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FOREWORD

The Pilot Flood Forecasting and Warning System in the Pampanga River Basin was instituted jointly by the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) and the Bureau of Public Works (BPW) of the Government of the Republic of Philippines as part of the ESCAP/WMO Typhoon Committee activities, and it has been in operation since September 1973.

The Government of Japan, upon the request of the Government of the Republic of Philippines, participated in the project and offered technical supports of dispatching survey teams, donating equipments and materials, providing services of specialists and experts and training the Philippine officers.

The system is a very useful one as a whole and has exhibited its function and proved very effective in the instances of flood in the past. However, it still involves a number of problems to be resolved urgently such as improvement of the hydrological techniques relative to forecasting and establishment of a system for effective maintenance and operation of telecommunication facilities.

This Manual is intended to provide procedures for the Government of the Republic of Philippines to follow in maintenance and management of the hydrological as well as telecommunication facilities for integral operation of the system. It may not be necessary to state here that the facilities of the system require constant maintenance and inspection in an effort for further improvement of the system, and it is hoped that this Manual will be helpful in such instance.

Finally, it is our sincere desire that the this system will serve as a typical model for relieving the people of the Philippines from the damage of flood and contribute to further development of the Republic of Philippines and promotion of the friendly relationship between the nations of the Philippines and Japan.

Chapter 1 Flood Forecasting Operation Manual

1. Maintenance and Management of Machines and Facilities

(1) Hydrological Observation Equipments and Facilities

1) Routine inspection

A) Patrol

(i) In order to maintain the equipments and facilities in proper operating conditions, periodical inspection and maintenance are required.

(ii) The watchman should perform the patrol, inspection and maintenance in accordance with the Instructions for Patrol of Rain Gauge Station and of Water Level Gauging Station.

(iii) The watchman should note the following particularly:

(a) If the recording pen is inked properly;

(b) Any clogging in the water piping (difference in the reading between the inside and outside gauges); and

(c) Any clock advance or delay.

(iv) The watchman should carry predetermined spare parts. Before departure for patrol, he should check the spare parts against the checklist specifying the names and quantities of required spare parts.

(v) After the patrol work, the watchman submits the report of the patrol.

(vi) The supervisor takes appropriate actions upon the patrol report.

B) Stock of spare parts

(i) A stock of spare parts should be maintained at the Center to meet demands at any time.

(ii) An inventory should be prepared to indicate the names and quantities of spare parts in stock.

(iii) For any spare part in shortage, a purchase procedure should be taken immediately.

2) For flooding

A) Surveillance

(i) When a flood is foreseeable, it is desirable to look over the principal stations in haste and check the three points specified in (1) 1) A) (iii) above.

(ii) As soon as the flood is over, it is also desirable to inspect the facilities for any damage in addition to the points referred to in (i) above.

B) Discharge observation

(i) At the water level observatory station, efforts should be exerted to continue observation of the discharge up to about maximum water level so that a water level-discharge formula is established.

(2) Telecommunication Facilities

1) Routine inspection

i) Responsible persons for one week shifts of inspection are determined. (When such a responsible person is in travel on duty, absent or otherwise not present, a vicarious person shall assume the task.)

ii) The responsible person should make entry to the journal and perform inspection of the following everyday.

a) If the room is properly arranged and kept in order.

b) Monitor the record of regular observation carried out at 08:00 hours every morning, and check for any anomality.

c) Adjust the accumulation rainfall counter at 08:00 hours every morning.

d) Check the time and data displays to see that they are correct.

e) Perform the lamp test of the display panel to insure that the lamp is not broken.

f) Check for any failure or difficulty in the other equipments.

2) Monthly inspection

i) Perform the following before a monthly inspection is conducted.

a) Prepare a schedule of the monthly inspection.

b) Before starting for the monthly inspection, there should be a meeting held at the Flood Forecasting Center (FFC) concerning the inspection. At the meeting, the following matters should be confirmed, and necessary arrangements therefor should be made.
Where there is a problem in the hydrological observatory facilities, a prior meeting should be had with hydrological engineers invited, and necessary arrangement be made with the BPW Apalit Office, if required.

(I) If the inspection schedule is not hard.

(II) Any station having a failure or difficulty currently.

(III) If any, examine the prospected causes in advance, and work out measures for the procedure of correcting the failure, etc.

(IV) What to do with the matters in suspension from the time of the preceding inspection?

(V) Check against the checklist what measuring instruments are to be carried.

(VI) Check the spare parts to be carried against the checklist.

(VII) In the case of a monthly inspection in rainy season, see if a vessel is available for use in the Candaba Swamp.

ii) The monthly inspection should be carried out as set forth in the following.

a) The inspection should be carried out for each station in accordance with the separate check sheet.

b) Where a hydrological problem is anticipated, the patrol staffs should include a hydrological engineer.

c) The inspection covers maintenance of precision instruments and telecommunication equipments so that the respective stations should conduct cleaning and proper arrangement in advance with particular care given for dust proofing.

d) In the measurements where meters are used, be sure to confirm the range selector of the meter at each measurement.

e) In the maintenance of alkaline batteries, tools for general maintenance should never be used for maintenance of lead storage batteries or other applications.

f) Trees around the station should have the branches trimmed occasionally so that the efficiency of solar batteries would be enhanced. Particularly, special care should be exercised for the Ipo and Dapaya Stations.

g) Check if the consumables (such as recording ink) provided in the respective stations are in shortage.

h) For the FFC, BPW and Sam Rafael and Apalit Stations, check the fuel, oil, etc. for the standby power equipment, and perform exercise operation of the standby equipment.

2. Forecasting Calculation Work

(1) Values of Measurement

1) Data screening

Telemetric values of measurement of the rainfall and water level are transfered onto the Table of Hourly Rainfall by Station (Form-1) and Table of Hourly Water Level by Station (Form-2). Simultaneously, hourly changes at the respective stations are drawn in graphs. Where a sharp change is observed in the rainfall or water level with respect to the place or time, it is important to consider if such is an actual phenomenon or due to a mechanical failure.

2) Diagrammatical representation

For precise understanding of the phenomenon, it is recommended to represent the change with time or place of the rainfall or water level in a diagram.

For the rainfall, plot the hourly and daily rainfalls on a specified form to give isohyetal curves and thus grasp where a heavy hyetal region is present in the basin and what is its movement with time.

For the water level, indicate the change with time for each station on a graph and thus grasp if and where a heavy hyetal region is present.

3) Supplementing the lacks of measurement

It is realistic to consider that the values of measurement of the rainfall and water level transmitted over the telemetry are not complete but are rather more or less ;acking and thus consider some measure of compensation beforehand.

Usually, such a lacking value of measurement is substituted by a value of measurement at a nearby point. In such a case, however, it is a precondition that the point of measurement failure and that of the substitution belong to a rainfall region of the same pattern respectively. Compensation of such measurement failure requires further study.

(2) Calculation Work

1) Calculation system

The method of calculation of runoff for flood forecasting is in accordance with

2) Work sheet

While the values of measurement are put into a computer for computation, the values of measurement used and those obtained through computation are entered on a specified format.

3) Reporting

When the forecast values are provided from the values obtained through computation, the past experience as well as the inaccuracy of the data should be taken into consideration so that they are announced with safety allowance incorporated in the water level and time of occurrence.

3. Themes for Further Study

(1) Improvement of the Calculation System

In the calculation system currently employed, the rainfall is represented by a mean value of the basin. Then, it will not be difficult to understand that a system taking more detailed distribution of rainfall into consideration with the basin divided into some sections will give more accurate values.

In view of the increasing social requirement for more accurate and faster forecasts, improvement of the calculation system should be initiated immediately.

(2) Supplementing the Lacks of Rainfall Measurement

Relationship between the rainfall distributions in the past storms and the climatic conditions is to be examined to investigate the types of rainfall pattern in the basin. Further, correlationship of the values of measurement of rainfall in the same rainfall region should be provided, and upon such correlationship, the rainfalls at the adjacent rain gauge stations are to be estimated.

(3) Development of Simple Calculation Formula

In this basin, large floods occur usually in July and August, but when medium floods are included, the flood season extends from May to September. It is a very difficult task to be alert continuously for more than half a year for flood forecasting. Therefore, it is also important to consider a simple formula which allows for a few people to calculate and thus enter into an alert.

(4) Effective Rainfall

In the formula employed currently, the consideration of the effective rainfall for runoff at the time of a flood is not exhausted. Thus, the past hydrological data should be arranged to clearly formulate the concept for the loss of the rainfall in the basin.

(5) Hydraulic Analysis of Swamp

The basin includes two swamps, and hydraulic analysis of these swamps will become necessary for improving the accuracy of flood forecasts in the future. Collection of data for basic hydraulic analysis should, therefore, be initiated.

4. Check Sheet

Republic of the Philippines
Department of National Defense
PHILIPPINES ATMOSPHERIC, GROPHYSICAL AND
ASTRONOMICAL SERVICES ADMINISTRATION (PACASA)
Quezon City

FLOOD FORECASTING AND WARNING SYSTEM IN THE PAMPANGA RIVER BASIN

STATION NAME ______________________

DATE ____________________ TIME ____________________ CHECK BY ____________

CHECK LIST

(TELMETRY GAUGING STATION)

1. CONNECTION

Check the wiring connection between each equipment. ___________

2. GAUGING FUNCTION

Check the gauging operation by pushing the manual test button

"TEST 1" ____________________

"TEST 2" ____________________

3. COMMUNICATION

Check the press-to-talk communication function by the hand-set. ______________

(To talk to the terminal station, make the repeater stations start in repeating operation.) After your communication, turn off the "MON" switch and pull off the connector of hand-set. _______________

4. SOLAR BATTERY

Check the dirt ___________ and crack of the surface. _______________

5. ALKALINE STORAGE BATTERY

Check the output voltage PC __________ V and level of the electrolyte. ____________

6. RAINFALL GAUGE

Remove the dust ________ and dead leave out of rainwater receiver. ______________
(Especially Ipo Station)

7. RAINFALL RECORDER

Replace chart _______ recording ink _______ battery ________ clean pen ________

Adjusted pen _________________ Adjusted time ________________________

8. WATER LEVEL GAUGE (NKC-404)

Check the float ___________ pulley _____________ wire ____________

Wind the clock ____________Replace the recording chart ______________

Recording ink _____________Clean pen _________________

Adjusted pen _____________ Adjusted time ____________

9. WATER LEVEL GAUGE (TAKUWA)

Check the gauging operation by manual test. _______________

Replace the clock battery for 1 year _________ Recording paper _________________

10. BATTERY TEST

TERMINAL NO.	1	3	5	6	8	10
Specific Gravity						
Voltage						

11. TENPERATURE __________________ °C

CHECK DATA SHEET (I)

I. TELEMETRY EQUIPMENT

I. NSE - 299 Transmitter

Item	Measuring Point	Rating	Measured	Remarks
OUTPUT POWER	CONNECTOR ANT.	0.5 - 1.2 W	W	POWER METER
PW	CHECK TERM. PW	2 - 5 VDC	V	TESTER
+ 11V	CHECK TERM. 11 V	9 - 11 VDC	V	TESTER

2. HXA - 3450 Power Amplifier

Item	Measuring Point	Rating	Mesured	Remarks
INPUT POWER	CHECK TERMINAL CONNECTOR ANT.	0.5 - 1.2 W	W	POWER METER
OUTPUT POWER	CONNECTOR ANT.	1.5 - 3.6 W	W	POWER METER
PW	CHECK TERM. PW	2 - 9 VDC	V	TESTER

3. NRE - 300 Receiver

Item	Measuring Point	Rating	Measured	Remarks
LOC. CURRENT	CHECK TERM. LOC.			TESTER
LIM. CURRENT	CHECK TERM. LIM.			TESTER
DISC. CURRENT	CHECK DISC.			TESTER
R OUTPUT	CHECK TERM. ROUT	-26 ± 6 dBM		LEVEL METER

4. TELEMETRY EQUIPMENT

Item	Measuring Point	Rating	Measured	Remarks
INPUT DC 12V		DC 12V ± 20%	V	TESTER
START DG 5V	PX 127R 5V	5 ± 10%	V	TESTER
MOD. IN FS SIG.	PX 127R FS	-10 dBM ± 3dBM	dBM	TESTER
SQ. OPEN + 7V	PX 128P 7V	6.5 - 8.5 V	V	TESTER
SQ. OPEN + 7V	PX 128P 7V	6.5 - 8.5 V	V	TESTER
CLOSED SQ. VOLT	PX 128P SQ.	-5 - -7V	V	TESTER
CONT. SIG. VOLT	PX 128P CONT. V	MORE THAN 3, 5	V	TESTER

CHECK DATA SHEET (II)

1. SOLAR CELL POWER BOX

Item	Rating	Measured	Remarks
BATTERY TERMINAL VOLTAGE (Vb)	30 V	V	CHECK METER
SOLAR BATTERY OPEN VOLTAGE V (Vop)	30 V	V	CHECK METER
CHARGE CURRENT (In)	1 A	A	CHECK METER
SOLAR BATTERY SHORT CIRCUIT CURRENT (Ish)	1 A	A	CHECK METER
OPERATING CURRENT (I_{L1})	5 A	A	CHECK METER
WAITING CURRENT (I_{L2})	50 μA	μA	CHECK METER

2. REMARKS AND RECOMMENDATION:

Chapter 2 Chronology

Mar 1964 The Twentieth Session of the ECAFE WMO and ECAFE Secretariat were recommended to study problems concerning typhoon.

Dec 1965 The First Typhoon Experts Conference (in Manila).

Dec 1966 - Apr 1967

The Typhoon Mission (Dr. T. Takenouchi and Dr. S. N. Sen) visited ten countries for survey, and recommended to specified a key basin for each country and to provide a pilot flood forecasting system. Reported at the Second Experts Conference.

Oct 1967 The Second Typhoon Experts Conference (in Bangkok).

Dec 1968 The First Session of the Typhoon Committee (in Bangkok).

The Philippine Government reported efforts for development of a pilot flood forecasting system and organization for the Pampanga River basin and requested support of the Japanese Government for integral survey, dispatch of experts and technical cooperation.

Dec The First Conference on Typhoon Damage Control (in Bangkok).

Concurrence of the respective countries to the requirement of a preliminary survey and the Dr. Takenouchi's recommendation confirmed.

Nov-Dec 1969

The First Survey Team dispatched.

Data collection, feasibility survey and system proposal.

(Name)	(Capacity)	(Official Title)
Yutaka INADA	Head	Consulting Engineer, River Bureau, Ministry of Construction
Toshio TAKENOUCHI	Consultant	Professor, Civil Engineering Department, Tokyo Institute of Technology
Kiyohide TAKEUCHI	Meteoro-gist	Deputy Head, Applied Meteorological Section, Observation Division, Japan Meteorological Agency
Terumi NAWATA	River Engineer	Deputy Head, River Improvement Division, River Bureau, Ministry of Construction
Takeo KINOSHITA	Hydrolo-gist	Head, Section of Hydrology, Public Works Research Institute, Ministry of Construction
Takayoshi YAMAMOTO	River Engineer	Chief, Operation Control Center for the Tone River Dams, Kanto Regional Construction Bureau, Ministry of Construction
Osamu TSUMURA	Tele-communica-tion Engineer	Deputy Head, Electricity and Telecommunications Division, Minister's Secretariat, Ministry of Construction

Kenichi SASAKI	Hydrologist	Deputy Head, River Planning Section, River Division, Tohoku Regional Construction Bureau, Ministry of Construction
Kiyoshi YAMANAKA	Telecommunication Engineer	Engineer, Electricity and Telecommunications Division, Minister's Secretariat, Ministry of Construction

Dec The Second Session of the Typhoon Committee (in Manila).

Mr. Takeuchi explained the survey generally.

Nov 1970 The Third Session of the Typhoon Committee (in Bangkok).

The Philippine representative expressed appreciation for the dispatch of the Japanese Survey Team.

May 1971 The Philippine Government requested support for the equipment and materials of the Flood Forecasting and Warning System in the Pampanga River Basin.

Feb 1972 The Second Survey Team dispatched.

Collection of data for construction design (mainly relative to telecommunications).

Shigeki YOSHIOKA	Head	Deputy Head. Electricity and Telecommunications Section, Minister's Secretariat, Ministry of Construction
Kiyoshi YAMANAKA		Engineer, Technical Integrity Division, Tokyo Expressway Public Corporation

Katsuo MUGISHIMA	Electricity and Telecommunications Section, Minister's Secretariat, Ministry of Construction

Dec	Donation of the equipment and materials determined. Exchange of letters between the Philippines and Japan (Philippine Foreign Minister Romulo - Japanese Ambassador Urabe).
Dec	Agreement on equipment. Between the Government of Philippines and the Japan Radio Company (Kintanar - JRC President). Total ¥80,000,000.
Mar 1973	Dispatch of experts for system installation requested.
Apr	Plant manufacture of the system completed.
May	Shipment of the system.
Jun	Experts dispatched for installation and adjustment.

Hiroshi MIYAI	Hydrologist (1.5 months)	Specialist, Planning Division, Kinki Regional Construction Bureau, Ministry of Construction
Shigeki YOSHIOKA	Telecommunication Engineer (1 month)	Deputy Head, Electricity and Telecommunications Section, Minister's Secretariat, Ministry of Construction
Masamichi KOMURA	Telecommunication Engineer (2 yrs, extended for additional 0.5 yr)	Planning Division, Kanto Regional Construction Bureau, Ministry of Construction

Aug	Expert dispatched.		
	Hideaki ODA	Hydrologist (3 months)	Head, Investigation Section, Fukushima Construction Work Office, Tohoku Regional Construction Bureau, Ministry of Construction
Sep	Completion Ceremony Attendants		
	Hon. David Consunji		Secretary, DPWTC
	Dr. Roman L. Kintanar		Administrator, PAGASA
	Mr. Juanito F. Lirios		Weather Services Coordinator
	Mr. Toshio Urabe		Ambassador of Japan
	Hon. Manuel Salientes		Under-Secretary, DND
	Dr. S. N. Sen		Chief, Typhoon Committee Secretariat
	Hon. Brigino Valensia		Governor of Pampanga
	Hon. Corlosro Castillo		Asst. Director, BPW
May 1974	Expert dispatched		
	Kiyotaka MUKAI	Hydrologist (7.5 months)	Consulting Engineer, Iwate Construction Work Office, Tohoku Regional Construction Bureau, Ministry of Construction

Aug	Toshio TAKEUCHI	Hydrolo-gist (1 month)	Professor, Defense Academy

Participants to Training

1969	Mr. Ernesto Reyes	Civil Engineer, B.P.W.
	Mr. Enrique Madamba	Chief of Designing Branch, Flood Control & Brainage Div., B.P.W.
	Mr. Epifanio Sadang	Meteorologist, Weather Bureau
1970	Mr. Nestor Canuel	Senior Meteorologist, W.B.
	Mr. Jacinto Reyes	Hydrographic Engineer II, B.P.W.
1971	Mr. Carmelino Villegas	Hydrographic Engineer I, B.P.W.
	Mr. Bayani S. Lomotan	Chief of Climatological Div., W.B.
1972	Mr. Javito A. Navarro	Hydrographic Engineer I, B.P.W.
1973	Mr. Arturo P. Ladislao	Hydrographic Engineer, B.P.W.
	(Individual)	
	Mr. Macaraig Zacarias	Acting Chief Hydrometeorological Div., W.B.
	Mr. Marquez Particto	Hydrographic Engineer I, B.P.W.
	Mr. Simeon Liccardo	Senior Meteorologist, W.B.
	Mr. Loreto Baraugan	Radiophone Operator, W.B.
	Mr. Victor M. Valdes	Junior Mechanical Electrical Engineer, B.P.W.
	Mrs. Lim	Senior Meteorologist, W.B.
1975	(Individual)	
	Mr. Francisco Rugayan, Jr.	Radiophone Operator, W.B.

Mr. Borja Jr.	Meteorologist, W.B.
Mr. Kagahastian	Chief, Water Resources Survey Div., B.P.W.
Mr. Lirios	Deputy Weather Service Chief, W.B.

Chapter 3 Pampanga River Basin Flood Forecasting and Warning System

1. Climate of Philippines

1-1 Monsoon

In Fig. 1a and 1b are shown the general directions of wind in January and July, the wind blowing over the Philippines from the northeast in January and from the southwest in July.

Fig. 1a Wind direction in January.

Fig. 1b Wind direction in July.

In January, a strong anticyclone as high as 1035 mbar or more is present over the Siberian Continent, while a low pressure region in the form of a strip is present over New Guinea to the northern part of Australia.

The seasonal wind from Siberia blows over Japan and Ryukyu Islands into the northeast monsoon over the Philippines. It appears from about October and is most prevalent in January but disappears in April.

In July, an anticyclone of 1024 mbar or more is present over the Indian Ocean, and the blow from the anticyclone becomes the southwest monsoon. Usually, it begins to appear in May and is most prevalent in August but disappears in October.

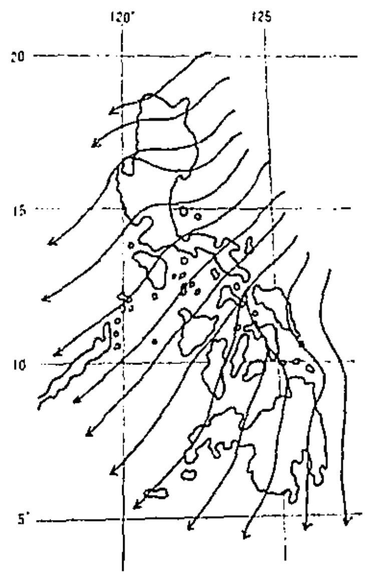


Fig. 1a Wind direction in January

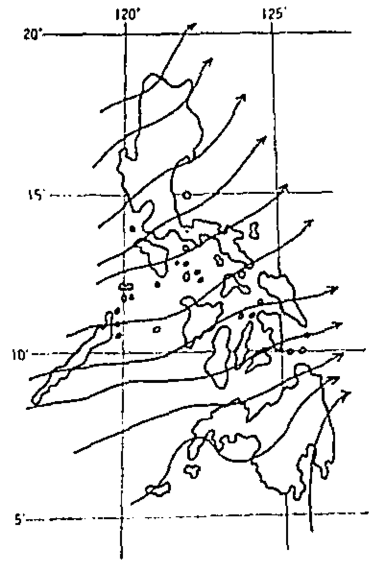


Fig. 1b Wind direction in July

1-2 Climatic Classification of Philippines

The climate of Philippines is classified in many ways by a number of scholars. In Fig. 2 is illustrated the classification proposed by Coronas in 1920. With little difference of temperature over the Philippines, Coronas noted the annual distribution of the monthly mean rainfalls and classified the climate of Philippines into four types.

1st Type: Dry season (less than 50 m/m) of winter and spring (for 3 to 7 months) and wet season of summer and autumn (for the rest).

2nd Type: No dry season but the rainfalls are particularly great in December or January normally.

3rd Type: Dry season lasting only to 1 to 3 months in winter or spring. This type is close to the 1st type.

4th Type: Rainfall is relatively small in winter, but no dry season, and in this respect, this type is close to the 2nd type.

The classification into these four types is more or less related to the monsoon described in paragraph 1-1. The East coast has many rains in winter and some rain in summer. The West coast has many rains in summer but is dry in winter. The annual mean precipitation of the Philippines as a whole is slightly over 2500 mm.

〈図－4〉 Coronasによる気候分類図

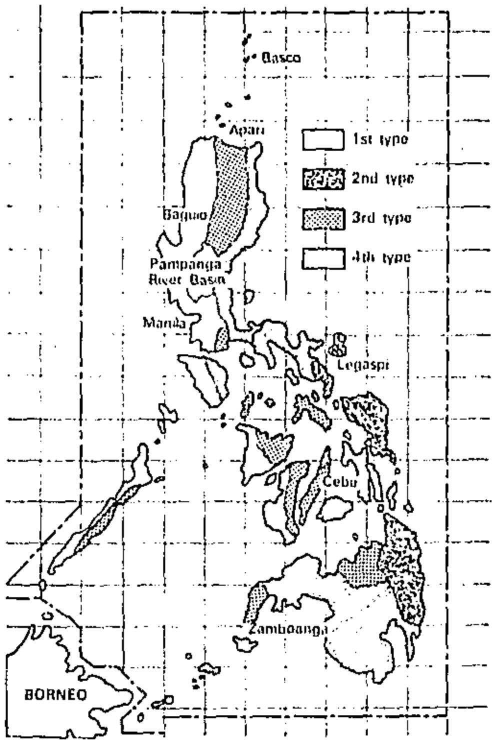


Fig. 2 Climatic classification by coronas

1-3 Tropical Cyclones

The Philippines is present in the area of the highest frequency of occurrence of tropical cyclones in the world. In the West Pacific Ocean and China Sea (5°-30° north; 105°-150° east), there are average 22 tropical cyclones generated annually. Tropical cyclones affecting the Philippines in one way or another are largest in number in August, and those occurring from June to December constitute about 89 percent of the whole.

1-4 Thunderstorms

Thunderstorms are climatic disturbances in a much smaller scale than the tropical cyclones. But, they occur at a high frequency over the Philippines except a part of the southwest. They occur concentratively in April to October. In most districts, they occur over ten days monthly so that their contribution to the total rainfall is considered to be fairly large.

2. Present Status of the Pampanga River Basin

2-1 General Condition of the Basin

The Pampanga River basin is situated at the central part of the Luzon Island and north of Manila. It covers the districts of Pampanga, Bulacan, Tarlac, Nueva Ecija, Rizal, Nueva Viscaya and Quezon partly or wholly and extends from 14°45' to 16°10' north and from 120°20' to 121°25' east (See

Fig. 2-1).

The main Pampanga River has an origin in Mt. Caraballo. It flows south for about 260 km into the Manila Bay. The length of the stream as measured from the river mouth to the main points respectively is illustrated in Table 2-1.

The basin has a total area of 10,540 km^2, and the area in the upstream of Calumpit is 8550 km^2.

The Pampanga River basin is divided into three geographical features of mountain, hill and plain. The mountainous site is constituted mainly by Mt. Sierra Madre and Mt. Eambales and includes Mt. Arayat. It is composed of the strata of the Mesozoic and Tertiary formation and the Tertiary and Quarternary volcanic rocks. The hilli site includes the intermount basis and river terraces and is, for the greater part, of diluvium. The plain is of alluvium and includes swamps. These three occupy about one-third of the whole area respectively.

Table 2-1 Distance from the river mouth

River mouth	0km
Sulipan, Apalit	25
Candaba	52
Arayat	69
Cabanatuan	about 140
Sapang Buho	177

Note: The distance is measured along the right bank side of the low water channel, on the map of a scale of 1:50,000 issued by the Government of the Philippines.

Main Stream

(1) From the source to Sapang Buho

From the source to Rizal, the stream flows through the mountainous area. The name Pampanga River is given to that part of the stream which is below the confluence of the Carranglan River and the Pantabangan River. At Sapang Buho, it joins the Santor River which is nearly of the same scale.

The annual depth of run-off is about 1400 mm.

(2) From Sapang Buho to Arayat

Near Sapang Buho, the stream flows through terraces. The river bed gradient is about 1/1000. It becomes increasingly gentle towards the downstream and is at 1/2000 and 1/3000 at Cabanatuan and Cabiao respectively. As the gradient decreases, the configuration of the adjacent land turns from the hill to the plain. Upstream the confluence with the Rio Chico River, there is the San Antonio swamp situated between the stream and the Rio Chico River. The length of this section is 108 km.

(3) From Arayat to Calumpit

There is an embankment on the right bank, but the Candaba Swamp spreads on the left bank. Down from Candaba, the minimum water level is substantially horizontal to form a tidal river with the water surface slope at the time of a flood at about 1/7000. At Calumpit, the Angat River joins from the left bank. The length of this section is abouy 45 km.

(4) From Calumpit to the river mouth

This is a delta zone, and the stream is divided into a number of channels. Near Calumpit, there are three outlets including a flood channel to the delta from the Candaba Swamp. Three bridges along the National Route No. 3 are constructed over the foregoing three outlets respectively. These outlets are normally tidal rivers.

Tributaries and Swamps

Principal tributaries are the Rio chico River and Angat River.

The Pampanga River basin is characterized by two swamps: Candaba Swamp between the Pampanga and Angat Rivers and San Antonio Swamp between the Pampanga and Rio chico Rivers. while the surface area and volume vary with the flood size, the surface area of both swamps included is about 344 km^2 in the instance of the flood in August 1960, and this figure represents about 3.3 percent of the whole Pampanga River basin.

For the same flood, the volume is calculated at 1,700,000,000 m^3. Dividing this volume by the area of the Pampanga River basin upstream Calumpit gives a figure of 200 mm. This indicates that the swamps have a remarkable delay effect and serve to alleviate the downstream flood. In Table 2-2

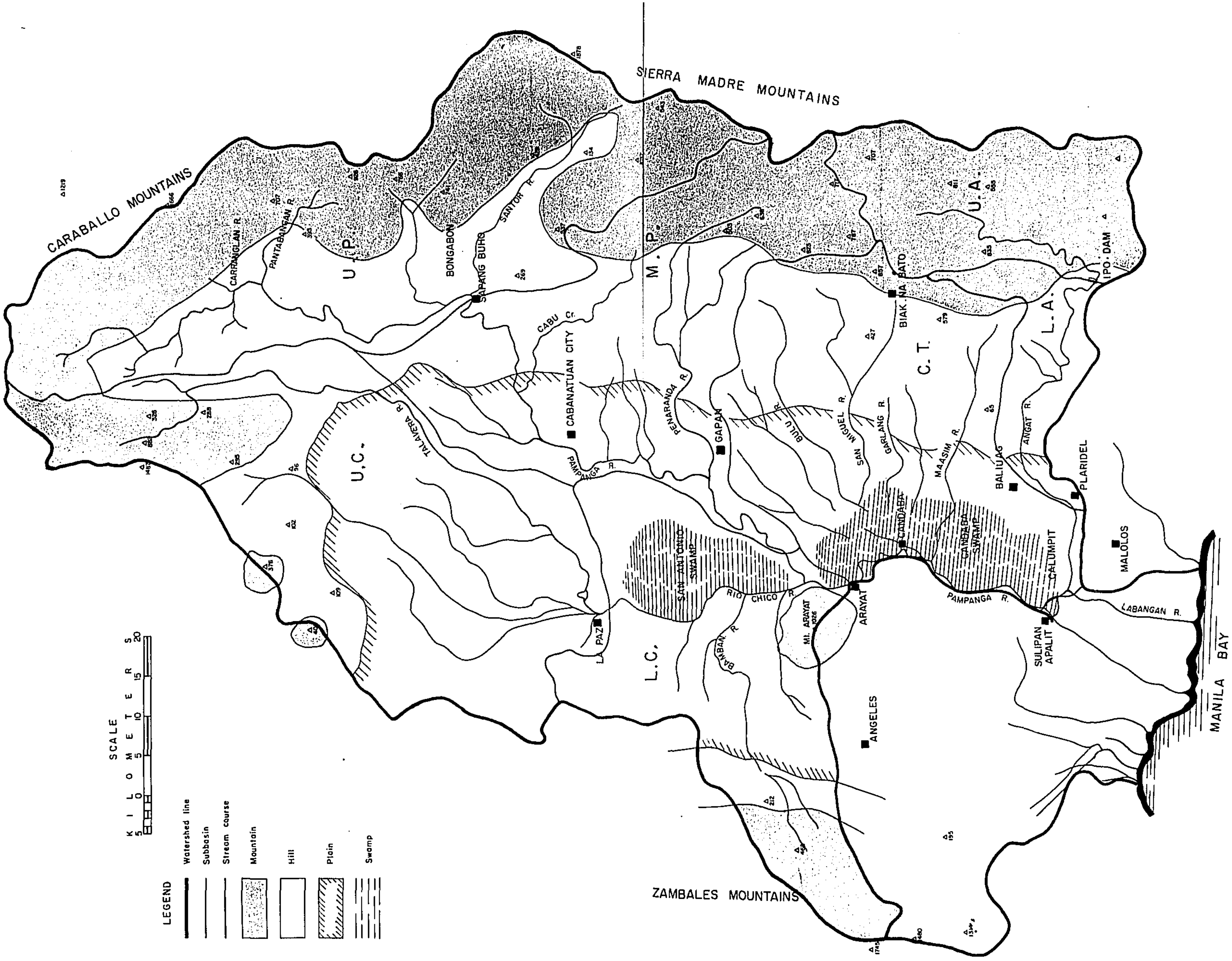


Fig. 2-1 Outline of topography of pampanga river basin

are shown the surface areas and other dimensions of the swamps.

The Angat River basin has an area of 939 km^2 which is about 9 percent of the whole Pampanga River basin. It is situated at the southeastern part of the whole basin and is an intermount basin with much rainfall and runoff. The annual runoff is as high as 2400 mm.

There are the Angat Dam and the Ipo Dam in the downstream of the Angat Dam. The water reserved in these dams is used for irrigation. Generally, the Angat River is the first to flood among other tributaries so that the initial storage of water in the swamps is affected by the flood of the Angat River.

The Rio Chico River has a basin of 2848 km^2 which is about 27 percent of the whole Pampanga River basin. This river runs out of the mountainous area in the northern part, but the basin is, for the greater part, of flat land. The annual runoff is 1400 mm. The Rio Chico River and its tributary, Talavera River, have the stream divided into a number of small channels respectively and flow into the San Antonio Swamp.

The main discharges are given by the average of three years from 1966 to 1962 according to the Water Supply Report (See Table 2-3).

Table 2-2 Dimensions of swamps

Swamp	Surface area*	2 Storage volume*	3 Drainage area	2/3
San Antonio	124 km	700×10^6 m^3	6,126 km^2	110 mm
Candaba	220	1000×10^6	2,424	
Total	344	1700×10^6	8,550	200

* Flood in August 1960

Table 2-3 Annual runoff of respective basins

Sub-basin	Gauging station	Drainage area km^2	Mean discharge m^3/s	Annual runoff mm/year
Upper Pampanaga	Malate	2,015	92.07	1,442
Middle Pampanaga	San Agustin	6,487	272.23	1,324
Upper Rio Chico	Catalanacan	284	8.27	
	Pason Intsik	208	12.13	
	Lomboy	261	12.14	
	Sub-total	753	32.54	1,364
Angat	Pulilan	959	73.06	2,404

Note: Mean discharges are the averages for 3 years from 1960 to 1962, calculated on the basis of Surface Water Supply Bulletin.

2-2 Dangerous Sites

In the following are listed the dangerous sites and other important matters for which special care should be exercised in view of the experience of flood damage and the present condition of the channel improvement in carrying out the flood forecasting and warning service.

1. Flood level against the height of the villages within and in the east and north of the Candaba Swamp.

2. Flood level against the height of the Arnedo Dike between Apalit and Arayat and the height of the ground of Candaba Town.

3. Flood level against the height of the embankment in the uncompleted section at the southern part of the ring levee between Arayat and Cabiao.

4. Flood level against the height of the fuse levee provided between Candaba and Arayat.

5. Flood level against the height of the embankment in the uncompleted section in the upstream of Plaridel in the Calumpit-Plaridel-Bustos levee.

6. Runoff from the Candaba Swamp through three floodways at Sulipan, Calumpit and Bagbag to the lower delta.

7. Combination of the tidal change in the Manila Bay and the flood runoff to the low land in the downstream delta.

3. Rainfall in the Pampanga River Basin

The Pampanga River basin belongs to the first type of the climatic classification described in paragraph 1 and has the distinguished rainy and dry seasons. The rainy season lasts normally from June (or May, when earlier) to November (or December, when later, and sometimes January).

In May every year, the basin begins to experience thunderstorms and has rainfalls for 8 to 12 days average per month until September. But, the rainfalls giving rise to a flood are caused by tropical cyclones or monsoons. As an exceptional case, there was a heavy local rainfall in the basin of the Penaranda River, a tributary of the Pampanga River, in November in 1974. It might be a concentrative rainfall caused by a front, but the possibility of a thunderstorm was much higher.

For the tropical cyclones, the situation may vary depending on the course, rainfall and speed of movement, but the flood caused by a single cyclone is, if taken not locally but as a whole, of a medium scale. What is dreadful is the successive assault of tropical cyclones. The flood in October 1973 was a typical example.

Monsoon rainfalls are also related to the tropical cyclones. In such rainfall, days without sunshine continue for a long period. In the flood in July 1972, they lasted for more than a month, and in the flood in August 1974, for nearly

20 days. There are rainfalls day after day, and the water level rises up gradually everywhere in the basin. What is dreaded is a situation such that a very large depression (typhoon) is present on the sea in the northeast of the Philippines at about 18°-25° north and makes a very slow movement. The monsoon is intensified greatly and inflicts a large amount of rainfall over a long period (3 to 4 days). The typhoons exerted a serious influence upon the Pampanga River basin in July 1972 and August 1974 were far off on the sea for more than 1000 km apart from the Philippines.

For the monsoon rainfalls, it is not known precisely under what conditions (or relationship with the surface and high pressure distributions or other tropical depression) is caused a large amount of rainfall.

4. Hydrological Observation Network

As shown in Fig. 4-1, there are 7 telemetered water level stations and 10 telemetered rainfall stations in the Pampanga River basin. The data of these stations are controlled at FFC in Quezon City. They can also be monitored at BPW in Manila. It is enabled to call up the data of all stations from FFC automatically at an interval of 30 minutes, 1 hour, 3 hours, 6 hours or 12 hours. But, generally, the system is set to the 12 hours interval in the dry season and the 6 hours interval in the rainy season. When a rainfall starts, it is set to the 3 hours interval. As the power in San Rafael is relatively unstable presently, it is avoided to set to the 1 hour interval operation so far as practicable.

The telemetering system for collection of such data is usable for communication. But, to insure communication between FFC, BPW in Manila and Apalit Office of BPW communication lines (V.H.F.) are provided separately.

For observation of the water level, two types are employed: well type for the four stations at Zaragoza, Arayat, Candaba and Apalit; and sensing pole type for the three stations at Sapang Buho, San Isidro and Ipo. Among these seven stations, those having the H-Q relationship at high water are the Apalit and Sapang Buho stations, and some values of observation are also obtained at Apalit. Further, for Candaba, analyses to obtain correlationship with the water level at Apalit and also storage between Candaba and Apalit from the water levels at both points are carried out.

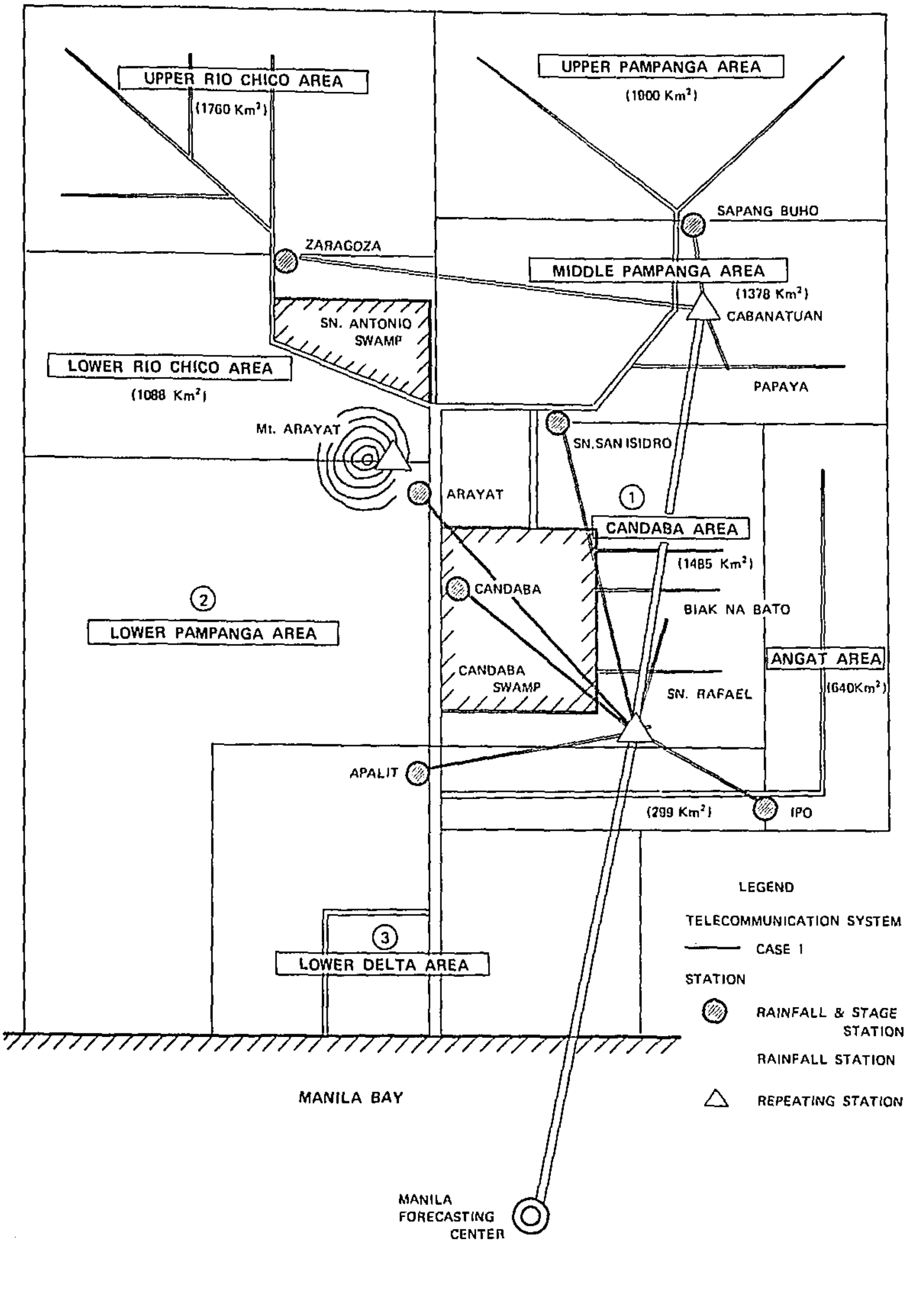


Fig. 4-1 Schematical diagram of flood forecasting system in the Pampanga river basin

5. Flood Forecasting and Warning Information System

Flows of information to, and out of, F.F.C. are shown in Tables 5-1 and 5-2 respectively. The tank model used for the Pampanga River is illustrated in Fig. 5-3.

Table 5-1 F.F.C. Flow Chart (sources of data & Information)

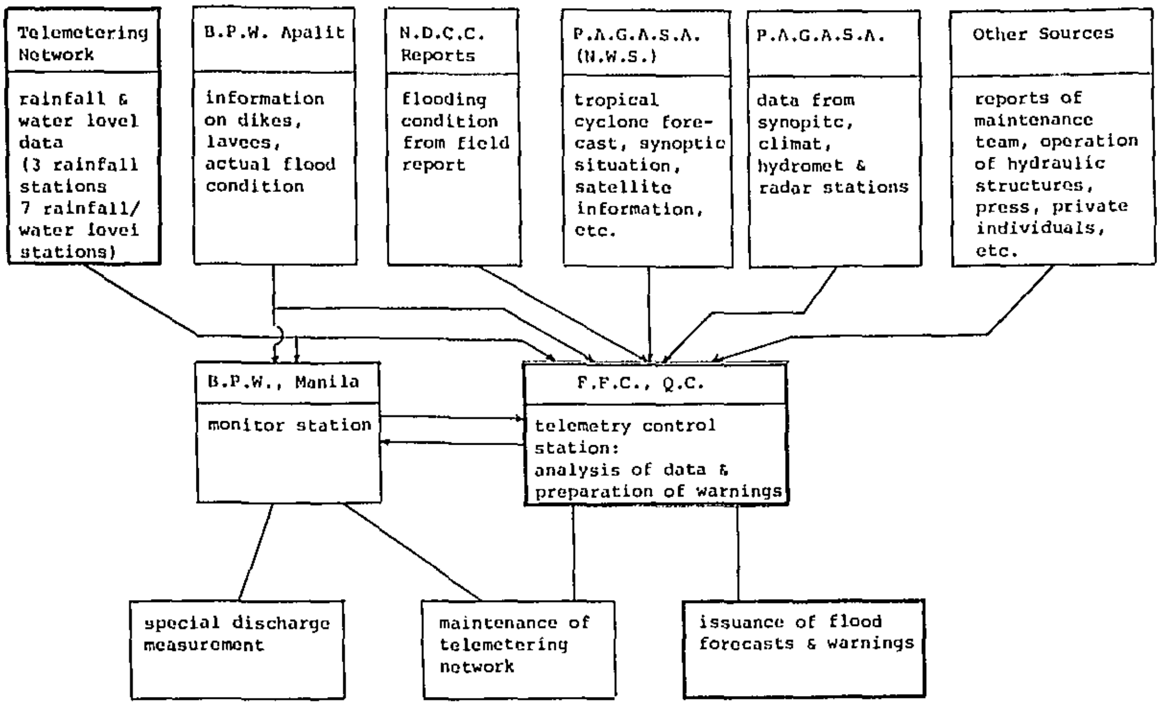


Table 5-2 Flow Chart of Flood Warnings for the Pampanaga River Basin

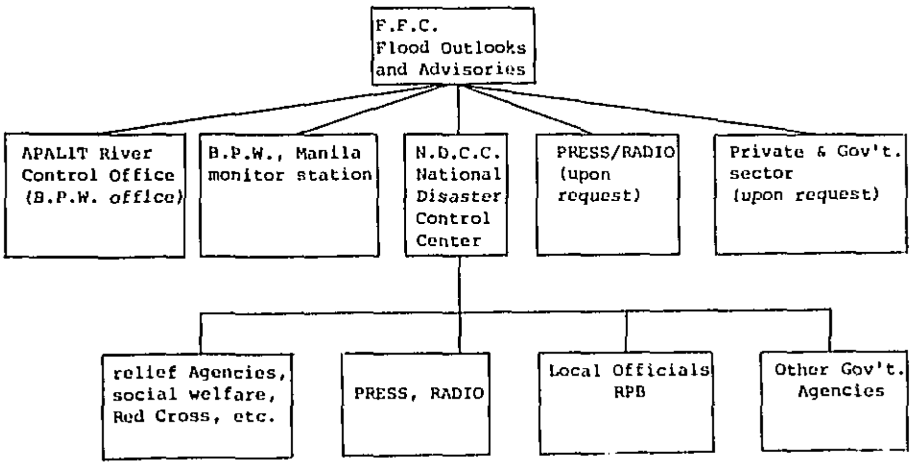
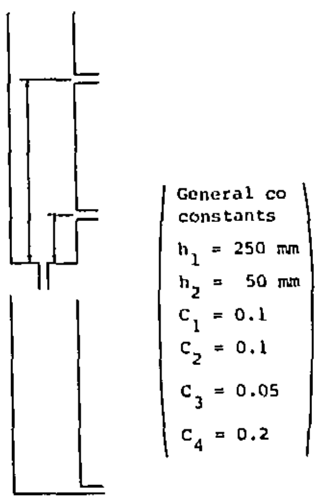


Fig. 5-3 Pampanga River (Sulipan) Tank Model



Chapter 4 Furnishments

1. Primary Survey (November 1969)

	Description of Good	Type & Rating	Q'ty
1	Portable VHF Radiotelephone	Toshiba IW	2
2	Water-level Gage	Suiken 62	2

2. Secondary Survey (February 1972)

	Description of Good	Rating	Q'ty	Type & Name of Maker	
1.	VHF Radio Telephone	152-275MHz Power 10W	3	ATR-150, MIO-16	NEC
2.	Antenna Pole & Coaxial Cable	Yagi 3 elc. Portable	2	V3S-1505 (Aut) VS-10(Pole) 8D-2D(Cable)	YAGI
3.	Thruline Power Milter	150 MHz Power 30W	2	PRM-S-71	NIHON KOSHUHA
4.	Field Strength Meter	25∿230MHz	1	M321C	Anritu
5.	AC Power Pack Doublet Antenna & Tripod	AC-100V	1	MZ 3A(Aut) MB9A (T)	Anritu
6.	Quasi Peak Meter	455∿1MHz 75∿80dB	1	MH33A	Anritu
7.	AC Power Pack & DC Power Pack	AC-100V DC-12V	1		Anritu
8.	CM Directional Coupler		1	ARZ-5823C	Anritu
9.	Electronic Polyrecorder With Accessories	0∿5V	1	EPR-2T	Toadenpa
10.	Portable AC Power Generator	0.8KW	2	REG-800	Tanaka
11.	Accessories for the above		2		Tanaka
12.	Automobile Battery	12V 30AH	2	NS-40	Yuasa
13.	Battery Charger	18V 4A/100V	2	8CP-15A	Yuasa
14.	Voltage Regulator	0∿130V 10A/110V	2	A-10S	Yokoyama

3. Machines and Materials for Installation Guidance and Operation (June 1973)

	Description of Good	Rating	Q'ty	Typr & Name of Maker	
1.	Oscillator	10Hz∿20MHz 6 Band	1	MG-43A	Anritu
2.	Level Meter	10Hz∿20MHz -70dBm∿22dBm	1	ML-44B	Anritu
3.	Signal Generator	54MHz∿68MHz 140MHz∿170MHz 2 Range with accessories	1	MG-54C	Anritu

	Description of Good	Rating	Q'ty	Type & Name of Maker	
4.	Output Testor	60,150,400MHz Band	1	MS-52A	Anritu
5.	CM Directional Coupler		1	MA-51A	Anritu
6.	Test Mobile		2	MB-5B	Anritu
7.	Terminate Type Power Meter	150MHz Band 6W 50 Ohm	1	TP-15N2	Fujisoku
8.	Frequency Counter	10Hz∿500MHz	1	TR-3787	Takedariken
9.	Synchroscope	DC∿2MHz	1	SS-5020	Iwasaki
10.	Frequency Meter	45Hz∿65Hz With Case	1	2038-01	YEW
11.	Megger	100 Mohm With Case	1	3213-03	YEW
12.	Ground Resistance Meter	With Case	1	3235-00	YEW
13.	Illuminator	AC100V500W With reflector lamp 500W	2	Tripod Standing	
14.	Antenna element	152.275MHz	2	V3S1505	Yagi
15.	VHF Radio Telephone Equipment	10W 152.275MHz With Whip antenna (Yagi)	1	Crl-15	JCR
16.	VHF Radio Telephone Equipment	10W 152.275MHz With 3 stage Colinear antenna (Yagi)	1	CRI-15 (For Cabanatuan Weather Station)	JRC
17.	Portable Radio Telephone Tranceiver	1W 152,275MHz With Accessories	1		JRC
18.	Calculator	8 Figure	2		
19.	Micro Computer	Program 253step 15 Figure	1	Sobax-2700A	Sony
20.	Float With Illuminator		120	Nippon Helplight (For flood current measurement)	
21.	Echo Sounder	0∿40m Multiple Rentype	1	SMR-685	Koden
22.	Rubber Boat	6 Seater	1		Fujikura
23.	Detachable engine	5 HP	2		Tohatsu
24.	Vehicle		1		Nissan Patrol

4. Furnishings upon Request of Mr. Komura, Engineer

	Description of Good	Rating	Q'ty	Type & Name of Maker
1.	Transistor Checker			
2.	Battery Charger			
3.	Parts of Water Level Guage			

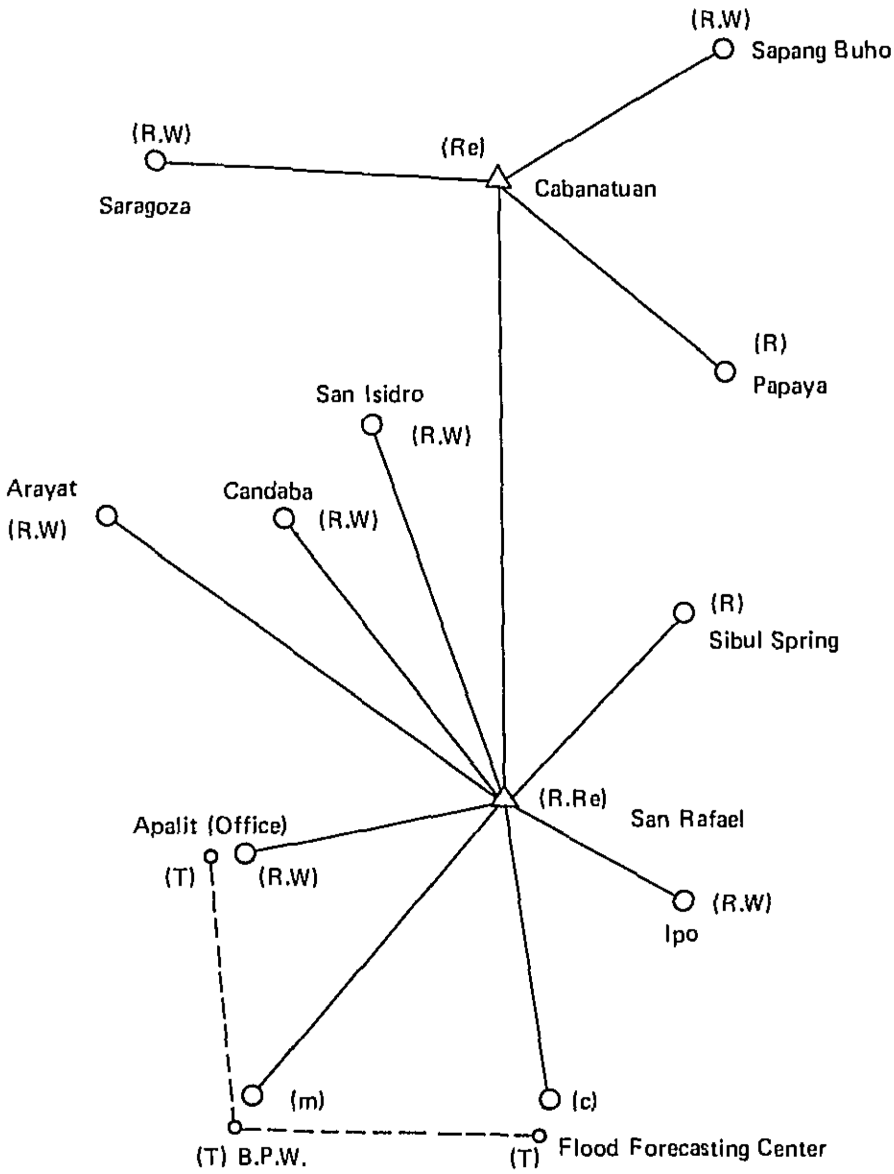
EQUIPMENT FOR FLOOD FORECASTING & WARNING SYSTEM

IN THE PAMPANGA RIVER BASIN

Item	Name of Equipment, etc.	Description	Q'ty	Remarks
I.	Equipment, Packing, Sea Transportation, Insurance			
1.	Terminal Telemetry and Control Equipment		1	
	a. Telemetry Equipment	Data capacity 25, equipped with 17	(1)	
	b. Control Console		(1)	with Desk
	c. Data Writer	Remington 26,21"	(1)	with Case and desk
	d. Graphic Display Panel	Self-standing	(1)	with chart panel
	e. Antenna	3-element Yagi, Vertical	(1)	
	f. Accessories/Spare Parts		(1)	
2.	Telemetry Monitor Equipment		1	
	a. Telemetry Equipment		(1)	
	b. Power Supply for Clock		(1)	
	c. Data Writer	Remington 26,21"	(1)	
	d. Display Panel	Wall-hung type	(1)	
	e. Antenna	3-element Yagi, vertical		
3.	Telemetry Gauging Equipment			
	a. Telemetry Equipment	Single data, 3W	(2)	Papaya, Sibul Springs
	b. "	Single data, no TRX	(1)	San Rafael
	c. "	Double data, 1W	(6)	Apalit, Arayat, Candaba, San Isidro, Sarugora Sapan Buho
	d. "	Double data, 3W	(1)	Ipo
	e. Antenna	3-element Yagi, vertical	(9)	
4.	Repeater Equipment			
	a. Telemetry Repeater Equipment	Squelch repeating system	(1)	San Rafael
	b. "	Cross repeating system	(1)	Cabanatuan
	c. Antenna	3-stage Colinear	(3)	
	d. "	3-element Yagi	(1)	
5.	Rainfall Gauging Equipment			
	a. Tipping Bucket Rain Gauge	Integrate type, with A/D converter	(1)	Apalit
	b. Rain Intake Section	Separate type	(9)	
	c. Rainfall Gauging Section	Separate type, with A/D converter	(9)	
	d. Rainfall Recorder	80 daily type	(10)	
6.	Water-level Gauging Equipment	SUIKEN 62 with auto-recorder and A/D converter	4	
7.	Water-level Gauging Equipment			
	a. Water-level Gauging Pole	3.5 m	(6)	
	b. "	3.0 m	(3)	
	c. Code Converter		(3)	
	d. Data Recorder		(3)	

Item	Name of Equipment, etc.	Description	Q'ty	Remarks
8.	VHF Radiotelephone Equipment		3	FFC, BPW, Apalit
	a. VHF Radiotelephone	CR1-15	(3)	
	b. Antenna	3-element Yagi	(1)	
	c. "	5-element Yagi	(2)	
9.	Portable VHF Radiotelephone Equipment		4	BPW, Apalit
10.	Voltage Stabilizer & Power Switch		2	
11.	Voltage Stabilizer		2	
12.	DC Power Supply		4	
13.	Solar Cell Power Supply Equipment			
	a. Solar Cell Rack	4.3W	(8)	
	b. "	20.16W	(1)	San Rafael
	c. Power Distributor	with over-charge protector	(9)	
	d. Alkaline Battery	12V, 30AH	(2)	
	e. "	12V, 40AH	(3)	
	f. "	12V, 50AH	(3)	
	g. "	12V, 200AH	(1)	
14.	Diesel Engine Generator	100V, 2KVA	2	Portable
15.	Diesel Engine Generator	100V, 2KVA	2	Fixed
16.	Antenna Tower	SUDA ST3181, 30m	3	
17.	Float Dropping Equipment		1	
	a. Winch		(1)	
	b. Dropper with wire rope		(1)	
18.	Cable Protector	20P	4	
19.	Measuring Instrument		3	
20.	Illuminator		10	
21.	Code Reel	30 m	6	
22.	Code Reel	50 m	4	
23.	Clock	SEIKO Vivron	2	

Net Work of Flood Forecasting System in The Pampanga River



Legend

(c) Control Station
(m) Monitor Station
(Re) Relay Station
(R) Rain fall Gauging Station
(W) Water Level Gauging Station
(T) Wireless Telephon Station

Recommendations

1. Organization

FFC is operated upon an agreement between PAGASA and BPW. But, the position of FFC is not clearly defined in the agreement, and the responsibilities of the respective divisions of FFC are not clearly established. Thus, it is difficult to state that FFC is operating and exhibiting its full capacity as an integral organization. The following is, therefore, recommended.

1) PAGASA and BPW should enter into a minute agreement concerning FFC so that FFC is established as one organization and has it character and position defined clearly.

2) Responsibilities of the respective divisions of the organization should be set forth clearly.

2. Budget

In FFC, a budgetary system for each quarter of a year is employed. The budget is an approximate one, and there are instances where the budget is hardly executed because of the lack of cash.

Particularly, the month of July is the time at which the flood season begins. Nevertheless, it corresponds to the break of budgetary appropriations. Thus, with no appropriation available, the operation has but to stop. Therefore, the following is recommended.

3) FFC should be established as an organization having an independent accounting system with shares determined between PAGASA and BPW.

4) A budgetary system of annual operation should be established in which the details of appropriations for the next fiscal year are determined previously and are executed by a designated chief.

5) A system enabling execution of appropriations at the transitional time of budgetary appropriations should be established.

3. Securing the Technology

Presently, FFC is satisfactory with respect to the number of personnel but not with respect to the technology. Specifically, the workers hired on a temporary basis are not well treated and are, sometimes, not responsible for their respective works. Moreover, when they acquire techniques more or less, they go out of FFC to private companies so that the proper operation of FFC is hindered. The following is thus recommended.

5) FFC should acquire excellent personnel and maintain a high level of technology through training, etc.

6) There are temporary employees who are excellent and are eager to do the work. Efforts should, therefore, be exerted for improvement of the treatment of temporary employees by,

for example, promoting such employees to regular officials,

7) It is required for the Center officials to acquire knowledge and skill concerning measurement, patrol, repair, runoff calculation, forecast preparation and other works necessary for operation of FFC.

8) For technical improvement of the officials, it is preferable to exercise the flood forecasting on the map during the non-flood season.

9) Training of the officials is of course such that it is carried out be a senior official to junior officials. But, it is desirable to commission the training to the outside persons of knowledge and experience, as required.

4. Maintenance and Management

10) The hydrological and telecommunication facilities should have the maintenance and inspection performed in accordance with the Manual for proper operation.

11) A supply system should be established so that the expendables, parts, etc. required for operation of the Center are always maintained.

5. Efforts for Better System

12) A comprehensive future plan should be developed, and its application should be investigated.

13) Efforts should be exerted for improvement of the system so that it will serve as a standard for establishment of other systems.