SECTION III SADONG RIVER BASIN (SARAWAK)

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CHAPTER 1 OUTLINE OF RIVER BASIN

The Sadong river basin is situated in the western part of Sarawak, or lat. 1° - 1°30' N and long 110° - 111°E. It is a relatively small river with about 3,640 km^2 of drainage area and about 180 km of main river length.

The river basin is nearly triangular-shaped-about 70 km from east to west and about 85 km from south to north.

1.1 Natural Environment

Starting at the confluence of the Kedup River and the Kayan River flowing out of the southwestern mountain district and the Krang River flowing in the eastern plain, the Sadong River winds its way through an alluvial plain and flows into the South China Sea. The Indonesian border with a chain of 600 to 1000 m mountains forms the divide of this river basin, which is relatively flat.

From Tanah Puteh located 109 km from the river-mouth, the river meanders markedly down to the mouth. It is also up to this point that tidal waves affect the water level. The grades of the Kedup River and the Kayan River meeting each other at about 10 km upstream from Serian, 129 km from the river-mouth, are 1/3,500 and 1/570, respectively. In the middle and lower reaches, the Sadong River is a primitive river overgrown on both shores with mangroves. In the rainy season from December to February, the river often overflows, combined with the king tides.

The climate of this area is a tropical climate of high temperatures and much rain, and the rainy season of Northeast Asian monsoon lasts from November fill March. 55 per cent of the yearly rainfall occurs during this rainy season, when rice can be grown without irrigation.

1.2 Socioeconomic Environment

1.2.1 Population within River Basin

The population of this river basin consists of 2,200 in downtown Serian, about 54,000 in the upper reaches including Serian, 630 in Simunjan situated at a downstream point and about 31,000 in the lower reaches including Simunjan. The total is therefore estimated to be about 85,000 people. The population density throughout the river basin is about 234 people/km^2.

1.2.2 Agriculture

Principal agricultural products in this river basin are paddy, rubber, pepper and coconuts. Emphasis is particularly placed on the production of paddy. Namely, there are such irrigation plans as the Sadon Middle Reaches Irrigation Plan, Raya Payang Irrigation Plan and Sadong-Krang Paddy Plan. The pepper, suited for cultivation on the hills, is also an important product of this river basin. There is a network of roads around Serian, and land use is advanced at Sadong and the surrounding middle reaches area.

1.2.3 Flood Damage

According to the flood record, the flood in January, 1976 was the largest since the commencement of observation. The observation data, fairly well recorded at Serian, show that the road was covered by about 2 feet of water and the maximum inundation reached about 6 feet. And Serian, Tabakana and Tanah Putoh suffered great damage from this flood.

In 1977, too, Serian was inundated by the water of 4 to 5 feet deep, the losses of grain, cattle and properties estimated to have amounted to M$464,000.

CHAPTER 2 TARGET AREA OF FLOOD FORECASTING AND WARNING

2.1 Target Area of Flood Forecasting and Warning

Based on the distribution of population and assets, and socio-economic characteristics, such as land utilization both the existing and the future, the area stated below of the Sadong river basin is proposed to be the target area taking hydrometeorological and topographical and run-off data into consideration.

The flood inundation areas along the Sadang river caused by the biggest flood ever recorded (January 1976), where major kampung, such as Tebakang, Serian, Tanah Puteh, Sebamban and Gedong are located.

2.2 Flood Forecasting Points

Representative locations for flood forecasting selected for the above target area are as follows:

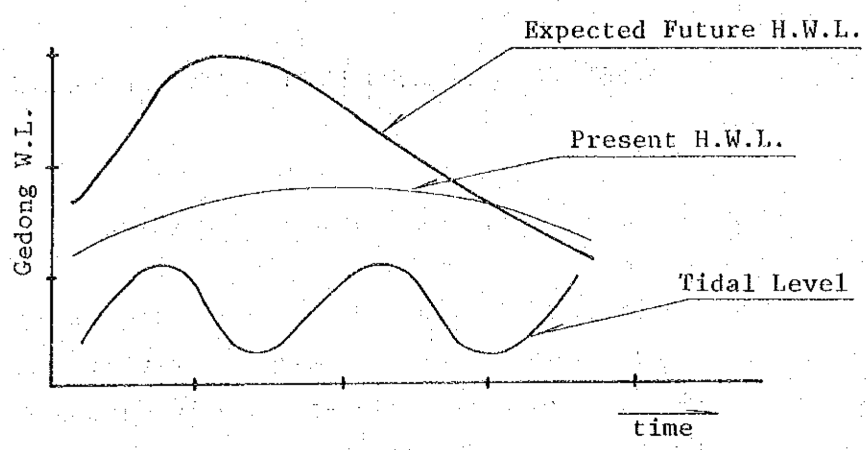
Serian
Gedong

2.3 Flood Warning Points

The major flood warning points selected for the above target areas are as follows:

Tebakang, Serian, Tanah Puteh, Sebamban and Gedong

Gedong which has not had serious flood effects as to be designated a warning point may suffer from remarkable effect caused by future basin development (increased runoff) and river improvement work (increased flood propagation time). For this reason, Gedong ought to be included in warning points. This expected future flooding could be illustrated as the diagram shown below. As may be observed, coincidence probability of spring tide and peak flood discharge is expected to increase substancially.



2.4 Location of Telemetry Stations

Along the Sadong river, a relatively large number of hydrological observation stations both ordinary and recording are located, and considerable volume of observation data are already accumulated. Therefore, telemetry observation stations are to be either of converted existing ordinary stations or new telemeterized stations located in the neighborhood of the existing.

2.4.1 Rainfall Gauging Stations

In locating telemetry rainfall gauging stations, it is required to divide the entire subject river basin into area where the rainfall characteristics are almost the same, and to located one station in each area.

In locating rainfall gauging stations, it is required to confirm easy maintenance and administration and undisturbed telecommunication based on the available data (See Chapter 3 FLOOD FORECASTING) and the findings of the field reconnaissance.

2.4.2 Water Level Gauging Stations

Actual locations of the water level gauging stations are to be determined with due regard to the following criteria:

- Availability of river stage data with high correlation to that of above-mentioned forecasting points, which

Fig. 2.1 Target Area for Flood Forecasting and Warning System in Sadong River Basin

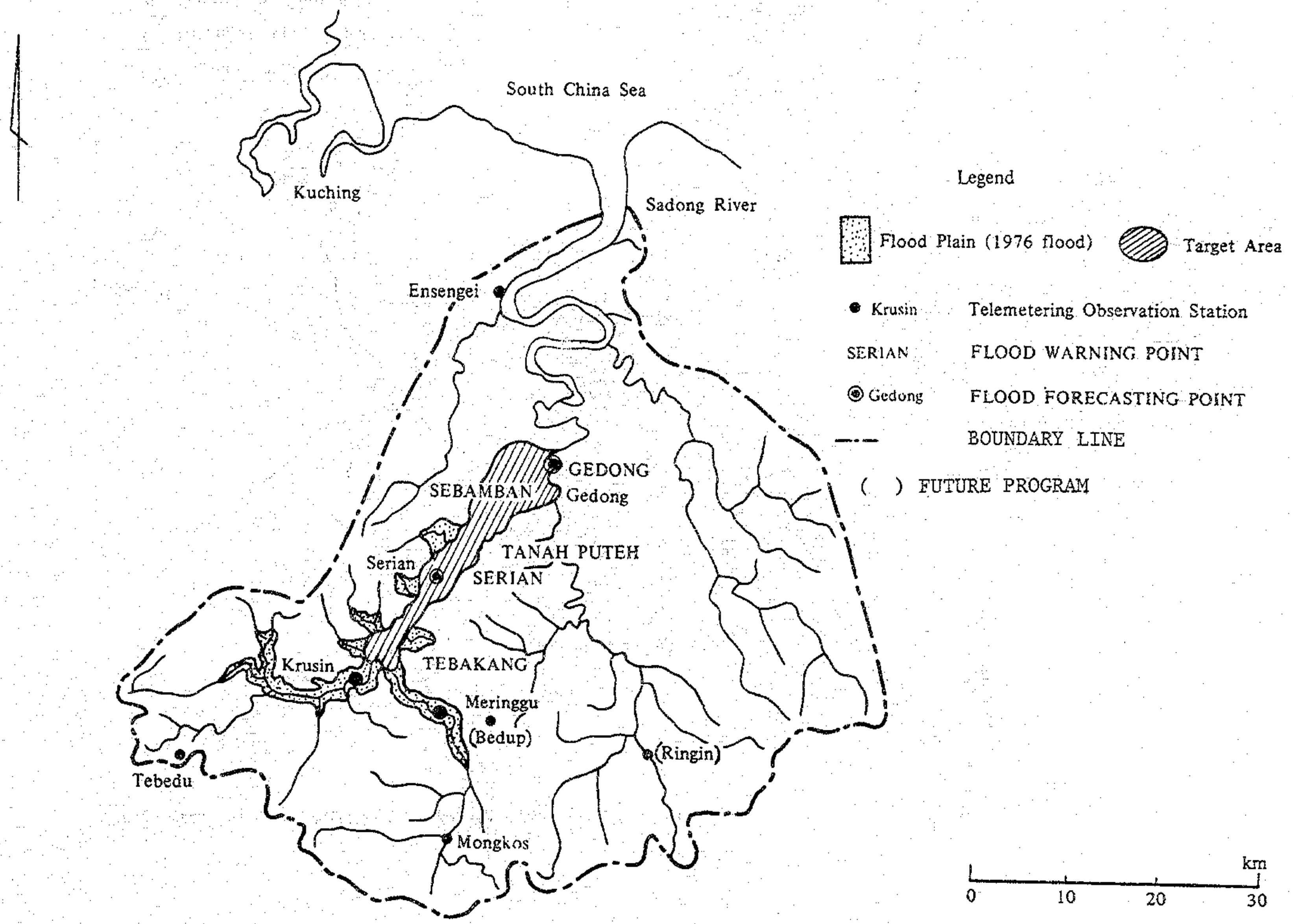
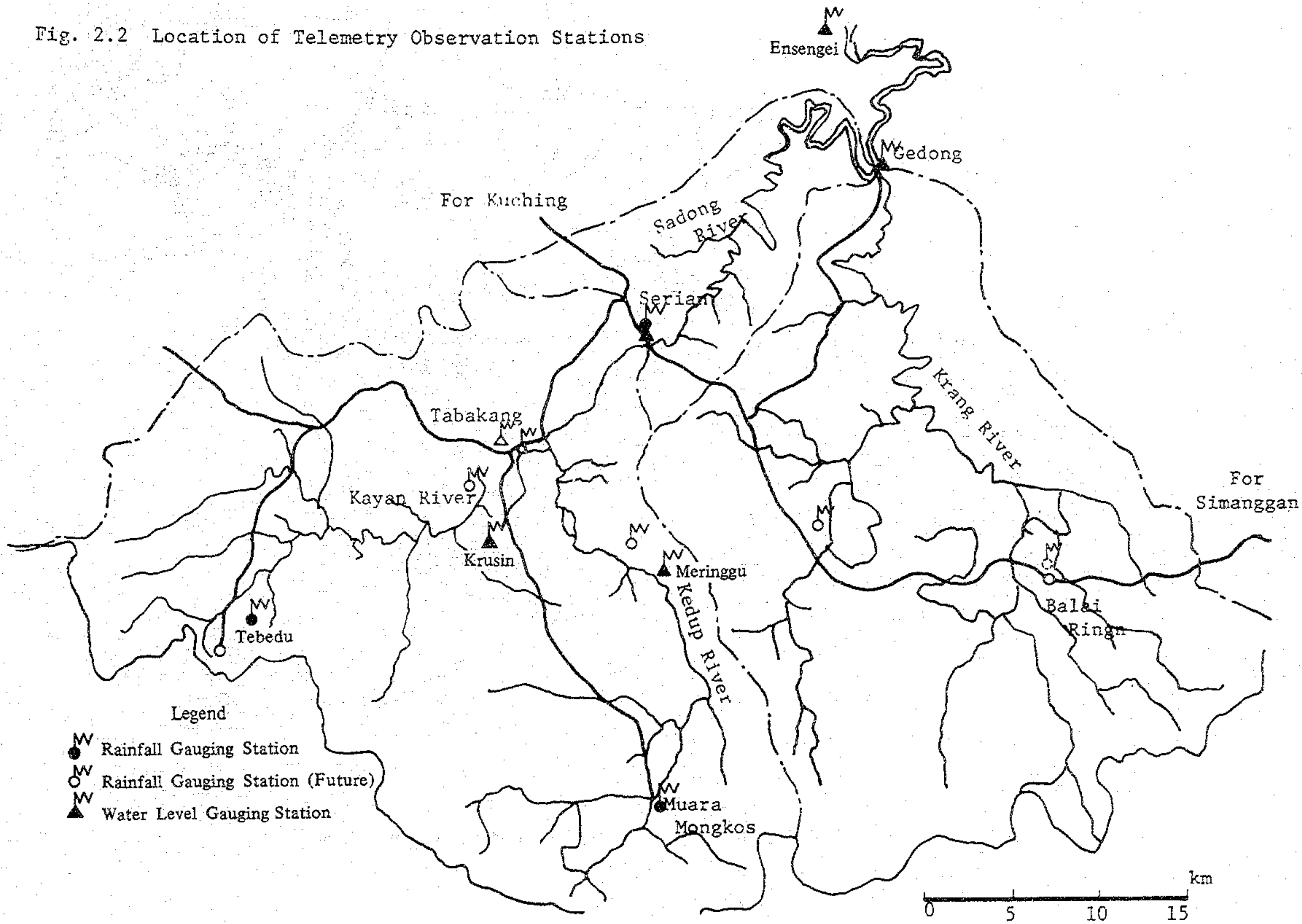


Fig. 2.2 Location of Telemetry Observation Stations



facilitate accurate forecasting. In addition to this, enough time lag for forecasting should be secured.

- Close to existing gauging station so as to use existing data effectively

- Easy operation and maintenance irrespective of water level

- Undisturbed telecommunication

Based on the preliminary study and field reconnaissance, the layout of location of water level stations is proposed as shown in Table 1 and Fig. 1.

From the findings of reconnaissance survey, it was found difficult to locate the Gedong station along the main course of the river as desired, therefore, the existing Gedong station is located at about 300 meters up-stream from the confluence of the main river and the Batang Krang, as a substitute.

With regard to practically acceptable location for telemetry station, Chapter 5 FACILITIES, and the APPENDIX may be referred.

2.4.3 Selection of Discharge Gauging Points

For a longer term and higher accuracy in flood forecasting, it is desirable to use data of forecast of flow discharge based on the observed rainfall.

In flow discharge observation, hydrograph of water-level and discharge at major observation points may have to be obtained. Hence, it is proposed that observation of flow discharge be conducted to prepare the hydrograph required.

The sites mentioned below are selected as suitable for flow discharge observation:

Sites		River
Krusin	-----	Kayan
Meringgu	-----	Kedup
Serian	-----	Sadong

2.4.4 Expansion Program for Future Location Plan of Observation Station Network

Telemetry Observation Station

- For improved accuracy and extended time-lag of flood forecasting, it is recommended to conduct flood forecasting by predicting discharge from rainfall. In this run-off prediction, however, an expanded rainfall gauging network is required.

  The locations for such expanded telemetry system would be the sites of recording raingauges proposed afterwords. Moreover, it is highly recommended to install telemetry equipments of both rainfall and waterlevel compatible type at Krasin and Meringgu, which for the time being only uses the waterlevel telemetry function. This would facilitate very much the future expansion and be economical in the long run.

- In this proposal, the area subject to flood forecasting and warning is limited to the main river course of Sadong River and its adjacent land. The river basin of Batang Krang, the right tributary, has a relatively developed road system and future accumulation of population and property could be expend from future development. The flood forecasting and warning system for that area would by them be highly demanded.

  Water level gauging station at Gedong, on the other hand, would be desirable to be newly installed on the main river course. Judging from river gradient and the width of river of Gedong, however, the existing gauge on Batang Krang would represent very well the water level of the main river course. It is desirable to make use of the existing facility from financial point of view as well.

The data collected at Gedong is indispensable to the forecast of upper reaches since marked effect of tidal level is observed. Moreover, to increase the forecasting accuracy at this location, a comprehensive flood forecasting and warning system of Betang Krang basin together with the main river course of Sadong is highly demanded.

From the reasons stated above as well as the analysis of available hydrological data, the following rainfall gauging stations are proposed for future telemeterization:

- ° Balai Ringin
- ° Bedup

Rainfall Recorder Station

- Presently, there are only 10 to 15 rainfall gauges and 5 water level gauges installed in the upper reaches of Sadong River. It is highly recommended, therefore, to increase by far the number of recording-type gauging stations not only to raise the accuracy of flood forecasting but also to provide fundamental data required for the future river development plan.

  Siting plans for raingauges are to be made out so that a gauge could be installed in each divided section of the target basin having uniform rainfall characteristics. It is generally understood, however, that these patterns of characteristic rainfall are difficult to detect. To solve this problem the Japanese Engineering Standard for River and Sabo has designated that one raingauge be placed in every 50 km^2 area.

  Another example is the AMEDAS* system operated by Japan Meteorological Agency which collects rainfall data of segmented area separated by grids 17 km apart. (Segment Area: Approx. 300 km^2)

For the siting of water level gauges, locations assumed important for river management as well as river improvement program are to be selected. For example the gauges may be placed at confluence of tributaries with main river, upper and lower reaches of river structures such as gates and weirs, bottleneck of river channel, and in the vicinity of lakes, inner basin, estuary and other locations as may cause phenomenal hydrological effects.

In the Sadong River Basin, suitable locations for water level gauges are to be selected after carefully reviewing the existing conditions of the river system as well as socio-economic features of the area represented by the stage of economic growth and the distribution of population and properties.

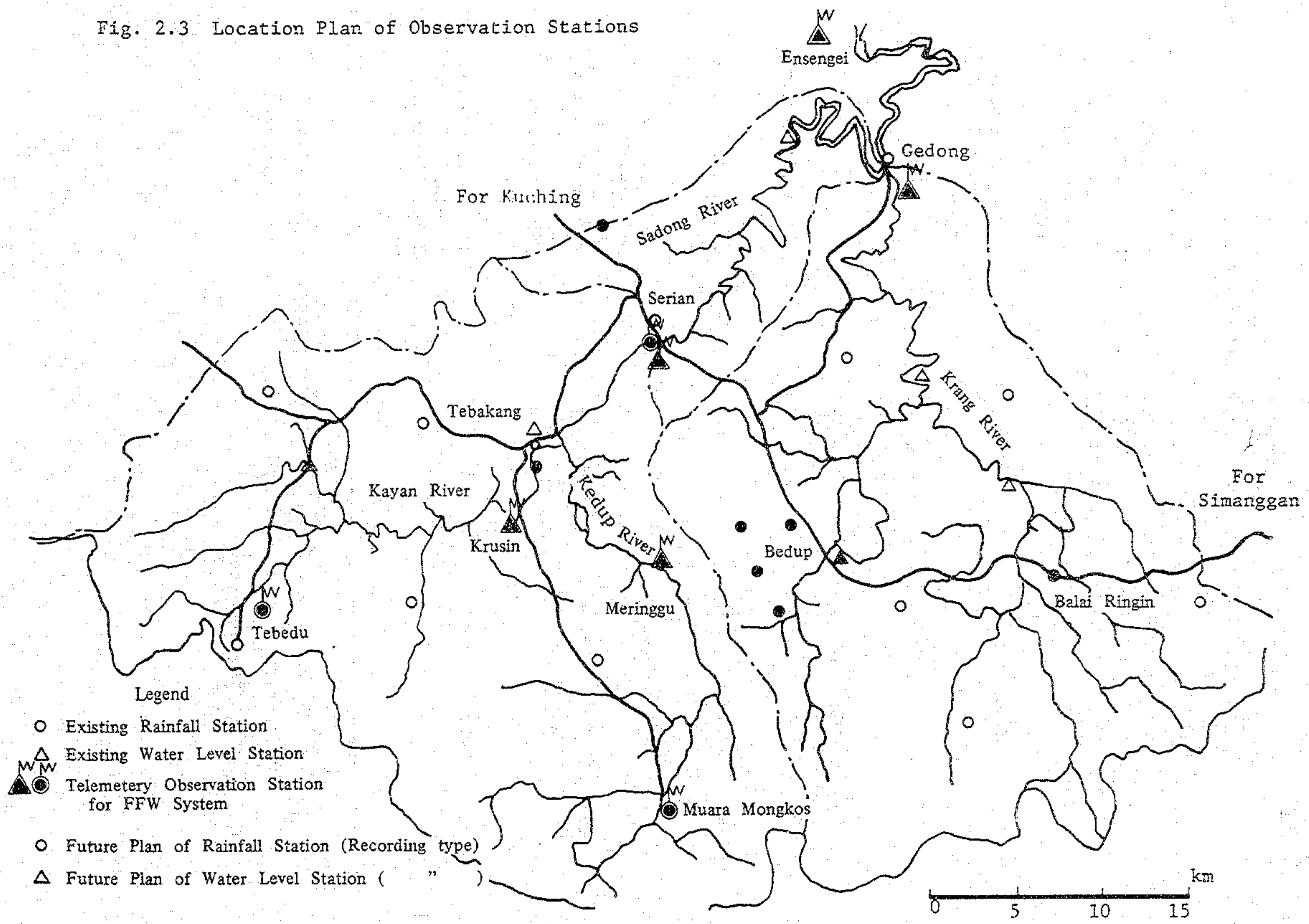
Fig. 2.3 shows the proposed locations considered necessary after this study. They are selected after hydrological study as well as locational conditions which would affect very much the construction and maintenance. The number is to be increased as soon as the surrounding conditions are improved to establish a thorough rainfall gauging network.

Table 2.1 Hydrological Observation Stations

	Station	River Basin	Classification	Remarks
1.	Tebedu	Kayan	R (Rainfall)	for upper reaches rainfall of Kayan River
2.	Mongkos	Kedup	R	for upper reaches rainfall of Kedup River
3.	Krusin	Kayan	W (Water level) [R,D (Discharge)]	
4.	Meringgu	Kedup	W (R,D)	
5.	Serian	Sadong	R,W (D)	Flood forecasting point
6.	Gedong	Sadong	W	Flood forecasting point
7.	Ensengei	Sadong	W	for tidal level observation
(8.	Balai Ringin)	Krang	(R)	for upper reaches rainfall of Krang River (future program)
(9.	Bedup)	Kedup	(R)	for upper reaches rainfall of Kedup River (future program)

Stations in paranthesis are to be installed in future for incorporation with the proposed system to achieve increased forecasting accuracy.

Fig. 2.3 Location Plan of Observation Stations



2.5 Relay Station and Flood Forecasting Center

2.5.1 Relay Station

A relay station is required to send the collected hydrological data from observation stations to flood forecasting center. From the field survey conducted, the T.V. station a top of Mt. Serapi belonging to Telecommunication Department would provide excellent location for the proposed telemetry system from economy as well as operation and maintenance points of view.

2.5.2 Flood Forecasting Center

This Center analyses all the data sent from the observation stations for making flood forecasting and warning.

The Center would be a vital organ for sending out in formations of expected floods, the flood warning as well as evacuation procedures. Experienced engineers with enough knowledge of hydro-meteorology are to be assigned for the task.

It is desirable, therefore, to place the Center within the D.I.D. Headquarters. Since the space available at the Headquarters is limited, the Center is to be placed in a building to be newly constructed at D.I.D. Biatawa Depot. Either public telephone or exclusive telephone link may be used for communication between the Center and the Headquarters.

CHAPTER 3 FLOOD FORECASTING

3.1 Hydrological Data

3.1.1 Rainfall Data

Rainfall Gauging Stations

There are nine rainfall gauging stations in the upper reaches of Sadong and Krang rivers as shown in Fig. 3.1. Most of the stations are equipped with a rainfall recorder, and observation has commenced since 1960.

Arrangement of Data

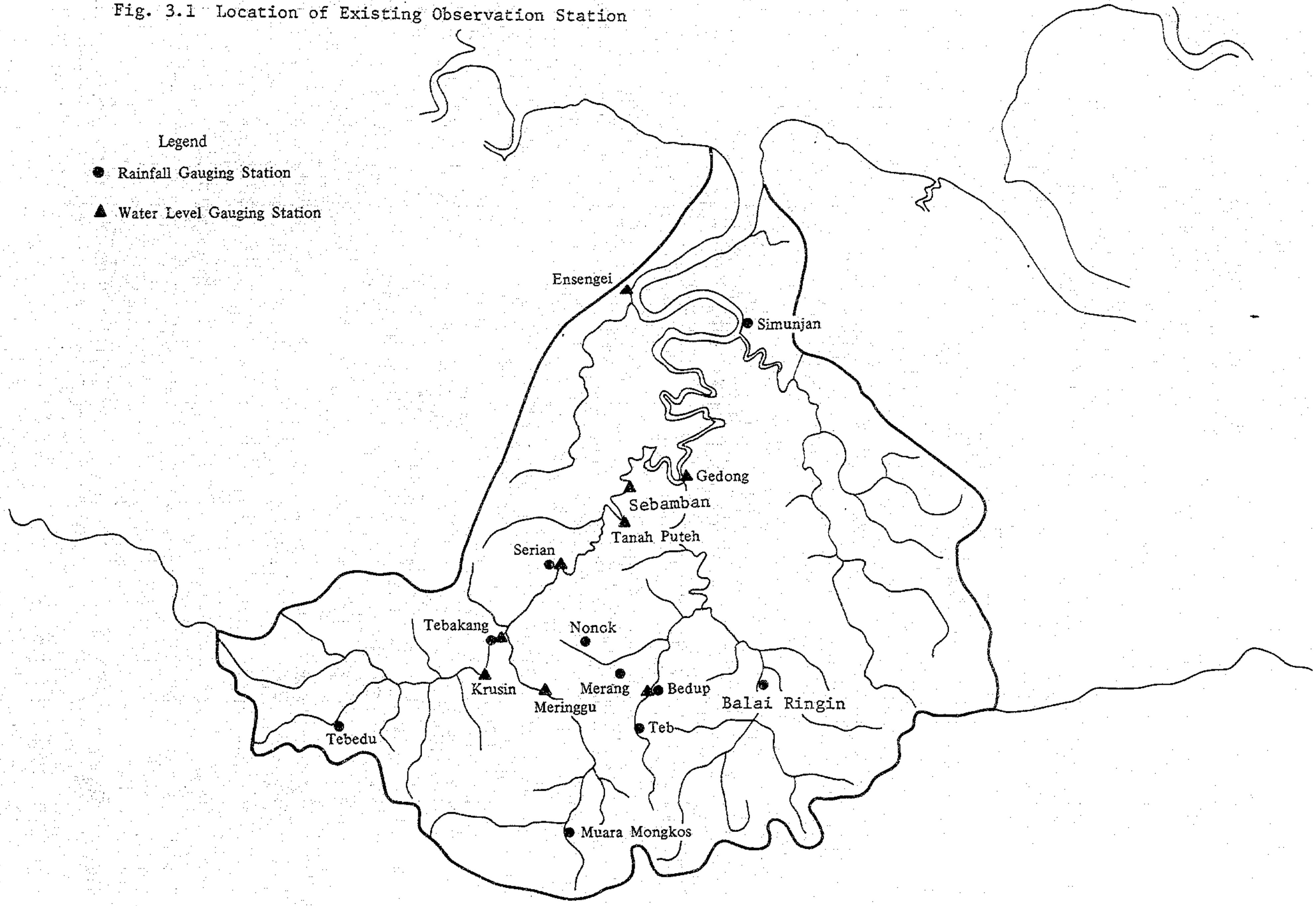
Daily rainfall data recorded at each station are compiled in "Sarawak Hydrological Year Book". Daily rainfall data in major floods experienced from 1963 to 1976 are summarized in the preliminaly survey report. Hourly rainfall data are quoted from "Flood Investigation Report Batang Sadong and B. Krang, Feb. 1974", as given in Fig. 3.2.

3.1.2 Water Level Data

Water Level Gauging Stations

Water level gauging stations at Serian and Bedup have been in operation since olden times, both of which are equipped with a water level recorder like the Gedong station. The Krusin and Meringgu stations have been installed in 1977 to collect hydrological data required for the construction of two flood control dams. At these stations, observation is done at 6:30 and 18:30 daily and at the three-hour interval in a flood.

Fig. 3.1 Location of Existing Observation Station



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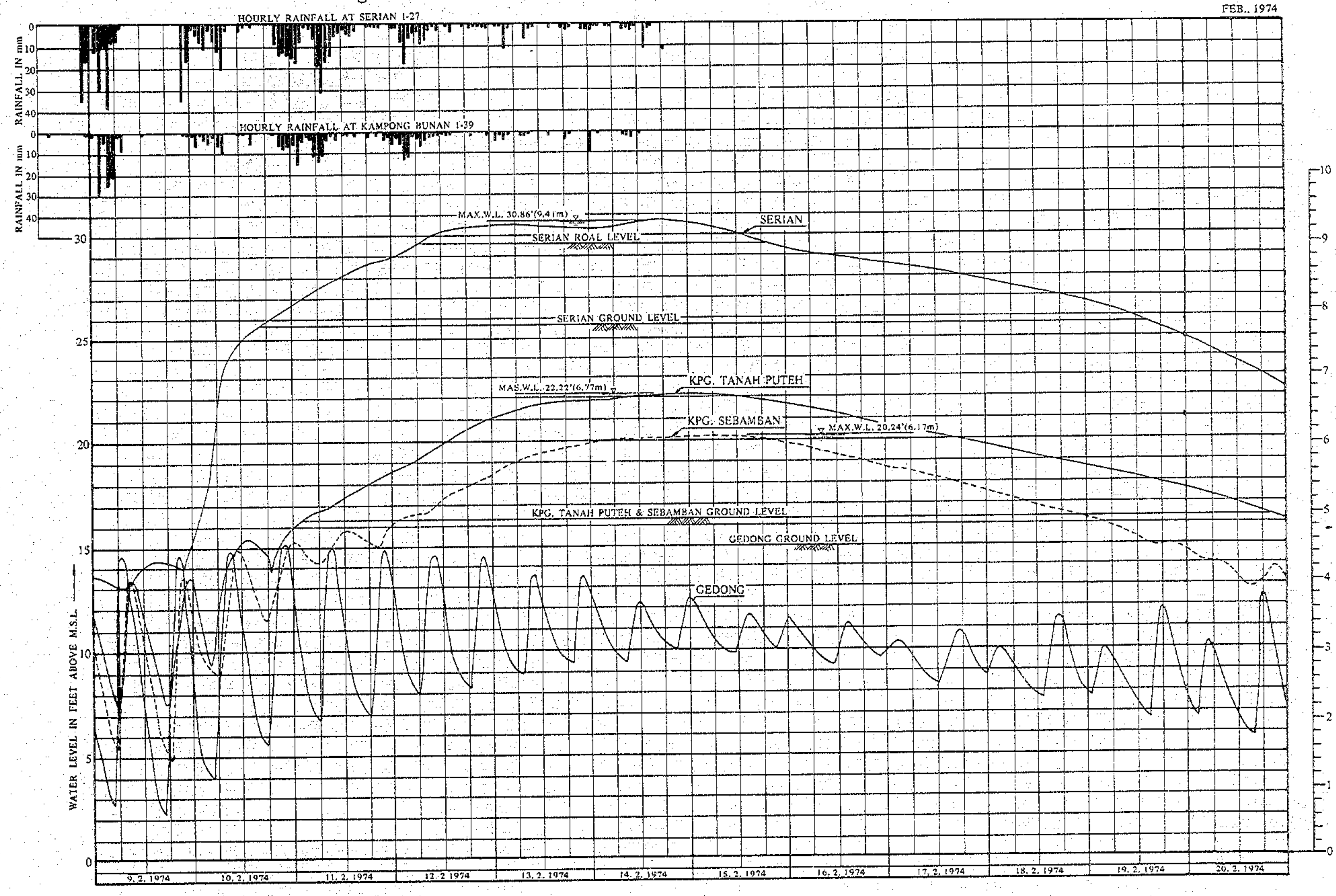
SARAWAK

Fig. 3.2 Flood Hydrograph of Btg. Sadong at Serian, Kpg. Tanah Puteh, Kpg. Sebamban & Gedong



The stations at Tanah Puteh and Sebemban were washed away by the flood in 1976.

Arrangement of Data

In the same way as the rainfall data, water level data at Serian and Bedup are compiled in "Sarawak Hydrological Year Book". Besides, data recorded in floods are available. Water level data in yearly major floods collected at Serian from 1963 to 1975 are summarized in the preliminary survey report. The water level data at Serian, Gedong, Tanah Puteh, Sebemban in the flood of February, 1974 are presented in Table 3.2.

3.2 Hydrological Examination of Telemetry Station Location

3.2.1 Rainfall Gauging Stations

Siting Criteria

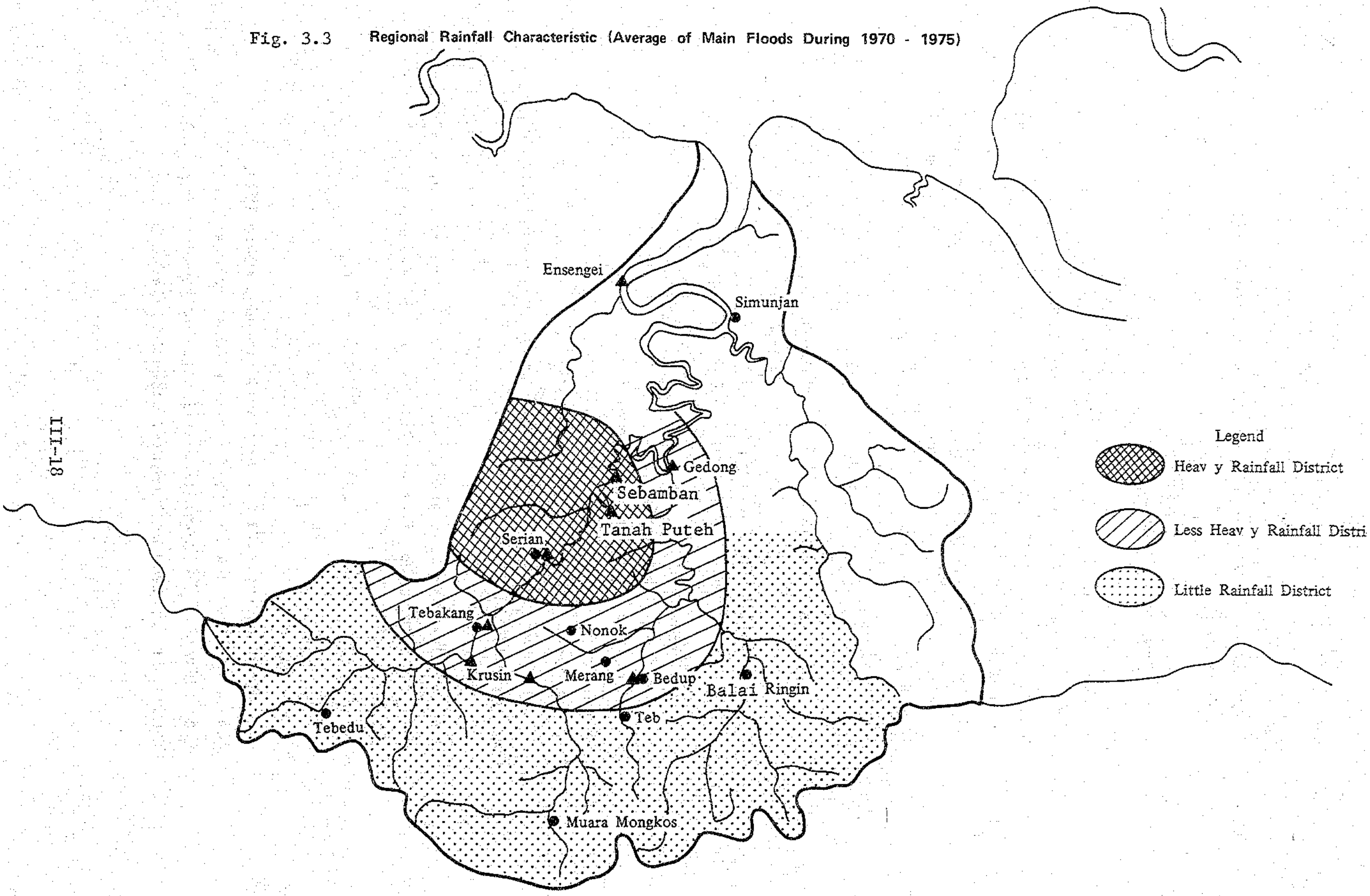
The rainfall gauging (telemetry) stations is to located in such positions that the rainfall characteristics in the target river basin area can be acquired with accuracy. For this purpose, surveys and analyses should be conducted based on the available hydrological data.

The location of rainfall stations to be equipped with a telemeter is determined after a careful study on the available data.

Location

Based on the rainfall data well-arranged since 1970, isohyetal lines are obtained from the total rainfall in the major floods. The rainfall distribution is shown in Fig. 3.3. Though the accuracy of isohyetal lines is relatively low

Fig. 3.3 Regional Rainfall Characteristic (Average of Main Floods During 1970 - 1975)



due to insufficient data, it is estimated that the middle reaches in the vicinity of Serian and Narok suffer from heavy rainfall during a flood, and that hilly lands of Tebede, Muara Mongkos and Barai Ringi have a relatively small rainfall. Tebakang, Merang and Bedup have the intermediate rainfall between the above two groups.

In the first hand, Serian can be nominated as a site for rainfall telemetry station, because Serian is located at the center of the heavy rainfall district. Secondary, Tebede and Mongkos in the upper reaches are selected.

The rainfall in the intermediate rainfall district can be estimated from the rainfall data of Serian and Tebede/Mongkos on the ground that its rainfall shows intermediate between those at Serian and Tebede/Mongkos. As a matter of course, it is preferable to install stations in the intermediate rainfall district in the near future.

3.2.2 Water Level Gauging Station

The points performing water level observation are Serian, Krusin and Meringgu along Sadong river, Gedong and Bedup along Krang river.

The existing water level gauging stations in the Sadong river system are schematically presented in Fig. 3.1. Water level gauges shall be placed at such a place that the water levels at warning points can be estimated. The flood warning points will be placed at Tebakang, Serian, Tanah Puteh, Sebamban and Gedong.

The relative position of these water level gauging stations and the target area for flood forecasting and warning could be illustrated as follows:

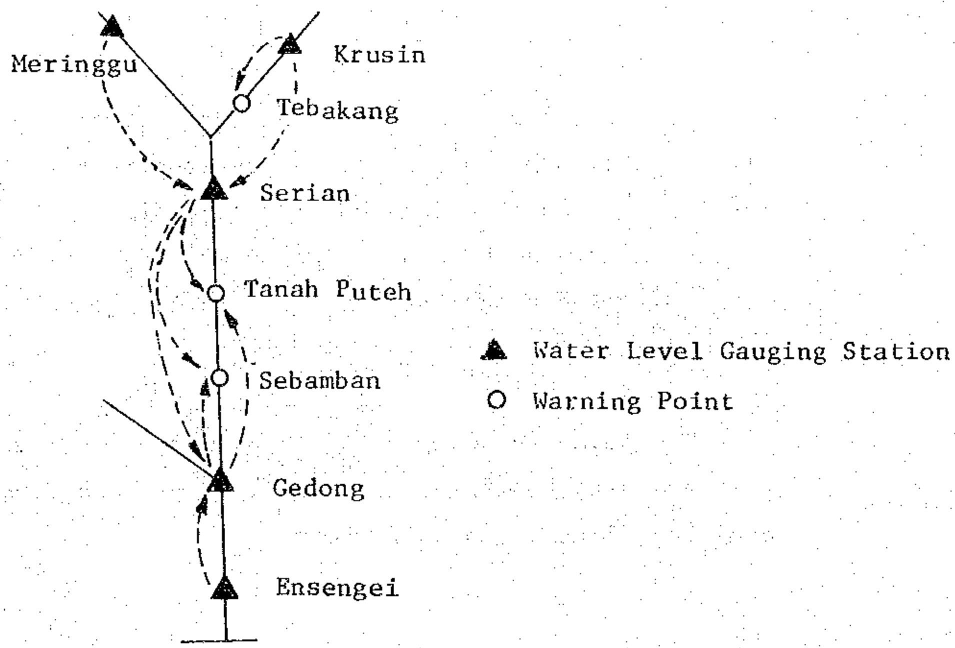
The water levels at Tebakang and Serian can be forecast by that at Krusin in the upper reaches and those at Krusin and Meringgu respectively. Flood forecasting at Tanah Puteh and Sebamban in the lower reaches of Serian, both of which are subject to tidal influence, can be made, judging from the water levels at Serian and Gedong. Gedong is so subject to tidal influence that a station has to be placed at Enssengei near the estuary to facilitate flood forecasting from the relation of water levels at Enssengei and Serian.

With due consideration for the above, the following locations were selected for water level gauging station:

Krusin, Meringgu, Serian, Gedong, Ensengei

For maintenance and examination of the proposed water level telemeter, land transportation is available for Serian, Krusin and Gedong, and boats can be used to go to Meringgu and Ensenggei.

For details, photographs and skatches are compiled in Appendix.



3.3 Flood Forecasting Methods

3.3.1 Flood Forecasting Methods

Principal flood forecasting methods used today are as follows:

Table 3.1 Classification of Flood Forecasting Method

Input	Output	Forecasting Process
Water level or discharge	Water level or discharge	Channel flow condition
Water level or discharge and basin rainfall	Water level or discharge	Residual basin run-off to channel flow
Basin rainfall	Discharge	Run-off from basin

3.3.2 Classification by Calculation Method

Correlation Method (correlation chart, coaxial correlation chart, correlation formula)

Using the existing hydrological data, the output factors (water level or discharge) of the forecasting point are projected through correlation analysis of the input factors (water level, discharge or rainfall) available at the data-collection point, taking the flood travel time between these points into consideration.

The output factors at the forecasting point are determined approximately by processing the input information gathered during floods using quantitatively-processed correlation charts or correction formulas. In some cases, the prediction accuracy could be improved by including as auxiliary parameters the water level (discharge) of major tributaries and the rainfall in the residual basin area between the data-collection point and the forecasting point.

In using this method, either the water level (discharge) versus water level (discharge) correlation or rainfall versus water level correlation is generally employed.

- Water Level (discharge) Versus Water Level (discharge) Correlation

  In the main stream channel of a large river, water level forecasting for a downstream point could be made on the basis of the water level (discharge) correlation and the flood travel time between the two points. This widely used method of flood forecasting can also be applied to the dam, which has a relatively long upstream channel extension (catchment area of more than 500 km^2). In many cases, the prediction of flow conditions with higher accuracy may be possible by introducing auxiliary parameters prepared with attention to the hydrological characteristics of the river basin (e.g., causes of rainfall, rainfall distribution, tributary runoff).

  The velocity of flood wave in the river channel is estimated to be 10-20 km/hr in the upper and middle reaches and 5-10 km/hr in the middle and lower reaches. This would serve as the basis of forecasting time-lag.

- Rainfall Versus Water Level (discharge) Correlation

  In this method which has also been used widely, the runoff and the hour when it will take effect are predicted by means of correlation diagram and simple correlation formulas. Though it is generally low in accuracy to the above correlation method (a), it could be both convenient and effective when advance forecasting is required.

The coaxial correlation method is the developed type of correlation method, in which the runoff phenomenon is evaluated using such auxiliary parameters as rainfall and various other conditions of the river basin. This method could be fairly accurate with the adequate choice of parameters and reliable statistical data.

Runoff Analysis (runoff function method, tank mode method, unit hydrograph)

In this method, the runoff characteristics in the basin area upstream of the forecasting point are converted into constants for the runoff calculation formulas by analyzing the existing hydrological data (rainfall and discharge). Then, at the time of flooding, the available rainfall data is put to computation with the runoff calculation formula to predict the discharge at the forecasting point.

This method, when compared with the correlation method, feature much longer time-lag of forecasting and an improved prediction accuracy. Particularly when a flood runoff is supposed to be affected by flood control facilities, it is desirable that the predictions be made using a series of runoff analysis models prepared beforehand.

When this calculation method is to be employed, discharge gauging at the forecasting point and one on two additional rainfall gauging stations at each major tributary would be required. Furthermore, complex computation of some sophisticated runoff calculation models would call for the use of electronic computer.

3.3.2 Proposal of Flood Forecasting Method

The correlation method for flood forecasting is recommended as an initial step of the flood forecasting system operation, view of the existing hydrological data, the number and location of proposed telemetry stations, the flood information available and required forecasting time-lag.

However, the future increase in population and properties within the warning area would require an improved prediction accuracy and longer forecasting time-lag and moreover the installation of flood control structure in the basin area would make it necessary to switch to the runoff analysis for flood forecasting.

As preparatory steps for the switchover to the runoff calculation method, therefore, it would be necessary to gather and analyze the hydrological data, conduct discharge observation and longitudinal and cross-sectional surveying of the river channel, and to increase and telemetrize the rainfall gauging stations.

3.4 Preparation of Flood Forecasting Models

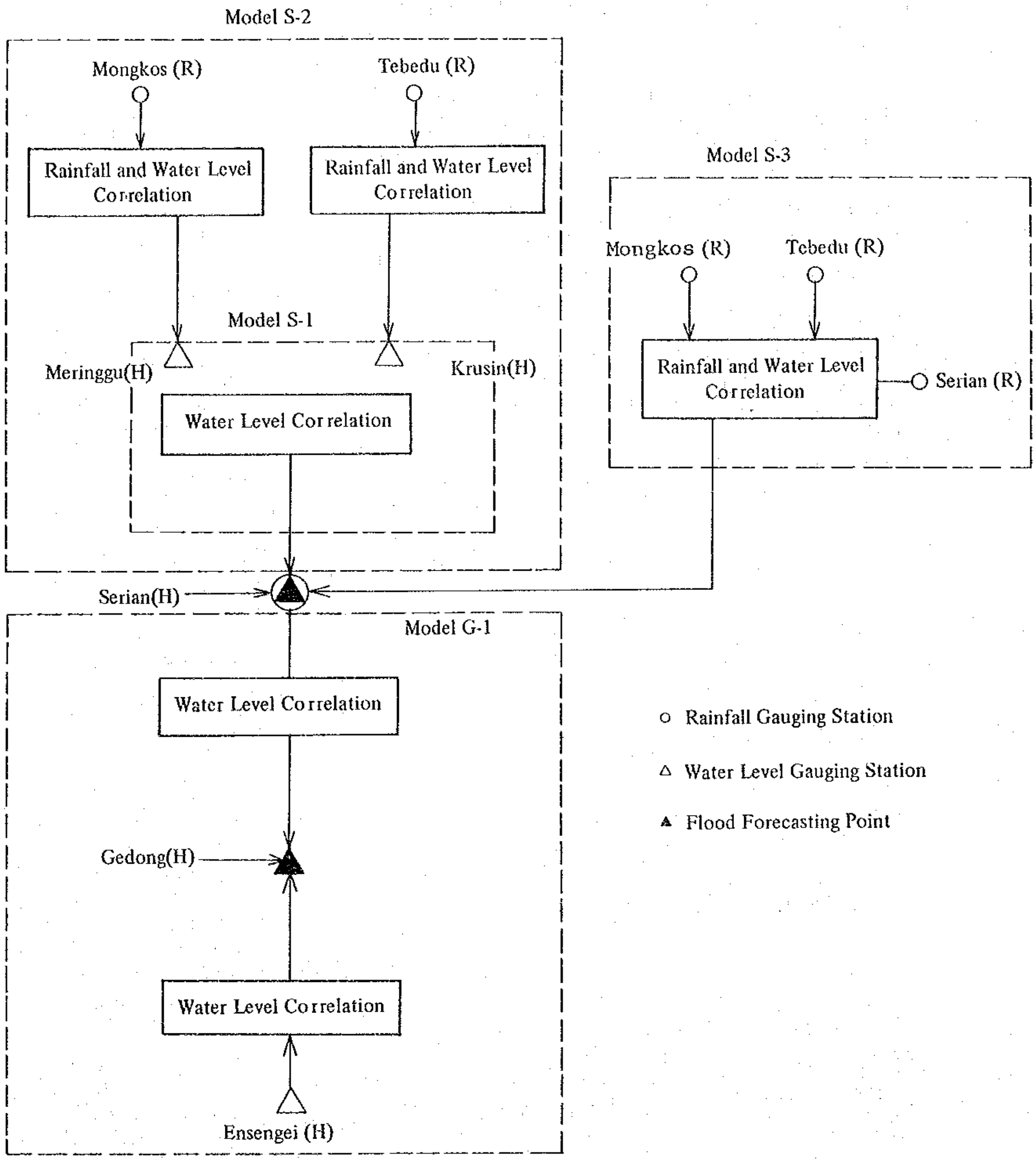
3.4.1 Flood Forecasting Models

The following table shows the proposed flood forecasting models for the Sadong river basin. With the accumulation of hydrological data, however, it would be necessary to continue to examine and analyze the validity of forecasting models, particularly the correctness of correlation, the necessity of parameters and the forecast accuracy.

Table 3.2 Flood Forecasting Model

Forecasting Model	Forecast Point	Input Factors	Application
Model S-1 (Water level - water level)	Serian	Krusin and Meringgu Water levels	Basic model for water level prediction of Serian (Short term forecasting)
Model S-2 (Rainfall - water level, water level - water level)	Serian (Krusin) (Meringgu)	Tebedu and Mongkos Rainfall	Water levels at Krusin and Meringgu are estimated using rainfall data of Tebedu and Mongkos. By Model S-1, the water level at Serian can be forecast. Long term forecasting is possible though its accuracy is not high. In the future, the accuracy can be improved by incorporating rainfall data at Krusin and Meringgu into the forecasting model. (Long term forecasting)
Model S-3 (Rainfall - water level)	Serian	Mongkos, Tebedu and Serian rainfall	Back-up model in case of lack of water level data at Krusin and Meringgu. Long term forecasting is possible in spite of poor accuracy.
Model G-1 (Water level - water level)	Gedong	Serian water level, Ensengei tidal level	Forecasting is based on the water level records. Actually, Serian water level forecast by the above model and the corresponding water levels at Ensengei will be used. Long term forecasting is possible, though the accuracy is low.

Fig. 3.4 **Flood Forecasting Model**
(Sadong River Basin)



In any model, further analysis and study on the items below are required as the data are accumulated.

- Improvement of forecasting model
- Adjustment of co-relation in a model
- Incorporation of sub-parameter
- Comprehension of forecasting accuracy

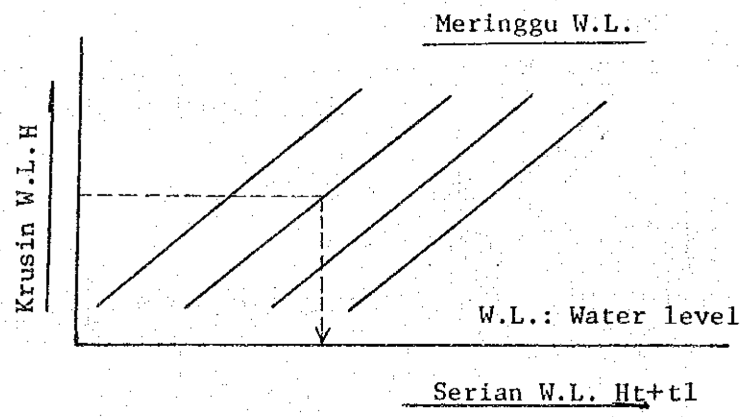
3.4.2 Procedures for Preparing Flood Forecasting Models

Forecasting Model S-1 (Krusin and Meringgu Water Levels into Serian Water level)

The water level at Serian is predicted from the water levels at Krusin and Meringgu, using the correlation chart which is shown in a simplified form below.

The correlation charts are to be prepared by the following procedure:

- Based on the results of discharge measurement, calculated flow velocity of floods, and water level correlation of three points, flood travel time tl_1 between Krusin and Serian and tl_2 between Meringgu and Serian are estimated. The shorter one of the above two flood times is regarded as the flood travel time tl.
- Taking into consideration each flood travel time, water level data summarized as below are plotted on the figure.



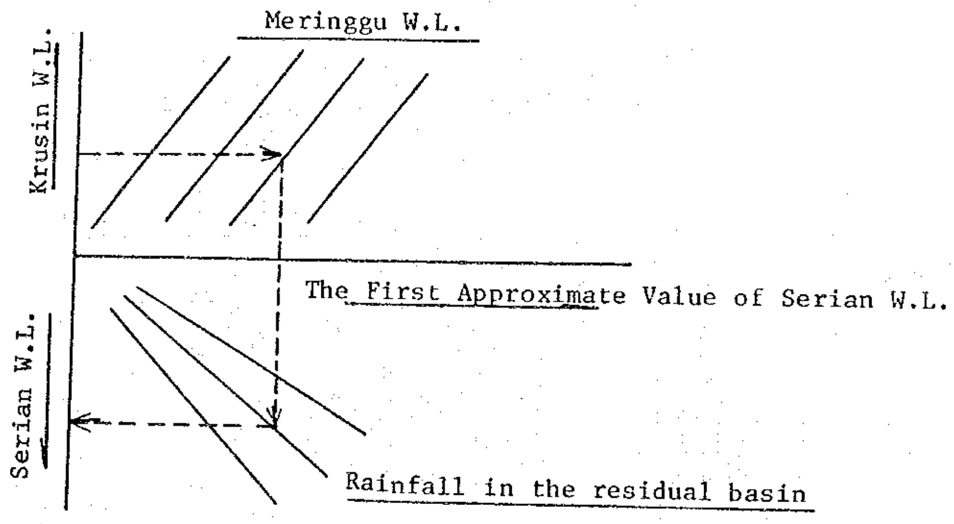
Time	Krusin Water level	Meringgu Water level	Serian Water level
t	$KH\ (t - tl_1)$	$MH\ (t - tl_2)$	SHt
1	$KH\ (1 - tl_1)$	$MH\ (1 - tl_2)$	SH1
2	$KH\ (2 - tl_1)$	$MH\ (2 - tl_2)$	SH2
3			

- The water level correlation curve with a parameter of Meringgu water level is drawn by either interpolation or extrapolation.

In case of tl_2 tl_1 for example, input data at the forecasting hour t shall be;

Krusin water level : KHt
Meringgu water level: $MH\ [t - (tl_2 - tl_1)$

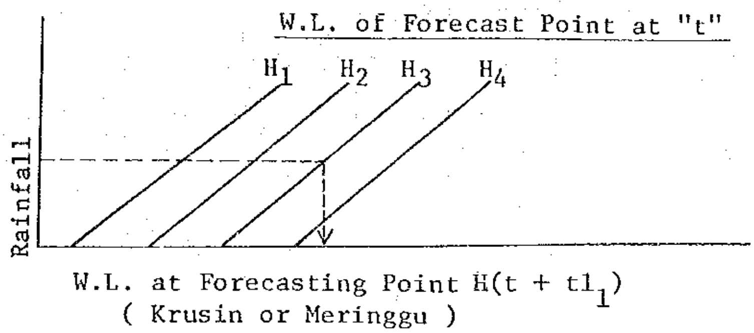
In case that a serious error of forecast values estimated from the above correlation appears due to run-off from the residual basin of the three point, a telemetry water level station shall be placed at the main tributary in the residual basin, and otherwise a telemetry rainfall station shall be installed at the important places in order to compensate the error.



Forecasting Model S-2 (Tebedu Rainfall into Krusin Water Level and Mongkos Rainfall into Meringgu Water Level, Krusin and Meringgu Water Levels into Serian Water Level)

Krusin and Meringgu water levels are estimated from Tebedu and Mongkos rainfall data, and further Serian water level is forecast using the forecasting Model S-1.

Correlation diagram between rainfall and water level is prepared after estimating Krusin and Meringgu water levels as shown below. The water level at the place in question and rain intensity $\bar{r}t$ during the time which controls flood run-off are used as input data.



$$\bar{r} = \frac{r\ (t-n) + r\ (t-n-1) + \ldots\ldots\ldots\ldots + rt}{n}$$

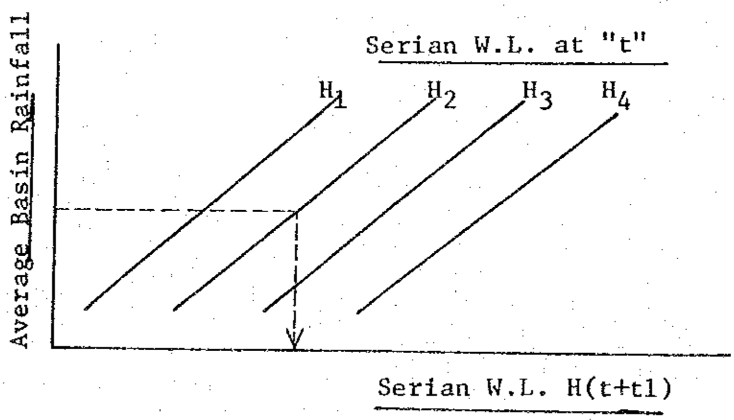
n : Rainfall duration which verifies a flood run-off.

The flood travel time "tl" and the above "n" are determined after a study on the existing and newly collected data.

The correlation diagram is prepared in the same way as the forecasting model S-1.

Forecasting Model S-3 (Tebedu, Mongkos and Serian Rainfall Data into Serian Water Level

A correlation between rainfall and water level is prepared from the rainfall data of three stations to forecast the Serian water level. The flood travel time tl and H(t+tl) are forecast from the average rainfall intensity $\bar{r}t$ and water level Ht at the forecasting point.



Average rainfall in the basin $\bar{R}t$

$$= \frac{\text{Tebedu Rt} + \text{Mongkos Rt} + \text{Serian Rt}}{3}$$

Average rainfall intensity in the basin $\bar{r}t$

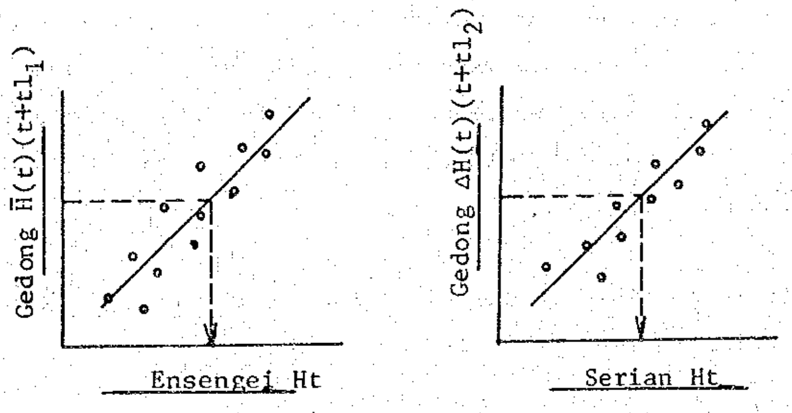
$$= \frac{\bar{R}\ (t-n) + \bar{R}\ (t-n-1) + \ldots\ldots\ldots + R\bar{t}}{n}$$

where, n : Rainfall duration which verifies flood run-off.

n and tl (flood travel time) are determined after a study on the hydrological data.

<u>Forecasting Model G-1 (Serian and Ensengei Water Levels into Gedong</u>

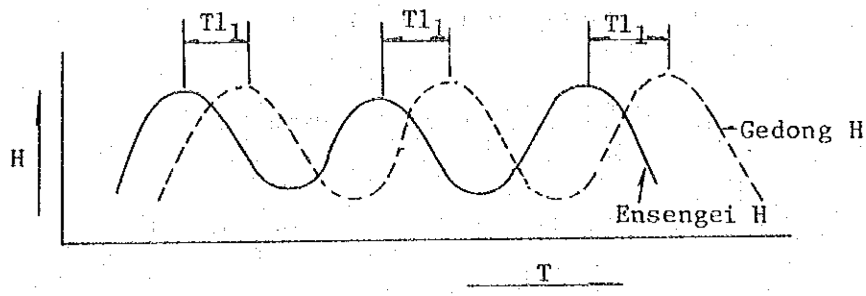
The water level forecast for Gedong, which is subject to the influence of tidal waves, is made on the basis of the water levels at Serian and Ensengei as follows:



Gedong $\bar{H}$ (t + tl) = Gedong H(t) + Gedong H(t) .... (3-1)

- Correlation between Ensengei Water Level and Gedong Water Level

The correlation between the Ensengei water level and the Gedong water level may be represented as follows:

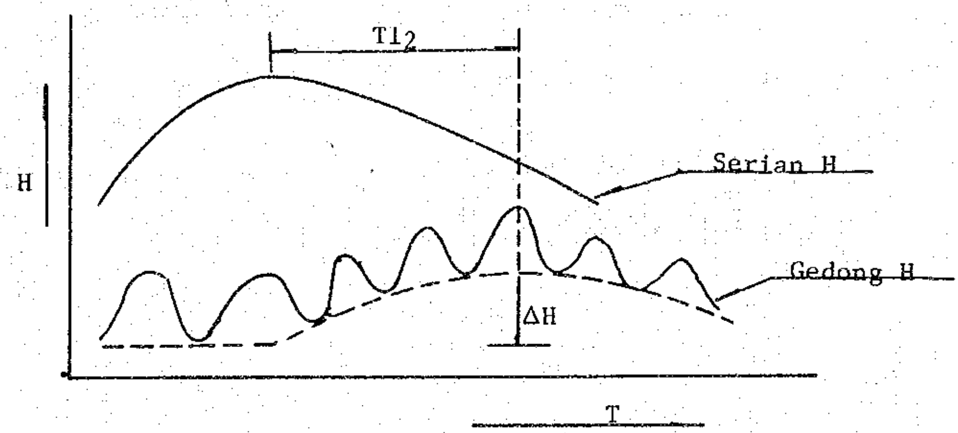


The correlation chart must be prepared based on the correlation between the Ensengei Water level and Gedong water level determined from normal time data, as shown above.

- Correlation between Serian Water Level and Gedong Water Level

At normal time, it could be assumed that no correlation exists between the water levels at Serian and Gedong because of the superseding effects of the tidal waves. At flood-period, however, the increased discharge will markedly affect the water level. The correlation betwen the water levels at Serian and Gedong is to be established by determining the water level rise at Gedong due to the flood discharge is to be examined for its correspondence with the water level at Serian for preparation of correlation diagram.

It is possible to calculate the water level at Gedong during a flood from formula (3-1).



3.5 Verification of Flood Forecasting Models

3.5.1 Preparation of Forecasting Formula

Although the data collected at the project site are insufficient to prepare a correlation diagram, diagrams at the following places are prepared as a trial and their accuracy is reviewed.

Correlation between the average total rainfall in the basin and Serian peak water level

Based on the hydrological data of major floods from 1963 to 1975, a correlation diagram is prepared.

Following Table presents the average total rainfall accumulated from the beginning and the corresponding Serian water level.

Table 3.3 Correlation between Serian water level and average rainfall

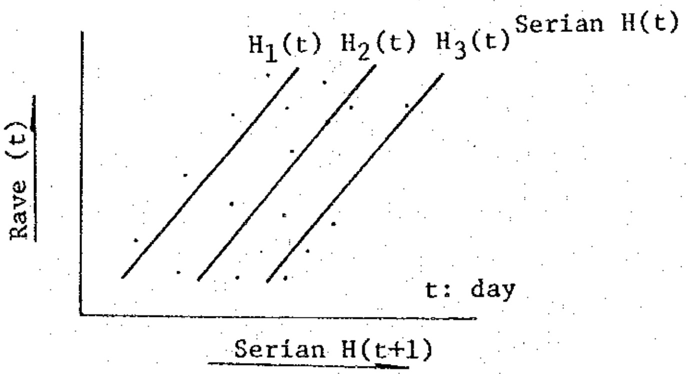
YEAR	Serian Peak water level MSL (m)	Average Rainfall (mm)
1963 Jan.	9.36	237.4
1965 Mar.	8.15	151.8
1966 Jan.	8.09	145.5
1967 Mar.	8.09	127.0
1968 Jan.	8.84	371.9
1969 Dec.	9.06	328.6
1970 Jan.	8.26	201.3
1971 Feb.	8.38	301.1
1972 Jan.	8.15	115.2
1973 Dec.	8.74	364.3
1974 Feb.	9.41	380.1
1975 Feb.	9.34	150.5

The diagram using the data in the Table is given in Fig. 3.5.

Correlation between the average daily rainfall and Serian water level

Average daily rainfall of the experienced major floods and Serian daily water level are studied in the following process to prepare a correlation diagram.

- Average daily rainfall in the basin is algebraically obtained.
- Serian daily water level and average rainfall in the basin are summarized in a table.
- Judging from the relation between rainfall and Serian water level, flood travel time is considered 20 to 30 hours. In this case the flood travel time is assumed at one day.
- The storage capacity of the channel is so great due to sluggish gradient that water level forecasting from the rainfall data is considered to vary by the initial water level.
- A diagram with a vertical axis of daily rainfall and a horizontal axis of water level (one day later) is prepared as below. The existing flood data are plotted in the diagram. Serian water level (at the same time) is also put down at the corresponding plotted points.



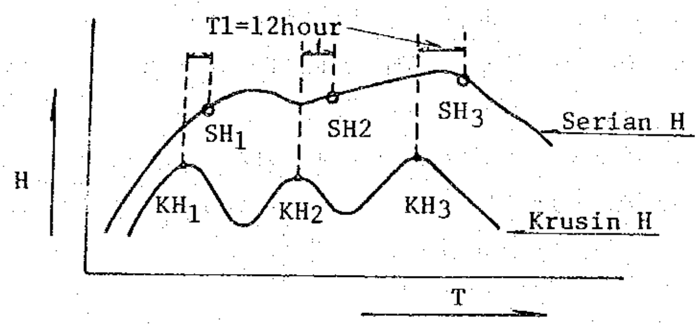
- Reading the values of the plotted points, Serian water levels (at the same time) are drawn in the figure.

Correlation between Krusin water level and Serian water level

Serian water level is forecast from the water levels at Meringgu of Kedup river and Krusin of Kagan river. The water level at Meringgue has to be estimated from the correlation diagram between Krusin water level and Serian water level.

- The time lag between the time of peak Krusin water level and that of peak Serian water level is considered to be 12 hours on an average.

- Correspondence between Krusin water level and Serian water level at 12 hours later is studied as shown below (January to February, 1977).



The water levels at Krusin and Serian are plotted in a figure, in which a relation curve is drawn as shown in Fig.

3.5.2 Verification of Correlation Diagram Accuracy

The accuracy of correlation diagram prepared in 2.5.1 is verified using the data of the experienced floods.

Correlation between the average daily rainfall and and Serian water level

The data of floods in 1963, 1974 and 1975 are reviewed by the method described in 3.5.1. Based on these data, Serian water level (one day later) is estimated from the correlation diagram between the average daily rainfall and Serian water level (at the same time) as shown in Fig. 3.5..

Correlation between Krusin water level and Serian water level

Based on the data of the flood in February of 1977, the accuracy is verified. The results are shown in Fig.3.7 and 3.8.

The above verification results show high accuracy in Fig. 3.9. It is possible to improve the accuracy by the data to be collected in the future.

Fig. 3.5 Correlation between Rainfall and Peak Water Level at Serian

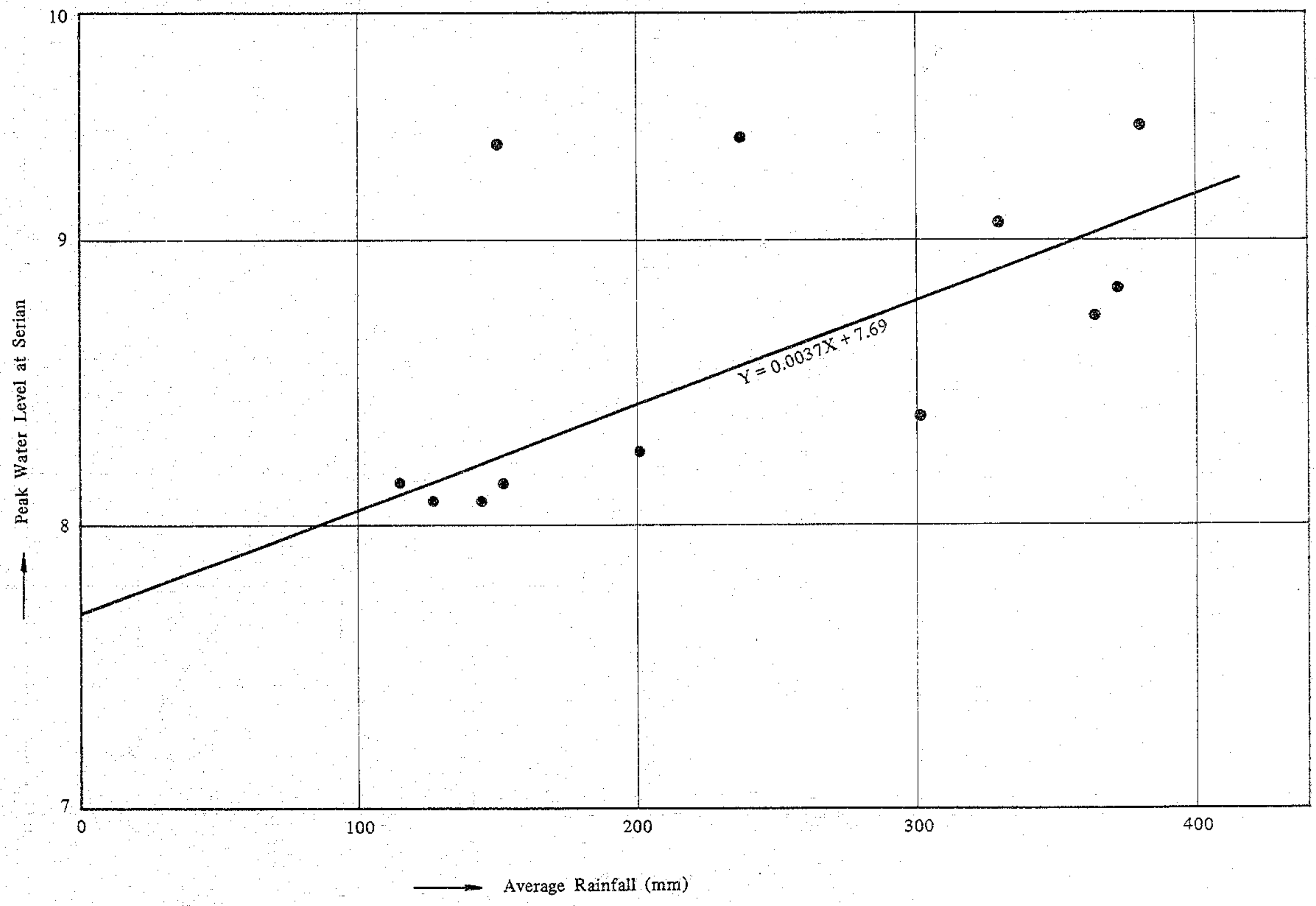


Fig. 3. 6 Correlation of Water Level between Krusin and Serian (1)

(Before Peak Water Level)

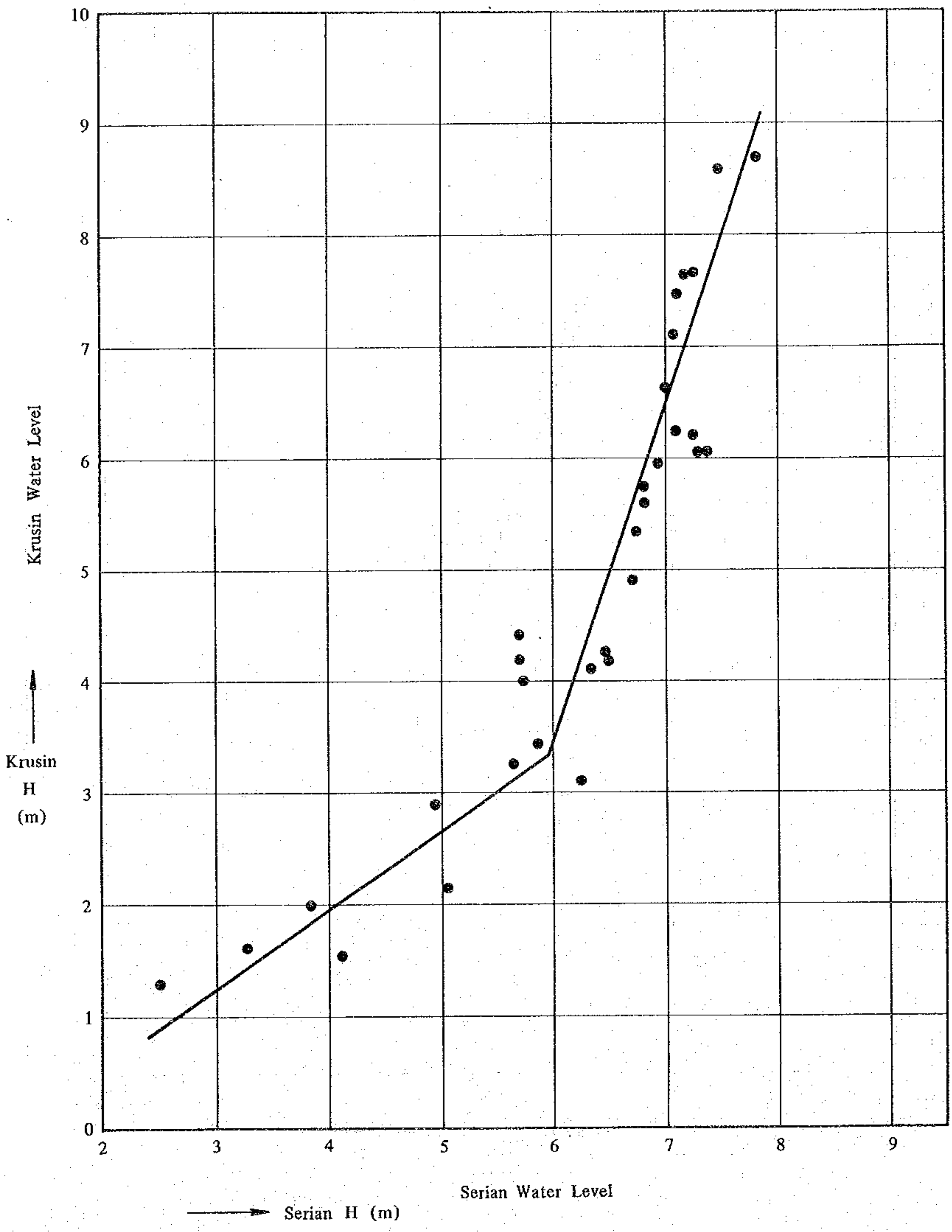


Fig. 3.7 Correlation of Water Level between Krusin and Serian (2)

(After Peak Water Level)

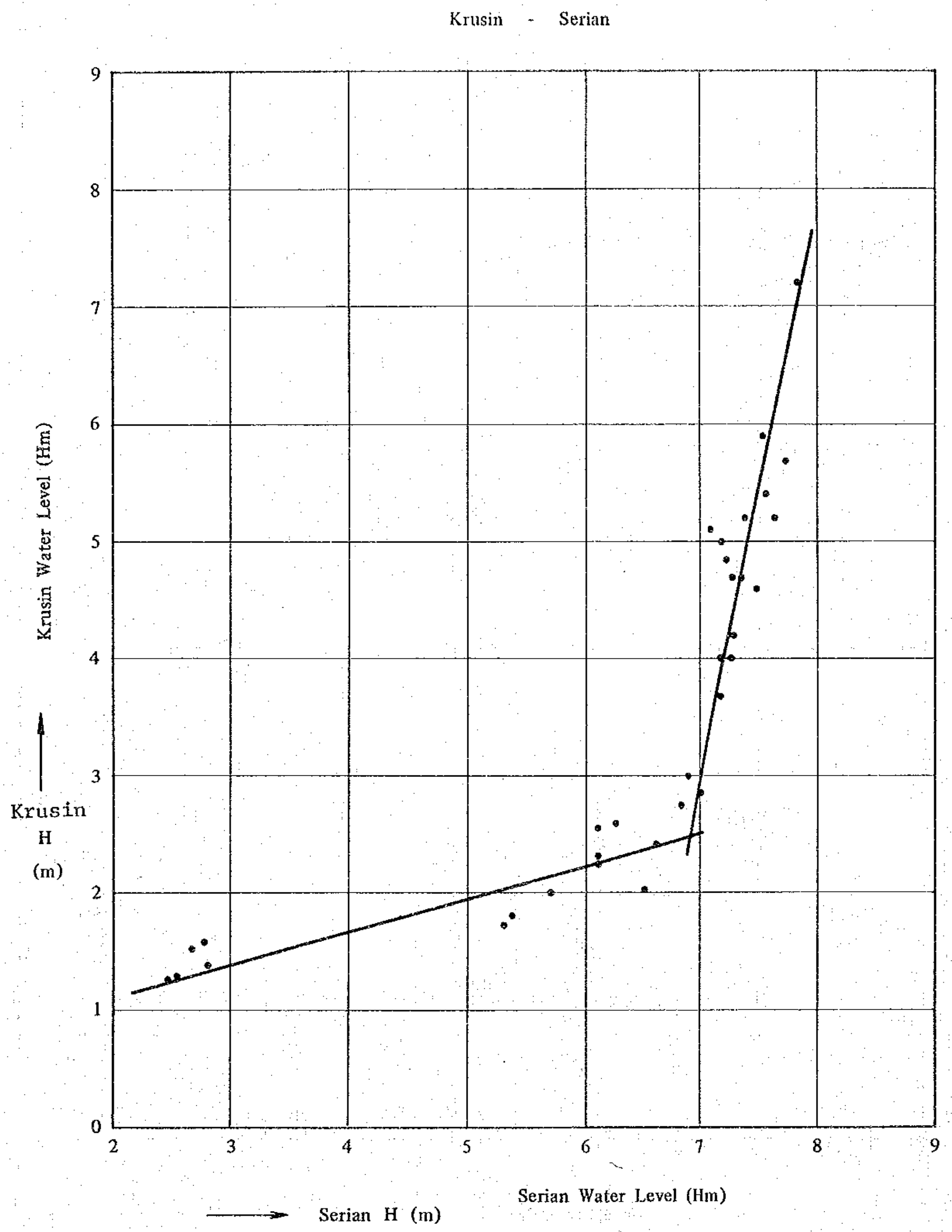


Fig.3.8 Correlation between Rainfall and Serian Water Level

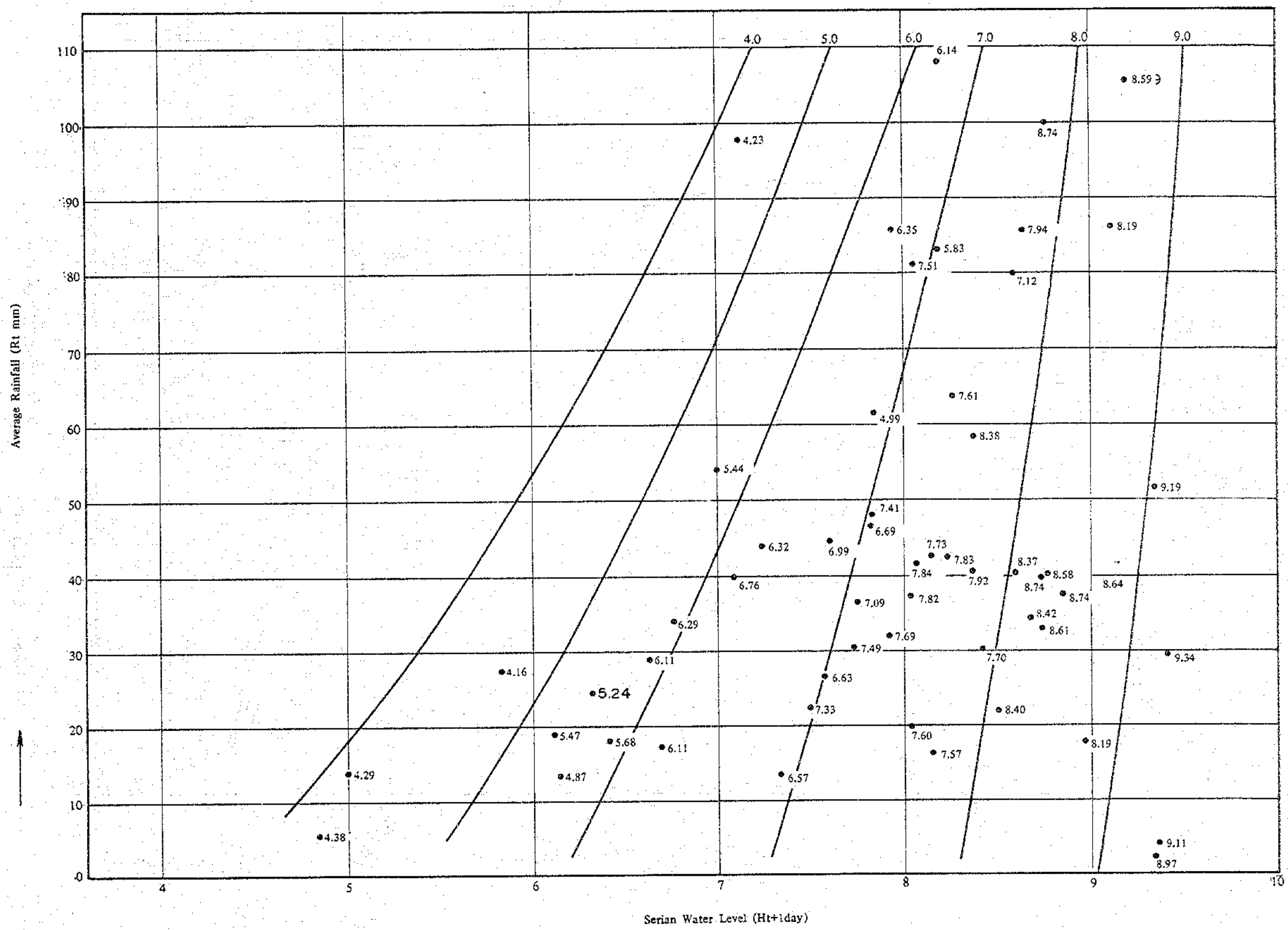
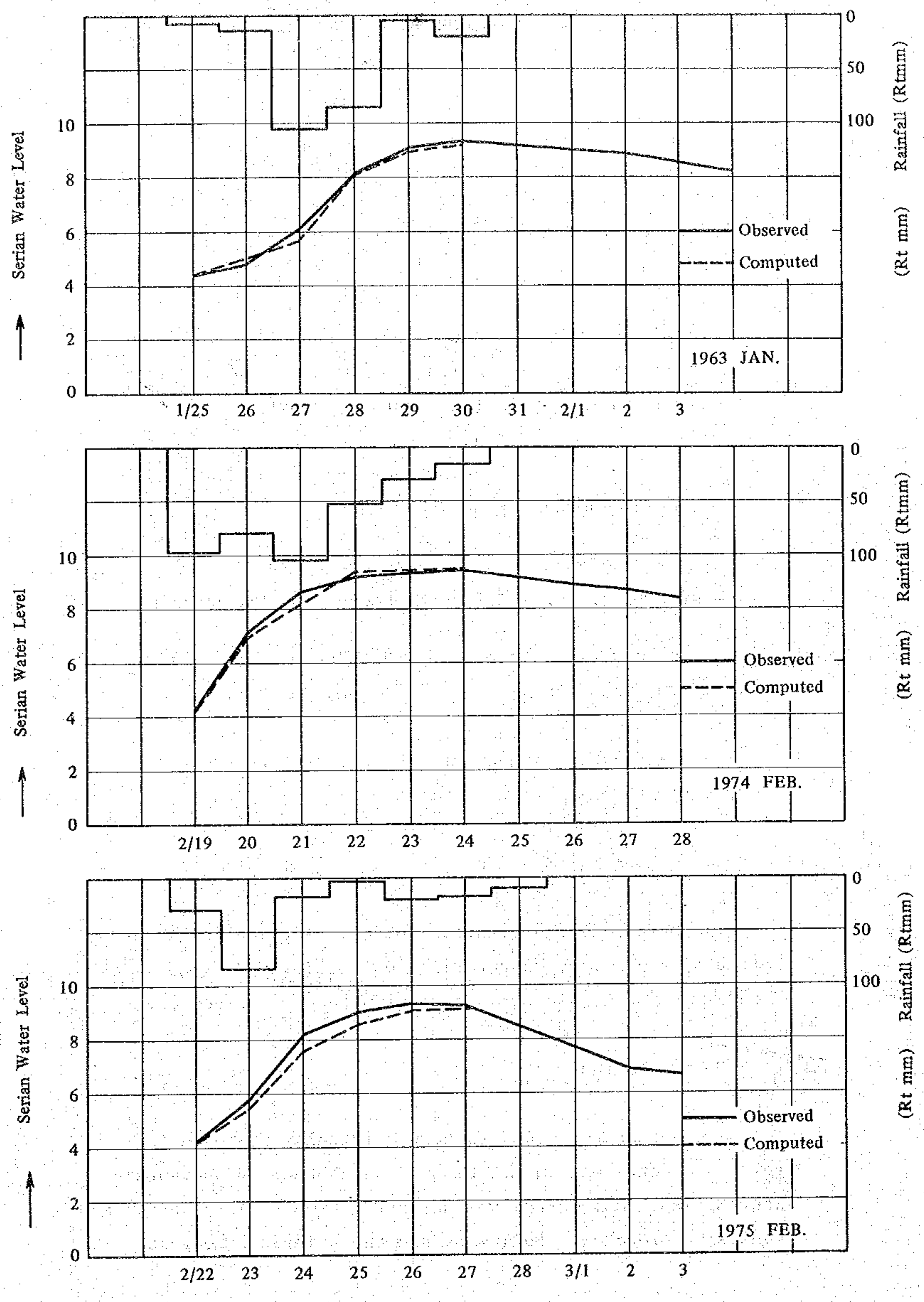


Fig. 3.9 Forecasting for Serian Water Level



CHAPTER 4 TELECOMMUNICATION SYSTEM

4.1 Outline

This survey has been conducted in accordance with the telemetry system plan recommended in the preliminary survey report.

In dealing with the telecommunication network of the telemetry system, consideration was given to the following points cited in the preliminary survey report:

- The network is to incorporate any usable facilities of the Telecommunication Department
- A VHF radio network is to be established in view of the stability, reliability and economy of the system
- The network is to be capable of accommodating future extension program

The telecommunication network of the telemetry system consists of the following stations:

4.1.1 Master Control Station

The Master Control Station is to be located in the DID Office of Bintawa in the outskirts of Kuching where the Flood Forecasting Center is also proposed to be located.

4.1.2 Relay Station

Two candidate locations were originally proposed for relay station. One is Mt. Serapi and another is a mountain near Serian. Mt. Serapi was selected through field survey and analysis conducted. Following are the principal reasons:

- The Telecommunication Department has its T.V. station on Mt. Serapi. Structures, tower, access road and power supply are already established thus providing a financial advantage by avoided newly construction

- Although remote from Sadong river basin, it is advantageous because it commands open vista to all station

- It will easily accommodate future extensions of the telemetry system

4.1.3 Observation Stations

- Rainfall gauging stations

  Tebedu
  Mongkos
  Balai Ringin (in the future)
  Bedup (in the future)

- Water level gauging stations

  Krusin
  Meringgu
  Gedong
  Ensengei
  Kayan (in the future)

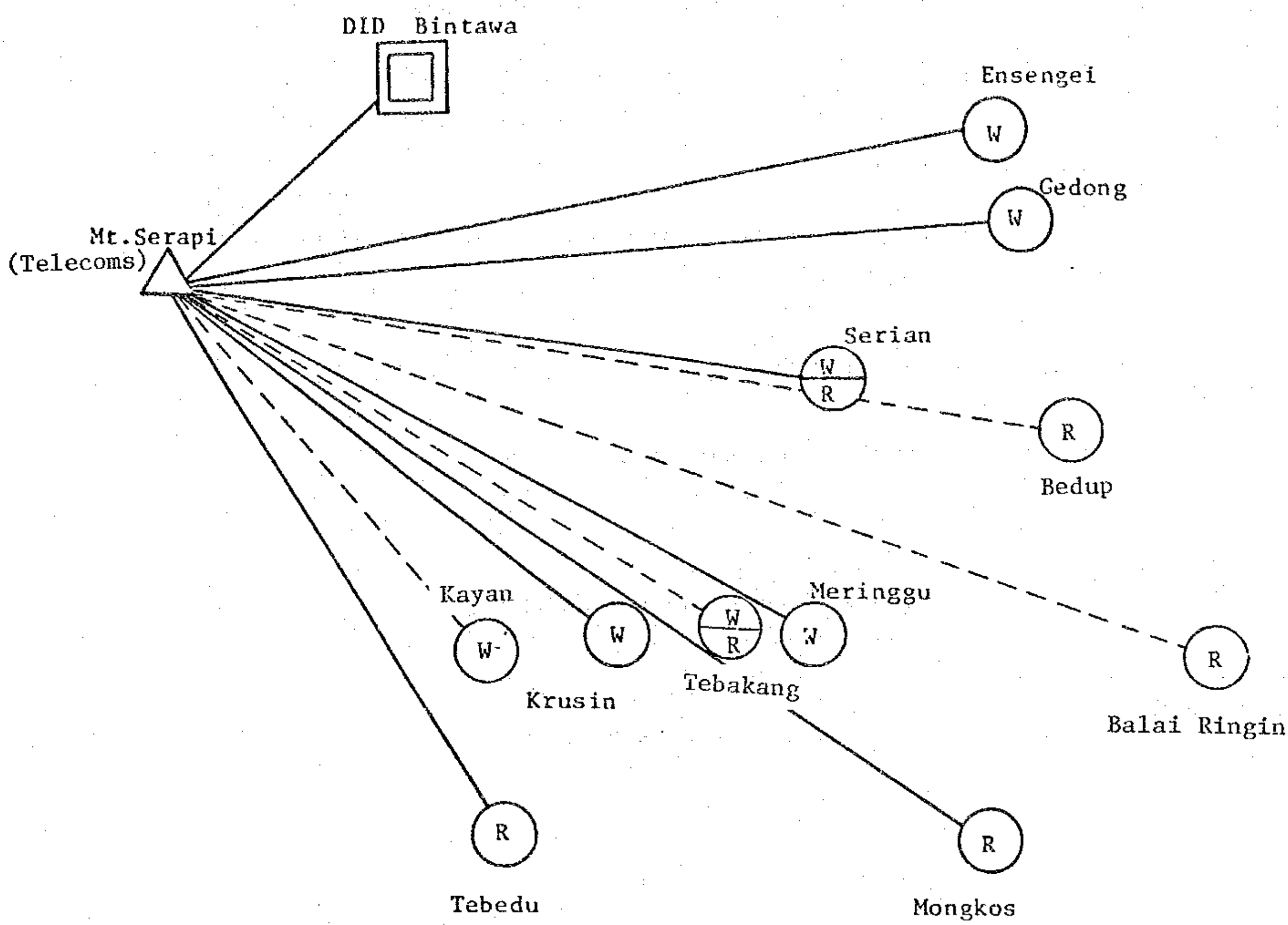
- Rainfall & water level gauging stations

  Serian
  Tebakang (in the future)

Fig. 4.1 shows the telecommunication network of the telemetry system.

The field survey, radio wave propagation test and circuit design have been conducted to determine whether the proposed telemetry system is suitable for the flood forecasting purpose.

Fig.- 4.1 Telecommunication Network
(Sadong River Basin)



○ Observation Station

W Water level gauging Station

R Rainfall gauging Station

▣ Master Control Station
(Flood Forecasting Center)

△ Relay Station

—— Radio Circuit

----- Future Construction Plan

4.2 Radio Wave Propagation Test and Noise and Interference Test

4.2.1 Radio Wave Propagation Test

The radio wave propagation test included the measurement of the receiving power and direction of arriving waves as well as the actual communication tests. The circuit loss of the tested span was calculated, and the stability of arriving waves was tested. The test items therefore covered the receiving power, the fluctuation in receiving power caused by different position and direction of the antenna equipment, and the quality of communication.

As shown in Fig. 4.2, the radio wave propagation tests were conducted between Mt. Serapi and Bintawa and between Mt. Serapi and the individual proposed sites for observation stations. Table 4.2 and Fig. 4.3 show the equipment and instruments used in the tests. The frequency used in these radio wave propagation tests was 70.525 MHz.

The following table shows the test results:

Table 4.1 Result of Propagation Test

(Sadong River Basin)

Span	Distance	Transmitting Power	Receiving Power	S/N Reading
Mt.Serapi - Tebedu	64.3 km	8.7 W	-90 dBm	35 dB
" - Kayan	58.4	9.3	-85.5	39
" - Krusin	66.3	8.8	-102.5	22
" - Tebakang	63.7	9.1	-101	24
" - Mongkos	82.7	9.0	-96.5	27
" - Meringgu	71.0	8.8	-88.5	36.5
" - Balai Ringin	85.0	8.8	-91.5	32.5
" - Bedup	73.3	8.8	-93.5	31.5
" - Serian	62.8	9.3	-81	42
" - Gedong	66.5	8.4	-77.5	43
" - Ensengei	53.1	9.5	-78.5	44
" - Bintawa	21.5	9.4	-55.5	45

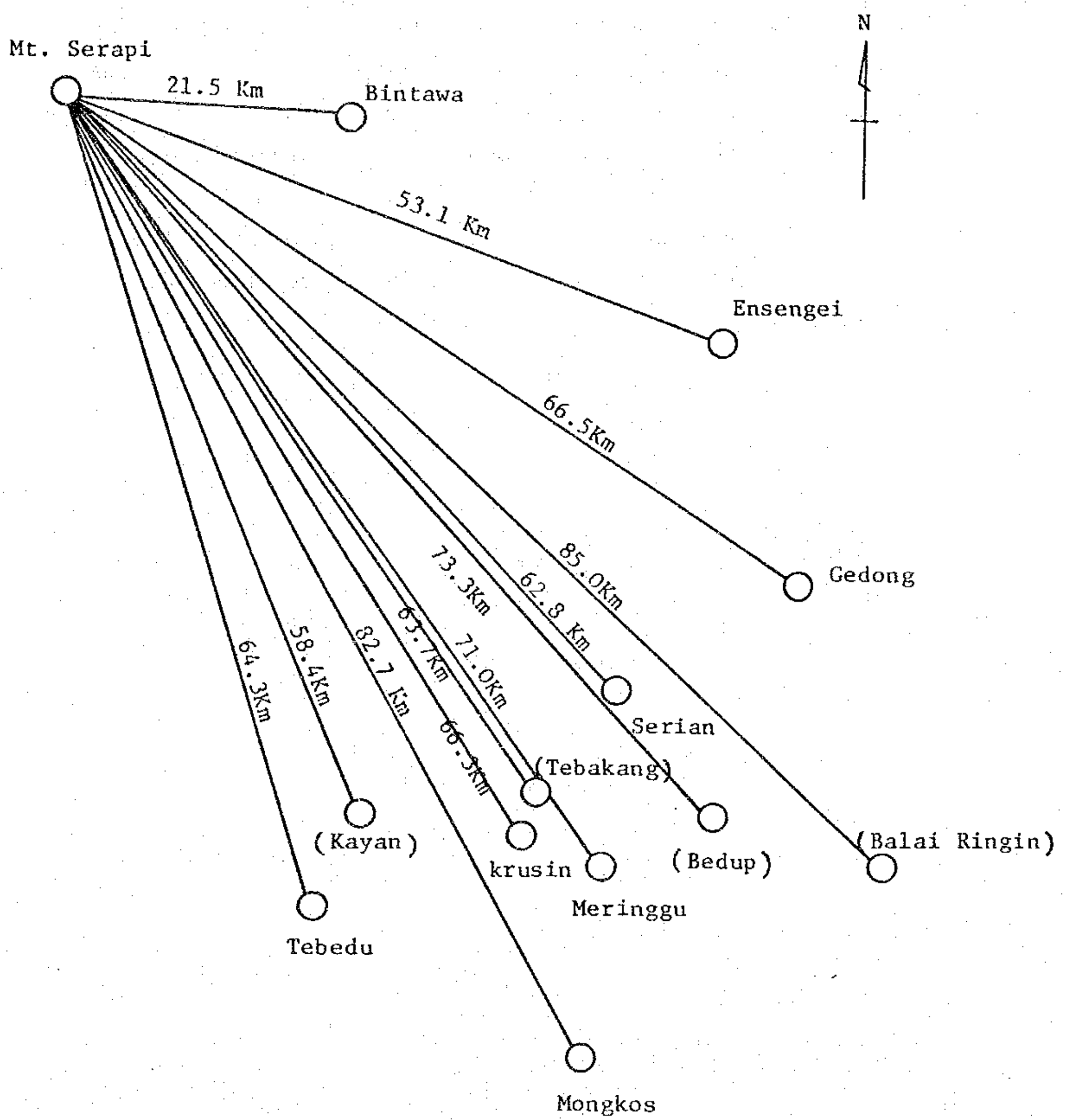
Remarks: At every location: Antenna - 3 Element YAGI Type
Antenna Height - 10 m
Cable - 5D-2V, 16 m

4.2.2 Noise and interference Test

The noise and interference test of about 10 minutes duration was conducted at each proposed station location. The noise level was so low in all cases that special concern in this aspect is not necessary in the circuit design.

Interference from T.V. transmission at Mt. Serapi was not detected as expected. Other interference was not present.

Fig. 4.2 Radio Wave Propagation Test Network
(Sadong River Basin)

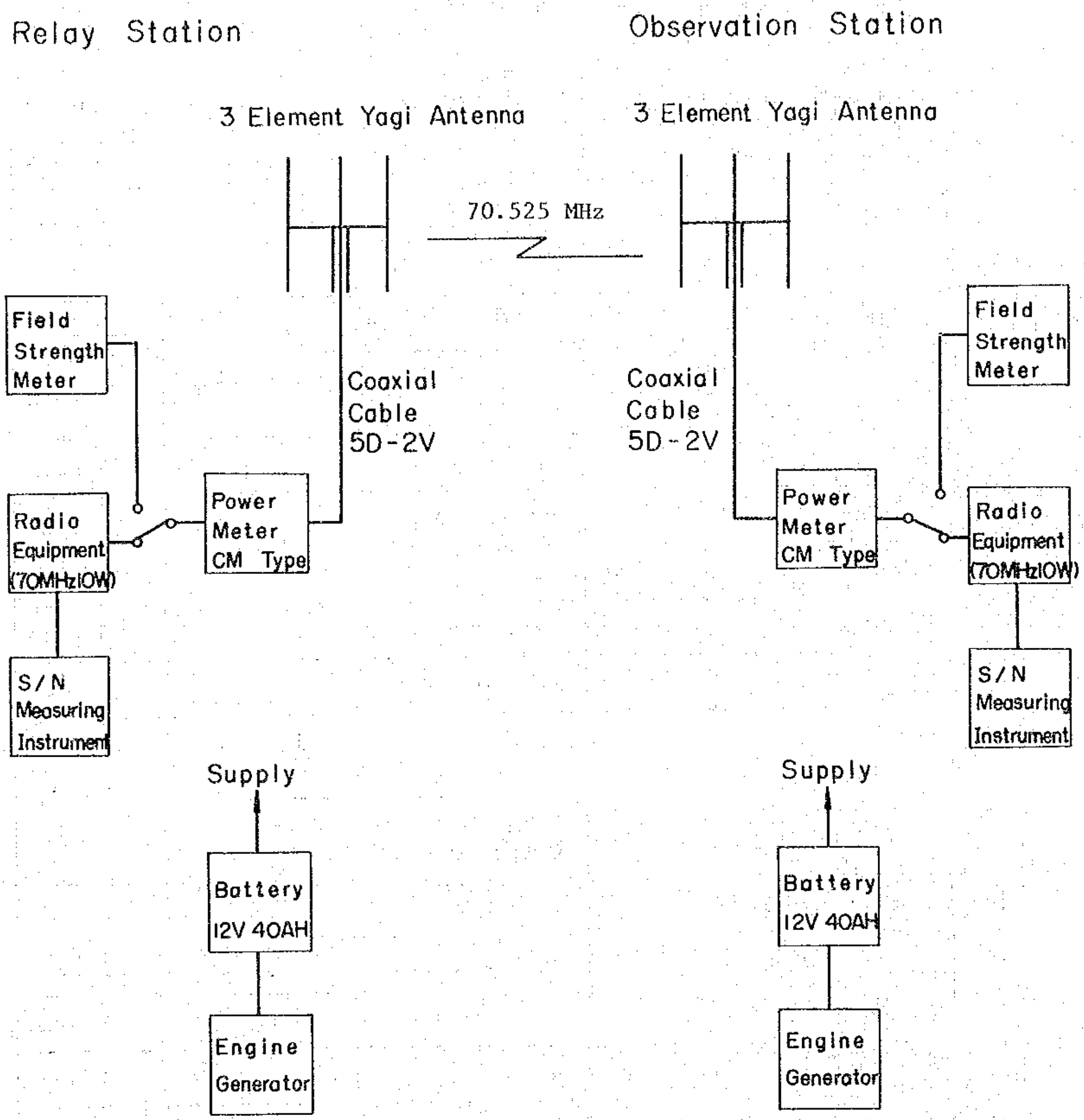


( ) : Future Construction Plan

Table 4.2 Equipment and Instruments used in Radio Wave Propagation Test (Sadong River Basin)

	Description of Goods	Rating	Quantity
1	Radio Equipment	CRI-06, 70.525 MHz, 10 W	4 sets
2	Antenna	3 Element Yagi	3 sets
3	Field Strength Meter	M-321G, 25-250 MHz	2 sets
4	Power Meter	CM Type, 70 MHz Band, 15 W	3 sets
5	"	Terminal Type, 70 MHz Band, 15 W	3 sets
6	Quasi-Peak Meter	MH 33A	1 set
7	Pen Recorder	VP 6723 A	1 set
8	S/N Measuring Instrument	KCD-1	3 sets
9	Storage Battery	12 V, 40 AH	5 sets
10	Engine Generator	EM 300, 300W	1 set
11	Charger	Input AC 100 - 115 V Output DC 15 V, 8 A	1 set
12	Voltage Regulator	Input 220V Output 0 - 230 V, 10 A	1 set
13	Band-Pass Filter	70.5 MHz	1 set
14	Coaxial Cable	5D - 2V, 15m	3 sets
15	Tester	TL - 700	3 sets
16	Tool set		3 sets
17	Spares & Accessories		1 set

Fig. 4.3 Discription of the Equipment of Radio Wave Propagation Test



4.3 Circuit Design

The desk circuit design to be examined by the radio propagation test was first made using 1/50,000 topographical maps, and the propagation loss (free space loss + addition loss*) was calculated. Then the difference between this desk design value and the actual propagation loss measured in the test was used as the compensation value in designing the actual operation circuit.

The design of the operation circuit was so conducted as to secure 30 dB or more of standard S/N and 0 dB or more of margin relative to threshold level at fading. The service frequency assumed in the design work was 70 MHz band.

* Additional loss consists of diffraction loss and topography coefficient. This coefficient was estimated according to the conditions of the propagation path.

4.3.1 Desk Circuit Design

- Profile maps of propagation paths were prepared using 1/50,000 topographical maps, and the additional loss of each path was calculated.

- Based on the additional loss thus obtained, the transmitting power and the type of antenna equipment, the desk circuit was designed.

The standards S/N is calculated by the following formula:

Standard S/N (dB) = Transmitting power (dBm)
+ Transmitting antenna gain (dB)
+ Receiving antenna gain (dB)
- Feeder loss (dB)
- Free space loss (dB)**
- Parallel receiving branch loss (3.5 dB)*
- Additional loss (dB)**
- Receiving noise power (-115 dBm)**

+ S/N improvement factor (12 dB)**

+ Parallel receiving combining gain (3dB)**

For example, the standard S/N between Mt. Serapi and Serian is calculated as follows:

Transmitting power = 30 dBm (1W)

Transmitting antenna gain = 8 dB (3 Element YAGI)

Receiving antenna gain = 11 dB (5 Element YAGI)

Feeder loss = 2 dB (10D-2V, 50 m)

Free space loss = 105.3 dB (62.8 km)**

Additional loss = 23 dB**

Standard S/N = 30 + 8 + 11 - 2 - 3.5 - 105.3 - 23 - (-115)
+ 12 + 3
= 45.2 dB

* Parallel receiving for combined gain

** Calculations are shown in APPENDIX

- The results of desk circuit design are shown in Table 4.4.

4.3.2 Calculation of Compensation Value

- The compensation value of propagation loss is calculated by the following formula, using the transmitting power, antenna equipment performance used in the radio wave propagation test and the actual measurement of receiving power:

Compensation value (dB) = Transmitting power (dBm)
+ Transmitting antenna gain (dB)
+ Receiving antenna gain (dB)
- Feeder loss (dB)
- Free space loss (dB)
- Additional loss (dB)
- Measured receiving power (dBm)

For example, the compensation value of propagation loss between Mt. Serapi and Serian is calculated as follows:

Transmitting power = 39.7 dBm (9.3W)
Transmitting antenna gain = 8.0 dB (3 Element YAGI)
Receiving antenna gain = 8.0 dB (3 Element YAGI)
Feeder loss = 3.2 dB (5D-2V, 32 m)
Free space loss = 105.3 dB (62.8 km)
Additional loss = 23 dB
Measured receiving power = -81 dBm

Compensation value = 39.7 + 8.0 - 8.0 - 3.2 - 105.3
- 23 - (-81)
= 5.2 dB

- The compensation values calculated for individual spans are shown in Table 4.5.

4.3.3 Circuit Design

- Based on the compensation value of propagation loss mentioned above, the transmitting power, and the type of antenna equipment, the operational circuit was designed.

The receiving power, the standard S/N and the margin relative to threshold level at fading are derived by the following formula respectively:

Receiving power (dBm) = Transmitting power (dBm)
+ Transmitting antenna gain (dB)
+ Receiving antenna gain (dB)
- Feeder loss (dB)
- Parallel receiving branch loss (3.5 dB)
- Free space loss (dB)
- Additional loss (dB)
- Compensation value (dB)

Standard S/N (dB) = Receiving power (dBm)
- Receiving noise power (-115 dBm)
+ S/N improvement factor (12 dB)
+ Parallel receiving combining gain (3 dB)

Margin relative to threshold level at fading (dB)
= Receiving power (dBm)
- Threshold level (-106 dBm)
- Fading loss (dB) (0.1 dB/km x distance)

For example, the receiving power, standard S/N and margin relative to threshold level at fading for the span between Mt. Serapi and Serian are calculated as follows:

Transmitting power = 30 dBm (1W)
Transmitting antenna gain = 8 dB (3 Element YAGI)
Receiving antenna gain = 11 dB (5 Element YAGI)
Feeder loss = 2 dB (10D-2V, 50 m)
Free space loss = 105.3 dB (62.8 km)
Additional loss = 23 dB
Compensation value = 5.2 dB
Fading loss = 0.1 x 62.8 = 6.3 dB

Receiving power = 30 + 8 + 11 - 2 - 3.5 - 105.3 - 23 - 5.2
= -90 dBm

Standard S/N = -90 - (-115) + 12 + 3 = 40 dB

Margin relative to threshold level at fading
= -90 - (-106) - 6.3
= 9.7 dB

Fig. 4.4 shows the horizontal-direction characteristic pattern of the 5-element Yagi antenna equipment used in the design work. The results of circuit design are shown in Table 4.3 and 4.6 the summary of which appears next.

Table 4.3 Summary of Circuit Design

Station	Transmitting Power	Antenna	Antenna Height	Receiving Power	Standard S/N	Margin at Fading
Tebedu	3 W	5 EL Yagi	10 m	-92.4 dBm	37.6 dB	7.2 dB
Kayan	1	3 EL Yagi	10	-95.5	34.5	4.7
Krusin	10	5 EL Yagi	10	-98.5	31.5	0.9
Tebakang	10	5 EL Yagi	10	-97.1	32.9	2.5
Mongkos	10	3 EL Yagi	10	-95.8	34.2	1.9
Meringgu	3	3 EL Yagi	10	-92.6	37.4	6.3
Balai Ringin	10	3 EL Yagi	10	-90.3	39.7	7.2
Bedup	3	5 EL Yagi	10	-94.4	35.6	4.3
Serian	1	3 EL Yagi	10	-90.0	40.0	9.7
Gedong	1	3 EL Yagi	10	-86.6	43.4	12.7
Ensengei	1	3 EL Yagi	10	-89.6	40.4	11.1
Bintawa	1	3 EL Yagi	10	-69.5	60.5	34.3
Mt. Serapi	10	5 EL Yagi	30	-	-	-

Mt. Serapi's antenna equipment is directed toward Bedup (139° from north).

As it is clear from the above table, the standard S/N for every span is over 30 dB and the margin relative to threshold level at fading is above 0 dB for all span. Therefore, establishment of good circuits could be expected.

4.3.4 Service Frequencies

Two frequencies of the 70 MHz band are required to manage this telemetry system. These two frequencies are to be set apart by more than 2 MHz to avoid interference at the relay station.

Aside from the above-mentioned interference, investigation is to be made into the mutual interference between these frequencies and the frequency currently in use by the Telecommunication Department at Mt. Serapi.

Fig. 4.5 shows the relay system of this telecommunication network.

Table 4.4 Desk Circuit Design Table (Sadong River Basin)

Item	Span	Tebedu –Mt. Serapi (64.3km)		Kayan –Mt. Serapi (58.4km)		Krusin –Mt. Serapi (66.3km)		Tebukang –Mt. Serapi (63.7km)	
Transmitting Power	dBm	34.8	3W	30	1W	40	10W	40	10W
Transmitting Antenna Gain	dB	11	5EL Yagi	8	3EL Yagi	11	5EL Yagi	11	5EL Yagi
Receiving Antenna Gain	dB	9.5	5EL Yagi 24°(-1.5dB)	10	5EL Yagi 19°(-1dB)	10.7	5EL Yagi 10°(-0.3dB)	10.8	5EL Yagi 8°(-0.2dB)
Feeder Loss	dB	(-)2	10D-2V 15+35m	(-)2	10D-2V 15+35m	(-)2	10D-2V 15+35m	(-)2	10D-2V 15+35m
Parallel Receiving Branch Loss	dB	(-)3.5		(-)3.5		(-)3.5		(-)3.5	
Free Space Loss	dB	(-)105.5	70 MHz 64.3km	(-)104.7	70 MHz 58.4km	(-)105.8	70 MHz 66.3km	(-)105.4	70 MHz 63.7km
Additional Loss	dB	(-) 27		(-)25		(-)41		(-)40	
Receiving Power	dBm	-82.7		-87.2		-90.6		-89.1	
Receiving Noise Power	dBm	-115		-115		-115		-115	
Radio Frequency S/N (C/N)	dB	32.3		27.8		24.4		25.9	
S/N Improvement Factor	dB	12		12		12		12	
Parallel Receiving Combining Gain	dB	3		3		3		3	
Standard S/N	dB	47.3		42.8		39.4		40.9	
Fading Loss	dB	(-)6.4	0.1dB/km	(-)5.8	0.1dB/km	(-)6.6	0.1dB/km	(-)6.4	0.1dB/km
S/N at Fading	dB	40.9		37.0		32.8		34.5	
Threshold Level	dBm	-106		-106		-106		-106	
Fading Margin Relative to Threshold Level	dB	23.3		18.8		15.4		16.9	
Margin Relative to Threshold Level at Fading	dB	16.9		13.0		8.8		10.5	

Item	Span	Mongkos –Mt. Serapi (82.7km)		Meringgu –Mt. Serapi (71.0km)		Balai Ringin –Mt. Serapi (85.0km)		Bedup –Mt. Serapi (73.3km)	
Transmitting Power	dBm	40	10W	34.8	3W	40	10W	34.8	3W
Transmitting Antenna Gain	dB	8	3EL Yagi	8	3EL Yagi	8	3EL Yagi	11	5EL Yagi
Receiving Antenna Gain	dB	10.5	5EL Yagi 13°(-0.5dB)	10.8	5EL Yagi 7°(-0.2dB)	10.9	5EL Yagi 5°(-0.1dB)	11	5EL Yagi
Feeder Loss	dB	(-)2	10D-2V 15+35m	(-)2	10D-2V 15+35m	(-)2	10D-2V 15+35m	(-)2	10D-2V 15+35m
Parallel Receiving Branch Loss	dB	(-)3.5		(-)3.5		(-)3.5		(-)3.5	
Free Space Loss	dB	(-)107.7	70 MHz 82.7km	(-)106.4	70 MHz 71.0km	(-)107.9	70 MHz 85.0km	(-)106.6	70 MHz 73.3km
Additional Loss	dB	(-)33		(-)29		(-)27		(-)33	
Receiving Power	dBm	-87.7		-87.3		-81.5		-88.3	
Receiving Noise Power	dBm	-115		-115		-115		-115	
Radio Frequency S/N (C/N)	dB	27.3		27.7		33.5		26.7	
S/N Improvement Factor	dB	12		12		12		12	
Parallel Receiving Combining Gain	dB	3		3		3		3	
Standard S/N	dB	42.3		42.7		48.5		41.7	
Fading Loss	dB	(-)8.3	0.1dB/km	(-)7.1	0.1dB/km	(-)8.5	0.1dB/km	(-)7.3	0.1dB/km
S/N at Fading	dB	34.0		35.6		40.0		34.4	
Threshold Level	dBm	-106		-106		-106		-106	
Fading Margin Relative to Threshold Level	dB	18.3		18.7		24.5		17.7	
Margin Relative to Threshold Level at Fading	dB	10.0		11.6		16.0		10.4	

Item	Span	Serian –Mt. Serapi (62.8km)		Gedong –Mt. Serapi (66.5km)		Ensengei –Mt. Serapi (53.1km)		Bintawa –Mt. Serapi (21.5km)	
Transmitting Power	dBm	30	1W	30	1W	30	1W	30	1W
Transmitting Antenna Gain	dB	8	3EL Yagi	8	3EL Yagi	8	3EL Yagi	8	3EL Yagi
Receiving Antenna Gain	dB	11	5EL Yagi 1°(0dB)	10.4	5EL Yagi 15°(-0.6dB)	9	5EL Yagi 29°(-2dB)	6	5EL Yagi 43°(-5dB)
Feeder Loss	dB	(-)2	10D-2V 15+35m	(-)2	10D-2V 15+35m	(-)2	10D-2V 15+35m	(-)2	10D-2V 15+35m
Parallel Receiving Branch Loss	dB	(-)3.5		(-)3.5		(-)3.5		(-)3.5	
Free Space Loss	dB	(-)105.3	70 MHz 62.8km	(-)105.8	70 MHz 66.5km	(-)103.8	70 MHz 53.1km	(-)96.0	70 MHz 21.5km
Additional Loss	dB	(-)23		(-)15		(-) 15		(-) 10	
Receiving Power	dBm	-84.8		-77.9		-77.3		-67.5	
Receiving Noise Power	dBm	-115		-115		-115		-115	
Radio Frequency S/N (C/N)	dB	30.2		37.1		37.7		47.5	
S/N Improvement Factor	dB	12		12		12		12	
Parallel Receiving Combining Gain	dB	3		3		3		3	
Standard S/N	dB	45.2		52.1		52.7		62.5	
Fading Loss	dB	(-)6.3	0.1dB/km	(-)6.7	0.1dB/km	(-)5.3	0.1dB/km	(-)2.2	0.1dB/km
S/N at Fading	dB	38.9		45.4		47.4		60.3	
Threshold Level	dBm	-106		-106		-106		-106	
Fading Margin Relative to Threshold Level	dB	21.2		28.1		28.7		38.5	
Margin Relative to Threshold Level at Fading	dB	14.9		21.4		23.4		36.3	

Table 4.5 Circuit Design Table at Test Condition

(Sadong River Basin)

Item \ Span		Tebedu -Mt. Serapi (64.3km)		Kayan -Mt. Serapi (58.4km)		Krusin -Mt. Serapi (66.3km)		Tebakang -Mt. Serapi (63.7km)		Mongkos -Mt. Serapi (82.7km)		Meringgu -Mt. Serapi (71.0km)		Balai Ringin -Mt. Serapi (85.0km)		Bedup -Mt. Serapi (73.3km)		Serian Mt. Serapi (62.8km)		Gedong -Mt. Serapi (66.5km)		Ensengei -Mt. Serapi (53.1km)		Bintawa -Mt. Serapi (21.5km)	
Transmitting Power	dBm	39.4	8.7W	39.7	9.3W	39.4	8.8W	39.6	9.1W	39.5	9W	39.4	8.8W	39.4	8.8W	39.4	8.8W	39.7	9.3W	39.2	8.4W	39.8	9.5W	39.7	9.4W
Transmitting Antenna Gain	dB	8	3EL Yagi	8	3EL Yagi	8	3EL Yagi	8	3EL Yagi	8	3EL Yagi	8	3EL Yagi	8	3EL Yagi	8	3EL Yagi	8	3EL Yagi	8	3EL Yagi	8	3EL Yagi	8	3EL Yagi
Receiving Antenna Gain	dB	8	3EL Yagi	8	3EL Yagi	8	3EL Yagi	8	3EL Yagi	8	3EL Yagi	8	3EL Yagi	8	3EL Yagi	8	3EL Yagi	8	3EL Yagi	8	3EL Yagi	8	3EL Yagi	8	3EL Yagi
Feeder Loss	dB	(-)3.2	5D-2V 16+16m	(-)3.2	5D-2V 16+16m	(-)3.2	5D-2V 16+16m	(-)3.2	5D-2V 16+16m	(-)3.2	5D-2V 16+16m	(-)3.2	5D-2V 16+16m	(-)3.2	5D-2V 16+16m	(-)3.2	5D-2V 16+16m	(-)3.2	5D-2V 16+16m	(-)3.2	5D-2V 16+16m	(-)3.2	5D-2V 16+16m	(-)3.2	5D-2V 16+16m
Free Space Loss	dB	(-)105.5	70 MHz 64.3km	(-)104.7	70 MHz 58.4km	(-)105.8	70 MHz 66.3km	(-)105.4	70 MHz 63.7km	(-)107.7	70 MHz 82.7km	(-)106.4	70 MHz 71.0km	(-)107.9	70 MHz 85.0km	(-)106.6	70 MHz 73.3km	(-)105.3	70 MHz 62.8km	(-)105.8	70 MHz 66.5km	(-)103.8	70 MHz 53.1km	(-)96.0	70 MHz 21.5km
Additional Loss	dB	(-)27		(-)25		(-)41		(-)40		(-)33		(-)29		(-)27		(-)33		(-)23		(-) 15		(-) 15		(-) 10	
Compensation Value	dB	(-) 9.7		(-) 8.3		(-) 7.9		(-) 8		(-) 8.1		(-)5.3		(-) 8.8		(-) 6.1		(-)5.2		(-) 8.7		(-)12.3		(-) 2.0	
Receiving Power	dBm	-90		-85.5		-102.5		-101		-96.5		-88.5		-91.5		-93.5		-81		-77.5		-78.5		-55.5	

Table 4.6 Circuit Design Table
(Sadong River Basin)

Item \ Span		Tebedu –Mt. Serapi (64.3km)		Kayan –Mt. Serapi (58.4km)		Krusin –Mt. Serapi (66.3km)		Tebakang –Mt. Serapi (63.7km)		Mongkos –Mt. Serapi (82.7km)		Meringgu –Mt. Serapi (71.0km)	
Transmitting Power	dBm	34.8	3W	30	1W	40	10W	40	10W	40	10W	34.8	3W
Transmitting Antenna Gain	dB	11	5EL Yagi	8	3EL Yagi	11	5EL Yagi	11	5EL Yagi	8	3EL Yagi	8	3EL Yagi
Receiving Antenna Gain	dB	9.5	5EL Yagi 24°(-1.5dB)	10	5EL Yagi 19°(-1 dB)	10.7	5EL Yagi 10°(-0.3dB)	10.8	5EL Yagi 8°(-0.2dB)	10.5	5EL Yagi 13°(-0.5dB)	10.8	5EL Yagi 7°(-0.2dB)
Feeder Loss	dB	(-) 2	10D-2V 15+35m	(-) 2	10D-2V 15+35m	(-) 2	10D-2V 15+35m	(-) 2	10D-2V 15+35m	(-) 2	10D-2V 15+35m	(-) 2	10D-2V 15+35m
Parallel Receiving Branch Loss	dB	(-) 3.5		(-) 3.5		(-) 3.5		(-) 3.5		(-) 3.5		(-) 3.5	
Free Space Loss	dB	(-)105.5	70 MHz 64.3km	(-)104.7	70 MHz 58.4km	(-)105.8	70 MHz 66.3km	(-)105.4	70 MHz 63.7km	(-)107.7	70 MHz 82.7km	(-)106.4	70 MHz 71.0km
Additional Loss	dB	(-) 27		(-) 25		(-) 41		(-) 40		(-) 33		(-) 29	
Compensation Value	dB	(-) 9.7		(-) 8.3		(-) 7.9		(-) 8		(-) 8.1		(-) 5.3	
Receiving Power	dBm	-92.4		-95.5		-98.5		-97.1		-95.8		-92.6	
Receiving Noise Power	dBm	-115		-115		-115		-115		-115		-115	
Radio Frequency S/N (C/N)	dB	22.6		19.5		16.5		17.9		19.2		22.4	
S/N Improvement Factor	dB	12		12		12		12		12		12	
Parallel Receiving Combining Gain	dB	3		3		3		3		3		3	
Standard S/N	dB	37.6		34.5		31.5		32.9		34.2		37.4	
Fading Loss	dB	(-) 6.4	0.1dB/km	(-) 5.8	0.1dB/km	(-) 6.6	0.1dB/km	(-) 6.4	0.1dB/km	(-) 8.3	0.1dB/km	(-) 7.1	0.1dB/km
S/N at Fading	dB	31.2		28.7		24.9		26.5		25.9		30.3	
Threshold Level	dBm	-106		-106		-106		-106		-106		-106	
Fading Margin Relative to Threshold Level	dB	13.6		10.5		7.5		8.9		10.2		13.4	
Margin Relative to Threshold Level at Fading	dB	7.2		4.7		0.9		2.5		1.9		6.3	

Item \ Span		Balai Ringin –Mt. Serapi (85.0km)		Bedup –Mt. Serapi (73.3km)		Serian –Mt. Serapi (62.8km)		Gedong –Mt. Serapi (66.5km)		Ensengei –Mt. Serapi (53.1km)		Bintawa –Mt. Serapi (21.5km)	
Transmitting Power	dBm	40	10W	34.8	3W	30	1W	30	1W	30	1W	30	1W
Transmitting Antenna Gain	dB	8	3EL Yagi	11	5EL Yagi	8	3EL Yagi	8	3EL Yagi	8	3EL Yagi	8	3EL Yagi
Receiving Antenna Gain	dB	10.9	5YE Yagi 5°(-0.1dB)	11	5EL Yagi	11	5EL Yagi 1°(0dB)	10.4	5EL Yagi 15°(-0.6dB)	9	5EL Yagi 29°(-2dB)	6	5EL Yagi 43°(-5dB)
Feeder Loss	dB	(-) 2	10D-2V 15+35m	(-) 2	10D-2V 15+35m	(-) 2	10D-2V 15+35m	(-) 2	10D-2V 15+35m	(-) 2	10D-2V 15+35m	(-) 2	10D-2V 15+35m
Parallel Receiving Branch Loss	dB	(-) 3.5		(-) 3.5		(-) 3.5		(-) 3.5		(-) 3.5		(-) 3.5	
Free Space Loss	dB	(-)107.9	70 MHz 85.0km	(-)106.6	70 MHz 73.3km	(-)105.3	70 MHz 62.8km	(-)105.8	70 MHz 66.5km	(-)103.8	70 MHz 53.1km	(-) 96.0	70 MHz 21.5km
Additional Loss	dB	(-) 27		(-) 33		(-) 23		(-) 15		(-) 15		(-) 10	
Compensation Value	dB	(-) 8.8		(-) 6.1		(-) 5.2		(-) 8.7		(-)12.3		(-)2.0	
Receiving Power	dBm	-90.3		-94.4		-90.0		-86.6		-89.6		-69.5	
Receiving Noise Power	dBm	-115		-115		-115		-115		-115		-115	
Radio Frequency S/N (C/N)	dB	24.7		20.6		25.0		-28.4		25.4		45.5	
S/N Improvement Factor	dB	12		12		12		12		12		12	
Parallel Receiving Combining Gain	dB	3		3		3		3		3		3	
Standard S/N	dB	39.7		35.6		40.0		43.4		40.4		60.5	
Fading Loss	dB	(-) 8.5	0.1dB/km	(-) 7.3	0.1dB/km	(-) 6.3	0.1dB/km	(-) 6.7	0.1dB/km	(-) 5.3	0.1dB/km	(-) 2.2	0.1dB/km
S/N at Fading	dB	31.2		28.3		33.7		36.7		35.1		58.3	
Threshold Level	dBm	-106		-106		-106		-106		-106		-106	
Fading Margin Relative to Threshold Level	dB	15.7		11.6		16.0		19.4		16.4		36.5	
Margin Relative to Threshold Level at Fading	dB	7.2		4.3		9.7		12.7		11.1		34.3	

Fig.4.4 Horizontal-Direction Characteristic
5 Element Yagi Antenna
(Sadong River Basin)

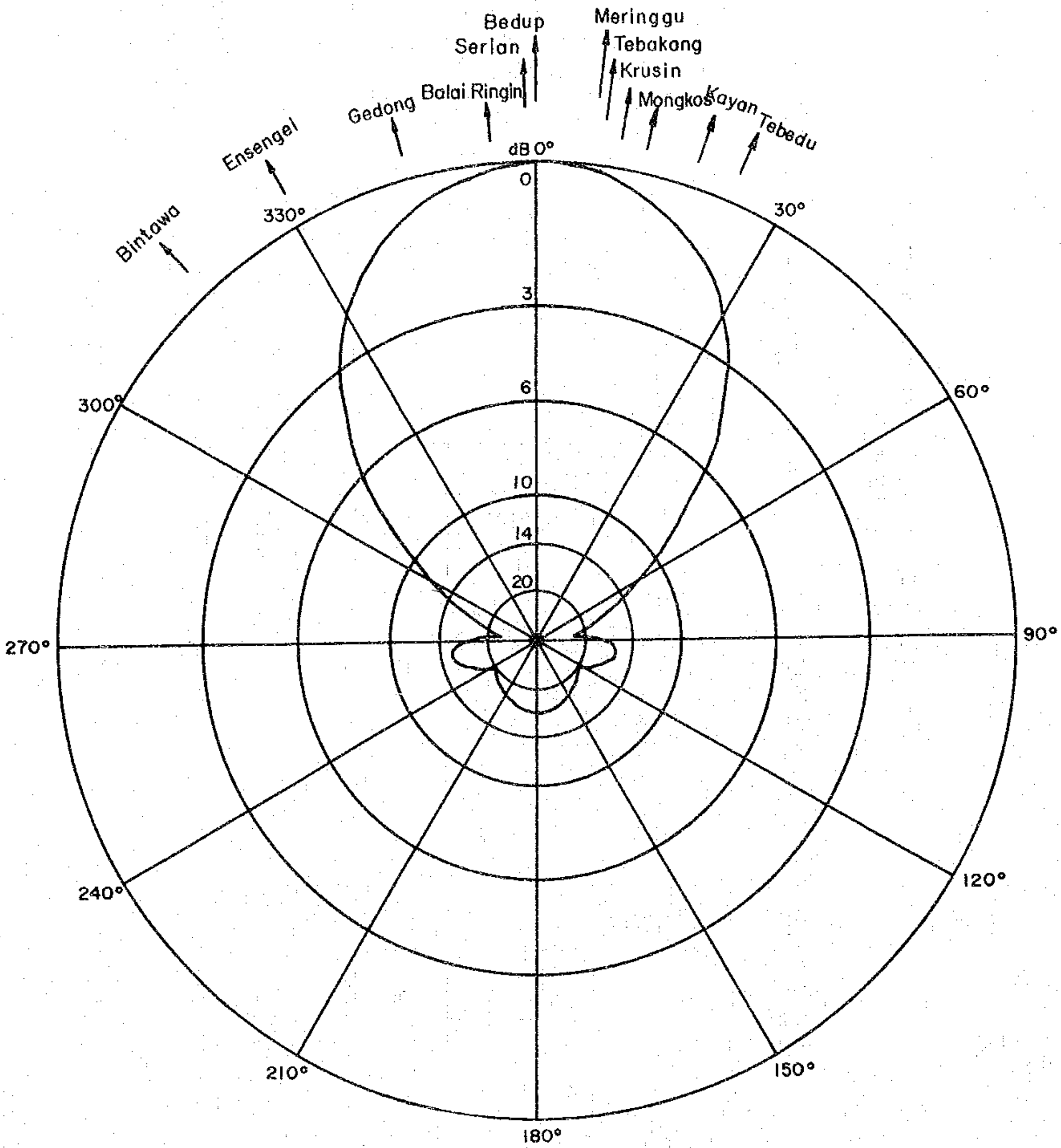
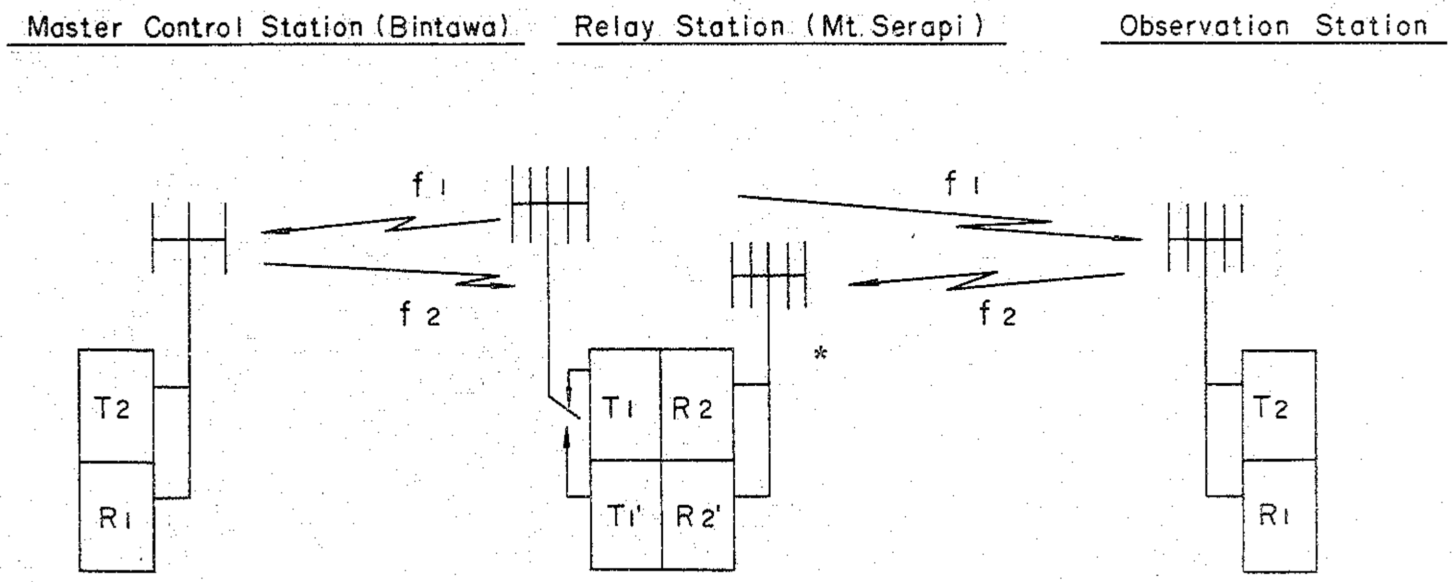


Fig. 4.5 Relay System of Telecommunication Network
(Sadong River Basin)



* Parallel Receiving for Combined Gain

T : Transmitter

R : Receiver

f_1, f_2 : 70MHz Band Radio Frequency

4.4 Siting Conditions of Stations

4.4.1 Master Control Station

Bintawa's D.I.D Office has an unobstructed vista in the direction of Mt. Serapi, thus providing a good radio propagation path. However, the antenna equipment should be 10 m or higher so as to clear structures and trees in the path.

Although the noise level seems to be the highest of all the stations, it may not require any special attention.

The location being subject to inundation, the telecommunication equipment should be installed upstairs.

4.4.2 Mt. Serapi Relay Station

Mt. Serapi is a 910 m high mountain situated some 20 km west of Kuching. It is markedly higher than other mountains around it. Commanding an open vista in the direction of Kuching and the Sadong river basin, it is most suitably located for a relay station. Besides, there is a TV transmitting station of the Telecom. Dept. with its structure, steel tower, access road and power. Making use of these facilities offers a great advantage in construction and maintenance.

4.4.3 Tebedu Rainfall Gauging Station

This station, with its rainfall gauge installed, is located some 30 km southwest of Serian. About 90 m a way from the gauge is a 45 m triangular tower belonging to the Telecom. Dept. Thus, the construction cost will be greatly reduced if the station is installed near it and the tower used.

4.4.4 Kayan Water Level Gauging Station (Future Program)

This station is located about 8 km north of Tebedu and near a bridge crossing the Kayan River. There is a small open flat land on the left bank, but a nearby hill obstructs the vista in the direction of Mt. Serapi. Therefore, the antenna should be so located as to avoid the hill.

4.4.5 Krusin Water Level Gauging Station

This station is located about 5 km south of Tebakang and near a bridge crossing the Kayan River. Since there are lots of trees growing along the river, some of them will have to be felled. The right bank, in particular, opens out in the direction of Mt. Serapi and has some flat land, providing a possible site for the station.

4.4.6 Tabakang Rainfall & Water Level Gauging Station (Future Program)

This site is on the right bank of the Sadong River facing stores in the town of Tebakang. Trees on the bank are rather tall but scattered here and there, and there is a flat land nearby opening in the direction of Mt. Serapi. To cross the river to the right bank, however, a boat is to be used without any usable access road.

4.4.7 Mongkos Rainfall Gauging Station

This station, with a rainfall gauge currently installed, is located about 2 6 km south of Serian. There is an open area near a store and the site around the rainfall gauge is flat enough to accommodate a station.

4.4.8 Meringgu Water Level Gauging Station

This station is located about 12 km south of Serian. Without any access road, a boat is to be used from Tabakang or Serian.

There is a 10 m x 10 m clearing on the right bank, providing a suitable site for the station.

4.4.9 Balai Ringin Rainfall Gauging Station(Future Program)

This station, with a rainfall gauge currently installed, is located some 25 km southeast of Serian. There is a relatively wide open space around, and therefore the site can be chosen easily. With a well-maintained road running from Serian, it is very advantageous from the maintenance point of view.

4.4.10 Bedup Rainfall Gauging Station

This station is located about 10 km southeast of Serian and midway to Balai Ringin. There are already a rainfall gauge and water level gauge installed there. With the Serian road running across the place, it is very advantageous from the maintenance point of view.

4.4.11 Serian Rainfall & Water Level Gauging Station

The existing station on the right bank of the Sadong River and just outside the center of Serian could be made use of. Being on the road, it provides convenience for the maintenance operation. But with the maximum past water level reaching the upper water level gauge room of the station, the equipment may have to be installed with due consideration given to this fact. The trees near the station, which might hinder the performance of the rainfall gauge and solar cells, should be cut down.

4.4.12 Gedong Water Level Gauging Station

This station is located some 15 km northeast of Serian. Without any access road, about 10 minutes of boat ride from the Gedong's DID pier is necessitated. A water level gauge is already there installed on the right bank. There is an open flat land in the neighborhood, providing a possible site for the station.

4.4.13 Ensengei Water Level Gauging Station

The station is located some 20 km upstream from the river mouth of the Sadong. Without any access road, this location, too, requires the use of a boat from Gedong. A water level gauge is already there installed on the left bank. There is an open flat area in its neighborhood, providing a possible site for the station.

4.5 Proposed Telemetry System

As already mentioned, it is considered possible that a fairly adequate telecommunication circuit is established for the flood forecasting and warning system in the Sadong river basin. The following is the outline of the proposed telemetry system.

4.5.1 Master Control Station

The Master Control Station performs supervision and control of the telemetry system, which includes the calls to observation stations, supervision of the operation of relay station and typewriter print-out of hydrological data sent from observation stations. In addition, it is to have a function of computing at least the hourly rainfalls and indicating the hydrological conditions thus obtained of the entire basin area on the display unit. To provide for the protection against lightning hazards, the antenna equipment is to be equipped with a coaxial arrester.

The space required for the telecommunication equipment of the Master Control Station will be about 20 m^2.

4.5.2 Relay Stations

The Relay Station, as well as the Master Control Station, is the mainstay of the telemetry system. Therefore this is to be equipped with two transmitters and receivers. To protect the equipment from lightning entering from the antenna equipment, this is to be equipped with a coaxial arrester.

Electric power is available from the Mt. Serapi station of the Telecom. Dept. However, at the time of commercial power failure, power is to be supplied to the relay equipment from the DC power supply combining rectifier and a storage battery.

The space required for the telecommunication equipments to be installed at the relay station within Mt. Serapi TV station of Telecommunication Department is to be about 1 m (W) x 1 m (D) x 2 m (H).

4.5.3 Observation Stations

Upon reception of a call signal from the Master Control Station, a observation station will automatically read the hydrological data and encode them into pulse signals for transmission to the Master Control Station.

A long distance between the water level gauge and the telemetry equipment at a water level gauging station tends to invite lightning damage. In such cases, some countermeasures are to be taken to cope with lightning hazards. To provide for the protection against such lightning entering from the antenna equipment, a coaxial arrester is to be installed.

As for the power source, it is desirable that each station be supplied with DC power by the combination of solar cells and a storage battery.

The space required for a observation station will be about 2.5 m x 2.5 m.

4.5.4 Future Program

This proposal does not include the telemetry station at Kayan, Tebakang, Balai Ringin and Bedup, which may be incorporated in the system as soon as telemetry equipments are attached to the existing recording gauges.

Fig. 4.6 shows the configuration of the proposed telemetry system. Fig. 4.7 shows the telecommunication network of the proposed telemetry system.

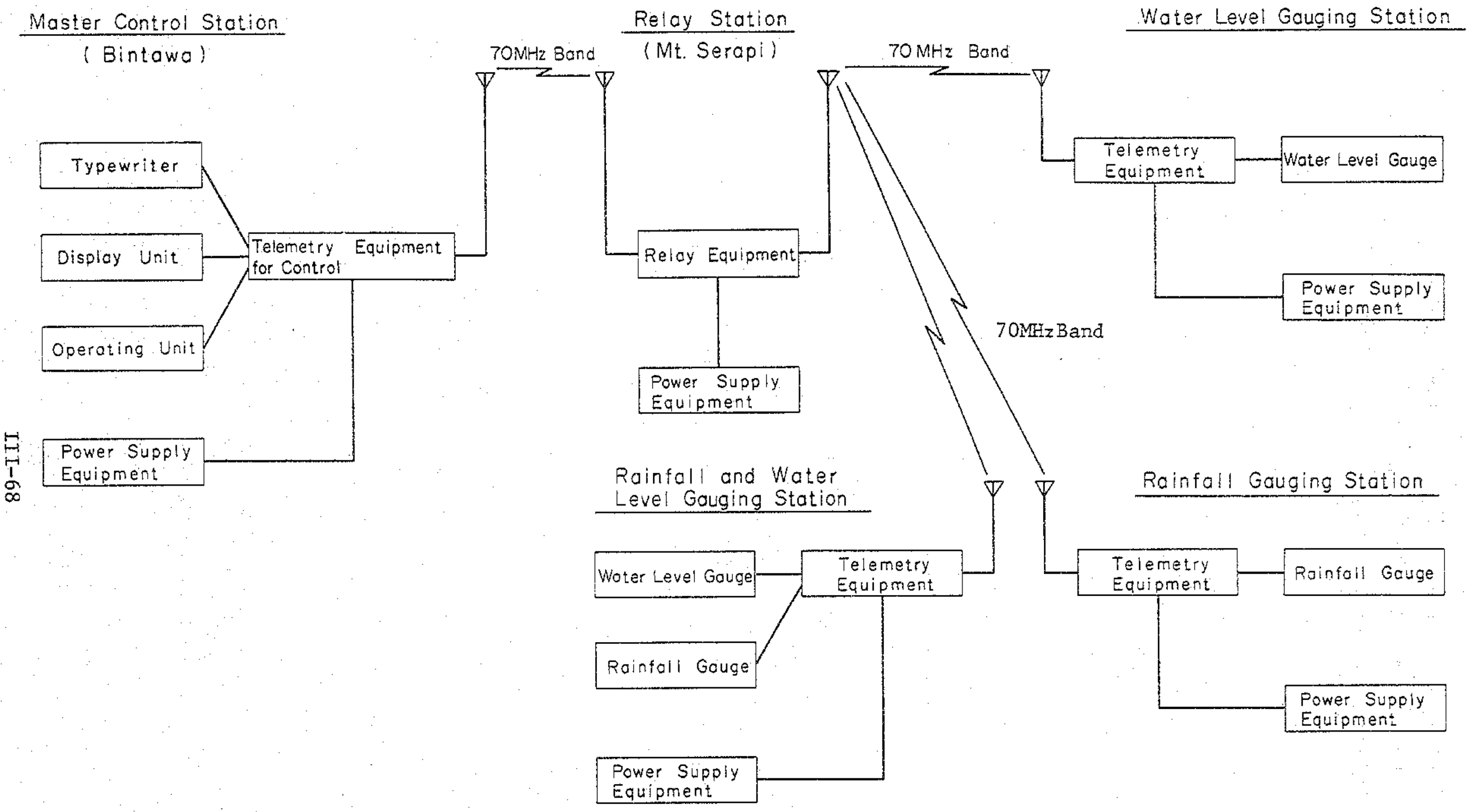
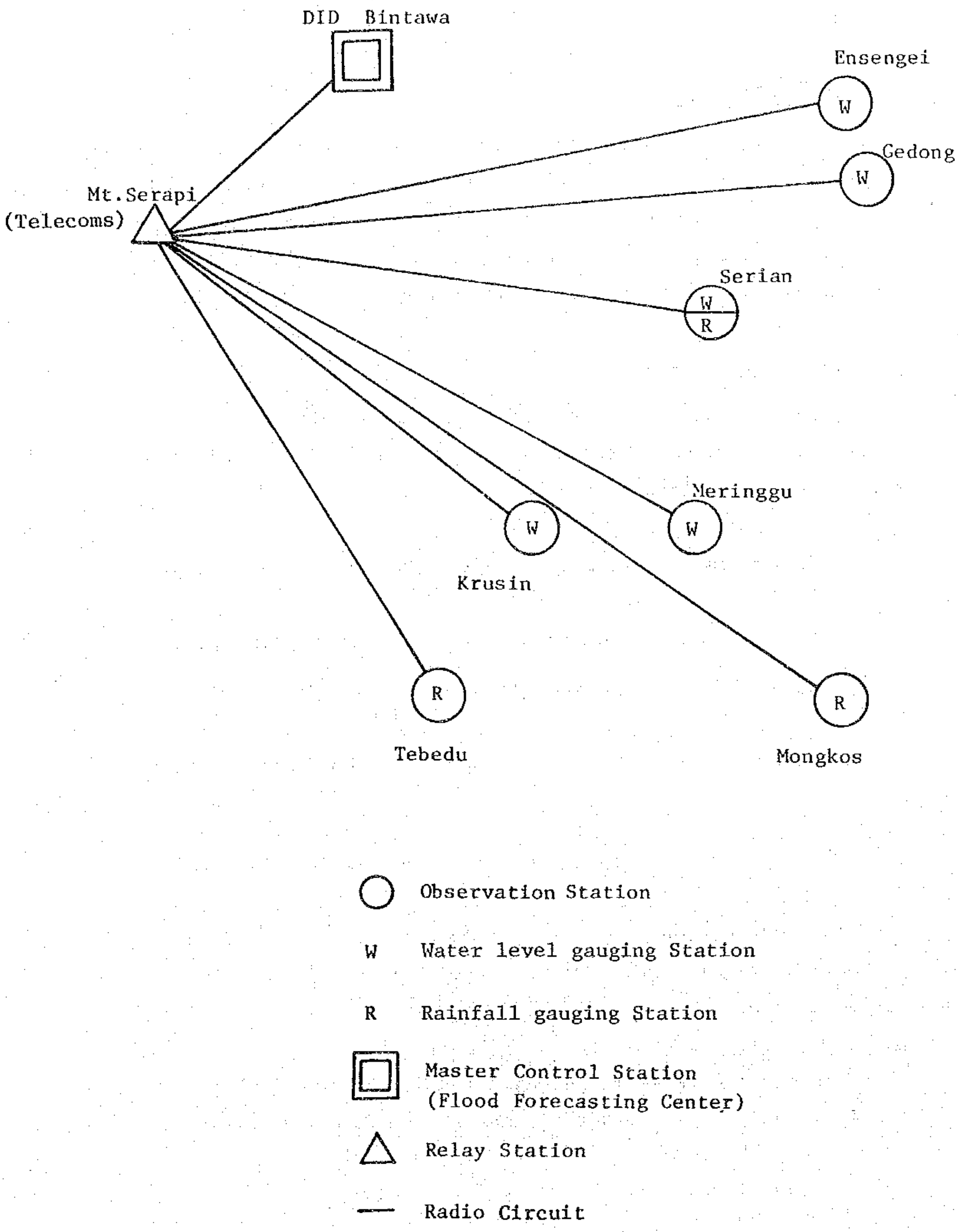


Fig. 4.6 Configuration of Proposed Telemetry System
(Sadong River Basin)

Fig. 4.7 Telecommunication Network of Proposed Telemetry System
(Sadong River Basin)



CHAPTER 5 FACILITIES

5.1 Design of Gauging Facilities

5.1.1 Selection of Gauges

Rainfall Gauge

The rainfall gauges most commonly used are recording rain gauges. They come in such types as tipping-bucket type, tank type and weight measure type, according to the sensor configurations. For ready telemeterization, the recording-type tripping-bucket rain gauges are recommended for this system.

Water Level Gauge

Table 5.1 shows the type of water level gauges. In selecting the gauges for the system, the following conditions need to be taken into account:

- Instrumental features : Analogue or digital, easy reading
- Environmental conditions : Waves, riverbed fluctuation
- Data processing method : Necessity of manual operation
- Cost : Cost including installation and maintenance

1) Existing Gauging Facilities (Ensengei, Gedong, Serian)

In the proposed telemetry stations of Ensengei, Gedong and Serian, recording waterlevel gauges of either British or German make are already installed.

The equipments could be converted for incorporating the facility into system network by making use of the mechanical torque produced by gears inside the recorder unit. Conversion work, however, is subject to thorough study by experts for its possibility. If the conversion of equipments proves to be either very difficult or costly, the existing water level gauges at above-mentioned three locations are to be replaced by equipments specially made for telemetry, so that total system quality is obtained. At any rate, float type gauges are to be employed using the existing facility as much as possible. At Ensengei, a float-less type water level gauge is recommended due to limited installation space.

2) Newly Installation (Krusin, Meringgu)

For the water level gauges to be newly installed at Krusin and Meringgu, bubble type water level gauges are recommended, based on the findings of field survey as stated below:

- Ease of Equipment Installation

  Topographically disadvantageous location of the stations does not allow the transport of a large quantity of construction materials. Also in view of the river shape it is difficult to construct, operate and maintain large-scale facilities, such as a stilling well.

- Wide Range of Water Level Gauging

  The water level to be measured at the gauging points varies greatly (large difference between minimum and maximum water levels). Therefore if the float type water level gauge is employed, construction of the stilling well would be very difficult in terms of both the technical and the financial matter.

- Riverbed Fluctuation

  The riverbeds at the gauging points are supposed to be fluctuating greatly. It is therefore necessary to select the facilities capable of coping with such riverbed fluctuation.

- Experience

  Since the existing water level gauging stations along the Kinabatangan River have been using the bubble type gauges, the employment of the same type of gauges for the proposed system will be of convenience for operation and maintenance.

Discharge Measurement Equipment

For usual discharge measurement, current meter is used during low water and float during high water period. For higher accuracy, however, current water with selection positions for high and low velocity is recommended for use even during high water period.

Table 5.1 Types and Features of Water Level Gauges

a. Float type	This type of water level gauge requires a stilling well for waveless water level measurement and a horizontal conduit (or side hole) to lead water to it. In this gauging system, a float is in the stilling well and a wire leading from the float hangs from the pulley. As the water level goes up and down, the wire moves up or down to turn the pulley, which in turn moves the pen of the recorder.
b. Pressure type	With these water level gauges, the pressure-sensitive part is positioned in the water and the stilling well is not necessary. There are water pressure type and bubble type.

b. Pressure type (cont'd)	(i) Water pressure type The water pressure is measured by the pressure-sensitive part in a bell-shaped protective container in the water. The measurements are brought to the recorder by means of two pipes for temperature compensation. The recorder with a 40-day roll of paper can be put in a watertight container. (ii) Bubble type A very small amount of gas is sent out from a pipe opening in the water. When the gas pressure balances with the water pressure, the water level can be determined by measuring the gas pressure.
c. Sensor pole type	With this type of water level gauge, the sensor pole is lowered slowly until it reaches the water surface and the pulley rotations required are detected electrically. In the other type, the water surface is always followed with one of the sensor poles kept in contact with the water and the other kept apart from it.
d. Reed switch type	This water level gauge has a pipe standing in the water which incorporates reed switches placed at intervals of 1 cm. As a magnet attached to a float moves up and down within the pipe, the reed switches open or close, indicating the water level. This water level gauge features the recording of limitless

d. Reed switch type (cont'd)	height range, (cm minimum reading, print-out or cassette tape type and 3-month long recording period at 10-min. interval.

5.1.2 Design of Gauging Facilities

Siting of Station Housings

1) Rainfall gauging stations

It is desirable that the area projected in this system be divided as such the rainfalls over respective areas are about equal to one another and one rainfall gauging station located in each area. Actual siting of the stations, however, should be made according to the following criteria:

- Availability of easy access to station for operation and maintenance of gauges and other equipment
- No hazard from winds and other factors that would affect observation data
- Availability of place with enough lot space for housing (minimum 10m x 10m)
- No possibility of inundation
- Availability of good radio wave propagation paths for telemetry

For ease of operation and maintenance, the existing rainfall gauge in Serian is to be transferred to the site of water level gauging well so that the gauge could be mounted on top of the roof.

Appendix shows the proposed sites of the rainfall gauging stations in the Sadong river basin selected according to the above criteria by the field survey team.

2) Water level gauging stations

Water level gauging stations are to be located in areas considered necessary for the flood forecasting purpose. Actual siting of the stations, however, should be made according to the following criteria:

- Easy operation and maintenance of gauges and other equipment
- Little riverbed fluctuation
- Safe observation during flood
- Possibility of observation during low-water period
- Protection from flood hazards, such as waves and driftwood
- Availability of good radio wave propagation paths for telemetry

Appendix shows the proposed sites of the water level gauging stations in the Sadong river basin selected according to the above criteria by the field survey team.

As to the Tebakang rainfall and water level gauging station prosed in the preliminary survey report published by JICA in March, 1979, is excluded from this proposal since the location of the station would be too close to both Krusin (4 km from Tebakang) and Serian (9 km from

Tebakang). In addition to the above fact, construction cost of Tebakang station would be very expensive since it is to be placed in the flood plain.

All water level gauging stations are to be equipped with ordinary staff gauges.

3) Housing

Each telemetry station is to have a housing for the hydrological gauging equipment and telecommunication equipment.

All housing but the existing Serian water level well structure are to be newly built of reinforced concrete structure of 2.5m x 2.5m floor space considered suitable for the placement of the various devices to be housed.

The equipment housing needs to be located where it is safe from inundation, i.e., the housing floor level must be determined giving sufficient clearance from the maximum water level expected. Where there is a stout levee against flooding, the housing is to be set up on the bank. In locations where the bank does not have enough levee free-board, it must be constructed on top of a steel tower of about 10 m.

At Gedong, for example, the levee height is not enough to protect the facilities. All housing and equipments are therefore proposed to be placed on a steel tower structure 10m in height.

5.1.3 Designing of Relay Station

Equipments required for relay between the observation stations and flood forecasting center are to be installed within Telecommunication Department Mt. Serapi T.V. Station. Total space required for this installation would be 1m x 1m and 2m high provided that electricity (including emergency power during commercial power failure) is supplied by the Department. The survey team would appreciate very much that D.I.D., Sarawak, further discuss the matter related to the above-mentioned use of building space with the Telecommunication Department.

5.1.4 Flood Forecasting Center

The flood forecasting center is to be placed within the building to be newly constructed in D.I.D. Biutawa Depot area.

5.2 Design of Telemetry Facilities

Telemetry stations proposed for the flood forecasting and warning system are classified and listed as follows:

Table 5.2 Telemetry Stations

Classification	Station	Quantity
Master Control Station	Kuching (Bintawa Depot)	1
Relay Station	Mt. Serapi	1
Rainfall Gauging Station	Tebedu, Mongkos	2
Water-level Gauging Station	Krusin, Meringgu, Gedong, Ensengei	4
Water-level and Rainfall Gauging Station	Serian	1

Each facilities of telemetry station classified are stated in the following sections.

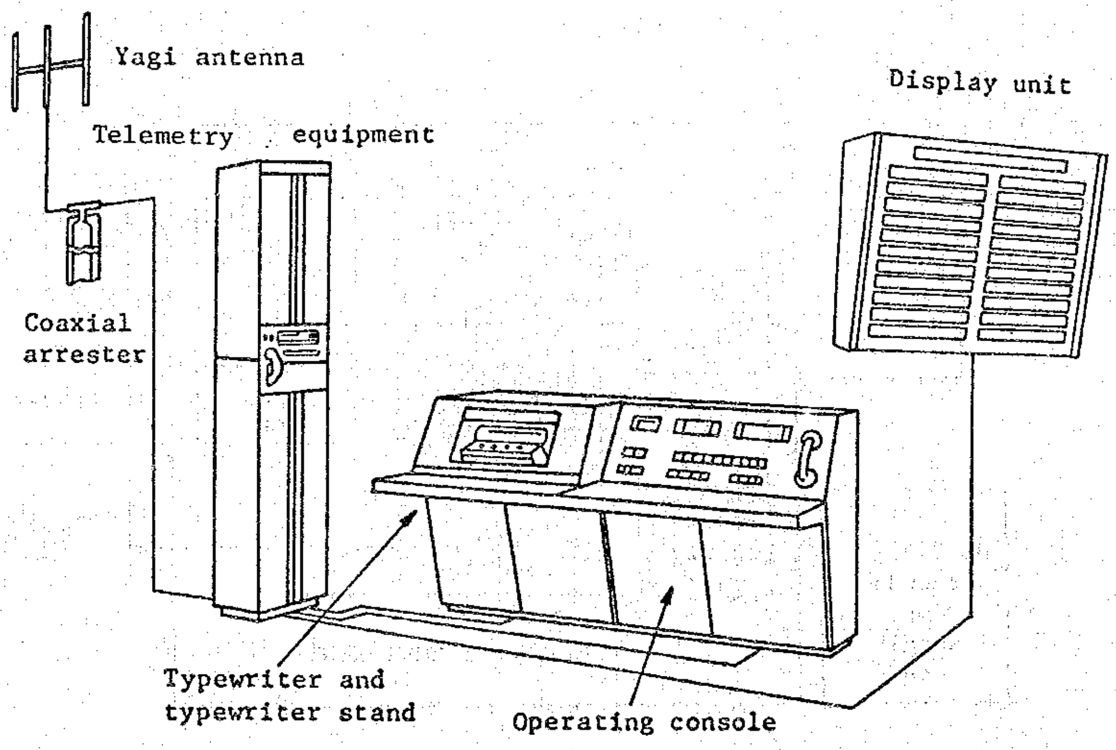
Further, representative specifications of telemetry facilities and example of capacity calculation for solar cell and storage battery are described in Appendix.

5.2.1 Master Control Station Equipment

Composition

The master control station consists of the following equipment.

- Telemetry equipment for control (containing radio equipment)
- Operating console
- Typewriter and typwriter stand
- Display unit
- Antenna equipment (with coaxial arrester)
- Clock
- Power supply equipment

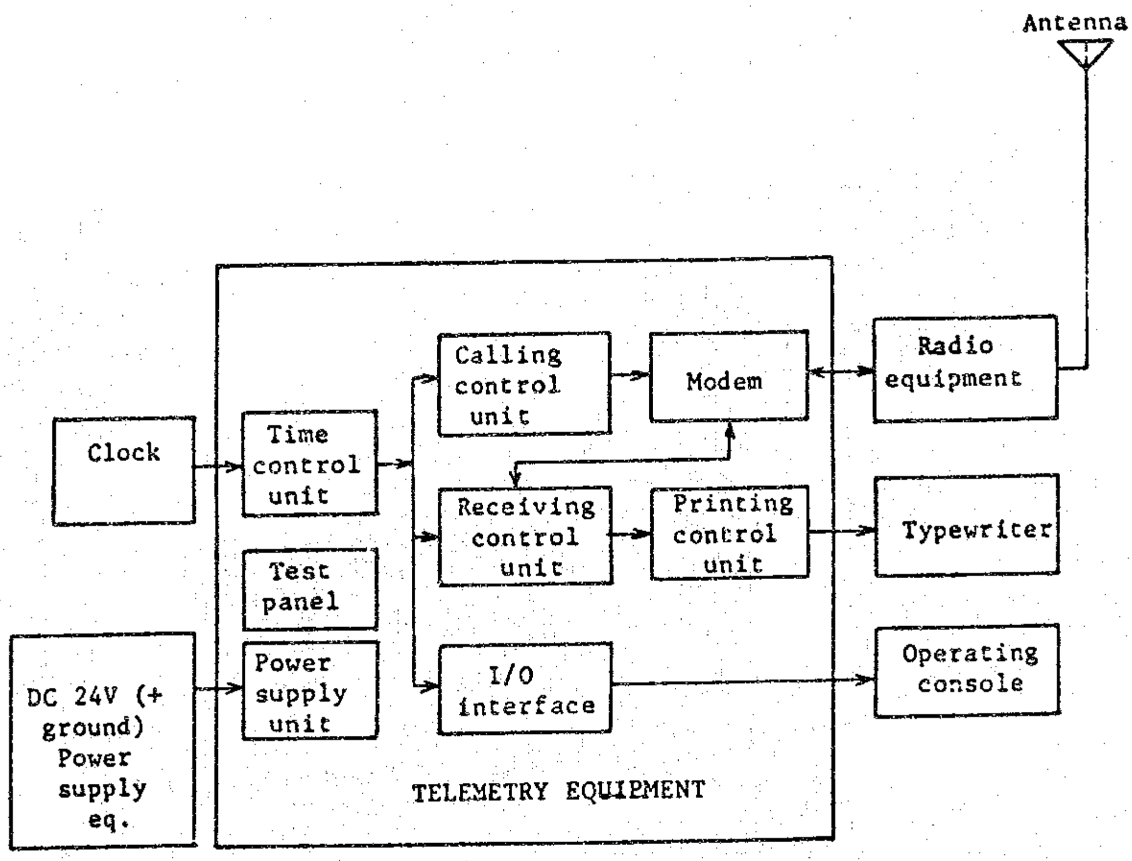


Master Control Station Equipment Composition

Telemetry Equipment

This equipment is a sheet iron bay type having exterior dimensions of approximately 2,350 mm x 520 mm x 250 mm. A modem unit, calling control unit, receiving control unit, printing control unit, time control unit, radio equipment, power supply unit, and test panel are housed in this bay. Each unit is of plug-in type for convenient inspection, except the power supply unit and test panel.

The block diagram of the telemetry equipment for master control station is given below.



Telemetry Equipment for Master Control Station

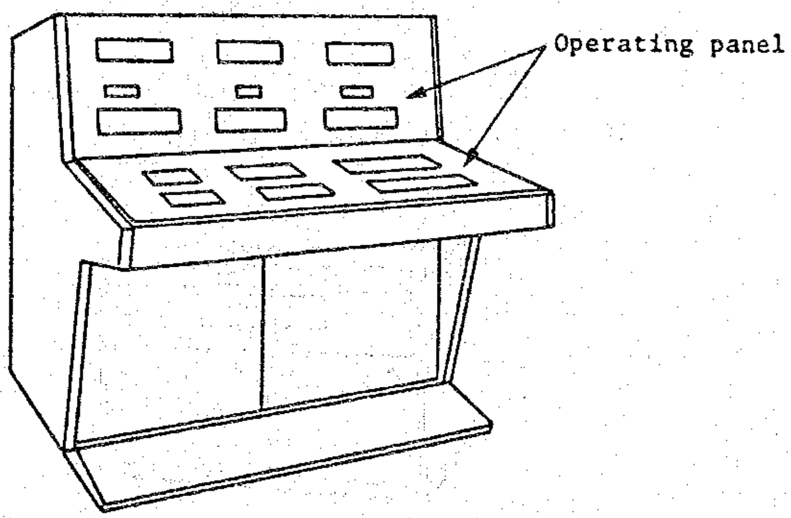
Block Diagram

Operating Unit

Operating unit is a console type and has the following functions:

Operation items and display items

- Calling time interval setting
- Manual measurement (all or individual calling control)
- Gauging station operation display and receiving failure display
- Measured value digital display
- Relay station start, stop, switching control
- Relay station status display
- Equipment operation and status display
- Alarm sounding at a failure and stopping
- Voice communication by handset and speaker
- Volume control



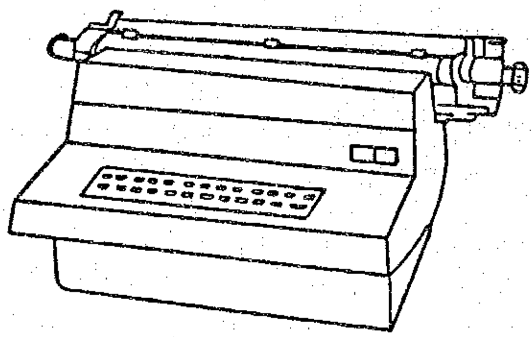
Exterior View of Operating Console

Typewriter

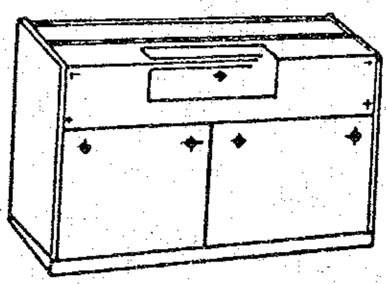
A 24 inches platen typewriter is used. Standard printing speed and character size are as follows:

Printing speed:	250ms/char or less
Character size:	12 chars/inch

The typewriter is normally housed in a typewriter stand such as that shown below for dustproofing and soundproofing.



(a) Exterior view of typewriter

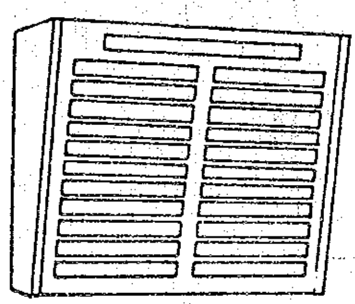


(b) Exterior view of typewriter stand

Display Unit

This unit displays the collected data by a wall-mount type numerical display. Water-level rising, falling or abnormal water-level, etc. may also be displayed. A display unit is not always necessary, but has many advantages such as:

- Data can be grasped simultaneously by a large number of persons.
- Status in river basins can be grasped at a glance.
- Back-up when trouble occurs at the typewriter.



Wall-mount type

Exterior View of Display Unit

5.2.2 Relay Station Equipment

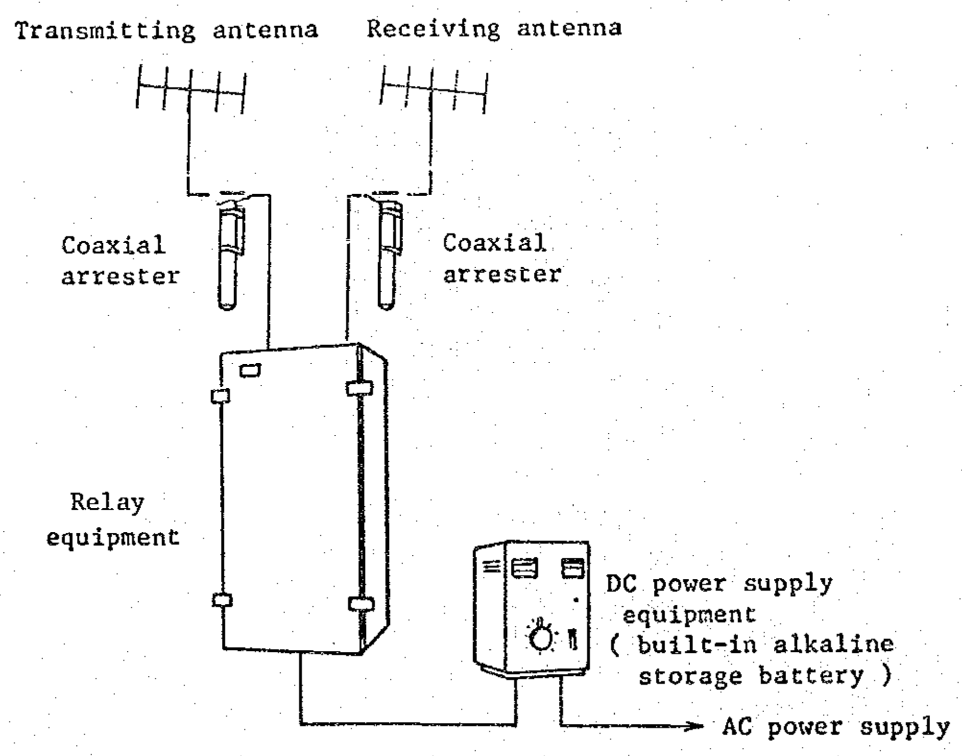
The relay station equipment has the following two main functions:

- Relay between master control station and each gauging station
- Remote control and self-check of relay station

Composition

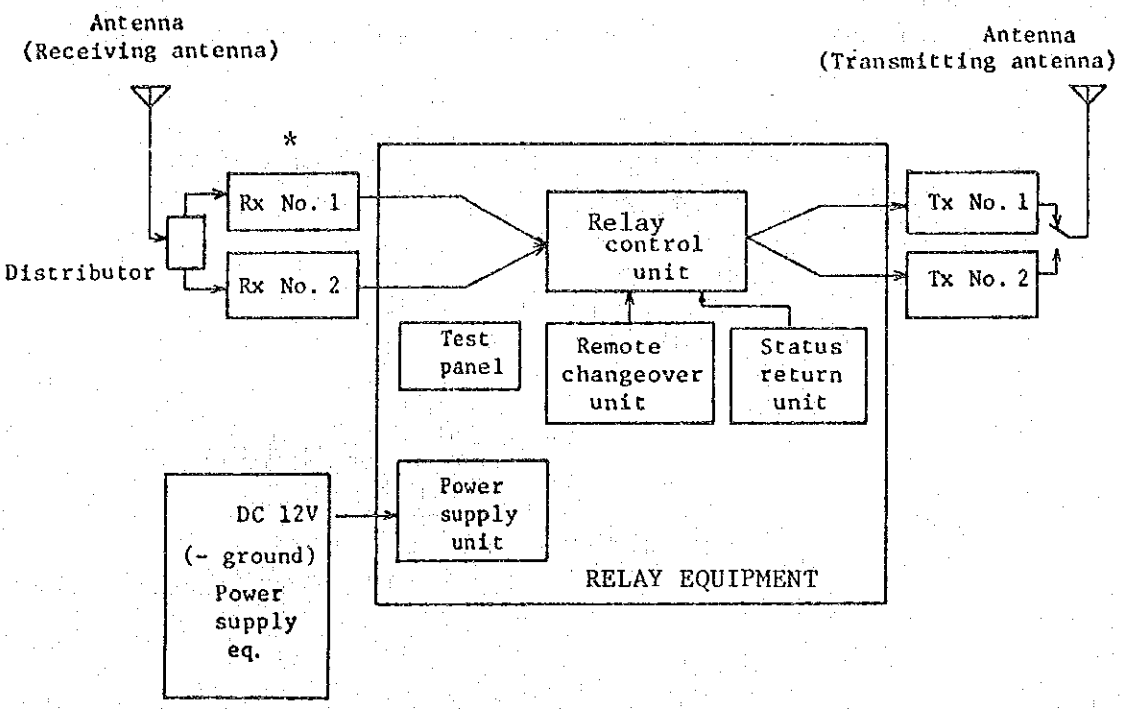
The relay station equipment consists of the following:

- Relay equipment (containing radio equipment)
- Antenna equipment (transmitting, receiving, 1 each, with coaxial arrester)
- Power supply equipment



Relay Station Equipment Composition

The block diagram of the relay equipment is given below.



* Parallel receiving for combined gain.

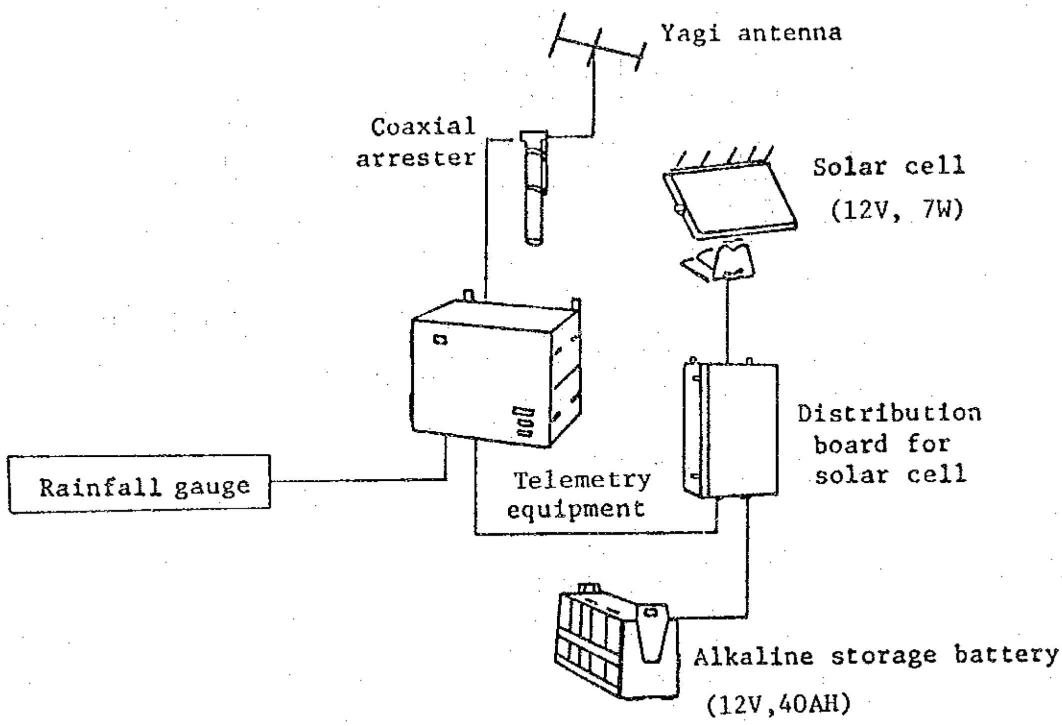
Relay Equipment Block Diagram

5.2.3 Rainfall Gauging Station Equipment

Composition

The rainfall gauging station equipment consists of the following equipment:

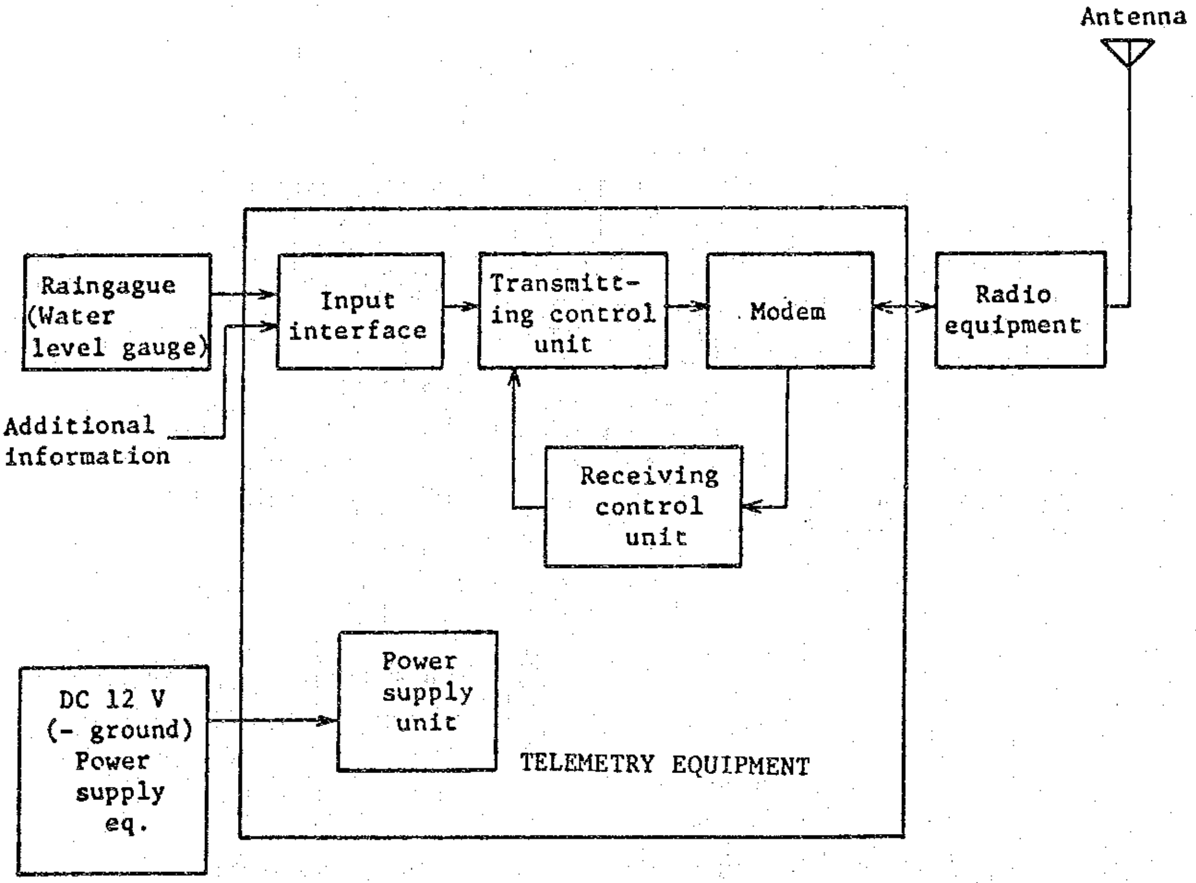
- Telemetry equipment (containing radio equipment)
- Rainfall gauging equipment
- Power supply equipment
- Antenna equipment (with coaxial arrester)



Rainfall Gauging Station Equipment Composition

Telemetry Equipment

This is the main part of the gauging station equipment, and includes a modem, transmitting and receiving control unit, input interface and power supply unit.
All circuits are accommodated on plug-in printed circuit boards for convenient inspection.
Since the installation site is unmanned and frequently humid, a moistureproof construction must be amply considered.
The block diagram of the gauging station equipment is given below.



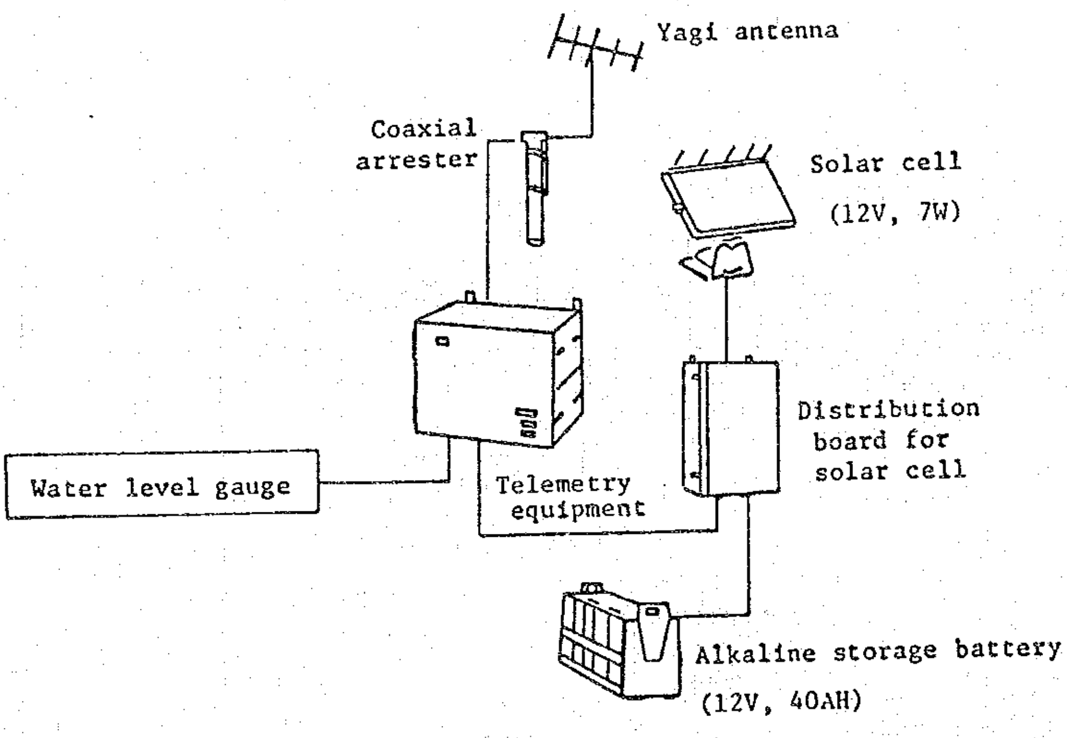
Telemetry Equipment Block Diagram

5.2.4 Water Level Gauging Station Equipment

Composition

The water level gauging station equipment consists of the following:

- Telemetry equipment (containing radio equipment)
- Water level gauging equipment
- Power supply equipment
- Antenna equipment (with coaxial arrester)



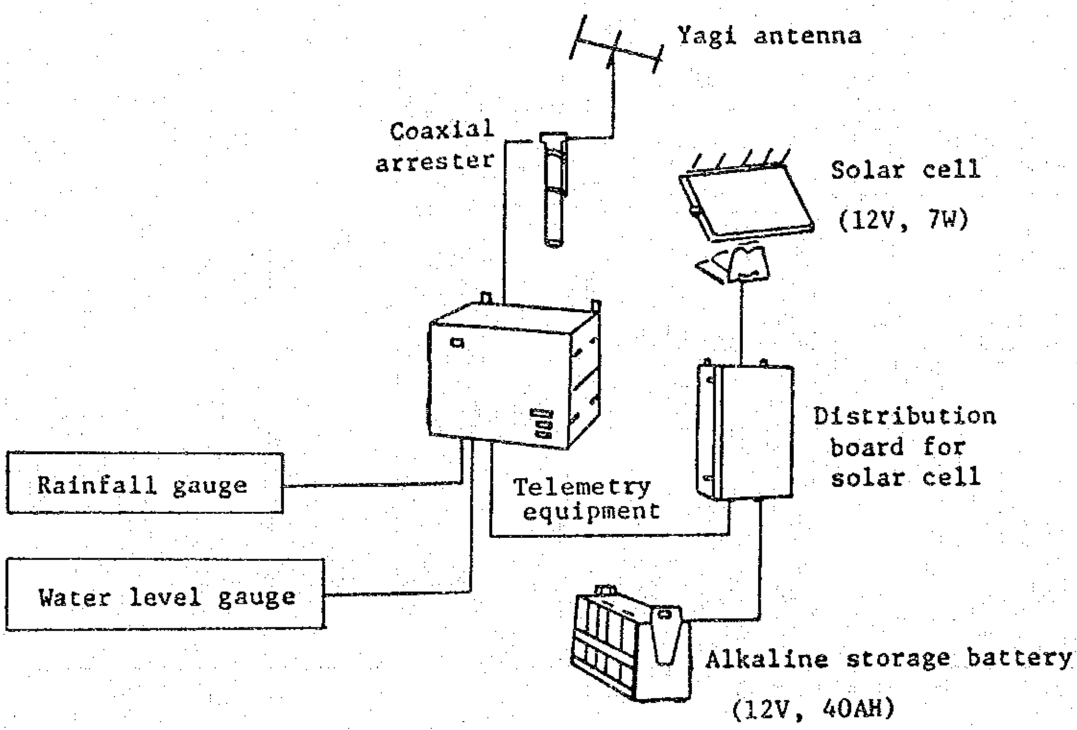
Water Level Gauging Station Equipment Composition

5.2.5 Rainfall and Water Level Gauging Station Equipment

Composition

The rainfall and water level gauging station equipment consists of the following:

- Telemetry equipment (containing radio equipment)
- Rainfall gauging equipment
- Water level gauging equipment
- Power supply equipment
- Antenna equipment (with coaxial arrester)



Rainfall and Water Level Gauging Station Equipment Composition

5.3 System Component

5.3.1 Civil Work

Table 5.3 Flood Forecasting and Warning System Facilities in Sadong River

No.	Station	Housing Space	Antenna	Equipment				Tower for Housing	Staff Gauge	Access
				Rainfall	Water Level	Float Dropper	Current Meter			
		m	m	set	type	set	set	m	m	set
1	FFC Bintawa	20 m^2	5	-	-	-	1	-	-	-
2	Relay St. Mt.Serapi	(1) (Height 2m)	(3) -	-	-	-	-	-	-	-
3	Tebedu	2.5x2.5	(3) -	(4) -	-	-	-	-	-	-
4	Mongkos	2.5x2.5	10	(4) -	-	-	-	-	-	-
5	Krusin	2.5x2.5	10	-	Bubble	-	-	-	10	-
6	Meringgu	2.5x2.5	10	-	Bubble	1	-	-	10	1
7	Gedong	2.5x2.5	10	-	Float	-	-	10	10	1
8	Serian	(2) -	10	(4) -	Float	-	-	-	10	-
9	Ensengei	2.5x2.5	10	-	Float	-	-	-	10	1

(1) Only equipment for telecommunication will be installed at the Mt. Serapi Station.

(2) Existing house will be used as the Serian Station.

(3) Existing telecom. antenna pole will be used as Antenna of Station.

(4) Existing rainfall gauge will be modified.

(5) New Water Level Gauge shall be provided because reconstruction of existing gauge costs expensive.

5.3.2 Telemetry Facilities

Table 5.4 List of Telemetry System Components
(Sadong River Basin)

Item	Station	Bintawa (Master Control)	Mt. Serapi (Relay)	Tebedu (Rainfall)	Krusin (Water Level)	Mongkos (Rainfall)	Meringgu (Water Level)	Serian (Rainfall & Water Level)	Gedong (Water Level)	Ensengei (Water Level)	Total
		Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity
Telemetry Equipment	for Control	1									1
Telemetry Equipment	for Rainfall Gauge with Magnetic Counter			1		1					2
Telemetry Equipment	for Water Level Gauge with Protective Device				1		1		1	1	4
Telemetry Equipment	for Rainfall & Water Level Gauge with Magnetic Counter, Protective Device							1			1
Relay Equipment	V-V Relay		1								1
Operating Unit	Console Type	1									1
Typewriter	24 inches	1									1
Display Unit	Wall-mount Type	1									1
Radio Equipment	70 MHz, 10W		2		1	1					4
Radio Equipment	70 MHz, 3W			1			1				2
Radio Equipment	70 MHz, 1W	1						1	1	1	4
Antenna Equipment	5 Elements Yagi with Coaxial Arrester		2	1	1						4
Antenna Equipment	3 Elements Yagi with Coaxial Arrester	1				1	1	1	1	1	6
Solar Cell	7W, with Distribution Board			1	1	1	1	1	1	1	7
Battery Charger	24V, 30A	1									1
Battery Charger	12V, 30A		1								1
Alkaline Storage Battery	24V, 150AH	1									1
Alkaline Storage Battery	12V, 250 AH		1								1
Alkaline Storage Battery	12V, 40AH			1	1	1	1	1	1	1	7
Automatic Voltage Regulator	10K VA, 220V	1									1
Automatic Voltage Regulator	1K VA, 220V		1								1
Surge Absorb Transformer	10K VA, 220V	1									1
Cable		1	1	1	1	1	1	1	1	1	9
Spares & Accessories		1	1	1	1	1	1	1	1	1	9

CHAPTER 6 OPERATION AND MAINTENANCE

6.1 Hydrological Observation Facilities

6.1.1 Maintenance of Hydrological Gauging Equipment

To conduct the hydrological observation with accuracy, it is essential to maintain the gauging equipment in perfect order. For this purpose, it is desirable that one maintenance man be appointed for each telemetry station who carries out weekly inspection and maintenance.

In this regular inspection, he is to repair troubles and supply consumables without fail in accordance with the inspection manual. In addition, he will be required to perform a thorough inspection and maintenance of equipment and facilities before the rainy season and after each flood. Refer to APPENDIX for the details of assignments.

6.1.2 Discharge Observations

Discharge observations are to be conducted with the purpose of establishing water level-discharge correlation formula at respective telemetry points.

Discharge measurements are to be taken for both low and high water stages at various timings and frequencies. The greater the frequency of observation, the higher the accuracy will be with which the correlation between the water level and discharge could be determined. The observation personnel are to stand by particularly for the very infrequent high water-level observation.

Observation personnel recommended to be assigned to station are:

Low water-level observation (current meter)	2 - 3 men/group
High water-level observation (float drop)	7 - 10 men/group

When the high water-level observation lasts long, two or three groups of observation personnel will be required. These observation personnel will have to be trained beforehand using the discharge observation manual. Also, the cross-sectional surveying of the river at the discharge observation points are to be conducted periodically (2 - 3 times per year - before and after a rainy season) to observe riverbed fluctuation. Another surveying is recommended immediate following a large flood for observing riverbed fluctuation. Refer to APPENDIX for description of assignments.

6.1.3 Arrangement of Observation Data

Observation data are to be arranged after ample accounting and then offered as basic data for statistical as well as hydrological analyses.

The basic data are to be kept on file for a long period of time.

6.2 Maintenance of Telecommunication System

For the flood forecasting and warning system to function efficiently, it is essential that the telemetry equipments and all other equipment used in the system are always maintained in a perfect order and the maintenance personnel are always stationed ready and trained for higher techniques. It is also very important that the budget enough for the adequate maintenance and operation is appropriated.

The necessary maintenance personnel include one supervisor engineer, one engineer and two electrical technicians. They are stationed at the Master Control Station and Monitoring Station and are assigned to perform such functions as the preparation and execution of maintenance plan, regular check plan, improvement plan, repair plan, parts and materials supply plan, gauges repair plan, etc. They also have to repair troubles when they have arisen and maintain parts, expendables and gauges in good repair.

The equipment to be used in this system are generally designed to withstand about 10 years of use. Therefore the equipment renewal plan should also be taken into account.

Though it depends on the years of service after the start of system operation, the maintenance cost will be about 5 % of the installation cost at least. In addition, about M$175 per mile rental charge of 9-year will have to be paid for the public telephone use.

6.3 Operation of Flood Forecasting and Warning System

6.3.1 Functions of Flood Forecasting Center

The Flood Forecasting Center in the proposed flood forecasting and warning system will perform the following functions:

- Collection of rainfall and water level data sent from telemetry stations
- Short-term flood forecast based on hydrological observation data collected
- Long-term prediction of flooding, based on above-mentioned short-term flood forecast and meteorological forecasts by the meteorological services. This long-term prospect will be conveyed to the Flood Control Center (FCC).

- Reporting of current and expected conditions of flooding to agencies concerned

- Research of improving prediction methodology

- Maintenance and management of equipments at telemetry stations

- Training of personnel

6.3.2 Personnel Organization

The following personnel are to be stationed at the Flood Forecasting Center for the smooth performance of their respective functions:

Hydrology engineer	Chief	1
	Supervisor	1
	Engineer	2
Telecommunication engineer	Supervisor	1
	Engineer	1
	Technician	2

6.3.3 Assignment of Personnel

Number of Personnel

For the efficient management of the system, the abovementioned personnel, namely, four hydrology engineers and four telecommunication engineers are required to be assigned before the system goes into operation.

Training Program

Since it is most desirable that the personnel are fully experienced in their respective fields, trainees (at least one hydrology engineer and one telecommunication engineer) are to be chosen and sent for training at some agency that has enough experience with advanced flood forecasting and warning. For training components, refer to APPENDIX.

On-the-job Training

On completion of the construction of the system, on-the-job traning for operation and maintenance is to be necessary to hold an education and training session for the duration provided by civil engineering consultants during a rainy season (3 to 4 months).

The staff to be assigned for operation and maintenance of the system (Chief-1, Supervisor-2, Engineer-3, Technician-2) does not necessarily be stationed at the flood forecasting center. The common pool of personnel may be used provided they are fully aware of the nature of the flood forecasting and warning sytem. For detailed items of assignment, refer to APPENDIX.

6.3.4 Budget for Operation of Flood Forccasting and Warning System

In order to maintain all the gauges and equipment used in the food forecasting and warning system in perfect order and continue studies and make improvements for the efficient operation of the system, it will be necessary to have a sufficient number of maintenance personnel and a study program for advanced techniques. At the same time, however, it is very important to have an independent budget appropriated for the necessary maintenance and operation of the system.

While maintenance cost for equipment will vary with the years in service after installation, about five per cent of the initial installation cost is to be appropriated for this purpose.

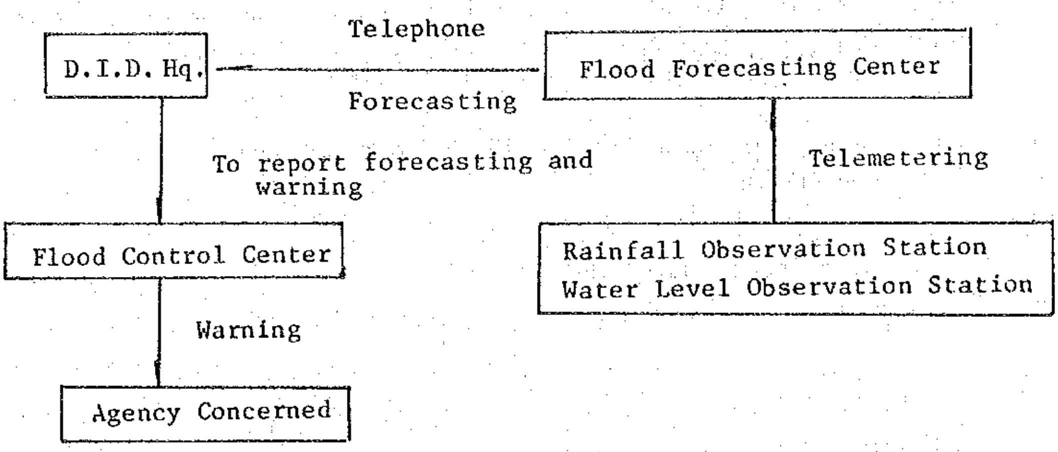
6.4 Flood Warning System

6.4.1 Organization of Flood Warning System

The Drainage and Irrigation Department (D.I.D.) of Sarawak is the direct administrator of this flood forecasting and warning system. Therefore, the Flood Forecasting Center will be incorporated in the organization of branches under it.

In the existing flood forecasting and warning mechanism, the D.I.D. has been taking charge of flood forecasting and the Flood Control Center (FCC) of each state has issued orders for evacuation and relief operations. Hence, the proposed flood forecasting and warning system will have to be incorporated in either the existing or already planned flood disaster relief control machinery.

Fig. 6.1 Conception of Flood Warning System



On the flood forecasting and warning system already established in Peninsular Malaysia, the warning system is being operated as shown on the flow chart of Fig. 6.2 . It is desirable that the same system be established as early as possible in the state of Sabah.

6.4.2 Methodology of Flood Warning System

There is no established methodology for a flood warning system, for there are variety of methods suitable for different characteristics of the river basin such as population and property distribution and the traffic network, as well as the organization of the flood forecasting and warning system to be adopted.

In many cases, however, residents are warned of the flood prospect in the following ways:

- The Flood Control Center contacts the concerned administrative agencies, which in turn warn the residents in each community through their respective organizations.

FIG.-6.2 FLOW CHART OF THE
FLOOD DISASTER RELIEF CONTROL MACHINERY

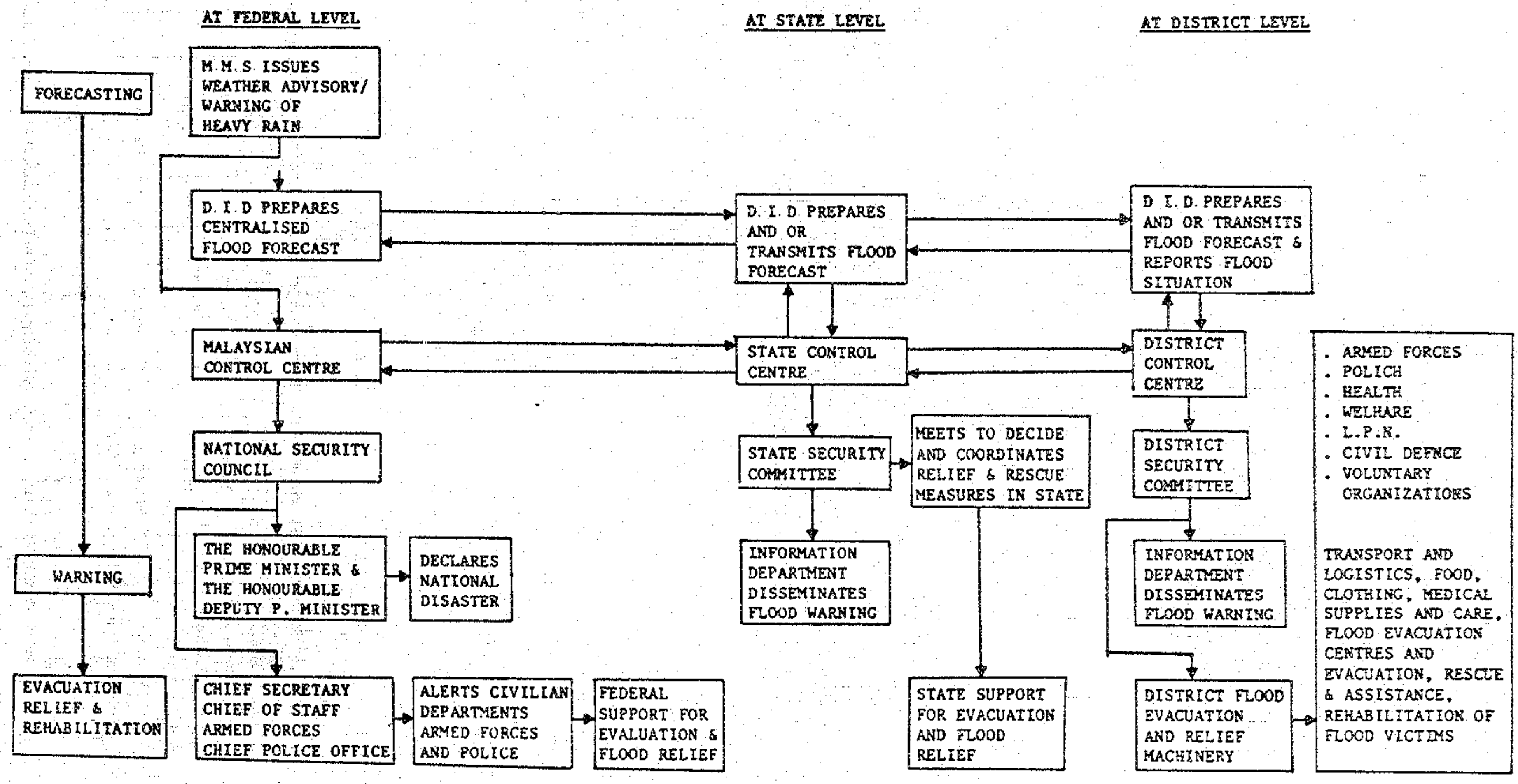
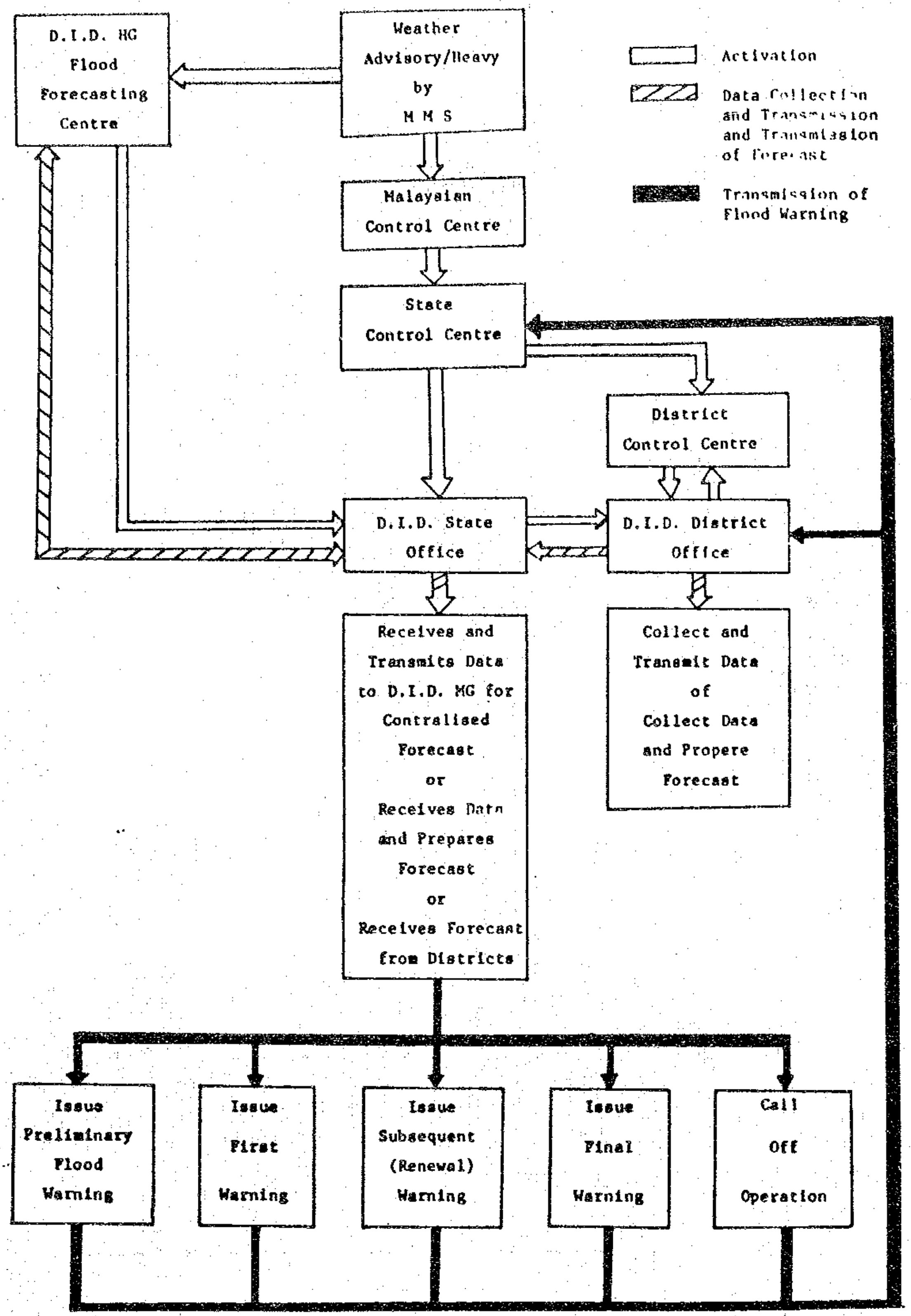


Fig.6.3 FLOW CHART OF PROCEDURE FOR REAL-TIME OPERATIONS



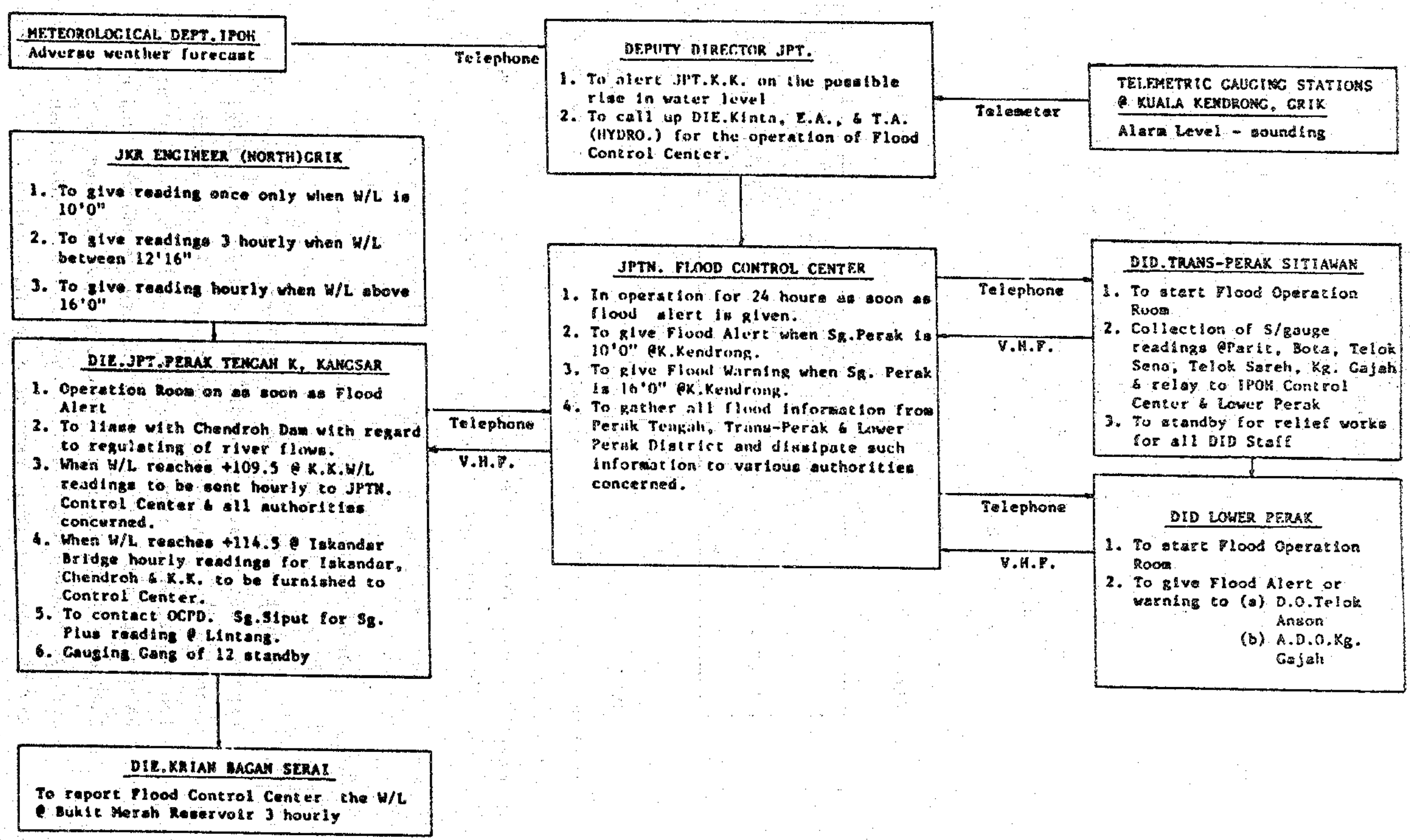


Fig.6.4 Flood Warning Procedure for Sungei Perak

- Alarm installations (sirens, speakers, flashlights, etc.) set up in the target area warn the residents by means of sound or light signals.

- Patrol vehicles and boats are used to warn the residents in the target area by voice, sound or light means.

- Chiefs of major villages or the branch offices of administrative agencies are provided with radio receivers through which the flood warning is conveyed. In this case, either a general broadcast network, or a newly established radio network for exclusive use in flood warning could be used.

Construction cost estimate of warning systems mentioned in the above three plans are as follows:

Type	Construction Cost(Incl.Consultancy Fee)
Warning Apparatus	812,000
Patrol Vehicle and Boat	430,000
Radio Receiver	180,000

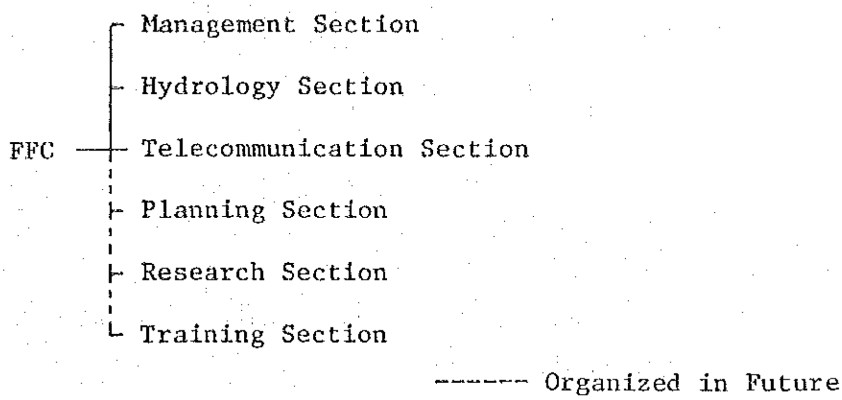
($US)

For detailed items of the above plans, refer to Appendix. The cost mentioned above are of aproximate estimate which are to be throughly examined after extensive radio test and population distribution survey for selection of appropriate receiver equipments. Above figures are meant for reference only.

6.5 Organization and Position in Administrative Offices

6.5.1 Organization of Flood Forecasting Center

A number of experienced engineers as well as a sum of expenses for management would be required to optimize the function of the flood forecasting and warning system. Therefore, it is recommended that the Flood Forecasting Center be set up as a part of Government Agency and provided an independent personnel assignment program and budget. The survey team would appreciate that Malaysian Government further investigate the above-mentioned recommendation for its viability.

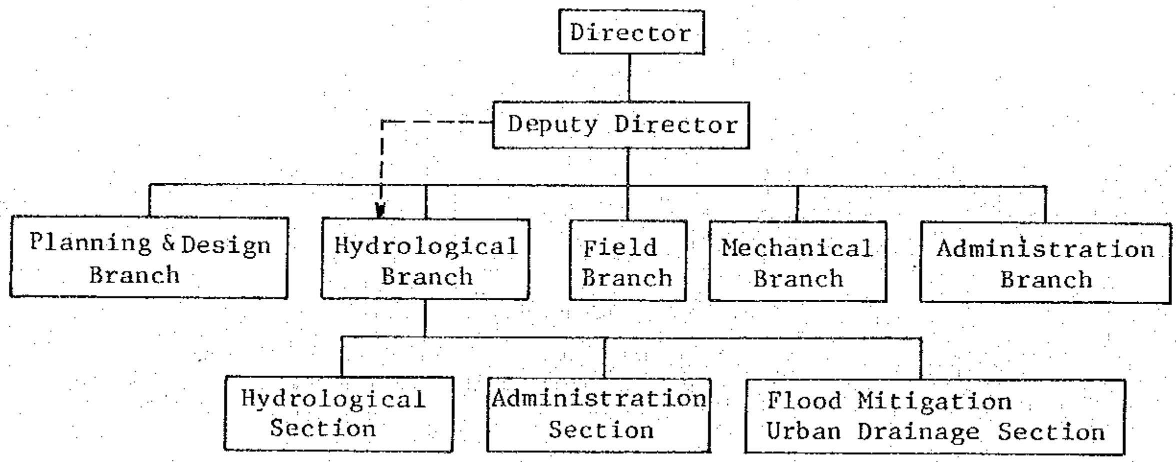


6.5.2 Position in Administrative Offices

Flood Forecasting Center of the Sadong River in Sarawak

The organization of the D.I.D., Sarawak is as shown below:

Fig. 6.5 D.I.D. Organization Chart



The Flood Forecasting Center can be positioned in the above administrative organization as follows:

- Initial stage : Upon the completion of the system, the Flood Forecasting Center should be placed under the Hydrological Section or Flood Mitigation Urban Drainage Section until its staff program, budget scheme and operations have been firmly established.

- Intermediate stage : As its procedures of operations become firmly established and the system extended to other river basins, the Flood Forecasting Center should be promoted to be a Section under Hydrological Branch, having its own personnel and budget program.

- Final stage : It is recommended that the Flood Forecasting Center, with independent personnel and budget. becomes one of the Branches of the D.I.D. or an organization directly under the D.I.D. Director capable of acting as a task force.

CHAPTER 7 COST ESTIMATE

7.1 Implementing Schedule

Construction of the flood forecasting center and the system network will start at once. Technical supervision for operation and maintenance will take a period of one year. Hence the system will come into operation in two and a half year after the commencement of construction. Each work section of the implementation will cover the period as stated below.

1.	Detailed Survey of Station Sites	1 month
2.	Detailed Design of Civil Work	3 months
3.	Detailed Design of Telecommmunication Facilities	2 months
4.	Preparation of Specifications and Bidding Documents	3 months
5.	Telecommunication Equipment Manufacture	10 months
6.	Equipment Delivery	3 months
7.	Telecommunication Equipment Installation and Adjustment	2 months
8.	Civil Work	13 months
9.	Gauging Equipment Installation and Adjustment	1 month
10.	On-the-job Training for Operation and Maintenance	12 months

Fig.7.1 WORK SCHEDULE

Item \ year	1	2	3
Detailed Survey of Station Sites	1		
Detailed Design of Civil Work	3		
Detailed Design of Telecommunicaiton Facilities	2		
Preparation of Specifications and Bidding Documents	3		
Telecommunication Equipment Manufacture	10		
Equipment Delivery		3	
Telecommunication Equipment Installation And Adjustment		2	
Civil Work		13	
Gauging Equipment Installation and Adjustment		1	
On-the-job Training for Operation and Maintenance		12	

7.2 Cost Estimate

7.2.1 Conditions for Estimate

Project cost of the System is estimated on conditions stated below:

i) Price quoted is the standard as of February 1980 in US Dollars.

ii) Contingencies are estimated at 10% of the costs of the machinery may equipment, and the facilities. The contingencies may be used to take care of the costs of operation and administration as well as the technical supervision.

iii) Station house for the tele-communication and observation machinery and equipment shall be constructed new. All preparation for procurement of project sites shall be performed by the authorities concerned of the Malaysian Government. The existing water-stage station houses will be utilized at Serian, Gedong and Ensengei. The construction cost of station houses in which the tele-communication machinery are equipment are to be installed is included in the estimates.

iv) All equipment (rain gauges, water level gauges, telemetry equipment and accessories) are to be provided by foreign suppliers.

v) Installation and adjustment of equipment is to be conducted by foreign technical assistance personnel, and the cost incurred shall be included in the estimates.

vi) Technical Assistance Cost is to include overseas training fee for Malaysian technical staff, supervision fee for detailed design, design modifications, contract and procurement as well as fee to be appropriated for on-the-job training. Twenty percent of the total construction cost is to be appropriated in the estimates. The percentage of the items would be:

Training	15%
On-the-job Training	35%

Detailed Design	30%
Contract and Procurement	5%
* Design Modification	15%

* Technical assistance is required in the civil works phase in case that the detailed design is modified in accordance with the latest conditions of the construction sites.

vii) Cost for housing of the Flood Forecasting Center is to cover only the floor space required. In other words, the Flood Forecasting Center is to occupy some rooms of the building to be constructed for purpose other than the proposed flood forecasting and warning sytem.

viii) Mt. Serapi Ralay Station is to be included within the station housing of the telecommunication department.

ix) Cost of maintenance vehicles and boats are not included in the estimates.

x) Cost of land lot required for housing is not included in the estimates.

xi) Technical Assistance Fee is appropriated only for foreign personnel.

Fees to be paid to local consultants for construction supervision, specification writing, contract document preparation, detailed design as well as cost to be incurred for training overseas of Malaysian hydrology and telecommunication staff are to be estimated separately.

xii) Equipments such as float droppers and current meters may be excluded from this estimate when they are not necessary to be procured anew.

7.2.2 Total Cost

Total cost to be incurred for the implementation of the flood forecasting and warning system in the Sadon River basin is as follows. Construction cost for the warning system is not included in the estimates.

Table 7.1 Total Cost (Sadong River Basin)

(US$)

Item	Observation Station	Flood Forecasting System	Total	Remarks
Equipments	100,800	367,800	468,600	
Facilities	58,600	142,600	201,200	
Sub-total	159,400	510,400	669,800	
Contingency	15,600	51,600	67,200	
Total	175,000	562,000	737,000	

Consulting Services	147,000
° Training	
Training Overseas	22,000
On-the-job Training	52,000
° Supervising	
Detailed Design	44,000
Contract and Procurement	7,000
Design Modification	22,000

The project cost has been estimated based on the current price as of February, 1980. The prices quoted has no inidication of inflation rates since estimation was difficult due to no definite origin of shipment. In this context the indicated prices may be referred to as the initial cost to be incurred at the commencement of the construction implementation.

7.2.3 Breakdown of Construction Cost

Unit Price

Table 7.2 Unit Price of Hydrological Observation Equipment

Item	Unit	Equipment	Indirect Cost	Total	Remarks
Rainfall Gauge (new)	per unit	4,100	1,300	5,400	Includes optional parts
Rainfall Gauge (modified)	"	2,000	1,000	3,000	
Water Level Gauge (bubble)	"	10,500	3,500	14,000	
Water Level Gauge (float)	"	5,000	1,500	6,500	
Water Level Gauge (float, modified)	"	7,000	1,500	8,500	
Staff Gauge	10 m 15 m	390 570	150 220	540 790	
Current Meter	per unit	4,600	1,000	5,600	
Float Dropper	"	32,000	4,000	36,000	

Table 7.3 Unit Price of Observation and Telemetry Stations Facilities

Item	Unit	Equipment	Indirect Cost	Total	Remarks
Tele-pole	5 m 10 m	4,500 9,200	500 900	5,000 10,100	
Triangular Tower	per unit	18,500	5,400	23,900	H=30 m
Station Housing (2.5mx2.5m)	per site			6,000	Housing re-building: 600
Station Housing (20 m²)	"			30,000	For rebuilding
Station Housing (5mx5m)				15,000	
Tower for Housing	"			15,000	
Cableway	"			16,000	
Staff Gauge Support	"			2,000	
Access Facility	"			10,000	Ladders and piers
Land Grading	"			2,000	300 sq. m

Table 7.4 Unit Price of Telemetry Equipment

US$

Item		Unit Price
Telemetry Equipment	for Control	41,000
"	for Rainfall Gauge with Magnetic Counter	5,300
"	for Water Level Gauge with Protective Device	7,000
"	for Rainfall & Water Level Gauge with Magnetic Counter, Protective Device	7,500
Relay Equipment	V - V Relay	16,000
Operating Unit	Console Type	15,700
Typewriter	24 inches	6,500
Display Unit	Wall-mount Type	32,000
Radio Equipment	70 MHz, 10 W	2,700
"	70 MHz, 3 W	2,400
"	70 MHz, 1W	2,100
Antenna Equipment	5 Element Yagi with Coaxial Arrester	800
"	3 Element Yagi with Coaxial Arrester	700
Solar Cell	7 W, with Distribution Board	1,200
Battery Charger	24 V, 30 A	6,000
"	12 V, 30 A	4,100
Alkaline Storage Battery	24 V, 150 AH	6,400
"	12 V, 250 AH	3,300
"	12 V, 40 AH	1,000
Automatic Voltage Regulator	10 KVA, 220 V	6,700
"	1 KVA, 220 V	2,300
Surge Absorb Transfomer	10 KVA, 220 V	2,000

Table 7.5 Breakdown of Observation Station Construction Cost
(Sadong River Basin)

(US $)

	Station / Item	Tebedu		Mongkos		Krusin		Meringgu		Gedong		Serian		Ensengei		Total	
		Q'ty	Amt.	Q'ty	Amt.	Q'ty	Amt.	Q'ty	Amt.	Q'ty	Amt.	Q'ty	Amt.	Q'ty	Amt.	Q'ty	Amt.
Equipments	Raingauge (w/modification)	1	3,000	1	3,000							1	3,000			3	9,000
	Waterlevel gauge (bubble)					1	14,000	1	14,000							2	28,000
	Waterlevel gauge (float)									1	6,500	1	6,500	1	6,500	3	19,500
	Staff gauge					10	540	10	540	10	540	10	540	10	540	50	2,700
	Current meter											1	5,600			1	5,600
	Float dropper							1	36,000							1	36,000
	Sub-total		3,000		3,000		14,540		50,540		7,040		15,640		7,040		100,800
Facilities	Station housing	1	6,000	1	6,000	1	6,000	1	6,000			1	600			7	24,600
	Access facility							1	10,000							3	10,000
	Housing tower																
	Land grading					1	2,000	1	2,000							2	4,000
	Staff gauge support					1	2,000	1	2,000							2	4,000
	Float dropper cableway							1	16,000							1	16,000
	Sub-total		6,000		6,000		10,000		36,000				600				58,600
Total			9,000		9,000		24,540		86,540		7,040		16,240		7,040		159,400

(US$ 1 = ¥ 220)

2) Breakdown of Telemetry Facilities

Table 7.6 Breakdown of Telemetry Facilities
(Sadon River Basin)

US$

Item	Station	Bintawa (Master Control)		Mt. Serapi (Relay)		Tebedu (Rainfall)		Krusin (Water Level)		Mongkos (Rainfall)		Meringgu (Water Level)		Serian (Rainfall & Water Level)		Gedong (Water Level)		Ensengei (Water Level)		Total	
		Q'ty	Amount	Q'ty	Amount	Q'ty	Amount	Q'ty	Amount	Q'ty	Amount	Q'ty	Amount	Q'ty	Amount	Q'ty	Amount	Q'ty	Amount	Q'ty	Amount
Telemetry Equipment	for Control	1	41,000																	1	41,000
Telemetry Equipment	for Rainfall Gauge with Magnetic Counter					1	5,300			1	5,300									2	10,600
Telemetry Equipment	for Water Level Gauge with Protective Device							1	7,000			1	7,000			1	7,000	1	7,000	4	28,000
Telemetry Equipment	for Rainfall & Water Level Gauge with Magnetic Counter, Protective Device													1	7,500					1	7,500
Relay Equipment	V-V Relay			1	16,000															1	16,000
Operating Unit	Console Type	1	15,700																	1	15,700
Typewriter	24 inches	1	6,500																	1	6,500
Display Unit	Wall-mount Type	1	32,000																	1	32,000
Radio Equipment	70 MHz, 10W			2	5,400			1	2,700	1	2,700									4	10,800
Radio Equipment	70 MHz, 3W					1	2,400					1	2,400							2	4,800
Radio Equipment	70 MHz, 1W	1	2,100											1	2,100	1	2,100	1	2,100	4	8,400
Antenna Equipment	5 Elements Yagi, with Coaxial Arrester			2	1,600	1	800	1	800											4	3,200
Antenna Equipment	3 Elements Yagi, with Coaxial Arrester	1	700							1	700	1	700	1	700	1	700	1	700	6	4,200
Solar Cell	7W, with Distribution Board					1	1,200	1	1,200	1	1,200	1	1,200	1	1,200	1	1,200	1	1,200	7	8,400
Battery Charger	24V, 30A	1	6,000																	1	6,000
Battery Charger	12V, 30A			1	4,100															1	4,100
Alkaline Storage Battery	24V, 150AH	1	6,400																	1	6,400
Alkaline Storage Battery	12V, 250AH			1	6,300															1	6,300
Alkaline Storage Battery	12V, 40AH					1	1,000	1	1,000	1	1,000	1	1,000	1	1,000	1	1,000	1	1,000	7	7,000
Automatic Voltage Regulator	10K VA, 220V	1	6,700																	1	6,700
Automatic Voltage Regulator	1K VA, 220V			1	2,300															1	2,300
Surge Absorb Transformer	10K VA, 220V	1	2,000																	1	2,000
Cable		1	2,300	1	1,000	1	1,000	1	1,000	1	1,000	1	1,000	1	1,000	1	1,000	1	1,000	9	10,300
Spares & Accessories		1	3,600	1	2,000	1	2,000	1	2,000	1	2,000	1	2,000	1	2,000	1	2,000	1	2,000	9	19,600
Installation and Adjustment		1	37,000	1	13,000	1	7,000	1	7,000	1	7,000	1	8,000	1	7,000	1	8,000	1	9,000	9	100,000
Total			162,000		48,700		20,700		22,700		20,900		23,300		22,500		23,000		24,000		367,800

Table 7.7 Breakdown of Flood Forecasting System Facilities Cost

MCS: Master Control Station
RS: Relay Station
GS: Gauging Station

(US$)

Item \ Station	Bintawa (MCS)	Mt.Serapi (RS)	Tebedu (GS)	Krusin (GS)	Mongkos (GS)	Meringgu (GS)	Serian (GS)	Gedong (GS)	Ensengei (GS)	Total
Tele-pole	5,000			10,100	10,100	10,100	10,100	10,100	10,100	65,600
Triangurar Tower										
Station Housing	30,000							6,000	6,000	42,000
Access Facility								10,000	10,000	20,000
Tower for Housing								15,000		15,000
Total	35,000			10,100	10,100	10,100	10,100	41,100	26,100	142,600

7.2.4 Foreign and Local Currency Allocation

Table 7.8 Currency Allocation of Hydrological Observation Equipment

Conversion Rate: 1US$=2.1M$=220Yen

Item	Unit	Total (US$)	Foreign (US$)	Local (M$)	Remarks
Rainfall Gauge (new)	per unit	5,400	4,100 (78%)	2,730	Frgn: Equipment, Shipping Local: Installation, Delivery
Rainfall Gauge (modified)	"	3,000	2,000 (67%)	2,100	Frgn: Modification, Optional Parts Local: Installation, Delivery
Water Level Gauge (bubble)	"	14,000	10,950 (78%)	6,405	Frgn: Equipment, Shipping Local: Installation, Delivery
Water Level Gauge (float)	"	6,500	5,100 (78%)	2,940	"
Water Level (float, modified)	"	8,500	6,600 (78%)	3,990	Frgn: Modification, Optional Parts Local: Installation, Delivery
Staff Gauge	10m 15m	540 790	440 640 (80%)	210 315	Frgn: Material, Shipping Local: Installation, Delivery
Current Meter	per unit	5,600	4,900 (87%)	1,470	Frgn: Equipment, Shipping Local: Delivery
Float Dropper	"	36,000	31,300 (")	9,870	"

Table 7.9 Currency Allocation of Observation and Telemetry Stations Facilities

Item	Unit	Total (US$)	Foreign (US$)	Local (M$)	Remarks
Tele-pole	5m 10m	5,000 10,100	1,500 3,000 (30%)	7,350 14,910	Frgn: Equipment, Shipping Local: Installation, Delivery
Triangular	per unit	23,900	15,600 (65%)	17,430	"
Station Housing (2.5mx2.5m)	per site	6,000	0 (0%)	12,600	Local: Material, Shipping Installation
Housing (5mx5m)	"	15,000	0 (0%)	31,500	"
Housing	"	30,000	0 (0%)	63,000	"
Tower for Housing(H=10m)	"	15,000	10,000 (67%)	10,500	Frgn: Tower Material Local: Foundation Material
Cableway	"	16,000	0 (0%)	33,600	Local: Material, Installation
Staff Gauge Support	"	2,000	"	4,200	"
Access Facility	"	10,000	"	21,000	"
Land Grading	"	2,000	"	4,200	"

Table 7.10 Currency Allocation of Total Cost
(Sadong River Basin)

Item	Foreign Currency (US$)		Local Currency (M$)		Remarks
	Observation Station	Flood Forecasting System	Observation Station	Flood Forecasting System	
Equipments	81,432	367,800	40,673	-	
Facilities	-	29,730	123,060	237,027	
Sub-total	81,432	397,530	163,733	237,027	
Contingency	8,568	39,470	16,267	23,973	
Total	90,000	437,000	180,000	261,000	

Consulting Services	147,000
° Training	
Training Overseas	22,000
On-the-job Training	52,000
° Supervising	
Detailed Design	44,000
Contract and Procurement	7,000
Design Modification	22,000

(US$1=M$2.1=¥220)