THE REPUBLIC OF THE PHILIPPINES

PROGRESS REPORT II

FOR

THE FLOOD FORECASTING SYSTEMS IN THE AGNO, BICOL AND CAGAYAN RIVER BASINS

MARCH 1977

JAPAN INTERNATIONAL COOPERATION AGENCY

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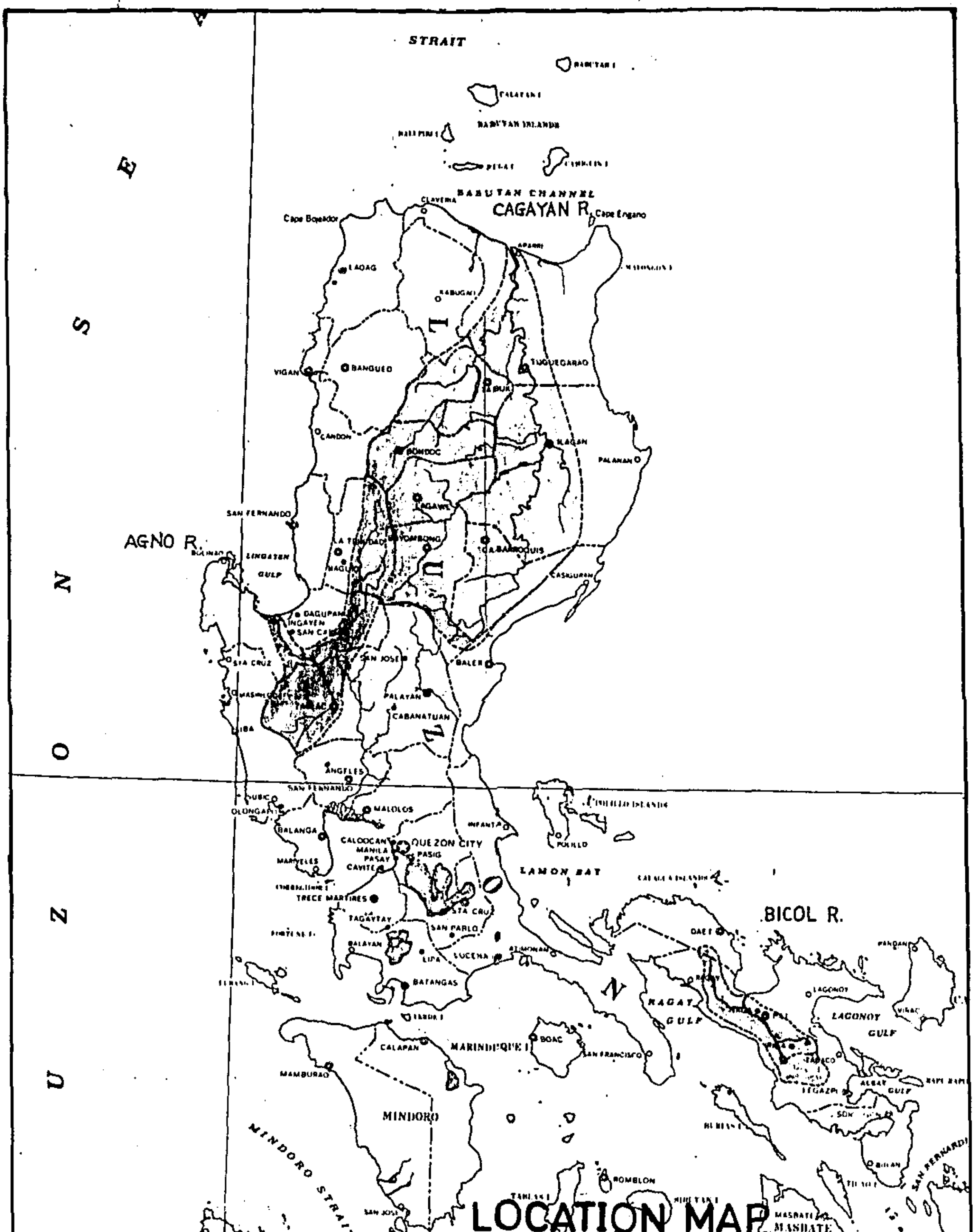
CONTENTS


LOCATION MAP
AGNO, BICOL and CAGAYAN RIVER BASINS
CAGAYAN R.
AGNO R.
BICOL R.
STRAIT
BABUYAN CHANNEL
Cape Bojeador
Cape Engano
LAOAG
BANGUED
VIGAN
TUGUEGARAO
ILAGAN
PALANAN
BONTOC
SAN FERNANDO
LINGAYEN GULF
LA TRINIDAD
BAYOMBONG
DAGUPAN
LINGAYEN
STA CRUZ
SAN JOSE
BALER
PALAYAN
CABANATUAN
IBA
ANGELES
SAN FERNANDO
OLONGAPO
MALOLOS
BALANGA
CALOOCAN
QUEZON CITY
MANILA
PASAY
PASIG
CAVITE
MARIVELES
INFANTA
LAMON BAY
TRECE MARTIRES
TAGAYTAY
STA CRUZ
SAN PABLO
LUCENA
LIPA
BATANGAS
CALAPAN
MAMBURAO
MINDORO
MINDORO STRAIT
MARINDUQUE I.
BOAC
RAGAY GULF
LAGONOY GULF
ALBAY GULF
LEGAZPI
MASBATE
ROMBLON
SAN JOSE
KALIBO
ROXAS
VISAYAN SEA
L U Z O N
L U Z O N S E

I. Summary

1. Background and Objective of the Project

The Philippine Islands are located near the eastern edge of the Eurasian Continent, between 10° and 20° N latitude. Naturally, the islands are directly influenced by both monsoons and typhoons. Every year the islands are assaulted by floods caused by heavy rains and storm surges caused by strong winds that accompany monsoons and typhoons. Since among the islands, Luzon is densely populated and highly developed, if this island is assaulted by floods or storm surges, inestimable damage to human life and property and social paralysis would result. It is one of the important national policies to prevent or mitigate disasters due to floods and storm surges in order to improve public securities, public welfare, the land conservations, and the development of the country.

The Government of the Philippines has been painstakingly engaged in a flood control work and river improvement. They are, however, far from completed. Yet, it may be said that "completion" is not possible in this kind of work. This is because natural forces may bring larger floods than that which a completed dyke is estimated to be able to handle safely.

Forecasting and warning about floods are therefore significant. Their role and functions are important the flood control work is completed, and after completion they will serve to assist the flood control work as well as to prepare for emergencies. When the forecasting and warning are performed successfully, many lives and properties are to be saved from floods and storm surges.

The Government of the Philippines, having fully recognized the importance of the forecasting and warning system, completed a flood forecasting and warning system in 1973 for the Pampanga River, one of the most important rivers in central Luzon, in cooperation with the Typhoon Committee, ESCAP and the Government of Japan. The fact that the Pampanga system demonstrated its effectiveness satisfactorily in the huge flood of May, 1976, and protected many lives and much property from disaster is well remembered. Based upon the lessons learned on that occasion, the Government of the Philippines requested the cooperation of the Government of Japan to extend the system to three rivers - the Agno River in central Luzon, the Bicol

River in southern Luzon and the Cagayan River in northern Luzon. In response to this request, through the Japan International Cooperation Agency (J.I.C.A.), the Government of Japan sent the Survey Team for Flood Forecasting and Warning Systems to the Philippines and assigned it the feasibility study.

2. Survey Objective

The purpose of this survey is to perform a feasibility study for the plan to extend the flood forecasting and warning system, which is currently effective on the Pampanga River, to three rivers, the Agno, Bicol and Cagayan. The survey includes the following items.

1) Discussions with the officials concerned

2) Collection and examination data

3) Reconnaissance of the basins and sites of proposed stations and subcenters

4) Survey of meteorological and hydrological characteristics

5) Socio-economic characteristics survey and study of the target area

6) Production of forecasting model and observatory network

7) Radio propagation test and survey of the necessary conditions for the establishment of the proposed telecommunication system

8) Preliminary design of civil works, telemetering and telecommunication facilities

9) Production of the operation and maintenance plan

10) Rough estimate of expenditures

11) Proposal of program for system construction and personnel training

3. Organization of Survey Team

The survey team comprises the following two teams:
First Survey Team
Second Survey Team

The first and second survey teams are organized as follows.

Team leader: Tsunetaka Kawai, Water Management Officer, River Planning Division, River Bureau, Ministry of Construction.

River Engineering Expert:

Kazuhiro Yamaguchi*, Deputy Head, River Improvement Division, River Bureau, Ministry of Construction.

Fumio Kodama*, Head, Operational Control Center for Tone River Dams, Kanto Regional Construction Bureau, Ministry of Construction.

Yumio Ishii*, Manager of Water Resources Department, C.T.I. Eng. Co., Ltd.

Toyoharu Hiruma**, Deputy Manager of Water Resources Department, C.T.I. Eng. Co., Ltd.

Takeshi Hashimoto, Researcher, Hydrology Section, Public Works Research Institute/AKABANE, Ministry of Construction.

Koichiro Katsuragi, Chief, Area Water Management Section, Operational Control Center for Yodo River Dams, Kinki Regional Construction Bureau, Ministry of Construction.

Meteorological Expert:

Seiji Miyazawa*, Chief Forecaster, Meteorological Agency.

Telecommunication Expert:

Osamu Tsumura*, Head, Electricity and Telecommunication Section, Minister's Secretariat, Ministry of Construction.

Kazuhiko Takayama**, Senior Engineer, Electricity and Telecommunication Section, Minister's Secretariat, Ministry of Construction.

Mitsuru Shimizu**, Staff, Electricity and Telecommunication Section, Minister's Secretariat, Ministry of Construction.

Masamichi Komura, Chief-clerk, Electricity and Telecommunication Section, Kanto District Construction Bureau, Ministry of Construction.

Shuji Suga, Association of Electrical Engineering.

Yoshiharu Nakagawa, - do -

Socio-economic specialist:

Joji Ishii, Deputy Manager of Research and Development Section, C.T.I. Eng. Co., Ltd.

Coodinator: Yuji Okazaki, Research & Development Section, Social Development & Cooperation Department, Japan International Cooperation Agency.

NOTE: * denotes member of First Survey Team.
** denotes member of Second Survey Team.

4. Process of Survey

The first survey was made from November 18th to December 17th, 1976 to obtain an understanding of the overall project. The purpose of the second survey was mainly the selection of the locations of telemetering stations and the radio propagation tests during the period from January 31st to Marth 5th, 1977.

Progress Report II (draft final report) is a consolidation of surveys completed up to this time. In addition, the Interim Report in December, 1976, and the Progress Report I in February, 1977, were submitted to the Government of the Philippines. Final Report is scheduled to be submitted in two months after the review of the Government of the Philippines.

5. Acknowledgement

The team herewith expresses its heartily gratitude to Dr. R.L. Kintanar, Administrator, Philippine Atomospheric, Geophysical and Astronomical Services Administration (PAGASA), Mr. D. Anolin, Director of Bureau of Public Works (BPW), Mr.J.E. Sunga, Director, infrastructure staff of National Economic Development Authority, (NEDA), Dr. S.N. Sen, Chief Typhoon Committee Secretariat (TCS), and the staff member of the above-mentioned agencies for their active cooperation.

II. Conclusions and Recommendations

Based on the surveys of hydrometeorology, socio-economy, radio wave propagation tests in the Philippines, and discussion with the officials concerned and studies in Japan, the survey team presents suggestions and recommendation as follows.

1. Target Area

Taking into consideration the socio-economic features such as distribution of population and houses, situation of land utilization, and damage of probable floods, as well as hydrometeorological features such as topographic features of the basin, run-off of rainfall, and frequency of flood attack, the survey team proposes the following districts as the target of flood forecasting system.

1) Agno river basin
   Entire Pangasinan Plain including the major municipalities of Dagupan, Lingayen, Bugallon, Sta.Barbara, Bayambang and Rosales. Central part of Tarlac Province including the major municipalities of Tarlac, Gerona, Paniqui and Moncada

2) Bicol river basin
   Central part of the basin, from Lake Bato to Lake Baao and the flood plain surrounding Naga city

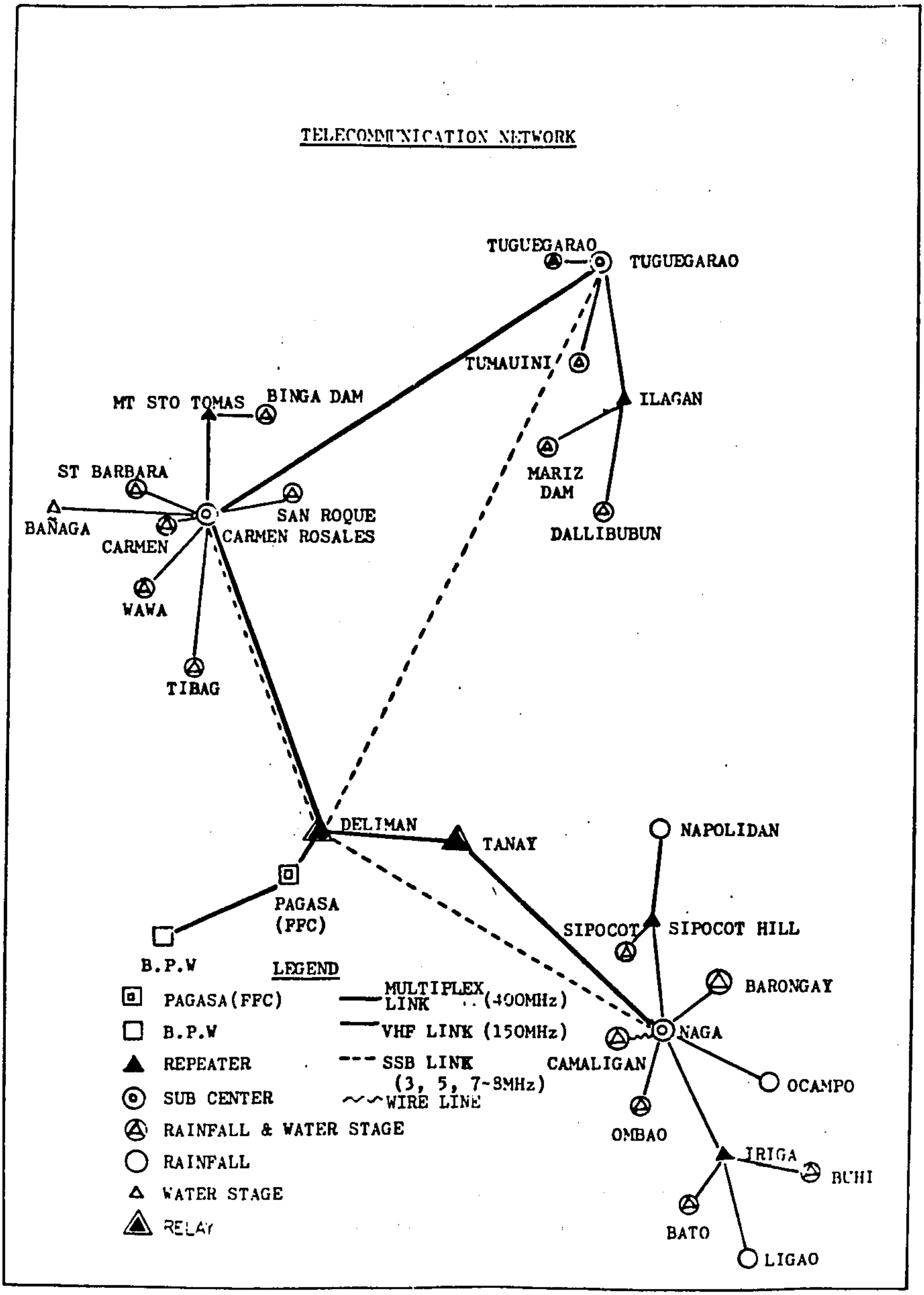
3) Cagayan river basin
   Flood plain along the middle reaches from Ilagan to Tumauini
   Flood plain along the lower reaches from Tuguegarao to Apari

2. Facilities and Networks

To achieve the purpose of this project, the following facilities and networks are to be established:

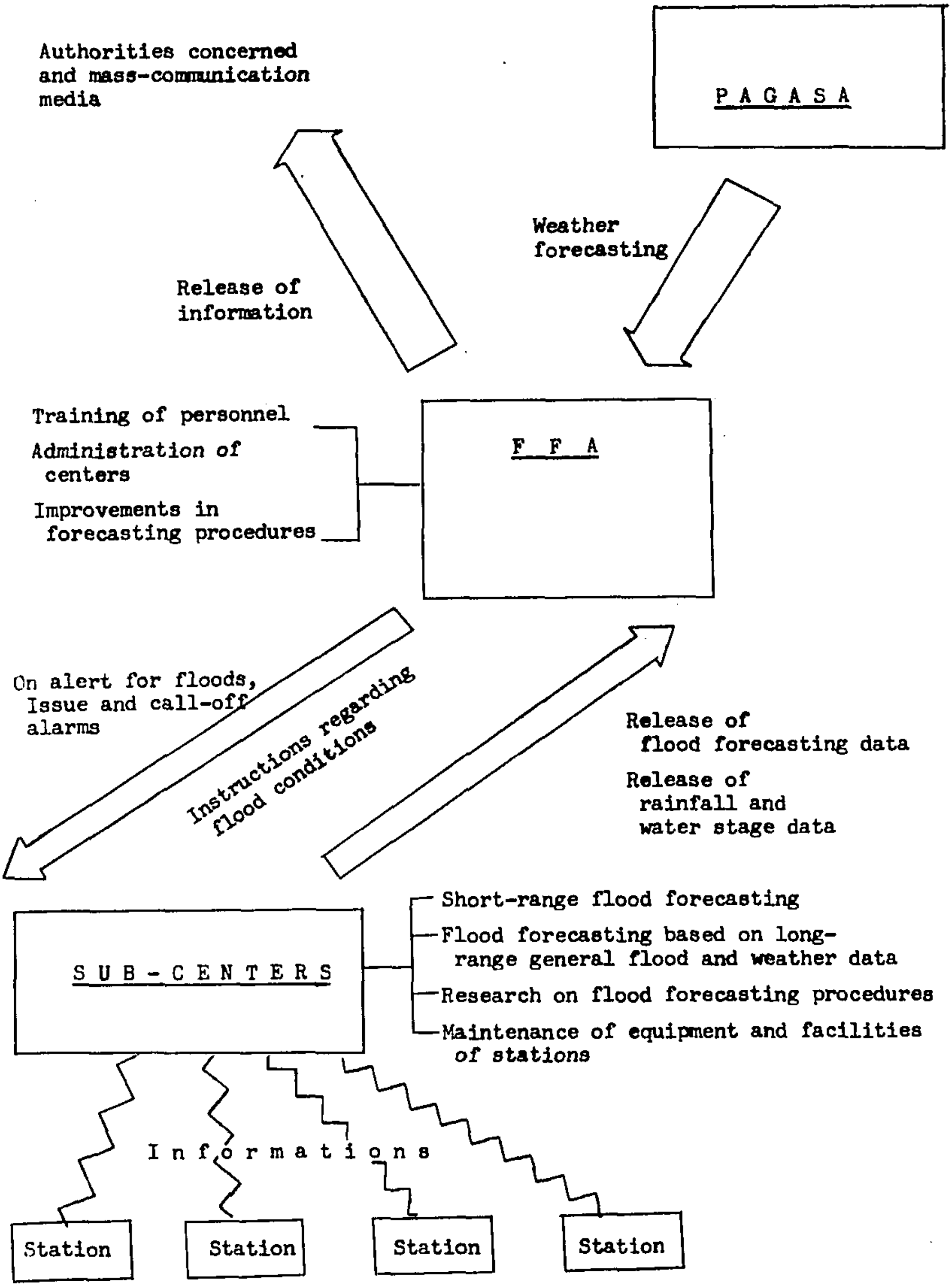
1) Agno River Basin
   Seven telemetering stations (one more rainfall station is to be added in the near future) (Binga Dam, St. Barbara, San Roque, Carmen, Wawa, Tibag & Banaga), one repeater station (Mt. Sto Tomas) and one sub-center (Carmen, Rosales)

2) Bicol River Basin
   Nine telemetering stations (Napolidan, Sipocot, Barongay, Camaligan, Ocampo, Ombao, Buhi, Bato & Ligao), two repeater stations



TELECOMMUNICATION NETWORK
TUGUEGARAO
TUGUEGARAO
TUMAUINI
ILAGAN
MARIZ DAM
DALLIBUBUN
MT STO TOMAS
BINGA DAM
ST BARBARA
BAÑAGA
CARMEN
SAN ROQUE
CARMEN ROSALES
WAWA
TIBAG
DELIMAN
TANAY
PAGASA (FFC)
B.P.W
NAPOLIDAN
SIPOCOT
SIPOCOT HILL
BARONGAY
NAGA
CAMALIGAN
OCAMPO
OMBAO
IRIGA
BUHI
BATO
LIGAO
LEGEND
PAGASA(FFC)
B.P.W
REPEATER
SUB CENTER
RAINFALL & WATER STAGE
RAINFALL
WATER STAGE
RELAY
MULTIPLEX LINK (400MHz)
VHF LINK (150MHz)
SSB LINK (3, 5, 7-8MHz)
WIRE LINE

FUNCTIONS OF FFA AND SUB-CENTERS



(Sipocot Hill & Iriga) and one sub-center (Camaligan, Naga)

3) Cagayan River Basin
Four telemetering stations (Tuguegarao, Tumauini, Maris Dam & Dalibubun), one repeater station (Ilagan) and one sub-center (Tuguegarao)
Various development projects are to be achieved in this basin. When the basin is further developed in the future, more accurate forcast will be necessary. A telemetering station, therefore, is needed additionally in the lower basin and Chico River Basin after the further survey.

4) A set of two relay stations at Deliman and Tanay, to connect the sub-center with the Flood Forecasting Center (FFC). Communication between the FFC and sub-centers will be achieved by multiplex telecommunication system and Single Side Band (SSB) radio telephone.

3. Functions and Organization of the Sub-centers
The function of sub-stations is as below.

1) To collect the meteorological and hydrological data from the telemetering station and transmit them to the FFC.

2) To predict a short-term feature of flood according to the collected hydrological data and transmit them to the FFC.

3) To receive the information of the long-term forecast about flood, and utilize it for flood forecast.

4) To study to improve the method of forecasting.

5) To maintain and administrate the equipment and facilities in the station.

One supervising engineer and one technician as hydrologists, and one supervising engineer, two qualified engineers and two technicians as telecommunication engineers, are to be assigned in each sub-center. In other words, there are seven persons - two hydrologists and five telecommunication engineers.

4. Functions and Organizations of the FFC

The functions of the Flood Forecasting Center (FFC) are:

1) To review the short-term flood forecasting from the sub-center.

2) To forecast the outlook of the long-term flood, based on information of the sub-center and weather forecast of Philippine Atmospheric Geophysical and Astronomical Service Administration (PAGASA), and to submit the outlook to each sub-center.

3) To issue the flood warning to each sub-center and direct sub-center to call it off.

4) To inform the Agencies concerned of the existing and predictable flood situations.

5) To study to improve the method of forecast.

6) To supervise the daily activities of the sub-centers, such as administration of the station and study of the method of forecast.

7) To train the personnel.

One chief engineer and four supervising engineers as hydrologists, one chief engineer and one supervising engineer and two qualified engineers and two technicians as telecommunication engineers are posted in FFC. In other words, there are eleven persons; five hydrologists and six telecommunication engineers.

5. Provision of Personnel

To ensure the effective operation of the system, staff members as mentioned below are to be required, the following schemes concerning the staff members are to be executed.

1) To assign eight hydrologists (two in each sub-center and two in FFC), and eleven telecommunication engineers (two in each sub-center and five in FFC including ones for Panpanga River system). As the matter of course, it is recommended to assign only disciplined personnel.

2) To increase three hydrologists in FFC and fifteen telecommunication engineers, three in each sub-center and six in FFC during

on-the-job training in addition to the above-mentioned number. Therefore, at the start of the operation of this system, the staff members are eleven hydrologists and twenty-six telecommunication engineers (total thirty-seven). Five of Telecommunication engineers assigned for the Pampanga River station are included in the above.

3) For training in hydrology and telecommunication, trainees are selected and despatched to suitable organizations with techniques and experiences in flood forecasting procedures.

4) Shortly before completion of the construction, consultants will commence training of staff members.

6. Schedule of Implementation

The following two alternative schedules are studied.

Case I: The construction of whole system which includes the telemetry network in each basin, communication between sub-center and FFC through multiplex telecommunication and SSB telephone network will be started at the same time. On-the-job training will be undertaken by consultants for two years. Therefore, the complete start of the system will be two and a half years later approximately.

Case II: The construction of sub-systems of three rivers (Agno, Bicol and Cagayan) will be started step-by-step in three years. On-the-job training will be undertaken by consultants for two years. Therefore, the complete start of the whole system will be in about five years.

The "Case I" is to meet with the urgent demand for the system by the Government of the Philippines.

In the "Case I", at a glance, construction period is shorter and it looks more effective, but in the light of the experience in the Pampanga River, greater difficulties are predicted in formation of organization and assignment of experienced personnel. The reason because it would require an excessively large number of thirty-seven – eleven hydrologists and twenty-six telecommunication engineers – and, moreover, all of them may have to be trained in a short time before assignment. And under the circumstance, mentioned above, the extended system may also have to be operated by a large number of less experienced. Therefore, the introduction of the schedule would require a special assistance and co-operation of the Government to overcome predicted difficulties.

On the contrary, the "Case II" will require a longer construction period but this is a steady schedule in which a smoother formation of organization, and training and assignment of the personnel may be easier.

Schedule of Implementation

Case I

Item \ Year	1	2	3	4	5
Manufacture of Telecommunication Equipments	6M				
Settlement of Equipments	2M				
Civil work	8M				
Training		24M			

Case II

Item \ Year	1	2	3	4	5
Agno system		30M			
Manuifacture of Telecommunication Equipments	6M				
Settlement of Equipments	2M				
Civil work	6M				
Training		24M			
Bicol system			30M		
Construction		8M			
Training			24M		
Cagayan system				30M	
Construction			8M		
Training				24M	

7. Cost Estimation

Expenditure will pay for civil work, telecommunication facilities and its installation, technical services, and operation and maintenance in the period of test run.

		Construction Cost	(Economic Cost)
Case I	Foreign Currency	US$6,094,000	(US$6,068,000)
	Local Currency	₱2,783,000	(₱2,783,000)
	Total	US$6,470,000	(US$6,445,000)
Case II	Foreign Currency	US$7,194,000	(US$6,556,000)
	Local Currency	₱2,955,000	(₱2,783,000)
	Total	US$7,600,000	(US$6,933,000)

(Exchange rate US$ 1=₱7.39)

Note:

1) The space for FFC and the monitor stations needs to be provided immediately by the Government of the Philippines.

2) Proposed 10% annual increase in the commodity price is included in the construction cost but is excluded in the economic cost.

Case 1 COST (Three sub-system by Simultaneous Construction Method)

	Foreign Currency	Local Currency
Civil works	1,019 $\times 10^3$ US$	2,262 $\times 10^3$ ₱
Telecommunication	3,131	-
Technical Services	989	-
Operation and Maintenance	125	68
Contingency	830	453
Total	6,094	2,783

6,470 $\times 10^3$ US$

Case 2 COST (Three Sub-system by Step-by-step Construction Method)

(priority: 1. Agno system 2. Bicol system 3. Cagayan system)

	Foreign Currency	Local Currency
Civil works	1,102 x 10^3 US$	2,401 x 10^3 ₱
Telecommunication	3,384	
Technical services	1,674	
Operation and Maintenance	136	72
Contingency	898	482
Total	7,194	2,955

7,600 x 10^3 US$

8. Benefit

The usual technique of economic analysis is hardly applicable to the flood forecasting and warning system, because the benefit is intangible like the case of education projects or public health project.

In fact human lives and properties of the inhabitants are heavily damaged by flood every year as listed in the following table. The system is very sure to play an important role for disaster prevention and promotion of public welfare, by timely and effective information for the operation of evacuation, flood defense and rescue.

Especially, it should be noted that through this operation numbers of human lives are brought out of vital danger caused by flood.

Besides, indirect benefits such as acceleration of development projects, increase of private and public properties, and promotion of the will to work of inhabitants are expected.

The flood forecasting warning system requires much shorter time and smaller expenditure than flood control works and the system carries out the benefit of disaster prevention to an extent even though it is not so big as the benefit by flood control works.

Estimated Maximum Damage by Probable Flood

River Basin	Target Area	Population	Property	Damage
	km^2	$x\ 10^3$	$x\ 10^6$ ₱	$x\ 10^6$ ₱
Agno	1,540	500	1,888	531
Bicol	570	200	553	143
Cagayan	1,420	180	581	139
Total	3,530	880	3,022	813
			$x\ 10^6$US$	$x\ 10^6$US$
			411	111

9. Proposal for the New Organization

In order to make the newly extended flood forecasting system function effectively, number of skilled engineers and large budget for operation and maintenance of the system are required.

However, the existing Flood Forecasting Center (F.F.C.) which may be mentioned as the operational center of the new system, has following problems unsolved. The effective management of the new system by FFC may become difficult without solving these problems.

1) Under the present system, FFC has no proper staff and budget, therefore, the necessary personnel and expenses cannot be smoothly secured.

2) New employment and/or trnsfer of number of personnel in a limited period may be difficult.

3) The existing FFC can hardly manage the extended system in an integrated and systematic manner.

4) Because the improvement of salary of the personnel is difficult, the skilled engineers are apt to transfer to other organizations.

5) Because of the lack of the research and planning section, improvement in the accuracy of forecasting and extention of the system to other rivers are difficult.

In order to solve these problems, andto operate the new system effectively, the Survey Team proposes establishment of the new organization, the Flood Forecasting Authority (F.F.A.).

The new FFA should have an appropriate position in the organization of the Government, proper staff and budget .

The new organization is a ' proposal ' by the Survey Team, therefore its implementaion will be reviewed as an issue of improvement of administrative organization by the Government of the Philippines.

Flood Forecasting Authority (F F A)

- FFA
  - New FFC
    - Management Division
    - Hydrology Division
    - Telecommunication Division
    - Planning Division
    - Research Division
    - Training Division (Training of engineers.)
  - Sub-Center
    - Management Section
    - Hydrology Section
    - Telecommunication Section

10. Additional Recommendation

1) The staffs and equipment of FFC will be transferred to FFA, when the new organization proposed in chapter eight starts.

2) Installation and restoration of hydrological stations which will come under the new-system should be completed as early as possible.

3) Under present level of Forecasting, a quantitative rainfall forecasting technique is not yet fully developed, therefore, forecasting may be performed by means of the existing technique. To assist this, an effective use of the PAGASA meteorological rader may be taken into consideration.

4) To up-grade accuracy of forecasting, use of computers is recommended.

III. Hydro-meteorological Characteristics

§-1 The Agno River

1. Geography

The Agno River has a drainage area of 5,646 km^2 (Estuary: Baay West), and is the third largest river in Luzon next to the Cagayan and Panpanga Rivers. A half of its drainage area, particularly the watershed in Banguet Province is mountainous having an average elevation of some 2,000 m above MSL.

The main branch is Tarlac River (the drainage area is about 1,900 km^2 including Poponto Swamp), which joins the Agno River in midstream from the left at Banyambang. The Tarlac River has its source on Mt. Pinatubo (elevation is 1,745 m) located in Tarlac Province.

The Agno River, after passing through the mountainous area, forms a vast alluvial fan and a delta, and then flows into Lingayan Gulf. This fan and delta is called the Pangasinan Plain, and has long been developed economically, together with Panpanga Plain, being the granary of Central Luzon.

The Agno River has a course of about 200 km, 90 km of which runs in mountainous zones, forming deep canyons. The average slope of the river bed is about 1/50 in canyons, and about 1/1,000 on the plain.

Ponpoto Swamp is located in the vicinity of Bayambang, where the Tarlac River joins the Agno River. The swamp has an area of about 25 km^2 and temporarily retains flood water from the Tarlac River.

Dagupan and St. Barbara form the center of the Pangasinan Plain, which was formed as a result of floods from the Agno River. Changes in river course as well as river improvement works led to the separation of the Agno River from the Plain. The plain is at present protected from the flood by the dykes along the right bank of the river.

2. Climate

Since temperature differences in the Philippine Archipelago are relatively small, climatic classification of the islands has been based upon the presence or absence of a dry season and rainy season. The four types of conditions selected for climatic classification are:

First type - This type is characterized by two pronounced seasons --- dry from November to April and wet the rest of the year.

Second type - This type has no dry season but has a pronounced rainy season from November to January.

Third type - This type has no pronounced rainy season and only a short dry period lasting for from one to three months.

Fourth type - This type has no dry season and a pronounced rainy season.

The climate in the Agno River basin is of the first type. Determinant factors are the 2,000 m mountains surrounding the basin, and monsoons and typhoons.

Floods are brought by heavy rains caused by monsoons and also by an average of 4 typhoons a year. Maximum and minimum mean monthly temperatures at Dagupan are 29°C in August and 26°C in January, a comparatively small temperature differential. Mean annual humidity is 75% in lowlands and 85% in the mountains.

3. Precipitation

In this drainage area, the dry season is from November to April and the wet season from May to October. Annual precipitation varies from 2,000 mm in the neighborhood of Tarlac to 4,000 mm in the upper stream of the Agno River. Such great variation is caused by the influence of mountains upon precipitation produced by monsoons. The records of heavy rains which caused floods were 3,462 mm within a month in August, 1911, and 1,168 mm in 24 hours in July, 1911, in Baguio city located in the watershed area of the Agno River. Recently, in 1972 and 1976 disasters due to heavy rain were experienced.

4. Flood and Storm Surge

Since the Agno River basin is characterized by mountainous topography, the flood runoff reaches the plain in several hours and the river mouth in a day. For this reason, the flood hydrograph of the river shows very sharp rise and falls. The largest recent flood was experienced in May, 1976, when some gaging stations were washed away resulting discontinuity of stream flow measurement thereafter. BPW has estimated the design flood with a 100-year return period as 10,000 m^3/sec at Wawa, Bayambang, (drainage area is 4,196 km^2), whereas in the NPC scheme, Binga Dam has a spillway with a designed discharge of 5,770 m^3/sec (drainage area is 936 km^2).

Considering the features of Lingayen Gulf, storm surges are expected to a certain extent.

As mentioned above, the Pangasinan Plain was formed by floods often. The largest was in May, 1976, producing inestimable damage, flooding the entire Pangasin Plain including the Tarlac River.

The Pangasinan Plain suffers from floods very often; the largest was in May, 1976, flooding the entire Plain including the flood plain along the Tarlac River, causing an inestimable damage.

5. Flood Control Works

BPW has been in charge of Agno River flood control, and its primary plan included construction of dyke systems and flood ways. The Agno tends to expand to the Pangasinan Plain beyond the right bank of the river, The dyke on this side is the most important structure. Also, the dyke on the right bank of Tarlac River between Tarlac and Poponto Swamp is no less important. At present, these dykes have been 70-80% completed. The left bank of these rivers has no dykes in many places, and construction work is now under way.

Poponto Swamp is located at the junction of the Tarlac River and Agno River, and retards the runoff from the Tarlac River at the confluence. The Alcara flood way has recently been completed with the view to divert the peak flow of 3,000 m^3/sec of the Agno River into the swamp. This flood way is expected to contribute much to minimizing possible floods in the lower reaches of Bayambang.

Flood control in the basin of the Dagupan River has not progressed, probably because this river does not drain landside waters. In order to facilitate better drainage of the Dagupan River basin, it seems that some sluices or pumping stations may be required in the future.

Concerning other hydraulic structures, the National Power Corporation (NPC) has Ambuklao Dam and Binga Dam, both having a height of nearly 100 m in the upstream of the Agno, the National Irrigation Administration

(NIA) has an intake dam of the Agno irrigation system at San Roque, San Manuel, and an intake dam at Tarlac on the Tarlac River.

6. Gaging Station

There are 10 stream gaging stations along the Agno River, one station along the Tarlac River and 3 stations along the Dagupan River. Discharge measurement is also performed at these stations, except those located in the tidal reaches. Observation of water level is performed three times a day --- morning, noon and evening --- and also is performed hourly as an extra precaution in case of a flood. The automatic water gages installed in many of these stations were broken down during the floods in 1972 and/or 1976. Observation at the most of these stations is currently done with the staff gages. The station at San Roque, San Mannuel, was half destroyed and a staff gage has been temporarily installed. The station at Tibag, Tarlac has been abandoned. All the data from the gaging stations are compiled at the BPW headquaters.

As regards meteorological observatories, there is the Dagupan Synoptic Station, PAGASA, which monitors all essential meteorological factors. The rain gaging stations, with PAGASA as the center, number as many as 22 including those in the Agno and Dagupan basins. In addition, both NIA and NPC have independent rain gaging networks.

Daily observation is performed at all gaging stations except the Synoptic Station. As compared with the water level gaging stations, the rain gaging stations have less interruption of recording. These data are gathered by the PAGASA headquarters via the Synoptic Station.

§-2 The Bicol River

1. Geography

The Bicol River is a medium sized river in the Philippines with a drainage area of 2,717 km^2 at Barongay Station covering the Provinces of Camarino Sur and Albay, the southernmost part of Luzon. The major part of the drainage area is flat alluvial land and tableland with volcanic deposits. The basin has higher mountains including volcanos over 2,000 m high to the east, and relatively lower mountains to the west. The runoff starts from Mayon volcano, the most famous mountain in Luzon, with an elevation of 2,421 m and after being regulated through the lakes of Bato, Baao and Buhi, comes into the main stream of the Bicol River.

The main tributary is the Sipocot River, which enters from the left at a point 8 km from the estuary. Unlike the main stream, the basin of the Sipocot is almost all mountainous terrain.

Rainfall in the mountains that are the source of the river immediately flows down the steep mountain slopes and rapids, and enters the main river course, which meanders considerably across the plain. Then it joins the Sipocot River and pours into San Miguel Bay.

The Bicol River has a very gentle slope. Lake Bato, in spite of its location about 70 km from the river mouth, has a minimum water level of only 5.0 m above MSL. This is 1/14,000 in terms of water surface slope.

In the case of the Sipocot River, the slope is 1/250 and the fall is 100 m in about 25 km between Napolidan and the junction with the main stream. The course of the Bicol River, after joining the Sipocot River, widens and finally becomes more than 1,000 m wide at its estuary.

Since the Bicol River flows so slowly, the tide can reaches the areas upstream from Naga City (about 35 km upstream from the river mouth).

The topographic features of the basin can be classified as follows: Sipocot basin and the surrounding mountains; plain of volcanic deposits upstream from Bato Lake; and low wetlands extending between Naga City and the river mouth.

2. Climate

The climate of this basin is of the second type described previously, having no dry season but has a pronounced rainy season from November to January. The climate is determined by topographical features open toward the northeast, and monsoons and cyclones.

Northeastern monsoons between November and February have a great influence on this basin, while the trade winds are obstructed by mountain ranges. There are low mountains only to the southwest, therefore the basin is only slightly affected by southwestern monsoons. Cyclones average two a year.

Average annual temperature is 27°C and temperature differentials between localities are small. Average humidity is 85% at Naga City.

3. Precipitation

There is no dry season in this district. There are possibilities of heavy rains in October, November and December, mainly due to the influences of wind direction and topography. The average annual rainfall varies from 2,000 mm in the southwestern area to 3,600 mm in the northwestern area.

The highest monthly rainfall was 2,900 mm at Naga. Recent heavy rains were recorded in December, 1975, and December, 1976.

4. Flood and Storm Surge

Rainfall on mountains reaches the plain soon, from where it flows very slowly to the estuary due to low, flat terrain including large lakes.

Frequent and heavy floods are caused by storm surges generated in San Miguel Bay. The bay is subject to high tides, and in addition many violent typhoons pass over the area. Maximum storm surge is estimated to be as high as 2.5-3 m, and the floodtide in San Miguel Bay is about 1.5 m above MSL. Therefore, the water level in the bay may reach 4 m above MSL, when the storm surge occurs simultaneously with the astronomical flood tide.

5. Flood Control Works

Concerning the flood control works of the Bicol River, the Bicol River Basin Development Program (BRBDP) works out the basic plan and BPW is in charge of execution. The only project under construction is 'Cut-off No. 3', which is intended to straighten the meandering channel in the vicinity of Naga City. Future programs, however, include drastic projects such as the dyke system in the lower reaches, direct diversion channel from Lake Bato to Ragay Gulf, dams in the upper Sipocot River.

As for the water resource development, the integration of irrigation networks including the Lalo River irrigation system by NIA is another construction project.

6. Gaging Stations

Gaging stations located at 27 place in all are generally under BPW control, and discharge measurements are made at the most of stations. Daily observations of water level are performed twice --- morning and evening --- or three times --- morning, noon and evening --- and also performed hourly as an extra precaution in case of a flood. Many stations are installed with automatic level recorder, which are out of order except one at Mabulo, Naga. Therefore, reading is done with staff gages.

A synoptic Station of PAGASA is located in Pili, Camarines Sur and monitors all essential meteorological factors. There are 14 rain gaging stations of PAGASA, where daily observation is performed.

Considering the size of the drainage area, the number of gaging stations is greater than in many other areas in the country. This indicates that the development of the overall drainage area is relatively advanced.

§-3 The Cagayan River

1. Geography

The Cagayan River is the largest river in Luzon, having a drainage area of 27,580 km^2 (at Aparri).

The river is located in the northernmost part of Luzon, and flows northward into Babuyan Channel. Mountains with elevations at the 2,000 m level surround the east, south and west of the drainage area, and the main stream is located to the east of the center. The Cagayan valley is comparatively flat and is divided into Ilagan, Tugegarao and Aparri areas by bordered gorges. Main branches are, the Chico River which joins from the left at a point 55 km from the river mouth, the Ilagan River which joins from the right at Ilagan, 200 km from the mouth, and the Magat River which joins from the left at Naguilian, 230 km from the estuary. Both the Chice River and Magat River have extensive drainage areas, which together cover 1/3 of the whole basin.

The river has a total length of 400 km, 120 km of which in mountains and about 300 km on plains. The average slope of the river bed on the plains is as gentle as 1/8,000 in the 230 km between the estuary and Naguilian. The river meanders extensively through the flood plain of the Cagayan valley.

Marsyes and swamps are found in some parts of the lower reaches.

2. Climate

The climate is controlled by high mountains in three directions, trade winds, monsoons, and cyclones which attack the basin four times a year in an average.

Mean annual temperature at Tuguegarao, located at central reaches, is 26.6°C, with small temperature differentials between months. Average humidity is 80% and does not change noticeably.

3. Precipitation

The dry season lasts from December to April, whereas rainy season from May to November. The average annual rainfall is 1,000 mm in Alcara or in the northern part, and 3,000 mm in the south-eastern mountains. The heaviest rain which brought floods was recorded in Tuguegarao in November, 1906, when a monthly rainfall of 1,316 mm with the maximum 24 hour rainfall of 318 mm was recorded.

4. Flood and Storm Surge

Floods caused by this river tend to flow down very slowly because of its detension over the extensive flood plain, extremely gentle slope, retardation of natural flood by several gorges, and meandering of the river.

Water stage gaging is performed at gaging stations located along the river course, but no discharge measurement is performed. Therefore, the discharge flow, up to this time, is unknown.

The water stage in case of floods may rise higher than 10 m above the normal stage. Valleys are very often damaged by the floods, and the maximum area damaged is estimated to be 2,080 km^2.

No serious damage due to high tide has been recorded. Considering the features of Babuyan Gulf into which the river pours, no significant storm surge would be expected to occur.

5. Flood Control Works

BPW has been principally in charge of flood control on the Cagayan River, although no plan has actually been completed. This may indicate that the river course remains natural. Development of water resources has been progressing. The Oscariz Dam on the Magat River, completed by NIA, can provide irrigation for vast farmland. Many other irrigation systems are now being planned.

Increasing demand for the flood control or river improvement will take place when these development projects are completed.

6. Gaging Stations

Gaging stations are generally under BPW control. There are 9 stations along the Cagayan River, 2 stations along the Chico River, 2 stations along the Magat River and one station along the Ilagan River. However, the number of stations seems to be insufficient for the extensive area of the river basin. These stations perform the water stage gaging only, 2 or 3 times a day with staff gages. Hourly reading is taken during the period of floods. All the data are compiled at the BPW headquarters.

With regard to meteorological observation, there is Tuguegarao Synoptic Station, PAGASA, which monitors all essential meteorological factors, and there are 26 rain gaging stations belonging to PAGASA, however many of them have already been abandoned. The number of this kind of stations seems to be too small considering the large drainage area. The rainfall data are gathered by the PAGASA headquaters through the synoptic station.

IV. Socio-Economic Characteristics

§-1 The Agno River

The drainage area of the river covers four provinces --- Mountain, Benguet, Pangasinan, Tarlac. The area administrated is 13,118 Km^2.

1. Population

The basin has a population of about 2,302 thousand. Population density is as high as 146.3 persons/km^2, which is fairly high compared with the national average.

The each following eight cities or municipalities has a population of more than 50 thousand. Baguio, Benguet: 84.5 thousand, Dagupan, Pangasinan: 84.3 thousand, Bayambang, Pangasinan: 56.4 thousand, Tarlac: 135.1 thousand.

Agno River Basin: Summary of Population Statistics

Population / Province	Population 1970 Census	Pop. Increase (1960 - 70)	Pop. Density (per sq.km)	Pop. Projection 1975	Pop. Distribution (%) Urban	Pop. Distribution (%) Rural	Literacy Rate (%) 1970
Province Total/Ave	2,302,513	26.6	146.3	2,609,203	18.01	81.99	78.73
Mountain	93,112	8.4	44.4	105,259	3.59	96.41	61.55
Benguet	263,550	43.5	99.3	309,656	31.84	68.16	79.87
Pangasinan	1,386,143	23.3	258.2	1,547,604	19.90	80.10	86.03
Tarlac	559,708	31.2	183.3	646,684	16.70	83.30	87.45

Source: Bureau of the Census and Statistics

Cities and Towns with 50,000 or More Inhabitants

Cities and Towns	Population 1970	Cities and Towns	Population 1970
Baguio, Benguet	84,538	Urdaneta, Pangasinan	58,690
San Carlos, Pangasinan	84,333	Bayambang, Pangasinan	56,415
Dagupan, Pangasinan	83,582	Lingayen, Pangasinan	56,096
Malasiqui, Pangasinan	61,423	Tarlac, Tarlac	135,128

1970 Population Census

2. Industry

In the mountainous area, mainly centered in the Provinces of Mountain and Benguet, medium latitude agricultural products (such as cabbage, tomatoes, carrots, cauliflower, etc.) are cultivated on the alluvial soil of the Trinidad Valley up to the skirt of the surrounding mountains, being the principal source of vegetable supply in the Philippines. Production in logging and forestry is the highest in Luzon and the second highest in the Philippines. Mining and quarrying are active, and Benguet Province has mining as the most important industry, including the refining of gold.

In the plain area around Pangasinan, agriculture is well developed producing mainly palay (unhulled rice), sugar cane, tobacco, livestock, and poultry. In the lower drainage area around Lingayen and Dagupan, fish culture is active. Besides these, copper refining, cement manufacture and salt making are found.

Economic Information

Name of Province	Mountain	Benguet	Pangasina	Tarlac
Area (ha)	209,733	259,938	536,817	305,345
Income (FY1972-73)	₱1,063,812	₱2,978,411	₱6,027,620	₱4,735,300
Industry	Agriculture Logging & Forestry Mining & Quarrying Manufacturing	Agriculture Logging & Forestry Mining & Quarrying	Agriculture Logging & Forestry Fishing Mining	Agriculture Logging & Forestry
Crope	Cabbage Tomatoes Carrots Cauliflower Strawberries etc.	Cabbage Tomatoes Carrots Cauliflower Strawberries etc.	Palay (rough rice) Tobacco Coconut Sugarcane Livestock Poultry	Palay (rough rice) Sugar Poultry Goats

Number of Establishments in Agna River Basin
by Major Industry Division

Province	Total Number of Establishments	Manufacturing	Wholesale and Retail Trade, Restaurants and Hotels	Transport, Storage and Communication	Community, Social and Personal Services	Other Economic Activities
Mountain	773	118	583	29	31	12
Benguet	5,722	448	4,507	96	490	181
Pangasina	20,561	2,307	12,397	3,934	1,610	313
Tarlac	9,980	941	6,068	2,087	704	180

3. Traffic

The traffic network in the Agno River basin is composed mainly of road systems and railroads. The road system includes the trunk roads connecting between this region and other regions, inter-regional semi-trunk roads and roads used for daily life. Among the trunk roads, national highways No. 3, No. 13 and No. 11 are most important. They are the key routes that connect this region to Manila. Highway No. 3 runs through the central part of Pangasinan Plain from north to south and connects the main cities; highways No. 13 and No. 11 crossing highway No. 3 serve effectively as inter-regional semi-trunk roads.

The results of the 1975 survey of traffic volume at places of heavy traffic are as follows (number of cars):

Places of comparatively easy access: 1,000 - 1,500/day.

Cities in Benguet Province (Bagivere, Taba, Cample): more than 5,000/day.

Cities in Pangasinan and Tarlac Province (Asingan, Sto. Tomas, Tarlac): 6,000/day.

Other cities (Sta Barbara, Dagupan, Lingayen): 3,000 - 4,000/day.

The first railway was constructed between Manila and Dagupan in the Philippines, and the northern line now starts at Manila and terminates at San Fernand union and plays an important role as a means of transportation in the area.

As mentioned above, this region forms an important traffic center with both railroad and national road. These routes pass through several flood plains.

Existing Highway Kilometerages
(As of June 30, 1972)

Name of Province / Rank / Item	Mountain			Benguet		
	National	Provincial Municipal and City	Total	National	Provincial Municipal and City	Total
Earth	44.03	114.19	158.22	13.71	422.89	435.60
Macadam	131.98	169.34	301.32	72.81	385.19	458.00
Low type bit	34.37	6.88	41.25	155.76	209.22	364.98
High type bit	—	—	—	45.19	40.68	86.87
Concrete	—	—	—	18.43	1.05	19.48
Misc. & Comb.	—	—	—	—	—	—
Total	210.38	290.41	500.79	305.90	1,059.03	1,364.93

Sorce: Department of Public Highways

Name of Province / Rank / Item	Pangasinan			Tarlac		
	National	Provincial Municipal and City	Total	National	Provincial Municipal and City	Total
Earth	28.28	297.80	326.08	8.59	110.43	119.02
Macadam	159.44	784.64	944.08	7.82	344.20	352.02
Low type bit	63.74	147.63	211.37	37.70	183.31	221.01
High type bit	129.55	92.10	221.65	36.48	—	36.48
Concrete	93.59	2.61	96.20	76.39	6.69	83.08
Misc. & Comb.	—	425.82	425.82	—	—	—
Total	474.60	1,750.60	2,225.70	166.98	644.63	811.61

Sorce: Department of Public Highways

4. Damage

In the Agno River basin, the average annual damage due to floods during the past 10 years is ₱60 million, and the areas suffered extends as much as 1,720 km^2. The amount of damage in the past 10 years (1966-1975), caused by typhoons, tropical cyclones, etc., are listed below.

Flood Information

Year	Name of Cyclone	Date	Damages	Rainfall
1966	Klaring	May 11 ~ 22	₱ 430,000	Baguio 286.8 mm
1967	Trimg	Oct.14 18	₱1,773,800	Baguio 1,215.7 mm
1967	Welming	Nov. 1 5	₱ 170,000	Baguio 96.1 mm
1968	Huaning	Aug.17 20	₱ 400,000	Nagupan 114.4 mm
1969	Elang	July24 27	₱2,000,000	Baguio 545.7 mm
1973	Luming	Oct. 2 9	₱6,300,000	Nagupan 34.6 mm

Sorce: Bureau of Public Works
Philippine Atomospheric Geophisical and
Astronomical Service Administration

5. Basin Development Projects

The government of the Philippines is making efforts to develop the Agno River basin, with priority of road systematisation and river improvement. The regional projects are listed below.

A. Manila North Road
B. Second Luzon Highway Package Project
C. Tarlac - Sta Rosa Road
D. Rosario - Baguio Road
   Bauang - Baguio Road
E. Paniqui - Camiling - Wawa - Bayambang Road
F. Agno and Tarlac River Control Projects
G. Rehabilitation of National and Commercial Irrigation Systems and Installation of Irrigation Pumps within Disaster Areas

6. Target Area

At this time, the selection of target area for flood forecasting and warning is made as follows: taking into consideration the distribution of population and houses, use and productivity of land, economic effects upon investment and their regional concentration, and topographic features in the Agno River basin, as well as the possibility of forecasting and warning about floods in the future. This possibility is based upon meteorology, hydrographical features, frequency of floods and data from past observations.

(1) The entire Pangasinan Plain including the major cities or municipalities of Dagupan, Lingayen, Bugallon, Sta Barbaba, Bayambang, and Rosales.

(2) The central part of Tarlac Province including the major municipalities of Tarlac, Gerona, Paniqui, and Moncada.

Next, in the estimation of the major indistries in the target area according to the statistic data, the general and public properties are as follows:

(1) General property

1 Private building construction

Number of private building construction	Floor area ($x10^3$ m^2)	Value ($x10^3$ ₱)
900	470	70,000

Source of basic data: National Census and Statistics Office

2 Household

Number of families ($x10^3$)	Annual family income (₱)	Value of household ($x10^3$ ₱)
100	5,190	519,000

Source of basic data: National Census and Statistics Office

Note: For house fixtures, a household is assumed to have properties equal to its annual income.

3 Mineral production

Value of metallics (10^3 ₱)	Value of me-metallics (10^3 ₱)	Total value ($x10^3$ ₱)
3,000	12,000	15,000

Source of basic data: Bureau of Mines

4 Manufacturing production

Firms	Employment	Value of fixed asset (x10 ₱)	Value of production ($x10^3$ ₱)
50	2,600	10,000	140,000

Source of basic data: National Census and Statistics Office

5 Commercial trade total gross receipts

	Number of establishments	Employment	Total gross receipts ($x10^3$ ₱)
Wholesale gross receipts	170	1,700	77,000
Retail gross receipts	7,400	23,000	119,000
Total	7,570	24,700	196,000

Source of basic data: National census and Statistics Office

6 Fish pond production

Area (ha)	Production (ton)	Value ($\times 10^3$ ₱)
9,200	8,000	61,000

Source of basic data: Fisheries Statistics of the Philippines

7 Crops production

	Area (ha)	Production ($\times 10^3$ ton)	Value ($\times 10^3$ ₱)
Palay	57,000	41,000	92.000
Corn	3,000	2,000	5.000
Sugarcane	4,000	23,000	13,000
Tobbaco	1,000	1,000	3,000
Coconut	2,000	2,000	3,000
Abaca	-	-	-
Other	7,000	70,000	62,000
Total	74,000	139,000	178,000

Source of basic data: National Food and Agriculture Council

8 Livestock and poultry on farms

	Number	Value ($\times 10^3$ ₱)
Carabao	84,000	35,000
Cattle	32,000	12,000
Swine	115,000	10,000
Horses	4,000	1,000.
Goats	42,000	1,000
Chicken	606,000	2,000
Ducks	-	-
Total	883,000	61,000

Source of basic data: Bureau of Agricultural Economics

Total General Property Value: 1,240,000 x 10^3 ₱ (169,000 x 10^3 US$).

(2) Public property

9 National road & railway reconstruction cost

National road kilometerages	Railway kilometerages	Reconstruction value ($\times 10^3$ ₱)
370	60	572,000

Source of basic data: Department of Public Highways, Philippine National Railways

10 School reconstruction cost

Number of private schools	Number of public schools	Reconstruction value (x10^3 ₱)
100	900	71,000

Source of basic data: Department of Education and Culture, Educational Statistics, Bureau of Public works.

11 Transportation

Traffic volume	Average of fare (₱)	Value (x10^3 ₱)
50,000 cars	100	5,000

Source of basic data: Department of Public Highways National Census and Statistics Office

Note: For transportation, an average income obtained from a car used for business purposes is assumed as a property value.

Total Public Property Value: 648,000 x 10^3 ₱ (88,000 US$)

(3) Target area property value

(x10^3 ₱)

(1) General Property	1,240,000
(2) Public Property	648,000
(3) Total (x10^3 ₱)	1,888,000
Total (x10^3 US$)	257,000

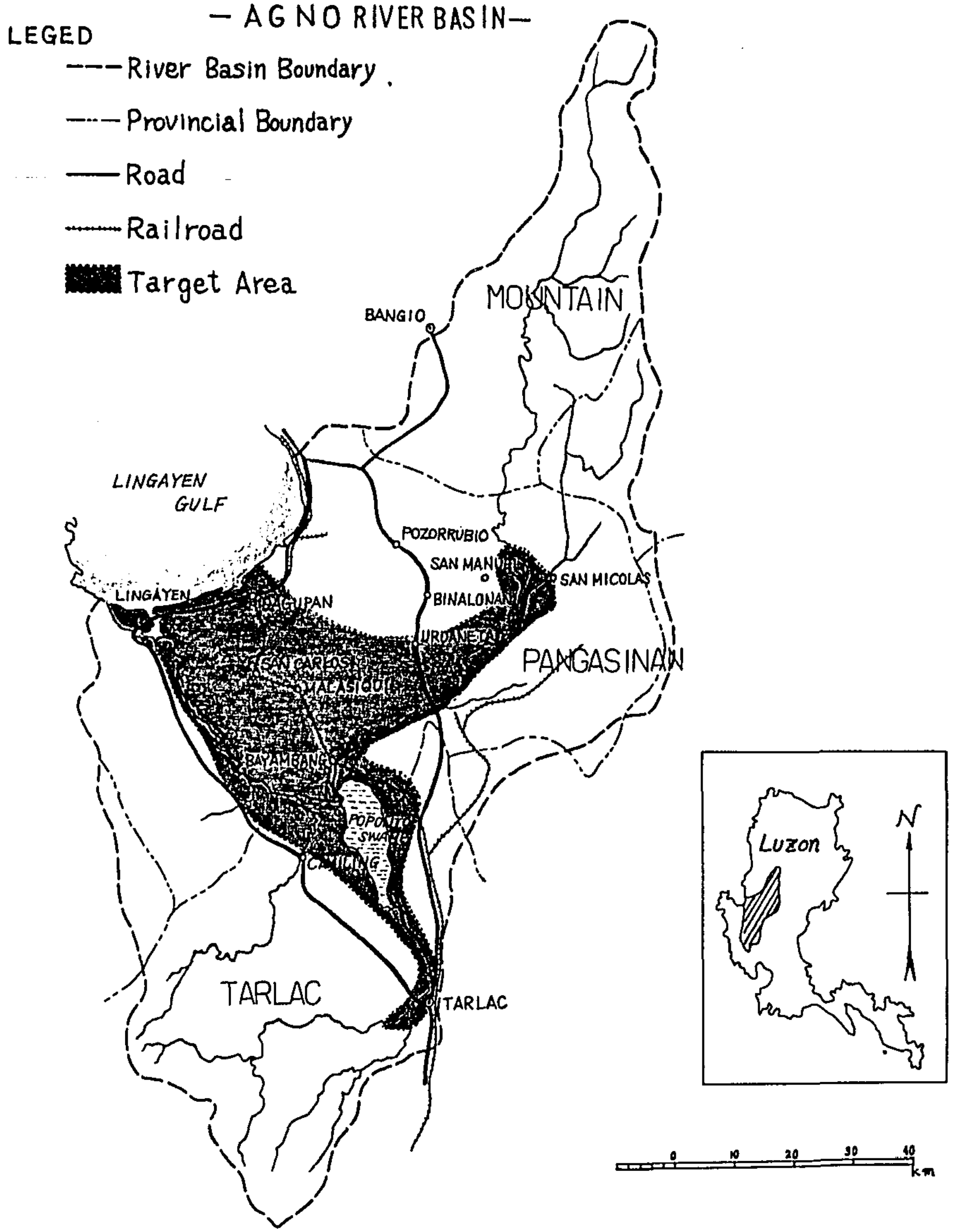
Note: (1) The properties in the target area were calculated according to the ratio of population or an area based on the statistical value of provinces and regions.

(2) The values of productions and properties (production value) in 1976 were calculated with reference to the growth ratios of consumers' prices and productions.

(3) In the conversion of Pesos into US Dollars, US$1 was calculated in terms of ₱7.39.

Fig. 4-1 TARGET AREA

— AGNO RIVER BASIN —



§-2 The Bicol River

The basin of this river covers three provinces — Camarines Norte, Camarines Sur and Albay --- and the area administrated is 9,930 km^2.

1. Population

The basin has a population of about 1,884 thousand. Density of population is about 189 persons/km^2, which is next to Metro Manila.

The each following seven cities has a populations of more than 50 thousand.

Legaspi, Albay: 84.1 thousand, Naga, Camarines Sur: 79.8 thousand, Iriga, Camarines Sur: 77.4 thousand, Libmanan, Camarines Sur: 62.8 thousand, Ligao, Albay: 56.8 thousand.

Bicol River Basin: Summary of Population Statistics

Population / Province	Population 1970 Census	Pop. Increase (1960 - 70) (%)	Pop. Density (per sq.km)	Pop. Projection 1975	Pop. Distribution (%) Urban	Rural	Literacy Rate (%) 1970
Province Total/Ave	1,884,624	28.7	189.3	2,057,153	20.30	79.70	88.97
Camarines Norte	262,207	39.4	124.1	303,337	25.98	74.02	92.22
Camarines Sur	948,436	15.7	180.0	994,626	21.08	78.92	87.68
Albay	673,981	30.9	264.0	759,190	13.86	86.14	87.02

Source: Bureau of the Census and Statistics

Cities and Towns with 50,000 or More Inhabitants

Cities and Towns	Population 1970	Cities and Towns	Population 1970
Legaspi, Albay	84,090	Tabaco, Albay	60,572
Naga, Camarines Sur	79,846	Daraga-Locsin, Albay	58,335
Iriga, Camarines Sur	77,382	Ligao, Albay	56,765
Libmanan, Camarines Sur	62,762		

2. Industry

Agricultural industry is active in the basin. Cultivation of palay, corn, vegetables, root crops, etc. is dominant mainly in the Bicol Plain. The plain is the granary of the regions. Other active industries are, livestock, poultry, etc., logging and forestry mainly for lumber and logs, coastal fishing and production of marine products entered around the fishing ports of Naga and Colobong, fishponds and fish culture, mining, coconut oil production and the chemical industry.

Economic Information

Name of Province	Camarines Norte	Camarines Sur	Albay
Area (ha)	211,249	526,682	255,257
Income (FY1972-73)	₱1,644,805	₱4,411,522	₱5,140,204
Industry	Agriculture Logging & Forestry Fishing Mining	Agriculture Logging & Forestry Fishing Mining & Quarrying	Agriculture Logging & Forestry Fishing
Crope	Palay, Corn Abaca, Banana Coconut,etc	Palay, Coconut Abaca, Banana Livestock, Poultry,etc	Palay, Corn, Vegetable, Root-crops, Coconuts, Abaca, etc

Number of Establishments in Bicol River Basin by Major Industry Division

Province	Total Number of Establish-ments	Manufac-turing	Wholesale and Retail Trade Res-taurants and Hotels	Transport Storage and Com-munication	Community Social and Personal Services	Other Economic Activi-ties
Camarines Norte	3,807	431	2,820	106	372	78
Camarines Sur	13,425	1,494	9,727	1,150	802	252
Albay	10,533	1,623	6,992	1,028	706	184

3. Traffic

The traffic network in the Bicol river basin is composed mainly of the road systems and railroads. The road system includes trank roads connecting between this region and other regions, inter-regional semi-trunk roads and the roads used in daily life. The most important road is national highway No. 1, which is the key route to the north (mainly to Manila), and also serves effectively as an inter-regional semi-trunk road, connecting the main cities, passing through the central part along the Bicol Valley. According to the 1975 traffic survey, traffic volume at main points is as follows: (No. of cars)

Places of comparatively easy access: 200-400/day.
Cities in Albay Province (Legaspi, Ligao, Qas, Polangui): 200-1,100/day.
Cities in Camarines Sur Province (Iriga, Pili, Naga, Nabua): 800-2,400/ day.

In addition to highways, the southern railway laid from Manila to Legaspi plays an important role as a means of transportation in the area. Railroad and national roads functioning as life lines generally run along the Bicol Vallay, and cross the main flood plains at several points.

Existing Highway Kilometerages
(As of June 30, 1972)

Name of Province	Camarines Norte			Camarines Sur		
Item \ Rank	National	Provincial Municipal and City	Total	National	Provincial Municipal and City	Total
Earth	—	14.58	14.58	10.00	622.27	632.27
Macadam	57.03	489.63	546.66	75.70	723.50	799.20
Low type bit	51.20	64.07	115.27	135.62	191.74	327.36
High type bit	20.27	79.78	100.05	71.63	21.91	93.54
Concrete	59.05	5.60	64.65	32.35	14.06	46.41
Misc. & Comb.	—	—	—	—	—	—
Total	187.55	653.66	841.21	325.30	1,573.48	1,898.78

Source: Department of Public Highways.

Name of Province		Albay	
Item \ Rank	National	Provincial Municipal and City	Total
Earth	63.4	319.23	383.57
Macadam	111.69	395.06	506.75
Low type bit	102.60	140.79	243.39
High type bit	97.53	78.38	175.91
Concrete	20.31	1.98	22.29
Misc. & Comb.	13.37		13.37
Total	409.84	935.44	1,345.28

Source: Department of Public Highways

4. Damage

In the Bicol River basin, the average annual damage due to flood in the past is ₱30 million, and the area damaged reached 580 km^2. The amount of the damages in the past 10 years (1966-1975), caused by typhoon, and tropical cyclone are listed below:

Flood Information

Year	Name	Date	Damages	Rainfall
1967	Welming	Nov 1 ~ 5	₱18,000,000	Daet Com. Norte 175.5 mm
1973	Luming	Oct 2 ~ 9	₱ 3,200,000	Daet Com. Norte 200.1 mm

Source: Bureau of Public Works, Philippine Atomospheric, Geophysical and Astronomical Services Administration

Note: Damages in December 1975 and December 1976 are not recorded.

5. Basin Development Projects

The government of the Philippines set up the 'Bicol River Basin Development Program' with the intention to develop the Bicol region. The potential for development in the region is rather high in view of the advanced agriculture and also the various transportation, water resources and flood control projects.

The regional projects are listed below.

A. Quirino Highway
B. Legaspi Airport (Package of 5 Airport Projects)
C. Port of Tabaco (Package of 4 Port Projects)
D. Southern Luzon Electrification Project, Stages IV & V
E. Tiwi Geothermal Pilot Plant (2-10 MW)

6. Target Area

The selection of target areas for flood forecasting and warning at this time is made as follows: taking into consideration the distribution of population and of houses, utility and productivity of land. Economical and social characteristics and topographic features in the Bicol River basin, as well as the certainty of forecasting and warning about floods in the future. This certainty is based upon meteorology, hydrographical features, frequency of floods and the data of observation so far.

(1) Central part of the basin, from Lake Baao to Lake Bato.

(2) Alluvial plain extending from Naga city to the river mouth.

Next, in the estimation of the major industries in the target area according to the statistic data, the general and public properties are as follows:

(1) General property

1 Private building construction

Number of private building construction	Floor area ($x10^3 m^2$)	Value ($x10^3$ ₱)
900	470	70,000

Source of basic data: National Census and Statistics Office

2 Household

Number of families ($x10^3$)	Annual family income (₱)	Value of household ($x10^3$ ₱)
50	3,180	159,000

Source of basic data: National Census and Statistics Office

Note: For household fixtures, a household is assumed to have properties equal to its annual income.

3 Manufacturing production

Firms	Employment	Value of fixed asset ($x10^3$ ₱)	Value of production ($x10^3$ ₱)
25	1,100	3,000	21,000

Source of basic data: National Census and Statistics Office

4 Commercial trade total gross receipts

	Number of establishments	Employment	Total gross receipts ($x10^3$ ₱)
Wholesale gross receipts	50	400	18,000
Retail gross receipts	1,300	4,000	17,000
Total	1,350	4,400	35,000

Source of basic data: National Census and Statistics Office

5 Fish pond production

Area (ha)	Production (ton)	Value ($x10^3$ ₱)
3,800	800	4,000

Source of basic data: Fisheries Statistics of the Philippines

6 Crops production

	Area (ha)	Production ($x10^3$ ton)	Value ($x10^3$ ₱)
Palay	30,000	46,000	27,000
Corn	6,000	5,000	2,000
Sugarcane	-	-	-
Tabbaco	-	-	-
Coconut	8,000	4,000	5,000
Abaca	4,000	4,000	9,000
Other	9,000	19,000	9,000
Total	57,000	78,000	52,000

Source of basic data: National Food and Agriculture Council

7 Livestock and poultry on farms

	Number	Value ($x10^3$ ₱)
Carabao	19,000	8,000
Cattle	3,000	1,000
Swine	34,000	3,000
Horses	-	-
Goats	-	-
Chicken	303,000	1,000
Ducks	-	-
Total	359,000	13,000

Source of basic data: Bureau of Agricultural Economics

Total General Property Value: 301,000 x 10^3 ₱ (41,000 x 10^3 US$).

(2) Public property

8 National road & railway reconstruction cost

National road kilometerages	Railway kilometerage	Reconstruction value ($x10^3$ ₱)
90	50	231,000

Source of basic data: Department of Public Highways
Philippine National Railways

9 School reconstruction cost

Number of private schools	Number of public schools	Reconstruction value ($x10^3$ ₱)
20	250	19,000

Source of basic data: Department of Education and Culture
Educational Statistics
Bureau of Public Works

10 Transportation

Traffic volume	Average of fare (₱)	Value ($\times 10^3$ ₱)
20,000 Cars	100	20,000

Source of basic data: Department of Public Highway
National Census and Statistics Office

Note: For transportation, an average income obtained from a car used for business purposes is assumed as a property value.

Total Public Property Value: $252,000 \times 10^3$ ₱ ($34,000 \times 10^3$ US$)

(3) Target area property value

($\times 10^3$ ₱)

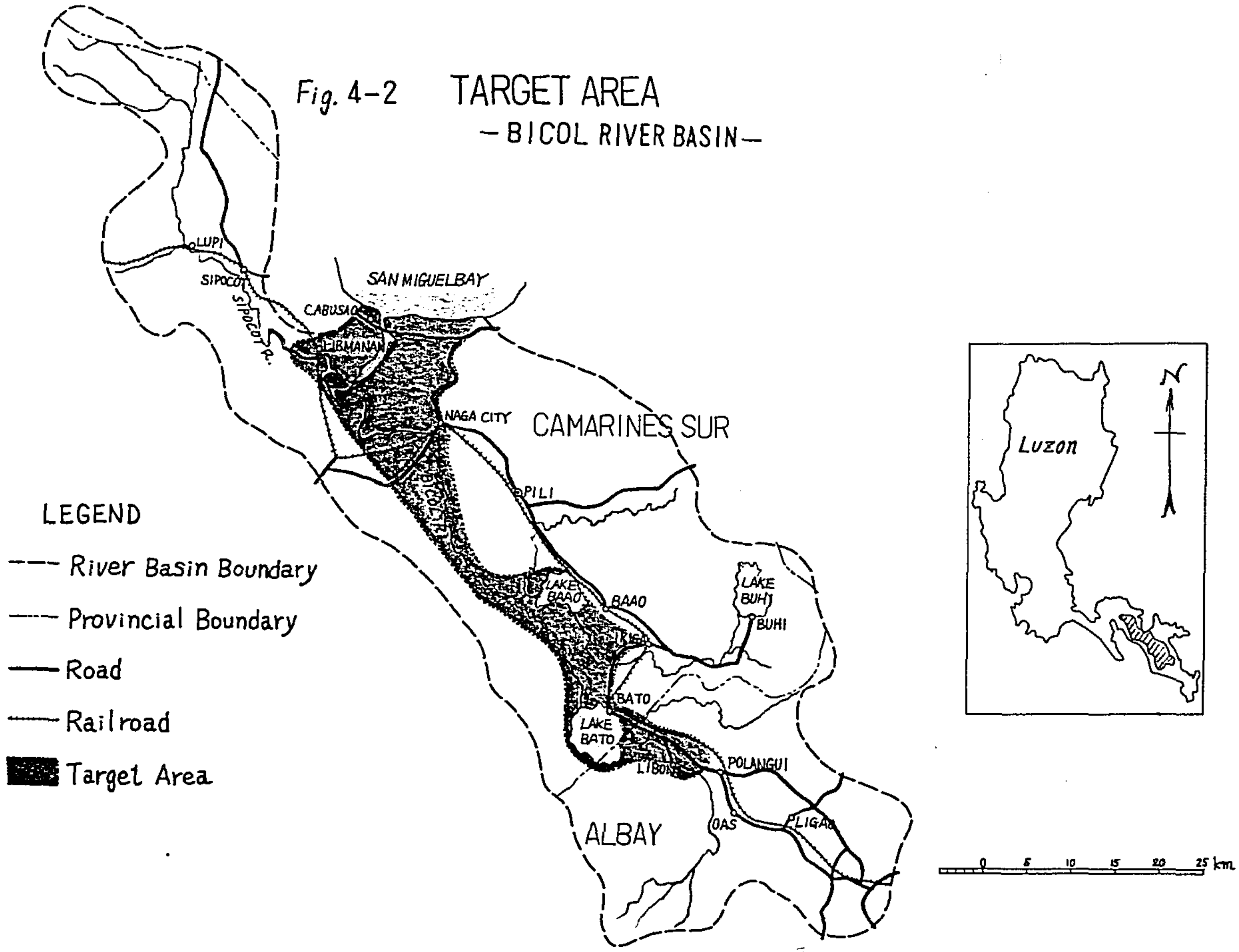
(1) General property	301,000
(2) Public property	252,000
(3) Total ($\times 10^3$ ₱)	553,000
Total ($\times 10^3$ US$)	75,000

Note: (1) The properties in the target area were calculated according to the ratio of population or an area based on the statistical values of provinces and regions.

(2) The values of productions and properties (production value) in 1976 were calculated with reference to the growth ratios of consumers' prices and productions.

(3) In the conversion of Pesos into US Dollars, US$1 was calculated in terms of ₱7.39.

Fig. 4-2 TARGET AREA
—BICOL RIVER BASIN—



§-3 The Cagayan River

The basins of this river covers seven provinces --- Cagayan, Isabela, Nueva Vizcaya, Benguet, Ifugao, Mountain, Kalinga Apayao --- and its area administrated is about 30,000 km^2.

1. Population

The basin has a population of about 2,037 thousand. Density of population is about 50 persons/km^2, which is lower than that in other regions.

There are only two cities of more than 50 thousand population each. Ilegan, Isabela: 62.1 thousand, Tuquegarao, Cagayan: 52.9 thousand.

Cagayan River Basin: Summary Population Statistics

Population / Province	Population 1970 Census	Pop. Increase (1960 - 69) (%)	Pop. Density (per sq.km)	Pop. Projection 1975	Pop. Distribution (%) Urban	Rural	Literacy Rate (%) 1970
Province Total/Ave	2,036,723	37.4	51.0	2,377,808	14.35	85.65	72.18
Cagayan	581,237	30.5	64.6	659,316	14.58	85.42	80.75
Kalinga Apayao	136,249	52.2	19.3	156,584	8.08	91.92	70.47
Isabela	648,123	46.6	60.8	768,727	13.39	86.61	81.91
Nueva Vizcaya	221,965	60.7	31.9	274,868	23.19	76.81	80.14
Ifugao	92,487	20.4	36.7	103,398	5.79	94.21	50.62
Mountain	93,112	8.4	44.4	105,259	3.59	96.41	61.55
Benguet	263,550	43.5	99.3	309,656	31.84	68.16	79.87

Source : Bureau of the Census and Statistics.

Cities and Towns With 50,000 or More

Cities and Towns	Population 1970
Ilagan, Isabela	62,118
Tuguegarao, Cagayan	52,956

Per 1970 Population Census

2. Industry

Although agriculture is the leading industry, the great majority of land is uncultivated. Palay, corn, native tobacco, and fruits are the main products from the limited farmland. In addition, logging and forestry are active, and the production of lumber is the second highest in Luzon. Coastal fishing as well as fishing ponds and fish culture industries are found.

Economic Information

Name of Province	Cagayan	Ifugao	Isabela	Nueva Vizcaya
Area (ha)	900,267	251,673	1,066,456	696,107
Income (FY1972-73)	₱8,058,248	₱ 971,600	₱9,122,962	₱1,395,627
Industry	Agriculture Logging & Forestry	Agriculture Fishing Mining	Agriculture Logging & Forestry Fishing	Agriculture Logging & Forestry
Crope	Palay, Corn Legumes, Rootcrops, Vegetables Fruits, Tobacco, Sugarcone, Caraboos, Hogs, etc	Rootcrops Corn, Vegetable, Fruits, Coconuts, Sugarcone, etc	Palay, Corn Tobacco, Fruits, Mango Peanuts, Tomatoes, Vegetables, Coconuts, Sugarcone, etc	Palay, Mango, Pomelo, Jackfruit, Vegetable, Potatoes, Maguey, etc

Number of Establishments in Cagayan River Basin by Major Industry Division

Province	Total Number of Establishments	Manufacturing	Wholesale and Retail Trade Restaurants and Hotels	Transport Storage and Communication	Community Social and Personal Services	Other Economic Activities
Cagayan	9,133	1,549	4,519	2,457	460	148
Ifugao	—	—	—	—	—	—
Isabela	5,578	748	3,583	583	556	108
Nueva Vizcaya	3,110	307	1,820	607	259	117

3. Traffic

The traffic network in the Cagayan River basin is composed mainly of the roads. The road system includes trunk roads connecting between this region and other regions, inter-regional semi-trunk roads and roads used for daily life. The Philippines-Japanese Friendship Road is the most important trunk road, which is the key route that links this region to the south (mainly to Manila), and also serves effectively as an inter-regional semi-trunk road, connecting the main cities, passing through the central part of the region from north to south. The Philippines-Japanese Friendship Road, functioning as life line, runs along the Cagayan Valley and crosses the main flood plains at several points.

Existing Highway Kilometerages
(As of June 30, 1972)

Name of Province	Cagayan			Ifugao		
Rank / Item	National	Provincial Municipal and City	Total	National	Provincial Municipal and City	Total
Earth	6.00	240.46	246.46	99.82	138.01	237.83
Macadam	355.18	658.23	1,013.41	163.42	84.78	248.20
Low type bit	11.31	51.36	62.67	18.72	1.80	20.52
High type bit	49.16	45.75	44.91		—	—
Concrete	63.40	0.08	63.48	0.97	—	0.97
Misc. & Comb.	—	—	—	—	—	—
Total	485.05	995.88	1,480.93	282.93	224.59	507.52

Source: Department of Public Highways

Name of Province	Isabela			Nueva Vizcaya		
Rank / Item	National	Provincial Municipal and City	Total	National	Provincial Municipal and City	Total
Earth		546.30	546.30	141.20	95.96	237.16
Macadam	189.92	1,191.22	1,381.14	176.71	208.54	385.25
Low type bit	26.88	17.56	44.44	20.63	7.75	28.38
High type bit	31.66	21.37	53.03	7.78	0.60	8.38
Concrete	44.63	—	44.63	46.53	0.20	46.73
Misc. & Comb.	—	—	—	70.36	—	70.36
Total	293.09	1,776.45	2,069.54	463.21	313.05	776.26

Source: Department of Public Highways

4. Damage

In the Cagayan River basin, the average annual damages due to the floods in the past is ₱2.7 million, and the area damaged reached 570 km^2. The amounts of damage in the past 10 years (1966-1975), caused by the violent typhoons and tropical cyclones, is listed below.

Flood Information

Year	Name of Cyclone	Date	Damages	Rainfall
1966	Klaring	May 11 ~ 22	₱ 1,400,000	Raxas City 310.7 mm
1967	Trining	Oct 14 ~ 18	₱10,000,000	Aparri 273.1 mm
1968	Huaning	Aug 17 ~ 20	₱ 200,000	Tuguegarao 178.7 mm
1968	Nitang	Sep 24 ~ 29	₱ 150,000	Aparri 241.3 mm
1969	Elang	Jul 24 ~ 27	₱ 350,000	Cagayan 222.5 mm
1970	Pitang	Sep 8 ~ 12	₱ 8,700,000	Tuguegarao 22.2 mm
1973	Luming	Oct 2 ~ 9	₱ 1,200,000	Tuguegarao 199.3 mm

Source: Bureau of Public Works, Philippine Atomospheric, Geophysical and Astronomical Services Administration.

5. Basin Development Projects

This region has large potential for development, and the government of the Philippines is making efforts to progress the program, a part of which is now under way.

Regional Projects

A. Magat River Multi-purpose Project (Irrigation Phase)

B. Cagayan Valley Electrification Project

C. Matuno River Project

D. Magat River Project (Power Phase)

6. Target Area

At this time, the selection of the target area for flood forecasting and warning is made as follows: in the light of the distribution of population and houses, and the use and productivity of land in the Cagayan River basin, as well as meteorology, hydrographic features and flood frequency.

(1) Areas along the lower reaches, from Tuguegarao city to Aparri.

(2) Alluvial plains along the river corse, from Ilagan to Tumauini.

Next, in the estimation of the major industries in the target area according to the statistic data, the general and public properties are as follows:

(1) General property

1 Private building construction

Number of private building construction	Floor area ($x10^3$ ₱)	Value ($x10^3$ ₱)
100	40	4,000

Source of basic data: National Census and Statistics Office

2 Household

Number of families ($x10^3$ ₱)	Annual family income (₱)	Value of household ($x10^3$ ₱)
40	2,230	89,000

Source of basic data: National Census and Statistics Office

Note: For household fixtures, a household is assumed to have properties equal to its annual income.

3 Manufacturing production

Firms	Employment	Value of fixed asset ($x10^3$ ₱)	Value of production ($x10^3$ ₱)
20	800	1,000	13,000

Source of basic data: National Census and Statistics Office

4 Commercial trade total gross receipts

	Number of establishments	Employment	Total gross receipts ($x10^3$ ₱)
Wholesale gross receipts	30	300	17,000
Retail gross receipts	1,700	5,000	24,000
Total	1,730	5,300	41,000

Source of basic data: National Census and Statistics Office

5 Fish pond production

Area (ha)	Production (ton)	Value ($x10^3$ ₱)
500	100	1,000

Source of basic data: Fisheries Statistics of the Philippines.

6 Crops production

	Area (ha)	Production ($x10^3$ ₱)	Value ($x10^3$ ₱)
Palay	71,000	101,000	58,000
Corn	63,000	43,000	19,000
Sugarcane	-	-	-
Tabbaco	6,000	5,000	9,000
Coconut	-	-	-
Abaca	-	-	-
Other	2,000	19,000	26,000
Total	142,000	168,000	112,000

Source of basic data: National Food and Agriculture Council

7 Livestock and poultry on farms

	Number	Value ($x10^3$ ₱)
Carabao	41,000	17,000
Cattle	5,000	2,000
Swine	46,000	4,000
Horses	4,000	1,000
Goats	-	-
Chicken	303,000	1,000
Ducks	-	-
Total	399,000	25,000

Source of basic data: Bureau of Agricultural Economics

Total General Property Value: 285,000 x 10^3 ₱ (39,000 x 10^3 US$)

(2) Public property

8 National road & railway reconstruction cost

National road kilometerages	Railway kilometerages	Reconstruction value ($x10^3$ ₱)
220	-	275,000

Source of basic data: Department of Public Highways
Philippines National Railways

9 School reconstruction cost

Number of private schools	Number of public schools	Reconstruction value ($x10^3$ ₱)
30	250	20,000

Source of basic data: Department of Education and Culture
Educational Statistics
Bureau of Public Works

10 Transportation

Traffic volume	Average of fare	Value ($x10^3$ ₱)
10,000 cars	100	1,000

Source of basic data: Department of Public Highway
National Census and Statistics Office

Note: For transportation, an average income obtained from a car kept for business purposes is assumed as a property value.

Total Public Property Value: 285,000 x 10^3 ₱ (39,000 x 10^3 US$)

(3) Target area property value

($x\ 10^3$ ₱)

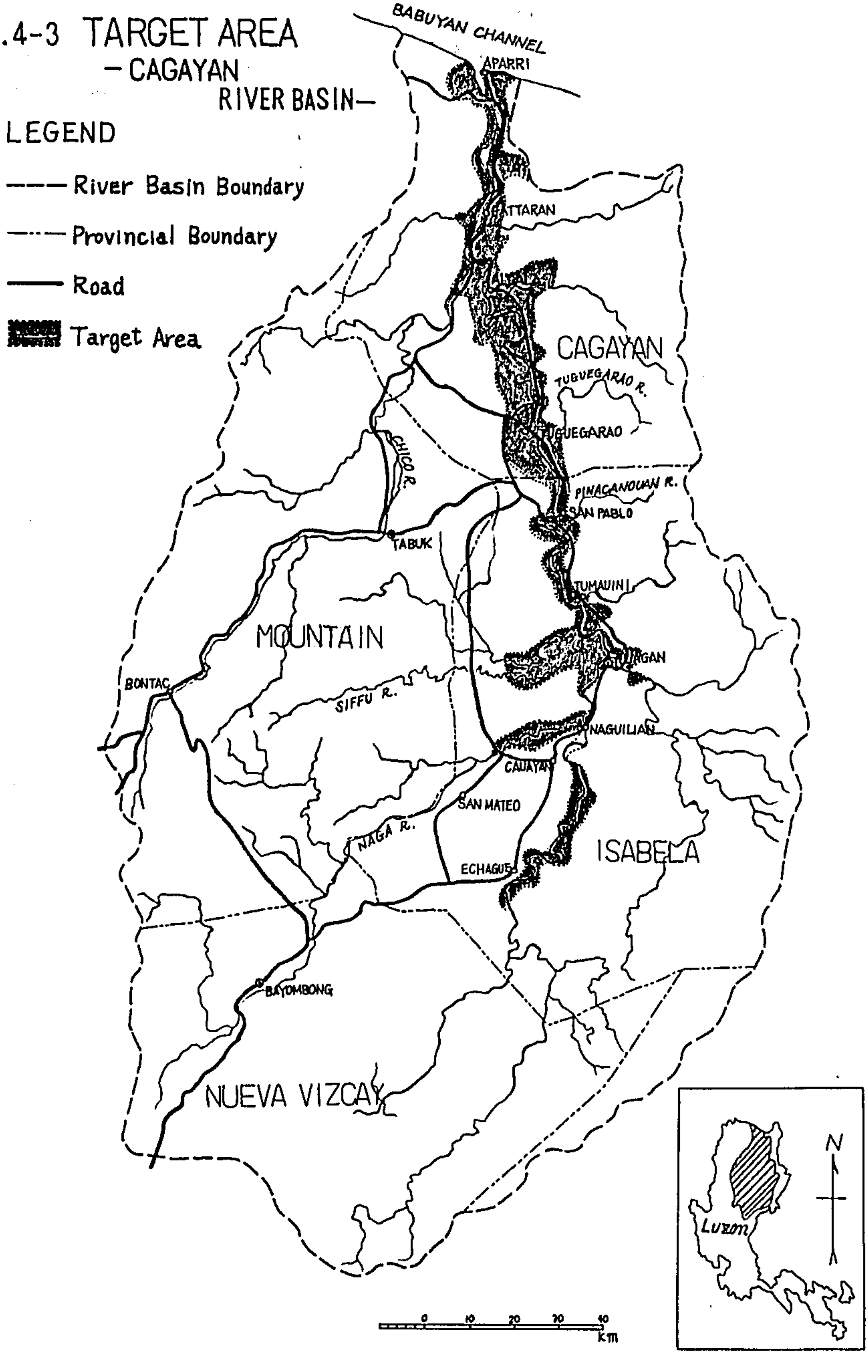
(1) General property	285,000
(2) Public property	296,000
(3) Total ($x10^3$ ₱)	581,000
Total ($x10^3$ US$)	79,000

Note: (1) The properties in the target area were calculated according to the ratio of population or an area based on the statistical values of provinces and regions.

(2) The values of productions and properties (production value) in 1976 were calculated with reference to the growth ratios of consumers' prices and productions.

(3) In the conversion of Pesos into US Dollars, US$1 was calculated in terms of ₱7.39.

Fig.4-3 TARGET AREA
– CAGAYAN
RIVER BASIN –



V. Flood Forecasting Procedure

It is essential to determine the location of the hydrological stations and the Forecasting and Warning stations necessary during times of floods in the regions in question. Methods of Flood Forecast can be examined from the released hydrological data and further, with reference to present flood records, the accuracy and reliability of Flood Forecasting Methods can be checked.

Since the existing flood records are in a daily basis, flood forecasting and its accuracy should be judged on daily basis. However, with the establishment of Flood Forecasting and Warning System, flood information can be obtained on hourly basis. It would then be necessary to check Flood Forecasting Methods through hourly flood information of the rivers.

§-1 The Agno River

1. Hydrograph and Hyetograph

1-1 Existing hydrological stations.

Water stage and rainfall gaging stations of the Agno River basin are located throughout the entire basin as shown in Fig.5-1. Most of the rainfall gaging station began operation in the period from 1974 to 1975. Tibac station, one of the hydrological stations was washed away by the floods in 1969 and since then observations was discontinued.

1-2 Rainfall Data

Data concerning rainfall which seems to have caused floods in the past 10 years (1967-1976) in the Agno River basin are recorded. These data and graphs are included in Appendix.

1-3 Water Stage Data

From the rainfall data, major floods in the Agno river were selected. The following points were selected for water stage telemetering stations in the Agno River system.

Binga Dam

San Roque

Carmen, Rosales

Tibag

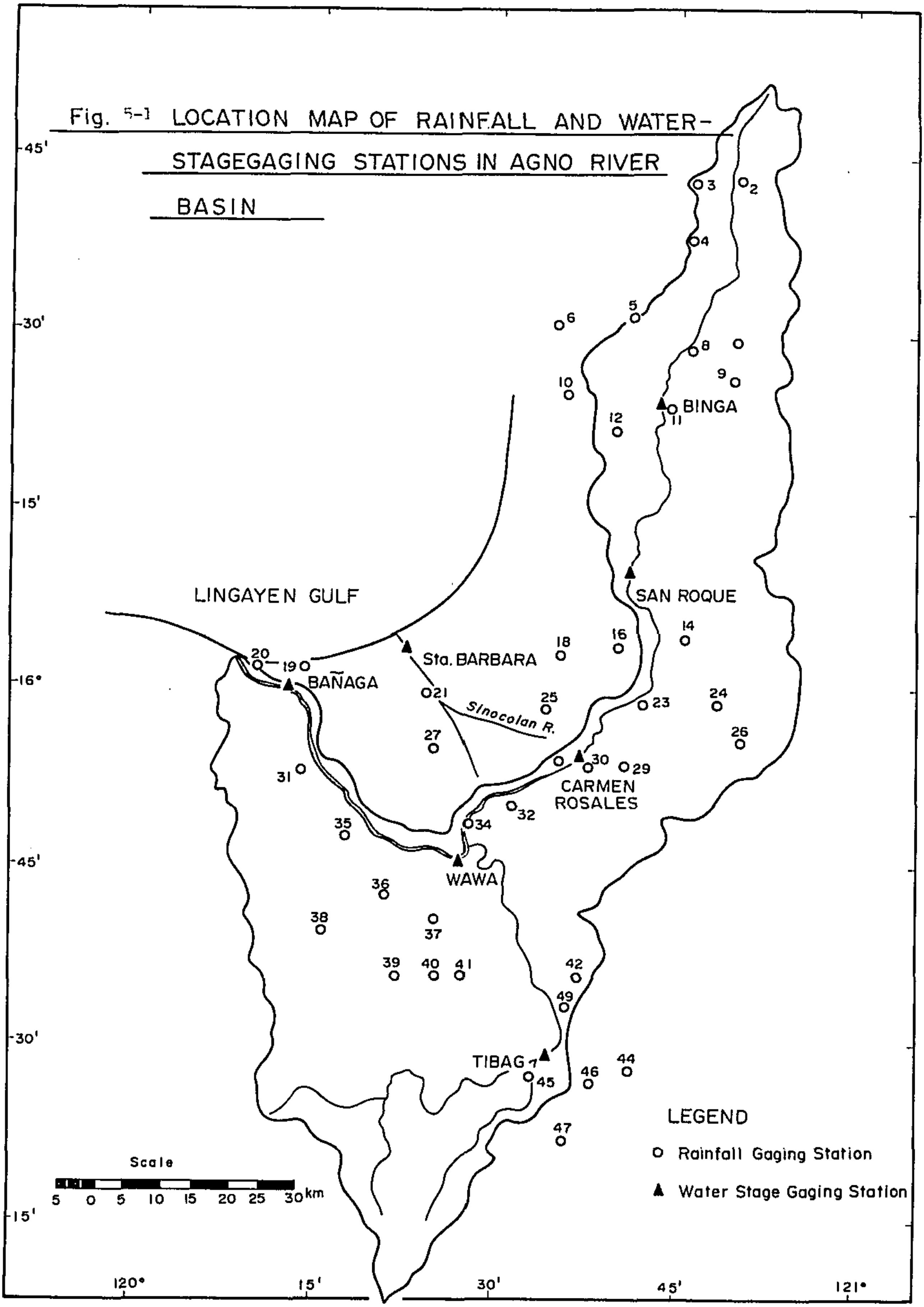


Fig. 5-1 LOCATION MAP OF RAINFALL AND WATER-STAGEGAGING STATIONS IN AGNO RIVER BASIN

Wawa

Bañaga (Because of lack of observation data for Banaga. data for Baay-West were substituted for them.)

Due to river improvement of the Agno River, the right bank became a flood region owing to everyflows of branch rivers, and in order to prevent Dagupan, the major city, from floods, Sta. Barbara was also selected.

Hydrological data from every hydrological station as well as the graphs are included in Appendix.

Table 5-2 shows the annual highest water stage at hydrological stations.

2. Travelling Time

The rate of movement of flood waters was calculated from the average speed of the flow, and the estimated traveling time of flood waters through sections of the river is shown in the table below.

Flood Water Travelling Time

Section of River	Distance	Slope	Rate of Flood Water Movement	Flood Water Travelling Time
Binga Dam~San Roque	50 km	1/100	5.0 m/s	3 hr
San Roque~Carmen	50	1/600	3.0	5
Carmen~Wawa	45	1/3,500	1.5	8
Tibac~Wawa	50	1/1,500	1.3	11
Wawa~Bañaga	70	1/20,000	1.0	19

3. Tributaries to be Forecast

3-1 Division of Drainage

Delineation of sub-basins must be worked out with regards to distribution of population and houses, land use and productivity.

The sub-basins were selected with regards to the topographical, meteorological and hydrological features of the area, frequency of floods, and the accuracy of flood forecast in the future depends on results of hydrological observations to date. As a result, 4 areas were selected as follows:

(1) Left bank of the Agno River, down stream of San Roque.

(2) Area along the Tarlac River, down stream of Tibag.

(3) Lingayen Area, down stream of Wawa.

(4) Dagupan Area.

3-2 Flood Forecasting Points

The forecasting points for the above areas are as follows:

San Roque

Carmen, Rosales

Tibag

Wawa

Sta. Barbara

4. Telemetering Stations

The points indicated in the following table are the telemetering stations for flood forecasting.

Discharging telemetering means the observation of discharge in ordinary times and in times of floods, drawing out stage-discharge rating curves, and converting the charged water stage into discharge.

Table Locasion of Rainfall Gaging Station

Table-5.1 Agno River Basin

No	Name of Stations	Location: Latitude	Location: Longitude	Elevation in meters	Type of Ins	Date Established	Managed by	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
1	Mt.Data, Mankayan,Benguet	16°52'00"	120°47'00"	2134	OG	Jan. 1966	CM								Δ	O		
2	Buguias,Agno river,Benguet	16°43'20"	120°49'40"	1400	OG	1950	CM	O		O	O		O	O				
3	Km.50, Benguet	16°43'00"	120°46'00"	2287	OG	Jan. 1968	CM			X	O	O						
4	Adaoay, Kabayan, Benguet	16°38'10"	120°45'40"	860	OG	1950	CM		X	O	O	O	O	Δ	O	O	O	Δ
5	Tubeyo, Atok, Benguet	16°31'30"	120°41'00"	1540	OG	1950	CM	O	X	O	O	O	O	O	O	O	X	O
6	Sayangan,Atok,Benguet	16°31'20"	120°34'20"	580	OG	1971	CM											
7	Karao, Bokod, Benguet	16°29'40"	120°49'40"	900	OG	1971	CM			O	O	O	O	O	O	O	X	X
8	Ambuklao,Bukud,Benguet	16°28'50"	120°45'40"	740	OG	1949	CM											
9	Bobok gauge #5, Benguet	16°26'30"	120°49'30"	360	OG	1950	CM										O	
10	Baguio City, Benguet	16°26'30"	120°49'30"	1501	RG/OG	1902-39;1947	MGSD											
11	Binga HE.plant,Itogan,Benguet	16°24'00"	120°44'00"	583	OG	1957	CM	O	O	O	O	Δ	Δ	O	Δ	O	Δ	X
12	Balatoc Mines,Itogan,Benguet	16°22'00"	120°39'00"	720	OG	1947	CM		O	O	O	O	O	O	O	O	O	Δ
13	Agno, Pangasinan	16°07'00"	119°48'50"	20	OG	1972	CM											
14	San,Nicolas, Pangasian	16°04'00"	120°45'45"		RG/OG	Spet.1974	HM									O	O	O
15	Mabini, Pangasian	16°04'10"	119°56'30"	20	OG	1947	CM											
16	San Manuel,Pangasian	16°04'00"	120°40'00"		RG/OG	July, 1974	CM											
17	Dagupan City, Pangasian	16°03'00"	120°20'00"	2	RG/OG	1902-39;1947	MGSD											
18	Binalonan, Pangasian	16°03'00"	120°35'20"	37	OG	1972	CM											
19	Matalava, Pangasian	16°02'00"	120°14'00"	2	RG/OG	Feb. 1971	HM											
20	Labrador,Pangasian	16°01'42"	120°08'30"		RG/OG	July, 1974	HM									O	O	O
21	Sta.Barbara, Pangasian	15°59'47"	120°24'14"	17	RG/OG	July, 1974	HM											
22	Dasol, Pangasian	15°59'30"	119°52'48"		RG/OG	Dec. 1974	HM											
23	Sta. Maria, Pangasian	15°59'11"	120°42'13"		RG/OG	July, 1974	HM									O	Δ	O
24	San Quintin, Pangasian	15°59'00"	120°48'38"	95	RG/OG	July, 1974	HM									O	X	X
25	Urdaneta, Pangasian	15°58'30"	120°34'10"	24	RG/OG	July, 1974	HM											
26	Umingan, Pangasian	15°55'37"	120°50'13"	128	RG/OG	July, 1974	HM									Δ	O	O
27	Malasigue, Pangasian	15°55'17"	120°24'43"	45	RG/OG	July, 1974	HM											
28	Villasis, Pangasian	15°54'15"	120°35'05"	21	RG/OG	July, 1974	HM									O	O	O
29	Balungao, Pangasian	15°54'00"	120°40'20"	50	OG	1971	CM						O	O	O	O	O	O
30	Rosales, Pangasian	15°53'36"	120°37'42"	27	RG/OG	Apr. 1969	HM				Δ	O	O	Δ	O	O	O	O
31	Aguilar, Pangasian	15°53'22"	120°14'15"		RG/OG	July, 1974	HM									O	O	O
32	Alcala, Pangasian	15°50'40"	120°31'22"	19	RG/OG	July, 1974	HM									O	O	O
33	Intanta, Pangasian	15°49'36"	119°54'18"		RG/OG	Dec. 1974	HM									Δ	Δ	X
34	Bayambang, Pangasian	15°48'42"	120°27'08"	13	RG/OG	July, 1974	HM									O	O	O
35	Magatarem, Pangasian	15°47'30"	120°17'30"		RG/OG	July, 1974	HM										O	Δ
36	Catagudingan,San Clemente tarlae	15°43'00"	120°21'00"		RG/OG	Jan. 1975	HM-NIA										O	O
37	Surgui 1st Camiling, Tarlae	15°41'00"	120°25'00"		RG/OG	May, 1970	HM					O	O	O	O	O	O	O
38	Anoling,Camiling, Tarlae	15°40'00"	120°15'30"		RG/OG	Jan. 1975	HM-NIA										O	O
39	Mayantoc, Tarlae	15°36'20"	120°21'50"	50	OG	1974	CM									O	O	O
40	Canamongan,Sta.Ignasia,Tarlae	15°36'00"	120°25'00"		RG/OG	Jan. 1975	HM-NIA										O	O
41	Nambalan,Mayantoc,Tarlae	15°36'00"	120°27'00"		RG/OG	Jan. 1975	HM-NIA										O	O
42	Matapitap,Gerona,Tarlae	15°36'00"	120°37'00"		RG/OG	Jan. 1975	HM-NIA										O	O
43	San Jaunto,Victoria,Tarlae	15°33'00"	120°36'00"		RG/OG	Jan. 1975	HM-NIA										O	O
44	Amucao, Tarlae	15°28'00"	120°41'00"		RG/OG	Jan. 1975	HM-NIA										O	O
45	Carangian Damsite, Tarlae	15°27'30"	120°33'00"		RG/OG	Jan. 1975	HM-NIA										O	O

Legend

O : Collected data

X : No data

Table 5-2 MAXIMUM WATER GAGE HEIGHT

The Agno River Basin

Unit: (m)
( ) Discharge(m^3/s)

Station / Year	BINGA DAM	SAN ROQUE		CARMEN ROSALES		WAWA		BAÑAGA (BAAY-WEST)		TIBAC		STA.BARBARA		BAYANBANG	
1966		May 20	(3694) 7.99	May 20	(2404) 26.60	—		Sept.13	3.24	Sept.27	(481) 2.88	May 21	(153) 5.33	May 21	(840) 16.25
67		Oct.18	(1182)	Oct.17	(3855) 27.60	Oct.19	13.00	Aug.19	3.20	July 30	(499) 2.76	Oct.18	(154) 5.34	Oct.18	(1229) 16.85
68		Sep.29	(4350) 8.40	Sep.28	(2764) 26.48	Aug.31	15.38	Aug.31	3.36	June 6	(29) 1.46	Aug.	(156) 5.40	Aug.29	(1251) 16.88
69		July29	(2158) 7.30	July28	(1658) 25.33	Aug.7	13.51	Aug.8	2.93	—		Aug.6	(148) 5.20	Aug.7	(521) 15.50
70		Oct.15	(550) 5.90	Sep.12	(1545) 25.18	Sep.2	12.95	Sep.11	2.84	—		Sep.12	(133) 5.36	Sep.12	(649) 75.85
71		Aug.14	(863) 6.99	Oct.11	(2307) 26.17	—		July	3.20	—		July21	(131) 5.30	Oct.11	(772) 16.12
72		July18	(1611) 9.19	July29	(3413) 27.25	July19	15.78	July17	3.98	—		July19	(135) 5.44	July19	(2425) 18.29
73		Oct.8	(455) 5.79	Oct.8	(1270) 24.80	Oct.17	11.77	Aug.27	2.98	—		Oct.9	(137) 5.48	Oct.9	(460) 18.29
74		July23	(390) 5.60	Oct.17	(2436) 26.33	Oct.18	15.59	Aug.17	3.80	—		Oct.20	(125) 5.14	Oct.29	(1929) 12.50
75				Sep.18	695 23.90	Oct.24	16.77	Aug.17	2.96					Jan.17	(31) 12.86
76		(June)		(May25	26.99)	(May26	14.22)							(May	)

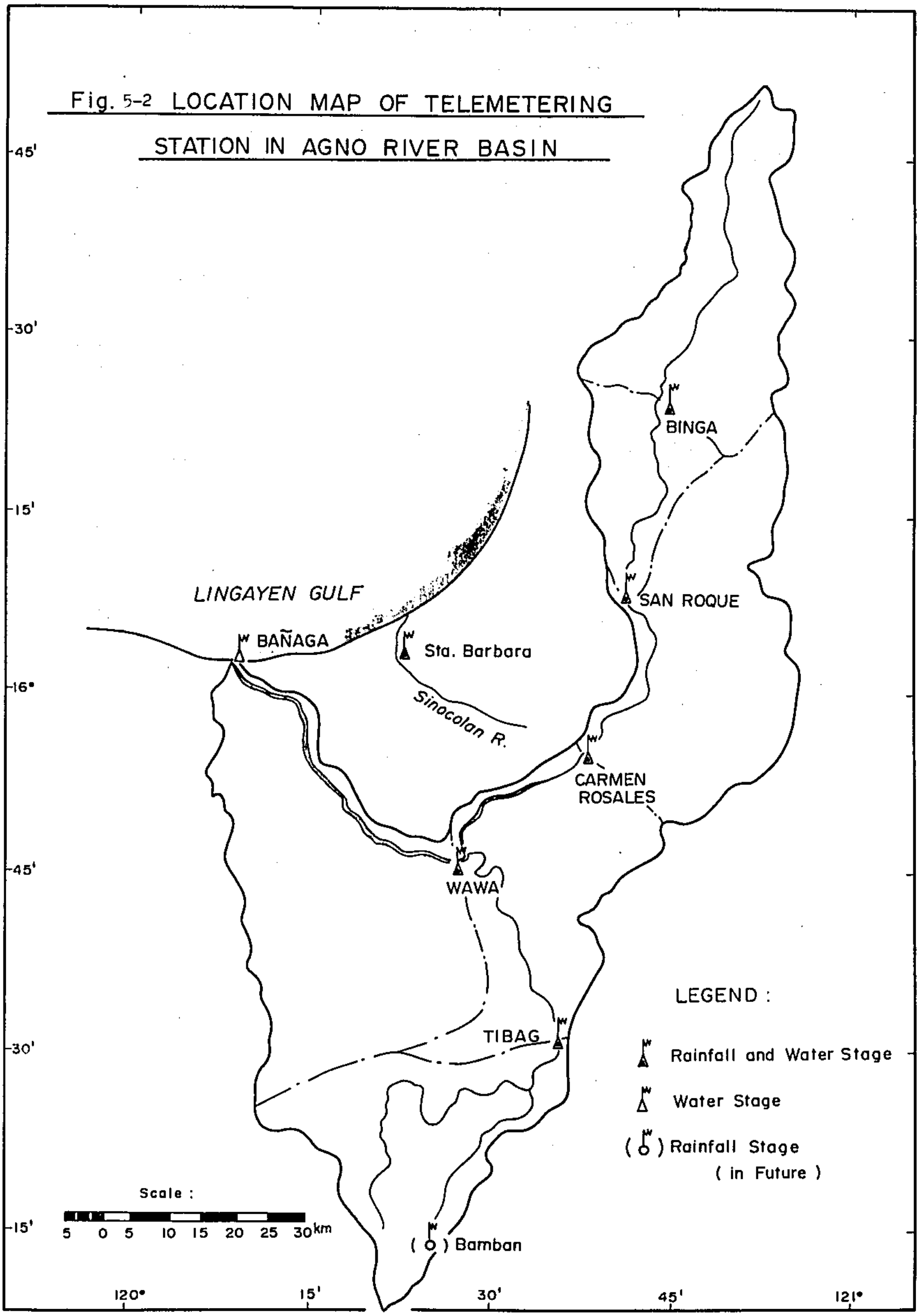


Fig. 5-2 LOCATION MAP OF TELEMETERING
STATION IN AGNO RIVER BASIN
45'
30'
15'
16°
45'
30'
15'
LINGAYEN GULF
BAÑAGA
Sta. Barbara
Sinocolan R.
BINGA
SAN ROQUE
CARMEN
ROSALES
WAWA
TIBAG
( ) Bamban
LEGEND :
Rainfall and Water Stage
Water Stage
( ) Rainfall Stage
(in Future)
Scale :
5 0 5 10 15 20 25 30km
120°
15'
30'
45'
121°

Agno River Basin: List of Gaging Station

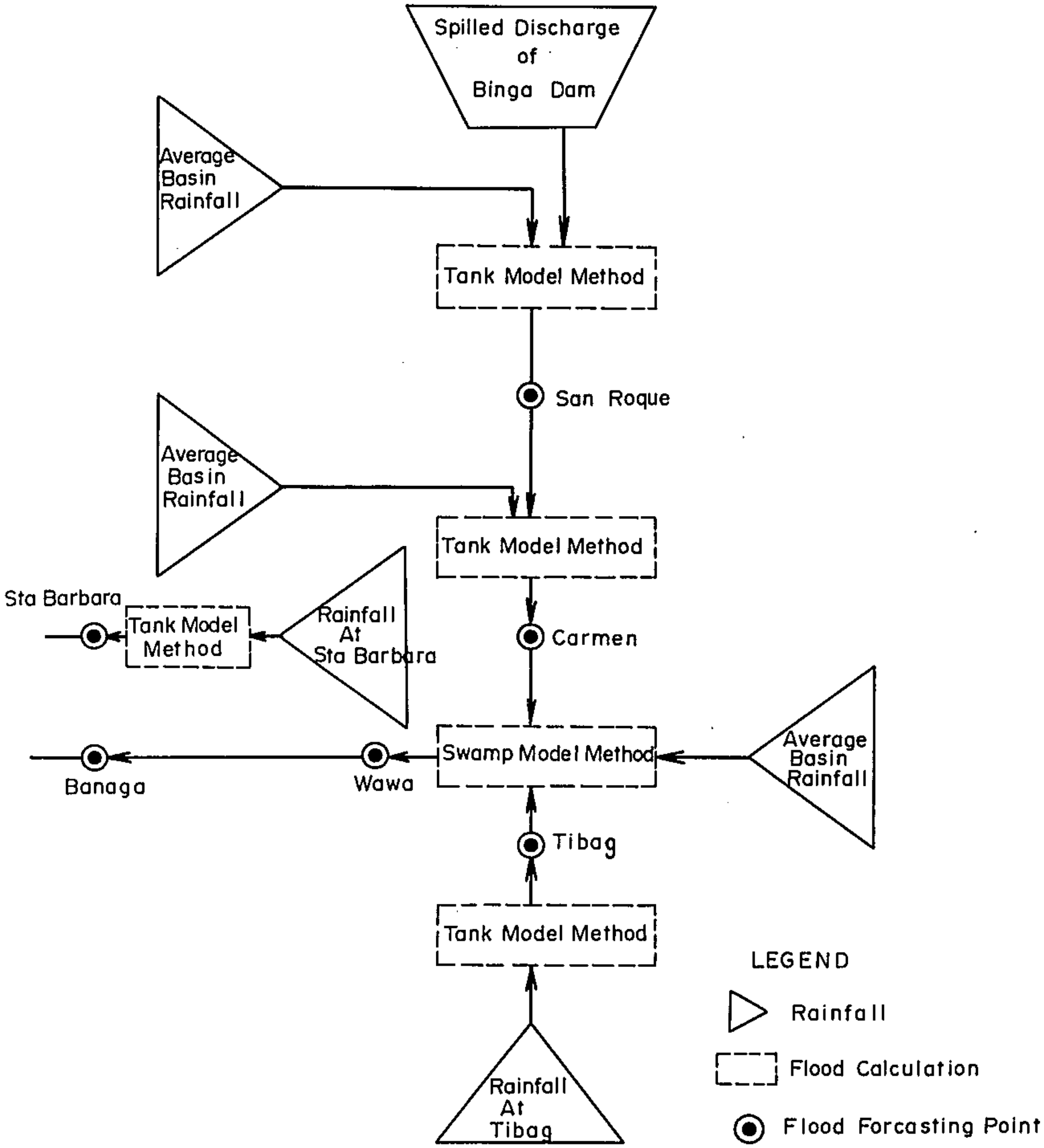
No.	Station	Location of Station	River Basin	Remarks
1.	Binga Dam	Downstream of Binga Dam: around the office	Agno R.	Newly constructed Rainfall, water level
2.	San Roque	Right Abutment of Agno Irrigation System Intake	Agno R.	Newly constructed Rainfall, water level, discharge
3.	Carmen	On the right bank of the Plaridal Bridge	Agno R.	Newly constructed Rainfall, water level, discharge
4.	Wawa	On the right bank of the Bridge under construction	Agno R.	Newly constructed Rainfall, water level, discharge
5.	Tibag	On the right bank of Bridge	Tarlac R.	Newly constructed Rainfall, water level, discharge
6.	Sta. Barbara	On the left bank of Maramiba Bridge	Sinocolan R.	Newly constructed Rainfall, water level, discharge
7.	Bañaga	On the left bank of Padilla Bridge	Agno R.	Newly constructed Rainfall, water level,
8.	Bamban	On the hill near Bamban overhead Bridge	Tarlac R.	in future

5. Flood Forecasting Model

The following figure shows the Flood Forecasting model of the Agno River, which has been worked out from the results of sub basins and forecasting point.

Fig. 5-3 FLOOD FORECASTING MODEL

THE AGNO RIVER BASIN

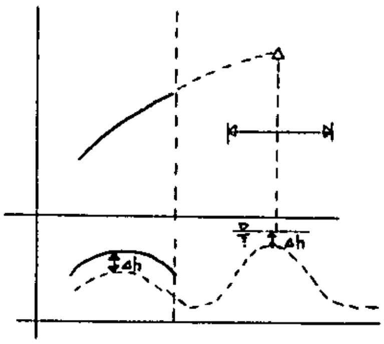


6. Storm Surge Model

Forecasting at Bañaga can be estimated through two methods --- flood time prediction and high tide prediction.

(1) Flood time prediction

Since the water stage of Baay-west, Lingayen, is influenced by flood water, there seems to be a considerable difference between the measured water level and the calculated tide level of Lingayen Gulf. Consequently correction must be made according to the difference between the actually observed water level and the calculated one.



(2) High tide prediction

Formula for calculations of high tide in Lingayen Gulf:

$$\Delta h = a\ (1{,}013 - P) + b.V^2$$

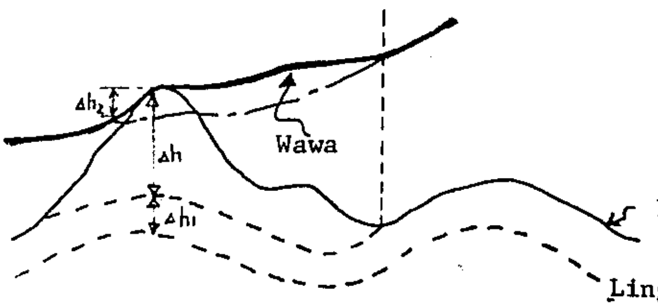
Where,

P: atmospheric pressure (mb)

V: wind velocity (m/s)

a) The course of typhoons, wind velocity and minimum atmospheric pressure can be forecasted from existing data.

b) Forecasting of the maximum deviation



Where, Δh_1 amount of increased water level during floods

Δh deviation

Δh_2 the difference in water lèvel between Bañaga and Wawa

Δh_2 = (Wawa W.L.) - (Bañaga W.L.)

However, when h_2 becomes below zero, a back current occurs. Therefore, in forecasting the water level of Wawa, a review must be made in connection with Δh_2.

Data available at Dagupan Synoptic Station or those supplied by F.F.C. through nearby observatory must be made use of in the computation of the maximum wind velocity and the lowest atmospheric pressure.

7. Flood Forecasting Method

7-1 San Roque point

(1) Estimation of area rainfall (daily rainfall)

The arithmetic mean of Binga dam rainfall (R_1) and San Roque rainfall (R_2) is taken.

$$R = \frac{R_1 + R_2}{2} \quad \text{(mm)}$$

(2) Spilled discharge of Binga dam

The amount of Binga dam discharge is converted into rainfall depth (R_{Bd}).

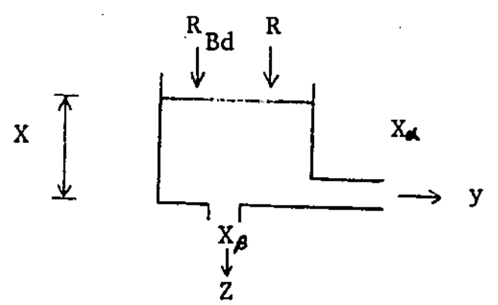
$$R_{Bd} = Q_{Bd} \times 86.4 \times / As \quad \text{(mm)}$$

Where, Q_{Bd} : spilled discharge of Binga Dam (m^3/s)

As : the drainage area between Binga Dam and San Roque

1225 - 936 = 289 km^2

(3) Tank model method



The model as shown in the sketch is an explanation of the tank model method. If, rainfall: $(R+R_{Bd})n$,
storage: X_n, outflow: Y_n, infiltration: Zn.
α times of X_n is Y_n and β times of X_n is Z_n.

Outflow rate $Y_n = \alpha . X_n$

Infiltration $Z_n = \beta . X_n$

Discharge rate $Q_n = Y_n \times As/86.4$

Storage X_n minus discharge Y_n and infiltration Z_n becomes residual X'_n.

$X'_n = X_n - Y_n - Z_n$

Adding the rainfall $(R+R_{Bd})_{n+1}$ at the time point (n+1) to this residual X'_n, storage X_{n+1} is obtained at the time point (n+1).

$X_{n+1} = X'_n + (R+R_{Bd})n+1$

In the tank model method, the travelling time of the flow in the river channel is not considered. So the calculated outflow must be shifted forward from the culculated time. Travelling time is inferred from actual measured results.

(4) Determination of model parameter and adjustment of actual measured values:

Model parameter α and β are determined from observed data. The ratio of the calculated discharge and observed discharge is the correction coefficient F. The adjustment of the predicted values is the product of F and the average rainfall in the region.

7-2 Carmen point

(1) Average basin rainfall (daily rainfall)

The average basin rainfall (R) is calculated by taking the arithmetic mean of the San Roque, (R_1) and Carmen, (R_2) rainfalls.

$$R = \frac{R_1 + R_2}{2} \quad (mm)$$

(2) Discharge at San Roque

The discharge at San Roque (Q_{sd}) is converted into rainfall depth (R_{sd}).

$$R_{sd} = \frac{Q_{sd} \times 86.4}{Ac}$$

Where Ac is drainage area between San Roque and Carmen, 2209 km^2.

(3) Tank model method

The calculation method is the same as for San Roque.

$Q_n = Y_n \times Ac/86.4$

Where Y_n: rainfall depth at San Roque point.

(4) Determination of model parameter and adjustment of the actual observed values

This is also the same as in the case of San Roque.

7-3 Tibag Point

(1) Average basin rainfall (daily rainfall)

Rainfall at Tibag (R_1), represents the basin rainfall. However, when Bamban telemetering station is established in the future, the arithmetic mean method will be applied.

(2) Tank model method

The calculation method is the same as in the case of San Roque.

$Q_n = Y_n \times A_4/86.4$

A_4: Drainage area at Tibag, 872 km^2

(3) Determination of model parameter and adjustment of the actual observed values

This is also the same as in the case of San Roque.

7-4 Wawa Point

(1) Average basin rainfall (daily rainfall)

The arithmetic mean values of Tibag rainfall (R_1), Carmen rainfall, (R_2) and Wawa rainfall (R_3).

$$R = \frac{R_1 + R_2 + R_3}{3} \quad \text{(mm/day)}$$

(2) Residual downstream outflow amount (Q_z)

$Q_z = R \times A_4/86.4 \quad (m^3/s)$

A_4: Residual drainage area (km^2)

4,196 - 872 - 2,209 = 1,115 km^2

(3) Inflow amount (Q)

Q_T: Tibag outflow (m^3/s)

Q_C: Carmen outflow (m^3/s)

Q_Z: Residual drainage area outflow (m^3/s)

(4) Flood adjustment calculation (flood retarding)

Generally,

I_n: Inflow amount at time n (m^3/s)

O_n: Outflow amount at time n (m^3/s)

V_n: Total storage amount at time n (m^3/s)

Δt: Time difference between time n and time n+1 (sec)

Since (average inflow) Δt = (average outflow) X Δt + (storage difference before and after Δt), if Δt is shortened enough so that there is no large error in assuming that the variations I and O is in a straight line, during Δt,

$$\left(\frac{I_n + I_{n+1}}{2}\right) . \Delta t = \left(\frac{O_n + O_{n+1}}{2}\right) . \Delta t + (V_{n+1} - V_n)$$

Where, values of I_n and I_{n+1} are known,

$$\frac{I_n + I_{n+1}}{2} = I_{(n,\ n+1)}$$

$$I_{(n,\ n+1)}\ \Delta t - O_n\ . \Delta t + \left(V_n + \frac{O_n}{2}\ . \Delta t\right) = \left(V_{n+1} + \frac{O_{n+1}}{2}\ . \Delta t\right)$$

and,

$\phi = V + \frac{O}{2} . \Delta t$, $\varphi = O . \Delta t$, is calculated.

Where, the value of O_n is calculated from $O = C \times \sqrt{2g \Delta h} \times B$

Δh: water level difference (m)

B: river width (m)

C: discharge coefficient

When conversion is made into water level, calculation is performed by the least square method using formula, $Q = AH^2 + BH + C$, where Q is the calculated discharge and H is the actual measurement value.

7-5 Sta Barbara point

(1) Average basin rainfall

Sta Barbara rainfall (R) represents the basin rainfall.

(2) Inflow amount

$Q = R \times A_5 / 86.4$ (m^3/s)

A_5: Dagupan river drainage area, 180 km^2

(3) Flood retarding

The method is the same as in the case of Wawa. However, the discharge

(O) is determined from the following formula.

$$O = C \cdot \sqrt{2g\,(H_1 - H_2)}$$

$$H_1 = H_{1\ n-1} + \Delta h$$

$$h = Q/(A \times 10^6)$$

Where, H_1: Inundated area W.L.

A: Dagupan River inundated area (km^2)

H_2: Calculated tide level in Bañaga

However, the application of the tank model method may become necessary when the effects of downstream tide level can be disregarded and discharge can be observed.

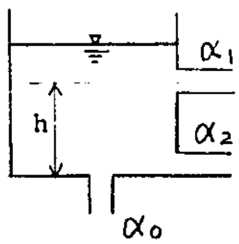
8. Verification of the Flood Forecasting Model

8-1 Verification of the Storm Surge Model at Bañaga Point

Comparison of the maximum wind velocity and lowest atmospheric pressure of Dagupan during recent big typhoons and the daily average water stage at the Bañaga point show no occurence of high tides. Analysis of high accuracy rate due to hourly report of hydrological information will become necessary after the establishment of Bañaga Telemetering Station.

8-2 Tank Model Analysis

The constants for the tank model obtained from existing flood data are as follows. The results of calculation for verification using these constants are shown in the following diagram.



Forecasting Point	α_0	α_1	α_2	h	Notes
San Roque	0.0	0.5	0.1	50	
Carmen	0.05	0.30	0.10	70	
Tibag	-	-	-	-	No analysis, lack of discharge data
Sta. Barbara	-	-	-	-	Ditto

8-3 Analysis of water level correlation

Since no sufficient rainfall and discharge data were available to verify the tank model, flood forecast calculations were made by the water level correlation formula.

Fig. 5-6·8 show a graphic representation of the water level correlation among the water level telemetering stations.

Fig.5-9~10 illustrates water level profiles estimated from the diagrams.

Fig. [illegible] WIND VELOCITY, ATMOSPHERIC PRESSURE AND WATER STAGE

Barongay (1)

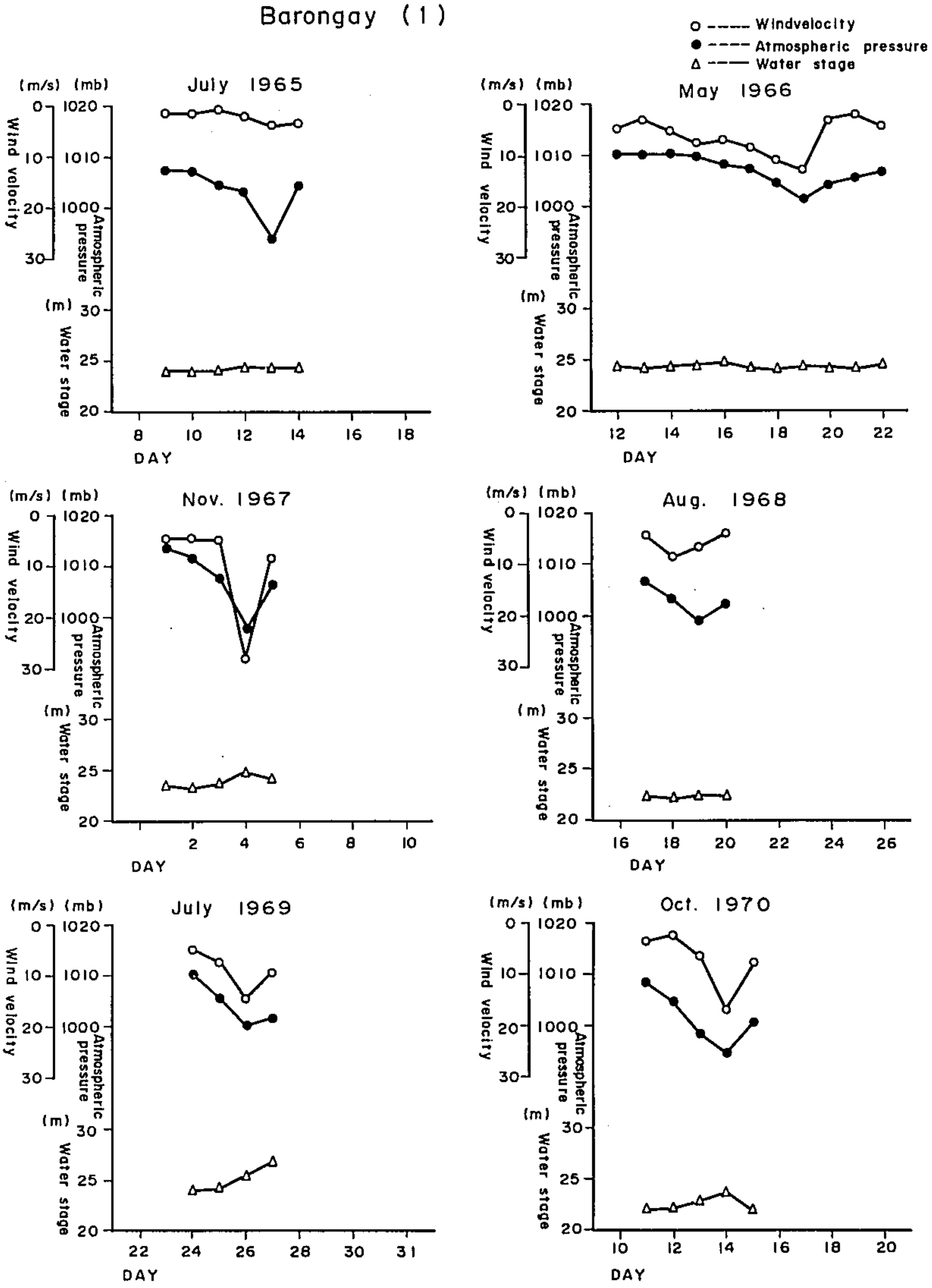


Fig. 5-4-2 WIND VELOCITY, ATMOSPHERIC PRESSURE AND WATER STAGE

Barongay (2)

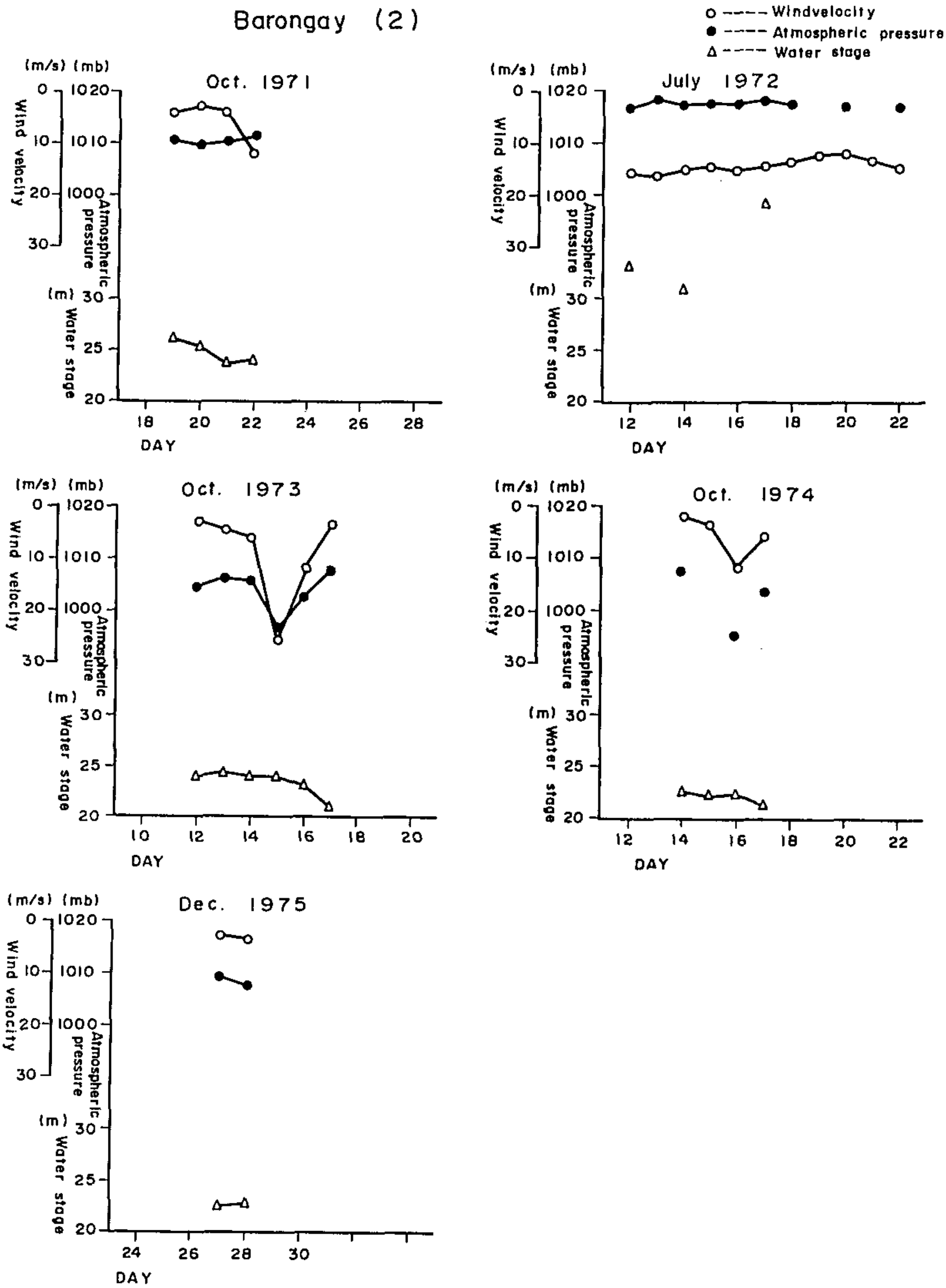


Fig. 5-5 OBSERVED AND CALCULATED RUNOFF AT AGNO RIVER
(TANK MODEL METHOD)
July Aug 1972

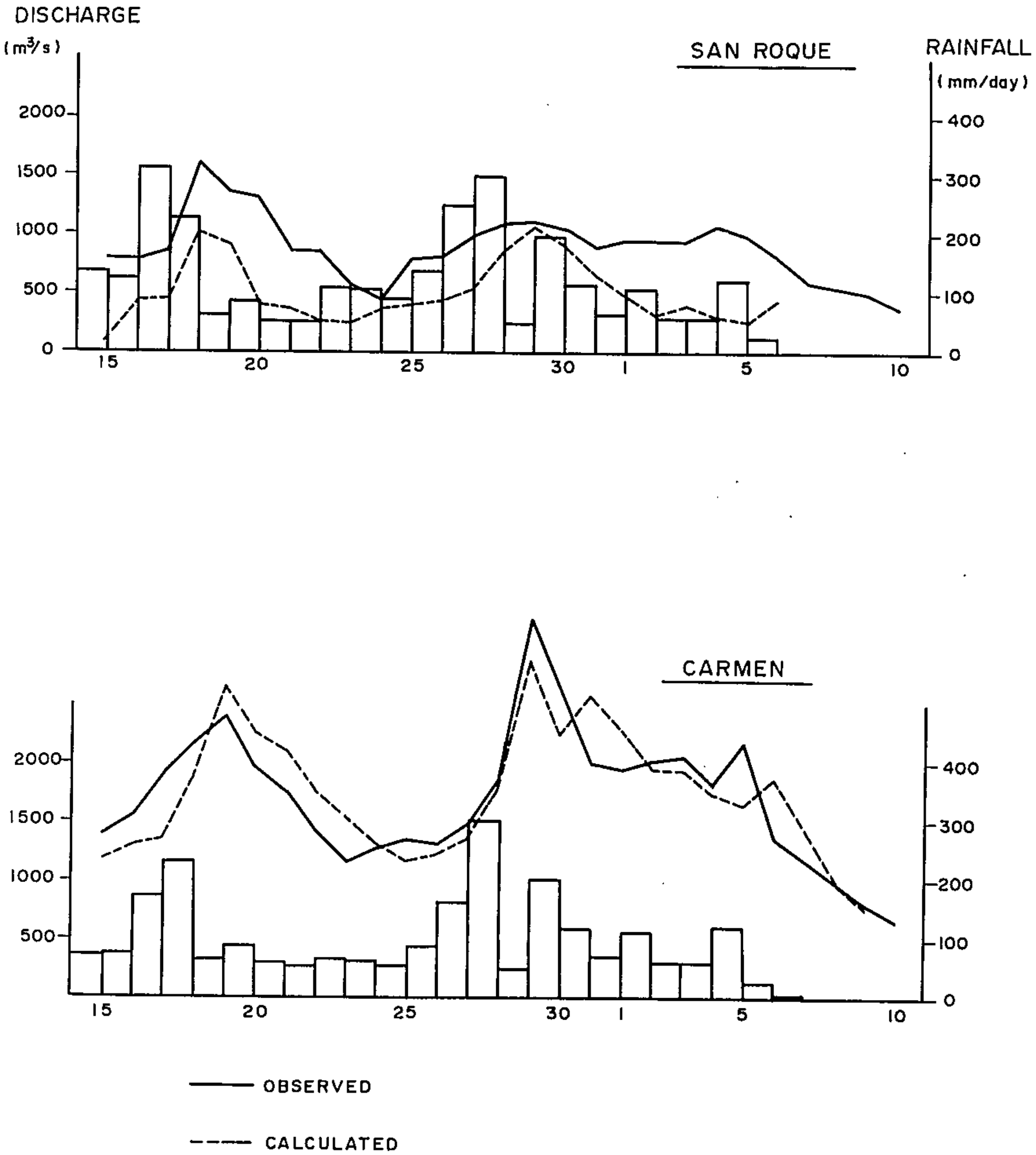


Fig. 5-6 CORRELATION BETWEEN GAGE HEIGHTS AT BINGA DAM AND SANROQUE

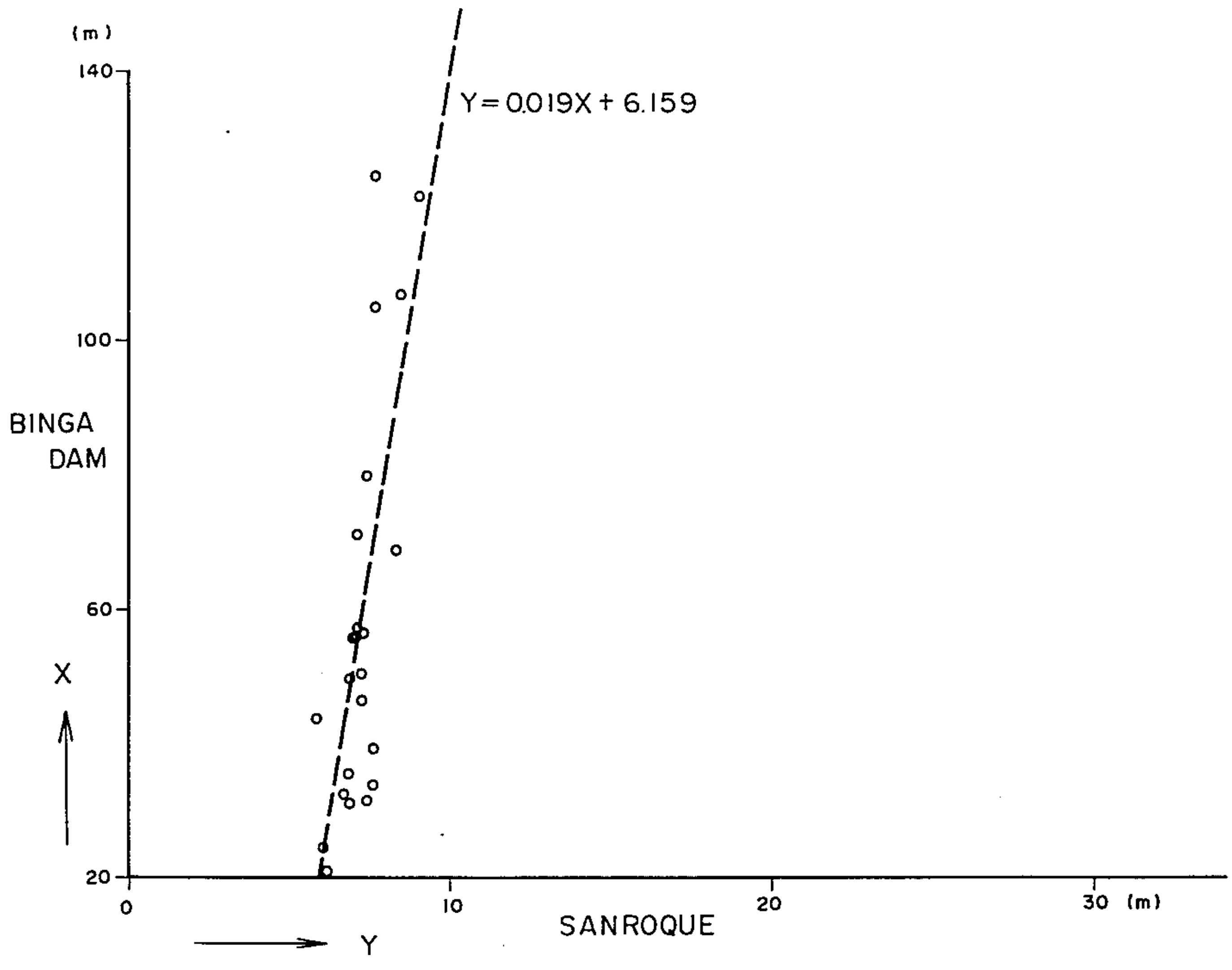


Fig. 5-7 CORRELATION BETWEEN GAGE HEIGHTS AT SANROQUE AND CARMEN

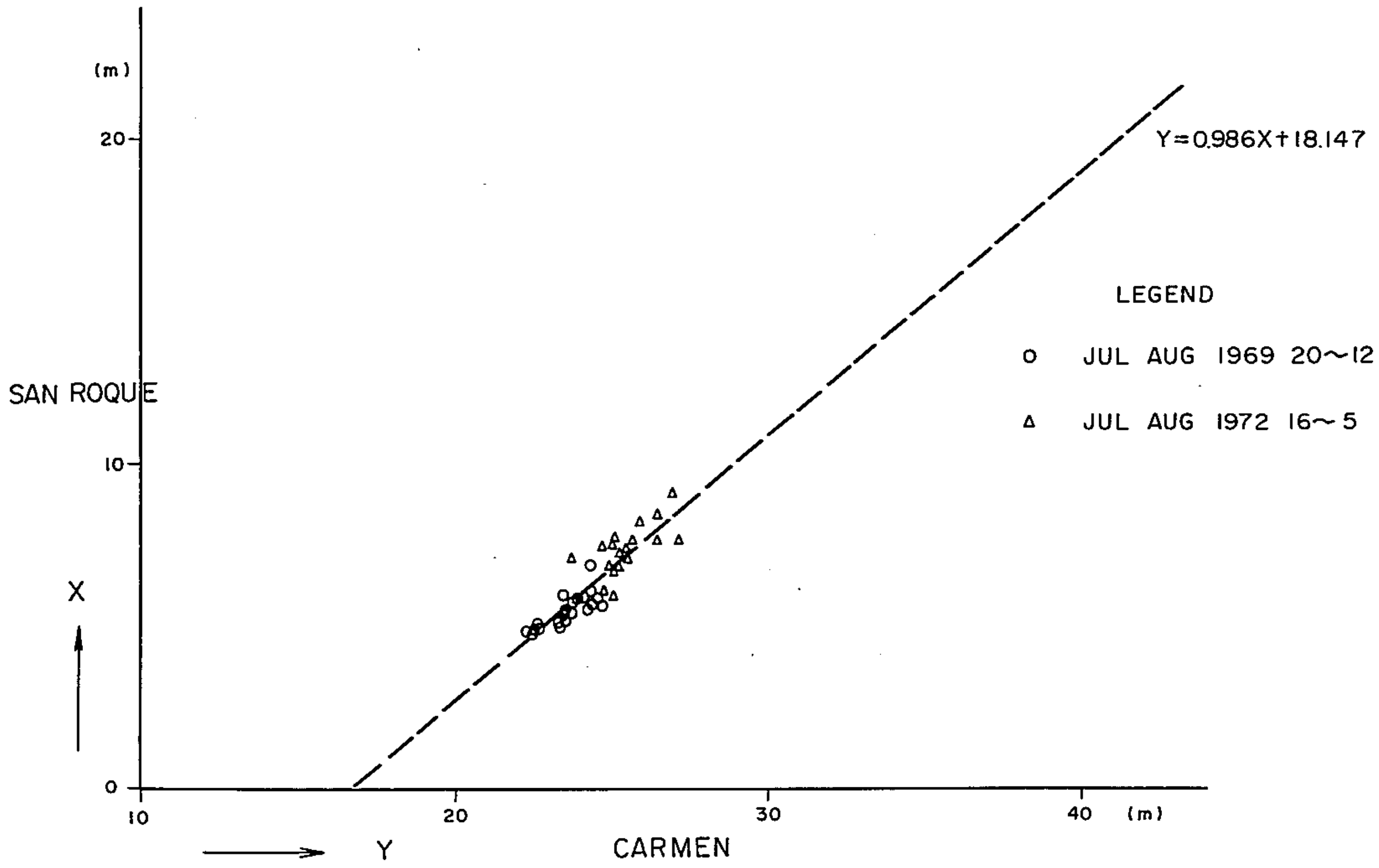


Fig. 5-8 CORRELATION BETWEEN GAGE HEIGHTS AT CARMEN AND WAWA

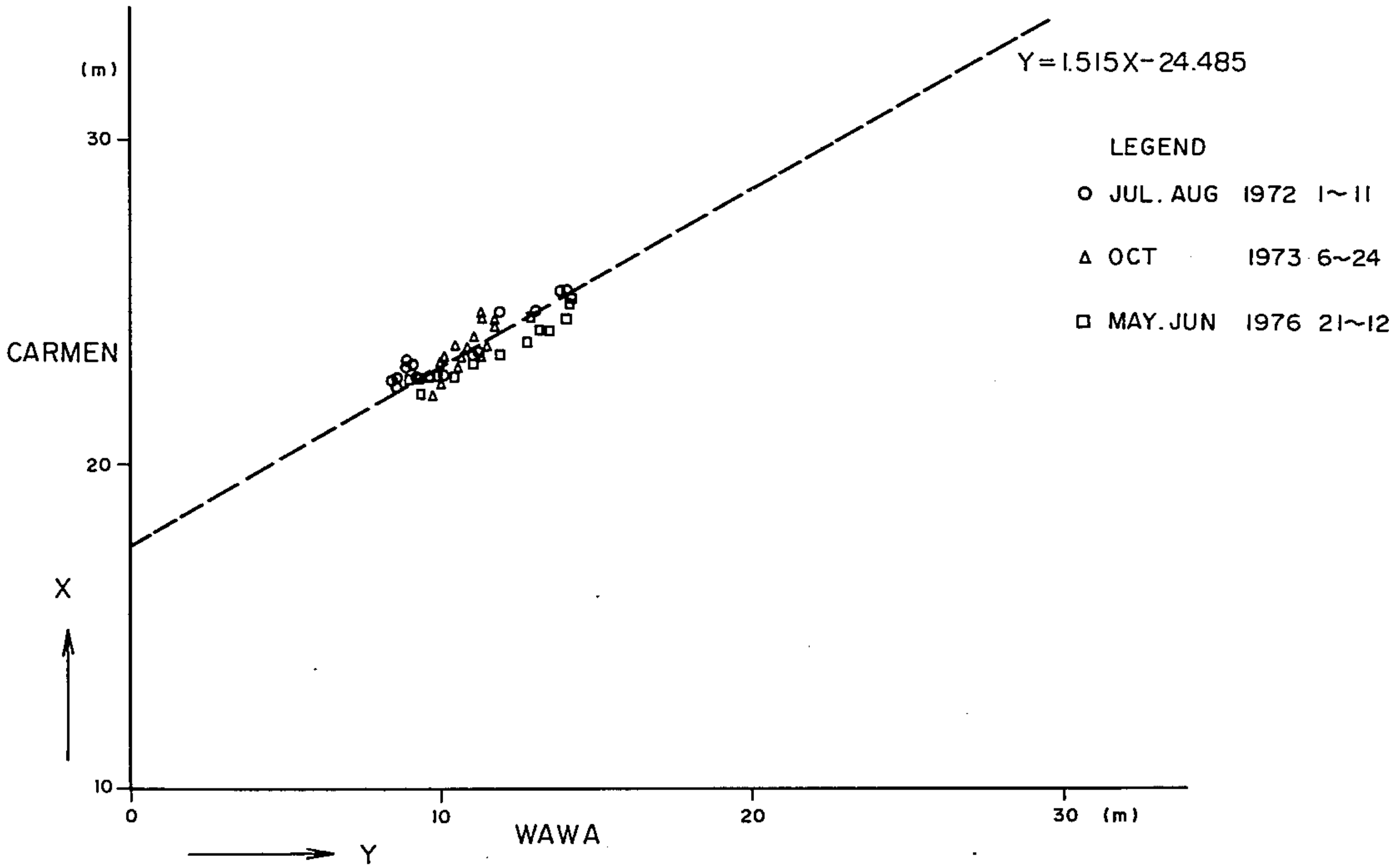


Fig 5-9 OBSERVED AND CALCULATED WATER GAGE HEIGHT
(CORRELATION METHOD)

Oct. 1974

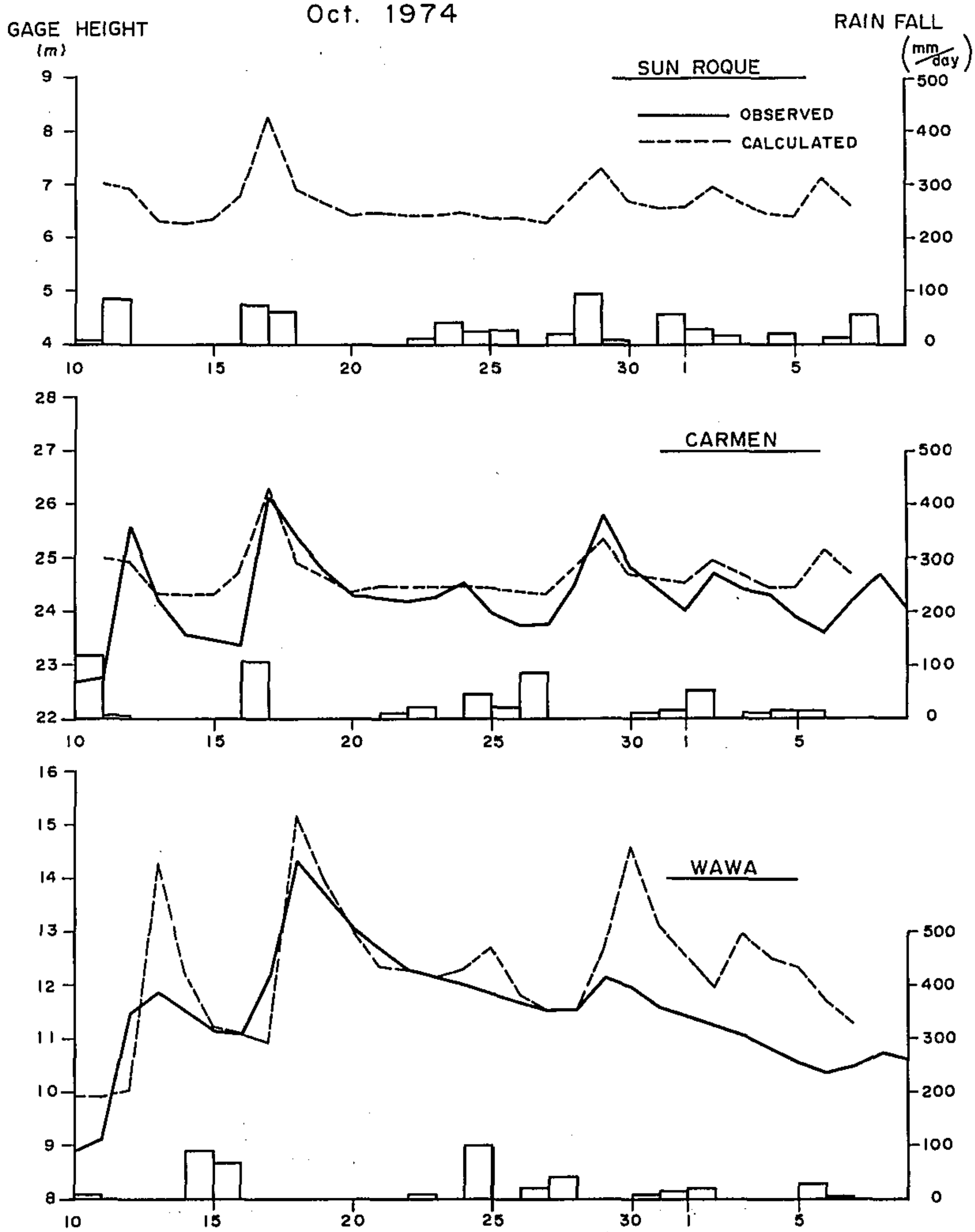
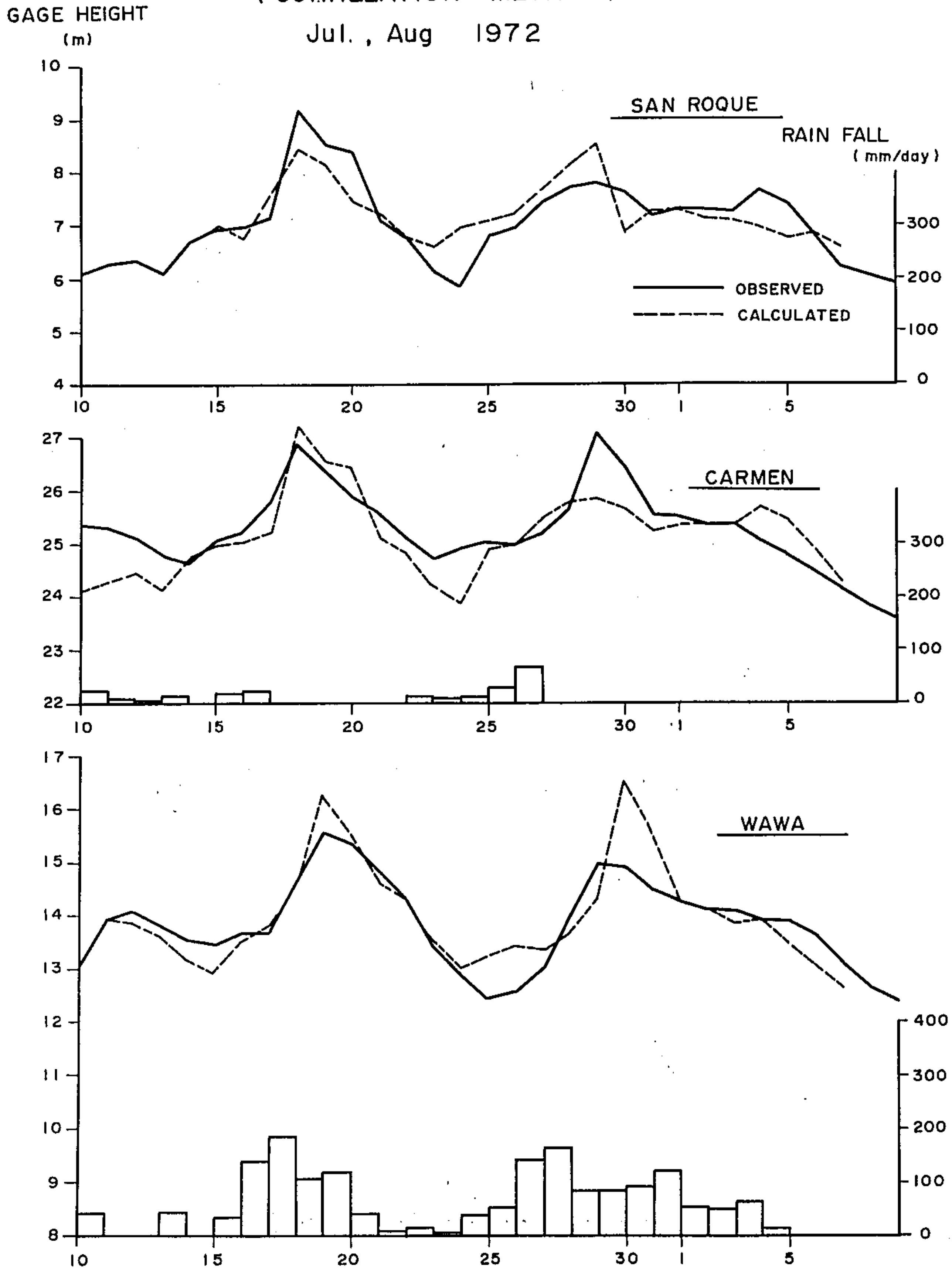


Fig. 5-10 OBSERVED AND CALCULATED WATER GAGE HEIGHT (CORRELATION METHOD) Jul., Aug 1972



§-2 The Bicol River

1. Hydrograph and Hyetograph

1-1 Existing hydrological stations

The major water stage and rainfall telemetering stations in the Bicol River basin as shown in Fig. 5-11 are distributed in the entire region and most of the rainfall gaging stations began operation after 1975.

1-2 Data of rainfall

Data of rainfall considered to have caused floods in the Bicol Region in the ten-year period from 1967 to 1976 are recorded and the graphs are also shown in Appendix.

1-3 Data of water stage

The following table shows the water level recorded at main stations including forecasting points.

Bato
Ombao
Camaligan
Sipocot
Barongay

Hydrological data of the various hydrological station and the graphs are shown in Appendix.

Table 5-4 shows the highest water stage of the various hydrological station every year.

2. Travelling Time

The rate of movement of flood waters was calculated from the average rate of the flow, and the estimated travelling time of flood water through sections of the river is shown in the following table.

Fig. 5-11 LOCATION MAP OF RAINFALL AND WATERSTAGE GAGING STATION IN BICOL RIVER BASIN

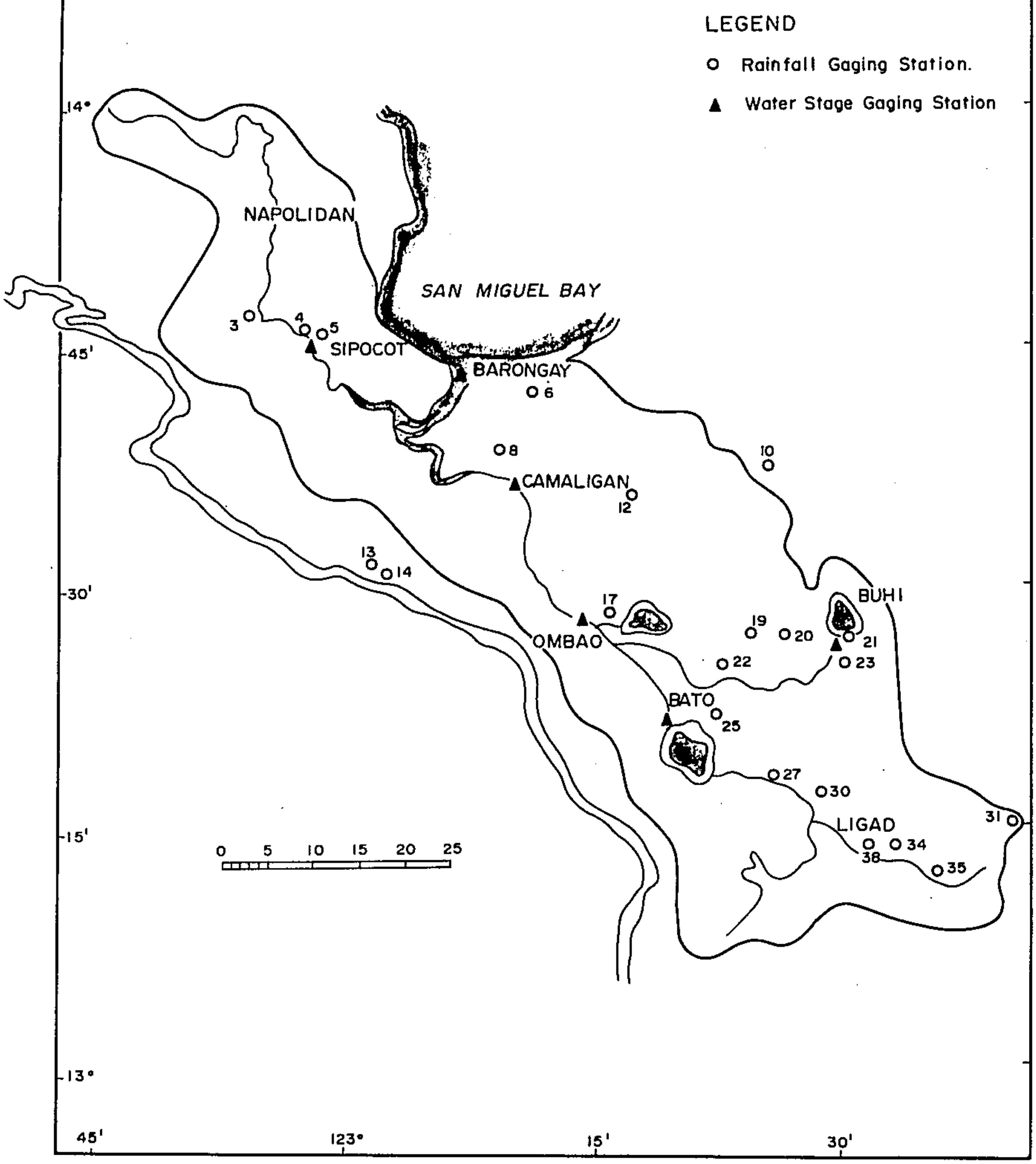


Table 5-3 Locasion of Rainfall Gaging Station

Bicol River Basin

No.	Name of Stations	Location			Type of Ins	Date Established	Managed by	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	
		Latitude	Longitude	Elevation															
1	Daet, Camarines, Norte	14°08'00"	122°59'00	4	RG/OG	1948	MGSD												
2	Caramoan,Camarines,Sur	13°47'20"	123°52'00"	10	OG	1972	CM												
3	Napolidan, Lupi,Cam.Sur	13°47'12"	122°55'00"		RG/OG	May, 1976	HM-NIA											○	
4	Sipocot, Cam. Sur	13°46'10"	122°58'30"	18	OG	1969	CM				○	○	○	○	○	○	○		
5	Impig, Sipocot, Cam. Sur	13°46'00"	122°59'00"		RG/OG	May, 1976	HM-NIA												
6	Inarihan,Calabanga,Cam.Sur	13°42'30"	123°12'00"		RG/OG	June, 1976	HM-NIA												
7	San Juan,Libmanan,Cam.Sur	13°41'42"	123°03'00"		RG/OG	Sept. 1976	HM-NIA											○	
8	Baras, Canaman,Cam.Sur	13°38'48"	123°10'00"		RG/OG	May, 1976	HM-NIA												
9	Tigaon,Camarines,Sur	13°38'00"	123°30'06"		RG/OG	May, 1976	HM-NIA												
10	Consocep.Ocanpo.Cam.Sur	13°37'42"	123°25'30"	200	RG/OG	May, 1976	HM-NIA												
11	NIA Compound Naga City	13°37'30"	123°11'00"		RG/OG	May, 1976	HM-NIA											○	
12	(CSAC)Pili,Camariners, Sur	13°36'00"	123°18'00"		RG/OG	Aug. 1976	AM												
13	Pasacao, Camarines, Sur	13°31'30"	123°02'20"	15	OG	1969	CM												
14	Caraman, Pasacao	13°31'00"	123°03'00"		RG/OG	May, 1976	HM-NIA												
15	Joroan,Tiwi, Albay	13°29'30"	123°37'00"	14	OG	1947	CM												
16	Naglabong,Tiwi,Albay	13°28'30"	123°39'20"	52	OG	1971	CM												
17	San Ramon,Bula,Cam.Sur	13°28'12"	123°16'18"		RG/OG	May, 1976	HM-NIA											○	
18	Pob.Tiwi,Albay	13°27'30"	123°40'30"	5	OG	1971	CM												
19	Mt.Iriga,Iriga City	13°27'00"	123°25'00"		RG/OG	Sept. 1976	HM-NIA												
20	Sta.Cruz,Baao,Cam.Sur	13°27'00"	123°27'00"	11	OG	1969	CM												
21	San Francisco,Buhi,Cam.Sur	13°26'42"	123°31'00"		RG/OG	May, 1976	HM-NIA											○	
22	Barit,Iriga City	13°25'00"	123°23'00"	100	RG/OG	May, 1976	HM-NIA												
23	Buhi Camarines Sur	13°25'00"	123°30'50"	10	OG	1950	CM			○	X	X	Δ	○	Δ	X	X		
24	Parapoto,Malinao,Albay	13°24'00"	123°42'00"		RG/OG	Dec. 1971	AM												
25	Bato,Camarines,Sur	13°22'20"	123°22'40"	15	OG	1972	CM												
26	Tabaco,Albay	13°21'30"	123°43'40"	8	OG	1971	CM												
27	Central Libon,Albay	13°18'00"	123°26'20"	13	OG	1972	CM						Δ	○	○	○	○		
28	Pob.Bacacay,Albay	13°17'40"	123°47'20"	4	OG	1971	CM												
29	Cabasan,Bacacay,Albay	13°17'40"	123°47'20"	4	OG	1971	CM												
30	Agus, Polangui,Albay	13°17'24"	123°29'00"		RG/OG	May, 1976	HM-NIA												
31	Mayon Rest House,Albay	13°15'00"	123°41'00"		OG	1971	CM						○	Δ	○	○	X		
32	Sto.Domingo(Libog)Albay	13°14'10"	123°46'30"	15	OG	1947	CM												
33	Pio,Duran,Albay	13°14'00"	123°32'00"		OG	1960	CM			○	X	○	○	○	○				
34	Alliang,Ligao,Albay	13°14'00"	123°33'00"		RG/OG	May, 1976	HM-NIA							○	○	Δ	○		
35	Guinobatan,Albay	13°12'00"	123°36'00"	80	OG	1947	CM			○	○	○	○	○	○	○	○		
36	Pantao,Libon,Albay	13°11'40"	123°26'00"	5	OG	1972	CM												
37	Rapu-Rapu,Albay	13°11'10"	124°07'20"	5	OG	1972	CM												
38	Villa Hermosa,Albay	13°11'1o"	124°07'40"	5	OG	1971	CM												
39	Malama,Ligao,Albay	13°09'00"	123°27'40"	99	OG	1971	CM						Δ	○	○	○	Δ	X	
40	Legaspi City,Albay	13°08'00"	123°44'00"	19	RG/OG	1949	MGSD												
41	Gogon Pawa, Marito,Albay	13°07'20"	123°52'00"	60	OG	1947	CM												
42	BLLm,Jovellar,Albay	13°04'20"	123°36'00"	10	OG	1972	CM												

Legend

○ : Collected data

X : No data

Table 5-4 MAXIMUM WATER GAGE HEIGHT

The Bicol River Basin

Unit: (m)
( ) Discharge(m^3/s)

Station / Year	OMBAO		NAGA		SIPOCOT		CUYAPI		BATO			
1966			—		—		—		—			
67			—		—		—		—			
68	Sep.27	(287) 6.02	—		Jan.2	(418) 4.51	Nov.21	3.16	Sep.30	7.50		
69	Dec.15	(142) 4.67	Jan.1	4.53	Nov.19	(280) 4.04	Nov.9	3.05	Dec.14	7.55		
70	Oct.14	(701) 8.92	Oct.14	6.39	Jan.4	(51) 2.26	Dec.29	3.10	Oct.14	16.14		
71	Dec.29	(549) 7.88	May 27	5.20	Jan.10	(59) 2.14	Feb.25	3.16	July16	7.99		
72	Jan.12	(412) 6.94	—		—		Mar.17	3.09	Jan.11	8.88		
73	Oct.17	(442) 7.15	—		—		—		Oct.17	9.21		
74	Jan.10	(581) 8.10	—		July20	(114) 2.93	—		Jan.12	8.37		
75	Oct.29	(283) 5.99	Aug.20	2.60	Dec.29	(137) 9.54	—		Dec.28			
76												

Flood Water Travelling Time

Section of River	Distance	Slope	Rate of Flood Water Movement	Flood Water Travelling Time
Poblacion Bato ~ Ombao Bula	17 km	$\frac{1}{18,000}$	0.4 m/s	12 hr
Ombao Bula ~ Mabulo	20	$\frac{1}{7,000}$	0.6	9
Mabulo ~ Cuyari	30	$\frac{1}{38,000}$	0.3	28
Sipocot ~ Cuyari	28	$\frac{1}{8,000}$	0.6	13

3. Tributaries to be Forecast

3-1 Division of sub-basins

Division of sub-basins is worked out as illustrated in Fig. 4-7 with considerations to the target areas of Bicol River.

3-2 Flood Forecasting Points

The forecasting points are as follows:

- Bato
- Ombao
- Camaligan
- Sipocot

Also, for forecasting high tides in San Miguel bay, actual tide measurements are carried out at Barongay.

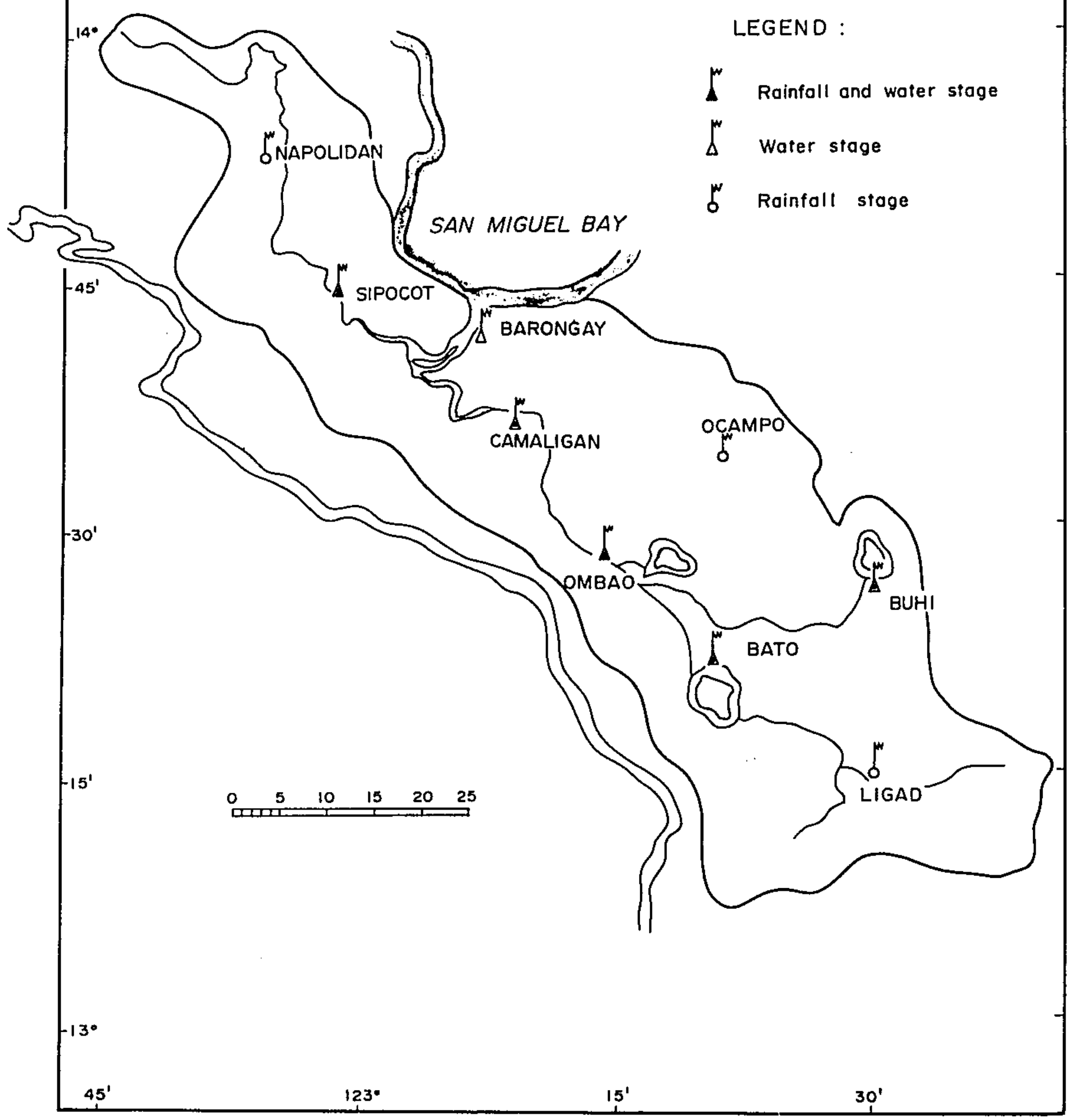
4. Telemetering Station

The following tables indicate the telemetering stations for forecasting floods on the Bicol River.

5. Flood Forecasting Model

The following figure represents the flood forecasting model for the Bicol River with regards to the results of the study of the tributaries to be forecasted.

Fig. 5-12 LOCATION MAP OF TELEMETERING STATION
BICOL RIVER BASIN

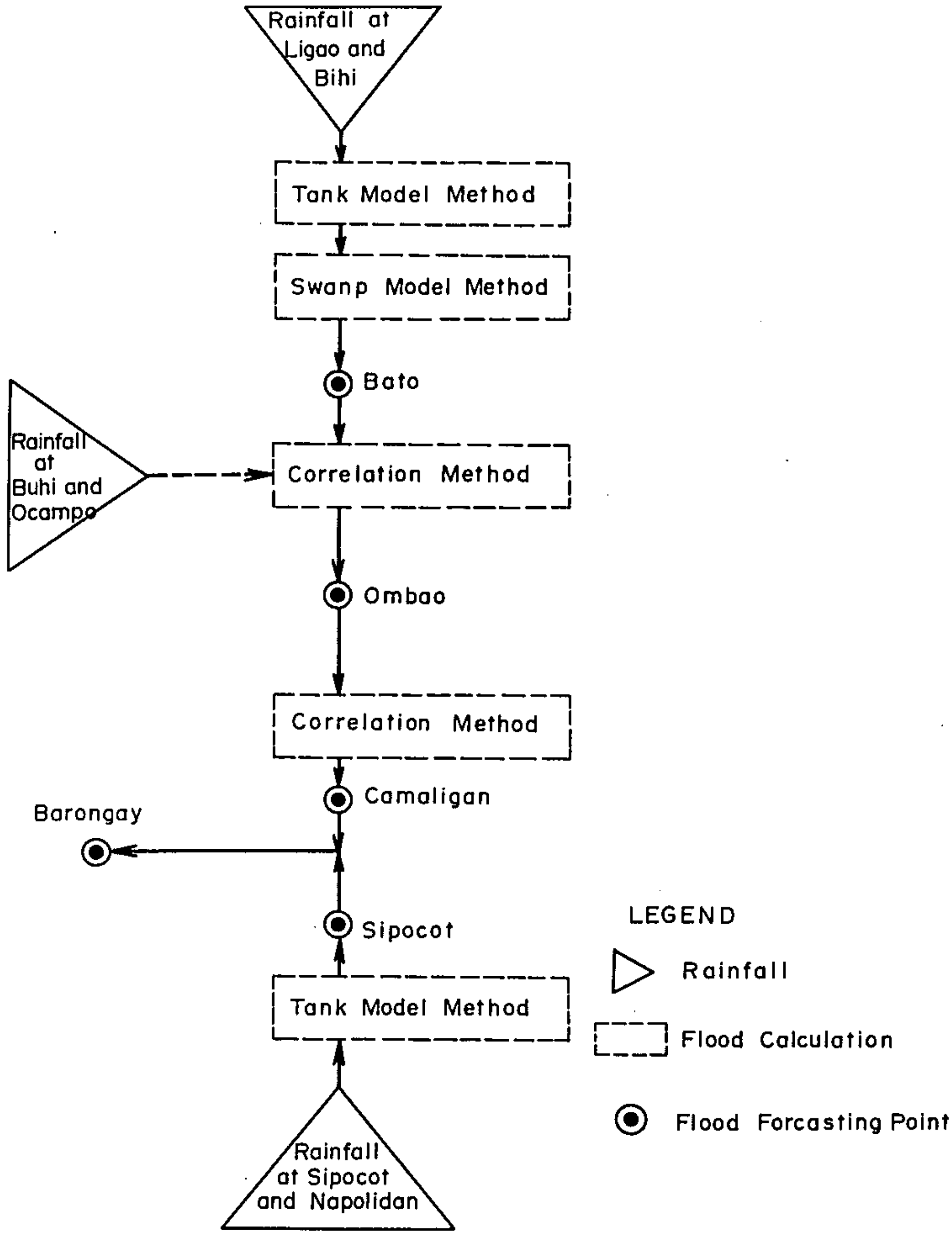


Bicol River Basin: List of Gaging Station

No.	Station	Location of Station	River Basin	Remarks
1.	Ligao	In the center of Ligao town	Bicol R.	Newly constructed Rainfall
2.	Bato	At the side of Lake Bato Pobulacion Bato	Bicol R.	Newly constructed Rainfall, water level
3.	Buhi	At the side of Lake Buhi Pobulacion Buhi	Bicol R.	Newly constructed Rainfall, water level,
4.	Ombao	On the right of bank of Bicol River	Bicol R.	Newly constructed Rainfall, water level, discharge
5.	Ocampo	In the Town Hall of Ocampo	Bicol R.	Newly constructed Rainfall
6.	Camaligan	In the office of Bicol Flood Control	Bicol R.	Newly constructed Rainfall, water level, discharge
7.	Barongay	On the right bank of Bicol River Barongang Dario	Bicol R.	Newly constructed water level
8.	Sipocot	On the left bank of Sipocot River	Sipocot R.	Newly constructed Rainfall, water level, discharge
9.	Napolidan	Next to highway Napolidan Village	Sipocot R.	Newly constructed Rainfall

Fig. 5-13 FLOOD FORECASTING MODEL

BICOL RIVER BASIN



6. Storm Surge Model

6-1 Barongay Point

Forecast of high tide at Barongay Point is done in the same way as in the Bañaga.

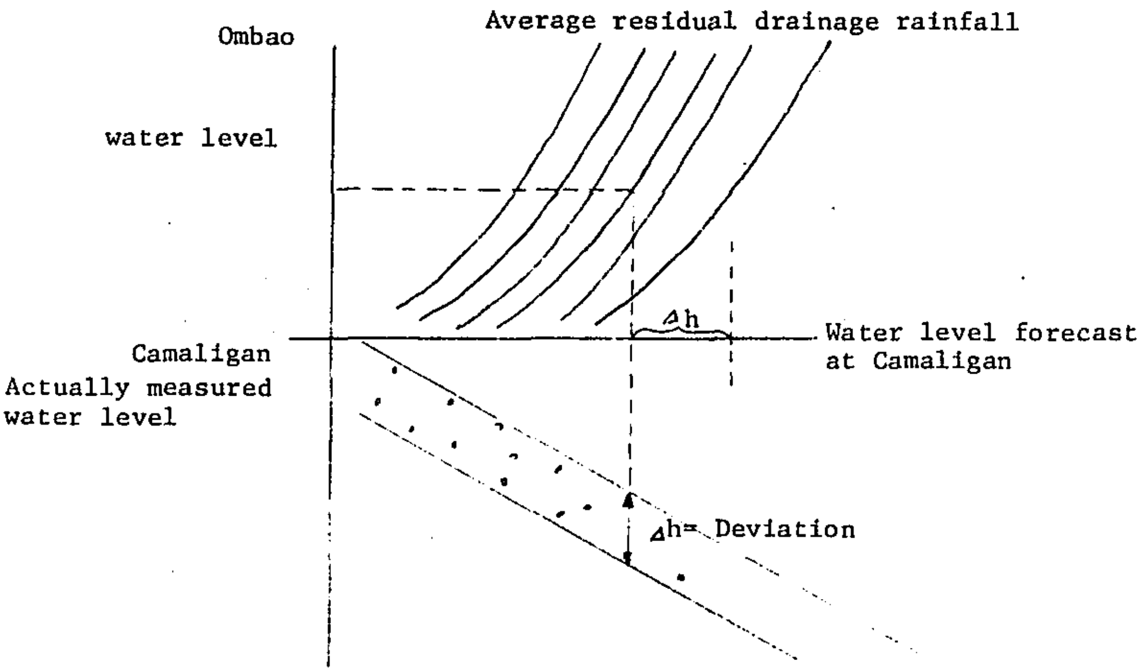
6-2 Camaligan, Naga point

(1) Average residual basin rainfall

The arithmetic mean between Ombao rainfall (R_1) and Camaligan rainfall (R_2) is taken.

$$R = \frac{R_1 + R_2}{2}$$

(2) Correlation of the Camaligan water level from residual drainage rainfall and the Ombao water level.



In case of high tide, the water level forecast is determined taking the deviation into consideration.

7. Flood Forecasting Method

7-1 Bato point

(1) Average basin rainfall

The arithmetic mean between Ligao rainfall (R_1) and Bato rainfall (R_2) is taken.

$$R = \frac{R_1 + R_2}{2}$$

(2) Lake Bato Inflow

Inflow at Lake Bato is calculated by the Tank Model Method.

$$QB = \frac{Y \times A_B}{86.4}$$

Where A_B is Drainage area of Bato Point (km^2)

(3) Water Stage at Lake Bato

Using the following formula, the rise in the water stage (ΔH) due to an increased inflow is calculated and added to the previous water stage (H_{n-1}).

$$\Delta H = \frac{Q_B \times 86.4}{A_L}$$

$$H_n = H_{n-1} + H$$

where A_L: Area of water level of Lake Bato (km^2)
H_{n-1}, H_n: Water level of the lake in the previous day and the observation day. (m)

Next, the water stage of the lake when there is no inflow is calculated by the following formula:

$$MH = 0.035H - 0.151$$

Where ΔMH: Fall in water stage of Lake Bato (m)
H: Water stage of Lake Bato (m)

7-2 Ombao Point

Taking into considerations the travelling time from Bato point to Ombao point, the water stage is calculated by the following correlation formula:

$$H_O = H_B + a$$

Where H_O: Ombao Point Water Stage (m)
H_B: Bato Point Water Stage in respect to Travelling Time
a: Constant

using the calculated water stage (H_0) and the measured water stage (Q_0), so that

$Q_0 = AH^2 + BH + C$

the discharge can be obtained by the least square method according to the model formula.

7-3 Camaligan Point

The same method is taken as in the Ombao Point.

$H_c = H_0 + b$

Where H_c: Camaligan Point Water Stage (m)

H_0: Ombao Point Water Stage in respect to Travelling Time (m)

7-4 Sipocot Point

The tank model method is taken. The average rainfall is the arithmetic mean of Napolidan rainfall (R_1) and Sipocot rainfall (R_2).

$$R = \frac{R_1 + R_2}{2}$$

8. Verification of the Flood Forecasting Model

8-1 Storm Surge at Barongay Point

(1) Meteorological data during typhoons

Data on wind velocity and atmospheric pressure during renowned typhoons at Daet point are recorded in separate sheets.

(2) Tide level deviation

The deviation is inferred from the astronomical tide at Legaspi Port and the daily water stage at Barongay Point.
Fig. 5-15 shows the relationship among wind velocity, atmospheric pressure and the tide deviation. The relationship can be recognized to a certain extent and since the data compared are collected on a daily basis, a quantitative analysis is not done. Thereafter, with the establishment of a telemetering station at Barongay Point, data can be obtained on an hourly basis, and detailed examination of data accumulated on an hourly basis will become necessary.

Fig5-14-1 WIND VELOCITY, ATMOSPHERIC PRESSURE AND WATER STAGE

Cuyapi (1)

○---- Windvelocity
●---- Atmospheric pressure
Δ---- Water stage

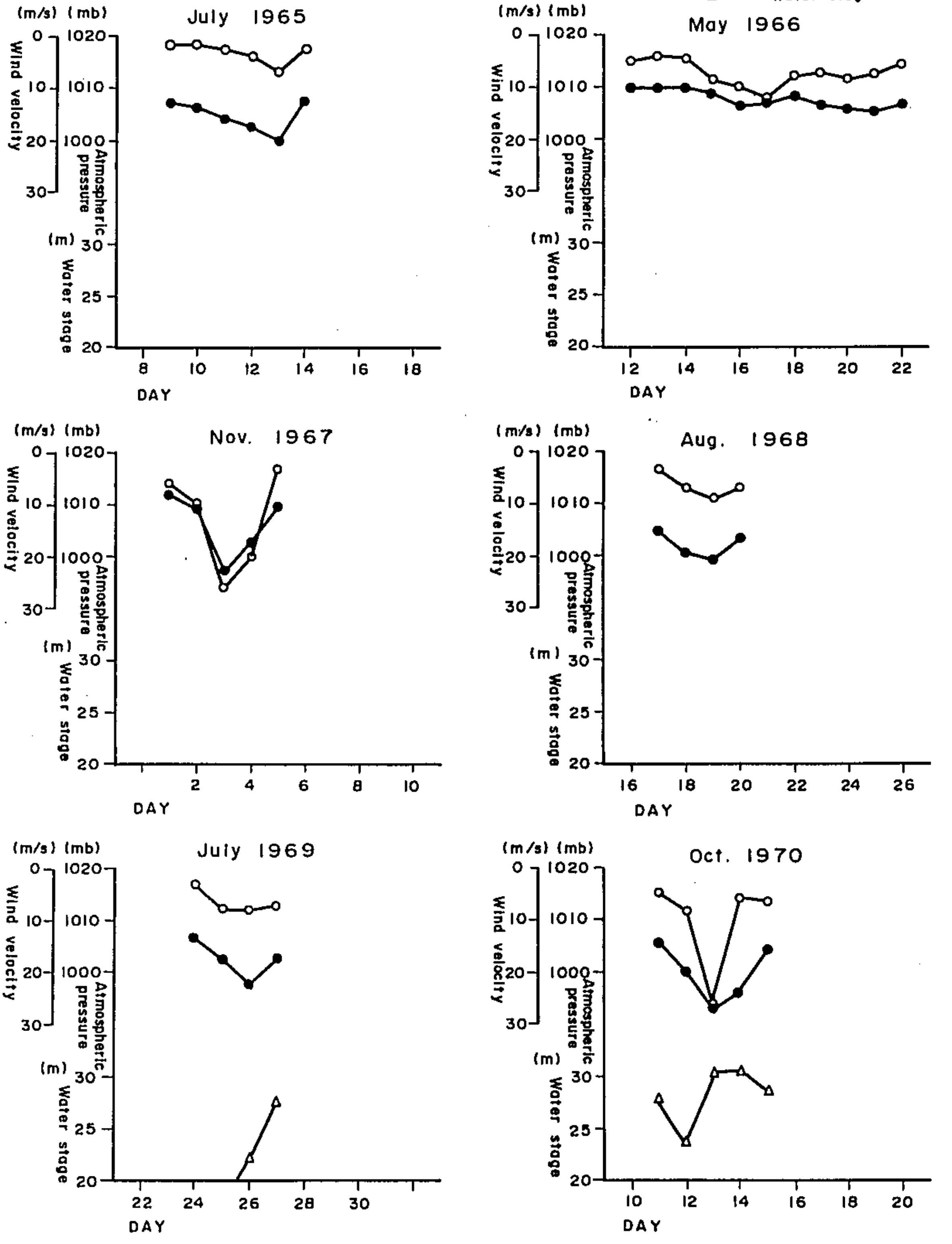


Fig.'-'4-' WIND VELOCITY, ATMOSPHERIC PRESSURE AND WATER STAGE
Cuyapi (2)

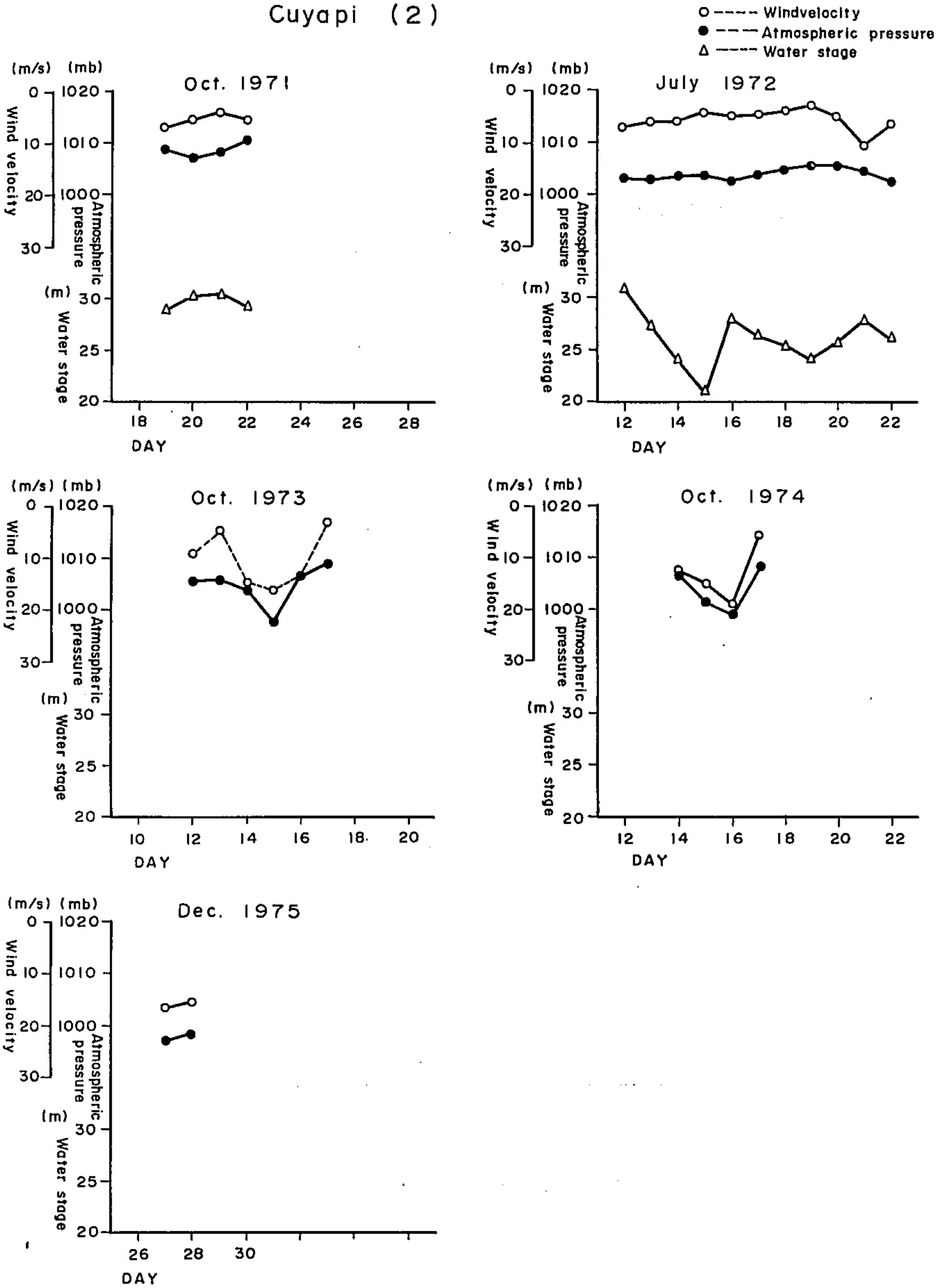
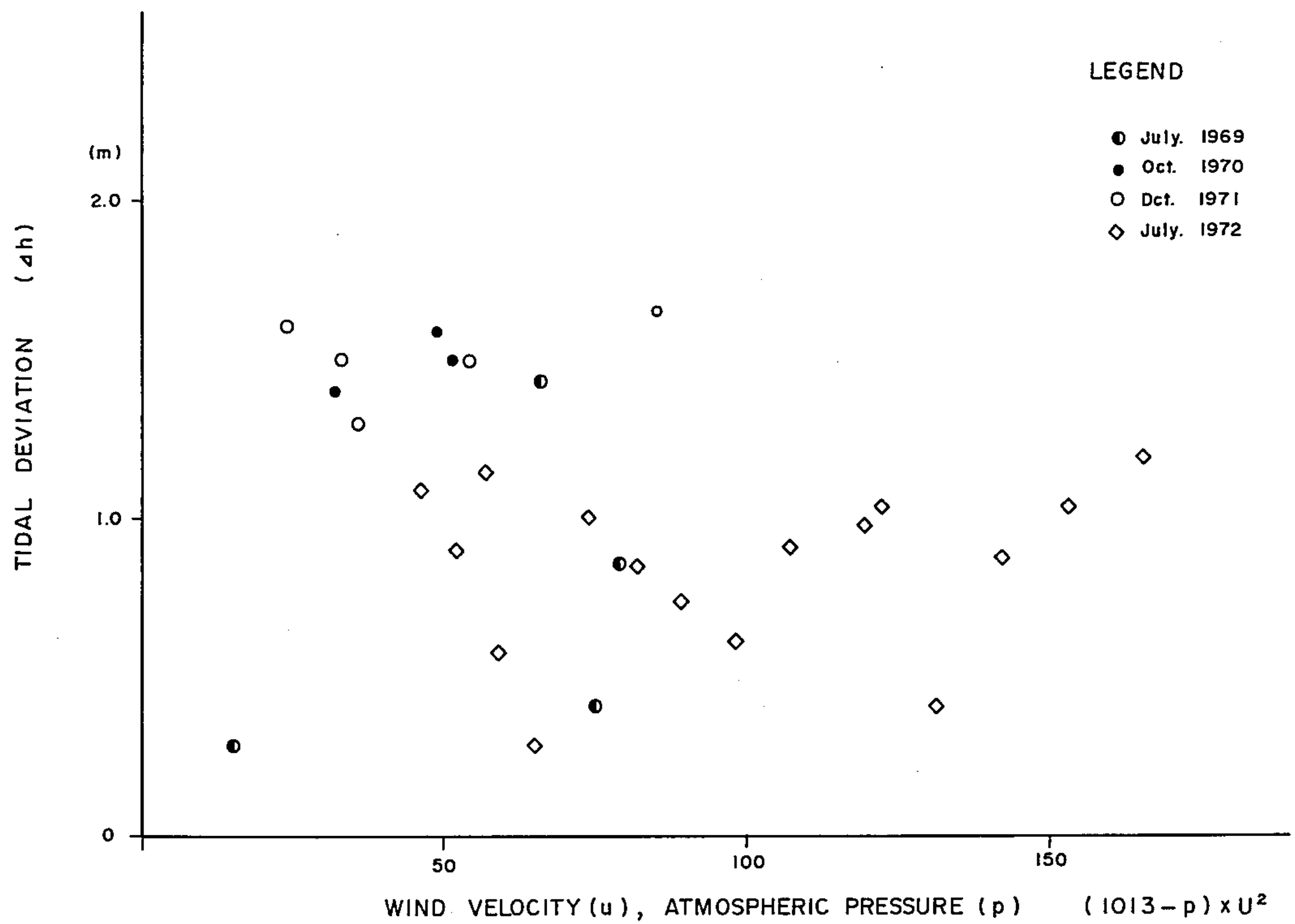


Fig. 5-15 WIND VELOCITY, ATMOSPHERIC PRESSURE AND TIDAL DEVIATION



8-2 Verification of the Flood Forecasting Method at Each Point

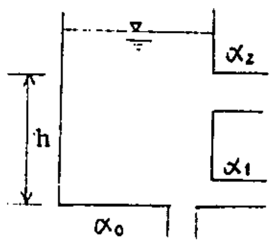
The method used at each flood forecasting point is shown in the following table.

Flood Forecasting Point	Flood Forecasting Method
Bato	Combination of tank model and fall of water level of the late.
Ombao	Formula indicating relationship with the Bato water level.
Camaligan	Formula indicating relationship with the Ombao water level.
Sipocot	Tank model.

The flood forecasting method at each point is shown below.

(1) Bato

Outflow model



$\alpha_c = 0.6$

$\alpha_1 = 0.05$

$\alpha_2 = 0.085$

$h = 20$ mm

Model of water reduction in the lake water level.

$\Delta H = 0.035H - 0.151$

ΔH: Amount of reduction in lake water level (m)

H: Lake (water) level (m)

(2) Ombao

$H_2 = 1.22\ H_1 - 3.8$ correlation coefficient = 0.970

H_2: Water level at Ombao Bula (m)

H_1: Water level at Poblacion Bato on the previous day (m)

(3) Camaligan

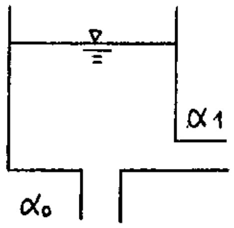
$H_2 = 0.596\ H_1 + 0.1$ correlation coefficient = 0.828

H_2: Water level at Camaligan Naga (m)

H_1: Water level at Ombao Bula on the previous day (m)

(4) Sipocot

Outflow model



$\alpha_0 = 0.01$

$\alpha_1 = 0.025$

Fig 5-16 CORRELATION AMONG WATER LEVELS AT BATO, OMBAO AND CAMALIGAN

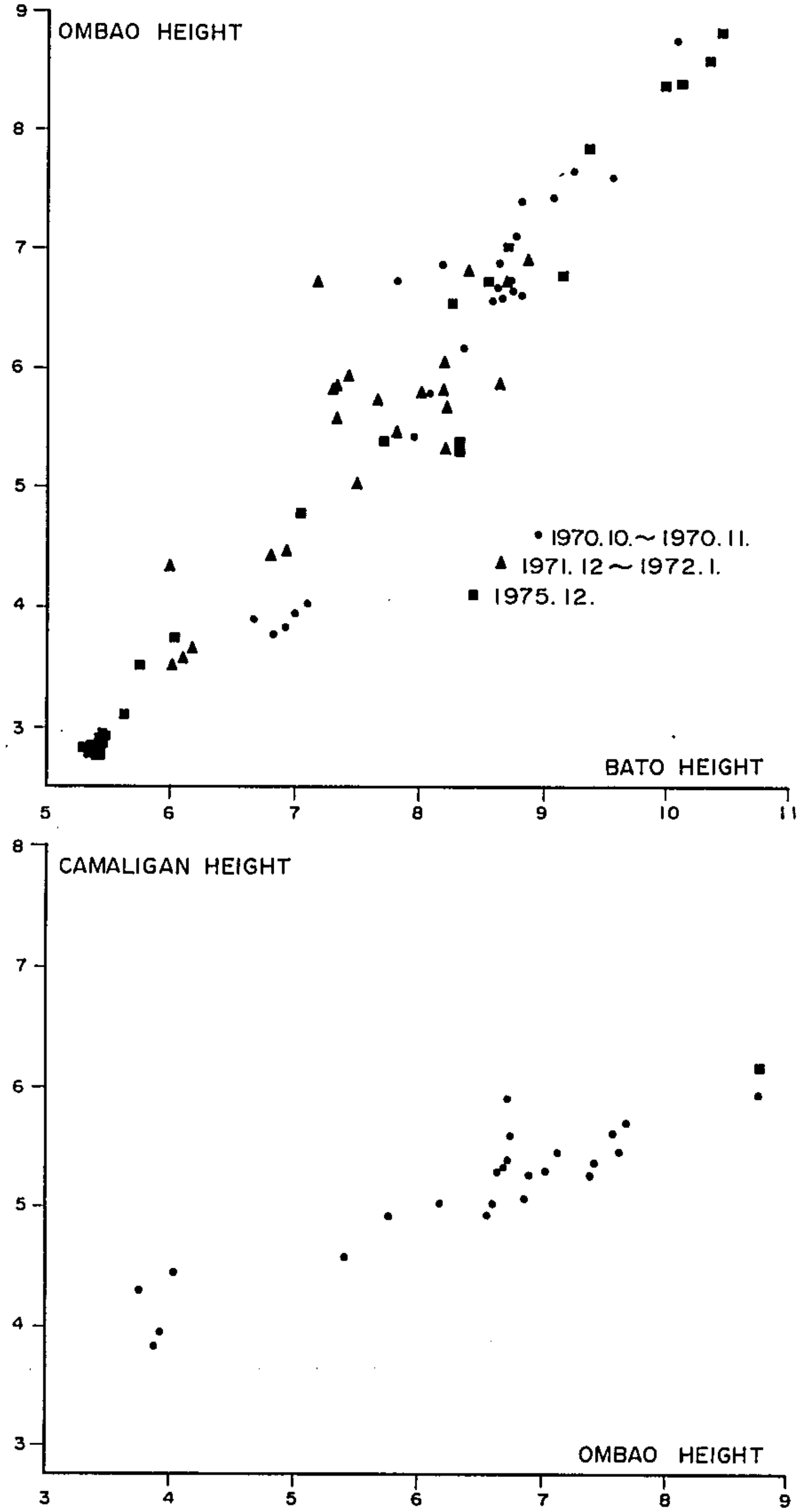


Fig. 5-17 OBSERVED AND CALCULATED WATER GAGE HEIGHT BICOL RIVER BASIN (1) Oct. 1970

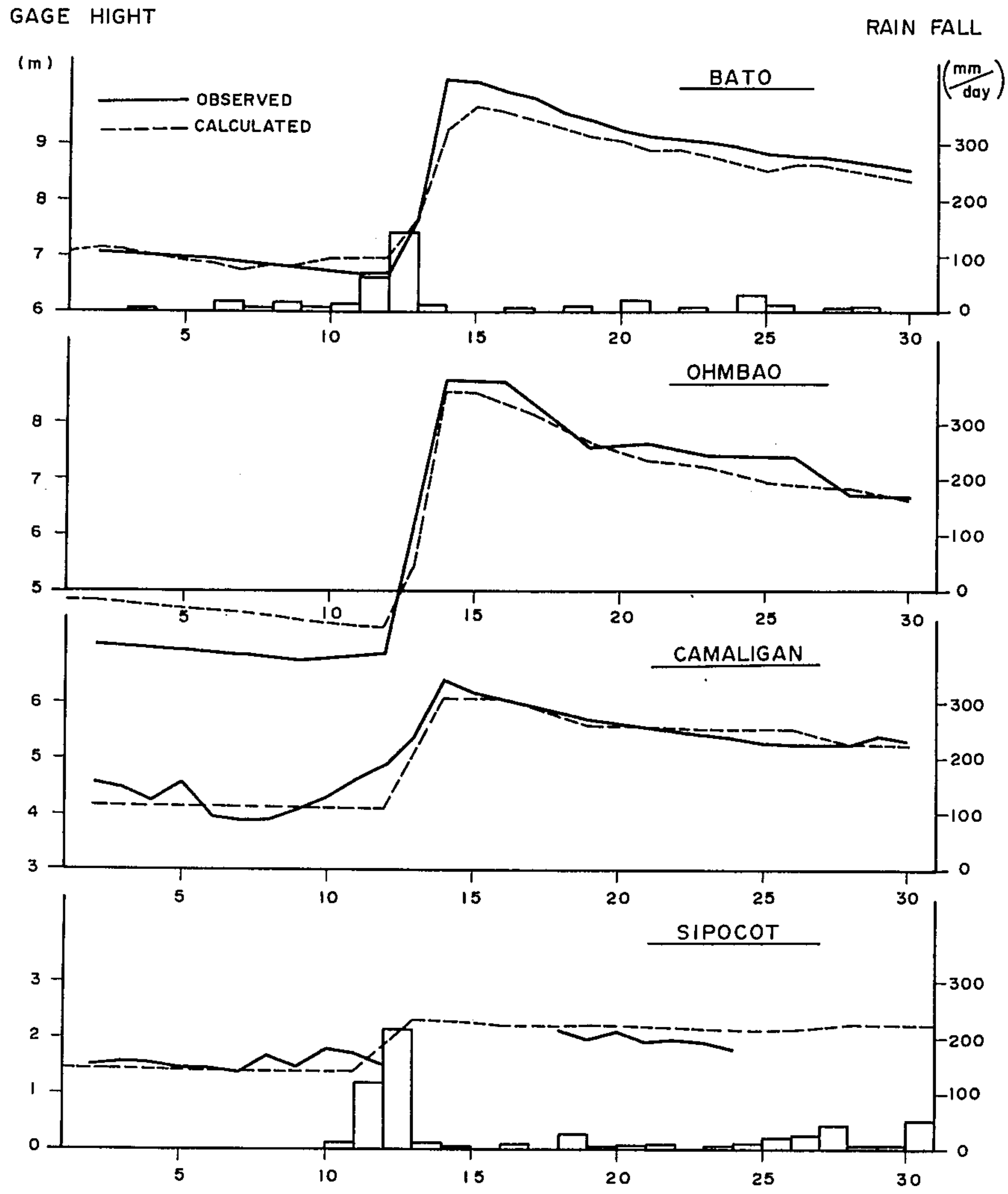
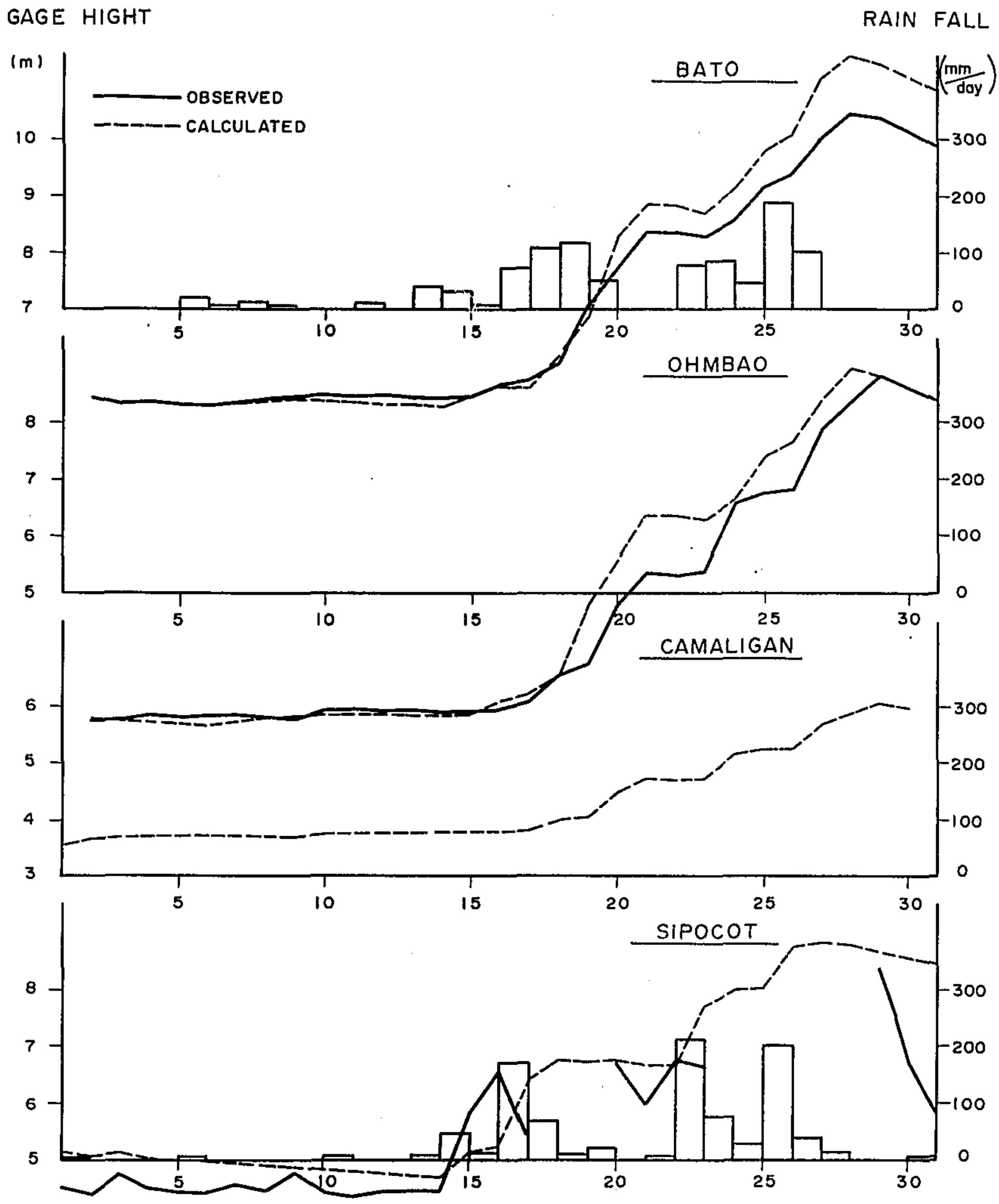


Fig. 5-18 OBSERVED AND CALCULATED WATER GAGE HEIGHT
BICOL RIVER BASIN (2)
Dec. 1975



8-3 The Cagayan River

1. Hydrograph and Hyetograph

1-1 Existing hydrological stations

As shown in Fig.5-19 , the major hydrological and rainfall gaging stations are distributed in the entire region of the Cagayan basin. The rainfall gaging stations began observations from a relatively early period.

1-2 Rainfall data

Data concerning rainfall which seemed to have caused floods in the Cagayan Region in the past ten years are recorded. These data and graphs are included in Appendix.

1-3 Water stage data

Water stage data in the Cagayan River during floods in the past are recorded. These data, together with water stage graphs are included in Appendix.

Table 5-6 shows the highest water stage every year.

2. Travelling Time

The rate of movement of flood waters was calculated from the average rate of flow of water, and the estimated travelling time of flood waters through sections of the river is shown in the table below.

Flood Water Travelling Time

Section of River	Distance	Slope	Rate of Flood Water Movement	Flood Water Travelling Time
Dalibubun~Tumauini	90 km	1/1,000	5.4 m/s	5 hr
Tumauini~Tuguegarao	50	1/3,500	3.4	4
Tuguegarao~Aparri	110	1/6,500	2.0	15

3. Tributaries to be Forecast

3-1 Division of the region

The target area of the Cagayan Basin is divided into 4 blocks taking into considerations the area extending from the lower part of the river to the estuary (Aparri). The blocks are shown in the following figure.

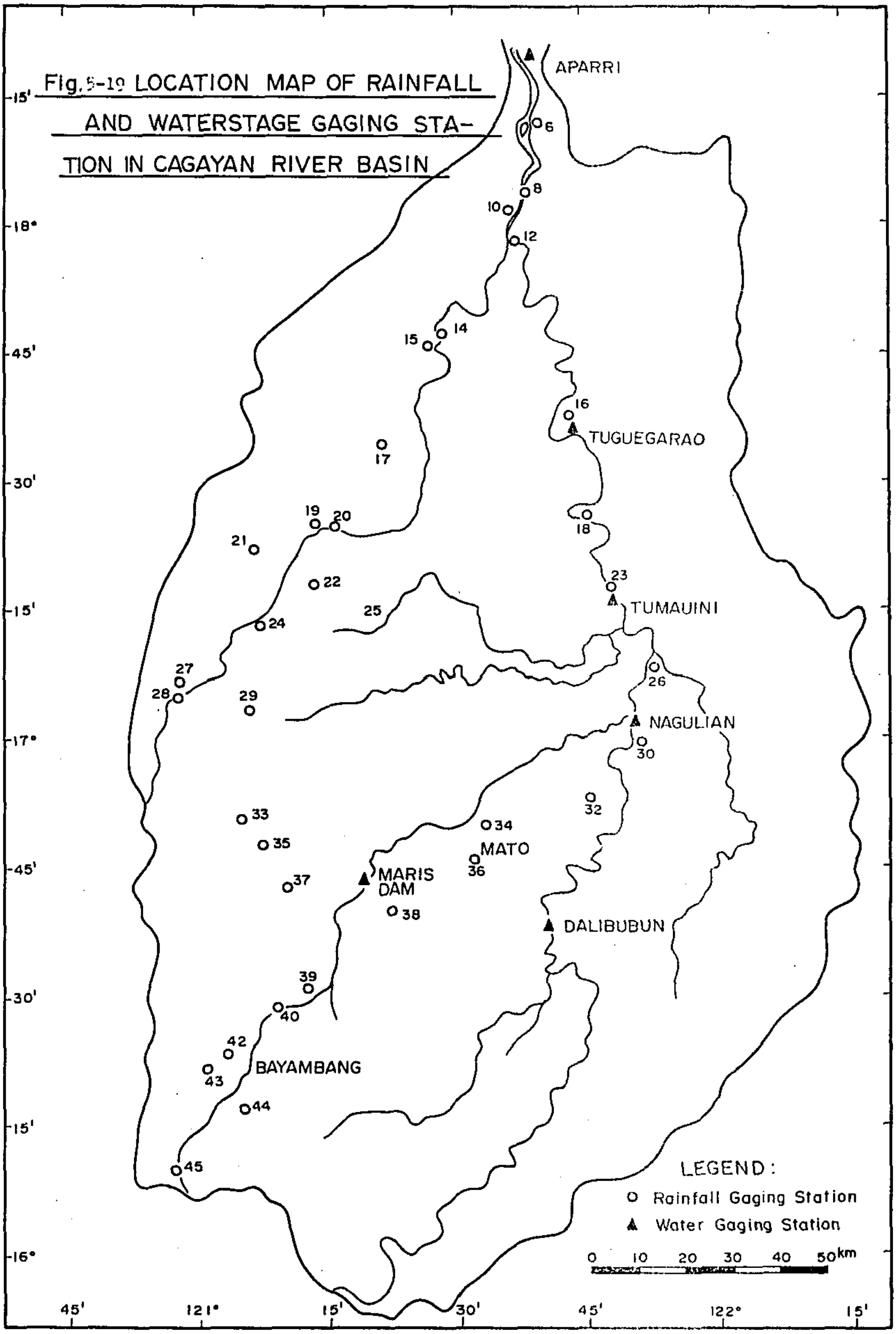


Fig. 5-19 LOCATION MAP OF RAINFALL AND WATERSTAGE GAGING STATION IN CAGAYAN RIVER BASIN

Table 5-5 Locasion of Rainfall Gaging Station

Cagayan River Basin

No.	Name of Stations	Location: Latitude	Location: Longitude	Location: Elevation	Type of Ins	Date Established	Managed by	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
1	Sanchez Miro, Cagayan	18°34'00"	121°13'00"		RG/OG	May, 1976	HM											
2	Baggo, Pamplona, Cagayan	18°27'40"	121°21'00"	5	OG	1973	CM											
3	Ballesferos, Cagayan	18°24'36"	121°30'42"		RG/OG	May, 1976	HM											
4	Apparri, Cagayan	18°22'00"	121°38'00"	4	RG/OG	1902-39; 1947	MGSD								O	X	O	O
5	Mataguisi, Pudtol, Kalinga-Apayao	18°13'00"	121°22'00"		OG	1971	CM											
6	Lal-lo, Cagayan	18°12'00"	121°39'40"	7	OG	1973	CM								O	O	O	O
7	Baliwanan, Kabuyao, Kalinga-Apayao	18°08'10"	121°08'00"	320	OG	1969	CM											
8	Gattaran, Cagayan	18°03'42"	121°38'24"	10	RG/OG	May, 1976	HM				O	O	O	O	O	O	O	O
9	Kabugao, Kabugao, Kalinga-Apayao	18°01'30"	121°11'00"	120	OG	1948	CM											
10	Aggunetan, Lasam, Cagayan	18°01'30"	121°37'10"	10	OG	1947	CM											
11	Mt. Polis Pass, Banawe, Ifugao	17°58'00"	121°01'30"	1900	OG	1963	CM											
12	Nassiping, Alcala, Cagayan	17°58'00"	121°37'40"	10	OG	1948-71	CM	Δ	O	O	Δ	Δ	Δ			X	X	X
13	Lenneng, Kabugao, Kalinga-Apayao	17°55'20"	121°12'40"	231	OG	1969	CM											
14	Piat, Cagayan	17°47'36"	121°28'36"	40	RG/OG	May, 1976	HM											O
15	Cagumifan, Tauo, Cagayan	17°45'50"	121°27'30"	35	OG	1947	CM	O	O	O	O	O	O	O	O	O	O	X
16	Tuguegarao, Cagayan	17°37'00"	121°44'00"	24	RG/OG	1903-39; 1947	MGSD	O	O	O	O	O	O	O	O	O	O	O
17	Pinukpuk, Kalinga-Apayao	17°34'40"	121°22'00"	120	OG	1971	CM					O	O	O	O	O	O	O
18	Cabagan, Isabela	17°25'42"	121°45'48"	20	RG/OG	May, 1976	HM										O	
19	Tomiangan, Tabuk, Kalinga-Apayao	17°25'00"	121°14'00"		OG	1974	CM								O	O	O	
20	Maneng, Tabuk, Kalinga-Apayao	17°24'40"	121°16'00"	360	OG	1947	CM	O		O	O	O	O	O		O	O	O
21	Latauan, Lubuagan, Kalinga-Apayao	17°22'00"	121°07'00"	740	OG	1963	CM			O	X	O	O	O	X	X	X	X
22	Guilguila, Tarudan, Kalinga-Apayao	17°18'00"	121°14'10"	500	OG	1963	CM	O	X	O	O	O	O	O	O	O	O	X
23	Tumauini, Isabela	17°16'42"	121°48'12"		RG/OG	May, 1976	HM											O
24	Basao, Tinglayan, Kalinga-Apayao	17°13'30"	121°07'20"	800	OG	1963	CM											
25	Calanasan, Bayog, Kalinga-Apayao	17°13'30"	121°19'00"		OG	1968-70	CM											
26	Ilagan, Isabela	17°08'00"	121°53'10"	40	OG	1925-39; 1949	CM	O	O	O	O	O	O	O	O	O	O	O
27	Banga-an, Sagada, Mt. Province	17°07'00"	120°58'00"		OG	1963 1960	CM	O	X	O	O	O	X	X	O	O	X	O
28	Bontoc, Mt. Province	17°05'00"	120°58'00"		OG	1950	CM	X	O	O	O	O	O	O	O	O	X	X
29	Barling, Mt. Province	17°03'30"	121°06'20"		OG	1963	CM	X	X	O	O	O	X	O	O	O	X	O
30	Reina Mercedes, Isabela	16°59'30"	121°51'00"		RG/OG	May, 1976	HM											O
31	Bauko, Mt. Province	16°57'00"	121°52'00"		OG	1963	CM			O	O	O	O	O	O	O	O	O
32	Nunnurgan, Canayan, Isabela	16°53'00"	121°45'00"		RG/OG	Dec. 1974	HM-NIA											
33	Namulditan, Lagawe, Ifugao	16°51'10"	121°05'10"	900	OG	1969	CM			O	X	O	X	O	O	O	X	
34	Sinamar, San Mateo, Isabela	16°50'00"	121°33'00"		RG/OG	Dec. 1974	HM-NIA										O	
35	Lagawe, Lagawe, Ifugao	16°48'00"	121°07'20"	470	OG	1970	CM			O		O		O	O	O	O	O
36	Raniag, Ramon, Isabela	16°46'00"	121°32'00"		RG/OG	Dec. 1974	HM-NIA										O	
37	Mayom, Lamut, Ifugao	16°43'20"	121°10'20"	320	OG	1971	CM						O	O	O	O	X	O
38	Magat (Ref. Proj), Diadi, N.V.	16°40'00"	121°22'00"	243	OG	Jan. 1966	CM		O	O	O	O	O	X				
39	Solano, Nueva Viscaya	16°31'10"	121°11'50"	225	OG	1967	CM		O	O	O	O	O	O	O	O	O	
40	Balbalan, Saleseg, Kalinga-Apayao	16°31'00"	121°50'00"		OG	1948	CM											
41	Bayombong, Nueva Viscaya	16°29'00"	121°09'00"	270	RG/OG	March, 1976	HM											O
42	Barat, Bambang, Nueva Viscaya	16°23'20"	121°03'20"	310	OG	1969	CM			O	O	O	O	O	O	O	O	O
43	Salinas (Ref. Proj.), Bampang, N.V.	16°22'30"	121°01'00"	610	OG	Jan. 1968	CM											
44	Dupat, Nueva, Viscaya	16°17'10"	121°05'20"	364	OG	1968	CM			O	O	O	O	O	O	O	O	O
45	Consuelo, Sta. Fe, Nueva, Viscaya	16°10'00"	120°57'00"	550	OG	1948	CM	O	O	O	O	O	O	O	O	O	O	O

Legend

O: Collected data

X: No data

Table 5-6 MAXIMUM WATER GAGE HEIGHT

Cagayan River Basin

Unit: (m)
( ) Discharge(m^3/s)

Station / Year	DARIBUBUN (PANGAL)		MARIS DAM	TUMAUINI (NAGULUAN)		TUGUEGARAO		APARRI					
1966	Nov.22	(7735) 15.55						Nov.14	0.92				
67	Nov.4	(7848) 17.50						June28	0.94				
68	Nov.30	(4258) 9.75		Nov.30	(2838) 7.7	Dec.1	17.50	July26	1.08				
69	Nov.24	(1302) 6.00		Nov.26	(2182) 6.78	Nov.27	18.03	Nov.28	1.15				
70	Sep.12	(7503) 12.50		Oct.14	(7899) 13.83	Oct.16	21.95	Aug.10	1.99				
71	Nov.16	(4511) 10.00		Oct.12	(9692) 15.90	Dec.2	20.97	Mar.22	1.77				
72	Nov.7	(2233) 7.25		Nov.7	(1879) 6.84	July19	18.37	Jan.14	7.21				
73	Oct.15	(5032) 10.75				Nov.22	15.20	(June	)				
74	June11	(4511) 16.00											
75													
76													

3-2 Flood forecasting point

The following flood forecasting points are selected from the target area and the sub-divisions:

Dalibubun

Maris Dam

Tumauini

Tuguegarao

.4. Telemetering Stations

The location of the telemetering station for flood forecast are selected as shown in the following table. In the future it will become necessary to set up stations at both the lower part of the Cagayan River and the Chico Basin. Dalibubun Station is located at the Pangal Station where B.P.W. had used for hydrological observations in the past.

Cagayan River Basin: List of Gaging Station

No.	Station	Location of Station	River Basin	Remarks
1	Dalibubun	Make use of Pangal Station (belonging to B.P.W.). Left Bank	Cagayan R.	Newly constructed Rainfall, water level
2	Maris Dam	Make use of existing hydrological station downstream from Maris Dam. Right Bank	Magat R.	"
3	Tumauini	Within Tumauini Town. Right Bank	Cagayan R.	"
4	Tuguegarao	Bandon Bridge. Right Bank	Cagayan R.	"

5. Storm Surge Model

In the Cagayan River basin, storm surge probably can be disregarded, therfore no study is made.

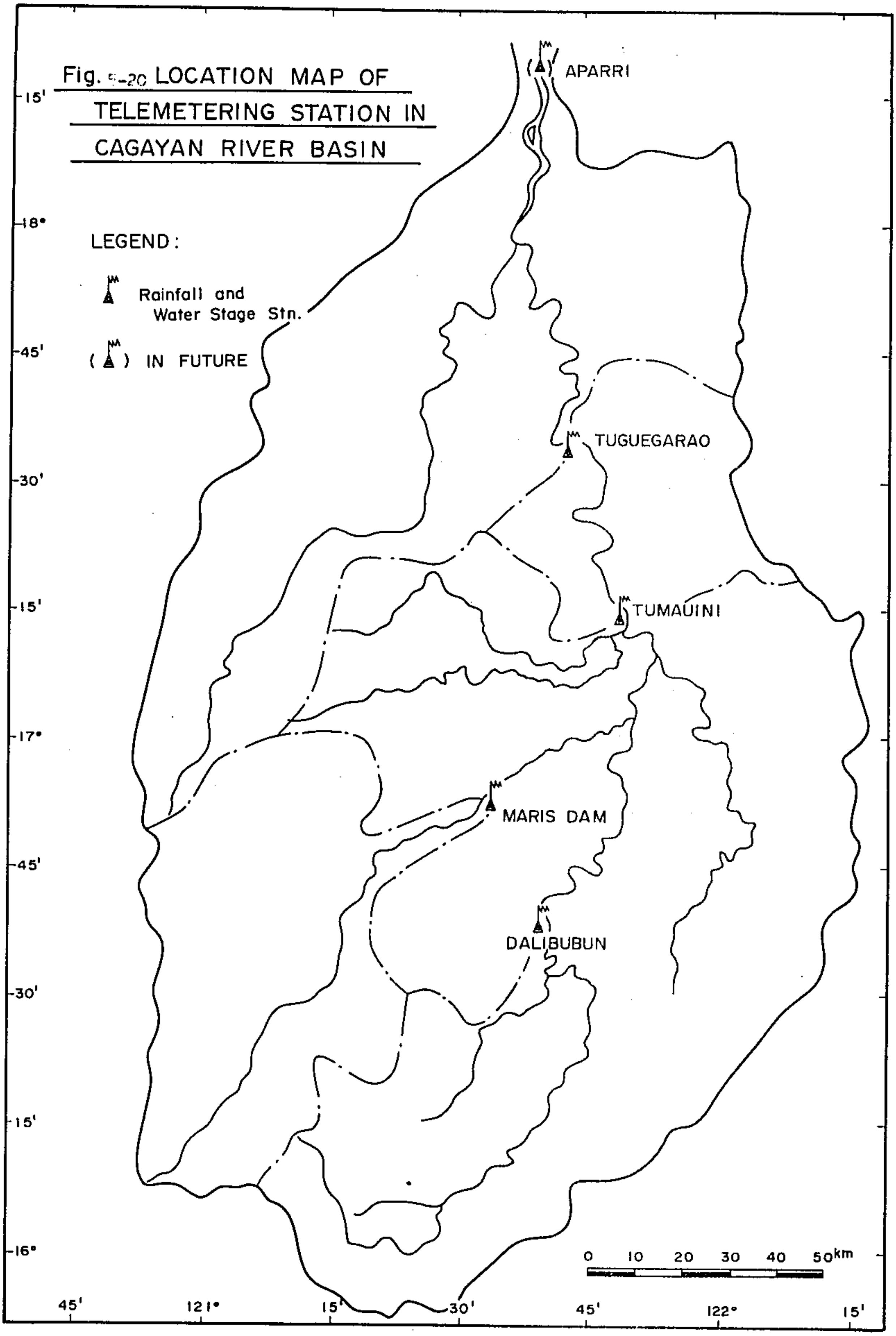


Fig. 5-20 LOCATION MAP OF TELEMETERING STATION IN CAGAYAN RIVER BASIN

6. Flood Forecasting Model

The Flood Forecasting Model as shown in the following figure was drafted with considerations to the Flood Forecasting Point in the Cagayan Region.

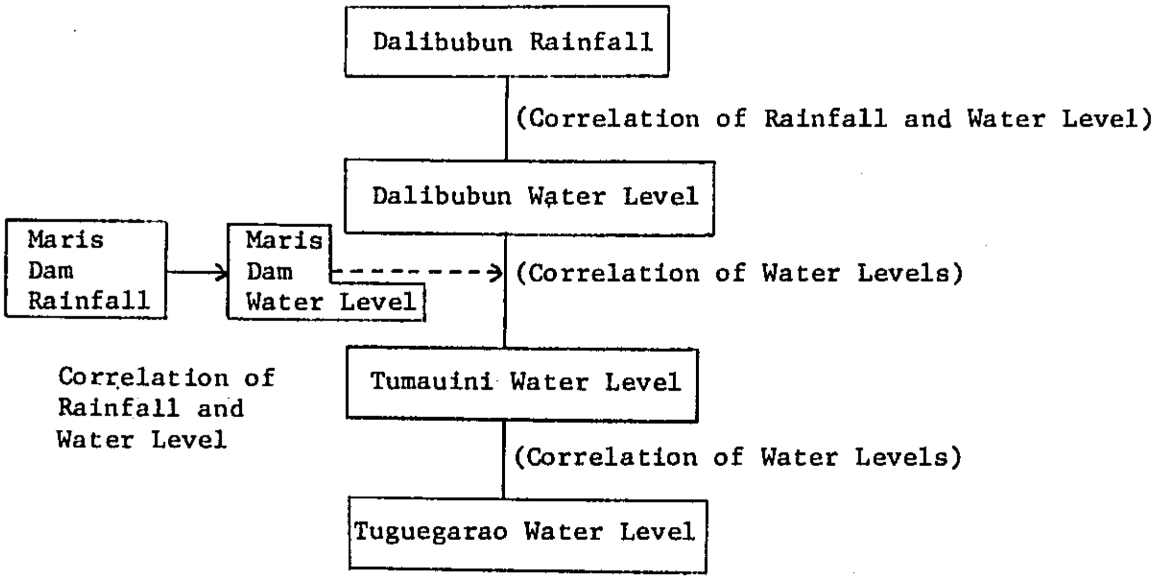
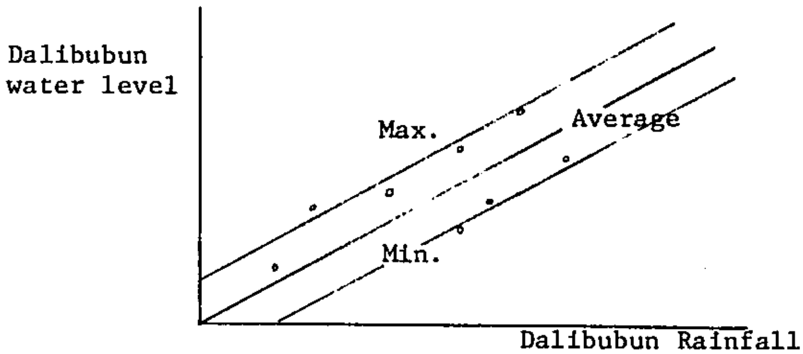


Fig. Flood Forecasting Model

7. Flood Forecasting Method

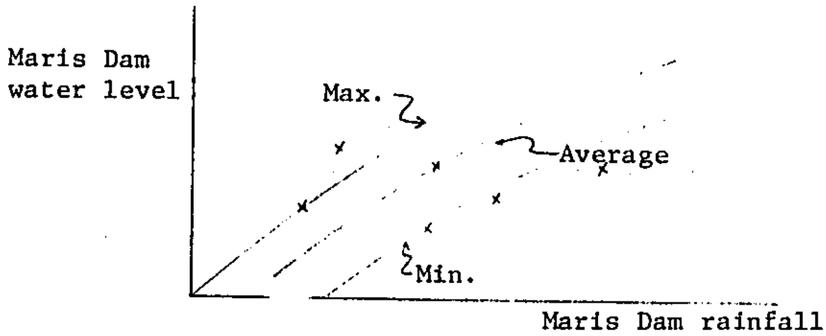
7-1 Dalibubun Point

Forecast on the basis of correlation between rainfall and water level at Dalibubun Point.



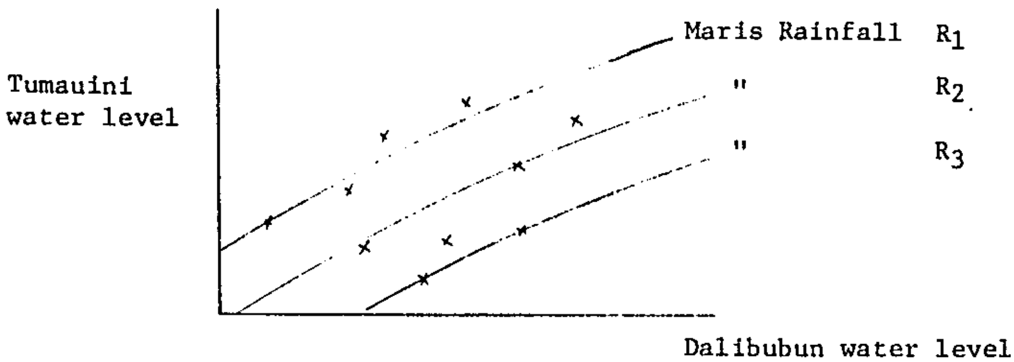
7-2 Maris Dam Point

Forecasting based on correlation between rainfall and water level at Maris Dam Point.



7-3 Tumauini Point

Forecasting of the water level at Tumauini Point is based on the Correlation Figure of the water levels at Dalibubun Point with respect to the travelling time. In cases when the water levels are scattered, the rainfall at Maris Dam is used as a parameter.



7-4 Tuguegarao Point

The forecasting method is the same as for Tumauini Point. The water level is forecasted with the use of a correlation figure, showing the water levels at Tumauini Point and Tuguegarao Point with respect to the following time.

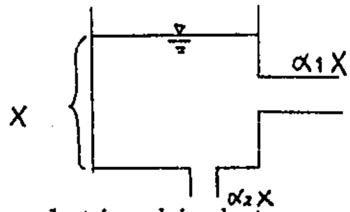
8. Verification of Flood Forecasting Model

(1) The relationship between rainfall and the water level at PANGAL is shown in Fig. 5-21.

For estimation of the Pangal water level, the tank model method is being studied.

Constants are $\alpha_1 = 0.2$, $\alpha_2 = 0.0$.

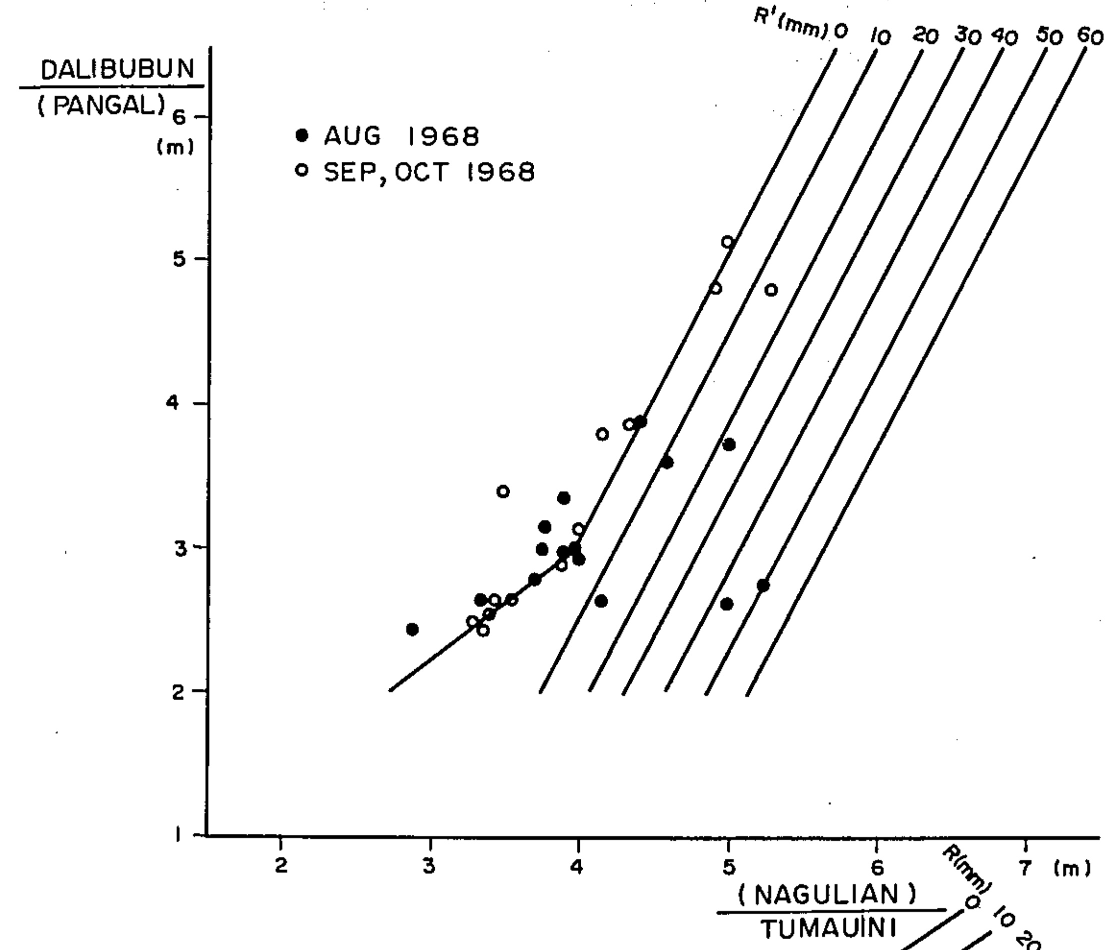
Original amount stored is 50 mm.



(2) With travelling time as one day, the relationship between Pangal water level and Tamauini water level is shown in Fig. 5-21. There is no information about the Tamauini water level, therefore the Magurian information is presented.

(3) With travelling time as one day, the relationship between the Tamauini water level and Tuguegarao water level is shown in Fig. 5-21.

Fig. 5-21 CORRELATION AMONG GAGE HEIGHTS AT DALIBUBUN TUMAUINI AND TUGUEGARAO



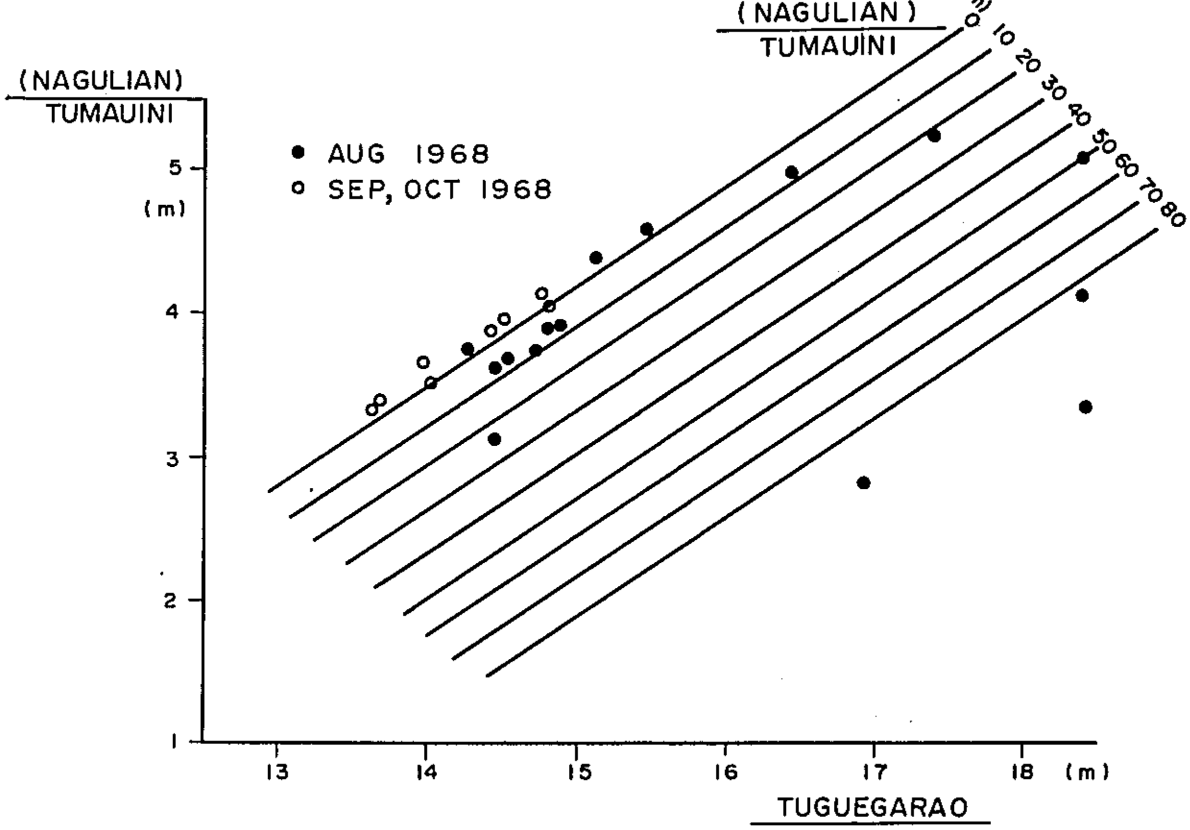


Fig. 5-22 OBSERVED AND CALCULATED WATER GAGE HEIGHT
CAGAYAN RIVER BASIN (1)
Aug. 1968

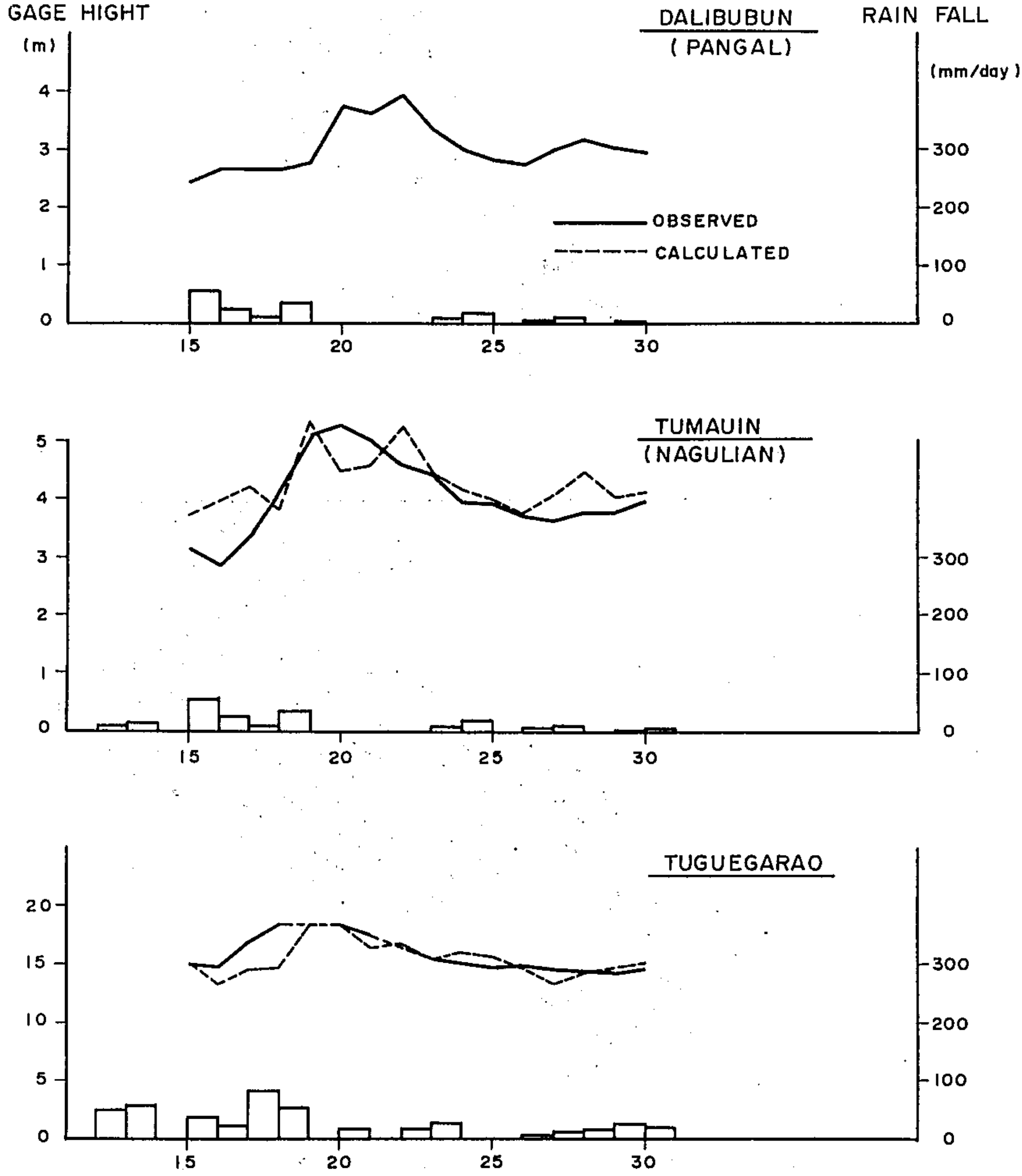
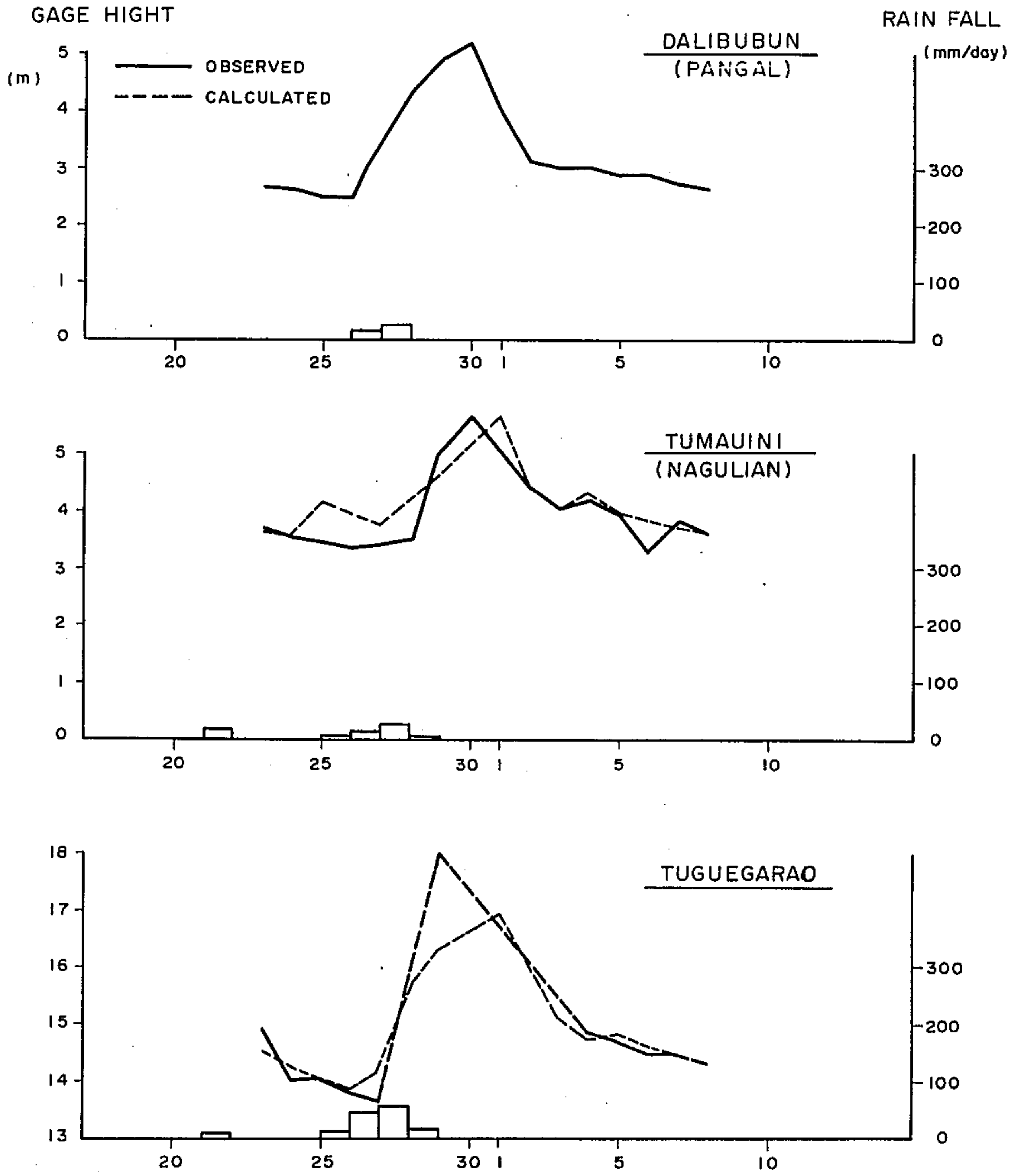


Fig. 5-23 OBSERVED AND CALCULATED WATER GAGE HEIGHT
CAGAYAN RIVER BASIN
Sept, Oct. 1968



VI. Telecommunication and Telemetry System

§-1 Outline

The team recommends the application of an automatic transmission and communication of data for the operation of flood forecasting and warning in each river basion. Subcenters should be established in the middle of each of the three river basins for the collection of data and the operation as well as maintenance of the systems. All the data observed at the gaging stations should be transmitted automatically to the subcenter by means of the telemetry network with VHF telecommunication links.

Two transmitting and receiving stations(relay station) should be set up in the suburbs of Manila for relaying data and other information to and from the subcenters. The team recommends that a multiplex telecommunication system by means of tropospheric scattering of radio wave with 400 MHz band should be set up for the transmission of data from the subcenters to the relay stations, and another multiplex telecommunication system with 400 MHz band be set up between the relay stations, Flood Forecasting Center (F.F.C.), and Bureau of Public Works (B.P.W.) for the automatic transmission of hydrological information and other data.

These telecommunication links connecting the subcenters with Manila are the heart of the flood forecasting and warning system and hence they are extremely important. Consequently, it is also advisable to set up a short wave telecommunication system with S.S.B. (single-side band system) as a back-up in case the telecommunication links are interrupted due to system faults or other troubles. For efficient maintenance work, it is also considered necessary to set up the base station and land mobiles and for each subsenter with VHF band to permit radiotelephone communication readily availble.

If the downstream of the Cagayan River Basin is to be included in the target area, it is preferable to set up several telemetering stations for collecting data. In that instance, radio wave propagation tests should be conducted before they are incorporated in the Flood Forecasting and Warning System of the Cagayan River Basin.

The operation ana maintenance records marked by the Pampanga Flood Forecasting and Warning System since 1973 have highlighted several pending issues to be solved or improved.

For successful expansion and improvement of the system, it is necessary to enlarge the maintenance staff of the telemetry system as well as to strengthen the basic requirement to support the system by acquiring the new techniques to cope with the situation created by the application of the multiplex troposcatter telecommunication system.

Sufficient experience on the part of the maintenance staff is necessary for the maintenance and operational control of the system, and therefore the efforts to help promote their experience through on-the-job training are vitally important. At the same time, systematic appropriation supported by necessary budgetary arrangement is a must for the proper management of the system.

Needless to say, a smooth and effective system operation is impossible without the due coordination and cooperation with all the related organizations including those which are not directly involved in the operation of the system.

In view of the above, the success of this project is solely dependent on the earliest possible formation of a viable man-organization system through effective training of the maintenance staff and efficient coordination and cooperation of agencies concerned.

§-2 Examination of Proposed System

An outline of the facilities and the systems proposed for the collection of data in each river basin is shown in Fig.6-1. The details are as follows:

1. Agno River System

PAGASA Synoptic Station in Dagupan and B.P.W. Office in Carmen Rosales have both been examined as the location of the subcenter. With consideration of the space, the number of personnel and the vehicle availability, the team recommends the subcenter be located at Agno River Control Office of B.P.W. at Carmen Rosales.

The results of the radio propagation tests have shown that each telemetering station can be connected directly to the subcenter except for that located at Binga Dam.

The proposed telemetry network is shown in Fig.6-2. The system set up is schematically shown in Fig.6-3.

With respect to the Binga Dam Station, a good telemetry network can be obtained if connection is made via the repeater station located at Mt. Sto Tomas.

The data collected at the subcenter can be transmitted automatically to F.F.C. at Manila through the 400 MHz band multiplex telecommunication system. The system should be such that each telemetering station can be monitored and controlled by F.F.C. By incorporating the troposcatter telecommunication system, this multiplex telecommunication system makes it possible to have a communication between two spots with fairly a long distance apart aided by the relay station provided at Deliman near Manila

It is also advisable to set up a short wave telecommunication system by using the S.S.B as a back-up against possible suspension of the multiplex telecommunication system.

The results of the investigations on the proposed locations of each telemetering stations are shown in Table 6-1.

To facilitate the maintenance work of this system, base station and land mobiles with VHF band should be provided for the subcenter.

Fig. 6-1 TELECOMMUNICATION NETWORK

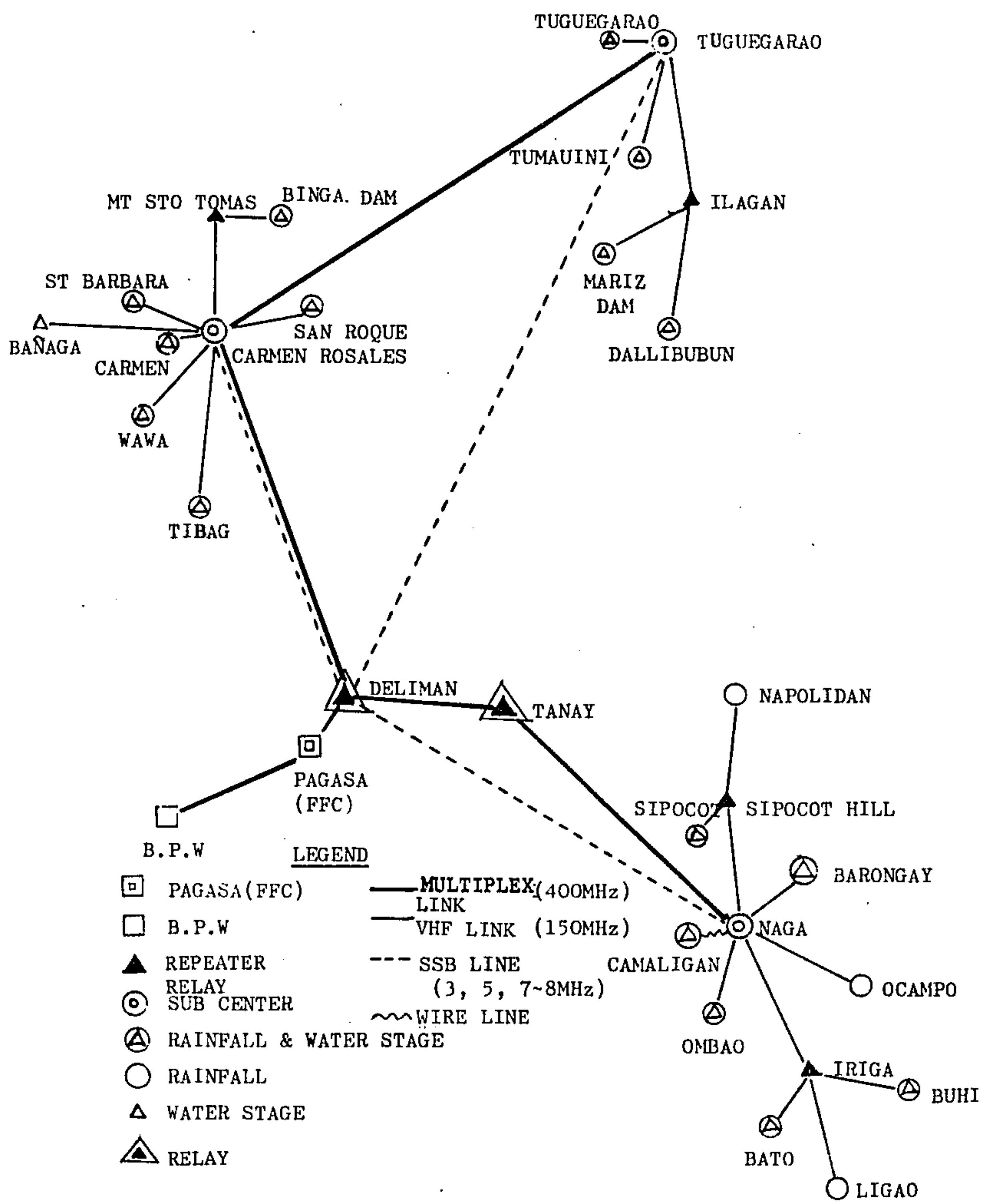
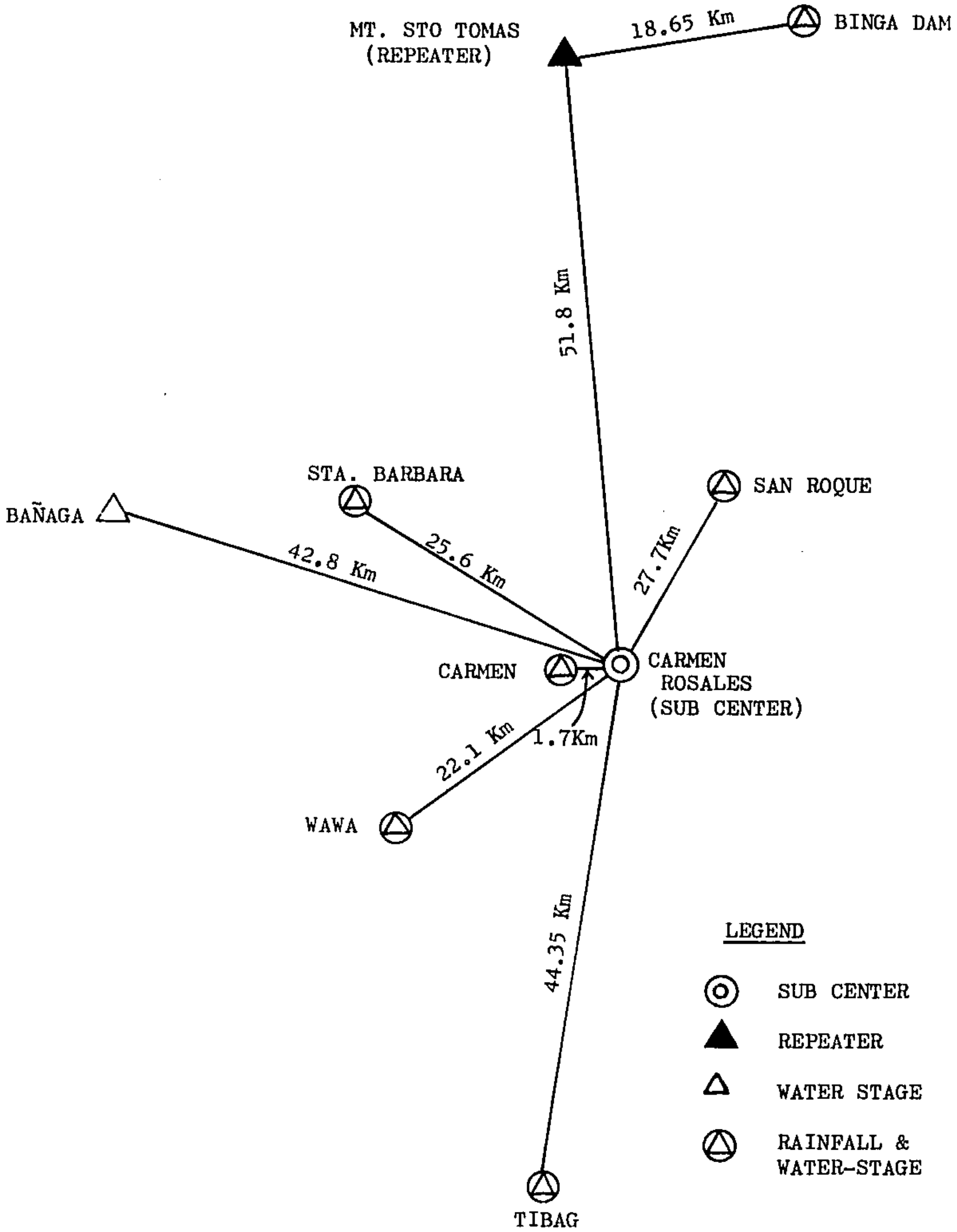


Fig. 6-2 TELEMETRY NETWORK

THE AGNO RIVER



Result of On-Site Investigations on the Proposed Telemetry Stations
(The Agno River Basin) Table 5-1.

Name of Station	Type	Remarks
Carmen Rosales	Subcenter	To be set up within the site of B.P.W. The space is ample to accommodate building and steel tower, but for safety precaution in times of flooding, the equipment including the generator set should be installed at a height equivalent to that of the 2nd floor.
Carmen	Rainfall & water stage	Being located near the subcenter, no problem may arise for radio propagation, but the telemetering station housing should be constructed on the hight of the river bank.
San Roque	Rainfall & water stage	The station housing is planned to be constructed on the existing irrigation water intake dam (4 ~ 5 m above the ground level). No problem exists for radio propagation. There will be no space-wise problem if the station housing can be constructed on the existing dam site as intended.
Sta. Barbara	Rainfall & water stage	The station housing is planned to be constructed within a site of the residence of an inhabitant located at the downstream of the Maramba bridge. Direct connection to the subcenter is feasible, but connection via the repeater station at Sto Tomas may also be considered if situation demands.
Bañaga	Water stage	The radio propagation test was conducted at relatively low ground area. The station housing should be constructed on an area of higher ground level. Direct connection to the subcenter is feasible, but connection via the repeater station at Sto Tomas may also be considered if situation demands.

Name of Station	Type	Remarks
Wawa	Rainfall & water stage	The site for the station housing ; is in coconut plantation, requiring land de-velopment. Direct connection to the sub-center can be made offering no specific radio propagation problem.
Tibag	Rainfall & water stage	The station housing is to be constructed on the left bank at the downstream of Agana bridge. No obstacle is found in the vicinity of the prospective housing site, and no radio propagation problem exists since connection is made directly to the subcenter.
Binga Dam	Rainfall & water stage	The telemetry link can be established if connection is made via the repeater station at Sto Tomas. In view of the unstable pro-pagation of radio wave due to the topo-graphical condition proved in the radio propagation test, the setting of the antenna poles requires special consideration and taking care.
Sto Tomas	Repeater station	The existing radar base should be utilized.

Fig. 6-3-1 SCHEMATIC DIAGRAM OF MONITOR AND CONTROL STATION

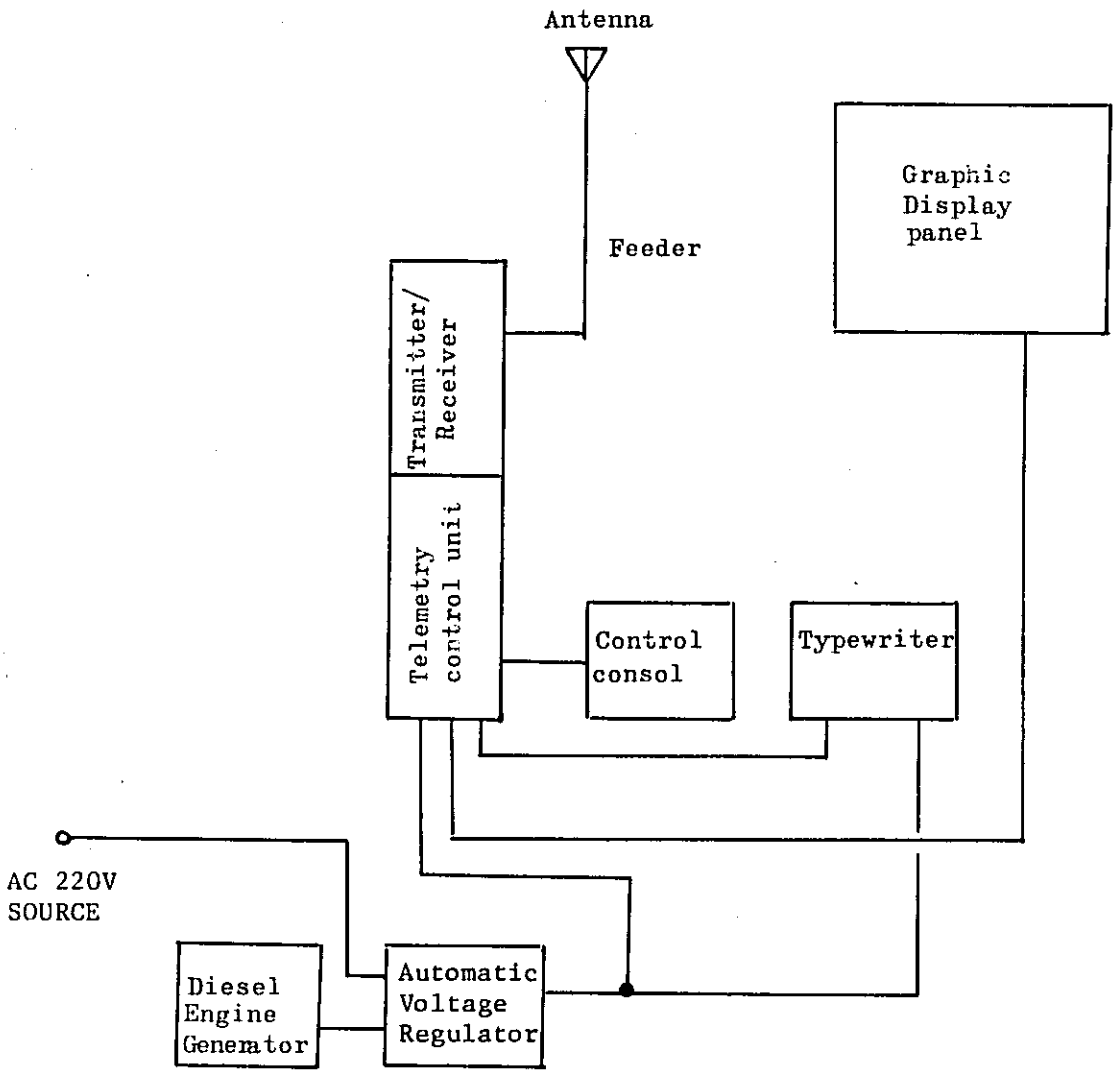


Fig. 6-3-2 SCHEMATIC DIAGRAM OF RAINFALL AND WATER LEVEL TELEMETERING STATION

(Example of the sensing pole type water stage gaging equipment)

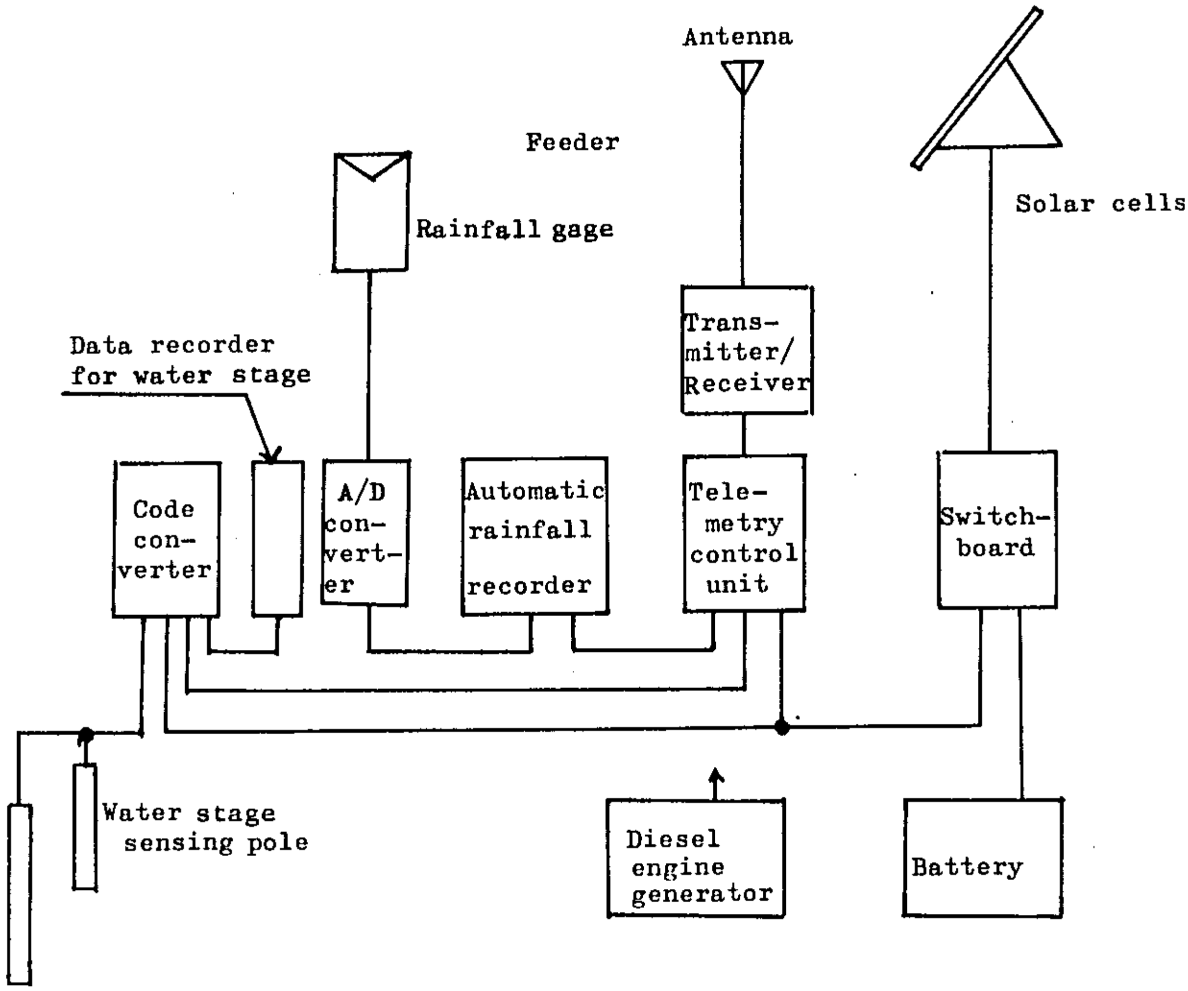
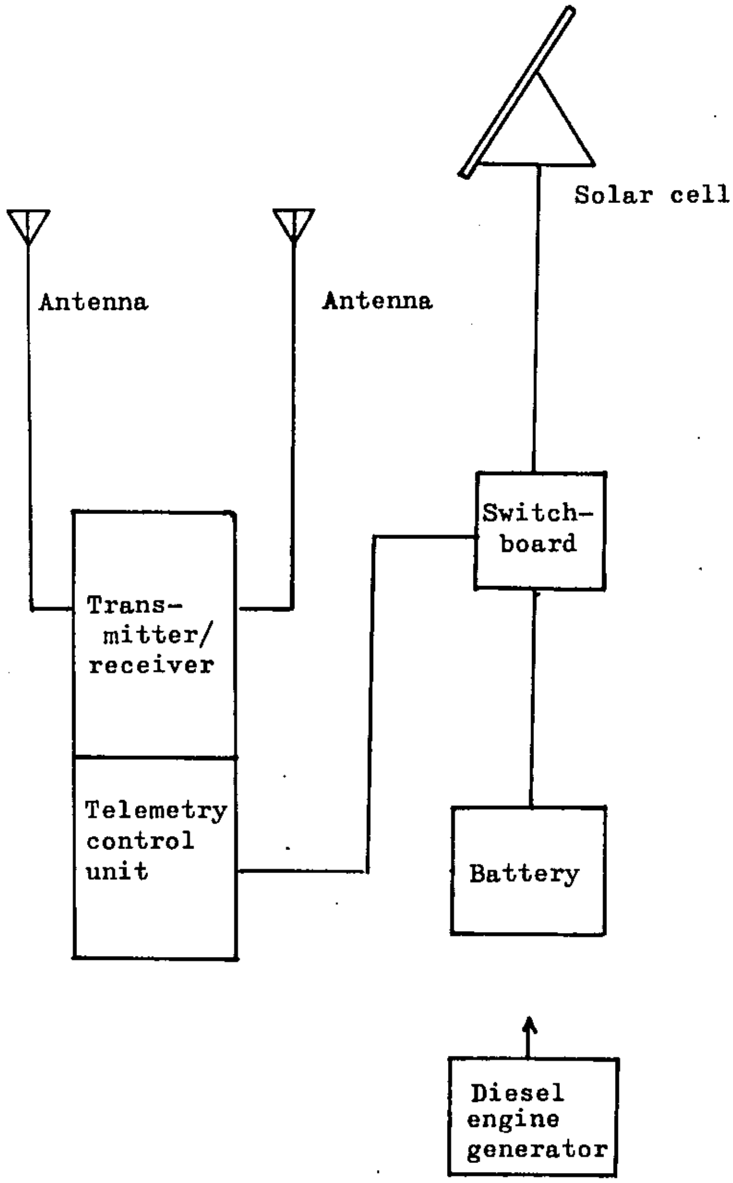


Fig. 6-3-3 SCHEMATIC DIAGRAM OF REPEATER STATION



2. Bicol River System

The subcenter should be located at the Bicol River Control Office, B.P.W. in Naga.

The network of the telemetering stations should be established on the basis of the radio propagation tests as follows:

The proposed telemetry network is shown in Fig.6-4. The system setups are the same as in that of the Agno River Basin.

As for the Bicol River Basin, the Ocampo, Ombao and Barongay telemetering stations can be directly connected to the subcenter, whereas the Camaligan station is to be connected through the wire line.

In the case of Sipocot River, two spots on the map, situated in high grounds some 3 km north of the town of Sipocot along the road are being considered for the site of a repeater station. According to the results of the propagation tests, it is shown that Napolidan and Sipcot stations can be connected to the telemetry network from either end of the proposed repeater stations, while in the case of Bicol River Basin where the locations of the repeater station was selected at the high grounds in the vicinity of the schools for the convenience of maintenance and the topographical conditions, telemetry network involving Bato, Buhi and Ligao can be established by setting up repeater stations at the hights near Iraga.

As in the case of the Agno River Basin, the 400 MHz band multiplex troposcatter telecommunication system should be applied for the automatic transmission of data to F.F.C.

The monitoring and controlling of the telemetering stations from F.F.C. are identical with that employed in the Agno River Basin.

The relay station for the multiplex telecommunication system should be set up in the suburbs of Manila, Tanay.

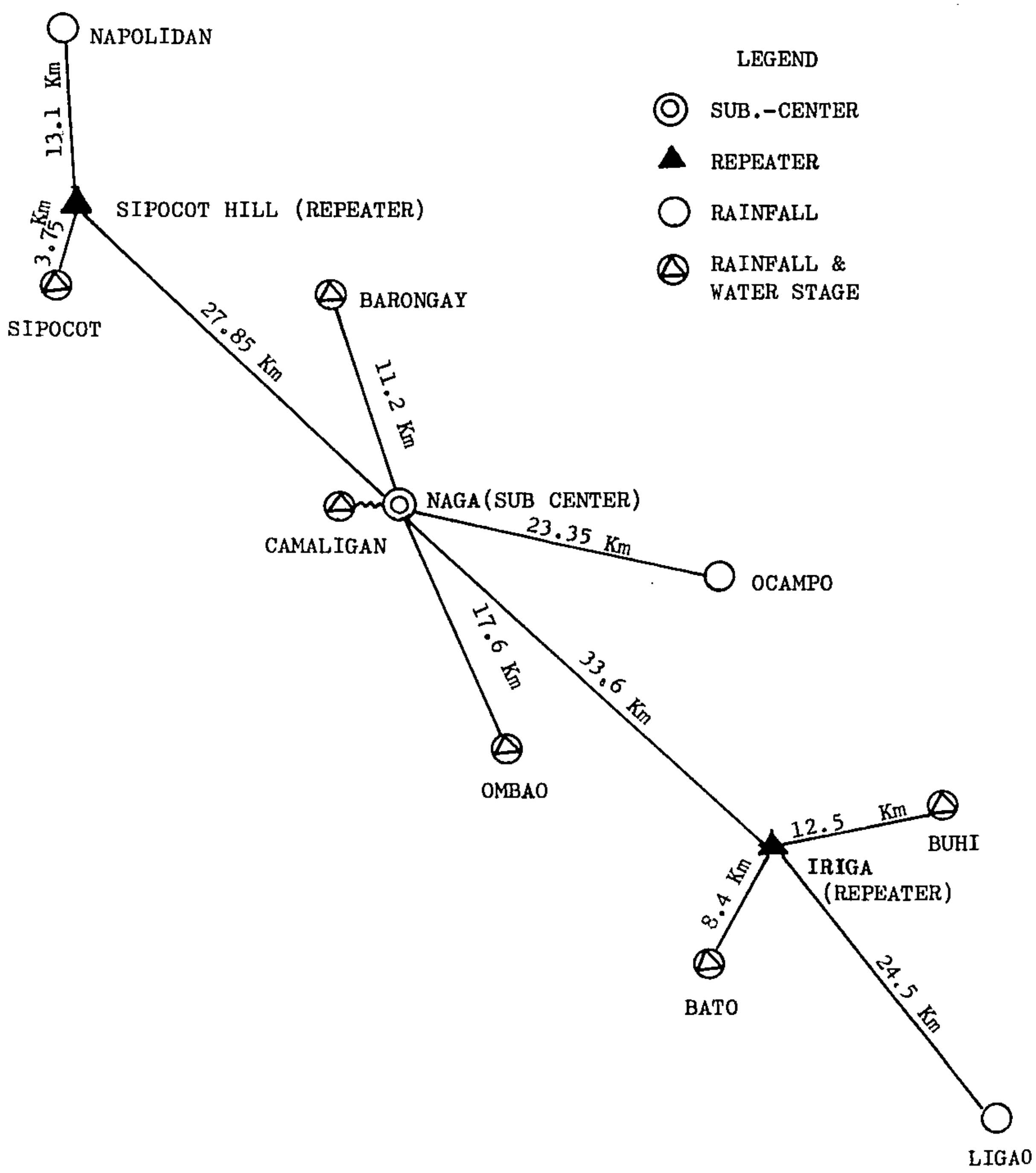
The S.S.B. short wave telecommunication system should be secured for back-up for possible interruption of the multiplex telecommunication system due to system faults or other reasons as is assumed in the Agno River Basin.

The results of the on-site investigations on the proposed telemetering stations are shown in Table 6-2.

For the satisfactory maintenance of this system, base station and land mobiles with VHF band should be set up for the subcenter as in the case of the Agno River Basin.

Fig. 6-4 TELEMETRY NETWORK

THE BICOL RIVER



Results of On-Site Investigations on the Proposed Telemetry Stations
(The Bicol River Basin)

Table 5-2

Name of Station	Type	Remarks
Naga	Subcenter	There is enough space for the station building steel tower, and no specific problem for the telemetry network. The station building should preferably be of the 2-story construction.
Camaligan	Rainfall & water stage	Being located in the site of the B.P.W. it is connected to the subcenter through the wire line, thus no specific problem is anticipated.
Barongay	Rainfall	No problem exists in the housing site, topographical condition, and radio propagation. Direct connection to the subcenter is feasible.
Ocampo	Rainfall	The Iriga repeater station can cover the areas within the network, thus the Ocampo repeater station will be unnecessary. No specific problem is anticipated in line configuration since it is possible to set up a station (for rainfall gaging only) in the vicinity of the highway.
Iriga	Repeater station	A total of four points enumerated from No. 3 to No. 6 were examined whereby No. 3 was concluded to be the best site for a repeater station. The site is in coconut plantation (private property), and is free from any fault in the vicinity. No specific problem exists concerning Naga, Buhi, Bato, and Ligao.
Buhi	Rainfall & water stage	The station housing is to be constructed at the low ground in the vicinity of the Lake Buhi nearly at the level of the Lake water. It is hence recommended that the station housing should be constructed at as high as possible level of the site.

Name of Station	Type	Remarks
Bato	Rainfall & water stage	Being located very close to the Iriga repeater station, no specific problem exists in the space and radio propagation.
Ligao	Rainfall & water stage	The point chosen in the basic investigation may be able to serve as a telemetering station in the network, but does not always provide a good link. It is hence desirable to transfer the location to a site closer to Ligao providing that there is no hydrographical difficulties. Considering the traffic and maintenance difficulties involved, any location in the areas along the existing road connected to the proposed point is not advisable.
Ombao	Rainfall & water stage	There is no problem in the space, based on the topographical condition and radio propagation. Direct connection to the subcenter is feasible.
Sipocot Hill	Repeater station	Two locations were examined in the desk plan. Both of them were, as a result of the propagation tests, found to be good stations in the directional evaluations to Naga, Sipocot and Napolidan. Priority should be given to No. 2 point, namely Sipocot, if there is no problem in purchasing necessary land or other specific restrictions. No fault is found in the vicinity. The station is to be named as the Sipocot Hill Repeater Station.
Sipocot	Rainfall & water stage	There is no propagation problem for the network via the Sipocot Hill Repeater Station as the distance is short. The site for the station housing requires reconsideration as it involves topographical difficulties. The cable between the sensing pole and the housing should preferably be

Name of Station	Type	Remarks
		laid underground.
Napolidan	Rainfall	The present location of the water stage gaging equipment presents difficulties for the telemetry link. At this stage of the project, the water stage in this area has no significance. Hence, no problem may arise if the rainfall gaging station is provided at an area in the vicinity of the highway.

3. Cagayan River System

The subcenter may be built either in the B.P.W. Region II Office or Tuguegarao Synoptic Station of PAGASA in Tuguegarao. In consideration of the space and buildings available, the B.P.W. Region II Office is a preferred site.

Of the telemetry stations within the system, those located in Tumauini and Tuguegarao are directly connected to the subcenter. For Mariz Dam and Dallibubun, direct connection to the subcenter is not feasible on account of the propagation difficulties, hence a repeater station is set up in Ilagan through which they are connected to the subcenter.

The telemetry network is shown in Fig. 6-5. The system setups are identical to that in the Agno River Basin.

As in the case of the Agno River Basin, the 400 MHz band multiplex troposcatter telecommunication system should be applied for the automatic transmission of data to F.F.C.

The monitoring and controlling of the telemetering stations from F.F.C. are identical with that employed in the Agno River Basin.

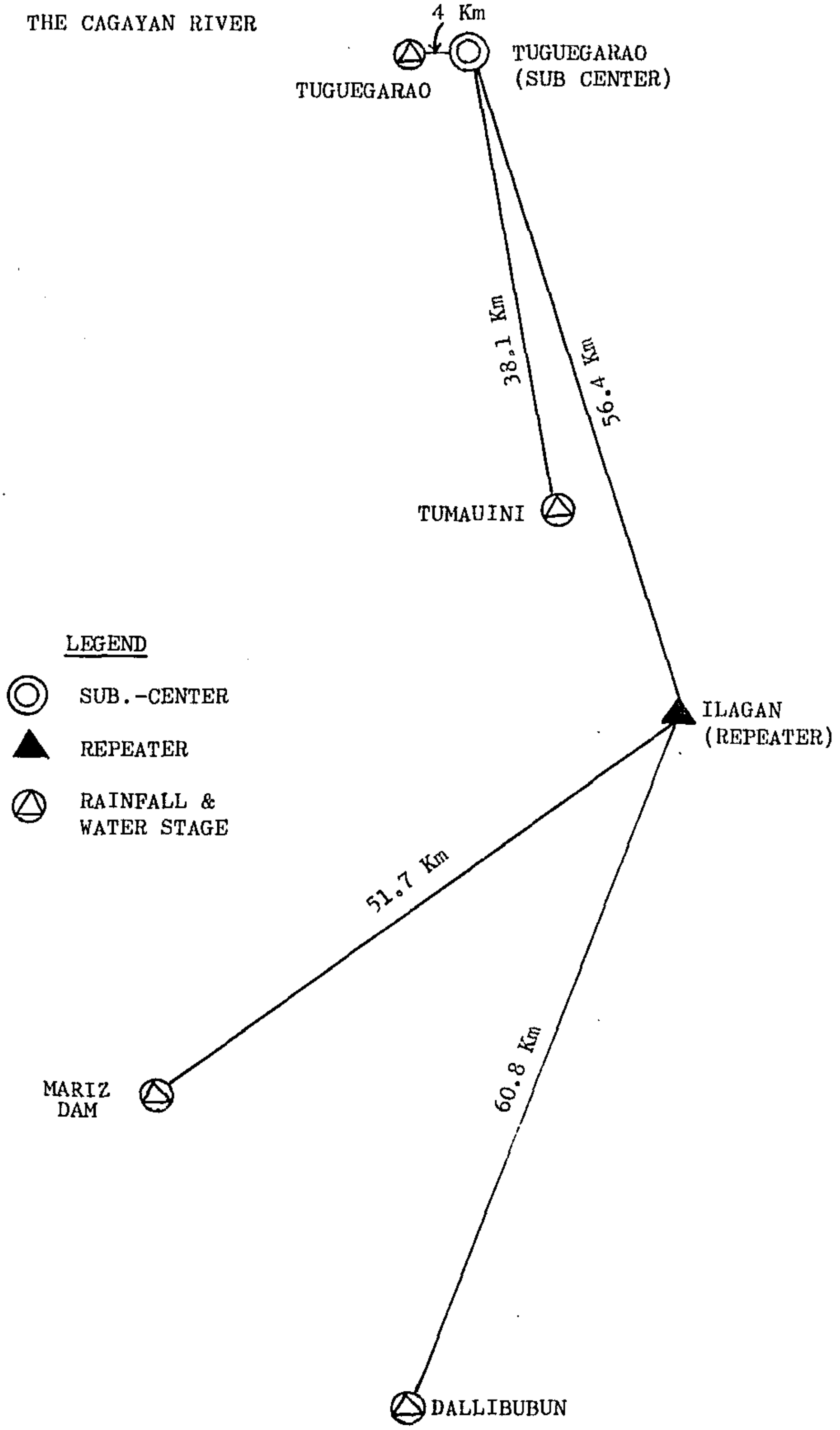
Since a direct connection to the relay station through the 400 MHz band multiplex telecommunication system is not feasible, a connection will be made from the subcenter in the Cagayan River Basin to that in the Agno River Basin, and both river basins will share the same multiplex telecommunication system between Carmen and Manila

The S.S.B. telecommunication system as in the case of the Agno River Basin will be provided to back-up the multiplex telecommunication system in a possible event of suspension due to system faults or other troubles.

The results of the on-site investigations on the proposed telemetry stations are shown in Table 6-3.

For the satisfactory maintenance of this system, base station and land mobiles with VHF band should be setup for the subcenter as in the case of the Agno River Basin.

Fig. 6-5 TELEMETRY NETWORK



Results of On-Site Investigations on the Proposed Telemetry Stations
(The Cagayan River Basin)

Table 6-3

Name of Station	Type	Remarks
Tuguegarao	Subcenter	The space for building and steel tower is ample, and there is no specific problem for telemetry network.
Tuguegarao	Rainfall & water stage	The space for the station housing offers no problem. Direct connection to the sub-center can be made, and there is no propagation problem since the distance is short.
Tumauini	Rainfall & water stage	There is no problem relative to the space and topographical conditions. Direct connection is made to the Tuguegarao sub-center. Connection via the Ilagan repeater station is also feasible without presenting specific problem.
Ilagan	Repeater station	It is located in front of B.P.W. Distric Engineers office. There is no problem relative to the space and topographical conditions.
Maris Dam	Rainfall &	The propagation test conducted in the vicinity of the gaging station shows that the connection via the Ilagan repeater station offers no problem. For the time being, the antenna pole is constructed on the existing gaging housing, but if it is transferred to an area on the river bank in the future, better network may be obtained. The San Mateo repeater station once considered in the desk plan will become unnecessary.

Name of Station	Type	Remarks
Dallibubun	Rainfall & water stage	With the present location of the water stage gaging station no satisfactory telemetry network can be established. The station housing should be constructed in a farm on the river bank. No propagation problem is anticipated if connection is made via the Ilagan repeater station. The cable between the gaging site and the station housing should preferably be laid underground.

§-3. Design of Telecommunication Systems

The team has made corrections to the desk plan according to the results of the radio propagation tests conducted at this time. The details are as follows:

1. Telemetry System

a. Equipment and instruments used in propagation test

Item	Rating	Quantity	Remarks
Radiotelephone	CRI-15, f.152.275 MHz	3	10W
Electric field strength meter	M-321C type, 20 ∿ 230 MHz	1	
Diesel engine generator	300W AC220V DC12V	3	
Battery	12V 40AH	3	
Battery charger	100/200V 12V 10A	1	
Yagi antenna	3E provided with 10 m of pole assembly	3	
Through type watt-meter	TLP-52A 15W	2	
Terminal type watt-meter	15W	1	
Circuit tester	TL-700	3	
Transmission characteristic measuring instrument	MS-20M type	1	
S/N measuring instrument	KCb-1 type	2	
High frequency coaxial cable	5D-2V 10 m	3	
Rheostat	200/100V 0 ∿ 220V	1	
Tools	S-10	3	
Spares and accessories		1	

b. Method of Propagation Test

(a) Propagation test equipments

The set up of the propagation test equipments are as shown in Fig.5-6. Measurements were made on the following items:

Received input power

Directivity of received wave

Relationship between antenna height and received power

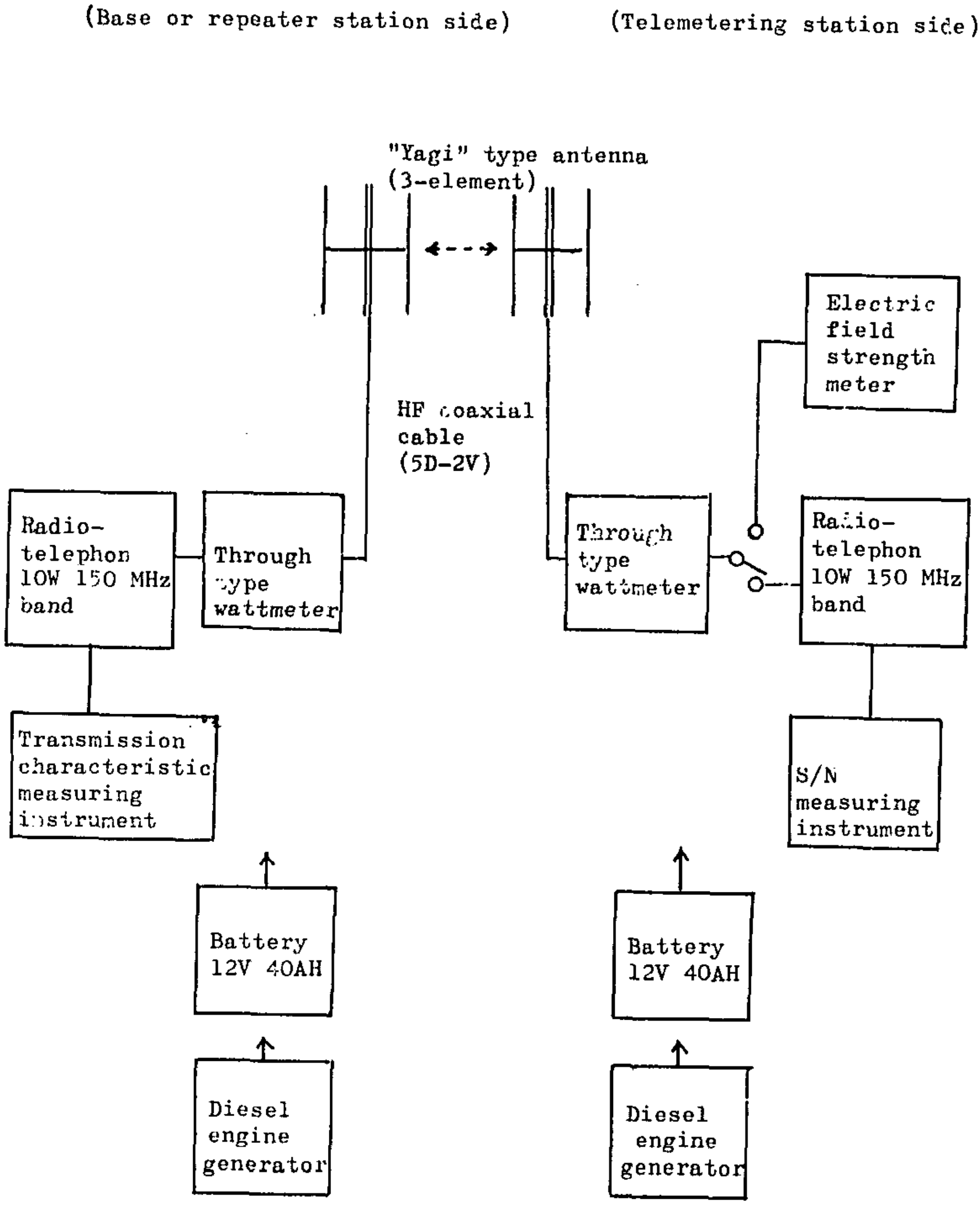
S/N ratio, etc.

(b) Team

Three teams were organized for the propagation tests: one team was assigned to the base (repeater) station, and two teams were assigned to the telemetering stations. One team comprised of the following six persons:

Telecommunication engineer	one
Telecommunication technician	one
Driver	one
Laborer	two
Telecommunication Expert	one

Fig. 6-6 SCHEMATIC DIAGRAM SHOWING RADIO WAVE PROPAGATION TEST EQUIPMENT



(c) Equation for propagation loss

$$L_p = X + \gamma + L_{ft} + L_{fr} - G_{At} - G_{Ar} - P$$

where

L_p : propagation loss

X : conversion factor of received power and received voltage . . . . 113 dB

γ : measured electric field strength . . . . dBμV

L_{ft} : feeder loss, transmitting side . . . . dB

L_{fr} : feeder loss, receiving side . . . . dB

G_{At} : antenna gain, transmitting side . . . . dB (GIS)

G_{Ar} : antenna gain, receiving side . . . . dB (GIS)

P : through type wattmeter reading (output power) . dBm

(d) Equation for S/N ratio

The S/N value of a channel in each section in standard state calculated by the equation below should be above 30 dB.

$$S/N = P_t - (L_p + L_f) + G_{At} + G_{Ar} - P_{rn} - I$$

where

S/N : signal to noise ratio in a channel . . . . . . dB

P_t : antenna power in transmission . . . . dBm

L_p : propagation loss . . . . dB

L_f : transmitting and Receiving feeder loss . . . . dB

G_{At} : antenna gain, transmitting side . . . . dB (GIS)

G_{Ar} : antenna gain, receiving side . . . . dB (GIS)

P_{rn} : received noise power . . . . dBm

* $P_{rn} = P_{rni} + P_{rne}$

where

P_{rni} : internal noise power of receiver . . dBm

P_{rne} : external noise power . . . . dBm

I : S/N improvement factor

* $I = 10 \log(\frac{3f_d^2 \cdot B}{2f_m^3})$ . . . . dB

where

f_d : maximum frequency shift . . . . KHz

B : noise equivalent bandwidth of receiver "

f_m : maximum modulation frequency . . . . "

(e) Reliability of link

The reliability of a single telecommunication link (above 95%) is justified acceptable when the antenna power P_t satisfies the criterion formula:

$P_t > A$

$A(dBm) = (L_p + L_f + LF) + G_{At} + G_{Ar} - P_{th}$

where

L_p : propagation loss . . . . dB

L_f : feeder loss . . . . dB

L_F : fading loss . . . . dB

= 0.1 (dB/km) × distance (km)

P_{th} : threshold level . . . . dBm

(a value higher than the addition of the internal noise power of a receiver (P_{rni}) and the external noise power (P_{rne}) by an amount equivalent to cf (9dB))

(f) Results of measurements

On the basis of the data obtained from the results of the propagation tests, telecommunication link in each river basin was designed. Shown in Table 6-4, Table 6-5 and Table 6-6 are the telecommunication links for each river basin.

(g) Applicable radio frequency

It is necessary to provide the Agno River Basin with two new frequencies from VHF band; the Bicol River Basin and the Cagayan River Basin with two frequencies, too. The repeater system for each river basin is shown in Fig.6-7, Fig.6-8 and Fig.6-9 respectively.

Aside from the telemetry links, another one frequency from VHF band is necessary for the land mobiles. Consequently, a total of five frequencies from VHF band will be necessary.

AGNO SYSTEM System Design Data Sheet TABLE 6-4

Item \ Name of Station	Unit	CARMEN ROSALES (Sub Center) - TIBAG 44.35 Km		- WAWA 22.1 Km		- BAÑAGA 42.8 Km		-Sto. BARBARA 25.6 Km		-Mt. Sto. TOMAS (Repeater) 51.8 Km		- CARMEN 1.7 Km		- SAN ROQUE 27.7 Km		Mt. Sto. TOMAS (Repeater) - BINGADAM 18.65 Km	
Antenna power	dBm	+ 34.8	3 W	+ 30	1 W	+ 40	10 W	+ 30	1 W	+ 40	10 W	+ 30	1 W	+ 30	1 W	+ 34.8	3 W
Free space loss	dB	-110		-103.9		-109.7		-105.2		-111.3		- 81.7		-105.9		-102.4	
Additional loss	"	- 37.1		- 35.1		- 40.8		- 33.7		- 29.5		- 13		- 23		- 41.1	
Feeder loss	"	- 2.1	APZE-50-4 60 m	- 2.1	APZE-50-4 60 m	- 2.1	APZE-50-4 60 m	- 2.1	APZE-50-4 60 m	- 3.1	APZE-50-4 90 m	- 2.1	APZE-50-4 60 m	- 2.1	APZE-50-4 60 m	- 2.1	APZE-50-4 60 m
Antenna gain (transmitting)	"	+ 8	Yagi 3E	+ 8	Yagi 3E	+ 8	Yagi 3E	+ 8	Yagi 3E	+ 6	3-stage co-linear	+ 8	Yagi 3E	+ 8	Yagi 3E	+ 8	Yagi 3E
Antenna gain (receiving)	"	+ 6	3-stage co-linear	+ 6	3-stage co-linear	+ 6	3-stage co-linear	+ 6	3-stage co-linear	+ 6	3-stage co-linear	+ 6	3-stage co-linear	+ 6	3-stage co-linear	+ 6	3-stage co-linear
	"																
	"																
Received power	dBm	-100.4		- 97.1		- 98.6		- 97		- 91.9		- 52.8		- 87		- 96.8	
Received noise power	"	-119		-119		-119		-119		-119		-119		-119		-119	
High frequency S/N,(C/N)	dB	18.6		21.9		20.4		22		27.1		66.2		32		22.2	
S/N improvement factor	"	12		12		12		12		12		12		12		12	
S/N in standard state	"	30.6		33.9		32.4		34		39		78.2		44		34.2	
Fading loss	"	- 7.4	0.1 dB/Km +3 dB	- 5.2		- 7.3		- 5.6		- 8.2		- 3.2		- 5.8		- 4.9	
S/N in each section during fading	"	23.2		28.7		25.1		28.4		30.9		75		38.2		29.3	
Total S/N	"																
Threshold level	dBm	-110		-110		-110		-110		-110		-110		-110		-110	
Fading margin against threshold level	dB	9.6		12.9		11.4		13		18.1		57.2		23		13.2	
Margin against threshold level during fading	"	2.2		7.7		4.1		7.4		9.9		54		17.2		8.3	
Remarks																	

BICOL SYSTEM System Design Data Sheet TABLE - 6-5

Item \ Name of station	Unit	NAGA (Sub Center) - BARONGAY 11.2 Km		- CANALIGAN (Wire system)	- OCAMPO 23.35 Km		- OMBAO 17.6 Km		- SIPOCOT HILL (Repeater) 27.85 Km		- IRIGA (Repeater) 33.6 Km	
Antenna power	dBm	+30	1 W		+30	1 W	+30	1 W	+40	10 W	+40	10 W
Free space loss	dB	-98.5			-104.6		-102.5		-106.5		-108	
Additional loss	"	-29			-36.4		-25.8		-22		-22.5	
Feeder loss	"	-2.1	APZE-50-4 60 m		-2.1	APZE-50-4 60 m	-2.1	APZE-50-4 60 m	-3.1	APZE-50-4 90 m	-3.1	APZE-50-4 90 m
Antenna gain (transmitting)	"	+8	Yagi 3E		+8	Yagi 3E	+8	Yagi 3E	+6	3-stage co-linear	+6	3-stage co-linear
Antenna gain (receiving)	"	+6	3-stage co-linear		+6	3-stage co-linear	+6	3-stage co-linear	+6	3-stage co-linear	+6	3-stage co-linear
Received power	dBm	-85.6			-99.1		-86.4		-79.6		-81.6	
Received noise power	"	-119			-119		-119		-119		-119	
High frequency S/N, C/N	dB	33.4			19.9		32.6		39.4		37.4	
S/N improvement factor	"	12			12		12		12		12	
S/N in standard state	"	45.4			31.9		44.6		51.4		49.4	
Fading loss	"	-4.1	0.1 dB/Km +3 dB		-5.3		-4.8		-5.8		-6.4	
S/N in each section during fading	"	41.3			26.6		39.8		45.6		43	
Threshold level	dBm	-110			-110		-110		-110		-110	
Fading margin against threshold level	dB	24.4			10.9		23.6		30.4		28.4	
Margin against threshold level during fading	"	20.3			5.1		18.8		24.6		22	
Remarks												

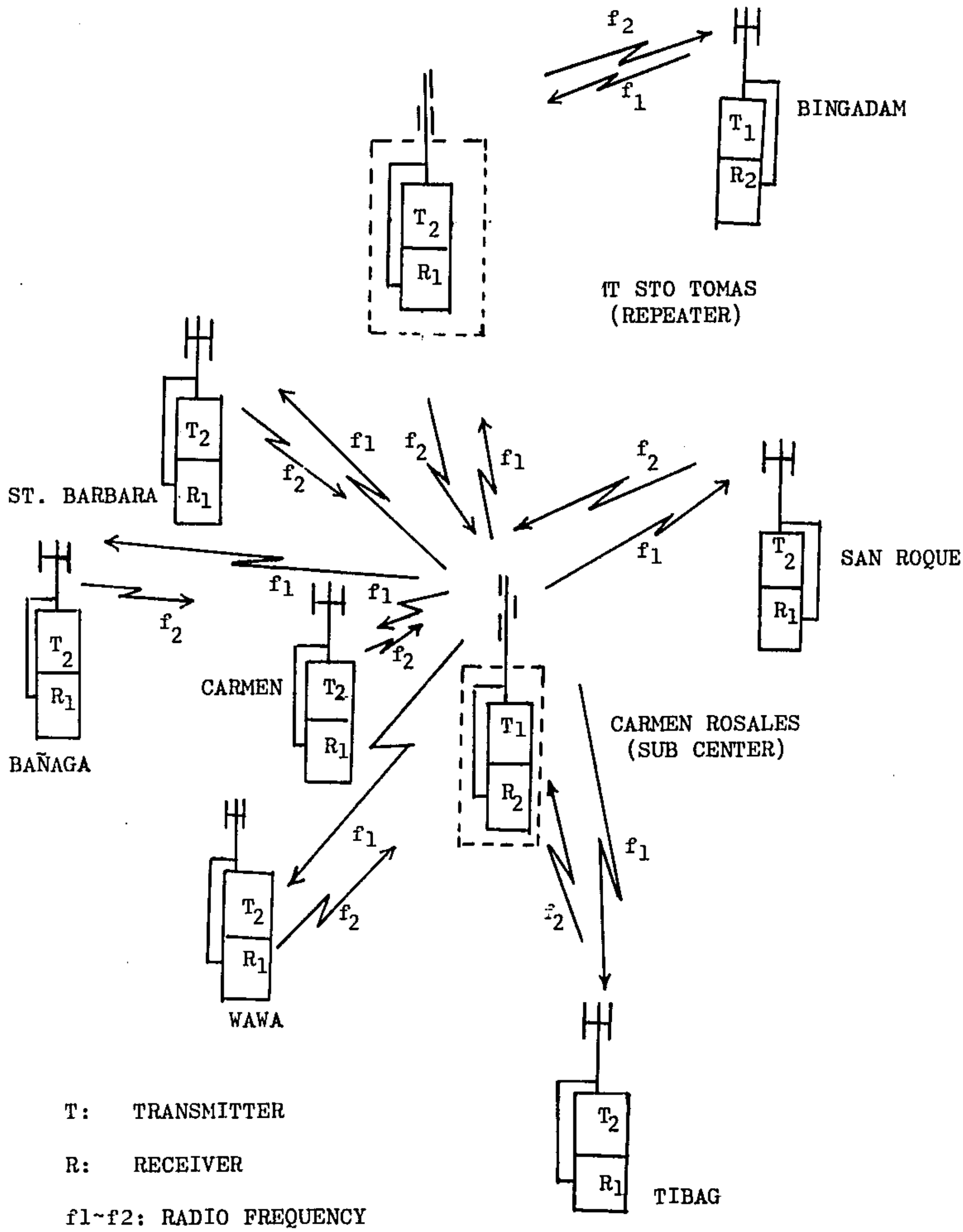
Item \ Name of station	Unit	SIPOCOT HILL (Repeater) - SIPOCOT 3.75 Km		- NAPOLIDAN 13.1 Km		- BATO 8.4 Km		IRIGA (Repeater) - BUHI 12.5 Km		- LIGAO 24.5 Km		- [illegible] 18.5 Km	
Antenna power	dBm	+30	1 W	+34.8	3 W	+30	1 W	+34.8	3 W	+ 40	10 W	+30	1 W
Free space loss	dB	-89		-100		-91.5		-99		-10.5		-103.	
Additional loss	"	-15		-42.5		-26.5		-45.5		-45.5		-27.5	
Feeder loss	"	-2.1	APZE-50-4 60 m	-2.1	APZE-50-4 60 m	-2.1	APZE-50-4 60 m	-2.1	APZE-50-4 60 m	-2.1	APZE-50-4 60 m	-2.1	APZE-50-4 60 m
Antenna gain (transmitting)	"	+8	Yagi 3E	+8	Yagi 3E	+8	Yagi 3E	+8	Yagi 3E	+8	Yagi 3E	+8	Yagi 3E
Antenna gain (receiving)	"	+6	3-stage co-linear	+6	3-stage co-linear	+6	3-stage co-linear	+6	3-stage co-linear	+6	3-stage co-linear	+6	3-stage co-linear
Received power	dBm	-62.1		-95.8		-76.1		-97.8		-98.6		-88.6	
Received noise power	"	-119		-119		-119		-119		-119		-119	
High frequency S/N, C/N	dB	56.9		23.2		42.9		21.2		20.4		30.4	
S/N improvement factor	"	12		12		12		12		12		12	
S/N in standard state	"	68.9		35.2		54.9		33.2		32.4		42.4	
Fading loss	"	-3.4		-4.3		-3.8		-4.3		-5.5		-4.9	
S/N in each section during fading	"	65.5		30.9		51.1		28.9		26.9		37.5	
Threshold level	dBm	-110		-110		-110		-110		-110		-110	
Fading margin against threshold level	dB	47.9		14.2		33.9		12.2		11.4		21.4	
Margin against threshold level during fading	"	44.5		9.9		30.1		77.9		5.9		16.5	
Remarks													

CAGAYAN SYSTEM System Design Data Sheet TABLE 6-6 Calculation Chart

Item \ Name of Station	Unit	TUGUEGARAO (Sub. Center) - TUGUEGARAO 4.0 Km		- TUMAUINI 38.1 Km		- ILAGAN 56.4 Km		ILAGAN (Repeater) - DALIBUBUN 60.8 Km		- MARIS DAM 51.7 Km		- TUMAUINI 18.65 Km	
Antenna power	dBm	+30	1 W	+40	10 W	+40	10 W	+40	10 W	+34.8	3 W	+30	1 W
Free space loss	dB	-89.5		-109		-112.5		-113		-112		-103	
Additional loss	"	-12.5		-43		-35		-40.3		-31.5		-19	
Feeder loss	"	-2.1	APZE-50-4 60 m	-2.1	APZE-50-4 60 m	-3.1	APZE-50-4 90 m	-2.1	APZE-50-4 60 m	-2.1	APZE-50-4 60 m	-2.1	APZE-50-4 60 m
Antenna gain (transmitting)	"	+8	Yagi 3E	+8	Yagi 3E	+6	3-stage co-linear	+11	Yagi 5E	+8	Yagi 3E	+8	Yagi 3E
Antenna gain (receiving)	"	+6	3-stage co-linear	+6	3-stage co-linear	+6	3-stage co-linear	+6	3-stage co-linear	+6	3-stage co-linear	+6	3-stage co-linear
	"												
	"												
Received power	dBm	-60.1		-100.1		-98.7		-98.4		-96.8		-80.1	
Received noise power	"	-119		-119		-119		-119		-119		-119	
High frequency S/N, C/N	dB	58.9		18.9		20.3		20.6		22.2		38.9	
S/N improvement factor	"	12		12		12		12		12		12	
S/N in standard state	"	70.9		30.9		32.3		32.6		34.2		50.9	
Fading loss	"	-3.4	0.1 dB/Km +3 dB	-6.8		-8.6		-9.1		-8.2		-4.9	
S/N in each section during fading	"	67.5		24.1		23.7		23.5		26		46	
Total S/N	"												
Threshold level	dBm	-110		-110		-110		-110		-110		-110	
Fading margin against threshold level	dB	49.9		9.9		11.3		11.6		13.2		29.9	
Margin against threshold level during fading	"	46.5		3.1		2.7		2.5		5		2.5	
Remarks													

Fig. 6-7 TELEMETER TRUNK NETWORK SYSTEM DIAGRAM

THE AGNO RIVER



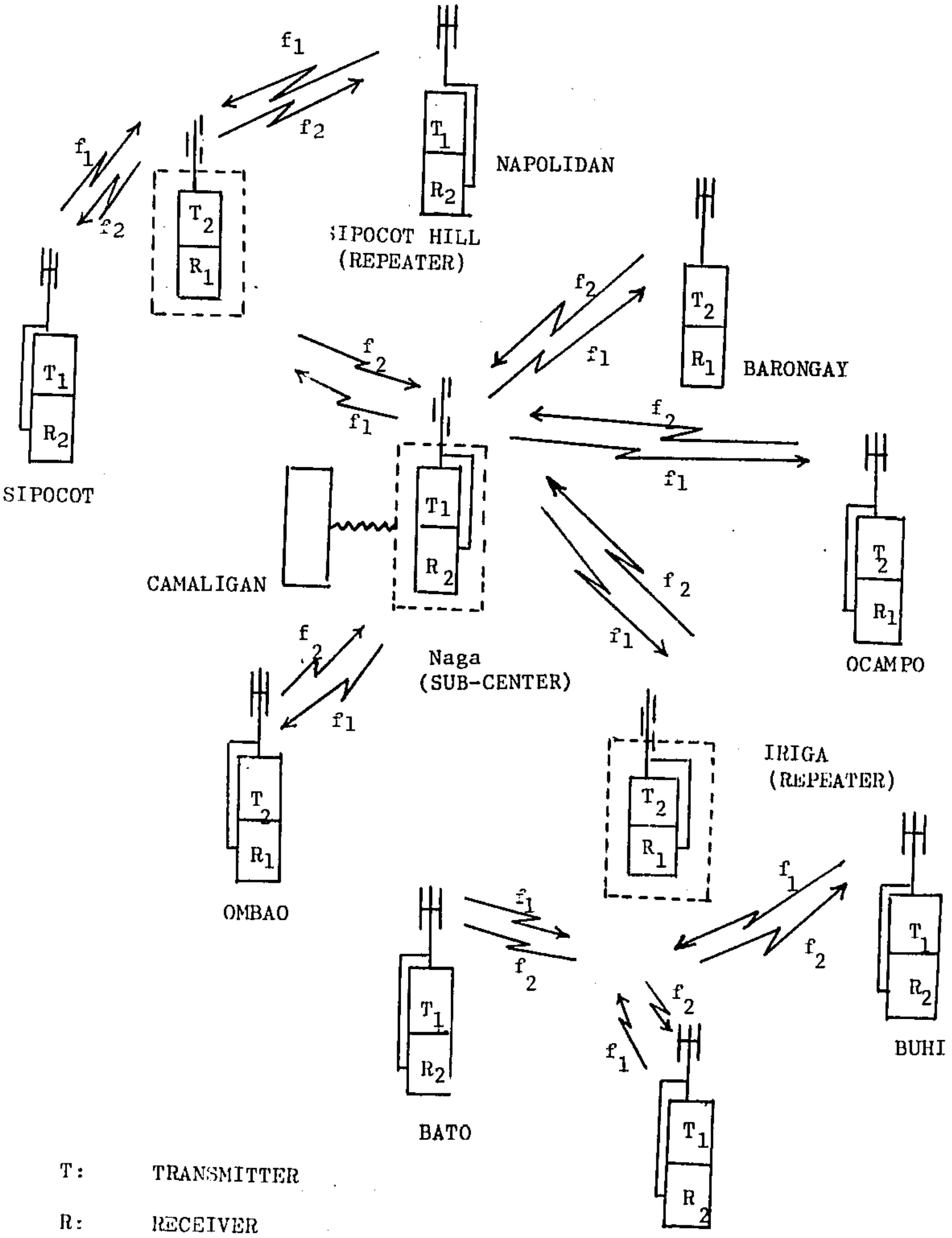
T: TRANSMITTER

R: RECEIVER

f1~f2: RADIO FREQUENCY

Fig. 6-8 TELEMETER TRUNK NETWORK SYSTEM DIAGRAM

THE BICOL RIVER



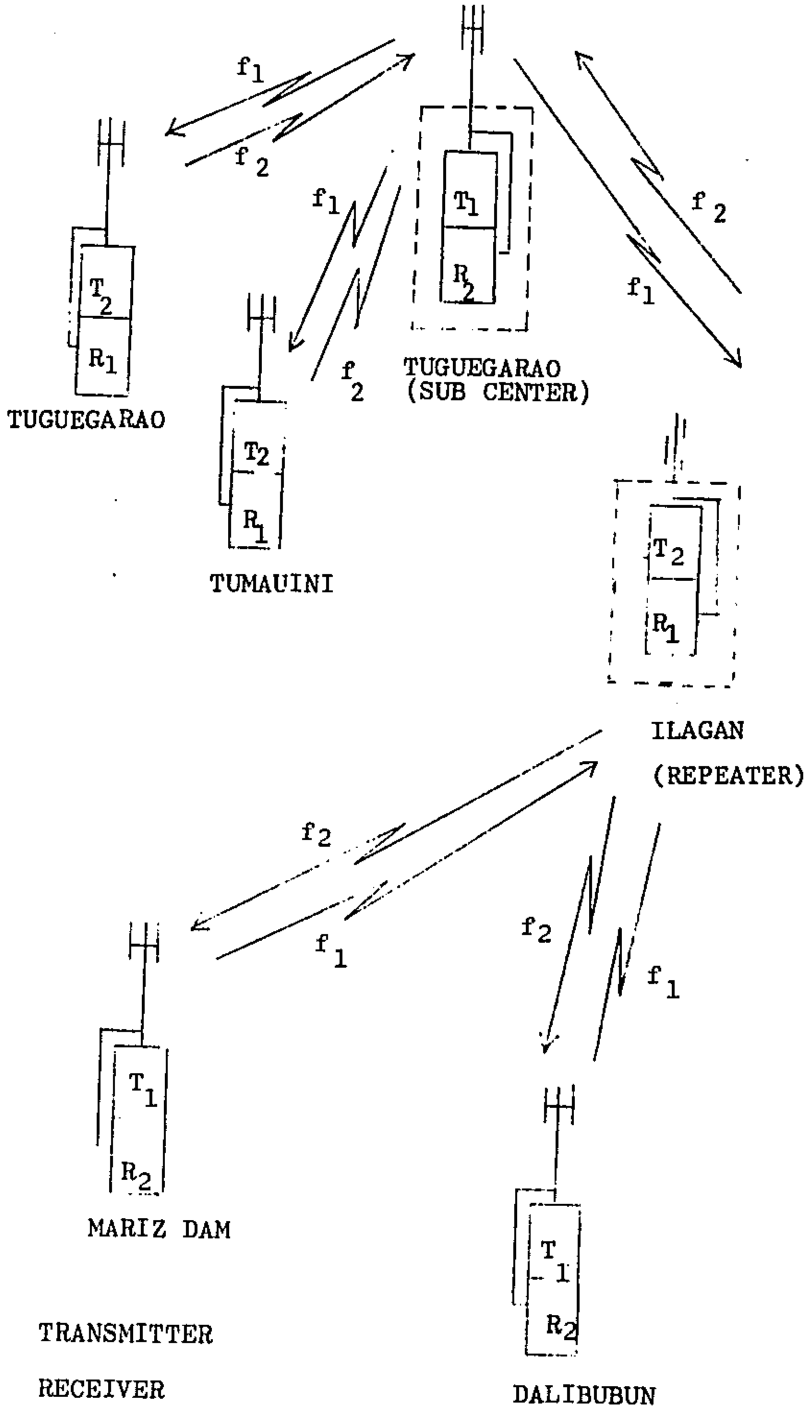
T: TRANSMITTER

R: RECEIVER

$f_1 \sim f_2$: RADIO FREQUENCY

Fig. 6-9 TELEMETER TRUNK NETWORK SYSTEM DIAGRAM

THE CAGAYAN RIVER



T: TRANSMITTER

R: RECEIVER

$f_1 \sim f_2$: RADIO FREQUENCY

2. Multiplex Telecommunication Network

The 400 MHz band multiplex telecommunication links which connect each subcenter with F.F.C. and B.P.W. in Manila via the relay stations have been examined in the desk plan, and are shown in Fig.6-10.
The system configuration is shown in Fig.6-11 , and the system design data are tabulated in Table 6-7. For the Agno River Basin and the Cagayan River Basin, the proposed links configuration envisage a repeater station to be constructed in Deliman in the vicinity of Manila for achieving connection to F.F.C. and B.P.W. Direct connection of the subcenter in the Cagayan River Basin to the relay station at Deliman will be difficult, hence, the Cagayan River Basin will be connected to the Agno subcenter and share the Agno telecommunication system up to F.F.C. and B.P.W.

In the case of the Bicol River Basin, direct connection to the subcenter will be difficult if a relay station is located at Deliman. Therefore, it is recommended that a relay station be established at Tanay, so that the Bicol River Basin will be connected via Tanay to Deliman or PAGASA, whichever is better. In view of fairly long distances between each subcenter and the relay station, it will be necessary to employ the frequency diversity system to mitigate the fading effects. For satisfactory implementation of this system, four pair (8 frequencies) of radio frequencies for the troposcatter system with 400 MHz band and three pair (6 frequencies) for the short distance telecommunication in the vicinity of Manila will be required.

Being the desk plan, radio propagation tests and on-site investigation are necessary before implementing the project. The outline of the project is as follows:

River System	Section	Type	Capacity	Antenna power	Distance	Remarks
Agno River Basin	Carmen Rosales (sub-center) ↔ Deliman (relay station)	Troposcatter system	(CH) 6 or 12	(W) 50	(km) 163.1	Frequency diversity system
	Deliman (relay station) ↔ PAGASA (F.F.C.)	Applicable standards	12 or 24	10	3.0	
	PAGASA (F.F.C.) ↔ B.P.W.	"	"	10	8.8	
Bicol River Basin	Naga (subcenter) ↔ Tanay (relay station)	Troposcatter system	6 or 12	50	222	Frequency diversity system
	Tanay (subcenter) ↔ Deliman (relay station)	Applicable standards	12 or 24	10	32	
Cagayan River Basin	Tuguegarao (sub-center) ↔ Carmen Rosales (subcenter)	Troposcatter system	6	(kw) 1.0	224.5	Frequency diversity system

3. Back-up Telecommunication Links

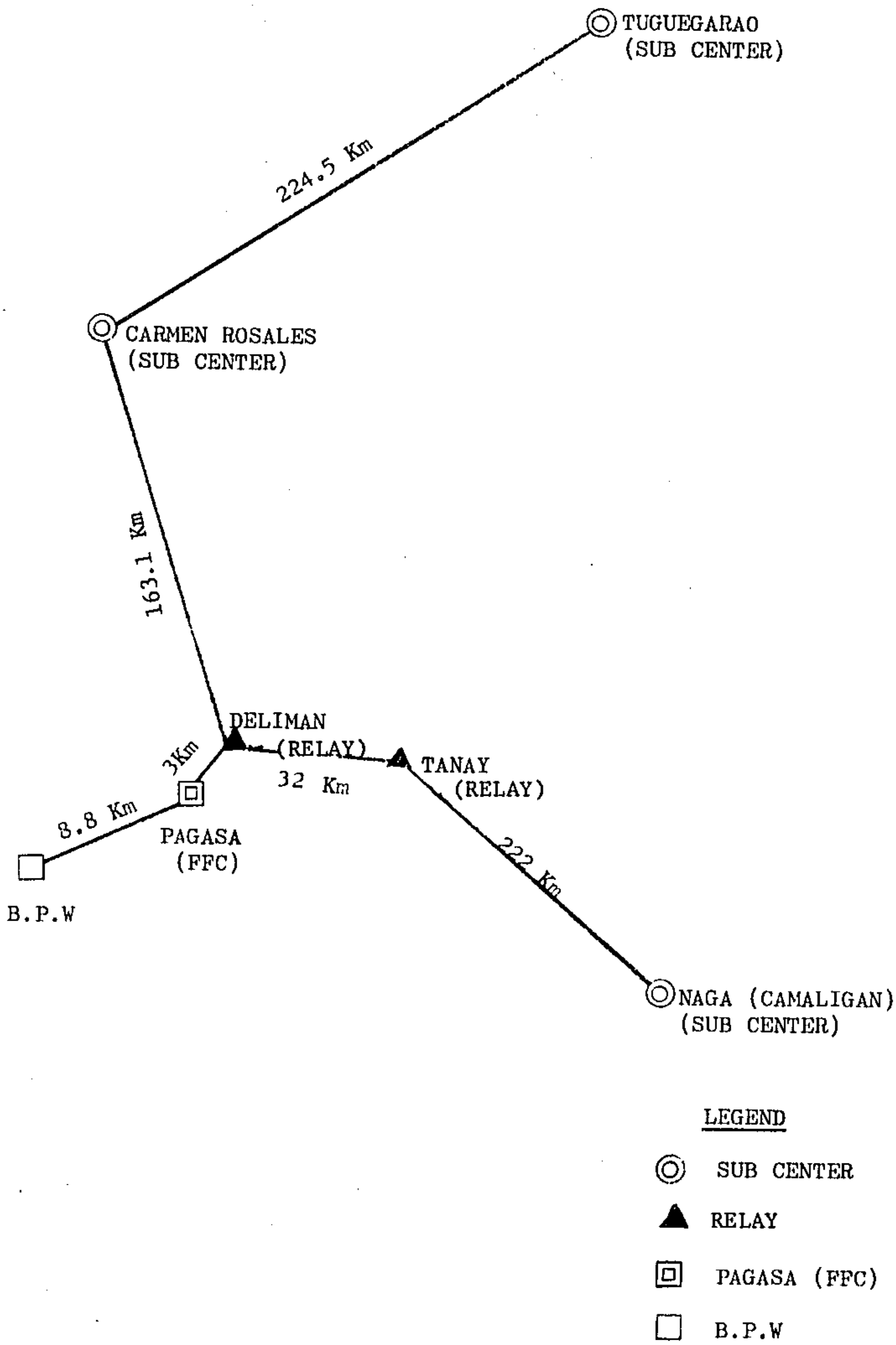
Short wave telecommunication system should be established from each subcenter to F.F.C. and B.P.W. as a back-up in case of suspension of the multiplex telecommunication network. Fig. 6-12 shows a schematic network of these back-up telecommunication links, and Fig. 6-13 shows the system setup of the links.

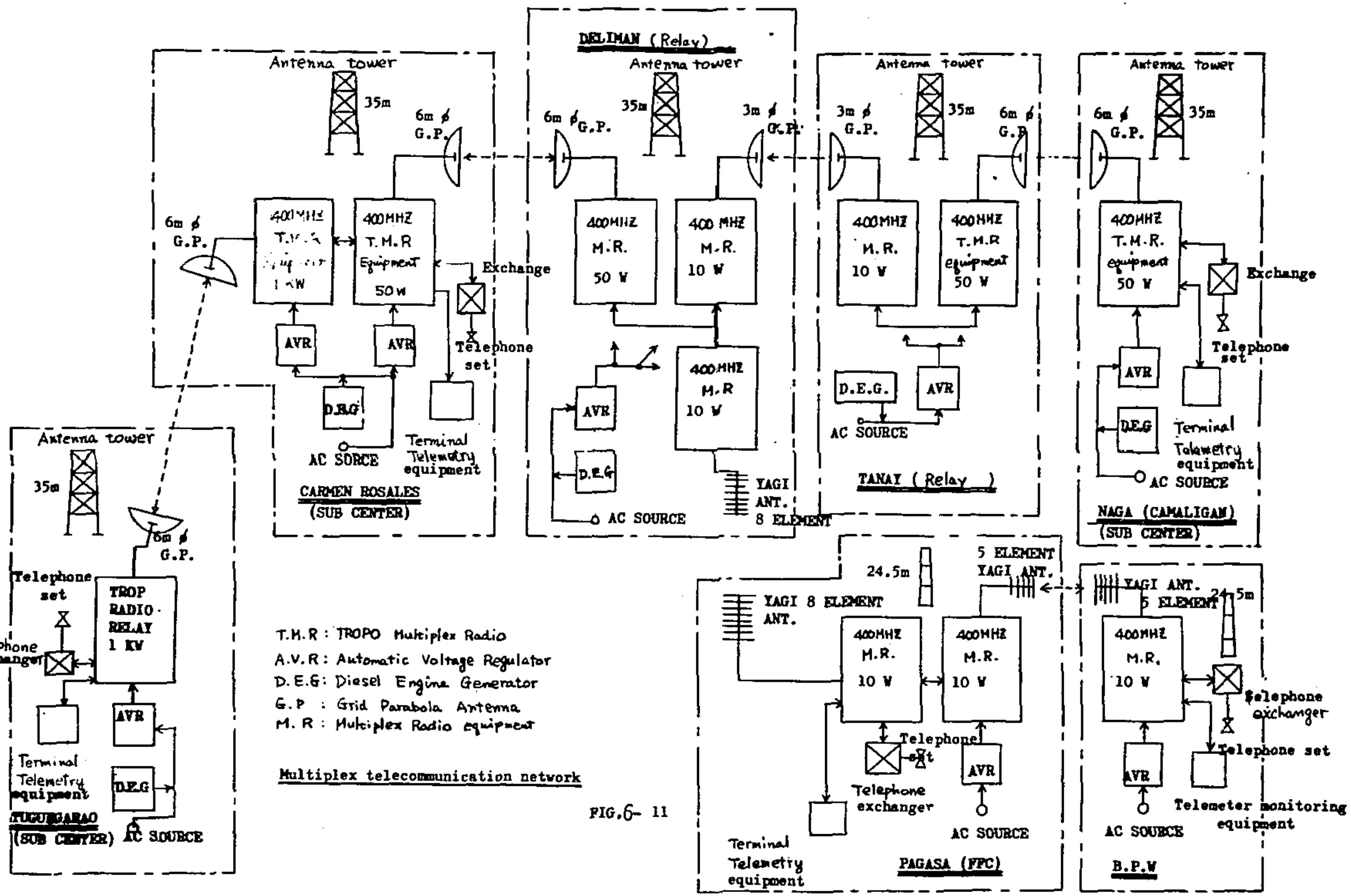
The frequency ranges will be 3 MHz, 5 MHz and 7 - 8 MHz. Alternative use of these three frequency ranges will ensure a satisfactory telecommunication system throughout the year.

4. VHF Telecommunication Links

For a smooth operation and maintenance of this system, each subcenter should be provided with base and mobile stations with VHF band to permit radio-telephone communication readily be available.

Fig. 6-10 MULTIPLEX TELECOMMUNICATION NETWORK





T.M.R : TROPO Multiplex Radio
A.V.R : Automatic Voltage Regulator
D.E.G : Diesel Engine Generator
G.P : Grid Parabola Antenna
M.R : Multiplex Radio equipment

Multiplex telecommunication network

FIG.6- 11

Network system calculation chart
(Multiplex telecommunication network)

System Design Data Sheet

TABLE 6-7

Item	Unit	Agno River Basin						Bicol River Basin				Cagayan River Basin	
Name of station		Carmen Rosales (Sub center) Deliman (Relay) (163.1 Km)		Deliman (Relay) - Pagasa (F.F.C.) (3 Km)		Pagasa (F.F.C.) - B.P.W. (8.8 Km)		Naga (Sub Center) - Tanay (Relay) (222 Km)		Tanay (Relay) - Deliman (Relay) (32 Km)		Tuguegarao (Sub Center) - Carmen Rosales (Sub Center) (224.5 Km)	
Antenna power	dBm	+47	50 W	+40	10 W	+40	10 W	+47	50 W	+40	10 W	+60	1 KW
Free space loss	dB	-171.2	f:400 MHz	-94	f: 400 MHz 3 Km	-103	f: 400 MHz 8.8 Km	-180.1		-114.5	f: 400 MHz 32 Km	-193.5	
Additional loss	"	-6	Experimental correction	-10	Topographic factor	-10	Topographic factor	-6	Experimental correction	-35	Topographic factor	-6	Experimental correction
Feeder loss	"	-4.2	APZE-50-10 70+70m	-5.6	APZE-50-7 70+70m	-5.6	APZE-50-7 70+70m	-4.2		-5.6	APZE-50-7 70+70m	-2.8	
Antenna gain (transmitting)	"	+25.5	6m ϕ G.P.B.R.	+11	Yagi 5E	+13	Yagi 8E	+25.5	6m ϕ G.P.B.R.	+19	3m ϕ G.P.B.R.	+25.5	6m ϕ G.P.B.R.
Antenna gain (receiving)	"	+25.5	"	+11	"	+13	"	+25.5	"	+19	"	+25.5	"
Duplex system loss	"	-3		-7	T 2dB,R 5dB	-7	T 2dB,R 5dB	-3		-7	T 2dB,R 5dB	-3	
	"												
Received power	dBm	-86.4		-54.6		-59.6		-95.3		-84.1		-94.3	
Received noise power	"			-110		-110				-110			
High frequency S/N,(C/N)	dB			55.4		50.4				25.9			
S/N improvement factor	"	+4	Frequency diversity improvement	+8		+8		+4	Frequency diversity improvement	+8		+4	Frequency diversity improvement
S/N in standard state	"	51.6		63.4		58.4		42.7		33.9		43.7	
Fading loss	"	-16		-3.6	0.2dB/Kmx3+3	-4.8	0.2dB/Kmx8.8 +3=4.76dB	-16		-9.4	0.2dB/Kmx32 +3=9.4dB	-16	
S/N in during fading	"	29		59.8		53.6		21		24.5		21	
Total S/N													
Threshold level	dBm	-105		-101		-101		-113		-101		-113	
Fading margin against threshold level	dB			46.4		41.4				16.9			
Margin against threshold level during fading	"	18.6		42.3		36.6		17.7		7.5		18.7	
Remarks		Troposcatter system						Troposcatter				Troposcatter	

Fig. 6 -12 SHORT WAVE TELECOMMUNICATION NETWORK

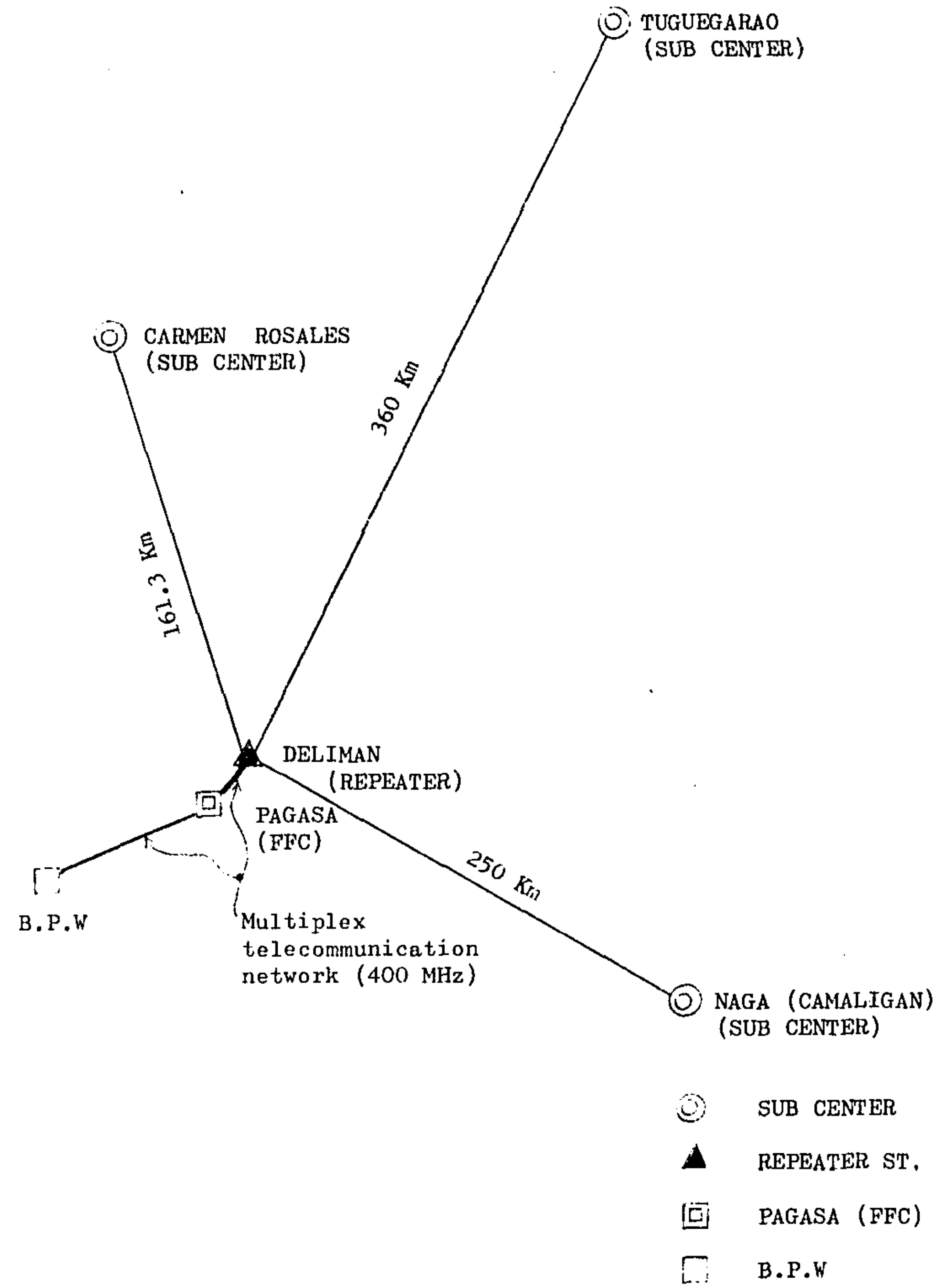
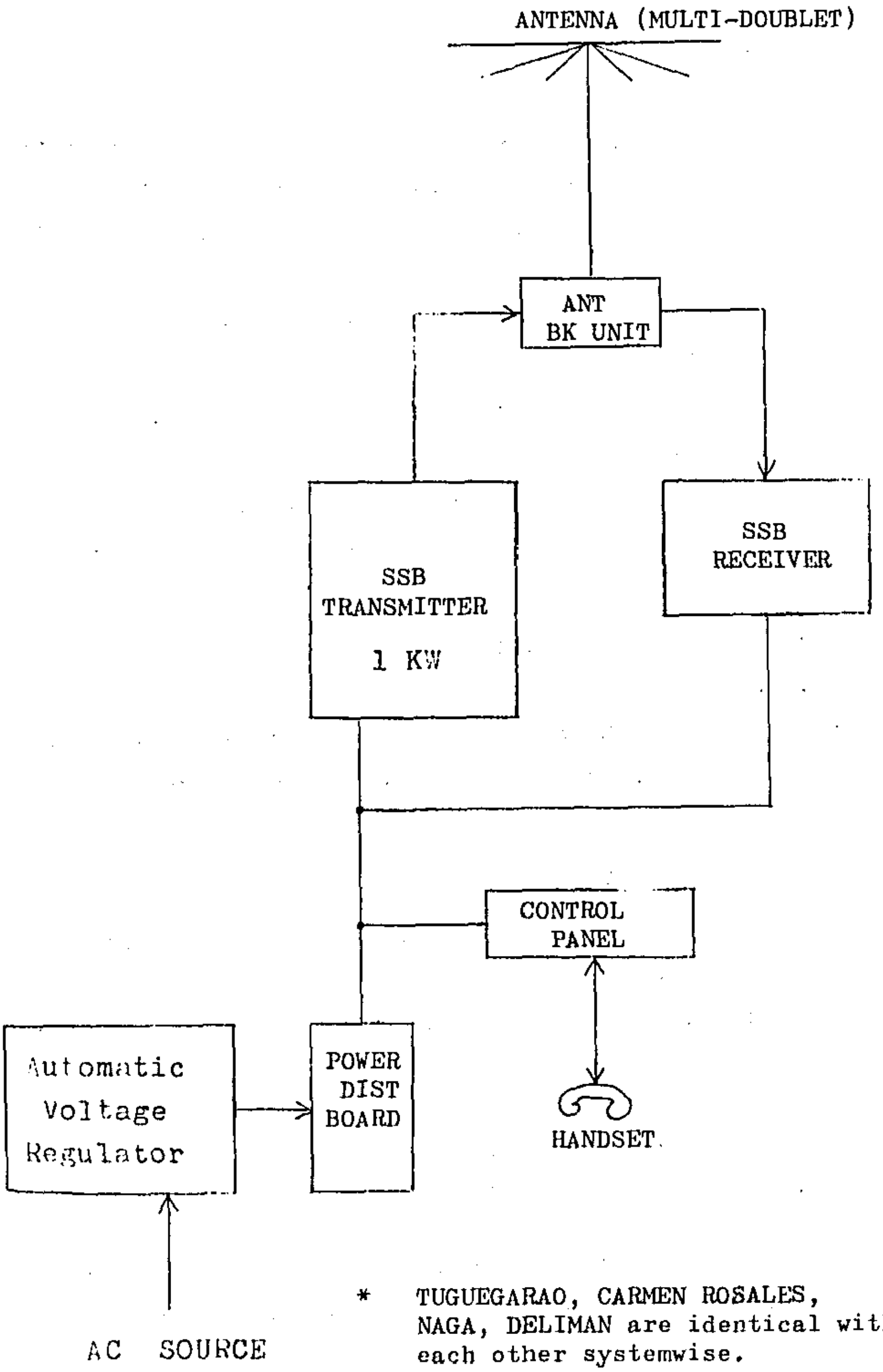


Fig.6-13 SCHEMATIC DIAGRAM OF RADIO STATION



* TUGUEGARAO, CARMEN ROSALES, NAGA, DELIMAN are identical with each other systemwise.

VII. Design of Gaging Stations and Telecommunications Facilities

§-1 Design of Gaging Stations

1. Housing

1-1 Rainfall gaging stations

(1) Location

It is desirable that the region in question be devided into areas where rainfall over the respective areas is about equal one another and a rainfall gaging station be located in each area.

Also for flood forecasting purposes these stations should be equipped with telemetering facilities to ensure positive collection of observation data.

(2) Selection of installation sites

In selecting the installation sites for the rainfall gaging stations, a field survey must be conducted to check the following conditions.

a. Avoid narrows where disturbances to wind direction and wind speed are observed.
b. Avoid location where rainfall conditions are disturbed by.
c. Sites providing less disturbances to telemeter communications.

(3) Determination of installation sites

The installation sites should be determined to meet the following requirements.

a. Open site at least 10 m^2 in area with less changes in the air streams.
b. Site free from flood.
c. Site which offers ready access to gaging and where gage keepers are readily available.

Generally, buildings and big trees located adjacent to the rainfall gaging stations can affect the wind conditions which in turn will likely to disturb rainfall measurements.

There is no accepted theory in regard to scope of such effects, however it is considered desirable that in Japan the station be located in an open site which is at least 600 m^2 in area or that there be a distance of four times the height of adjacent buildings or trees. However it is really infeasible to obtain sites meeting such requirements in Japan, so open sites 10 m^2 approx. have been selected.

The sites of the rainfall gaging stations to be constructed in the Agno, Bicol and Cagayan River Basins, are described in Table. Sketches of the proposed sites are as shown in Appendix .

The construction of Banban gaging station in the Agno River Basin is proposed only when an overall flood forecasting system covering the Rampanga River is completed in the future.

1-2 Water level gaging stations

(1) Location

Water level gaging stations were to be located in areas where considered necessary for flood forecasting purposes.

(2) Selection of installation sites

Following factors have been considered in selecting the suitable sites for the water stage gaging stations.

a. Sites with normal water where the flow is steady and show no significant changes in the flow conditions with changes in flow discharge.

b. Sites where river channel and river bed conditions are relatively steady are to be selected to secure a continued observation for uninterrupted observation records.

c. Sites with a minimum of possible hazards during observation and which provide ease of observation even during flooding.

d. Sites where gage keepers are readily available.

e. Sites having no concern of lakes and marshes and reservoirs being formed, or stationery points (or sections).

f. Sites where water will not dry up during a dry season.

g. Sites which are free from the attack of high waves, driftwood, etc. or where a special protections are provided against these attacks.

h. Sites where mooring of boats or rafts are prohibited.

i. Sites where propagation of telemeter waves is good.

The installation site for each river basin has been determined considering the above factors. (See Table) The sketch of proposed sites is as shown in Appendix

No detailed survey has been conducted on the possible construction of the Aparri gaging station along the Cagayan River, however it should be constructed taking the future development of the river basin into consideration.

1-3 Selection of flow rate gaging points

The following eight locations were selected for observing the flow rates for flood forecasting purposes.

		Survey method
Agno river basin	Sta Barbara	Current Meter
	Wawa	"
	San Roque	Float
	Carmen	Current Meter
	Tibag	"
	Binga Dam	Obtain H-Q curve based on Binga Dam water discharge
Bicol river basin	Sipocot	Current Meter
	Camaligan	"
	Ombao	"

Flow rate observation will be carried out in the vicinity of the water stage gaging station. For points where current meter is used, measurement is made from the bridge above. The float method will be used at San Roque by means of a float dropper; it may, however, be switched to a weir discharge curve (weir method) because of the existing weir for irrigation water.

Criteria for the selection of installation sites are as follows.

a. Water current is steady

b. Rate of flow is not too rapid or too slow.

c. Variations in water channel and river bed are as little as possible.

d. Observation is possible even during dry seasons.

e. Safety in observation work.

f. The site is conveniently located.

2. Facilities

2-1 Rainfall gage

(1) Telemeterization

Possible telemeterization of a gaging station should involve a study of the following conditions.

a. The representative quality of measurement values

b. Check-up method for measurement

c. Electrical power supply conditions, etc.

(2) Selection of rainfall gages

The recording rain gage is the most commonly used.
There are several types of the gage according to the sensor configuration; tumbling type, tank type and weight measure type. For ready access to telemeterization, tumbling type rainfall gages were adopted.

2-2 Recording water level gages

(1) Selection of recording water stage gages

In the selection of recording water stage gages, instrumental features (analogue or digital, ease of reading, etc.), environmental conditions (waves, river bed fluctuations, etc.), processing method (degree of need for manual operation), cost (including the installation cost) and after-service by makers are to be considered.

(2) Types of recording water stage gages

a. Suiken Model 62

Uses two types of pen, ensures recording widths of 10, 20 and 50 m with a minimum of 1 cm. Clocks are available in two types; one-month and three-month winding.

b. Suiken Model 70

Similar to Suiken Model 62, equipped with a damper that allows use of the equipment where high waves are anticipated.

c. Sensing pole type

Lead switches are installed at intervals of 1 cm on the inside wall of a pipe placed vertically in water, and the movement of a magnet attached to the float within the pipe causes the lead switch to open and close to read the water stage. This water stage gage has no limitations in the recording width, allowing a minimum recording width of 1 cm. Recording is either by print method or cassette tape method and permits three-month measurements at time intervals of 10 minutes.

Water stage gages have thus been selected taking the instrumental features, river conditions, and water stage fluctuations, etc. into consideration.

A listing of the gaging stations in the Agno, Bicol and Cagayan River Basins for flood forecasting is shown in the following table.

List of the Gaging Station

No	Location of station	River basin	Type of water level gaging station	Rainfall gaging station	Discharge
1	Bañaga	Agno	well-type	1	
2	Sta. Barbara	"	"	1	Current meter
3	Wawa	"	"	1	"
4	Binga Dam	"	Sensing pole type	1	
5	San Roque	"	"	1	Float dropper
6	Carmen	"	"	1	Current meter
7	Tibag	"	"	1	"
8	(Banban)	"		(1)	
Sub total			well 3 pole 4	7 (8)	
9	Napolidan	Bicol		1	
10	Sipocot	"	sensing pole-type	1	current meter
11	Barongay	"	"	1	
12	Camaligan	"	well-type	1	Current meter
13	Ocampo	"		1	
14	Ombao	"	well-type	1	Current meter
15	Bato	"	sensing pole-type	1	
16	Buhi	"	well type	1	
17	Ligao	"		1	
Sub total			well 3 pole 4	9	
18	Dalibubun	Cagayan	well-type	1	
19	Maris Dam	"	sensing pole-type	1	
20	Tumauini	"	"	1	
21	Tuguegarao	"	"	1	
22	(Aparri)	"	well-type	(1)	
Sub total			well 1 (2) pole 3	4 (5)	
Total			well 7(8) pole 11		

§-2 Design of Telecommunications Facilities

1. Housing, Telepole and Tower

For station housing intended for water stage gaging (for sensing pole type) and rainfall gaging, Type B (station with a space of 2.5 m x 2.5 m) was selected, and for station housing intended for rainfall gaging only, Type A (station with a space of 1.8 m x 1.8 m) was selected.

One telepole was provided in each station. The repeater station was furnished with a 30 m high triangular type tower. A 35 m high iron tower was installed in the subcenter in each basin and in the relay stations in Deliman and Tanay.

R.S. was of the same type in each basis, having a spacing of 5.0 m x 5.0 m (Machinery room 15 m^2, stand by generator room 10 m^2)

S.C. had the following spacings depending on the changing capacity in the individual river basins.

Agno River Basin	Carmen Subcenter	2.0 m x 10 m (Machinery room 25 m^2, generator room 25 m^2)
Bicol River Basin	Naga Subcenter	10 m x 8 m x 2 F (Machinery room 25 m^2, generator room 15 m^2)
	Two-storied due to the concern of possible flooding	
Cagayan River Basin		
	Tuguegarao Subcenter	10 m x 8 m
	Deliman	20 m x 10 m
	Tanay	10 m x 8 m

The type of pole and tower for each basin are as shown in the following chart.

Fig.-7- ARRANGEMENT OF TYPE FOR RAINFALL, WATER STAGE, DISCHAGE & HOUSING

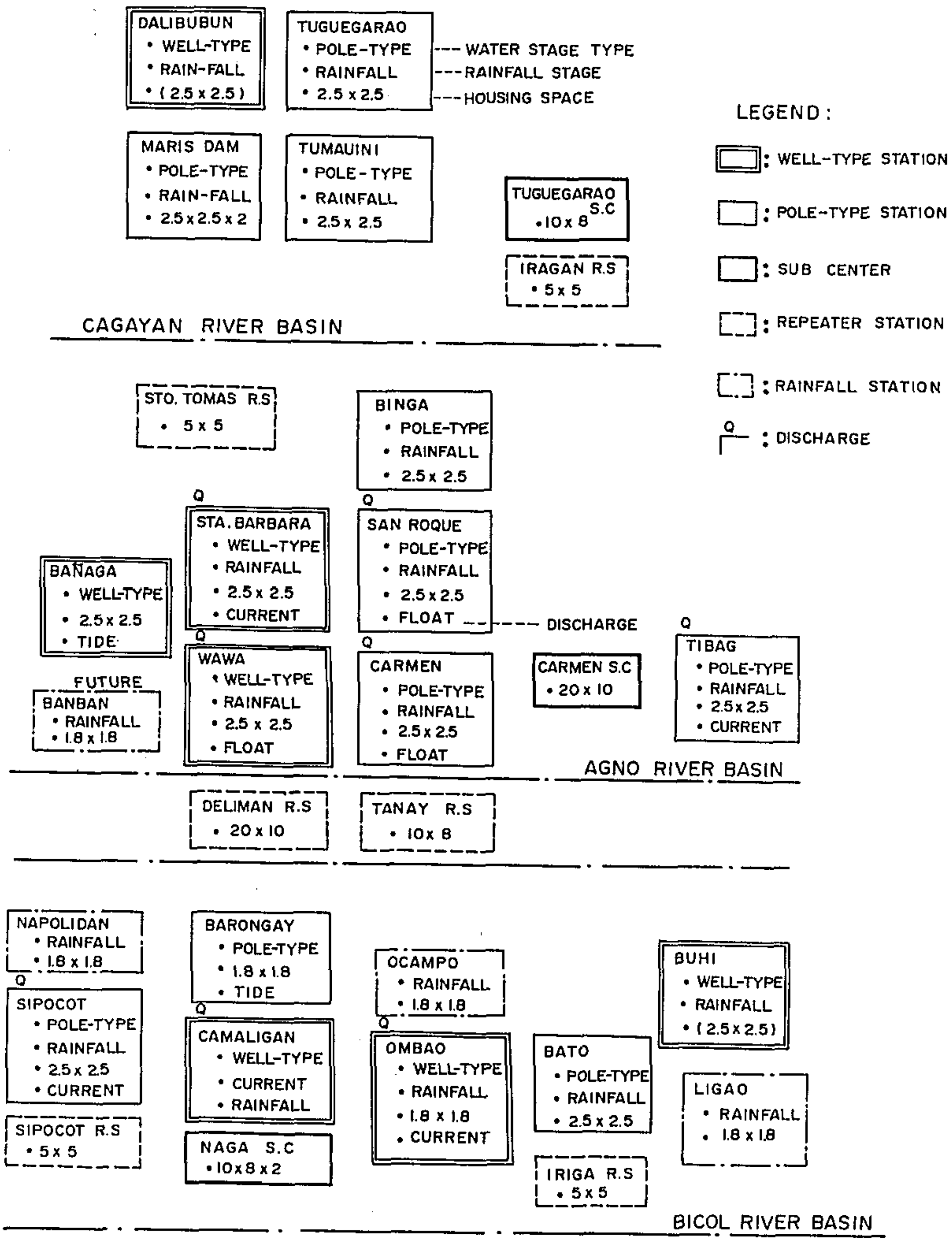


Fig 7-2 WATER STAGE STATION POLE - TYPE

UNIT : mm

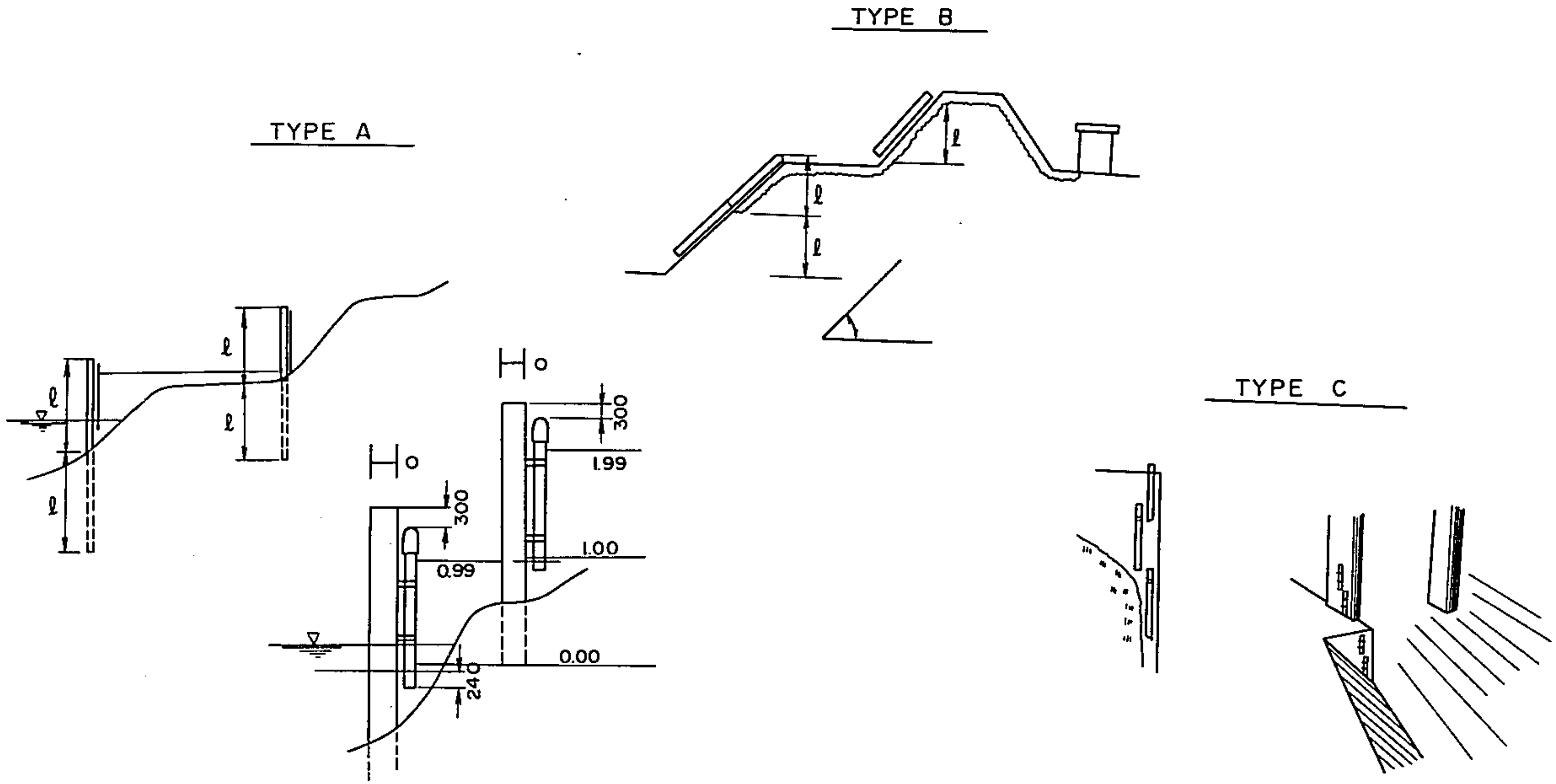


Fig. 7-3 WATER STAGE STATION WELL TYPE

UNIT : mm

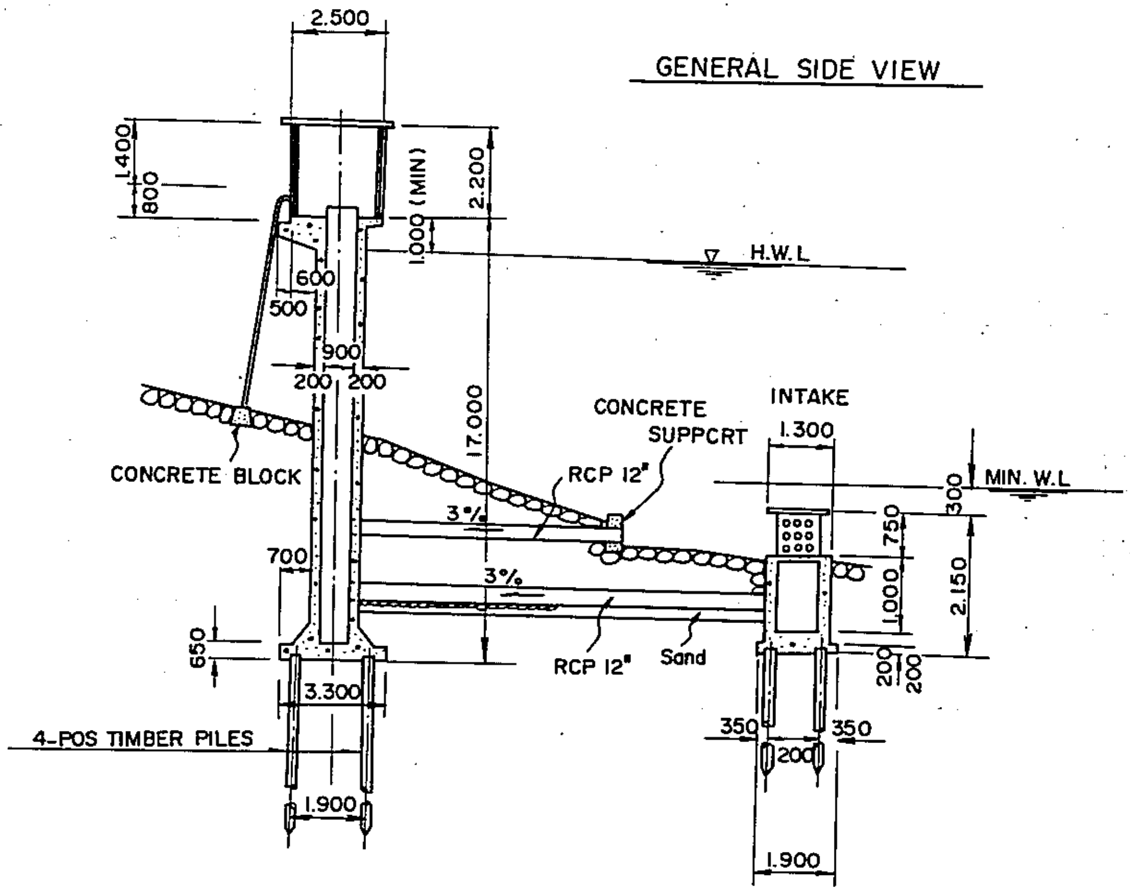
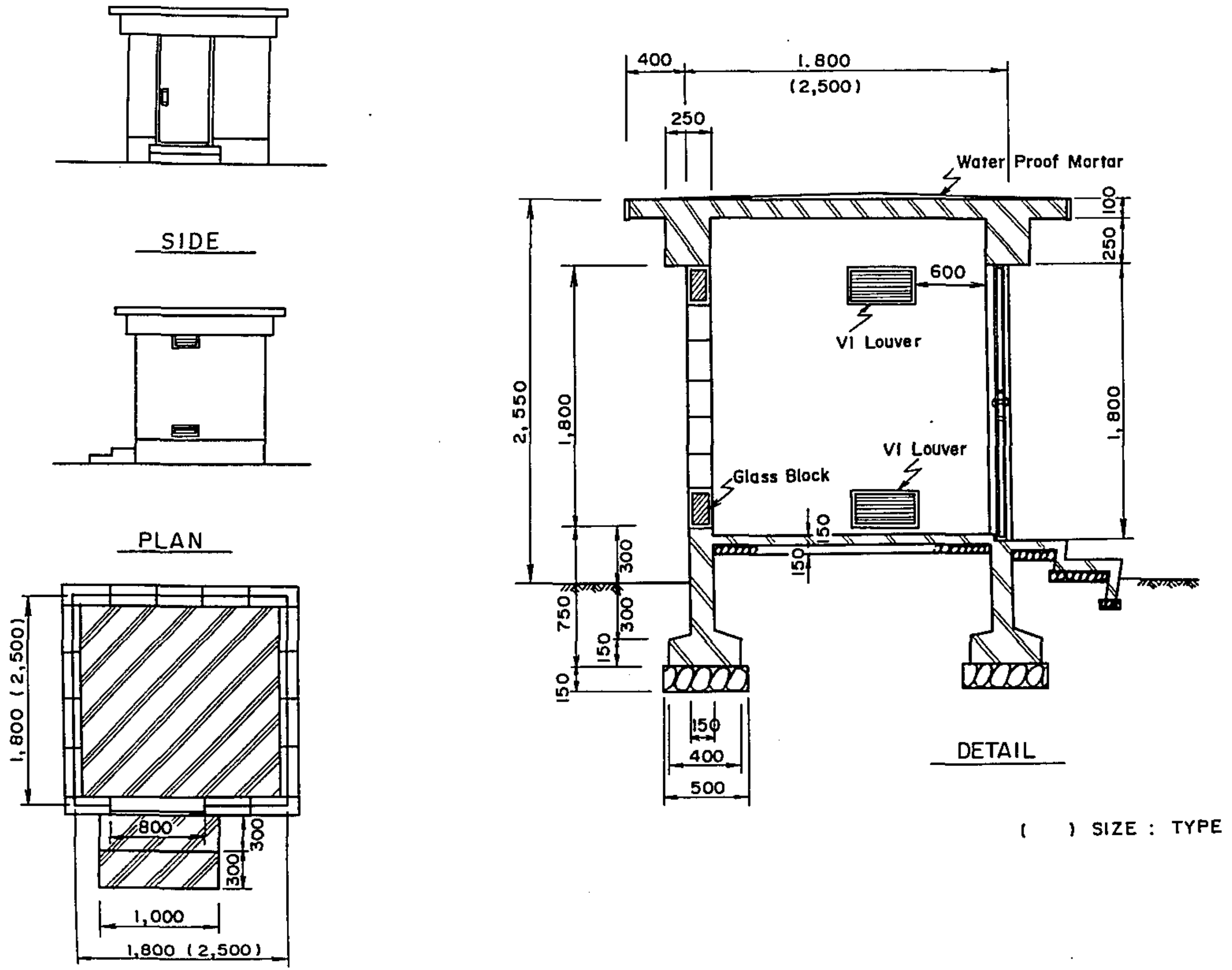


Fig.-7-4 STATION HOUSE TYPE A : 1.80^m x 1.80^m TYPE B : 2.50^m x 2.50^m

UNIT : mm



( ) SIZE : TYPE B

Fig 7-5 FLOATER DROPPING FACILITIES

UNIT : mm

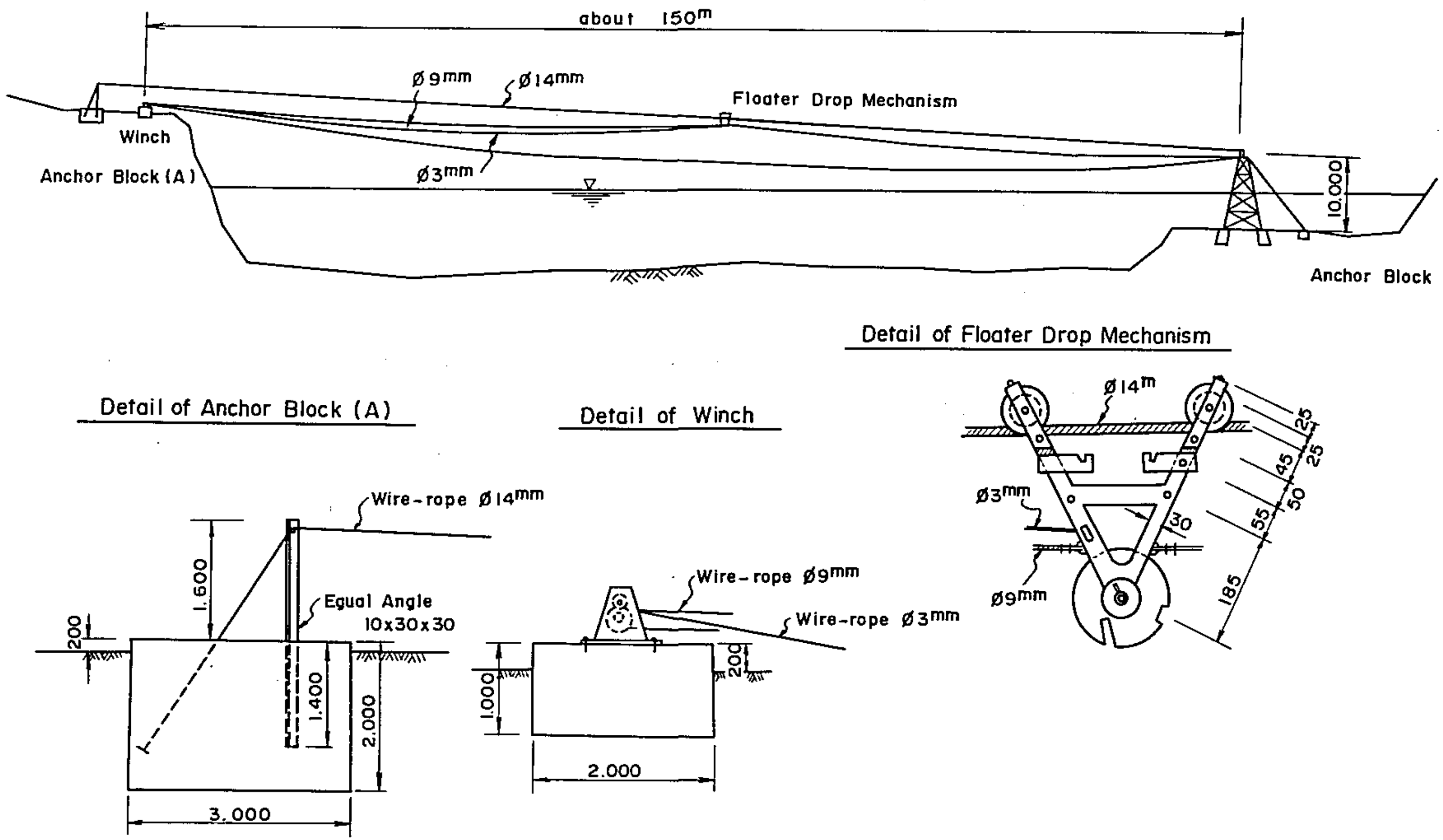


Fig-7-5 TIPPING BUCKET RAINFALL GAUGE INTEGRATE TYPE

UNIT : mm

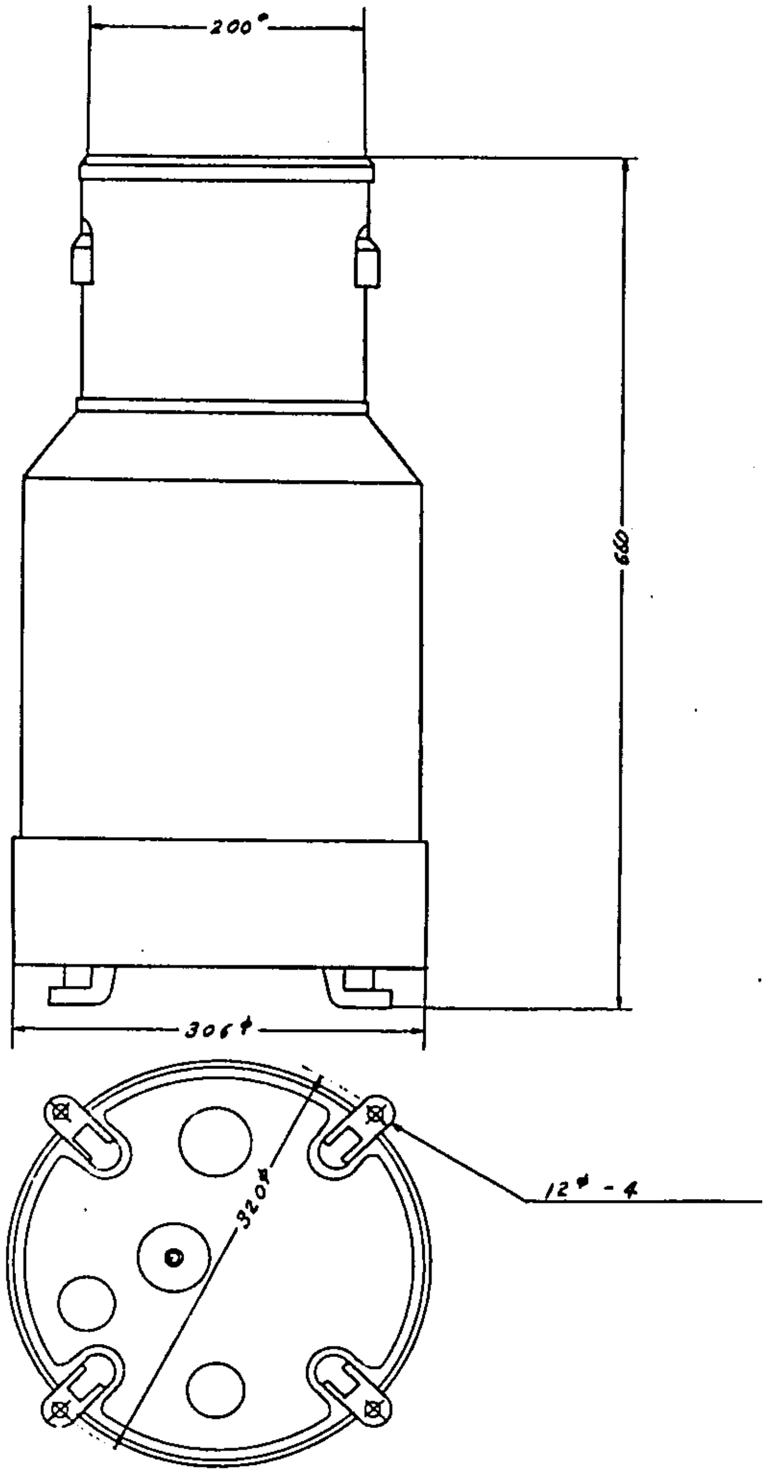
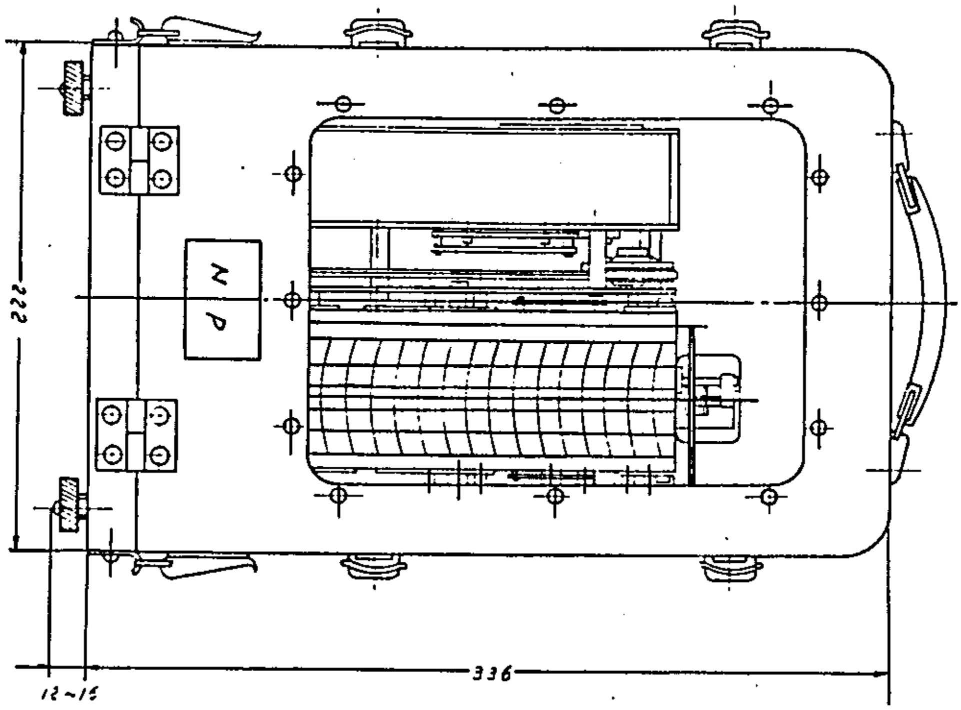


Fig.-7-7 RAINFALL RECORCER

UNIT : mm



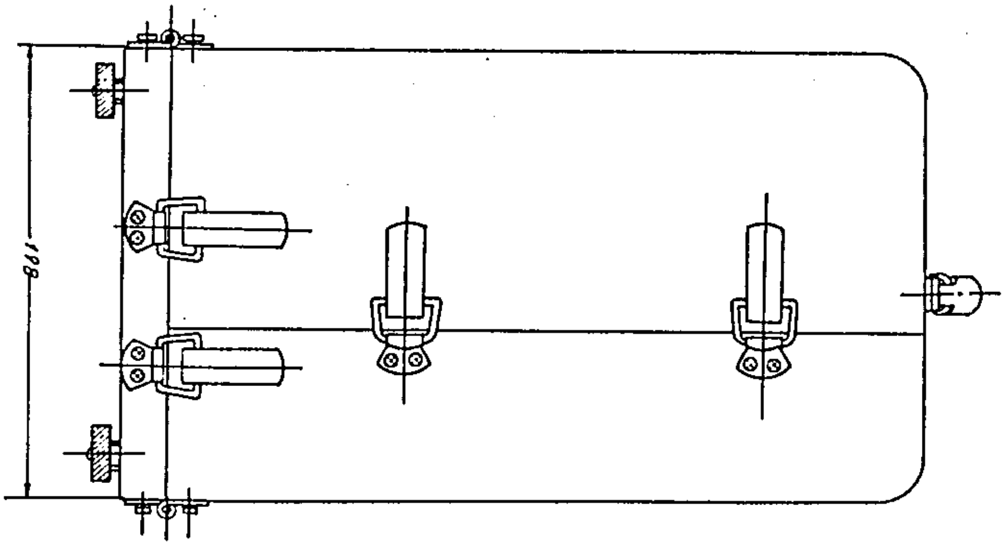
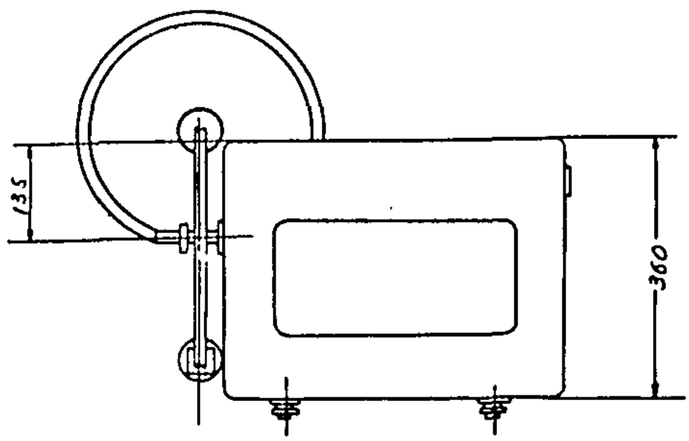


Fig-7-8 WATER LEVEL GAUGE FLOAT TYPE SUIKEN 62

UNIT . mm



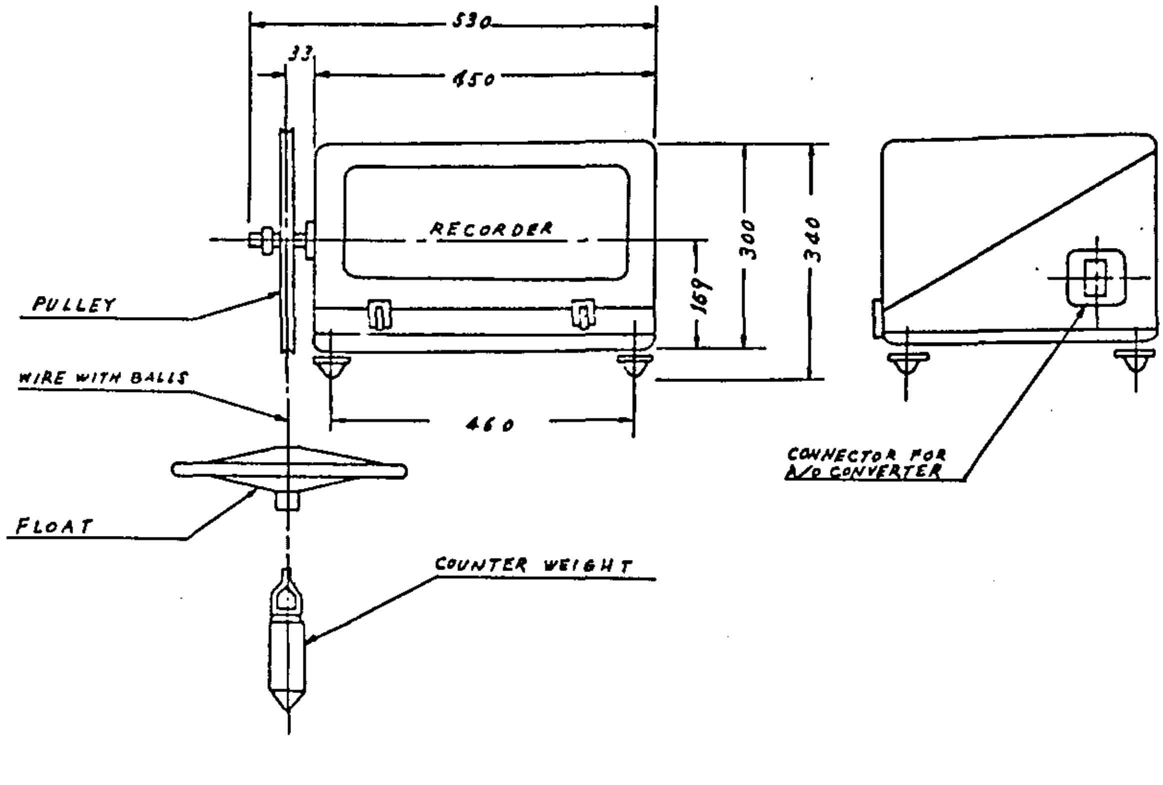


Fig-7-9 POLETYPE WATER LEVEL GAUGE
GAUGEING POLE

UNIT: mm

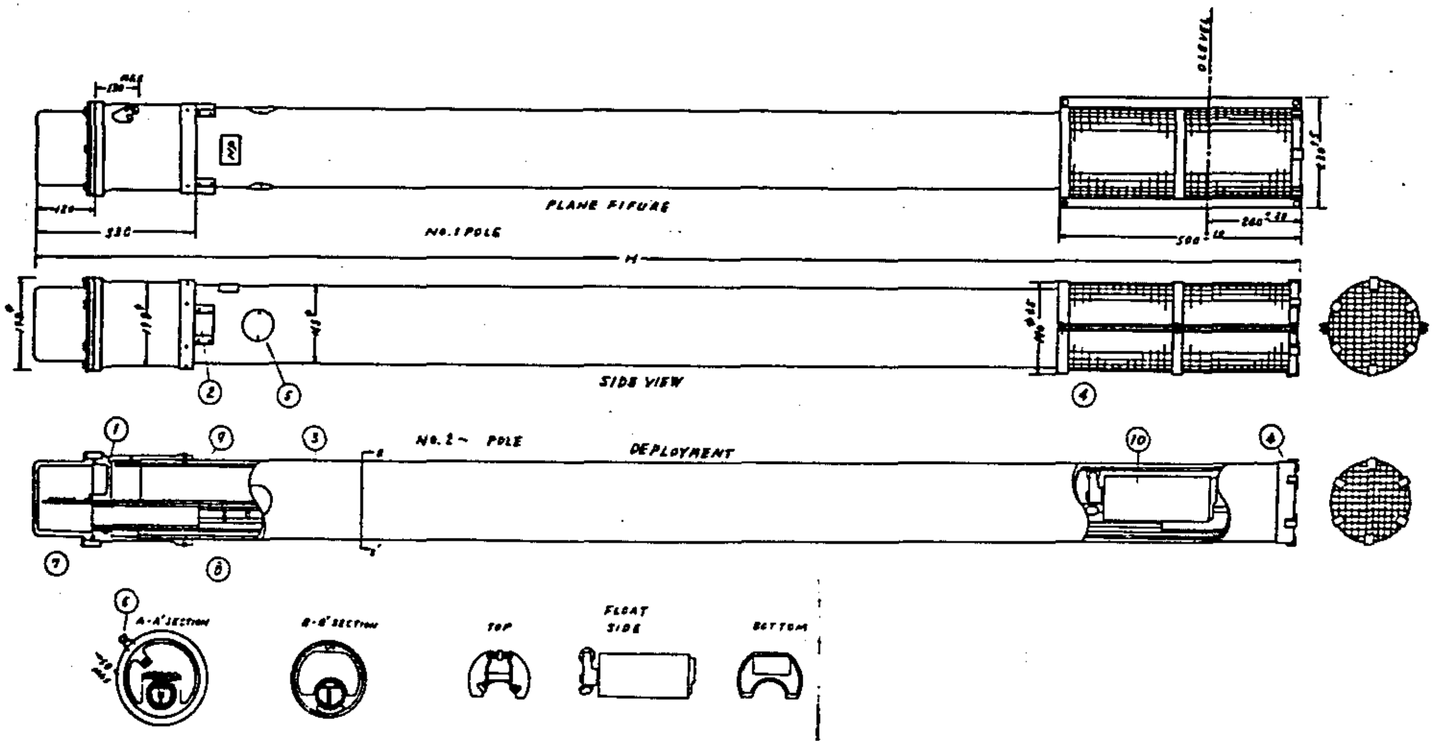
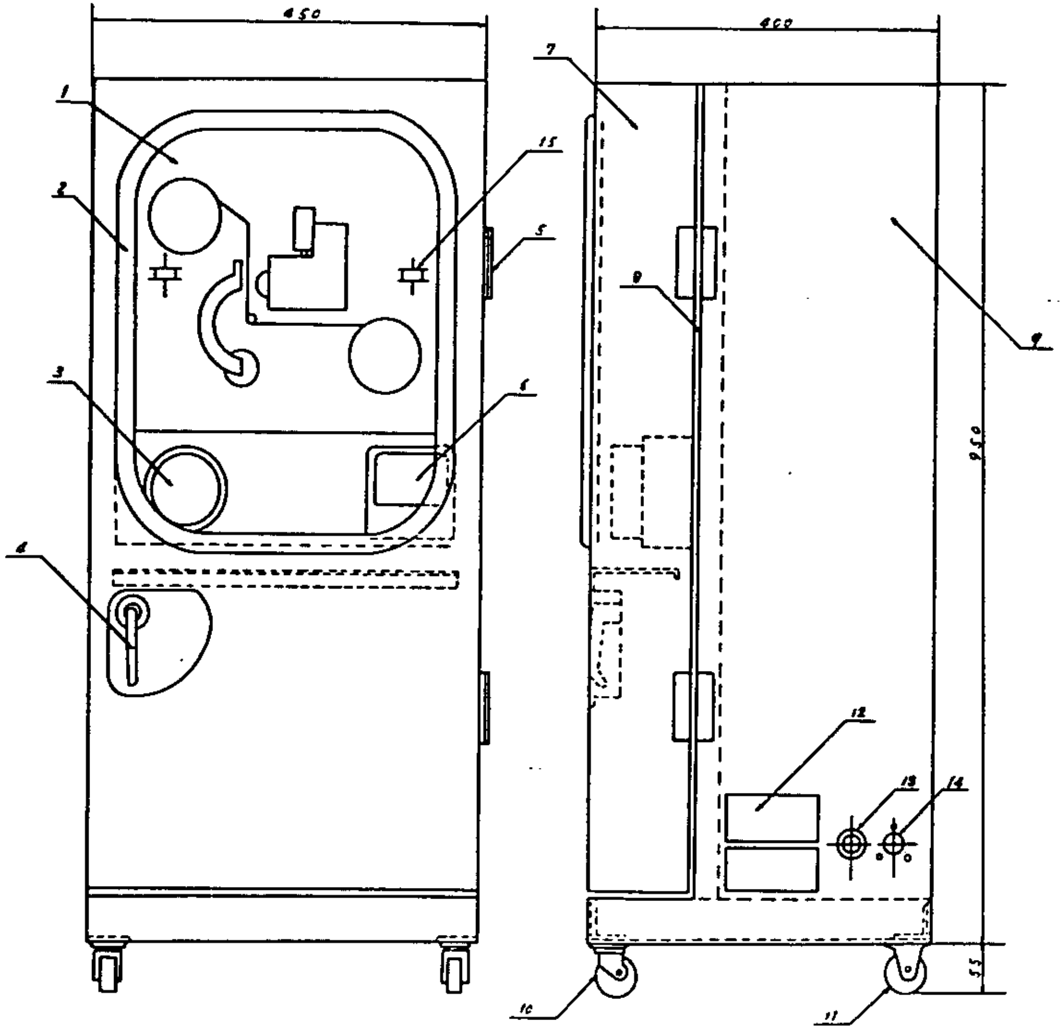


Fig-7-10 POLE TYPE WATER LEVEL GAUGE DATE RECORDER

UNIT: mm



NO.	NAME
1	WINDOW GLASS
2	RUBBER SEAL
3	CLOCK
4	HANDLE
5	HINGE
6	VOLT METER
7	DOOR
8	GASKET
9	HOUSING
10	FREE WHEEL
11	WHELL
12	COVER
13	GROMMET
14	CONNECTOR
15	TYPEING RIBBON

Fig- 7 - 11 POLE TYPE WATER LEVEL GAUGE
CORD CONVERTER UNIT : mm

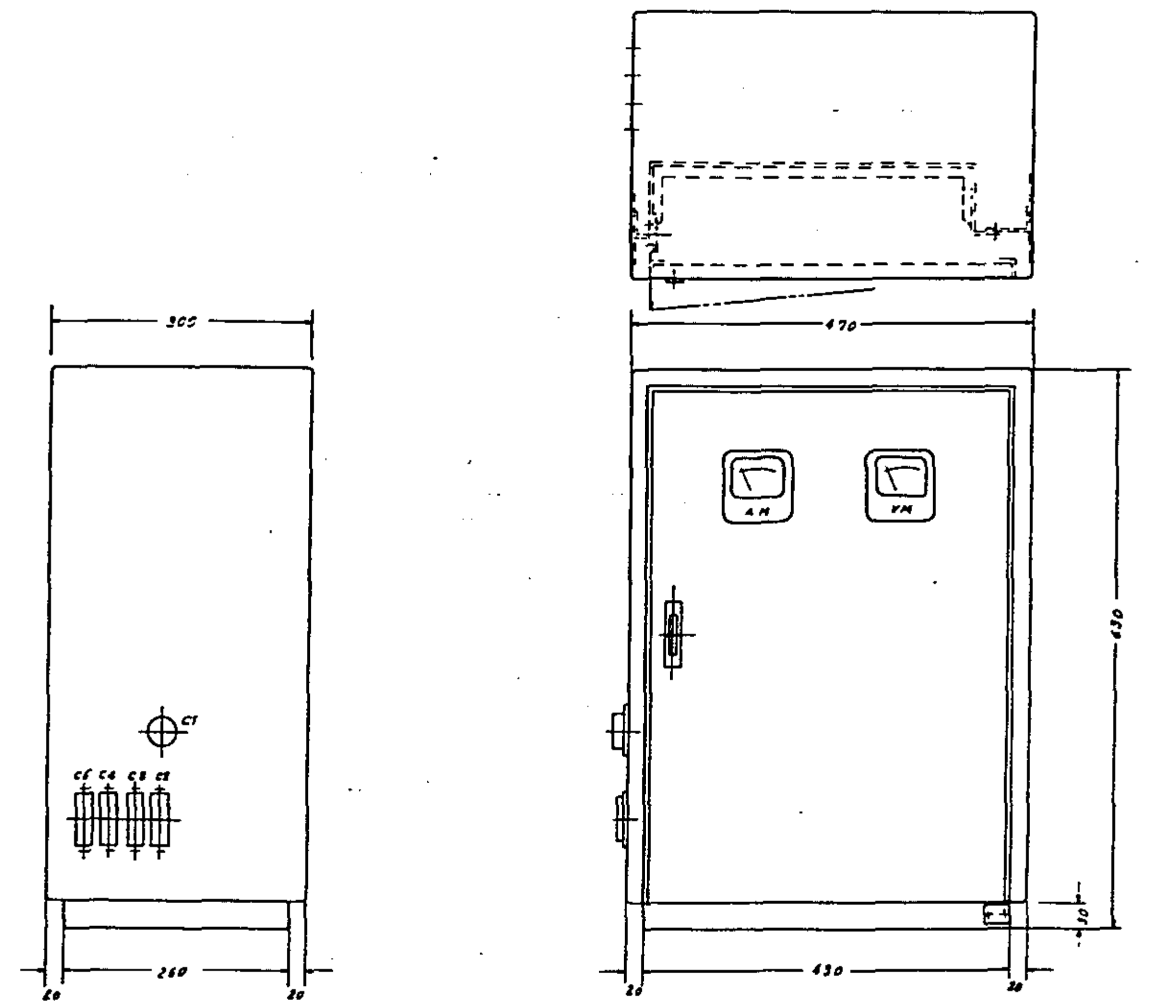


Fig.-7-12 TYPES OF TOWER & POLE FOR PROPERGATION

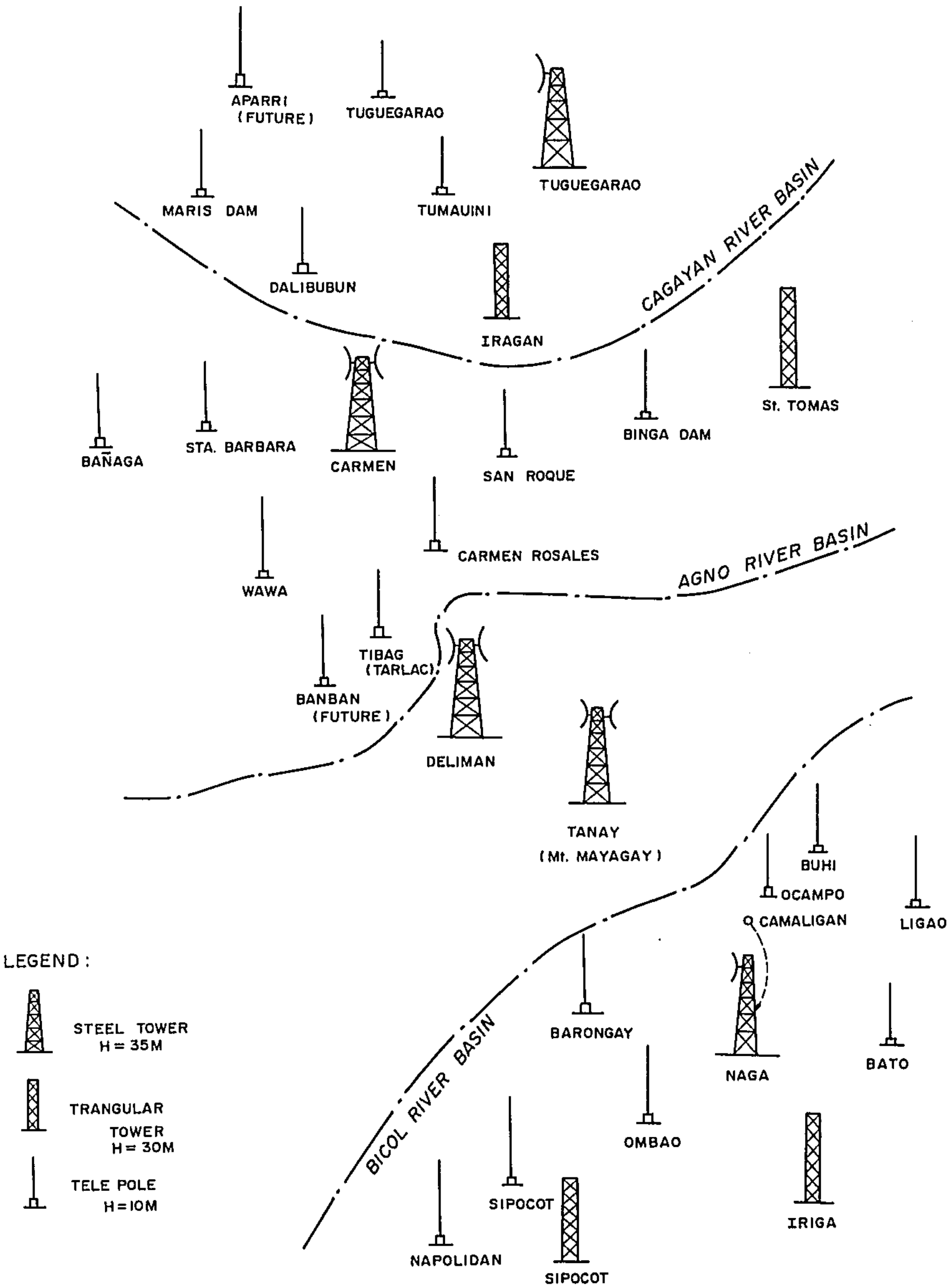


Fig 7-13 TELE POLE H= 10M

UNIT : mm

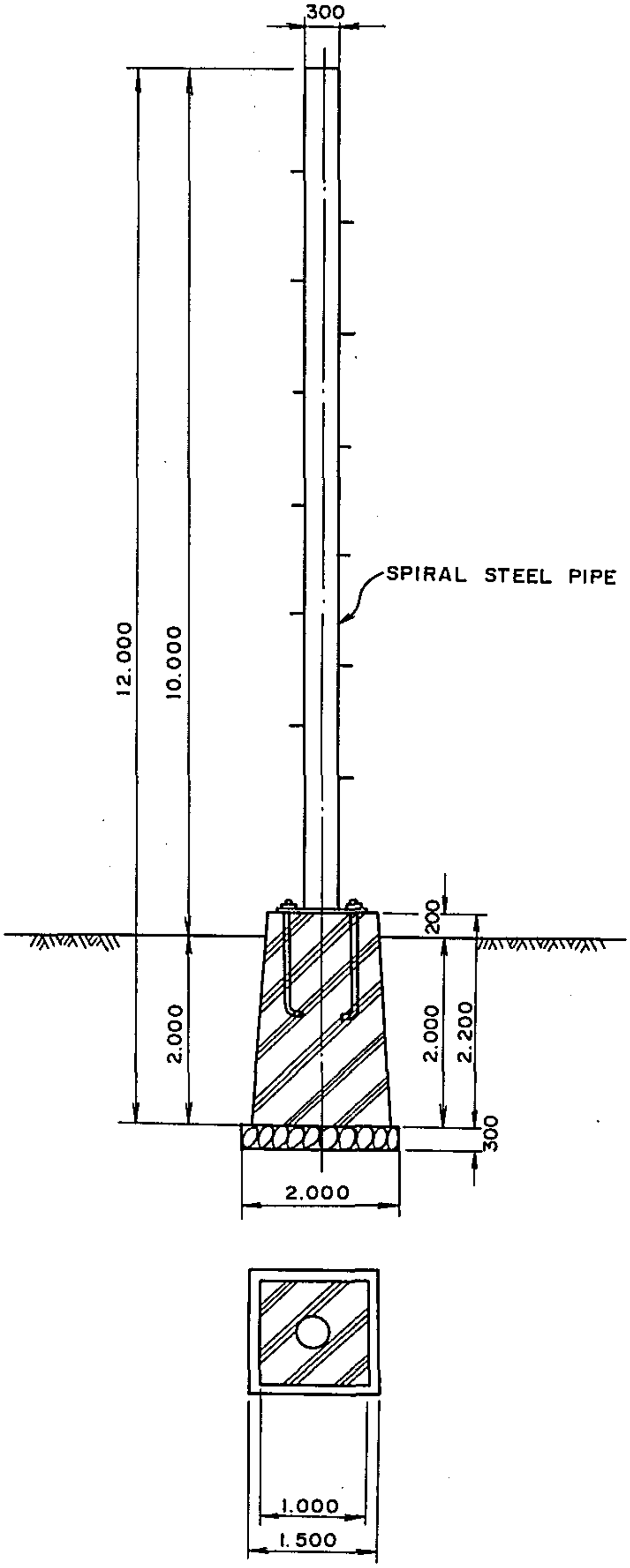


Fig.-7-14 TRIANGULAR TOWER H=30M

UNIT : mm

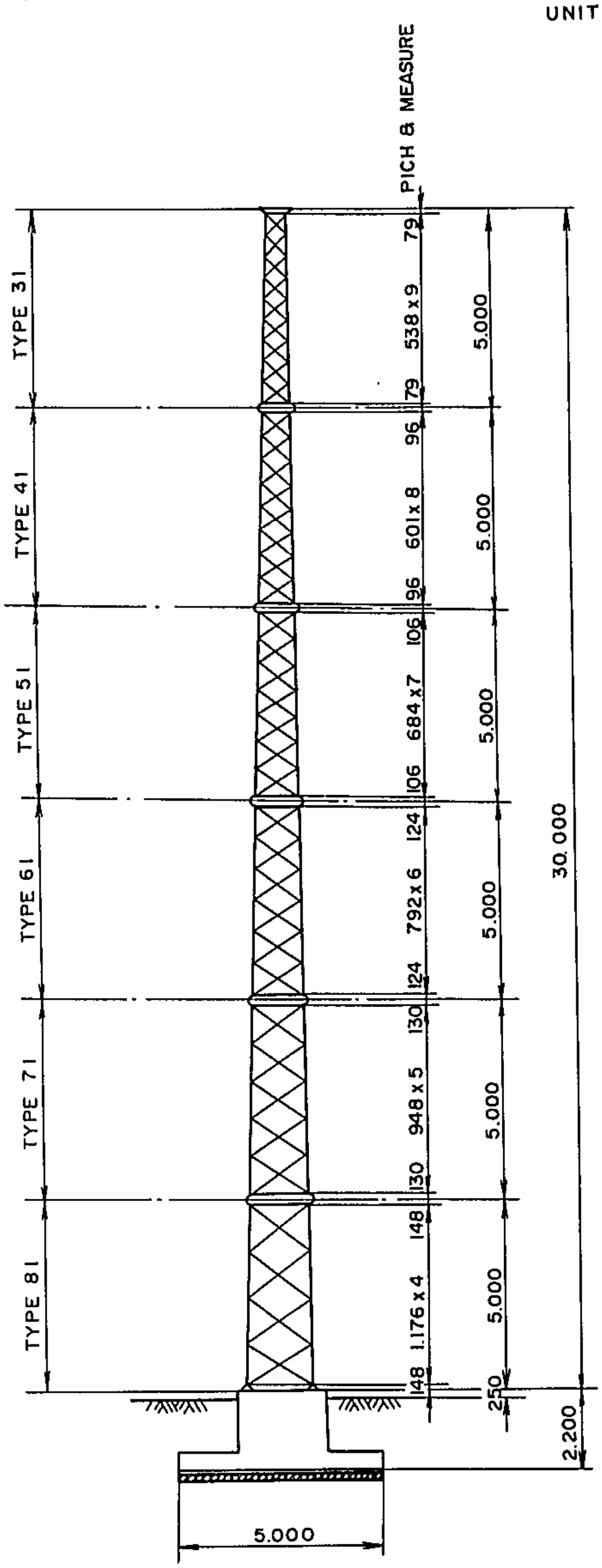


Fig.-7-5 STEEL TOWER FOR WIRELESS H=35M

UNIT : mm

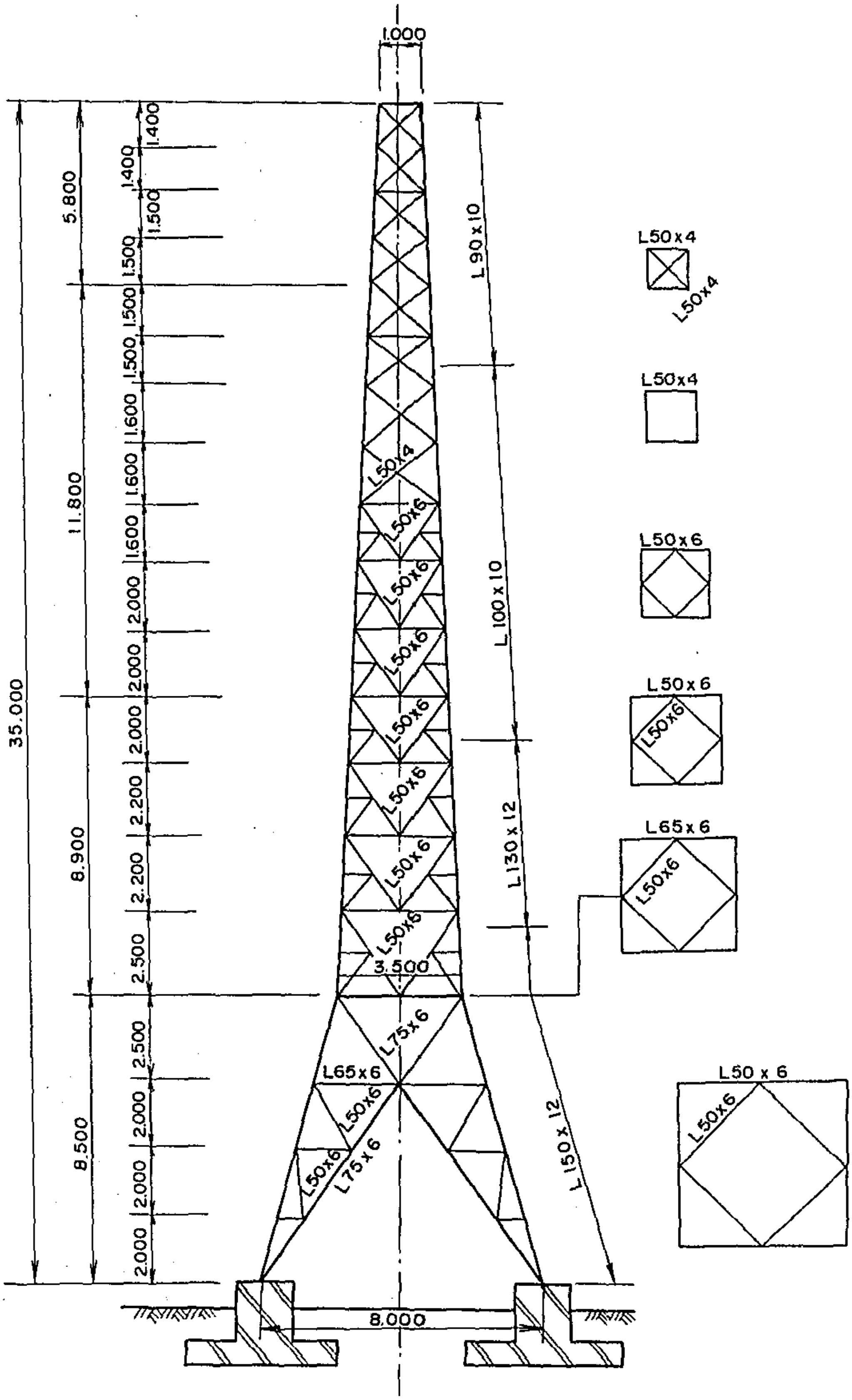
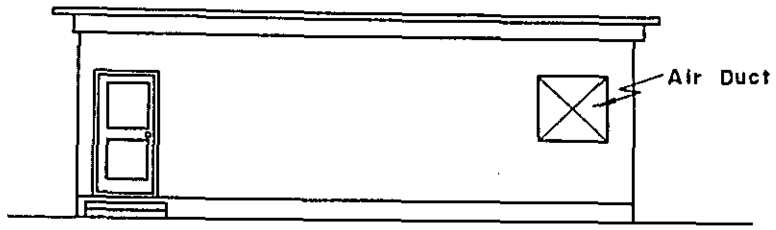


Fig.-7-16 SUB CENTER HOUSE

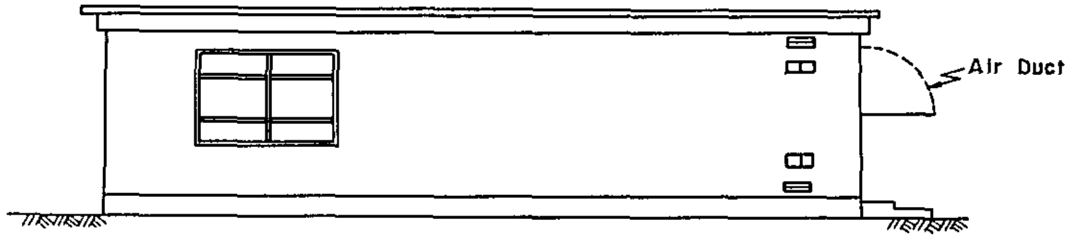
$10^{M} \times 8^{M}$

UNIT : mm

ELEVATION



SIDE



PLAN

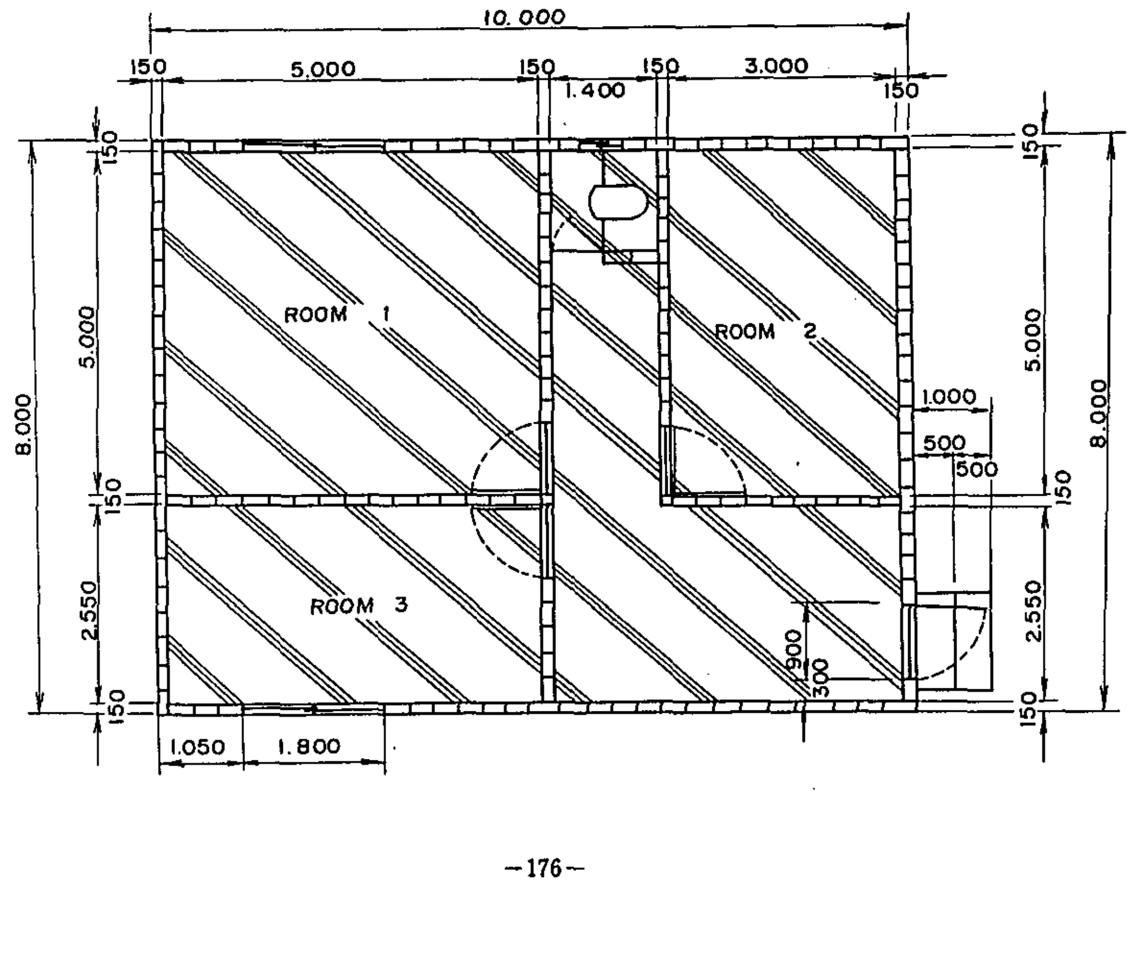
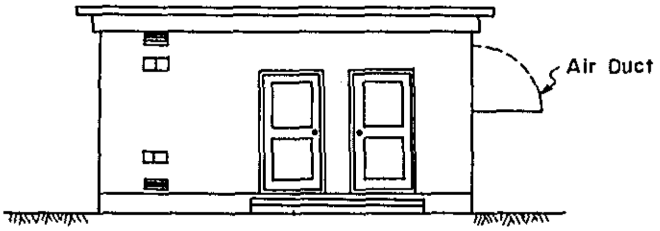


Fig.7-17 REPEATER STATION HOUSE

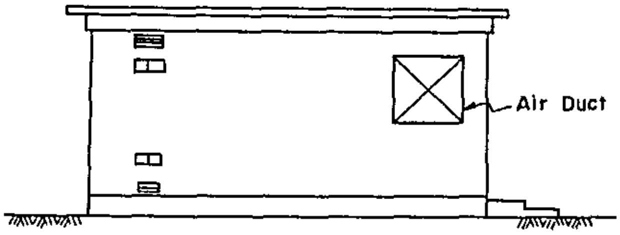
5ᵐ x 5ᵐ

UNIT : mm

ELEVATION



SIDE



PLAN

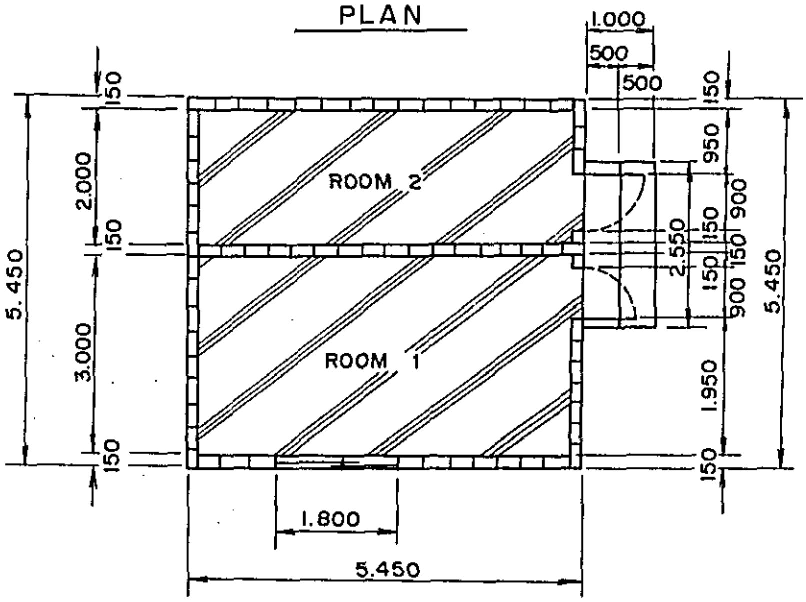
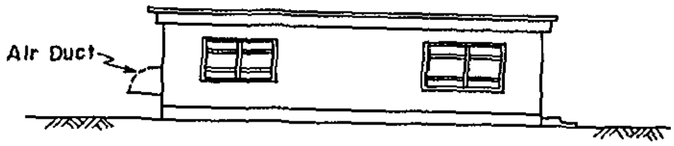


Fig.-7-18 SUB CENTER HOUSE

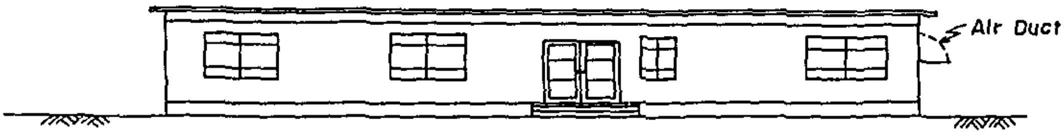
10^M x 20^M

UNIT : mm

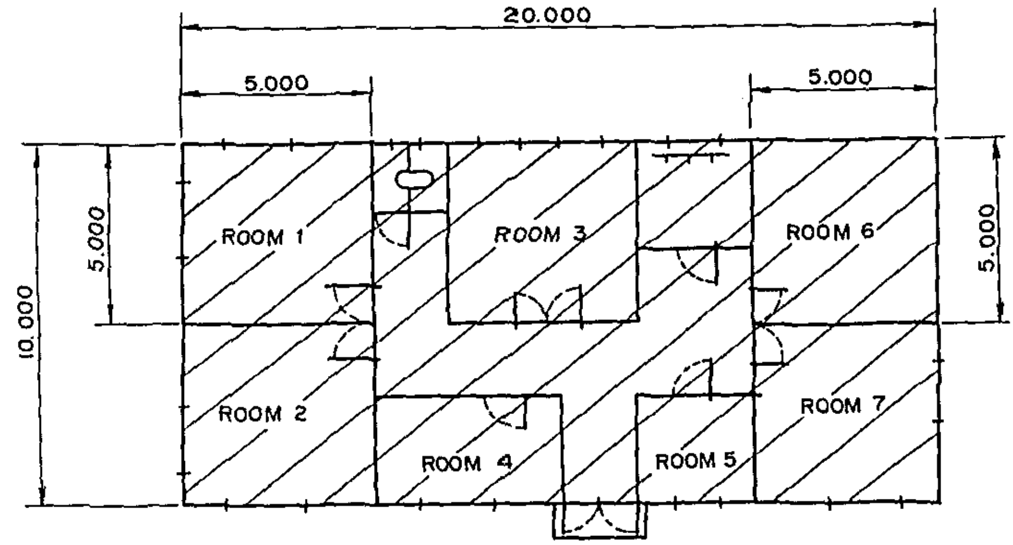
SIDE



ELEVATION



PLAN



2. System Components

(1) Telemetry Network

The equipment and instruments to be used in this system shall conform to the existing standard.

The facilities used in each river system are tabulated in Table7-2-7-4 The classified stations are as follows:

River Basin	Monitor & Control Station	Monitoring Station	Repeater Station	Telemetering Station	Remarks
Agno River Basin	PAGASA Carmen Rosales	B.P.W.	Sto Tomas	Tibag Bañaga Sta Barbara Carmen San Roque Binga Dam Wawa	
Bicol River Basin	PAGASA Naga	B.P.W.	Sipocot Hill Iriga	Barongay Ocampo Ombao Sicopot Napolidan Bato Buhi Ligao	
Cagayan River Basin	PAGASA Tuguegarao	B.P.W.	Ilagan	Tuguegarao Tumauini Dallibubun Mariz	

List of system components Table 7-2

1. Telecommunication and telemetry system

(1) Agno River Basin

Item	Application (Location)	Pagasa monitor and control station	B.P.W. monitor-ing station	Carmen Rosales monitor and control station	Sto. Tomas repeater station	Tibag rainfall and waterstage	Vava rainfall and waterstage	Bañaga waterstage	Sta. Barbara rainfall and waterstage	Carmen rainfall and waterstage	Sanroque rainfall and waterstage	Bingadam rainfall and waterstage	Total
		Quantity	"	"	"	"	"	"	"	"	"	"	"
Telemetry control unit	For monitor control	1											1
"	"			1									1
"	For monitoring		1										1
"	For rainfall and water stage					1	1		1	1	1	1	6
"	For waterstage							1					1
"	For repeater station				1								1
Antenna system	3-stage co-linear			1	1								2
Antenna system	Yagi 3E				1	1	1	1	1	1	1	1	8
Graphic panel	Self-contained type	1	1										2
Indicator panel	Wall-hanging type			1									1
Control consol	Console type	1		1									2
Typewriter	Remington model 26	3	3	1									7
Stabilizer power unit	7.5 or 1.5 kVA	1	1	1									3
DC power unit	Battery 60AH	1	1	1									3
Diesel engine generator	2 or 7.5 kVA	1	1	1	1	1	1	1	1	1	1	1	11
Solar cell power unit	12V for telemetrying station					1	1	1	1	1	1	1	7
"	12V for repeater station				1								1
Cable protector						1	1	1	1	1	1	1	7
Instruments		1	1	1									3
Sub-station stand-by equipment				1									1
Timer power unit				1									1
Spares and accessories		1	1	1	1	1	1	1	1	1	1	1	11

List of system components

Table - 7-3

(2) Bicol River Basin

Item	Application \ Location	Nagà monitor and control station	Sicopot repeater station	Iriga repeater station	Barongay rainfall and waterstage	Camaligan rainfall and waterstage	Ocampo rainfall	Ombao rainfall and waterstage	Bato rainfall and waterstage	Sicopot rainfall and waterstage	Napolidan rainfall	Buhi rainfall and waterstage	Ligao rainfall	Total
		Quantity	"	"	"	"	"	"	"	"	"	"	"	
Telemetry control unit	For monitor and control	1												1
"	For rainfall and water stage				1	1		1	1	1		1		6
"	For rainfall						1				1		1	3
"	For waterstage													-
"	For repeater station		1	1										2
Antenna system	3-stage co-linear	1	1	1										3
"	Yagi 3E				1		1	1	1	1	1	1	1	8
Indicator panel	Wall-hanging type	1												1
Control console	Console type	1												1
Typewriter	Remington model 26	1												1
Stabiliser power unit	1.5 kVA	1												1
DC power unit	Battery 60AH	1												1
Diesel engine generator	2 kVA	1	1	1	1	1		1	1	1		1		9
Solar cell power unit	12V for telemetrying stn.				1	1	1	1	1	1	1	1	1	9
"	12V for repeater station		1	1										2
Cable protector					1	1		1	1	1		1		6
Instruments		1												1
Spares and accessories		1	1	1	1	1	1	1	1	1	1	1	1	12
Sub-station stand-by equipment		1												1

List of system components

Table - 7-4

(3) Cagayan River Basin

Item \ Location	Application	Tuguegarao monitor and control station	Iragan repeater station	Tuguegarao rainfall and waterstage	Tumauini rainfall and waterstage	Dallibubun rainfall and waterstage	Mariz rainfall and waterstage	Total
		Quantity	"	"	"	"	"	
Telemetry control unit	For monitor and control	1						1
"	For rainfall and water stage			1	1	1	1	4
"	For repeater station		1					1
Antenna system	3-stage co-linear		1					1
"	Yagi 3E	1		1	1	1	1	5
Indicator panel	Wall-hanging type	1						1
Control console	Console type	1						1
Typewriter	Remington model 26	1						1
Stabilizer power unit	1.5 kVA	1						1
DC power unit	Battery 60 AH	1						1
Diesel engine generator	2 kVA	1	1	1	1	1	1	6
Solar cell power unit	12V for teremetrying stn.			1	1	1	1	4
"	12V for repeater station		1					1
Cable protector				1	1	1	1	4
Instruments		1						1
Spares and accessories		1	1	1	1	1	1	6
Sub-station stand-by equipment		1						1

(2) Multiplex Telecommunication Network

The equipment and instruments to be used in this system shall conform to the applicable standard. For those to be used for the transhorizon communication system, special specification may be applied.

The facilities used in each river basin are tabulated in Table 7-5~7-7

List of system components

Table - 7-5

2. Multiplex telecommunication network

(1) Agno River Basin

Item	Location / Application	BPW monitoring	Pagasa monitor and control station	Deliman repeater station	Carmen Rosales sub-center	Total
		Quantity	"	"	"	"
400 MHz Multiplex radio equipment	10W SS-PM 24CH	1	2	1		4 sets
"	50W SS-PM 12CH Troposeater			1	1	2 "
Carrier-frequency terminal equipment	24/24 CH	1	2			3 "
"	6/6 CH				1	1 set
"	for repeater station			1		1 "
Parabolic antenna	6 mø with grid rack			1	1	2 sets
Yagi antenna	8E with ST 400 MHz	1	1			2 "
"	5E		1	1		2 "
Coaxial cable	(AFZE-50-10) (AFZE-50-7)	1	1	1	1	4 "
DC power unit	Alkali battery 24V 100 AH	1	1	1	1	4 "
Stand-by generator	100V 10KVA with automatic starter panel	1	1	1	1	4 "
Remote control equipment	Master station cyclic		2			2 "
"	Sub-station cyclic	1		1	1	3 "
Simple telephone exchanger	Provided with 10 telephone sets				1	1 set
Telephone exchanger	XB type 60CH with charger and battery	1	1			2 sets
Automatic voltage regulator	5 kVA	1	1	1	1	4 "
Repeater bay		1	1	1	1	4 "
Instruments		1	1	1	1	4 "
Spares and accessories		1	1	1	1	4 "

List of system components

Table ·7-6

2. Multiple telecommunication network

(2) Bicol River Basin

Item	Application	Naga sub-center	Tanay repeater station	Deliman repeater station	Total
	Location				
		Quantity	"	"	"
400 MHz Multiplex radio equipment	10W SS-PM 24CH		1	1	2 sets
"	50W SS-PM 12CH Tropo	1	1		2 "
Carrier-frequency terminal equipment	6/6CH	1			1 set
"	for repeater station		1	1	2 sets
Parabolic antenna	6 mø with grid rack	1	1		2 "
"	3 mø with grid rack		1	1	2 "
Coaxial cable assortment	(AFZE-50-10) (AFZE-50-7)	1	1	1	3 "
DC power unit	Alkali battery 24V 100AH	1	1	1	3 "
Stand-by generator	10 kVA automatic starting	1	1	1	3 "
Remote monitoring and control equipment	Sub-station cyclic	1	1	1	3 "
Simple telephone exchange	Provided with 10 telephone sets	1			1 set
Automatic voltage regulator	5 kVA	1	1		2 sets
Repeater bay		1	1		2 "
Instruments		1	1		2 "
Spares and accessories		1	1	1	3 "

List of system components Table 7-7

2. Multiplex telecommunication network

(3) Cagayan River Basin

Item	Application	Carmen Rosales sub-center	Tuguegarao sub-center	Total
		Quantity	"	"
400 MHz Multiplex radio equipment	1 kW SS-PM 6CH Troposcatter	1	1	2 sets
Carrier-frequency terminal equipment	6/6 CH		1	1 set
Parabolic antenna	6 mø with grid rack	1	1	2 sets
Coaxial cable assortment	AFZE-50-13W	1	1	2 "
DC power unit	Alkali battery 24V 100AH		1	1 set
Stand-by generator	100V 20 kVA automatic starting		1	1 "
Remote monitor and control equipment	sub-station cyclic		1	1 "
Simple telephone exchange	Provided with 10 telephone sets		1	1 "
Automatic voltage regulator	15 kVA	1	1	2 sets
Repeater bay		1	1	2 "
Instruments		1	1	2 "
Spares and accessories		1	1	2 "

(3) Short Wave Telecommunication Network

The facilities used in each river basin are tabulated in Table7-8.

(4) Land mobiles with VHF Band for maintenance of the Tele7-9. communication Network

The base station and land mobiles to be provided at the subcenter in each river basin and the vehicle for the maintenance of the telecommunication network are tabulated in Table - 11.

List of system components　　　　　　Table 7-8

Short wave telecommunication network

Agno, Bicol and Cagayan River Basin respectively

Item	Application	Agno River: Carmen Rosales (sub-center)	Agno River: Deliman (repeater station)	Agno River: Total	Bicol River (sub-center)	Cagayan River (sub-center)	Total
		Quantity	"	"	Quantity	"	"
SSB transmitter	1 kW 3-wave mounting	1	1	2	1	1	4 sets
SSB receiver	all waves	1	1	2	1	1	4 "
SSB receiver	Antenna BK unit	1	1	2	1	1	4 "
Antenna		1	1	2	1	1	4 "
Switchboard		1	1	2	1	1	4 "
Automatic voltage regulator	5 kVA, 100V	1	1	2	1	1	4 "
Operator desk		1	1	2	1	1	4 "
Instruments		1	1	2	1	1	4 "
Spares and accessories	special tools included	1	1	2	1	1	4 "

VHF Band mobile stations and maintenance vehicles for telecommunication network

Table 7-9

Item	Application	Agno River Basin: Carmen Rosales (sub-center)	Agno River Basin: Carmen Rosales (sub-center)	Agno River Basin: Deliman repeater station	Bicol River Basin: Tuguegarao sub-center	Bicol River Basin: Tuguegarao sub-center	Cagayan River Basin: Naga sub-center	Total
		Quantity	"	"	"	"	"	
Base Station								
Radiotelephony equipment	150 MHz 10W	2	1	1	1	1	1	7 sets
Antenna system		2	1	1	1	1	1	7 "
AC power unit		2	1	1	1	1	1	7 "
Spares and accessories		2			1		1	4 "
Handie-Talkie	1W	2			2		2	6 "
Mobil Station								
Radiotelephony equipment	150 MHz 1W	1	1	1	2	2	1	8 "
Antenna		1	1	1	2	2	1	8 "
Others								
Liaison vehicle	land cruiser	1			1		1	3 "
Observatory boat	STR-16					1		1 set

VIII. Operation and Maintenance

?-1 Hydrological Facilities

1. Maintenance of Hydrological Observation Equipment

To maintain hydrological observation equipment in their best condition is a must for the satisfactory observation of floods.

For the purpose, it is recommended to keep one gage keeper at each station for one a day inspection and maintenance service of the equipment.

To perform periodical inspection, it is recommended to prepare an inspection manual specifying all necessary procedures for routine and emergency repairs and for replenishment of expendables, etc. Also recommended is special close check-ups before rainy seasons.

2. Discharge Survey

To obtain water stage/discharge correlation formula, discharge survey will be performed at subject areas. Observation should cover practically all different conditions from low-water to high-water and an increase in number of observation means a higher accuracy of observation.

An observation party will be consisting of 5 to 10 persons for low-water and 10 to 15 for high-water observations. When period of high-water observation is prolonged, two to three parties may be needed, it is necessary to secure required number of observation personnel and discipline the personnel based on the observation manual.

3. Filing of Observation Data

Observation data, after careful examination, will be filed as basic reference materials for statistical presentations and hydrological analyses.

The basic reference materials mentioned above may have to be preserved a long period.

§-2 Telecommunication Systems

It is important that all instruments, in particular the telemeter equipment must be maintained in perfect condition and improved incessantly to best suit the objectives so that the Flood Forecast and Warning System can function smoothly. For this purpose, not only the employment of maintenance personnel and endless training to improve the techniques but also the provision of the necessary budget for maintenance and operation are important. The maintenance expenditure generally differs from year to year, but the minimum requirement will be an annual 3 to 5% of the new installation cost.

One supervising engineer, two qualified engineers, and two technicians are needed for the telemetry system and the multiplex telecommunication links at each subcenter. These employees will reside in the various subcenters and they will draw up a long term plan for investigations as well as its execution, repair the equipments in case of failures, and check the parts, wear-out instruments and meters, etc. And besides, the maintenance staff for the telemetry snstem at the Pampanga River, one supervising engineer and two qualified engineers and two technicians are required to maintain and operate the . transmitting and receiving stations at Deliman and Tanay, the monitor station for F.F.C. and B.P.W., and their jobs will be the co-ordination of the entire system and plannings for maintenance, improvement, training, equipment supply, provision of measuring instruments and its execution. Besides, one chief engineer is assigned to F,F.C. to administrate the whole system.

A systematic plan of the above will be shown in Table 8 - 1.

Table 8 - 1 <u>Staffing Schedule</u>

[Case I] and [Case II]

	Hydrologist			
	Chief Engineer	Supervising Engineer	Technicial	
F.F.C	1	4		5
Agno sub center		1	1	2
Bicol "		1	1	2
Cagayan "		1	1	2
Pampanga "				
Total	1	7	3	11

[Case I] and [Case II]

	Telecommunication Engineer					
	Chief Engineer	Supervising Engineer	Qualified Engineer	Technicial		
F.F.C	1	1	2	2	6	11
Agno sub center		1	2	2	5	7
Bicol "		1	2	2	5	7
Cagayan "		1	2	2	5	7
Pampanga "		1	1	3	5	5
Total	1	5	9	11	26	37

§-3 Technical supervision

1 Despatching of technical supervisors

Correct technology and knowledge is essential to the proper operation of the systems. For this purpose it is necessary to despatch engineers as part of the technical co-operation transfer project.

In the present discussion it is considered necessary to despatch at least one hydrologist and four telecommunications engineers for the on-the-job training service to assist the local engineers with the correct knowledge, and operation and maintenance procedures.

2. Training of engineers

To ensure that the systems, after completion, will provide smooth flood forecasting operation over long periods of time, Philippine engineers will be trained in the following manner.

1 Training of at least eight hydrologists and eleven telecommunications engineers will be conducted before the systems are put into operation.

2 Training of additional three hydrologists and 15 telecommunications engineers will be conducted before the on-the-job training is complete.

3 This means that for the operation of the systems at least 11 hydrologists and 26 telecommunications engineers will be trained in the Philippines.

3. Forecasting and warning communications systems

Flood forecasting and warning services are carried out via many different stages of work, from gaging to reporting of the information to terminal points and to flood control activity centers. Without rapid, correct perfection of the work it will be impossible to utilize the service efficiently.

To prevent disasters, it is essential to clearly specify the communications system and the network of communications. To achieve this following disater prevention measures should be taken into consideration and the communications systems made clear.

1. Maintenance of disaster prevention organizations
2. Education and training in disaster prevention knowledge
3. Supply and maintenance of disaster prevention commodities and materials
4. Maintenance of disaster prevention equipment and facilities
5. Designation of areas potentially liable to disaster and correction of hazardous points

§-4 Setting up a New Organization

As an organization responsible for steering the Flood Forecasting and Warning System, Flood Forecasting Center (FFC) has been in operation since 1973 to cover the Pampanga River Basin.

The organization, established as a joint project pursuant to an agreement by and between the PAGASA and the BPW, features that:

a) There is no proper personnel within the organization, so that all activities are being performed by PAGASA and BPW officials.

b) Expenses necessary for operating the organization are borne by either of the two parties depending on the expense items.

The features, however, have turned out the following disadvantages:

a) Absence of proper personnel makes the line of demarcation between job responsibilities thin, or the organization is heavily dependent on the members' voluntariness for operation.

b) The lack of its own exclusive budget results in poor treatment of capable technicians, giving much incentive to trained personnel to give up jobs for better positions in governmental agencies or private firms.

c) Equipment and materials necessary for the maintenance and operation of the organization are undersupplied.

In the light of this experience, it is considered extremely difficult for the present FFC to efficiently operate the new system.

In addition, there is a possibility that Flood Forecasting and Warning System may be extended from the Luzon Island to other islands such as Mindanao. Should this happen, operation by the FFC is expected to become further difficult.

It is beyond the scope of the survey team to discuss circumstances around the Philippine governmental establishment, however, the team would like to propose that Flood Forecasting Authority (FFA) be established to supplement the existing FFC. The new organization should have experience in flood control activities and have the capacity to supply necessary personnel.

One important point to be noted here is that FFA will be made part of the governmental organization and have its own exclusive budget as well as proper personnel.

FFA will have as its primary function to operate the Flood Forecasting and Warning System, but it should also be provided with a research division and a planning division for better forecasting accuracy and future expansion, respectively.

The new organization will offer the following benefits:

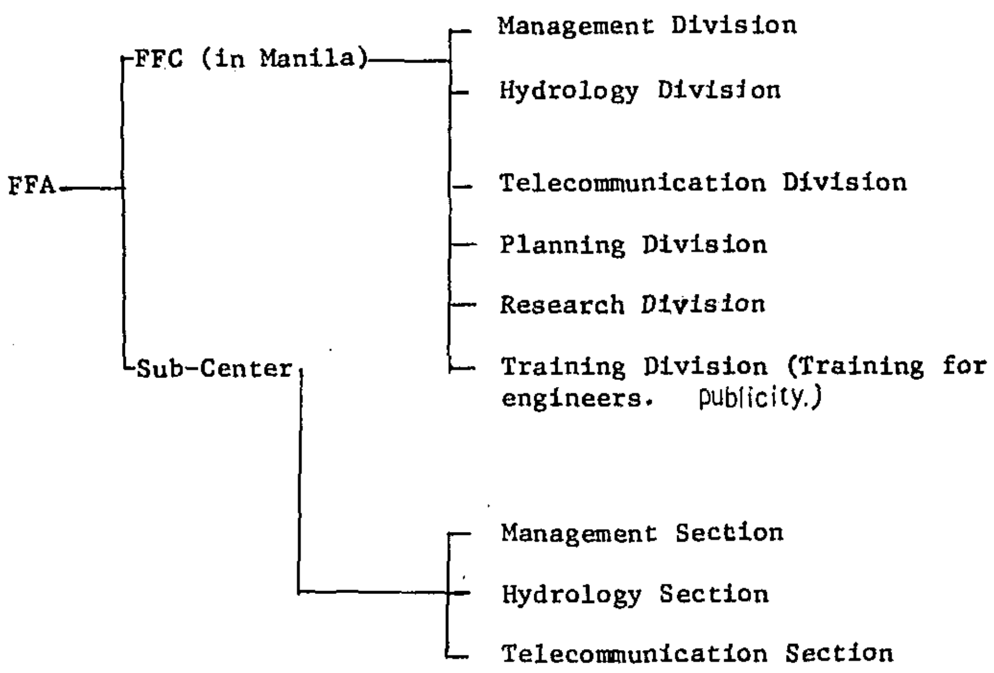
1) It facilitates new staffing and moving in of personnel from other existing organizations.

2) The centralized organization assures operation of efficient activities.

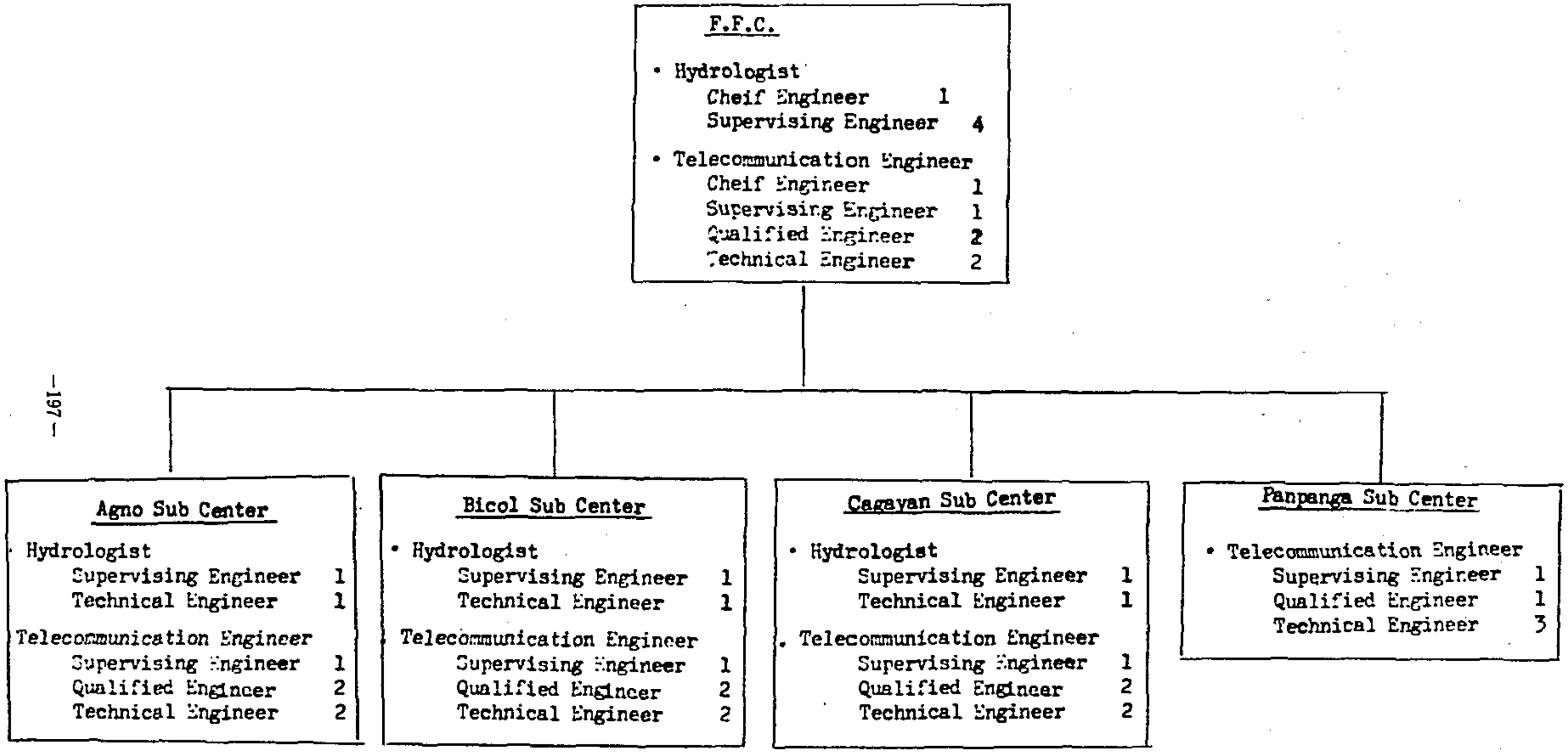
3) Improvement of labor conditions is easier to attain.

4) The budget for maintenance and management of the organization is easier to obtain.

5) The research and planning division serves to enhance the forecasting accuracy and facilitates expansion of the flood forecasting and warning services into other river basins.



STAFFING OF F.F.C. AND SUB-CENTERS



IX. Cost Estimation

§-1 Schedule of Implementation

There are two alternative processes for the completion of these systems.

①. When three systems are completed simultaneously

Case in which the Agno, Bicol and Cagayan systems are brought into construction simultaneously for simultaneous completion.

②. When the systems are completed on a step-by-step basis

Case in which the systems are completed one by one according to the priority schedule.

1. Simultaneous completion of the three systems

In this case the schedule of implementation is as follows:

① Detail design of facilities and structure	6 months
② Multiple line test and detail design	5 months
③ Manufacture of telecommunications facilities	8 months
④ Installation and adjustment of telecommunications facilities	2 months
⑤ Civil work	8 months

2. Completion on a step-by-step basis

The schedule of implementation here is three years, with the Agno, Bicol, and Cagayan systems completed in the following order.

First year ----- Agno system

Second year ---- Bicol system

Third year ----- Cagayan system

Table 9-1 Schedule of Implementation

Case 1 (The rhree systems are to be completed at the same time.)

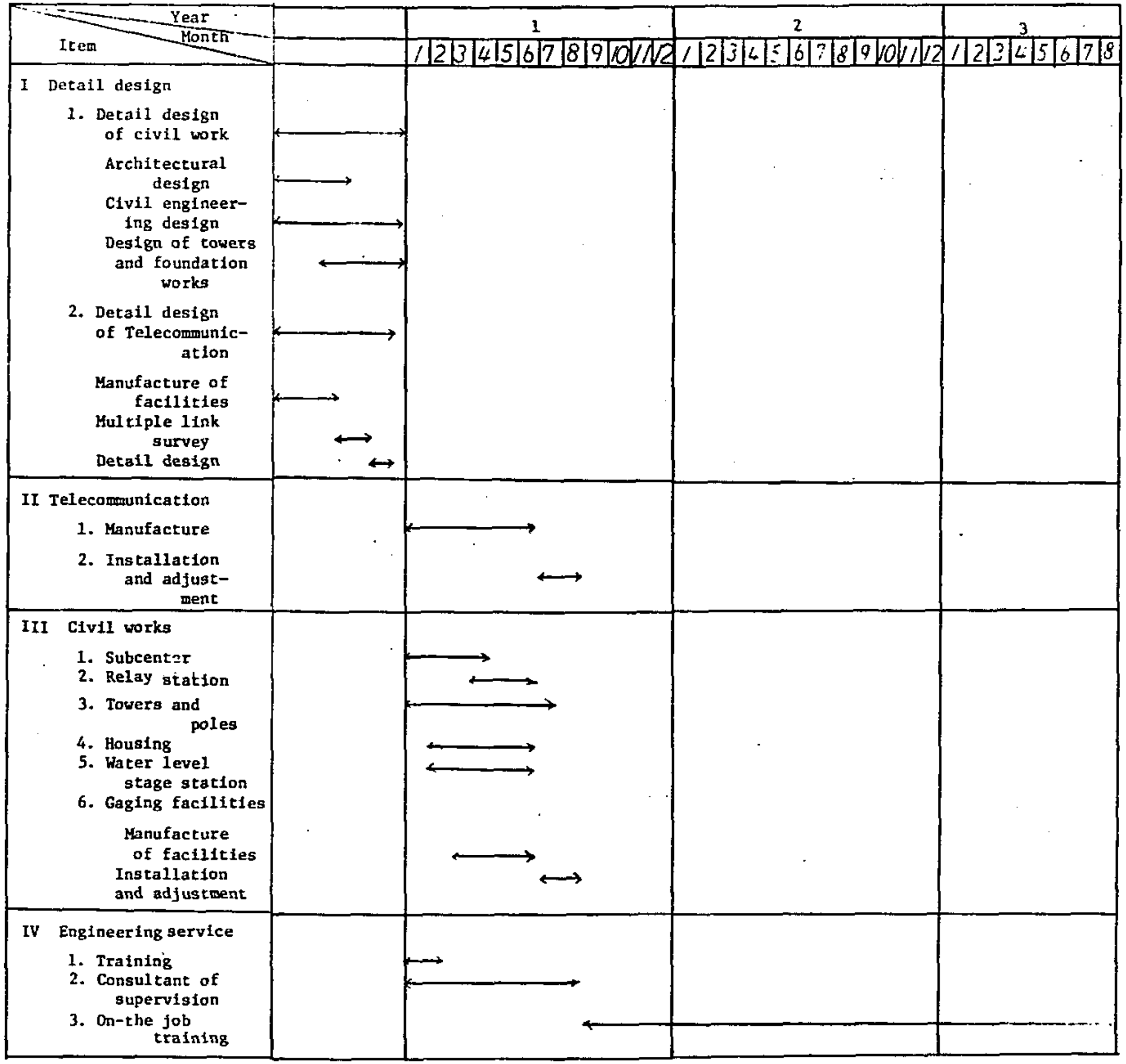
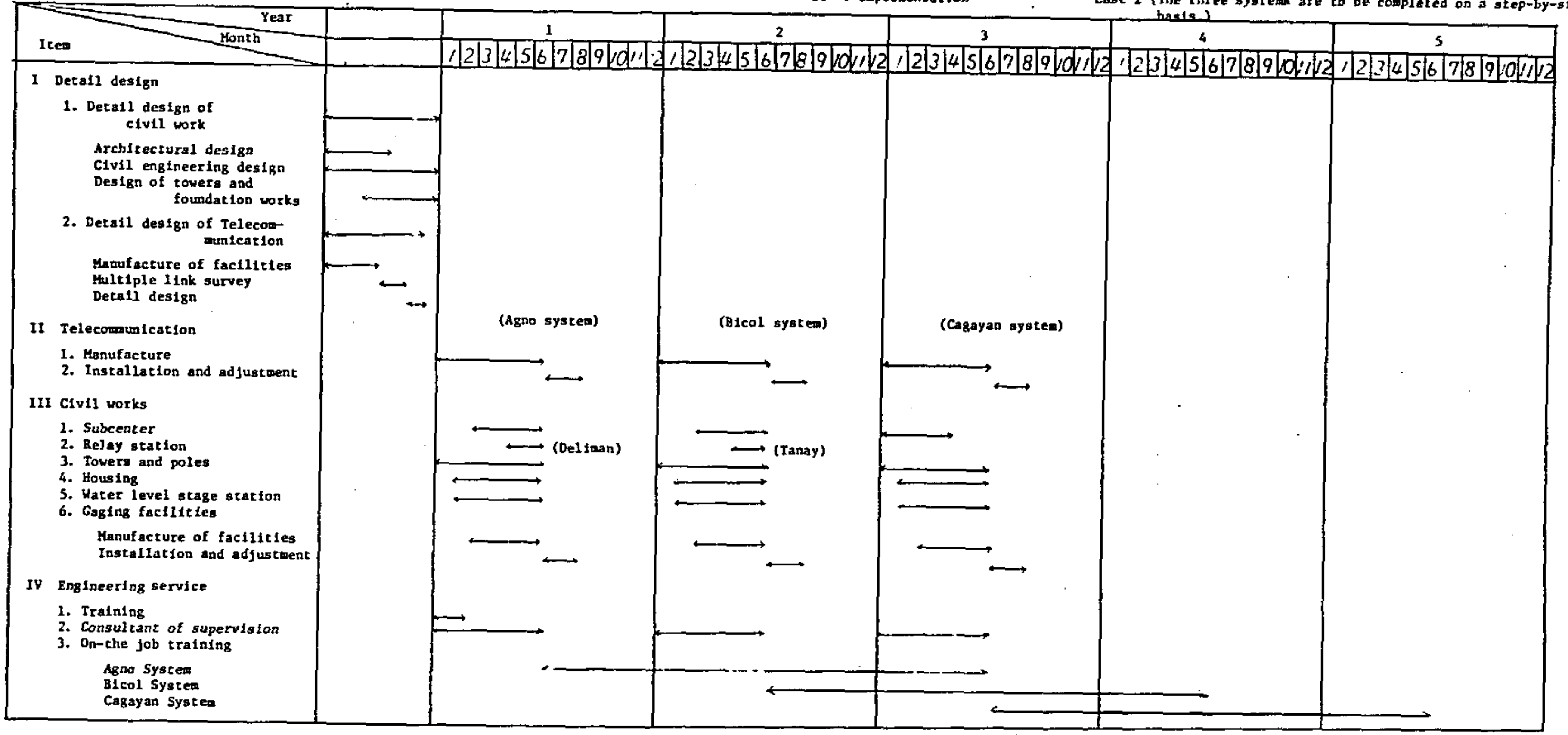


Table 9-2

Schedule of Implementation

Case 2 (The three systems are to be completed on a step-by-step basis.)



§-2 Cost Estimation

1. Condition of the Estimation

The following conditions have been considered in the estimation of the cost of the systems.

1) Estimation is based as of March 1977 and reflects a yearly 10%* price increase in the yearly schedule.

2) The provision for reserves is equal to 20% of the total sum of the construction and equipment costs allowing for the cost of technical supervision and operation and maintenance.

3) A sum equal to 3% of the total cost of construction and equipment is appropriated as the cost of operation and maintenance.

4) Water level, rainfall and flow rate gaging facilities, already existing, will be utilized as they are, with no cost of new construction allowed in the estimation. Cost of adjustment of telecommunications facilities will be reflected, however.

5) For existing gaging facilities, housing cost will be appropriated as new construction items (Cagayan River Basin, Mariz Dam, and Dallibubun gaging stations).

6) Design of new gaging facilities will be such that they will combine wireless station function. The purchase of such construction lot will be undertaken by the Government of the Philippines for estimation purposes.

Cost of each facility will be estimated by the Philippine B. P. W. personnel, with the price prevailing as of March 1977, expressed in unit cost in terms of Peso.

7) The cost of rainfall gages, water level gages, desk-top computers, and wireless installations as well as accessories, spare parts, installation and adjustment materials and maintenance cars will be estimated with respect to Japanese suppliers on the basis of unit cost prevailing as of March 1977, expressed in terms of US$. The freight from Yokohama to Manila, insurance, handling fee, transportataion from Manila to local sites have been estimated and incorporated as unit price prevailing as of March 1977 based on the estimation information available from the Philippine B. P. W.

8) Installation and adjustment cost means the cost required by Japanese engineers in making installation and adjustment on the site and has been estimated in unit price prevailing as of March 1977 in terms of US$.

9) Training expenditure means the cost expense necessary to train eight hydrologists and eleven telecommunications engineers in Japan for two months, in the study of flood forecasting and warning projects in the Philippines, and has been estimated in unit price prevailing as of March 1977 in terms of US$.

10) Design and engineering charge refers to the design and engineering service rendered by one Japanese hydrologist five telecommunications engineers and one architect (especially for the pole type stations), and has been estimated in price prevailing as of March 1977 in terms of US$.

11) Techinical supervision fee refers to the expense incurred by one Japanese hydrologist and four telecommunications engineers to train three Philippine hydrologists and fifteen telecommunication engineers for two years as local supervision service, and has been estimated in price prevailing as of March 1977 in terms of US$.

12) The cost of detail design of civil engineering work refers to the cost incurred in local survey and design of buildings, pole type stations, and towers, and has been estimated in price prevailing as of March 1977 in terms of US$.

13) The cost of detail design of telecommunications facilities refers to the cost of multiple line survey and design, and has been estimated in price prevailing as of March 1977 in terms of US$.

14) All US$ and Peso conversions will be made on a 1 US$ = 7.39 Peso basis.

* In regard to percentage increase in wages, and cost of materials, and machinery and equipment, etc., the Deflator GNP of Japan is adopted taking the upward trend in the Philippines into consideration. Because it is presumed, especially for the costs of machinery and equipment, that the rates of price hike in Japan reflect considerably in the above-mentioned percentage increase. The Deflator GNP of 10% is based on the forecast by the Japan Economic Research Center, and the latest economic trend in Japan (approx. 10% increase in the Consumer Price Index: 1976 - 1977).

GNP (GDP) DEFLATOR INCREASE PERCENTAGE

ORGANIZATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Countries / Year	1959/60 - 1972/73	1974	1975*	1976**
Developed Countries (US, W. Europe, Japan)	4.1	12.2	10.75	8.0

JAPAN ECONOMIC RESEARCH CENTER

Countries / Year	1960 - 1970	1970 - 1975*
South-East Asia	1.8	11.8
Africa	2.7	10.3
Middle & Near-East	1.9	10.0
Central & South America	3.0	8.5
Developing Countries	2.4	10.0
World, average	3.0	9.6

Note: * Presumed ** Forecasting

(1) When the three systems are to be completed at the same time

Total Cost

Table 9-3

Item	Agno System		Bicol System		Cagayan System		Total	
	Foreign	Local	Foreign	Local	Foreign	Local	Foreign	Local
I. Civil works	473	1,226	301	723	245	313	1,019	2,262
II. Telecommunication	1,443	-	928	-	760	-	3,131	-
III. Technical services	371	-	401	-	217	-	989	-
(1) Expenditure for training	21	-	21	-	20	-	62	-
(2) Supervision	50		54	-	27	-	131	-
(3) Detail design for civil works	72	-	79	-	39	-	190	-
(4) Detail design for telecom.	25	-	25	-	20	-	70	-
(5) On -the-job training	203	-	222	-	111	-	536	-
IV. Operation and Maintenance	58	37	37	22	30	9	125	68
V. Contingency	383	246	246	145	201	62	830	453
VI. Total	2,728	1,509	1,913	890	1,453	384	6,094	2,783
							6.470x10³US$	

Foreign : x10³US$

Local : x10³₱ 1US$=7.39₱=291¥

Technical services are divided into individual systems according to the number of stations involved.

Yearly costing schedule

	First year		Second year*	
Item	Foreign	Local	Foreign	Local
Cost of system	5,813x10³US$	2,783x10³₱	281x10³US$	

Note: * Cost for the second year is on-the-job training charge.

(2) When the three systems are to be completed on a step-by-step basis

Table 9-4

Total Cost

Item	Agno System		Bicol System		Cagayan System		Total	
	Foreign	Local	Foreign	Local	Foreign	Local	Foreign	Local
I. Civil works	473	1,226	332	796	297	379	1,102	2,401
II. Telecommunication	1,443	-	1,021	-	920	-	3,384	-
III. Technical services	527	-	519	-	628	-	1,674	-
(1) Expenditure for training	21	-	21	-	20	-	62	-
(2) Supervision	79	-	53	-	58	-	190	-
(3) Detail design for civil works	72	-	79	-	39	-	190	-
(4) Detail design for telecom.	25	-	25	-	20	-	70	-
(5) On-the job training	330	-	341	-	491	-	1,162	-
IV. Operation and Maintenance	58	37	41	24	37	11	136	72
V. Contingency	383	246	271	160	244	76	898	482
VI. Total	2,284	1,509	2,184	980	2,126	466	7,194	2,955
							$7,600 \times 10^3$ US$	
Deflator	1.0	1.0	1.10	1.10	1.21	1.21		

Foreign : $\times 10^3$ US$

Local : $\times 10^3$ ₱ 1US$=7.39₱=291¥

Table 9-5 Yearly Costing Schedule

Item	1st year		2nd year		3rd year		4th year	5th year	Total	
	Foreign	Local	Foreign	Local	Foreign	Local	Foreign	Foreign	Foreign	Total
I. Civil works	473	1,226	332	796	297	379	0	0	1,102	2,401
Agno Basin	473	1,226	-	-	-	-	-	-	473	1,226
Bicol Basin	-	-	332	796	-	-	-	-	332	796
Cagayan Basin	-	-	-	-	297	379	-	-	297	379
II. Telecommunication	1,443	-	1,021	-	920	-	-	-	3,384	-
Agno Basin	1,443	-	-	-	-	-	-	-	1,443	-
Bicol Basin	-	-	1,021	-	-	-	-	-	1,021	-
Cagayan Basin	-	-	-	-	920	-	-	-	920	-
III. Technical service	512	-	289	-	371	-	341	161	1,674	-
°Expenditure for training	62	-	-	-	-	-	-	-	62	-
°Supervision	79	-	53	-	58	-	-	-	190	-
Agno Basin	79	-	-	-	-	-	-	-	79	-
Bicol Basin	-	-	53	-	-	-	-	-	53	-
Cagayan Basin	-	-	-	-	58	-	-	-	58	-
°Detail design for civil works	190	-	-	-	-	-	-	-	190	-
°Detail design for telecom.	70	-	-	-	-	-	-	-	70	-
°On-the job training	111	-	236	-	313	-	341	161	1,162	-
Agno Basin	111	-	157	-	62	-	-	-	330	-
Bicol Basin	-	-	79	-	164	-	98	-	341	-
Cagayan Basin	-	-	-	-	87	-	243	161	491	-
IV. Operation and Maintenance	58	37	41	24	37	11	-	-	136	72
V. Contengency	383	246	271	160	244	76	-	-	898	482
VI. Total	2,869	1,509	1,954	980	1,869	466	341	161	7,194	2,955
	3,073x10^3 US$		2,087x10^3 US$		1932 x 10^3 US$		341x10^3 US$	161x10^3 US$	7,600x10^3 US$	

Foreign :x10^3 US$
Local :x10^3 ₱

1US$ = 7.39₱=291¥

§-3 Construction Cost

1. Unit cost for civil works

Unit cost for civil works is shown in the following table.

Table 9-6(1)

UNIT COST

ITEM	UNIT	AGNO RIVER BASIN		BICOL CAGAYAN RIVER BASIN		REMARKS
		FOREIGN	LOCAL	FOREIGN	LOCAL	
1. HOUSING, FACILITIES, ETC.		US$	₱	US$	₱	
① STATION HOUSING	PLACE	-	4,000	-	4,500	TYPE A
	"	-	7,000	-	8,500	TYPE B
② WELL-TYPE GAGING STATION	"	-	35,000	-	42,000	
③ POLE-TYPE GAGING STATION	"	-	-	-	-	
④ FLOATER DROPPING FACILITIES	"	10,000	10,000	12,000	12,500	
⑤ FENCE	SET	-	1,800	-	2,000	
⑥ REPEATER STATION HOUSE	PLACE	-	37,500	-	45,000	5^{M}x5^{M}
⑦ SUB CENTER HOUSE	"	-	160,000	-	192,000	10^{M}x8^{M}
⑧ SUB CENTER HOUSE	"	-	400,000	-	480,000	10^{M}x20^{M}
⑨ SITE, COST	m^2	-	8	-	5	
⑩ REMOVAL	SET		10,000		10,000	
⑪ FOOTING	SET		10,000		10,000	
2. TOWER, ANTENNA						
① TEL POLE.	SET	-	2,200	-	2,500	
② TRAIANGULAR TOWER	"	8,000	1,000	8,000	1,000	
③ STEEL TOWER	SET	65,000	1,500	65,000	1,500	

Table 9-6(2) UNIT COST

ITEM	UNIT	AGNO RIVER BASIN		BICOL CAGAYAN RIVER BASIN		REMARKS
		FOREIGN	LOCAL	FOREIGN	LOCAL	
3. EQUIPMENT FACILITIES and INSTALLATION						
① RAINFALL GAGING	SET	6,500	100	6,600	100	
② WATER LEVEL GAGING						
POLE TYPE	m	1,500	200	1,700	200	
FLOAT TYPE	SET					
SUIKEN 62	"	10,000	500	11,000	500	
" 70	"	12,000	500	13,000	500	DUMPER
③ VACUUM PUMP	SET	3,500	-	3,600	-	
④ CURRENT METER	SET	1,500	-	1,600	-	
⑤ CAR	SET	15,000	-	15,000	-	
⑥ DESK-TOP COMPUTER	SET	30,000	-	30,000	-	

Table 9-7

Recorder Housing R.C (AGNO RIVER BASIN)

$0.90^{m}\phi$ x 17.00^{m} Circular Stilling Well

2.50^{m} x 2.50^{m} Housing

(I) ESTIMATED COST OF PROPOSED WORK:

SCOPE OF WORK TO BE DONE ITEM	% OF TOTAL	UNIT	QUANTITY	UNIT COST	AMOUNT (P)		
					TOTAL	MATERIALS	LABOR
I. EARTH WORK					255.00	255.00	3,200.00
II. CONCRETE & MASONRY					7,207.10	7,207.10	
III. FABRICATED & MATERIALS					3,746.00	3,746.00	
IV. LUMBER & HARDWARE					855.60	855.60	
V. FORM LUMBER					2,960.55	2,960.55	
LABOR							6,360.00
TOTAL					15,024.25	15,024.25	9,560.00

(II) BREAKDOWN OF ESTIMATED EXPENDITURES

ITEM	% OF TOTAL	AMOUNT
1. DIRECT COST:		
a. TOTAL COST OF MATERIALS	43.04	15,024.25
b. LABOR	27.30	9,560.00
c. GSIS/SSS	1.23	430.20
d. EQUIPMENT EXPENSES	1.43	500.00
e. CONTINGENCIES	3.65	1,275.70
f. SUB-TOTAL FOR DIRECT-COST		26,790.15
2. INDIRECT COST:		
a. CONTRACTOR'S PROFIT	11.50	4,018.52
b. CONTRACTOR'S TAX	2.65	924.25
c. SURCHARGE	9.09	3,263.28
SAY	100.00	34,996.20
TOTAL PROJECT COST		35,000.00

Table 9-8

Recorder Housing R.C (Bicol, Cagayan River BASINS)

$0.90^m\phi \times 17.00^m$ Circular Stilling Well

$2.50^m \times 2.50^m$ Housing

(I) ESTIMATED COST OF PROPOSED WORK:

SCOPE OF WORK TO BE DONE ITEM	% OF TOTAL	UNIT	QUANTITY	UNIT COST	AMOUNT (P)		
					TOTAL	MATERIALS	LABOR
I. SITE PREPARATION					5,700.00	4,340.65	1,359.35
II. REINFORCED CONCRETE & MASONRY					21,913.73	17,119.00	4,794.73
III. BACKFILLING					640.00	-	650.00
IV. RIPRAPPING					2,219.00	1,619.00	600.00
V. WELDING OF DOOR					150.00	-	150.00
IV. HARDWARE					3,026.70	3,026.70	-
TOTAL					33,659.43	26,105.35	7,554.08

(II) BREAKDOWN OF ESTIMATED EXPENDITURES

ITEM	% OF TOTAL	AMOUNT
1. DIRECT COST:		
a. TOTAL COST OF MATERIALS	62.67	26,105.35
b. LABOR	18.14	7,554.08
c. LEAVES	1.51	629.51
d. GSIS/SSS	1.72	717.64
e. MODICARE	0.14	60.43
f. STATE INSURANCE FUND	0.18	75.54
g. CONTINGENCIES	4.33	1,803.12
2. INDIRECT COST:		
a. SURCHARGE	11.31	3,786.57
SAY	100.00	41,652.23
TOTAL PROJECT COST		42,000.00

2. Construction Cost of Civil Works

Construction cost of civil engineering works for each of the stations in the Agno, Bicol, and Cagayan systems

(1) AGNO River Basin

Table 9-10 Construction and Equipment Cost of Civil Works

Location of Station	Foreign (US$)	Local (₱)
(Banban)	(6,500)	(8,100)
Tibag	23,750	14,000
Binga Dam	59,000	22,100
San Roque	31,500	21,300
Carmen Rosales	21,500	18,100
Wawa	21,500	47,600
Bañaga	15,500	52,500
Santa Borbora	21,500	46,800
Sto.Tomas R.S	8,000	38,500
Carmen S.C	65,000	401,500
Deliman R.S	65,000	401,500
Tanay R.S	65,000	161,500
Sub Total	397,250 (403,750)	1,225,400 (1,233,500)
Car (3 sets)	45,000	-
Desk-top Computer	30,000	-
Sub Total	75,000	-
Total	472,250 (478,750)	1,225,400 (1,233,500)
	638,069 (645,665) US$	

1 US$ = 7.39 ₱

(2) Bicol River Basin

Table 9-11

Construction and Equipment Cost of Civil Works

Location of Station	Foreign (US$)	Local (₱)
Napolidan	6,600	9,100
Sipocot	42,200	17,600
Ligao	6,600	10,100
Bato	18,500	26,025
Buhi	21,200	50,500
Ocampo	6,600	10,000
Camaligan	22,800	43,500
Ombao	22,800	62,500
Barongay	11,900	8,400
Sipocot R.S	8,000	50,000
Iriga R.S	8,000	49,000
Naga S.C	65,000	385,500
Sub Total	240,200	722,225
Car (2 set)	30,000	-
Desk-top Computer	30,000	-
Sub Total	60,000	-
Total	300,200	722,225
	404,531 US$	

(3) Cagayan River Basin

Table 9-12 Construction and Equipment Cost of Civil Works

Location of Station	Foreign (US$)	Local (₱)
Maris	23,600	23,600
Dalibubun	29,200	7,750
Tumauini	32,100	14,800
Tugnegarao	27,000	27,200
(Aparri)	(29,200)	(49,750)
Tuguegarao S.C	65,000	193,000
Iragan R.S	8,000	46,000
Sub Total	184,900 (214,100)	312,350 (362,100)
Car (2 set)	30,000	-
Desk-top Computer	30,000	-
Sub Total	60,000	-
Total	244,900 (274,100)	312,350 (362,100)
	287,166 (323,099) US$	

1 US$ = 7.39 ₱

3. Cost of Telecommunications Facilities

Table 9-13 Estimated cost of flood forecasting systems in the Agno, Bicol and Cagayan River Basins

Item / River	Tele-metering	Multiple lines	Wave sensing lines	VHF lines and other	Total
Agno R.	614	685	113	31	1443
Bicol R.	360	485	60	28	928
Cagayan R.	237	440	60	23	760
Total	1211	1605	233	82	3131

UNIT: x 10^3US$

Telecommunication Cost of Agno Systems

Table 9-14 UNIT: x 10^3 US$

Station	Tele-metering	Multiple lines	Wave sensing lines	VHF lines and others
PAGASA	223.0	228.37	-	-
B. P. W	154.3	146.6	-	-
Carmen S.C	103.0	171.63	58.0	22.68
Sto. Tomas R.S	30.8	-	-	-
Tibag	14.7	-	-	-
Wawa	14.7	-	-	-
Bañaga	14.7	-	-	-
Sta. Barbara	14.7	-	-	-
Carmen	14.7	-	-	-
San Roque	14.7	-	-	-
Binga dam	14.7	-	-	-
Deliman R.S	-	138.4	55.0	8.32
Total	614.0	685.0	113.0	31.0

Telecommunication cost of Bicol Systems

Table 9-15

UNIT : x 10^3 US

Station	Tele-metering	Multiple lines	Wave sensing lines	VHF lines and others
Naga S.C	128.0	163.93	60.0	28.0
Sipocot R.S	30.8	-	-	-
Iriga R.S.	30.8	-	-	-
Barongay	14.7	-	-	-
Camaligan	14.35	-	-	-
Ocampo	10.3	-	-	-
Ombao	14.7	-	-	-
Bato	14.7	-	-	-
Sipocot	14.7	-	-	-
Napolidan	10.3	-	-	-
Buhi	14.7	-	-	-
Ligao	10.3	-	-	-
B. P. W	17.0	30.0	-	-
PAGASA	34.65	30.1	-	-
Deliman	-	93.92	-	-
Tanay	-	162.05	-	-
Total	360.0	480.0	60.0	28.0

Telecommunication Cost of Cagayan Systems

Table 9-16

UNIT : x 10^3 US$

Station	Tele-metering	Multiple lines	Wave sensing lines	VHF lines and others
Tuguegarao S.C	97.0	244.0	60.0	17.6
Iragan R.S	30.8	-	-	5.4
Tuguegarao	14.7	-	-	-
Tumauini	14.7	-	-	-
Dalibubun	14.7	-	-	-
Mariz	14.7	-	-	-
B. P. W	15.4	20.0	-	-
PAGASA	35.0	20.0	-	-
Carmen Rosales S.C	-	156.0	-	-
Total	237.0	440.0	60.0	23.0

§-4 Cost of Engineering Service

1. Expenditure for training

Expenditure necessary for training Bhilippine engineers. The training will be conducted for a period of two months.

Tuter $2^{person} \times 2^{month} \times 5000 = 20,000$ US$

Training				
Hydrologists	$8^{persons}$	x 2^{months}	x 800	= 12,800
Telecommunication engineers	$11^{persons}$	x 2	x 800	= 17,600
Transportation charge				
	19	x 600		= 11,400
	Total			61,800 US$

2. Consultant fee for supervision

(1) When the three systems are to be completed at the same time

One hydrologist will be stationed for eight months to provide engineering and design supervising service, so will be five telecommunication engineers for four months and one architect for two months.

. Salary, overhead, fee, living expense

Hydrologist	1^{person}	x 8^{month}	x 6000	= 48,000 US$
Telecommunication Engineer	1	x 4	x 6000	= 24,000
"	4	x 4	x 3000	= 48,000
Construction engineer	1	x 2	x 3000	= 6,000

. Transportation charge

$(1^{person} \times 2^{time}) + (6^{person} \times 1^{time}) \times 600 = 4,800$ US$

The estimate is based on the assumption that enginners stationed for more than six months will incur the transportation exepnses to and from their country on vacation or for other reasons.

Total 130,800 US$

(2) When the three systems are to be completed on a step-by-step basis.

. Salary, overhead, fee, living expense

Agno Basin (First year)

Hydrologist	1 person	x 6 month	x 6,000	= 36,000 US$
Telecom. Engr.	1	x 3	x 6,000	= 18,000
Telecom. Tech.	2	x 3	x 3,000	= 18,000
Const. Engr.	1	x 1	x 3,000	= 3,000
		Subtotal		= 75,000 US$

. Bicol Basin (Second year)

Hydrologist	0.5 person	x 6 month	x 6,000	= 18,000
Telecom. Engr.	0.5	x 3	x 6,000	= 9,000
Telecom. Tech.	2	x 3	x 3,000	= 18,000
Const. Engr.	1	x 0.5	x 3,000	= 1,500
		Subtotal		46,500 US$

46,500x1.1=51,150 US$

. Cagayan Basin (Third year)

Hydrologist	0.5 x 6 x 6,000	= 18,000
Telecom Engr.	0.5 x 3 x 6,000	= 9,000
Telecom Tech.	2 x 3 x 3,000	= 18,000
Cost. Engr.	1 x 0.5 x 3,000	= 1,500
		46,500 US$

46,500x1.21=56,265 US$

. Transportation charge

Agno Basin	1 person	x 2 time	x 600	= 1,200	Subtotal
	4	x 1	x 600	= 2,400	3,600 US$
Bicol Basin	2 person	x 1 time	x 600	= 1200	1200x1.1=1,320US$
Cagayan Basin	2	x 1	x 600	= 1200	1200x1.21=1,452US$

. Total

Agno Basin	78,600 US$
Bicol Basin	52,470 US$
Cagayan Basin	57,717 US$

3. Detail design of civil works

(1) Design quantity

① Architectural design

Subcenter	10m x 8m	Two-storied	1 site
	10m x 8m		2 sites
	20m x 10m		2 sites
Repeater center			
	5m x 5m		4 sites

② Facilities

Station	1.8 x 1.8	6 sites
	2.5 x 2.5	14 sites
Well type		7 sites
Pole type		11 sites

③ Tower and foundation work

Earth filling-up work	2 sites
Footing foundation work	3 sites
Tower and foundation work	5 sites
Pole (18 sites) and triangular tower (5 sites) foundation work	23 sites

(2) Cost

① Architectural design

o Design

Subcenter: 2 types

Architect 1 person x 2 month x 6000 US$ = 12,000 US$

" 2 x 2 x 3000 = 12,000

Repeater station: 1 type

Architect 1 person x 0.4 month x6000 = 2,400

" 1 x 1.5 x3000 = 4,500

Subtotal 30,900 US$

o Survey: 9 places

Survey engineers

2 person x 1 month x 3000 = 6000 US$

Subtotal 6000 US$

o Arrangement plan: 9 places

Architect $1^{person} \times 1.5^{month} \times 6000 = 9000$ US$

Subtotal 9000 US$

o Transporation charge

Architect(1)

Survey engineers(2) $3^{person} \times 1^{time} \times 600 = 1800$ US$

Subtotal 1800 US$

Total-1 47,700 US$

② Civil engineering design

o Well type and stations -- To be designed by the Philippine officials

o Pole type and stations -- 11 places (Survey to be carried out in 20 sites)

. Design

Designer 1 person x 3 x 6000 = 18,000 US$

" 2 x 6 x 3000 = 36,000

. Survey

Survey engineer

2 persons x 3 x 3000 = 18,000

. Transportation charge (Designers)

3 persons x 1 time x 600 = 1800

Subtotal 73,800 US$

③ Design of towers and foundation work

Tower design: 2 types

Designer $1^{person} \times 2^{month} \times 6000 = 12,000$ US$

" 1 x 2 x 3000 = 6,000

Foundation work design

5 types

Designer $1^{person} \times 2^{month} \times 6000 = 12,000$

2 x 4 x 3000 = 24,000

Survey 36 sites

Survey engineers

$2^{person} \times 2^{month} \times 3000 = 12000$

Transportation charge

$4^{persons} \times 1^{time} \times 600 = 2,400$

Subtotal 68,400 US$

Total-2 142,200 US$

Total 189,900 US$

4. Detail design of telecommunication facilities

(1) Line (multiple link) survey

The multiple line survey between subcenters will involve six engineers and require three months for the manufacture of equipment, one month for survey and one month for arrangement.

. Survey Telecommunication engineer

$1^{person} \times 1.5^{month} \times 6,000 = 9,000$ US$

$5 \times 2.5 \times 3,000 = 37,500$

. Transportation expense

$6^{person} \times 1^{time} \times 600 = 3,600$

Subtotal 50,100 US$

(2) Detail design

Deisgn Telecommunication engineer

$1^{person} \times 1.0 \times 6000 = 6,000$

" $3^{persons} \times 1.5 \times 3000 = 13,500$

Transportation charge

$1^{person} \times {}^{time} \times 600 = 600$

Subtotal = 20,100 US$

Total 70,200 US$

5. On-the-job training

(1) When the three systems are to be completed at the same time

After system completion engineers will be sent on the site to ensure proper operation and maintenance. One hydrologist and four telecommunication engineers will provide technical supervision for two years in the Philippines.

① First year

. Salary, overhead, fee, living expense

Hydrologist	1 person	x 12 month	x 6,000	= 72,000
Telecommunication Engineer	1	x 12	x 6,000	= 72,000
" Technologist	3	x 12	x 3,000	=108,000

. Transportation charge

	5 person	x 1 time	x 600	= 3000
	Subtotal			255,000 US$

② Second year

280,500 US$

Total 535,500

(2) When the three systems are to be completed on a step-by-step basis

① Agno River Basin

. Salary, overhead, fee, living expense

First year

Hydrologist	1 person	x 6 month	x 6,000	= 36,000
Telecom. Engr.	1	x 6	x 6,000	= 36,000
Telecom. Tech	2	x 6	x 3,000	= 36,000
				108,000 US$

Second year

Hydrologist	0.5 person	x 12 month	x 6,000	= 36,000
Telecom Engr.	1 0.5	x 3 x 9	x 6,000	= 45,000
Telecom Tech	2	x 12	x 3,000	= 72,000
				153,000

153,000 x 1.1 = 154,100 US$

Third year

Hydrologist $0.2^{person} \times 6^{month} \times 6{,}000 = 7{,}200$

Telecom. Engr. 0.2 x 6 x 6,000 = 7,200

Telecom Tech. 2 x 6 x 3,000 = 36,000

50,400

50,400 x 1.21 = 60,984 US$

Transportation

First year $4^{person} \times 1^{time} \times 600 = 2400$

Second year 4 x 1 x 600 = 2400 x 1.1 = 2,640

Third year 2 x 1 x 600 = 1200 x 1.21 = 1,452

6,492 US$

Total 329,576 US$

② Bicol River Basin

. Salary, overhead, fee, living expense

Second year

Hydrologist $0.5^{person} \times 6^{month} \times 6{,}000 = 18{,}000$

Telecom. Engr. 0.5 x 6 x 6,000 = 18,000

Telecom. Tech. 2 x 6 x 3,000 = 36,000

72,000

72,000 x 1.1 = 79,200 US$

Third year

Hydrologist $\begin{pmatrix}0.3 \times 6\\ 0.5 \times 6\end{pmatrix} \times 6000 = 28{,}800$

Telecom. Engr. $\begin{pmatrix}0.5 \times 9\\ 0.3 \times 3\end{pmatrix} \times 6000 = 32{,}400$

Telecom. Tech. 2 x 12 x 3000 = 72,000

133,200

133,200 x 1.21 = 161,172 US$

Fourth year

Hydrologist 0.5 x 6 x 6000 = 18,000

Telecom. Engr. 0.5 x 6 x 6000 = 18,000

Telecom Tech 2 x 6 x 3000 = 36,000

72,000

72,000 x 1.33 = 95,760 US$

. Transportation

Third year $4^{person} \times 1^{time} \times 600 = 2400 \times 1.21 = 2,904$

Fourth year $2 \times 1 \times 600 = 1200 \times 1.33 = 1,596$

4,500US$

Total 340,632 US$

③ Cagayan River Basin

. Salary, overhead, fee, living expense

Third year

Hydrologist $0.5^{person} \times 6^{month} \times 6000 = 18,000$

Telecom, Engr. $0.5 \times 6 \times 6000 = 18,000$

Telecom. Engr. $2 \times 6 \times 3000 = 36,000$

72,000

72,000 x 1.21 = 87,120 US$

Fourth year

Hydrologist $\binom{0.5 \times 6}{1 \times 6} \times 6000 = 54,000$

Telecom. Engr. $\binom{0.5 \times 6}{1 \times 6} \times 6000 = 54,000$

Telecom. Tech. $2 \times 12 \times 3000 = 72,000$

180,000

180,000 x 1.33 = 239,400 US$

Fifth year

Hydrologist $1^{person} \times 6^{month} \times 6000 = 36,000$

Telecom. Engr. $1 \times 6 \times 6000 = 36,000$

Telecom. Tech. $2 \times 6 \times 3000 = 36,000$

108,000

108,000 x 1.46 = 157,680 US$

. Transportation

Fourth year $4^{person} \times 1^{time} \times 600 = 2,400 \times 1.33 = 3,192$

Fifth year $4 \times 1 \times 600 = 2,400 \times 1.46 = 3,504$

6,696US$

Total 490,896 US$

§-5 Cost of Operation and Maintenance

1. Maintenance of communications facilities
2. Maintenance of flood forecasting facilities

For maintenance of these facilities it is a normal practice to appropriate a sum equal to 3-5% of the costs of civil enginnering works and telecommunications facilities. For the present systems a 3% sum will be appropriated.

X. Benefit of the Project

The benefit of the Flood Forecasting and Warning System, being generally intangible, is not adaptable to an economic analysis in terms of monetary values. Flood control works are of vital importance in the endeavor to eliminate the potential substantial damages to the human life and the properties in the applicable basin areas as described below. The works, however, will require an enormous amount of meney and a long period of time from inception to completion. The Flood Forecasting and Warning System, while its benefit is intangible, will prove efficient at less cost and in a shorter period and continue to play an important role after the Flood control works are completed. The system will provide timely, accurate flood information for more efficient evacuation of residents, moving of their properties, and proper flood control as well as rescue activities, thereby stabilizing the livelihood of the residents in the basin areas and enhancing their welfare.

§-1 Damage Potentiality

The properties of the target areas in these three basins as well as the damage potentiality are summarized as follows:

1) Properties and Population within the Target Area

The population living in the Target Areas of the Agno, Bicol, and Cagayan Rivers is as follows:

Population Living in the Target Areas

River Basin	Target Area	Population
	km^2	persons
Agno	1,540	500,000
Bicol	570	200,000
Cagayan	1,420	180,000
Total	3,530	880,000

The values of the major properties in the Target Areas are as follows:

Values of Properties in the Target Areas

x10³₱

Item \ River Basin	Agno	Bicol	Cagayan	Total
I. General property	1,240,000	301,000	285,000	1,826,000
1) Private building construction	70,000	17,000	4,000	91,000
2) Household	519,000	159,000	89,000	767,000
3) Mineral production	15,000	---	---	15,000
4) Manufacturing production	140,000	21,000	13,000	174,000
5) Commercial trade	196,000	35,000	41,000	272,000
6) Fish pond production	61,000	4,000	1,000	66,000
7) Crops production	178,000	52,000	112,000	342,000
8) Livestock and poultry on farms	61,000	13,000	25,000	99,000
II. Public property	648,000	252,000	296,000	1,196,000
9) Road railway reconstruction cost	572,000	231,000	275,000	1,078,000
10) School reconstruction cost	71,000	19,000	20,000	110,000
11) Transportation	5,000	2,000	1,000	8,000
Total (x10³₱)	1,888,000	553,000	581,000	3,022,000
Total (x10³US$)	257,000	75,000	79,000	411,000

Note: Items (1), (2), (9), (10) and (11) are real estate properties, and other items indicate annual production.

2) Anticipated Maximum Damages in the Target Areas

1. Anticipated maximum damage rates

The following table gives a listing of anticipated maximum damage rates in the target areas along the Agno, Bicol and Cagayan basins classified by the kind of properties, worked out on the basis of past statistics in Philippines and Japan.

Anticipated Maximum Damage Rates by the Kind of Properties

Kind of Properties / Scale of Flooding	1.0 m Average Flood or Higher
Houses (wooden and non-wooden)	0.40
Household	0.10
Business establishments	0.40
Cattle and cultured fish	0.40
Crops production	0.20
Highways and railways	0.20
Schools	0.10
Transportation	0.40

Anticipated Mean Maximum Damage

x10[6] ₱

Maximum Damage Rate / Kind of Properties	Agno			Bicol			Cagayan		
	Value of properties	Maximum damage rate	Maximum damage	Value of properties	Maximum damage rate	Maximum damage	Value of properties	Maximum damage rate	Maximum damage
I. General property									
1) Private building construction	70	0.4	28	17	0.4	7	4	0.4	2
2) Household	519	0.3	156	159	0.3	48	89	0.3	27
3) Mineral production	15	0.4	6	-	0.4	-	-	0.4	-
4) Manufacturing production	140	0.4	56	21	0.4	8	13	0.4	5
5) Commercial trade	196	0.4	78	35	0.4	14	41	0.4	16
6) Fish pond production	61	0.4	24	4	0.4	2	1	0.4	-
7) Crops production	178	0.2	36	52	0.2	10	112	0.2	22
8) Livestock and poultry on farms	61	0.4	24	13	0.4	5	25	0.4	10
II. Public property									
9) Road and railway reconstruction cost	572	0.2	114	231	0.2	46	215	0.2	55
10) School reconstruction cost	71	0.1	7	19	0.1	2	20	0.1	2
11) Transportation	5	0.4	2	2	0.4	1	1	0.4	-
III. Total	1,888	0.28	531	553	0.26	143	581	0.24	139

Total anticipated damages in the three river basins:

Value of properties	411,000 x 10^3 US$
Value of damages	111,000
Damage rate	0.27

2. Anticipated Maximum Damages

The following table shows the estimated maximum damages within the Target Areas in the Agno, Bicol, and Cagayan Rivers. In times of major floods, 27% of the properties are expected to be damaged.

In addition, significant loss of human lives would result which are not c onvertible in monetary values.

Anticipated Maximum Damages

River Basin	Value of Properties	Damage Rate	Maximum Damage
Agno	1,888,000 ₱	0.28 ₱	531,000
Bicol	553,000	0.26	143,000
Cagayan	581,000	0.24	139,000
Total (x10^3₱)	3,022,000	0.27	813,000
Total (x10^{3}US$)	411,000	0.27	111,000

Future further development along the Rivers would concentrate more people in the particular areas with increasing properties being accumulated.

Therefore, if a flood of the same magnitude occurred, the extent of damages would be much more amplified.

§-2 Benefit of the Project

In general, the direct purpose of the Flood Forecasting and Warning system is to estimate the extent of coming floods timely, and to spread such information over as large an area as possible and to lessen damages by evacuation flood defense and rescue operation, etc. Besides this, indirect purpose will be to remove unnecessary fears among inhabitants and thus to stabilize their livelihood.

Since the benefits of the project are intangible because of the particular characteristics of the project, it is difficult to indicate its feasibility by a general economic approach. Yet, in order to lessen the potential vast diamages as stated, it is essential to put the Flood Forecasting and Warning System into practice in the Agno, Bicol and Cagayan River Basins having enormous population and industry adjacent to their banks.

Specifically, following benefits are expected to accrue:

1) According to the Flood Forecasting and Warning System, evacuation preparations will not be just a waste of labor, and due to the increase in the time for preparations, a large number of harvested products, personal belongings, household utensils, etc. can be removed from the affected areas.

2) The extent of damages can be narrowed by efficient implementation of flood defense and rescue by timely forecasting and warning.

3) The lessened damages can lead to increase in personal properties and indirectly help improve the residents' motivation for work and life.

4) Smooth implementation of regional development projects is expected.