THE REPUBLIC OF THE PHILIPPINES

NATIONAL IRRIGATION ADMINISTRATION

FEASIBILITY STUDY REPORT ON THE IMPROVEMENT PROJECT OF THE OPERATION AND MAINTENANCE OF NATIONAL IRRIGATION SYSTEMS (AMRIS)

(APPENDIX A)

VOLUME II

FEBRUARY 1984

JAPAN INTERNATIONAL COOPERATION AGECY

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CHAPTER I. INTRODUCTION

CHAPTER I INTRODUCTION

1.1 Objectives and Components of the Project

1.1.1 Objectives and Scope

The Government has been actively instituting a policy of rehabilitation, upgrading and expansion of national irrigation systems since 1967. The main goal of all these efforts is to enhance the agricultural production and disperse benefits to a large number of small farmers throughout the country.

The development plan aims at the expansion of new irrigation and drainage systems, rehabilitation of irrigation and drainage systems, development of on-farm facilities and road systems, turnover of marginal national irrigation systems to capable irrigators associations, and promotion of increasing collection efficiency of irrigation fees.

The Project Area is one of the most advanced paddy cropping zone in the Philippines. Development Strategy for the Project comprises two specific aspects: one is development to the fullest extent of the natural and social potential in the Area and the other is establishment of a more advanced agricultural zone as a model in the country.

In line with the national policy and area potentiality, the Project envisions an increase in cropping intensity, upgrading of system management including irrigation efficiency, rehabilitation of the existing facilities, expansion of the irrigation service area with appropriate irrigation and drainage facilities, upgrading of collection efficiency of irrigation fees, and partial turnover of operation and maintenance works to capable irrigators associations. Furthermore, the Project will promote the extension of crop diversification through agricultural supporting services in the Area.

1.1.2 Project Components

In order to fulfill these objectives, the Project service area of about 35,000 ha including some 3,500 ha of new expansion areas involves the following components:

(1) Rehabilitation and upgrading of existing irrigation and drainage facilities including some expansion of these facilities in the existing service area of about 31,500 hectares;

(2) Construction of irrigation and drainage facilities for new expansion area of about 3,500 ha with the same level of upgrading standard;

(3) Upgrading of existing roads and construction of additional service and access roads;

(4) Consolidation of on-farm facilities in the new expansion areas as well as in part of the existing service area;

(5) Strengthening of NIA operation and maintenance structures through joint operation between NIA and capable irrigators associations;

(6) Establishment of capable irrigators associations (IAs) and gradual turnover of operations and maintenance works of the systems below sub-lateral canals level to IAs taking development stage and capability of the IAs into consideration;

(7) Establishment of a demonstration farm for the crop diversification programs and promotion of scheme extension and;

(8) Procurement of equipment and vehicles for construction of on-farm facilities, and instrument for operation and maintenance works.

1.2 Scope of Study and Data Used

1.2.1 Project Plan Fromulation

The contents of this Appendix. A comprise meteorology and hydrology, irrigation, drainage and geology and soil.

The plan of an irrigation/drainage project may be considered as a system. The project formulation of the system is generally called systems design, and the objective of systems design is to select the combination of variables that maximize net benefits in accordance with the requirements of the design criteria. The design so achieved is known as optimal design. The maximization or optimization is subject to the requirements of the design criteria or constraints imposed. The constraints may be technical, budgetary, social or political, and the benefits may be real or implied. Hence the optimal plan is subject to technical as well as economic and socio-political limitations.

This Appendix is prepared against this sort of background, but presents only a brief outline of the principles. As concerns technical subjects where irrigation and drainage plans are related, the constitution of the report consists of i) present status prevailing in the project area as it relates to problems, ii) basic data collection and investigation method or methodologies for solution, iii) data processing and iv) possible plans and solution of the problems.

As a basis for formulation of the project, hydrological studies were made combining every aspects of hydrology inclusive of rainfall analysis, rainfall-runoff conversion, water requirement, irrigation water balance which consists of the reservoir operation, flood runoff estimation and long-term flood simulation. The analyses were conducted covering the existing project area as well as the areas proposed for new expansion.

All analyses were made based on the available data obtained mainly from the PAGASA meteorological stations and the NWRC hydrological stations, supplemented by the hydrological data on the reservoir collected and reported by NPC. Some existing data and findings of the preceding hydrological study were referred to in the feasibility report on the Pampanga Delta Development Project by JICA.

Digital electronic computers were fully used to cope with an enormous volume of data to be processed throughout the study. Computers used are as below:

(1) FACOM M140F 500KB System in the Transport Training Center (TTC), the University of Philippines
(2) FACOM M160 in the National Computer Center (NCC), Office of the President
(3) FACOM M 140F 3MB System in Sanyu Consultants Inc. for the use during domestic assignment period

1.2.2 Available Data and Report

(1) Rain Gage Station

There are ten rain gauge stations within or near the project boundary. Most of the stations are managed by PAGASA. Beside these stations which have daily observation rainfall records of less than 16 years, long-term records for 29 years have been kept at Cabanatuan City.

Rain Gage Station

Station	Location Lat.	Location Long.	Period of Observation	Authority	Type
41 Calawitan, San ildefonso	15 - 05	120 - 55	1974 - 1979	PAGASA	HY 1/
42 Talacsan, San Rafael	14 - 58	120 - 59	1973 - 1982	-do-	-do-
43 Sabang, Baliwag	14 - 58	120 - 55	1970 - 1982	-do-	-do-
45 Makinabang, -do-	14 - 35	120 - 53	1969 - 1982	-do-	OR 2/
50 Borol II, Balagtas	14 - 49	120 - 54	1973 - 1979	-do-	-do-
52 Santa Maria	14 - 49	120 - 57	1969 - 1980	-do-	-do-
76 Balucoc, Apalit	14 - 58	120 - 51	1975 - 1982	-do-	
77 Cansinala, Apalit	14 - 58	120 - 47	1967 - 1982	-do-	HY
78 Sulipan, Apalit	14 - 56	120 - 45	1973 - 1982	-do-	
- Ulingao Research C.					
20 Cabanatuan City	15 - 29	120 - 45	1982 - 1979	PAGASA	SY 3/

Notes: 1/ ····· Hydrometeorological Station where observes meteorological and hydrological elements.

2/ ····· Official Rain Station where rainfall observations are made twice daily.

3/ ····· Synoptic Station where observation of almost all meteorological elements are made at fixed observation time.

(2) River Gate Station

According to the Philippines Water Data - Surface Water Records published by NWRC, which is reponsible for coordinating and integrating all water resources development of the Philippines, there are 14 hydrological gauging stations in and around the project area. Since the river stage are under influence of the tidal motion, most stations only keep water height records. In addition, all observations are made by NWRC.

River Gage Station

Station	River	Location Lat.	Location Long.	Period of Observation	Record
51 Pasig, Candaba	Pampanga	15 - 06	120 - 49	1958 - 1974	Discharge
53 Santa cruz	-do-	15 - 00	120 - 47	1948 - 1978	Height
54 Poblacion	-do-	15 - 01	120 - 47	1946 - 1978	-do-
55 Bahay-Pare	Maasim	15 - 02	120 - 55	1956 - 1976	Discharge
56 Diliman	-do-	15 - 02	120 - 57	1919 - 1975	-do-
57 Ducma, Candaba	Candaba	15 - 01	120 - 51	1953 - 1971	Height
63 Sulipan, Apalit	Pampanga	14 - 56	120 - 46	1946 - 1978	-do-
64 -do-	-do-	14 - 56	120 - 45	1946 - 1977	-do-
69 Poblacion	-do-	14 - 55	120 - 46	1910 - 1976	-do-
76 Pungo, Calumpit	Angat	14 - 54	120 - 47	1961 - 1979	-do-
77 Pobulacion	-do	14 - 54	120 - 51	1961 - 1971	-do-
78 Longos, Pulilan	-do-	14 - 55	120 - 52	1909 - 1978	Discharge
79 Pulong Samplok	Bayabas	14 - 57	121 - 04	1965 - 1973	-do-
80 Ipo, Norzagaray	Angat	14 - 53	121 - 08	1956 - 1971	

(3) Eisting Reports

	Report or Title	Entity Concerned	Issued in
i)	Report on Angat-Magat Integrated Agricultural Development Project	ADB	1972
ii)	Report on Pampanga Delta Development Project	JICA	1981
iii)	Report on Study for Improvement of Eighteen National Irrigation Systems	NIA-JICA	1983
iv)	Progress Report (1)	JICA	1982
v)	-do- (2)	-do-	1983

1.3 National Economy

1.3.1 Population

The population of the Philippines in 1981 was 49.2 million and its average growth rate since 1970 was 2.7%. The average family size is 5.6 persons (see Table A.1.3-1). Table A.1.3-2 shows that the agricultural sector employs the largest portion or 52% of the total labor force followed by the service sector. There has been no major structural changes in the composition of the labor force since 1971.

1.3.2 General Economy

Gross National Product (GNP) has been increasing at the annual average rate of 5.8% since 1977 and in 1981 it reached 97.44 billion pesos at 1972 constant prices. The rate of increase in the last five years is on the downward trend, i.e., 6.8% in 1977/78, 6.1% in 1978/79, 5.4% in 1979/80, and 4.9% in 1980/81.

The service sector contributed most to GDP in 1981 followed by the manufacturing sector and the agriculture which accounts for only 25.4%. The composition of GDP has also remained more or less unchanged since 1977.

The balance of trade in the Philippines has been in the deficit for the last five years (see Table A.1.3-5), which is partly accounted for by the declining proportion of export value of such agricultural products as coconut products, sugar, and sugar products.

The rice export, though not large in volume, has been expanding lately and reached 230,000 ton in 1980.

Income per capita in 1979 was 1,481 pesos at 1972 constant prices, and its annual growth rate has been 3.3% on average since 1975. The wholesale price index remained rather stable until 1978, but jumped to 117 on average in the subsequent three years, which might be attributed to the remarkable price increase in petro-chemical goods as shown in Table A.1.3-10. The consumer price index, on the other hand, has remained 115.4 on average since 1978 as compared with the 4-year average of 108.3 prior to 1978. This, however, declined to 112.3 in 1980/81.

1.3.3 Agricultural Production

Palay, corn, and coconut account for a large share of the total area planted in the Philippines and these three crops account for about 82% of the total harvested area. The harvested area of these crops has remained relatively the same in recent years, but that of sugarcane is on the decline. The unit yield of rice, owing to the diffusion of improved varieties and irrigation system, increased to 2.14 ton/ha in 1980 from 1.72 ton/ha in 1976. Table 1.3-13 presents the volume of production of various crops.

1.3.4 National Development Plan

The Five Year Development Plan (1983 - 87) published in 1982 aims to reach per capita income of 13,199 pesos in 1987 from the current 6,168 pesos as well as to realize the GNP growth rate of 6.5%. The target rate of population growth is 2.2% and the population is forecasted to reach 56.8 million in 1987. The primary products to be promoted are corn, sugar, banana, and palay and these are expected to increase self-sufficiency in food so well as to raise the foreign exchange reserve.

TABLE A.1.3-1 POPULATION

Year	Population	Average Annual Rate of Increase
1903	7,635,426	2.87
1918	10,314,310	1.90
1939	16,000,303	2.22
1948	19,234,182	1.91
1960	27,087,685	3.06
1970	36,684,486	3.02
1975	42,070,660	2.79
1980	48,098,460	2.71
1981	49,200,000	2.28

Source: Philippine Statistical Yearbook, 1982 - NEDA

TABLE A.1.3-2 EMPLOYED PERSONS BY MAJOR OCCUPATION

(Unit: %)

Major Industry Group	1961 Oct.	1971 Nov.	1975 Aug.	1978
Agriculture, Forestry Hunting, Fishing	60.6	50.4	53.5	52.2
Mining, Construction Manufacturing etc.	14.2	15.3	14.9	11.9
Commerce, Transport and Services etc.	25.2	34.3	31.6	35.9
Total	100.0	100.0	100.0	100.0

Source: Philippine Statistical Yearbook, 1982 - NEDA

TABLE A.1.3-3 GROSS NATIONAL PRODUCT

(Unit: million pesos)

Items	1977	1978	1979	1980	1981
at current prices	154,280	178,067	218,263	264,265	313,563
at 1972 constant prices	77,789	83,070	88,128	92,930	97,446

Source : Philippine Statistical Yearbook, 1982 - NEDA

TABLE A.1.3-4 GROSS DOMESTIC PRODUCT - 1972 constant prices

(Unit: million pesos)

Items	1977	1978	1979	1980	1981	
1. Agriculture, Fishing & Forestry	20,646	21,620	22,595	23,695	24,722	(25.4)
2. Industrial Sector	27,554	29,598	31,741	33,848	35,579	(36.6)
a. Mining & Quarring	1,742	1,809	2,134	2,236	2,275	
b. Manufacturing	19,532	21,108	22,420	23,739	24,958	
c. Construction	5,568	5,913	6,338	6,952	7,353	
d. Electricity, Gas & Water	712	768	849	921	993	
3. Service Sector	29,790	31,579	33,408	35,249	36,955	(38.0)
a. Transport, Communication & Storage	4,234	4,501	4,613	4,827	5,025	
b. Commerce	15,838	16,861	18,085	19,086	20,040	
c. Services	9,717	10,217	10,710	11,336	11,890	
Gross Domestic Product	77,990	82,797	87,744	92,792	97,256	(100.0)

Source : Philippine Statistical Yearbook, 1982 - NEDA

TABLE A.1.3-5 FOREIGN TRADE OF THE PHILIPPINES - F.O.B prices

(Unit: million US dollars)

Items	1977	1978	1979	1980	1981
Exports	3,150.9	3,424.9	4,601.2	5,787.8	4,362.0
Imports	3,914.8	4,732.2	6,141.7	7,726.9	6,006.7
Balance	-763.9	-1,307.3	-1,540.5	-1,939.1	-1,644.7

Source : Philippine Statistical Yearbook, 1982 - NEDA

TABLE A.1.3-6 EXPORT VALUE OF AGRICULTURAL PRODUCTS

(Unit: million US dollars)

Commodities	1977	1978	1979	1980	1981
Coconut Products	761	908	1,024	811	577
Sugar & Sugar Products	535	216	240	657	514
Fruits & Vegetables	157	177	214	365	289
Abaca & Products	29	25	38	31	18
Tobacco & Products	29	30	33	30	41
Total	1,511 (48)	1,356 (40)	1,549 (34)	1,894 (33)	1,439 (33)
Gross Value	3,151 (100)	3,425 (100)	4,601 (100)	5,788 (100)	4,362 (100)

Source : Philippine Statistical Yearbook, 1982 - NEDA

TABLE A.1.3-7 RICE EXPORT

Year	Deliveries (t)	Value of Deliveries (million US dollars)
1977	15,000	4.20
1978	46,854	14.00
1979	127,053	35.56
1980	230,625	64.48

Source : Philippine Statistical Yearbook, 1982 - NEDA

TABLE A.1.3-8 IMPORT BY END USE

(Unit: million US dollars)

Year	Total Imports	Consumer Goods	Capital Goods	Raw Materials & Intermediate Goods
1976	3,633.5	545.0	1,224.9	1,863.6
1977	3,914.8	636.2	1,077.3	2,201.3
1978	4,732.2	817.2	1,400.8	2,514.1
1979	6,141.6	1,067.4	1,784.9	3,289.3
1980	7,726.9	1,425.7	1,986.4	4,314.8

Source : Philippine Statistical Yearbook, 1982 - NEDA

TABLE A.1.3-9 PER CAPITA NATIONAL INCOME

(Unit: Peso)

	1975	1976	1977	1978	1979
Estimates in current prices	2,153	2,450	2,814	3,108	3,749
Estimates in 1972 prices	1,303	1,370	1,405	1,436	1,481

Source: Pocketbook of philippine statistics, 1980 - NEDA

TABLE A.1.3-10 WHOLESALE PRICE INDEX (1978 = 100)
(Metro Manila)

Items	1976	1977	1978	1979	1980	1981
All Items	88.8	95.4	100.0	119.0	140.8	159.7
Food	89.1	95.1	100.0	116.2	133.2	156.5
Beverage & Tobacco	93.7	97.9	100.0	115.0	134.6	147.2
Crude Materials inedible except Fuel	89.5	101.3	100.0	125.3	137.9	140.8
Mineral Fuels Lubricants and related Materials	92.0	98.0	100.0	128.4	203.0	255.1
Chemicals including Animal and Vegetable Oils and Fats	85.0	93.4	100.0	121.1	135.4	137.7
Manufactured Goods Classified chiefly Materials	89.4	94.4	100.0	121.0	146.1	162.8
Machinery & Transport Equipment	84.7	89.8	100.0	100.7	123.9	136.9
Miscellaneous Manufactured Articles	85.2	91.4	100.0	115.3	140.0	157.7

Source: Philippine statistical yearbook, 1982 - NEDA

TABLE A.1.3-11 CONSUMER PRICE INDEX IN THE PHILIPPINES

(Unit: 1972 = 100)

Items	1974	1975	1976	1977	1978	1979	1980	1981
All Items	156.3	166.9	182.3	200.4	215.0	250.5	294.7	331.1
Food, Alcoholic Beverages & Tobacco	155.2	163.4	178.5	195.6	207.9	239.2	274.7	308.2
Clothing	172.2	186.5	195.2	215.5	235.6	275.6	336.2	378.6
Housing & Repair	155.0	162.7	181.2	205.2	225.0	262.7	307.3	345.6
Fuel, Light & Water	153.7	170.5	189.2	205.2	230.5	290.2	389.4	472.2
Services	144.6	160.8	175.4	196.9	214.1	160.1	325.6	363.2
Miscellaneous	170.3	190.6	210.3	223.7	238.4	277.4	326.2	357.5

Source : Philippine Statistical Yearbook, 1982 - NEDA

TABLE A.1.3-12 AGRICULTURAL AREA HARVESTED

(Unit: ha)

Crops	1976	1977	1978	1979	1980
Food Crops					
Palay	3,579.3	3,547.5	3,508.9	3,468.9	3,503.0 (28.7)
Corn (Shelled)	3,257.0	3,320.6	3,222.1	3,326.9	3,318.7 (27.2)
Banana	297.7	300.4	284.4	327.8	317.6 (2.6)
Mango	35.8	36.2	35.4	38.6	39.4 (0.3)
Pineapple	35.2	36.1	45.3	54.6	62.7 (0.5)
Citrus	22.3	22.1	23.5	24.9	24.9 (0.2)
Rootcrops	400.9	451.2	460.7	480.7	486.7 (4.0)
Coffee	76.8	76.2	84.5	95.2	109.2 (0.9)
Vegetables	136.5	138.4	141.2	130.3	135.1 (1.1)
Other food Crops	213.2	223.5	203.0	212.9	290.3 (2.4)
Sub-total	8,054.7	8,152.2	8,009.0	8,160.8	8,287.6 (67.9)
Commercial Crops					
Coconut	2,521.2	2,728.2	2,889.8	2,994.6	3,125.9 (25.6)
Sugarcane	572.6	573.1	521.6	451.2	424.6 (3.5)
Abaca	243.8	250.3	243.8	234.7	235.9 (1.9)
Tobacco	86.3	76.0	73.8	66.9	56.1 (0.5)
Rubber	55.1	58.5	53.7	53.7	54.1 (0.5)
Other Commer-tial Crops	4.3	4.5	7.3	6.7	9.2 (0.1)
Sub-total	3,483.3	3,690.6	3,790.0	3,807.8	3,905.8 (32.1)
Total	11,538.0	11,842.8	11,799.0	11,968.6	12,193.4 (100)

TABLE A.1.3-13 AGRICULTURE, FISHERY & FORESTRY PRODUCTION, CROP YEARS 1970-1981 (CONCLUDED)

(THOUSAND METRIC TONS)

Item	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
AGRICULTURE, FISHERY & FORESTRY												
Agricultural Crops Production												
Palay	5,233.4	5,342.9	5,100.1	4,414.6	5,594.1	5,660.0	6,159.5	6,456.1	6,894.9	7,197.6	7,835.8	7,722.7
Corn	2,008.2	2,005.0	2,012.6	1,831.1	2,288.7	2,568.4	2,766.8	2,843.4	2,855.2	3,167.4	3,176.2	3,247.2
Vegetables including root & tuber crops	1,661.0	1,567.8	1,565.9	1,609.6	1,855.5	2,322.9	2,329.8	3,359.3	3,607.5	4,127.2	4,072.3	3,988.0
Beans and peas	40.4	42.5	42.6	44.1	44.7	71.1	81.9	87.9	78.9	91.3	97.2	78.1
Root, bulb & tuberous veg.	47.1	49.3	55.6	62.9	68.8	90.8	81.9	102.9	112.9	66.1	64.3	62.0
Fruit-bearing vegetables	176.0	162.6	145.9	179.2	207.9	219.6	231.9	232.9	239.8	236.8	251.1	241.4
Leafy & stem vegetables	62.6	65.8	69.0	67.6	80.2	89.6	99.4	110.2	116.4	59.3	110.1	119.7
Root & tuber vegetables	1,330.4	1,243.1	1,242.3	1,243.4	1,436.2	1,827.6	1,802.8	2,792.4	3,024.5	3,600.6	3,506.6	3,443.5
Vegetables, n.e.c.	4.5	4.5	10.5	12.4	17.7	24.2	31.9	33.7	35.0	96.0	43.0	43.3
Fruits & nuts (excluding coconut)	1,640.2	1,725.9	1,804.0	1,867.2	2,153.7	2,765.0	3,450.8	3,773.6	4,585.0	5,876.6	6,289.8	5,685.4
Banana	896.0	1,034.8	980.1	1,012.6	1,235.5	1,686.0	2,270.6	2,447.4	3,155.8	4,179.0	3,977.1	4,072.9
Pineapple	233.4	234.3	282.1	293.4	338.3	424.4	419.9	421.8	464.9	604.6	1,280.7	1,292.7
Mango	151.7	137.5	139.1	187.6	191.5	239.3	293.1	307.6	335.2	363.3	377.2	369.9
Citrus Fruits	70.7	62.7	65.5	63.8	61.6	77.9	120.2	126.0	122.7	122.1	130.5	129.9
Fruits & nuts (excluding coconut), n.e.c.	288.4	256.6	337.2	309.8	326.8	337.4	347.0	470.8	506.3	607.6	524.3	518.2
Coconut (million nuts)	7,745.2	7,814.0	8,424.4	8,097.5	8,376.3	9,368.0	11,301.5	11,985.9	11,388.7	12,970.3	13,800.2	14,014.3
Sugar cane	20,353.7	22,134.8	19,432.1	24,033.6	26,066.4	25,356.5	30,328.0	27,763.8	24,936.1	24,148.3	23,685.9	24,135.3
Tobacco	61.2	55.8	56.3	64.8	63.4	57.1	58.8	50.4	56.7	51.3	42.0	38.9
Virginia	22.0	20.0	20.5	21.1	18.6	22.2	25.4	22.5	22.2	23.2	18.5	17.9
Native	39.2	35.8	35.8	43.7	44.8	34.9	33.4	27.9	34.5	28.1	23.5	21.0
Fiber crops	129.5	111.6	116.8	126.0	132.3	137.6	143.2	154.7	136.1	166.8	167.3	161.2
Abaca	122.4	104.6	110.1	119.2	125.9	133.6	139.3	150.6	129.8	159.9	157.2	148.6
Other fiber crops	7.1	7.0	6.7	6.8	6.4	4.0	3.9	4.1	6.3	6.9	10.1	12.6
Agricultural crops, n.e.c.	140.3	153.2	164.2	190.7	209.1	278.4	442.6	482.7	482.7	525.7	584.1	605.7
Coffee	49.0	49.5	51.6	50.9	53.0	91.4	80.8	105.1	118.8	115.5	125.3	131.8
Cacao	4.3	3.6	3.5	3.6	4.1	3.3	3.2	2.9	3.1	3.8	4.1	4.1
Rubber	19.0	20.9	21.7	23.1	28.6	45.7	57.7	58.2	54.4	58.8	67.7	72.0
Other agricultural crops, n.e.c.	68.0	79.2	87.4	113.1	123.4	138.0	301.3	316.5	306.4	347.6	387.0	397.8
Production of Livestocks, Poultry and Other Animals												
Livestock (thousand heads)	13,337.4	14,325.7	15,468.9	16,911.0	17,830.0	13,629.0	10,950.5	10,490.6	11,688.8	12,081.2	12,686.8	12,260.1
Poultry (thousand heads)	59,130.9	58,864.3	52,703.0	52,871.0	51,163.1	51,262.0	49,775.1	51,979.7	64,257.6	54,658.3	57,485.9	60,767.1
Fishery 1	988.9	1,023.1	1,122.4	1,195.8	1,268.4	1,336.8	1,393.5	1,508.9	1,580.4	1,581.3	1,672.3	1,755.3
Ocean and Coastal fishing	381.9	382.3	424.8	456.4	470.7	498.6	508.2	518.2	505.8	500.7	488.5	490.0
Inland Fishing	510.5	542.9	598.7	639.8	684.5	731.7	772.5	874.9	955.9	947.0	1,047.8	1,113.3
Operation of fish farms	96.5	97.9	98.9	99.6	113.2	106.5	112.8	115.8	118.7	133.6	136.0	152.0
Forestry												
Logging operations (cu.m.)	10,679.5	11,051.7	8,437.1	8,990.3	6,979.2	7,331.9	8,440.7	7,901.9	7,873.8	6,655.6	6,352.0	5,399.5

TABLE A.1.3-14 GROSS NATIONAL PRODUCT, GROSS DOMESTIC PRODUCT AND POPULATION PROJECTION

Item	Constant Level (billion pesos)					Average Annual Growth Rates			Constant Level (billion pesos)				
	Actual		Estimate	Projection		Actual	Estimate	Projection	Actual		Estimate	Projection	
	1980	1981	1982	1983	1987	1980-81	1981-82	1983-87	1980	1981	1982	1983	1987
Gross National Product	92.6	96.1	100.0	105.2	136.7	3.8	4.1	6.5	265.0	305.5	352.7	408.2	749.2
Gross Domestic Product	92.7	96.2	100.2	105.3	136.3	3.8	4.2	6.3					
Population (in thousands)	48,317	49,526	50,740	51,956	56,761	2.5	2.5	7.2					
Per Capita GNP (in pesos)	1,918	1,941	1,975	2,026	2,403	1.2	1.8	3.5	5,484	6,168	6,951	7,856	13,199

Source : EPRS - NEDA

TABLE A.1.3-15 EXPECTED GROSS AGRICULTURAL OUTPUT, 1982-1987

Items	1982 (1,000t)	1987 (1,000t)	Average Annual Growth Rate
All Crops			5.3
Food Crops			4.9
Palay	8,198.5	9,769.2	3.6
Corn	3,392.0	5,900.0	11.7
Coconut	2,311.1	2,422.2	0.9
Sugar	2,530.0	3,320.0	5.6
Banana	2,271.0	2,710.0	3.6
Non-food Crops			16.6
Livestock Fish Poultry			7.3

Source : Ministry of Agriculture

CHAPTER II. METEROLOGY AND HYDROLOGY

CHAPTER II METEOROLOGY AND HYDROLOGY

2.1 Meteorology

The climate in the project area is the typical tropical wet and dry climate which is characterized by two pronounced seasons, dry in winter and spring, and wet in summer and autumn. Only the cyclonic or summer rainfall prevails with other types being hardly noticeable.

Factors in the general atmospheric circulation, called climatic controls, acting with various intensities and in different combinations, produce the observed changes in the climatic elements. Aside from the geographic and topographic conditions, the most important climatic controls are semi-permanent cyclones and anti-cyclones, air streams, ocean currents, linear systems, tropical cyclones and thunderstorms.

The climate is controlled to a great extent by the location and intensity of nearby semi-permanent cyclones and anti-cyclones so far as these semi-permanent pressure features produce air streams and ocean currents which greatly affect the climate observed in the project area. The principal air streams are the Northeast Monsoon, the Southwest Monsoon, the North Pacific Trades, the Temperate Zone Wester lies, and the South Pacific Trades.

The Northeast Monsoon originates in the cold, intense Asiatic winter anti-cyclone. Generally it follows a pass across Japan towards the northwestern Pacific Ocean. It first reaches the area generally as a weak northeasterly stream in October, attaining maximum strength in January, gradually weakens in March and finally disappears in April.

Although this air stream starts as a continental polar air mass with a low temperature and a low humidity, as it passes over the Pacific it is finally transformed into a maritime tropical air mass, with a surface temperature of about 25°C.

The Southwestern Monsoon originates as the Indian Ocean Trades from the Indian Ocean Anti-cyclone during the Southern Hemisphere winter season. On crossing the equator, the winds are deflected to the right in the Northern Hemisphere. It is classified as a maritime equatorial air mass, generally arriving from a southwestern direction. It usually appears in early May, attains maximum intensity in August and gradually disappears in October. However, occasionally this air stream may appear as early as in April and persist up to November or December. The Southwestern Monsoon is warm and very humid with surface temperatures between 25.5°C and 27.5°C, and with relative humidity of more than 70%.

The North Pacific Trade is the southern portion of the North Pacific Anti-cyclone and is therefore classified as a maritime tropical air mass. It travels over a vast expanse of the North Pacific Ocean, arriving at the project area from varying directions, generally northeast, east or southeast but sometimes south or southwest. This air stream is warmest which affects the climate in the project area having a temperature of about 27°C.

The main ocean current affecting Luzon Island is the North Equatorial Current moving westward across the North Pacific Ocean. Upon reaching the eastern coastal areas of the Luzon, it splits into nothward and southward branches of which the northward branch flows along the east coasts of Luzon and becomes the Kurosho Current. The surface temperature of the sea is relatively high and quite uniform with the annual range of temperature variations of about 5°C in the South China Sea and the Pacific Ocean bordering the western and eastern coast of Luzon.

Tropical cyclones contribute largely to the rainfall from May to December. They affect prevailling winds, humidity and cloudiness, and are usually responsible for the maximum values of rainfall, strongest winds and minimum air pressure. They follow widely variable tracks with widely varying speeds ranging from less than 2 m/sec to more than 10 m/sec in the vicinity of the Philippines. During the months of April, May and June, the cyclones pass generally crossing the Visayas. During the months of July, August and September, most of the cyclones cross northern luzon or the Batanes Islands. Again, during the months from October to March, they generally cross the Bisayas.

Compared with tropical cyclones, thunderstorms are relatively small and short period disturbances. According to the statistics, the project area receives 50 to 60 days of thunderstorms annually. Generally, effects of thunderstorms on the climatic elements are not very pronounced, but in some instances the rainfall accompanying them may be considerable.

The characteristics and behaviour of climatic controls affecting the area have notable effects on the climatic elements. The most important of the climatic elements are temperature, rainfall, humidity, cloudiness and winds.

Temperature

The project area, situated in central Luzon which is categorized in the tropics and consequently in a region of high insolation, surrounded by warm seas, and with warm air currents flowing over the area, has inevitably high temperatures throughout the year.

Mean annual temperature observed at the Ulingao Research Center, situated in the center of the project area, is 26.4°C as the recent 10 years average. The hottest months are April with monthly mean maximum temperatures of 33.5°C and May with 32.4°C. The coldest months are February with monthly mean minimum temperature of 19.7°C and January with 19.9°C. The average annual range of temperature is about 5°C. In addition, the highest temperatures usually occur between 1 p.m. and 3 p.m. while the lowest temperatures occur between 5 a.m. and 7 a.m. The diurnal range of temperature is known to be much larger than the annual range. Tables A.2.1-1 presents monthly mean maximum and minimum temperatures observed at the Ulingao Research Center during the past 10 years from 1980 up to 1979.

Rainfall

The rainfall in the area is influenced to a large extent by the air streams, tropical cyclones and topography, and is influenced to a lesser extent by local thunderstorms. The rainfall in the area, characterized by the tropical monsoon, is estimated at 1,710 mm on average per year. Compared to the annual average rainfall of 2,700 mm, in the entire Luzon, the project area receives a relatevely small annual mean of less than 2,000 mm mainly due to the fact that the area is located in a plain shielded from the dominant air streams by high mountain ranges.

During the months from May to September, the southwest monsoon wind is predominant over the area providing a large amount of rainfabl. The heaviest rainfall in the area is generally associated with typhoons. Based on the monthly averages of rainfall, August has the highest average with about 390 mm, February has the smallest average with about 4 mm. May to November is considered to be the wet season, during which almost 95 percent of the annual rainfall is concentrated. The dry season covers the period from December to April when the northern or northeastern monsoon is predominant providing little rainfall in the area.

Rainfall data are available to formulate the project within or nearby the project boundary at nine meteorological stations managed by PAGASA (Philippine Atmospheric, Geophysical and Astronominal Services Administration), as presented in Figures A.2.1-1 and 2.1-2. As is clear in Figure 2.1-2, each of the stations keeps relatively short period of records of 6 to 16 years, which are in complete for section times.

Humidity

Throughout the year the humidity of the air is relatively high, mainly caused by extensive evaporation from the sea surrounding the island, the rich vegetation, the moist air streams flowing over the area and rainfall. The average annual relative humidity observed at the Ulingao Research Center for six years from 1972 to 1977 was 87 percent. Table A.2.1-2 shows the monthly mean relative humidity, in which the miximum value of 90 percent is recorded in December, while the minimum value of 79 percent is in March. The diurnal behaviour of relative humidity, in general, is characterized by high values at night and early morning, and low values during the day and early evening.

Evaporation

The annual evaporation measured by use of A-pan is obtainable at the Ulingao Research Center for the period from 1970 to 1979, as given in Table A.2.1-3. The amount of evaporation is as much as 5.1 mm/day or 1,850 mm annually, almost corresponding to the annual amount of rainfall in the area. The monthly evaporation varies in close correlation with rainfall amount as well as relative humidity, ranging from 4.2 mm/day in December to 6.8 mm/day in April.

Cloudiness, Surface Winds and Atmospheric Pressure

The cloudiness is generally related to the humidity. The average annual cloudiness observed at Cabanatuan City is about 4 oktas with values ranging from 3 oktas to 6 oktas. The cloudy months are June to November wherein the average cloudiness is about 5.5 oktas while the other months are less cloudy with average cloudiness of 3.3 oktas. Table A. 2.1-4 presents cloudiness, prevailing wind direction and speed, and atmospheric pressure observed at Manila as well as at Cabanatuan City.

For the purpose of visualization, monthly average values of rainfall, temperature, relative humidity and evaporation are plotted as shown in Figure A.2.1-3.

TABLE A.2.1-1 (1) MONTHLY MEAN MAXIMUM AND MINIMUM TEMPRATURE

MAXIMUM TEMPERATURE

(Unit: ^{o}C)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1970	29.7	30.0	32.6	33.6	33.4	30.6	29.6	28.3	29.1	30.8	28.8	29.2	30.5
1971	27.9	28.2	28.5	30.7	29.5	28.3	27.1	29.6	29.6	28.4	27.9	27.8	28.6
1972	27.2	29.5	28.7	31.0	29.8	29.3	26.3	27.4	30.2	31.9	31.1	30.5	29.4
1973	30.6	30.8	33.0	34.5	35.1	32.6	31.5	31.0	32.8	29.7	30.9	31.9	32.0
1974	29.4	31.3	34.2	35.7	33.2	31.9	32.8	30.4	32.9	31.3	30.4	29.6	31.9
1975	30.0	31.2	34.6	34.9	29.4	38.6	34.3	29.8	31.2	32.2	31.3	29.3	32.2
1976	28.8	34.4	32.4	-	-	-	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	31.3	31.7	30.5	31.9	31.5	30.5	-
1978	30.8	31.2	33.6	35.4	35.3	31.9	32.2	29.4	30.4	30.0	31.6	32.0	32.0
1979	32.0	32.9	31.7	32.1	33.1	33.3	33.0	38.5	34.3	31.5	32.5	30.9	32.9
Mean	29.6	31.1	32.1	33.5	32.4	32.1	30.9	30.7	31.2	30.9	30.7	30.2	31.3

TABLE A.2.1-1 (2) MONTHLY MEAN MAXIMUM AND MINIMUM TEMPERATURE

(Unit: °C)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1970	20.3	19.3	20.9	22.5	23.7	24.1	24.2	23.6	23.3	23.5	23.2	22.4	22.6
1971	18.6	20.1	20.1	22.0	23.7	23.5	23.2	22.9	23.2	22.6	22.0	21.4	21.9
1972	20.6	20.0	19.2	21.6	23.2	23.6	22.9	22.2	22.6	22.4	21.9	21.0	21.8
1973	19.9	21.0	20.1	20.7	23.9	23.7	23.3	22.8	22.8	22.6	22.8	21.7	22.1
1974	18.3	19.4	18.8	21.3	23.2	23.2	23.1	23.2	22.0	22.7	21.8	22.0	21.6
1975	20.3	19.7	20.1	21.1	18.3	22.9	22.7	23.2	21.9	22.3	21.4	20.8	21.2
1976	20.3	18.0	19.5	-	-	-	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	24.8	24.1	23.3	22.3	21.4	20.9	-
1978	20.3	19.6	21.3	19.9	23.5	23.8	23.9	23.4	22.9	22.9	22.4	22.1	22.2
1979	20.6	20.6	21.2	21.6	23.6	23.9	24.4	23.4	23.6	23.2	23.3	20.4	22.5
Mean	19.9	19.7	20.1	21.3	22.9	23.6	23.6	23.2	22.8	22.7	22.2	21.4	22.0

TABLE A.2.1-2 MONTHLY MEAN RELATIVE HUMIDITY

(Unit: %)

Month	1972	1973	1974	1975	1976	1977	MEAN
Jan.	-	90	86	86	87	-	87
Feb.	-	86	83	87	85	-	85
Mar.	-	71	82	84	78	-	79
Apr.	-	78	81	87	88	-	84
May	-	83	86	86	92	-	87
Jun.	-	89	97	76	88	-	87
Jul.	-	91	91	85	87	84	89
Aug.	-	92	94	85	-	86	89
Sept.	-	90	90	82	-	89	88
Oct.	88	90	90	85	-	79	87
Nov.	91	91	89	87	-	78	87
Dec.	89	91	89	91	-	-	90
Mean	89	87	88	85	86	83	87

TABLE A.2.1-3 MONTHLY MEAN DAILY PAN EVAPORATION AT ULINGAO

(Unit mm/day)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1970	4.19	4.76	7.25	6.94	6.61	4.10	4.35	3.49	3.75	4.51	3.99	4.15	4.84
1971	4.39	4.88	6.17	7.88	5.18	4.78	5.15	5.43	4.63	3.94	3.65	3.86	5.00
1972	4.29	5.56	6.50	7.67	6.47	6.10	4.23	4.71	5.07	4.90	4.25	4.28	5.34
1973	4.38	5.30	7.01	9.16	7.46	6.67	5.58	4.72	5.01	5.22	4.39	3.61	5.71
1974	4.58	5.27	5.90	7.13	5.37	5.20	5.63	3.62	5.38	3.97	4.47	3.59	5.01
1975	3.81	5.33	4.98	3.96	4.58	3.19	4.00	4.12	5.02	5.59	4.67	3.38	4.39
1976	3.93	4.45	6.32	7.14	6.51	5.91	4.74	4.57	4.80	5.06	4.64	4.38	5.20
1977	4.93	4.38	5.68	6.60	5.86	5.81	4.42	5.42	5.03	5.21	4.46	4.12	5.16
1978	5.15	4.78	6.11	6.06	5.79	4.39	4.74	3.07	4.69	3.84	4.17	4.69	4.79
1979	5.14	5.29	5.68	5.33	4.43	3.70	5.22	4.35	5.22	5.72	5.94	5.59	5.13
Mean	4.48	5.00	6.16	6.79	5.83	4.99	4.81	4.35	4.86	4.80	4.46	4.17	5.06

TABLE A.2.1-4 CLOUDINESS, WIND AND AIR PRESSURE

STATION	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1. Cloudiness in oktas														
Cabanatuan	9	3	3	3	3	4	5	6	6	6	5	5	4	4
Manila CO	59	5	4	4	3	5	6	6	6	6	6	6	5	5
Manila MMO	8	6	5	4	4	5	6	6	7	7	6	6	6	6
2. Prevailing Winds and Average Wind Speeds in m/sec														
Cabanatuan		-	-	-	-	-	-	-	-	-	-	-	-	-
Manila CO		NE/2	E/2	SE/2	SE/3	SE/3	SW/3	SW/3	SW/4	SW/3	NE/2	NE/2	NE/2	SW/3
Manila MMO		E/3	SE/4	SE/4	SE/4	SE/4	SE/3	SW/3	SW/3	SE/2	SE/2	SE/2	E/2	SE/3
3. Atmospheric Pressure in Mbar														
Cabanatuan		1014	1013	1013	1012	1010	1009	1009	1009	1010	1010	1011	1013	1011
Manila CO		1013	1013	1012	1010	1009	1008	1007	1007	1008	1009	1010	1012	1010
Manila MMO		1013	1013	1012	1011	1010	1009	1009	1008	1009	1010	1010	1013	1011

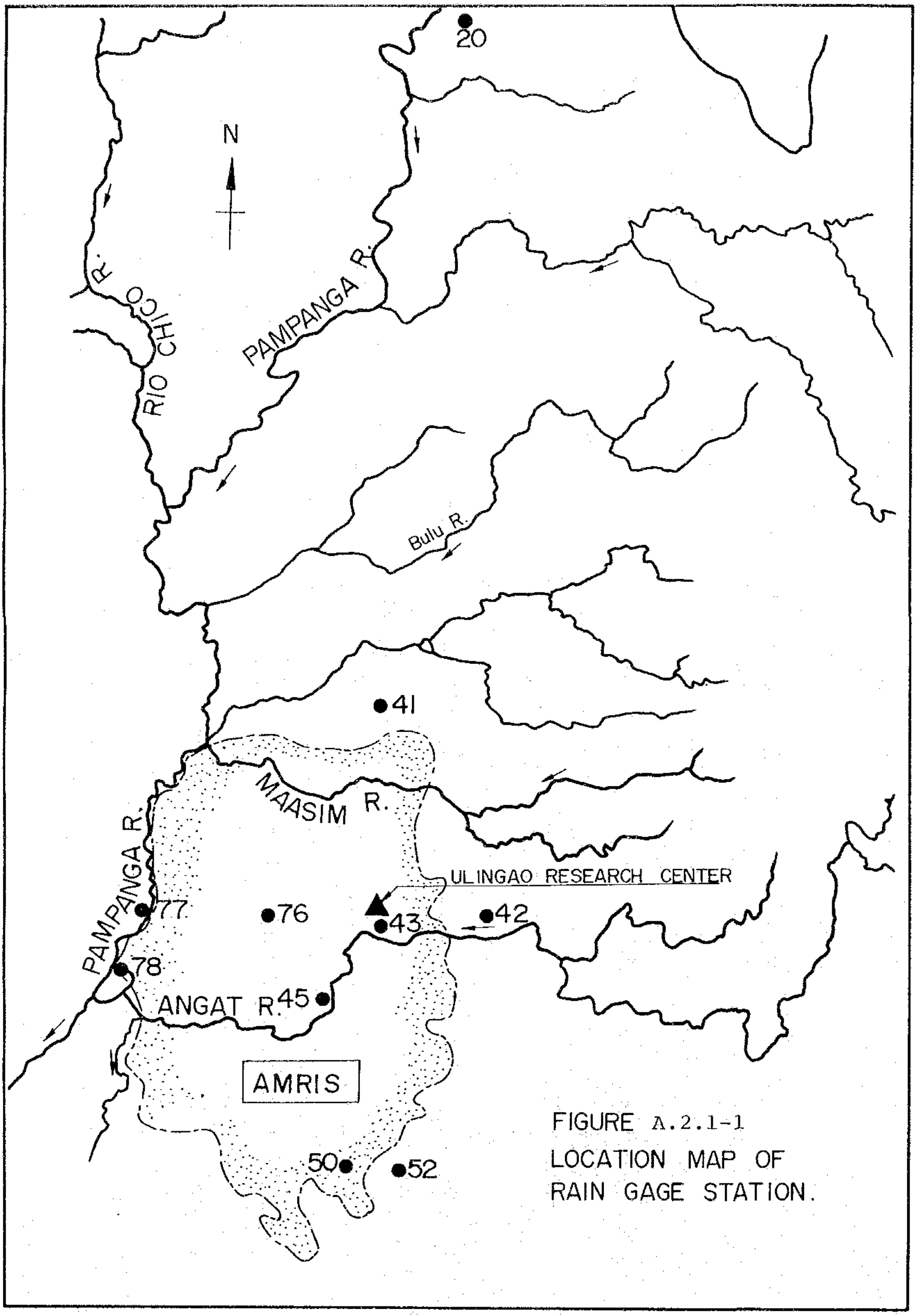
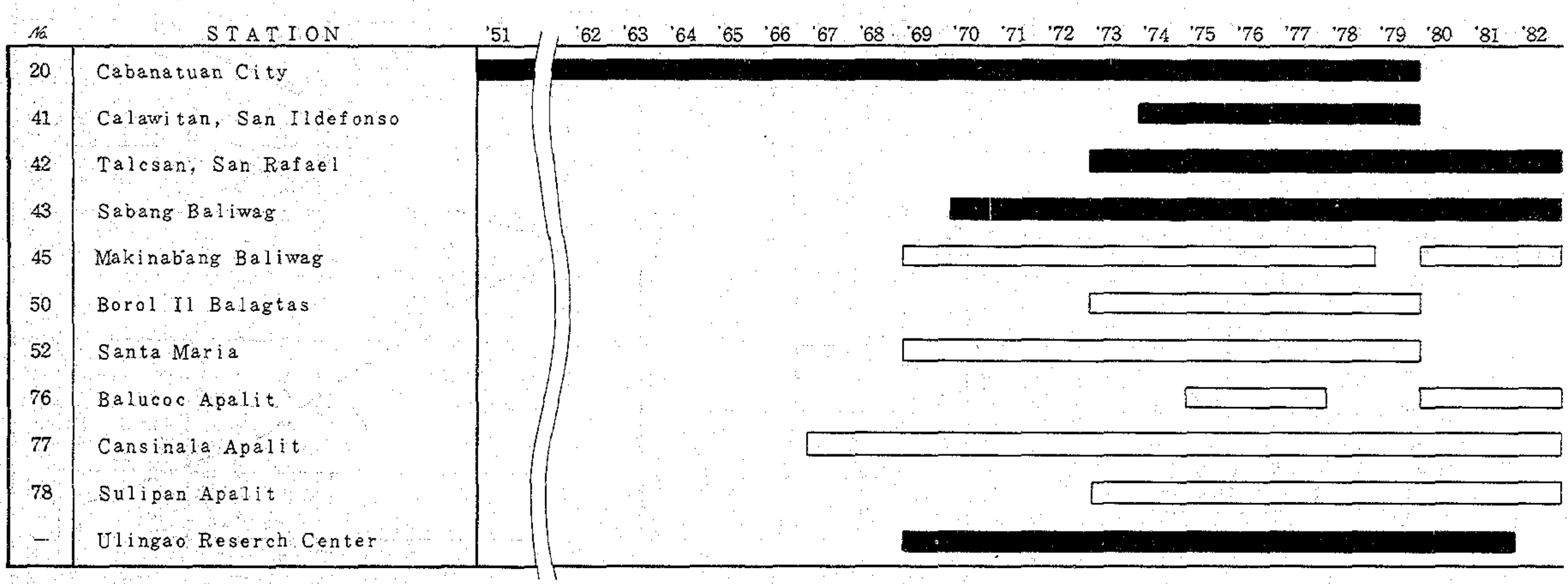


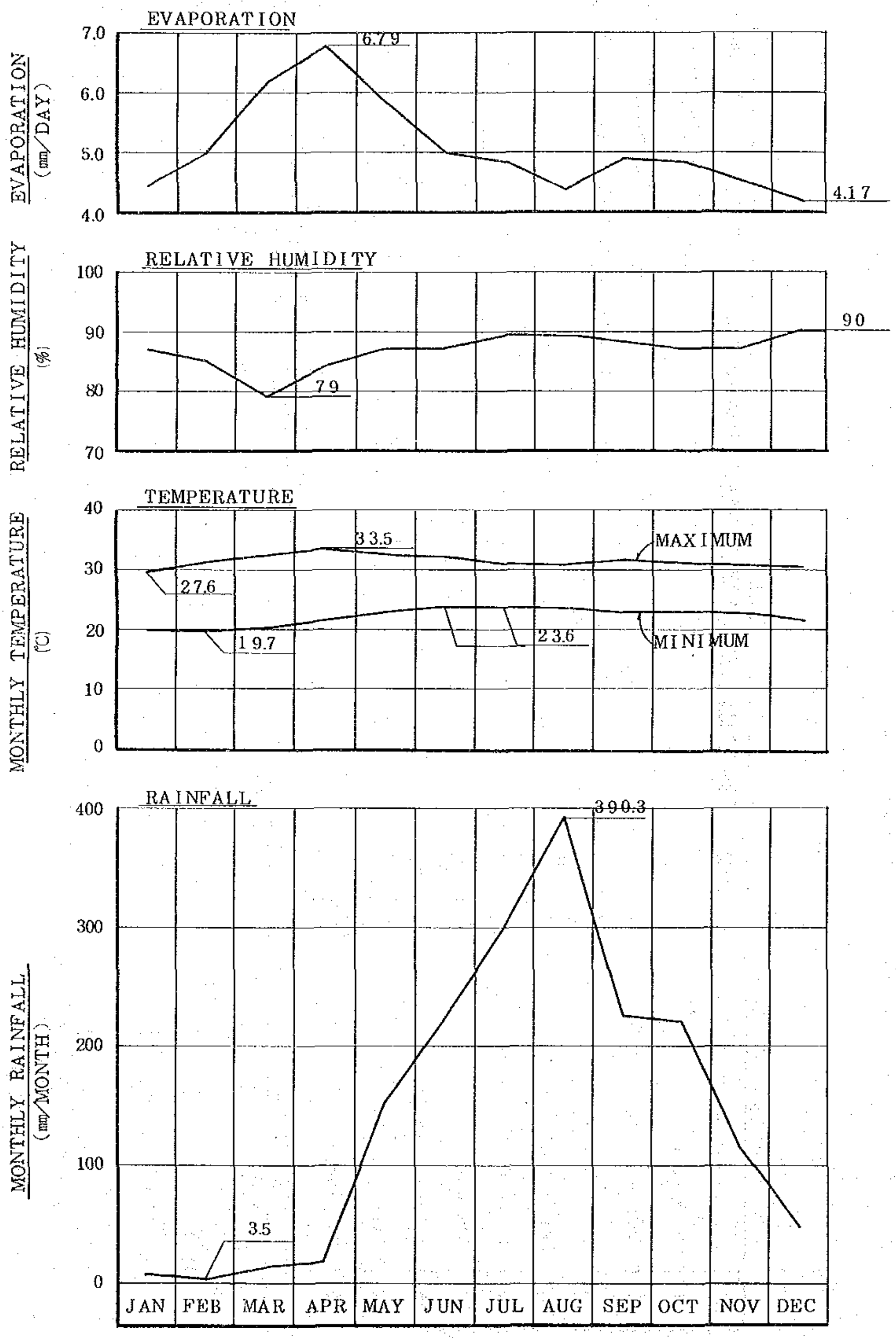
FIGURE A.2.1-1
LOCATION MAP OF
RAIN GAGE STATION.

FIGURE A.2.1-2 LOCATION OF RAIN GAGE STATION AND PERIOD OF AVAILABLE RECORDS



№	STATION	LATITUDE	LONGITUDE	№	STATION	LATITUDE	LONGITUDE
20	Cabanatuan City	15°29′	120°58′	52	Santa Maria	14°49′	120°57′
41	Calawitan, San Ildefonso	15°05′	120°58′	76	Balucoc Apalit	14°58′	120°51′
42	Talcsan, San Rafael	14°58′	120°58′	77	Cansinala Apalit	14°58′	120°47′
43	Sabang Baliwag	14°58′	120°58′	78	Sulipan Apalit	14°56′	120°45′
45	Makinabang Baliwag	14°35′	120°58′	—	Ulingao Reserch Center	—	—
50	Borol Il Balagtas	14°49′	120°58′				

FIGURE A.2.1-3 MONTHLY VARIATION OF CLIMATIC ELEMENTS



2.2 River Regime

Three major rivers provide irrigation water to the service area of the AMRIS.

The Pampanga River flows southwards on the western border of the AMRIS area. The Maasim River, which runs westward near the northern border of the area joins the Pampanga River at about 10 km upstream from San Luis. In the center of the area, the Angat River also flows westward dividing the area into North and South. Along these rivers, there are 14 gauging stations in and around the AMRIS area. The locations of these stations are shown in Figure A.2.2-1 and the time period of available records is summarized in Figure A.2.2-2. The hydrological observations were made by the National Water Resource Council (NWRC) since the beginning of 1960s. Observations were, however, terminated at all the stations at the end of the 1970s.

The drainage area of the Pampanga River is estimated to be 7,715 km^2 at the confluençe of the Angat River. The river is affected by tidal intrusion far up the area. Only gauge height records are available at all the stations along the Pampanga River except for gauging station No.51 where no seawater intrusion is observed. The river water floods annually over left banks during the wet season. The carrying capacity of the river is estimated to be about 1,800 m^3/sec.

On the Maasim River, there are two hydrological gauging stations: one about 0.5 km downstream from the lower Maasim Dam, and the other about 3.8 km upstream from the Upper Maasim Dam. The drainage area is 174 sq.km at the Lower Maasim gauging station and 150 sq.km at the Upper Maasim gauging station. The river divides the Candaba Swamp into two, which acts as a natural retarding basin for the Pampanga River. The carrying capacity of the river is estimated to be about 100 m^3/sec in the downstream section of the Lower Maasim Dam.

On the Angat River, there are three existing dams, which are in order from upstream, the Angat Reservoir, Ipo and Bustos Diversion Dams. The drainage area of the river is 568 km^2 at the site of the Angat Dam and about 920 s.q. km at the confluence of the Pampanga River. The Angat Reservoir has an effective capacity of 850 million cubic meters. The stored water in the reservoir is used for hydroelectric power generation by the National Power Corporation (NPC), for water supply to Metro Manila by the Metropolitan Waterworks and Sewerage System (MWSS) and for irrigation by NIA. In addition the reservoir also functions for flood control of the river. For the purpose of supplying water for all multiple uses, NPC is operating the reservoir based on the established operation rule curve.

The carrying capacity of the river is estimated to be about 900 m^3/sec in the AMRIS area and floods seldom occur because the river water is duly controlled by the Angat Reservoir.

Pampanga River

On the basis of the daily water level record at the gauging stations at Sulipan Apalit, No.63 and San Simon, No.54, the water level is chronologically shown for a period of 18 years in Figure A.2.2-3 and Figure A.2.2-4 repectively.

As shown in Figure A.2.2-3, the Pampanga River water level at San Simon is often more than 2 meters above the mean sea level during the four months from July to October.

The probable high water level at the above two stations is estimated by statistical treatment. The results are shown below.

Probable High Water Level of the Pampanga River

Return Period	San Simon, No.54	Sulipan Apalit, No.63
2 years	EL. 5.0 m	EL. 4.0 m
5	EL. 5.4 m	EL. 4.9 m
10	EL. 6.3 m	EL. 5.4 m
20	EL. 6.7 m	EL. 5.9 m
50	EL. 7.2 m	EL. 6.4 m
100	EL. 7,6 m	EL. 6.8 m

Maasim River

There are two gauging stations along the Maasim River. Since the river water is diverted for irrigation at the Upper and Lower diversion dams before it reaches No.55 gauging station, discharge records obtained at No.56 gauging station are the only ones to help evaluate available runoff in the Maasim River. The monthly mean discharges of the Maasim River are summarized in Table A.2.2-1 for a period of 13 years from 1962 to 1975, excluding 1972.

As can be seen in the said table, the discharge during the four months from January to April is negligibly small. On the basis of the same record, the probable flood discharge of the Maasim River has been estimated as summarized hereunder.

Probable Flood Discharge of Maasim River

Return period (year)	2	5	10	20	50	100
Flood discharge (m /sec)	415	563	647	720	806	866

Angat River

The inflow into the Angat Reservoir has been estimated by NPC based on the actual measurement of the reservoir surface water level, released water through main and auxiliary power generators and spillage. As shown in Table A.2.2-2, the Angat reservoir receives about 2,080 MCM of inflow from the drainage area of 568 sq.km as an annual average in the last 11 years from 1972 up to 1982, of which 1,667 MCM are released from the reservoir through main power generators for the purposes of irrigation as well as additional power generation.

Concerning the use of the Angat River water, an agreement was closed among three governmental agencies concerned, namely; NPC, MWSS and NIA. According to the agreement, the use of water is defined as follows.

The average regulated flow from the reservoir was shown to be 58 cubic meters per second. Of this, MWSS will get 22 cu.m per second, or up to 500 million gallons per day while NIA will get 36 cu.m per second which is still short of the total volume required for irrigation. However, NIA expects to get an additional 4.0 cu.m/sec from tributaries downstream of the Ipo Dam and so, it will eventually get a total of 40 cu.m which is recognized as water rights.

TABLE A.2.2-1 MONTHLY DISCHARGE OF MAASIM RIVER (GAGING STATION NO.56)

(Unit : cms)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1962	0.50	0.24	0.16	0.45	0.35	1.04	83.3	14.5	38.8	3.65	1.50	0.64	12.1
1963	0.30	0.21	0.08	0.07	0.05	33.8	9.52	11.7	80.7	2.87	0.74	0.45	11.7
1964	0.18	0.08	0.07	0.05	4.11	28.1	17.0	23.5	14.8	5.86	9.59	24.6	10.7
1965	1.10	0.50	0.26	0.12	0.78	4.04	47.0	4.95	22.8	3.43	3.15	0.78	7.41
1966	0.26	0.14	0.10	0.06	32.4	9.33	3.73	29.0	38.8	6.55	58.4	8.33	15.6
1967	1.77	0.42	0.18	0.02	0.11	23.3	8.71	21.3	16.5	8.53	8.45	1.30	7.55
1968	0.32	0.26	0.02	0.01	0.52	0.43	7.34	46.9	24.0	8.75	1.18	1.35	7.59
1969	0.59	0.07	0.01	0.01	0.24	-	49.7	17.3	8.03	6.57	2.12	1.18	-
1970	0.75	0.12	0.06	0.14	0.16	4.34	15.5	9.69	57.6	29.9	13.6	3.68	11.3
1971	0.89	0.23	0.10	0.04	1.35	29.6	12.1	6.24	9.59	24.1	35.6	13.9	11.1
1972	-	-	-	-	-	-	-	-	-	-	-	-	-
1973	0.31	0.01	0.01	0.01	0.04	0	26.3	11.4	3.76	42.4	19.8	4.30	9.03
1974	0.56	0.04	0.05	0	0.01	31.0	26.5	68.1	1.90	25.3	0.75	0.60	12.9
1975	0.43	0.13	0.02	0	0	15.5	16.5	56.6	-	-	-	-	-
Average	0.61	0.19	0.09	0.07	3.09	14.8	24.9	24.7	26.4	13.9	12.9	5.10	10.6

TABLE A.2.2-2 INFLOW INTO THE ANGAT RESERVOIR

(Unit: MCM)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1972	223	67	79	59	64	85	960	475	280	167	286	250	2,993
1973	63	89	40	22	24	30	84	96	122	436	371	214	1,592
1974	54	86	72	13	71	136	113	639	81	276	640	507	2,688
1975	238	101	63	122	41	73	59	219	150	173	190	582	2,011
1976	155	66	63	30	618	270	250	157	264	162	243	213	2,489
1977	162	84	76	33	66	33	208	169	201	83	272	73	1,461
1978	55	11	22	16	39	67	79	298	373	672	251	245	2,128
1979	95	47	34	47	65	119	139	265	141	252	334	105	1,645
1980	77	43	127	38	48	132	324	90	217	363	425	144	2,030
1981	85	57	19	18	26	170	276	253	149	341	555	263	2,211
1982	84	60	44	48	42	50	316	297	188	112	239	157	1,636
Average	117	65	58	41	100	106	255	269	197	276	346	250	2,080

Notes: (1) Drainage area = 568 sq.km

(2) Mean daily inflow = 2,080 MCM/365 days/86400sec
= 66 cum/sec

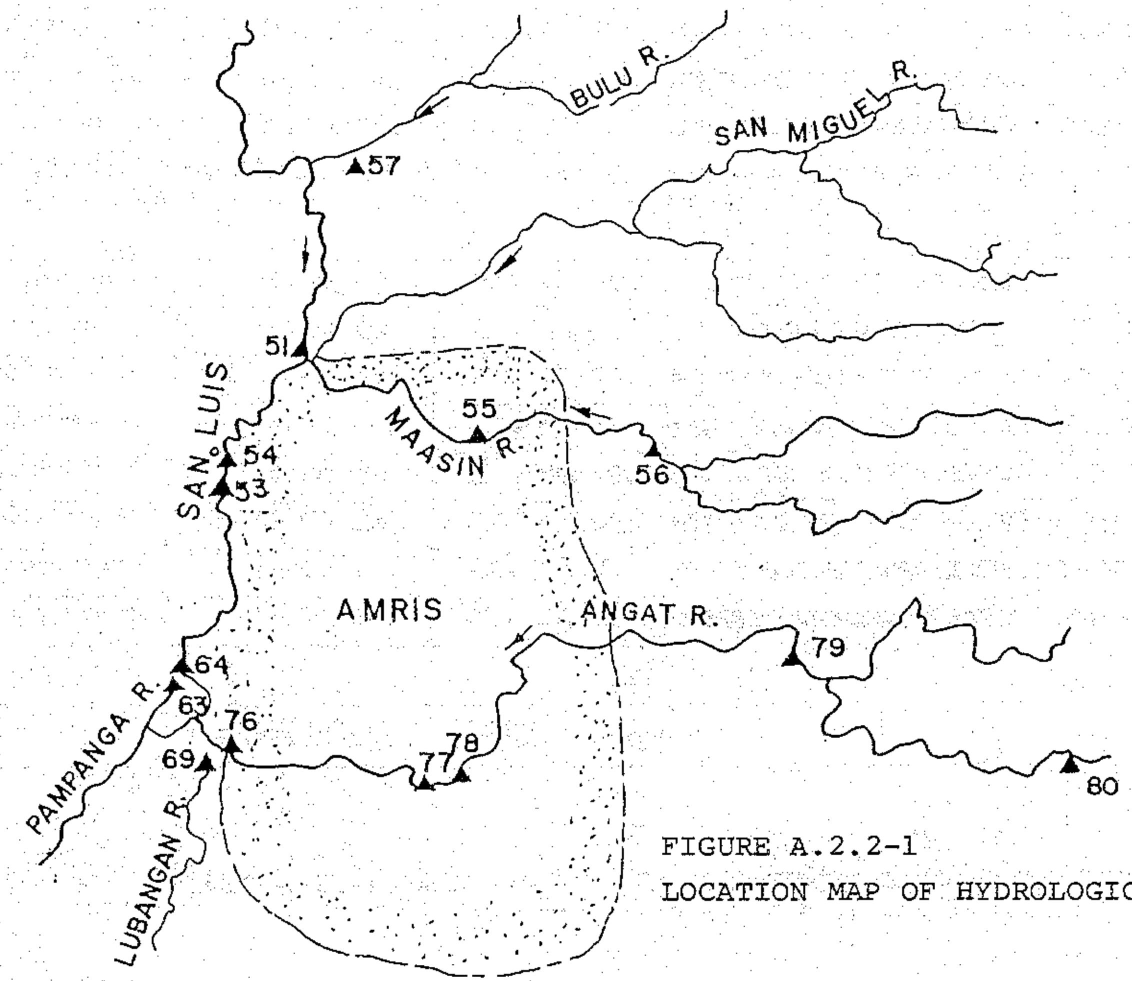
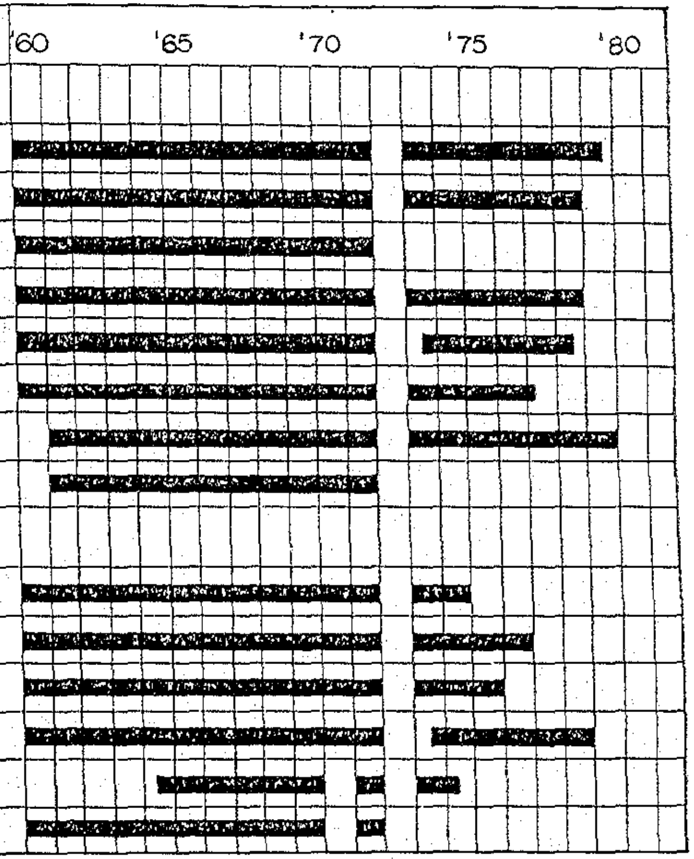


FIGURE A.2.2-1
LOCATION MAP OF HYDROLOGICAL STATION

FIGURE A.2.2-2 LOCATION OF HYDROLOGICAL STATION AND PERIOD OF AVAILABLE RECORDS

NO.	STATION	LATITUDE	LONGITUDE
	GAUGE HEIGHT		
53	Santa Cruz, San Luis, Pampanga	15° 00' 26"	120° 46' 35"
54	Poblacion, San Juan, San Simon	15° 00' 51"	120° 46' 37"
57	Ducma, Candaba, Pampanga	15° 00' 37"	120° 51' 00"
63	Sulipan, Apalit, Pampanga	14° 56' 24"	120° 45' 43"
64	Sulipan, Apalit, Pampanga	14° 56' 13"	120° 45' 26"
69	Poblacion, Calumpit, Bulacan	14° 55' 20"	120° 45' 52"
76	Pungo, Calumpit, Bulacan	14° 54' 07"	120° 47' 00"
77	Poblacion, Pulilan, Bulacan	14° 53' 55"	120° 50' 36"
51	Pasig, Candaba, Pampanga	15° 05' 48"	120° 49' 18"
55	Bahay-Pare, Candaba, Pampanga	15° 01' 58"	120° 55' 00"
56	Diliman, San Rafael, Bulacan	15° 02' 15"	120° 57' 25"
78	Longos, Pulilan, Bulacan	14° 55' 30"	120° 51' 50"
79	Pulong, Sampalok, Angat, Bulacan	14° 57' 20"	121° 03' 45"
80	Ipo, Norzagaray, Bulacan	14° 52' 36"	121° 08' 30"



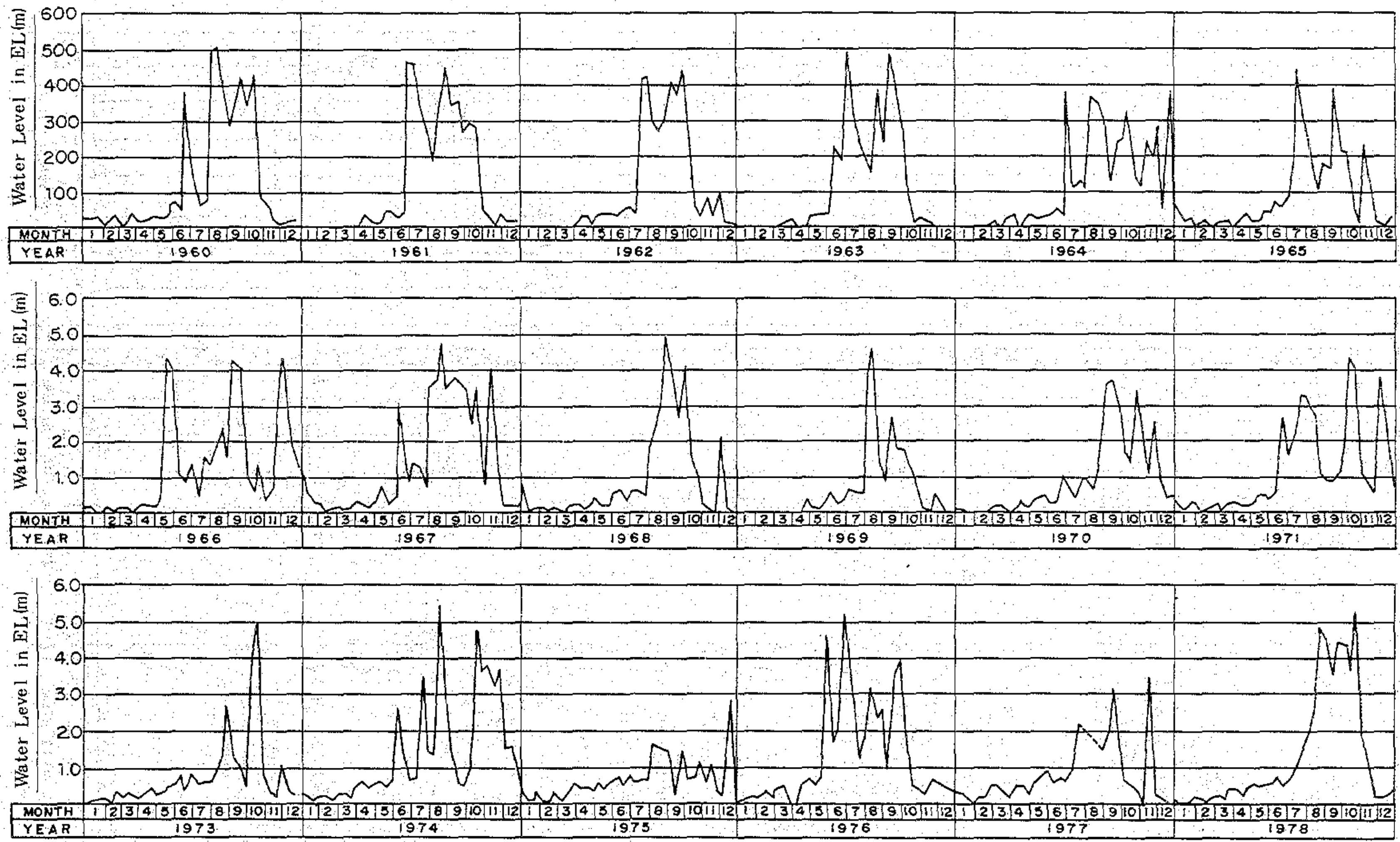


FIGURE A.2.2-3 WATER LEVEL OF PAMPANGA AT SAN SIMON

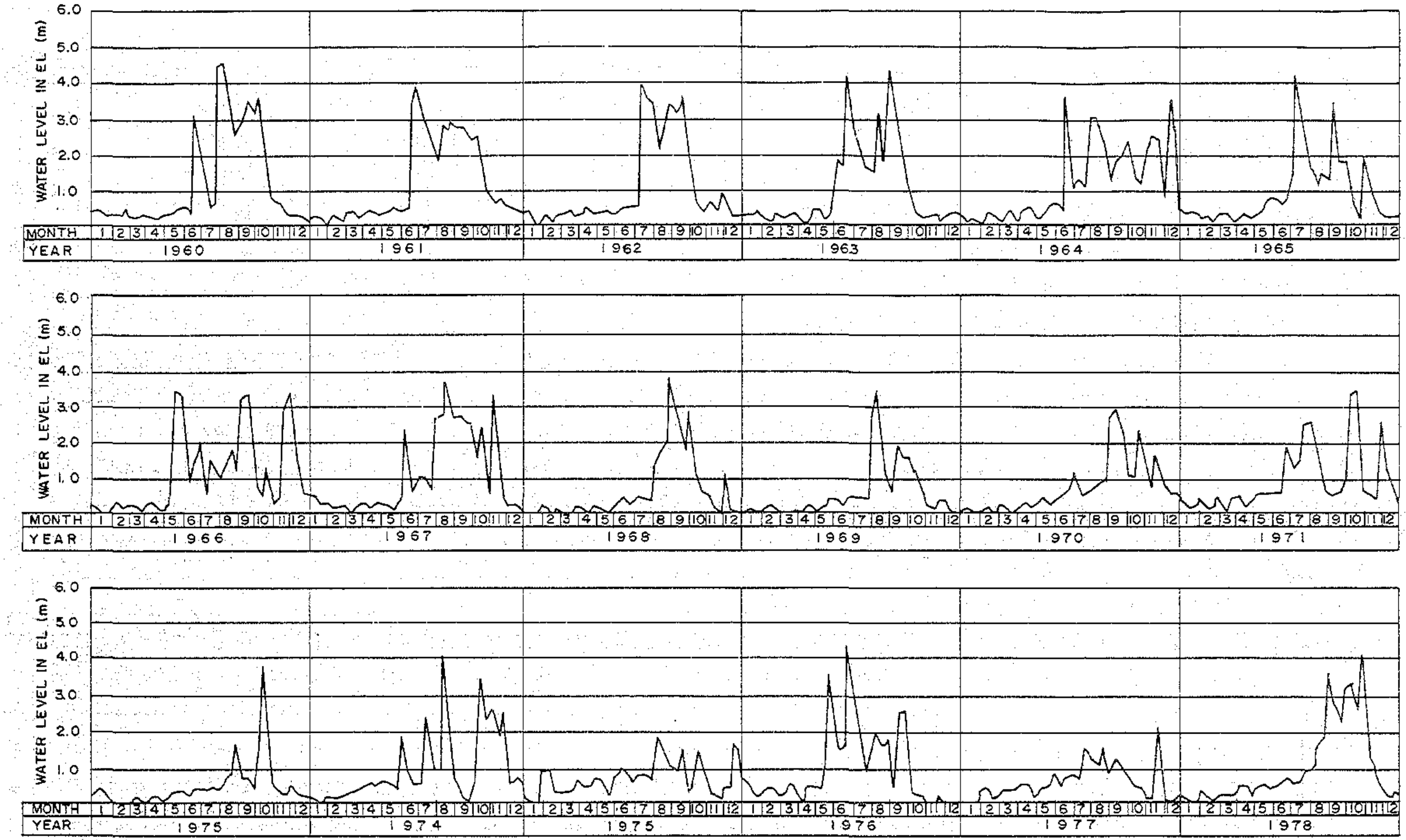


FIGURE A.2.2-4 WATER LEVEL OF PAMPANGA AT SULIPAN APALIT

2.3 Areal Rainfall

Since the irrigation systems have to be developed and designed based on the statistical evaluation of water resources, it is very important to have records covering a period of more than 10 years of daily rainfall observations. At nine meteorological stations, only four stations; namely No.42, 43, 77 and 78, have kept a complete set of daily rainfall observations in the last 10 years.

Table 2.3-1 shows monthly average rainfall observed at each station. In terms of arithmetic mean, areal rainfall in the AMRIS service area is added to the said table. Amounts of rainfall as well as seasonal patterns were examined between areal average rainfall and actually observed value at each station aiming at the selection of the representative rain gauge station in the area. In this connection, correlation study was done on the basis of monthly rainfall.

The coefficient of correlation and equations of linear regression were obtained statistically by means of the method of least square on a monthly basis among the stations inclusive of areal average rainfall. From the Table A.2.3-2, three stations, namely No.43, 45 and 52 were extracted as being stations having the highest correlation coefficient of more than 0.98 with the areal average rainfall. From the view points of seasonal pattern, amount of rainfall, location of the station as well as the available period of observations, No.43 rain gauge station was finally selected as being representative of the AMRIS area.

TABLE A.2.3-1 MONTHLY AVERAGE RAINFALL IN AMRIS

(Unit; mm)

No	STATION	(TERM)	JAN	FEB	MAR	APR.	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
41	CALAWITAN, SAN ILDEFONSO	('74-'79)	10.0	2.4	14.7	15.6	233.3	280.6	208.4	400.7	302.5	274.9	140.4	76.7	1,960.2
42	TALACSAN, SAN RAFAEL	('73-'82)	5.1	2.1	11.1	13.2	161.7	185.0	261.6	284.1	234.5	285.4	134.2	55.8	1,633.8
43	SABANG BALIWAG	('70-'82)	7.9	5.9	17.7	19.6	151.2	247.1	400.7	410.5	231.9	216.1	126.1	39.3	1,874.0
45	MAKINABANG BALIWAG	('69-'82)	9.6	6.7	10.8	11.5	147.8	203.7	320.0	433.7	214.1	200.2	111.0	55.8	1,724.9
50	BOROL II BALAGTAS	('73-'79)	9.7	5.6	10.3	25.1	160.7	273.9	224.9	393.3	220.9	261.5	72.1	46.2	1,704.2
52	SANTA MARIA	('69-'80)	10.6	6.3	12.5	22.1	179.9	281.4	440.7	527.1	245.5	237.0	155.0	67.9	2,186.0
76	BALUCOC APALIT	('75-'82)	3.5	0.3	12.9	30.5	106.5	161.1	200.2	210.2	164.7	79.2	79.5	21.9	1,070.5
77	CANSINALA APALIT	('67-'82)	2.3	1.4	11.2	9.4	106.6	178.7	337.8	388.7	166.1	164.6	95.4	34.8	1,497.0
78	SULIPAN APALIT	('73-'82)	3.8	0.4	18.9	19.3	126.5	175.5	187.4	416.6	200.4	237.7	85.9	42.7	1,515.1
	AMRIS AVERAGE		7.1	3.5	13.6	18.5	152.5	221.4	296.6	390.3	224.5	219.5	113.3	48.2	1,709.0
20	CABANATUAN CITY	('51-'79)	6.5	4.7	10.9	29.6	199.1	244.8	291.4	392.5	290.4	153.3	115.7	42.2	1,781.1

TABLE A.2.3-2 CORRELATION OF MONTHLY RAINFALL AMONG STATIONS

R: Correlation coefficient Regression line: Y = AX + B

		(41)	(42)	(43)	(45)	(50)	(52)	(76)	(77)	(78)	AVERAGE
(41)	R	1.000	0.940	0.881	0.912	0.969	0.887	0.893	0.850	0.946	0.943
CALAWITAN	A	1.000	1.132	0.826	0.917	1.021	0.706	1.577	0.901	1.049	1.008
SAN MIGUEL	B	0.00	9.283	34.380	31.495	18.335	34.703	22.631	50.902	30.897	19.522
(42)	R	0.940	1.000	0.925	0.918	0.932	0.907	0.881	0.888	0.910	0.950
TALACSAN	A	0.780	1.000	0.720	0.767	0.815	0.600	1.292	0.782	0.839	0.844
SAN ILDEFONSO	B	8.660	0.00	23.693	25.832	20.418	26.792	20.885	38.588	30.251	15.829
(43)	R	0.881	0.925	1.000	0.984	0.925	0.993	0.964	0.990	0.906	0.985
SABANG	A	0.939	1.187	1.000	1.056	1.039	0.844	1.815	1.120	1.072	1.123
BALIWAG	B	2.744	-5.500	0.0	4.416	8.622	2.487	-5.767	16.505	20.820	-3.993
(45)	R	0.912	0.918	0.984	1.000	0.947	0.995	0.944	0.990	0.957	0.933
MAKINABANG	A	0.906	1.099	0.917	1.000	0.992	0.787	1.657	1.043	1.055	1.055
BALIWAG	B	-4.275	-5.914	0.542	0.0	2.908	0.291	-4.034	13.654	10.537	-6.735
(50)	R	0.969	0.932	0.925	0.947	1.000	0.931	0.900	0.908	0.970	0.970
BOROL II	A	0.920	1.065	0.823	0.905	1.000	0.704	1.509	0.914	1.022	0.984
BALAGTAS	B	-8.328	-2.982	13.429	11.949	0.0	13.719	7.378	27.964	12.990	1.597
(52)	R	0.887	0.907	0.993	0.995	0.931	1.000	0.953	0.996	0.928	0.988
SANTA MARIA	A	1.113	1.372	1.169	1.236	1.231	1.000	2.114	1.326	1.293	1.325
	B	0.368	-4.591	-0.394	1.581	7.288	0.0	-6.389	61.799	18.959	-6.856
(76)	R	0.893	0.881	0.964	0.944	0.900	0.953	1.000	0.937	0.859	0.954
BALUCOC	A	0.506	0.600	0.512	0.537	0.537	0.430	1.000	0.562	0.539	0.578
APALIT	B	6.622	7.458	9.318	11.950	12.991	10.901	0.0	19.074	21.112	6.816
(77)	R	0.850	0.888	0.990	0.990	0.908	0.996	0.937	1.000	0.915	0.976
CANSINALA	A	0.802	1.009	0.876	0.939	0.902	0.748	1.560	1.000	0.958	0.984
APALIT	B	-6.215	-12.566	-11.985	-10.216	-3.375	-11.539	-14.430	0.0	3.830	-15.541
(78)	R	0.946	0.910	0.906	0.957	0.970	0.928	0.859	0.915	1.000	0.961
SULIPAN	A	0.852	0.988	0.766	0.868	0.921	0.666	1.367	0.875	1.000	0.926
APALIT	B	-12.982	-3.275	6.653	1.518	-4.571	4.850	4.284	17.115	0.0	-5.784
AMRIS	R	0.943	0.950	0.985	0.993	0.970	0.988	0.954	0.976	0.961	1.000
AVERAGE	A	0.882	1.070	0.864	0.935	0.956	0.736	1.577	0.968	0.997	1.000
	B	-1.505	-3.084	7.711	8.299	6.900	8.587	1.944	21.919	16.758	0.0

2.4 River Runoff

The discharge record of the Maasim River is available at both the hydrological gauging stations No.55 and No.56 by NWRC during 16 years from 1960 to 1976 and 15 years from 1960 to 1975, respectively, excluding 1972.

No.55 station is situated at Bahay Pare, Candaba, Pampanga, on the highway bridge along the Baliwag - Bahay Pare road and about 500 m downstream of the Lower Maasim diversion dam. The flow is therefore affected by irrigation diversion and furthermore during flood, the flow is affected by bank-overflow upstream from the station. No.56 station is located

bridge at Diliman, San Rafael, Bulacan, 900m downstream from the old station at Barrio Maasim and about 3.8 km upstream from the Upper Maasim diversion dam. Records are, according to NWRC, fair except those above 50 cms. The observation period, however, covers only three years within the recent 10 years.

The hydrological analysis should be based on the long-term reliable records of, at least, the last 10 years, and thus a conceptual model of rainfall to runoff conversion was employed to synthesize the discharges of the Maasim River. The tank model method, which was introduced by Dr.M.Sugawara in 1956, uses the conceptual use of a simple mechanism consisting essentially of linear reservoirs with several holes, as analogous physical model to analyse river runoffs.

The advantages and characteristics of the tank model would be summarized as (1) the conception of surface, subsurface and groundwater (base flow) runoffs is spontaneously involved in combination of tanks of itself; (2) non-linearity found in the rainfall to runoff conversion is represented by the number and height of holes even within each tank; (3)a clearance beween the lowest hole and bottom of a tank denotes the moisture content of each soil layer and contributes to the vertical infiltration as water supply source whether there is a side outflow or not; (4) it is not necessary to separate the effective rainfall, even if evaporation, snow melt and agricultural intake amount are taken into account; and (5) the model can be constructed to such an extent as to meet satisfactory fitting between observed and computed runoffs by combining type and number of models as well as by setting size and height of holes. The disadvantage would be that the size of holes and their height as well as initial water depths have to be empirically determined by trial and error which requires a certain degree of practice and skill.

In order to generate the daily runoffs from the drainage area of 150 sq.km of the Maasim River at the guaging station for the lacking period of data up to 1982, rainfall to run-off conversion was made employing the Tank Model. General conception of the tank model is as illustrated in Figure A.2.4-1 in which the most popular combination designated as a series of four stages is demonstrated. Each tank is deemed to represent layers of soil, namely, T1 corresponds to the surface layer contributing to surface runoff. T2 and T3 receives infiltrated water through T1 and T2 respectively and supply the subsurface flow, and T4 is located at the bottom of the system, representing the deepest layer of the basin and would have the groundwater flow.

In the case of the Maasim River, the dimension of the model was determined by means of model verification based on the actually measured patterns of rainfall at No.43 rain gauge station and runoff as accomodated in Figure A.2.4-1.

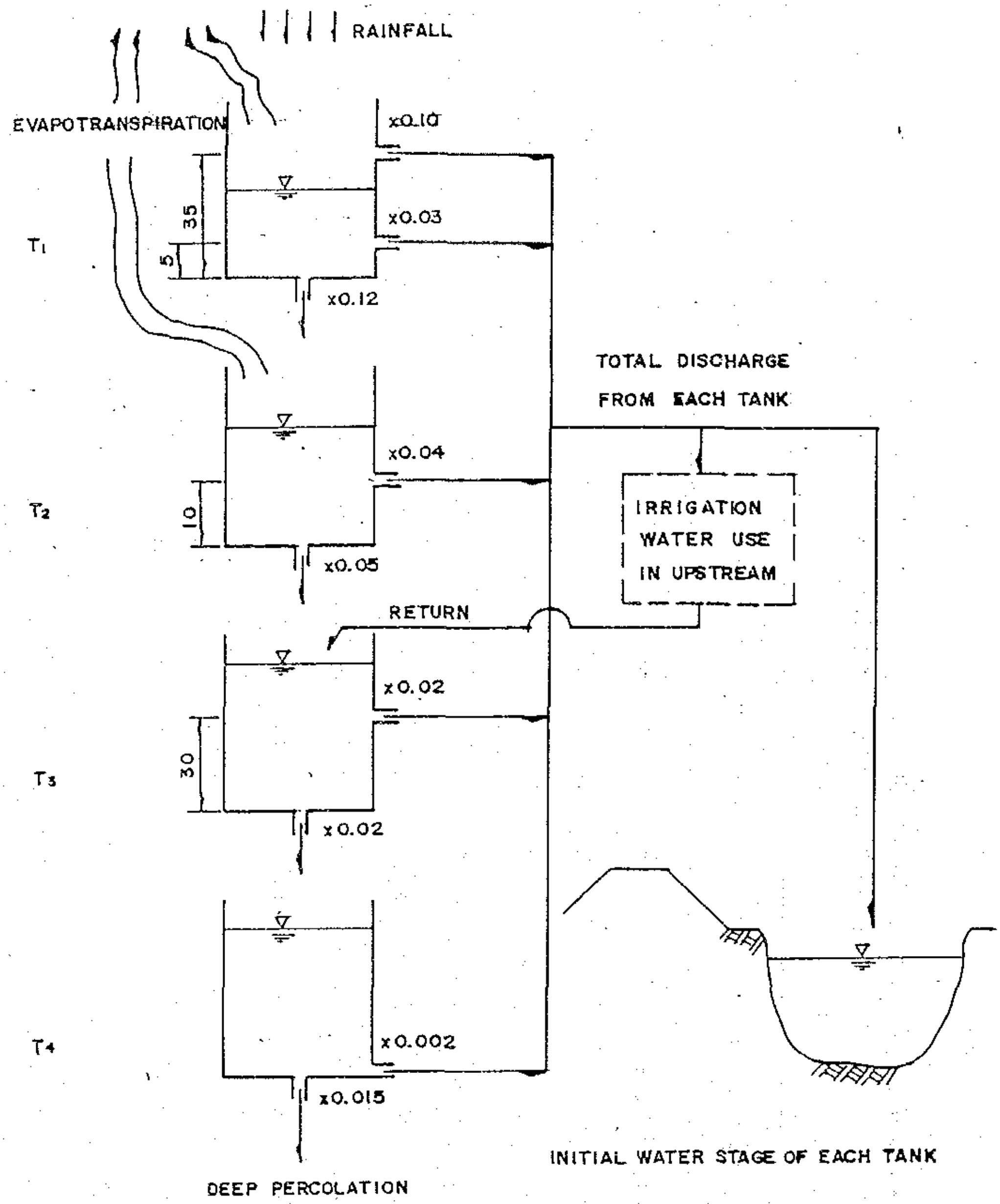
Annual mean runoff at No.56 gauging station is estimated at 175 MCM in volume or 5.6 cu.m/sec in discharge. As is clear in Table A.2.4-1 as well as in Figure A.2.4-2 almost 93 percent of the annual runoff falls during the wet season from June to November. This means the discharges into the Maasim River are not well distributed for irrigation purpose especially during the dry season.

TABLE A.2.4-1 GENERATED RUNOFF OF THE MAASIM RIVER
(AT GAGING STATION NO. 56, D.A = 150 km²)

(Unit: MCM)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Remarks
1972	2.52	0.52	0.54	0.50	3.13	22.30	146.47	128.33	46.61	13.00	3.72	1.23	368.86	
1973	0.79	0.41	0.30	0.85	0.58	6.37	26.92	19.30	22.34	58.49	15.27	4.09	155.70	
1974	0.79	0.59	0.36	1.26	0.54	26.00	13.78	84.92	19.87	32.69	38.38	19.49	236.64	
1975	3.63	0.96	0.61	0.36	0.25	19.59	12.43	48.84	20.95	32.84	10.11	1.71	152.26	
1976	0.59	0.39	0.34	0.18	55.93	29.30	47.82	37.34	46.99	19.41	3.84	1.21	243.35	
1977	0.72	0.37	0.28	0.18	8.06	9.08	42.68	41.90	37.42	8.05	14.87	1.41	165.01	
1978	0.53	0.34	0.26	0.30	1.78	11.32	21.36	71.86	21.19	50.41	20.47	3.04	202.85	
1979	0.74	0.46	0.35	0.22	3.07	12.03	10.16	35.69	11.39	8.56	3.45	0.52	86.65	
1980	0.36	0.24	1.79	0.34	2.45	1.76	28.35	28.70	42.70	9.31	10.69	0.91	127.59	
1981	0.48	0.31	0.23	0.15	0.10	6.83	16.53	16.03	7.93	2.78	8.07	0.54	59.99	
1982	0.33	0.22	0.18	0.16	3.49	11.73	37.67	34.41	29.43	5.63	1.11	0.72	125.07	
Average	1.04	0.44	0.48	0.41	7.22	14.21	36.74	49.76	27.89	21.92	11.63	3.17	174.91	
"	(0.39)	(0.18)	(0.18)	(0.16)	(2.70)	(5.48)	(13.72)	(18.58)	(10.76)	(8.18)	(4.49)	(1.18)	(5.55)	(Unit: m^3/s)

FIGURE A.2.4-1 GENERAL CONCEPTION OF SERIES TANK MODEL



INITIAL WATER STAGE OF EACH TANK

T_1 ; HH_1 = 0.0
T_2 ; HH_2 = 25.0
T_3 ; HH_3 = 60.0
T_4 ; HH_4 = 70.0

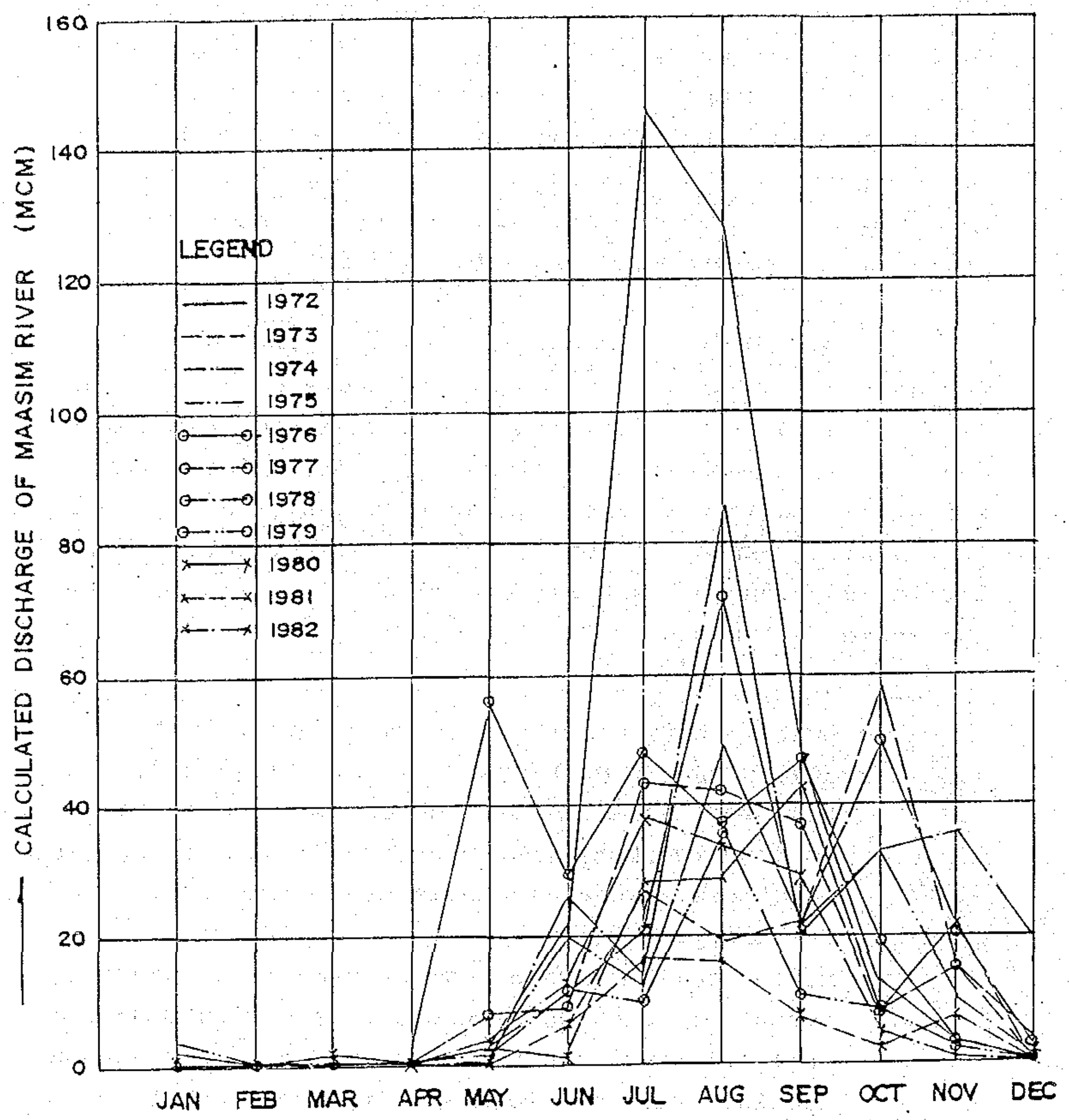


FIGURE A.2.4-2 SEASONAL PATTERN OF MAASIM RUNOFF
(AT GAGING STATION NO.56, D.A. = 150 SQ.KM)

2.5 Water Quality

In the rivers bordering the AMRIS area, salinity of water was measured by the electric conductivity meter at five selected sample sites as shown in Figure A.2.5-1. The measurement and sampling were practiced at both water surface and bottom during the spring tide. The selected water samples were analysed by the AMRIS office and results are presented in Table A.2.5-1.

The United States Department of Interior, Bureau of Reclamation (USBR) has recently offered a classification as a guide in making preliminary evaluation of water quality and expressed symbols as follows. As far as the salinity sodium hazard is concerned, water is classified into four grades with respect to conductivity, namely, below 250, 250 to 750, 750 to 2,250 and over 2,250 micromhos/cm, and expressed in symbols of C_1, C_2, C_3, and C_4.

C_1: Low salinity water can be used for irrigation with most crops on most soils with little likelihood, that soil salinity will develop. some leaching is required but this occurs under normal irrigation practices, except in soils of extremely low permeability.

C_2: Medium salinity water can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control.

C_3: High salinity water cannot be used on soils with restricted drainage, even with adequate drainage, special treatment for salinity control may be required, and plants with good salt tolerance should be selected.

C_4: Very high salinity water is not suitable for irrigation under ordinary conditions, but may be used occasionally under very special circumstances. The soils must be permeable, drainage condition must be adequate, irrigation water must be applied in excess to provide considerable leaching and very salt-tolerant crops should be selected.

The measurement and sampling were practiced in February, 1983 selecting the time during the spring tide in the dry season under the most severe condition. Accordingly the analysed values of conductivity vary from 800 to 2,800 micromhos/cm which are classified into the grades C_3 and C_4, indicating high salinity water and very high salinity water, respectively.

In general these kinds of water are not suitable for irrigation under ordinary conditions. Along the Pampanga river during the dry season, several small irrigation systems are at present utilizing river water by use of pumping facilities in the upstream portions of the water sample sites, and in fact, no adverse effects have been noted during the past years of using the river water for irrigation.

TABLE A.2.5-1 RESULTS OF SALINITY TEST

Station	Location	Date of Observation	Depth	Electric Conductivity at 27°C (Micromhos/cm)
1 - A	Apalit, Pampanga	Feb. 27, 1983	Surface	850
			Bottom	1,050
1 - B	-do-	-do-	Surface	1,300
			Bottom	1,350
2 - A	Gatbuca, Calumpit, Bulacan	Feb. 24, 1983	Surface	1,020
			Bottom	1,050
2 - B	-do-	-do-	Surface	925
			Bottom	940
3 - A	Iba-Este, Calumpit, Bulacan	Feb. 22, 1983	Surface	1,200
			Bottom	1,470
3 - B	San Marcos, Calumpit, Bulacan	-do-	Surface	1,080
			Bottom	1,400
4 - A	Kanalate. Malolos. Bulacan	Feb. 26, 1983	Surface	2,800
			Bottom	2,000
4 - B	Sto. Nino. Paombong, Bulacan	-do-	Surface	1,870
			Bottom	1,800
5 - A	Sapang Bayan, Calumpit, Bulacan	Feb. 22, 1983	Surface	981
			Bottom	1,650
5 - B	-do-	-do-	Surface	795
			Bottom	1,200

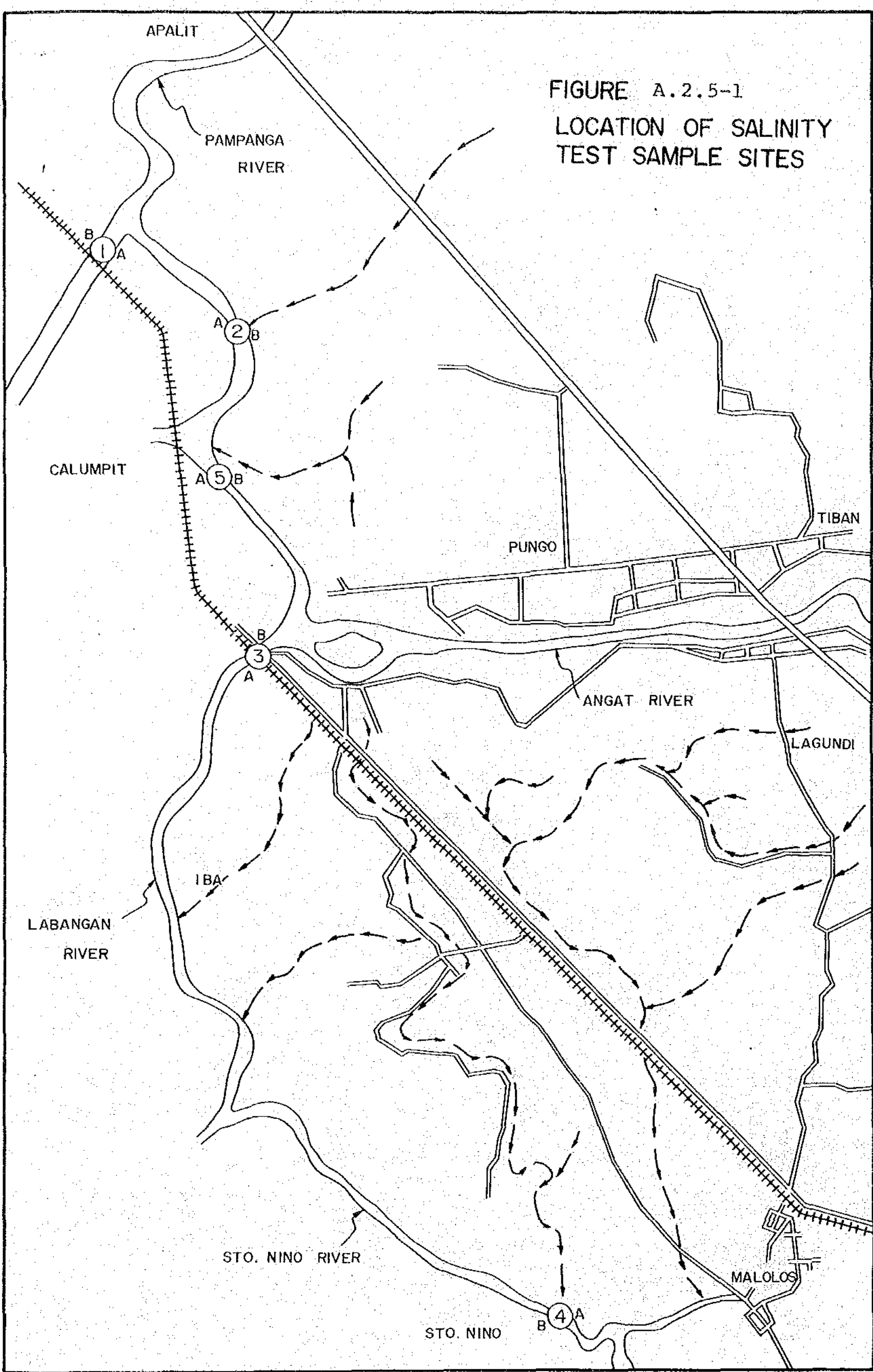


FIGURE A.2.5-1
LOCATION OF SALINITY
TEST SAMPLE SITES
APALIT
PAMPANGA
RIVER
CALUMPIT
PUNGO
TIBAN
ANGAT RIVER
LAGUNDI
IBA
LABANGAN
RIVER
STO. NINO RIVER
STO. NINO
MALOLOS
1
2
3
4
5
A
B

CHAPTER III. IRRIGATION

CHAPTER III IRRIGATION

3.1 General

According to the study made on the avalability of water the present service area of the AMRIS suffers from a frequent lack of irrigation water diversion at the Bustos Dam especially during the dry season. The study on the water balance under the present condition of the area estimates that the area would suffer no shortage of water in critically droughty period of once in five years occurrence, if the operation rule curve for the Angat Reservoir be modified slightly just to meet the actual demand needed in the area.

It was also presumed from the study that the expansion area proposed by the Project would be covered by the water of the Angat Reservoir after a proper rule curve for operating the reservoir was established.

Detailed water balance studies were conducted for this purpose giving the proposed condition of the area, inclusive of the operation of the Angat Reservoir. Various operation rule curves were included in the study in order to simulate the optimal solution of the reservoir operation which meets all demands of water required by MWSS for water supply to Metro Manila, NPC for power generation and NIA for irrigation, even during a critically dry period.

The studies were made paying great attention to the following;

- 100 percent of MWSS requirement was considered with the first priority of utilizing water.
- NPC's actual achievements of production of power

generation was fully condidered in terms of both amount and seasonal pattern.

- Hydrological records on inflow into the reservoir as well as on the operated water stages in the reservoir by time were carefully reviewed and examined in order to ensure storage capacity required for flood control.

Consequently through simulation studies, the operation rule of the Angat Reservoir was proposed by two curves presenting the upper and lower limits of the reservoir water stage by time. The upper and lower rule curves function in operating the reservoir water stage as follows.

- The water surface elevation in the Angat Reservoir is not allowed to fall below the lower rule curve at any given time.
- The water surface elevation in the reservoir is not allowed to rise, during flood season from the beginning of July to the end of October, above the upper rule curve unless the water release provided to the main power generators exceeds allowable carrying capacity of 168.8 cu.m/sec.

The computed results of the study, under the proposed condition of the irrigation schedule accompanied with the proposed operation rule curves, indicate the following.

- No shortage of MWSS water supply during the whole period of 11 years was examined.
- Estimated possible production of power generation and its seasonal pattern almost follows the actually generated results.
- Irrigated area of the AMRIS, inclusive of the possible expansion area, would suffered from shortage of water during the most critical drought period in 1978, which would occur once in more than 10 years.

3.2 Present Irrigation Condition

3.2.1 Existing Irrigation Condition

(1) Present Service Area

The present service area, defined as the net irrigable area commanded by the existing irrigation facilities, is composed of 31,485 ha of paddy. The service area is generally flat and low with an elevation of 2 to 14 meters above mean sea level, except for about 1,300 ha served by the pumping irrigation systems in the east of the Project Area.

From the view point of topography and water sources the Project Area is divided into five irrigation systems, namely, Angat North, Angat South, Tibagan Pump Irrigation System (TPIS), Upper Maasim and Lower Maasim.

The Angat North area is located on the right bank of the Angat River with a total service area of 14,968 ha. The irrigation water is diverted from the Angat River at the Bustos Diversion Dam and is conveyed by the Angat North Main Canal. The Angat South area, on the other hand, is located on the left bank of the Angat River with a total service area of 12,061 ha. The irrigation water is also diverted from the Angat River at the Bustos Diversion dam and is conveyed by the Angat South Main Canal. Both Angat North and South areas are situated in the center of the Project Area occupying about 86 percent of the total service area of the Project.

The TPIS is located in the southeastern part of the Project Area with a total relatively high service area of 1,286 ha. The area utilizes the Angat River water by the existing pumping station situated 1.0 km upstream from the Bustos Diversion Dam with a maximum capacity of 3.24 cm. The diverted irrigation water is conveyed to the area through two main canals of High and Low Lines.

The irrigated area situated on both right and left bank of the Maasim river comprises the Upper and Lower Maasim areas depending on the existing diversion facilities. The Upper Maasim Diversion Dam serves 2,111 ha of paddy by use of the Maasim River water. However, this area is subject to frequent damage by drought especially in the dry season, mainly due to unfavorable distribution of the Maasim River water. The Lower Maasim Diversion Dam commands 1,059 ha of existing paddy receiving water from the Maasim River and supplimentary from the Angat River. The Angat River water is conveyed to the area through creeks and lateral canals so that the area can be planted to rice constantly even during the dry season.

Although the service area of AMRIS slightly varies year by year mainly due to change in land use schedule, it is summarized as finalized by the field investigation, as follows:

Present Service Area of The AMRIS

Irrigation System	Service Area (ha)	Water Resources
Angat North	14,968	Angat river
Angat South	12,061	"
TPIS	1,286	"
Upper Maasim	2,111	Maasim river
Lower Maasim	1,059	Maasim and Angat rivers
Total	31,485	

The actually planted and irrigated area also varies annually depending on the amount of available water, submerged conditions in wet season and others. The presently

Irrigated areas in AMRIS are summarized by season based on the Harvest Report prepared by each Working Station in the past three years, as follows:

Present Irrigated Area and Crop Intensity

Year	Irrigated Area (ha)		Crop Intensity (%)	
	Wet Rice	Dry Rice	Wet Rice	Dry Rice
1980	22,880	28,741	72.7	91.3
1981	23,845	28,144	75.7	89.4
1982	23,375	28,905	74.2	91.8
Mean	23,366	28,627	74.2	90.9

As is clear in the above table, almost 90 percent of the service area is actually planted and irrigated in the dry season. The remaining 10 percent of the area is mainly located in the Upper Maasim where irrigation water diversion is impossible due to lack of available water in the Maasim River. On the other hand, only 74 percent of the area is planted in the wet season. The remaining 26 percent mainly lies in the lower reaches of the service area where a large scale of submerged area extends along the Pampanga River.

With regard to operation and maintenance of the irrigation systems, the Project Area is divided into 12 Working Stations. Each Working Station commands about 2,500 ha under management of a Supervising Water Management Technologist (SWMT). Working Stations are further sub-divided into 4 to 5 Divisions, each of which is controled by a Water Management Technician (WMT) commanding about 500 ha of service area on average.

The service area covered by each Working Station is summarized in the following table.

Service Area by Working Station

Working Station (Division)		Service Area (ha)	Irrigation System
I	A	746	Angat South
I	B,C,D	1,286	TPIS
II		2,773	Angat South
III		2,680	"
IV		3,311	"
V		2,551	"
VI	A,B,C	1,938	Angat North
VI	D,E	2,111	Upper Maasim
		1,549	Angat North
VII	A,B,C,D	1,059	Lower Maasim
VII	C,D,E*/		
VIII		2,551	Angat North
IX		2,299	"
X		2,249	"
XI		2,337	"
XII		2,045	"
Total		31,485	

Note: */ Division C and D of the Working Station VII are supplied with irrigation water from both the Maasim and Angat rivers.

(2) Irrigation System and Practice

In the Project Area, about 23,400 ha and 28,600 ha of the existing paddy are at present irrigated by the irrigation systems including four diversion dams, three pumping facilities and canal systems, during wet and dry seasons, respectively.

The irrigation systems are operated and maintained by the AMRIS office which consists of main office and twelve working stations in the service area. The AMRIS main office, headed by the Irrigation Superintendent V, is under the organization of the Regional Irrigation Office III in Bulacan Province, and with the aid of working stations it is directly in charge of operation and maintenance works on such irrigation facilities as diversion dams, main, lateral and sub-lateral canals and turnouts connected to those.

The major activities of the AMRIS main office and working stations in operation and maintenance works are to distribute irrigation water equitably and timely to the service area by means of controlling the irrigation systems and of maintaining the irrigation facilities.

The irrigation plans are prepared based on the programed area, cropping patterns, farming practice, and soil and topographic conditions by the staffs of the Water Control Coordinating Section (WCCS) in the AMRIS office.

Diversion water requirements of the Bustos Dam are requested from NPC by the Irrigation Superintendent of AMRIS through SMD in NIA central.

Major rules and standards on water distribution to the terminal area from the dam are set up as follows:

Availability at the Bustos	Standard
° 100 - 80% of designed discharges	° Simultaneous irrigation in the entire area
° 80 - 60% of designed discharges	° Rotational irrigation at the lateral or sub-lateral level
° 60 - 40% of designed discharges	° Rotational irrigation at the upper, middle and lower part of the respective main canal
° Below 40% of designed discharges	° Rotational irrigation between the North and South main canals

Water distributions from lateral level up to farm turnouts are practiced by the respective working station staffs concerned and major changes of the distibution are directed to each working stations by the Irrigation Superintendent III through respective zone engineers.

One of the major constraints is to coordinate more timely between NIA and NPC on the water release especially in the dry season. According to the information received from the field office, when available water at Bustos Diversion Dam is less than diversion water requirements without any critical conditions at Angat Reservoir, these are no adjustments to meet the requirement. Accordingly, water distribution to the North and South Main Canal is being made within available water divided by the ratio of water demands required at that time in the service area of the Angat North and South Main Canal. Therefore, it is difficult to follow promptly actual condition at the lateral and or sub-lateral level.

Secondly, proper water management with appropriate distribution facilities such as check, headgates and measuring devices, farming practices in the service area should follow the programed watering schedule as much as possible and/or adjustment of the watering schedule should be made timely based on the actual practice by the staffs concerned.

Thirdly, data collection and record maintenance are comparatively well functioning following the regulations. The processing and evaluation of collected data, however, are not executed satisfactorily and some of them are not used effectively for the purpose of improved activities on the water management. It is desirable that collected data are analysed and put into practice timely by means of computerization.

(3) Water Resources Availability

Major water sources of the AMRIS are the river water of the Angat and Maasim River. The Angat River, supported by the storage function of the Angat Reservoir, allows irrigation water diversion that is almost adequate to meet the needs in the AMRIS area at the point of the Bustos Diversion Dam.

The Maasim river, on the contrary, does not contributed well to the purpose of irrigation water supply because of inadequate distribution of runoffs during the dry season.

Some areas are irrigated by use of return flow from the upstream irrigated area, and others are served by the Pampanga water by use of pumping facilities.

1) Angat River

There are three existing dams on the Angat River namely; the Angat Reservoir, the Ipo and Bustos Diversion Dams.

The Angat Reservoir is operated under the specified operation rule curve by NPC, in order to assure the water release from the reservoir is just adequate to meet the needs of water supply required by MWSS, irrigation by NIA and additional water release for power generation by NPC even under a critical stream flow condition.

Concering the administration of the Angat Reservoir, NWRC recommended in a Memorandum dated 16 January 1979 the adoption of a specified operation rule curve, which was based on the reservoir operation studies extracted from the "Staff Report on the Cost Allocation and Operational Guidelines for Multi-Purpose Storage Project, Report No.34". At that time, the reservoir operation studies were made based on the MWSS water requirements as conceived in the "Supply Report" for water supply as well as on the irrigation water requirements which was prepared by NIA in 1978 under application of an anticipated long-range cropping calendar including a considerable acreage of area for upland crops.

The NWRC rule curve was further revised based on the actual water demand for irrigation as attached in Memorandum dated 17 March 1983, in which NWRC called the attention of NPC to the critical situation of the Angat Reservoir indicating the current shortages of inflow into the reservoir are a lot less than the minimum stream flow used in the development of the rule curve and the low reservoir level below the rule curve.

On the other hand NPC, in charge of controlling the reservoir, has been operating the reservoir with rule curves calibrated yearly so as to meet the current pattern of available water resources and various demands, based on the accumulated experiences of more than 15 years in operating the reservoir.

The Angat Reservoir receives 2,080 MCM of inflow from the drainage area of 568 sq.km, (the annual average area the past 11 years from 1972 to 1982) of which 1,667 MCM are released from the reservoir throught main power generators for the purpose of irrigation as well as additional power generation. Inflow into the reservoir is estimated by NPC based on the actual measurement of the reservoir water stage, released water through main and auxillary power generators and spillage as shown in Table A.3.2-1 to A.3.2-3.

In addition to the water release through main power generators, the AMRIS area can use the runoff from the residual drainage area of the Angat River between the Ipo and Bustos Diversion Dams as available water resources for irrigation.

2) Maasim River

In order to generate the daily runoffs from the drainage area of 150 sq.km of the Maasim River at the gauging station for the lacking period of data up to 1982, rainfall to runoff conversion was made employing the Tank Model. The computed results are summarized as in Table A.3.2-4.

Annual mean runoff at the gauging station is estimated at 175 MCM in volume or 5.6 cu.m/sec in discharge. As regards the seasonal distribution of the Maasim River water which contributes to irrigation, almost 93 percent of the annual runoff is concentrated in the wet season from June to November. This means the discharges in the Maasim River are not well distributed for irrigation purpose especially during the dry season.

The Angat River provides supplemental irrigation water to the Lower Maasim area through the Lateral B of the Angat North Main Canal. Though the carrying capacity of the Lateral B limits the maximum supplemental water to 1.5 cm, the Angat River water covers mostly the required water in the said area during the dry season.

3) Return Flow

In the lower reaches of the north side service area, along the existing drainage creeks such as Tenejeros, Balite, Duyang and Bitukang Manok, there is a considerable expansion of area receiving irrigation water from those creeks. Based on the actual observation of discharges conducted in February 1983, rough computation of water balance was made in the upstream portion of the Tenejeros creek for the purpose of estimating the amount of available water in the creek. Although data are too few to conclude the study, about 30 percent of irrigated water in the upstream is estimated to be re-used in the downstream as a return flow. From this value, it is estimated that about 1,010 hectares are irrigated receiving water form the existing creeks.

Adjacent to and north of the Maasim river, in North Candaba, there are about 680 hectares of area temporaily served by an earth dam which was constructed downstream of the Lower Maasim Dam and maintained only during the dry season. The major source of water at this dam is considered to be return flow from the area served by the

Angat North Main Canal. This area is proposed to be included in the AMRIS confirming the steady supply of irrigation water from the systems.

4) Pampanga River

As shown in Figure A.3.2-1, in the relatively high elevated area along the left bank of the Pampanga river, there are 22 local portions which utilize the Pampanga water by means of pumping up. In total 1,540 hectares are irrigated in this manner spending ₱680 per hectare on operation and maintenance. Table A.3.2-5 and A.3.2-6 present details related to this, and so it is also proposed to include these areas in the AMRIS service area by converting pump irrigation systems to gravity systems.

(4) Existing Irrigation Facilities

The existing irrigation facilities comprise intake facilities, conveyance canal systems and their appurtenant structures. Present condition and prevailing constraints of these facilities are summarized as follows:

1) Intake Facilities

There are four diversion dams along the Angat and Maasim Rivers of which three are permanent dams and the other is a temporary earth dam, and three pumping stations situated along the Angat River.

a) Bustos Diversion Dam

The Bustos Dam which was completed in 1957, is equipped with six sector gates 79 meters long and 2.5 meters high. Automatic gate operation, however, was only possible for two years after the installation of operational mechanisms. The mechanisms such as control panel, gate opening indicators and its accessories should be replaced in order to operate the gates stably and satisfactorily. The rubber gate sealer is also extremely super-annuated. It is affected by sedimentation of sand in the gate chambers.

b) Upper Maasim Diversion Dam

The Upper Maasim Dam, which was constructed in 1949, is of a movable type equipped with eight gates. With flood damage, the operation of the gates became impossible and the flood way gates were fixed by concrete in 1963. At the same time, the upper portion of the intermediate piers were demolished to make for smooth flood flush-out.

c) Lower Maasim Diversion Dam

There are no remarkable constraints except flood way gates systems of the dam which was constructed in 1967. Major constraints are the leakage flow from the wooden-made gates and that it is impossible to operate the gates timely in case of flood.

d) Third Maasim Diversion Dam

The dam is temporarily constructed every year in the initial period of the dry season crop, in order to irrigate the service area of about 700 ha located on the right bank of the Maasim River. Permanent dam construction, therefore, is requested by the beneficial farmers concerned.

Three pumping stations are located high in the eastern part of the service area. Of these, the Tibagan Pump Irrigation System (TPIS) is situated about 1.0 km upstream from the Bustos Diversion Dam and is diverting the Angat River water for irrigation of about 1,300 ha of the service area.

The Buenavista Pump Irrigation System (BPIS) and Bustos Pandi Extension (BPE) are located within the service areas commanded by the Angat North Main Canal and South Main Canal, respectively.

The major dimensions of the facilities are as follows:

Existing Intake Facilities

Facilities	Constructed	Water Source	Major Dimension
Bustos Dam	1967	Angat River	Ogee Type 6 Sector Gates H = 2.5 m, L = 79.0 m each
Upper Maasim Dam	1949	Maasim River	Sluice Gate Type
Lower Maasim Dam	1967	Maasim and Angat River	- do -
Third Maasim Dam	-	- do -	Temporary Earth Dam
BPIS	1976	Angat North Main Canal	16" Diameter x 2 Units
TPIS	1976	Angat River	Higher Line: 24" x 2 Units Lower Line: 36" x 2 Units
BPE	1972	Angat South Main Canal	4" x 3 Units

2) Converyance Canal System

Irrigation canals are classified into main, lateral and sub-lateral. Irrigation canals are well developed within the entire area with a total length of 788 km, of which 113 km are main, 293 km are lateral and 382 km are sub-lateral canal.

Major constraints of irrigation canals are siltation, erosion of canal sideslopes and vegetation control. Carrying capacity of the canals in several parts is decreased due to heavy siltation, erosion and poor maintenance works. On the other hand, present method of grass cutting in and around canals is being carried out by ditchtenders on a regular basis but it is not sufficient especially in the canal. As a result, grass growth restricts flow, accelerates silt despostion, and creates problems in delivering water to the end users.

3) Appurtenant Structures

A large number of appurtenant structures exist in the Project Area consisting of head gate, weir, pershall flume, spillway, check, diversion box, siphon etc. Most of the existing structures are in comparatively good condition except some structures where damage is found mainly in gates and steel portion. Some of the concrete structures are damaged mainly because of insufficient concrete thickness and reinforcing bars.

Consequently through the field investigation, major problems are found to be a) scour and bank erosion immediately below and around structure outlet transitions, b) gate maintenance due to lack of rust prevention, c) damage and missing spare parts and d) a large number of unoperable and illegal turnouts.

3.2.2 Irrigation Water Requirement

(1) Potential Evapotranspiration

Potential evapotranspiration (ETp), generally recognized as a fairly reliable index in calculating consumptive use of crops, is determinable by a number of methods, such as the evaporation measurement from evaporation pan and the application of empirical formula based on the climatological data. In the Project, the evaporation of the proposed crops is estimated by applying the pan evaporation to evapotranspiration conversion, based on the actual measurement of pan evaporation as well as empirical values of crop coefficient.

$$ET = Kc \times Ep$$

Where, ET: Consumptive use of water (mm/day)
Kc: Crop coefficient for paddy
Ep: Pan evaporation (mm/day)

Evaporation measurements by A-Pan are available at Ulingao station in Bulacan for 10 years from 1970 to 1979. To estimate the consumptive use of water for paddy, the monthly mean daily pan evaporation data were prepared as shown in Table A.3.2-7. Crop coefficient of paddy was investigated in the NIA agricultural research station at Sabang for 10 years since 1970. Based on the results of investigations, the crop coefficient for paddy is proposed with respect to the growing stages in the feasibility report on the Pampanga Delta Development Project by JICA. Seasonal variation of crop coefficient of paddy is shown in Figure A.3.2-2.

Crop Coefficient for Paddy

Growing Stage (%)	10	20	30	40	50	60	70	80	90	100
Coefficient	0.80	0.83	0.93	1.04	1.12	1.20	1.21	1.15	1.01	0.85

(2) Field Irrigation Water Requirement

Field irrigation water requirement on a 10 day basis is estimated based on the cropping pattern of presently adopted, percolation losses and water requirement for land soaking. Table A.3.2-8 presents the present service area classified by the cropping patterns adopted in the AMRIS area at present.

1) Percolation Rates

Percolation rates were observed in the Project Area by NIA in 53 sample sites for wet season paddy and in 34 sites for dry season paddy during the course of investigation on the Angat-Magat Integrated Agricultural Development Project from January, 1977 to May, 1978. Percolation rate in the paddy field is referred to the weighted average figures obtained by means of actual observation in each soil texture as shown below:

Percolation Rate in mm/day

Soil Texture	Area (ha)	Ratio	Wet Seaon		Dry Season	
			Average	Rate	Average	Rate
Caly Loam	12,133	0.39	1.74	0.68	1.61	0.63
Silt Loam	14,476	0.46	1.88	0.86	1.64	0.75
Silty Clay Loam	2,656	0.08	2.11	0.17	1.76	0.14
Sandy Loam	2,220	0.07	2.43	0.17	1.75	0.12
Total	31,485	1.00		1.88		1.64

From the above, the percolation rate was determined as:

Wet Season : 1.9 mm/day

Dry Season : 1.6 mm/day

2) Land Soaking and Preparation Water Requirement

Land soaking irrigation requirement consists of soil saturation requirement (Sn) and submergence water (S). In the operation and maintenance plan for irrigation systems management prepared for Region III, the land soaking irrigation requirement is calculated in detail considering soil moisture content before soaking and standing water depth in the field. The detailed procedures are given inclusive of estimation of soil saturation requirement shown as follows:

$$Sn = (Sc - Mc \times Bd) \times Drz/100$$

Where,
- Sc: Soil saturation capacity (%)
- Mc: Moisture content (%)
  - Wet season rice: Mc = Pwp
  - Dry season rice: MC = (Fc + Pwp)/2
- Pwp: Permanent wilting points (%)
- Fc: Field capacity (%)
- Bd: Bulk density
- Drz: Depth of root zone = 300 mm

As the results of calculation, the followings were obtained.

Land Soaking Irrigation Requirement

	For Dry Season	For Wet Season
Soil Saturation Req.	66 mm	95 mm
Standing Water Depth	50	50
Water Req. for Land Soaking	116	145

In the estimation, the representative physical properties of soils given in terms of Sc, Fc, Bd and Pwp are used by NIA, as shown in the following table, in National Irrigation Projects in the Philippines. In the Project, figures for Clay Loam are applied since clay Loam and Silt Loam are dominant occupying almost 85 percent of the entire project area.

Representative Physical Properties of Soil

Soil Texture	Sc (%)	Fc (%)	Bd (G/cc)	Pwp (%)
Sandy (S)	32-42 (38)	6-12 (9)	1.55-1.80 (1.65)	2-6 (4)
Sandy Loam (SL)	40-47 (43)	10-18 (14)	1.40-1.60 (1.50)	4-8 (6)
Loam (L)	43-49 (47)	18-26 (22)	1.35-1.50 (1.40)	8-12 (10)
Clay Loam (CL)	47-51 (49)	23-31 (27)	1.30-1.40 (1.35)	11-15 (13)
Silty Clay (SC)	49-53 (51)	27-35 (31)	1.25-1.35 (1.30)	13-17 (15)
Clay (C)	51-35 (53)	31-39 (35)	1.20-1.30 (1.25)	15-19 (17)

3) Field Irrigation Requirement

During the period of land soaking and preparation, field water requirement is equal to the land soaking water requirement and to the land preparation requirement. From transplanting to terminal drainage, field irrigation requirement is computed by adding the percolation loss to the evapotranspiration or consumptive use of crops.

The computation was made on a 10 day basis and the summarized 10-day and monthly values are as shown in Table A.3.2-9 to A.3.2-14.

(3) Diversion Water Requirement

In order to estimate the diversion water requirement, effective rainfalls on the irrigated field of paddy and water losses are taken into consideration in addition to the estimated field water requirement. The criteria for estimation of the effective rainfall as well as irrigation efficiency used for the Project are as follows:

1) Effective Rainfall

Effective rainfall was determined from the daily average of areal rainfall and allowable flooding depth for the different stages of farming activities. Effective rainfall during land soaking period of the paddy field is estimated at 250 mm considering land soaking capacity. The maximum effective rainfall during normal irrigation stage of the paddy is estimated at 60 mm. The maximum standing water of 20 mm which is necessary for normal crop growth was taken into consideration, and therefore, the maximum allowable flooding depth is 80 mm.

2) *Irrigation Efficiency*

Water losses for paddy field consist of the farm application losses and conveyance losses. The farm application loss is furthermore classified into the farm waste and distribution loss. According to the operation and maintenance plan for irrigation systems management prepared for NIA Region III, the overall irrigation efficiency is estimated by the following equation.

$$\frac{1}{IF} = \frac{1 + (FW + DL)}{1 - CLt}$$

Where, IF: Overall irrigation efficiency
FW: Farm waste
DL: Distribution loss
CLt: Conveyance loss

In the Project Area, farm application losses (FW + DL) are assumed at 30% of field irrigation water requirement, and this is considered to be one of the standard criteria for the existing irrigation systems. Conveyance losses in the system are calculated by the following equation.

$$CLt = \frac{Wpa \times L \times CL}{8.64}$$

Where, Wpa: Average wetted perimeter of the canal in every standard section (m)

L: Length of canal or canal section (m)

CL: Rate of cenveyance losses (cu.m/sq.m/day)

In the Project Area, three different values of CLt are prepared in the said plan for Region III, based on the actual observations of canal conveyance losses.

Canal Conveyance Losses in Percent

Zone	Wet Season	Dry Season
North	30.10	23.55
South	31.11	29.14
TPIS	28.76	28.33
Average	29.99	27.01

From the above table, CLt is taken to be 30 percent in this study for both wet and dry season paddy. Substituting CLt into the above formula, the overall efficiency is calculated at 54 percent.

3) Diversion Water Requirement

Based on the cropping schedule and pattern at present adopted in the Project Area, computation of diversion water requirement was made on a daily basis and then summarized with 10 daily unit so as to be inputted in the water balance study. The computed monthly summary is as follows:

Diversion Water Requirement

	Present Condition (I.E. = 0.54)[1/]					
Year	Upper Maasim	Lower Maasim	TPIP	North Main Canal	South Main Canal	Total
1972	6.25	13.53	18.36	198.99	154.83	391.96
1973	5.88	12.02	16.83	179.37	141.31	355.41
1974	7.19	9.72	16.10	158.73	133.57	325.31
1975	6.52	12.34	16.68	180.82	140.37	356.73
1976	5.70	14.10	19.32	208.19	162.52	409.83
1977	5.32	13.59	19.17	203.89	161.19	403.16
1978	7.38	14.60	23.33	233.90	194.15	473.36
1979	12.19	15.43	23.61	241.49	197.16	489.88
1980	13.24	14.49	21.60	223.76	180.86	453.95
1981	10.43	14.99	23.56	238.16	196.52	483.66
1982	6.62	15.10	21.81	229.30	183.00	455.83
Max.	13.24	15.43	23.61	241.49	196.52	489.88
Min.	5.32	9.72	16.10	158.73	133.57	325.31
Average	7.88	13.63	20.03	208.78	167.77	418.10

Irrigated Area Wet: 23,366 ha, Dry: 28,627 ha

Note: 1/; I.E. = Irrigation Efficiency