THE REPUBLIC OF THE PHILIPPINES

RE-STUDY
OF
THE SAN ROQUE MULTI-PURPOSE PROJECT

FINAL REPORT

(SUPPORTING REPORT)

SEPTEMBER 1985

JAPAN INTERNATIONAL COOPERATION AGENCY

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TABLE OF CONTENTS

TABLE OF CONTENTS

APPENDIX "A"

DATA OF THE HYDROLOGIC ANALYSIS

CONTENTS FOR APPENDIX "A"

DATA OF THE HYDROLOGIC ANALYSIS

LIST OF TABLES FOR APPENDIX "A"

LIST OF FIGURES FOR APPENDIX "A"

APPENDIX "A" DATA OF THE HYDROLOGIC ANALYSIS

1. Introduction

(1) Objectives of the Study

As for the San Roque Multipurpose Project, the feasibility study had been made by the hand of the Electroconsults (hereinafter referred to as ELC) during a period from 1974 through 1979. Further, short study was added in 1983 by ELC. The present study (hereinafter referred to as the Study) is made for the purpose to confirm the appropriateness of the results of hydrologic studies made in these preceding studies in respect to two items such as the discharge and the probable maximum discharge of the Agno River at the proposed San Roque dam site.

(2) Items of the Study

The two items are detailed as follows;

(a) Discharge: It is estimated on the basis of the records obtained by the actual operations of existing two dams and attached hydro-electric power stations such as Ambuklao and Binga, both of which are located on the Agno River upstream from the proposed San Roque dam site. Estimation of this item is made for the purpose to reconfirm the amount of water resources available at the proposed San Roque dam site.

(b) Probable maximum flood discharge (PMF): It is estimated on the basis of the probable maximum precipitation (PMP) of the rain gauge stations located in and around the catchment basin of the proposed San Roque dam. Result of this estimation will be put to use for the detailed design of the dam and spillway to be made in future.

(3) Scope of the Study

Prior to the hydrologic analysis, data collection is made. Data collected consist of rainfall data in and around the catchment basin of the proposed San Roque dam, operation records of power generation and spillway of the Ambuklao and Binga dams, and other related records. These data are good for estimating the outflow from the upper basin of the Binga dam which occupies two thirds or 68 per cent of the San Roque catchment basin.

In the hydrologic analysis, the inflow into two existing reservoirs are calculated firstly, and results are examined putting into use of the collected rainfall data.

Based on the analysis results which are examined to be appropriate, the characteristics of inflow into the existing reservoirs and outflow from the dams are studied. Then, the mean discharge at the proposed San Roque dam site is estimated from the calculated outflow from the Binga dam referring to the rainfall pattern in the San Roque catchment basin as well as to the discharge data and outflow characters of two rivers such as Ambayoan and Toboy which flow neighbouring to the east and west of the upper Agno River.

Whilst in parallel with the said works, the actually measured discharge data of the upper Agno River at the San Roque gauging station are examined to clarify the dependability. Reliable portions of the data are thus selected and the mean discharge are calculated. These results are used for the examination of the reliability of the analysis results mentioned before.

For the study and analysis, the daily records are used so far as practicable except the cases when daily data are not available but monthly data are available in stead.

Process to estimate PMF adopted in the study is as follows; namely (1) PMP is calculated for important rain-gauge stations in and around the San Roque catchment basin, (2) point rainfall is converted into area rainfall, (3) outflow analysis is made, and finally PMF is calculated. As for PMP, also the probable precipitation is calculated for examining the calculated PMP. For these calculation, an assumption is made that the two reservoirs presently operated are not exsisting because these two reservoirs don't have flood control capacity sufficient to decrease the flood peak discharge which flows into the proposed San Roque reservoir.

2. Catchment Basin

(1) Topography

The Agno River originates in the Data Mountain Range in the northern part of the Luzon Island, flows southward, changes the direction southwestward near San Manuel, again changes the direction northwestward near Bayambang, and debouches to the Bay of Lingayen of the South China Sea. The main river course is about 260 km long, and the whole watershed is about 5,000 km^2. The proposed San Roque dam site is located on the mid-course with 1,250 km^2 of catchment basin.

The upper reaches of Agno River are surrounded by mountains of which peaks range more than 2,000 m high above sea level. There are two existing dams such as

Ambuklao and Binga upstream from the proposed San Roque dam site. River bed elevations at the Ambuklao, Binga and the proposed San Roque dam sites are 630 m, 480 m and 100 m, respectively, indicating that the proposed San Roque dam site is situated on the border of the mountainous area and plain. Basin is slender in the north-south direction as shown in Figure A-1.

(2) Meteorologic and Hydrologic Characteristics

The upper Agno River basin receives as high precipitation as more than 3,000 mm a year influenced by the south-west monsoon, steeply sloped topography and a fact that the Luzon Island is on the passage route of typhoons.

Rainy season extends over six months from May to October, and the dry season over six months in the rest of the year. The hydrologic year coincides approximately to the calendar year. As observed on the isohyetal map as illustrated in Figure A-2, precipitation is heavier along the eastern and western watershed than in the northern mountain area or in the strip along the Agno River within its watershed.

The Baguio city, located slightly outside the western watershed, is well known for heavy rainfall. The yearly rainfall of 9,038 mm recorded in 1911 is the largest record among accurate records in the Luzon Island. Among recent monthly records, such a high monthly rainfall as 4,775 mm in July 1972, having yearly rainfall of 7,256 mm, is seen. In spite of the fact that the Banguio city is not in the watershed, the rainfall of Baguio is thought to represent the hydrologic characteristics of the upper Agno River basin.

The upper Agno River basin is not only heavy rainfall area, but also shows very high outflow having a mean specific outflow of 6.5 m^3/s from every 100 km^2 of the basin and an outflow coefficient of 0.7.

(3) Upstream Existing Dams

There are two existing dams on the Agno River upstream from the proposed San Roque dam site. The Ambuklao and Binga dams had been put to commission in December 1956 and January 1960, respectively. Main features of them are as shown in Table A-1.

As seen from Table A-1, the effective capacities of existing reservoirs are not large as compared with the yearly inflow volume. Especially, the Binga reservoir has an effective capacity which is smaller than one-half month's average inflow. Hence the time difference between the inflow and outflow is not large. In case

of Ambuklao reservoir, the time difference is not more than one month even in the rainy season. In case of Binga reservoir, monthly-wise time difference is not noticeable. This fact is confirmed by the Study.

3. Preceding Studies

(1) Mean Discharge at Proposed San Roque Dam Site

The San Roque gauging station is located immediately downstream from the proposed San Roque dam site. Records of water level and discharge of this station covering a considerable long time period are available, but the dependability of these records has been said to be low for various reasons. On the other hand, the rainfall records of Baguio cover long time period and their accuracy is dependable. The rainfall of Baguio has fair co-relationship with the hydrologic characteristics of the upper Agno River basin.

In the hydrologic analysis of ELC's feasibility study, measured discharge records of the San Roque gauging station are used for the years in which good correlation is observed with the Baguio rainfall. For the years in which the good correlation is not observed, as well as for the years in which discharge data at the existing two dam sites are not available, the discharge at the proposed San Roque dam site is estimated based on the rainfall data of Baguio. The results of the hydrologic analysis in ELC's study are as summarized in Table A-2.

As shown in Table A-2, the mean discharge at the proposed San Roque dam site is 94.2 m^3/s. Later in July 1983, ELC made a review on the hydrologic study, and presented a revised mean discharge of 93.7 m^3/s. This revised value is smaller than the value in the preceding feasibility report made by ELC by 0.5 per cent.

(2) Flood Discharge

In ELC's feasibility report, the design flood discharge of 12,800 m^3/s is adopted for the design of the spillway. This value is a sum of 11,000 m^3/s as the basic design value and 1,700 m^3/s as a surplus capacity. The basic value is introduced based on PMF analysis. The surplus capacity is explained as a possible artificial flood discharge caused by the gate operation of the Binga dam under abnormal condition. Namely, when a flood discharge of 8,000 m^3/s with a recurrence period of 10,000 years flows into the Binga reservoir in which water level is nearly at the high water level, the gates under full open condition will discharge 9,700 m^3/s. The difference of 1,700 m^3/s is considered as the surplus.

4. Data Used for the Study

(1) Data of Reservoir Operation

As to the Ambuklao and Binga dams, data of reservoir operation and power generation are collected. Data coverages are from 1957 for the Ambuklao dam and from 1960 for the Binga dam, both of which are the years of completion of respective dams, up to 1982. Data of outflow volume are exceptionally collected for 1973 and 1974. Both data are almost continuous and consecutive except for the said two years though data for some months are not collected.

Kinds of collected data are water level of reservoir, electric power output or water discharge used for power generation, and spillage through spillway. The records of stored water in the reservoir are collected but not used for the Study. These data are collected in the daily basis and used without being processed. Spillway data are collected in the hourly basis, and used being converted into the daily basis. In the same data, some daily and hourly data are missing. For such blank periods, the monthly data are used as substitution. Effective coverage periods of all of the said data are as tabulated in Table A-3 and graphed in Figure A-3.

In addition to the above-mentioned data, the reservoir water level viz storage curve and table as well as the reservoir water level viz necessary discharge for generation of 1 kWh curve and table are used. As for the former of the Ambuklao reservoir, there are three data; namely those immediately after completion, those of 1967 after sounding, and those of 1980 after the second sounding. As for the former of Binga reservoir, there are two data; namely those immediately after completion and those of 1967 after the sounding. As the curves of these data run almost in parallel with each other, only one line suffices the function for the inflow-outflow analysis, hence the data immediately after completion are used for the both cases of Ambuklao and Binga reservoirs. These curves are as shown in Figure A-4.

(2) Rainfall Data

Rainfall data of 17 rain-guage stations are collected. Of them, 12 stations are located in the San Roque catchment basin, four stations are located around and near the San Roque catchment basin, and one is located on the plain along lower reaches of the Agno River. Location of these stations are as shown in Figure A-1. Data coverage periods are as shown in Table A-4 and Figure A-5.

For the San Roque catchment basin of 1,250 km^2, each of the said 12 rain-gauge stations covers about 100 km^2 on the average, or each of 16 stations in and

around the San Roque catchment basin covers about 80 km^2 on the average. These coverages are judged adequate in size. On the other hand, the locations are biased rather in the upper basin of Ambuklao dam site. Especially in the left bank side of the lower basin of Ambuklao dam site, there is none except for the Binga rain-gauge station. This fact is a hindering factor in estimating the outflow from the basin between the Binga and proposed San Roque dam sites.

As shown in Table A-4, data consist of daily and monthly records on 11 stations, only of daily data on one station, and only of monthly data on the rest five stations. On five stations, there are data from the pre-war time. Of them, two stations cover only the pre-war time.

Rainfall data of Baguio is the longest in coverage period out of the data collected this time. The record covers a period from 1902 up to date for more than 70 years except for some blank periods. However, the data of the pre-war time are excluded from the Study as the blank periods continue intermittently in 1909, 1911 and 1937 to 1939. After 1949 through 1983, the data cover fully though blank periods of short time are seen.

Monthly rainfall data collected are as shown in Tables A-5 through A-21.

(3) Discharge Data

Data of water level and discharge are collected on 14 gauging stations. Of them, 12 stations are located on the upper reaches of Agno River upstream from the proposed San Roque dam site and two are located on the neighbouring rivers. Locations are as shown in Figure A-1. Data coverage periods are as shown in Table A-22 and Figure A-6.

Of said 12 stations, six stations have small catchment areas and two stations cover only short periods. Hence data of the rest four stations are useful for the Study. These four stations are Adaoay, Ambuklao, Binga and San Roque.

As for the Ambuklao and Binga gauging stations near which dams are existing, there are water level and discharge records for four to six years measured perior to the dam constructions. On the other hand, more than 50 years' data are available on the San Roque gauging station since the beginning of this century with number of blank periods. However, these data have not been appriciated so much because of the facts that the water level does not always stand in relation to discharge and that the change of river bed is frequent.

For the period after the commission of the Binga dam, the discharge at the San Roque gauging station is influenced very much by the discharge from the Binga hydro-electric power station which is made on hourly basis. However, measurement

of water level at the San Roque gauging station is made with the ordinary gauge staff by twice readings a day and not with the water level recording machine. Hence the discharge data at the San Roque gauging station do not fully reflect the actual status of discharge.

Monthly mean discharge collected is as shown in Table A-23 through A-36.

5. Discharge at Proposed San Roque Dam Site

(1) Discharge at Existing Dam Sites

1) Procedure of analysis

As afore-mentioned, there are daily data of the Ambuklao and Binga dams on the reservoir water level, electric energy output, discharge through turbine and spillage through spillway. Further, the relations between reservoir water level and storage capacity together with discharge necessary for generation of 1 kWh are available in form of graph and table.

Putting use of these data, the daily inflow into the two reservoirs and the daily outflow from the two dams are calculated. The calculation formulas are as follows:

$$O_i = Q_{G,i} + Q_{SP,i}$$
$$I_i = (S_i - S_{i-1}) + O_i$$

provided that $Q_{G,i} = a \cdot E_i$

$S_i = f(WL_i)$

where,
- O_i : outflow in i'th day (m^3/day)
- $Q_{G,i}$: used discharge for power generation in i'th day (m^3/day)
- $Q_{SP,i}$: spillage in i'th day (m^3/day)
- I_i : inflow in i'th day (m^3/day)
- S_i : storage in i'th day (m^3/day)
- a : discharge necessary to generate 1 kW (m^3/kWh) (see Figure A-4)
- E_i : energy output in i'th day (kWh)
- WL_i : reservoir water level on i'th day (m)
- f : relation between water level and stored water (see Figure A-4)

Besides, differences between values in (i)'th day and (i-1)'th day are calculated considering that the original values are those at 12 p.m.

2) Discharge at Ambuklao dam site

As for the discharge at the Ambuklao dam site, measured values before construction of the dam for four years from 1949 through 1952 are available, and the operation data after the dam construction from 1957 through 1982 are also useful. By the latter, outflow from the Ambuklao dam is calculated throughout the data coverage period. As to the inflow, the values for 1957, 1973 and 1974 can not be calculated directly because of absence of the daily reservoir water level data. The daily inflow are estimated through the procedure to be mentioned in subsection 5.(3).1), and examined in two steps in form of monthly mean values. Method of the examination is described below.

Firstly, the inflow into the Ambuklao reservoir obtained from the measured values and estimation is compared in monthly form with the rainfall of Baguio and Ambuklao, and periods during which inflow is obviously smaller than the rainfall are found. Such unbalances are caused mostly by the absence of daily data of spillage or by the daily data which are wrongly expressed in the smaller side. Hence the values in such periods are corrected or supplemented referring to the reservoir water level data, then the analysis of inflow and outflow is made again. Such periods for which monthly data are referred are as shown in Table A-37.

Mean value of the inflow and outflow is 40.8 m^3/s including those estimated by the said method. Monthly values are as shown in Table A-38 for the inflow and Table A-39 for the outflow.

Next, the correlation between the analysis results and the rainfall in the surrounding area is examined. Correlation of 1960 and 1968 is poor as shown in Figure A-7. These two years' data are excluded in the further study in consideration that there may be some problems in the inflow-outflow analysis. Number of years used for the calculation is 28 for the outflow and 25 for the inflow. The adjusted monthly inflow into the reservoir and outflow from the dam at Ambuklao are summarized in Table A-40.

3) Discharge at Binga dam site

Discharge at the Binga dam site is known on the data which consist of six years' measured records from 1950 to 1955 before the dam construction and 23 years' records of dam operation and power generation. There are one to two months' blank in 1953 and 1955 in the measured daily records. Also, there are blanks in more than six months' records of 1960. Further, the reservoir water level data for three years from 1973 through 1975 are not collected.

In the same manner as mentioned in the above, examination of analysis for the inflow and outflow as well as the results is made. Like the case of Ambuklao,

there is deficiency of daily spillage data, hence the supplement, as shown in Table A-41, is done and analysis is made again.

Mean monthly values of inflow and outflow calculated from the values which include the measured values are 57.3 m^3/s and 57.2 m^3/s, respectively. Monthly values are as shown in Table A-42 for the inflow for the period of 26 years and Table A-43 for the outflow for the period of 29 years.

Next examination is made on correlation with the rainfall of surrounding area in the same manner as given in the above. As illustrated in Figure A-8, there is no year for which correlation is poor. Results of inflow and outflow calculation are same as the monthly values as shown in Tables A-42 and A-43.

(2) *Outflow from the Basin between Ambuklao and Binga Dams*

1) Procedure

The catchment area of the basin between Ambuklao and Binga dams is 243 km^2 and its outflow is calculated by means of subtracting the Ambuklao outflow from the Binga inflow. As to the Ambuklao outflow and the Binga inflow, the actual measured values of the inflow into the reservoir and outflow from the dam are used on monthly value basis. Namely, differences of measured values at the Ambuklao and Binga dam sites are deemed to be the outflow from the remnant basin for the period before construction of each dam, and the differences of outflow from the Ambuklao dam and inflow into the Binga reservoir are deemed to be the remnant flow for the period after the dam construction.

Analysis is made on the monthly value basis. In case the remnant flow becomes negative, namely the Binga inflow is smaller than Ambuklao outflow, the remnant outflow is deemed nil.

2) Outflow

In line with the aforesaid procedure, the remnant flow is calculated. The results are as shown in Table A-44. To examine the appropriateness of these results, the correlation with the rainfall is examined. The results are as shown in Figure A-9. Results of 1967, 1968 and 1972 have poor correlation. In fact, the case of 1968 has already been excluded from the inflow-outflow analysis for Ambuklao because of poor correlation. Also the case of 1960 which has been excluded from the analysis for Ambuklao as well as the case of 1961 which includes many negative remnant values are unfavourable.

Considering the above-mentioned unfavourable facts, the said cases of five years are excluded; and the remnant outflow is calculated from the remaining 22

years' results. Obtained results are as tabulated in Table A-45.

(3) Discharge at Proposed San Roque Dam Site

1) Procedure

The outflow from the upper basin of the Binga dam has been estimated. Next need is to estimate the run-off from the remnant catchment area between the Binga and proposed San Roque dam sites. For the estimation of this remnant flow, there are problems mentioned below:

(a) There is no measured discharge record in this remnant basin except for those at the San Roque gauging station.

(b) Rainfall data in this remnant basin are insufficient. On the right bank side, there are data of Main Camp and Open Pit, but the data include many blanks and the accuracy is not so high. On the left bank side, there is no rain-gauge station at all.

Under this condition, the long term mean discharge at the proposed San Roque dam site is estimated in the manner mentioned below:

(a) Specific run-off and run-off coefficient are calculated based on the out-flow from the upper basin of Binga dam and the mean area rainfall over the same basin.

(b) Discharge at the proposed San Roque dam site is estimated putting use of thus obtained specific run-off and run-off coefficient.

At the same time, characteristics of two neighbouring river basins are put into consideration for increasing the dependability of the estimated values. Namely, the discharge data of the Ambayoan River of the Agno River system and the Toboy River of the Dagupan River system are used for the examination purpose.

2) Run-off of neighbouring basin

There is the Ambayoan gauging station on the Ambayoan River of the Agno River system to the east of the proposed San Roque dam site as well as the Kalipkip gauging station on the Toboy River of the Dagupan River system to the west of the proposed San Roque dam site. The catchment areas of these rivers are adjoining to the main Agno River on which the proposed San Roque dam site is located, and these guaging stations are located on similar latitudes. Catchment areas are 281 km^2 and 74 km^2, respectively, for the Ambayoan and Kalipkip gauging stations.

Locations are as shown in Figure A-1, and monthly mean discharge records of both gauging stations are as shown in Tables A-26 and A-27.

Yearly mean discharge of these guaging stations, obtained omitting the months for which no data are available, and the rainfall of Baguio have excellent relationship except a few exceptions as illustrated in Figure A-10.

Mean discharge of the Ambayoan gauging station is calculated excluding data of 1958, 1966, 1976 and 1977 which have poor correlation with the Baguio rainfall. Mean discharge of the Kalipkip gauging station is calculated excluding data of 1964 and 1972 which have poor correlation with the Baguio rainfall. Average monthly discharges at both stations are as shown in Table A-46.

3) Estimated mean discharge at Proposed San Roque dam site

From the aforementioned arguments on the inflow into reservoirs and the outflow from dams at Ambuklao and Binga, mean discharge of the Ambayoan and Toboy Rivers at the Ambayoan and Kalipkip gauging stations, respectively, and mean yearly rainfall over each catchment area which is introduced from the isohyetal map as shown in Figure A-2, the specific run-off and run-off coefficients of each catchment area are calculated as shown in Table A-47.

Both of the specific run-off and run-off coefficients are generally high probably because of the facts that the topography consists of steep slopes and that more than 90 per cent of yearly rainfall is concentrated in six months' rainy season. Specific run-off of each catchment area shows the value around 0.065 except the case of Kalipkip, 0.073, which receives heavier precipitation influenced by the south-western monsoon and of which catchment area is small.

The outflow from the remnant basin between the Binga and proposed San Roque dam sites is calculated on the following basis; namely,

(a) Mean yearly rainfall of this basin is 3,200 mm. This value is calculated, like the case of other catchment areas, from the isohyetal map as shown in Figure A-2.

(b) Catchment area between the Ambuklao and Binga dam sites, and also the Ambayoan River basin are adjacent to this basin and the sizes are in similar order.

(c) These three catchment areas receive similar yearly precipitation, the difference being around 10 per cent. Hence the outflow characteristics of three catchment areas are thought to be similar.

(d) In consideration of,

- specific run-off from the remnant basin between the Ambuklao and Binga dam sites,
- specific run-off from the Ambayoan River basin, and

– mean yearly rainfall over the basins related, the specific run-off of the subject basin is calculated as follows;

$$\text{Specific run-off} = 3{,}200 \times \frac{0.062 + 0.065}{3{,}000 + 2{,}800} = 0.070$$

The catchment area between the Binga and proposed San Roque dam sites is 390 km^2, while the whole San Roque catchment basin is 1,250 km^2 and the catchment area of Binga dam is 860 km^2. The outflow from this catchment area is estimated to be 27.3 m^3/s on an average. Long term mean discharge is thus calculated to be 84.5 m^3/s as shown in Table A-48.

(4) Average Discharge at Proposed San Roque Dam Site

1) Observed discharge at San Roque gauging station

Daily or monthly discharge record at the San Roque gauging station are available for 49 years as shown in Table A-23. It is, however, known that the records are not so reliable. The observed record is, therefore, used to confirm the average discharge analyzed from the existing reservoir operation records and so on.

Out of the whole period that observation record is available at the San Roque gauging station, data reliability is examined for the period after 1949 because outflow values from the Binga dam are obtained from 1949 including discharge observation period. The examinations are made through the correlation analysis of observed discharge at San Roque with rainfall at Baguio and outflow from the Binga dam. The results of examinations are as shown in Figure A-11. The discharge records at San Roque for years that well relation is not given from one of either correlation are excluded from the average estimation. Monthly discharge records in the years with some monthly data interruptions in the above records are also excluded since the dependability of discharge at San Roque of these years cannot be confirmed. Years excluded or judged to be reliable are as shown in Table A-49.

The monthly average discharge for 21 years described above is as summarized in Table A-50 out of whole data period as shown in Table A-23. The average value of discharge at San Roque for 21 years judged to have the reliability is calculated to be 84.1 m^3/s. It is as almost same value as that calculated from the operation records of the existing two dams.

2) Average discharge at proposed San Roque dam site

To estimate a long term average discharge at the proposed San Roque dam site,

the run-off from the catchment areas of Ambuklao and Binga dams is evaluated as first step. The above drainage area occupies over two thirds of the San Roque catchment basin. The average run-off from the drainage area of existing Binga dam is analyzed to be 57.2 m^3/s using the existing reservoir operation records. This average value is obtained reflecting actual annual and seasonal variation.

The run-off from the remnant basin between the Binga and proposed San Roque dam sites is estimated to be 27.3 m^3/s on the average. It is obtained from the analysis on run-off characteristics in the basin between the Ambuklao and Binga dam sites and the catchment areas of Ambayoan and Kalipkip rivers. Discharge at the proposed San Roque dam site is, consequently, estimated to be 84.5 m^3/s on the average. It corresponds to about 90 per cent of 94.2 m^3/s estimated by ELC's feasibility study, and of 93.7 m^3/s by its additional study.

The average of observed discharge records at the San Roque gauging station is 84.1 m^3/s for 21 years that is found to be reliable among 32 years for 1949 through 1980.

Average discharge of 84.5 m^3/s is concluded as a long term average at the proposed San Roque dam site, and monthly average discharge as shown in Table A-50 is obtained taking monthly variation of observed discharge at the site into account.

(5) Available Discharge at Proposed San Roque Dam Site

It is evaluated to be 84.5 m^3/s as a long term average discharge at the proposed San Roque dam site. Mean of observed discharge during the selected period of 21 years among 1949 to 1980 is obtained to be 84.1 m^3/s. The said period is seemed to have reliable record judging from correlation examination between observed discharge at San Roque and rainfall record at Baguio or outflow released from Binga dam. Estimated average value has no difference with mean of observed record. It is proved that annual average of the observed record at the San Roque gauging station is rather reliable if the unreliable record period to be discarded could be found. Among monthly observed discharge records at the San Roque gauging station as shown in Table A-23, the records for 21 years that are proved to be reliable through the Study are as summarized in Table A-51.

In ELC's feasibility and additional studies, annual average discharge at the proposed San Roque dam site were estimated principally from the correlation with Baguio rainfall. As to the result of ELC's studies, a long term average discharge at the proposed San Roque dam site was estimated to be 94.2 m^2/s and 93.7 m^3/s, respectively. Average discharge obtained by the Study has 10.3 per cent difference with the former and 9.8 per cent with the latter. Out of monthly discharge estimated by ELC's studies, that for the period after 1949, chosen as a period for the Study, is

as shown in Table A-52.

As regards discharge estimated by ELC's studies, 83.4 m^3/s and 90.9 m^3/s are obtained as the average for the period of 34 years from 1949 to 1982 and for 21 years, selected among 34 years above as a reliable data period, respectively. Both of the above are lower than the average discharge estimated through the Study or the average of observed records for selected 21 years. The mean discharge estimated in ELC's studies for the period of 42 years from 1902 to 1948 except 1941 to 1945 is around 101 m^3/s. Out of 70 years of ELC's studies period, the latter period of 30 years has only 83 per cent of discharge on the average compared with that of the first period of 40 years. Taking the result of the Study into consideration, there is slight possibility of coming to an overestimated design discharge unless the record for the former 40 years, the period before the World War II, would be availed for the Study with any consideration.

Since a part of inflow volume into the reservoir will be released directly through the spillway during flood, the effective discharge should be estimated excluding high inflow parts beyond a level. It is assumed that inflow over monthly average of 200 m^3/s becomes uneffective although reservoir operation study shall be made precisely as released volume depends on the reservoir water level variation. For the period of 21 years as shown in Table A-51 and A-52, the average effective discharge is obtained assuming that monthly discharge over 200 m^3/s is uneffective and counted as 200 m^3/s. As to the long term average of effective discharge for 21 years, 72.2 m^3/s for the observed record at the San Roque gauging station and 76.4 m^3/s for the estimation by ELC's studied are obtained. The latter one indicates 5.8 per cent as large as the former.

(6) Observations

From all of the above-mentioned studies, it is summarized as follows;

(1) The mean discharge of 84.5 m^3/s estimated under the Study is similar to the mean value of the measured discharge of 84.1 m^3/s at the San Roque gauging station as a mean of 21 years' data which are selected as dependable data. It is induced by this fact that the flow pattern of each hydrologic year as well as of the seasonal pattern are well incorporated in the estimation under the Study for the reason that the analysis and estimation are made based on the outflow from the upstream dams.

(2) Difference between the mean discharge of 94.2 m^3/s shown in ELC's feasibility report and the mean discharge of 84.5 m^3/s estimated under the Study is approximately 10 per cent.

(3) Effective portion of the yearly run-off is estimated by means of substracting the spillage through the proposed San Roque dam's spillway from the run-off. Effective portion of the mean value of the measured data is approximately 5 per cent smaller than that of ELC's feasibility and additional studies.

(4) Taking into account the topographic conditions of the proposed dam site and the reservoir area, such facts as mentioned above would have no influence upon the dam Plan Proposed in ELC's feasibility study.

6. Probable Maximum Flood at Proposed San Roque Dam Site

(1) Probable Maximum Precipitation at Baguio

1) Available records for probable maximum precipitation study

Daily rainfall records at Baguio are collected for the period of 1909, 1911, 1937 to 1939, and 1950 to 1982 for the Study. For the period after 1978, daily records during wet season are scarcely collected. The records for 33 years are, therefore, available for the Study on the estimation of PMP. Maximum monthly records on various duration-rainfall are also available for the period from 1950 to 1977. The maximum daily rainfall records for 33 years are as listed in Table A-53.

Daily rainfall records during the biggest five storms are as shown in Table A-54. These five storms are selected out of the storms observed at Baguio, and these storms contains higher daily rainfall and larger total rainfall volume than the other storms. In Table A-54, daily rainfall records observed at five stations in the Agno River basin are also as shown together with the inflow into the Ambuklao reservoir estimated by the inflow-outflow analysis.

The various duration-rainfall records during 24 hours at Baguio are as shown in Table A-55. The records as shown in Table A-54 are not for the biggest five storms but for the following big storms since that of biggest storms are not available for the Study.

2) Estimation of probable maximum precipitation by statistical method

The moisture adjustment method is generally applied for the estimation of PMP. Thus, PMP is estimated through the aforesaid method that magnitude of adjustment factor derived from supplied moisture analysis. No other records except that of daily rainfall and depth-duration are, however, available for the Study. The statistical method, developed by Hershfield based on the observed records, is applicable for the PMP study in case that only annual maximum daily records are available.

Through Hershfield's method, PMP can be estimated applying maximum daily record to the following equation;

$$Pm = \overline{Pn} + K \cdot \sigma n$$

where, Pm : Probable maximum precipitation

$\overline{Pn}$: Average of annual maximum daily precipitation records for n years

σn : Standard deviation of annual maximum daily precipitation records for n years

K : Constant to be determined

Applying annual maximum records as shown in Table A-53, the following values are obtained;

$\overline{Pn}$ = 378.4 mm, σn = 221.8 mm

$\overline{Pn}$-m = 359.3 mm, σn-m = 198.6 mm

where, $\overline{Pn}$-m and σn-m mean the average and standard deviation, respectively, calculated without the maximum daily rainfall record among n years' record.

The corrected values of $\overline{Pn}$ and σn are obtained from the figures which show the relation between adjustment factors for these two values and the values of $\overline{Pn}$-m, σn-m, and available record period. The value of K is given by the corrected $\overline{Pn}$ and σn. Their results are shown as follows:

$\overline{Pn}$ = 374.5 mm, σn = 228.5 mm, K = 8

Consequently, PMP at Baguio is concluded to be 2,203 mm/day.

3) Frequency distributions

Several frequency distributions, such as Iwai, Gumbel and Pearson III, are examined applying annual maximum daily rainfall records at Baguio. The result of examination is as shown in Table A-56.

Probable maximum precipitation of 2,203 mm/day at Baguio estimated through the statistical method is equivalent to 1.37 to 1.47 times as high as 1,000 years values of each distribution. As to 10,000 years values, it is indicated to be almost same or 11 to 13 per cent high.

In ELC's feasibility report, 24 hours rainfall of 1,350 mm is shown as maximum rainfall at Baguio. This is the point rainfall estimated through the maximization of observed storm applying return period of 1,000 years rainfall. Values for return period of 1,000 years estimated in the Study are as 11 to 19 per cent high as the maximum value said above. The estimated PMP of 2,203 mm/day indicates as 63 per cent high as the value estimated in ELC's feasibility study. It is judged to be reasonable that the extreme value differs much each other depending on the data sampling period since the record series of annual maximum daily rainfall at Baguio has rather high variance.

The result of PMP analysis is expected to be rather high in case that the statistical method is applied to the population with high variance. It is proved by the fact that PMP of 2,203 mm/day estimated through the Study corresponds to 2.25 times high as the maximum record of daily rainfall of 979.4 mm/day at Baguio.

4). Rainfall depth and duration

The relation between rainfall depth and duration equivalent to the estimated PMP shall be analyzed. The relation said above is expressed by the following equation;

$$Rt = R_{24} \left(\frac{t}{24}\right)^a$$

where, Rt : Rainfall density over t hours
R_{24} : 24 hours rainfall
t : hours
a : constant to be determined

The value of a is determined from the observed depth-duration record at Bagio as shown in Table A-55. It is estimated to be 0.62 on an average taking durable rainfall pattern at Baguio or in upper Agno river basin into consideration. The equation expressed above are re-expressed as follows:

$$Rt = R_{24} \left(\frac{t}{24}\right)^{0.62}$$

Applying the equation above, hourly relation between rainfall depth and duration equivalent to the PMP at Baguio are as summarized in Table A-57.

(2) Probable Maximum Flood at Proposed San Roque Dam Site

1) Average rainfall over Agno River basin

The value of PMP is estimated as a point rainfall at Baguio. Daily rainfall records at representative five stations in the San Roque catchment basin are analyzed to transpose the point rainfall to the basin rainfall over the drainage area. Selected five stations are Buguias, Ambuklao, Bobok, Binga and Ba'ltok. To estimate average rainfall over the drainage area, simple mean value without any weighted factor is used since the location of five stations is concentrated in upper part of the catchment basin. Daily rainfall records at the five stations and average rainfall over the drainage area during selected five of biggest storms are as shown in Table A-54.

The ratio of point rainfall at Baguio to basin average rainfall are as shown in Table A-58. Two kinds of ratio of rainfall depth both on the most heavy rainy day and during storm period are as shown in Table A-58. The transposition rate of Baguio point rainfall to the upper Agno average rainfall is evaluated to be 0.6 considering that the objective of the Study is to estimate probable maximum flood, and that maximum point of flood will be exceedingly caused by the peak rainfall during a storm. Accordingly, the probable maximum rainfall all over the San Roque catchment basin is evaluated to be 1,322 mm/day that is 60 per cent of 2,203 mm/day of Baguio point rainfall.

2) Effective rainfall over Agno River basin

A run-off coefficient during flood period is estimated from the calculated inflow into Ambuklao reservoir since hourly discharge records for Agno River are not available for the Study. The run-off coefficients during the selected five storms as shown in Table A-54 are represented in Table A-58. The coefficients are estimated from total inflow volume into the reservoir and total rainfall volume during flood or storm period. Among them, the run-off coefficient indicates more than 1.0 for the storm in 1967. It is considered that the coefficient attains an unreasonable value because basin rainfall records seem to be too small in consideration of rainfall record at Baguio. The run-off coefficient in the basin during a storm is estimated to be 0.8 taking the maximum value out of selected storms excluding a storm in 1967 into consideration.

The probable maximum precipitation in terms of effective rainfall over the catchment basin of San Roque dam site is evaluated to be 1,057 mm/day cor-

responding to 2,203 mm/day of Baguio point rainfall, transposition rate of 60 per cent and run-off coefficient of 80 per cent. Hourly rainfall depth and duration within 24 hours equivalent to the effective PMP are as summarized in Table A-59.

3) Probable maximum flood at proposed San Roque dam site

The probable maximum flood at the proposed San Roque dam site is analyzed in accordance with PMF in terms of effective rainfall over the catchment basin of the dam.

Run-off volume for PMF is estimated by the analysis of Nakayasu's unit hydrograph method since the information for the past flood is scarcely available for the Study.

The characteristic values of Nakayasu's method are expressed as follows:

$$Qp = \frac{1}{3.6} \cdot A \cdot Ro / (0.3tp + tk)$$

$$Q/Qp = (t/tp)^{2.4} \quad \text{(for ascending limb of the hydrograph)}$$

$$Q/Qp = 0.3^{(t-tp)/tk} \quad (1 \geqq Q/Qp \geqq 0.3)$$

$$= 0.3 \times 0.3^{t-(tp+tk)/1.5t} \quad (0.3 \geqq Q/QP \geqq 0.3^2) \quad \text{(for descending limb of the hydrograph)}$$

$$= 0.3^2 \times 0.3^{t-(tp+tk+1.5tk)/2.0tk} \quad (0.3^2 \geqq Q/QP)$$

$$tk = 0.47\,(AL)^{0.25}$$

$$tp = 0.8\,to + tg$$

$$tg = 0.21 \cdot L^{0.7} \quad (L=15\ km)$$

$$= 0.4 + 0.058L \quad (L=15\ km)$$

where,
- Qp : peak discharge (m^3/s)
- Q : discharge on the hydrograph (m^3/s)
- Ro : unit rainfall (mm)
- tp : time from beginning of hydrograph to peak discharge (hr)
- t : time from peak discharge to 30 per cent discharge of peak in recession (hr)
- to : unit time (hr)
- tg : lag time (hr)
- A : drainage area (km^2)
- L : maximum length of river course up to the site (km)

Drainage area and maximum length of river course are given as 1,250 km^2 and 120 km, respectively. Rainfall depth and duration are re-arranged in a critical

hourly rainfall pattern to give a hydrograph with highest run-off. The critical rainfall pattern with a peak rainfall depth of 147.4 mm/hr is as shown in Figure A-12.

Peak discharge of PMF at the proposed San Roque dam site is estimated to be 15,130 m^3/s through the run-off analysis described above. A hydrograph for PMF at the proposed San Roque dam site is as shown in Figure A-12.

4) Evaluation of spillway capacity

Spillway design flood of 12,800 m^3/s is given through ELC's feasibility study for the proposed San Roque dam. Peak discharge of PMF at the proposed San Roque dam site obtained through the Study is 18 per cent large as the above design value.

The peak discharge of PMF, however, has still some allowance to the spillway maximum capacity of 15,600 m^3/s designed in ELC's feasibility study.

As described before, the analysis method applied in the Study for PMP has a tendency to indicate rather large result in case that the method is applied to the population with a high variance such as annual maximum daily rainfall record at Baguio. Flood control capacity of 150,000,000 m^3 is, furthermore, planned through ELC's feasibility study. The capacity said above corresponds to 11.5 per cent of PMF's inflow volume for 96 hours that is estimated to be around 1,310,000,000 m^3.

Table A-1 MAIN FEATURES OF EXISTING AMBUKLAO AND BINGA DAMS

Item	Ambuklao	Binga
Catchment area (km^2)	617	860
Mean inflow (m^3/s)*1	41.3	57.3
Type of dam	Rockfill	Earth-Rockfill
Height of dam (m)	129	107
Crest elevation (El. m)	758	586
Fill volume of dam (million m^3)	6.02	1.89
Spillway gate (m x m x nos.)	12.5×12.5×6	12.5×12.0×6
Normal high water level (El. m)	752	575
Low water level (El. m)	694	555
Effective capacity (million m^3)	258	48.2
Effective capacity/yearly inflow*2	0.20	0.03
Installed capacity of power station (MW)	75	100

Source; *1: Value obtained by the present study
*2: Booklet by Public Relation Office, NPC

Table A-2 SUMMARIZED RESULTS OF HYDROLOGIC STUDY IN ELC FEASIBILITY REPORT

	Catchment Area (km^2)	Mean Yearly Discharge (m^3/s)	Specific Run-off ($m^3/s/100\ km^2$)
Upstream from Ambuklao	617	46.0	7.5
Ambuklao - Binga	243	14.1	5.8
Binga - San Roque	390	34.1	8.7
Total	1,250	94.2	—
Mean	—	—	7.5

Table A-3 RESERVOIR OPERATION RECORD AVAILABLE FOR THE STUDY

Record		Period
(1) Ambuklao Dam		
Reservoir waterlevel	Daily	Jan. 1958 — Jan. 1962 Mar. 1962 — Dec. 1972 Jan. 1975 — Dec. 1982
	Monthly	1957 — 1974
Generated energy	Daily	Jan. 1958 — Oct. 1967 Dec. 1968 — Dec. 1972 Jan. 1975 — Dec. 1982
	Monthly	1957 — 1974
Water consumption by power generation	Daily	Jan. 1957 — Dec. 1957 Jan. 1960 — Feb. 1964 Dec. 1964 — Dec. 1982
	Monthly	1957 — 1974
Spillout volume	Daily	1957 — 1960, 1962 — 1982
	Monthly	1957 — 1977
(2) Binga Dam		
Reservoir waterlevel	Daily	Feb. 1960 — Mar. 1969 Sept. 1960 — Dec. 1972 Jan. 1976 — Dec. 1982
	Monthly	1960 — 1974
Generated energy	Daily	Jan. 1960 — Mar. 1960 Sept. 1960 — Dec. 1972 Jan. 1976 — Dec. 1982
	Monthly	1960 — 1974
Water consumption by power generation	Daily	Jan. 1964 — Dec. 1982
Spillout volume	Daily	1957 — 1960, 1962 — 1982
	Monthly	1957 — 1977

Table A-4 RAINFALL RECORD AVAILABLE FOR THE STUDY

Station	Elevation (m)	Record	Period
Baguio	1,483	Daily	Jan. 1950 — Nov. 1977
			Sept. 1979 — May 1982
		Monthly	1949 — 1983
		Annual daily max.	1909, 1911, 1937 — 1939, 1950 — 1977
Ambuklao	735	Daily	May 1949 –Sept. 1976
		Monthly	1949 — 1983
Bobok	1,367	Daily	Jan. 1964 — Nov. 1977
		Monthly	1950 — 1983
Mount Data	2,050	Daily	Feb. 1950 — Dec. 1978
		Monthly	1934 — 1938, 1950 — 1983
Suyoc		Monthly	1934 — 1937
Buguias	1,316	Daily	Jan. 1950 — Nov. 1977
		Monthly	1950 — 1980
Adaoay	816	Daily	Jan. 1950 — Nov. 1977
		Monthly	1950 — 1980
Km 50 Atok (Sayangan)	2,286	Daily	Jan. 1965 — Dec. 1976
		Monthly	1921 — 1933, 1950 — 1981
Palpalan (Karao)	1,780	Daily	Jan. 1951 — Apr. 1955
			Mar. 1968 — Nov. 1977
		Monthly	1950 — 1966, 1968 — 1983
Bokod		Monthly	1921 — 1933
Tabeyo (km 21 Atok)	1,723	Daily	Jan. 1950 — Nov. 1977
		Monthly	1950 — 1981
Binga	588	Daily	Apr. 1957 — Apr. 1977
			Aug. 1981 — June 1982
		Montly	1957 — 1983
Balatok	950	Daily	Jan. 1956 — Dec. 1965
			Jan. 1967 — Aug. 1977
		Monthly	1956 — 1965, 1967 — 1983
Open Pit	1,500	Monthly	1961 — 1982
Main Camp	1,350	Monthly	1961 — 1982
San Roque	60	Daily	Jan. 1978 — Sept. 1982
Dagupan	5	Monthly	1947 — 1983

A-5 MONTHLY RAINFALL RECORD AT BAGUIO STATION

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1949	0	1	95	54	75	204	700	370	616	510	32	180	2,836
1950	14	11	115	153	304	350	1,076	1,505	409	449	44	31	4,460
1951	19	4	17	59	374	491	927	958	591	151	95	12	3,698
1952	19	24	32	200	305	347	268	669	306	208	102	57	2,538
1953	3	13	37	80	321	462	462	1,190	275	101	707	46	3,695
1954	0	2	140	103	108	109	245	622	405	411	378	4	2,528
1955	5	1	4	146	222	179	450	326	556	198	97	2	2,185
1956	12	24	18	150	326	208	309	627	1,199	322	232	25	3,452
1957	6	0	32	28	101	817	281	600	811	160	105	11	2,951
1958	37	2	3	31	194	729	841	306	558	190	11	5	2,906
1959	10	0	93	22	263	262	241	493	265	120	262	9	2,049
1960	35	113	29	289	348	250	275	1,918	270	205	68	20	3,821
1961	0	0	120	63	191	575	1,483	612	565	197	72	8	3,884
1962	3	0	9	93	264	185	1,249	695	833	154	30	8	3,523
1963	10	4	10	8	125	1,092	490	384	1,458	76	42	46	3,746
1964	3	1	19	158	233	520	300	1,871	572	444	203	144	4,468
1965	3	22	119	202	509	687	708	374	365	107	25	9	3,120
1966	20	1	45	27	743	242	374	602	957	60	175	37	3,283
1967	2	5	19	82	214	1,277	444	1,157	423	1,564	123	1	5,310
1968	4	0	6	51	276	347	1,044	1,672	1,481	31	19	0	4,931
1969	8	1	7	86	354	382	1,212	607	895	279	52	49	3,932
1970	21	3	21	69	341	417	406	677	614	181	65	51	2,866
1971	13	12	4	144	160	487	1,321	757	386	306	67	47	3,703
1972	19	2	12	80	428	455	4,775	1,041	332	41	47	26	7,256
1973	1	0	1	52	106	373	419	540	225	816	54	14	2,600
1974	15	0	(7)	105	269	550	390	1,488	332	2,274	631	49	—
1975	17	0	2	58	215	224	153	788	477	296	29	43	2,302
1976	22	0	38	21	1,310	1,225	377	677	372	176	82	8	4,307
1977	30	0	6	31,295	159	695	734	1,274	136	186	0	3	545
1978	0	0	6	65	266	424	614	1,413	584	345	20	30	3,766
1979	—	1	1	117	40	239	587	1,078	250	206	21	48	—
1980	1	2	17	—	1,040	88	1,323	238	562	211	885	35	—
1981	39	3	0	242	248	500	466	1,165	634	196	206	0	3,700
1982	0	23	22	168	228	340	1,071	924	445	238	124	47	3,629
1983	328	15	—	0	96	—	—	—	—	—	—	—	—
Mean	21	8	33	95	311	447	764	855	527	334	156	32	3,654

Remarks; Elevation: 1,483 m

Table A-6 MONTHLY RAINFALL RECORD AT AMBUKLAO STATION

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1949	---	---	---	---	72	214	371	218	394	366	31	98	—
1950	7	11	68	136	366	214	481	897	336	406	26	13	2,961
1951	4	10	1	20	328	318	492	517	341	100	77	19	2,229
1952	0	4	94	98	172	307	146	512	320	114	24	41	1,833
1953	16	1	37	106	185	501	494	576	255	26	182	47	2,426
1954	4	36	84	105	64	64	215	490	193	219	258	1	1,732
1955	3	0	0	145	143	114	350	380	252	73	61	8	1,529
1956	1	3	10	135	18	22	86	204	(158)	(160)	(143)	(29)	—
1957	0	0	92	126	26	77	272	340	526	92	51	10	1,613
1958	0	3	38	36	237	458	372	286	297	131	5	0	1,863
1959	4	4	50	56	183	144	324	398	224	152	178	10	1,726
1960	6	93	46	263	192	428	401	1,039	368	154	23	6	3,018
1961	0	0	90	56	118	275	501	237	259	115	33	0	1,684
1962	1	0	6	84	75	126	553	264	475	38	4	1	1,628
1963	1	1	6	6	71	520	180	252	393	33	47	35	1,546
1964	0	0	26	122	166	284	108	742	312	335	107	68	2,271
1965	3	3	88	160	179	259	477	135	200	36	23	0	1,562
1966	4	12	64	53	789	208	252	401	429	23	196	23	2,455
1967	3	6	4	220	144	694	404	744	330	737	146	1	3,433
1968	4	0	30	136	267	155	492	1,180	847	28	10	0	3,147
1969	2	0	14	61	224	202	862	366	266	214	7	2	2,219
1970	15	5	33	79	231	361	411	417	391	256	37	28	2,263
1971	5	7	51	88	221	385	751	304	220	279	85	59	2,455
1972	19	0	40	175	252	202	2,528	711	337	7	37	19	4,326
1973	0	0	5	7	225	294	211	362	95	406	21	15	1,641
1974	49	0	29	170	163	399	299	846	119	806	363	15	3,257
1975	6	0	226	54	183	126	178	433	189	170	12	5	1,580
1976	1	3	13	27	788	882	242	350	275	126	25	36	2,765
1977	2	0	8	7	57	45	98	118	593	76	97	0	1,099
1978	0	1	7	119	102	255	358	1,047	378	266	16	16	2,564
1979	0	2	1	239	252	150	312	396	325	100	27	20	1,824
1980	1	1	64	31	350	57	652	288	489	99	462	7	2,500
1981	5	2	0	100	106	436	370	443	354	103	201	0	2,120
1982	0	22	36	169	79	215	585	365	122	156	33	17	1,799
1983	17	9	49	7	—	—	—	—	—	—	—	—	—
Mean	5	7	41	100	207	276	436	478	330	189	88	19	2,177

Remarks; Elevation: 735 m

Table A-7 MONTHLY RAINFALL RECORD AT BOBOK STATION

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1950	3	11	46	102	274	303	740	874	413	561	13	34	3,374
1951	6	1	—	79	237	308	558	719	351	140	106	36	—
1952	7	3	59	151	335	391	173	491	367	271	37	71	2,356
1953	8	4	33	113	220	502	419	596	342	174	262	43	2,715
1954	22	0	71	80	144	128	399	597	253	276	362	0	2,333
1955	2	0	27	84	12	138	435	325	431	109	77	1	1,642
1956	0	2	40	258	167	88	331	322	598	130	304	46	2,286
1957	0	6	37	56	161	453	234	381	406	141	101	4	1,980
1958	0	0	18	31	208	399	426	399	420	189	21	1	2,113
1959	6	0	—	—	207	217	384	364	467	77	228	22	—
1960	5	143	50	133	177	302	141	1,045	412	173	34	0	2,614
1961	0	0	115	88	172	449	676	389	332	191	72	0	2,483
1962	0	0	50	49	128	332	930	496	418	108	93	1	2,604
1963	4	5	67	34	90	683	251	390	675	48	0	51	2,298
1964	0	1	29	20	174	521	155	833	408	415	200	148	2,902
1965	5	0	45	50	271	237	712	167	417	175	25	0	2,114
1966	27	18	54	62	776	177	274	410	447	40	250	20	2,554
1967	3	0	9	140	86	729	448	618	463	407	263	2	3,168
1968	31	0	16	36	196	245	676	1,196	698	44	29	0	3,167
1969	2	5	6	54	235	197	768	497	408	201	30	4	2,407
1970	29	22	86	62	179	429	319	459	449	351	84	39	2,508
1971	0	19	60	64	192	425	660	416	259	466	89	50	2,700
1972	11	0	30	110	258	218	2,328	698	327	15	89	6	4,090
1973	—	0	1	15	367	275	177	381	174	523	50	8	—
1974	15	0	39	157	184	446	374	919	286	881	318	42	3,663
1975	14	0	30	30	326	186	265	523	455	232	12	28	2,101
1976	17	2	43	38	1,070	977	379	262	415	118	22	3	3,346
1977	0	0	1	5	225	208	516	532	596	49	197	0	2,328
1978	0	1	23	71	102	902	331	842	524	329	19	26	3,17
1979	0	0	2	77	241	106	485	428	324	114	19	24	1,819
1980	3	0	39	78	334	70	684	290	619	245	735	0	3,096
1981	0	0	0	36	164	537	601	551	368	158	222	4	2,641
1982	0	35	17	108	64	319	516	551	187	171	49	19	2,034
1983	2	2	3	—	—	—	—	—	—	—	—	—	—
Mean	7	8	36	77	242	361	508	544	415	228	134	22	2,582

Remarks: Elevation: 1,367 m

Table A-8 MONTHLY RAINFALL RECORD AT MOUNT DATA STATION

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1934	—	—	—	180	498	105	929	511	720	717	523	182	—
1935	2	33	54	268	683	271	852	1,051	551	192	532	119	4,605
1936	22	13	154	72	—	416	433	—	560	1,987	194	468	—
1937	9	60	158	343	—	380	817	—	—	125	287	—	—
1938	23	—	—	—	82	216	296	—	—	208	343	131	—
1950	—	33	112	125	722	295	609	752	443	318	100	(45)	—
1951	28	10	32	109	437	419	762	704	346	137	193	77	3,257
1952	17	9	130	435	359	308	331	594	405	431	126	181	3,326
1953	10	44	161	133	306	465	446	642	337	209	522	211	3,486
1954	3	20	128	247	136	261	367	475	273	263	425	39	2,636
1955	40	8	50	136	323	148	421	383	479	188	232	33	2,440
1956	8	30	23	303	197	217	421	677	601	219	431	123	3,248
1957	9	11	94	179	246	440	193	324	567	225	439	105	2,832
1958	11	16	34	24	363	326	320	371	597	238	9	53	2,361
1959	27	4	76	70	380	175	317	373	127	—	135	119	—
1960	87	298	85	185	231	206	122	1,014	333	264	25	27	2,878
1961	0	0	133	324	297	343	627	543	427	353	112	42	3,201
1962	0	62	84	190	217	428	998	679	389	313	582	—	—
1963	22	38	4	109	102	839	3,441	498	815	141	37	164	6,210
1964	9	15	89	218	426	718	305	886	556	422	597	296	4,536
1965	34	9	91	257	464	357	544	255	393	129	121	29	2,682
1966	18	13	108	180	668	312	347	398	275	122	503	137	3,081
1967	51	0	11	241	327	774	541	520	554	502	128	13	3,659
1968	13	0	80	105	408	443	599	1,023	1,125	62	24	0	3,882
1969	53	0	29	40	489	374	1,101	262	377	264	117	38	3,143
1970	77	4	73	107	416	249	393	432	619	351	134	—	—
1971	0	59	35	90	204	353	1,028	488	298	281	269	44	3,148
1972	0	0	14	340	548	275	783	383	237	244	114	244	3,181
1973	0	41	62	76	405	380	330	549	339	513	242	15	2,951
1974	31	1	176	533	426	459	386	1,147	416	1,375	—	—	—
1975	77	0	59	204	309	—	—	—	—	—	47	33	—
1976	25	0	94	44	826	1,297	533	360	438	237	58	(52)	—
1977	29	29	54	79	—	346	602	598	648	94	316	0	—
1978	0	14	53	347	155	333	455	660	—	516	80	74	—
1979	0	0	—	343	470	345	461	562	335	—	—	—	—
1980	—	—	—	—	—	—	—	—	—	—	—	—	—
1981	—	—	—	—	—	696	698	—	—	—	165	11	—
1982	—	48	72	438	374	240	599	519	472	320	90	98	—
1983	81	26	68	13	—	—	—	—	—	—	—	—	—
Mean	24	27	79	197	378	395	622	582	470	362	236	103	3,476

Remarks; Elevation: 2,050 m

Table A-9 MONTHLY RAINFALL RECORD AT SUYOC STATION

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1934	—	—	—	—	—	—	—	—	—	—	260	95	—
1935	7	77	36	226	647	183	749	903	249	124	552	53	3,807
1936	35	31	94	153	453	244	494	587	335	832	49	215	3,521
1937	17	31	179	264	358	361	645	596	318	75	69	68	2,978
Mean	20	46	103	214	486	263	629	696	301	343	232	108	3,440

Table A-10 MONTHLY RAINFALL RECORD AT BUGUIAS STATION

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1950	4	6	72	101	292	206	836	706	333	351	46	33	2,985
1951	10	5	53	97	160	198	452	424	(328)	283	118	23	—
1952	7	5	100	112	258	118	122	448	274	344	28	118	1,932
1953	13	5	56	176	248	531	478	494	305	172	424	131	3,031
1954	1	1	41	114	107	156	236	402	247	244	183	19	1,752
1955	28	0	11	158	135	121	341	262	296	69	155	9	1,585
1956	1	4	80	252	61	75	265	474	393	233	404	76	2,320
1957	14	0	111	64	93	388	152	420	273	163	271	41	1,989
1958	1	1	68	38	158	294	521	279	392	195	49	4	2,000
1959	3	8	23	30	301	169	262	787	311	49	167	25	2,136
1960	58	40	88	66	52	358	139	1,345	363	101	31	0	2,642
1961	0	0	94	41	200	436	330	468	221	38	108	0	1,938
1962	0	15	15	53	77	181	733	429	273	50	110	0	1,936
1963	15	0	22	40	116	458	291	212	475	3	6	71	1,709
1964	0	3	16	16	191	250	247	959	534	128	272	91	2,707
1965	8	11	37	79	292	261	301	167	351	74	76	0	1,657
1966	4	17	16	60	592	214	191	383	375	85	262	129	2,326
1967	32	28	0	137	86	328	498	595	365	555	85	0	2,707
1968	10	0	72	95	60	202	589	527	469	27	27	0	2,077
1969	37	0	0	53	190	236	569	495	223	105	72	19	1,998
1970	48	11	42	63	183	267	325	279	300	306	200	47	2,070
1971	0	27	40	39	147	487	583	386	303	423	183	62	2,678
1972	30	0	45	159	239	170	1,280	446	216	28	60	14	2,685
1973	0	0	5	52	198	169	172	365	176	278	93	10	1,517
1974	16	0	44	148	113	613	272	971	223	486	104	84	3,074
1975	57	10	29	46	152	174	219	860	230	285	17	69	2,147
1976	6	0	43	50	857	1,376	298	169	208	122	26	4	3,160
1977	6	0	11	15	173	214	457	453	501	23	134	—	—
1978	0	0	17	109	136	390	257	853	385	305	34	32	2,519
1979	0	0	0	112	250	291	190	430	222	114	18	47	1,674
1980	21	0	9	11	—	—	—	—	—	—	—	—	—
Mean	14	6	41	83	204	311	387	516	319	188	125	40	2,234

Remarks; Elevation: 1,316 m

Table A-11 MONTHLY REINFALL RECORD AT ADAOAY STATION

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1950	20	19	83	166	475	292	488	898	488	469	6	36	3,438
1951	2	12	26	146	344	228	628	505	487	228	123	22	2,750
1952	1	49	25	154	340	310	164	556	328	290	44	112	2,375
1953	15	6	69	171	208	486	578	518	386	150	196	—	—
1954	29	3	86	33	162	206	325	429	256	357	284	1	2,171
1955	1	0	22	162	169	187	352	358	452	90	126	4	1,924
1956	4	9	21	347	267	170	376	1,458	753	519	697	266	4,888
1957	64	3	132	53	166	420	222	325	497	152	158	17	2,210
1958	0	0	4	38	314	280	318	405	288	277	19	8	1,950
1959	10	91	17	5	66	120	154	182	123	23	150	3	944
1960	10	101	73	106	213	252	172	814	321	149	62	9	2,282
1961	0	0	140	87	211	350	414	356	363	198	37	11	2,167
1962	0	25	56	146	125	189	683	484	457	114	121	6	2,406
1963	4	0	29	8	134	645	251	366	634	49	98	40	2,258
1964	26	0	11	85	288	426	209	885	383	352	201	160	3,024
1965	8	16	65	64	344	267	618	226	322	134	52	0	2,116
1966	8	9	40	45	443	162	410	408	161	36	271	6	1,998
1967	0	0	31	138	86	499	367	564	446	555	295	0	2,981
1968	30	0	65	64	190	386	1,973	3,995	3,508	38	71	10	10,330
1969	14	0	31	278	943	258	680	455	196	211	63	12	3,140
1970	34	9	55	66	230	368	303	299	384	361	144	31	2,281
1971	3	38	41	70	180	281	649	296	242	489	94	60	2,441
1972	20	6	28	168	146	201	1,936	504	367	43	65	26	3,509
1973	—	0	0	3	455	251	188	337	350	353	106	37	—
1974	11	5	112	89	124	395	257	756	121	1,109	361	45	3,386
1975	25	5	20	36	353	208	141	338	344	235	47	59	1,180
1976	27	27	55	29	990	37	425	338	312	182	46	–	–
1977	37	0	36	0	150	160	488	340	590	61	157	–	–
1978	0	2	63	106	86	282	303	620	495	344	30	31	2,363
1979	—	—	—	—	234	—	—	317	—	-	36	15	-
1980	2	0	48	38	258	146	726	319	468	182	464	59	2,710
Mean	14	15	49	97	280	282	493	602	484	258	149	39	2,762

Remarks; Elevation: 816 m

Table A-12 MONTHLY RAINFALL RECORD AT ATOCK STATION (KM 50 SAYANGAN)

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1921	—	—	—	—	—	563	673	1,708	716	218	169	45	—
1922	32	125	97	148	445	503	745	757	1,178	391	214	173	4,806
1923	35	90	155	195	650	967	1,109	1,863	367	243	209	108	5,991
1924	—	0	62	31	249	410	666	1,303	766	466	249	32	—
1925	26	96	299	352	567	990	1,452	1,134	1,013	649	20	56	6,653
1926	119	70	25	189	469	775	706	421	665	398	34	16	3,887
1927	57	3	246	360	519	694	817	926	473	268	70	42	4,475
1928	30	18	53	233	410	662	1,030	1,063	562	287	227	6	4,580
1929	26	258	281	396	647	371	1,173	1,219	505	322	132	8	5,337
1930	32	0	114	236	749	339	2,085	728	822	494	59	125	5,783
1931	11	2	129	166	813	567	464	1,196	831	525	500	53	5,256
1932	19	29	155	115	444	618	1,374	662	566	546	173	38	4,737
1933	103	104	—	—	—	—	—	—	—	—	—	—	—
1950	51	59	87	274	434	377	906	1,400	533	601	57	43	4,823
1951	28	8	72	113	646	728	1,124	1,478	574	369	111	37	5,288
1952	35	45	152	227	447	405	244	831	525	213	105	160	3,388
1953	28	29	199	—	366	820	959	1,413	650	151	836	182	—
1954	8	46	244	281	226	268	324	932	585	491	495	7	3,906
1955	46	0	51	267	313	332	649	523	746	184	165	7	3,282
1956	29	24	45	313	341	302	519	1,079	657	489	286	127	4,211
1957	14	24	190	185	235	871	353	903	1,055	230	215	48	4,324
1958	2	7	36	98	343	842	1,158	553	923	227	28	37	4,255
1959	12	102	108	91	283	273	484	819	627	148	579	25	3,550
1960	109	245	81	260	173	387	249	1,836	258	123	48	35	3,804
1961	0	0	235	118	414	847	1,710	964	746	322	65	272	5,692
1962	14	102	121	275	201	255	1,836	688	590	121	147	10	4,360
1963	33	20	36	72	199	1,418	529	506	1,431	90	93	70	4,495
1964	0	14	55	123	486	658	375	2,357	737	617	221	360	6,002
1965	38	35	183	185	726	476	1,022	402	671	237	32	3	4,011
1966	46	17	53	233	818	374	362	715	985	181	112	85	3,982
1967	6	26	23	296	137	1,920	656	1,194	705	867	36	0	5,867
1968	42	5	95	163	391	412	1,477	1,838	1,694	116	9	0	6,241
1969	61	4	20	260	509	663	827	876	729	461	61	36	4,507
1970	97	9	153	127	348	485	500	770	827	419	89	45	3,868
1971	3	118	(63)	140	253	307	1,042	511	705	549	123	69	—
1972	96	0	432	968	933	1,417	3,090	2,601	1,449	476	438	178	12,077
1973	231	206	209	141	1,837	1,474	1,327	1,056	592	742	660	285	8,761
1974	609	118	667	37	129	298	202	626	64	736	119	54	3,660
1975	584	33	116	255	499	182	447	1,062	372	293	26	165	4,034
1976	65	67	288	91	1,647	1,648	577	566	424	123	72	57	5,625
1977	67	4	21	76	176	169	(700)	(900)	(1,300)	(150)	182	0	—
1978	18	1	71	101	304	358	747	1,300	365	308	10	5	3,586
1979	6	(5)	4	84	560	(300)	(600)	(1,100)	364	279	0	0	—
1980	0	23	46	13	310	108	(1,300)	(250)	371	((200)	(900)	13	—
1981	0	0	31	183	(250)	56	499	1,179	304	231	(200)	(2)	—
1982	0	(45)	50	356	223	306	1,265	904	535	498	86	96	—
1983	19	—	6	27	—	—	—	—	—	—	—	—	—
Mean	64	51	132	201	485	611	899	1,068	688	365	176	73	4,813

Remarks; Elevation: 2,286 m

Table A-13 MONTHLY RAINFALL RECORD AT PALPALAN STATION (KARAO)

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1950	34	408	155	398	135	607	1,130	937	433	375	41	71	724
1951	15	31	6	164	340	433	571	899	373	(364)	429	111	—
1952	16	27	22	55	330	(253)	434	2,223	1,158	2,724	34	(224)	—
1953	48	51	23	111	528	642	846	1,529	661	668	(394)	192	—
1954	0	32	132	95	(324)	(453)	912	111	811	877	487	248	—
1955	56	25	24	219	526	625	1,301	1,478	896	500	361	49	6,059
1956	28	36	46	187	208	502	724	1,134	1,595	728	1,149	62	6,398
1957	136	26	28	135	253	595	279	1,155	1,294	450	379	93	4,823
1958	61	16	40	129	548	1,105	1,337	1,459	2,034	1,045	174	62	8,010
1959	73	131	124	4	624	385	1,014	1,445	1,240	320	781	97	6,237
1960	78	160	34	293	398	869	880	2,640	1,267	346	97	69	7,128
1961	22	8	138	235	805	945	1,262	1,035	935	894	397	77	6,752
1962	11	0	36	133	83	453	1,304	1,264	1,228	416	503	76	5,507
1963	25	27	33	22	402	1,476	788	1,057	1,631	243	77	177	5,960
1964	35	57	34	74	863	1,740	756	1,411	945	649	716	354	7,634
1965	34	26	47	194	466	546	844	907	929	260	180	31	4,463
1966	23	35	116	204	1,191	645	898	1,466	820	455	102	76	6,030
1968	—	—	23	102	150	156	550	982	839	42	42	0	—
1969	13	0	13	132	226	256	676	532	381	249	25	8	2,509
1970	24	0	94	65	252	343	320	378	390	452	128	37	2,482
1971	0	21	50	46	208	307	613	342	346	348	136	60	2,478
1972	9	0	23	172	313	(284)	349	1,394	162	13	34	13	—
1973	0	0	0	13	220	222	186	308	56	294	60	(1)	—
1974	6	0	21	98	80	206	205	688	153	308	217	51	2,032
1975	3	0	6	23	276	203	235	462	429	99	40	37	1,811
1976	17	13	75	51	414	330	373	218	323	151	10	22	1,995
1977	24	0	16	9	189	394	267	264	241	36	(38)	—	—
1978	0	0	50	75	63	270	(300)	(600)	583	459	48	(30)	—
1979	20	0	0	301	217	235	288	273	842	104	114	(50)	—
1980	3	0	54	9	261	115	593	242	424	333	758	10	2,801
1981	5	0	0	88	167	491	338	551	214	131	(200)	0	—
1982	0	68	71	103	48	267	420	267	250	319	65	95	1,973
1983	6	13	—	—	—	—	—	—	—	—	—	—	—
Mean	26	38	48	123	380	530	668	937	746	461	261	81	4,298

Remarks; Elevation: 1,780 m

Table A-14 MONTHLY RAINFALL RECORD AT BOKOD STATION

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1921	—	—	—	—	—	—	—	—	—	—	166	4	—
1922	2	10	9	64	282	295	431	412	505	343	46	136	2,536
1923	10	23	38	85	253	518	—	828	312	43	271	2	—
1924	1	5	51	317	79	458	439	805	389	379	133	40	3,094
1925	3	16	96	290	313	619	764	476	250	113	0	5	2,943
1926	0	0	66	45	176	824	1,030	621	755	223	46	6	3,792
1927	5	0	5	138	164	539	419	561	409	275	11	0	2,527
1928	13	2	9	102	264	310	543	351	411	59	284	0	2,345
1929	19	83	14	83	212	175	505	396	295	245	23	5	2,054
1930	17	0	60	38	301	209	1,099	386	432	295	1	24	2,861
1931	4	0	13	43	213	277	185	726	420	256	261	29	2,425
1932	1	4	4	35	110	342	579	268	344	246	78	6	2,015
1933	35	—	—	—	—	—	—	—	—	—	—	—	—
Mean	9	13	33	113	215	415	599	530	411	225	110	21	2,694

Table A-15 MONTHLY RAINFALL RECORD AT TABEYO STATION (KM 21 ATOK)

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1950	36	65	100	205	569	404	980	1,402	736	493	27	33	5,051
1951	8	9	22	55	390	468	494	1,397	481	197	114	32	3,666
1952	9	58	207	193	473	387	284	710	438	201	212	117	3,290
1953	5	32	57	113	258	330	629	693	421	110	272	60	2,981
1954	0	26	192	205	136	105	265	763	387	391	323	1	2,795
1955	16	3	3	220	244	171	493	347	458	162	100	3	2,221
1956	11	11	10	95	202	136	385	410	848	356	242	21	2,728
1957	6	0	77	245	40	647	271	575	742	77	112	19	2,811
1958	7	0	7	126	306	708	830	309	386	166	23	10	2,878
1959	6	30	52	0	71	407	475	535	299	—	195	8	—
1960	35	178	48	306	326	235	306	2,106	345	248	67	1	4,200
1961	0	0	179	59	173	516	1,177	821	700	239	72	30	3,966
1962	0	29	16	77	164	227	1,387	696	853	95	13	38	3,595
1963	0	0	10	90	419	1,097	458	236	2,367	215	73	113	5,078
1964	0	0	18	169	458	554	271	1,467	409	425	201	178	4,151
1965	0	61	116	180	491	301	711	324	85	139	45	0	2,453
1966	14	34	18	140	770	227	413	1,171	809	89	269	0	3,953
1967	0	5	0	201	117	1,255	234	1,066	323	879	61	0	4,141
1968	0	0	25	266	368	302	415	735	425	35	14	0	2,585
1969	11	3	27	82	483	316	830	422	469	261	41	20	2,964
1970	36	10	104	96	376	396	380	544	681	164	67	46	2,900
1971	9	21	58	121	180	296	824	534	358	463	106	63	3,033
1972	32	9	4	97	216	256	3,206	1,060	510	69	93	8	5,560
1973	—	0	1	13	399	283	304	573	402	549	26	22	—
1974	27	4	93	240	211	545	680	1,292	286	1,340	211	33	4,962
1975	26	22	32	94	449	215	280	716	324	393	27	26	2,603
1976	62	98	271	61	1,216	871	355	488	382	140	49	29	4,022
1977	2	4	75	81	187	132	950	438	1,395	51	182	1	3,498
1978	0	0	8	175	167	223	461	1,447	693	291	116	7	3,586
1979	0	0	4	251	638	636	901	581	533	240	80	30	3,895
1980	48	22	42	333	827	1,173	727	423	1,090	391	(116)	11	—
1981	19	19	0	177	238	441	670	479	395	73	168	0	2,679
Mean	14	24	59	149	361	446	658	774	595	288	116	30	3,512

Remarks; Elevation: 1,723 m

Table A-16 MONTHLY RAINFALL RECORD AT BINGA STATION

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1957	—	—	—	78	100	445	265	245	246	75	74	0	—
1958	0	0	—	29	332	487	583	351	302	118	3	0	—
1959	12	0	32	0	485	50	386	283	(205)	57	253	7	—
1960	0	—	—	—	—	—	—	—	—	91	40	1	—
1961	0	0	—	82	200	410	690	462	335	120	39	1	—
1962	2	0	(24)	109	170	216	944	501	498	84	14	0	—
1963	1	0	60	15	158	776	351	377	697	66	61	57	2,620
1964	2	1	31	87	224	—	148	833	387	288	147	97	—
1965	0	1	74	121	256	280	723	178	263	109	8	0	2,012
1966	3	3	32	52	623	261	188	411	391	28	113	0	2,104
1967	0	0	—	63	57	506	232	639	287	500	108	0	—
1968	3	0	21	65	172	133	464	1,157	679	50	16	0	2,760
1969	1	—	—	103	281	147	669	491	—	—	11	—	—
1970	7	2	(23)	61	199	461	—	258	—	—	—	—	—
1971	—	—	—	50	76	210	703	424	199	439	—	—	—
1972	—	—	—	—	—	—	2,531	734	336	29	90	17	—
1973	0	0	0	37	292	258	229	416	132	475	44	2	1,884
1974	66	0	21	111	215	421	394	1,000	303	1,048	182	22	3,784
1975	9	0	47	58	225	134	233	479	281	243	1	23	1,733
1976	4	82	44	—	941	732	361	395	378	66	14	19	—
1977	13	0	18	9	174	246	393	374	383	71	105	0	1,785
1978	0	0	1	4	(276)	281	378	478	262	189	45	38	—
1979	10	0	—	—	—	—	—	—	—	—	11	23	—
1980	2	2	27	51	407	89	848	268	525	91	508	5	2,824
1981	11	0	(30)	82	198	470	466	562	392	109	237	0	—
1982	0	6	40	106	119	240	668	385	239	236	65	18	2,123
1983	0	5	18	—	—	—	—	—	—	—	—	—	—
Mean	6	5	31	62	268	330	559	488	358	199	91	14	2,411

Remarks; Elevation: 588 m

Table A-17 MONTHLY RAINFALL RECORD AT BALATOK STATION

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1956	0	21	41	202	290	209	248	610	677	234	135	17	2,685
1957	8	0	138	76	56	679	373	549	669	198	52	—	—
1958	—	—	—	—	297	371	668	458	460	113	14	0	—
1959	10	—	34	7	284	240	259	390	220	97	225	4	—
1960	38	117	5	143	302	392	162	1,720	401	187	42	0	3,510
1961	0	0	118	61	281	505	826	416	419	117	34	0	2,776
1962	3	1	17	148	198	212	(1,213)	489	588	142	15	83	—
1963	4	0	0	22	77	945	383	415	831	43	7	88	2,815
1964	0	0	15	129	320	530	200	1,595	369	634	188	83	4,063
1965	—	6	97	141	408	305	938	248	407	123	42	0	—
1967	0	17	3	154	109	810	278	940	276	702	204	0	3,492
1968	1	0	26	109	237	144	863	1,599	1,004	36	47	0	4,066
1969	0	0	0	90	266	269	923	531	598	145	28	0	2,851
1970	13	1	71	70	362	503	427	424	577	208	60	54	2,770
1971	3	12	19	91	220	549	828	481	275	477	114	57	3,124
1972	12	0	34	151	225	302	3,336	881	286	44	43	6	5,319
1973	0	0	0	72	186	237	264	446	156	651	49	0	2,060
1974	19	0	0	127	183	698	489	1,152	306	1,767	303	34	5,077
1975	13	0	15	44	253	206	231	638	299	435	4	31	2,170
1976	18	62	63	0	974	1,703	299	503	473	122	23	28	4,267
1977	2	0	68	20	119	242	523	555	896	53	168	0	2,645
1978	0	1	17	48	154	220	508	1,162	428	618	9	3	3,168
1979	0	0	2	215	275	143	463	688	327	111	28	68	2,321
1980	0	4	42	53	575	109	1,280	293	559	201	563	2	3,679
1981	0	0	0	213	114	509	517	724	564	173	350	0	3,163
1982	0	5	5	133	139	208	906	567	272	274	53	28	2,590
1983	3	0	0	0	63	—	—	—	—	—	—	—	—
Mean	6	10	32	97	258	432	648	710	474	304	108	23	3,102

Remarks; Elevation: 950 m

Table A-18 MONTHLY RAINFALL RECORD AT OPEN PIT STATION

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1961	-	-	137	176	494	1,218	1,295	1,083	929	259	36	0	-
1962	7	2	25	96	407	296	1,836	805	1,102	75	41	—	—
1963	10	2	2	—	161	1,583	708	631	1,701	105	51	90	—
1964	11	0	59	101	506	595	321	2,670	702	937	289	215	6,405
1965	5	6	206	207	714	675	1,180	469	572	146	66	1	4,248
1966	0	32	10	35	1,659	296	593	884	1,212	67	234	69	—
1967	—	—	8	317	260	1,698	646	1,599	502	1,476	216	7	—
1968	15	—	77	127	297	395	1,413	3,171	2,005	138	81	—	—
1969	27	—	6	36	439	629	1,586	978	1,160	290	98	8	—
1970	18	6	119	74	297	911	586	859	873	346	83	40	4,252
1971	—	34	20	68	317	693	1,474	987	588	656	145	84	—
1972	24	3	75	101	371	683	6,125	1,710	467	69	40	24	9,692
1973	—	—	—	133	130	457	490	705	275	1,293	70	—	—
1974	15	2	33	355	273	1,014	382	2,514	353	2,904	—	—	—
1975	—	17	—	115	258	688	404	1,161	449	773	19	31	—
1976	170	51	94	25	3,057	—	—	—	—	—	—	—	—
1979	—	4	5	239	459	504	1,010	1,345	638	339	73	50	—
1980	25	—	40	—	879	203	1,966	555	717	847	1,220	—	—
1981	10	—	—	286	242	1,173	685	1,479	702	204	395	—	—
1982	—	8	13	168	163	809	1,738	1,244	703	446	5	65	—
Mean	28	13	55	148	569	764	1,286	1,310	824	598	176	53	5,823

Remarks; Elevation: 1,500 m

Table A-19 MONTHLY RAINFALL RECORD AT MAIN CAMP STATION

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1961	—	—	111	112	377	1,101	1,184	845	735	275	33	1	—
1962	7	2	2	75	260	294	1,974	877	1,445	83	45	—	—
1963	8	5	2	—	172	1,760	627	603	1,851	94	62	77	—
1964	20	0	54	98	433	565	290	2,447	607	831	227	158	5,729
1965	6	4	215	155	641	594	1,000	378	596	162	54	1	3,805
1966	—	42	14	43	1,522	277	60	755	1,095	31	210	44	—
1967	—	—	3	304	219	1,608	625	1,561	444	1,354	143	10	—
1968	14	—	77	149	212	295	1,441	2,453	1,995	74	50	—	—
1969	38	—	3	21	365	505	1,568	926	1,296	367	87	7	—
1970	24	6	118	88	271	701	659	1,069	822	342	92	88	4,280
1971	—	31	11	79	303	703	1,699	922	514	568	132	82	—
1972	42	4	27	95	356	587	5,649	1,600	477	51	41	23	8,952
1973	3	—	4	99	169	442	568	706	337	1,416	69	—	—
1974	13	—	21	339	262	1,160	375	2,415	312	2,903	696	40	8,540
1975	—	17	—	122	251	648	409	1,145	449	774	20	31	—
1976	163	28	93	27	3,049	1,391	705	901	880	187	38	1	7,459
1977	—	—	168	33	320	449	1,006	906	1,702	71	404	—	—
1978	—	—	41	98	250	445	673	2,408	732	538	16	5	—
1979	—	4	5	235	438	465	1,004	1,238	558	291	60	49	—
1980	20	—	35	—	848	186	1,931	521	682	798	1,157	—	—
1981	10	—	—	272	236	1,156	671	1,361	714	190	390	—	—
1982	—	8	13	162	162	802	1,721	1,194	682	445	5	65	—
Mean	28	12	51	130	505	733	1,174	1,238	860	538	183	42	5,496

Remarks; Elevation: 1,350 m

Table A-20 MONTHLY RAINFALL RECORD AT SAN ROQUE STATION

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1978	0	6	13	17	31	21	292	1,033	(92)	—	(4)	0	—
1979	0	0	11	26	215	14	264	(601)	—	—	0	—	—
1980	(4)	0	18	2	(250)	(96)	(426)	169	427	146	(461)	(1)	—
1981	—	—	—	—	—	462	(380)	416	215	189	136	1	—
1982	0	6	12	78	57	165	462	434	304	0	—	—	—
Mean	0	3	11	31	101	165	339	513	315	111	68	0	1,659

Remarks; Elevation: 60 m

Table A-21 MONTHLY RAINFALL RECORD AT DAGUPAN STATION

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1947	0	0	1	161	72	314	433	469	369	208	341	111	2,479
1948	0	7	7	169	88	297	490	992	348	84	6	38	2,526
1949	2	6	36	31	117	252	426	332	479	237	47	42	2,008
1950	0	9	41	91	98	391	809	781	432	312	10	20	2,993
1951	8	15	0	83	160	370	509	738	263	99	16	15	2,277
1952	7	14	27	151	169	205	261	527	230	110	38	44	1,785
1953	3	2	44	76	198	246	549	601	172	32	177	33	2,132
1954	1	34	105	82	116	198	400	424	285	84	181	—	—
1955	5	—	0	177	141	163	271	289	288	160	38	7	—
1956	4	41	1	130	215	169	319	318	678	79	172	34	2,160
1957	3	0	98	83	83	401	372	356	428	50	32	23	1,929
1958	0	3	2	99	20	482	602	261	470	252	7	1	2,199
1959	3	0	8	. .	280	263	311	431	191	104	31	6	—
1960	6	52	14	85	395	261	158	1,099	240	165	34	1	2,509
1961	—	0	2	40	163	653	464	449	347	297	26	0	—
1962	18	0	10	63	220	125	1,224	279	457	31	35	—	—
1963	1	0	3	1	100	1,122	216	246	573	52	54	28	2,396
1964	0	0	56	91	235	253	278	886	255	500	99	115	2,768
1965	0	0	66	138	352	296	485	339	296	67	17	0	2,055
1966	10	2	2	105	688	209	429	344	946	62	118	15	2,931
1967	0	0	0	41	79	456	245	678	284	281	70	0	2,133
1968	0	0	1	150	131	175	561	1,500	373	89	64	0	3,045
1969	0	0	0	44	312	261	732	457	337	136	60	5	2,343
1970	10	4	10	92	174	534	293	611	293	223	31	17	2,293
1971	30	0	0	84	119	448	333	376	179	204	47	32	1,851
1972	13	2	30	26	80	296	2,659	1,274	201	60	3	16	4,659
1973	5	13	9	26	251	271	201	495	166	185	36	0	1,658
1974	3	0	0	61	256	576	339	1,260	126	569	149	9	3,349
1975	5	0	33	55	262	174	216	444	280	198	21	11	1,697
1976	16	22	19	6	863	631	334	.	499	69	0	—	—
1977	53	0	11	70	101	176	302	524	547	32	248	0	2,064
1978	—	0	0	32	142	353	494	1,060	310	205	76	1	—
1979	0	0	0	70	441	126	316	812	225	216	5	3	2,213
1980	1	3	23	6	201	24	704	165	301	212	(300)	4	—
1981	1	4	0	(10)	(150)	535	418	694	168	135	203	1	—
1982	0	1	1	(5)	178	248	694	525	145	87	2	27	—
1983	13	0	2	0	57	—	—	—	—	—	—	—	—
Mean	6	6	18	77	210	332	496	601	338	163	71	20	2,339

Remarks; Elevation: 5 m

Table A-22 DISCHARGE RECORD AVAILABLE FOR THE STUDY

Station	River	Catchment area (km^2)	Record	Period
San Roque	Agno	1,225	Daily	Jan. 1950 — Dec. 1956, Jan. 1960 — Dec. 1965, Jan. 1970 — Dec. 1980
			Monthly	1909 — 1913, 1920 — 1922, 1932 — 1936, 1945 — 1980
Ambuklao	Agno	617	Daily	Mar. 1949 — Dec. 1952
Binga	Agno	860	Daily	Jan. 1950 — Dec. 1955
Ambayoan	Ambayoan	281	Daily	Jun. 1958 — Dec. 1971, Jan. 1973 — Aug. 1977
Kalipkip	Toboy	74	Daily	May 1964 — Oct. 1973
Adaoay	Agno	246	Daily	Jan. 1966 — Mar. 1974
			Monthly	1959 — 1974
Luakan	Agno	376	Daily	Jan. 1950 -Dec. 1952
Tabu	Agno	1,070	Daily	Aug. 1962 — Aug. 1964
Bokod (Bangao)	Bokod	102	Daily	Jan. 1950 — Dec. 1958
			Monthly	1950 — 1970
Bokod (Poblacion)	Bokod	48	Daily	Feb. 1967 — Mar. 1974
Nawal	Nawal creek	12	Daily	Jan. 1953 — Nov. 1955
Pesak	Pesak creek	19	Daily	Jan. 1950 — Nov. 1955
Bantay	Bantay	13	Daily	Jan. 1950 — July 1964
Baloy	Twin	87	Daily	July 1967 — Nov. 1975

Table A-23 MONTHLY OBSERVED DISCHARGE RECORD AT SAN ROQUE

Unit: m³/s

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1909	43.0	30.0	22.2	30.8	48.6	39.9	170.0	125.0	143.1	455.1	116.1	43.5	105.6
1910	38.3	31.1	27.5	28.8	40.2	74.2	55.0	41.0	191.8	160.0	97.8	62.6	70.7
1911	31.5	21.7	18.1	18.3	30.1	25.5	640.0	529.0	471.0	216.0	61.2	39.9	175.2
1912	25.4	17.8	14.2	12.1	22.5	26.4	52.7	380.7	285.7	191.8	93.0	53.8	98.0
1913	43.8	25.9	20.7	24.5	42.9	52.7	239.0	366.0	479.6	113.0	53.0	(57.9)	-
1920	27.9	22.0	16.7	14.8	21.4	46.0	351.3	118.7	105.6	52.2	55.9	34.0	72.2
1921	23.4	17.9	15.2	11.2	24.4	52.6	76.3	309.8	191.7	83.6	71.3	35.6	76.1
1922	21.1	15.9	13.3	11.3	20.5	28.2	104.1	167.4	221.3	104.0	65.2	42.0	67.9
1932	29.7	21.0	15.2	12.3	16.1	33.2	67.8	187.0	96.3	82.7	91.5	52.3	58.8
1933	21.1	15.9	13.3	11.3	20.5	28.2	164.1	167.4	221.3	104.3	65.2	42.9	73.0
1934	23.4	17.9	15.2	11.2	24.4	52.6	76.3	309.8	191.7	83.7	71.3	35.6	76.1
1935	37.6	27.3	19.2	17.9	73.7	60.0	138.3	366.2	146.7	113.8	127.2	57.7	98.8
1936	31.9	22.2	17.6	17.4	30.3	32.0	119.4	258.5	203.3	305.0	95.7	133.2	105.5
1945	-	-	-	-	-	-	-	-	-	198.1	181.7	93.7	-
1946	44.9	30.8	24.4	24.3	31.0	48.5	222.5	173.4	278.4	127.4	46.3	34.1	90.5
1947	22.3	14.4	14.1	25.0	23.8	126.1	101.5	109.3	171.3	253.0	340.0	141.4	111.8
1948	61.9	30.5	21.5	21.7	22.5	60.2	199.4	296.6	385.3	138.3	55.0	121.8	117.9
1949	31.9	21.1	16.2	13.8	11.9	25.0	97.6	126.5	181.3	165.5	64.0	51.1	67.2
1950	45.7	23.4	18.5	18.5	43.7	49.6	180.8	357.9	121.9	289.6	56.7	31.3	103.1
1951	22.9	16.1	10.6	12.5	54.6	68.0	105.3	327.3	212.0	70.9	53.9	35.1	82.4
1952	21.1	18.0	13.0	18.7	37.1	56.3	49.5	180.6	154.2	139.1	58.2	31.8	64.8
1953	24.5	16.6	13.7	13.4	15.2	148.0	219.2	358.2	184.7	121.8	116.2	56.2	107.3
1954	31.3	19.6	17.0	18.8	19.9	24.1	37.1	148.8	182.9	121.0	143.0	65.4	69.1
1955	26.1	18.6	13.1	11.3	15.8	21.5	46.7	84.3	107.4	81.4	42.0	17.2	40.5
1956	21.9	14.3	12.4	18.1	26.9	24.0	40.9	82.6	170.0	84.2	74.7	54.7	52.1
1957	37.8	27.5	27.0	32.9	29.7	49.3	73.5	106.9	207.2	119.6	74.4	60.9	70.6
1958	42.9	28.0	25.5	23.2	25.2	42.8	69.9	61.1	66.4	44.6	23.5	21.5	39.5
1959	17.4	19.9	22.2	25.6	28.5	31.5	36.8	46.6	84.2	62.2	—	—	—
1960	30.4	20.9	15.5	19.9	29.3	74.8	84.8	444.8	112.9	80.9	27.4	14.8	79.7
1961	25.0	25.2	23.2	22.2	29.3	47.2	164.7	135.4	157.1	106.3	46.2	40.1	68.5
1962	27.2	20.4	29.1	31.5	43.5	36.4	180.2	175.0	243.8	104.8	45.1	44.9	81.8
1963	48.9	39.5	35.2	28.1	22.3	153.6	112.3	131.9	347.6	92.0	36.7	18.6	88.9
1964	17.2	18.8	10.0	24.1	17.1	21.4	55.7	502.1	255.3	282.2	99.5	57.0	113.4
1965	14.0	9.2	13.6	10.4	6.3	33.4	193.6	167.2	129.7	116.4	29.9	16.0	61.6
1966	7.9	8.0	8.1	8.6	229.4	175.9	156.8	178.6	244.6	60.0	54.3	58.5	99.2
1967	-	-	52.6	103.1	100.8	132.8	117.0	257.6	201.9	226.2	208.5	83.2	-
1968	27.1	14.5	10.3	14.9	18.5	15.7	108.0	561.1	726.0	275.0	60.1	24.9	154.7
1969	21.7	20.4	24.0	10.0	43.0	64.3	213.7	244.8	350.2	188.3	58.2	18.2	104.7
1970	9.1	6.3	6.6	11.9	14.0	108.5	161.8	184.3	201.5	244.2	158.4	121.9	102.4
1971	72.2	70.4	54.9	41.3	47.8	84.3	200.5	270.9	240.6	259.6	71.2	23.1	119.7
1972	31.0	35.2	33.7	30.1	34.8	55.5	382.9	278.0	82.2	56.7	42.8	32.4	91.3
1973	32.8	19.3	12.9	7.4	18.8	42.7	50.1	55.9	57.6	86.6	54.7	19.8	38.2
1974	18.2	10.6	8.6	8.3	13.4	61.4	54.9	-	-	-	-	-	-
1975	79.7	77.2	76.7	81.9	83.6	85.3	92.0	126.4	156.8	165.0	78.4	68.5	97.6
1976	69.1	-	45.4	69.7	180.7	(135.6)	243.2	136.2	131.7	85.5	63.9	48.6	-
1977	—	—	—	31.9	34.8	55.5	—	84.8	344.9	111.3	142.8	74.8	—
1978	33.3	37.9	36.6	—	—	—	—	—	—	—	—	—	—
1979	—	—	—	—	—	119.9	118.1	123.1	115.3	101.0	83.5	80.1	—
1980	36.5	32.0	24.9	28.7	77.5	95.4	124.1	95.0	123.6	109.7	350.3	79.3	98.1
Mean	32.3	23.9	21.7	23.6	40.1	60.7	142.4	216.1	210.4	145.4	89.3	52.8	88.2

Remarks; Catchment area: 1,225 km²

Table A-24 MONTHLY OBSERVED DISCHARGE RECORD AT AMBUKLAO

Unit: m^3/s

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1949	14.4	10.8	11.2	9.7	8.0	17.7	54.8	55.7	81.9	70.9	29.1	37.1	33.4
1950	17.4	10.9	9.7	9.4	23.5	29.0	83.2	202.1	61.8	126.1	25.4	16.5	51.3
1951	12.2	8.5	7.2	7.9	23.0	27.6	93.7	186.9	96.4	41.2	31.4	21.9	46.5
1952	12.6	9.4	8.2	10.0	17.5	25.1	21.3	74.0	74.6	66.5	33.3	22.2	31.2
Mean	14.1	9.9	9.1	9.2	18.0	24.8	63.2	129.7	78.7	76.2	29.8	24.4	40.6

Remarks; Catchment area: 617 km^2

Table A-25 MONTHLY OBSERVED DISCHARGE RECORD AT BINGA

Unit: m^3/s

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1950	21.7	15.1	12.0	11.3	30.2	34.7	116.4	309.5	83.4	200.8	35.3	23.4	74.5
1951	15.1	10.0	8.7	8.9	30.3	39.7	106.3	243.1	129.0	43.9	36.0	23.4	57.9
1952	14.8	13.1	11.6	16.8	24.0	34.2	29.1	97.3	87.1	67.0	34.0	28.6	38.1
1953	15.9	11.4	9.6	11.8	14.1	97.5	122.8	160.0	(86.3)	(38.2)	127.1	42.8	—
1954	22.3	14.2	15.0	14.6	13.7	15.1	26.8	75.7	69.9	64.1	124.6	23.9	40.0
1955	17.1	8.3	6.4	12.4	15.4	14.1	21.3	32.4	(36.5)	60.3	41.0	16.0	—
Mean	17.8	12.0	10.5	12.6	21.3	39.2	70.4	153.0	92.4	87.2	66.3	26.4	50.8

Remarks; Catchment area: 860 km^2

Table A-26 MONTHLY OBSERVED DISCHARGE RECORD AT AMBAYOAN

Unit: m^3/s

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1958	—	—	—	—	(2.6)	21.0	20.2	26.9	37.3	17.1	7.7	7.0	—
1959	5.1	4.0	3.7	3.1	5.2	2.9	9.5	19.1	20.8	13.0	14.1	7.1	9.0
1960	3.3	2.7	2.5	1.9	2.4	5.4	7.0	107.7	26.2	26.8	12.3	7.4	17.1
1961	4.6	3.2	3.6	2.7	3.4	24.1	134.8	26.8	23.7	15.8	6.0	3.2	21.0
1962	3.0	2.9	2.7	3.0	2.8	5.5	82.3	38.1	56.8	26.9	12.2	7.1	20.3
1963	4.7	3.8	3.2	3.3	3.6	56.2	43.5	39.4	60.7	15.2	11.3	6.7	21.0
1964	6.4	5.4	3.7	3.3	7.0	10.7	9.8	72.4	40.9	46.2	23.1	15.9	20.4
1965	7.5	4.0	3.6	3.9	6.3	15.8	53.1	26.6	33.5	19.8	10.1	6.9	15.9
1966	4.3	3.1	2.7	2.3	37.8	32.8	44.5	67.4	92.7	20.9	21.1	12.9	28.5
1967	7.5	7.8	6.6	9.7	6.7	51.4	24.7	82.4	61.5	71.5	26.1	12.5	30.7
1968	8.4	7.0	5.0	3.9	(6.7)	5.5	19.7	85.4	110.1	34.7	13.0	6.6	—
1969	3.5	4.3	3.9	3.4	2.5	5.0	33.6	73.3	55.4	25.2	7.7	3.3	18.4
1970	3.1	2.1	2.2	1.8	2.4	12.7	15.0	34.7	53.8	30.0	13.4	8.3	14.9
1971	5.7	5.1	4.5	3.7	4.6	14.3	36.3	42.0	31.2	57.0	14.1	7.3	18.8
1973	4.3	2.7	2.5	1.7	3.1	4.9	7.6	15.0	13.5	52.1	8.1	3.5	9.9
1974	2.7	2.4	2.1	3.6	3.0	28.0	23.1	86.2	24.8	94.3	30.1	4.8	25.4
1975	2.7	2.3	2.5	1.4	2.1	2.6	2.4	14.9	15.3	21.3	8.9	2.6	6.6
1976	2.2	2.0	1.9	2.0	(73.8)	171.2	(78.1)	55.0	63.0	57.1	55.8	24.2	—
1977	18.7	9.9	4.1	2.2	1.8	2.1	23.6	42.8	—	—	—	—	—
Mean	5.4	4.1	3.4	3.2	5.9	24.8	32.8	50.3	45.6	35.8	16.4	8.2	19.7

Remarks; Catchment area: 281 km^2

Table A-27 MONTHLY OBSERVED DISCHARGE RECORD AT KALIPKIP

Unit: m^3/s

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1964	—	—	—	—	0.6	2.1	1.4	4.8	3.9	5.0	4.1	3.0	—
1965	(2.4)	(2.4)	(2.4)	2.5	3.2	8.4	11.7	7.9	7.1	10.5	1.7	1.3	—
1966	0.8	0.4	0.5	0.4	(3.0)	5.1	(7.1)	6.3	8.4	(3.6)	3.2	2.1	—
1967	—	—	—	—	1.5	11.6	11.4	16.2	13.9	22.1	8.3	1.2	—
1968	1.1	1.1	0.6	0.4	0.6	0.8	7.4	30.4	44.4	10.9	1.7	0.9	8.4
1969	0.4	0.2	0.2	(0.2)	—	(1.9)	12.7	16.2	12.3	4.4	1.2	0.6	—
1970	0.2	0.2	0.2	0.7	0.8	4.0	4.8	9.0	11.4	5.3	2.1	1.1	3.3
1971	0.6	0.4	0.3	0.3	0.9	6.5	15.1	18.5	8.1	13.6	2.7	1.7	5.7
1972	0.6	0.5	0.4	0.3	0.8	3.9	55.3	(27.2)	9.0	4.0	1.7	1.0	—
1973	0.3	0.3	0.2	0.1	0.3	—	6.9	11.3	8.9	17.2	—	—	—
Mean	0.6	0.4	0.3	0.7	1.1	5.3	14.1	13.4	12.7	10.3	3.0	1.4	5.3

Remarks; Catchment area: 74 km^2

Table A-28 MONTHLY OBSERVED DISCHARGE RECORD AT ADAOAY

Unit: m^3/s

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1959	—	—	—	—	—	—	—	—	35.2	18.7	40.0	19.8	—
1960	10.3	10.9	9.1	9.0	6.9	15.3	12.7	78.1	40.7	33.1	11.8	7.9	20.5
1961	5.7	4.6	6.3	4.3	9.8	21.4	77.1	49.2	43.7	38.5	16.1	9.2	23.8
1962	6.7	4.9	5.0	4.6	4.6	8.0	—	—	—	—	—	11.2	—
1963	7.4	6.2	5.6	5.3	5.8	35.2	38.3	38.5	65.2	23.3	11.4	9.5	21.0
1964	6.8	3.6	2.6	3.5	8.4	37.6	49.6	83.1	45.3	30.4	29.5	33.5	27.8
1965	23.9	15.4	8.3	8.1	12.8	33.1	112.8	68.9	41.7	33.1	23.2	18.1	33.3
1966	12.6	9.2	5.8	5.0	37.7	24.9	39.5	65.2	96.6	15.0	59.9	23.8	32.9
1967	10.5	5.2	2.9	2.3	2.8	40.6	22.7	44.0	67.6	110.8	80.2	8.4	33.2
1968	5.3	3.8	3.5	4.3	8.9	6.8	32.7	86.2	147.3	42.5	9.5	4.9	29.7
1969	8.4	3.4	2.6	3.4	9.3	8.3	89.6	45.3	22.5	33.7	8.8	2.0	19.8
1970	2.9	2.5	2.5	2.4	2.5	3.9	2.8	5.4	8.2	6.4	6.3	6.0	4.3
1971	9.4	10.1	9.1	8.1	8.2	10.4	37.4	12.8	12.2	47.1	15.5	11.3	16.0
1972	9.3	6.9	5.5	3.4	4.4	6.3	77.2	37.0	10.7	9.5	8.3	7.8	15.5
1973	5.8	2.7	2.3	2.3	3.2	4.3	20.2	8.4	16.5	19.6	8.5	7.4	8.4
1974	6.4	4.4	4.8	—	—	—	—	—	—	—	—	—	—
Mean	8.8	6.2	5.1	4.7	9.0	18.3	47.1	47.8	46.7	33.0	23.5	12.1	21.9

Remarks; Catchment area: 246 km^2

Table A-29 MONTHLY OBSERVED DISCHARGE RECORD AT LUAKAN (GAUGE 1-B)

Unit: m^3/s

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1950	12.7	7.8	6.7	6.7	17.0	22.0	53.9	95.7	43.4	71.0	14.5	10.1	30.1
1951	7.7	5.7	5.6	4.7	17.7	18.2	47.7	91.1	56.6	21.6	20.9	13.4	25.9
1952	6.4	5.8	4.9	5.5	9.8	10.9	10.6	36.1	38.9	40.9	18.3	14.2	16.9
Mean	8.9	6.5	5.7	5.6	14.9	17.0	37.4	74.3	46.3	44.5	17.9	12.6	24.3

Remarks; Catchment area: 376 km^2

Table A-30 MONTHLY OBSERVED DISCHARGE RECORD AT TABU

Unit: m^3/s

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1962	—	—	—	—	—	—	—	317.8	408.2	98.3	39.3	34.4	—
1963	39.3	34.8	32.1	29.5	28.7	86.4	104.7	102.4	463.8	93.2	58.5	52.9	93.9
1964	38.6	34.2	33.2	26.8	43.0	56.8	76.4	602.4	—	—	—	—	—
Mean	39.0	34.5	32.7	28.1	35.8	71.6	90.6	340.9	436.0	95.8	48.9	43.7	108.1

Remarks; Catchment area: 1,070 km^2

Table A-31 MONTHLY OBSERVED DISCHARGE RECORD AT BOKOD (BANGAO)

Unit: m^3/s

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1950	3.0	1.8	1.3	1.3	3.6	5.4	11.6	23.6	11.6	18.5	5.0	2.4	7.4
1951	1.9	1.1	0.8	1.0	3.5	4.8	9.4	26.3	13.7	6.2	5.5	3.8	6.5
1952	2.2	1.7	1.4	1.4	2.2	4.1	3.5	9.5	10.4	10.0	6.7	3.7	4.7
1953	2.5	1.8	1.3	1.5	2.4	9.6	12.0	16.0	11.7	9.3	8.4	6.0	6.9
1954	3.5	1.8	1.5	1.4	1.2	1.3	3.3	11.4	10.8	9.7	17.3	4.4	5.6
1955	3.0	1.9	1.5	1.5	1.8	1.6	3.4	6.0	17.1	6.0	3.3	2.8	4.2
1956	1.8	1.4	1.1	3.1	2.2	2.7	7.2	7.2	15.1	9.4	8.8	7.9	5.7
1957	3.5	2.0	1.6	1.5	1.6	5.9	6.9	7.0	13.8	8.1	5.6	3.1	5.0
1958	2.4	1.6	1.0	1.1	2.2	(5.6)	10.9	9.6	11.3	7.7	4.8	2.9	—
1959	—	—	—	—	—	—	—	—	16.4	4.8	—	—	—
1960	1.7	1.6	1.3	1.2	1.3	3.4	5.1	21.6	16.0	8.5	2.7	1.5	5.5
1961	1.1	0.8	1.0	0.9	1.4	3.8	16.6	9.5	10.2	8.9	3.3	2.2	5.0
1962	1.6	1.1	0.8	0.8	0.9	2.0	14.7	12.9	13.2	6.2	4.9	2.4	5.1
1963	1.4	1.1	0.8	0.3	0.7	6.4	7.5	9.1	—	—	—	2.5	—
1964	1.4	0.8	0.6	0.7	1.7	4.9	7.9	24.2	21.9	14.8	11.6	9.0	8.3
1965	3.6	2.1	1.3	1.1	1.4	4.6	—	7.4	10.4	9.5	4.3	2.2	—
1966	1.6	1.2	1.0	0.6	7.7	6.0	5.4	10.4	10.5	4.0	6.7	7.8	5.2
1967	3.8	3.6	4.1	5.2	3.6	6.0	7.8	9.1	4.7	7.8	12.2	3.2	5.9
1968	—	4.5	3.9	3.9	0.8	0.9	4.9	11.5	16.3	9.2	3.0	2.0	—
1969	0.6	0.4	1.0	1.0	2.1	0.3	7.8	10.7	7.1	5.3	2.9	2.3	3.5
1970	1.4	0.6	0.4	0.6	1.2	3.8	4.1	5.4	11.0	9.1	7.1	4.6	4.1
Mean	2.2	1.6	1.4	1.5	2.2	4.1	7.9	12.4	12.7	8.6	6.5	3.8	5.4

Remarks; Catchment area: 102 km^2

Table A-32 MONTHLY OBSERVED DISCHARGE RECORD AT BOKOD (POBLACION)

Unit: m^3/s

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1967	—	4.5	4.0	3.9	0.8	0.9	7.8	9.1	4.7	7.8	12.2	3.2	—
1968	3.8	3.6	4.1	5.2	3.7	6.0	4.9	11.5	16.3	9.2	3.0	1.9	6.1
1969	0.6	0.4	1.0	1.1	2.1	2.8	7.7	10.6	6.9	4.4	2.9	2.3	3.6
1970	1.4	0.6	0.4	0.6	1.2	3.8	4.2	5.4	11.0	9.1	7.1	4.6	4.1
1971	2.8	1.5	1.2	1.2	1.0	2.5	7.7	5.7	5.0	12.0	4.4	4.3	4.1
1972	3.2	1.8	0.8	0.5	1.4	2.8	37.4	22.9	6.2	10.5	3.1	1.0	7.6
1973	0.8	0.7	0.7	0.7	0.9	1.4	1.8	2.2	2.3	4.9	2.6	1.7	1.7
1974	1.1	1.1	1.0	—	—	—	—	—	—	—	—	—	—
Mean	1.9	1.8	1.6	1.9	1.6	2.9	10.2	9.6	7.5	8.3	5.0	2.7	4.6

Remarks; Catchment area: 48 km^2

Table A-33 MONTHLY OBSERVED DISCHARGE RECORD AT NAWAL (GAUGE 1—C)

Unit: m^3/s

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1953	0.1	0.1	0.0	0.0	0.2	5.0	2.6	5.2	(1.3)	0.7	6.9	0.4	—
1954	0.2	0.2	0.2	0.2	0.2	0.3	0.6	1.8	1.4	1.3	3.8	0.3	0.9
1955	0.2	0.1	0.1	0.1	0.1	0.1	0.8	0.9	6.7	1.1	0.9	—	—
Mean	1.9	1.8	1.6	1.9	1.6	2.9	10.2	9.6	7.5	8.3	5.0	2.7	4.6

Remarks; Catchment area: 12 km^2

Table A-34 MONTHLY OBSERVED DISCHARGE RECORD AT PESAK (GAUGE 1—G)

Unit: m^3/s

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1950	0.3	0.3	0.3	0.3	0.8	0.8	3.5	8.6	3.5	5.3	0.8	0.4	2.1
1951	0.3	0.2	0.2	0.2	0.5	0.7	5.8	(5.7)	3.0	1.0	0.5	0.3	—
1952	0.3	0.2	0.2	0.2	0.5	1.1	0.8	3.8	2.5	1.3	0.6	0.4	1.0
1953	0.3	0.3	0.2	0.1	0.2	9.2	5.6	6.4	3.2	1.3	5.1	0.7	2.7
1954	0.4	0.2	0.2	0.4	0.1	0.2	0.4	1.9	2.9	3.0	6.4	0.7	1.4
1955	0.4	0.3	0.1	0.2	0.2	0.2	1.0	1.3	8.3	1.5	0.6	—	—
Mean	0.3	0.3	0.2	0.2	0.4	2.0	2.8	4.4	3.9	2.2	2.3	0.5	1.6

Remarks; Catchment area: 19 km^2

Table A-35 MONTHLY OBSERVED DISCHARGE RECORD AT BANTAY (GAUGE I-H)

Unit: m^3/s

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1950	0.3	0.2	0.3	0.8	1.0	1.1	4.5	8.7	3.0	6.1	0.9	0.4	2.3
1951	0.2	0.2	0.2	0.2	0.4	1.3	7.1	7.9	6.4	1.1	0.5	0.3	2.2
1952	0.2	0.2	0.2	0.5	2.3	2.5	1.8	4.5	4.0	1.4	0.8	0.6	1.6
1953	0.7	0.2	0.2	0.3	4.2	10.7	4.3	5.8	3.5	0.8	11.3	1.0	3.6
1954	0.4	0.3	0.3	(0.3)	0.2	0.2	0.2	0.9	3.5	4.9	8.3	1.2	—
1955	0.5	0.3	0.2	0.3	0.2	0.2	0.9	1.2	3.5	1.8	0.9	(0.4)	—
1956	0.2	0.2	0.2	0.3	0.2	0.2	1.0	(2.2)	5.7	1.6	0.3	0.7	—
1957	0.2	0.2	0.3	0.2	0.2	1.3	2.2	2.1	3.3	1.1	0.6	1.3	1.1
1958	0.7	1.0	0.9	0.7	0.5	2.3	4.9	1.1	2.8	0.5	0.3	0.3	1.3
1959	0.3	0.2	0.2	0.2	0.3	0.4	0.8	2.3	1.6	0.4	1.3	0.8	0.7
1960	3.0	1.4	1.1	3.2	3.1	6.3	7.4	477.5	2.5	4.0	1.3	1.3	42.7
1961	0.9	0.6	0.4	0.2	0.4	8.6	22.2	32.6	20.2	4.3	1.4	0.9	7.7
1962	0.5	0.3	0.3	0.4	0.5	0.3	1.6	2.0	2.2	1.0	0.5	0.3	0.8
1963	0.3	0.3	0.3	0.3	0.7	2.1	2.5	1.7	3.9	0.7	0.4	0.3	1.1
1964	0.3	0.3	0.3	0.3	0.4	1.1	0.8	—	—	—	—	—	—
Mean	0.6	0.4	0.4	0.6	1.0	2.6	4.1	42.2	4.7	2.1	2.1	0.7	5.1

Remarks; Catchment area: 13 km^2

Table A-36 MONTHLY OBSERVED DISCHARGE RECORD AT BALOY

Unit: m^3/s

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1967	—	—	—	—	—	—	6.5	11.4	9.7	11.6	12.5	12.9	—
1968	10.8	7.2	6.2	6.2	7.6	8.1	10.0	16.4	13.2	5.4	3.2	1.9	8.0
1969	1.8	1.5	1.3	1.2	1.3	2.8	4.5	5.1	4.8	3.1	2.1	1.4	2.6
1970	0.6	0.7	0.7	0.7	0.9	1.7	3.1	3.8	3.7	1.5	0.8	0.7	1.6
1971	0.7	0.7	0.6	0.6	0.7	2.1	4.3	2.7	1.2	2.4	0.7	0.6	1.4
1972	1.5	1.4	1.4	1.4	1.6	3.0	20.7	4.5	3.0	2.3	2.8	1.4	3.8
1973	0.9	0.9	1.6	2.4	2.0	1.5	1.5	1.5	0.9	1.2	0.7	0.6	1.3
1974	0.5	0.4	0.4	0.4	0.5	—	1.1	1.7	0.8	4.6	1.0	0.2	—
1975	0.1	0.1	0.1	0.2	0.7	1.0	1.1	1.0	0.8	0.2	0.1	—	—
Mean	2.1	1.6	1.5	1.6	1.9	2.9	5.9	5.4	4.2	3.6	2.7	2.5	3.0

Remarks; Catchment area: 87 km^2

Table A-37 CORRECTED OR SUPPLEMENTED SPILLAGE DATA OF AMBUKLAO RESERVOIR

Year	Month	Monthly Total Spillage		Discharge Increment (m^3/s)
		Daily Record (10^6 m^3)	Monthly Record (10^6 m^3)	
1957	Sept.	7.73	67.32	23.0
	Oct.	2.75	24.20	8.0
1961	July	0.0	222.87	83.2
	Aug.	0.0	97.62	36.4
	Sept.	0.0	134.25	51.8
	Oct.	0.0	38.87	14.5
1962	Aug.	82.69	131.98	18.4
	Sept.	84.83	140.22	21.4

Table A-38 MONTHLY INFLOW INTO AMBUKLAO RESERVOIR

Unit: m^3/s

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1949	14.4	10.8	11.2	9.7	8.0	17.7	54.8	55.7	81.9	70.9	29.1	37.1	33.4
1950	17.4	10.9	9.7	9.4	23.5	29.0	83.2	202.1	61.8	126.1	25.4	16.5	51.3
1951	12.2	8.5	7.2	7.9	23.0	27.6	93.7	186.9	96.4	41.2	31.4	21.9	46.5
1952	12.6	9.4	8.2	10.0	17.5	25.1	21.3	74.0	74.6	66.5	33.3	22.2	31.2
1957	—	—	—	—	—	—	—	—	—	—	—	—	—
1958	4.3	8.7	4.4	5.7	10.0	34.6	67.4	55.8	86.0	51.1	24.7	12.2	30.4
1959	7.8	5.3	4.6	4.9	8.1	11.6	18.1	51.7	69.5	30.4	51.4	26.0	24.1
1960	14.5	15.2	10.8	11.8	11.8	25.8	27.6	78.0	31.8	37.5	20.0	12.2	24.8
1961	8.9	6.2	10.6	7.7	17.6	24.6	171.9	85.6	98.5	59.9	23.5	12.5	44.0
1962	9.3	—	5.9	5.4	7.0	14.5	127.7	93.9	99.3	42.2	32.9	15.8	—
1963	8.4	6.1	4.0	4.5	5.1	75.3	70.6	71.3	137.0	36.8	15.7	13.4	37.4
1964	8.2	4.3	2.6	2.6	10.8	35.4	49.3	195.6	105.8	98.2	65.4	54.9	52.8
1965	19.7	10.9	7.9	7.2	14.2	37.9	106.0	52.9	67.7	40.3	20.1	10.5	32.9
1966	7.3	5.1	2.9	3.8	59.0	35.3	44.7	87.2	93.1	24.0	44.5	33.7	36.7
1967	16.0	9.1	7.6	10.1	5.1	100.6	64.6	140.6	106.5	187.3	99.5	19.4	63.9
1968	10.0	5.7	3.1	2.2	7.1	16.8	88.0	145.3	153.8	82.6	16.9	8.6	45.0
1969	5.8	4.4	1.8	2.7	11.7	21.5	113.8	116.2	76.0	52.7	21.0	16.1	37.0
1970	11.2	5.4	5.6	5.7	11.6	44.9	31.7	64.4	110.2	109.4	47.1	27.4	39.5
1971	13.4	10.8	11.2	3.9	9.0	36.1	149.8	87.2	60.2	142.2	38.6	31.9	49.5
1972	21.5	10.9	8.2	10.4	26.8	40.0	461.4	222.1	77.4	33.0	21.3	11.3	78.7
1973	—	—	—	—	—	—	—	—	—	—	—	—	—
1974	—	—	—	—	—	—	—	—	—	—	—	—	—
1975	22.9	12.9	8.7	7.2	18.3	21.6	19.5	93.9	65.6	46.5	22.1	19.5	29.9
1976	15.0	6.9	5.0	0.0	142.8	148.7	160.8	62.5	60.4	39.6	17.1	5.6	55.4
1977	10.6	4.3	5.7	5.2	6.7	9.4	49.9	66.2	131.5	38.1	31.7	14.1	31.1
1978	8.7	3.9	3.6	2.5	1.7	18.8	38.4	178.2	148.5	117.5	52.6	21.6	49.7
1979	9.6	4.9	3.2	5.5	17.3	25.3	44.7	79.1	46.6	48.1	18.7	12.5	26.3
1980	7.3	4.2	4.2	1.3	9.5	5.1	104.3	48.9	83.2	44.4	163.0	20.6	41.3
1981	9.8	5.0	2.8	4.5	10.3	64.2	90.3	90.0	95.9	44.9	61.6	24.7	42.0
1982	8.3	4.9	2.2	4.5	0.0	7.5	76.0	90.7	63.2	48.5	21.2	12.6	28.3
Mean	11.7	7.5	6.0	5.8	18.3	35.4	90.0	102.8	88.2	65.2	38.9	19.8	40.8

Remarks; Catchment area: 617 km^2

Table A-39 MONTHLY OUTFLOW FROM AMBUKLAO DAM

Unit: m^3/s

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1949	14.4	10.8	11.2	9.7	8.0	17.7	54.8	55.7	81.9	70.9	29.1	37.1	33.4
1950	17.4	10.9	9.7	9.4	23.5	29.0	83.2	202.1	61.8	126.1	25.4	16.5	51.3
1951	12.2	8.5	7.2	7.9	23.0	27.6	93.7	186.9	96.4	41.2	31.4	21.9	46.5
1952	12.6	9.4	8.2	10.0	17.5	25.1	21.3	74.0	74.6	66.5	33.3	22.2	31.2
1957	7.0	7.9	15.2	18.6	20.1	21.4	20.6	21.9	58.3	53.0	33.1	28.7	25.5
1958	18.2	18.3	18.4	17.7	17.8	19.0	36.7	53.9	51.9	43.8	30.0	21.0	28.9
1959	20.6	20.9	14.6	18.1	19.5	22.9	25.0	23.9	34.4	36.1	21.3	23.4	23.4
1960	19.9	17.1	16.2	18.4	21.0	33.5	35.1	30.1	30.5	38.9	31.6	18.8	25.9
1961	16.7	23.9	17.5	20.7	21.9	15.5	121.1	83.0	98.9	61.0	34.7	21.1	44.7
1962	15.4	18.0	20.4	19.7	19.5	19.8	42.0	93.3	98.6	49.5	27.5	22.9	37.2
1963	23.6	24.5	23.6	20.3	12.9	44.1	59.4	59.2	106.2	51.1	23.0	18.2	38.9
1964	20.2	18.3	13.4	17.7	15.6	22.5	36.0	139.6	105.4	99.7	64.4	57.2	50.9
1965	22.5	22.8	24.2	26.8	23.9	37.9	46.1	57.8	61.8	48.2	17.8	11.7	33.5
1966	16.5	25.3	22.6	20.2	26.2	55.1	54.7	50.5	65.4	31.1	34.0	41.1	36.9
1967	21.5	18.6	28.7	32.1	26.1	42.0	58.5	121.8	103.3	187.6	110.6	29.7	65.1
1968	23.1	21.8	20.7	22.4	18.2	16.7	31.5	107.6	152.6	88.9	19.1	11.9	44.5
1969	14.0	15.1	17.2	18.3	24.2	35.6	34.7	109.7	77.3	57.1	31.9	24.7	38.3
1970	12.2	11.8	20.1	22.9	26.9	39.1	41.8	48.4	50.3	98.2	48.0	37.8	38.1
1971	31.0	26.0	25.6	32.4	17.9	27.1	66.0	86.6	60.5	143.0	45.7	30.0	49.3
1972	27.9	26.5	30.1	28.3	27.7	46.9	397.9	212.2	76.9	47.9	36.8	26.7	82.2
1973	29.4	15.2	9.0	4.9	13.6	20.0	29.9	35.9	49.2	49.2	50.0	35.6	28.5
1974	16.0	12.4	15.6	19.5	19.6	46.4	44.2	88.6	68.8	253.1	154.3	54.2	66.1
1975	28.1	23.9	25.0	25.5	25.9	26.4	37.3	48.6	56.5	54.9	31.9	17.7	33.5
1976	13.4	13.2	17.2	22.1	57.6	150.6	188.9	62.7	60.7	53.0	39.2	37.5	59.7
1977	11.0	6.8	2.3	1.4	5.8	11.1	27.8	38.5	86.2	43.4	31.9	14.4	23.4
1978	6.7	16.5	25.1	32.7	16.4	23.2	28.7	104.9	147.3	117.2	61.0	18.0	49.8
1979	18.1	22.0	26.3	17.7	15.8	38.3	41.9	48.4	30.9	34.3	18.0	13.7	27.1
1980	9.4	13.0	26.1	20.8	27.9	17.2	24.1	45.1	73.1	46.0	165.6	21.1	40.8
1981	10.2	17.2	17.5	13.6	24.2	39.4	61.5	89.4	96.0	46.1	60.7	28.3	42.0
1982	16.9	19.5	20.9	24.0	21.7	14.5	17.8	56.2	61.3	50.3	26.1	17.1	28.9
Mean	17.5	17.2	18.3	19.1	21.3	32.9	62.1	81.2	75.9	72.9	45.6	26.0	40.8

Remarks; Catchment area: 617 km^2

Table A-40 ADJUSTED MONTHLY INFLOW TO RESERVOIR AND OUTFLOW FROM AMBUKLAO DAM

Unit: m^3/s

Month	Inflow	Outflow
January	11.7	17.2
February	7.3	17.0
March	5.9	18.3
April	5.7	19.0
May	19.0	21.4
June	36.5	33.5
July	92.6	64.2
August	102.1	82.1
September	87.8	74.8
October	65.6	73.5
November	40.5	47.0
December	20.6	26.8
Mean	41.3	41.2

Table A-41 CORRECTED OR SUPPLEMENTED SPILLAGE DATA OF BINGA RESERVOIR

Year	Month	Monthly Total Spillage		Discharge Increment (m^3/s)
		Daily Record (10^6 m^3)	Monthly Record (10^6 m^3)	
1961	June	0.0	228.79	88.3
	July	0.0	141.75	52.9
	Aug.	0.0	191.35	71.4
	Sept.	0.0	59.62	23.0
1962	July	0.0	203.93	76.1
	Aug.	0.0	283.47	105.8
	Sept.	0.0	16.44	6.3
1963	Sept.	0.0	241.21	93.1
1967	Nov.	0.0	84.08	32.4

Table A-42 MONTHLY INFLOW INTO BINGA RESERVOIR

Unit: m^3/s

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1950	21.7	15.1	12.0	11.3	30.2	34.7	116.4	309.5	83.4	200.8	35.3	23.4	74.5
1951	15.1	10.0	8.7	8.9	30.3	39.7	106.3	243.1	129.0	43.9	36.0	23.4	57.9
1952	14.8	13.1	11.6	16.8	24.0	34.2	29.1	97.3	87.1	67.0	34.0	28.6	38.1
1953	15.9	11.4	9.6	11.8	14.1	97.5	122.8	160.0	(86.3)	(38.2)	127.1	42.8	—
1954	22.3	14.2	15.0	14.6	13.7	15.1	26.8	75.7	69.9	64.1	124.6	23.9	40.0
1955	17.1	8.3	6.4	12.4	15.4	14.1	21.3	32.4	(36.5)	60.3	41.0	16.0	—
1960	—	20.3	20.3	—	—	—	—	—	54.4	49.3	40.0	23.4	—
1961	18.8	25.9	16.7	19.8	19.5	100.7	113.8	128.6	79.9	56.5	43.1	25.2	54.0
1962	18.0	20.7	21.3	21.2	13.2	22.5	131.1	170.9	68.8	60.2	35.6	28.8	51.0
1963	28.5	28.2	26.4	20.8	15.5	71.1	84.4	86.9	181.3	65.3	30.2	23.3	55.1
1964	24.0	21.3	17.5	21.6	22.1	36.6	47.8	222.4	150.0	134.5	81.2	66.7	70.5
1965	29.3	28.3	29.1	31.0	31.5	49.7	91.5	78.5	85.5	64.3	26.6	18.3	47.0
1966	20.7	29.2	26.2	23.2	53.9	66.7	69.1	81.9	108.8	42.6	50.0	47.0	51.6
1967	26.0	21.8	29.8	35.3	29.3	68.5	78.3	142.3	132.1	208.0	95.8	36.5	75.3
1968	29.7	25.8	25.6	25.9	23.9	23.2	59.9	238.0	333.6	117.4	27.6	19.0	79.1
1969	19.3	17.8	21.0	22.1	29.9	41.0	70.9	145.4	108.9	74.0	40.6	30.8	51.8
1970	17.5	16.3	23.1	25.2	31.5	53.6	52.8	71.2	92.4	101.3	59.0	44.7	49.0
1971	37.9	28.7	27.9	35.9	22.8	39.2	92.5	121.3	80.7	174.2	56.6	38.6	63.0
1972	32.5	29.8	33.0	31.6	32.9	57.5	520.9	288.9	105.3	61.3	44.4	34.1	106.0
1973	—	—	—	—	—	—	—	—	—	—	—	—	—
1974	—	—	—	—	—	—	—	—	—	—	—	—	—
1975	—	—	—	—	—	—	—	—	—	—	—	—	—
1976	17.3	16.6	22.7	24.6	107.2	201.9	266.5	102.4	98.7	68.1	46.2	44.2	84.7
1977	16.5	10.1	1.8	1.4	6.9	14.2	43.1	61.6	146.4	62.4	42.7	19.8	35.6
1978	9.8	20.8	29.4	36.9	20.6	28.8	43.8	171.4	178.0	147.9	76.2	26.0	65.8
1979	24.1	26.6	28.0	19.1	20.2	44.8	54.9	81.1	49.6	52.1	25.1	17.7	36.9
1980	12.8	14.3	26.4	22.1	35.1	23.5	69.3	64.7	109.6	61.2	212.4	29.8	56.8
1981	14.4	21.3	20.2	16.1	25.9	56.0	93.1	137.5	138.3	64.7	76.4	37.0	58.4
1982	23.3	25.0	26.3	30.0	27.8	20.8	50.6	96.6	83.7	70.9	36.8	23.6	42.9
Mean	21.1	20.0	20.6	21.6	27.9	50.2	98.3	136.4	114.8	86.9	59.4	30.5	57.3

Remarks; Catchment area: 860 km^2

Table A-43 MONTHLY OUTFLOW FROM BINGA DAM

Unit: m^3/s

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1950	21.7	15.1	12.0	11.3	30.2	34.7	116.4	309.5	83.4	200.8	35.3	23.4	74.5
1951	15.1	10.0	8.7	8.9	30.3	39.7	106.3	243.1	129.0	43.9	36.0	23.4	57.9
1952	14.8	13.1	11.6	16.8	24.0	34.2	29.1	97.3	87.1	67.0	34.0	28.6	38.1
1953	15.9	11.4	9.6	11.8	14.1	97.5	122.8	160.0	(86.3)	(38.2)	127.1	42.8	—
1954	22.3	14.2	15.0	14.6	13.7	15.1	26.8	75.7	69.9	64.1	124.6	23.9	40.0
1955	17.1	8.3	6.4	12.4	15.4	14.1	21.3	32.4	(36.5)	60.3	41.0	16.0	—
1960	—	20.4	20.2	—	—	—	—	—	54.2	50.4	39.8	23.2	—
1961	20.9	23.6	18.3	18.5	20.2	102.4	110.9	128.6	81.1	56.0	45.9	22.3	54.1
1962	19.7	20.6	23.1	19.1	18.3	28.3	118.2	170.2	69.6	62.5	33.0	28.9	50.9
1963	28.8	28.4	26.9	22.9	28.2	62.4	84.3	81.7	178.8	67.0	29.5	23.4	55.2
1964	26.3	18.3	17.8	23.7	26.0	40.4	50.7	208.4	150.6	136.3	80.5	66.5	70.5
1965	29.6	27.8	29.9	32.6	33.6	60.1	76.9	88.8	73.7	65.2	26.4	18.3	46.9
1966	20.7	29.2	26.5	25.2	58.2	74.3	68.1	75.2	103.7	41.7	49.0	49.2	51.7
1967	25.2	26.2	30.4	31.3	34.6	71.3	82.9	127.4	131.8	208.6	98.4	35.0	75.3
1968	30.1	26.8	27.3	26.4	35.3	21.3	47.3	237.2	335.0	119.5	25.0	18.0	79.1
1969	20.7	17.2	20.4	22.1	33.9	48.9	59.3	149.7	106.2	78.7	34.6	30.8	51.9
1970	21.3	17.3	20.9	34.9	32.8	54.0	54.2	66.7	82.0	101.0	57.0	55.0	49.8
1971	31.0	35.9	30.9	33.4	27.3	37.4	78.9	122.9	79.2	175.9	64.5	32.1	62.4
1972	37.4	37.0	32.7	31.1	35.5	54.6	508.9	287.7	105.6	72.3	46.4	30.7	106.7
1973	39.4	19.2	11.7	1.6	19.6	29.9	40.6	45.5	63.5	74.1	63.8	39.3	37.3
1974	21.8	23.5	17.7	19.6	23.7	62.1	63.9	141.0	102.5	326.6	199.4	68.7	89.2
1975	33.4	28.0	27.3	30.6	31.2	29.7	47.6	65.4	84.1	73.1	44.6	23.0	43.2
1976	17.8	18.8	15.2	24.6	100.8	203.5	269.8	102.1	94.7	72.3	58.3	36.9	84.6
1977	16.9	13.9	5.5	1.5	5.3	15.8	39.1	54.6	139.9	63.1	45.3	18.7	35.0
1978	8.9	20.5	29.8	38.4	23.2	37.1	38.6	166.3	175.2	147.4	79.9	23.6	65.7
1979	24.9	26.1	33.7	26.8	19.4	45.2	55.9	74.8	48.7	51.9	20.2	16.1	37.0
1980	12.5	16.8	25.4	26.7	44.1	24.6	52.6	68.9	105.2	68.0	206.9	29.4	56.7
1981	14.8	23.2	19.4	15.4	30.0	57.4	88.9	134.5	138.4	70.1	71.6	37.2	58.4
1982	22.7	28.5	23.9	35.6	26.2	27.0	39.8	96.4	83.2	71.6	37.0	24.0	43.0
Mean	22.6	21.3	20.6	22.1	29.8	50.8	89.3	129.0	109.5	96.1	64.0	31.3	57.2

Remarks; Catchment area: 860 km^2

Table A-44 MONTHLY RUN-OFF FROM THE REMNANT BASIN BETWEEN AMBUKLAO AND BINGA DAMS

Unit: m^3/s

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1950	4.2	4.1	2.3	1.9	6.7	5.7	33.2	107.4	21.6	74.8	9.9	6.9	23.2
1951	3.0	1.5	1.5	1.0	7.4	12.2	12.7	56.2	32.6	2.7	4.6	1.5	11.4
1952	2.2	3.7	3.3	6.8	6.5	9.1	7.7	23.3	12.5	0.5	0.7	6.4	6.9
1960	—	3.1	4.1	—	—	—	—	—	23.8	10.4	8.4	4.7	—
1961	2.1	2.0	0.0	0.0	0.0	85.2	0.0	45.7	0.0	0.0	8.4	4.1	12.3
1962	2.6	2.8	0.9	1.5	0.0	2.7	89.1	77.6	0.0	10.7	8.1	5.9	16.8
1963	4.9	3.6	2.8	0.5	2.6	26.9	24.9	27.7	75.1	14.2	7.1	5.1	16.3
1964	3.7	2.9	4.1	3.9	6.6	14.0	11.8	82.8	44.6	34.8	16.8	9.5	19.6
1965	6.7	5.5	4.9	4.2	7.6	11.8	45.4	20.7	23.6	16.1	8.8	6.6	13.5
1966	4.2	3.8	3.6	3.0	27.7	11.6	14.4	31.4	43.4	11.5	16.0	5.9	14.7
1967	4.5	3.2	1.0	3.2	3.1	26.4	19.8	20.5	28.8	20.4	0.0	6.8	11.5
1968	6.5	4.0	4.9	3.4	5.7	6.5	28.4	130.4	181.0	28.5	8.5	7.1	34.6
1969	5.3	2.8	3.8	3.9	5.6	5.5	36.2	35.7	31.6	16.9	8.7	6.0	13.5
1970	5.3	4.5	3.0	2.3	4.7	14.5	11.0	22.7	42.1	3.1	11.0	6.9	10.9
1971	6.9	2.7	2.3	3.5	4.9	12.1	26.5	34.7	20.2	31.2	10.9	8.6	13.7
1972	4.5	3.2	2.9	3.3	5.2	10.6	123.0	76.7	28.3	13.5	7.6	7.4	23.9
1973	—	—	—	—	—	—	—	—	—	—	—	—	—
1974	—	—	—	—	—	—	—	—	—	—	—	—	—
1975	—	—	—	—	—	—	—	—	—	—	—	—	—
1976	3.9	3.4	5.5	2.5	49.7	51.2	77.6	39.7	38.0	15.2	7.0	6.7	25.0
1977	5.5	3.3	0.0	0.1	1.1	3.1	15.3	23.1	60.3	18.9	10.8	5.4	12.2
1978	3.0	4.3	4.2	4.2	4.2	5.6	15.2	66.5	30.8	30.7	15.2	8.0	16.0
1979	6.0	4.6	1.7	1.4	4.4	6.6	12.9	32.7	18.6	17.9	7.1	4.0	9.8
1980	3.3	1.4	0.3	1.3	7.2	6.3	45.2	19.6	36.5	15.1	46.8	8.8	16.0
1981	4.3	4.2	2.7	2.6	1.7	16.5	31.5	48.1	42.3	18.6	15.7	8.7	16.4
1982	6.4	5.5	5.4	6.0	6.1	6.3	32.8	40.4	22.4	20.6	10.7	6.5	14.1
Mean	4.5	3.5	2.8	2.7	7.7	15.9	32.5	48.3	37.3	18.5	10.8	6.4	15.9

Remarks; Catchment area: 243 km^2

Table A-45 ADJUSTED MONTHLY RUN-OFF FROM THE REMNANT BASIN BETWEEN AMBUKLAO AND BINGA DAMS

Unit: m^3/s

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
4.5	3.6	2.9	2.8	8.6	12.3	30.2	43.9	33.1	19.6	12.0	6.5	15.0

Table A-46 AVERAGE MONTHLY DISCHARGE AT AMBAYOAN AND KALIPKIP STATIONS

Unit: m^3/s

Month	Ambayoan	Kalipkip	Month	Ambayoan	Kalipkip
Jan.	4.8	0.6	Aug.	50.9	14.5
Feb.	3.9	0.4	Sept.	41.9	14.3
Mar.	3.5	0.3	Oct.	36.0	12.0
Apr.	3.4	0.8	Nov.	14.0	3.0
May	3.9	1.2	Dec.	6.9	1.2
June	16.3	6.1			
July	33.5	10.1	Mean	18.3	5.4

Table A-47 SPECIFIC RUN-OFF AND RUN-OFF COEFFICIENTS OF CATCHMENT AREA

Catchment Area	Upstream from Ambuklao	Between Ambuklao and Binga	Ambayoan	Kalipkip
Drainage area (km^2)	617	243	281	74
Mean discharge (m^3/sec)	41.3	15.0	18.3	5.4
Mean run-off depth (mm/year)	2,111	1,947	2,054	2,301
Mean rainfall (mm/year)	3,000	3,000	2,800	3,750
Specific run-off ($m^3/s/km^2$)	0.067	0.062	0.065	0.073
Run-off coefficient	0.704	0.649	0.733	0.614

Table A-48 LONG TERM MEAN DISCHARGE CALCULATED

Basin	Catchment area (km^2)	Discharge (m^3/sec)	Note
Outflow from Binga dam	860	57.2	ref. to 3.1.3
Remnant basin between Binga and San Roque	390	27.3	run-off coefficient = 0.070
San Roque dam proposed site	1,250	84.5	

Table A-49 YEAR JUDGED TO BE RELIABLE

	No. Years	Year
Years to be examined	32	1949 through 1980
Excluded because of poor correlation	4	1970, 1972, 1973, 1975
poor correlation with Binga discharge	2	1972, 1973
poor correlation with Baguio rainfall	3	1970, 1972, 1975
Excluded because of no examination by the correlation	7	1959, 1967, 1974, 1976 to 1979
Year judged to be reliable	21	21 years out of 1949 through 1980

Table A-50 MONTHLY MEAN OBSERVED DISCHARGE FOR 21 YEARS AND LONG TERM MONTHLY MEAN DISCHARGE AT PROPOSED SAN ROQUE DAM SITE

Month	Mean of Observed Discharge (m^3/s)	Ratio to Annual Total (%)	Long Term Average Discharge (m^3/s)
Jan.	30.2	2.99	30.3
Feb.	23.0	2.28	23.1
Mar.	19.8	1.96	19.8
Apr.	20.0	1.98	20.1
May	40.2	3.98	40.4
June	62.4	6.18	62.7
July	119.8	11.87	120.4
Aug.	225.8	22.37	226.9
Sept.	215.2	21.32	216.2
Oct.	138.7	13.74	139.3
Nov.	75.5	7.48	75.8
Dec.	39.1	3.87	39.2
Mean	84.1	–	84.5

Table A-51 SELECTED MONTHLY DISCHARGE OBSERVED AT SAN ROQUE GAUGING STATION FOR THE STUDY

Unit: m^3, s

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1949	31.9	21.1	16.2	13.8	11.9	25.0	97.6	126.5	181.3	165.5	64.0	51.1	67.2
1950	45.7	23.4	18.5	18.5	43.7	49.6	180.8	357.9	121.9	289.6	56.7	31.3	103.1
1951	22.9	16.1	10.6	12.5	54.6	68.0	105.3	327.3	212.0	70.9	53.9	35.1	82.4
1952	21.1	18.0	13.0	18.7	37.1	56.3	49.5	180.6	154.2	139.1	58.2	31.8	64.8
1953	24.5	16.6	13.7	13.4	15.2	148.0	219.2	358.2	184.7	121.8	116.2	56.2	107.3
1954	31.3	19.6	17.0	18.8	19.9	24.1	37.1	148.8	182.9	121.0	143.0	65.4	69.1
1955	26.1	18.6	13.1	11.3	15.8	21.5	46.7	84.3	107.4	81.4	42.0	17.2	40.5
1956	21.9	14.3	12.4	18.1	26.9	24.0	40.9	82.6	170.0	84.2	74.7	54.7	52.1
1957	37.8	27.5	27.0	32.9	29.7	49.3	73.5	106.9	207.2	119.6	74.4	60.9	70.6
1958	42.9	28.0	25.5	23.2	25.2	42.8	69.9	61.1	66.4	44.6	23.5	21.5	39.5
1960	30.4	20.9	15.5	19.9	29.3	74.8	84.8	444.8	112.9	80.9	27.4	14.8	79.7
1961	25.0	25.2	23.2	22.2	29.3	47.2	164.7	135.4	157.1	106.3	46.2	40.1	68.5
1962	27.2	20.4	29.1	31.5	43.5	36.4	180.2	175.0	243.8	104.8	45.1	44.9	81.8
1963	48.9	39.5	35.2	28.1	22.3	153.6	112.3	131.9	347.6	92.0	36.7	18.6	88.9
1964	17.2	18.8	10.0	24.1	17.1	21.4	55.7	502.1	255.3	282.2	99.5	57.0	113.4
1965	14.0	9.2	13.6	10.4	6.3	33.4	193.6	167.2	129.7	116.4	29.9	16.0	61.6
1966	7.9	8.0	8.1	8.6	229.4	175.9	156.8	178.6	244.6	60.0	54.3	58.5	99.2
1968	27.1	14.5	10.3	14.9	28.5	15.7	108.0	561.1	726.0	275.0	60.1	24.9	154.7
1969	21.7	20.4	24.0	10.0	43.0	64.3	213.7	244.8	350.2	188.3	58.2	18.2	104.7
1971	72.2	70.4	54.9	41.3	47.8	84.3	200.5	270.9	240.6	259.6	71.2	23.1	119.7
1980	36.5	32.0	24.9	28.7	77.5	95.4	124.1	95.0	123.6	109.7	350.3	79.3	98.1

Remarks; Catchment area: 1,250 km^2

Table A-52 MONTHLY DISCHARGE AT PROPOSED SAN ROQUE DAM SITE ESTIMATED BY ELC FEASIBILITY AND ADDITIONAL STUDIES

Unit: m^3/s

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1949*	24.3	16.2	13.0	13.8	22.7	43.7	133.6	164.4	145.0	124.7	67.2	41.3	67.5
1950*	37.5	25.0	20.0	21.3	35.0	67.6	206.5	254.1	224.0	192.7	103.9	63.8	104.3
1951*	29.8	19.9	15.9	16.9	27.8	53.7	163.9	201.7	177.9	153.0	82.5	50.7	82.8
1952*	23.4	15.6	12.5	13.3	21.8	42.1	128.7	158.3	139.6	120.1	64.7	39.8	65.0
1953*	38.9	25.9	20.7	22.0	36.3	70.0	213.8	263.1	232.0	199.6	107.6	66.1	108.0
1954*	24.9	16.6	13.3	14.1	23.3	44.8	137.0	168.6	148.6	127.9	68.9	42.4	69.2
1955*	14.6	9.7	7.8	8.3	13.6	26.3	80.4	98.9	87.2	75.0	40.4	24.8	40.6
1956*	18.8	12.5	10.0	10.6	17.5	33.8	103.2	126.9	111.9	96.3	51.9	31.9	52.1
1957*	25.5	17.0	13.6	14.4	23.8	45.8	140.0	172.2	151.9	130.7	70.4	43.3	70.7
1958	14.3	9.5	7.6	8.1	13.3	25.7	78.6	96.7	85.3	73.4	39.5	24.3	39.7
1959	14.1	9.4	7.5	8.0	13.2	25.5	77.8	95.7	84.4	72.6	39.1	24.1	39.3
1960*	28.9	19.3	15.4	16.4	27.0	52.0	519.0	195.6	172.5	148.4	80.0	49.1	80.3
1961*	24.8	16.5	13.2	14.0	23.1	44.6	136.2	167.6	147.8	127.1	68.5	42.1	68.8
1962*	29.7	19.8	15.8	16.8	27.7	53.4	163.2	200.7	177.0	152.3	82.1	50.4	82.4
1963*	31.9	21.3	17.0	18.1	29.8	57.5	175.6	216.1	190.5	163.9	88.3	54.3	88.7
1964*	41.1	27.4	21.9	23.3	38.4	74.1	226.3	278.4	245.5	211.2	113.8	70.0	114.3
1965*	22.4	14.9	11.9	12.7	20.9	40.3	123.2	151.5	133.6	114.9	62.0	38.1	62.2
1966*	28.4	18.9	15.1	16.1	26.5	51.1	156.2	192.2	169.5	145.8	78.6	48.3	78.9
1967	42.2	28.2	22.5	23.9	39.4	76.0	232.3	285.7	252.0	216.8	116.8	71.8	117.3
1968*	45.2	30.1	24.1	25.6	42.2	81.3	248.5	305.7	269.6	231.9	125.0	76.8	125.5
1969*	29.4	19.6	15.7	16.7	27.5	52.9	161.8	199.0	175.5	151.0	81.4	50.0	81.7
1970	29.1	19.4	15.5	16.5	27.2	52.4	160.2	197.1	173.8	149.5	80.6	49.5	80.9
1971*	33.4	22.2	17.8	18.9	31.1	60.1	183.5	225.8	199.1	171.3	92.3	56.7	92.7
1972	61.5	41.0	32.8	34.9	57.4	110.7	338.4	416.3	367.1	315.8	170.2	104.6	170.9
1973	20.6	13.7	11.0	11.7	19.2	37.1	113.3	139.3	122.9	105.7	57.0	35.0	57.2
1974	51.7	34.5	27.6	29.3	48.3	93.1	284.5	350.1	308.7	265.6	143.1	87.9	143.7
1975	24.2	16.1	12.9	13.7	22.5	43.5	132.9	163.5	144.1	124.0	66.8	41.1	67.1
1976	34.9	23.3	18.6	19.8	32.6	62.8	191.9	236.0	208.1	179.1	96.5	59.3	96.9
1977	27.5	14.3	11.4	11.4	16.0	28.6	108.2	142.5	237.9	103.2	68.2	34.5	67.0
1978	25.9	19.7	18.4	21.8	22.2	51.2	126.6	325.5	263.7	203.2	107.5	53.9	103.5
1979	25.5	17.7	13.6	14.9	29.0	47.5	95.5	153.0	105.2	101.3	46.2	29.3	56.6
1980*	26.5	17.9	14.8	16.2	54.5	68.8	205.5	94.6	136.9	101.9	353.9	79.9	97.6
1981	27.3	18.8	14.2	17.2	27.4	109.8	188.9	223.8	215.4	128.7	114.8	58.1	95.4
1982	24.1	18.0	16.1	20.0	18.3	31.5	142.8	184.4	135.4	112.0	57.0	33.6	66.1
Mean	29.5	19.7	15.9	17.4	28.1	54.7	162.3	201.3	180.6	149.7	90.8	50.8	83.4

Remarks; Catchment area: 1,250 km^2

*: Discharge records are hydrologically reliable.

Table A-53 DAILY MAXIMUM RAINFALL AT BAGUIO

No.	Year	Date		Rainfall (mm)
1.	1909	Oct.	17	689.7
2.	1911	July	14	879.8
3.	1937	July	2	408.8
4.	1938	Oct.	5	72.9
5.	1939	Oct.	8	255.5
6.	1950	Oct.	2	237.7
7.	1951	July	30	486.7
8.	1952	Aug.	16	109.0
9.	1953	Nov.	17	546.6
10.	1954	Nov.	8	210.3
11.	1955	Sept.	23	388.9
12.	1956	Sept.	2	233.9
13.	1957	June	23	291.1
14.	1958	June	8	140.5
15.	1959	Nov.	17	227.1
16.	1960	Aug.	22	213.1
17.	1961	July	13	183.4
18.	1962	Aug.	30	309.6
19.	1963	Sept.	9	319.5
20.	1964	Aug.	6	369.6
21.	1965	July	13	368.0
22.	1966	Sept	6	269.3
23.	1967	Oct.	17	979.4
24.	1968	Sept.	28	649.7
25.	1969	July	26	512.2
26.	1970	Sept.	11	119.7
27.	1971	July	19	379.5
28.	1972	July	17	479.6
29.	1973	Oct.	7	379.1
30.	1974	Oct.	11	781.4
31.	1975	Aug.	10	163.6
32.	1976	May	25	605.3
33.	1977	Aug.	20	215.8
	Average			378.4
	Standard deviation			221.8

Table A-54 SELECTED BIG STORM

	Date	Rainfall at Baguio (mm)	Agno Basin Rainfall						Inflow to Reservoir (m^3/s)
			Buguias (mm)	Ambuklao (mm)	Bobok (mm)	Binga (mm)	Balatok (mm)	Average (mm)	
July	14, 1911	879.8	—	—	—	—	—	—	—
	15	733.6	—	—	—	—	—	—	—
	16	424.9	—	—	—	—	—	—	—
	17	200.4	—	—	—	—	—	—	—
	Total	2,238.7	—	—	—	—	—	—	—
Oct.	16, 1967	374.8	182.1	203.7	118.1	49.0	162.6	143.1	63.2
	17	979.4	253.8	313.7	84.6	282.2	325.5	272.0	1,769.6
	18	—	—	—	—	—	—	—	916.0
	19	—	—	—	—	—	—	—	404.2
	Total	1,354.2	435.9	517.4	202.7	331.2	588.1	415.1	3,153.0
Sept.	27, 1968	51.6	56.4	29.2	75.0	15.5	29.7	41.2	54.7
	28	649.7	73.9	237.0	128.3	201.2	21.3	132.3	152.8
	29	157.0	67.1	86.6	101.6	73.7	243.9	114.6	340.3
	30	—	—	—	—	—	—	—	282.9
Oct.	1	—	—	—	—	—	—	—	264.2
	Total	858.3	197.4	352.8	304.9	290.4	294.9	288.1	1,094.9
Oct.	10, 1974	93.9	61.5	38.1	12.2	19.1	20.8	30.3	—
	11	781.4	89.2	57.2	192.8	220.2	421.9	196.3	—
	Total	875.3	150.7	95.3	205.0	239.3	442.7	226.6	—
May	24, 1976	201.9	91.5	218.3	179.1	229.9	181.6	180.1	187.0
	25	605.3	199.1	406.2	343.0	367.0	334.5	330.0	1,303.2
	26	153.8	162.5	91.7	157.7	158.5	166.9	147.5	1,328.1
	27	—	—	—	—	—	—	—	529.5
	28	—	—	—	—	—	—	—	318.7
	Total	961.0	453.1	716.2	679.8	755.4	683.0	657.6	3,666.5

Table A-55 INTENSITY-DURATION IN STORMS AT BAGUIO

Unit: mm

Storms Duration (hour)	Aug. 30 1962	Sept. 9 1963	Aug. 6 1964	July 13 1965	July 19 1971	July 17 1972	Oct. 7 1973
0.5	—	—	—	—	—	39.9	—
1	40.9	—	78.2	59.4	65.9	—	36.1
2	59.9	65.8	146.8	96.3	82.4	—	64.9
3	73.4	88.4	201.7	120.9	102.0	128.0	87.6
6	129.8	152.7	298.2	218.4	141.1	—	148.2
12	188.5	227.8	342.2	309.6	248.2	320.8	318.3
24	309.6	319.5	269.6	368.0	379.5	479.6	379.5

Table A-56 PROBABLE MAXIMUM PRECIPITATION ESTIMATED

Unit: mm

Return Period (Years)	Iwai	Gumbel	Person III
2	333	222	332
5	531	453	541
10	669	601	681
20	803	744	820*
50	980	928	980
100	1,119	1,066	1,102
200	1,260	1,204	1,220
500	1,456	1,386	1,400*
1,000	1,606	1,523	1,500*
10,000	2,200*	1,979	1,950*

Remarks; *: Figures are perceived from a line extended.

Table A-57 HOURLY RELATION BETWEEN RAINFALL DEPTH AND DURATION AT BAGUIO

Duration (hr)	Depth (mm)	Duration (hr)	Depth (mm)
1	307.1	13	1,506.4
2	472.0	14	1,577.2
3	606.9	15	1,646.1
4	725.4	16	1,713.1
5	833.0	17	1,778.9
6	932.7	18	1,843.1
7	1,026.2	19	1,905.9
8	1,114.8	20	1,967.5
9	1,199.3	21	2,028.0
10	1,280.2	22	2,087.3
11	1,358.1	23	2,145.6
12	1,433.4	24	2,203.0

Table A-58 TRANSPOSITION FACTOR OF BAGUIO RAINFALL TO AGNO BASIN AND RUN-OFF COEFFICIENT

Date	Transposition factor		Run-off coefficient
	Daily peak volume	Total volume	
July 1911	-	-	-
Oct. 1967	0.28	0.31	1.09
Sept.1968	0.20	0.34	0.53
Oct. 1974	0.25	0.26	-
May 1976	0.55	0.68	0.78
Applied value	0.60		0.80

Table A-59 HOURLY RAINFALL DEPTH AND DURATION WITHIN 24 HOURS EQUIVALENT TO EFFECTIVE PROBABLE MAXIMUM PRECIPITATION IN SAN ROQUE CATCHMENT BASIN

Duration (hr)	Depth (mm)	Duration (hr)	Depth (mm)
1	147.4	13	723.1
2	226.6	14	757.1
3	291.3	15	790.1
4	348.2	16	822.4
5	399.8	17	853.9
6	447.7	18	884.7
7	492.6	19	914.8
8	535.1	20	944.4
9	575.7	21	973.4
10	614.5	22	1,001.9
11	651.9	23	1,029.9
12	688.0	24	1,057.4

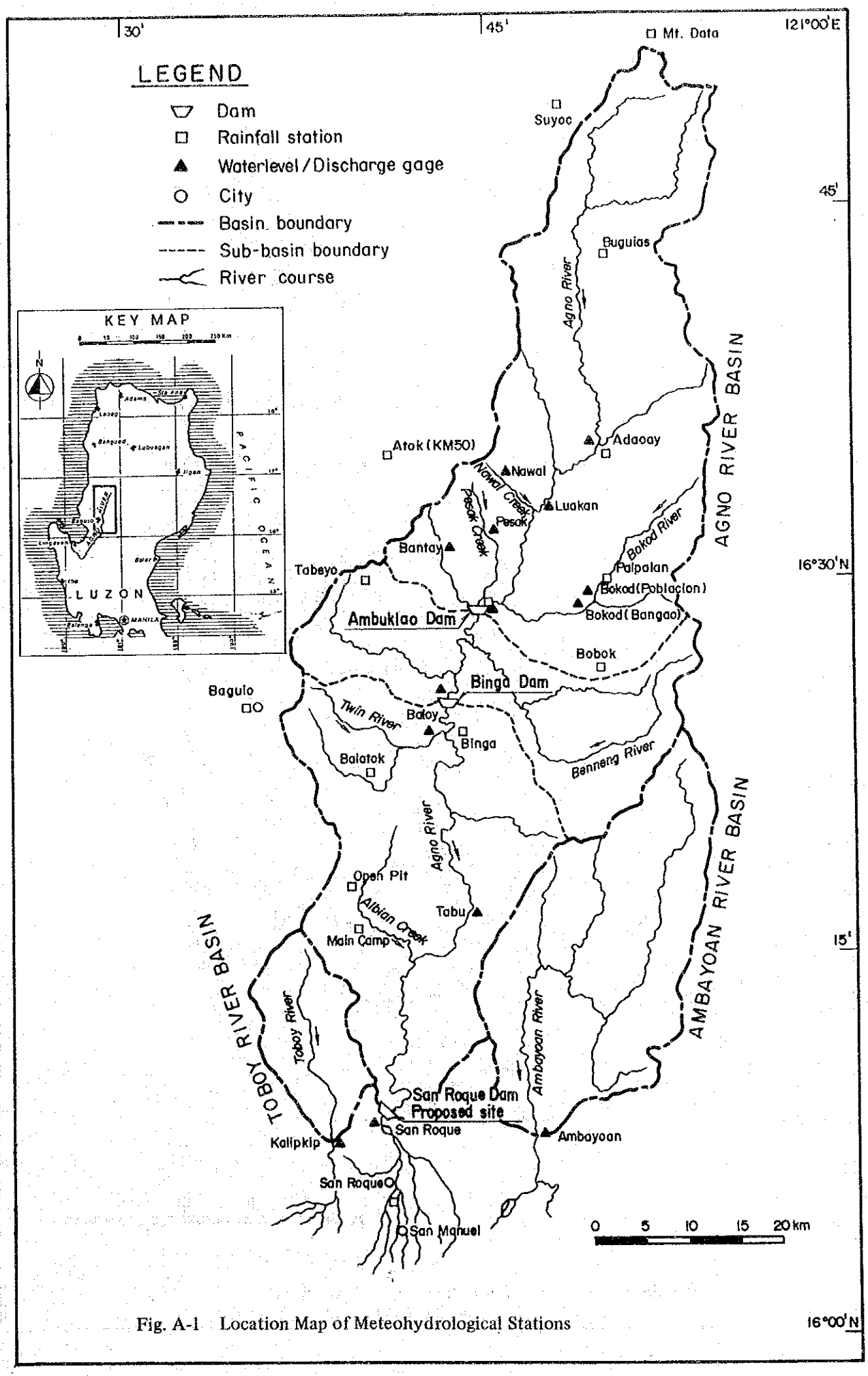


Fig. A-1 Location Map of Meteohydrological Stations

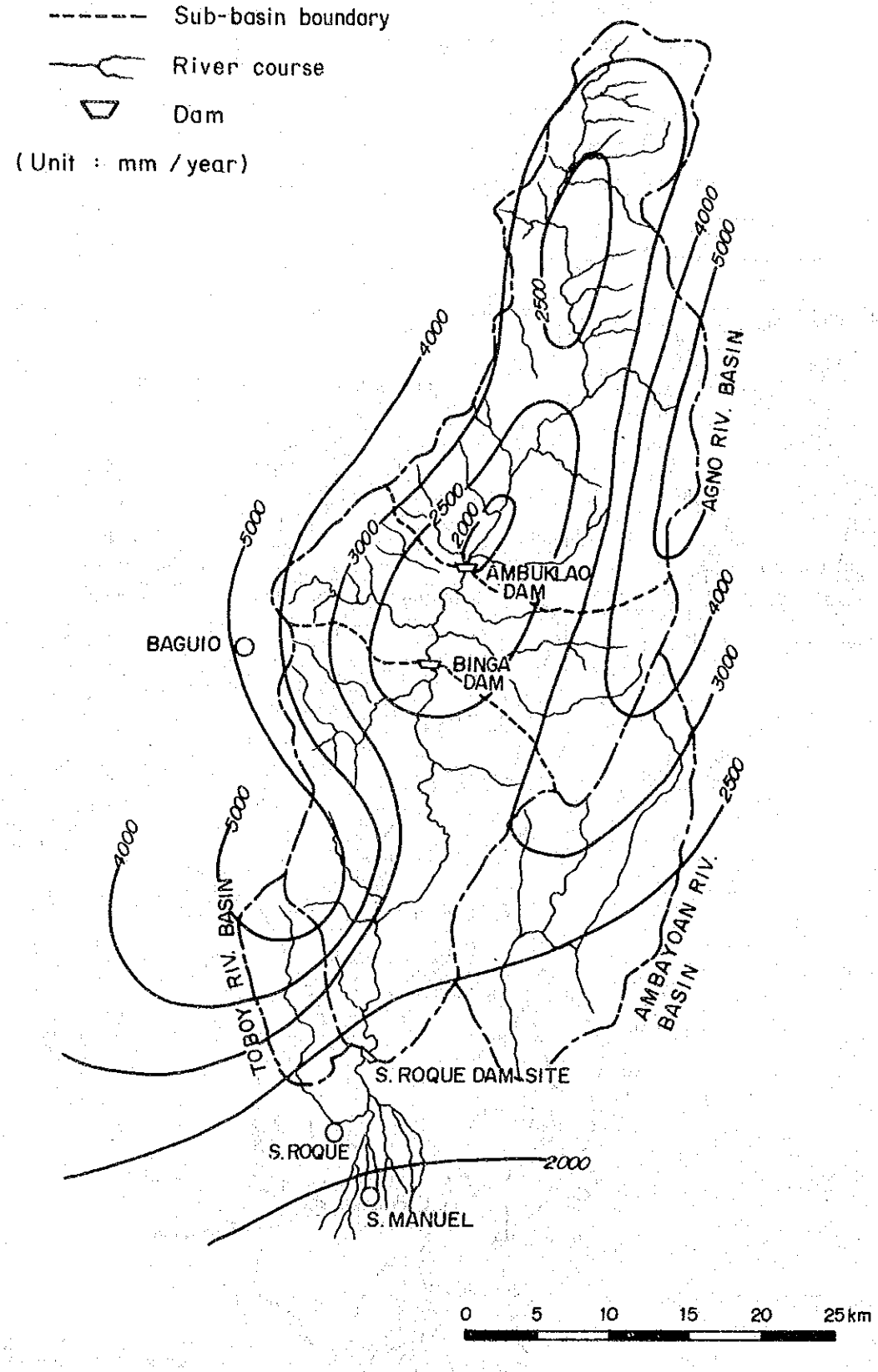


Fig. A-2 Isohyetal Map for Upper Agno River Basin

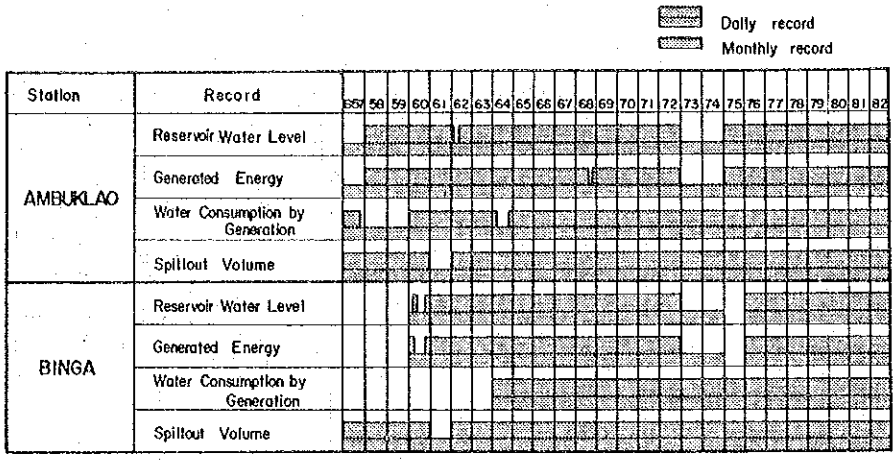
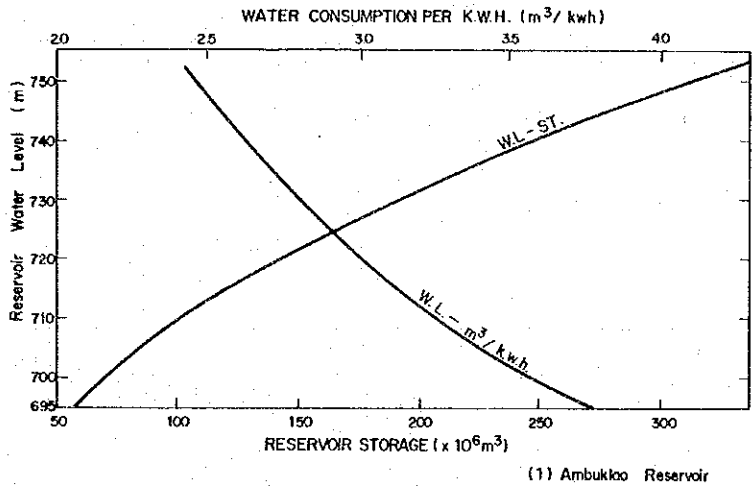


Fig. A-3 Reservoir Operation Record Available for the Study



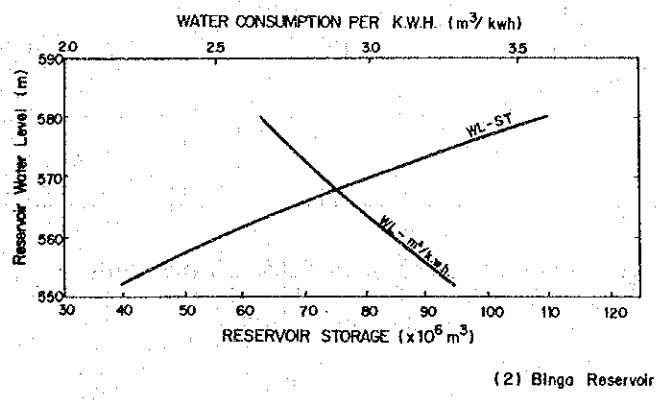


Fig. A-4 Rating Curves on Waterlevel-Storage-Water Consumption

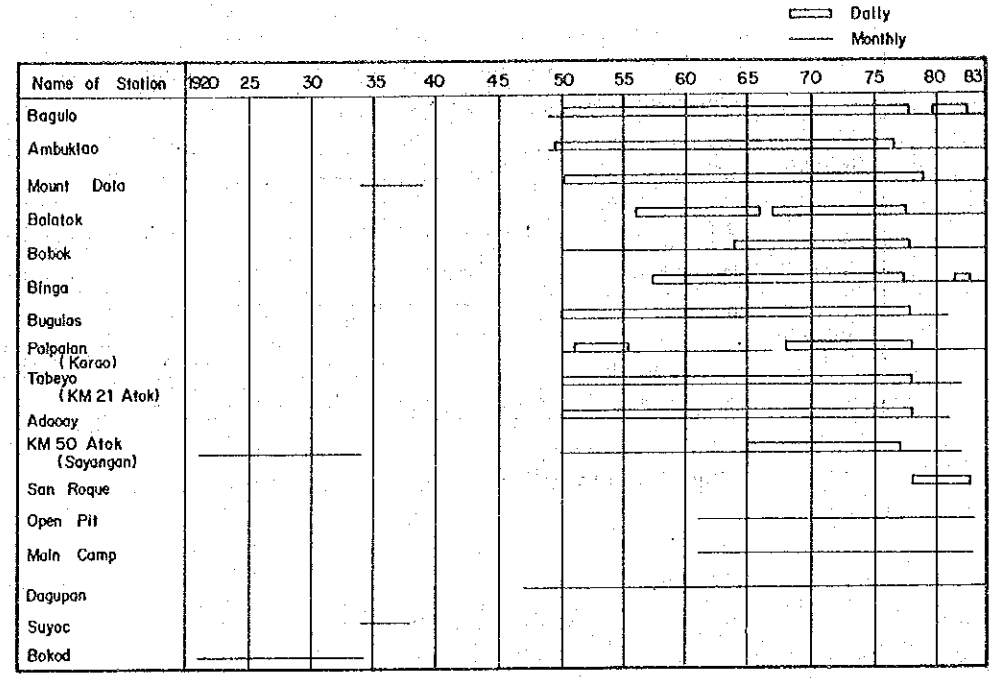


Fig. A-5 Rainfall Record Available for the Study

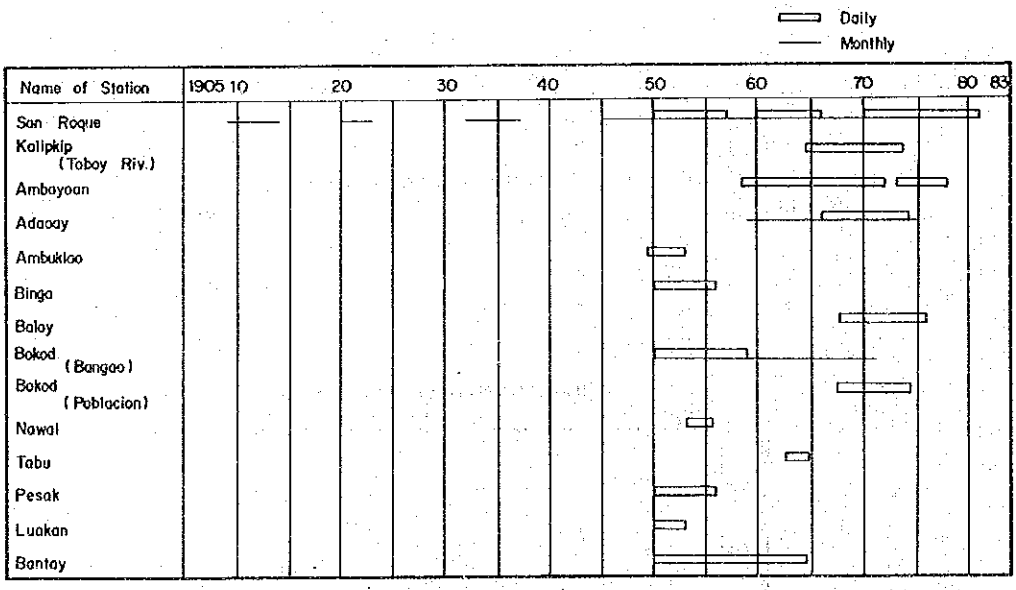
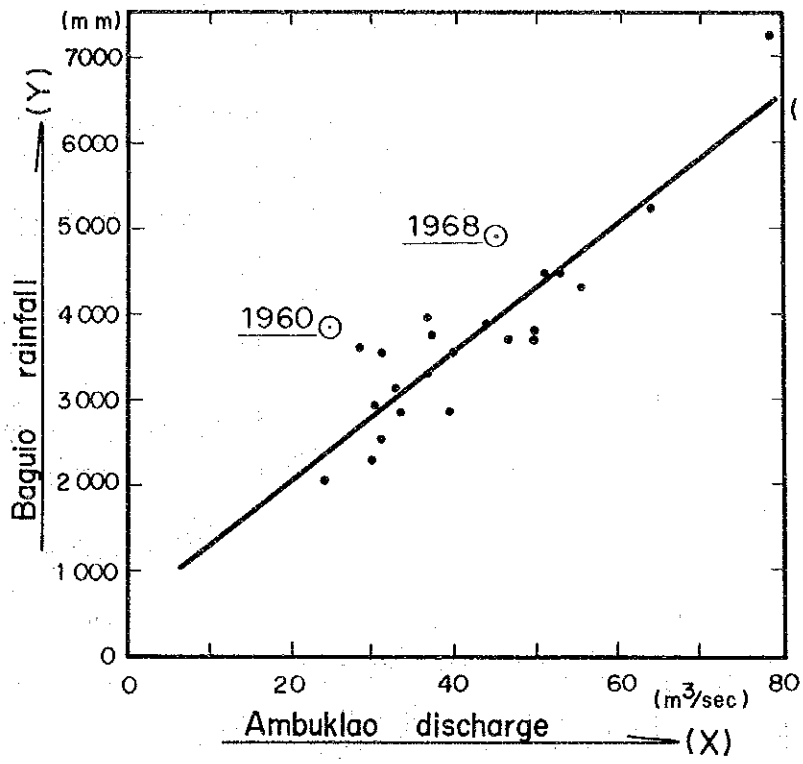


Fig. A-6 Discharge Record Available for the Study

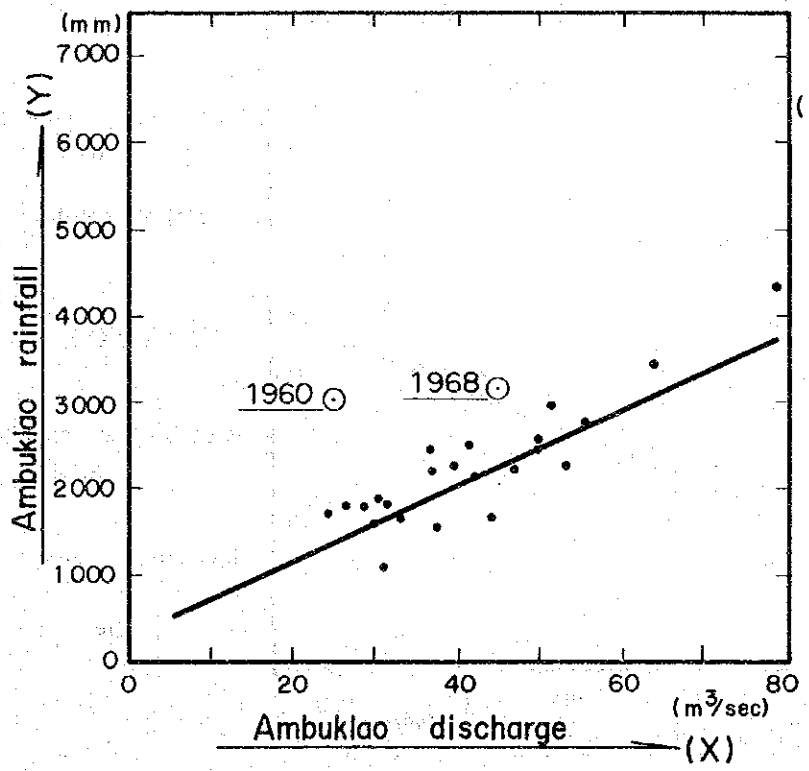


(1) Ambuklao discharge (X)
and
Baguio rainfall (Y)

Y = 76.7X + 469.0

Correlation coefficient:
r = 0.91

Excluded year:
1960, 1968



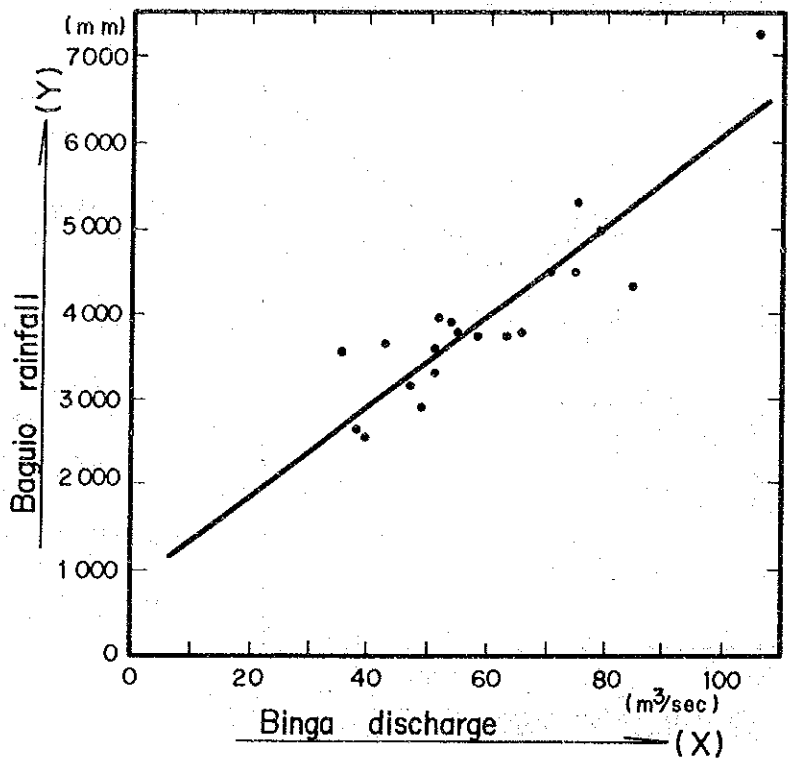
(2) Ambuklao discharge (X)
and
Ambuklao rainfall (Y)

Y = 47.2X + 249.5

Correlation coefficient:
r = 0.89

Excluded year:
1960, 1968

Fig. A-7 Annual Correlation of Ambuklao Discharge with Rainfall



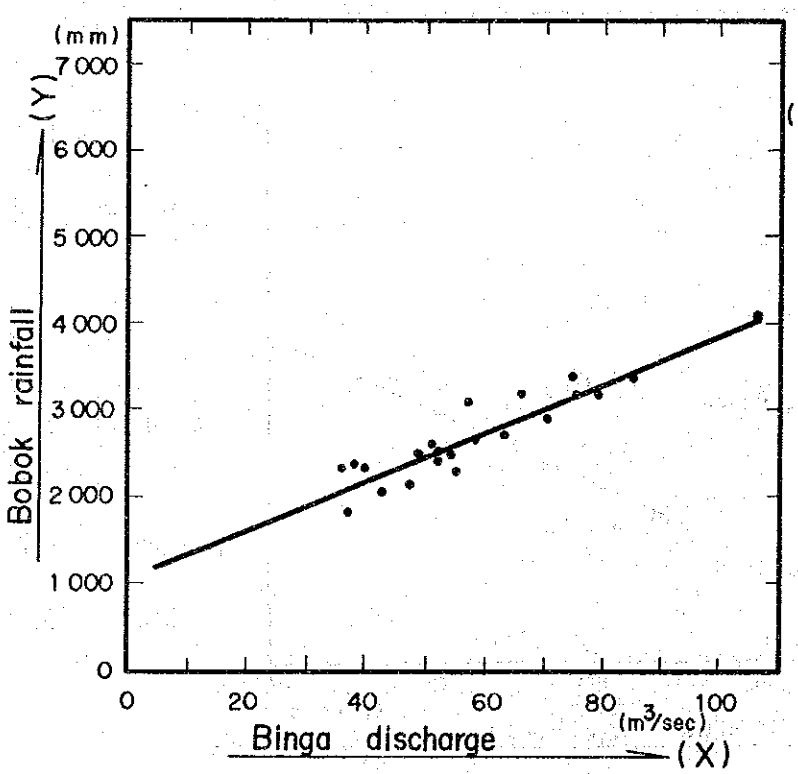
(1) Binga discharge (X)
and
Baguio rainfall (Y)

Y = 53.2X + 745.5

Correlation coefficient :
r = 0.89

Excluded year :

None



(1) Binga discharge (X)
and
Bobok rainfall (Y)

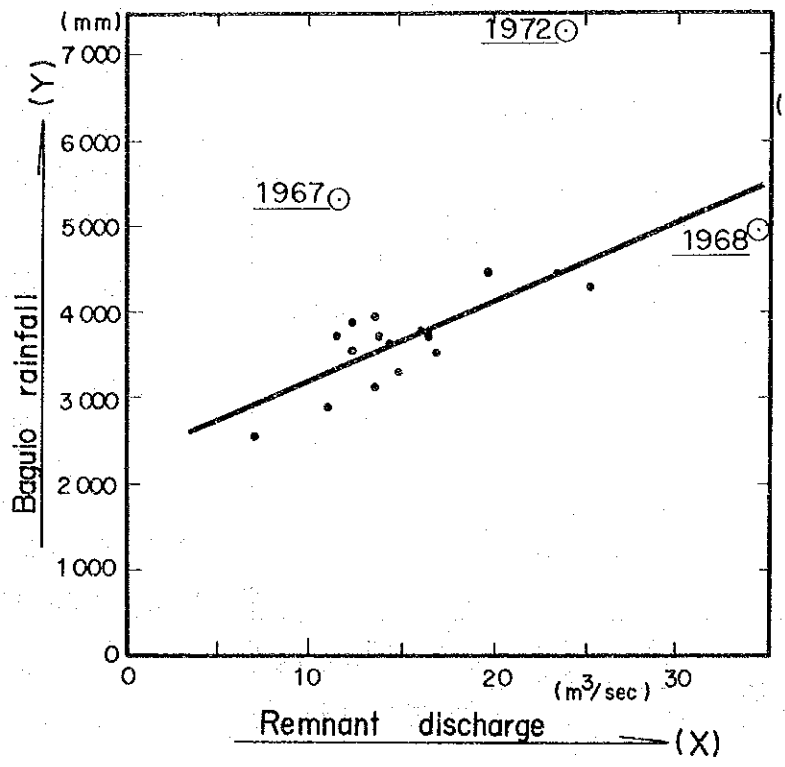
Y = 28.0 X + 1064.8

Correlation coefficient :
r = 0.93

Excluded year :

None

Fig. A-8 Annual Correlation of Binga Discharge with Rainfall



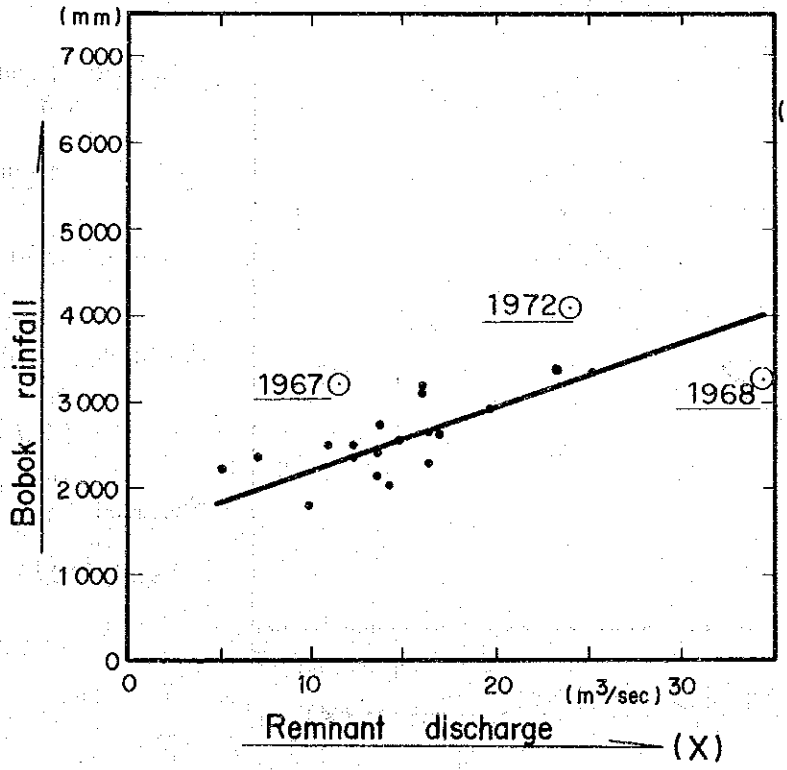
(1) Remnant discharge (X)
and
Baguio rainfall (Y)

Y = 93.0X + 2253.2

Correlation coefficient :
r = 0.80

Excluded year :

1967, 1968, 1972



(2) Remnant discharge (X)
and
Bobok Rainfall (Y)

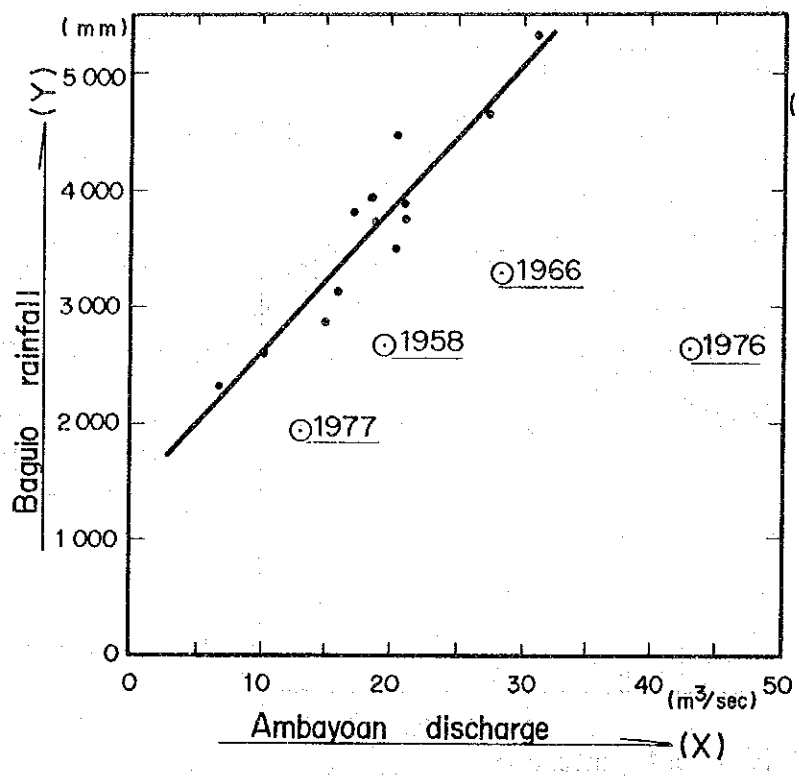
Y = 75.5X + 1459.7

Correlation coefficient :
r = 0.76

Excluded year :

1967, 1968, 1972

Fig. A-9 Annual Correlation of Remnant Discharge (Ambuklao ~ Binga) with Rainfall



(1) Ambayoan discharge (X)
and
Baguio rainfall (Y)

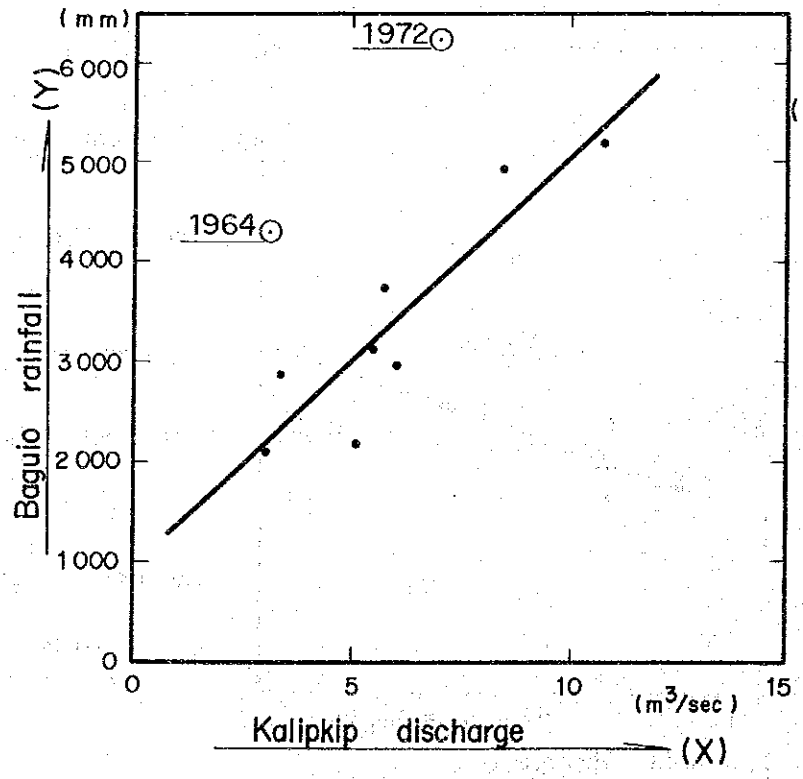
$Y = 125.0 X + 1358.7$

Correlation coefficient:

$r = 0.94$

Exculded year:

1958, 1966, 1976, 1977



(1) Kalipkip discharge (X)
and
Baguio rainfall (Y)

$Y = 406.6X + 957.2$

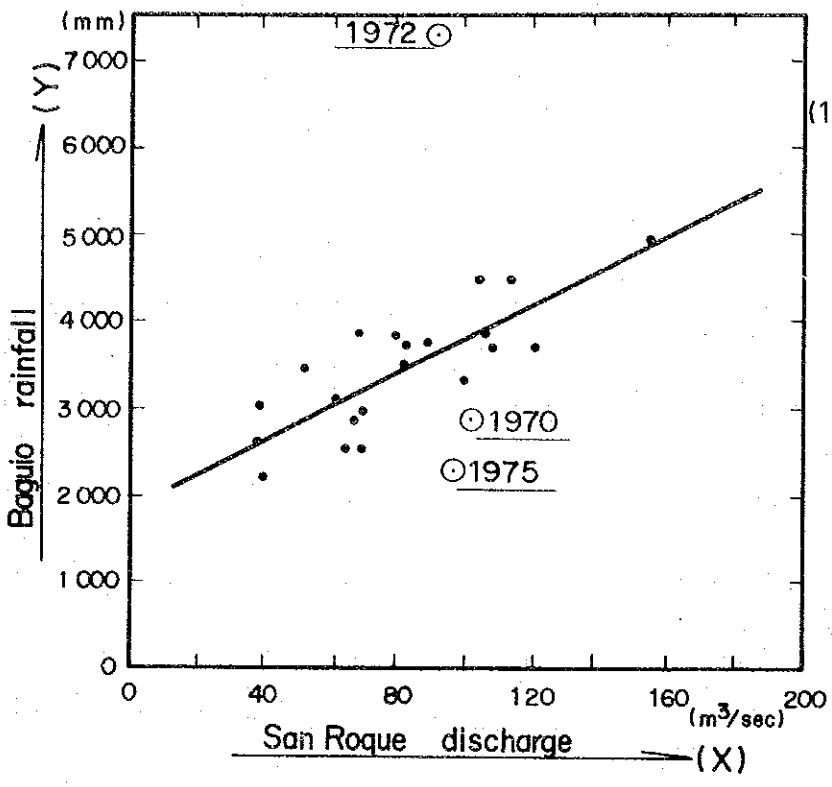
Correlation coefficient:

$r = 0.90$

Excluded year:

1964, 1972

Fig. A-10 Annual Correlation of Ambayoan/Kalipkip Discharge with Rainfall



(1) San Roque discharge (X)
and
Baguio rainfall (Y)

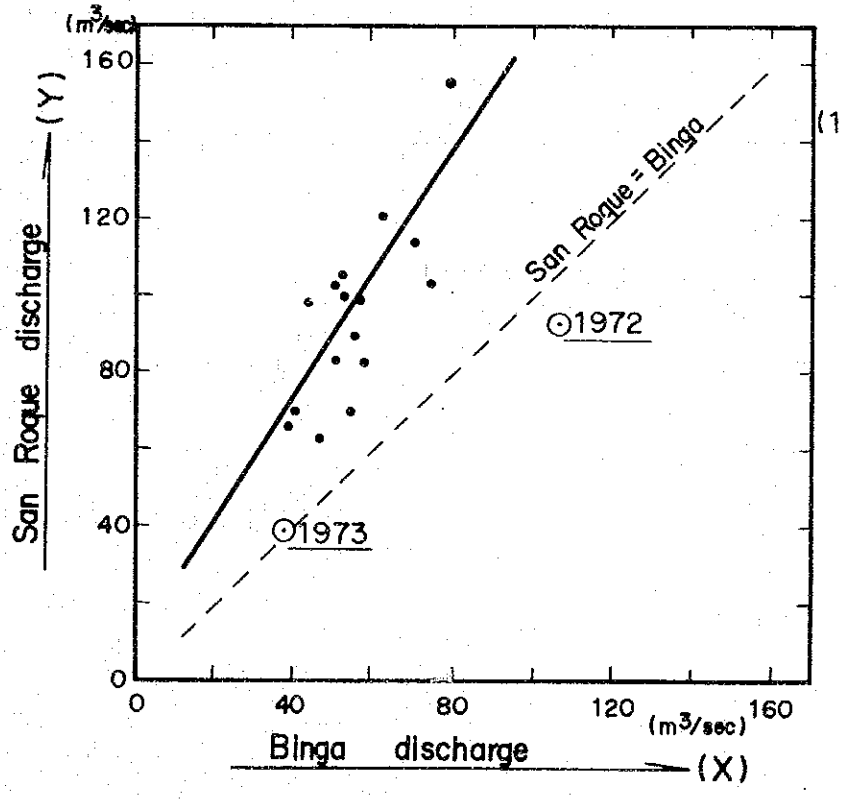
Y = 19.7X + 1842.1

Correlation coefficient:

r = 0.81

Excluded year :

1970, 1972, 1975



(1) Binga discharge (X)
and
San Roque discharge (Y)

Y = 1.55X + 9.0

Correlation coefficient :

r = 0.76

Excluded year :

1972, 1973

Fig. A-11 Annual Correlation of San Roque Discharge with Rainfall/Discharge

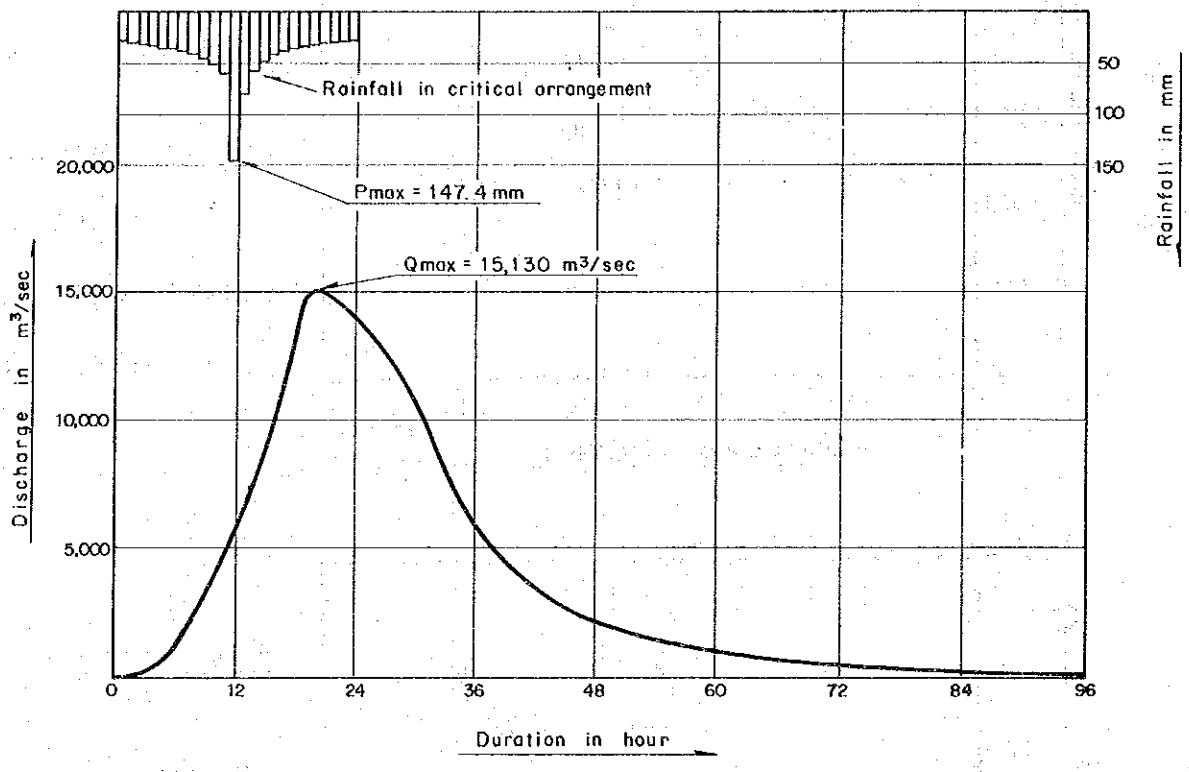


Fig. A-12 Hydrograph for P.M.F.

APPENDIX "B"

DATA OF THE FIXED POINTS OBSERVATION

CONTENTS FOR APPENDIX "B"

DATA OF THE FIXED POINTS OBSERVATION

LIST OF TABLES FOR APPENDIX "B"

LIST OF FIGURES FOR APPENDIX "B"

APPENDIX "B" DATA OF THE FIXED POINTS OBSERVATION

1. Scope of the survey

In order to grasp the status of pollutions as a natural process and as a phenomenon contingent upon mining activities, such as mine drainages, seepage waters from the tailings dam, etc., five observation points were fixed. At the fixed points, measurements and sample collection shown in Fig. B-1 were carried out.

Methods of the measurements and the sample collection are mentioned here.

(1) Flow rate

The flow rate was measured mainly by a current meter method and subsidiarily by a float method.

Current meter method – The most suitable cross line was selected depending upon a condition of the point to be measured; and an area of cross section along the line was measured, while the speed of a current was determined by the current meter. Then the flow rate was calculated by both of the area of cross section and the speed of a current.

Float method – In case of a high water level caused by a flood or a heavy discharge from the Binga dam, when use of the current meter was restricted, a speed of float flowing down was applied to measure the speed of a current. Then the flow rate was calculated.

The flow rate was measured by the method mentioned above at the Fixed Points B–D, but the discharge records of the Binga Power Plant were utilized at the Fixed Point A.

Current meters used for the survey are;

TAMAYA	Current meter UC-2
SANEI	Current meter SANEI-1 LP type

(2) pH, EC and DO

These items were measured by the following instruments;

HORIBA	pH meter H-7SD
TOA DENPA	Portable electoric conductivity meter CM-K
KASAHARA	Dissolved oxygen meter KDO-301

(3) Turbidity

As the turbidity fluctuated in a wide range, two kinds of turbidity meters shown below were used properly depending upon the extent of turbidity.

NIKKYO	Portable turbidity meter NSK-2P
	(Turbidity : under 500 ppm)
TOA DENPA	Portable turbidity meter WQC-1A
	(Turbidity : 500 ppm – 2,000 ppm)

(4) Transparency

Glass cylinders for the transparency tests were used.

(5) Concentration of suspended solids

Suspended solids in a standard capacity of water were:

filtered through glass-fiber filter paper and
dried in a furnace at a temperature of 110°C; and
cooled in a desicator and
weighed by a precision balance.

This handling was repeated 3 times for each sample and an average of 3 measurements was accepted as SS concentration.

The balance used for this measurement is;

Mettler, Switzerland AE160 (Readability: 0.1 mg)

(6) Sample collection for chemical analysis

At each fixed point, water was filtered in the field and the following samples were collected;

Principal samples

Solid : Cake on No. 3 filter paper (5μ)

Water : Filtrate through GS-25 filter paper (0.6μ)

Additional samples for reference

Solid : Cake on GS-25 filter paper which is SS in the filtrate through No. 3 filter paper

Water : Filterate through No. 3 filter paper

Water samples were pre-treated under the following condition;

Element	Pretreatment	Quantity
Cl	none	0.5 ℓ
Cu, Pb, Zn, Cd, Mn, Fe, SO_4, Na, K, Ca, Mg	add HCl to control pH1	2 ℓ
Hg As	add HNO_3 to control pH1	1 ℓ
CN	add NaOH to control pH 12	0.5 ℓ

2. Results of the Survey

Findings of the fixed point observations are commented below.

(1) Fixed Point A

* Water level in the Binga reservoir was maintained in a nearly high without drought during the period of observation.
* There were overflows from the spillway during the period from the end of August to the early part of September due to the result of a big flood caused by Typhoon Maring and at the end of October. During the remaining period, water only used in the power plant was discharged.
* Although turbid water covering the whole strata occurred at the end of August and lasted until the early part of September, when turbidity of the surface water was over 100 ppm, the surface water is generally clear as is obvious from the record of turbidity.
* The reservoir water turned out to be of good quality. It is clean and contained little noxious dissolved matters as is apparent from the record of EC and results of the chemical analysis.
* That the pH value shows 8 to 9 suggesting a weak alkaline condition indicates one of the remarkable features of the natural water in this area.

(2) Fixed Point B

* The flow rate is higher in July to November which corresponds to the rainy season.
* EC is high especially during the dry season, and As, Ca, Mg and SO_4 concentrations are high in the dry season and relatively low during the rainy season. This phenomenon shows that the dilution grade tends to increase in the rainy season.

* Cu and CN concentrations do not decrease in the rainy season, therefore, the dissolved load is shown to get larger in the rainy season.
* Zn concentration is generally low.

(3) Fixed Point C

* Flow rate is higher in July to November, corresponding to the feature of the rainy season.
* EC and Ca, Mg, SO_4 concentrations are decreased in contrast to the increasing of the flow rate, which shows an increasing dilution grade in the rainy season.
* Concentrations of noxious dissolved matters such as Cu, Zn, As and CN are very low.

(4) Fixed Point D

* Flow rate is higher in July to November as at Point C.
* Turbidity is high next to the Point C.
* EC and Ca, Mg, SO_4 concentrations are decreased in rainy season as at Point C.
* Concentrations of noxious dissolved matter are very low.

(5) Fixed Point E

* Width of the stream at the Fixed Point E, which is located below the proposed San Roque dam, was usually 50 m to 70 m, but it widened up to 180 m during flooding.
* The flow rate underwent large fluctuations in a daily cycle during the dry season. On the average, it increases in June and the peak at the early part of September then it tends to decrease.
* pH value is fluctuated in the range of 7.2–9.0 indicating a weak alkaline condition.
* EC value fluctuates according to the flow rate. In general, it is higher during the period from December to July than during the rainy months.
* Turbidity is higher during the period from June to November corresponding to the increasing amount of natural turbid water.
* Ca, Mg, SO_4 concentrations are decreased in contrast to an increase of the flow rate.
* Cu and CN concentrations increase late in June and maintain a high level up to the middle of August.
* As shown in the Table B-48 and Fig. B-13, a significant positive correlation is observed among EC, As, Ca, Mg and SO_4 concentrations and significant negative correlation between these 5 elements and flow rate.

Fluctuation in a daily cycle

As stated above, the flow rate underwent a big fluctuation in the daily cycle. Therefore the flow rate (water level) and water quality were observed continuously every hour or every two hours in order to evaluate the tendency. The findings of this survey are as follows;

* The water level tends to go up at about 3:00 p.m., to stay high for about 10 hours and to go down thereafter.
* The pH-value does not show any tendentious fluctuations.
* EC shows its peak in the beginning of a flooding and drastically goes down in the course of a prolonged flooding. It increases gradually as the flooding decreases and retrieves its value which it had before the peak.
* The interrelation between DO and water level is not clear. DO increases from the night to the morning and decreases during the daytime, suggesting its fluctuations are due to water temperature changes.
* Turbidity shows a similar tendency as that of the EC, i.e. showing an acute peak in the beginning of a flooding and drastically decreases in the course of a prolonged flooding. It increases gradually as the flooding decreases and retrieves its value which it had before the peak.