The costs required for agricultural supporting services are included.

5) Operation and Maintenance

The project cost involves operation and maintenance cost for five years from FY 1984 to FY 1987, during which the O & M is required for the project facilities constructed already in the construction period.

6) Project Facility and Project Administration

Project Facility:	to estimate the required cost for project facilities such as buildings, furnitures and equipment.
Project Administration:	to evaluate the overhead charge for government staff to be engaged in the newly organized project office.
	eight percent of required local currency in the items of (1) to (7) are alloted.

7) Consulting Services

Engineering fee for consulting services covers the implementation of final design and supervision of the Project (see Appendix 5D-1).

8) Contingency

Allocation for contingencies is included in the total base to cover minor differences in actual and estimated quantities, unforeseeable difficulties in construction, possible changes in plan because of site conditions or uncertainties regarding foundation conditions. The adopted percentages of contingencies on civil work for the Project are 15 percent.

9) Price Escalation

Price escalation was estimated using the following international price index of World Bank and the rate reported by Philippine Government:

Price Escalation Index

(Unit: %)

	1980	1982	1984	1986
Foreign content	10.4	8.0	6.7	6.3
Local content	16.0	8.0	8.0	7.0

10) Unit Cost

The cost of construction materials to be used in the Project is estimated on the basis of the prevailing prices as of January 1980, prepared by NIA. The labor cost is estimated on the basis of the wage rate of laborers for every type of job used by NIA.

The unit cost for construction on the contract basis includes ten percent for contractors' profit, overhead and miscellaneous as well as three percent for taxes.

11) Foreign and Local Procurements of Materials

The cost of such materials as cement, fuel and oil, deformed-bars, etc. is divided into two portions of foreign and local procurements as shown below:

Percentage of Foreign and Local Procurement

Item	Foreign Procurement (%)	Local Procurement (%)
Cement (Portland)	75	25
Fuel and Oil	50	50
Deformed-bar	80	20
Explosive (Dynamite)	–	100
Fuse and Cap	100	–
Bit and Rod	100	–

CHAPTER V. PROJECT IMPLEMENTATION

CHAPTER V. PROJECT IMPLEMENTATION

A. Executing Agency and Coordination

Ilocos Norte Irrigation Project involving irrigation and hydropower components is a part of the Ilocos Norte Integrated Rural Area Development Project (INIDP), so that the executing agency of the project will be organized and operated, prior to the establishment of the executing agency of the said INIDP. Under the situation, the NEDA will make overall coordination of the project whereas NIA and NPC will function as the executing agencies for implementation of irrigation and hydropower components respectively. In order to make a good coordination between above agencies, Joint NIA/NPC Technical Committee will be organized.

Under the control of the Project Manager, the divisions such as administration, agriculture, equipment and engineering will be organized. These divisions will keep close cooperation each other as shown in Figure 5-1, which indicates the Proposed Organization for the Project Implementation. In the organization, the Engineering Division would be responsible for preparation of plans, programs, design and construction cost estimates of facilities as well as necessary revisioins to be dictated by field conditions for the works designed in the central office. Equipment Division would be responsible for equipment management and operation.

The Administrative Division would be responsible for personnel and records management, accounting, property, procurement and other services. The agricultural phase of the Project would be handled by the Agricultural Division.

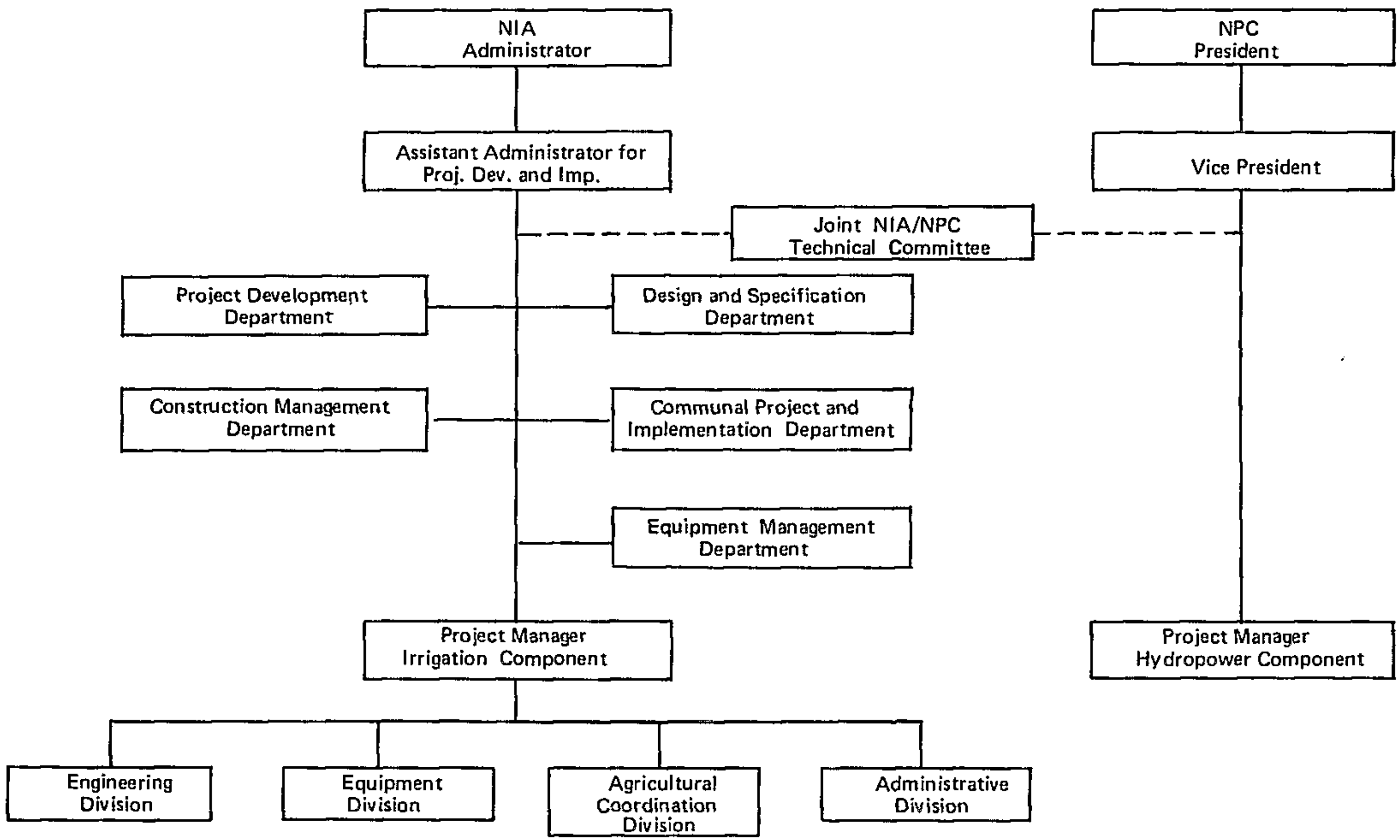
Furthermore, the Project Manager will keep close contact with local offices of the related Ministries and Authorities so that the Project works will be smoothly executed.

B. Construction Method and Schedule

1. Construction Method

The Project includes various kinds of civil works such as construction of a multipurpose dam, diversion dams, irrigation and drainage canals, roads, and hydropower plants, etc.

FIGURE 5-1 ILOCOS NORTE IRRIGATION PROJECT
PROPOSED ORGANIZATION CHART FOR PROJECT IMPLEMENTATION



There are two ways in implementing such civil works, that is, force account and contract basis. The contract basis will be adopted in the Project for the following reasons:

- Shortage in the number of engineers and skillfull equipment operators in the related organizations; and
- Intension to level up the technology of contractors

Under the circumstances, contractors will execute the construction works by making use of machinery and materials to be imported by the Government.

2. Construction Schedule

The Project involves relatively large-scaled civil works. Apart from this, the construction period will inevitably depend upon the work volume, climate condition and existing planting conditions of crops. Especially the construction period of civil works is naturally restricted by climate and hydrological conditions in the area. Namely, the structure of Palsiguan dam, Nueva Era dam, diversion dams, canals and on-farm facilities should be constructed in the dry season, November to May, to avoid the damage caused by river flooding.

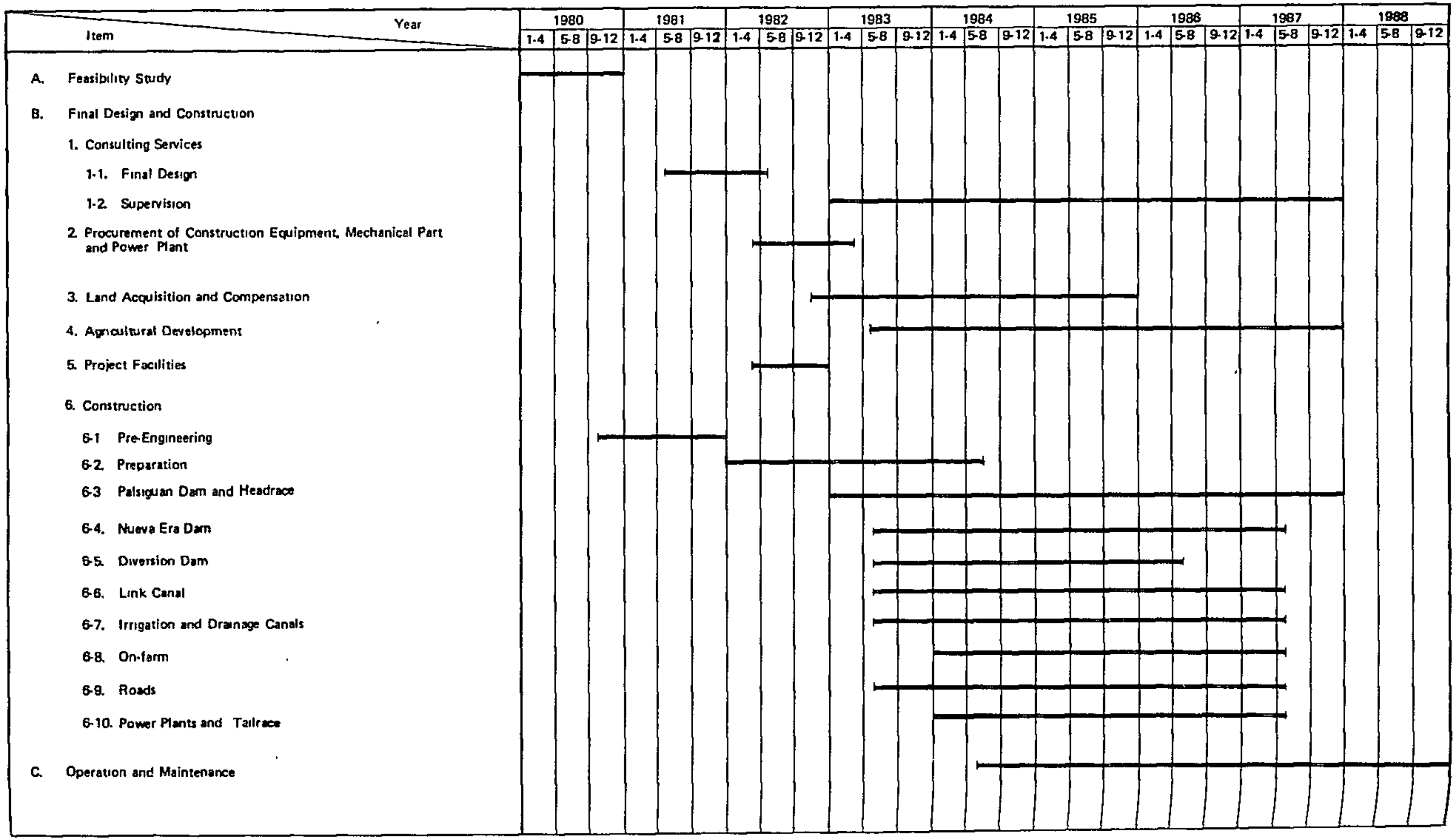
In consideration of these facts, the construction period of seven years from June 1981 to December 1987 has been scheduled including the final design from June 1981 to May 1982, and the construction of facilities will start in FY1983 (see Figure 5-2).

Construction planning of the major civil works is given in Appendix 5B-1. In order to complete the Project in FY1984, due consideration shall be paid to the following items.

i) Final design for the Project should be completed in May 1982 and, by that time, the tender for procurement of construction machinery and materials shall be completed.

ii) Observation, surveying and geological investigations at the sites of major facilities shall be completed before the commencement of final design (see Appendix 5B-2).

FIGURE 5-2 IMPLEMENTATION SCHEDULE FOR THE PROJECT



C. Operation and Maintenance

1. Executing Agency and Organization

Upon completion of the Project, the entire Project works will be turned over to the NIA Regional Office No. 1, and the responsibility for operation and maintenance of all irrigation and drainage facilities will be given to the newly organized Ilocos Norte Irrigation Systems Office (INISO).

The proposed organization chart for the operation and maintenance is shown in Figure 5-3.

The headquarter under the Irrigation Superintendent would be sub-divided into four supporting sections of Operation and Maintenance Section, Engineering Section, Agricultural Section and Administrative Section. The Operation Section would be responsible for day-to-day operations of the system including water distribution schedule, and Maintenance Section would handle the equipment for maintenance activities of the Project. The Engineering Section would be responsible for designs, cost estimates and execution of minor works and of on-farm facilities for the purpose of maintenance of facilities. The Agricultural Section should be responsible for introduction of new water management techniques and farming methods as well as for ensuring necessary agricultural supporting services to be extended to the area, and Administration Section would handle the personnel and records management, accounting and other services.

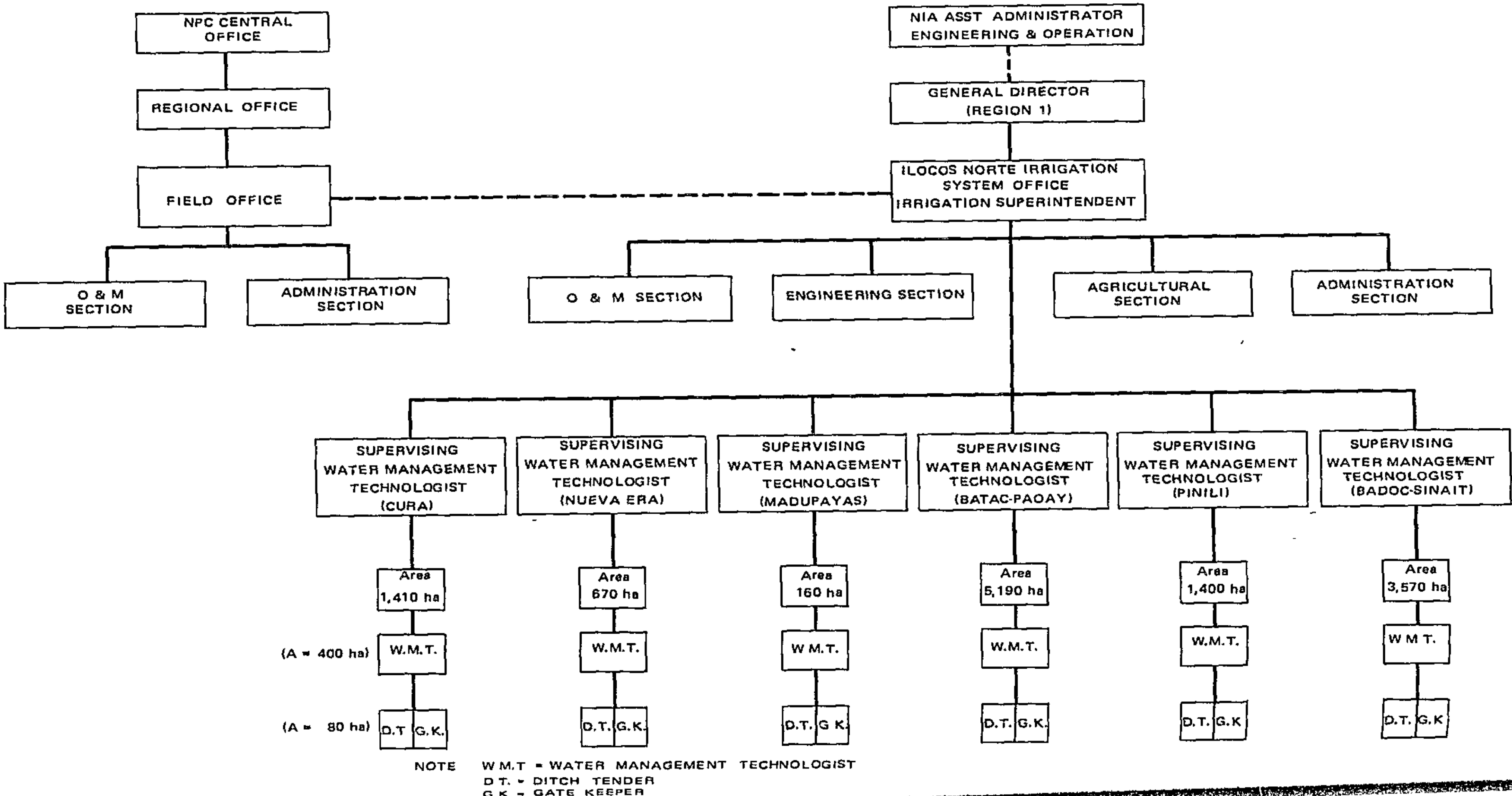
The Project Area will be divided into six areas of Cura, Nueva Era (L.B.), Madupayas, Batac-Paoay, Pinili and Badoc-Sinait, and each area will be managed by a Supervising Water Management Technologist (SWMT).

These areas would be subdivided into units of about 400 ha and each unit will be managed by a Water Management Technologist (WMT). A Ditch Tender and Gate Keeper would be employed for each of about 80 ha, that is, two rotation blocks. Each WMT, therefore, would be responsible for about five units of the Ditch Tender and Gate Keeper.

2. Operation and Maintenance of Facilities

Operation and maintenance of the irrigation facilities will be performed by the Irrigators' Association under the jurisdiction of the Ilocos Norte Irrigation System Office (INISO). On the other hand, the operation and maintenance of the hydropower facilities will be undertaken by the NPC.

FIGURE 5-3. PROPOSED ORGANIZATIONAL CHART FOR OPERATION AND MAINTENANCE



Communication among the INIS Office, NIA Regional No. 1 Office, and Operation Offices at Palsiguan dam site and Nueva Era dam site would be made by wireless line, and also communication among INIS Office and each Division Office by wireless line. Transportation for operation and maintenance services would be performed by motorcycle. The descriptions of water management systems of the proposed facilities are attached in Appendix 5C-1.

3. Operation and Maintenance Cost

The operation and maintenance costs are summarized as follows:

Annual Operation and Maintenance Cost

Items	O & M Cost (₱'000)	O & M Cost (₱/ha)
I. Irrigation		
1) Salary and Wages	1,757	142
2) Equipment Operations	1,507	121
3) Materials and Supplies	1,973	159
4) Administration & General Expenditure	527	43
Total	5,764	465

II, Hydropower (at life period of power station of 20-year)

			(₱'000)
a)	Salary and Wages	:	46
b)	Depreciation Cost	:	2,583
c)	Material and Supplies	:	413
d)	Administration & General Expenditure	:	700
e)	Repair Cost	:	1,768
	Total	:	5,510

Note: Detailed estimate is given in Appendix 5C-2.

D. Consulting Services

The Consultant's services include those for final design and supervision of the Project.

The consultant's services are divided into the following three phases:

i) The final detail design of the project as well as the preparation of tender document. It will cover 86 man-months periods starting from June 1981. Highly qualified experts will be employed, including irrigation engineer, hydrologist, engineering geologist, soil mechanical engineer, design engineer, mechanical engineer and economist.

ii) Construction supervision and training of local counterpart personnel in all aspects of the Project activities. The service period would cover 126 man-months from January 1983 to December 1987. The required experts would be project engineer, engineering geologist, soil mechanical engineer, mechanical engineer for equipment and power plant.

iii) Training for irrigated agriculture. It would cover 29 man-months. Highly qualified experts will be engaged including agronomist and water and farm management expert.

The Terms of Reference for the Consultant's Services and the proposed schedule for them are given in Appendix 5D-1.

CHAPTER VI. PROJECT JUSTIFICATION

CHAPTER VI. PROJECT JUSTIFICATION

A. General

The main objectives of the Project are to increase the farm labor opportunity and cash income for small size farmers and to improve the living status of the people in terms of farm economy in a view of farm economy. These benefits would be realized as the results of increase and stabilization in yield commercial crops, intensive utilization of fields and organization of irrigation water control.

This Project was also planned to meet the requirements of national economy, such as supply of staple food, increase in the exporting crops and substitution crops with the trading commodities, employment opportunity, correction of income disparity and contribution to relieve energy problem.

To accomplish these purposes, the Project components mentioned in the previous chapter have been made up. After the completion of the Palsiguan dam, the Nueva Era dam, several diversion dams, irrigation and drainage canals, the direct benefit would be generated from the cultivation of crops in the lands of 12,400 hectares in Phase II area and in Phase I Project areas of 2,120 hectares for the wet season and 7,240 hectares for the dry season.

The electric capacity of 42,800 KW to be expected from the Bonga and Nueva Era power station would grow a great deal of social and economic benefit.

B. Method of Economic Evaluation

The measurable economic benefits and costs are expressed in monetary terms and both streams of benefit and cost in annual forms over the evaluation period are converted to the respective present worth values. In general, the economic price is applied to economic evaluation. This is presented as border price. The internal rate of return (RR) is used as the main indicator for the economic evaluation of the Project. The Project is evaluated based on the difference between the "development with the project" and the "development without the project". Thus, the project evaluation deals with incremental benefits and required costs.

C. Economic Evaluation

1. Economic Price of Commodities and Labor

The value to the economy of traded goods is measured by border prices, in local currency. The value of nontraded goods which had been measured by domestic prices should be converted into border prices using conversion factor evaluated on the Philippines by World Bank.

A forecast of commodity prices was made in 1980 constant prices using the up-to-date data by World Bank.

Official exchange rate used for this study is US$1.00 = ₱7.40

a) Crop Price

Rice

The quantity of palay, which had been produced under low productivity up to 1970 in the Ilocos Norte Province, has been increased since 1977. The first time in the history of the province, the Ilocos Norte Branch of the NGA, shipped about 27,000 bags of export quality milled rice to Indonesia and Brazil in1979. It may be said that Ilocos Norte has been transformed from a rice deficit province in 1973 and 1975 to a self-sufficient province in a fruitful year of 1979. And the Philippines has exported rice of about 300,000 tons since 1977.

In future, the incremental rice to be produced in this Project Area will be not only sold to Banguet and La Union, but also exported abroad, contributing the national trading policy.

Farm gate price of rice was evaluated based on the export price of the Philippines 25 - 35 percent broken rice, f.o.b. San Ferando, by 290 US$/ton = 2,150 Pesos in 1980.

Export price of rice, f.o.b. San Fernando in 1990 was estimated based on Commodity Price Forecasts, January 1980, World Bank.

Price Structure for Rice

	1980	Financial (₱/ton)	Economic (₱/ton)	(US$/ton)
1)	Export price f.o.b., San Fernando	2,150	2,150	290
2)	Port handling charges and transportation cost from Project Area to port	150	120	

3)	Rice price, ex-mill area	2,000	2,030	
4)	Paddy equivalent price	1,240	1,260	
5)	Farm gate paddy price (per cavan)	1,215	1,240	
		(60)	(62)	
	1990			
1)	Export price f.o.b., San Fernando constant in 1980	3,405	3,405	460
2)	Rice price, ex-mill area	3,255	3,285	
3)	Paddy equivalent price	2,155	2,135	
4)	Farm gate paddy price (per cavan)	2,090	2,115	
		(105)	(106)	

Virginia Tobacco

The Philippines exported tobacco unmanufactured of 25,680 tons in 1977 and gained 27.9 million dollars in f.o.b. value. In the quality of fluecured Virginia type 7,300 tons of tobacco was exported and 12.7 million dollars in f.o.b. value was earned. It is clear that the international tobacco market gives Virginia type more profitable price of about 1,740 US$/ton than native tobacco of about 820 US$/ton, according to 1977 trade statistics.

World export quantities of tobacco amount to about 1,274,000 tons in 1977. This occupies about 23 percent of the world production of 5,450,000 tons. The World Bank economist projects the exporting ratio by 30 percent to the total production in 1990. This progress may depend mainly upon tobacco productivity in the developing countries. The Philippines occupies only about two percent of the world export quantities at present. In the above projection, however, it is expected that the country will keep the same share in the world market in 1990. Then, the projection of the Philippines Virginia Tobacco export would be promising in the future trade.

The farm gate price of Virginia tobacco (constant price, 1980) was evaluated based on the world market price of export value of fluecured leaf, f.o.b. India 2,350 US$/ton in 1980 and 2,608 US$/ton in 1990.

According to the appraisal report of the World Bank, the Philippines Virginia Tobacco commands a premium of about 15 percent over the Indian Virginia tobacco. This margin was accounted into evaluation of the farm gate price of Virginia tobacco.

Farm Gate Price of Virginia Tobacco

(Unit: ₱/ton)

	1980	1990
Financial	18,055	19,940
Economic	18,275	20,190

Garlic

Garlic is also one of the trade goods. However, the quantity exported has not been so much yet until 1977 according to the BAEcon data, and the export is unsteady in quantity; four tons in 1974 but only 160 kg in 1977. In 1978, much quantity of 932 tons was exported to Singapore and Hongkong to earn about 742,000 US$. This quantity corresponds to six percent of national production of garlic in 1977. The depression in export may be due to a high domestic retail price.

The garlic production in the Ilocos Norte Province has retained a large share of about 70 percent in its national production. The projection of garlic production in the Province, based on Regional Development Investment Program, suggests that it will be expanded in future as well. In consideration of income-quantity elasticity for garlic, a surplus supply in future would result in decline in retail price. The international market therefore, would be more hopeful than domestic market in future garlic business.

According to BAEcon data, actual farm gate price in 1978 is ₱5,770 per ton per year on an average and ₱4,100 in February and ₱3,900 in March during harvesting season.

It would be considered that the exporters buy garlic at low price during harvesting season and ship immediately; then the farm gate price based on export f.o.b. price is less than actual average price per year.

Considering this price trend, 5,930 pesos in 1990 were used as economic price of garlic.

Farm Gate Price of Garlic

(Unit: ₱/ton)

	1980	1980
Financial	3,980 (5,770)1/	5,630
Economic	4,360	5,930

1/ Actual average price per year

Cotton

The Philippines imported cotton of 20,460 tons in 1977 and thereby about 32.8 million dollars in f.o.b. were abroad. This value was more than 27.9 million dollars of the exported tobacco. About 90 percent of total quantity of imported cotton was shipped from U.S.A.

The world production of cotton was about 13.8 million tons, about 4.1 millions of which were exported. The U.S.A., the largest cotton producer in the world, has supplied about 30 percent of all exported cotton to the international market. The World Bank data suggests that cotton to be traded internationally would be increased in quantity up to 117 percent of that in 1977.

In the country, cotton is used as a raw material by 43 percent for the total fabrics locally manufactured. For these 10 years (1966 - 1976), the average annual demand for cotton was 37,000 tons, and the Philippine Cotton Corporation has forecasted that the raw cotton demand will increase to about 60,000 tons by 1987.

As an import substitute, cotton domestic production will not only generate foreign exchange savings, but also boost the national well-being in terms of self-sufficiency, employment opportunities in rural areas and increased farm income.

The PCC drew up a comprehensive 10-year national development program covering the period from 1977/78 to 1986/87. According to this program, the country needs for cotton self-sufficiency is 115,000 hectares of lands. Actual areas planted was 3,162 hectares in 1977/78, 3,072 hectares in 1978-79 and 7,083 hectares in 1979-80. The PCC would have to make efforts to accomplish the target in cotton field development.

Estimation of farm gate price of cotton was based on Mexican SM-1-1/16" c.i.f., N. Europe, 1,810 US$/ton in 1980 and 2,460 US$/ton in 1990 (World Bank, Price prospects for major primary commodities, January 1980).

The PCC has no warehouse at San Juan, Ilocos Sur. Marketing channel of seed cotton is traced as farmers, buying station in municipality, warehouse at San Juan and textile mill in Manila. Farm gate price used in this study is as follows.

Farm Gate Price of Cotton

(Unit: ₱/ton)

	1980	1990
Financial	13,505	18,240
(Actual	4,400)1/	
Economic	13,785	18,550

1/ The figures indicate that the Philippines imports cotton at higher price than domestic price at present.

Mungbeans

Mungbean was grown in the fields of about 45,120 ha throughout the country in 1978, 12,440 ha of which were found in the Ilocos Region, including 2,970 ha in the Ilocos Norte Province. The cropping areas in the Ilocos Region have been expanded since 1973. The national average of mungbean production is about 26,000 tons per annum. Exported mungbean was as small in quantity, as 54 tons in 1976 and 106 tons in 1977.

The demand and supply of mungbean is in deficit throughout the nation. The incremental quantities produced in the Project would be sold to the domestic market.

In this study, the average price which was actually received by farmers in Ilocos Region will be used for the forecast of future price. Economic price estimated in using standard conversion factor is above as follows:

Farm Gate Price of Mungbeans

(Unit: ₱/ton)

	1980	1990
Financial	4,500	5,090
Economic	3,700	4,180

Onion

The production of onion in the Philippines was about 54,300 tons in 1976, 75,300 tons in 1977 and 84,700 tons in 1978. The share of export to the total production was 6.0 percent, 9.1 percent and 1.6 percent in the above years respectively. The f.o.b. price of 320 US$/ton in 1978 is used for evaluation of economic price.

Farm Gate Price of Onion

(Unit: ₱/ton)

	1980	1990
Financial	1,910	1,910
(Actual	2,910)	
Economic	2,010	2,010

b) Fertilizer

The domestic production of fertilizers could cover only about 33 percent of the local demand in metric tons of plant nutrients in 1978. The domestic supply is unstable due to the low productivity of the plant which cannot meet the yearly increasing demand. Consequently, it has been indispensable to import the necessary amount of fertilizers to fill the gap between the demand and the domestic supply. The statistics in 1977 indicates that the Philippines imported fertilizers of 424,500 tons in paying 49 million dollars in c.i.f. value.

The supply of N, P_2O_5 and K_2O by local production accounted for 22 percent, 73 percent and 38 percent to gross demand respectively, in 1978. The shortage was covered by import, excluding P_2O_5.

The F.P.A. drew up the supply and demand projection covering the period from 1979 to 1990. The shortage in fertilizers will continue during the forecasting term; in particular, Urea, Ammonium sulfate and 14-14-14. The Philippines, however, will be supplied in future with fertilizers by the ASEAN Fertilizer Project now under way so as to meet the shortage. Under the situation, it would be better to make an economic evaluation of the fertilizer prices on the basis of the ASEAN Project prices; however, the World Bank's forecasting price are adopted herein for the study, since the ASEAN Project prices are not available at present. Economic prices in nutrients are shown as follows:

Farm Gate Price of Fertilizer

(Unit: ₱/kg)

		1980	1990
N:	(F.O.B. Indonesia, Bagged)	(196 US$/ton)	(270 US$/ton)
	Financial	4.27	5.49
	(Actual)	(4.37)	
	Economics	4.18	5.40
P:	(F.O.B. US Gulf)	(185 US$/ton)	(221 US$/ton)
	Financial	3.85	4.42

	(Actual)	(5.85)	
Economics		3.76	4.34
K: (F.O.B. Vancouver)		(95 US$/ton)	(109 US$/ton)
Financial		1.81	1.98
	(Actual)	(1.45)	
Economics		1.74	1.91

c) Farm Labor

Family labor and hired labor are the main labor sources for paddy growing, and the hired labor accounts for 25 to 35 percent of the total man/days required per hectare. The busiest seasons necessitating the most hired labor are the transplanting and the harvesting seasons. The commercial crops such as tobacco, garlic and mungbean, requires not so much hired labor as paddy growing.

The hired labor is supplied from small-size farmers and non-farmers who inhabit in the same village or the adjacent villages. It is reported that the hired labor in Batac and Paoay is supplied from the Phase I Project Area. According to the agricultural Census, 1971, the number of non-farm households which are keeping carabao or cattle amounts to 2,300 in Phase II Project Area.

The wage is paid in kind or in cash including meal cost. The present wage rate varies from 18 pesos a day as the highest to five pesos as the lowest, and the average is 12 pesos a day without meal.

The labor requirements under the present cropping pattern are about 1.9 million man/days per year, and about 340 thousand man/days per month during labor peak of October. The labor requirements in future is projected at 1.7 times as much as at present under the proposed cropping pattern. This projected labor would be covered by intensive family labor, farm mechanization and hired labor.

The farm labor is defined as unskilled labor. Economic pricing of farm labor is the assessment of the opportunity cost. It is postulated that the marginal opportunity cost of labor supplied for farm work in the Project Area can be estimated by "S-shaped" curve. This method is based on some hypothesis that a labor wage is decided through a balance between supply and demand of labor under free mobility of labor in rural area.

A part of construction labor of the Project would be supplied by the under-and unemployment labor and farm labor both inside and outside the Project Area. This labor is costed as unskilled labor.

The shadow wage rate of unskilled labor was computed as annual average rate of about nine pesos to ten pesos during 1983 to 1987 and about 12 pesos after 1988.

2. Evaluation of Agricultural Benefit

a) Irrigable Area with the Project

The formation of annual benefited area was decided to cope with the annual construction schedule. The irrigable area in the Phase II covers not only 12,400 hectares of Phase II area, but also the 7,240 ha in the dry season of the remaining benefited area in the Phase I.

Irrigable Area with Project - Phase II

(Unit: ha)

Sub-Area	Project Area	Wet Season	Dry Season
Cura	1,410	1,410	1,410
Nueva Era (L.B.)	670	670	670
Madupayas	160	160	160
Batac-Paoay	5,190	5,190	5,190
Pinili	1,400	1,400	1,400
Badoc-Sinait	3,570	3,570	3,570
Total	12,400	12,400	12,400
Labugaon	(1,560)	–	780
Solsona	(2,140)	–	1,530
Madongan	(3,190)	900	2,470
Papa	(2,560)	1,220	2,160
Nueva Era (R.B.)	(750)	–	300
Total	(10,200)	2,120	7,240
Grand Total		14,520	19,640

The formation of irrigable area is divided into two stages. The first stage is the formation of partial benefit due to the construction of diversion dams of Tibangran and Madupayas, link canals, main canals and on-farm facilities.

The second stage is the formation full benefit due to water shortage into Palsiguan dam reservoir as well as Nueva Era Dam reservoir.

According to the computation in hydrological study the irrigable area commanded by diversion dam only, not depending on storage dams, is shown below.

Irrigable Area due to Diversion Dam

(Unit: ha)

Sub Area	Irrigable Area Wet Season	Benefited Area Wet Season[1/]
Cura	1,410	1,410
Nueva Era (L.B.)	670	0
Madupayas	160	160
Pinili	1,400	1,220
Badoc-Sinait	3,570	3,390
Batac-Paoay	5,190	0
Total	12,400	6,180

Note: 1/ Area which target yield will be attained.

The benefited area for the dry season before starting in dam operation is not expected.

The start of water storage into the Palsiguan dam reservoir is planned in April, 1987. The following table shows the irrigable areas expanded by years. In 1988, all the irrigable areas for both seasons would become operative.

b) Cropping Area with the Project

Cropping area is estimated on the yearly basis by applying the proposed cropping pattern to each sub-area. It will take nine years to crop in full-scale for both seasons in all irrigable areas as shown in the following table.

Cropping Area with Project

(Unit: ha)

	1984	1985	1986	1987	1988	
	Wet	Wet	Wet	Wet	Dry	Wet
(Phase II Area)						
Paddy	1,410	4,800	6,180	7,210	4,970	12,400
Garlic	–	–	–	–	4,270	–
Tobacco	–	–	–	–	2,130	–
Cotton	–	–	–	–	1,030	–
Mungbeans	–	–	–	–	2,065	–
Sub-total	1,410	4,800	6,180	7,210	14,465	12,400
(Phase I Remaining Area)						
Paddy	–	–	–	–	6,530	2,120
Garlic	–	–	–	–	250	–
Tobacco	–	–	–	–	210	–
Onions and Others	–	–	–	–	250	–
Sub-total	–	–	–	–	7,240	2,120
Grand Total	1,410	4,800	6,180	7,210	21,705	14,520

Table 6 - 1 Irrigable Area with the Project by Year - Phase II

(Unit: ha)

Field	Area	Sub Area	1984		1985		1986		1987		1988	
			Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Benefited	Phase II	Cura	–	1,410	–	1,410	–	1,410	–	1,410	1,410	1,410
		Nueva Era (L.B.)	–	–	–	–	–	–	–	670	670	670
		Madupayas	–	–	–	–	–	160	–	160	160	160
		Batac-Paoay	–	–	–	–	–	–	–	–	5,190	5,190
		Pinili	–	–	–	–	–	1,220	–	1,400	1,400	1,400
		Badoc-Sinait	–	–	–	3,390	–	3,390	–	3,570	3,570	3,570
		Sub-Total (A)	–	1,410	–	4,800	–	6,180	–	7,210	12,400	12,400
	Phase I	Labugaon	–	–	–	–	–	–	–	–	780	–
		Solsona	–	–	–	–	–	–	–	–	1,530	–
		Madongan	–	–	–	–	–	–	–	–	2,470	900
		Papa	–	–	–	–	–	–	–	–	2,160	1,220
		Nueva Era (R.B.)	–	–	–	–	–	–	–	–	300	–
		Sub-total (B)	–	–	–	–	–	–	–	–	7,240	2,120
	Grand Total (A + B)		–	1,410	–	4,800	–	6,180	–	7,210	19,640	14,500

c) Annual Production

Multiplying annual benefited area by target yield gives gross production with the Project.

Full benefit accrual, which will be attained by 1992, will take 12 years starting from the detailed design in 1981.

The incremental productions are expected to arrive at about 80,000 tons by palay, 5,600 tons by garlic, 1,080 tons by tobacco, 2,580 tons by cotton and 1,780 tons by mungbeans by 1992.

d) Incremental Net Production Value

Incremental net production value is shown in the following table.

Incremental Net Production Value

(Unit: Million Pesos)

Benefit		1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
With	GPV	147	152	163	171	181	335	373	410	437	448
Project	GPC	31	32	33	34	34	62	66	70	74	74
	NPV	116	120	130	138	147	273	307	340	363	374
Without	GPV	147	149	150	152	153	155	156	158	160	161
Project	GPC	31	31	31	31	32	32	32	32	32	32
	NPV	116	117	119	120	122	123	125	126	128	129
Incremental NPV		0	3	11	17	25	149	182	213	235	245

Note: GPV: Gross Production Value
GPC: Gross Production Cost
NPV: Net Production Value

The benefit evaluated is to be created from the Phase II area as well as the Phase I remaining area.

3. Power Benefit

Annual power benefits are generally evaluated by using the standard capacity-energy approach. Dependable capacity and average annual energy production were evaluated based on the cost of an alternative oil-thermal plan.

The proposed installed capacity and average annual energy are 42,800 KW and 199.2 GWh, respectively. A dam operation study for 10 years between November 1959 and October 1969 has found that a firm peak capacity is 30,510 KW on an average minimum. An average peak capacity estimated on the 10-day basis for 10 years is 38,290 KW. This electric power generated in the Project will be supplied through the NPC Luzon Grid in future, so that an effective output is estimated at 38,290 KW (Ref. to Appendix 6C-3).

The location of the alternative oil-thermal plant for estimation of capacity unit value was assumed around the San Fernando port where the oil unloading facilities are available.

A unit construction cost of this alternative plant was estimated at 4,630 pesos per KW.

The capacity cost (KW value) was assumed to be equal to the annual fixed cost of the alternative plan. The items involved in the fixed cost consist of interest, depreciation, personal and repairing expenses in O & M cost, administration charge for main office and tax. The unit capacity value was estimated at 700 pesos/KW (see Appendix 6C-3).

The energy cost (KWh value) was assumed to be equal to the sum of the annual fuel cost and operation and maintenance cost of the alternative thermal plant. The energy value was estimated at 0.429 pesos/KWh. This value was computed based on NPC's data, that is, the high viscosity (hi vis fuel oil) cost in Batan thermal power plant (see Appendix 6C-3).

Generated energy obtained from Bonga and Nueva Era power stations are forecasted to supply the Ilocos Norte, Abra and Ilocos Sur province service areas which are covered by NPC transmission line system of 115 KW.

The annual energy of 199.2 GWh is expected to be generated from 1988. The power consumption in the Area, however, will be less than the supply for several years after completion of the Project. Consequently, the surplus energy will be transmitted to the La Union area through 230 KV line from the Narvacan substation. It is forecasted that the demand and supply of the energy in the Area will become balance by 1996. The energy taken as benefit is estimated at 189.2 GWh including five percent transmission losses.

Using the unit value of power and energy, the annual benefit is 1996 was estimated as follows.

KW value	(₱ x 10^3)	28,945
KWh value	(₱ x 10^3)	81,183
Total	(₱ x 10^3)	110,128

4. Economic Evaluation of Project Cost

The direct cost to be used in project justification consists of those costs for engineering design, properties, construction, equipment and facilities, project administration, consulting services, and contingency, but does not include interest during construction of the Project.

Financial project costs excluding the escalation factor are 2,449.9 million pesos (US$331.0 million) including purchased cost of construction equipment and 2,269.5 million pesos (US$306.7 million) including a depreciation cost of equipment. This financial cost is estimated using domestic market prices other than the international price for construction equipment. Then this financial cost has to be revised using economic price, that is, shadow price.

Both interest and tax are considered as transfer payments, so that they are not included in the economic cost. The project economic cost in this study includes the purchased cost of equipment which will be dealt with sensitivity analysis.

The unskilled labor cost and oil cost were re-estimated using opportunity cost or shadow price. The acquisition cost for arable land in the Project Area was excluded because a decrease of incremental benefit obtained from such land was already computed in the benefit stream.

The reestimation of project cost was made using the conversion factors. The World Bank conducted the social cost benefit analysis in December 1978. In this analysis the shadow prices and country parameters were estimated. According to these data, standard conversion factor is 0.820 and conversion factor for capital goods, consumption, transportation and construction are 0.865, 0.840, 0.777 and 0.827 respectively.

The financial project cost of 2,269.5 million pesos excluding escalation factor was reestimated at economic cost of 1,872.6 million pesos as shown in the following table.

Evaluation of Project Economic Cost

(Unit: ₱ x 10^6)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	Total
Financial Cost	1.27	9.48	84.31	199.54	312.31	546.68	588.21	526.87	0.86	2,269.53
Economic Cost	1.07	8.53	67.92	162.46	257.11	446.57	485.36	435.74	7.84	1,872.61

This integrated investment consists of both sections of irrigation and electric power. Palsiguan Dam, headrace and Nueva Era Dam are the joint facilities to be allocated over the both sections. The joint cost was allocated to irrigation and electric power sections, using the Alternative Justifiable expenditure method. The ratios of allocation are 56.5 percent to irrigation and 43.5 percent to electric power (see Appendix 6C-4).

Price escalation was estimated on the both of foreign and local contents using the international price index of World Bank and the rate reported by Philippines Government (see Table 6C-61, Appendix 6C-4).

Price Escalation Index

	1980	1982	1984	1986
Foreign Content	10.4	8.0	6.7	6.3
Local Content	16.0	8.0	8.0	7.0

D. Internal Rate of Return

The internal rate of return was estimated using a linear interpolation method. The incremental benefits are computed by subtracting the project cost from the benefits by each project year. The Project cost consists of initial capital and operation and maintenance cost for irrigation and power plant, and benefits are incremental production benefits and power benefits. The total present worth value of incremental benefits are positive in discount rate of 13 percent and negative 14 percent. The value of the internal rate of return can be interpolated between the both discount rates as shown in Tables 6D-1 to 6D-3 in Appendix 6D-1.

The internal rate of return should be rounded to the nearest percentage, and the rate is estimated at 14 percent as shown below;

$$IRR = 0.13 + \frac{80.01}{80.01 + 3.72} \times 0.01 = 0.1396$$
$$\fallingdotseq 0.14$$

This integrated project would be considered justifiable from the economic view point.

The internal rates of return for each single project of irrigation and power were estimated at 15 percent and 12 percent respectively.

The power project is considered justifiable, though low in its internal rate of return.