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THE REPUBLIC OF THE PHILIPPINES

PLANNING REPORT ON THE PASIG-POTRERO RIVER FLOOD CONTROL AND SABO PROJECT

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APPENDIX I

METEOROLOGY AND HYDROLOGY

SEPTEMBER 1978

JAPAN INTERNATIONAL COOPERATION AGENCY

THE REPUBLIC OF THE PHILIPPINES

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国際協力事業団
受入月日 56. 1. 27 '84. 5. 16
登録No. 04823

PLANNING REPORT
ON
THE PASIG-POTRERO RIVER FLOOD CONTROL AND SABO PROJECT

APPENDIX I METEOROLOGY AND HYDROLOGY

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I GENERAL

This report is a compilation of the hydrological finding of the survey in connection with the Pasig-Potrero Flood Control and Sabo Project, the Republic of the Philippines, during the wet season, August 22nd - September 20th, 1977 (preliminary survey), and the dry season, December 12th, 1977 - March 31st, 1978 (main survey).

The Pasig-Potrero River, a small river with the catchment basin of 125 sq.km. and the total length of 35 km., rises from Mt. Pinatubo (1,600 meters above sea level) of the Cabusilan mountain range in the west of the downstream delta of the Pampanga River, flows down in the Southeasterly direction, and joins the Gua-Gua River.

A huge amount of degraded volcanic soil and sand over the river-head mountain area washed away by the Flood, forms a fan-shaped delta in the middle stream. The obstructing delta and the poor drainage in the low-lying area in the downstream are the causes of damage to the property of the area by repeated floods with high contents of sediment load.

With regard to the Pasig-Potrero River Flood Control Project, the Channel Improvement Project (Design Flood Discharge: 900 cu.m/sec.) of the Mancatian Bridge was already taken up by the Bureau of Public Works (BPW) in 1964. Accordingly the main objects of the present Project are divided into the following five categories; i. Sand arresting plans over the upstream mountain area (Sediment distribution plan), ii. Sand arresting facility planning, especially Sabo dam, groundsill, iii. Security of the stability of flood and sediment transport in the downstream river channel, iv. Improvements in drainage over the downstream plain, v. Effective Functions of the sand arresting basin located in between the upstream mountain areas and the downstream river channel.

Accordingly, in this Report, with regard to general meteorological elements over the Philippine Islands, the effort is focused, except whereever it is necessary otherwise, upon the establishment of the design flood discharge of the Pasig-Potrero River, and also upon sorting out of the required hydrological data on the Sabo dam and the river channel improvement projects.

II. METEOROLOGY

Based on the data collected, the meteorological features in the Philipppines are stated briefly as follows.

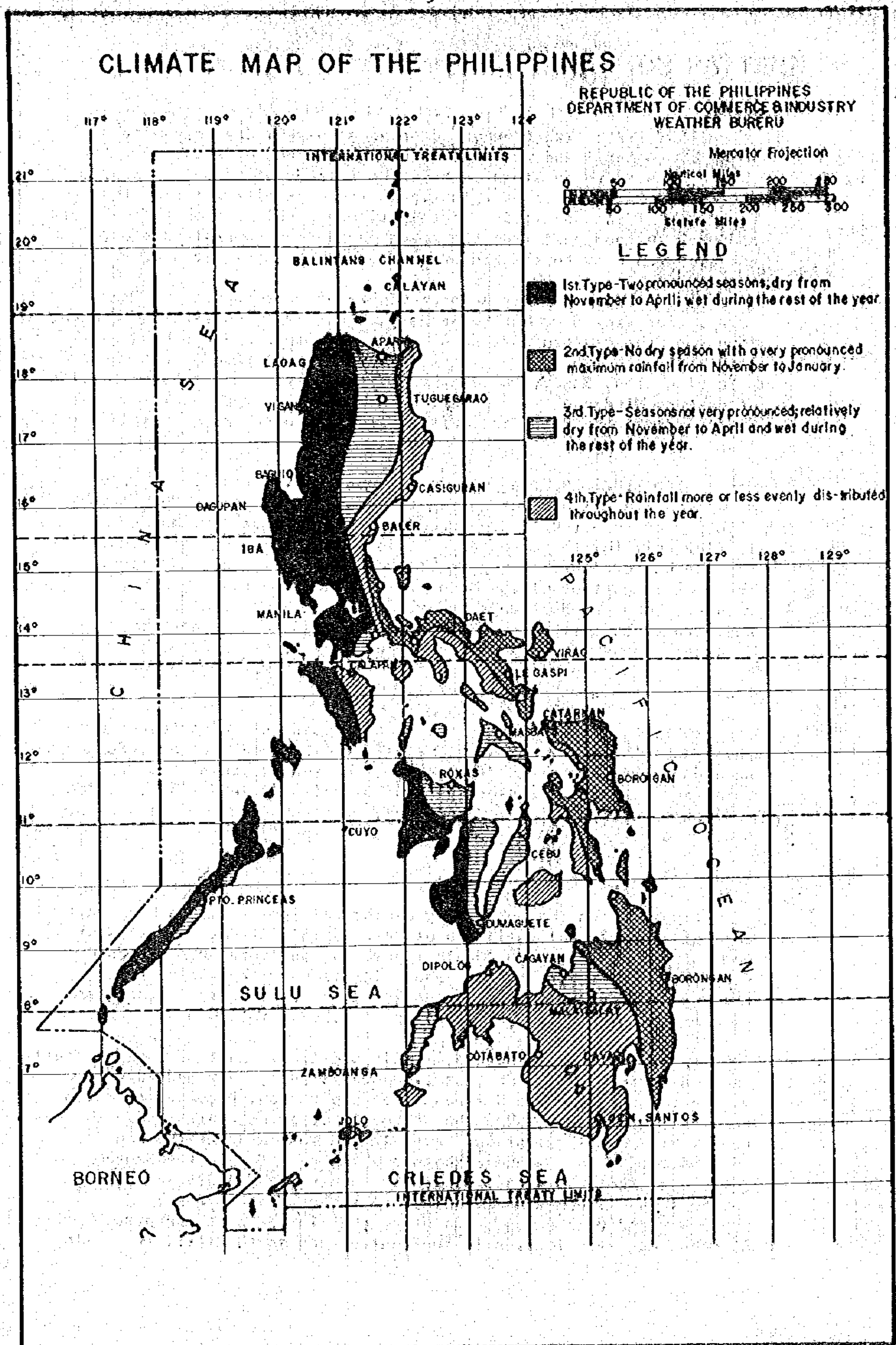
II-1 Climate

The Philippine Archipelago extends from north to south over thirteen degrees in the topics. She is composed of more than 7,000 islands, whose form and area vary exceedingly and whose total area is about 114,400 square miles. Some, as Luzon and Mindanao, cover an extent of over 30,000 square miles, 20 between 1 and 100 square miles, with more than 6,800 islets of less than 1 square mile each. Bearing these facts in mind and considering also the bold relief of some of these islands constituting various plateaus in the mountainous regions, it can be said that these features vary climatic conditions which cannot be comprehended in a single or uniform type of climate. The foundations for a classification of climatic conditions found in the different parts of the Archipelago depend mainly on the local air currents, which in turn are a resultant of the general air streams, the position of the islands, and the most usual storm tracks.

Purely local air currents are caused by various thermal conditions of the islands and their adjacent seas, and they are more or less independent of small differences of latitudes; the general air streams, however, are caused by the thermal differences between polar and equatorial regions, or they owe their existence to the normal differences of temperature corresponding to latitude. The influence of the general currents or latitude upon some of the climatic elements for the Philippines may be very slight.

Generally speaking, the main Philippine air currents can be divided into three groups; (a) the northers (loosely called Northeast Monsoon), streaming along the east and southeast side of the Great Asiatic high-pressure area; (b) the Trade Wind, reaching the islands from a generally eastern direction and coming from the tropical high-pressure area of the Pcific; (c) equatorial air (loosely called the Southwest Monsoon), pushing its way across the equator from the Strong tropical high-pressure areas of the southern hemisphere. The general direction of winds from these three sources are as follows: (a) from north to east (northers and trade) during the period from October to January; (b) from east to southeast (trade wind) from February to April; (c) for the rest of the year southern directions, mainly southwest (Southwest Monsoon and the influence of Typhoon centers). Air currents from northwest and west are generally cyclonic in origin.

Since temperature difference in the archipelago are really very slight and since rainfall differences are on the contrary important and considerably variant due to the combined influence of topography and air stream direction, classification of the Philippine climate is based upon the type of rainfall. In other words, four types of climate chosen and of a maximum rain period.


CLIMATE MAP OF THE PHILIPPINES
REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF COMMERCE & INDUSTRY
WEATHER BUREAU
Mercator Projection
Nautical Miles
Statute Miles
LEGEND
1st Type-Two pronounced seasons; dry from November to April; wet during the rest of the year.
2nd Type-No dry season with a very pronounced maximum rainfall from November to January.
3rd Type-Seasons not very pronounced; relatively dry from November to April and wet during the rest of the year.
4th Type-Rainfall more or less evenly dis-tributed throughout the year.
INTERNATIONAL TREATY LIMITS
BALINTANG CHANNEL
CALAYAN
APARRI
LAOAG
VIGAN
TUGUEGARAO
BAGUIO
CASIGURAN
DAGUPAN
BALER
IBA
MANILA
DAET
VIRAC
LEGASPI
CATARMAN
MASBATE
ROXAS
BOROGAN
CUYO
CEBU
PTO. PRINCESA
DUMAGUETE
DIPOLOG
CAGAYAN
BORONGAN
SULU SEA
ZAMBOANGA
COTABATO
DAVAO
GEN. SANTOS
JOLO
BORNEO
CELEBES SEA
CHINA SEA
PACIFIC OCEAN

FIRST TYPE: Two pronounced seasons, namely dry season from November to April and wet season during the rest of the year. All the regions on the western part of the islands of Luzon, Mindro, Negros and Palawan are of this type. The controlling factor is topography. The localities of this type are shield from the northers and even in good part from the trade decided by mountain ranges, and are open only to the Southwest Monsoon and cyclonic storms.

SECOND TYPE: No dry season; with a very pronounced maximum rain period from November to January. In this class fall Catanduaes, Sorsogon, the eastern part of Albay, the eastern and northern part of Camarines Norte and Camarines Sur, a great portion of the eastern part of Quezon, Samar, the eastern part of Leyte, and a large portion of eastern Mindanao. These regions are along or very near the eastern coast and Sheltered neither from the northers and trade nor from cyclonic storms.

THIRD TYPE: Seasons not so pronounced; relatively dry from November to April and wet during the rest of the year. The maximum rain period is not very pronounced, with the short dry seasons lasting only for three months. Regions with this type of climate are the western part of Cagayan (Luzon), Isabela, Nuera Vizcaya, the eastern portion of the Mountain Province, Southern Quezon, Masbate, Romblon, Northeast Panay, eastern Negros, central and southern Cebu, part of northern Mindanao, and most of eastern Palawan. These localities are only partly sheltered from the northers and Trade Winds and open to the Southwest Monsoon or at least to frequent cyclonic storms.

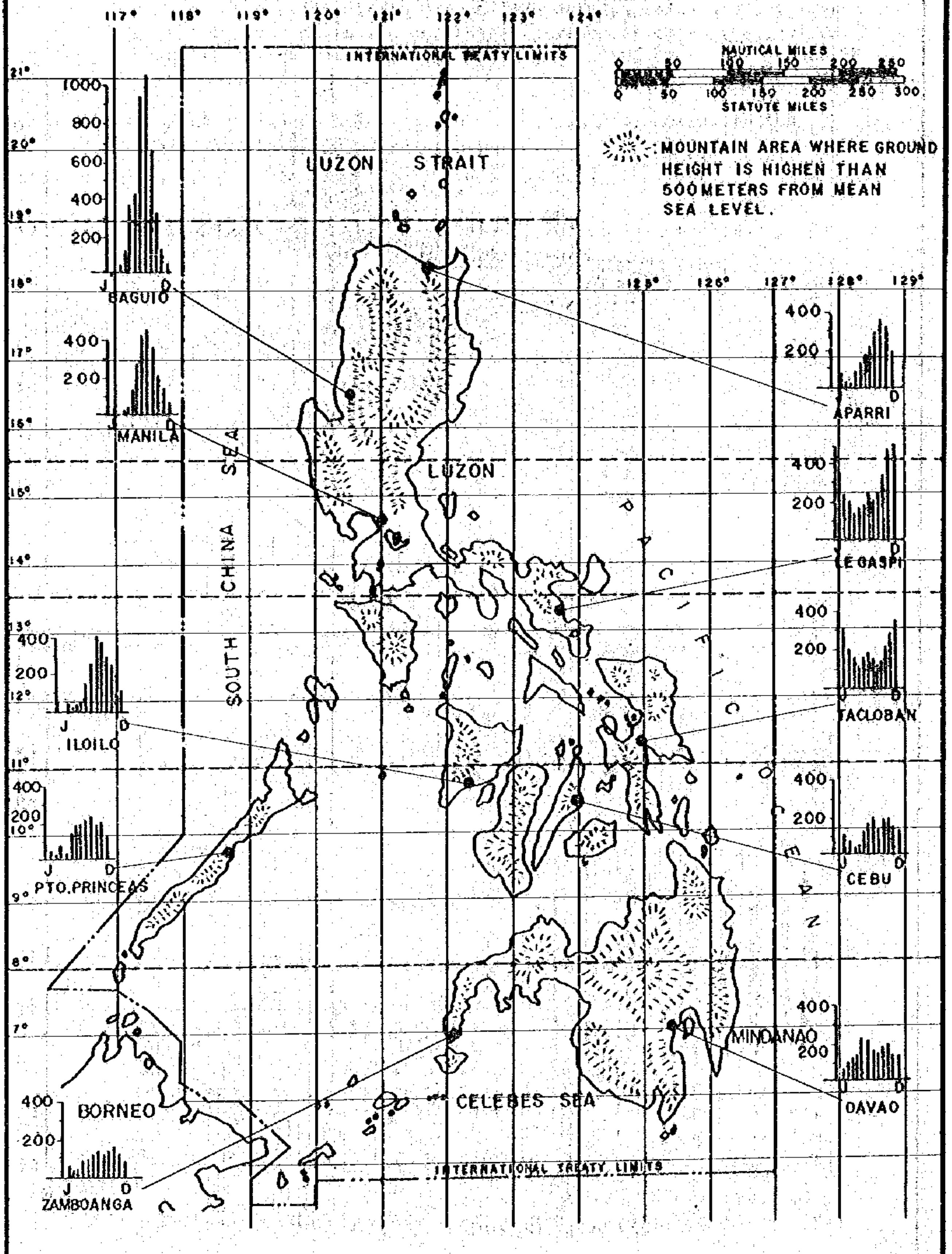
FOURTH TYPE: Rainfall is more or less evenly distributed throughout the year. The regions affected by this type are the Batanes Province, northeastern Luzon, the southwestern part of Camarines Norte, the western part of Camaries Sur and Albay, Bondoc Peninsula, estern Mindro, Marindugue, Western Leyte, Northern Cebu, Bohol and most of central, eastern and southern Mindro.

II-2 Rainfall

Figure shows the topography of the Philippines and a bar chart regarding the annual variation of monthly rainfall at 10 representing points. In the topographic figure, areas above 500m are colored for distinction. The annual mean rainfall over the whole area of the Philippines ranges as much as 2,000mm. Especially in the east-side of the Archiperago, it reaches to 3,000mm to 4,000mm.

In the west-side, Baguio, Manila and Iroilo sustain much rainfall at the maximum in the Southwest Monsoon season, July and August. On the contrary, in the Northeast Monsoon season, December to March, rainfall in those areas can be scarecely observed, which shows the remarkable annual variation. Even in the west side at the southern part of Pro. Princesa and Zamboanga which do not face the South China sea, remarkable distinction between rainy and dry seasons can not be seen. The maximum rainfall in these areas is observed in September and October, subsequent to that in the northern part. At Cebu and Davao located in the central and south districts, it is

Fig. I-1 MONTHLY RAINFALL DISTRIBUTION PATTARN



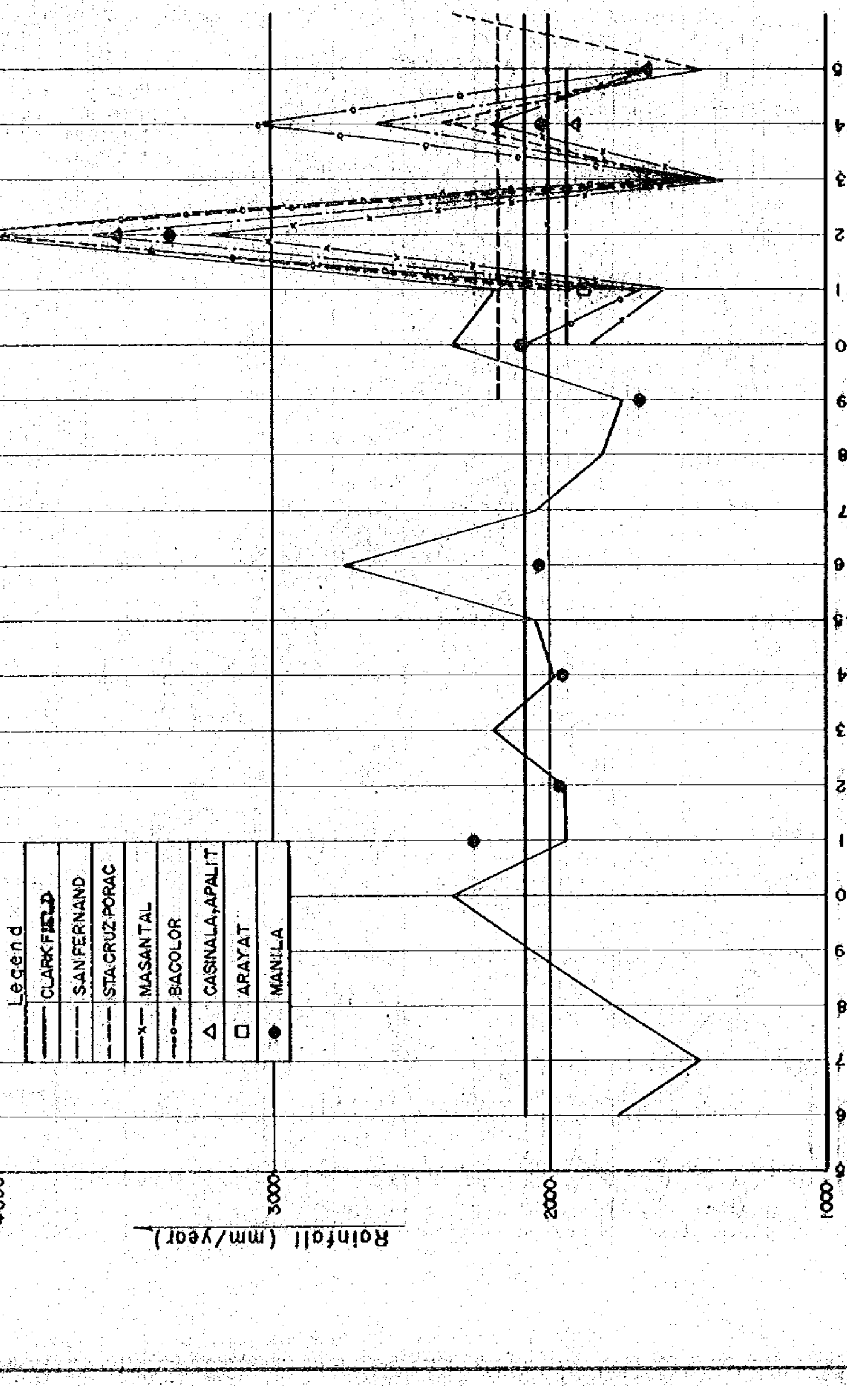


FIG. I-2 ANNUAL RAINFALL DISTRIBUTION

considerable difficult to draw a line between rainy and dry seasons. Aparri is located in the north-east part experiences the maximum rainfall in the North-east Monsoon season, and has a dry season in March and April.

Legaspi and Tacloban, the maximum rainfall areas in the Philippines, located along the east coast sustain a great deal of rainfall in the North-east Monsoon season, especially in December, and also much rainfall in a rainy season due to cyclonic storms, low-pressure and thunderstorms. The annual variation of monthly rainfall in these areas is caused by the following climatric and topographic features.

Climatric features

1) Influence of Monsoon season

2) Cyclonic storms passing through the northern part in July to September and through the southern part in December to February.

3) Seasonal variation on occurence of low-pressure and thunderstorms

Topographic features

1) A lot of mountainous areas

2) Existence of coastal areas facing various seas such as the South China Sea, the Pacific Ocean and the southwest sea

Variations of annual rainfall and monthly rainfall at the main gauging stations along the Pasig Potrero River are shown in FIGURE I-2 and FIGURE I-14. Except for the extraordinary rainfall observed in 1966, 1972 and 1974, the annual rainfall is approximately 2,000mm.

As to the monthly rainfall variation, the maximum rainfall is experienced in July and August due to Southwest Monsoon. And a clear line is drawn between rainy and dry seasons, similar to Manila.

II-3 Temperature and Humidity

The annual variation of monthly mean temperature obtained from the data collected in Luzon Island (20 stations), Visayas (14 stations) and Mindanao (10 stations) by the Weather Bureau under the Department of Commerce and Industry is presented in TABLE I-1. The annual mean temperature over the whole Archipelago is 27°C without temperature locality. For the annual variation, the highest monthly mean temperature (28.3°C) is observed in May, which is a transition month from a dry season to a rainy season.

The lowest monthly mean temperature (25.9°C) is observed in December immediately after a rainy season. The deviation exists

TABLE I-1 REPUBLIC OF THE PHILIPPINES
Department of Commerce and Industry
WEATHER BUREAU
Manila

Average Temperature in the Philippines in °C

Region	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
LUZON	24.3	25.3	26.4	27.7	28.4	28.1	27.6	27.5	27.3	26.9	26.2	25.3	26.8
VISAYAS	26.2	26.4	27.1	28.0	28.3	27.9	27.5	27.6	27.5	27.3	27.0	26.5	27.3
MINDANAO	26.3	26.4	26.9	27.4	27.5	27.2	26.9	27.1	27.0	27.0	26.9	26.4	26.9
PHILIPPINES	25.6	25.9	26.7	27.7	28.3	27.9	27.4	27.4	27.3	27.1	26.6	25.9	27.0
MANILA	25.1	25.6	26.9	28.3	28.7	28.0	27.2	27.0	26.9	26.8	26.0	25.3	26.8

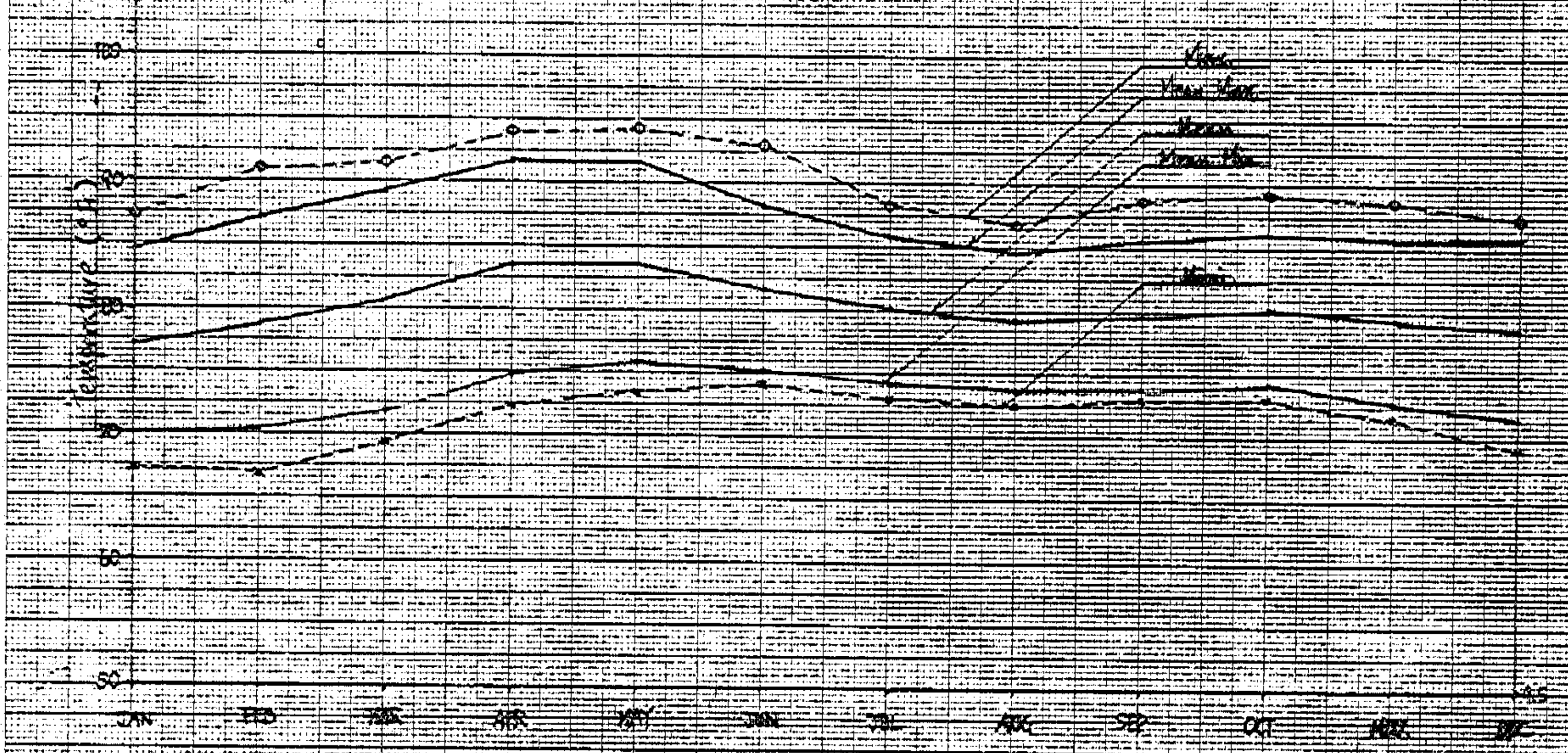
Temperature Extremes Ever Recorded in °C

Region	Highest Temperature	Lowest Temperature
LUZON	42.2 on April 29, 1912 at Tuguegarao, Cagayan	7.3 on Jan.11, 1932 and Feb.1, 1930 at Baguio City, Mt. Province
VISAYAS	38.2 on May 21 and June 2, 1915 at Romblon, Romblon	16.1 on Jan.8, 1949 at Catbalogan, Samar
MINDANAO	38.2 in April, 1906 at Cotabato, Cotabato	11.7 on Jan.16, 1956 at Malaybalay, Bukidnon

Note:
The above data were based on the records of Synoptic Stations operating as of 1960. The years of record range from 12 to 71 years.

Fig. I-3 MONTHLY MEAN MAX., MEAN MIN. AND MEAN TEMPERATURE

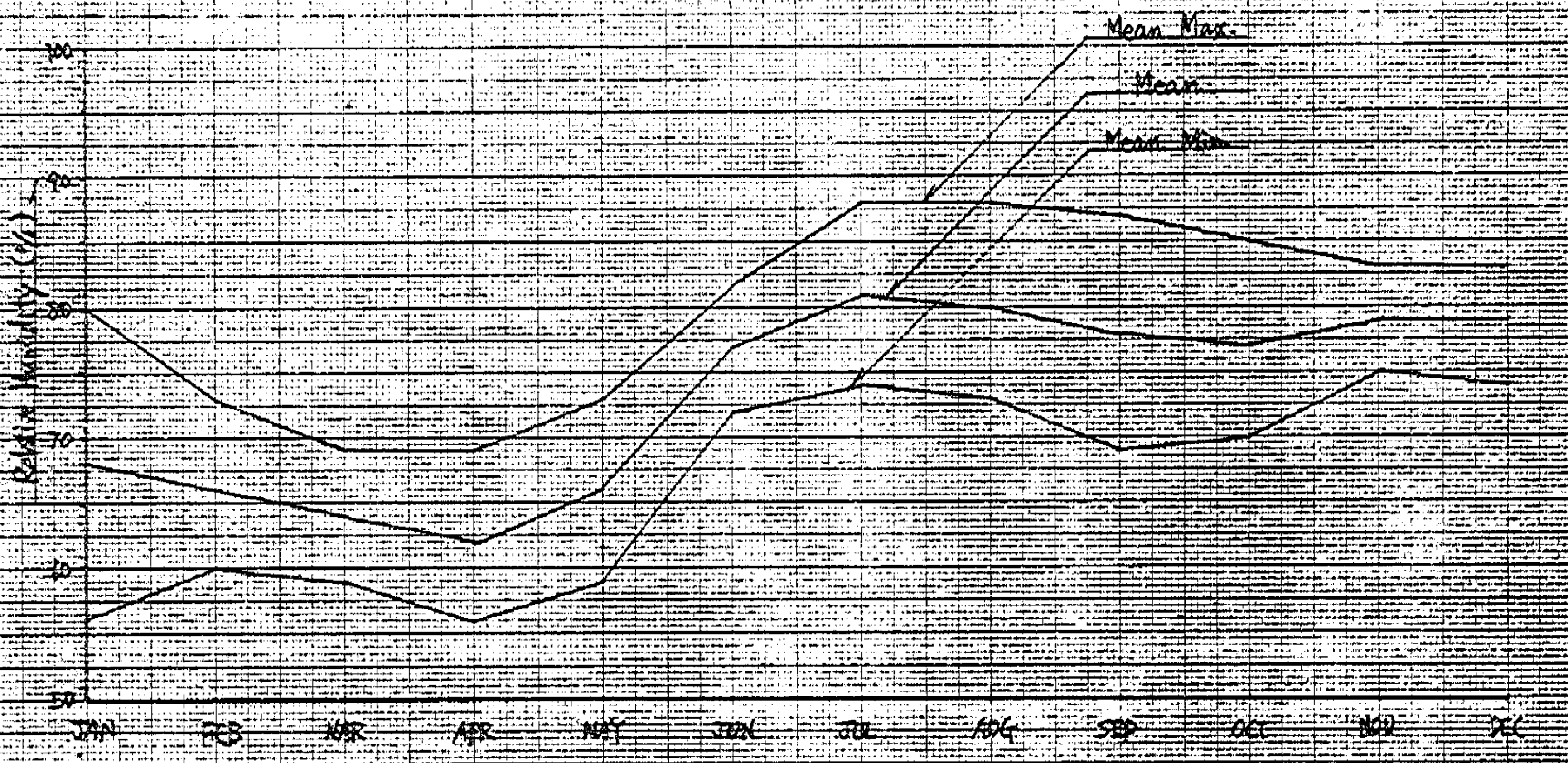
Clark Field (1956 — 1972)



	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP	OCT	NOV	DEC
Mean Max.	84.6	87.2	89.8	91.9	91.6	88.0	85.9	84.6	86.6	87.2	86.7	85.6
Mean Min.	77.3	70.8	80.6	82.9	82.9	81.7	80.4	75.3	77.4	78.4	79.4	78.7
Mean	70.0	70.3	71.7	76.7	76.9	75.1	74.2	74.0	72.8	74.1	72.0	71.5

Fig. I-4 MONTHLY MEAN MAX. MEAN MIN. AND MEAN HUMIDITY

MIA Manila (1966 - 1976)



Unit %

	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP	OCT	NOV	DEC
Mean Max.	80	73	69	68	73	83	88	88	87	85	83	83
Mean Min.	56	60	59	56	59	72	74	73	69	70	75	74
Mean	68	66	64	62	66	77	81	80	78	77	79	79

within the limits of ±3°C. The analysis of the data (FIGURE I-3) collected at Clark Field (United States Air Force) by the Team shows the similar tendency.

The annual mean relative humidity is as high as 73% with the highest monthly humidity of 81% in July and the lowest one of 62% in April within 20% deviation as shown in FIGURE .

II-4 Evaporation

Evaporation is a complex physical phenomenon. The actual process can be subdivided into two main factors. The first one is closely related to the extra terrestrial energy supplied by the sun, which is more or less attenuated and absorbed by the atmosphere. Thus, the energy reaching the surface of the earth is more or less efficent depending an moisture content and cloud amounts, and movement of the air masses (wind run).

The other factor in the evaporation process are closely related to the specific physical properties of the body or mass exposed to the evaporation. Thus some external energy and atomospheric conditions will induce different depth or amount of evaporation from moist surface as a deep or shallow water body, various types of plants and base soils. For these reasons it is extremely difficult to measure actual evaporation (Ea) or potential (Evp), or evapotranspiration (Etp).

In the Rehabilitation Project for Pampanga Delta/Candaba Swamp, the annual amount of evaporation and the daily mean evaporation obtained from the data recorded at Cabanatuan City, Binga H. E Plant, Mountain Province and Baguio City by means of the Hargreaves Method range from 1,700 to 2,100mm/year and from 4.5 to 5.7mm respectively. These values are not appropriate for this river basin having a high permeability and an annual rainfall of 2,000mm. Evaporation in this river basin is estimated from the observation data collected at Butos nearest to this river basin. The evaporation data at Bustos station have been collected in five years during 1961 - 1965. The data are recorded five kinds of evaporators, such as open rim pan, pitch tube, black atmometer and white atmometer. Prior to the estmation of the annual evaporation, relaiability of the data observed by each evaporator was checked based on the measured annual evaporation. Each of these annual evaporation and the ratio to the open rim pan's are shown in FIGURE I-5. According to this figure, the ratio of open rim pan versus shaded rim pan is kept mostly constant while other ratios after 1963 decrease unreasonably corresponding to a half of that before 1963.

Futher-more evaporation records by open rim pan are coincident with the evaporation records at Manila by same type of evaporator as shown in FIGURE I-6. Therefore, the evaporation data by open rim pan and shaded rim pan are concluded to be reliable. Monthly

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* [PAMPANGA DELTA/CANDABA SWAMP AREA DEVELOPMENT PROJECT]
Planning & Project Development Office, B. P. W. T. C.

mean evaporation recorded by open rim pan and shaded rim pan at Bustos station during 1961 - 1965 is shown in TABLE I-2, and the annual mean evaporation for each evaporator is 1.95 mm/day and 1,602 mm/year respectively. The actual evaporation is estimated by multipling a coefficient of less than 1.0 by the record in such evaporators since evaporator is heated by sunshine, and indicates larger evaporation values than the actual. As the coefficients, 0.60 to open rim pan and 0.81 to shaded rim pan, has been recommended to be utilized based on the results of the experiments in Los Baños, Laguna using the Lake Hefner studies and the Corolado experiments as guides. The above mentioned coefficients gives 1,174 mm/year and 1,297 mm/year of annual evaporation for open and shaded rim pans respectively.

Since the difference between the two values is so little as 100 mm/year, the mean values of two evaporator records after multipling the said constant are adopted as evaporation from the basin. Therefore, the daily mean evaporation and the actual mean evaporation are estimated at 3.5 mm/day and 1,250 mm/year respectively.

II-5 Wind Direction and Wind Velosity

The main air streams that dominates the Philippines are most generally distinguished as the Northeast Monsoon, the Indian Southwesterlies and the North and South Pacific Trades as shown in FIGURE I-8. The Northwest Monsoon streams in along the eastern and southeastern side of the Great Asiatic high-pressure, which is distinguished in a period from October to January.

The Indian Southwesterlies, called Southwest Monsoon, usually push its way across the equator from the strong tropical high-pressure areas of the southern hemisphere. Since air currents from northwest and west are generally cyclonic in origin, and the Trade Wind reaches the Philippine Archipelago generally coming from the eastern direction and also partly from the tropical high-pressure, winds from the eastern and southeastern direction dominate from February to April. The monthly mean wind direction and wind velocity in a period of ten years from 1966 to 1975 are shown in FIGURE I-8. The wind direction in a dry season influenced mainly by the Trade Wind is remarkably different from that in a rainy season with a dominance of the Southeast Monsoon.

The mean wind velocity in this period of ten years is 5.4 knot/hr. respectively. According to the analysis of 5-year data of surface and upper air charts and rainfall at Manila Port Area and Manila International Airport stations*, to different synoptic scale weather systems contribute to the following percentages of rainfall from July to September:

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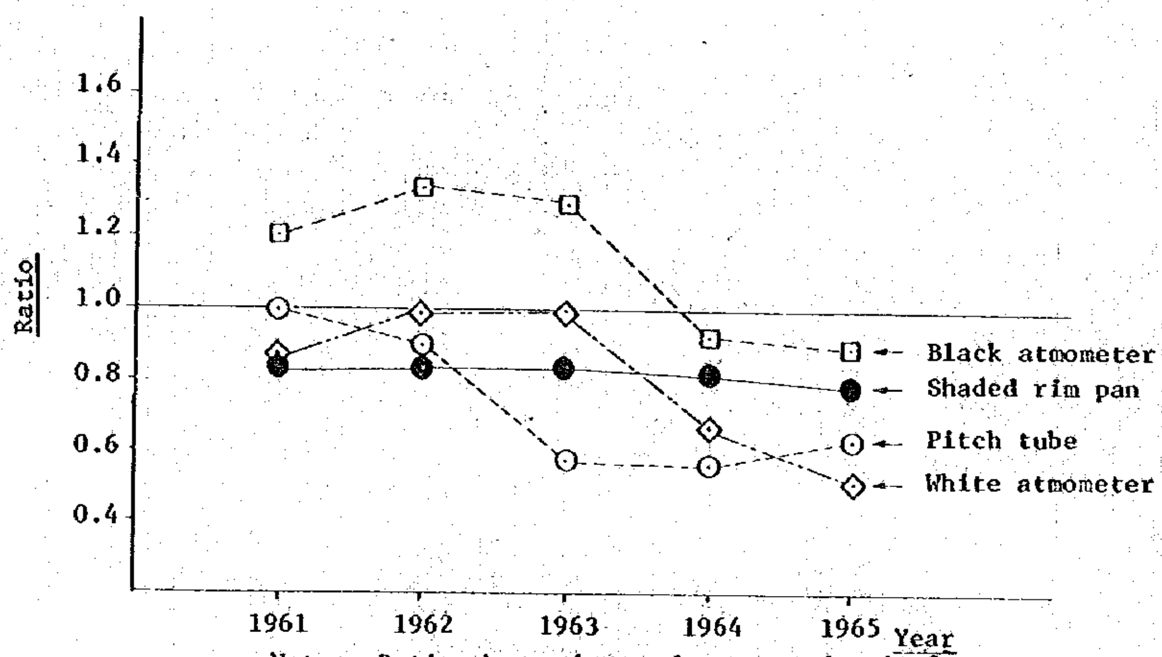
* [An Analysis of Manila Rainfall Data] by Aida M. Josa, Technical Series No.9 issued by the WMO/UNDP Project, Department of Meteorology, University of the Philippines.

Fig. I-5 CHECK ON RELIABILITY OF MEASURING INSTRUMENT OF EVAPORATION

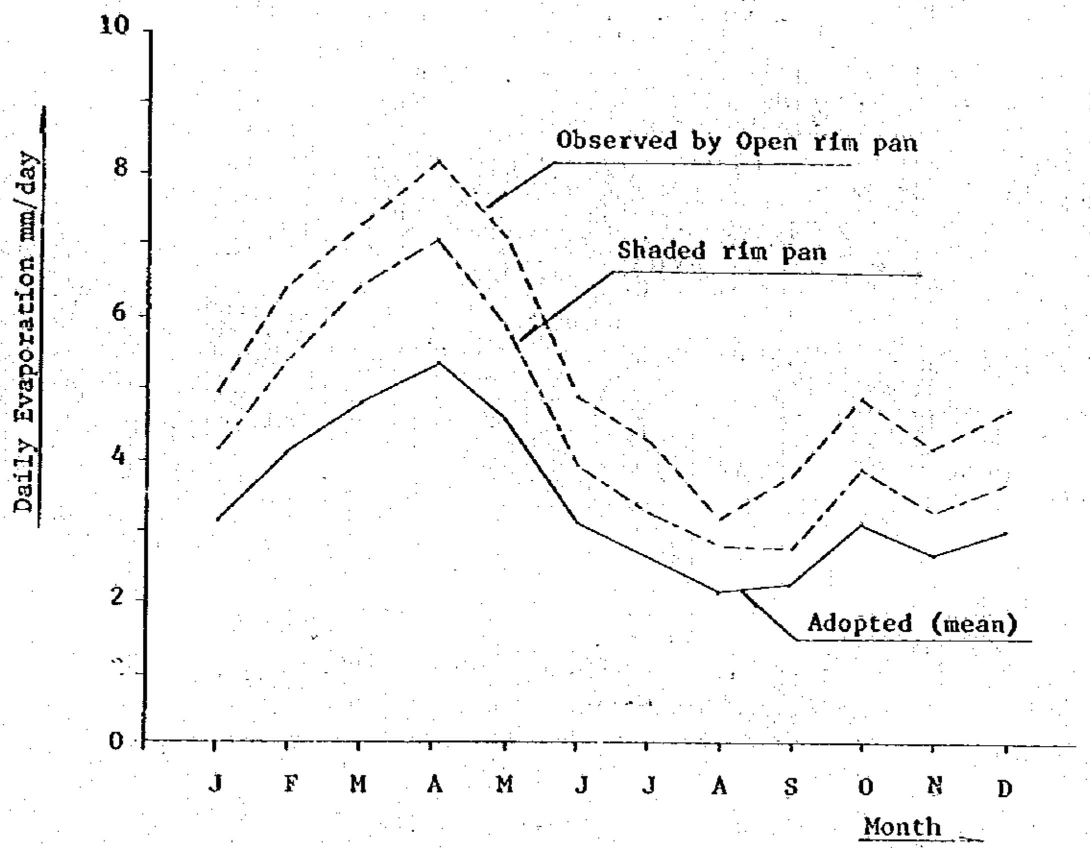


Note; Ratio shows observed evaporation in four instruments to open rim pan

Instrument	Year				
	1961	1962	1963	1964	1965
Open rim pan	1893 (1.00)	1903 (1.00)	1897 (1.00)	1894 (1.00)	2199 (1.00)
Shaded rim pan	1573 (0.83)	1577 (0.83)	1577 (0.83)	1551 (0.82)	1733 (0.79)
Pitch tube	1881 (0.79)	1720 (0.90)	1104 (0.58)	1079 (0.57)	1398 (0.64)
Black atmometer	2294 (1.21)	2560 (1.35)	-- (1.29)	1793 (0.95)	1751 (0.80)
White atmometer	1590 (0.84)	1874 (0.98)	-- (1.00)	1264 (0.67)	1130 (0.51)

Note; Numerics show annual total evaporation.
( ) show ratio observated evaporation in four instruments to open rim pan.

Fig. I-6 DAILY MEAN EVAPORATION



Daily Mean Evaporation

Unit: mm/day

Instrument	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
Open rim pan	4.9 (2.9)	6.4 (3.8)	7.3 (4.4)	8.1 (4.9)	7.1 (4.3)	4.8 (2.9)	4.2 (2.5)	3.1 (1.9)	3.7 (2.2)	4.8 (2.9)	4.1 (2.5)	4.6 (2.8
Shaded rim pan	4.1 (3.3)	5.4 (4.4)	6.4 (5.2)	7.0 (5.7)	5.8 (4.7)	3.8 (3.1)	3.2 (2.6)	2.7 (2.2)	2.7 (2.2)	3.8 (3.1)	3.2 (2.6)	3.6 (2.9)
Mean (Adopted)	3.1	4.1	4.8	5.3	4.5	3.0	2.6	2.1	2.2	3.0	2.6	2.9

Note; Numerics show the observed evaporation.
( ) shows the modified value multipling coefficient.
Mean shows the mean of modified value.

Table I-2 DAILY MEAN EVAPORATION AT BUSTOS STATION (unit: mm/day)

(1) Open rim pan

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1961	5.60	6.60	7.20	8.62	6.69	4.50	3.44	3.24	3.76	4.21	3.85	4.64	--
1962	5.03	6.61	7.59	7.52	6.69	5.32	3.47	4.11	2.89	4.66	4.28	4.67	--
1963	4.65	5.98	7.73	8.40	8.55	3.83	3.69	3.24	2.97	4.54	4.67	4.18	--
1964	4.68	5.97	6.84	8.45	6.76	4.67	5.37	3.92	4.02	4.10	3.02	4.28	--
1965	4.66	6.73	7.79	7.58	6.55	5.69	4.88	4.19	4.84	6.32	4.52	5.28	
Mean	4.92	6.38	7.43	8.11	7.05	4.80	4.17	3.09	3.68	4.77	4.07	4.61	5.26

(2) Shaded rim pan

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1961	4.82	5.58	6.10	7.32	5.51	3.80	2.57	2.45	2.76	3.24	2.99	3.85	--
1962	4.23	5.61	6.47	6.29	5.38	4.24	2.59	3.16	2.14	3.69	3.44	3.85	--
1963	3.94	5.13	6.31	7.18	7.59	1.80	2.60	2.44	2.35	3.64	3.86	3.40	--
1964	3.86	5.14	5.89	7.38	5.15	3.64	4.17	2.65	2.88	3.25	2.18	3.60	--
1965	3.85	5.74	6.68	6.66	5.52	4.54	3.97	2.92	3.50	4.97	3.48	3.43	--
Mean	4.14	5.44	6.39	6.97	5.83	3.80	3.18	2.72	2.73	3.76	3.19	3.63	4.32

Fig. I-7 THE FOUR DIFFERENT STREAMS IN THE TROPICAL NORTHWESTERN PACIFIC DURING MAY TO DECEMBER.

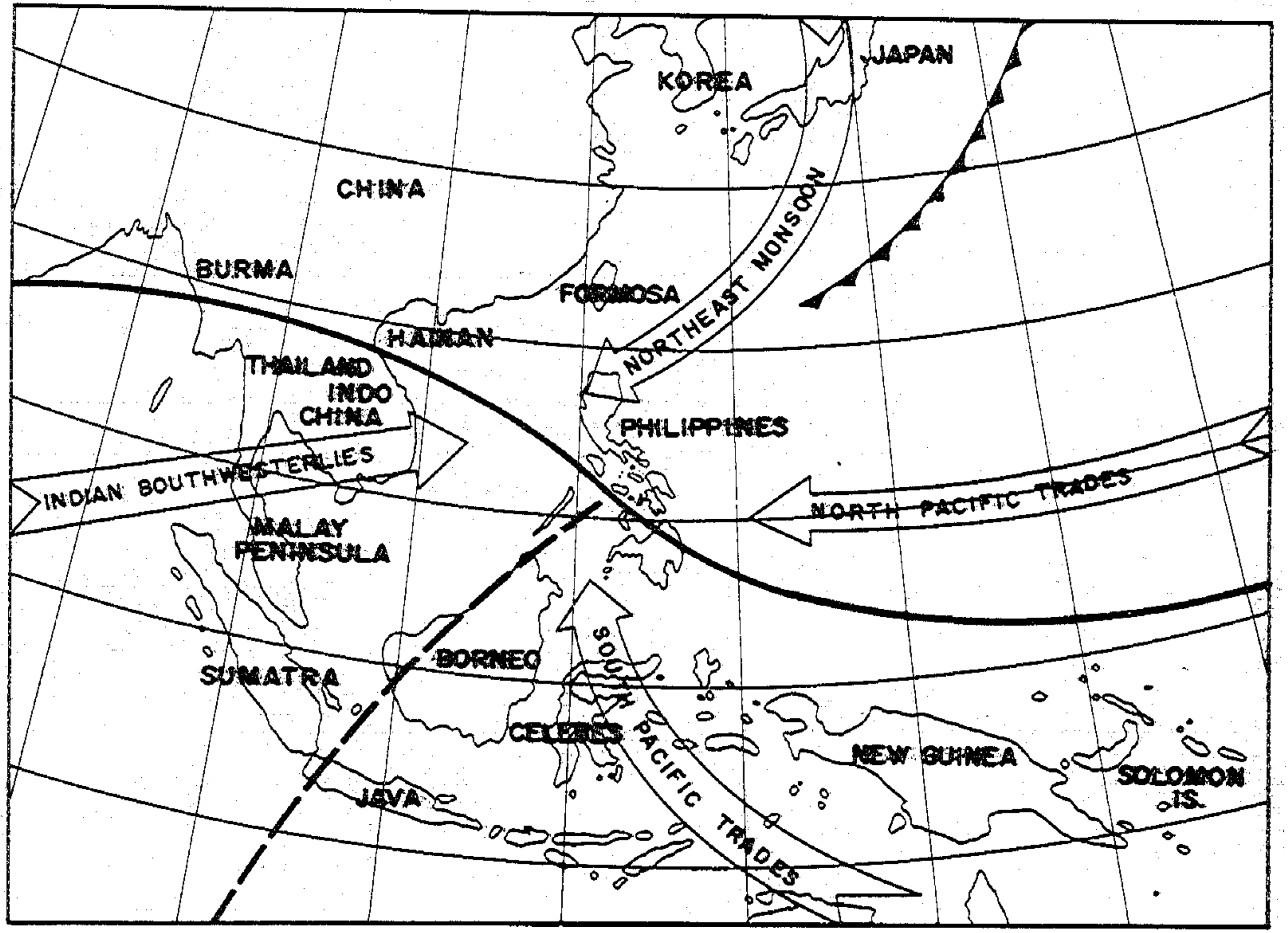
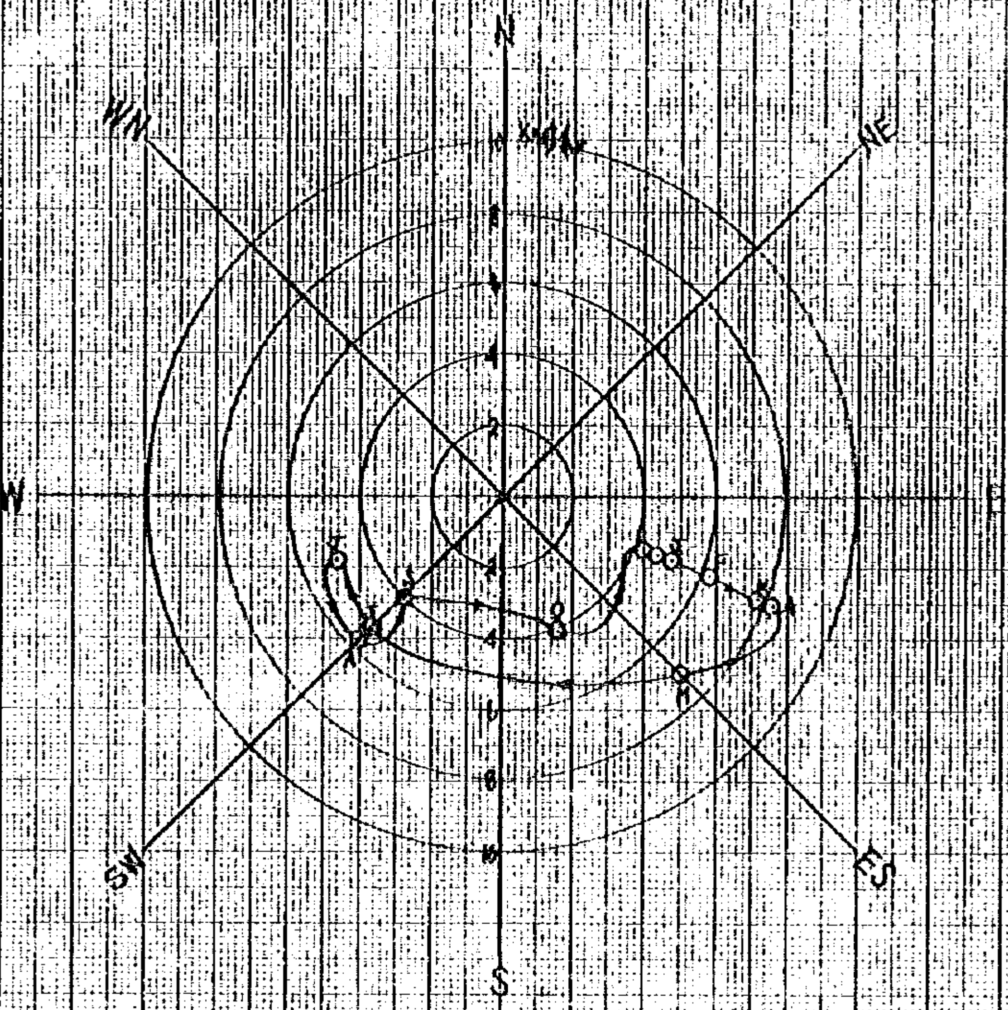


Fig. I-8 WIND DIRECTION AND WIND VELOCITY



MIA Manila

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Wind Direction	ESE	ESE	ESE	ESE	ES	WSW	SW	SW	SW	SES	ESE	ESE
Mean	5	6	7.6	7.8	6.6	4.7	5.1	5.4	4.1	3.8	4.1	4.2
Mean Max.	6	8	9	9	7	7	9	6	[illegible]	5	5	5
Mean Min.	4	6	6	7	5	4	3	5	3	3	3	3
Max.	11	13	13	11	18	10	15	12	13	22	22	9
Min.	2	3	3	3	3	2	2	2	1	1	1	1

Unit: Knot/hr

* Max. and Min. Value is daily mean value.

TABLE I-3 FREQUENCY OF PASSAGE OF TROPICAL CYCLONE CENTERS OVER GEOGRAPHICAL REGIONS OF THE PHILIPPINES

1948 to 1977
(30 Years)

REGIONS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	Ave./Yr.	Rank	% of 259
BATANES (19°N - 22°N)	0	0	0	0	5	6	15	18	19	4	5	2	74	2.47	2nd	28.6%
NORTHERN LUZON (16°N - 19°N)	0	0	0	2	3	7	18	15	23	17	12	3	100	3.3	1st	38.6%
CENTRAL LUZON (14.5°N - 16°N)	0	0	0	0	3	6	3	4	3	7	7	1	34	1.13	5th	13.1%
BICOL & SOUTHERN TAGALOG (12.5°N - 14.5°N)	2	1	0	0	4	4	4	1	4	10	13	8	51	1.7	4th	19.7%
VISAYAS & PALAWAN (09.5°N - 12.5°N)	5	0	3	3	6	6	4	1	0	6	18	14	66	2.2	3rd	25.5%
NORTHERN MINDANAO (07.5°N - 09.5°N)	5	0	1	1	2	1	0	0	0	3	9	8	28	0.93	6th	10.8%
SOUTHERN MINDANAO (05.5°N - 07.5°N)	0	0	0	0	0	0	0	0	0	1	0	0	1	0.03	7th	0.4%

NOTE: 1 - A tropical syclone may cross one or more regions.
2 - Total number of cyclones crossing the Philippines is 259 (1948 - 1977).

Wind discontinuities	58%
Southwest flow	31%
Closed isobar cyclonic circulation	4%
Ridge	4%
Others	3%

Wind discontinuities and southwest flow categories give the greatest number of occasions of rainfall equal to or above 1 inch precipitation

July August and September have the highest frequency of tropical cyclones and they are the wettest months of the year. In most cases, the wind discontinuities and southwest flow are closely related to the occurrence of tropical cyclones in the area concerned.

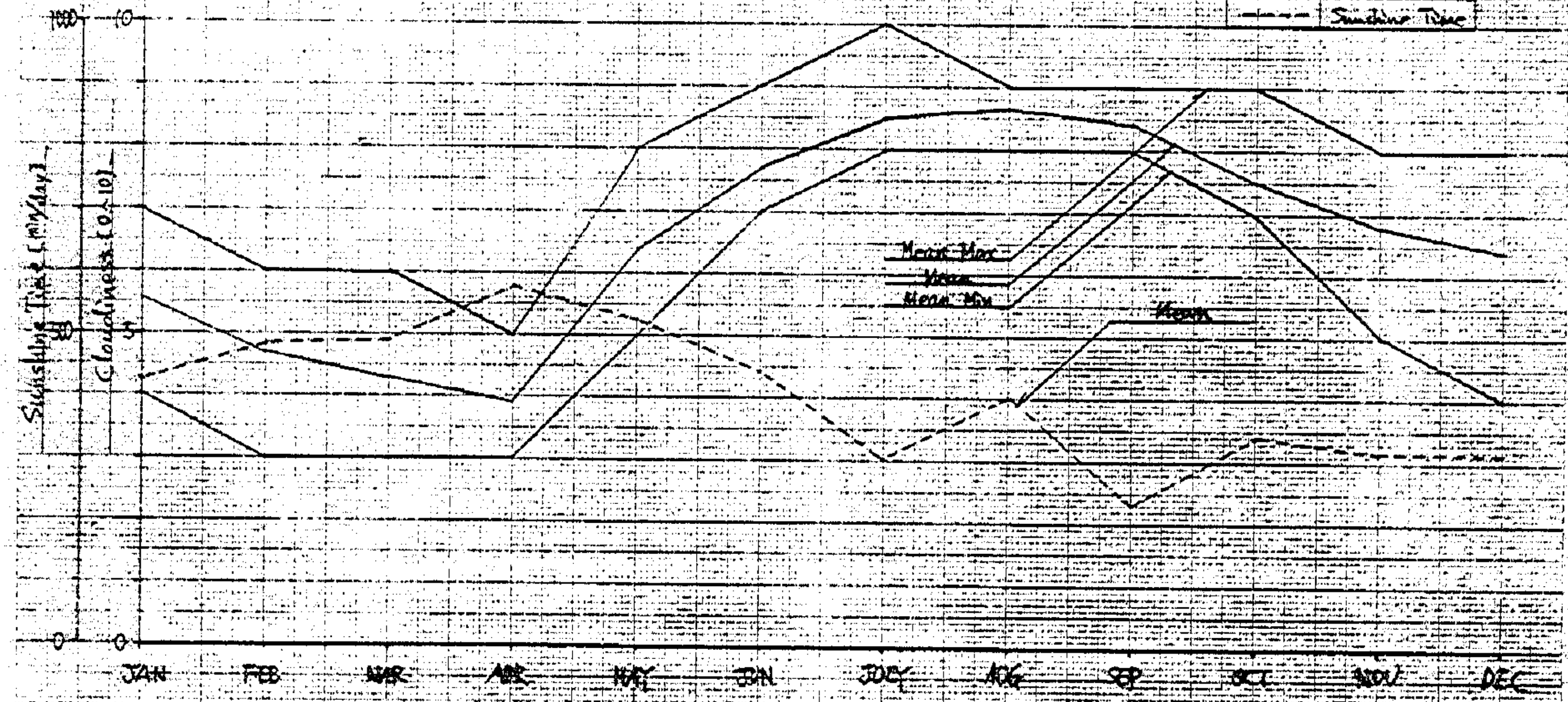
II-6 Sunshine Time and Cloudiness

Cloudiness [0-10] and sunshine [min/day] obtained from the records at MIA (Manila International Airport) from 1966 to 1976 are summarized in FIGURE I-9. The mean cloudiness in a rainy season from May to November and in a wet season from December to April is 7.7 and 5.0 respectively. The daily mean sunshine time in rainy and wet seasons is 365 min/day and 458 min/day respectevely, which shows reasonably the adverse tendency of cloudiness.

Especially in April and May, a transition period from a dry season, the longest sunshine time has been recorded; naemly, the daily mean sunshine time in April and May is 550 min/day. and as mentioned in II-3, high temperature and low humidity are experienced in April and May.

Fig. I-9 SUNSHINE TIME AND CLOUDINESS

MIA Manila (1966 - 1976)



		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Cloudiness	Mean Max	7	6	6	5	8	9	10	9	9	9	8	8
	Mean	5.55	4.70	4.38	3.90	6.40	7.70	8.54	8.67	8.40	7.56	4.80	6.40
	Mean Min	4	3	3	3	5	7	8	8	8	7	5	4
Sunshine Time	Mean	422.6	484.0	492.0	520.5	523.0	440.0	307.0	401.0	230.0	391.6	315.0	316.0

III. HYDROLOGY

In the preceding chapter, the meteorological features in the Philippines are presented. In this chapter, concentrating on the Project Area, a design high-water discharge serving as a Foundation of the Project is established based on the rainfall and water level data collected through a study of rainfall and discharge features in the basin.

III-1 Project Area

The Pasig Potrero River originates in Mt. Pinatubo located in the Cabusilan Mountain Range flows down through the fan-delta area in the middle reaches taking in some tributaries such as Yanca and Timbu and joins the Gua-Gua River 18 km down of Mancatian Bridge. Gua-Gua, similar to San Fernando and Angels, is a control town in a fan-delta granary in the down reaches of the Pampamga River, and serves as a key place of commerce and aquatic transportation as a water channel network existing in the large delta area. Recently it has become characteristic of a satellite city of Manila through arrangement of transportation system and motorization.

The Project Area is geographically divided into three areas; i) up-stream mountainous area, ii) middle-stream fan-delta area and iii) down-stream plain area. Mt. Pinatubo (EL 1,600 m) in which the Pasig - Potrero River originates consists of relatively old volcanic soils in the Quaternary Era. Different features can be found between the Porac River side and the Abacan River side. In other words, the mountain-side in the Porac River side is characteristic of ruggedness of its surface due to erosion and precipitous slope in the N-S direction, which that in the Abacan River side forms a plain by sedimentation of volcanic ejecta, which slopes down from west to east.

A great deal of sediment is discharged from Mt. Pinatubo due to devastation during a flood and deposit in the middle reaches, forming a fan-delta area.

According to the results of the soil survey conducted in 1964 by department of Agriculture and National Resources, Bureau of Soil, soil texture in the up-stream mountainous area is Catana sandy loam in the Porac side and Camachile sandy loam in the Abacan side, Soil texture in the down reaches of the fan-delta consists of Banaba sandy loam and Banaba loamy sand in the Porac and Angeles sand and gravelly phase in the Abacan side.

A fundamental river improvement plan in the down reaches of the Mancatian Bridge was set up in 1964 by B.P.W. River improvement works has been launched since May of 1966 when Typhoon "Irma" destroyed the right side levee in the up-stream of the Mancatian Bridge. In July of 1972, unprecedented sediment and ponding damages are sustained mainly in the down reached on the Pasic-Potrero River by Typhoon "Edeng", Dredging and embankment works were commenced in 1975 and now still under implementation.

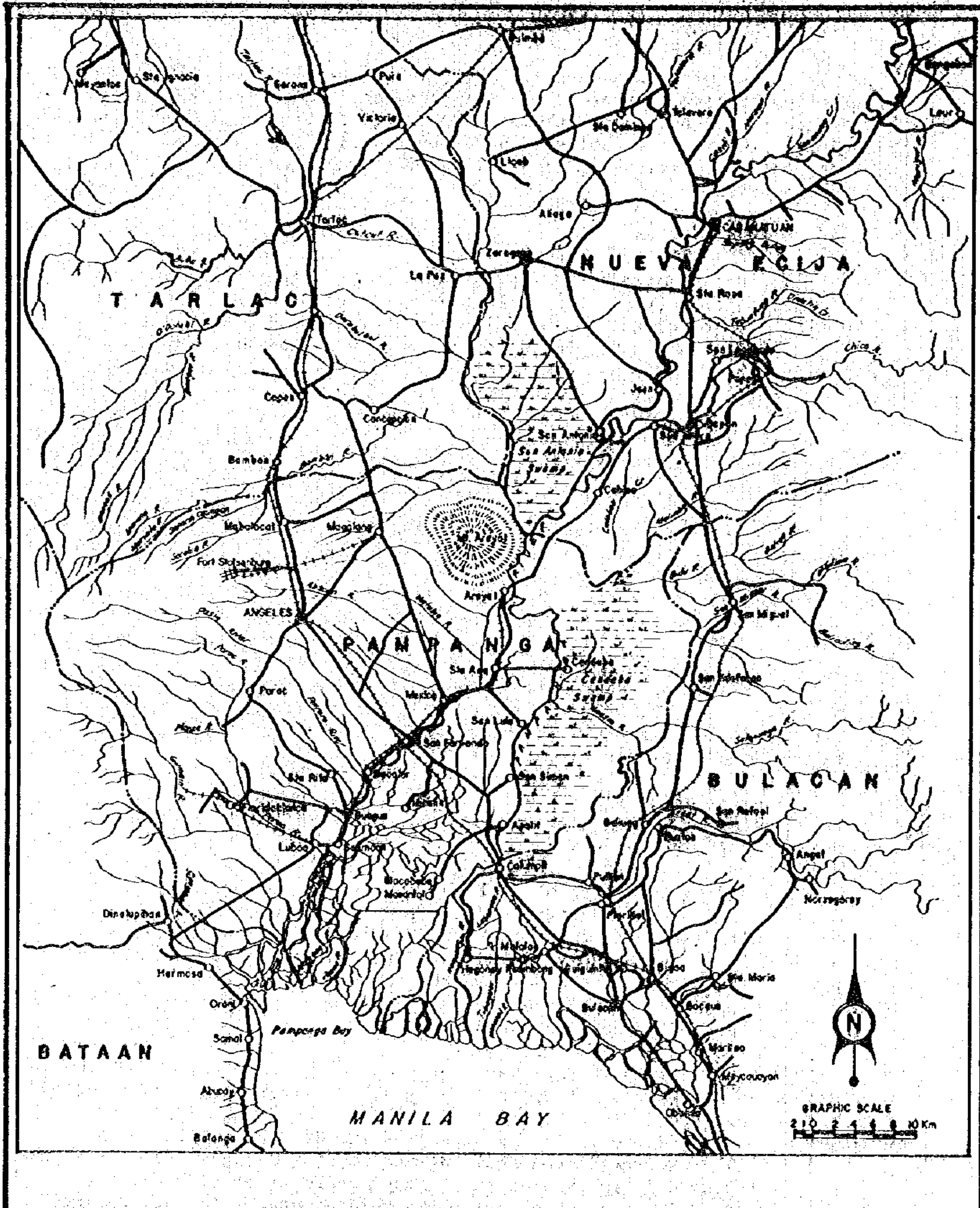


Fig. I-10 LOCATION MAP OF PROJECT AREA.

III-2 Current Net Work of Observation

The Pasig-Potrero River is located between north latitude 15°00'N and 15°08'N, east longitude 120°25'E and 120°38'E, with a catchment area of 125 km^2 and a total length of 35 km. According to the plan of B.P.W., the catchment area is 44 km^2 at the Mancatian Brdige. This value is adoptable because the levees in its down streams do not allow residual water to flow into the main stream. Observation stations are well installed considering a small catchment area; 22 rainfall observation stations (7 automatic rainfall gauges included), 7 water level observation stations (3 in the Pasig-potrero River, 2 in the Porac River and 2 in the Gua-Gua River), all of which equip staff gauges, as shown in FIGURE I-13.

III-3 Accessible Data Existing Condition

The present conditions of the accessible data at above mentioned observation stations in a period of 1945-1977 are shown in TABLE I-4 and TABLE I-6. These observation stations are under the superintendence of the four administrations mentioned below.

a) PAGASA; Philippine Atmospheric Geophysical and Astoronomical Service Administration

b) NIA; National Irrigation Administration

c) B.P.W; Bureau of Public Works

d) P.S.C; Philippine Sugar Commission

Rainfall data are supposed to be collected at the Main Office of PSC from each observation station (No. 15 - No. 20) through the Branch Office at Der Carmen where observation records are preserved. However, only monthly rainfall records could be obtained. Data in the Clark Air Base at Angels which were recorded every six hours have been collected from the United States thanks to Detachment 5, 1st Weather Wing.

Water level and discharge data of the Porac River and the Pasig-Potrero River have been recorded at Der Carmen since 1945 and at HDA Dolores and Cabetican Bacolor since 1966 respectively.

At the Mancatian Bridge (No. 5), S.L. Gua-Gua (No. 6) and S.F. Minalin (No. 7) observation stations, which area newly constructed in March of 1977, no observation records can be found. Periodical observation is recommended at these stations in the same way of other four stations. Especially at the Mancation Bridge along the Pasig-Potrero River, the Bacolor Bridge now under construction and a high-way bridge located between the two bridges mentioned above, staff gauges should be installed because it is advantageous to observe the high water level during a flood. And it is recommended that an observation network covering the whole river basin be prepared and improved considering the relation with other places such as HDA Dolores, S.F. Minalin and S.L. Gua-Gua to comprehend the runoff mechanic in the basin whose river bed is exposed in an ordinary condition.

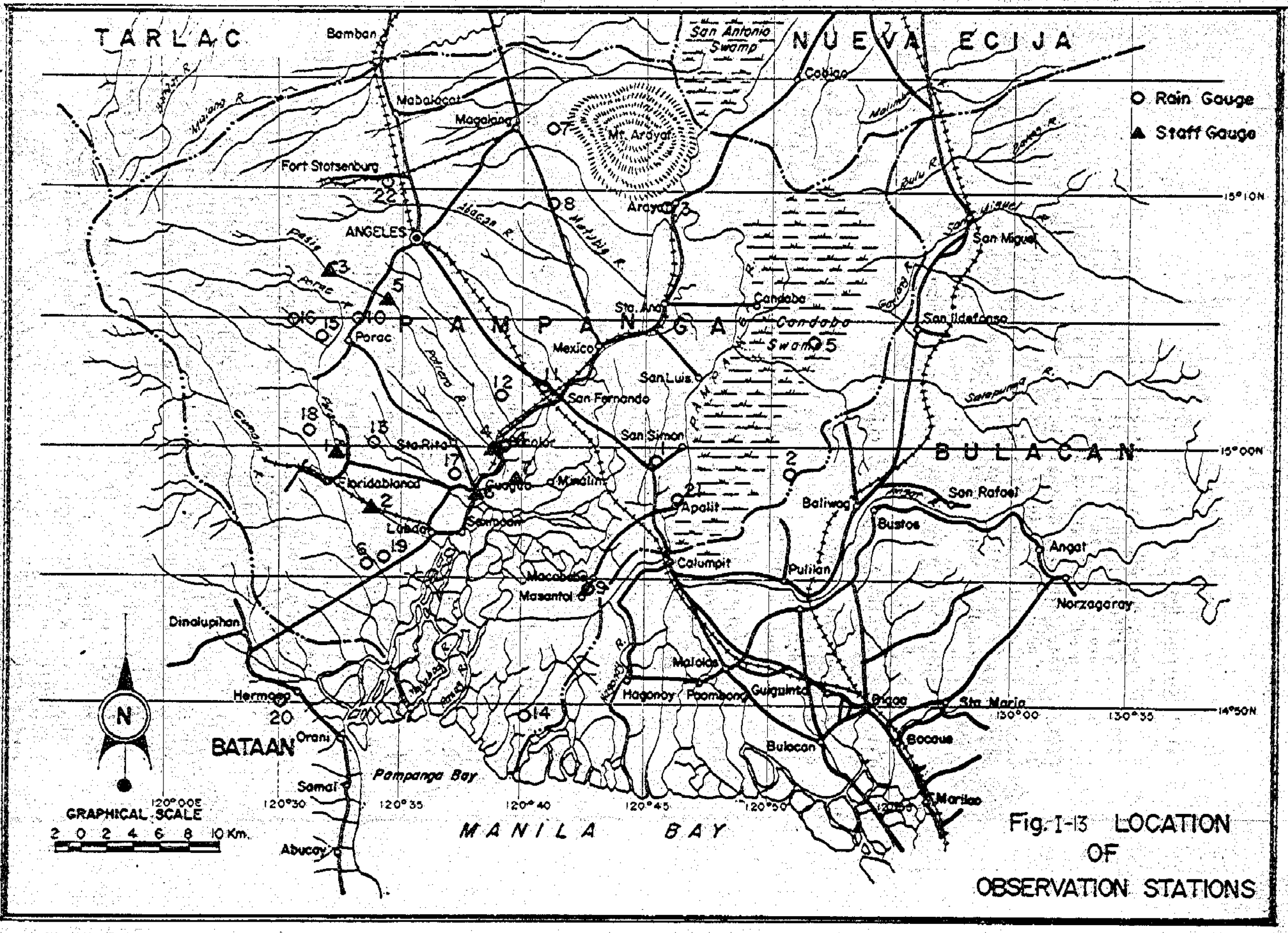


Fig. I-13 LOCATION OF OBSERVATION STATIONS

Table I-4 RAINFALL DATA EXISTING CONDITION

Observation Station	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	Remarks
	Data Existing Condition (19 —)																																	
1 Casinula, Apalit	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	▲	●	▲	●	●	●	●	▲	▲	▲	▲	
2 Balucuc, Apalit	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	○	○	△	
3 San Agustin, Arayat	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	▲	▲	▲	▲	▲	●	▲	▲	▲	▲	▲	▲	
4 Bacolor	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	△	○	○	○	○	○	○	△	*	
5 Bahaypare, Candaba	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	△	○	△	
6 Lubao, Pampanga	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	▲	▲	▲	
7 Magaran	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	○	
8 PAC Magaran	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	○	○	
9 Masantol	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	△	○	○	○	○	○	○	△	*	
10 Sta Cruz, Porac	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	▲	▲	▲	▲	▲	●	●	●	▲	
11 San Fernando	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	○	○	○	○	○	○	△	*	
12 Dar Common San Fernando	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	▲	▲	▲	
13 Becuran, Sta Rita	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	○	○	△	
14 San Matias, St. Thomas	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	▲	▲	▲	
15 Mancatian, Porac	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	○	○	△	Monthly Only
16 Babo Pangulo, Porac	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	△	△	△	"
17 San Pablo, Guagua	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	○	○	△	"
18 San Pedro, F. Blanka	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	○	○	△	"
19 Sta Maria, Lubao	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	○	○	△	"
20 Hermosa, Bataan	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	○	○	△	"
21 PRCS Apalit	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	●	▲	*	*	
22 Clark Field Air Base	/	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	Every Six Hours
23 MIA Manila	/	/	/	/	○	○	○	●	●	●	●	▲	/	/	/	●	●	●	▲	▲	●	●	●	●	○	○	△	○	△	○	△	△	△	
24 Diliman Science Garden	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	○	○	○	○	○	●	○	△	▲	●	▲	▲	▲	*	*	

[Legend] ○ : Data Exist, △ : Data Exist Incompletly, / : No Data (●, ▲ : Include Hourly Record)

* : Supose to be exist but not yet avairable

TABLE I-5 LIST OF RAINFALL OBSERVATION STATION

NO.	Observation Station	Coordinate Long.	Coordinate Lat.	Elevation (MSL)	Date of Establishment	Observer	Administrative Office	Current Operation D:Daily H:Hourly		Remarks
1	Casinala, Apalit	14°58N	120°46E	2.0m	Aug 1967	Carlos Ramos	PAGASA	O	H	
2	Balucoc, Apalit	14°58N	120°52E		Jun 1975	Lorefo Banal	PAGASA / NIA	O	H	
3	San Augstin, Arayat	15°09N	120°46E		Jun 1966	Donisio DungCa	TRP / PAGASA	O	H	
4	Bacotor	15°00N	120°39E	5.0m	1969	Eduardo Maitari	PAGASA	O	D	
5	Bahaypare, Candaba	15°04N	120°52E		Jun 1975	Rogerio Cunanan	PAGASA / NIA	O	H	
6	Lubao, Pampamga	14°56N	120°33E		Jul 1975	Piosdado Vitag	TRP	O	H	
7	Magalang	15°13N	120°42E		1977	Aloria Manalili	CRS	O	D	
8	PAC Magalan	15°13N	120°39E		1976	Sase Mariwaf	PAGASA	O	D	
9	Masantol	14°54N	120°43E	3.0m	1969	Primo Y Buslos	〃	O	D	
10	Sta Cruz, Porac	15°05N	120°33E		Feb 1969	Ricardo T Yotung	〃	O	H	
11	San Fernando	15°02N	120°42E	5.0m	1920~1932 1970	Ruirino Sanchez	〃		D	
12	Der Carmen, San Fernado	15°02N	120°38E		Jul 1973	Luzrismiuda Diaz	〃	O	H	
13	Becuran, Santa Rita	15°00N	120°34E		Jul 1975	Teodoro Cayanon	〃		H	
14	San Matias, St Thomas	14°49N	120°40E	8.0m	Jul 1975	Elelyn Datahan	〃	O	H	
15	Mancation, Porac	(15°04N)	(120°32E)		(1975)	Peue De Mesa	PSC	O	D	Monthly only
16	Babo Paugto, Guagua	(15°05N)	(120°31E)		(1975)	Jaime Chan	〃	O	D	〃
17	San Pablo, Guagua	(14°58N)	(120°37E)		(1975)	Pblo Malang	〃	O	D	〃
18	San Pedro, F. Blanka	(15°01N)	(120°31E)		(1975)	Honoris Tuazan	〃	O	D	〃
19	Sta Maria, Lubao	(14°56N)	(120°34E)		(1975)	Francisco Macuspal	〃	O	D	〃
20	Herwasa, Bataan	(14°50N)	(120°30E)		(1975)	Autonio Hauatili	〃	O	D	〃
21	PRCS Apalit	( )	( )		1972	Mr Ladislao	FFC / BPW	O	H	
22	Clark Field Air Base	15°11N	120°33E	160.0m	1945	James O Ivory	USAF	O	D	
23	MIA Manila	14°06N	121°01E	3.5m	1949	Rodolfo Felisalta	PAGASA	O	H	
24	Dilimon, Science Gorden	14°39N	121°03E	15.0m	1963	Elisio Salazar	〃	O	H	

(Legend) PAGASA : Philippine Atomospheric Geophysical Astoronomical Services Administration, NIA : National Irrigation Administration,
CRS : Cooperative Rainfall Station, BPW : Bureau of Public Work, PSC : Philippine Sugar Commission, TRP : Tarac River Project,
WBFC : Weather Bureau Focasting Control, USAF : United State Air Force.

TABLE I-6 WATER STAGE DATA EXISTING CONDITION

Water Stage

No.	Observation Station	Data Existing Condition (19–)																																	Remarks
		'45	46	47	48	49	'50	51	52	53	54	55	56	57	58	59	'60	61	62	63	64	65	'66	67	68	69	'70	71	72	73	74	'75	76	77	
1	Der Carmen	Δ	O	O	O	O	O	O	O	O	O	O	O	O	O	O	Δ	O	O	O	O	O	O	O	O	O	O	O	Δ	/	/	/	/	/	
2	Valdez	/	/	/	/	/	/	/	/	/	/	/	/	/	Δ	O	O	O	Δ	O	O	O	Δ	O	O	O	O	O	O	Δ	O	O	O	Δ	
3	HDA Dolores	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	Δ	Δ	Δ	O	O	O	Δ	/	/	/	/	/	
4	Cabetican Bacolor	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	Δ	Δ	O	O	O	O	O	O	O	O	O	Δ	
5	Manation Bridge	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	
6	S.L. Guagua	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	
7	S.F. Minalin	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	
8																																			
9																																			
10																																			

Discharge

No.	Observation Station	Data Existing Condition (19–)																																	Remarks
		'45	46	47	48	49	'50	51	52	53	54	'55	56	57	58	59	'60	61	62	63	64	'65	66	67	68	69	'70	71	72	73	74	'75	76	77	
1	Der Carmen	Δ	O	O	O	O	O	O	O	O	O	O	O	O	O	O	Δ	O	O	O	O	O	O	O	O	O	O	O	Δ	/	/	/	/	/	
2	Valdez	/	/	/	/	/	/	/	/	/	/	/	/	/	Δ	O	O	O	Δ	O	O	O	Δ	O	O	O	O	O	O	Δ	O	O	/	/	
3	HDA Dolores	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	Δ	Δ	Δ	O	O	O	Δ	/	/	/	/	/	
4	Cabetican Bacolor	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	Δ	Δ	O	O	/	/	/	/	/	/	/	/	
5	Manation Bridge	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	
6	S.L. Guagua	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	
7	S.F. Minalin	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	
8																																			
9																																			
10																																			

TABLE I-7 LIST OF WATER STAGE OBSERVATION STATION

	Observation Station	River	Type of Gauge	Cordinate		Date of Establishment	Administrative Bureau	O-Point Elevation (M.S.L)	Present Operation	Observer	Remarks
				Long.	Lat.						
1	Der Carmen	Porac	Staff Gauge	14°59'N	120°32'E	Nov. 1910	B. P. W	18.016 m	O		3 times (6:00 AM, 12:00 PM 6:00 PM)
2	Vardez	〃	〃	14°58'N	120°32'E	Oct. 1958	〃	12.886	O		3 times (7:00AM, 12:00 PM, 5:00 P.M)
3	HDA Dolores	Pasig Potorero	〃	15°06'N	120°31'E	Sep. 1966	〃	7.572	×		2 times (7:00AM, 5:00 PM)
4	Cabetican Bacolor	〃	〃	15°59'N	120°38'E	Apr. 1965	〃	4.499	O		2 times (7:00 AM, 5:00 P.M)
5	Mancation Bridge	〃	〃	(15°05'N)	(120°33'E)	Mar. 1977	〃	M.S.L	O		
6	Sapang Labuan, GuaGua	Gua Gua	〃	(14°58')	(120°37')	Mar. 1977	〃	〃	O		
7	San Francisco, Minalin	〃	〃	(14°57')	(120°39')	Mar 1977	〃	〃	O		
8											
9											
10											

Note:

PAGASA:	Philippine Atomospheric, Geophysical Astoronomical Service Administration
NIA:	National Irrigation Administration
BPW:	Bereau of Public Work
PSC:	Philippine Sugar Comission
TRP:	Tarac River Project
USAF:	United States Air Force

B.M. Height

i)	Mancatian Bridge:	TBM = 96,228 m
ii)	Porac Bridge:	BM = 69.723m
iii)	Cabetican Bocolaor:	BM = 4,414 m
iv)	San Matias:	BM = 3.153 m
v)	Sanfrancisco Minalin	TBM = 2,663m (On the Gate of Church).
vi)	Gua-Gua:	BM = 2,388m (PA No. 41)
vii)	Zaldez Bridge	BM = 21,219 (PA No. 69)

[Legend[]

* B.M is the elevation from M.S.L. surveyed by Geodetic and coastal Survey in 1956.

** [Bureau of Coast and Geodetic Survey, Special Publucation No. 200A First Order leveling in the Province of Tarac, Pampanga, Zambales and Bulacan] Region 1V.