3.3.8. Marketing

a) Marketing and Processing

1) Rice

Rice is the most stable and prevailing crop in Bohol province and in the project area as follows;

	Rice Field Area	Percentage for Total Area
Whole Bohol Island	46,000 ha	11.2%
Project Area	2,180 ha	17.2%

The rice production in Bohol province reaches about 63 percent of the total production amount in the Central Visayas and fulfills the important role to their rice demand. The rice demand in the Central Visayas, however, is considerably large and can not be covered with supply amount of rice by Bohol province and the other provinces in the Central Visayas. NFA, Region VII Office estimates the shortage of rice at 55,000 tons which is the difference between about 161,000 tons of production and about 216,000 tons of consumption in 1985.

Number of rice mills and warehouses in Bohol province amounts to 209 and 117 respectively according to the data offered by NFA, Region VII Office. These marketing facilities are located by 51 percent and 39 percent of total numbers in Region VII respectively. Capacity of mills is 1,881 tons per hour or 68 percent of total capacity in Region VII. Capacity of warehouses is 498,100 bags of 50 kilogram per bag or 22 percent of those in Region VII. It is noticed that mill capacity is concentrated in Bohol province in contrast to big capacity of warehouse in Cebu.

Three municipalities concerned with the project have rice mills of 27 units including one unit in use both for rice or corn and warehouses of 13 units respectively. Capacity of 27 mills per day is 165 tons or about nine percent of total capacity in Bohol province. Warehouses are owned by dealer or miller. Total capacity of 13 warehouses is 43,140 bags or 2,157 tons.

Source of marketable rice is rice paid for land rent or harvesting and surplus farm rice. The rice paid for rent is marketed through the channel such as wholesaler or miller in production area and middleman in consumption area. The rice paid for harvesting and surplus farm rice are sold to miller, local retailer and NFA. Number of wholesalers only, retailers only and wholesalers and retailers in the project area amounts to 31, 2 and 33 persons respectively.

The destination of palay produced by farmer are estimated at 55.3 percent for home consumption, 15.7 percent for harvester/thresher, 12.4 percent for land rent, 10.0 percent for sale/to be sold and 6.6 percent for seeds based on the results of agro-economic survey conducted by NIA. All quantities for sale/to be sold, most of land rent and a part of quantities for harvester/thresher shall be marketable. Hence, it is assumed that around 20 percent of produced rice shall be marketable using the destination rate mentioned above.

In 1982, rice transported outward Bohol province was 4,588 tons, of which 338 tons were transported from Tagbilaran port and 4,250 tons from Tubigon port. On the other hand, rice transported inward Bohol province was 6,275 tons of which 2,825 tons were transported into Tagbilaran port and 3,450 tons into Tubigon port. According to the statistics of conventional cagoes in domestic trade at Tagbilaran port, rice produced in 1982 was mainly transported outward in each month of May, December and February. By contrast, the months transported inward were mainly August, September, October and February.

The present rice trading outward in spite of a little marketable quantity in Bohol province causes the shortage of retail rice to be supplied to consumer during the off-season.

When the production of rice is more expanded, the rice transported outward will be increased, and the rice transported inward will be decreased.

In 1983, Bohol's rice production was suffered from the drought, so that production of rice fell down from about 104,000 tons in 1982 to about 42,000 tons in 1983. In order to supplement the hard deficit of rice supply, about 25,600 tons of rice was transported inward at Tagbilaran port. In spite of this national aid, actual rice consumption per capita of rice eating in Bohol province decreased from 103 kg in 1982 to 75 kg in 1983 as shown below (see Annex G, TABLE K3-6).

Rice Consumption

		1982		1983	
Palay Production	(a)	104,455	ton	42,042	tons
Seeds	(b)	5,300	"	5,300	"
Waste	(c)	6,200	"	2,500	"
Other Usage	(d)	4,100	"	1,700	"
Outward Trading	(e)	6,848	"	4,634	"
Actual Consumption					
a - (b to e), Palay	(f)	82,007	"	28,908	"
Converted to Rice	(g)	54,940	"	19,370	"
Inward Trading Rice	(h)	6,275	"	25,643	"
Total Consumption, g + h =	(i)	61,215	"	45,013	"
Population in 1982	(j)	824,068	persons	833,394	persons
Rice eating in Bohol Area Population j x 0.72	(k)	593,329	"	600,044	"
Actual consumption per capita, i/k		103.2	kg	75.0	kg

2) Corn

Number of corn marketing facilities is small in comparison with those of rice. Corn millers and rice and corn millers amount to 4 and 45 in Bohol province. Three municipalities have only one miller in Trinidad.

Crop area of corn in Bohol province is limited because of soil and water conditions. Corn products are not enough to full consumption of Boholanos. The inward trading of corn grid was 9,795 tons in 1981, 6,588 tons in 1982 and 6,943 tons in 1983. These quantities correspond to about 30 percent to 50 percent of consumption volume per year.

Actual consumption of corn grid is estimated as follows (see Annex K, TABLE K3-6).

<u>Corn Consumption</u>

Corn Production in 1982	(a)	26,970 tons
Seeds	(b)	370 "
Waste	(c)	810 "
Other Usage	(d)	540 "
Outward Trading	(e)	1,514 "
Actual Consumption		
a - (b to e)	(f)	23,736 "
Converted to Corn Grid	(g)	15,430 "
Inward Trading Corn Grid	(h)	6,588 "
Total Consumption, g + h	(i)	22,018 "
Population in 1982	(j)	824,068 persons
Corn eating Bohol Area population j x 0.28	(k)	230,739 persons
Actual consumption per capita, i/k		95.4 kg

3) Cassava

A large portion of cassava production in Bohol province is collected for the processing of starch and glucose at the factory of the Philippine Starch Industrial Corporation which is located at Carmen. The existing capacity of factory is designed to be 800 tons fresh tubes per day, which is planned to be expanded up to 80,000 ton by 1988 under the program of the Ministry of Agriculture/NFAC's Bohol Cassava Production. However, the present operation capacity reaches only ten percent of the said designed capacity due to the low production of cassava in Bohol province.

4) Vegetable

The production quantity of vegetable in Bohol province has been limited. But some of products are marketable. Peanuts of 185 tons and Gabi of 36 tons were marketed in Cebu in 1979-80.[1/] Each city in urban area and each town (poblacion) in municipality have public markets. Number of local markets in three municipalities concerned with the project is four places with about 49,000 sq.m. Number of stalls amounts to 194.

According to the results of the survey conducted in the Central Agro-Market in Tagbilaran, origin of vegetables was classfied into local products and vegetable transported from Cebu as follows;

- Local products: Mungbean, tomato, stringbean, cucumber, sweet potato, eggplant, ginger, redpepper, ampalaya, squash, pechai, rice, corn grits.
- Incoming from Cebu: Watermelon, tomato, white onion, red onion, cabbage, greenpea, carrot, ginger, baguio beans, sayote, garlic, white potato.

The quantities of vegetable sold in Trinidard town market are limited, and the main kinds are marketed by local producers. Eggplant, ampalaya, pechai, squash, stringbeans, camote, tomato in small size are supplied from Trinidad's farmers. Watermelon, peanuts, tomato in large size are transported from Gabi in Ubay, Carmen and Cebu respectively.

On the marketing channel, Cebu strongly connects with Bohol. Bohol's products marketed in Cebu are mainly peanuts and gabi. Bohol peanuts share about 40 percent of total volume debt by nine peanuts dealers and gabi is eight percent by 22 dealers. The comparatively large volumes of onion, mungbeans, carrot and tomatoes are transported to the Bohol province.

1/: Market demand for selected vegetables in Cebu, 1980 MDA

b) Farm Input Materials

Certified seed production is controlled by BPI and seeds are produced in 31 ha of a private seed farms located in the adjoining area of the project area. However, only less than 0.5 percent of the production in the seed farm is actually distributed through the agricultural extension agencies or bought directly by farmers. The varieties of the distributed seeds by the extension agencies are IR-36, IR-42, IR-56 and IR-60. The BPI Bohol Experiment Station also has seed production farms to experiment the seed multiplication of rice and upland crops.

Fertilizer is applied by almost all farmers, that is, about 90 percent in the wet season and about 70 percent in the dry season according to the results of agro-economic survey. But applied amount per hectare is very small as described in the previous paragraph. Pesticides and herbicides are applied by 30 percent to 50 percent and 10 percent to 15 percent of total farmers respectively. Marketing chanel of these inputs is constituted by the regular agricultural cooperatives (Kilusan Bayon) of 23 and one of Area Marketing Cooperative and Commercial Rural Bank.

c) Price of Products and Inputs

According to the result of the agro-economic survey by NIA, prices of products and inputs are informed as follows:

Price of Products and Inputs
(Agro-economic Survey)

Commodities	Units	Prices at Farm Level	No. of Farmers Reported
Palay: Wet Season	₱/cavans	142.10	25
Dry Season	"	118.68	16
Average		133.57	41
Cassava	₱/Kilo.	3.46	8
Camote	"	2.42	6
Seeds of Palay	₱/cavans	121.5	88
Fertilizer			
16-20-0	₱/bag	230	25
14-14-14	"	253	114
45-0-0	"	320	1
Herbicides	₱/quarts	38.5	22
Pesticides	"	102	65
Milling Cost of Palay	₱/cavan	10	41
Transportation Cost	"	2	41
Distance to selling Point	Km	5.4	41
Transportation Cost	₱/cav./km	0.37	41

Prices of commodities handled by the farm marketing cooperative, Kadiwa Center, public market and merchant were surveyed by JICA Team as shown in Annex K, TABLE K4-13 to TABLE K4-17. Transportation cost and port handling charge are also shown in Annex K, TABLE K4-18 to TABLE K4-19.

Wage rate of hired labor is different by operation. Rate of wage in palay farming ranges from minimum rate of land weeding and fertilizing to maximum rate of seed-bedding and plowing as shown in the following table.

Wage Rate per Man-day

(Unit: ₱/day)

Palay	Wet Season	Dry season
Seed-bedding	13.8	14.3
Plowing	13.6	13.9
Harrowing	13.5	14.0
Leveling	13.5	13.6
Repair of Dikes	13.5	14.1
Pulling/Distribution	11.5	11.6
Transplanting	11.2	11.9
Hand Weeding	10.2	10.2
Weedicides	11.1	13.1
Fertilizing	9.9	12.8
Camote		
Land Preparation	11.7	
Planting	10.7	
Harvesting	10.5	
Cassava		
Land Preparation	13.8	
Planting	10.8	
Hilling-Up	15.0	

3.3.9. Farm Economy

a) Farmers Income

Gross Farm Income

Main source of farmers income consists of agricultural income and non-agricultural income. Agricultural income in the project area has been mainly gained by crop production of rice, camote, cassava, coconuts and animal husbandry. Rice production is the most important income source followed by cassava and camote. Animal husbandry does not play an important role yet. According to the result of the agro-economic survey conducted by NIA, value of rice income shares about 94 percent of gross farm income. Income share of camote and cassava produced by a small size group, less than one ha, seems to be higher than those in a larger size group. It is noticeable that the farmers in class of size from 1.0 ha to 1.99 ha can gain the highest gross farm income per hectare, and the farmers from 3.0 ha to 6.5 ha can not gain the high gross income. The main reason of the difference by size of land is due to cropping intensity and paddy yield as shown in the following table.

Gross Farm Income

Class of Size	No. of Sample	Average Farm Size (ha)	Gross Farm Income (₱/Farm)	Rice (%)	Camote & Cassava (%)	Livestock (%)
less 0.99 ha	9	0.56	2,145	88.1	9.2	2.7
1.0 to 1.99 ha	35	1.22	5,383	91.9	5.2	2.9
2.0 to 2.99 ha	16	1.94	7.148	85.6	5.9	8.5
3.0 to 6.5 ha	15	4.10	12,678	91.4	4.9	3.7
Total/Average	75	1.87	6,829	90.0	5.3	4.7

Note: Excluding coconuts land in the average farm size

Class of Size	Gross Farm Income per Ha (₱/ha)	Cropping Intensity (%)	Paddy Yield Wet Season (cavan/ha)	Paddy Yield Dry Season (cavan/ha)
less 0.99 ha	3,830	165	19.1	16.1
1.0 to 1.99 ha	4,412	169	20.3	16.2
2.0 to 2.99 ha	3,685	164	15.4	14.5
3.0 to 6.5 ha	3,092	150	18.3	11.4
Total/Average	3,455	160	18.3	13.9

Note: Sample with the negative farm income is excluded. Paddy yield is estimated using planting area. Area and income on coconuts are not estimated.

Other Sources of Income

About 75 percent of farmers sampled by the agro-economic survey depend upon other sources of income. Main income sources are the working on other's farm, the salaries or wages, the receipt of gifts from relatives and the earnings from cottage industries.

Earnings obtained from the working on other's farm and the salaries or wages amount to about 600 pesos and 4,000 pesos per farm respectively.

Farm Income

Farm income is estimated by deducting production cost from gross farm income. Farm income for average farmer is about 3,500 pesos. This is in the range from about 1,360 pesos gained by a small farmer (less than 0.99 ha) to about 5,500 pesos obtained by a large farmer. Gross income added by other source income amounts to about 2,170 pesos for a small farmer (less than 0.99 ha) and about 6,170 pesos for a farmer with a land of 3.0 ha to 6.5 ha as shown in the following table.

Farm Income

Class of Size	No. of Sample	Ave. Size (ha)	Gross Farm Income (₱)	Prod. Cost 1/ (₱)	Farm Income (₱)	Other Source Income (₱)	Gross Income (₱)
less 0.99 ha	9	0.56	2,145	782	1,363	812	2,175
1.0 to 1.99 ha	35	1.22	5,383	2,576	2,807	838	3,645
2.0 to 2.99 ha	16	1.94	7,148	2,875	4,273	885	5,158
3.0 to 6.5 ha	15	4.10	12,678	7,126	5,552	618	6,170
Total	75	1.87	6,829	3,335	3,494	835	4,329

Source: Agro-Economic Survey by NIA, 1985

1/ inclusive of livestock production cost

The 12 samples or 14 percent of total samples 88 are in negative farm income in spite of farm size of 2.5 ha. Average farm income is about 3,000 pesos in comparison with about 4,400 pesos of production cost. The main reason for the negative income is due to low cropping intensity of 132 percent and low paddy yield such as 5.6 cavans in the wet season and 4.2 cavans in the dry season.

b) Farmer's Expenditure

Production Cost

Cost items for crop production consist of seeds, fertilizer, pesticides, hired man labor, hired animal labor and land rent. Ratio of production cost to gross farm income is estimated at 35 percent in class of land size (less than 0.99 ha), 48 percent in land size of 1.0 ha to 1.99 ha, 42 percent in land size of 2.0 ha to 2.99 ha, 52 percent in land size of 3.0 ha to 6.5 ha and 48 percent in average size of farm.

The farmers in size from 1.0 ha to 1.99 ha invest the most intensive input, hence they can earn the highest gross farm income. The farmers in size from 3.0 ha to 6.5 ha seem to restrict from the intensive input because of high price of fertilizer and hired labor.

Crop Production Cost per Hectare

(Unit: Peso)

Class of Size	No. of Sample	Prod. Cost per Farm	Cost per Hectare					
			Prod. Cost	Seed	Ferti-lizer	Hried Labor Man & Animal	Land Rent	Others
less 0.99 ha	9	726	1,296	153	264	511	330	38
1.0 to 1.99 ha	35	2,531	2,075	218	415	1,025	384	33
2.0 to 2.99 ha	16	2,739	1,412	193	297	718	182	22
3.0 to 6.5 ha	15	6,302	1,537	147	384	521	420	65
Average	75	3,113	1,665	180	370	718	352	45

Total sample farmers of 75 are classified by land owners of 50 and tenant farmers of 25 who own a part of land or does not. Average ratio is estimated at 21 percent. The ratio of land rent in kind paid by 25 tenants is shown as the following table.

Ratio of Land Rent for Paddy

(Unit: Number of Sample)

	5 to 10%	11 to 20%	21 to 30%	31 to 40%	41 to 50%
Wet Season Paddy	2	6	10	4	2
Dry Season Paddy	1	3	6	1	1

Household Expenditure

Household expenditure consists of food, housing, clothing, fuel, light, household furnishing, medical care, transportation and communication, recreation and education. Expenditures on food and education are a burden to farmer's living cost.

c) Category of Farm Management

According to the NIA agro-economic survey, all sample farmers are rice growers. The typical pattern of their farm management is as follows.

Typical Pattern of Farm Management

1. Farm Size
   - Rice Land 1.0 ha
   - Upland 1.0 ha
2. Farm Labor Force 2.3 person (converted 20-59 years old man)
3. Crop Production

Crop	Planted Area (ha)	Harvested Area (ha)	Unit Yield (ton/ha)	Production (ton)
Rice				
- Wet Season	0.90	0.76	1.37	1.04
- Dry Season	0.75	0.64	1.26	0.81
Upland Crops				
- Sweet Potato	0.23	0.23	2.02	0.46
- Cassava	0.30	0.30	4.71	1.41

CHAPTER IV. THE PROJECT FORMULATION

CHAPTER IV. THE PROJECT FORMULATION

4.1. Objectives and Components of the Project

4.1.1. Objectives of the Project

Agriculture is the biggest and the most important industry in the province of Bohol, however, unfavorable conditions surrounding current agriculture, such as water resources, irrigation facilities, farm roads, farming problems associated with cultivation, land ownership and marketing systems are seen at present and causes the low productivity in agriculture sector, resulting in poverty of living standard in the area. Therefore, the income of inhabitants in the province is lower than the national average, and its population emigrates to Manila, Cebu and other cities.

The objectives of the project are, i) to establish the irrigated agricultural development, ii) to improve the agricultural and rural circumstances mentioned in the above, iii) to increase the agricultural productivity and income of rural habitants and iv) to contribute to the rural economy in Bohol province.

4.1.2. Components of the Project

The project components will be made with the following development concept to activate the project objectives mentioned in the above.

a) Water Resources Development

The water resources in the project area are limited only in the Bayongan and Bayang rivers with small runoff of about 10 MCM per annum respectively.

The project in Phase II should consider to use the surplus water which is diverted from the Malinao damsite and introduced to Phase II area after utilizing the irrigation in Phase I project. This surplus water, however, has a considerable fluctuation depending on the wet and dry months and its discharge pattern can not meet irrigation requirements in the Phase II project.

Accordingly, the water resources development to control the existing river water and the surplus water by the storaged reservoir should be established.

b) Land Resources Development

The land of about 12,700 ha in the project area is generally located with undulated topography and a shallow soil depth and scattered over the river terraces and hilly area. The existing paddy area is only about 1,800 ha along the creek and streams.

The land resources development should be made with the following considerations.

i) Existing paddy field is included in the project service area.

ii) New reclamation land should be selected in the area to be irrigated by the gravity irrigation system, to be formed with a gentle slope and to have suitable soil properties for cultivation.

iii) The land leveling development is established for the new land reclamation area to prepare the farm land suitable for paddy field.

c) Irrigation Development

Irrigation canal system is not existing at all in the project area. New irrigation canal system to deliver irrigation water by the reservoir newly constructed should be provided taking into account the irrigation requirements and methods at the terminal farm area.

Water operation and management methods for irrigation should be also established.

d) Irrigated Agricultural Plan

The irrigated agricultural plan is established with the following components.

i) Selection of suitable cropping pattern and intensity to realize maximum utilization of water and land resources.

ii) Formulation of cultivation practice to increase the agricultural productivity and the farmer's income.

iii) Formulation of concept agro-processing and market establishment.

4.2. Land Use Plan

4.2.1. Basic Concept for Land Use Plan

The proposed land use was formulated very carefully in accordance with the topographic map of 1:4,000 in scale prepared by JICA, soil conditions, land classification, present land use and the following considerations;

- Since the project area of 12,700 ha involves high elevation lands, which can not be irrigated by gravity irrigation canal systems, those higher lands are excluded from the project service area.

- The existing paddy fields should be included in the project service area, because the existing land will not need an additional investment to the land leveling for preparation of paddy field and the existing farmer should receive the project contribution with the first priority.

The existing paddy field of about 1,780 ha which has a possibility of the development by the gravity irrigation system is included in the project, 1,280 ha for Bayongan system and 500 ha for Capayas system.

- The Class I lands having a land slope less than three percent in the existing upland fields and grass lands will be converted to new paddy fields.

  Total area of 4,020 ha, out of which the upland field of 1,600 ha and grass land of 2,420 ha is converted to the new paddy land.

- The converted areas will be utilized for paddy cultivation during the wet season and upland crop during dry season, because crop diversification of upland crop will be introduced in order to save the irrigation water as well as to meet the demand of upland crop in the province of Bohol.

  Valuable and marketable upland crops in Bohol island such as mungbean, corn, peanut and vegetable are proposed as dry season upland crops for the area of one third of the irrigation area. These upland crops will be introduced in higher elevation area in the Class I land, because lower elevation area has a high ground water level which is not suitable for upland crops cultivation due to drainage problem but for paddy field.

- Class II land in the existing upland crop area and grass land is suitable for upland crop area under rainfed condition. Area of 1,060 ha in Bayongan system and 240 ha in Capayas system are proposed. In this area, cassava and sweet potato sufficiently growable under rainfed conditions and will be introduced.

- Class III, IV and V lands are not proposed as cultivation land and remain as grass land to protect land erosion, to collect green manure and to feed livestock.

- Existing coconut areas will also remain as they are.

- Seven to ten percent against the total irrigation service area will be excluded from the net service area and is used for the right-of-way for irrigation networks.

4.2.2. Proposed Land Use Plan

In accordance with the above concept, the proposed land uses in Bayongan and Capayas systems are formulated as shown in TABLE 4-1 and summarized as follows;

Description	Bayongan System (ha)	Capayas System (ha)	Total (ha)
- Total Project Service Area	5,580	1,520	7,100
- Net Irrigation Area	4,140	1,160	5,300
- Net Upland Crop Area under Rainfed	980	220	1,200
- Other Land Occupied by Right-of-Way	460	140	600

4.3. Available Water Resources

4.3.1. Available Water from Phase I Area

a) Review of Runoff Discharge at Malinao Damsite

Runoff discharge analysis at Malinao damsite has been made at Detailed Design stage of Phase I project. The discharge measurement

TABLE 4-1 PROPOSED LAND USE

(Unit: ha)

Present Land Use	Bayongan System				Capayas Systems				Total
	Irrigated Paddy	Rained Upland	Others	Sub-total	Irrigated Paddy	Rained Upland	Others	Sub-total	
Existing Paddy	1,230	-	50	1,280	470	-	30	500	1,780
Upland Class I	1,110	-	120	1,230	320	-	50	370	1,600
Upland Class II	-	220	10	230	-	60	10	70	300
Grass Land I	1,800	-	210	2,010	370	-	40	410	2,420
Grass Land II	-	760	70	830	-	160	10	170	1,000
Total	4,140	980	460	5,580	1,160	220	140	1,520	7,100

Note:
1) Project total service area, 7,100 ha
2) Net irrigation paddy area, 4,140 + 1,520 = 5,300 ha
3) Net upland crop area, 980 + 220 = 1,200 ha
4) Other land occupied by canal, etc. 460 + 140 = 600 ha

data, however, were available only for three years from 1978 to 1980, which were not sufficient to analyze accurately the runoff of the Wahig-Pamacsalan river.

The discharge measurement data up to 1984 accounting 48 points are presently available. Preparation of rating curve and a runoff analysis, therefore, have been reviewed on the basis of the new data.

The rainfall on the basis of runoff analysis has been reviewed collecting the data at five stations in the catchment area and at the Dagohoy station.

1) Rating Curve

Discharge measurement of the Wahig-Pamacsalan river at the proposed Malinao damsite has been observed since 1978 up to now, and measurement data of 48 points are available as shown below. The correlation coefficient between staff gauge reading and measurement of discharge is also shown in the table.

Year	Number of Observations	Correlation Coefficient
1978	6	0.982
1979	9	0.978
1980	6	0.999
1981	8	0.988
1982	12	0.912
1983	1	-
1984	6	0.979
Total	48	0.907

The rating curve of the Wahig-Pamacsalan river can be made by using the above data. However, measurement data were collected at the lower stage of water (less than 1.0 m), due to the hardness of observation. Therefore, Manning formula was adopted to analyze a big discharge based on the surveyed cross section and profile of gauging station. The roughness coefficient of Manning formula was adopted at 0.045, considering the conditions of river bed and vegetation of river. The hydraulic energy gradient was adopted at 1/300 based on the surveyed profile.

The estimated rating curve of the Wahig-Pamacsalan river is shown in FIGURE 4-1.

2) Observed Discharge

The discharge can be calculated by using the rating curve and reading the daily height of staff gauge which has been installed at the national highway bridge (Pilar).

According to the results of estimation, an annual observed runoff from 1978 to 1984 is summarized as follows;

Year	Runoff Discharge MCM	Runoff Discharge mm	Remarks
1978	173.4	1,250	December missing
1979	101.9	734	
1980	177.7	1,280	December missing
1981	145.1	1,045	
1982	116.7	840	
1983	101.9	734	
1984	169.5	1,221	
Average	127.0	915	

3) Rainfall Analysis

There are five rain gauge stations in the catchment area of Malinao reservoir. The observation period of each station is not so long as shown follows;

Station	Observation Period	Number of Year
Matinao	1978 - 1984	7
Abachanan	1978 - 1984	7
Danicop	1978 - 1984	7
Catagda-an	1978 - 1984	7
Pamacsalan	1967 - 1981	15

The monthly mean rainfall of each station is shown in Annex B, FIGURE 2B-1. On the other hand, there are successive long term data at the Dagohoy station near the Malinao damsite. Therefore, all of the missing data of each station were complemented by a regression line after correlation analysis was made.

4) Correlation Analysis

Correlation analysis among six stations (between the Dagohoy station and the other five stations) was made on the basis of monthly total.

According to the result, the correlation between Dagohoy and other five stations is a little poor, because the rainfall pattern between the plain and mountainous area in the catchment area is rather different. The estimated correlation coefficients are shown in the following table.

Station	Correlation Coefficient	Number of Data
Pamacsalan	0.697	169
Matinao	0.645	82
Abachanan	0.682	83
Danicop	0.694	84
Catagda-an	0.756	84

The missing data of each of five stations were complemented with the Dagohoy data by the equations shown below, that were obtained from the correlation analysis.

Station	Regression Equation
Pamacsalan	$0.686 \cdot x + 56.3$
Matinao	$0.745 \cdot x + 75.4$
Abachanan	$0.684 \cdot x + 61.7$
Danicop	$0.687 \cdot x + 66.3$
Catagda-an	$0.670 \cdot x + 58.8$

Where; X: Monthly rainfall of Dagohoy station (mm)

5) Areal Rainfall

The Thiesen polygon method was adopted to estimate the areal rainfall as the representative rainfall by using the five rainfall data observed in the catchment area. The occupied area of each station and the ratio are shown as follows;

Station	Area (sq.km)	Ratio	Annual Mean Rainfall (mm)
Pamacsalan	30.1	0.216	2,051
Matinao	15.8	0.114	2,355
Abachanan	23.4	0.169	2,042
Danicop	42.5	0.306	2,140
Catagda-an	27.0	0.195	2,018
Total	138.8	1.000	

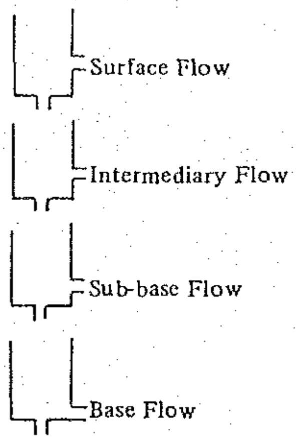
For the analysis of runoff for 28 years from 1956 to 1984, the areal rainfall is required. However, the rainfall data of each station in the catchment area are available only for several years, thus the areal rainfall was estimated by using the above-mentioned regression line.

The complemented data of the Malinao areal rainfall were used for the runoff analysis at the Malinao damsite. The complemented areal rainfall from 1956 to 1984 is shown in Annex B, TABLE B2-11. Annual mean rainfall of areal rainfall is 2,165 mm.

6) Runoff Analysis

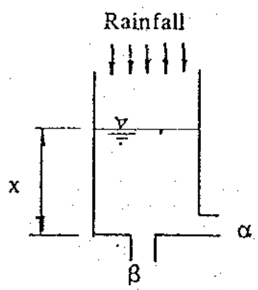
It is clear that the runoff curve for a given rainfall distribution can be estimated from the relation between rainfall and runoff. The runoff was estimated by Tank-Model method described below.

The basic concept of the Tank-Model method is that the runoff and percolation from outlets of the tank shall be expressed in an exponential function.



- Several tanks with outlets on their side and bottom are arranged in series. And rainfall would pour into the first tank, and the evapotranspiration would be deducted from the first tank and the second tank respectively.

- Some water in each tank would be discharged out from the side outlet of the tank, and the other would be transferred to the next tank through the bottom outlet (percolation outlet). In this study, the total amount of water to be discharged out from the side outlets would be estimated as the runoff from a catchment area.



- When the rainfall of X mm pours into the first tank, the water depth would be X mm per unit area in that tank. When the stored water is X, the amount of αX would be discharged as runoff and βX as percolation per unit hour; in other words, $(\alpha + \beta) X$ is discharged and the remainder in the tank is $\{1 - (\alpha + \beta)\} \cdot X$.

- Consequently, the rate of remaining water is equivalent to $\{1 - (\alpha + \beta)\}$, and thereby the ratio of runoff and percolation is β. By this model, the runoff would be expressed in the exponential function with the rate of $\{1 - (\alpha + \beta)\}$.

Models with various scales were designed and analyses were tried repeatedly in order to determine the coefficient of a suitable tank-model. A series of studies together with verification of the observed runoff records at the damsite for the period of 1978 to 1984 have resulted in the definite scale of the tank-model. The Model determined is shown in Annex B, FIGURE B3-4.

7) Consideration of Results

The estimated runoff by using the Tank-Model is summarized as follows:

Year	Areal Rainfall (mm)	Observed Data Runoff (mm)	Observed Data Runoff Coefficient	Estimated Result Runoff	Estimated Result Runoff Coefficient
1978	2,261.0	1,249.6	- 1/	1,030.7	0.456
1979	1,853.6	733.9	0.396	723.4	0.390
1980	2,460.6	1,280.1	- 2/	1,014.2	0.412
1981	1,927.0	1,045.5	0.543	927.5	0.481
1982	1,924.9	840.4	0.437	763.3	0.397
1983	1,935.4	734.3	0.381	795.5	0.413
1984	2,271.8	1,220.9	0.537	967.9	0.426
Average	2,090.6	915.0 3/	0.438 3/	888.9	0.425

Note: 1/ December missing data
2/ December missing data
3/ Except 1978 and 1980

According to the result that the annual runoff in the dry years of 1979 and 1983 is close to the observed discharge, the Tank-Model is adopted as final proposed model. The annual runoff discharge and runoff coefficient of the adopted Tank-Model between 1956 and 1984 is shown in TABLE 4-2 and summarized as follows.

Season	Period	Runoff Discharge (MCM)	Percentage (%)
Dry Season	Feb. - May	27.2	23.2
Wet Season	Jun. - Jan.	89.9	76.8
Total		117.1	100.0

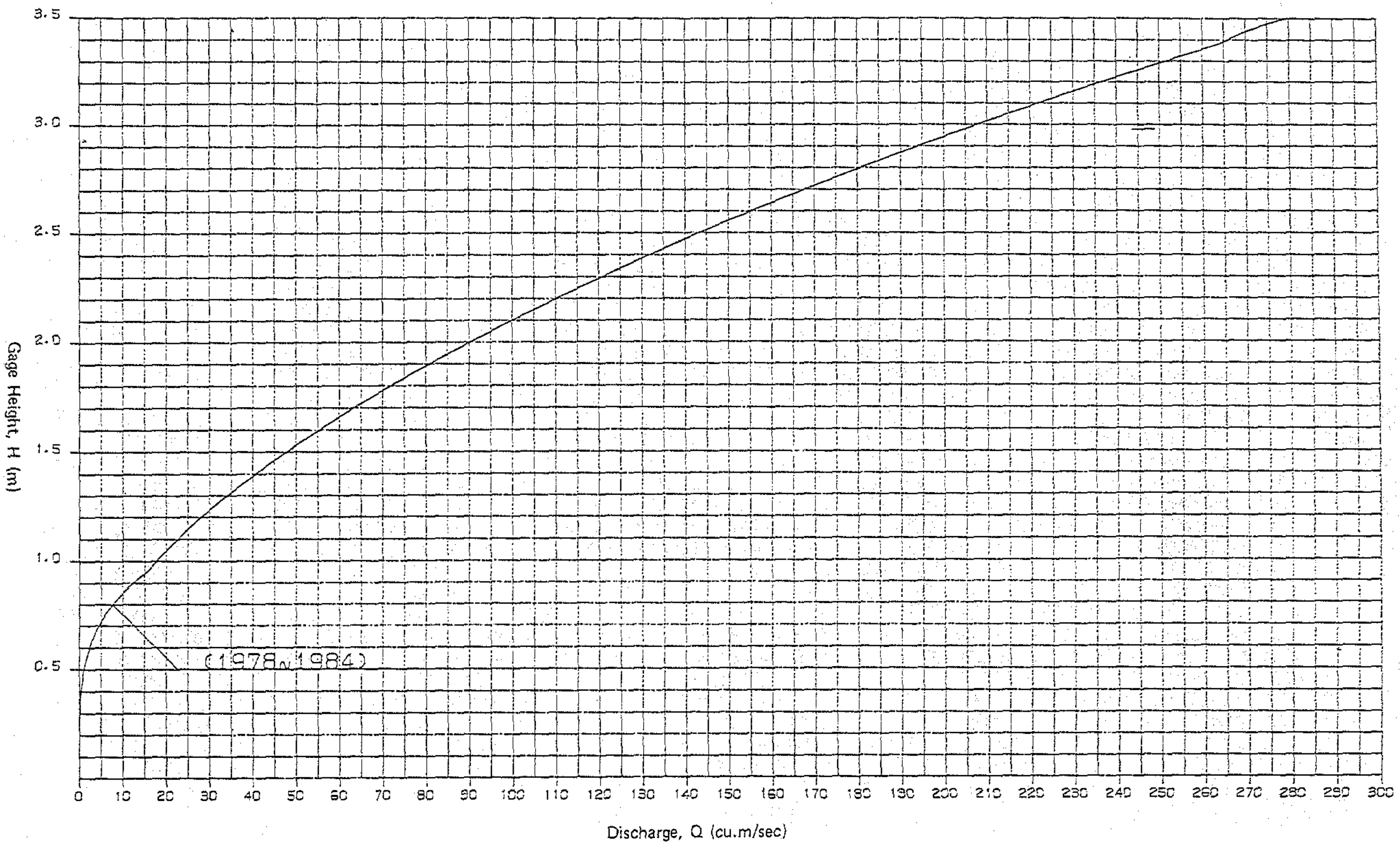
TABLE 4-2 ESTIMATED ANNUAL RUNOFF OF WAHIG-PAMACSALAN RIVER

Year	Annual Rainfall (mm)	Annual Runoff (mm)	Annual Runoff (MCM)	Runoff Coefficient
1956[1/]	891.8	364.3	50.6	0.408
1957	2,294.7	973.1	135.1	0.424
1958	1,775.4	571.4	79.3	0.322
1959	2,160.3	699.8	97.1	0.324
1960	2,188.5	797.0	110.6	0.364
1961	2,234.8	766.5	106.4	0.343
1962	2,484.7	967.0	134.2	0.389
1963	2,287.0	973.4	135.1	0.426
1964	2,781.6	1,136.2	157.7	0.408
1965	2,189.0	865.5	120.1	0.395
1966	2,042.7	685.4	95.1	0.336
1967	2,301.4	910.4	126.4	0.396
1968	2,001.6	755.4	104.8	0.377
1969	1,697.2	572.0	79.4	0.337
1970	2,126.2	797.6	110.7	0.375
1971	2,494.9	985.5	136.8	0.395
1972	2,193.6	910.8	126.4	0.415
1973	2,150.8	894.7	124.2	0.416
1974	2,206.0	830.1	115.2	0.376
1975	2,235.8	872.6	121.1	0.390
1976	1,955.6	734.3	101.9	0.375
1977	2,185.7	799.3	110.9	0.366
1978	2,261.0	955.8	132.7	0.423
1979	1,853.6	709.1	98.4	0.383
1980	2,460.4	1,011.2	140.4	0.411
1981	1,927.0	926.9	128.7	0.481
1982	1,924.9	763.2	105.9	0.396
1983	1,935.4	799.5	111.0	0.413
1984	2,271.8	967.9	134.3	0.426
Average	2,165.1	844.0	117.1	0.391

Note: Average; from 1957 to 1984
1/ ; from September to December

FIGURE 4–1 RATING CURVE AT MALINAO DAMSITE

River : Wahig–Pamacsalan
Station : Malinao, Pilar



b) Review of Water Requirements in Phase I Area

Irrigation water requirements for the Phase I area were reviewed on the following conditions:

i) Proposed land use and cropping pattern are the same as those formulated in the Phase I Feasibility Study,

ii) Reviewal on crop evapotranspiration, effective rainfall and irrigation efficiency will be made, and

iii) Irrigation water demand will be reviewed taking into account actual water management after project implementation.

1) Crop Evapotranspiration (ETPc)

Crop evapotranspiration of rice was reviewed as follows;

Potential evapotranspiration (ETo) was estimated on the monthly basis by applying the Penman Method using the climatological data observed at Tagbilaran. Following table shows the comparison of the estimated both figures of the ETo.

Estimated ETo Values

(Unit: mm/day)

Month	ETo Phase I F/S	ETo Phase II F/S	Ratio of ET/ETo 1/	ETPc (ET) Phase I F/S	ETPc (ET) Phase II F/S
Jan.	3.58	3.60 2/	1.47	5.3	5.3
Feb.	3.67	3.94	1.37	5.0	5.4
Mar.	4.26	4.66	1.38	5.9	6.4
Apr.	4.72	4.94	1.46	6.9	7.2
May	4.41	4.48	1.50	6.6	6.7
Jun.	3.80	3.84	1.50	5.7	5.8
Jul.	3.66	3.98	1.49	5.5	5.9
Aug.	3.94	4.18	1.42	5.6	5.9
Sep.	3.79	4.00	1.27	4.8	5.1
Oct.	3.72	3.72	1.28	4.8	4.8
Nov.	3.45	3.69	1.41	4.9	5.2
Dec.	3.25	3.24	1.34	4.4	4.3
Average	3.85	4.01	1.42	5.5	5.7

Note; 1/: Derived from data at Dumaguete, Negros Oriental.
2/: Details are given in Annex F, Paragraph 1.1.1, a).

In the irrigation plan under the National Irrigation Systems in NIA, the consumptive use of water for paddy (actual evapotranspiration, ETPc) is assumed to be equal to evaporation (ET). So, the consumptive use of paddy is estimated by using the ratio of ET/ETo derived from data at Dumaguete, Negros Oriental, as shown in above table.

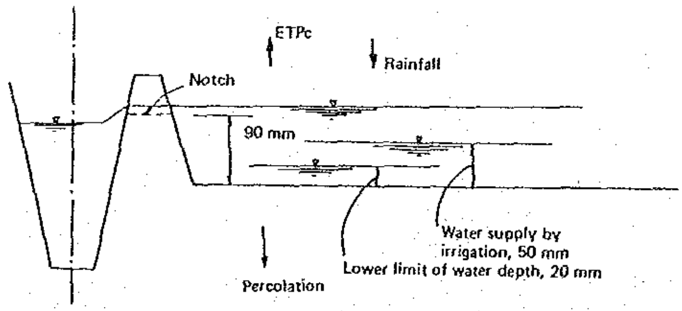
As seen in the above table, the estimated ETPc in this review is slightly larger with an annual average of 5.7 mm/day than those estimated in the Feasibility Study of the Phase I project. However, the estimated ETPc in the Feasibility Study of the Phase I project includes the considerable conservative factor[1/], so that the original ETPc values are to be adopted in the reviewal study for estimation of water demand.

2) Estimation of Effective Rainfall

Effective rainfall to be used for estimation of irrigation water requirements is reviewed based on the following considerations:

- Dagohoy observation station is selected as representative data for estimation of effective rainfall in the Phase I area.

- Since crops to be introduced in the Phase I project is rice for both seasons, wet and dry, effective rainfall for the paddy cultivation is estimated on the daily basis in paddy field which will be considered as small pond shown below, taking into account rainfall, evapotranspiration, percolation, water depth and irrigation water supply.



1/: Crop evapotranspiration (ETPc) is generally calculated by multiplying the ET value by distinct crop coefficient (Kc) during the vegetative stage of crop. The ratio of ET/ETo in the above table is same nature of the Kc. However, when compared with such Kc value of paddy rice, the adopted ratio of ET/ETo is large enough.

- 10-day constant water supply during cropping season is to be planned, because of difficulty for forecasting in available runoff discharge to be expected, due to small storage capacity of Malinao dam (effective storage capacity, V = 5.0 MCM)

- Criteria for estimating an effective rainfall are as follows:

  - Initial water depth at paddy field is assumed to be 50 mm.

  - Daily water balance in field will be made considering ETPc, rainfall and percolation, and when water depth at paddy field drops to less than 20 mm, irrigation water is to be supplied up to the depth of 50 mm.

  - In case much rainfall can be obtained in the paddy field, such rainfall can be stored in the field at the maximum depth of 90 mm, and the rain water more than 90 mm will be drained to terminal drainage canal as no effective use for crops. This depth of 90 mm is decided taking into account the height of ridge in the field.

Based upon the above mentioned criteria, following procedures were taken to calculate an effective rainfall.

- Monthly rainfall observed at Dagohoy station is tabulated in each cropping season, 1st crop (Oct. 21 - Apr. 10), 2nd crop (May 21 - Nov. 10), for the period of 28 years, 1956 - 1984, and total rainfall during both cropping seasons is decided in order from the minimum to the maximum (see TABLE 4-3).

- 15 years of rainfall belonging to the relative dry years are selected out of 28 years and water balance study on the daily basis are conducted by using the selected rainfall data. The results of calculation for effective rainfall is tabulated on 10 days basis as shown in TABLE 4-4.

- ° Calculated effective rainfall in the year of 1982 - 1983 is 1,055 mm, which corresponds to the return period of about 30 years with extreme dry year. Therefore, seven years rainfalls exclusive of such extreme dry year are selected as representative dry year, and 10 day average effective rainfall in each month is estimated as shown in TABLE 4-5.

As seen in TABLE 4-5, an average effective rainfall for the 1st crop and 2nd crop in case of dry year is 532 mm and 773 mm respectively, totaling 1,305 mm, which corresponds to approximately return period of five years as indicated in FIGURE 4-2.

3) Irrigation Efficiency

The proposed irrigation efficiency adopted in the Detailed Design Report is 53.6 percent for wet season paddy and 55.8 percent for dry season paddy, as shown below:

Efficiency	Wet Season Paddy (%)	Dry Season Paddy (%)
Application Efficiency	70	73
Conveyance Efficiency	85	85
Operation Efficiency	90	90
Overall Efficiency	53.6	55.8

Furthermore, in order to compare the irrigation efficiency prevailing in the existing National Irrigation Projects, the following table is prepared.

Name of Project	Wet Season Paddy (%)	Dry Season Paddy (%)
Bohol I.A.D.P.	53.6	55.8
UPRIS	54.0	57.0
AMRIS	60.0	60.0
Jalaur I.P.	48.0	55.0

The projected irrigation efficiency of 53.6 percent for wet season paddy and 55.8 percent for dry season paddy in the Bohol Irrigated Agricultural Development Project shows an average figure among the above data, in the other projects, and are judged to be suitable.

4) Irrigation Water Requirements for Phase I Area

Irrigation water requirements for the Phase I area are estimated on the basis of the following conditions:

- ° Cropping Pattern : Same pattern formulated in the Feasibility Study
- ° Irrigation Water Requirement: Estimated based on the following criteria

Item	West Season	Dry Season
Water Requirements		
- Land Preparation	210 mm	170 mm
- ETPc	refer to paragraph	1)
- Percolation	1.0 mm/day	1.0 mm/day
Effective Rainfall	10-days base (refer	to paragraph 2))
Irrigation Efficiency	53.6%	55.8%

Irrigation water requirements for the dry season paddy (1st crop) and wet season paddy (2nd crop) are calculated in accordance with the above mentioned criteria, and its result is tabulated in TABLE 4-6. Irrigation water requirements per hectare is 691.2 mm for the dry season paddy and 572.3 mm for the wet season paddy. Total irrigation water requirements for the project area of 4,960 ha with cropping intensity of 160 percent are estimated at about 49.0 MCM.

c) Review of Water Balance in Malinao Dam

The water operation study in Phase I project was reviewed based on the reviewed daily runoff at the Malinao damsite and reviewed irrigation requirements mentioned in the previous paragraph.

TABLE 4-3 MONTHLY RAINFALL DURING CROP PLANTING PERIODS (PHASE I AREA)

(Unit: mm)

Month	1956-1957	1957-1958	1958-1959	1959-1960	1960-1961	1961-1962	1962-1963	1963-1964	1964-1965	1965-1966	1966-1967	1967-1968	1968-1969	1969-1970
1st crop														
Oct.	20.6	0	13.0	15.9	73.3	156.9	55.6	53.3	43.7	23.0	102.1	17.9	24.7	83.7
Nov.	201.8	123.7	163.9	128.2	264.1	182.2	390.9	168.6	934.3	122.3	106.5	186.9	399.5	132.3
Dec.	458.2	91.0	62.8	154.7	154.5	179.1	161.3	75.2	257.9	189.2	187.0	191.6	319.9	228.8
Jan.	195.4	131.9	264.8	261.0	179.7	124.9	317.0	139.2	364.9	93.0	436.9	123.8	33.0	78.4
Feb.	187.2	108.3	84.0	97.1	101.9	291.1	132.5	320.2	171.5	58.4	260.7	51.7	9.4	142.2
Mar.	101.9	75.3	238.7	56.8	54.9	185.7	221.4	19.4	136.4	29.1	255.7	82.7	81.6	34.0
Apr.	126.4	0.8	10.9	19.6	56.4	0	48.8	33.8	6.6	0.6	14.0	0	0	5.6
2nd crop														
May	3.3	61.5	41.2	116.9	13.1	87.4	4.0	123.3	3.5	19.1	107.8	0.8	81.2	9.4
Jun.	310.9	159.1	116.8	285.8	103.3	232.1	47.4	107.6	326.6	61.3	129.3	151.7	151.0	349.7
Jul.	409.7	252.1	442.9	172.7	410.4	240.0	326.9	206.4	155.4	372.3	147.0	115.9	248.7	263.4
Aug.	177.5	152.1	207.2	90.5	123.1	297.4	232.3	56.4	173.9	219.4	112.6	110.8	126.8	140.5
Sep.	134.5	130.4	178.0	244.5	240.3	300.3	288.6	269.7	150.1	106.8	189.2	210.3	164.2	153.6
Oct.	309.3	72.8	116.9	158.1	395.7	130.2	331.8	179.1	206.2	352.5	145.3	263.3	123.1	388.6
Nov.	76.0	38.8	49.3	85.7	36.8	159.4	139.6	248.1	27.4	41.2	116.4	30.7	76.7	29.7
Total	2,712.7	1,397.8	1,990.4	1,887.5	2,207.5	2,566.7	2,718.1	2,000.3	2,958.4	1,688.2	2,310.5	1,537.1	1,839.8	2,039.9
	(25)*	(2)	(12)	(11)	(17)	(24)	(26)	(13)	(27)	(6)	(20)	(3)	(10)	(15)

Month	1970-1971	1971-1972	1972-1973	1973-1974	1974-1975	1975-1976	1976-1977	1977-1978	1978-1978	1979-1980	1980-1981	1981-1982	1982-1983	1983-1984	Average
1st crop															
Oct.	260.1	10.1	100.3	15.1	30.3	78.0	43.2	30.5	37.9	107.1	34.1	84.1	16.6	72.9	57.2
Nov.	209.1	330.5	161.3	564.0	304.8	116.0	71.9	201.2	114.6	101.9	194.6	127.3	61.5	131.1	221.3
Dec.	124.8	92.3	147.4	262.6	253.2	172.3	342.6	49.8	192.9	132.3	301.3	428.3	99.3	297.8	200.3
Jan.	266.7	388.7	33.8	53.5	362.9	298.8	347.4	292.1	128.0	227.5	225.1	83.9	30.2	181.1	202.3
Feb.	49.9	33.8	35.0	278.6	126.9	65.7	296.4	133.7	42.2	310.5	95.3	147.2	9.4	254.2	139.8
Mar.	117.5	97.1	28.0	123.9	94.9	42.3	67.1	29.0	32.8	29.7	59.7	213.2	1.3	157.7	95.3
Apr.	2.3	24.2	2.5	109.3	30.7	1.0	1.5	8.9	17.2	31.9	0.5	7.5	0	6.9	20.3
2nd crop															
May	26.7	183.4	0	47.3	13.2	17.9	101.9	19.1	61.9	11.0	45.7	21.8	3.0	2.3	43.8
Jun.	339.5	207.6	209.4	267.5	228.6	198.1	125.9	333.4	314.4	216.5	77.5	152.8	119.1	62.6	192.3
Jul.	239.8	135.6	194.4	114.9	251.9	144.6	272.9	173.3	228.8	338.4	323.4	152.1	337.1	57.3	240.3
Aug.	179.9	255.7	303.0	105.7	153.2	337.7	283.6	85.0	71.1	714.5	98.9	271.8	148.1	28.8	187.7
Sep.	202.6	284.8	244.1	86.0	263.3	117.9	132.2	218.8	148.4	271.5	192.4	139.1	236.1	281.2	199.2
Oct.	214.3	168.2	158.0	119.2	226.0	47.4	158.6	172.1	126.6	441.8	295.9	269.1	227.2	222.4	214.9
Nov.	185.4	64.6	88.9	146.7	43.0	14.8	116.7	26.6	27.8	32.5	58.6	17.3	78.5	76.0	76.2
Total	2,418.6	2,276.6	1,706.1	2,294.3	2,382.9	1,652.5	2,361.9	1,773.5	1,544.6	2,967.1	2,003.0	2,114.5	1,367.4	1,832.5	2,091.0
	(23)	(18)	(7)	(19)	(22)	(5)	(21)	(8)	(4)	(28)	(14)	(16)	(1)	(19)	

Note: *Order of monthly rainfall magnitude from the minimum to the maximum

TABLE 4-4 10-DAYS EFFECTIVE RAINFALL IN SELECTED DRY YEAR (PHASE I AREA)

Station: Dagohoy (Unit: mm/10-day)

Cropping periods			'57-'58	'58-'59	'59-'60	'63-'64	'65-'66	'67-'68	'68-'69	'69-'70	'72-'73	'75-'76	'77-'78	'78-'79	'80-'81	'82-'83	'83-'84
1st crop:	Oct.	III	0	13.0	15.9	53.3	23.0	17.9	24.7	75.3	99.0	78.0	30.5	37.9	34.1	16.6	72.9
	Nov.	I	70.1	38.8	49.3	104.9	27.4	97.0	30.7	76.7	58.5	43.0	99.0	26.6	32.5	17.3	78.1
		II	38.0	87.9	29.0	15.8	42.7	29.3	95.6	15.4	25.2	30.4	34.0	73.0	52.6	34.0	20.4
		III	9.7	37.2	49.9	13.2	52.2	41.2	18.7	38.2	59.4	42.6	50.5	9.6	94.8	10.2	32.2
	Dec.	I	28.0	40.4	53.1	15.7	52.3	16.2	78.0	79.9	28.6	32.0	38.9	103.2	54.3	39.3	71.6
		II	51.3	14.4	15.2	36.8	89.7	116.6	21.2	43.2	16.6	91.2	6.8	35.5	34.2	53.4	61.3
		III	11.7	8.0	82.3	22.7	30.3	3.4	105.4	29.3	9.5	31.1	3.6	54.2	79.2	6.6	64.8
	Jan.	I	63.7	94.3	2.3	21.1	22.4	27.0	13.3	31.5	33.8	63.2	86.0	47.0	57.8	13.3	65.7
		II	33.7	51.1	57.1	44.7	57.6	31.0	18.2	3.0	0	15.6	79.0	8.9	32.0	15.4	60.7
		III	34.5	27.6	115.2	73.4	33.0	65.8	1.5	43.9	0	111.0	39.5	72.1	97.5	1.5	41.4
	Feb.	I	18.2	73.7	45.5	27.0	5.1	26.7	7.2	61.5	10.1	21.6	29.3	29.0	70.7	7.2	33.2
		II	78.9	7.3	15.8	87.1	14.4	4.4	0.2	21.1	24.9	37.2	52.9	8.6	0	0.2	73.6
		III	11.2	3.0	35.8	70.5	38.9	20.6	2.0	59.6	0	6.9	25.3	4.6	24.6	2.0	107.6
	Mar.	I	51.7	38.0	2.6	7.6	6.8	57.4	67.6	7.6	3.5	27.1	25.7	22.6	24.9	1.3	69.0
		II	1.7	91.1	36.7	7.2	22.3	21.0	7.9	17.5	0.7	0	0	0	1.8	0	5.1
		III	21.9	55.2	17.5	4.6	0	4.3	1.7	8.9	23.8	15.2	3.3	10.2	33.0	0	58.9
	Apr.	I	0.8	10.9	19.6	33.8	0.6	0	0	5.6	2.5	1.0	8.9	17.2	59.7	0	6.9
	Sub-total		525.1	691.9	642.8	639.4	498.7	579.8	493.9	618.2	396.1	647.1	613.2	560.2	763.7	218.3	923.4
2nd crop:	May	III	61.5	30.3	89.2	123.3	19.1	0.8	81.2	9.4	0	17.9	19.1	61.9	45.7	3.0	2.3
	Jun.	I	30.3	32.0	60.1	5.1	1.5	52.1	60.8	63.7	3.3	37.8	19.1	10.7	37.2	10.8	17.1
		II	57.6	24.8	56.9	73.5	33.1	7.0	35.9	83.5	124.8	79.9	108.7	64.8	0	5.1	32.8
		III	71.2	60.0	45.9	29.0	26.7	92.6	54.3	60.3	55.7	62.9	58.6	73.7	29.4	85.6	12.7
	Jul.	I	103.5	74.2	75.7	50.6	35.4	54.8	105.0	71.7	71.3	55.9	58.1	52.0	114.1	89.3	0
		II	11.7	57.4	14.1	67.6	98.8	25.7	77.9	31.2	4.2	32.4	21.9	52.0	26.0	32.5	10.8
		III	69.7	82.1	63.2	65.6	71.7	9.0	0	34.9	86.8	56.3	54.1	29.3	61.5	76.3	46.5
	Aug.	I	46.8	16.2	52.4	3.1	32.4	97.0	11.9	59.0	61.0	62.9	29.4	0	9.2	37.5	15.3
		II	88.5	119.3	8.2	0.2	20.3	5.9	34.3	62.5	51.6	117.8	38.0	30.5	8.6	4.1	0
		III	16.8	16.1	22.0	53.1	125.3	5.4	58.9	16.6	108.6	1.0	17.6	40.6	81.1	81.9	13.5
	Sep.	I	7.4	38.5	50.7	58.3	30.3	4.4	72.0	23.4	46.0	80.6	51.0	23.4	0	0	69.0
		II	82.4	63.6	83.1	60.5	5.4	113.5	54.3	50.1	63.5	19.0	110.1	44.5	69.0	116.1	14.5
		III	40.6	75.9	75.7	53.6	46.2	14.1	37.9	80.1	64.5	0	33.6	61.5	82.2	62.5	61.2
	Oct.	I	8.4	46.8	41.2	81.1	98.5	88.2	8.9	57.5	15.4	2.3	79.1	11.9	54.3	46.8	63.2
		II	51.4	54.2	43.6	38.1	58.0	52.4	30.5	70.4	6.0	16.7	55.1	7.6	54.9	67.9	83.8
		III	13.0	15.9	73.3	43.7	46.4	24.7	83.7	73.2	15.3	28.4	37.9	93.0	78.0	50.7	17.4
	Nov.	I	38.8	37.7	83.9	105.2	41.2	30.7	76.7	20.3	88.9	14.8	26.6	27.8	56.2	67.4	76.5
	Sub-total		799.6	845.0	939.2	911.6	810.3	678.3	884.2	867.8	866.9	686.6	818.0	685.2	807.4	837.5	536.6
	Total		1,324.7	1,536.9	1,582.0	1,551.0	1,309.0	1,258.1	1,378.1	1,486.0	1,263.0	1,333.7	1,431.2	1,245.4	1,571.1	1,055.8	1,460.0
			(7)*	(12)	(15)	(13)	(5)	(3)	(8)	(11)	(4)	(7)	(9)	(2)	(14)	(1)	(10)

Note: *Order of monthly rainfall magnitude from the minimum to the maximum.

TABLE 4-5 10-DAYS RAINFALL AND ITS EFFECTIVE RAINFALL IN SELECTED DRY YEAR

(Unit: mm)

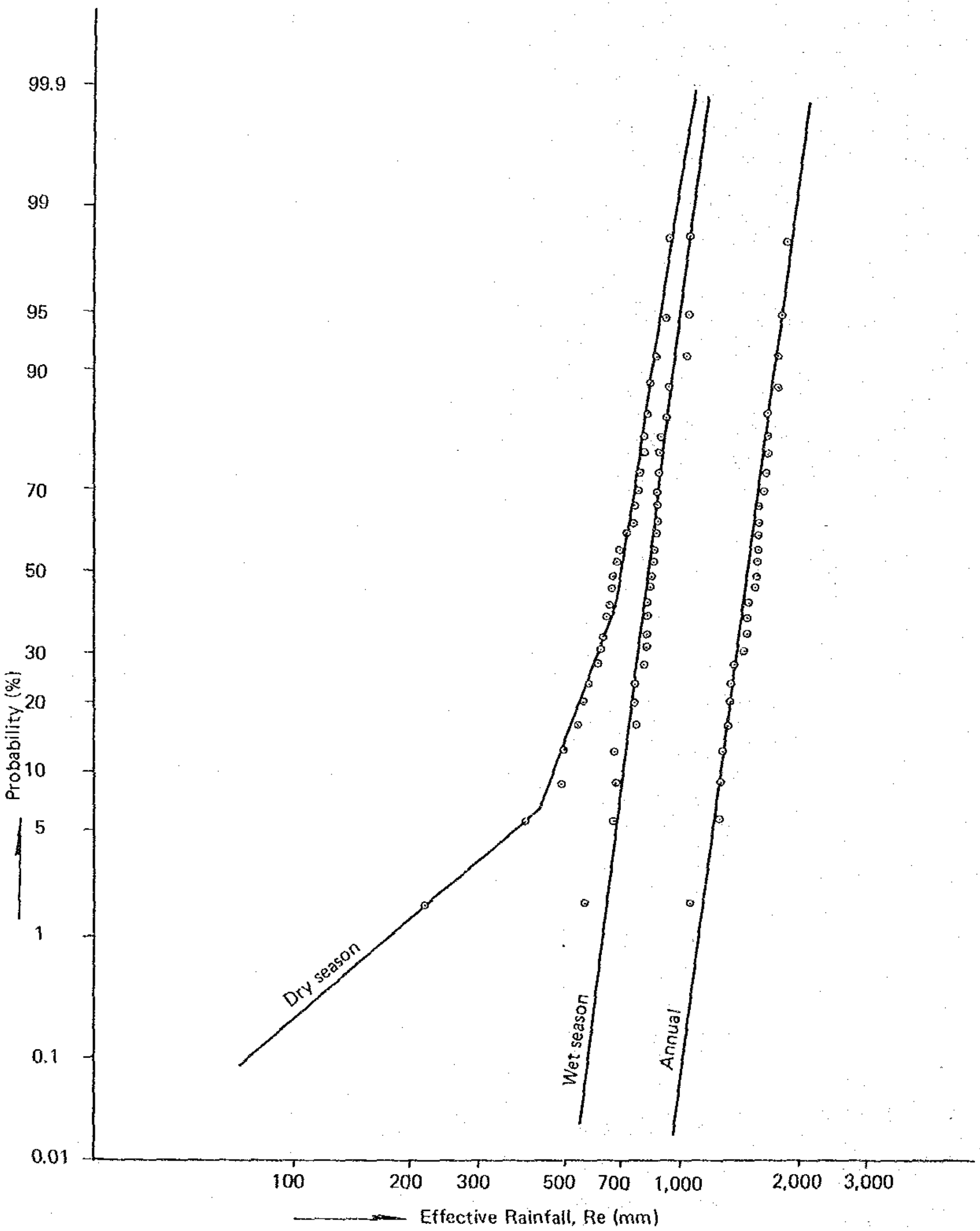
Cropping Period	1957-1958 Rain-fall	1957-1958 Effective Rainfall	1965-1966 Rain-fall	1965-1966 Effective Rainfall	1967-1968 Rain-fall	1967-1968 Effective Rainfall	1968-1969 Rain-fall	1968-1969 Effective Rainfall	1972-1973 Rain-fall	1972-1973 Effective Rainfall	1975-1976 Rain-fall	1975-1976 Effective Rainfall	1978-1979 Rain-fall	1978-1979 Effective Rainfall	Total Rain-fall	Total Effective Rainfall
1st crop																
Oct. III	0	0	23.0	23.0	17.9	17.9	24.7	24.7	100.3	99.0	78.0	78.0	37.9	37.9	40.5	40.1
Nov. I	76.0	70.1	27.4	27.4	116.4	97.0	30.7	30.7	64.6	58.5	43.0	43.0	26.6	26.6	55.0	50.0
II	38.0	38.0	42.7	42.7	29.3	29.3	350.1	95.6	25.2	25.2	30.4	30.4	78.4	73.0	84.9	47.7
III	9.7	9.7	52.2	52.2	41.2	41.2	18.7	18.7	71.5	59.4	42.6	42.6	9.6	9.6	35.1	36.3
Dec. I	28.0	28.0	52.3	52.3	16.2	16.2	193.3	78.0	121.3	28.6	32.0	32.0	103.2	103.2	78.0	48.3
II	51.3	51.3	106.6	89.7	172.0	116.6	21.2	21.2	16.6	16.6	109.2	91.2	35.5	35.5	73.2	60.3
III	11.7	11.7	30.3	30.3	3.4	3.4	105.4	105.4	9.5	9.5	31.1	31.1	54.2	54.2	35.1	35.1
Jan. I	63.7	63.7	22.4	22.4	27.0	27.0	13.3	13.3	33.8	33.8	63.2	63.2	47.0	47.0	38.6	38.6
II	33.7	33.7	37.6	37.6	31.0	31.0	18.2	18.2	0	0	15.6	15.6	8.9	8.9	20.7	20.7
III	34.5	34.5	33.0	33.0	65.8	65.8	1.5	1.5	0	0	220.0	111.0	72.1	72.1	61.0	45.4
Feb. I	18.2	18.2	5.1	5.1	26.7	26.7	7.2	7.2	10.1	10.1	21.6	21.6	29.0	29.0	16.8	16.8
II	78.9	78.9	14.4	14.4	4.4	4.4	0.2	0.2	24.9	24.9	37.2	37.2	8.6	8.6	24.1	24.1
III	11.2	11.2	38.9	38.9	20.6	20.6	2.0	2.0	0	0	6.9	6.9	4.6	4.6	12.0	12.0
Mar. I	51.7	51.7	6.8	6.8	57.4	57.4	72.0	67.6	3.5	3.5	27.1	27.1	22.6	22.6	34.4	33.8
II	1.7	1.7	22.3	22.3	21.0	21.0	7.9	7.9	0.7	0.7	0	0	0	0	7.7	7.7
III	21.9	21.9	0	0	4.3	4.3	1.7	1.7	23.8	23.8	15.2	15.2	10.2	10.2	11.0	11.0
Apr. I	0.8	0.8	0.6	0.6	0	0	0	0	2.5	2.5	1.0	1.0	17.2	17.2	3.2	3.2
Sub-total	531.0	525.1	515.6	498.7	654.6	579.8	868.1	493.9	508.3	396.1	774.1	647.1	565.6	560.2	631.1	531.6
2nd crop																
May III	61.5	61.5	19.1	19.1	0.8	0.8	81.2	81.2	0	0	17.9	17.9	61.9	61.9	34.6	34.6
Jun. I	30.3	30.3	1.5	1.5	52.1	52.1	60.8	60.8	3.3	3.3	37.8	37.8	10.7	10.7	28.1	28.1
II	57.6	57.6	33.1	33.1	7.0	7.0	35.9	35.9	149.3	124.8	57.9	79.9	92.0	64.8	66.1	57.6
III	71.2	71.2	26.7	26.7	92.6	92.6	54.3	54.3	56.8	55.7	72.4	62.9	211.7	73.7	83.7	62.4
Jul. I	170.7	103.5	35.4	35.4	81.2	54.8	166.0	105.0	103.4	71.3	55.9	55.9	157.7	52.0	107.2	68.3
II	11.7	11.7	166.4	98.8	25.7	25.7	82.7	77.9	4.2	4.2	32.4	32.4	61.8	52.0	55.0	43.2
III	69.7	69.7	170.5	71.7	9.0	9.0	0	0	86.8	86.8	56.3	56.3	29.3	29.3	60.2	46.1
Aug. I	46.8	46.8	69.9	32.4	99.5	97.0	11.9	11.9	85.6	61.0	116.6	62.9	0	0	61.5	44.6
II	88.5	88.5	20.3	20.3	5.9	5.9	34.3	34.3	51.6	51.6	350.1	117.8	30.5	30.5	64.5	49.8
III	16.8	16.8	129.2	125.3	5.4	5.4	80.6	58.9	165.8	108.6	1.0	1.0	40.6	40.6	62.8	50.9
Sep. I	7.4	7.4	55.2	50.3	4.4	4.4	72.0	72.0	70.3	46.0	98.9	80.6	23.4	23.4	47.4	40.6
II	82.4	82.4	5.4	5.4	191.8	113.5	54.3	54.3	77.3	63.5	19.0	19.0	44.5	44.5	67.8	54.7
III	40.6	40.6	46.2	46.2	14.1	14.1	37.9	37.9	96.5	64.5	0	0	80.5	61.5	45.1	37.8
Oct. I	8.4	8.4	167.4	98.5	103.6	88.2	8.9	8.9	136.7	15.4	2.5	2.5	11.9	11.9	62.7	33.4
II	51.4	51.4	83.0	58.0	134.0	52.4	30.5	30.5	6.0	6.0	16.7	16.7	7.6	7.6	47.0	31.8
III	13.0	13.0	102.1	46.4	24.7	24.7	83.7	83.7	15.3	15.3	28.4	28.4	107.1	93.0	53.5	43.5
Nov. I	38.8	38.8	41.2	41.2	30.7	30.7	76.7	76.7	88.9	88.9	14.8	14.8	27.8	27.8	45.6	45.6
Sub-total	866.8	799.6	1,172.6	810.3	882.5	678.3	971.7	884.2	1,197.8	866.9	878.4	686.6	979.0	685.2	992.7	773.0
Total	1,397.8	1,324.7	1,688.2	1,309.0	1,537.1	1,258.1	1,839.8	1,378.1	1,706.1	1,263.0	1,652.5	1,333.7	1,544.6	1,245.4	1,623.8	1,304.6

TABLE 4-6 IRRIGATION WATER REQUIREMENT FOR 100 HA (PHASE I AREA)

Item	Oct. I	Oct. II	Oct. III	Nov. I	Nov. II	Nov. III	Dec. I	Dec. II	Dec. III	Jan. I	Jan. II	Jan. III	Feb. I	Feb. II	Feb. III	Mar. I	Mar. II	Mar. III	Apr. I	Apr. II	Apr. III
			Dry Season Paddy (1st Crop)																		
1. Cropping Area (ha)																					
Land Preparation			4.0	12.0	18.0	20.0	20.0	16.0	8.0	2.0	-	-	-	-	-	-					
Transplanting / Growing			-	-	2.5	20.0	40.0	60.0	80.0	97.5	100.0	100.0	100.0	99.0	70.0	50.0	30.0	10.0			
2. Water Requirement (mm)																					
Land Preparation			170	170	170	170	170	170	170	170	-	-	-	-	-	-	-	-			
Transplanting / Growing			-	-	59	59	54	54	59	63	63	69	60	60	48	69	69	76			
3. Effective Rainfall (mm)			40	51	48	36	48	60	35	39	21	45	17	24	12	34	8	11		Total=529 mm	
4. Irrigation Efficiency (%)			55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8			
5. Diversion Water Demand (10^3 m^3)			9.3	25.6	39.8	56.3	48.0	31.5	53.8	46.6	75.3	43.0	77.1	63.9	45.2	31.4	32.8	11.6		Total=691.2x10^3 m^3	

Item	May I	May II	May III	June I	June II	June III	July. I	July. II	July. III	Aug. I	Aug. II	Aug. III	Sep. I	Sep. II	Sep. III	Oct. I	Oct. II	Oct. III	Nov. I	Nov. II	Nov. III
			Wet Season Paddy (2nd Crop)																		
1. Cropping Area (ha)																					
Land Preparation			4.0	12.0	18.0	20.0	20.0	16.0	8.0	2.0	-	-	-	-	-	-	-	-			
Transplanting / Growing			-	-	2.5	20.0	40.0	60.0	80.0	97.5	100.0	100.0	100.0	99.0	70.0	50.0	30.0	10.0			
2. Water Requirement (mm)																					
Land Preparation			210	210	210	210	210	210	210	210											
Transplanting / Growing			-	-	67	67	65	65	72	66	66	73	58	58	58	58	58	58			
3. Effective Rainfall (mm)			35	28	58	62	68	43	46	45	50	51	41	55	38	33	32	44		Total=729 mm	
4. Irrigation Efficiency (%)			53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6			
5. Diversion Water Demand (10^3 m^3)			13.1	40.7	51.5	57.1	53.0	74.5	63.3	44.4	29.9	41.0	31.7	5.5	26.1	23.3	14.6	2.6		Total=572.3x10^3 m^3	

FIGURE 4-2 PROBABLE EFFECTIVE RAINFALL



The water operation study in Phase I project was carried by the Study Team having several meeting and discussion with NIA and the Consulting Team in charge of implementation of the Phase I project.

The study result of water operation in Phase I is described below;

1) Operation Criteria

The water operation criteria of the Malinao reservoir were initially formulated as follows taking into account the practical water management in Phase I.

- Effective reservoir capacity of Malinao reservoir is 5.0 MCM which is the same capacity decided in the Detailed Design Stage of Phase I.

- Runoff at the Malinao damsite reviewed by the Study Team is used as inflow in reservoir and the estimated daily runoff for the period of 28 years is put in the computer.

- Irrigation requirement in Phase I project is estimated as a constant release in average dry year with about five years return period and on the 10 days basis as mentioned in the previous paragraph.

- In the reservoir operation, the Malinao reservoir should be firstly recovered up to the full water level with the inflow of the Wahig river, because the Malinao reservoir has a small effective capacity of 5.0 MCM and should keep the full water level as much as possible to meet the irrigation requirements of dry period in Phase I, which will take place frequently during irrigation season and can not be forecasted.

2) Alternative Water Balance Study

The irrigation area in Phase I is fixed as 4,960 ha, but the water requirements are changeable in accordance with cropping season of paddy and cropping intensity in wet and dry seasons. The following six alternative water operation studies for the different cropping intensity in wet and dry seasons have been made.

Alternative Plan	Wet Season Cropping Intensity (%)	Dry Season Cropping Intensity (%)
I - 1	100	50
I - 2	100	60
I - 3	100	70
II - 1	50	100
II - 2	60	100
II - 3	70	100

The water balance studies for six alternatives have been conducted for the period of 28 years, 1956 - 1984 and their result is summarized as shown in TABLE 4-7.

In accordance with the study results of water operation of the Malinao dam shown in TABLE 4-7, the Alternative I-2 plan was judged as the most suitable and recommendable one in Phase I project for the following reasons.

- In case of comparison between the Alternative I-1 and I-2, the Alternative I-2 is better than the Alternative I-1, because the Alternative I-2 can introduce the cropping intensity of 160 percent with same water shortage frequency of six times and same shortage amount of 1.0 MCM per annum, which is more profitable than the Alternative I-1 with the cropping intensity of 150 percent.

- In case of Alternative I-3 with cropping intensity of 170 percent, the water shortage year of 8 times during 28 years corresponding with three years return period will take place. This fact will bring the problem that a stable irrigated agriculture can not be materialized in Phase I project.

- All cases of the Alternative II bring more water shortage problem such as 11 times during 28 years and water shortage amount of 3.2 MCM per annum due to the differences of irrigation requirements between the wet season of 572.3 mm/ha and the dry season of 691.2 mm/ha, so that the Alternative II should not be considered in the water operation and agricultural plan in Phase I project.

3) Main Canal Capacity of Phase I Project

The main canal capacity of 6 to 7 cu.m/sec at the maximum will be sufficient to irrigate the Phase I service area of 4,960 ha by applying the canal design criteria of 1.2 to 1.4 lit./sec/ha against total irrigation area.

The main canal of Phase I, however, should have the function to convey the surplus water from the Malinao dam to Phase II project together with Phase I irrigation requirements.

The amount of surplus water, especially the amount in dry year gives a big influence to the storage capacity of the Bayongan dam, which is proposed in Phase II and receives the surplus water at the terminal point of Phase I main canal.

The differences in the amount of surplus water have been studied by the Study Team in accordance with the different canal capacity of 7.0 to 13.0 cu.m/sec. The study has been made on the daily discharge basis introduced from the Malinao reservoir and 10 days basis of irrigation requirements with a cropping intensity of 160 percent in the Alternative I-2 decided in the pervious paragraph.

In accordance with the result of the study, the surplus water has a big allowance in wet season to meet the irrigation requirements in Phase II, but is considerably less in dry year, because the diversion water from Malinao dam in the dry season has small amount, and mostly used for the irrigation supply for Phase I project.

The surplus water amount in the dry year which gives an influence to the storage capacity of the Bayongan dam is summarized as follows depending on each canal capacity of 7.0 cu.m/sec to 13.0 cu.m/sec.

Surplus Water by Different Main Canal Capacity in Dry Year

(Unit: MCM)

Dry Year	7 cu.m /sec	8 cu.m /sec	9 cu.m /sec	10 cu.m /sec	11 cu.m /sec	11.8 cu.m /sec	13 cu.m /sec
1957 - 58	19.8	21.0	22.0	22.8	23.4	23.8	24.3
1958 - 59	28.0	29.6	30.8	31.9	32.9	33.7	34.8
1959 - 60	28.3	30.2	31.8	33.2	34.3	35.1	36.3
1967 - 68	23.6	25.2	26.6	27.9	29.0	29.7	30.6
1968 - 69	21.3	22.6	23.8	24.9	25.7	26.3	26.8
1982 - 83	28.1	30.1	31.7	32.9	34.0	34.8	35.6
Average	24.9	26.5	27.8	29.0	29.9	30.6	31.4
Difference		1.6	1.3	1.2	0.9	0.7	0.8

The surplus water for the canal capacity of 7.0 cu.m/sec to 10 cu.m/sec increases more than 1.2 MCM per annum against increase of each 1.0 cu.m canal discharge capacity, but the increase ratio of surplus water becomes mostly constant as 0.8 to 0.9 MCM per annum in case of canal capacity between 10 cu.m/sec and 13 cu.m/sec. The optimum canal capacity, therefore will be 11.0 cu.m/sec or 11.8 cu.m/sec, because the increase of the amount of surplus water changes at the point of 11.0 cu.m/sec and becomes constant.

On the other hand, the increase of surplus water of 1.0 MCM per annum in the dry year will approximately correspond to decreasing the storage capacity of 1.0 MCM in the Bayongan dam, because the Bayongan storage capacity drops generally up to a low water level in dry year and requires a big capacity in case of less surplus water in dry year in order to meet the irrigation requirements in Phase II project area.

The difference of canal construction cost between 7.0 cu.m/sec and 11.8 cu.m/sec is small amount of only about 1.0 million Pesos which corresponds only to two percent of Phase I construction cost.

The main canal capacity of Phase I, therefore was decided as 11.8 cu.m/sec which is same capacity designed in the Detailed Design Stage taking into account the Phase II project. This capacity is finally determined and decided under the joint meeting of NIA, the Study Team and the Consultant engaging in the Phase I project implementation, and then the surplus water to Phase II is to be estimated by this canal capacity.

4) Results of Review for Water Balance in Malinao Dam

The water balance study has been made based on the following initial conditions:

Irrigation Area	:	4,960 ha
Cropping Intensity	:	160%
Effective Reservoir Capacity	:	5.0 MCM
Main Canal Capacity	:	11.82 cu.m/sec

The relation curve between water surface elevation and reservoir capacity is presented in FIGURE 4-3.

The water balance for Phase I was studied for the periods from October 1956 to October 1984, and its study result is shown in TABLE 4-8 and FIGURE 4-4. The major dimension relating to the water operation are summarized as follows;

1st Crops	:	100% (4,960 ha)
2nd Crops	:	60% (2,980 ha)
Inflow	:	116.9 MCM
Water Demand	:	49.0 MCM
Surplus to Bayongan	:	49.0 MCM
Spillage	:	16.5 MCM
Evaporation	:	2.7 MCM
Shortage	:	-0.3 MCM
Shortage Years	:	6 times

Ten water shortage years throughout 28 years appear in the actual water operation. However, four years out of ten years present only a few water shortage day, which is no influence to the paddy cultivation and are negligible. Thus, year with actual water shortage is considered as six times during 28 years and its return period is about five years.

The reservoir operation curve of the Malinao reservoir is shown in FIGURE 4-4.

d) Available Surplus Water to Phase II Area

The surplus water to Phase II area was estimated by the difference between the amount diverted from the Malinao dam with main canal capacity of 11.8 cu.m/sec and the constant irrigation requirements of Phase I project in the average dry year under 160 percent cropping intensity.

The estimate of surplus water was made on the basis of daily discharge at the Malinao dam and 10 days basis of irrigation requirements. The estimated result is shown in TABLE 4-9.

As clear in TABLE 4-9, the monthly pattern of surplus water presents a big fluctuation in wet and dry seasons. The characteristics of the surplus water is summarized as follows;

TABLE 4-7 SUMMARY OF WATER OPERATION STUDY FOR RPASE I AREA

Description	Alternative - I			Alternative - II		
	I - 1	I - 2	I - 3	II - 1	II - 2	II - 3
1. Cropping Intensity (%)						
Wet Season (May to Oct.)	100	100	100	50	60	70
Dry Season (Oct. to Mar.)	50	60	70	100	100	100
2. Cropping Area (ha)						
Wet Season	4,960	4,960	4,960	2,480	2,980	3,470
Dry Season	2,480	2,980	3,470	4,960	4,960	4,960
3. Runoff at Malinao Dam (MCM)						
Annual Average	116.9	116.9	116.9	116.9	116.9	116.9
Dry Year Average	92.2	92.2	92.2	92.2	92.2	92.2
4. Water Requirements (MCM)	45.5	49.0	52.4	48.5	51.4	54.2
Wet Season (572.3 mm/ha)	28.4	28.4	28.4	14.2	17.1	19.9
Dry Season (691.2 mm/ha)	17.1	20.6	24.0	34.3	34.3	34.3
5. Water Shortage						
Number of Shortage Year (Times)	6	6	8	11	11	11
Annual Shortage Amount (MCM)	1.0	1.0	1.1	3.2	3.2	3.2

Note: Detail operation result is shown in TABLE E1-3 to TABLE E1-8.

TABLE 4-8 SUMMARY TABLE OF RESERVOIR OPERATION FOR MALINAO DAM

(CASE I-2: 160%)

* RESERVOIR CAPACITY 5.99 (MCM)
* MAIN CANAL CAPACITY 11.82 (CU.M/S)

YEAR	INFLOW (MCM)	DEMAND (MCM)	BALANCE (MCM)	EVAPORAT. (MCM)	REMAIN (MCM)	INTAKE (MCM)	BAYONGAN (MCM)	SPILLAGE (MCM)	SHORTAGE (MCM)
56-57	154.863	48.982	105.879	2.812	103.068	110.421	61.438	41.630	0.0
57-58	82.539	48.982	33.556	2.639	30.918	72.798	23.816	7.102	0.0
58-59	93.277	48.982	44.294	2.719	41.576	82.680	33.698	7.878	0.0
59-60	102.310	49.150	53.158	2.707	50.452	84.295	35.144	15.308	0.0
60-61	105.817	48.982	56.834	2.732	54.102	95.052	46.070	8.033	0.0
61-62	127.738	48.982	78.755	2.791	75.964	107.499	58.516	17.448	0.0
62-63	145.489	48.982	96.505	2.675	94.839	117.959	69.985	24.854	-1.008
63-64	107.888	49.150	58.737	2.682	56.055	91.373	42.222	13.833	0.0
64-65	170.697	48.982	121.713	2.659	119.737	112.725	64.424	55.313	-0.682
65-66	96.303	48.982	47.320	2.637	45.386	87.143	38.863	6.523	-0.702
66-67	120.092	48.982	71.109	2.605	68.504	101.894	52.911	15.593	0.0
67-68	89.151	49.150	39.999	2.596	37.404	78.844	29.693	7.711	0.0
68-69	97.590	48.982	48.606	2.557	46.240	75.046	26.230	20.011	-0.165
69-70	99.041	48.982	50.058	2.793	47.240	90.934	41.952	5.288	0.0
70-71	138.153	48.982	89.170	2.806	86.364	122.274	73.291	13.073	0.0
71-72	132.374	49.150	83.222	2.634	81.238	107.825	59.323	21.915	-0.649
72-73	102.780	48.982	53.796	2.527	51.271	84.381	35.399	15.872	0.0
73-74	131.711	48.982	82.728	2.638	80.091	100.341	51.358	28.733	0.0
74-75	133.290	48.982	84.306	2.754	81.553	110.785	61.802	19.751	0.0
75-76	99.228	49.150	50.076	2.728	47.644	87.771	38.916	8.728	-0.295
76-77	115.904	48.982	66.921	2.778	64.143	101.262	52.279	11.864	0.0
77-78	127.288	48.982	78.304	2.575	77.244	102.225	54.757	22.487	-1.515
78-79	103.704	48.982	54.721	2.682	52.040	90.944	41.961	10.078	0.0
79-80	119.475	49.150	70.323	2.824	67.500	102.147	52.996	14.504	0.0
80-81	128.923	48.982	79.939	2.528	78.537	111.683	63.825	14.712	-1.125
81-82	131.176	48.982	82.192	2.797	79.396	105.642	56.660	22.737	0.0
82-83	92.566	48.982	43.583	2.276	41.623	83.490	34.824	6.800	-0.316
83-84	124.810	49.150	75.658	2.563	74.191	117.065	69.010	5.181	-1.095
AVE.	116.935	49.024	67.909	2.668	65.511	97.732	48.977	16.534	-0.270

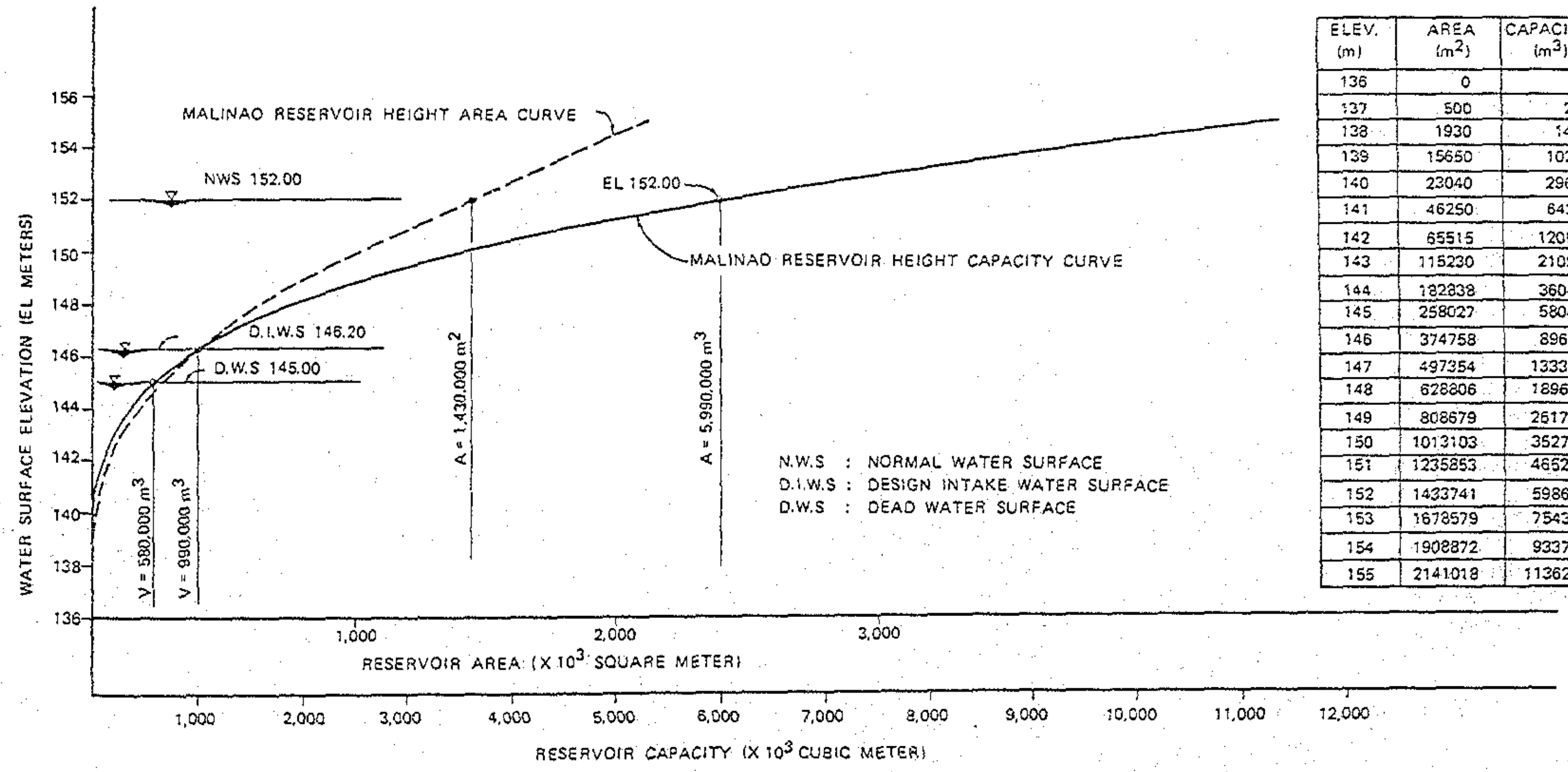
TABLE 4-9 ESTIMATED SURPLUS WATER FROM PHASE I AREA TO PHASE II AREA

UNIT ; MCM

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
56-57	1.322	4.022	11.193	7.983	2.070	4.172	6.080	4.218	3.913	4.255	2.071	2.298	7.843	61.438
57-58*	1.759	3.347	0.939	1.513	1.122	2.166	4.278	3.519	0.852	1.735	0.0	0.410	2.176	23.815
58-59*	0.805	2.658	0.890	2.226	0.710	3.746	3.228	3.255	0.179	5.106	4.296	3.812	2.787	33.697
59-60*	0.899	2.871	3.303	4.140	1.497	2.281	5.441	4.669	3.698	2.191	0.0	2.715	1.441	35.144
60-61	2.725	6.302	3.397	4.489	2.083	0.862	4.042	4.329	1.774	2.221	2.378	5.105	6.362	46.071
61-62	5.932	3.777	4.145	2.168	4.232	7.792	3.948	2.530	4.343	2.782	4.930	9.754	2.182	58.516
62-63	1.854	7.529	4.793	10.704	3.804	6.936	4.562	3.277	0.0	0.0	7.195	7.385	11.946	69.986
63-64	2.806	4.652	1.342	1.700	4.302	2.325	3.938	10.185	1.839	0.0	0.0	4.583	4.550	42.222
64-65	1.615	15.325	8.300	7.462	3.096	6.532	5.251	3.544	5.393	1.101	0.0	2.762	4.043	64.425
65-66	2.874	1.607	5.511	0.918	0.0	1.107	3.053	8.222	0.0	1.868	3.503	4.344	5.855	38.862
66-67	3.970	2.392	2.713	10.093	5.661	10.311	4.292	3.442	1.335	2.286	0.0	2.001	4.416	52.912
67-68*	0.640	4.405	6.119	2.229	0.0	1.452	2.814	2.289	0.264	0.362	0.0	3.209	5.909	29.693
68-69*	0.925	5.477	7.358	0.895	0.0	1.685	3.988	3.126	0.0	1.196	0.0	1.193	0.386	26.229
69-70	3.389	2.657	7.424	0.563	2.580	1.318	2.949	2.678	4.857	5.746	1.796	2.586	3.407	41.951
70-71	7.976	8.114	5.697	4.225	2.129	4.254	3.932	9.730	9.970	4.488	1.730	5.493	5.554	73.293
71-72	3.311	10.364	2.808	9.304	0.0	3.843	4.234	7.010	1.908	3.949	0.0	8.211	4.383	59.325
72-73	3.170	5.605	3.055	1.251	0.0	0.0	0.687	2.558	1.548	1.855	1.609	8.117	5.945	35.400
73-74	0.628	10.772	8.676	2.116	4.247	6.321	8.074	5.888	2.139	0.116	0.0	0.015	2.368	51.359
74-75	3.303	7.620	5.644	10.994	3.273	2.878	6.638	2.942	1.551	2.001	1.307	8.076	5.577	61.803
75-76	2.509	2.256	4.621	6.636	1.884	2.353	3.121	3.676	2.294	0.0	6.071	3.452	0.042	38.916
76-77	1.224	2.774	8.155	6.077	10.232	4.892	3.048	4.962	0.259	1.353	2.615	3.918	2.771	52.280
77-78	1.209	4.131	1.858	8.949	2.212	0.612	5.148	4.571	4.990	0.026	0.0	12.949	8.102	54.757
78-79	2.806	4.306	5.612	2.879	0.0	0.0	4.055	5.057	7.877	4.063	0.0	2.577	2.730	41.962
79-80	1.663	2.770	4.375	5.266	3.614	0.265	3.328	1.647	4.040	4.706	10.616	4.750	5.955	52.996
80-81	5.112	9.596	11.065	15.545	3.327	2.163	4.314	2.604	0.185	1.830	0.0	0.049	8.034	63.825
81-82	2.029	5.054	9.117	3.085	4.553	6.983	4.429	4.906	1.169	2.104	5.041	2.079	6.112	56.660
82-83*	1.353	2.054	1.535	0.0	0.0	0.0	0.0	0.0	0.0	4.009	9.077	9.251	7.546	34.825
83-84	3.336	4.278	11.040	5.435	7.004	7.279	5.060	4.167	1.278	0.0	3.552	9.436	7.146	69.011
AVE.	2.541	5.240	5.382	4.959	2.630	3.376	4.069	4.250	2.416	2.191	2.421	4.662	4.842	48.977
DRY-YEAR	1.064	3.469	3.357	1.834	0.555	1.888	3.291	2.810	0.832	2.433	2.229	3.432	3.374	30.567

Note: Year with an asterisk shows the year with less surplus water amount (dry year)

FIGURE 4–3 MALINAO RESERVOIR AREA AND CAPACITY CURVE



ELEV. (m)	AREA (m^2)	CAPACITY (m^3)
136	0	0
137	500	250
138	1930	1465
139	15650	10255
140	23040	29600
141	46250	64245
142	65515	120564
143	115230	210952
144	182838	360460
145	258027	580413
146	374758	896992
147	497354	1333152
148	628806	1896231
149	808679	2617117
150	1013103	3527706
151	1235853	4652292
152	1433741	5986779
153	1678579	7543661
154	1908872	9337228
155	2141018	11362806

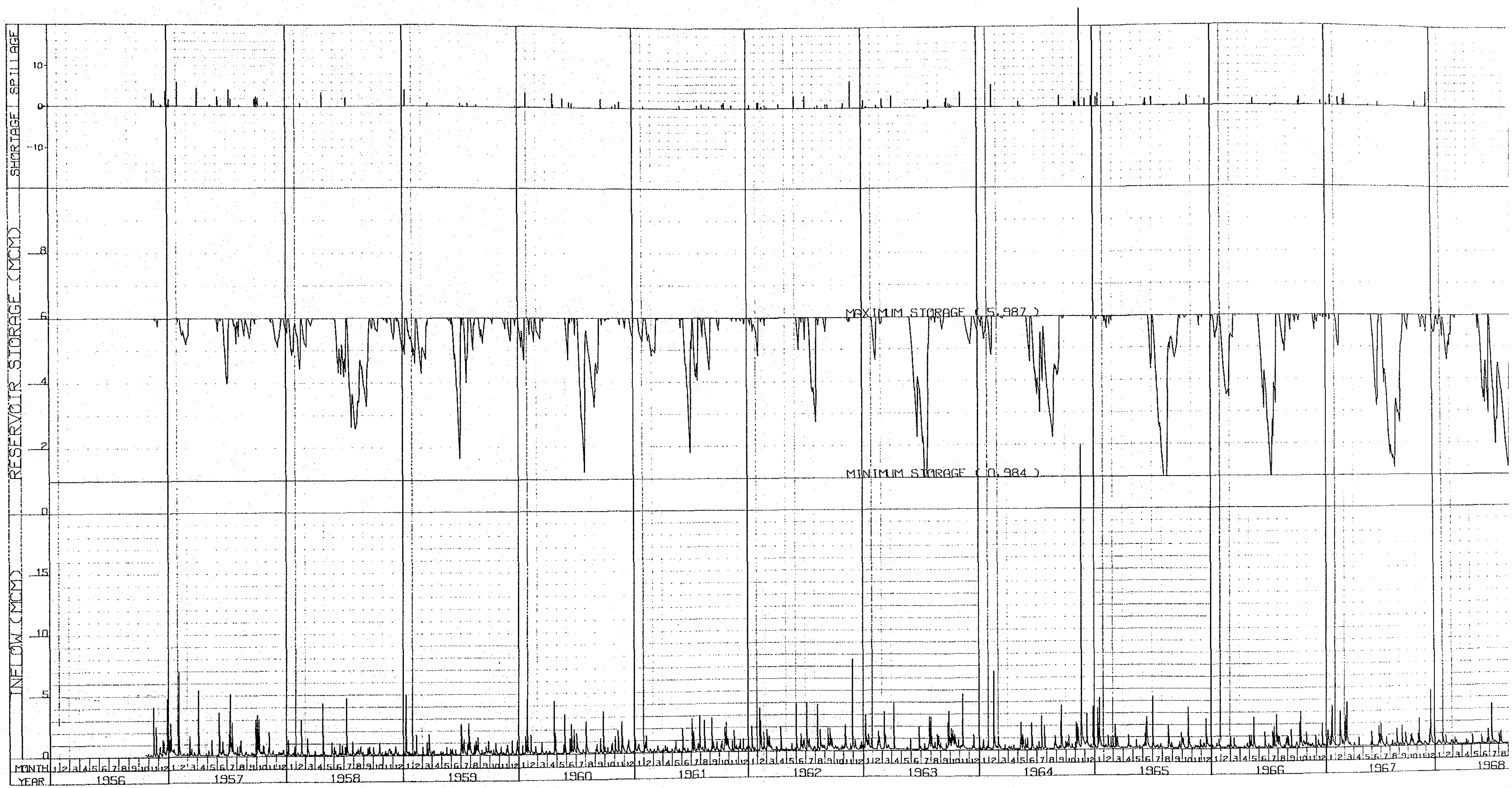


FIGURE 4-4 RESERVOIR OPE

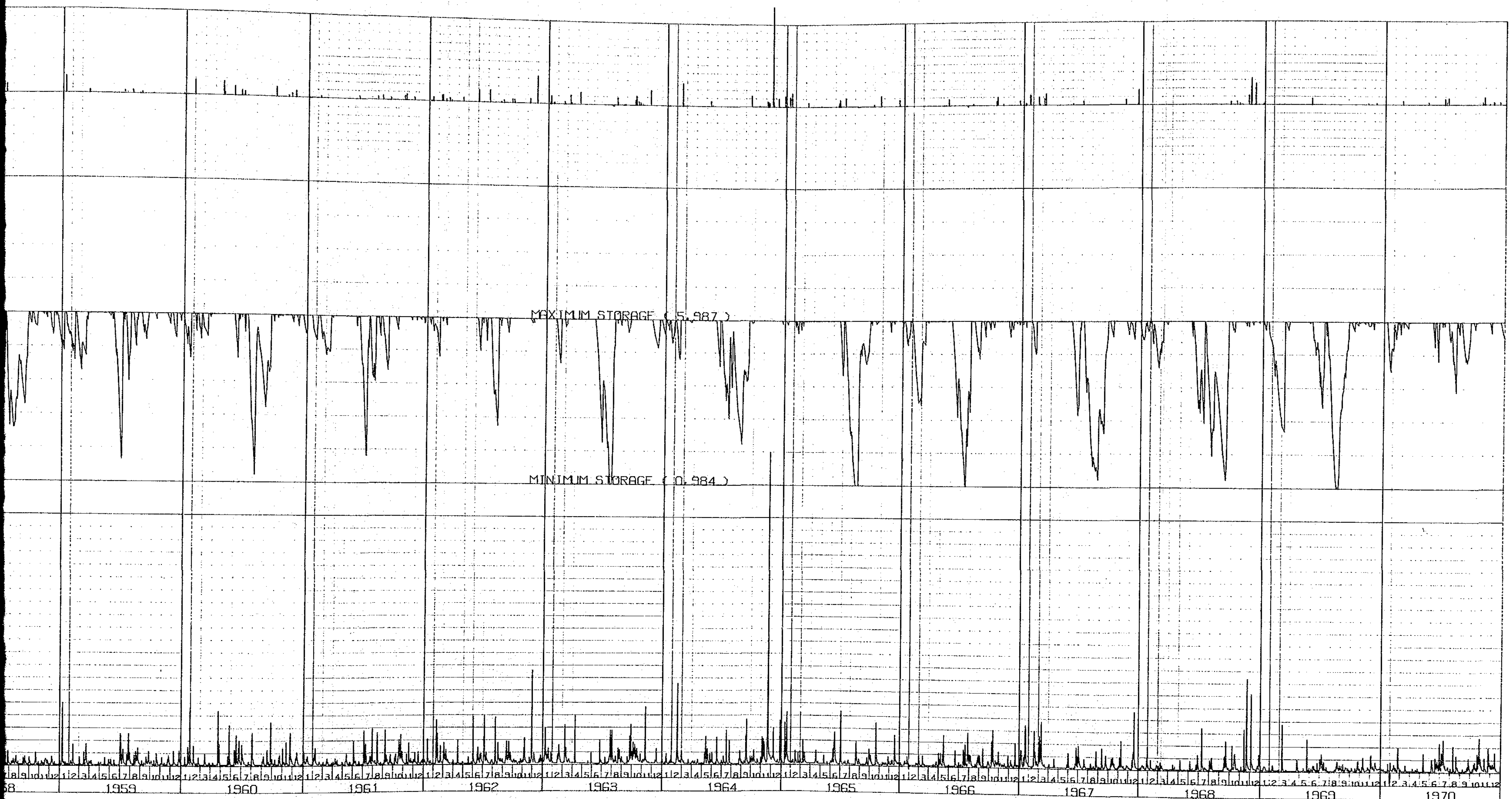
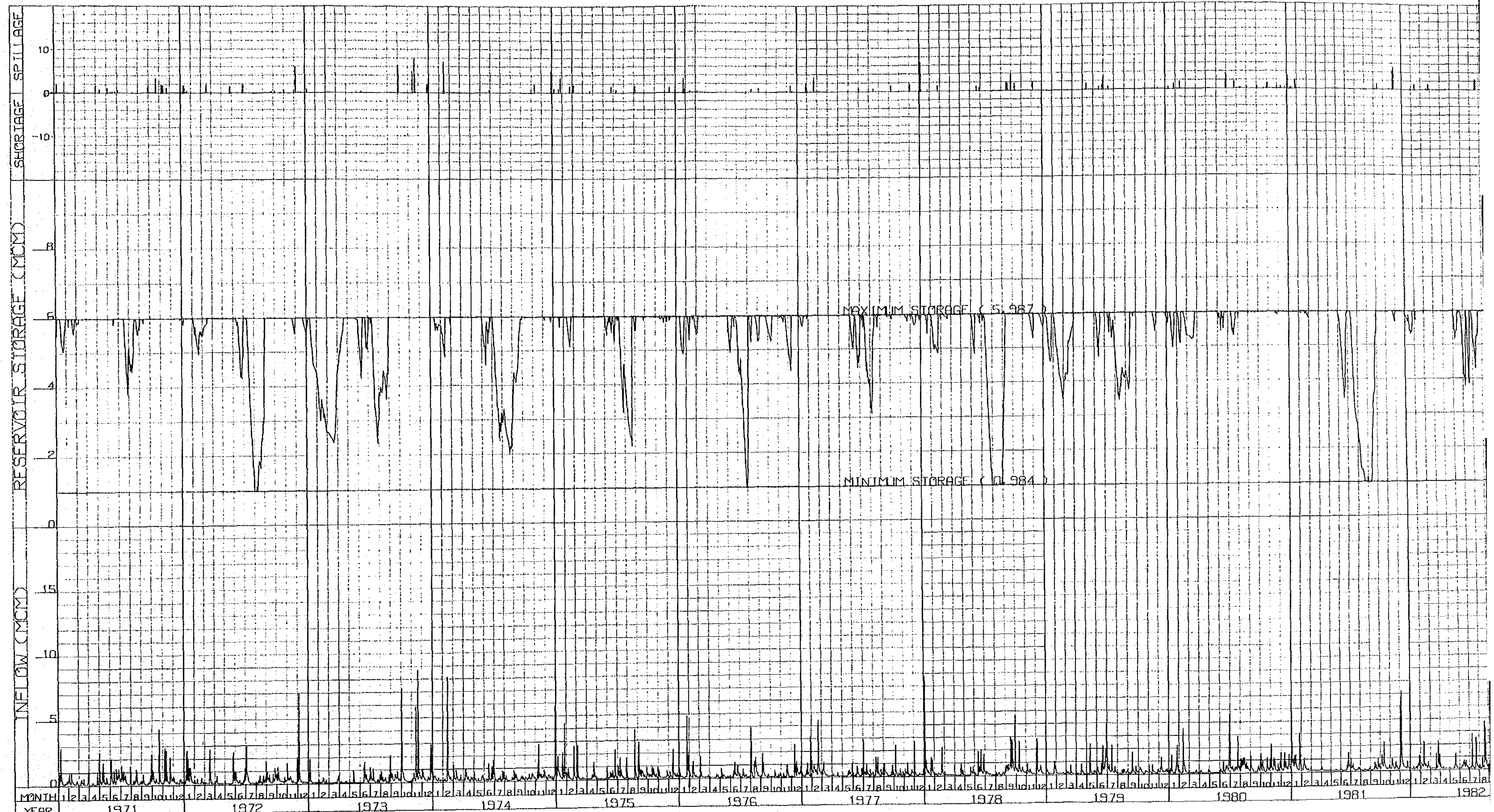
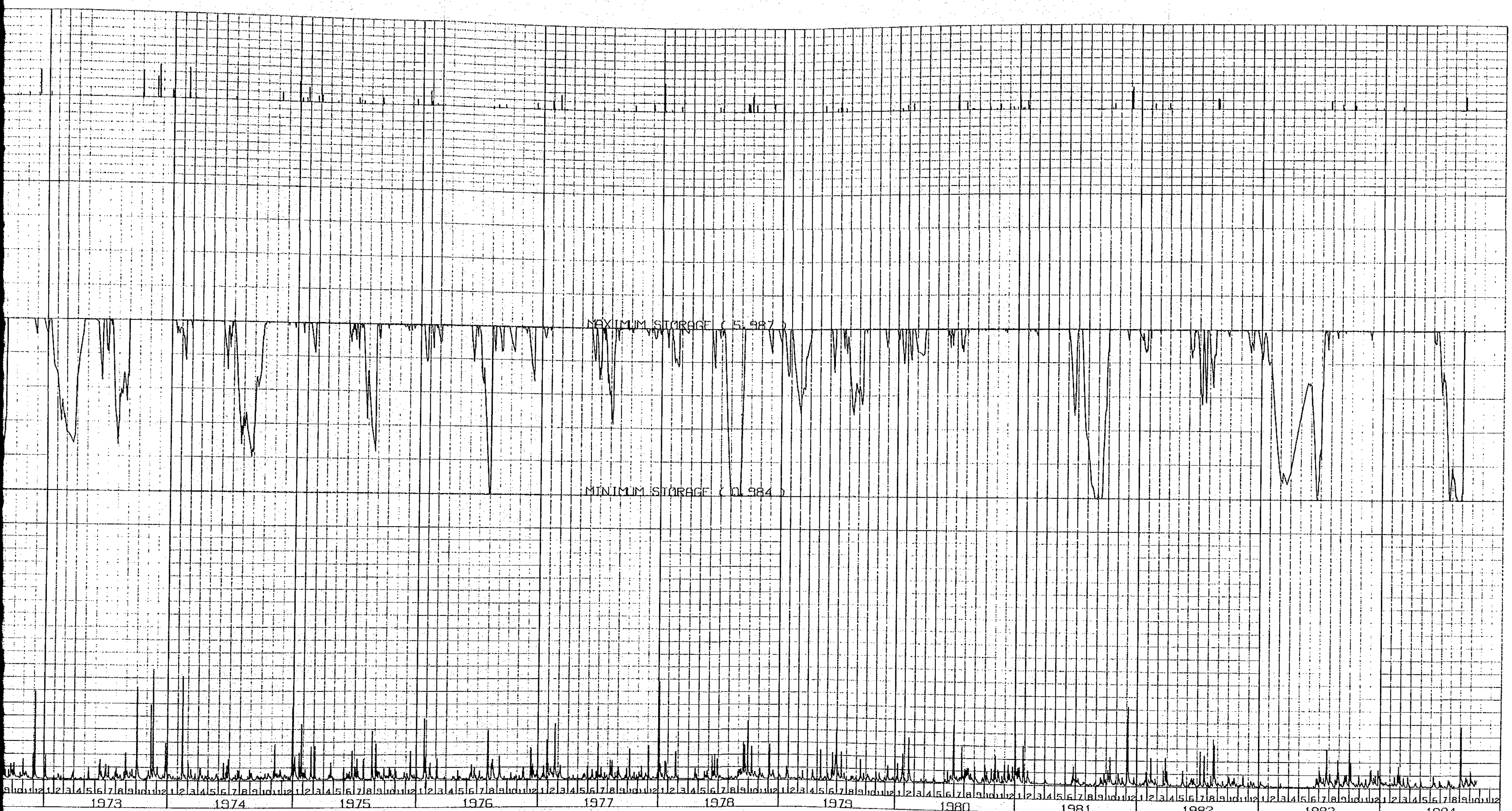


FIGURE 4-4 RESERVOIR OPERATION CURVE FOR MALINAO RESERVOIR



RESERVOIR OPERATION FOR MALINAO DAM



RESERVOIR OPERATION FOR MALINAO DAM

- Average annual surplus water is 49.0 MCM which seems to be much amount but annual surplus water in dry year is only 23.8 to 35.1 MCM which will take place six times during 28 years. This surplus water in dry year will give a big influence to determine the Bayongan reservoir capacity in Phase II project.

- In the year such as 1983, no surplus water is introduced to Phase II area for continuous 6 months from January to June, because this year is an exceptional dry year.

4.3.2. Available Water for Phase II Area

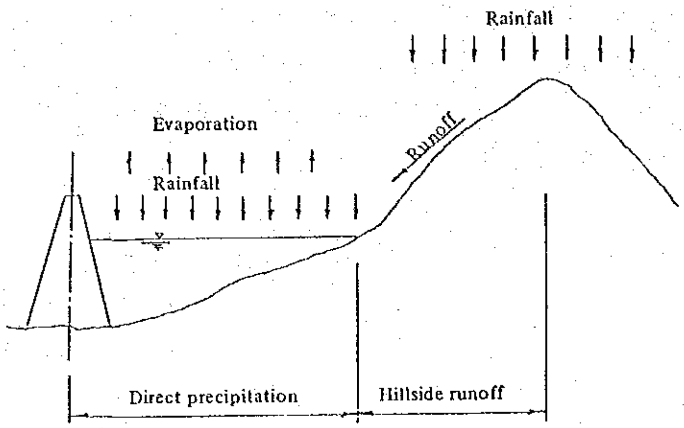
Available water resources for irrigation in Phase II project service area are the runoff water of Bayongan and Bayang rivers located nearly San Miguel and Ubay municipalities respectively and also the surplus water introduced from the main canal of Phase I project.

a) Available Water for the Bayongan Reservoir

Available water for the Bayongan reservoir is the river runoff of the Bayongan river from its catchment area and the surplus water from Phase I project area.

The catchment area of the proposed Bayongan damsite is 11.2 sq.km. Though discharge measurement of the Bayongan river was commenced in 1984, there are only eight times records since it has been commenced. Thus, this measurement is not sufficient to make a rating curve for the Bayongan river.

Generally speaking, it is necessary to make a rating curve based on more than 20 points of observation data distributed moderately. Therefore, a simple method as illustrated below would be adopted to analyze the runoff of the Bayongan river.



The reservoir inflow is separated into direct inflow and hillside runoff as above-mentioned.

While the catchment area at the proposed Bayongan dam is only 11.2 sq.km, the reservoir area is 2.8 sq.km corresponding to about 25 percent of the catchment area. Therefore, reservoir inflow should be analyzed dividing into two patterns of direct inflow and indirect inflow from hilly area except reservoir area.

The direct precipitation on reservoir area can be considered to the direct inflow into the reservoir. On the other hand, there is the evaporation loss from reservoir surface. Therefore, the reservoir inflow by direct precipitation would be estimated by the following equation.

$$\text{In (direct)} = (P - \text{Evap.}) \times (\text{Water surface})/1{,}000$$

where;	In	:	reservoir inflow	(cu.m)
	P	:	precipitation	(mm/day)
	Evap.	:	evaporation	(mm/day)
	water surface	:	1.85×10^6 sq.m	

The hillside runoff would be estimated by the following equation, because there are no data available to analyze the runoff discharge. The rainfall on the hilly area is converted to runoff with some runoff coefficient. The runoff coefficient of 0.4 which is the same value analyzed in the Phase I project is applied to estimate the Bayongan river runoff.

$$In\ (indirect) = P \cdot C \cdot Ar/1{,}000$$

where;	In:	runoff discharge	(cu.m)
	P :	precipitation	(mm/day)
	C :	runoff coefficient of 0.4	
	Ar:	residual catchment area, 9.35 sq.km (11.2 - 1.85)	

The total inflow integrated by direct inflow and indirect inflow as above-mentioned is shown in Annex E, TABLE E2-1, and the monthly mean runoff is summarized in Annex E, FIGURE E2-1.

The approximate annual runoff is as follows;

Annual mean runoff	:	10.3 MCM
Annual maximum runoff	:	16.4 MCM
Annual minimum runoff	:	6.9 MCM

The annual available water in cropping year between the third ten days of October and the second ten days of the following October would be summarized as follows.

Available Water for Bayongan Reservoir

(Unit: MCM)

Year	Runoff from Catchment Area	Surplus Water from Phase I Project	Available Water for Bayongan Dam
56-57	13.675	61.438	75.113
57-58	7.021	23.815	30.836
58-59	9.814	33.697	43.511
59-60	9.366	35.144	44.510
60-61	10.569	46.071	56.639
61-62	11.978	58.516	70.494
62-63	12.777	69.986	82.763
63-64	9.867	42.222	52.089
64-65	15.346	64.425	79.771
65-66	8.856	38.862	47.718
66-67	11.144	52.912	64.056
67-68	7.339	29.693	37.032
68-69	8.612	26.229	34.841
69-70	8.907	41.951	50.858
70-71	12.782	73.293	86.075
71-72	10.599	59.324	69.923
72-73	7.968	35.400	43.368
73-74	11.492	51.358	62.850
74-75	12.090	61.803	73.893
75-76	8.251	38.916	47.167
76-77	11.496	52.280	63.776
77-78	9.031	54.757	63.788
78-79	7.857	41.962	49.819
79-80	15.382	52.996	68.378
80-81	9.744	63.825	73.569
81-82	10.864	56.660	67.524
82-83	6.118	34.825	40.943
83-84	9.236	69.011	78.247
Average	10.292	48.977	59.270

b) Available Water for Capayas Reservoir

The water resources of the Capayas system are the only runoff from the catchment area of 13.1 sq.km. There are not sufficient data to analyze the runoff as same as that in the case of the Bayongan reservoir. Therefore, the same method was adopted to estimate the runoff discharge from the catchment area. The rainfall data of the Dagohoy station is also used for the Capayas dam, because of no rainfall station in the catchment area.

According to the result, the runoff is summarized as follows;

Annual mean runoff	:	11.0 MCM
Annual maximum runoff	:	17.2 MCM
Annual minimum runoff	:	7.5 MCM

The annual available water in cropping year can be summarized as follows.

Available Water for Capayas Reservoir

(Unit: MCM)

Year	Available Water	Year	Available Water
56-57	14.489	70-71	13.701
57-58	7.736	71-72	11.379
58-59	10.577	72-73	8.585
59-60	10.083	73-74	12.327
60-61	11.402	74-75	12.809
61-62	12.873	75-76	8.881
62-63	13.584	76-77	12.190
63-64	10.672	77-78	9.595
64-65	16.062	78-79	8.438
65-66	9.631	79-80	16.134
66-67	11.868	80-81	10.317
67-68	7.950	81-82	11.484
68-69	9.181	82-83	6.534
69-70	9.609	83-84	9.754
		Average	10.994

As the results, the total available water resources for the Phase II project is summarized as follows;

Item	Average Year (MCM)	Dry Year (MCM)
Bayongan Reservoir		
Bayongan River	10.3	8.0
Surplus Water	49.0	30.6
Capayas Reservoir		
Bayang River	11.0	8.7
Total	70.3	47.3

4.4. Reservoir Plan

4.4.1. Concept of Reservoir Plan

a) Reservoir Location and Function

All water resources can not be utilized for irrigation without control by reservoir, because of their discharge fluctuation.

Two reservoirs have been proposed, one is at Bayongan and the other is at Capayas[1/]. Both damsites are suitable for storing and controlling the fluctuating runoff and surplus water.

Especially, the Bayongan reservoir is located nearby the terminal point of the Phase I main canal and can easily store the surplus water, in addition, the Bayongan reservoir has a possibility to store water with capacity of 25 to 30 MCM with a low dam height of 30 to 35 m.

1/: As the alternative plan, the project plan with Bayongan reservoir only was studied and the results of study are shown in Annex E, Chapter IV, 4.2.

On the other hand, the Capayas reservoir is located nearby Ubay and can receive the surplus water diverted through the main canal from the Bayongan reservoir to the Capayas reservoir by gravity system. Although the Capayas reservoir has a small capacity about 2.3 MCM, many advantages mentioned below will be brought for Phase II project.

- The runoff of the Bayang river can be controlled and used for irrigation of the Capayas system service area. The water operation to use the Bayang river water by the Capayas reservoir can reduce the reservoir capacity of the Bayongan dam.

- The irrigation supply to the Capayas system area from Capayas dam can be easily made from the viewpoint of water operation and management, because the Capayas dam is located near the Capayas system area and can supply water on time so as to meet the area water requirements.

- The Capayas reservoir will have a function to regulate the surplus water delivered from the Phase II main canal from Bayongan reservoir. The water released from the Bayongan reservoir but not utilized for irrigation due to missing reservoir operation or effective rainfall could be storaged into the Capayas reservoir. This storage function can save the water losses in the irrigation system of the project.

- The Capayas reservoir can easily supply the domestic water to Ubay suffering from its shortage at present.

- The construction of the Capayas dam and its irrigation system can be completed at early stage than that of Bayongan due to small scale works, so that the model of land reclamation, cultivation practices and water management can be also introduced in the Capayas system area, prior to completion of the Bayongan dam and its service area with a little large scale. This completion of the Capayas system in advance will contribute to the stage development of Phase II project.

b) Capayas Reservoir Plan

The Capayas reservoir plan is formulated with the following criteria from the viewpoint of water operation;

- The Bayang river water is controlled by the Capayas reservoir and used for the Capayas system service area of about 1,160 ha.

- When the runoff or storage water at the Capayas damsite is not sufficient for the irrigation requirements in the Capayas service area, supplementary water is delivered from the Bayongan via main canal and covers the water shortage in the service area.

- No water is delivered from the Bayongan reservoir in case the Capayas reservoir has enough storage water or receive enough runoff from the Bayang river.

- The Capayas reservoir will have a function to serve the irrigation in the Capayas system area and the water supply of Ubay municipality.

In accordance with the above mentioned concept, the Capayas reservoir is planned to have a small reservoir capacity taking into account topographical conditions at the damsite and the economical construction cost.

c) Bayongan Reservoir Plan

The Bayongan reservoir is a main reservoir and the most important facility in Phase II project. The following criteria for water operation of the reservoir are considered;

- The inflow in the reservoir will consist of the runoff of the Bayongan river at the damsite and surplus water diverted from Phase I project.

- The outflow from the reservoir is the irrigation requirements in the Bayongan system service area of 4,140 ha and supplementary release for the Capayas system service area of 1,160 ha.

- The size of the reservoir will be changed based on the irrigation requirements for different cropping intensity of Phase II project area, so that an optimum reservoir capacity will be determined based on the alternative plans.

4.4.2. Capayas Reservoir

Reservoir operation of the Capayas dam was made for the five cases with different cropping intensity of 160, 170, 180, 190 and 200 percent, taking into account the following consideration;

- Irrigation Area : 1,160 ha
- Water Demand
  - ° Irrigation Use, C.I = 160% : 8.3 MCM (average)
    - 170% : 8.7
    - 180% : 9.2
    - 190% : 9.6
    - 200% : 10.1
  - ° Domestic Use : 0.30 MCM (refer to Paragraph 4.5.2.)

- Reservoir Dimension
  - Total Storage Capacity : 2.34 MCM (see FIGURE 4-5)
  - Effective Storage Capacity : 1.63 MCM

The study results are summarized as follows:

Results of Reservoir Operation for Capayas Dam

Alternative Plan	Reservoir Capacity (MCM)	Cropping Intensity (%)	Average Water Demand (MCM)	Average Water Shortage (MCM)
Case II-1	2.34	160	8.4	1.8
II-2	2.34	170	8.8	2.0
II-3	2.34	180	9.3	2.2
II-4	2.34	190	9.7	2.4
II-5	2.34	200	10.2	2.6

Note: Detail calculation is shown in Annex E, TABLE E3-1 to TABLE E3-5.

The water balance study without the Bayongan is also made in order to find the possibility to irrigate the Capayas system service area in advance with only the Capayas reservoir. The area of 1,320 ha can be irrigated annually on average for 28 years, 700 ha in the dry season and 620 ha in the wet season, with the water shortage frequency of 10 years for 28 years, equivalent to about 3-years return period (see Annex E, Paragraph 4.3.). However, in the normal year, 750 ha of land can be irrigated by the stored water in the Capayas reservoir.

4.4.3. Bayongan Reservoir

a) Alternative Operation Study for Bayongan Reservoir

To analyze the optimum size of the Bayongan reservoir capacity, reservoir operation studies with three sizes of reservoir capacity were made for the following 11 cases;

Alternative I ;	Cropping intensity of 160, 170 and 180 percent against reservoir capacity of 25.0 MCM.
Alternative II ;	Cropping intensity of 160, 170, 180 and 190 and 200 percent against reservoir capacity of 27.5 MCM.
Alternative III;	Cropping intensity of 170, 180 and 190 percent against reservoir capacity of 30.0 MCM.

The reservoir operation studies in each case of alternative plan were made based on the following conditions;

- Irrigation Area : 5,300 ha
- Water demand
  - ° Irrigation Use, C.I = 160%: 38.1 MCM
    - 170%: 40.0
    - 180%: 42.1
    - 190%: 44.3
    - 200%: 46.2
  - ° Domestic Use : 0.3 MCM
- Reservoir Dimension
  - ° Total Storage Capacity : 25.0-30.0 MCM (see FIGURE 4-6)

The summary of reservoir operation studies is shown in TABLE 4-10.

b) Optimum Size of Reservoir Capacity

After the careful reservoir operation study, the optimum size of the Bayongan reservoir was evaluated by using benefit and cost (B/C) ratio as one of the indexes for project evaluation. Following table indicates the results of studies from the viewpoint of reservoir operation and project evaluation in terms of B/C Ratio.

Results of Study on Optimum Size of Bayongan Reservoir

Alternative Plan	Total Reservoir Capacity (MCM)	Cropping Intensity (%)	Water Shortage[1/] Year (time)	Water Shortage[1/] Amount (MCM)	B/C Ratio[2/]
Case I-1	25.0	160	4	1.2 - 16.1	1.05
I-2	25.0	170	4	1.4 - 18.0	1.12
I-3	25.0	180	5	1.3 - 20.9	1.17
Case II-1	27.5	160	4	3.4 - 14.6	1.02
II-2	27.5	170	4	5.5 - 16.6	1.08
II-3	27.5	180	5	3.0 - 18.7	1.13
II-4	27.5	190	6	1.7 - 21.5	1.17
II-5	27.5	200	6	2.9 - 23.4	1.21 (Max.)
Case III-1	30.0	170	4	3.5 - 14.5	1.06
III-2	30.0	180	5	3.0 - 16.7	1.12
III-3	30.0	190	5	4.6 - 18.9	1.16

Note: 1/: Details are shown in Annex E, TABLE E3-7 to TABLE E3-17.
2/: Comparison of present values of incremental benefits from 5,300 ha and construction costs, of which details are given in Annex E, TABLE E3-21 to TABLE E3-27.

As is shown in the table, the plan of Case II-5 having the reservoir capacity of 27.5 MCM and cropping intensity of 200 percent will be suitable as the optimum size of the Bayongan reservoir from the viewpoint of water shortage frequency and project evaluation, namely the plan of Case II-5 will have six times of water shortage during 28 years, which is almost the same frequency to that of the Phase I project and have the highest B/C ratio of 1.21 in case of 10 percent of interest rate.

FIGURE 4-7 indicates the reservoir operation curve in case of Case II-5.

Average annual cropping intensity will decrease as 177 percent taking into account the area deduction due to water shortage in the dry year. Namely, an annual cropping area can be calculated at about 9,400 ha, 4,980 ha in the dry season and 4,420 ha in the wet season, which are equivalent to 94 percent and 83 percent of the irrigation area respectively as shown follows;

Item	Dry Season	Wet Season	Total
Irrigation Area (ha)			
Proposed:	5,300	5,300	10,600
Average:	4,980	4,420	9,400
Cropping Intensity (%)			
Proposed:	100	100	200
Actual:	94	83	177

Note: Detail calculation is shown in Annex E, TABLE 3E-19.

4.4.4. Reservoir Operation Rule

a) Capayas Reservoir

Capayas reservoir is operated with the Bayang runoff and the water conveyed through main canal from the Bayongan reservoir. In wet month having a much runoff in the Bayang river, the Capayas reservoir controls and supplies it to the service area in the Capayas system without receiving the water from the Bayongan reservoir.

When the runoff of the Bayang river decreases and the Capayas reservoir water level drops near the low water level, an additional water is released from the Bayongan reservoir and conveyed by the main canal to the Capayas reservoir in accordance with the water requirement of the Capayas service area.

Since the Capayas reservoir presents always a water shortage to the water requirement of the Capayas service area in the dry month, the Bayongan reservoir water should be delivered in advance so that the Capayas reservoir can keep the reservoir water level higher than the low water level in the dry month.

b) Bayongan Reservoir

- The Bayongan reservoir keep generally the full reservoir capacity of 27.5 MCM at October, which is the beginning month of the irrigation in the dry season crop, because a much inflow empties into the reservoir from September to October every year.

When the reservoir presents the full water level at October, the reservoir can supply the reservoir water without any water shortage to the irrigation in the service area of 5,300 ha in accordance with the water requirement for the cropping intensity of 100 percent in the dry season cropping pattern.

- The Bayongan reservoir water level will become generally lower than the full water level at the end of May which is the beginning time of the irrigation in the wet season paddy plantation.

  In case the reservoir water level is located higher than the elevation of 43 m, the irrigation for the cropping intensity of 100 percent in the wet season paddy of 5,300 ha can be made without water shortage problem except the exceptional dry year, because some much inflow emptying into the reservoir will be expected at June to September and cover the irrigation requirement at such period. Namely, the reservoir water is mostly used for the irrigation requirement in the dry month between the end of May and July.

  If the water level becomes at the elevation less than 43 m at the end of May in the dry year, the reservoir capacity drops less than 12 MCM, which can not cover sometimes the irrigation requirement of successive dry month from the end of May to July, so that an adjustment to reduce some irrigation area or irrigation requirement will be necessary in such water level.

TABLE 4-10 SUMMARY OF BAYONGAN RESERVOIR OPERATION STUDY FOR ALTERNATIVE PLANS

Item	Alternative - I			Alternative - II					Alternative - III		
	Case I-1	Case I-2	Case I-3	Case II-1	Case II-2	Case II-3	Case II-4	Case II-5	Case III-1	Case III-2	Case III-3
1. Cropping Intensity (%)											
Dry Season (Oct. - Mar.)	60	70	80	60	70	80	90	100	70	80	90
Wet Season (May - Oct.)	100	100	100	100	100	100	100	100	100	100	100
Total	160	170	180	160	170	180	190	200	170	180	190
1. Cropping Area (ha)											
Dry Season	3,190	3,710	4,240	3,190	3,710	4,240	4,770	5,300	3,710	4,240	4,770
Wet Season	5,300	5,300	5,300	5,300	5,300	5,300	5,300	5,300	5,300	5,300	5,300
Total	8,490	9,010	9,540	8,490	9,010	9,540	10,100	10,600	9,010	9,540	10,100
3. Dam and Reservoir											
Total Storage Capacity (MCM)	25.0	25.0	25.0	27.5	27.5	27.5	27.5	27.5	30.0	30.0	30.0
Dam Height (m)	30.0	30.0	30.0	50.0	31.0	31.0	31.0	31.0	32.0	32.0	32.0
4. Water Demand (MCM)											
Demand in Average Year	38.2	40.1	42.2	38.2	40.1	42.2	44.4	46.3	40.1	42.2	44.3
Demand in Shortage Year	44.4-48.1	49.1-55.9	52.6-58.5	42.1-53.6	44.9-56.0	47.8-58.5	43.3-61.1	56.2-63.4	44.9-56.0	47.8-58.5	43.3-61.1
5. Water Shortage											
Number of Shortage Year	4 (8)1/	4 (8)	5 (10)	4 (4)	4 (5)	5 (5)	6 (8)	6 (8)	4 (5)	5 (5)	5 (6)
Shortage Amount/Year	1.2-16.1	1.4-18.0	1.3-20.9	3.4-14.6	5.5-16.6	3.0-18.7	1.7-21.5	2.9-23.4	3.5-14.5	3.0-16.7	4.6-18.9

Note:

	Storage Capacity (MCM)	F.W.L. (m)	Dam Top Elevation (m)	Dam Height (m)
Alternative - I	25.0	49.0	52.0	30.0
Alternative - II	27.5	50.0	53.0	31.0
Alternative - III	30.0	51.0	54.0	32.0

1/: Figures with a parenthesis show the calculated total number of shortage years out of 28 years and figures without parenthesis show the year having the continuous water shortage days more than ten days, which is considered to be the maximum day for paddy to bring the drought damage due to no available water supply.

Detailed calculations are shown in Annex E. TABLE E3-7 to TABLE E3-17

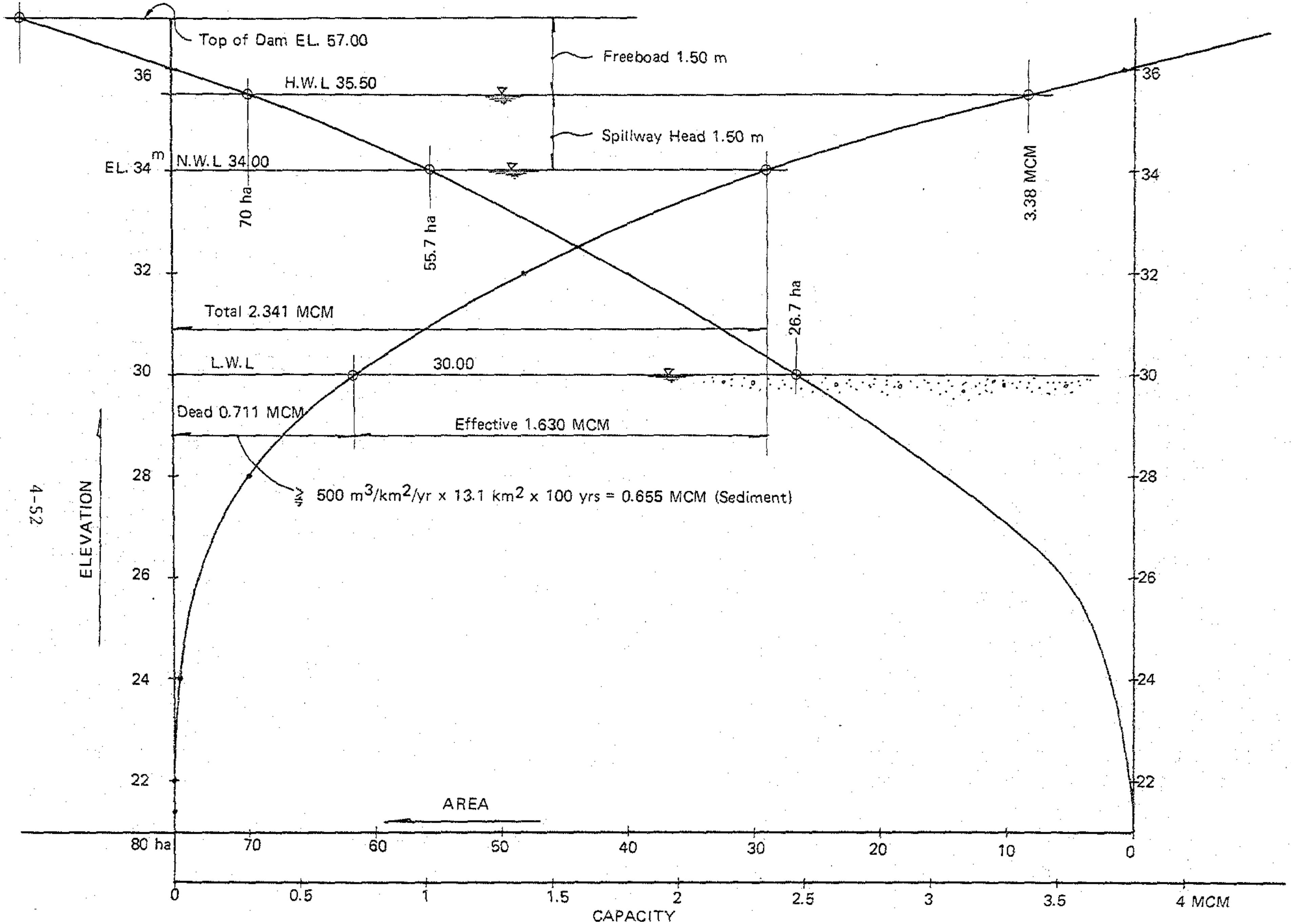


FIGURE 4–5 RESERVOIR AREA AND CAPACITY CURVE (CAPAYAS DAM)

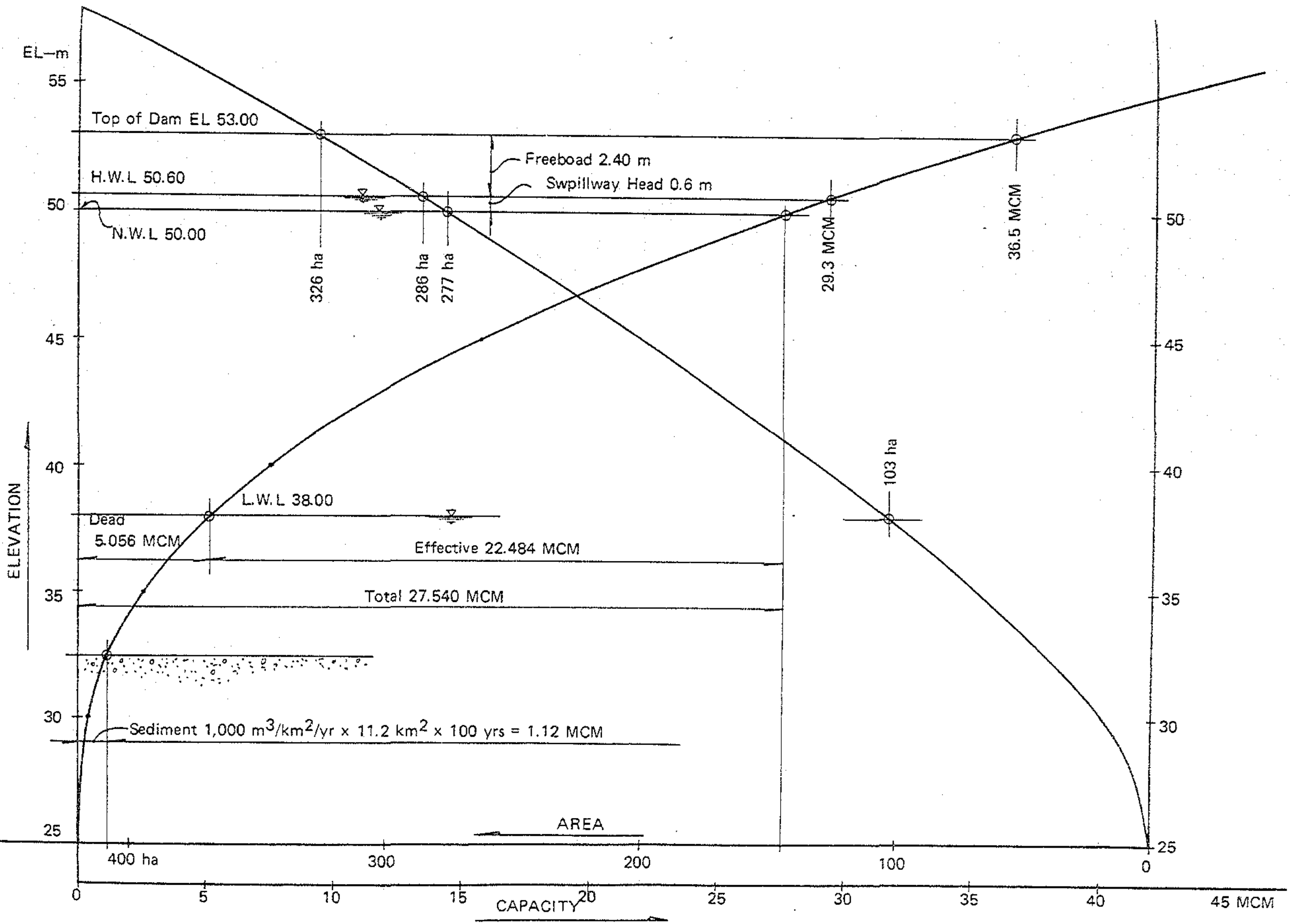


FIGURE 4–6 RESERVOIR AREA AND CAPACITY CURVE (BAYONGAN DAM)

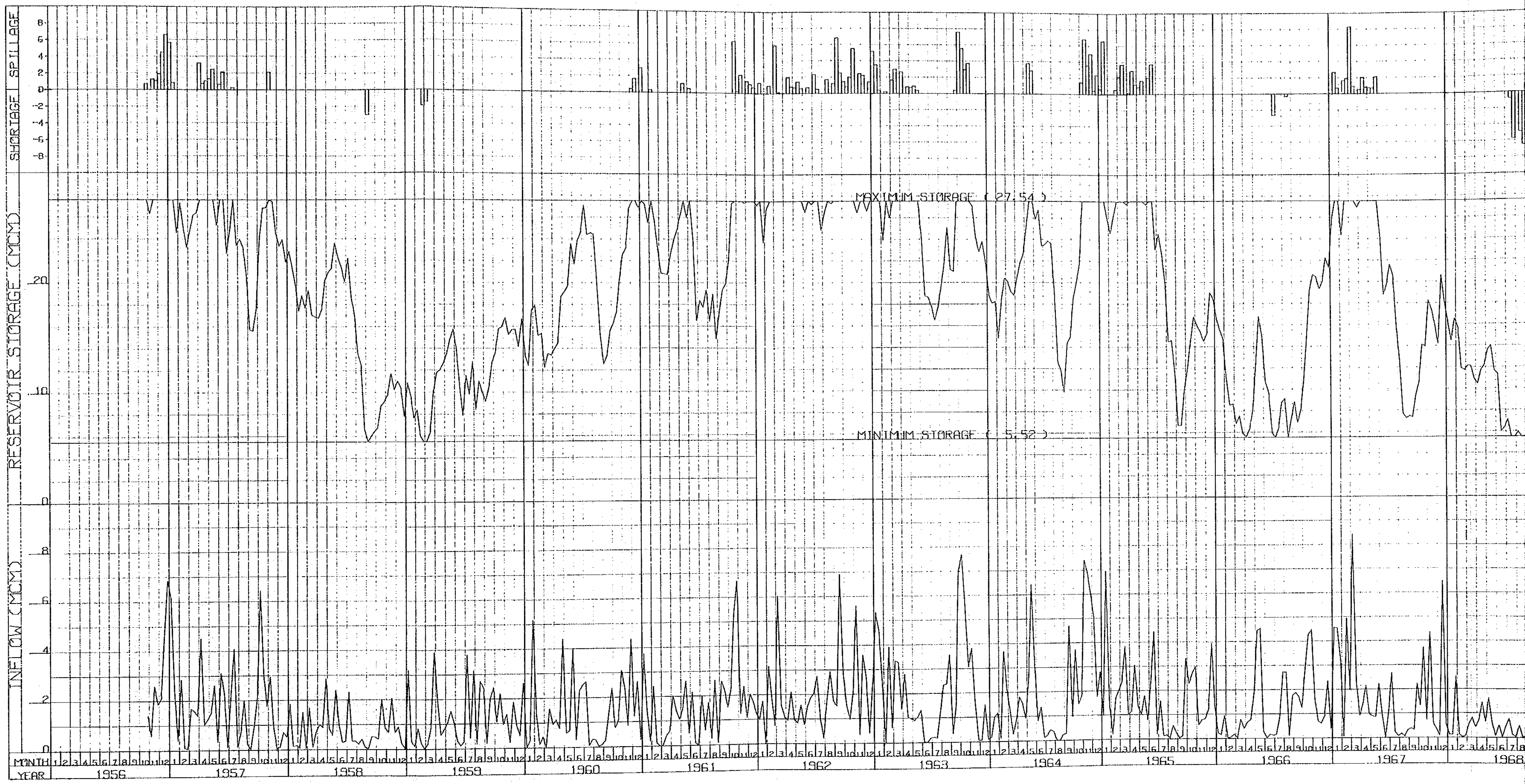


FIGURE 4–7 RESERV

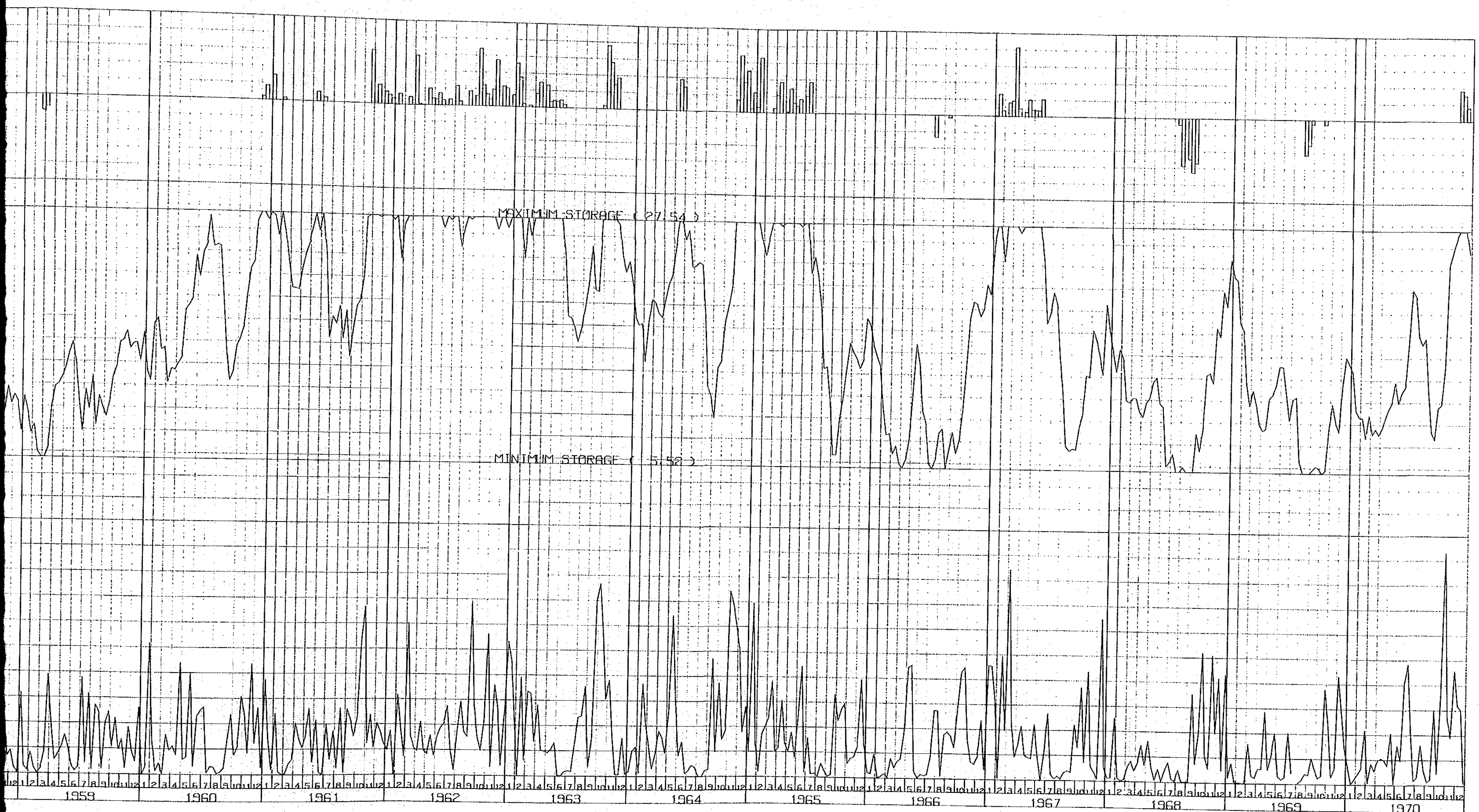
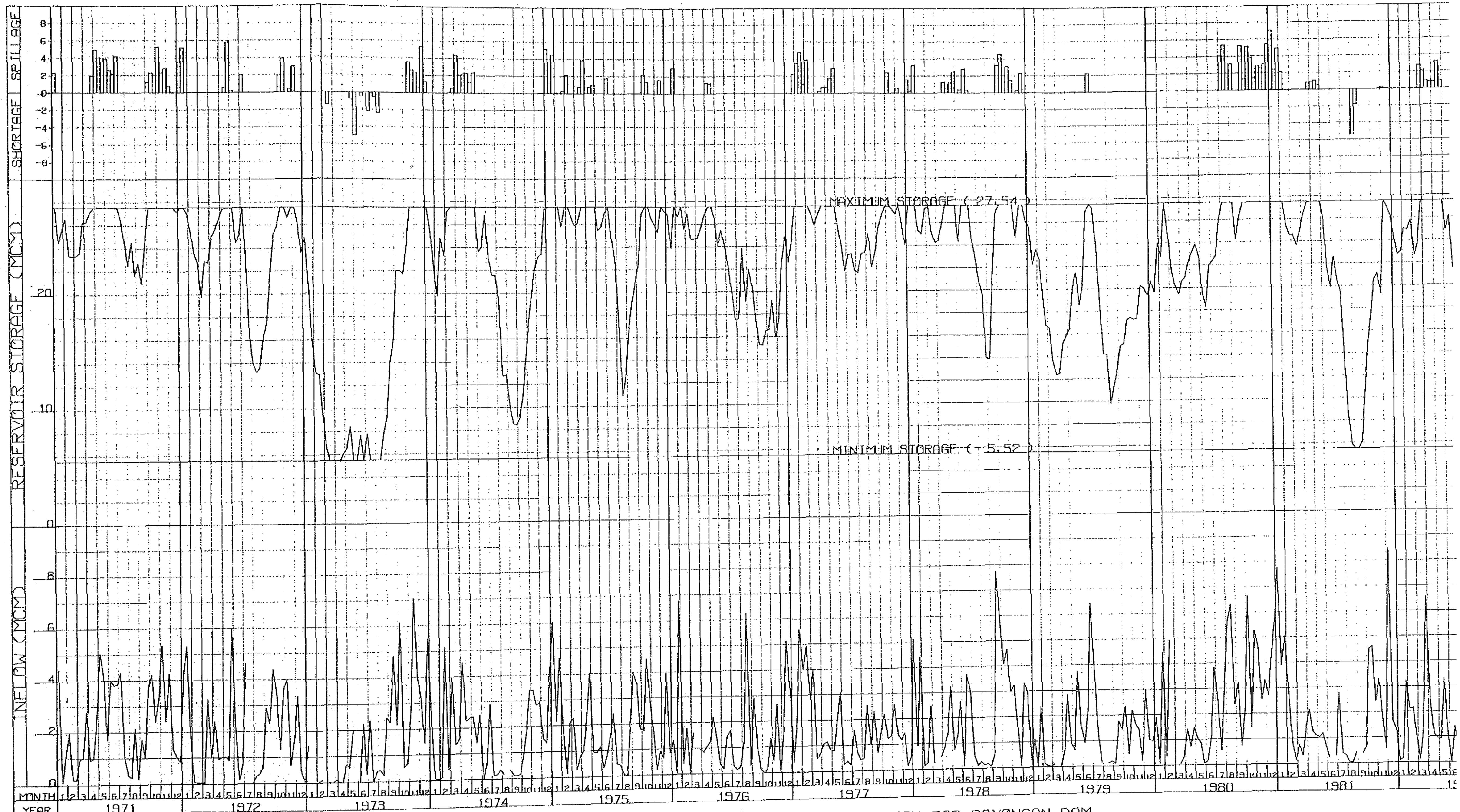
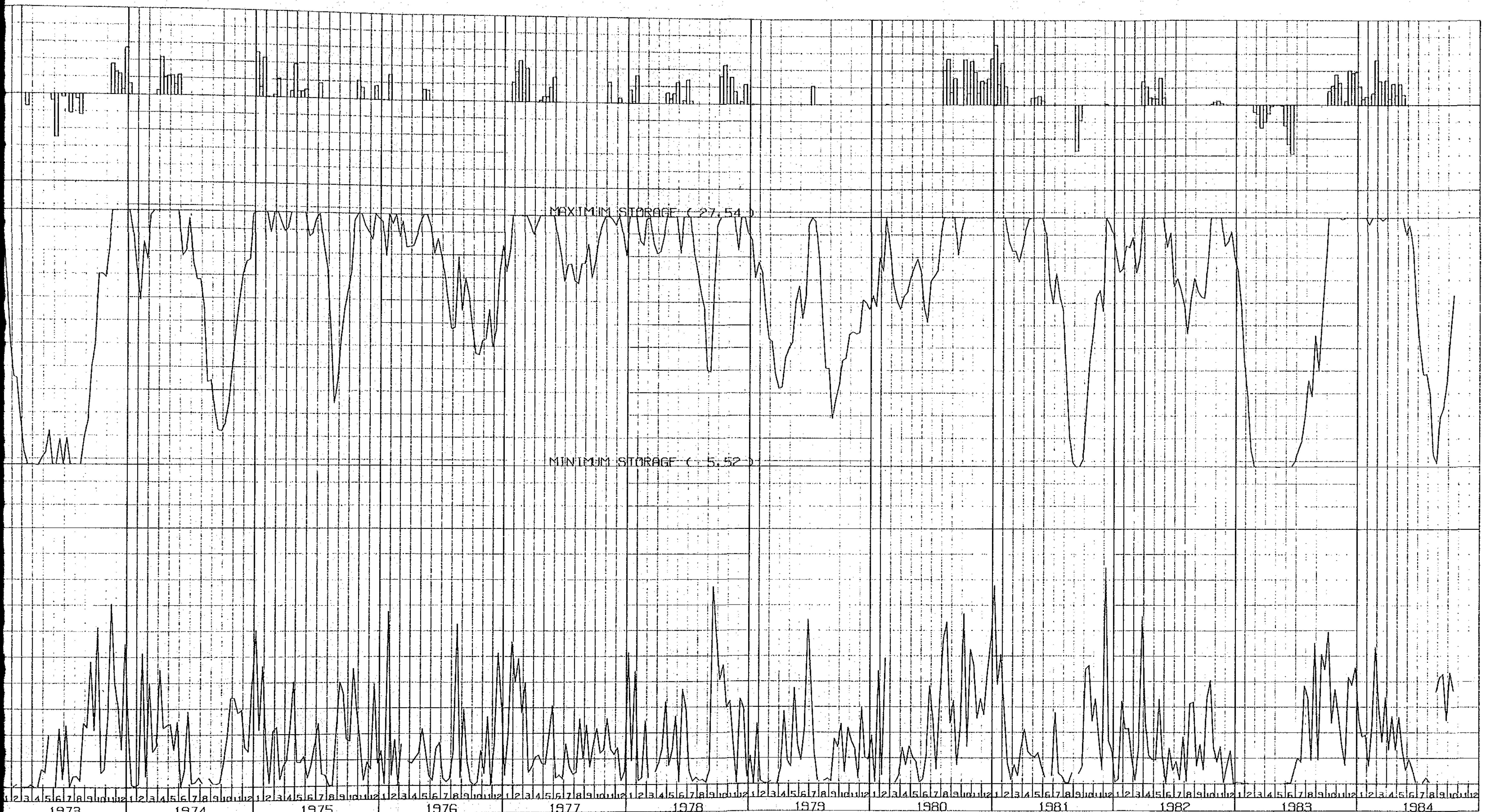


FIGURE 4-7 RESERVOIR OPERATION CURVE FOR BAYONGAN RESERVOIR



RESERVOIR OPERATION FOR BAYONGAN DAM



RESERVOIR OPERATION FOR BAYONGAN DAM

- In case the water level drops at the elevation less than 41 m at the beginning of August after the irrigation water from the end of May to the end of July has been released from the reservoir, an adequate countermeasures such as the introduction of rotational irrigation or allocation of less irrigation requirement than the designed one should be taken for the irrigation in the remained period between August and September taking into account of the remained reservoir capacity, the forecasted inflow and the irrigation requirement in the remained period.

- If the reservoir water level becomes considerably lower loss than 38 m at May and August, the wet season paddy will be completely damaged due to no available irrigation water in the reservoir. However, such year presenting the water level less than 38 m is extreme dry year having a return period of once in 15 year.

4.5. Irrigation and Drainage Plan

4.5.1. Irrigation Water Requirements

a) Crop Water Requirements

1) Potential Evapotranspiration (ETo)

As described previously, evapotranspiration (ETo) for Phase II project was estimated on the monthly basis by applying the Penman Method using the climatological data observed at the Tagbilaran station. The estimated ETo values are summarized as follows;

Estimated ETo Value

Month	ETo mm/day	ETo mm/month	Month	ETo mm/day	ETo mm/month
Jan.	3.60	111.6	Jul.	3.98	123.4
Feb.	3.94	110.3	Aug.	4.18	129.6
Mar.	4.66	144.5	Sep.	4.00	120.0
Apr.	4.94	148.2	Oct.	3.72	115.3
May	4.48	138.9	Nov.	3.69	110.7
Jun.	3.84	115.2	Dec.	3.24	100.4
			Average	4.01	122.0

Note: Details are shown in Annex F, Paragraph 1.1.1, a).

2) Consumptive Use

Paddy Cultivation

The consumptive use (actual evapotranspiration, ETPc) is, in general, estimated by multiplying the estimated ETo values by the crop coefficients (Kc) which express the relation between potential and actual evapotranspiration during distinct vegetative stage of the crops.

The consumptive use of paddy was estimated by using the same procedures adopted in the estimation of consumptive use for the Phase I area. As the result, the estimated consumptive use of paddy is summarized as follows;

Estimated ETPc Values for Paddy

Month	ETPc mm/day	ETPc mm/month	Month	ETPc mm/day	ETPc mm/month
Jan.	5.3	164.3	Jul.	5.5	170.5
Feb.	5.0	140.0	Aug.	5.6	173.6
Mar.	5.9	182.9	Sep.	4.8	144.0
Apr.	6.9	207.0	Oct.	4.8	148.8
May	6.6	204.6	Nov.	4.9	147.0
Jun.	5.7	171.0	Dec.	4.4	136.4
			Average	5.5	165.8

Upland Cultivation

Since the crop coefficients (Kc) related to the upland crops are not available around the project, such coefficients were estimated on the 10-days basis in accordance with the FAO Irrigation and Drainage Paper No.24. Following table gives the coefficients adopted for the estimation of consumptive use of upland crops.

Crop Coefficient (Kc) for Upland Crops

Month		Mungbean	Peanut	Corn	Vegetable
Dec.	I				
	II				
	III		0.54	0.54	
Jan.	I		0.57	0.57	
	II		0.63	0.65	
	III	0.52	0.75	0.80	0.50
Feb.	I	0.56	0.87	0.95	0.57
	II	0.70	0.95	1.05	0.70
	III	0.87	0.97	1.08	0.88
Mar.	I	0.96	0.95	1.07	0.97
	II	0.97	0.88	1.04	0.96
	III	0.91	0.55	0.95	0.96
Apr.	I	0.85			0.50
	II				
	III				

Note: Details are given in Annex F, Paragraph 1.1.1, b).

TABLE 4-11 shows the consumptive use of crops estimated by the above mentioned procedures on the monthly basis.

3) Crop Water Requirements

Crop water requirements on the 10-days basis are estimated based on the proposed cropping pattern. In this estimation, the following considerations are accounted:

- Percolation rates in fields are 1.0 mm/day on average throughout the growing period of paddy. Percolation rates were measured at 16 sites in the existing paddy fields, and it was found that most of all paddy fields have impervious nature with low percolation rate around one millimeter per day (see Annex F, Paragraph 1.1.1, c)).

- Additional water for land soaking and land preparation is decided at 210 mm for the wet season paddy and 170 mm for the dry season paddy as shown below;

Water Requirement for Land Soaking and Preparation

Item	Dry Season Paddy (mm)	Wet Season Paddy (mm)
1st irrigation	114	132
2nd irrigation	27	29
3rd irrigation	33	45
Total	170 (174)	210 (206)

Note; Details are given in Annex F, Paragraph 1.1.1, d).

Estimated crop water requirements for each crop are summarized as shown below, details of which are shown in TABLE 4-12.

Paddy		
Dry Season Paddy		
- Transplanting paddy	:	711.6 mm
- Direct sowing paddy	:	775.3
Wet Season Paddy		
- Transplanting paddy	:	789.3
- Direct sowing paddy	:	847.8
Mungbean	:	260.8
Peanut	:	314.1
Corn	:	361.3
Vegetable	:	251.6

b) Diversion Irrigation Water Requirements

Diversion water requirements can be calculated by taking into account the effective rainfalls and water losses in adding to the crop water requirements. The criteria of the effective rainfalls and water losses used for the Project are to be described herein after.

1) Effective Rainfall

For Paddy Cultivation

- The same procedures used in estimating an effective rainfall for the Phase I area were adopted.

For Upland Crops

- Diversified crops such as mungbean, peanut, corn, and vegetable are to be introduced during the dry season after the harvesting of wet season paddy.

- According to the physical features of soil tests conducted at seven sites in the project area, an average field capacity (Fc) and wilting point (Wp) are observed at 15.5 percent and 7.4 percent respectively in the range of soil depth of 50 cm from soil surface. From these observation results, it can be said that an average net amount of water to be replaced (net irrigation application) is about 55 mm[1/] and average water depth of wilting point is about 20 mm[2/] for the upland crops.

- Namely, irrigation water supply for upland crops considering the soil moisture is quite similar to the water supply for paddy. Therefore, same procedure and criteria are taken to estimate an effective rainfall in case of upland crops.

1/: (86.3 + 57.6 + 47.3 + 28.8) x 1/4 = 55.0 mm (see Annex F, TABLE F1-38 to TABLE F1-41).

2/: (200 mm x 1.42 g/cu.cm x 7.4%)/100 = 20.0 (see Annex F, TABLE F1-37)

Areal rainfall to estimate the effective rainfall is formulated with three stations, Ubay (Central), Ubay (Bayang) and Ubay (Gabi).

The results of estimation are shown in TABLE 4-13 and TABLE 4-14, and they are summarized as shown below;

Estimated Effective Rainfall

Crops	Rainfall		Effective Rainfall	
	Average Year (mm)	Dry Year (mm)	Average Year (mm)	Dry Year (mm)
Paddy				
Dry Season Paddy	739.6	740.4	695.9	547.6
Wet Season Paddy	874.0	829.9	866.0	749.4
Total	1,613.6	1,563.3	1,561.9	1,296.8
Upland Crops	894.7	709.0	456.5	353.4

Note: Details are given in Annex F, Paragraph 1.1.2, a).

As is seen in the above table, estimated effective rainfall of 548 mm for the dry season paddy in case of dry year is larger than the Phase I area effective rainfall of 532 mm, while an estimated effective rainfall for the wet season paddy of 749 mm is smaller than that of Phase I area of 773 mm. These facts are considered to be derived from different rainfall distribution patterns in both seasons between the Phase I and Phase II areas with different elevation.

2) Irrigation Efficiency

After the careful study on irrigation efficiency prevailing in the existing large scale irrigation projects, irrigation efficiency is decided at 55.8 percent for dry season paddy and 53.6 percent for wet season paddy respectively, and 42.1 percent for upland crops, as shown follows;

Efficiency	Paddy Dry Season (%)	Paddy Wet Season (%)	Upland Crop (%)
Application Efficiency	73	70	55
Conveyance Efficiency	85	85	85
Operation Efficiency	90	90	90
Overall	55.8	53.6	42.1

Note: Details are shown in Annex f, Paragraph 1.1.2, c).

Irrigation water requirements for the Phase II area of 5,300 ha are estimated based on the above mentioned criteria for the period of 28 years, 1956 - 1984, in the cases of five cropping intensities, 160, 170, 180, 190 and 200 percent as shown in TABLE 4-15 and they are summarized as follows;

Irrigation Water Requirements for Phase II Area

Cropping Intensity (%)	Capayas Area (MCM)	Bayongan Area (MCM)	Total (MCM)
160	8.32	29.77	38.09
170	8.74	31.30	40.04
180	9.20	32.92	42.12
190	9.62	34.69	44.31
200	10.08	36.13	46.21

Note: Irrigation Area
Capayas area : 1,160 ha
Bayongan area : 4,140 ha
Total 5,300 ha

Details are given in Annex F, TABLE F1-22 to TABLE F1-36.

The irrigation water requirements in each crop in cases of average and dry years are tabulated as shown below;